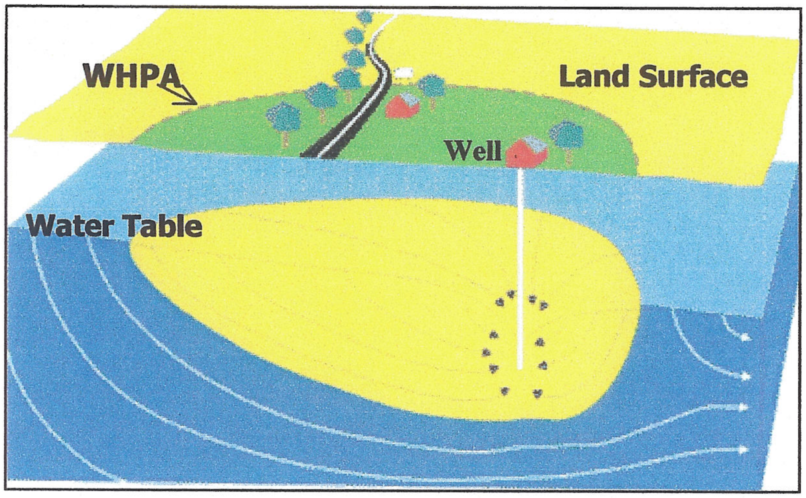
SOURCE WATER ASSESSMENT

for

BOONSBORO/KEEDYSVILLE REGIONAL WATER SYSTEM

Washington County, Maryland



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MDE

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SUMMARY

The Maryland Department of the Environment's Water Supply Program (MDE-WSP) has conducted a Source Water Assessment for the Boonsboro/Keedysville Regional 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. This assessment is focused on the source of water and does not review the treatment employed.

The source of the Boonsboro/Keedysville water supply is an unconfined, carbonate, fractured rock aquifer. The system currently uses two wells (Graystone Well 8 and Shafer Park Well), and the Warrenfeltz and Keedysville Springs. A third well (Crestview Well 9) and two test wells exist but are not in use. The water system supplies the needs of the Towns of Boonsboro and Keedysville. A Source Water Assessment area has been delineated for the Boonsboro/Keedysville Regional Water System using U.S. EPA approved methods specifically designed for each source.

Potential point sources of contamination within the assessment area were identified from MDE contaminant inventory databases. The Maryland Department of Planning's 2002 land use map for Washington County was used to identify non-point sources of contamination. Well information and water quality data were also reviewed.

The susceptibility analysis is based on a review of the existing water quality data for the Boonsboro/Keedysville Regional Water System, the presence of potential sources of contamination in the Wellhead Protection Areas, the construction of the sources, and the inherent vulnerability of the aquifer. It was determined that the Keedysville and Warrenfeltz Springs, and the Shafer Park and Crestview wells are susceptible to contamination by microbiological contaminants. This water supply is also susceptible to contamination by nitrates, but is not presently susceptible to organic or other inorganic contaminants. The system would be susceptible to radon, if the EPA adopts a lower proposed MCL of 300 pico Curies per liter.

INTRODUCTION

The Towns of Boonsboro and Keedysville are located approximately seven miles southeast of the City of Hagerstown, in Washington County. One water system serves both towns and is known as the Boonsboro/Keedysville Regional Water System. A 1994 MDE study indicated that the system served 2880 people and 1067 connections. The 2000 U.S. Census indicates that the total population of the Boonsboro and Keedysville is 3285 and the total number of housing units is 1297. In addition, the 1990 U.S. Census indicates that 96% of the housing units in the two towns were served by public water. Recent water use reports indicate that there have been a significant number of additional units hooked into the system. The Boonsboro/Keedysville Regional Water System obtains its water supply from the Warrenfeltz and Keedysville Springs and two wells (Graystone Well 8 and the Shafer Park Well). The springs and the Shafer Park well have been determined to be ground water under the influence of surface water (GWUDI). One other well (Crestview Well 9) is unused and has been determined to be GWUDI. No GWUDI determination has been made for two test wells.

This document summarizes information from various studies and activities and also contains the required components of Maryland's Source Water Assessment Plan, delineation, contaminant source inventory, and susceptibility analysis.

WELL AND SPRING INFORMATION

A review of the well completion reports and sanitary surveys of the Boonsboro/Keedysville water system indicate that all wells were installed after implementation of the 1973 well construction regulations. Table 1 contains a summary of the well construction data and listed information for the springs. The locations of the production wells and springs are shown in Figure 1.

PLANT ID	SOURCE ID	USE CODE	SOURCE NAME	PERMIT	TOTAL DEPTH	CASING DEPTH	YEAR DRILLED
01	02	PRODUCTION	Warrenfeltz Spring				
01	05	PRODUCTION	Shafer Park Well	WA-94-0902	500	105	1997
02	01	PRODUCTION	Graystone Well 8	WA-81-2325	125	68	1988
02	98	UNUSED	Test Well	WA-81-2329	265	260	1988
02	99	UNUSED	Test Well	WA-81-2332	305	54	1988
03	03	PRODUCTION	Keedysville Spring				
04	04	UNUSED	Crestview Well 9	WA-88-0060	367	61	1989

Table 1. Boonsboro/Keedysville Well and Spring Information

Permit	Source	gpd avg	gpd max
WA1979G012	Keedysville Spring	220,000	250,000
WA1979G013	Warrensfeltz Spring	130,000	150,000
WA1988G006	Shafer Park & Graystone Wells	332,000	415,000
WA1989G022	Crestview Well 9	1,000	2,000
	Total	683,000	817,000

Table 2. Water Appropriation and Use Permit Information

The Boonsboro/Keedysville Regional Water System has four ground water appropriation permits issued for a total daily average of 683,000 gallons on a yearly basis and 817,000 gpd during the month of maximum use. General information for each permit is given in Table 2. Based on the semi-annual pumpage reports (1979-2004), water use changed from 321,000 gpd avg in 1980 (per capita use-138 gpdpc) to 335,000 gpd avg in 2000 (106 gpdpc). Water use then increased to 428,400 gpd avg in 2004. The significant increase in demand in recent years appears to be related to growth and not a higher leak rate. It is noted that production from the Graystone and Shafer Park wells (159,910 gpd avg / 197,947 gpd max) during the 2002 drought was only about ½ of the permitted amounts, while the Town's operating records indicate that the Graystone Well was operated 24 hr/day continuously and the Shafer Park Well was 24 hr/day about 4-5 days/week at the peak of the drought. This can mean that the drought yield of the wells has been over-estimated and that a detailed water level monitoring program should be started. Due to the fairly rapid increase in water use since 2000, the monitoring program should be started in the near future.

HYDROGEOLOGY

Boonsboro and Keedysville are located on the boundary of the Valley and Ridge and the Blue Ridge provinces, in the Hagerstown Valley. The Boonsboro/Keedysville area is underlain by the carbonate dolomites of the Cambrian Tomstown Formation on its western side and by Blue Ridge crystalline, non-carbonate rocks of on its eastern side.

All of the production wells and springs obtain water from the Tomstown Formation, which is a water table carbonate rock aquifer that is susceptible to contamination, due to dominant flow through shallow epi-karst zones. In 1990, MDE determined that the Graystone Well 8 was not under the influence of surface water (GWUDI) at that time. In 1993, MDE determined that the Keedysville and Warrenfeltz Springs were GWUDI. In 1994, MDE notified Boonsboro that the Crestview Well 9 was also GWUDI. To date, no method for treating the GWUDI problem with that well has been installed. In 1997, Boonsboro indicated that the Shafer Park Well was to be added to the filtration plant for the Warrensfeltz Spring; consequently, no GWUDI determination for that well was needed. Finally, no GWUDI determination has been made for the two test wells; however, it is unlikely that those wells will ever be used, due to their low blown yields (5 and 45 gpm).

