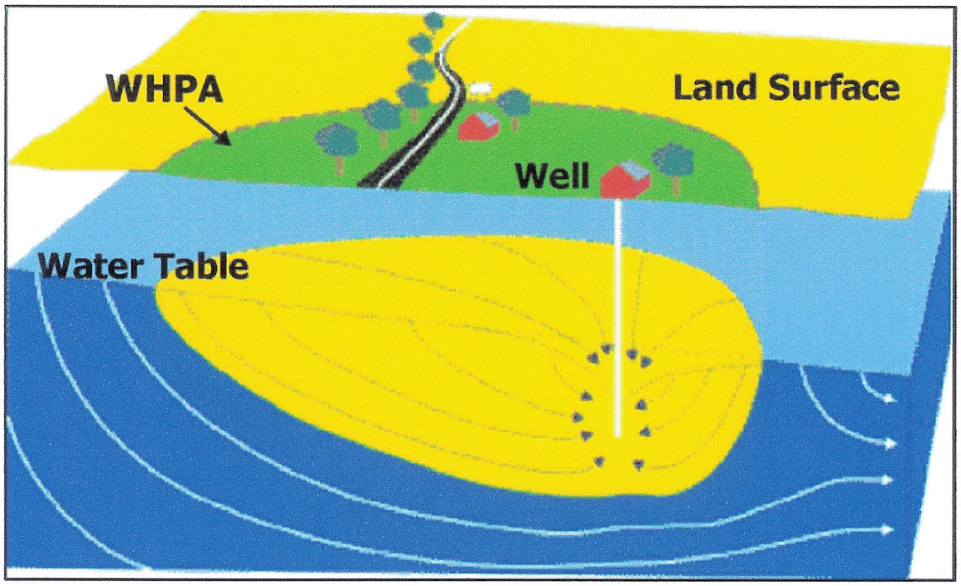
Source Water Assessment
for the Cloverhill III Water System
Frederick County, Maryland



Prepared By
Maryland Department of the Environment
Water Management Administration
Water Supply Program
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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 Cloverhill III 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 Cloverhill III'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 1997 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 Cloverhill III 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 Cloverhill III water system in Frederick County. The Cloverhill III community is located approximately three miles northwest of the City of Frederick. The water system serves a total population of 880 and has 326 service connections. Cloverhill III currently obtains its water supply from two 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 Cloverhill III system obtains it water supply from two wells (Table 1). The two production wells are located adjacent to residential properties east of Yellow Springs Road (Fig. 1). A review of the well completion reports and sanitary surveys of Cloverhill III'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	WELL NAME	PERMIT	TOTAL DEPTH	CASING DEPTH	YEAR DRILLED
01	WELL 1	FR-81-4199	600	62	1987
02	WELL 2	FR-81-5372	450	33	1988

Table 1. Cloverhill III well information

The Cloverhill III water system has an appropriation permit to draw water from the New Oxford formation for an average use of 74,300 gallons per day (gpd) and a maximum of 124,100 gpd in the month of maximum use. Based on the most recent pumpage reports, the average daily use was 74,442 gallons in 1999 and 71,781 gallons in 2000. The months of maximum use for the last two reported years were June 1999 and July 2000 with an average daily use of 110,982 and 82,661 gallons respectively.

HYDROGEOLOGY

Cloverhill III lies in the western part of the Frederick Valley in the Piedmont physiographic province, which is bound by Catoctin Mountain to the west and the low Piedmont ridges to the east. The western portion of the Frederick Valley is underlain by a series of sedimentary rocks that form a narrow band on the edge of the valley. The New Oxford Formation is the underlying bedrock in the Cloverhill III area and is composed of red and gray sandstone, siltstone, and shale of Triassic age (Reinhardt, 1974). Based on the drillers report, the deeper well penetrates the basal limestone conglomerate of the formation. 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, bedding planes, and joint openings - and is recharged by precipitation percolating through soil and saprolite. Greenhorne & O'Mara, Inc. completed a fracture trace analysis in 1992 in a well exploration project (Appendix A, Fig. 2) described further below.

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). Greenhorne and O'mara (1992) mapped fracture traces and lineaments in and around the Cloverhill property using aerial photography and determined that they were predominantly oriented along strike of the bedrock layers (Appendix A, Figs 2, 4). Pump tests confirmed that the aquifer was anisotropic, with the ground water flow direction being dominated by strike of the bedrock. This analysis was later used to assess potential

adverse effects of the Cloverhill wells on neighboring users and it was determined that the greatest drawdown due to pumping would occur along this NE-SW trend (Appendix A, Fig. 9). This estimate was used to draw the WHPA around the wells, which is oriented along the strike of the bedrock. The delineated area is the watershed drainage divide on the northwest border and is extended in the other directions to include enough recharge area to supply the annual appropriated amount of 74,300 gpd. The WHPA is approximately 290 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 point source of contamination within the WHPA. Several point sources were identified **outside** the WHPA boundary, in the Fort Detrick property (Fig. 3). Area B in Fort Detrick is a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site and the federal government together with MDE's CERCLA program is monitoring a ground contamination plume of chlorinated solvents. The plume is currently moving in a southeasterly direction and is very unlikely to impact the Cloverhill III water supply, but is mentioned here for awareness only. Leaking underground storage tanks (LUST) are also located in the Fort Detrick property, but are also **outside** the WHPA and should not impact the Cloverhill water supply.

