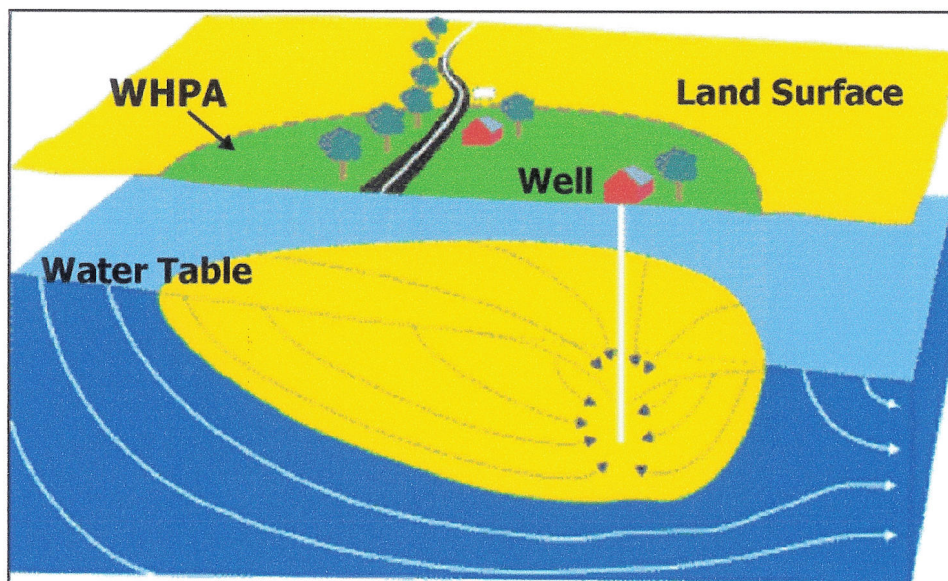


# **Source Water Assessment for the Windsor Knolls Water System Frederick County, Maryland**



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December 2002**



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## SUMMARY

The Maryland Department of the Environment's Water Supply Program (WSP) has conducted a Source Water Assessment for the Windsor Knolls 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 Windsor Knolls's water supply is an unconfined fractured-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 Frederick County was used to identify non-point sources of contamination. Well information and water quality data were also reviewed. An aerial photograph and maps showing 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 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 Windsor Knolls water supply is susceptible to nitrate and some microbiological contaminants. This water supply is not susceptible to other inorganic compounds, radiological contaminants, volatile organic compounds, synthetic organic compounds, and surface water microorganisms.

## INTRODUCTION

The Water Supply Program has conducted a Source Water Assessment for the Windsor Knolls water system in Frederick County. The Windsor Knolls community is located approximately ten miles southeast of the City of Frederick near the Frederick – Montgomery county border. The water system serves a total population of 1,459 and has 228 service connections. Windsor Knolls currently obtains its water supply from three wells. The water system is owned and operated by the Frederick County Division of Utilities and Solid Waste Management.

## 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. The Windsor Knolls system currently obtains its water supply from three wells. In addition, there are five test wells located in the community that are planned for future use. Well 3 is located adjacent to residential properties in the southern part of the community, one is located west of Green Valley Road on the Friends School property, and the remaining wells are located adjacent to an old farmhouse on the east side of Green Valley Road (Fig. 1). A review of the well completion reports and sanitary surveys of Windsor Knoll's water system indicates the wells were drilled after 1973 and should meet construction standards for grouting and casing. A summary of the well information is located in Table 1.

SOURCE ID	USE	SOURCE NAME	PERMIT	TOTAL DEPTH	CASING DEPTH	YEAR DRILLED
01	PRODUCTION	WELL 1 FARMHOUSE	FR-73-6013	200	26	1978
02	PRODUCTION	WELL 4 FRIENDS SCHOOL	FR-88-2279	300	40	1991
03	PRODUCTION	WELL 3 LINDSEY CT	FR-88-2282	200	133	1991
04	FUTURE	WELL B	FR-94-1551	520	78	2000
05	FUTURE	WELL J	FR-91-1550	220	51	2000
06	FUTURE	WELL K	FR-94-1552	160	58	2000
07	FUTURE	WELL Q	N/A	200	53	2000
08	FUTURE	WELL M	FR-94-1553	200	58	1999

*Table 1. Windsor Knolls well information*

The Windsor Knolls water system has an appropriation permit to draw water from the Ijamsville Formation and Sam's Creek metabasalt for an average use of 106,800

gallons per day (gpd) and a maximum of 177,300 gpd in the month of maximum use. Based on the most recent pumpage reports, the average daily use was 55,917 gallons in 1999 and 49,924 gallons in 2000. The months of maximum use for the last two reported years were July 1999 and June 2000 with an average daily use of 82,923 and 58,103 gallons respectively. The reported use is considerably less than the total appropriated amount because not all of the properties in the subdivision have been built.

