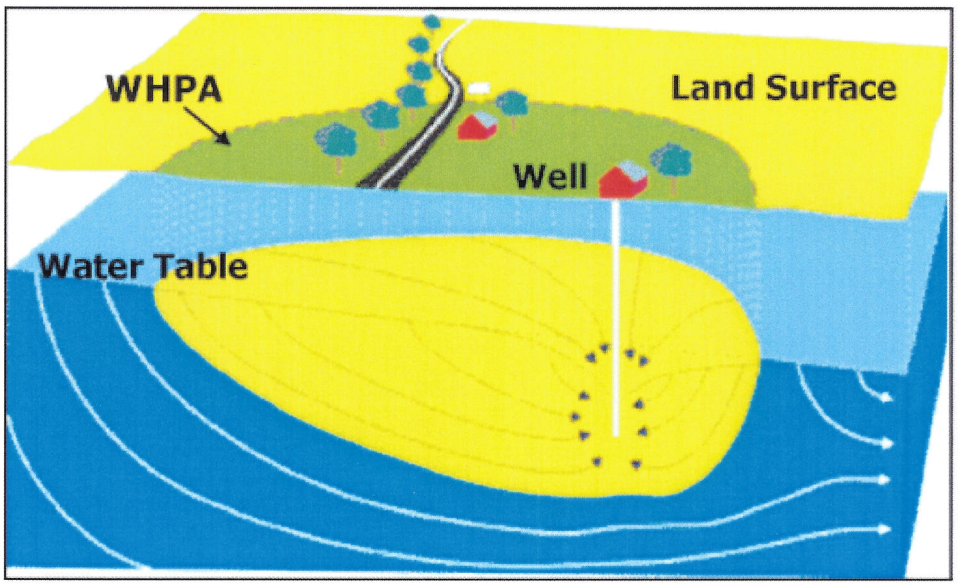
Source Water Assessment
for the Saint James School Water System
Washington County, Maryland



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Maryland Department of the Environment
Water Management Administration
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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 St. James School 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 St. James School's water supply is a spring issuing from an unconfined carbonate rock aquifer. 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 identified within the assessment area from field inspections, contaminant inventory databases, and previous studies. The Maryland Office of Planning's 2000 digital land use map for Washington County was used to identify non-point sources of contamination. Source information and water quality data were also reviewed. An aerial photograph and maps showing potential contaminants 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 water system, the presence of potential sources of contamination in the source water assessment area, source integrity, and the inherent vulnerability of the aquifer. It was determined that the St. James School water supply is susceptible to contamination by nitrate, radionuclides, volatile organic compounds, synthetic organic compounds, and microbiological contaminants. Radon-222, a naturally occurring contaminant, may pose a risk to the water supply. The water supply is not susceptible to contamination by other inorganic compounds or other radionuclides.

INTRODUCTION

The Water Supply Program has conducted a Source Water Assessment for the St. James School water system in Washington County. St. James School is located in central Washington County approximately 5 miles southwest of the City of Hagerstown. The water system serves a population of 200 and has 20 service connections. The water system is owned by the Saint James School and is contractually operated by the Washington County Water and Sewer department.

SOURCE INFORMATION

Source information was obtained from the Water Supply Program's database, site visits, well completion reports, sanitary survey inspection reports, and published reports. The St. James School presently obtains its water supply one spring (Fig 1). The spring was determined to be a ground water under direct influence of surface water (GWUDI) source and the school has been filtering their water in order to comply with the surface water treatment rule since February 2000. A well was drilled as an emergency backup source to supplement the spring during the dry conditions experienced in the summer of 2002. The well is not assessed in this report, because it has not been incorporated into the water system due to the recovery from drought conditions. The spring and the backup well are located on the school property near the main buildings (Fig. 1). An inspection of the springhouse revealed that it was in good condition and had a locked door to prevent improper entry. The photos below show the condition of the springhouse in June 2000.

The St. James spring: Outside and inside views of the springhouse.

The St. James School water system has an appropriation permit to draw water from the Conococheague Limestone formation for an average use of 8,200 gallons per day (gpd) and a maximum of 12,900 gpd in the month of maximum use. Based on the most recent monthly operating reports, the average daily use was 10,183 gallons from the period of April 2001 to March 2002. The month of maximum use was April 2001 with an average daily use of 15,020 gallons.

HYDROGEOLOGY

The St. James School lies within the Hagerstown Valley physiographic province, which occupies the area from the western base of South Mountain to the Bear Pond Mountains west of Clear Spring. The spring is a discharge point from the upper member of the Conococheague formation. The Conococheague limestone is a sequence of carbonates that have developed into a karst-like aquifer that underlies this portion of Washington County. Duigon (2001) has identified sinkholes, wells that penetrate cavernous zones, and other karst features in this area. A tributary to St. James Run was documented as a losing reach in a section just north of the school. In general, karst aquifers can be prolific water producers due to solution-enlarged fractures, joints, and bedding planes that rapidly transport water. Ground water is recharged by precipitation percolating though soil and saprolite, through direct runoff into sinkholes, and by losing streams. The majority of water circulation is in the subsurface in karst areas, and the density of perennial streams is low in the Hagerstown valley for this reason (Duigon, 2001). The discharge of the St. James spring represents a significant area of ground water flow in the valley.

SOURCE WATER ASSESSMENT AREA DELINEATION

The source water assessment area for public water systems using springs that have been determined ground water under direct influence of surface water (GWUDI) is the watershed drainage area that contributes to the spring. In karst areas such as this one, the area should be modified to account for geological boundaries, ground water divides, and by annual average recharge needed to supply the spring (MD SWAP, 1999).

Dye Tracing

A dye trace study was conducted during the summer of 2000 in order to help delineate the recharge area and ascertain ground water flow directions for the St. James Spring. The summary report for this study is attached in the Appendix. The results of the dye tracing study were used to delineate the source water assessment area based on the results summarized below.

The losing stream near St. James School does not contribute to the recharge of the St. James spring, although it does appear that the stream loses some water to the ground, which then flows to the southeast. Eosine dye, which was introduced into the tributary to St. James Run, was not detected in the school's spring. It was detected in Site 2, a spring fed pond southeast of the injection site. Eosine was detected at Site 2 nine days after injection, and again 23 days after injection. This indicates that the tributary is losing and recharging the aquifer. However, the amount of recharge appears to be minimal based on the low intensity of the Eosine peak detected at Site 2 and the fact that it was only detected in two of six recovery samples. Additionally, recharge to the aquifer from the stream flows to the southeast, away from the St. James spring, based on the Eosine trace. Eosine was not detected at any other recovery sites.