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 WHPA represents the area around a well in which any contaminant present could ultimately reach the well. The source water assessment area for public water systems using wells or springs in fractured-rock aquifers is the watershed drainage area that contributes to the well or spring. The WHPA could be modified in carbonate aquifers to account for inflow from other watersheds. The area should be modified to account for geological boundaries, ground water divides, and by annual average recharge needed to supply the well (MD SWAP, 1999). The capture zone for a well, however, will be greatest during a drought, because the zone has to expand due to the reduced recharge in order to supply the annual average demand. Also, wells completed in carbonate rock aquifers may capture significant amounts of surface water, so the surface drainage area to such wells should be considered in any wellhead protection study.

In December 1994, MDE developed a Wellhead Protection Plan for the Town of Boonsboro. Due to the complexity of the geology in the area, it was determined that a Wellhead Protection Area (WHPA) could not be determined solely using the EPA approved (groundwater flow model) WHPA Code. In that case hydrogeologic mapping was, also, used to identify the physical and hydrologic features that might control ground water flow.

In the 1994 study, a WHPA was developed for each existing or proposed source at that time, which were the Warrenfeltz Spring and the Graystone, Crestview and Boonsboro West (never constructed) wells. One combined WHPA was produced that, essentially, includes the drainage areas up gradient of each source, terminating at the regional carbonate/non-carbonate rock boundary. It did not; however, include the Keedysville Spring.

In this report, the results of a 1993 MDE surface water influence study were used to delineate two WHPAs for the Boonsboro/Keedysville water supply. Those results are discussed in greater detail in the water quality section of this report. The two WHPAs are shown in Figure 1.

The first or upper WHPA is the watershed area of Zittlestown Branch up gradient of Monroe Road (4.2 sq.mi.). The upper WHPA is underlain by about 80% Blue Ridge, crystalline, non-carbonate rocks and about 20% carbonate rocks. This WHPA was chosen because surface water runoff from the watershed could be captured and routed through a ground water conduit to the Keedysville Spring.

The second or lower WHPA includes most of the 1994 WHPA, plus that portion of the Keedysville Spring drainage area not covered by the upper WHPA. About 95% carbonate and 5% non-carbonate rocks underlie this WHPA. It contains most of the point sources of contamination, including the Boonsboro wastewater lagoon, and much of the agricultural lands in the area.

The WHPA should cover an area large enough to supply water at the average appropriated amount using effective recharge. The 2002 drought year base flow (effective recharge) in the Yellow Breeches Basin (PA), which has the best available data for carbonate recharge rates, was estimated by MDE (Hammond, 2000, revised 2004) to be 8.4 in/yr (625 gpd/acre). The area of the lower WHPA is 3.8 sq. mi, which would produce a recharge of about 1,520,000 mgd avg during the drought. A composite estimate average baseflow for the Blue Ridge during the drought was about 500 gpd/ac. When this value is applied to the drainage area of the upper WHPA (4.2 sq.mi.), the result is 1,344,000 gpd avg. The sum of the calculated drought year recharge for the two WHPAs is several times greater than the actual and appropriated uses by the Towns.

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 15 potential point sources of contamination within the WHPAs, and one other near the WHPAs, (Table 3 and Figure 2). All but four of the sources are in the lower WHPA. The higher concentration of carbonate rocks and sources of contamination in the lower WHPA suggest that it is more susceptible to contamination than the upper WHPA. All of the point sources are included for historical purposes. Underground storage tanks (UST) were identified at 10 facilities. If they leak, USTs are potential sources of volatile organic compounds. The Town of Boonsboro has an NPDES-municipal permit to discharge into Boonsboro Branch, within the lower WHPA. Wastewater effluent can contain a variety of contaminants; including pathogens, partially treated organic compounds and inorganic compounds, such as nitrates or metals that are not completely removed by the treatment process. Four facilities were identified as CHS (Controlled Hazardous Substances)-generators and could be sources of volatile and synthetic organic compounds.

ID	Type	Facility Name	Address	Comments	Tax Map	Parcel
A	CHS-gen UST-in use	Boonsboro High School	10 Campus Avenue	Lab chemicals Heating oil	600	1381
B	UST-in use	Boonsboro Elementary School	5 Campus Avenue	Heating oil	600	1381
C	UST-out of use	Lum's Amoco (now Frank's Used Cars)	280 N. Main St.	Gasoline, heating oil, kerosene, & used oil	601	410
D	CHS-gen UST-out of use	London Fog (now Country Village LTD)	3 Orchard Drive	Heating oil	600	530
E	UST-out of use	Bast Furniture, Inc.	109 N. Main St.	Gasoline	602	440
F	UST-out of use	Boonsboro Post Office (now Glausier, et.al.)	5 Potomac St.	Heating Oil	601	606
G	UST-out of use	Thompson's Gas & Electric (now R. Hartle or Glausier?)	7 Potomac St. (present-6708 Old National Pike)	Heating Oil	601	606 or 607?
H	UST-in use	Reeders Memorial Home	141 S. Main St.	Heating oil	601	415
I	CHS-gen & UST	State Highway Admin.	Junction US 40 & MD67	none	73	14
J	UST-in use	Old South Mountain Inn	6132 Old National Pike	Heating Oil	74	14
K	NPDES-mun	Boonsboro WWTP	6927 Monroe Road	WWTP & sewage lagoon	73	130
L	CHS-gen	C&P Telephone Co. (now Bell Atlantic)	95 North Main St. Keedysville	Transformer	72-1	254-5

Table 3. Potential Contaminant Sources in or near Boonsboro/Keedysville WHPAs

Non-Point Sources

Based on the Maryland Department of Planning's 2002 Land Use map, the land use within the upper and lower WHPAs is primarily forested (40.5%), agricultural (cropland and pasture) (38.8%), with smaller proportions of residential areas (16.1%), and other uses (4.6%), Figure 4. About 60% of the upper WHPA is forested and contains the majority of the forested land for both WHPAs. Table 4 outlines the distribution of land use within the WHPAs.

Land Use Code	Land Use Type	Total Acres	% WHPA
11	Low Density Residential	417.5	8.2
12	Medium Density Residential	383.1	7.5
13	High Density Residential	14.4	0.3
14	Commercial	60.3	1.2
15	Industrial	6.8	0.1
16	Institutional	100.9	2.0
18	Open Urban Land	21.2	0.4
21	Cropland	1434.4	28.3
22	Pasture	535.9	10.6
23	Horticulture	8.5	0.2
41	Deciduous Forest	2058.1	40.5
50	Water	9.9	0.2
242	Farmstead-Aquaculture	26.2	0.5
	Total	5077	100

Table 4. Land Use Summary of Boonsboro/Keedysville WHPAs

Cropland is commonly associated with nitrate loading of ground water and also represents potential sources of SOCs depending on fertilizing practices and use of pesticides. Pasture and residential areas are also sources of microbiological pathogens from human and animal wastes. Additionally, residential areas may be a source of nitrate and SOCs, if fertilizer, pesticides, and herbicides are not applied carefully to lawns and gardens.

The Maryland Department of Planning's 2002 digital sewer map of Frederick County shows that 85.7% of the WHPAs has no planned sewer service, and is primarily forest or agricultural lands (Figure 4). The remaining area has existing sewer service or is planned for service (no time frame). Table 5 summarizes the sewer service categories in the WHPAs.