## **HYDROGEOLOGY**

Windsor Knolls is in the Piedmont lowlands physiographic province of eastern Frederick County, which is characterized by gently rolling hills with some deeply-cut valleys. This portion of the county is underlain by a series of meta-sedimentary and metavolcanic rocks that are structurally complex and the stratigraphic and structural relationships of these geologic units are poorly understood. Ijamsville, Urbana, and Sam's Creek formations are mapped at the surface and any of these formations are likely to be encountered in the subsurface. Lenses of Wakefield Marble are often layered with the Sam's Creek metabasalt, which may be a significant source of ground water if the hydrogeologic conditions are right. The metavolcanic formations are generally fine-grained phyllite and schist or massive to schistose metabasalt (Cleaves, et al., 1968). These formations are fractured rock aquifers whose primary porosity and permeability are small due to compaction and re-crystallization associated with metamorphism. This is an unconfined, fractured rock aquifer whose primary porosity and permeability are small due to the cementation and consolidation of sediments. Ground water moves principally through secondary porosity - fractures, fault planes, and joint openings - and is recharged by precipitation percolating through soil and saprolite. Due to the low primary porosity, large production wells are not common in this formation unless significant, water-bearing fractures are encountered. Advanced Land and Water, Inc. completed a fracture trace analysis in a well exploration project (Appendix A, Fig. 2). The test wells were constructed based on this analysis and this information, together with pump test data, was used in the delineation as described in the next section of this report.

Ground water systems in crystalline rock tend to be localized and flow is within topographic divides towards the nearest perennial stream (Bolton, 1998). The water table is generally in the saprolite, which is characterized by high porosity and thus, the amount of storage often depends on the thickness of the saprolite. Stream valleys tend to follow fracture traces and as a result wells drilled in draws and stream valleys tend to have higher yields than those on hilltops and slopes.

## **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 using wells in fractured-rock aquifers is the watershed drainage area that contributes to the well. The area should be modified to account for geological

boundaries, ground water divides, and by annual average recharge needed to supply the well (MDE, 1999).

Hydrogeologic mapping identifies the physical and hydrologic features that control ground water flow (EPA, 1991). Hydrogeologic mapping was used to identify drainage basin boundaries and geologic features that influence ground water flow. Fracture traces are surface expressions of vertical, closely spaced joints and fractures in the bedrock below. Highly developed fracture systems in bedrock aquifers readily transmit water; thus fracture trace analysis is commonly used to locate high yield wells in fractured bedrock aquifers. A well intercepting a fracture, or fracture zone, will demonstrate a drawdown pattern that is greatest along the trace of the fracture(s). Advanced Land and Water, Inc. (2000) mapped fracture traces and lineaments in and around the Windsor Knolls property using aerial photography (Appendix A, Fig. 2). Pump tests confirmed that the aquifer was anisotropic, but only the small fracture traces closest to the wells appeared to be hydraulically connected to the wells. Thus, drawdown patterns were modeled based on the orientation of these fractures (Appendix A, Fig. 5). This model output was used to approximate the WHPA border on the down gradient side of the main wellfield. The rest of the WHPA is delineated as the watershed upgradient of the wells and fracture traces and includes enough area to supply for the average appropriated amount based on a drought year recharge of 400 gpd/acre. A separate area was delineated for Well 3, since it is in a separate drainage basin. Based on pumpage data, it was estimated that Well 3 supplies approximately 15% of the total appropriated amount of 106,800 gpd. The area delineated around this well roughly follows topographic divides and contains sufficient area for drought-year recharge to supply the well at its current production rate. The WHPA is a total of 305 acres and is shown in 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. 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 no potential point source of contamination within the WHPA.

### *Non-Point Sources*

The Maryland Office of Planning's 2000 digital land use for Frederick County was used to determine the predominant types of land use in the WHPA (Fig. 3). The land

use summary is given in Table 2. The majority of the WHPA is residential land and there are smaller proportions of agricultural, forested, and other land uses.

Land Use Type	Total Acres	Percent of WHPA
Low-density Residential	110	36.2
Medium Density Residential	49	16.2
Institutional	42	13.7
Open Urban Land	14	4.6
Cropland	23	7.5
Pasture	21	6.9
Forest	46	15.0
Total	304	100

*Table 2. Land Use Summary*

Agricultural land (cropland and pasture) may be associated with nitrate loading of ground water and also represents a potential source of SOC's depending on fertilizing practices and use of pesticides. Residential areas without sewer service may be a source of nitrate from septic systems. Additionally, residential areas may present a source of nitrate and SOC's if fertilizers, pesticides, and herbicides are not used carefully in lawns and gardens.