The sewer system was leaking and contaminants in the near surface area will reach the spring within days. Rhodamine WT was detected in the St. James spring four days after it was introduced to the sewer system. It continued to linger in the spring water throughout the sampling period, with peak intensities declining over time (chart 1, appendix). This data shows strong evidence of not only the problems with the sewer system, but of the influence on shallow ground water on the spring. The sewer lines are 1-3 feet below the surface approximately 100 feet up gradient from the spring. Therefore, contaminants at the surface near the spring will also have a short travel time to the spring. Rhodamine was not detected at any other recovery sites.

Delineation

The results of the Eosine dye trace indicate that the recharge area of the St. James spring should not include the entire watershed of St. James Run. Furthermore, the Rhodamine WT trace indicates that the area directly up slope of the stream is an extremely vulnerable due to the short travel times revealed in this study. A source water assessment area (SWAA) for the St. James spring has been delineated using the information gathered here, and discharge data for the spring and effective recharge published in previous reports. Figure 2 is a map of the SWAA.

Discharge from the St. James spring was measured between August, 1958 and August 1959 (MGS, BDR No. 18). The average discharge for the year was approximately 640 gallons per minute (gpm). Average precipitation in the Hagerstown area is 39 inches annually. The effective ground water recharge is estimated to be 13 inches annually in the St. James Run basin based on water budgets from Duigon and Dine, 1991. Over the long term, ground water recharge is equal to ground water discharge. Based on the available flow data from the spring, a recharge area of 41,600,000 square feet (approximately 950 acres) was calculated for the spring. The SWAA was delineated, based on topography, to include the area upgradient of the spring that comes closest to the calculated recharge area. The final area delineated is 926 acres (Fig. 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. 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

A review of MDE contaminant databases revealed a few potential point sources of contamination within the SWAA borders (Table 2). Underground storage tanks (UST) were identified in three facilities, two of which are currently in use (Fig. 3). Three tanks were listed for the St. James School facility, but the status of these tanks was listed as unknown in the Oil Control Program's database.

ID[1]	Type	Facility Name	Comments
1	UST	Robert S. Strauch	1 - 6,000 gal. heating oil tank in use
2	UST	Hagerstown Corporate Center	2 - 6,000 gal. gasoline tanks in use, 1- 1,000 gal. diesel tank in use, 4 older tanks removed from ground
3	UST	Main Building	3 Tanks with unknown status listed for facility (Main Building, Gymnasium, and Onderdonk Building)

Table 2. Potential Contaminant Sources in St. James School SWAA **([1]See Figure 3)**

Underground Storage Tanks (UST's) are a potential source of volatile organic compounds from petroleum products if they leak. Newer tanks are less likely to leak due to new construction standards, however leaks may still be common in underground piping. Leaks often go undetected unless a water supply is impacted, because they are located in the subsurface.

Non-Point Sources

The Maryland Office of Planning's 2000 digital land use coverage of Washington County was used to determine the predominant types of land use in the SWAA (Fig. 4). The land use summary is given in Table 3. The majority of the SWAA consists of agricultural land, with smaller proportions of a variety of forested, residential, and commercial areas.

Land Use Type	Total Acres	Percent of SWAA
Low Density Residential	52	5.6
Commercial and Institutional	80	8.7
Cropland	492	53.1
Pasture	118	12.8
Intensive Feeding Operations	20	2.1
Forest	163	17.6
Water	1	0.1
Total	926	100

Table 3. Land Use Summary

Agricultural land (cropland and pasture) is commonly associated with nitrate loading of ground water and also represents a potential source of SOCs depending on fertilizing practices and use of pesticides. Intensive Feeding Operations are of particular concern, due to the amount of animal waste produced over a small area and the ability to discard of this waste properly. Residential areas without sewer service may be a source of nitrate and microbiological pathogens from septic systems if they fail. However, as shown by the dye trace, failing sewer lines in close proximity to a drinking water source represent a significant threat as well. Additionally, residential areas may be a source of nitrate and SOCs if fertilizers, pesticides, and herbicides are not used carefully in lawns and gardens. Commercial and industrial areas are associated with facilities that may have point sources of contamination as described above.

Forested areas within the SWAA serve as protective buffers for the water supply as they generally do not contribute contaminants and may take up nutrients (such as nitrogen) that may be introduced to ground water from other types of land use.

The Maryland Office of Planning's 1996 digital sewer map of Washington County shows that most of the SWAA (86%) is in an area of the county that is not planned for sewer service and is a mix of residential, forested, and agricultural land (Fig. 5). The school is on its own sewer system as an existing service area. In addition, the northernmost section of the SWAA is in the Washington County's Conococheague sewer service area.

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 an 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 St. James School water system has one point of entry or plant, which uses chlorination and ultra-violet radiation for disinfection, pH adjustment for corrosion control, cartridge filtration for particulate removal, and ion exchange for softening.

A review of the monitoring data for St. James School's water indicates that the water supply meets drinking water standards. Nitrate is the only inorganic compounds that has been detected above the SWAP threshold level. Radon-222 has been detected in the water supply but other radionuclides were not detected at a level of concern. Volatile organic compounds and synthetic organic compounds, have not been detected above the SWAP threshold level. The water quality sampling results are summarized in Table 4.

Contaminant Group	No. of Samples Collected	No. of Samples over 50% of an MCL
Inorganic Compounds (except Nitrate)	58	0
Nitrate	31	16
Radiological Contaminants	4	1[2]
Volatile Organic Compounds	7	0
Synthetic Organic Compounds	4	0

Table 4. Summary of Water Quality Samples

[2]Proposed MCL for Radon-222

Inorganic Compounds (IOCs)

A review of the data shows that nitrate levels in the water supply range from non-detected to 7.9 parts per million (ppm), but are consistently below the MCL of 10 ppm (Table 5). Nitrate was detected above the SWAP threshold level of 5 ppm in 52% of the samples collected. No other inorganic compounds were detected above 50% of an MCL.

