GROUNDWATER APPROPRIATION PERMIT APPLICATION

HYDROGEOLOGIC REPORT

Prepared for

BLACK & DECKER (U.S.), INC.
Hampstead, Maryland

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SECTION 1

INTRODUCTION

1.0 PURPOSE AND OBJECTIVES

The purpose of this report is to provide the information necessary to obtain a Groundwater Appropriation Permit for the Black & Decker (U.S.), Inc. (B&D) facility located in Hampstead, Maryland. The proposed groundwater withdrawal is a part of a groundwater remedial plan which involves the development of a pump and treat system designed to restrict potential off-site contaminant migration and to recover and treat contaminated groundwater from the B&D property. The design of the pump and treat system is the result of an extensive site investigation conducted by Roy F. Weston, Inc. (WESTON®).

1.1 SITE DESCRIPTION

The B&D facility is located in Hampstead, Maryland, in northeastern Carroll County, approximately 35 miles north of Baltimore (Figure 1-1). The plant is situated on 185 acres of property in a predominantly rural setting. Two separate parcels of farmland are situated on 138 and 173 acres of property to the north and west of the site, respectively. The population center of Hampstead is approximately 0.8 mile north of the plant along Hanover Road, State Route 30.

Currently, water supply for the plant is obtained from five water supply wells which line the northwest boundary of the site. Well yields of the existing supply wells range from 20 to 45 gpm. After the Groundwater Appropriation Permit is granted to B&D, the existing supply wells will be abandoned and treated water from the recovery wells will be used to supply the plant's water.