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. 4). The land use summary is given in Table 2. The WHPA is split fairly evenly between residential and agricultural land.

Land Use Type	Total Acres	Percent of WHPA
Low-density Residential	9	2.9
Medium Density Residential	130	44.6
Cropland	39	13.3
Pasture	114	39.1
Total	291	100

Table 2. Land Use Summary

Agricultural land (pasture and cropland) may be associated with nitrate loading of ground water depending on fertilizing practices and number or density of livestock. Cropland can also be a potential source of SOCs depending on the use and application of pesticides. Residential areas without sewer service may be a source of nitrate from septic systems. Additionally, residential areas may present a source nitrate and SOCs 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 either existing or planned for sewer service, however most of the area designated as planned is now existing service (Fig. 5). A fairly large portion of the WHPA has not been classified, but it appears that this area will have not have sewer service as long as it remains agricultural land. The remaining area, which comprises the Cloverhill subdivisions, is connected to either County or Frederick City sanitary sewer systems. Table 3 summarizes the sewer service categories in the WHPA.

Service Category	Total Acres	Percent of WHPA
Existing Service	168	57.7
Unknown	123	42.3
Total	291	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 Cloverhill III 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 Cloverhill III water indicates that the water supply has met drinking water standards with the exception of nitrate. Nitrate levels in finished water have been below the MCL since the installation of an ion exchange unit in August 1995. Samples collected before the additional treatment was completed often exceeded the nitrate MCL. 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)	6	0
Nitrate	44	44
Radiological Contaminants	3	2 [1]
Volatile Organic Compounds	10	0
Synthetic Organic Compounds	11	0

Table 4. Summary of Water Quality Samples
[1]Lower proposed MCL for Radon-222

Inorganic Compounds (IOCs)

The nitrate data shows that levels in finished water since August 1995 range from 5 to 8 ppm, but are consistently below the MCL of 10 ppm (Table 5). Prior to the installation of the ion-exchange unit, nitrate levels were above 10 ppm and were as high as 12.5 ppm. Nitrate was detected above the SWAP threshold level of 5 parts per million (ppm) in all samples collected. Table 5a lists all available nitrate results from the point of entry for the water system. Nitrate is also measured in raw water from each well on a monthly basis and the most recent data is listed in Table 5b. Nitrate levels in the raw water have declined since the wells were first installed, but have not been consistently below 5 ppm. According the the County, they will continue with nitrate removal treatment until raw water levels are consistently below 5 ppm. No other inorganic compounds were detected above 50% of an MCL.

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. Two Radon-222 results have been reported for Cloverhill III, at levels of 540 and 580 pCi/L, both of which are above 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 VOCs have **not** been detected in eleven samples collected since 1994.

Microbiological Contaminants

Raw water bacteriological data is available for each of the wells from evaluation for ground water under the direct influence of surface water (GWUDI). This data showed that the wells were 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 very low levels.

SAMPLE DATE	RESULT (ppm)
29-Mar-94	9.7
14-Apr-94	**10.4**
25-May-94	**11.0**
04-Jul-94	**12.5**
20-Dec-94	**11.0**
02-Jan-95	9.9
21-Feb-95	**10.2**
20-Mar-95	9.7
15-Aug-95	6.4
19-Sep-95	5.7
01-Nov-95	6.1
13-Nov-95	6.0
29-Feb-96	6.4
13-May-96	5.9
04-Sep-96	6.9
04-Nov-96	5.7
27-Jan-97	6.6
22-May-97	8.0
06-Aug-97	5.8
06-Oct-97	8.0
12-Jan-98	6.0
30-Mar-98	5.5

SAMPLE DATE	RESULT (ppm)
15-Apr-98	7.1
08-Jul-98	7.3
07-Oct-98	6.8
01-Feb-99	6.6
10-May-99	5.3
19-Jul-99	5.6
27-Oct-99	5.0
27-Oct-99	5.0
26-Jan-00	5.5
05-Apr-00	5.7
12-Jul-00	5.8
10-Oct-00	6.4
07-Feb-01	5.5
18-Apr-01	6.4
24-Apr-01	6.5
11-Jul-01	6.4
11-Jul-01	7.5
11-Jul-01	7.8
18-Oct-01	5.4
30-Jan-02	5.6
10-Apr-02	5.8
03-Jul-02	5.6

Table 5a. Nitrate Data from Cloverhill point of entry finished water
(Results in bold indicate above MCL. MCL for nitrate is 10 ppm)

	NITRATE RESULTS (ppm)	
DATE	**WELL 1**	**WELL 2**
Oct-01	4.7	4.8
Nov-01	6.9	2.8
Dec-01	6.4	5.6
Jan-02	6	2.8
Feb-02	5.5	5.1
Mar-02	n/a	3.9
Apr-02	4.4	3.4
May-02	4.9	5
June-02	7.8	4.7
Jul-02	5	4.5
Aug-02	6.2	4.6
Sep-02	6.3	3.3
Average	5.8	4.1
Well 1 and 2 Average		5.0

Table 5b. Raw Water Nitrate Data

SUSCEPTIBILITY ANALYSIS

The wells serving the Cloverhill III 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 Cloverhill III'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 finished water samples at or above 5 ppm (Table 5a). The MCL for nitrate is 10 ppm. All of the results that exceeded 10 ppm were taken prior to August 1995 and are indicative of the levels of nitrate in the ground water, at that time, without the benefit of nitrate removing treatment. Nitrate levels in raw water (Table 5b) have declined in the last seven years, but can be as high as 8 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. Agricultural land in the WHPA has decreased significantly when comparing 1990 and 2000 land use data, from 90% to 52% of the WHPA.