SAMPLE DATE	RESULT (PPM)
18-Feb-94	5.2
22-Feb-94	5.5
13-Jul-94	4.5
30-Sep-94	4.5
17-Nov-94	1.7
23-Jan-95	3.3
14-Mar-95	5.3
02-May-96	-0.5
13-Jun-97	5.3
07-Apr-98	5.7
12-May-98	5.2
03-May-99	3.5
01-May-00	7.9
01-Aug-00	4.7
20-Nov-00	4.2
01-Feb-01	5.1

SAMPLE DATE	RESULT (PPM)
07-Feb-01	5.1
12-Apr-01	4.8
01-May-01	6.2
01-Aug-01	4.2
17-Dec-01	5.0
04-Feb-02	4.4
06-May-02	5.3
02-Aug-02	4.2
17-Oct-02	4.3
07-Nov-02	4.5
07-Feb-03	5.8
21-Mar-03	4.4
02-May-03	6.7
01-Aug-03	6.0
06-Nov-03	5.6

Table 5. Nitrate Data from the St. James Spring

Radionuclides

A review of the data shows that the only radionuclide at a level of concern was Radon-222. There is currently no MCL for Radon-222, however EPA has proposed an MCL of 300 pCi/L or an alternate 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. The EPA received many comments in response to their proposed rule, and promulgation may be delayed. The only Radon-222 result available was collected in May 1999 and the level was 475 pCi/L. This result is greater than the lower proposed MCL, but below 50% of the higher proposed MCL.

Volatile Organic Compounds (VOCs)

A review of the data shows that regulated VOCs have not been detected in the water supply. Disinfection byproducts grouped as trihalomethanes (THMs) have been detected at very low levels are currently unregulated for systems serving less than 10,000 people. In 2004, the MCL for total THMs will be 80 ppb for these systems, which is unlikely to affect the St. James School based on the current levels.

Synthetic Organic Compounds (SOCs)

A review of the data shows that synthetic organic compounds have not been detected above 50% of an MCL in the water supply.

Microbiological Contaminants

Raw water bacteriological data is available for the spring from evaluation for ground water under the direct influence of surface water (GWUDI). The raw water data is shown in Table 6. Total and fecal coliform levels exceeded the detection limits in several instances and the concentrations are shown with a greater than symbol for these results.

Rain Amount (inches)	Comment	Sample Date	Temp (°C)	pH	Turbidity* (Ntu)	Total Coliform* (Colonies/ 100ml)	Fecal Coliform* (Colonies/ 100ml)
0	Dry Weather Sample	02-Jun-99	12.2	7	< 1	> 8	> 8
1.4	Wet Weather Set	03-Jun-99	12	7	0.8	> 80	> 80
		04-Jun-99	12	7	< 1	> 800	> 800
		05-Jun-99	11.9	6.9	< 1	4600	4600
		06-Jun-99	11.9	7.1	< 1	< 1100	< 1100
0.8	Wet Weather Set	07-Sep-99	12.1	7	< 1	> 80	> 80
		08-Sep-99	12.1	7.1	< 1	2600	< 1100
		09-Sep-99	12.2	6.9	n/a	> 8000	> 8000
		10-Sep-99	12.2	7.1	< 1	> 8000	> 8000
0.5	Wet Weather Set	04-Oct-99	12.5	7.1	0.6	> 800	> 800
		05-Oct-99	12.3	7.1	< 1	> 800	> 800
		06-Oct-99	12.3	7.1	< 1	< 1100	< 1100
		07-Oct-99	12.3	7.1	< 1	< 1100	< 1100

Table 6. Ground Water Under the Direct Influence Data from raw water of St. James Spring.
*A less than symbol indicates below the detectable level shown
*A greater than symbol indicates greater than the detectable level shown

Turbidity

The turbidity standard for GWUDI sources is not to exceed 0.5 NTU 95% of the time or not to exceed the 5.0 NTU at any time. The school monitors raw water turbidity daily and a review of the data shows that the levels range from 0.2 to approximately 2.0 NTU and has not exceeded turbidity standards.

SUSCEPTIBILITY ANALYSIS

The spring serving the St. James School water supply receives its water from an unconfined karst-limestone aquifer. Wells in karst aquifers are generally vulnerable to any activity on the land surface that occurs within the source water assessment area due to the rapid transport of water from the surface to the ground. 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 SWAA, 2) water quality data, 3) source integrity, and 4) the aquifer conditions. Table 7 summarizes the susceptibility of St. James School's water supply to each of the groups of contaminants.

Due to the vulnerable nature of the karst aquifer, the water supply is considered susceptible to a contaminant if a source of those contaminants is present within the SWAA, despite the fact that not all contaminants have been detected (e.g. SOCs, VOCs).

Inorganic Compounds

Nitrate is present in 52% of samples at or above 5 ppm (Table 5). The MCL for nitrate is 10 ppm. Sources of nitrate can generally be traced back to land use. Fertilization of agricultural fields and residential lawns, residential septic systems, and livestock are all common sources of nitrate loading in ground water and are all present to some extent in the WHPA. Nitrate levels do not seem to fluctuate in a discernible pattern, such as seasonally, or do not show an increasing or decreasing trend in concentration over the nine years of available data. Due to the levels of nitrate found, the vulnerability of the aquifer to land activity, and the presence of nitrate sources in the WHPA, the water supply **is** susceptible to this contaminant.

The water supply is **not** susceptible to other inorganic compounds due to the lack of potential contaminant sources within the WHPA.

Radionuclides

The water supply **may be** susceptible to Radon-222. The source of radionuclides in ground water is the natural occurrence of uranium in rocks. The concentration of constituents such as Radon-222, Radium-226, and Radium-228 can vary considerably in the same aquifer to due to many factors such as pH, exposed surface area of minerals, and other natural conditions. The concentration of Radon-222 is above the lower proposed MCL of 300 pCi/L in the lone sample available. Depending on the MCL that is eventually adopted, the water supply may be determined susceptible to Radon. Gross-Alpha and Gross-Beta results indicate that other radionuclides are not likely to be a problem in the water supply.

Volatile Organic Compounds

The water supply **is** susceptible to contamination by VOC's, due to the presence of contaminant sources in the SWAA. VOC's have not been detected, however the presence of underground storage tanks that carry petroleum products in the SWAA make the water supply susceptible to this group of contaminants.

Synthetic Organic Compounds

The water supply **is** susceptible to synthetic organic compounds. SOCs were not detected in the water supply, however pesticide or herbicide use in the cropland areas, which is a considerable portion of the SWAA, can be a source of these contaminants.