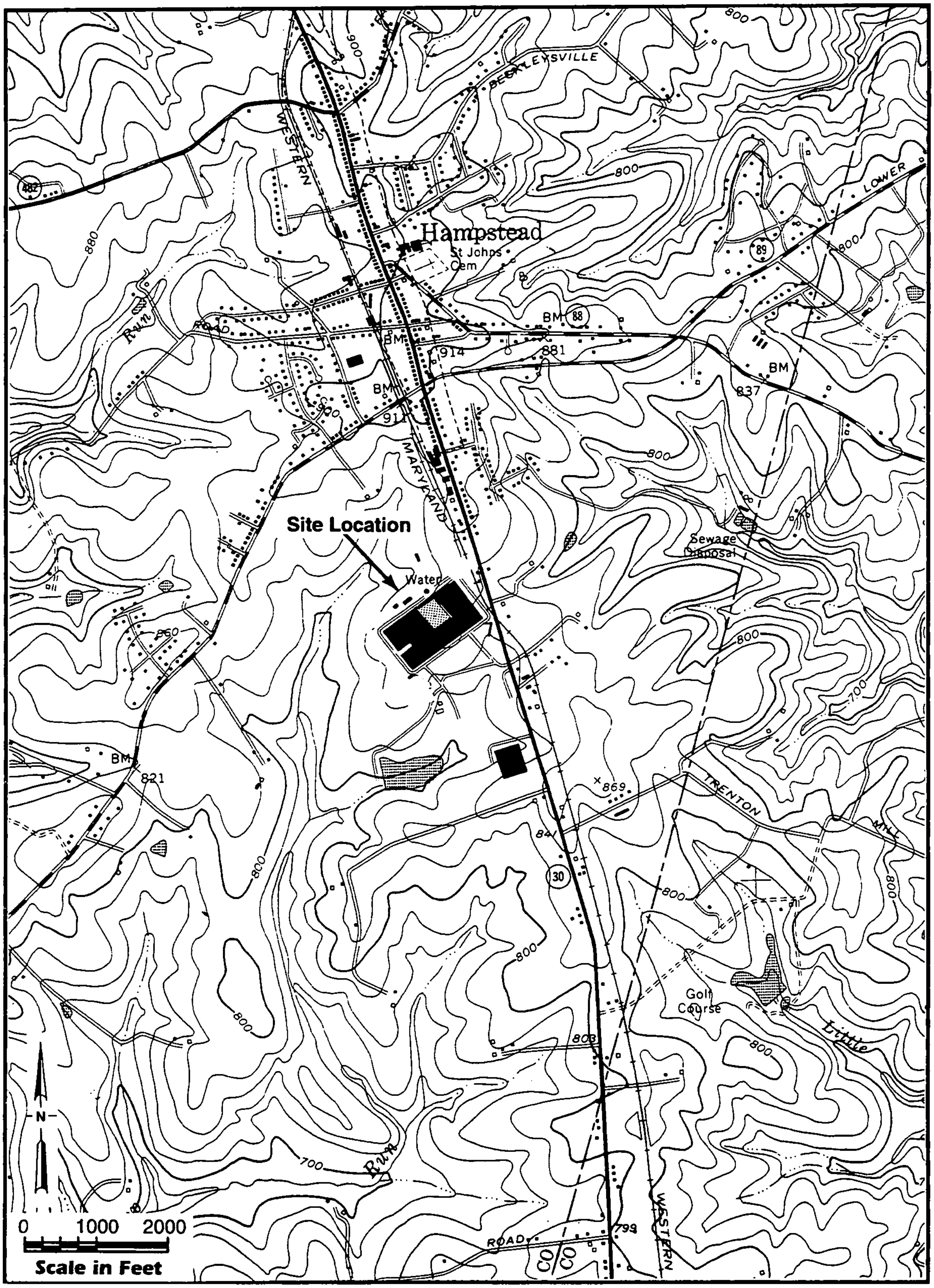

FIGURE 1-1 SITE LOCATION MAP, BLACK & DECKER, HAMPSTEAD, MD

1.2 SITE HISTORY

An environmental site investigation was initiated in 1987 at the request of B&D for its Hampstead facility. The investigation was completed by WESTON in several phases which culminated in the submission of an Environmental Investigation Report (April 1989) to the Maryland Department of the Environment (MDE) Groundwater Investigation Division. The site investigation included an examination of the groundwater quality, hydrogeology, and potential source areas and indicated the following:

- A PCE plume is present primarily on the western half of the facility, while TCE is present in groundwater primarily in the northeastern part of the facility.
- Groundwater is migrating predominantly along the hydraulic gradient both in the saprolite and bedrock to the south-southwest.
- A minor component of groundwater flow on the northeastern corner of the facility may be directed east toward State Route 30.
- Soils located in the area of a former underground storage tank farm contain PCE, TCE and petroleum hydrocarbons.
- Other potential source areas investigated were found not to be contributing significant contaminants to the environment.

Based on these conclusions, remediation strategies to recover and treat the contaminated groundwater were proposed in the 1989 Environmental Investigation Report. A work plan for soil and groundwater remediation was developed and submitted to MDE in December, 1989 (WESTON 1989). Results of the field activities completed as part of the work plan are discussed in this report. A description of the field activities is presented in Section 2. Results of the field activities and a description of the site geology and hydrogeology are presented in Section 3. Conclusions of the investigation are presented in Section 4.

SECTION 2

REMEDIAL FIELD INVESTIGATION

The field investigation for the remedial design of the groundwater recovery and treatment system at the B&D facility involved geophysics, well installation, aquifer testing and groundwater sampling. Each of these activities is described in the following sections.

2.1 WELL INSTALLATION

Seven new recovery wells, capable of yielding significant quantities of water (>20 gpm), were installed to create a cone of depression on the east and west sides of the B&D facility to control the groundwater plume. Prior to installation of the new wells, a geophysical investigation was conducted to locate areas which had the greatest potential for intercepting water-bearing fractures. Two different instruments (Geonics EM-31 and ABE Wadi VLF System) were used to measure the electromagnetic conductance of the subsurface. The areas which have higher electrical conductance properties typically indicate fracture locations.

A series of pilot holes were drilled at locations which were chosen based on the results of the geophysical investigation. While fractures were intercepted at most of the pilot holes, many were filled with clay and did not produce significant water. Additional pilot holes were drilled as a result of a field reconnaissance of the site and were positioned in locations where recovery wells were suspected to be needed.