Residential land has replaced the agricultural land during that time period. As less land is used for agriculture, fertilizer use may decrease; however, fertilizing new lawns in newly built residential subdivisions can also result in an increase in nitrate levels in ground water.

It appears, based on land use characteristics, that there are several probable sources of nitrate to the water supply. 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 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 consolidated 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. SOCs were not detected in the water supply. A potential source of SOCs in the WHPA may be herbicide and pesticide use in agricultural areas and residential gardens. However, these contaminants have not been detected at significant levels.

Microbiological Contaminants

Both 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*. Total coliform bacteria were detected, 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. The well **is** susceptible to total coliform bacteria but not fecal coliform bacteria.

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	YES	YES[2]	NO	YES	YES – Total Coliform only

Table 6. Susceptibility Analysis Summary.

[2] There is no MCL for total coliform in raw water; 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 Cloverhill III 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 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 underground 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

- Cloverhill III's Contingency Plan was submitted to MDE and approved 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.

REFERENCES

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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., and J.R. Dine, 1987, Water Resources of Frederick County, Maryland, MGS Bulletin 33, 101 pp.

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Nutter, L.J. and E.G. Otton, 1969, Ground Water Occurrence in the Maryland Piedmont: Maryland Geological Survey Report of Investigations No. 10, 56 pp

Reinhardt, J. (1974), Geologic Map of the Frederick Valley, from Maryland Geological Survey Report of Investigations No. 23 (Plate 1).

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 FR1986G026
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 Frederick
USGS Topographic 7.5 Minute Quadrangles for Frederick
Maryland Office of Planning 1997 Frederick County Digital Land Use Map
Maryland Office of Planning 1996 Frederick County Digital Sewer Map