Microbiological Contaminants

The presence of fecal coliform in the raw water from the spring indicates its susceptibility to pathogenic microorganisms. Pathogenic protozoa, viruses, and bacteria normally associated with surface water can contaminate the spring due to the rapid recharge from surface to ground in the karst aquifer. Sources of these pathogens are generally improperly treated wastewater or failing septic systems, waste material from mammals, and urban runoff in developed areas. The presence of large pasture areas and the area designated as a confined feeding operation are also significant sources of fecal contamination. As a GWUDI source, the spring is susceptible to all microbiological contaminants.

Contaminant Group	Are Contaminant Sources Present in SWAA?	Are Contaminants Detected Above 50% of MCL?	Is the Aquifer Vulnerable?	Is the System Susceptible?
Nitrate	YES	YES	YES	YES
Inorganic Compounds (except nitrate)	NO	NO	YES	NO
Radiological Compounds	YES (aquifer)	YES[3]	YES	YES[3]
Volatile Organic Compounds	YES	NO	YES	YES
Synthetic Organic Compounds	YES	NO	YES	YES
Microbiological Contaminants	YES	YES	YES	YES

Table7. Susceptibility Analysis Summary.

[3]Proposed MCL, See explanation in text above

Management of the Source Water Assessment Area

With the information contained in this report the St. James School and the Washington County Water and Sewer Department are in a position to protect the water supply by staying aware of the area delineated for source water protection and evaluating future development and land planning. Specific management recommendations for consideration are listed below:

Form a Local Planning Team

- The St. James School and he Department of Water and Sewer should contact the County Planning Department to form a local planning team to begin to implement a wellhead protection plan. The team should represent all the interests in the community, such as the water supplier, home association officers, the County Health Department, local business, developers, and property owners, and residents within and near the SWAA. The team should work to reach a consensus on how to protect the water supply.
- A management strategy should be consistent with the level of resources available for implementation. MDE remains available to assist in anyway we can help the process.
- MDE has grant money available for Wellhead Protection projects.

Public Awareness and Outreach

- The Consumer Confidence Report should list that this report is available to the general public through their county library, by contacting the Water and Sewer Department or MDE.
- Conduct educational outreach to the facilities that may present potential contaminant sources. Important topics include: (a) compliance with MDE and federal guidelines for UST's, (b) monitoring well installation near UST's, (c) appropriate use and application of fertilizers and pesticides, (d) chemical storage and disposal (e) and best management practices for large-scale animal feeding operations.
- Road signs at the SWAA boundary are an effective way of keeping the relationship of land use and water quality in the public eye, and help in the event of spill notification and response.

Monitoring

- Continue to monitor for all Safe Drinking Water Act contaminants as required by MDE.

Planning/ New Development

- Review the State's model wellhead protection zoning ordinances for potential adoption. Coordinate with Washington County Department of Planning to adopt a wellhead protection ordinance.

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 SWAA. Loans are currently offered at zero percent interest and zero points. Contact the Water Supply Program for more information.

Contingency Plan

- St. James School should have a Contingency Plan for its water system. COMAR 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.

Contaminant Source Inventory Updates/ Inspections

- The Department of Water and Sewer should conduct their own field survey of the source water assessment area to ensure that there are no additional potential sources of contamination.
- Periodic inspections and a regular maintenance program for the spring will ensure its integrity and protect the aquifer from contamination.

Changes in Use

- The school is required to notify MDE if new wells are to be put into service. Drilling a new well outside the current SWAA would modify the area; therefore the Water Supply Program should be notified if a new well is being proposed.

REFERENCES

Bolton, D.W., 1996, Network Description and Initial Water-Quality Data from a Statewide Ground-Water-Quality Network in Maryland: Maryland Geological Survey Report of Investigations No. 60, 167 pp.

Committee on Health Risks of Exposure to Radon, 1999, Health Effects of Exposure to Radon: BEIR VI, (http://www.epa.gov/iaq/radon/beirvi1.html).

Duigon, M.T., 2001, Karst Hydrogeology of the Hagerstown Valley, Maryland, MGS Report of Investigations No. 73, 128 pp.

Duigon, M.T., and J.R. Dine, 1991, Water Resources of Washington County, Maryland, MGS Bulletin 36, 109 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 WA1968G010
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 Quadrangles for Williamsport
USGS Topographic 7.5 Minute Quadrangles for Williamsport
Maryland Office of Planning 2000 Washington County Digital Land Use Map
Maryland Office of Planning 1996 Washington County Digital Sewer Map

APPENDIX

St. James School Dye Trace Investigation Results

Water Supply Program, MDE
February 2001

Background

As stipulated in Maryland's Source Water Assessment Plan (SWAP), water systems using springs that have been determined under the direct influence of surface water (GWUDI) require further investigation to delineate a source water assessment area for the spring. The St. James School relies on its spring as the only source of water serving a population of approximately 200. The school has installed advanced treatment methods to comply with the Surface Water Treatment Rule (SWTR).

The St. James spring is located in the Hagerstown Valley of Maryland, approximately 5 miles southwest of Hagerstown. The spring is a discharge point from the upper member of the Conococheague formation. The Conococheague limestone is a sequence of carbonate formations that have developed into a karst-like aquifer that underlies this portion of Washington County. Duigon (in prep.) has identified sinkholes, wells that penetrate cavernous zones, and other karst features in this area. A tributary to St. James Run was documented as a losing reach in a section just north of the school (Fig. 1). Preliminary results from fecal coliform testing of the tributary show levels comparable to that of the spring.

The St. James spring: Outside and inside views of the spring house.

The spring was determined under direct influence of surface water based on high bacteria levels that indicated that the water flowing from this spring has a shallow source. Fecal coliform levels in the spring water have been measured as high as 8000 colonies/100 ml .

The purpose of this study was to determine the recharge area of the St. James spring in order to delineate a source water assessment area. Dye tracing was used to 1) determine if the tributary to St. James Run is a losing stream and if it is contributing to the recharge of the St. James spring; and 2) to determine if the school's sewer lines are leaking and contaminating the spring.

Preliminary work

The St. James spring was determined as a GWUDI source in November 1999 due to high fecal coliform concentrations in the raw spring water (Table 1). Immediately following this determination, the Washington County Environmental Health department attempted to determine if the sewer lines were leaking by introducing a fluorescent dye into the sewer system. No visual detection of the dye was observed in the spring, however this may be due to the fact that the dye was diluted below this visual detection level. At this point, the school initiated installation of filtration devices to comply with the SWTR.