At each potential recovery well location, an 8-inch "pilot hole" was drilled a minimum of 25 feet into competent bedrock using the air rotary drilling method (previous drilling has indicated that no significant water-bearing zones are encountered further than 25 feet into competent bedrock). All cuttings generated during drilling were containerized on site pending proper disposal. Once the total depth was reached, the borehole was developed and the yield was estimated. If the total yield was less than 40 gpm, and the pilot hole was in a location that could be used as an observation point, a 2-inch diameter well was installed to aid in the characterization of aquifer properties during pumping tests. In areas where there was an adequate number of observation wells, boreholes were abandoned by tremie piping a cement/bentonite grout from the bottom of the borehole to ground surface.

In cases where the total yield of the borehole exceeded 40 gpm, the 8-inch borehole was widened to a diameter of 12 inches and completed to a depth of approximately five feet below the deepest observed water producing zone. The borehole was developed until the discharge water cleared. Once all drilling rods were removed, a 6-inch diameter PVC well was constructed. A sand filter pack was emplaced in the annular space between the screen and the borehole to a minimum of five feet above the top of the screen. An approximate five foot bentonite seal was placed on top of the sand and the remaining annular space was pressure-grouted (using tremie methods) to ground surface with a cement/bentonite grout.

Each of the newly installed recovery wells and piezometers are shown on Figure 2-1. Existing wells which will be converted to recovery wells are also shown in Figure 2-1. A new well identification number (EW-#) has been assigned to each of the wells which will be converted to an extraction well. These new identification numbers are provided for future reference. Lithologic descriptions of each new recovery well and piezometer are included in Appendix A. Well and piezometer completion forms are included in Appendix B.

2.2 AQUIFER TESTING

A series of well performance and aquifer tests were conducted as part of the field work to collect data required for the design of the groundwater recovery system. An 8 hour step-drawdown test was conducted at each potential recovery well to evaluate well performance and to estimate the maximum sustainable well yield. Three long-term