The Maryland Office of Planning's 1996 digital sewer map of Frederick County shows that the most of the WHPA is in an area of the county which is not planned for sewer service (Fig. 4). The remainder is in the 3-year planned service area, which includes most of the Windsor Knolls subdivision. As of this writing, the homes are still using individual septic systems. Table 3 summarizes the sewer service categories in the WHPA.

Service Category	Total Acres	Percent of WHPA
3 Year Planned Service	97	31.9
Not Planned for Service	207	68.1
Total	304	100

*Table 3. Sewer Service Area Summary*

## 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 Windsor Knolls water system has one point of entry or plant,

which has chlorination for disinfection, pH adjustment for corrosion control, ion exchange for nitrate removal, and fluoridation for health benefits.

A review of the monitoring data since 1993 for Windsor Knolls water indicates that the water supply has met drinking water standards. Nitrate levels in raw water are above 50% of the MCL, which was the reason for installing the ion exchange unit when the treatment plant was designed. Nitrate levels have remained below the MCL and thus the ion exchange unit is not currently used. Radon is the only other contaminant present at a level of concern. No other contaminants were detected above 50% of an MCL. The water quality sampling results are summarized in Table 4.

Contaminant Group	No. of Samples Collected	No. of Samples above 50% of an MCL
Inorganic Compounds (except Nitrate)	7	0
Nitrate	24	24
Radiological Contaminants	3	1 <sup>1</sup>
Volatile Organic Compounds	8	0
Synthetic Organic Compounds	9	0

*Table 4. Summary of Water Quality Samples*

<sup>1</sup>Lower proposed MCL for Radon-222

#### ***Inorganic Compounds (IOCs)***

A review of the data shows that nitrate levels in the water supply range from 5.1 to 8.3 ppm, but are consistently below the MCL of 10 ppm (Table 5a). Nitrate was detected above the SWAP threshold level of 5 parts per million (ppm) in all samples collected. Initial sampling from the test wells is shown in Table 5b. No other inorganic compounds were detected above 50% of an MCL.

SAMPLE DATE	RESULT (PPM)	SAMPLE DATE	RESULT (PPM)
14-Apr-94	7.4	23-May-97	8.3
20-Dec-94	7.6	05-Aug-97	5.8
14-May-95	6.5	08-Oct-97	5.9
02-Jun-95	6.8	06-Jan-98	5.9
07-Jun-95	6.9	07-Apr-98	7.4
28-Sep-95	6.2	07-Jul-98	6.3
16-Nov-95	6.6	14-Oct-98	5.4
27-Feb-96	7.6	05-Jan-99	5.3
14-May-96	6.7	03-Feb-99	5.6
04-Sep-96	7.9	05-May-99	6.1
05-Nov-96	7.9	05-Apr-00	5.1
30-Jan-97	8.0	17-Apr-01	5.5

*Table 5a. Nitrate Data from the Windsor Knolls treatment Plant*

WELL NUMBER	RESULT (PPM)
B	5.4
J	5.2
K	5.1
M	4.7
Q	4.8

**Table 5b. Raw water nitrate data from test wells**  
(all samples collected 8/8/99)

### ***Radionuclides***

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. Only one Radon-222 results have been reported for Windsor Knolls at 225 pCi/L, which is above 50% of the lower proposed MCL. No other radionuclides have been detected in the water supply.

### ***Volatile Organic Compounds (VOCs)***

A review of the data shows that VOCs have not been detected above 50% of an MCL. Disinfection byproducts grouped as trihalomethanes (THMs) are the only VOC's that have been detected, but at very low levels.

### ***Synthetic Organic Compounds (SOCs)***

A review of the data shows that SOCs have not been detected above 50% of an MCL. Two contaminants that were detected were dalapon and atrazine, which are a common herbicide and pesticide, however the levels reported were well blow the MCL's.

### ***Microbiological Contaminants***

Raw water bacteriological data is available for each of the three production wells from evaluation for ground water under the direct influence of surface water (GWUDI). This data showed that the wells are not under the direct influence of surface water. The raw water quality was very good with very low turbidity and was free of fecal coliform. Some samples had total coliform present at low levels.

## **SUSCEPTIBILITY ANALYSIS**

The wells serving the Windsor Knolls water supply draw water from unconfined fractured-rock aquifers. Wells in unconfined aquifers 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 6 summarizes the susceptibility of Windsor Knoll's water supply to each of the groups of contaminants.