SAMPLE DATE	RESULT (colonies/100 ml)
6/3/99	80.1
6/4/99	800.1
6/5/99	4600
6/6/99	-1100
9/7/99	80.1
9/8/99	-1100
9/9/99	8000.1
9/10/99	8000.1
10/4/99	800.1
10/5/99	800.1
10/6/99	-1100
10/7/99	-1100

Table 1. Results of fecal coliform sampling at the St James Spring. All samples collected after storm events. (A negative value indicates not detected.)

In order to determine if the stream had comparable levels of fecal coliform as the spring, weekly samples were collected from the tributary (Table 2) for two months in the spring of 2000. Fecal coliform levels were as high as 17,000 colonies/100 ml following a significant rainfall.

SAMPLE DATE	RESULT (colonies/100 ml)
4/4/00*	17000
4/5/00	500
4/13/00	500
4/19/00*	8000
4/20/00	3000
4/25/00	800
5/2/00	2300
5/9/00	2200
5/17/00	500
5/24/00	2300

*Table 2. Results of fecal coliform sampling at the tributary to St James Run. *Samples collected after storm event.*

Discharge at the tributary to St. James Run was measured prior to the dye trace. Three sites were gaged (Fig. 1). Stream discharge data was collected after no measurable precipitation was recorded for five consecutive days. This was required to ensure base flow conditions. Results of discharge measurements are listed in Table 3. Site 1, which was also gaged by Duigon, is located approximately 1.3 miles north of the spring, just downstream of the Rench Road crossing. Sites 2 and 3 are upstream of the College Road crossing. Site 3 was chosen to determine if the section between sites 1 and 3 was gaining or losing. Site 2 was chosen after field investigation revealed an outcrop of bedrock in the streambed, which represented a possible location for stream water to enter the ground water system. Site 2 is approximately 200 feet upstream from the outcrop.

Measuring discharge on the tributary to St James Run at stream gaging site 1.

	Stream Discharge in Gallons Per Minute (gpm)		
Date	Site 1	Site 2	Site 3
08/09/2000	601	n/a	799
08/22/2000	633	698	724
average	617	698	762

Table 3. Stream discharge measurements from the tributary to S. James Run.

Eight recovery sites (Fig. 1), including the St. James spring, were identified from a field reconnaissance of the study area and a review of springs, seeps, and drilled wells identified in previous studies. The locations were selected in a radial pattern around the injection point to better characterize the local flow regime and the impact of surface water influence on ground water supplies in the immediate vicinity.

Background dye recovery samples were collected on a weekly basis at all sample recovery sites until it was confirmed that the selected dyes were not present in the system.

Tracing and Sample Collection

During preliminary work for this study, a problem emerged that necessitated a revised study plan. During the first two weeks of background sampling, a fluorescein-like substance was detected in the St. James School spring. It was determined that yellow-green tracing dye was placed into the sewer system, prior to repairs made to the sewer lines, in August 1999. Because it was unknown how long the fluorescein-like substance would remain in the ground water system, other fluorescent dyes not present at background levels (Eosine, Rhodamine WT) were chosen for this tracing study.

The original sole purpose of this investigation was to determine if the tributary to St. James Run is recharging the aquifer and if the contaminated surface water is reaching the school's spring. The presence of the fluorescein-like substance indicated that the old sewer infrastructure was leaking and contaminating the spring. However, it was unclear whether or not the sewer line repair had completely resolved the leakage problems. Therefore, two different dyes were introduced simultaneously into the stream and the sewer system to determine whether or not either sources of contamination were reaching the spring.

Fluorescent dyes were injected into the sewer system at the St. James School and the tributary of St. James Run. Approximately 1 pound of Rhodamine WT was introduced into the sewer system on September 1, 2000 in two locations in the campus restroom facilities. Approximately 1.5 pounds of Eosine was introduced to the stream at the upstream stream gaging location (site 1) on September 11, 2000. Rhodamine WT (C.I. Acid Red #388) is a deep red fluorescent dye and Eosine (Color Index 45380) is a dark red dye at very high concentrations, but becomes a yellow-green fluorescent dye as it is diluted. Both dyes are common to ground water and potable water supply tracing.

Recovery samples were collected for 8 weeks after injection using activated charcoal samplers. Approximately 5 grams of activated charcoal contained in nylon screen mesh bags were placed at each recovery point. The sample collection schedule is listed in Table 4.

Rhodamine WT dye in the holding tanks of the St. James School wastewater treatment plant (Photo taken 9/1/00).

Eosine dye in the tributary to St James Run immediately following injection (Photo taken 9/11/00).

Laboratory Analysis

Charcoal samplers were prepared for analysis upon return to the laboratory after collection. Each charcoal sample was rinsed and eluted for 1 hour with a solution of potassium hydroxide and isopropyl alcohol for analysis. Sample analysis was performed using a Shimadzu RF-5301 spectrofluorophotometer.

Results

Summaries of the results of the recovery samples are listed in Table 4. Figure 1 shows locations of the recovery sites. Raw data from analysis on the Shimadzu is included in the appendix. A positive result shows as a peak on the raw data charts. If background samples show any peaks in the vicinity of the dye peak, then a positive hit is defined as having a peak intensity of 10 times greater than the background peak height. The wavelengths for the dyes detected in this study are 516 nm for Fluorescein, 544 nm for Eosine, and 578 nm for Rhodamine WT.

Recovery Site No.	Sample Date	Eosine	Rhodamine WT
1 (St James Spring)	9/5/00	Negative	Positive
1 (St James Spring)	9/11/00	Negative	Positive
1 (St James Spring)	9/13/00	Negative	Positive
1 (St James Spring)	9/20/00	Negative	Positive
1 (St James Spring)	9/27/00	Negative	Negative
1 (St James Spring)	10/4/00	Negative	Negative
1 (St James Spring)	10/11/00	Negative	Positive
1 (St James Spring)	10/25/00	Negative	Negative
1 (St James Spring)	11/03/00	Negative	Positive
2	9/5/00	Negative	Negative
2	9/11/00	Negative	Negative
2	9/13/00	Negative	Negative
2	9/20/00	Positive	Negative
2	9/27/00	Negative	Negative
2	10/4/00	Positive	Negative
2	10/11/00	Negative	Negative
2	10/25/00	Negative	Negative
3	All dates	Negative	Negative
4	All dates	Negative	Negative
5	All dates	Negative	Negative
6	All dates	Negative	Negative
8	All dates	Negative	Negative
9	All dates	Negative	Negative

Table 4. Summary of results from dye recovery sites.