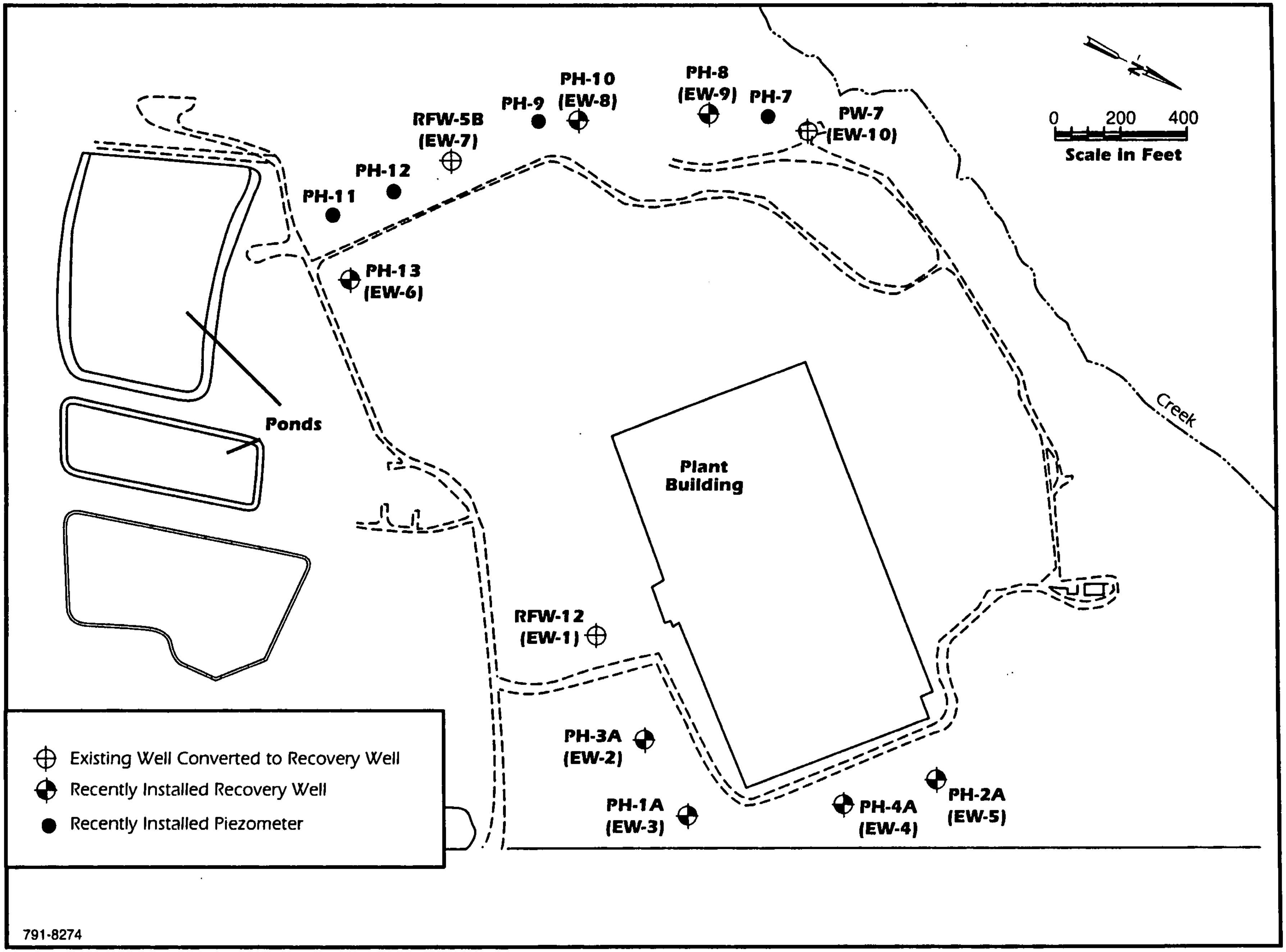

FIGURE 2-1 LOCATION OF RECOVERY WELLS

(duration of 24 hours or longer) aquifer tests were conducted to characterize aquifer properties at the site. Table 2-1 summarizes the specifications of each of the aquifer tests conducted at the site. The results of the pumping tests were used to develop an analytical flow model to determine the number and spacing of wells needed to create a hydraulic barrier (see Section 3).

A decontaminated submersible pump was used to discharge the groundwater during the pumping test at each well. The discharge water was routed through a 2-inch line to the air stripper on the B&D property. The discharge rate was regulated with a flow valve and monitored with an in-line flowmeter. An outlet port, located at the wellhead, was used for collecting samples from the discharge line. Water levels and elapsed time data were collected using a data logger (In-Situ Model SE2000) and transducers and Stevens recorders. Transducers were used in the pumping well and those wells located closest to the pumping well. In addition, water level measurements were collected manually at wells more distant to the pumping that, based on knowledge of the site and site area, could potentially have been affected during the pumping tests.

2.3 GROUNDWATER SAMPLING

Time series groundwater samples were collected from selected recovery wells during five of the seven pumping tests. The time series samples were collected periodically during each pumping test to characterize potential trends in VOC concentrations as pumping continued. The results of the time series sampling were used to evaluate the efficiency of the wells in recovering contaminated groundwater and as input to the design of the treatment system.

In addition, groundwater samples were collected during the week of 17 February 1992 as part of the quarterly groundwater sampling program initiated at the B&D facility based on agreement with the MDE Groundwater Investigation Division. Groundwater samples were collected at seven of the ten recovery wells and were analyzed for VOCs. Additional