Service Category	Total Acres	Percent of WHPA
Existing Service	655.9	12.9
Planned Service (no time frame)	70.3	1.4
Not Planned for Service	4350.7	85.7
Total	5077	100

Table 5. Sewer Service Area Summary of Boonsboro/Keedysville WHPAs

WATER QUALITY DATA

Water Quality data were reviewed from the Water Supply Program's database for Safe Drinking Water Act contaminants. All data reported is from the finished (treated) water unless otherwise noted. The methods used to treat the water supply are given in Table 6.

SYSTEM	PLANT ID	TREATMENT	PURPOSE
WARRENFELTZ SPRING SCHAFER PARK WELL	01	FILTRATION GASEOUS CHLORINATION FLUORIDATION	MICROBIAL REMOVAL DISINFECTION DENTAL HEALTH
GRAYSTONE WELL 8	02	FLUORIDATION GASEOUS CHLORINATION	DISINFECTION
KEEDYSVILLE SPRING	03	FILTRATION GASEOUS CHLORINATION FLUORIDATION	MICROBIAL REMOVAL DISINFECTION
CRESTVIEW WELL 9	04	NONE (REQUIRED TO FILTER)	MICROBIAL REMOVAL

Table6. Treatment Methods for Boonsboro/Keedysville Water Treatment Plants

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, the written 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. A review of the monitoring data since 1988 for the Boonsboro/Keedysville Regional Water Supply indicates that nitrates, di(2-ethylhexyl)phthalate, 1,1-Dichloroethylene and Radon-222 (proposed standard) exceed 50% MCL thresholds. In addition, other contaminants of concern were microbiological pathogens in all sources except the Graystone Well 8. A summary of the results of the water quality sampled is given in Table 7.

	Plant 01		Plant 02		Plant 03		Plant 04	
Contaminant Group	No. of Samples Collected	No. of Samples > 50% of an MCL	No. of Samples Collected	No. of Samples > 50% of an MCL	No. of Samples Collected	No. of Samples > 50% of an MCL	No of Samples Collected	No. of Samples > 50% of an MCL
Inorganic Compounds (except nitrate)	11	0	7	0	9	0	1	0
Nitrate	32	9	35	17	32	11	1	0
Radiological Contaminants	3	*1	3	*1	3	*1	1	0
Volatile Organic Compounds	23	1	17	0	12	0	3	0
Synthetic Organic Compounds	4	1	5	0	4	0	1	0

Table 7. Summary of Water Quality Samples for Boonsboro/Keedysville Plants
**based on a proposed MCL for radon of 300 picocuries per liter*

Inorganic Compounds (IOCS)

No inorganic compounds were detected above 50% of an MCL, except nitrate, which has an MCL of 10 ppm. The range and average nitrate levels at each plant were as follows: Plant 01, 2.7-8.0 ppm, average 4.5 ppm; Plant 02, 2.9-7.8 ppm, average 4.9 ppm; Plant 03, 1.2-8.3 ppm, average 4.8 ppm; and Plant 04, 2.2 ppm, average (one sample).

Volatile Organic Compounds (VOCs)

A review of the data shows that there were no VOC results above 50% of an MCL, except one sample of 1,1-Dichloroethylene in Plant 01 on 25-Aug-92 at a level of 5.2 ppb relative to an MCL of 7 ppb. Multiple detections (11) at Plant 01 and single detections at Plants 02 and 04 of 1,1,1-Trichloroethane were made at levels about 1 to 2 orders of magnitude less than the MCL of 200 ppb. Single detections of benzene, carbon tetrachloride, styrene, trichloroethylene, tetrachloroethylene, toluene, and xylenes were made at levels about 1 to 4 orders of magnitude below the respective MCLs. Methyl-Tertiary-Butyl-Ether (MTBE) was detected at low levels (1 ppb) at Plants 01 and 03.

Radionuclides

A review of the data shows that no radionuclides were detected above 50% of an MCL. There is currently no MCL for Radon-222, however EPA has proposed an MCL of 300 picocuries per liter (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. Radon-222 results from all Plants 01-03 (360-650 pCi/L) have exceeded the lower proposed MCL. No samples taken from Plant 04 were found in MDE records.

Synthetic Organic Compounds (SOCs)

SOCs were detected in one sample at a level above 50% of an MCL. This was di(2-ethylhexyl)phthalate at a level of 3.4 ppb relative to the MCL of 6 ppb, taken from Plant 01. Di(2-ethylhexyl)phthalate is commonly found in analyses of laboratory blanks, and the result is therefore not believed to represent the actual water quality in the well.

Microbiological Contaminants

Boonsboro and Keedysville were notified by MDE (Parrish, 1993) that the Warrenfeltz and Keedysville Springs were classified as "Ground Water Under the Direct Influence of Surface Water" (GWUDI) source as defined in COMAR and the Surface Water Treatment Rule. On June 30, 1994 (Parrish, 1994) Boonsboro was notified that the Crestview Well 9 was GWUDI. These determinations were based on the results of bacteriological sampling and the presence of surface water indicators. On April 26, 1990, MDE notified Boonsboro that the Graystone Well 8 was **not** a GWUDI source. Boonsboro notified MDE on July 18, 1997 that the Shafer Park Well would be hooked into the filtration plant for Warrenfeltz Spring and that has been completed, so no GWUDI testing was needed for that well. The results of the GWUDI testing are shown in Table 8.

SOURCE	RAIN DATE	RAIN AMT	REMARK	SAMPLE DATE	TOTAL COLIFORM	FECAL COLIFORM
GRAYSTONE WELL 8	13-Jun-94	0.5	WET SET	13-Jun-94	0	0
GRAYSTONE WELL 8	13-Jun-94	0.5	WET SET	14-Jun-94	0	0
GRAYSTONE WELL 8	13-Jun-94	0.5	WET SET	15-Jun-94	0	0
GRAYSTONE WELL 8	13-Jun-94	0.5	WET SET	16-Jun-94	0	0
GRAYSTONE WELL 8	28-Jun-94	0.6	WET SET	28-Jun-94	0	0
GRAYSTONE WELL 8	28-Jun-94	0.6	WET SET	29-Jun-94	0	0
GRAYSTONE WELL 8	28-Jun-94	0.6	WET SET	30-Jun-94	0	0
GRAYSTONE WELL 8	28-Jun-94	0.6	WET SET	1-Jul-94	0	0
WARRENFELTZ SPRING	14-Dec-92	0.5	AVG WET SAMPLES 1993 STUDY	14-Dec-92	28	6
WARRENFELTZ SPRING	14-Dec-92	0	AVG DRY SAMPLES 1993 STUDY	14-Dec-92	10	2
KEEDYSVILLE SPRING	14-Dec-92	0.5	AVG WET SAMPLES 1993 STUDY	14-Dec-92	58	7
KEEDYSVILLE SPRING	14-Dec-92	0	AVG DRY SAMPLES 1993 STUDY	14-Dec-92	15	2
CRESTVIEW WELL 9	25-May-94	0	DRY	25-May-94	110	110
CRESTVIEW WELL 9	6-Jun-94	0	DRY	6-Jun-94	80	80
CRESTVIEW WELL 9	7-Jun-94	0.1	DRY	7-Jun-94	80	80
CRESTVIEW WELL 9	13-Jun-94	0.5	WET SET	13-Jun-94	81	81
CRESTVIEW WELL 9	13-Jun-94	0.5	WET SET	14-Jun-94	81	81
CRESTVIEW WELL 9	13-Jun-94	0.5	WET SET	15-Jun-94	800	460
CRESTVIEW WELL 9	13-Jun-94	0.5	WET SET	16-Jun-94	260	110
CRESTVIEW WELL 9	28-Jun-94	0.6	WET SET	28-Jun-94	800	800

Table 8 continued:

SOURCE	RAIN DATE	RAIN AMT	REMARK	SAMPLE DATE	TOTAL COLIFORM	FECAL COLIFORM
CRESTVIEW WELL 9	28-Jun-94	0.6	WET SET	29-Jun-94	800	800
CRESTVIEW WELL 9	28-Jun-94	0.6	WET SET	30-Jun-94	800	800
CRESTVIEW WELL 9	28-Jun-94	0.6	WET SET	1-Jul-94	800	260

Table 8. GWUDI Data Boonsboro/Keedysville Wells and Springs

MDE STUDY OF SURFACE WATER INFLUENCE ON WARRENSFELTZ/KEEDYSVILLE SPRINGS.