Discussion

Dye Tracing

The results of the dye tracing indicate that the stream is not contributing to the recharge of the St. James spring, although it does appear that the stream loses some water to the ground, which then flows to the southeast. Based on the Rhodamine WT trace, the sewer system does leak and contaminants in the sewer system will reach the spring within days.

Rhodamine WT was detected in the St. James spring four days after it was introduced to the sewer system. It continued to linger in the spring water throughout the sampling period, with peak intensities declining over time (chart 1, appendix). This data shows strong evidence of not only the problems with the sewer system, but of the influence on shallow ground water on the spring. The sewer lines are 1-3 feet below the surface approximately 100 feet up gradient from the spring. Therefore, contaminants at the surface near the spring will also have a short travel time to the spring. Rhodamine was not detected at any other recovery sites.

Eosine, which was introduced into the tributary to St. James Run, was not detected in the school's spring. It was detected in Site 2, a spring fed pond southeast of the injection site. Eosine was detected at Site 2 nine days after injection, and again 23 days after injection. This indicates that the tributary is losing and recharging the aquifer. However, the amount of recharge appears to be minimal based on the low intensity of the Eosine peak detected at Site 2 and the fact that it was only detected in two of six recovery samples. Additionally, recharge to the aquifer from the stream flows to the southeast, away from the St. James spring, based on the Eosine trace. Eosine was not detected at any other recovery sites.

Source Water Assessment Area Delineation

The results of the Eosine dye trace indicate that the recharge area of the St. James spring should not include the entire watershed of St. James Run. Furthermore, the Rhodamine WT trace indicates that the area directly up slope of the stream is an extremely vulnerable due to the short travel times revealed in this study. A source water assessment area (SWAA) for the St. James spring has been delineated using the information gathered here, and discharge data for the spring and effective recharge published in previous reports. Figure 2 is a map of the SWAA.

Discharge from the St. James spring was measured between August, 1958 and August 1959 (MGS, BDR No. 18). The average discharge for the year was approximately 640 gallons per minute (gpm). Average precipitation in the Hagerstown area is 39 inches annually. The effective ground water recharge is estimated to be 13 inches annually in the St. James Run basin based on water budgets from Duigon and Dine, 1991 (10 inches) and ground water evapotranspiration rate of 3.5% (Otton, et al., 1988) which equates to approximately 3 inches. Over the long term, ground water recharge is equal to ground water discharge. Based on the available flow data from the spring, a recharge area of 41,600,000 square feet (approximately 950 acres) was calculated for the spring. The

SWAA was delineated, based on topography, to include the area upgradient of the spring that comes closest to the calculated recharge area. The final area delineated is 926 acres (Fig. 2).