TABLE 2-1

PUMPING TEST SPECIFICATIONS
BLACK & DECKER
HAMPSTEAD, MARYLAND

Pumping Well	Duration of Test (hrs)	Purpose of Test
PH-8	4	Well Performance
PH-8	70	Aquifer Characterization
PH-1A	4	Well Performance
PH-1A	30	Aquifer Characterization
RFW-12	8	Well Performance
PH-2A	24	Well Performance/ Aquifer Characterization
PH-13	8	Well Performance
PH-10	8	Well Performance
RFW-5B	8	Well Performance

inorganic parameters (alkalinity, chloride, hardness, sulfate, total dissolved solids, and total suspended solids) were analyzed at six of the eight wells included in the quarterly sampling program. The purpose of collecting the groundwater samples was not only to characterize general groundwater quality, but also to quantify the levels of contamination present to aid in the design of the groundwater treatment system. The additional parameters were analyzed to evaluate whether pretreatment would be required prior to air-stripping to prevent scaling, bio-fouling, etc. During both sampling events, standard QA/QC procedures were followed as detailed in the September 1987 work plan (WESTON, 1987). A summary of the analytical program for the pumping test samples and the quarterly sampling program is presented in Table 2-2.

TABLE 2-2

Summary of Groundwater Analytical Program

Black and Decker, Inc., Hampstead, MD

Analysis for Quarterly Sampling Program	Location						
	PH-1A	PH-2A	PH-8	PH-10	PH-13	RFW-5B	RFW-12
VOC	X	X	X	X	X	X	X
Iron	X	X	X			X	X
Manganese	X	X	X			X	X
Sodium	X	X	X			X	X
Alkalinity	X	X	X			X	X
Chloride	X	X	X			X	X
Hardness	X	X	X			X	X
pH	X	X	X			X	X
Sulfate	X	X	X			X	X
Specific Conductance	X	X	X			X	X
Total Suspended Solids	X	X	X			X	X
Total Dissolved Solids	X	X	X			X	X
Number of Samples Collected During Pumping Test*	**2**	**3**	**4**	**0**	**2**	**0**	**3**

* - Each sample collected during the pumping test was analyzed for VOCs.

B&D-IVHAMP2-2.TBL

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SECTION 3

RESULTS OF INVESTIGATION

3.1 GEOLOGY

As in most of eastern Carroll County, an indeterminate thickness of the albite-chlorite schist facies of the Wissahickon Formation underlies the B&D property. This facies consists principally of tightly folded albite schist or phyllite interbedded with layers of chlorite and or muscovite schist. Cream to yellow, vitreous, micaceous quartzite veins are locally present along the planes of foliation.

Thin quartz veins (< 5 feet thick) are interbedded with the phyllite near the base of the formation. As is common in the Piedmont, the Wissahickon Formation underlying the site has been highly deformed and fractured. Zones of intense fracturing may have surface expression as valleys or draws, or as other linear topographic features. Meyer (1958) reports that the strike of schistosity in the plant area ranges from N36°E to N46°E.

Chemical weathering has produced a 25- to 80-foot thickness of weathered schist, referenced to as saprolite, overlying the crystalline bedrock on-site. The saprolite grades from a micaceous, clayey reddish-brown silt at shallow depths to a medium soft, grayish-brown, slightly weathered schist/phyllite near the interface with competent bedrock. Residual quartz veins are encountered throughout the overburden.

3.2 HYDROGEOLOGY

In the Hampstead area, groundwater occurs predominately in fractures, joints and shear zones within the Wissahickon Formation, and in the pore spaces of the overlying saprolite. Recharge to the bedrock is principally from the downward percolation of water stored in the saprolite (Meyer, 1958). In the site area, these two lithologic units are hydrologically strongly inter-connected and act essentially as a single aquifer system.

The yields of wells drilled in the area range from less than one gpm to a reported 300 gpm, and average about 16 gpm (Meyer, 1958). These variable yields are considered a result of the relatively limited storage capacity of the bedrock, and as a result of the highly transmissive capabilities of the fracture zones within the bedrock, as compared to the competent bedrock itself. With increasing depth, fracture spacing and intensity is consistently strongly reduced due principally to pressure from overlying rocks. In the Piedmont, fractures which will yield water are generally extremely rare below 300 feet; thus, most water supply wells are less than 200 feet deep (Richardson, 1980).