The MDE Compliance division conducted a study (Steinfort, et. al., 1993) to determine the surface water influence on the Warrensfeltz and Keedysville Springs. It consisted of dye trace studies, streamflow measurements, and bacteriological monitoring. The results of the streamflow measurements and bacteriological monitoring from that investigation are given in Tables 9 and 10, with additional data and calculations completed for this study.

Dye Trace Study

The Compliance Monitoring Division, MDE (1993) completed an investigation of surface water influence on the Warrensfeltz and Keedysville springs. During that study dye trace methods were used, bacteriological monitoring was conducted and stream flow measurements were taken.

Three dye trace studies were completed during the period 2/13-5/26, 1993.

The first was a pulse release of 1.5 l of Rhodamine WT (in about 25 gallons of stream water) at each of two sites in Boonsboro Branch (one at Campus Avenue and the second immediately upstream of Boonsboro's wastewater lagoons). A 60-hr dosing period was used, starting on 2/13/1993. Samples were collected, using automatic samplers, once/hr for the first 12 hours and every two hours for the next 10 days, with no recovery of dye at either spring.

The second trace was a pulse release of 1.5 l of Rhodamine WT (in about 25 gallons of stream water) at each of two sites in Zittlestown Branch (one at Zittlestown Road and the other at Mountain Road). A 48-hr dosing period was used, starting on 3/4/1993. Samples were collected, using automatic samplers, once/hr for the first 24 hours and every two hours for the next week, with no recovery of dye at either spring.

For the third dye trace, four simultaneous slug (impulse) releases were made on May 19, 1993 at the same four sites from the two previous traces. At the Warrensfeltz Spring there were low concentration recoveries (0.1-0.2 ug/l) staring 20 hours after injection and continuing for 16 hours. At the Keedysville Spring, low concentration recoveries (0.1 ug/l) started 76 hours after injection, ending 52 hours later. The detection level of the flourometer used during the tests was 0.1 ug/l. During this trace, dye was detected in elutants of charcoal packets at both springs. The maximum concentration (0.12 ug/l) at Warrensfeltz occurred six days following injection. At the Keedysville Spring, the maximum concentration (0.50 ug/l) occurred three days after injection. Both samples were less than 10 times background levels. Charcoal packets were installed in Boonsboro Branch at the entrance of Keedysville Spring. The highest concentration recorded was 85 ug/l, three days after the slug release. In the case, there were no background levels reported.

Streamflow Discharge Measurements

As part of the dye trace study, streamflow measurements were taken at six sites on an unnamed tributary to Little Antietam Creek. The study was divided into two streams designated Boonsboro Branch, which crosses in Boonsboro near the junction of MD Route 66 and Alternate U.S. Route 40, and Zittlestown Branch, which starts in Zittlestown, about ½ mile west of Turners Gap.

These measurements were conducted to identify areas of streamflow loss, that might suggest a connection to ground water. The results are shown in Table 9. The six flow measurement sites were in Boonsboro Branch, just above the Boonsboro wastewater lagoon, at the passage by the downstream cell of the lagoon, at the discharge from the lagoon, in Zittlestown Branch at Monroe Road, in Boonsboro Branch, at MD Route 34 (near Crystal Grotto Cave) and just upstream of Keedysville Spring.

A 40% loss was reported in the vicinity of the lagoon. In addition, it was reported that, between Crystal Grotto and Keedysville Spring, there was a marked net loss of flow in Boonsboro Branch under low flow conditions and less loss, as a percentage of total flow, under high flow conditions. It was, also, concluded that the total streamflow data indicated entry of ground water of limited capacity.

The streamflow study did not compare the effects of the differences of the drainage areas of the various sites. The best way to compare difference reaches of a stream is to use unit area flow values (total flow at a site divided by the drainage area of that site) in making the comparison. In this report, the watershed has been divided into two basins of roughly equal area, which were also used to derive the upper and lower WHPAs. The upper basin includes the area (4.2 sq.mi.) of Zittlestown Branch upstream of Monroe Road. The lower basin consists of the remainder of the watershed (3.6 sq. mi.) above Keedysville Spring.

When the flows in Zittlestown Branch at Monroe Road are divided by the drainage area above the measuring point, that result is multiplied by the total watershed area (7.8 sq.mi.); then the flows in the stream at Keedysville Spring are subtracted, making the overall result a relatively constant difference of 4.1 (+/- 20%) cfs. Only one known flow measurement is available for Keedysville Spring (MGS RI 42), which was 3.6 cfs on 4/22/1981. That flow was about 1% of the flow in Antietam Creek (near Sharpsburg). Using these data and daily flows measured in Antietam Creek and the Albert Powell Hatchery Spring, estimates of the discharge Keedysville Spring can be made for the period of the 1993 MDE study. The results are estimated spring flows of

4.5 (+/- 20%) cfs, or values nearly the same as the lost stream flows in the lower part of the watershed. These data indicate that all or nearly all of the flow lost in the lower part of the watershed is routed through a conduit system and discharged at the Keedysville Spring.

Table 9. Boonsboro and Zittlestown Branch Streamflow Data

Site	Line no.	Stream Mi.	D.A.(sq.mi.)	04/22/1981	12/01/1992	12/30/1992	01/18/1993	01/19/1993	01/20/1993	01/21/1993	01/22/1993	01/25/1993	
Boonsboro Br, upstream WWTP Lagoons	1	1.22			0.42	0.37	0.46	0.44	0.56	0.66	0.70	0.74	
Boonsboro Br, upstream chlorine contact tank outside lagoons	2	1.37			0.23	0.22	0.28	0.22	0.33	0.47	0.51	0.55	
effluent of lagoon at stream	3	1.67			N/A	0.70	0.71	0.74	0.73	0.74	0.72	0.74	
Zittlestown Br at Monroe Rd	4	N/A	4.2		4.48	4.58	4.66	5.11	6.93	7.99	8.09	8.22	
	5	Unit flow (cfs/mi.)			1.07	1.09	1.11	1.22	1.65	1.90	1.93	1.96	
Boonsboro Br at Crystal Grotto, MD 34	6	2.30			5.80	5.66	5.81	6.30	7.42	9.44	9.37	10.06	
Boonsboro Br, upstream Keedysville Spring	7	3.75	7.8		3.98	4.02	3.90	5.55	9.68	10.50	10.71	11.98	Average
	8	Unit flow line 5 X 7.8 sq.mi.			8.32	8.51	8.65	9.49	12.87	14.84	15.02	15.27	11.6
	9	Difference Line 8-Line 7			4.3	4.5	4.8	3.9	3.2	4.3	4.3	3.3	4.1
Antietam Cr(Sharpsburg)	10	N/A		359	203	543	471	445	427	422	490	449	
Albert Powell Spring	11	N/A		N/A	7.5	12	10	10	10	10	10	11	
Keedysville Spring	12				Estimated flows Keedysville Spring								
				3.6	3.4	5.4	4.5	4.5	4.5	4.5	4.5	5.0	4.5

Bacteriological Monitoring

Bacteria samples were taken from the Warrensfeltz and Keedysville Springs in December 1992 and January 1993. The results given in Table 10 showed high bacteria concentrations in both springs immediately after heavy rainfall that occurred on December 11, 1992, with a general decline in levels over the following month. Also, the bacteria concentrations were generally much higher in the Keedysville Spring relative to the Warrensfeltz spring.