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FIGURES

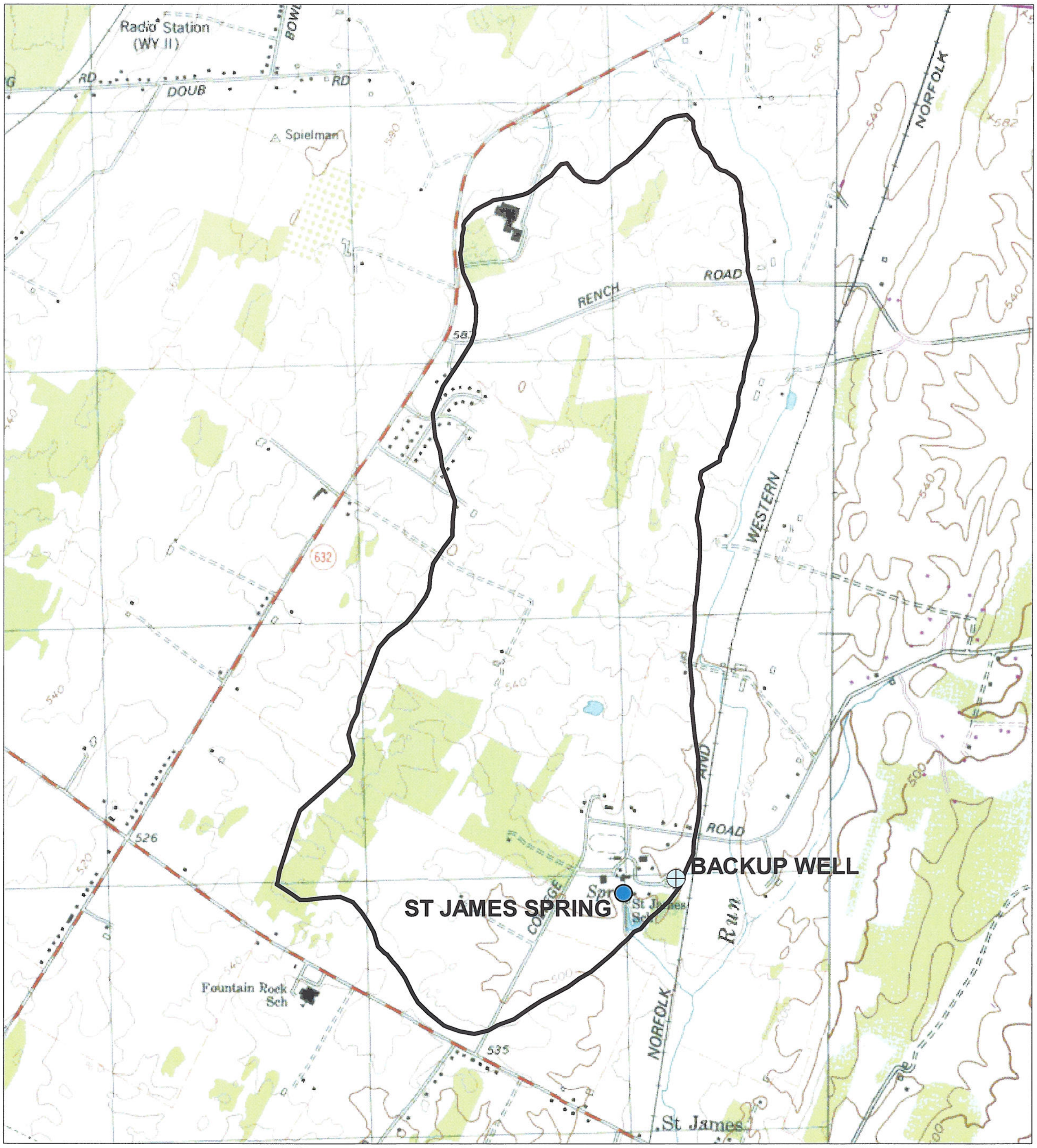

Figure 2. St. James School Source Water Assessment Area

Legend

- Spring
- Well
- Source Water Assessment Area

N

1000 0 1000 2000 Feet

Base Map: USGS 7.5' Quadrangle for Williamsport

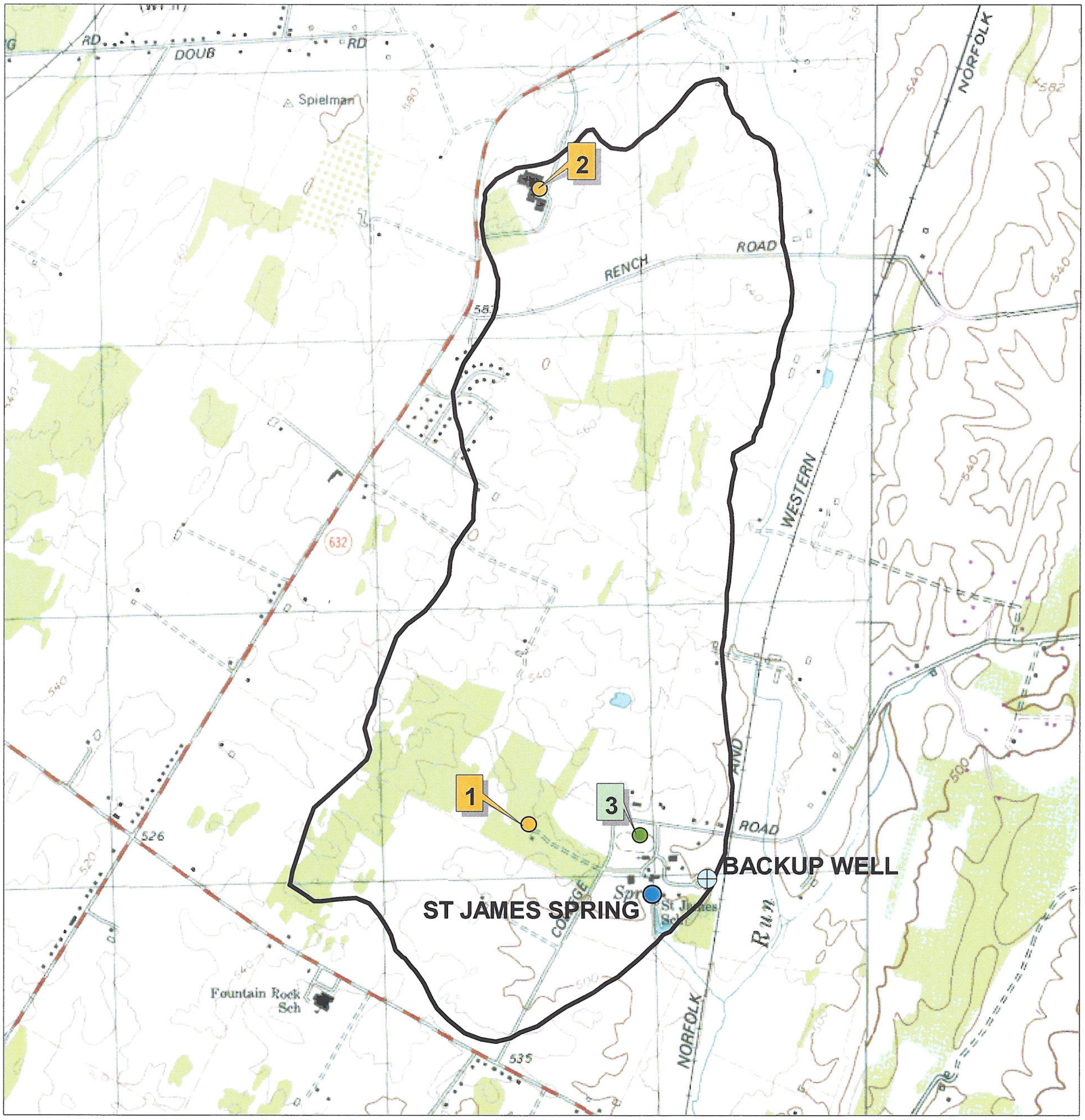

Figure 3. St. James School Source Water Assessment Area with Potential Contaminant Sources

Legend

- Spring
- Well
- Source Water Assessment Area

Underground Storage Tanks (USTs)