3.2.1 Site Hydrogeology

Information pertaining to site hydrogeology has been gathered during the extensive drilling program conducted by WESTON and by the series of well performance and aquifer tests completed at the site. The site hydrogeology is consistent with that described above, with the exception that the largest quantities of water appear to be associated with those wells that intersect fractures filled with quartz veins. This was evident during the installation of the pilot holes, particularly at PH-1A, where the highest yield was obtained after a large quartz vein was intersected.

During the recent drilling program, no quartz veins or significant quantities of water were encountered more than 25 feet into competent rock at any location. Below this zone, drilling indicated that very few fractures existed, and for those fractures which did exist, little or no water was associated with them.

All wells onsite were surveyed to establish an exact location and elevation. Depth to water measurements were taken at each well and are listed in Table 3-1. Using this data, a groundwater contour map was constructed (see Figure 3-1). At the time the data was

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Table 3-1
Groundwater Elevation Measurement
Black & Decker
Hampstead, Maryland

Well	Top of Casing Elevation	Depth to Water (ft) 9 Dec 91	Groundwater Elevation 9 Dec 91
RFW-1A	864.37	38.65	825.72
RFW-1B	864.23	38.64	825.59
RFW-2A	857.41	19.35	838.06
RFW-2B	857.73	19.91	837.82
RFW-3B	839.21	31.40	807.81
RFW-4A	830.37	37.38	792.99
RFW-4B	830.37	37.41	792.96
RFW-5A	817.50	22.01	795.49
RFW-5B	818.14	22.85	795.29
RFW-6	785.04	2.10	782.94
RFW-7	805.14	7.73	797.41
RFW-8	860.07	37.02	823.05
RFW-9	858.21	30.01	828.20
RFW-10	852.06	30.62	821.44
RFW-11A	849.32	32.23	817.09
RFW-11B	849.62	32.83	816.79
RFW-12A	844.58	26.75	817.83
RFW-12B	844.87	27.38	817.49
RFW-13	849.11	56.24	792.87
RFW-14	812.39	25.60	786.79
RFW-16	856.14	29.90	826.24
PH-7	805.94	18.06	787.88
PH-8	810.97	16.76	794.21
PH-9	814.94	18.94	796.00
PH-10	810.89	9.30	801.59
PH-11	820.68	35.52	785.16
PH-12	828.35	38.10	790.25
PH-13	832.13	46.35	785.78
P-8	812.07	10.39	801.68
S-1	813.71	11.92	801.79
W-1	813.72	11.77	801.95
S-3	822.12	16.88	805.24
B-1	815.55	20.19	795.36
B-2	807.68	5.01	802.67
B-3	803.02	10.62	792.40
PH-1A	846.64	29.31	817.33
PH-2A	863.36	41.50	821.86