From late January to early April 1993, bacteriological samples were taken at five points along the streams, the wastewater lagoon effluent, and the two springs. These data indicate that the highest concentration of fecal coliform bacteria occurred immediately downstream of the wastewater lagoon (Boonsboro Branch at Monroe Road), which would suggest that the lagoon may be leaking. The concentrations were lower at the next downstream point (Crystal Grotto), which was probably due to mixing with less polluted flows from Zittlestown Branch. The concentrations of fecal matter then increased between the Crystal Grotto and in Boonsboro Branch at Keedysville Spring. This would indicate that there is another source of contamination in the lower part of the watershed, which land use records indicate could be due to agricultural activity. Finally, it is noted that the bacteria concentrations in the two springs are about one to two orders of magnitude lower than those in the streams.

Table 10. Boonsboro/Keedysville Bacteriological Result (Total and Fecal Coliform)
All data are MPN/100 Ml

Line no.	Sample Date	Boonsboro Br @Alt Rt 40		Warrenfelts Spring		Boonsboro WWTP Lagoon Effluent		Boonsboro Br @ Monroe Rd		Zittlestown Br @ Monroe Rd		Boonsboro Br @ Crystal Grotto		Boonsboro Br @ Keedysville		Keedysville Spring		Remarks
		Total	Fecal	Total	Fecal	Total	Fecal	Total	Fecal	Total	Fecal	Total	Fecal	Total	Fecal	Total	Fecal	
1	12/14/1992			79	7.8											4600	130	heavy rain
2	12/14/1992			79	13.0											3300	130	beginning
3	12/14/1992			230	23.0											4900	49	12/11/1992
4	12/15/1992			21	2.0											1300	23	
5	12/15/1992			790	2.0											790	23	
6	12/15/1992			330	13.0											1300	29	
7	12/16/1992			79	13.0											460	49	
8	12/16/1992			49	2.0											700	33	
9	12/16/1992			110	4.5											1300	79	
10	12/21/1992			4	<2.0											280	7.0	no rain
11	12/21/1992			4	<2.0											220	4.0	
12	12/29/1992			49	2.0											23	13	some rain
13	12/29/1992			33	4.5											23	13	
14	12/29/1992			23	7.8											23	13	
15	01/05/1993			LA	LA											130	79	no rain
16	01/05/1993			33	11.0											110	14	
17	01/05/1993			23	11.0											64	14	
18	01/11/1993			11	<1.8											23	4.5	some rain
19	01/11/1993			13	<1.8											33	2.0	
20	01/11/1993			17	<1.8											33	<1.8	
21	01/27/1993	1100	170	<1.8	<1.8	<1.8	<1.8	220	130	350	49	430	49	9200	9200	22	4.5	no rain
22	02/04/1993	330	**79**	7.8	<1.8	4.5	2.0	7000	**7000**	1800	**220**	1300	**330**	1400	**950**	9.3	<1.8	no rain
23	02/08/1993	490	**79**	13	4.5	4.5	<1.8	2300	**2300**	4900	**490**	790	**330**	2200	**1100**	4.5	<1.8	no rain
24	02/10/1993	330	**130**	70	<1.8	2.0	<1.8	7900	**4900**	2300	**490**	460	**130**	790	**790**	33	2.0	no rain
25	02/16/1993	3300	**130**	4.5	2.0	2.0	<1.8	3300	**3300**	490	**490**	2300	**790**	2800	**1300**	2	<1.8	some rain
26	02/17/1993	3300	**230**	23	<1.8	7900	4900	790	**3300**	4900	**460**	7900	**1300**	7900	**2300**	7.8	<1.8	no rain
27	02/18/1993	79	49	17	<2.0	11	<1.8	2300	79	3300	490	1300	170	3300	330	4.5	2.0	no rain
28	02/22/1993	46	**4.5**	23	13.0	23	23	1700	**1100**	2800	**180**	2300	**1300**	11000	**7900**	23	7.8	some rain
29	02/25/1993	130	11	11	<2.0	<1.8	<1.8	1300	49	1100	230	2100	230	1700	230	4.0	2.0	no rain
30	03/08/1993	330	33	17	<1.8	1300	330	4900	**1700**	3300	**230**	7000	**330**	3300	**700**	49	23	heavy rain
31	03/09/1993	330	4.5	17	4.5	330	70	2200	490	7900	330	7900	490	4900	220	70	17	>2 in/24 hr
32	03/10/1993	790	**7.8**	23	2.0	1300	280	2300	**2300**	11000	**790**	7000	**170**	7900	**280**	170	4.5	03/05/1993
33	03/18/1993	4900	70	170	22.0	110	33	4900	490	4900	49	2800	130	13000	140	79	7.8	moderate RF
34	03/22/1993	330	49	23	4.5	70	6.8	1700	33	4300	27	1800	17	1800	21	7.8	2.0	snowmelt
35	03/30/1993	330	33	<1.8	<1.8	1700	110	35000	1700	7900	460	6.8	<1.8	11000	11000	1700	330	heavy rain
36	04/05/1993	1100	**49**	9	1.8	170	<1.8	2800	**1700**	2200	**330**	1100	**110**	280	**70**	4.0	<1.8	no rain
	Avg Bold		**82**						**3067**		**409**		**532**		**1710**			
	Avg lines 22-26		64						2029		351		416		1822			

Conclusions

The streamflow data suggest that a strong hydraulic connection exists between Boonsboro Branch and Keedysville Spring, while the dye recovery and bacteria data would suggest that there is a poor connection. The data from the tracer tests may, however, have been affected by dye losses, probably due to absorption by sediments in the streambed sediments and the ground water conduit system. These sediments may, also, provide natural filtration for removing a significant portion of the microbiological contaminants.

It is suggested that additional dye trace studies and streamflow measurements, and possibly bacteriological monitoring, be conducted. This may help to better define surface and ground water interactions and identify sources of microbiological contamination in the Wellhead Protection Areas.

SUSCEPTIBILITY ANALYSIS

The wells and springs supplying the Boonsboro/Keedysville Regional Water System draw water from unconfined, carbonate, fractured-rock aquifers. Wells and springs 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 and spring integrity, and 4) the aquifer conditions. Table 11 summarizes the susceptibility of the Boonsboro/Keedysville water supply to each of the groups of contaminants.

Due to the nature of the karst aquifer and the rapid movement of water through the aquifer coupled with the presence of potential contaminant sources within the WHPA, the water supply is considered vulnerable to all contaminants, since some levels of all major contaminants groups have been detected. At present, Boonsboro/Keedysville water supply is only considered to be susceptible to microbiological contaminants (except the Graystone Well 8) and nitrates.

Inorganic Compounds

All results were less than 50% the MCL for all inorganic compound levels, except nitrate. Sources of nitrate can generally be traced back to land use. Fertilization of agricultural fields and residential lawns, residential septic systems, and areas with high concentrations of livestock are common sources of nitrate loading in ground water. The levels of nitrate in the water supply indicate that it **is** presently susceptible to nitrates. Due to the vulnerability of the aquifer to land activity, and the presence of nitrate sources in the WHPAs, the nitrate levels should be monitored closely to ensure that they do not rise. The water supply is **not** presently susceptible to other inorganic compounds, based on the available water quality and contaminant source data.