- Currently in Use
- Status Unknown

N

1000 0 1000 2000 Feet

Base Map: USGS 7.5' Quadrangle for WIlliamsport

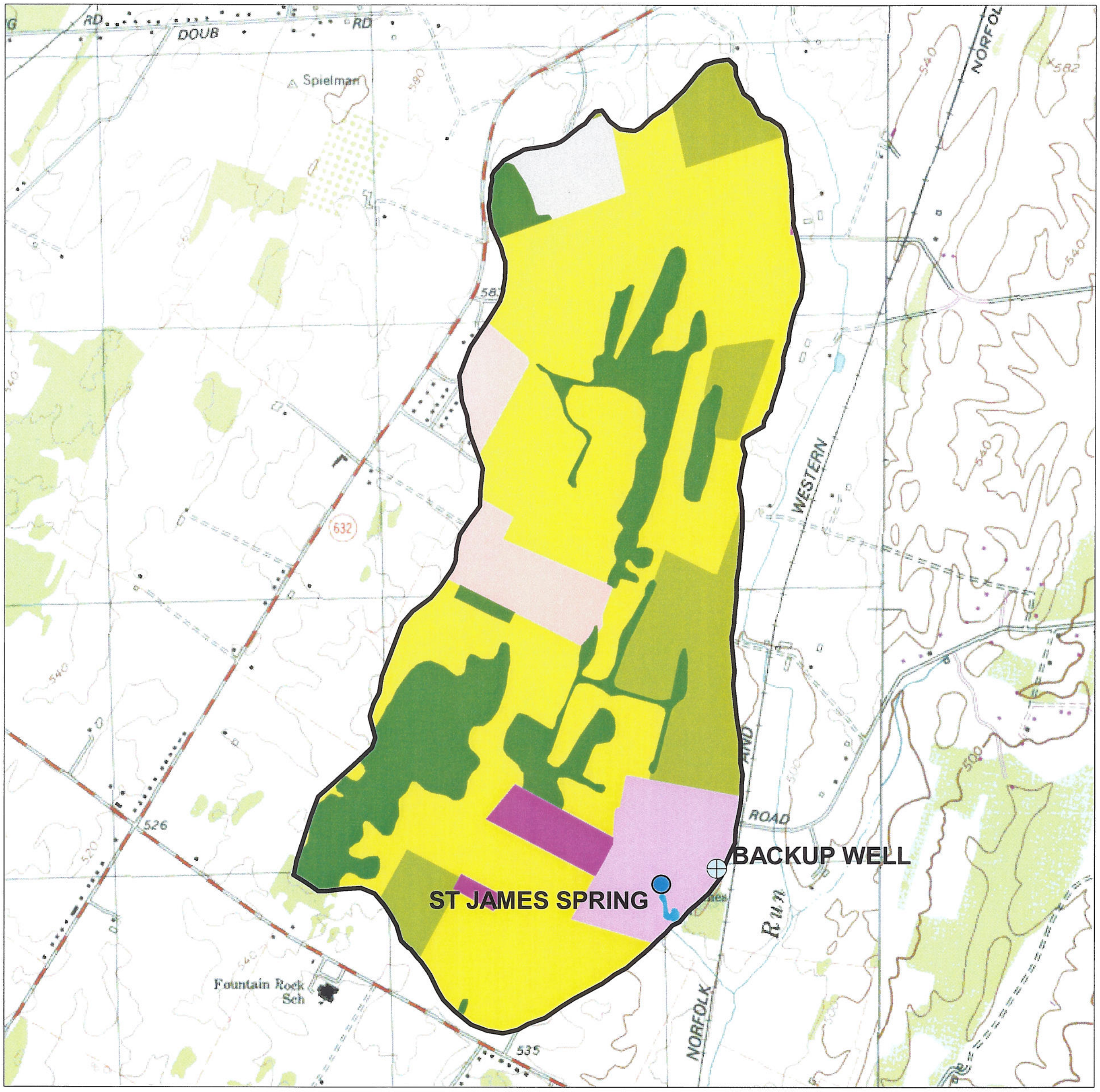

Figure 4. St. James School Source Water Assessment Area with Land Use

Legend

Washington County 2000 Land Use

- Low Density Residential
- Institutional
- Commercial
- Cropland
- Pasture
- Forest
- Water
- Feeding Operations

Drinking Water Sources

- Spring
- Proposed Well
- Source Water Assessment Area

N

1000 0 1000 2000 Feet

Base Map: USGS 7.5' Quadrangle for Williamsport

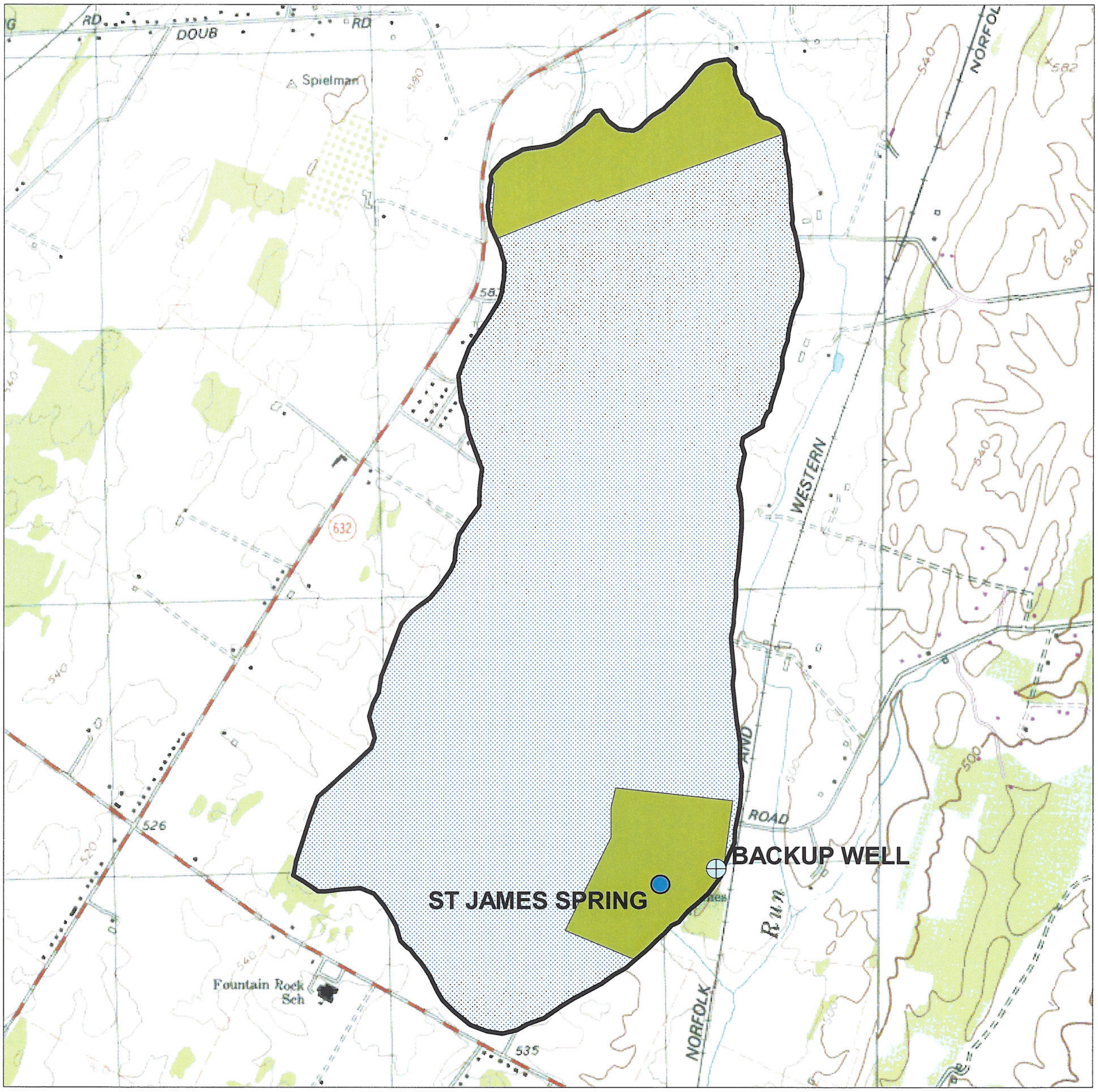

Figure 5. St. James School Source Water Assessment Area with Sewer Service Areas