In the Piedmont region, if a well is constructed properly with the casing extended to competent rock and with sufficient grout, the saprolite serves as a natural filter and protective barrier. Properly constructed wells with no potential sources of contamination in their WHPA should be well protected from contamination.

### *Inorganic Compounds*

Nitrate is present in 100% 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. The most recent nitrate data shows that nitrate levels in the water supply are decreasing, which may be due to many factors. One scenario is that the construction of residential areas may coincide with a nitrate "spike" to ground water due to initial landscaping and fertilization practices. Once lawns are established, fertilizer use is generally decreased. The addition of Well 3 to the system, which has the lowest levels of nitrate in raw water, may be the most predominant factor determining nitrate levels in the water supply. This well was put into service in June 1997 and since then nitrate levels average 5.8 ppm in finished water samples. Prior to the addition of this well, nitrate levels averaged 7.3 ppm, thus it is likely the trend of decreasing nitrate levels is due to the addition of this well. Well 3 is in an area that was not previously grazed or farmed, whereas there is some agricultural activity in the area of the other wells, which indicates this is the source of nitrate to the wells.

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 based on water quality data and lack of potential contaminant sources within the WHPA.

### *Radionuclides*

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 if the State has a program to address the more significant risk from radon in indoor air. Radon is present in the water supply above 50% of the lower proposed MCL of 300 pCi/L. The source of radon in ground water can be traced back to the natural occurrence of uranium in rocks. Radon is prevalent in ground water of crystalline rock aquifers due to radioactive decay of uranium bearing minerals in the bedrock. The EPA has information on proposed regulations for radon in indoor air and drinking water on their web site

(<http://www.epa.gov/OGWDW/radon.html>). Currently, it appears that the water supply may be susceptible to radon if the lower MCL is adopted.

The water supply is **not** susceptible to other radionuclides. Other radionuclides were not detected and thus, the aquifer is not a source of these contaminants in this area.

#### ***Volatile Organic Compounds***

The water supply is **not** susceptible to contamination by VOC's. No potential sources were identified within the WHPA, and VOC's have not been detected in significant levels.

#### ***Synthetic Organic Compounds***

The wells are **not** susceptible to synthetic organic compounds. Dalapon and Atrazine were detected at very low levels in the water supply. A potential source of SOC's in the WHPA may be herbicide and pesticide use in agricultural areas and residential gardens. However, these contaminants have not been detected at high enough levels to deem the water supply susceptible.

#### ***Microbiological Contaminants***

The production wells did not have fecal coliform bacteria in their raw water samples and were determined not under direct influence of surface water. Therefore, the wells are **not** susceptible to microbiological contaminants that may be present in surface water such as *Giardia* and *Cryptosporidium*. Wells 1 and 4 did have low levels of total coliform bacteria, which are ubiquitous in the environment, and *may* be indicators of organisms with longer survival rates such as viruses. Without additional data however, it is not possible to determine whether or not the water supply is susceptible to viral contamination. Wells 1 and 4 **are** susceptible to total coliform bacteria but not fecal coliform bacteria. Well 3 was free of coliform bacteria and is **not** susceptible to microbiological contaminants.

Sufficient data was not available to determine the GWUDI status of the test wells, therefore their susceptibility to surface microbiological pathogens cannot be determined at this time.

Contaminant Group	Are Contaminant Sources Present in WHPA?	Are Contaminants Detected Above 50% of MCL?	Is Well Integrity a Factor?	Is the Aquifer Vulnerable?	Is the System Susceptible?
Nitrate	YES	YES	NO	YES	YES
Inorganic Compounds (except nitrate)	NO	NO	NO	YES	NO
Radiological Compounds	NO	NO	NO	NO	NO
Volatile Organic Compounds	NO	NO	NO	YES	NO
Synthetic Organic Compounds	YES	NO	NO	YES	NO
Microbiological Contaminants <sup>2</sup>	YES	YES <sup>3</sup>	NO	YES	YES <sup>2</sup> – Wells 1 and 4 (Viruses only)

**Table 6. Susceptibility Analysis Summary.**

<sup>2</sup> See paragraph above.

<sup>3</sup> There is no MCL for total coliform, presence is considered a violation in *finished* water samples.

## **MANAGEMENT OF THE SOURCE WATER ASSESSMENT AREA**

With the information contained in this report the Frederick County Division of Utilities and Solid Waste Management is in a position to protect the Windsor Knolls 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 Division of Utilities and Solid Waste Management should continue to work with the County Planning Department and Wellhead Protection committee to implement a County Wellhead Protection Ordinance. The committee should ensure that all interests in the community are represented, such as the water supplier, home association officers, the County Health Department, local businesses, developers, and property owners, and residents within and near the WHPA.
- A management strategy adopted by the Division and the County 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, such as developing and implementing wellhead protection ordinances, digitizing layers that would be useful for wellhead protection (such as geology), and developing additional protection strategies. An application can be obtained by contacting the water supply program.