Radionuclides

The source of radionuclides in ground water is the natural occurrence of uranium in rocks. The water supply is **not** susceptible to radionuclides; however, the results from all of the Boonsboro/Keedysville Water Plants (360-650 pCi/L), except Plant 04 which has not been sampled, have exceeded the lower MCL of 300 pCi/L, proposed by the EPA.

Volatile Organic Compounds

One VOC sample produced a result (1,1, Dichloroethylene) greater than 50% of an MCL. The sample was taken in Plant 01 and none of the follow-on samples produced results greater than 50% of the MCL. Both of the USTs sites in the WHPAs that were used to store gasoline are no longer active. Given the long history of monitoring data without significant levels of VOC contamination, and the reduction in risk due to removal of these USTs, the water supply was determined to **not** be presently susceptible to contamination by VOC's. While there continues to be potential contaminant sources in the WHPAs, these are not the type that are likely to create significant levels of contamination.

Synthetic Organic Compounds

One SOC were detected, one of which was above 50% of a MCL. That one was di(2-ethylhexyl)phthalate, for which one sample (3.4 ppb) was above 50% of the MCL This contaminant is commonly found in laboratory blank samples. The method for analyzing this contaminant was started in 1995 and had produced many false positive results, and is therefore not believed to represent the actual water quality of the system.

The water supply was determined to **not** be susceptible to synthetic organic compounds. Potential sources of SOCs in the WHPA may be pesticide or herbicide use in agricultural and residential areas. None of these SOCs were detected in the fourteen samples analyzed to date.

Microbiological Contaminants

The presence of fecal coliform bacteria in the Warrenfeltz and Keedysville Springs and the Crestview Well 9 indicates the susceptibility of these sources to pathogenic microorganisms. Pathogenic protozoa, viruses, and bacteria normally associated with surface water can contaminate the wells through these connections. Sources of these pathogens are generally improperly treated wastewater, waste material from mammals, and urban runoff in developed areas. Pastureland and discharges from septic systems are the most likely sources of fecal contamination in the WHPAs. If the Crestview Well 9 were to be used by the Town, a filtration system should have been installed by January 18, 1999 to treat for the microbiological contaminants. Information contained in the Water Appropriation Permit file indicates that the Shafer Park well was intended as a replacement for the Crestview Well. Since it is well past the 18-month EPA compliance period and no plans to install treatment on the Crestview Well 9 have been received, the well should be abandoned and sealed.

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?[1]
Nitrate	YES	YES	NO	YES	YES
Inorganic Compounds (except nitrate)	NO	NO	NO	YES	NO
Radiological Compounds	NO	NO(2)	NO	NO	NO
Volatile Organic Compounds	YES	NO(3)	NO	YES	NO
Synthetic Organic Compounds	YES	NO	NO	YES	NO
Microbiological Contaminants	YES	YES	NO	YES	YES

Table 11. Susceptibility Analysis Summary.

1. At present time.
2. Radon-222 detected in all plants above 300 Ci/L, except Plant 04, which has not been sampled.
3. One sample in 1992 exceeded 50% of an MCL, but follow-on samples did not.

MANAGEMENT OF THE WHPA

This report is intended to help build on the foundation of earlier wellhead protection plans. The Department is aware that Boonsboro has seriously considered the merits of adopting a wellhead protection ordinance in the past. Now that a protection area for all sources has been mapped (Figure 1), the efforts should be renewed with this new information. Some ideas for continuing to reduce the risk of contamination to the water sources are highlighted below:

Form a Local Planning Team

- The Boonsboro/Keedysville Regional Water Board should take a leadership role in reactivating wellhead protection efforts. County Planning should be requested to participate along with other local interests.
- MDE has grant money available for Wellhead Protection projects, such as developing and implementing wellhead protection ordinances, conducting more detailed inspections of potential contaminant sources, digitizing layers that would be useful for wellhead protection (such as geology), and developing public information education campaigns and additional protection strategies. An application can be obtained from 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 Boonsboro/Keedysville Regional Water System or MDE.
- Conduct educational outreach to the facilities and residents of the community focusing on activities that may present potential contaminant sources. Important topics include: (a) compliance with MDE and federal guidelines for gasoline and heating oil UST's, (b) monitoring well installation and maintenance of UST's, (c) appropriate use and application of fertilizers and pesticides, and (d) 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.

Local Ordinance

- The local planning team should work to develop an Ordinance for Wellhead Protection that encompasses both municipalities and Washington County.

Monitoring

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

Crestview Well 9/Test Wells

- Boonsboro should properly abandon and seal Crestview Well 9, as no plans have been presented by the Town to construct the necessary treatment to this well to make it a safe source of water. Also, if not already complete, test wells WA-81-2329 and WA-81-2332 should be properly abandoned and sealed.

Land Acquisition/Easements

- The Town and State parks provide protection to the Town's water sources. Boonsboro's purchase of the former Warrenfeltz property made a substantial reduction in the risk of contamination of that source. Additional properties may be considered for the program. 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

- The Boonsboro/Keedysville water system 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 local planning team may wish to 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 (and springs) will ensure their integrity and protect the aquifer from contamination.

Changes in Use

- The Boonsboro/Keedysville water system is required to notify MDE prior to constructing any new wells that are used for water supply. 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

MDE, Public Drinking Water Program, December 1994, A Wellhead Protection Plan for the Town of Boonsboro, 12 p.

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

Otten, E. and Hilleary, J., 1985, Maryland Springs – Their Physical, Thermal, and Chemical Characteristics, Report of Investigations No. 42, Maryland Geological Survey, 151 p.

Parks, R., 1997, Water Treatment Plant, letter dated July 18, 1997, ACER, 1 p.

Parrish, Jr., W, 1990, WSP #21-0002, Boonsboro, Washington County, letter dated April 26, 1990, Maryland Department of the Environment, Water Supply Program, 2 p.

Parrish, Jr., W, 1993, letter dated July 2, 1993, Maryland Department of the Environment, Water Supply Program, 4 p., 8 tables, & 1 attachment.

Parrish, Jr., W, 1994, letter dated June 30, 1994, Maryland Department of the Environment, Water Supply Program, 3 p., 1 table, & 2 attachments.

Steinfort, et.al., 1993, Findings of an Investigation of Surface Water Influence on Warrensfeltz and Keedysville Springs, Addressing Bacteriological Monitoring, Streamflow Discharges, and Various Fluorometric Protocals, Technical Report 93-002, Maryland Department of the Environment, Water Quality Monitoring Program, 18 p.