FIGURES

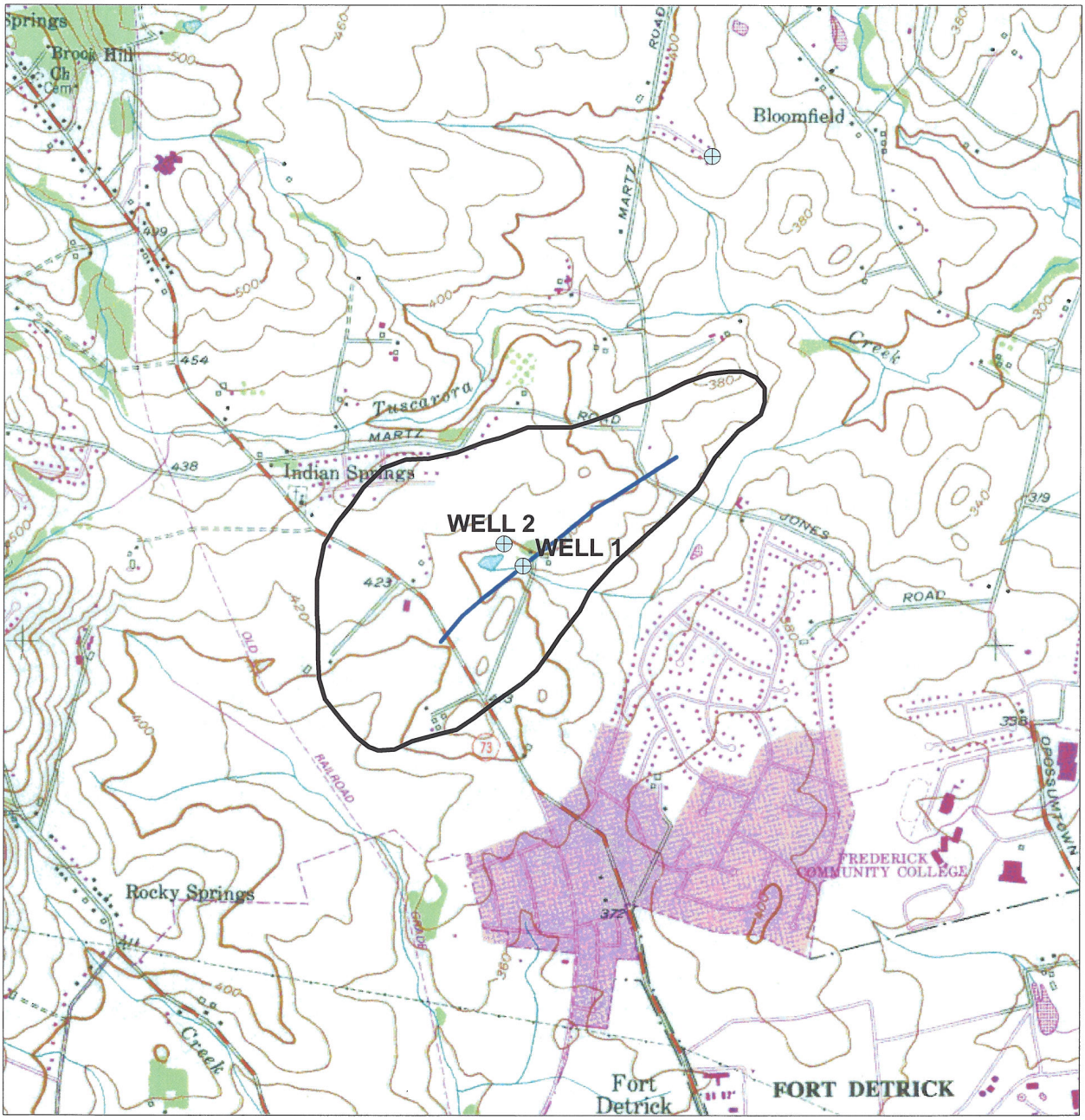


Figure 2. Cloverhill III Wellhead Protection Area (WHPA).

Legend

Wells

Bedrock Strike Orientation

Wellhead Protection Area (WHPA)

N

1000 0 1000 2000 Feet

Base Map: USGS Topographic 7.5 Minute Quad for Frederick

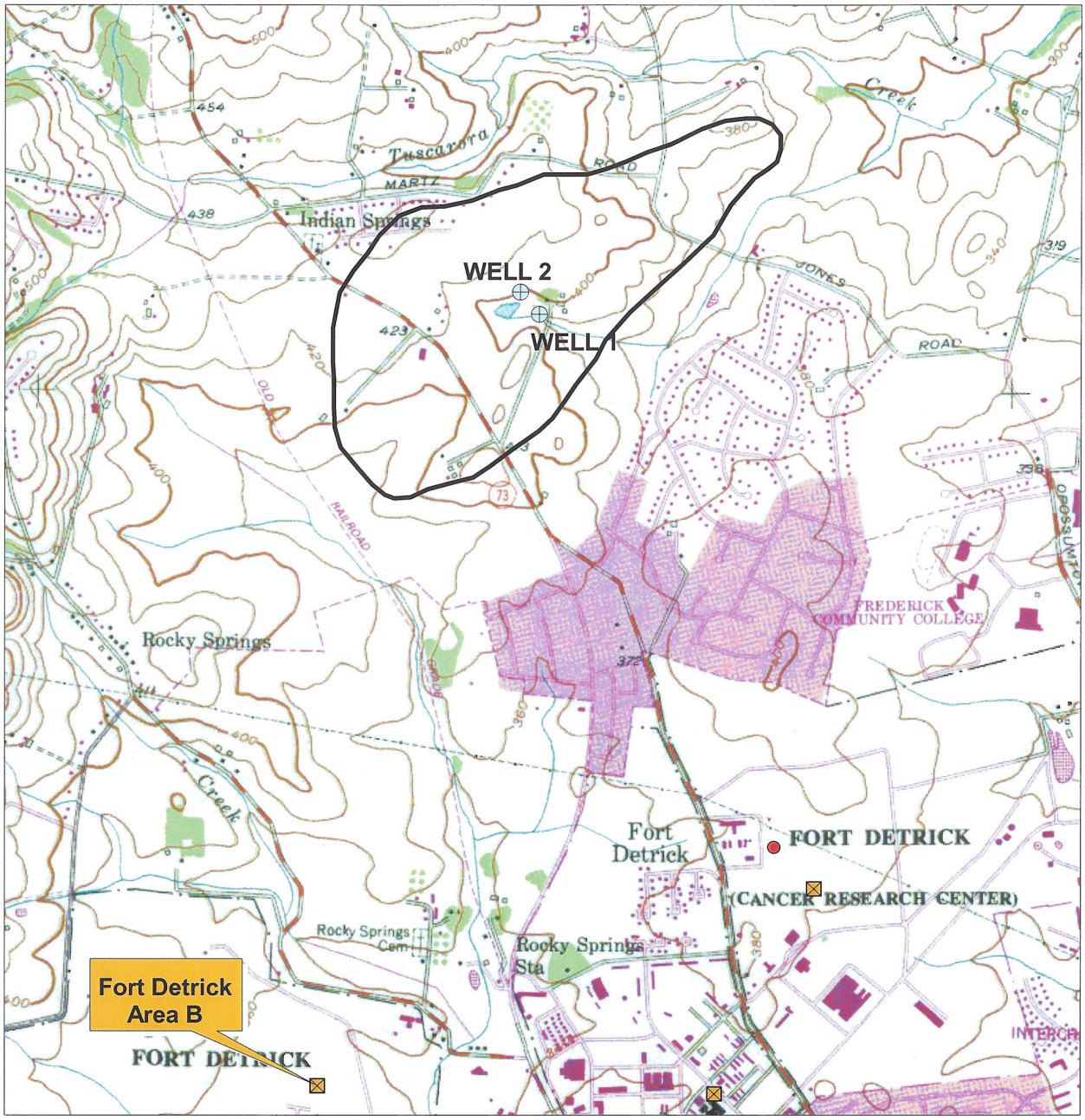


Figure 3. Cloverhill III WHPA with Potential Contaminant Sources.