### ***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 Division or MDE.
- Conduct educational outreach to the facilities and the residents of the community focusing on activities that may present potential contaminant sources. Important topics include: (a) compliance with MDE and federal guidelines for heating oil and gasoline underground storage tanks, (b) appropriate use and application of fertilizers and pesticides, and (c) hazardous material disposal and storage.
- Road signs at the WHPA 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.
- Annual raw water bacteriological testing is a good test for well integrity.

### ***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.

### ***Contingency Plan***

- Windsor Knolls contingency plan was submitted and approved by MDE in November 2001. 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 Division 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 supply wells will ensure their integrity and protect the aquifer from contamination.

### ***Changes in Use***

- The Division 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.

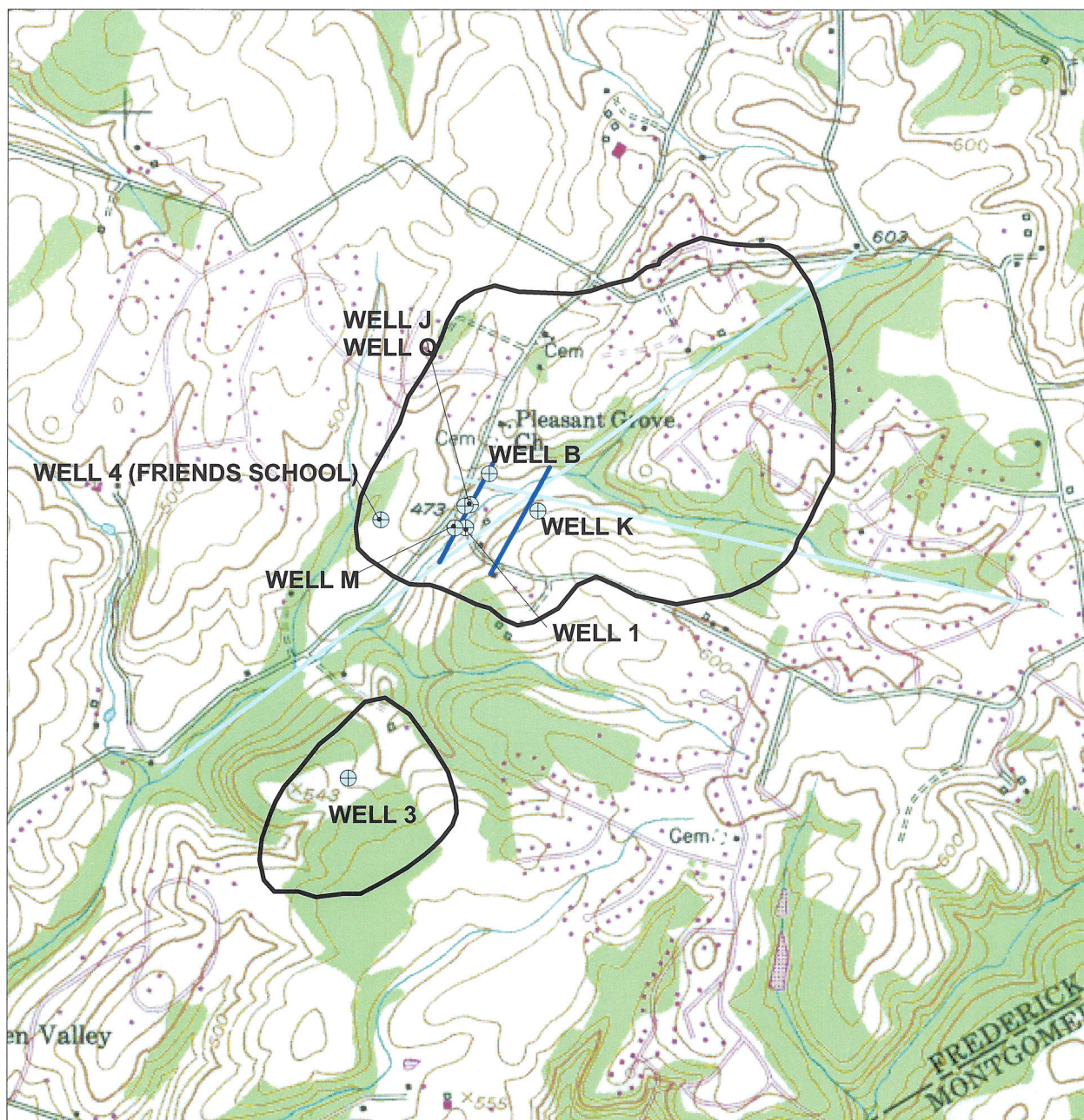
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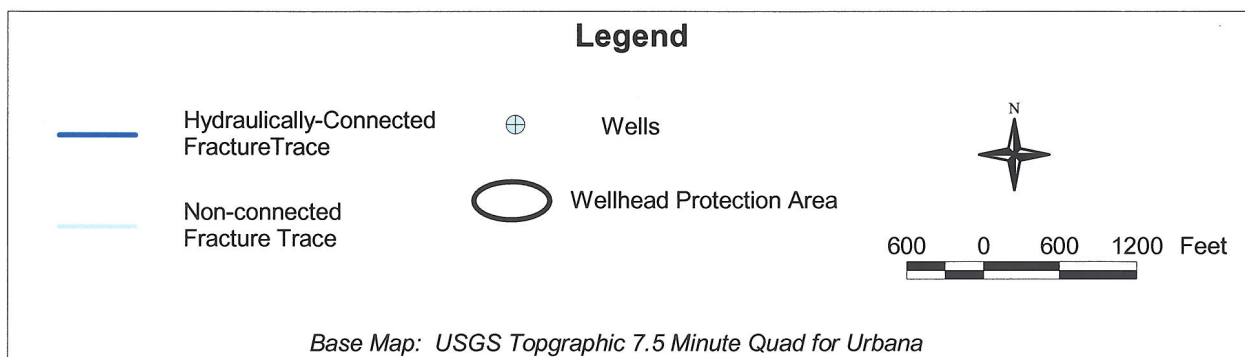
## OTHER SOURCES OF DATA