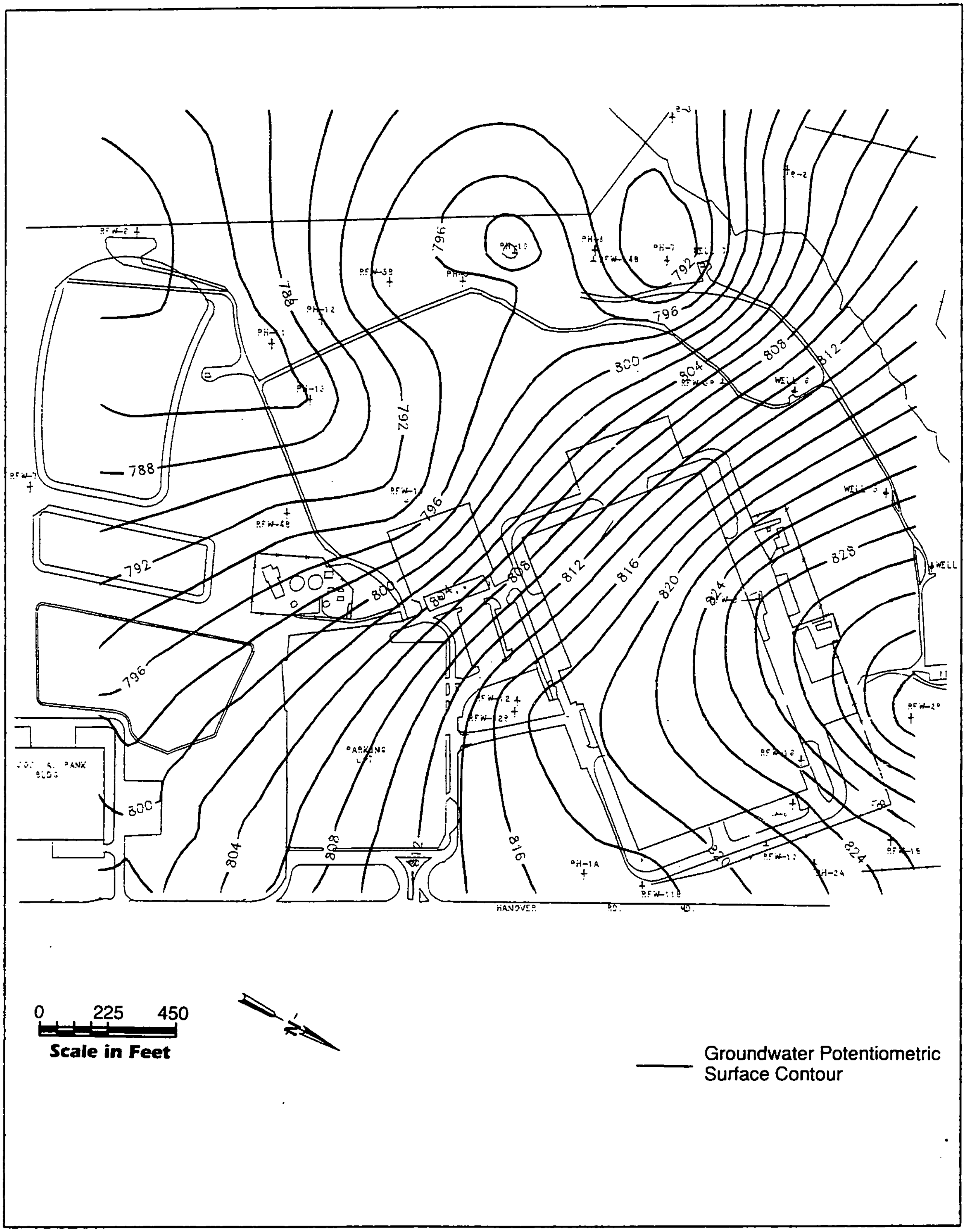

FIGURE 3-1 GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR MAP, DECEMBER 1992

collected, water supply well No. 7 had been pumping at a rate of approximately 40 gpm. As evidenced by the groundwater potentiometric surface contour map, groundwater flow at the site is principally to the southwest, but also to the south and east. A small depression, due to pumping well No. 7, is evident from the potentiometric surface map.

3.2.2 Pumping Test Results

The results from the pumping tests conducted on site are summarized in Table 3-2. Semi-log graphs of time versus drawdown were constructed for each piezometer where drawdown was observed and are presented in Appendix C. Aquifer properties were characterized using both drawdown and recovery data. Analysis of the data was completed using Jacob's method and the Theis recovery method (Driscoll, 1986). A literature search revealed that a pumping test was conducted at the B&D facility in 1958 and the results presented in Meyer and Beall (1958). The results of this aquifer test are also summarized in Table 3-2.

The individual pumping tests indicated that the maximum sustainable yield varied from 35 gpm (RFW-12) to 84 gpm (PH-1A and PH-2A). The maximum sustainable yields were calculated using data collected during step-drawdown tests conducted at each well and reflect the maximum pumping rate which could be consistently relied upon given the following assumptions: 1) annual precipitation is normal; and 2) no other pumping wells exist nearby which would interfere with the ability of the well to produce water. Given the number of recovery wells which will be located at the B&D facility (see Subsection 3.2.3), it is unlikely that a well will be able to produce the maximum sustainable yield. Actual maximum sustainable yields will likely be much lower when each of the recovery wells is operational.