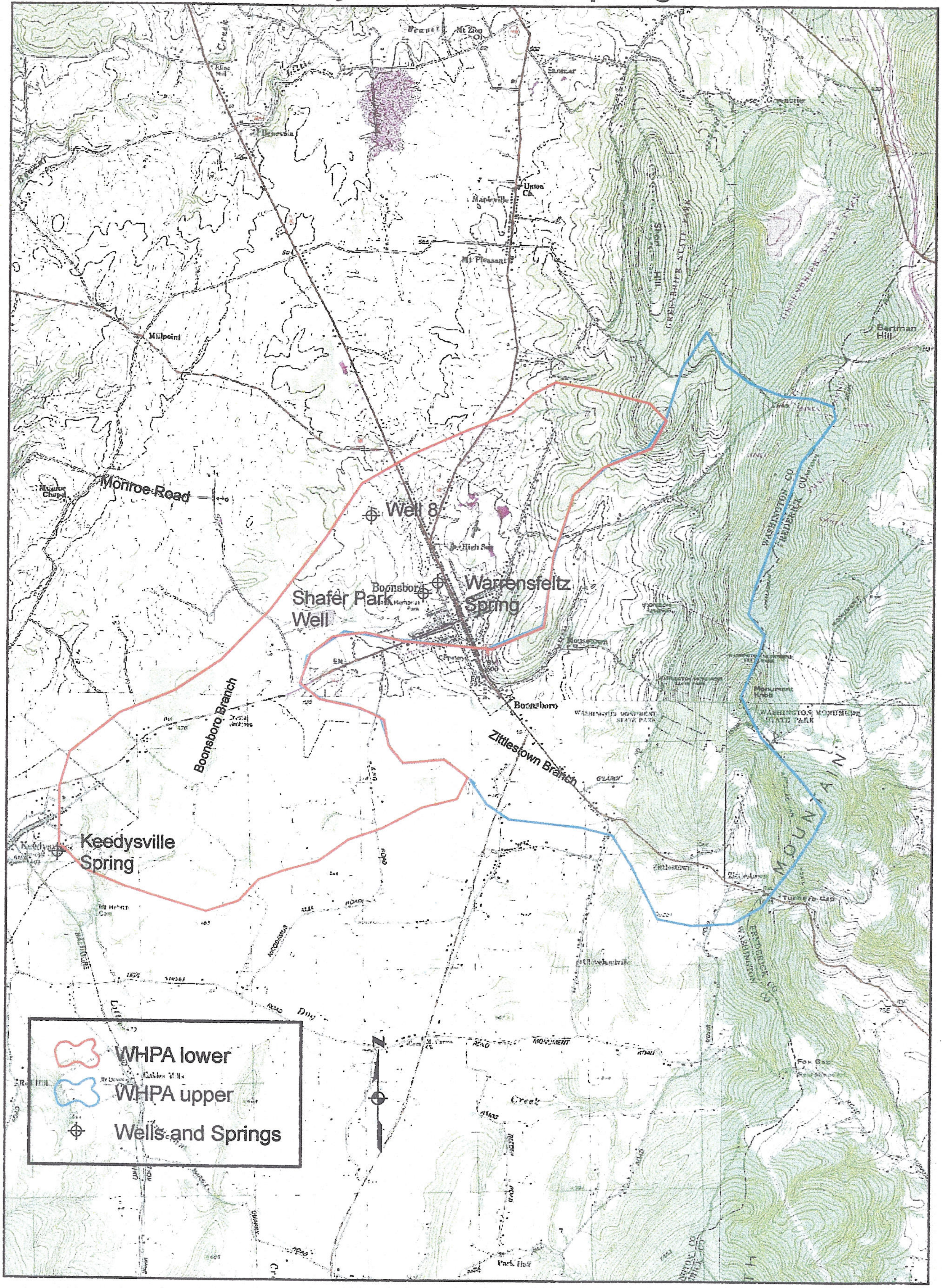
U.S. Environmental Protection Agency, 1991, Delineation of Wellhead Protection Areas in Fractured Rocks: Office of Ground Water and Drinking Water, EPA/570/9-91-009, 144 pp.

OTHER SOURCES OF DATA

Water Appropriation and Use Permit Nos. WA1979G012-13/WA1988G006/ WA1989G022
Public Water Supply Inspection Reports
MDE Water Supply Program Oracle® Database
MDE Waste Management Sites Database
USGS Topographic 7.5 Minute Emmitsburg Quadrangle
Maryland Office of Planning 2002 Frederick County Digital Land Use Map
Maryland Office of Planning 2002 Frederick County Digital Sewer Map

FIGURES

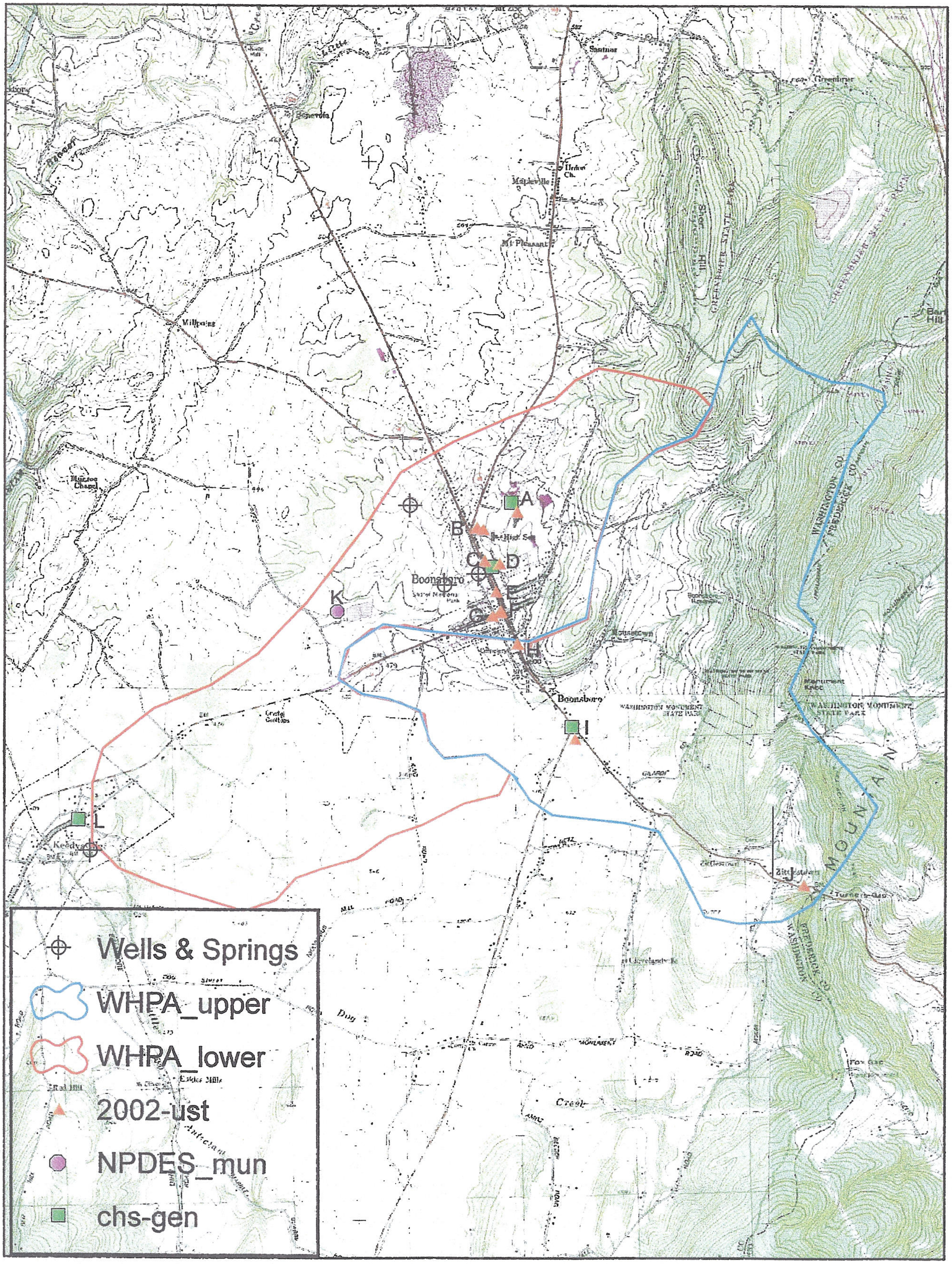
Boonsboro/Keedysville Wells, Springs & WHPAs