Legend

Wells

WHPA

Potential Contaminant Sources
(See Table 2 in text)

LUST

CERCLA

N

1000 0 1000 2000 Feet

Base Map: USGS Topographic 7.5 Minute Quad for Frederick

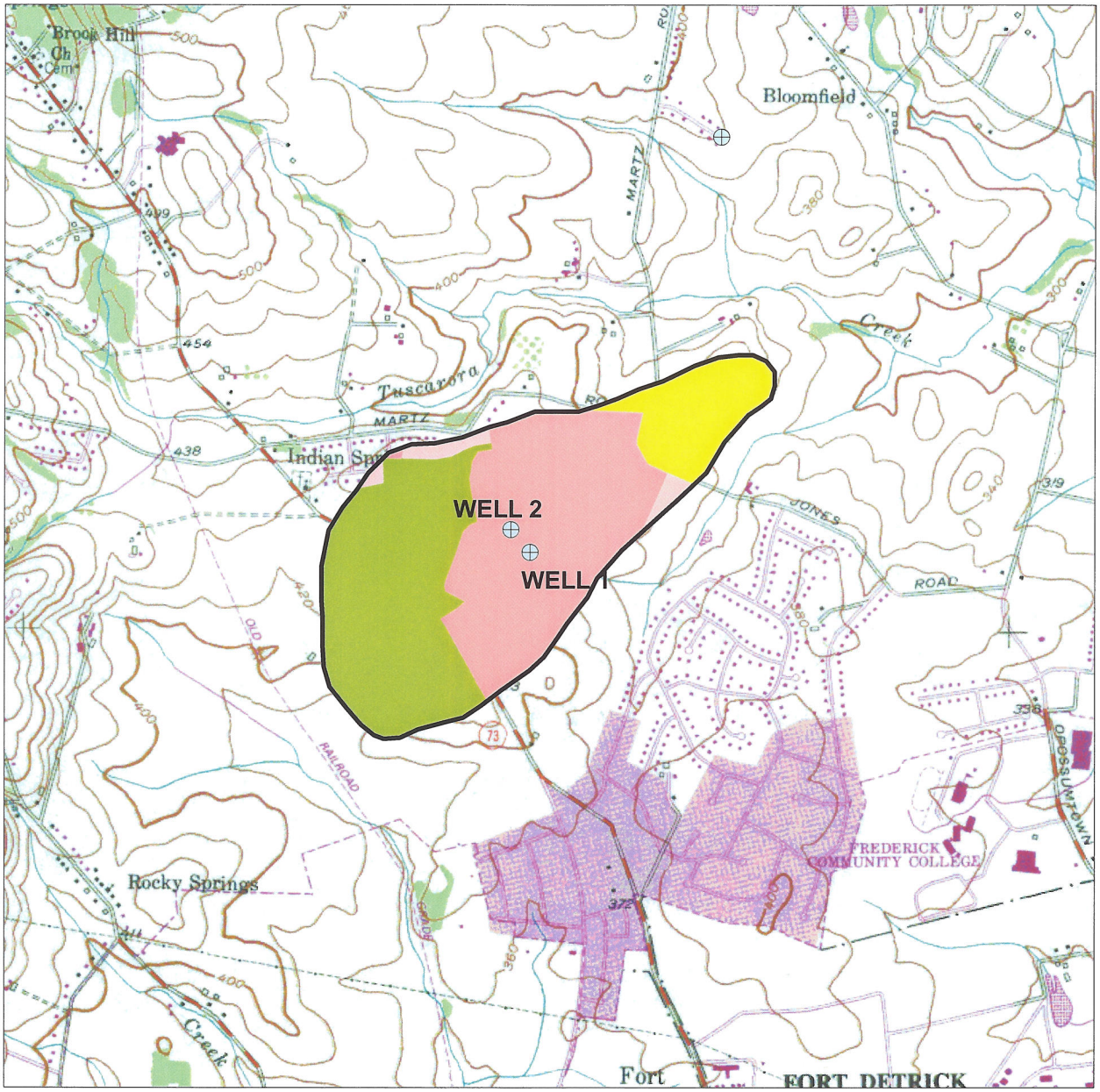


Figure 4. Land Use in the Cloverhill III WHPA.