Calculated values for transmissivity ranged from 160 gallons per day per foot (gpd/ft) to 100,000 gpd/ft. The majority of the values were between 4,000 and 8,000 gpd/ft. This range of values is common for fractured bedrock aquifers. Table 3-2 also lists values for

Table 3-2
Pumping Test Summary
Black & Decker

Pumping Well	Observation Well	Duration of Pumping Test (hours)	Distance to Observation Well (ft)	Maximum Observed Drawdown (ft)	Transmissivity (gpd/ft)	Specific Yield	Method of Analysis	Estimated Maximum Sustainable Yield of Pumping Well (gpm)
PH-8	B-1	70	73.5	27	160	0.04	Boulton	33
	PH-10	70	280	0.5	14,300	0.03	Jacob	
					*	*	Theis Recovery	
PH-2A	RFW-10	24	145	3.2	4,950	0.01	Jacob	75
	RFW-8	24	220	1.4	8,080	0.01	Jacob	
	RFW-1B	24	272	0.1	***	***	***	
					930	--	Theis Recovery	
Well #3	(Meyer & Beal 1958)**	107	--	--	5,000	0.02	Jacob	
PH-1A	RFW-11B	30	224	5.8	5,100	0.001	Jacob	90
					6,720	--	Theis Recovery	
RFW-5B	PH-9	8	315	0.4	***	***	***	70
	RFW-5A	8	8	1.75	11,800	0.25	Jacob	
					4,750	--	Theis Recovery	
PH-13	PH-11	8	228	1.6	7,600	0.002	Jacob	45
					1,570	--	Theis Recovery	
RFW-12	--	8	--	--	3,000	--	Theis Recovery	35
PH-10	PH-9	8	97	0.15	*	*	Jacob	80
	PH-8	8	280	0.2	*	*	Jacob	
					*	*	Theis Recovery	

* Unable to accurately estimate due to heavy precipitation.

** Meyer, G., & Beall, R.M., 1958, The Water Resources of Carrol and Frederick Counties, Maryland Board of Natural Resources, Dept. of Geology, Mines and Water Resources, Bulletin 22, 355p.

*** Insufficient drawdown to reliably estimate aquifer properties.

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specific yield. Once again, the variability of these values is common to fractured bedrock aquifers. A value of 0.02 is considered the best estimate for specific yield, and is characteristic of unconfined aquifers (Fetter, 1988). During the pumping tests at wells PH-1A and PH-2A water levels in off-site Well #22 (owned by the Village of Hampstead) were monitored. No drawdown was observed in Well #22 during either pumping test.

Potential anisotropy in the bedrock was evaluated using the aquifer test data reported by Meyer and Beall (1958). This aquifer test was conducted on B&D supply well No. 3 for a duration of 107 hours. Nine piezometers were installed and were used to monitor aquifer response throughout the aquifer test. The data from Meyer and Beall's test was evaluated for anisotropy by WESTON using two methods. The first evaluation of anisotropy utilized the Hantush method (Kruseman and DeRidder, 1990) which estimates the directions of the major and minor axes of anisotropy and also calculates the anisotropy ratio. The second method involved plotting the observed drawdown from each piezometer after 1,000 minutes of pumping on a map. A line connecting points of equal drawdown was drawn, and the resulting shape of the cone of depression was used to characterize aquifer anisotropy. The results of the Hantush method indicate the major anisotropy axis is oriented N84°E and the anisotropy ratio is 1.9. The anisotropy ratio indicates that the hydraulic conductivity in the direction of the major axis is nearly two times greater as compared to the direction of the minor axis, which is located 90° from the major axis. The results of the graphical method indicate the major anisotropy axis is orientated N22°E and the anisotropy ratio is 1.2. The significance of these findings is that, in the bedrock, the anisotropy ratio can be expected to vary from 1.0 (isotropic conditions) to 2.0 and is dependent upon the degree of inter-connectivity of the local fracture network and fracture spacing. The direction of the major anisotropy axis likely varies with local fracture orientation, but can be assumed to be coincident with regional lineaments which are oriented approximately N25°E (WESTON, 1989).