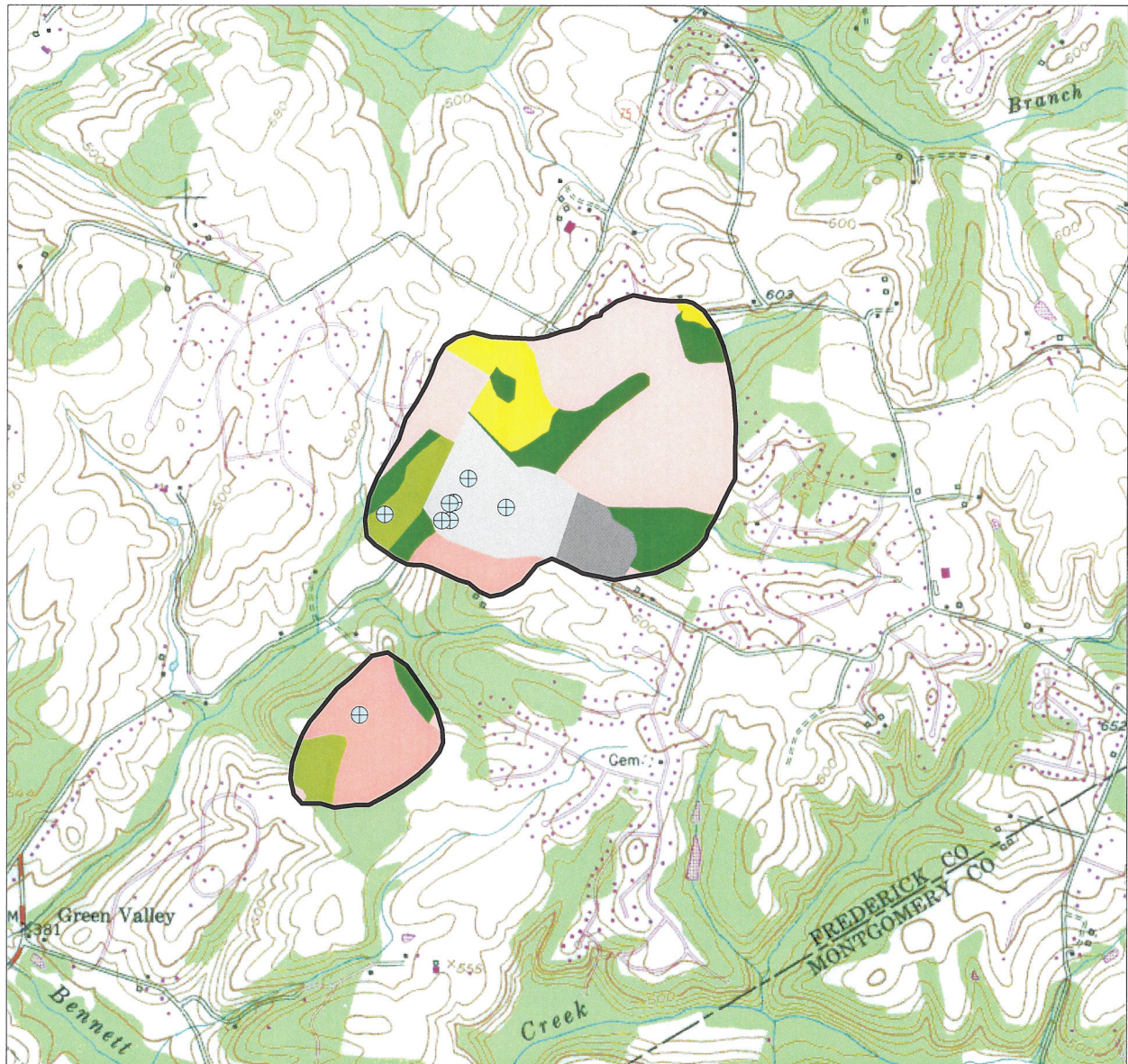
Water Appropriation and Use Permit FR1990G031  
Public Water Supply Sanitary Survey Inspection Reports  
MDE Water Supply Program Oracle® Database  
MDE Waste Management Sites Database  
Department of Natural Resources Digital Orthophoto Quarter Quadrangles for Urbana  
USGS Topographic 7.5 Minute Quadrangles for Urbana  
Maryland Office of Planning 2000 Frederick County Digital Land Use Map  
Maryland Office of Planning 1996 Frederick County Digital Sewer Map