Legend

Wells

WHPA

Frederick County 2000 Land Use

Low Density Residential

Medium Density Residential

Cropland

Pasture

N

1000 0 1000 2000 Feet

Base Map: USGS Topographic 7.5 Minute Quad for Frederick

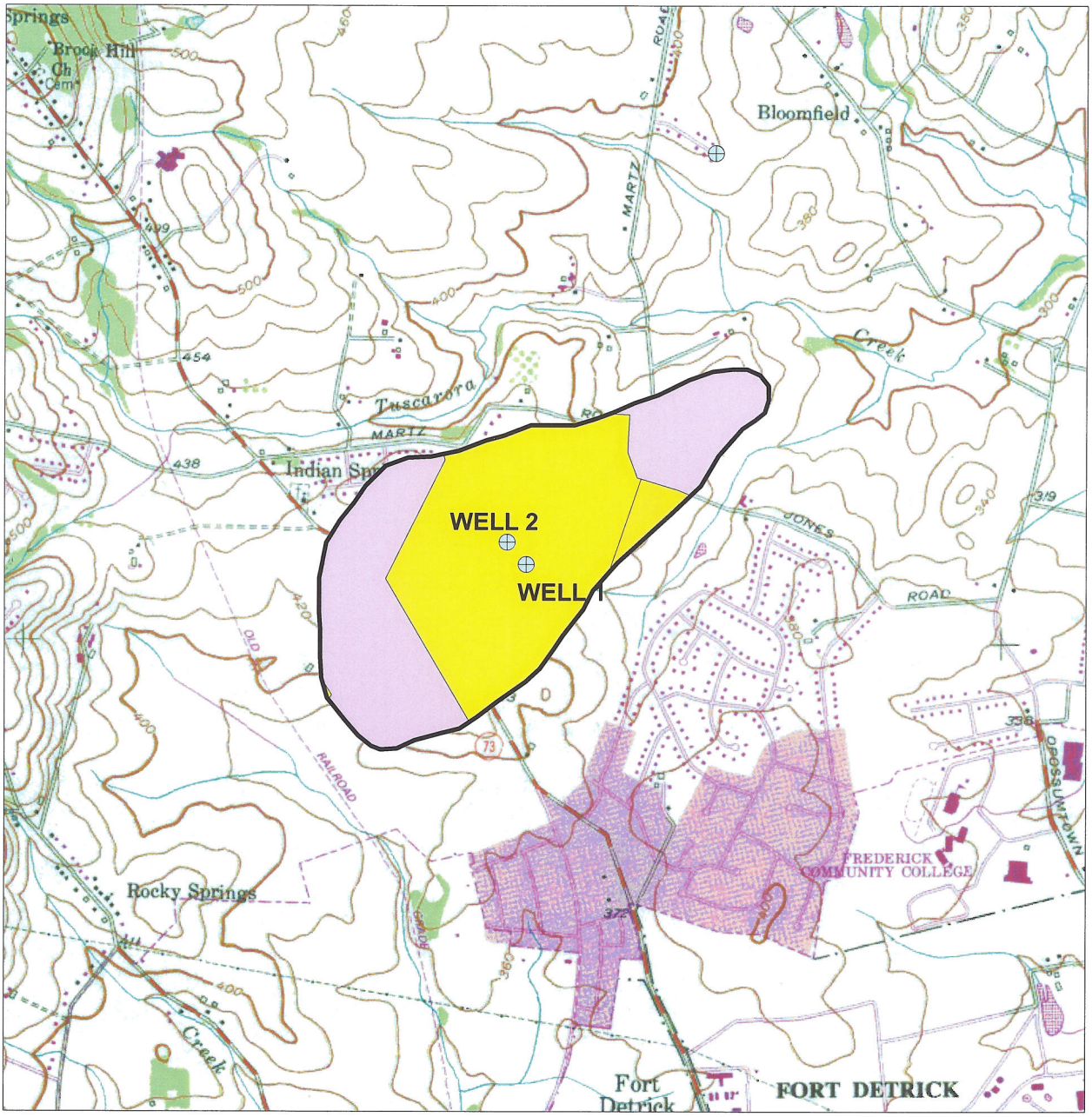
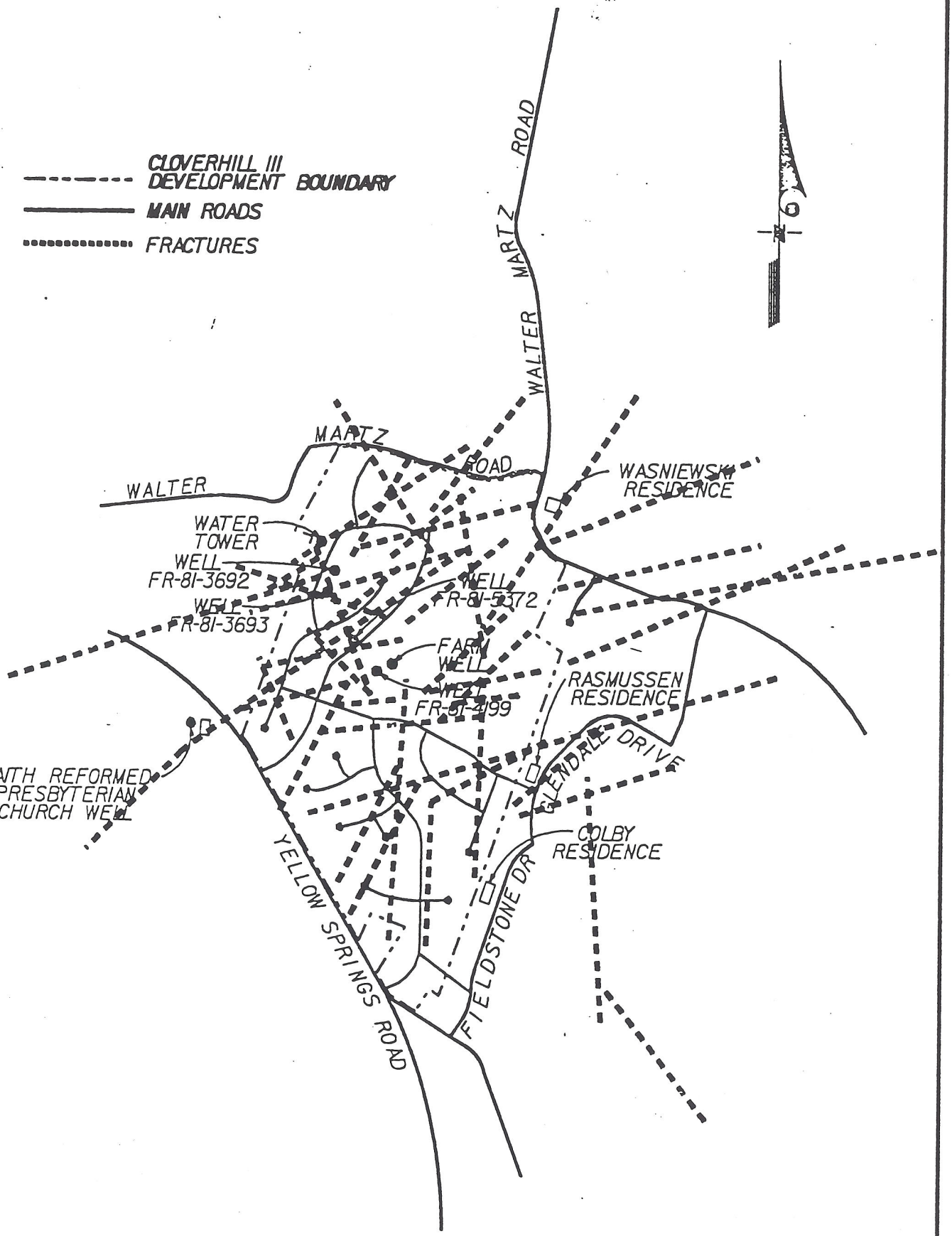