0 2,000 4,000 Feet

Figure 1

Map of Potential Point Sources of Contaminants



0 2,000 4,000 Feet

Figure 2

Boonsboro/Keedysville Land Use/WHPA Map

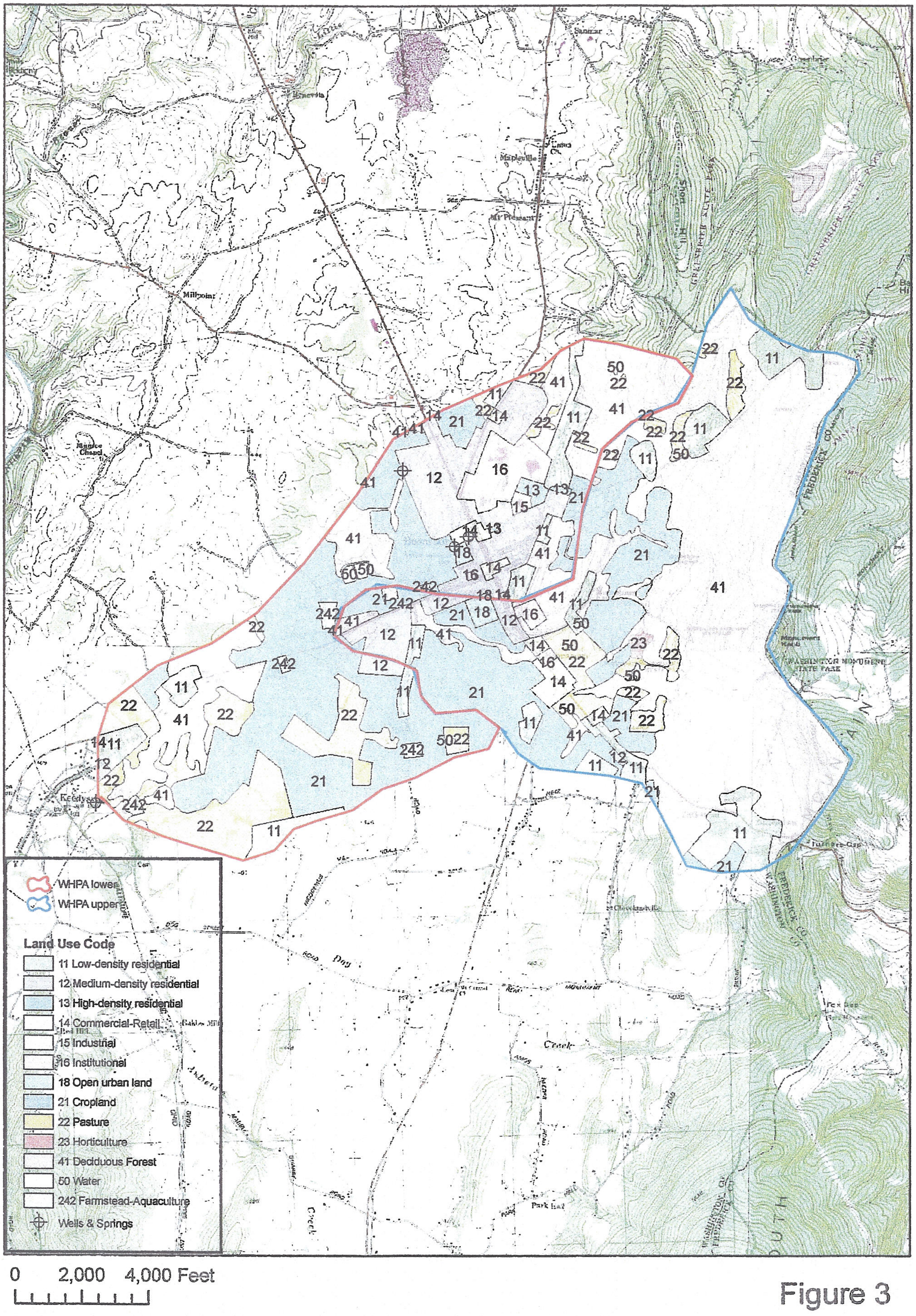


Figure 3

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Boonsboro/Keedysville Sewer Service/WHPA Map

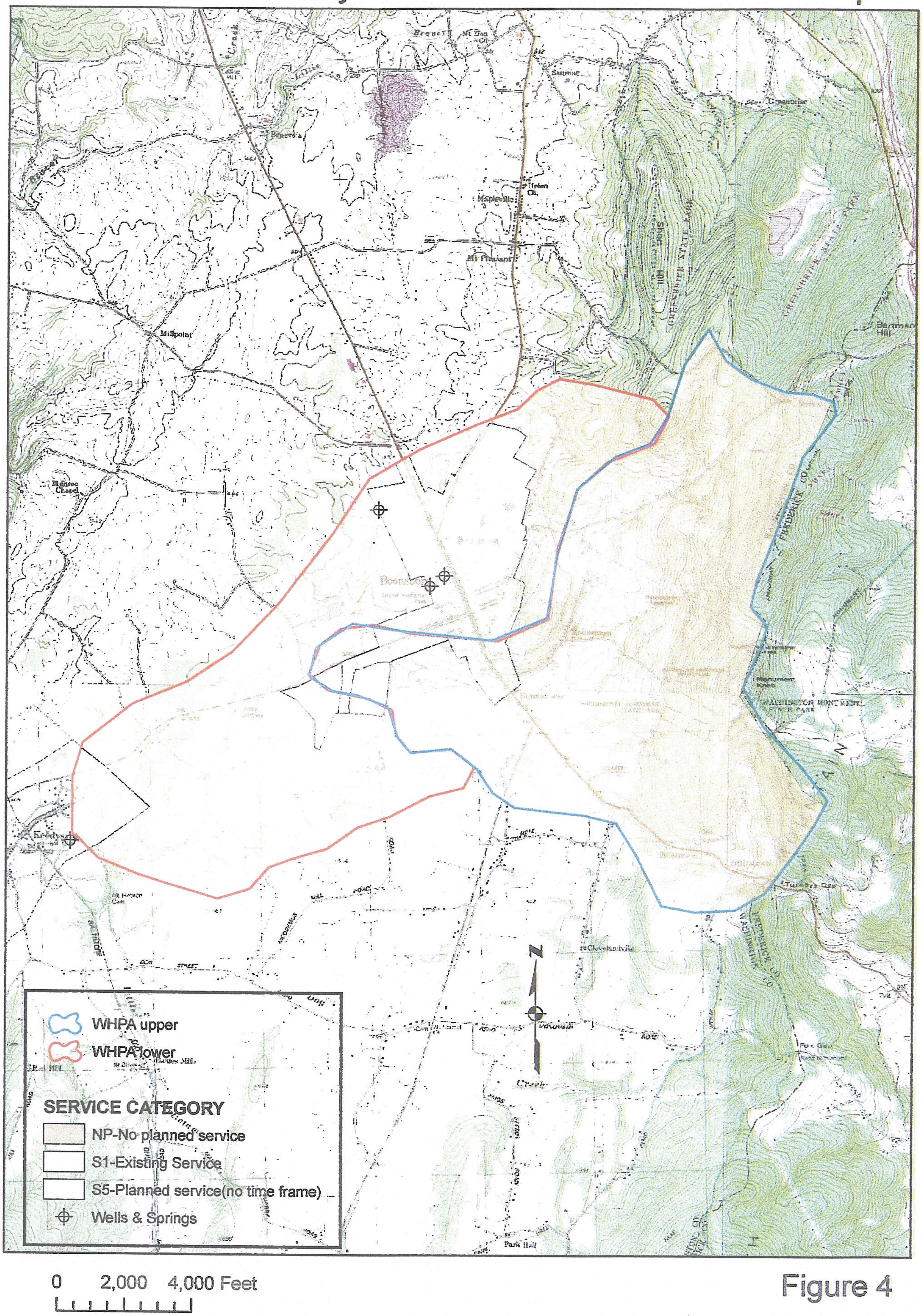

Figure 4