## FIGURES

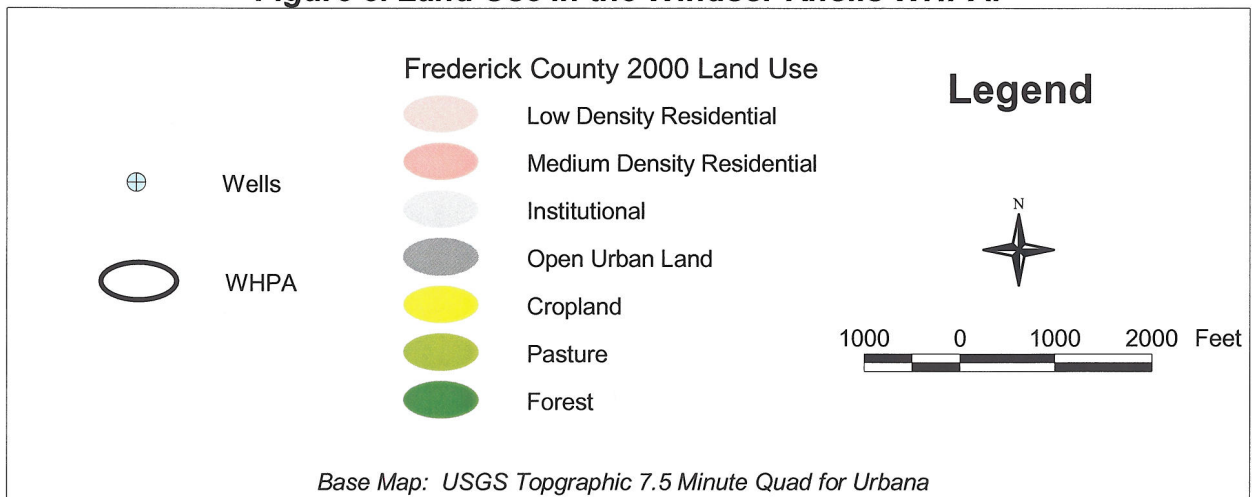


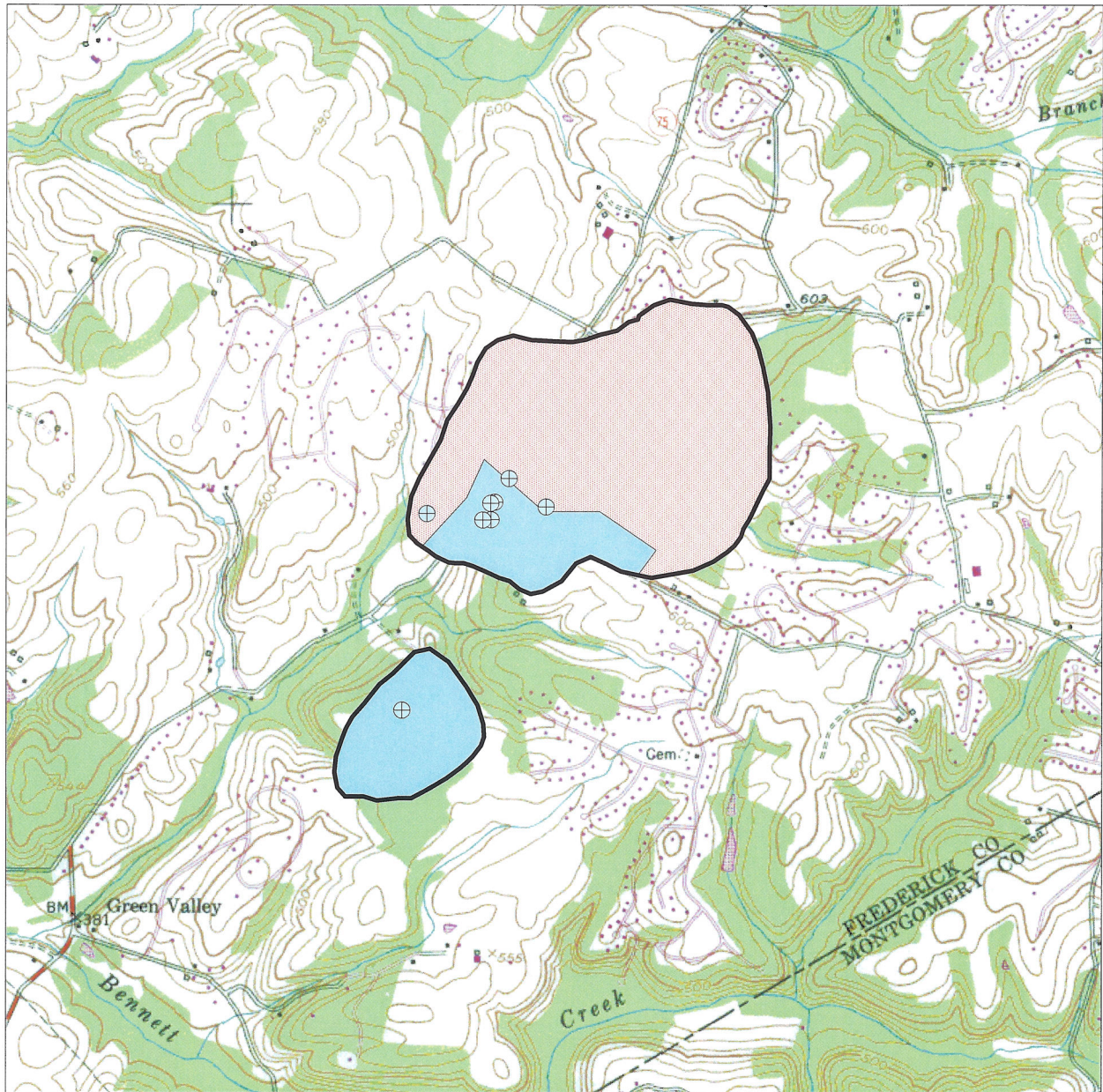
**Figure 2. Windsor Knolls Wellhead Protection Area (WHPA).