Figure 5. Sewer Service Areas in the Cloverhill III WHPA.

APPENDIX

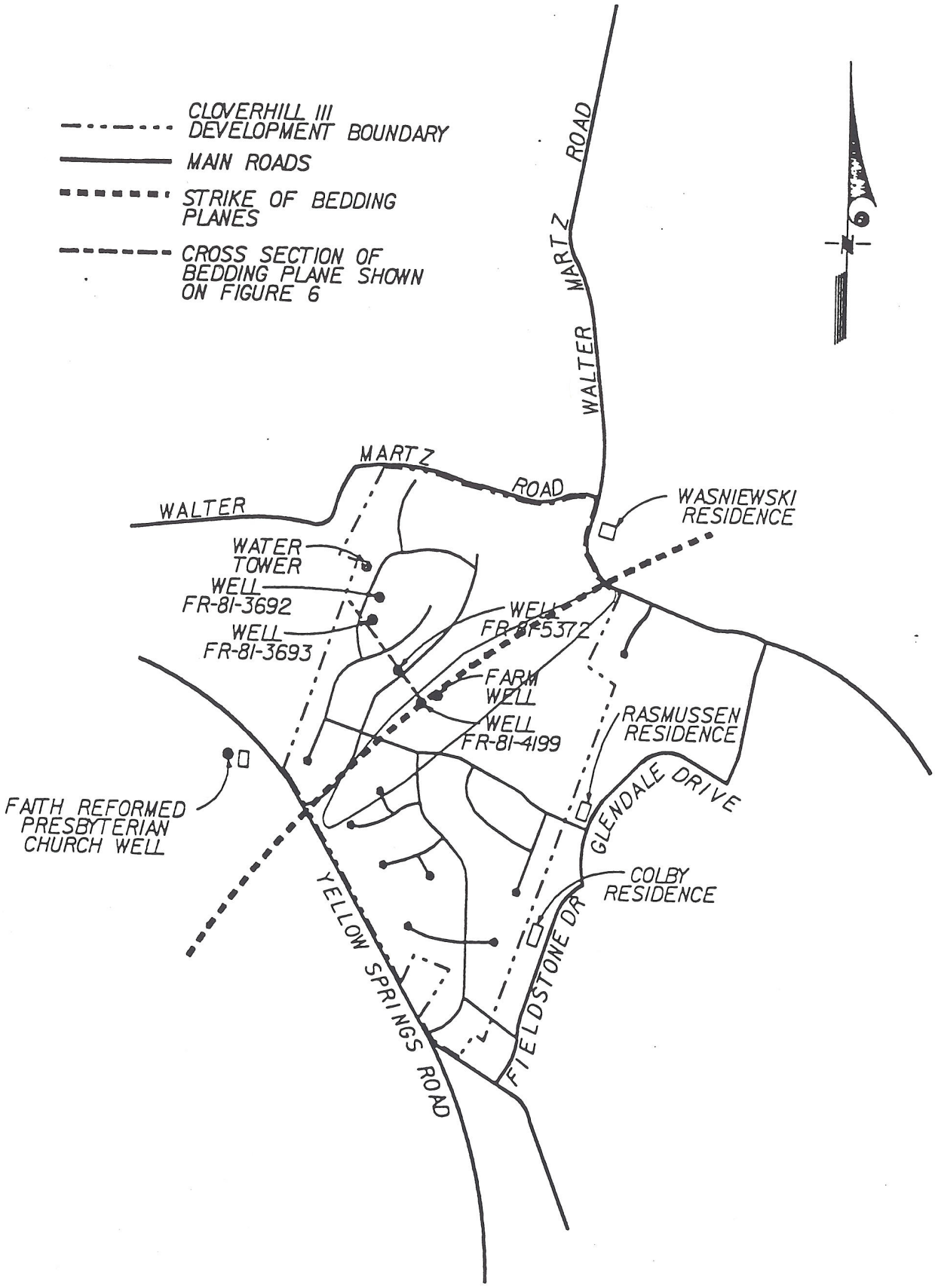


GREENHORNE & O'MARA, INC.

FIGURE 2

CLOVERHILL III

FRACTURED ROCK AQUIFER



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3001 EDMONSTON ROAD, GREENBELT, MARYLAND 20770
(300 982-2800

FIGURE 4
CLOVERHILL III
DIRECTION OF STRIKE
OF BEDDING PLANES

DESIGN | SCALE 1" = 1000'
DRAWN | OF
CHECKED | SHEET
DATE | JOB No. | FILE No.

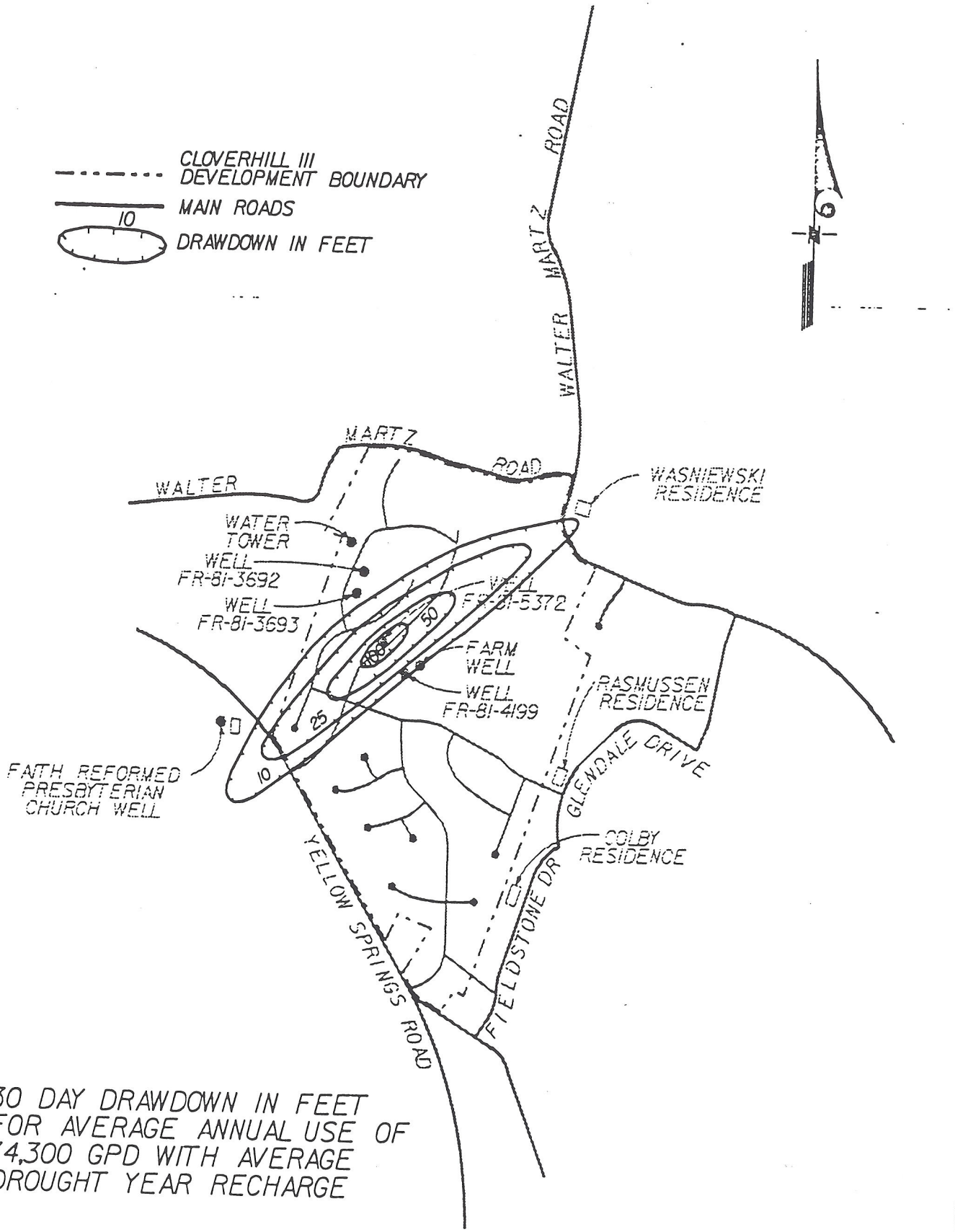

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FIGURE 9
CLOVERHILL III
30 DAY DRAWDOWN MAP

DESIGN | SCALE 1" = 1000'
DRAWN | OF
CHECKED | SHEET
DATE