**



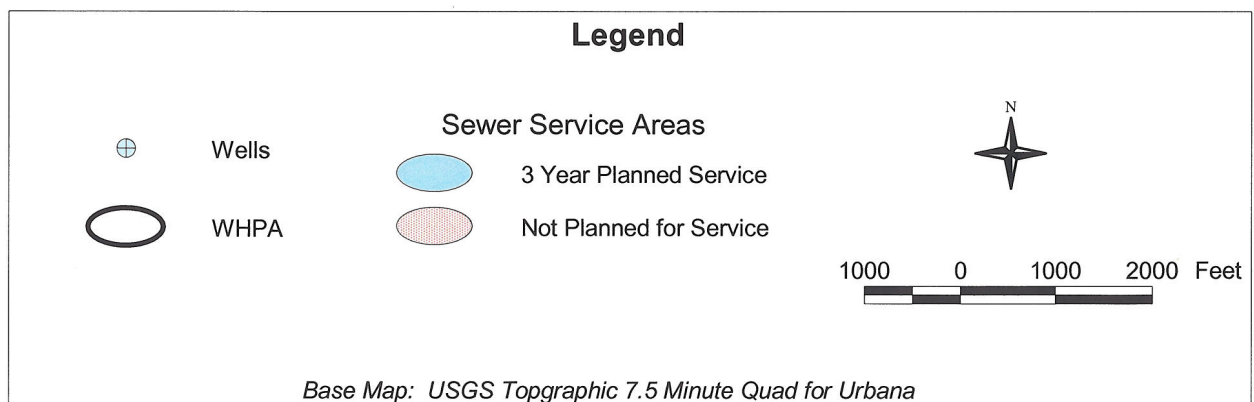


**Figure 3. Land Use in the Windsor Knolls WHPA.**





**Figure 4. Sewer Service Areas in the Windsor Knolls WHPA.**



## **APPENDIX**

