DESIGN, DEVELOPMENT, AND IMPLEMENTATION OF A GROUND-WATER QUALITY MONITORING NETWORK FOR SOUTHERN NEW CASTLE COUNTY, DELAWARE

PHASE III - IMPLEMENTATION
RESULTS OF PHASE III
FIRST QUARTER OF SAMPLING

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INTRODUCTION

New Castle County will continue to experience increased development of its water resources, especially ground water, for public, domestic, agricultural, and industrial use. At this time, aquifers provide more than 25 million gallons of water each day for all uses. All of the potable water used in southern New Castle County (6.8 MGD) comes from aquifers (Metcalf and Eddy, 1991). Surface water from four major streams is used for water supply in northern New Castle County. Between 60 and 70 percent of water in streams throughout New Castle County is attributable to ground water that has been naturally discharged from seeps and springs. The ground- and surface-water systems function as a related and interconnected hydrologic system.

A significant amount of the ground water used in New Castle County is withdrawn from regional, shallow, water-table aquifer systems. These near-surface aquifers, which naturally receive water from infiltration of precipitation, are protected by a relatively thin soil zone that acts as a filtering mechanism. Favorable hydrologic characteristics coupled with the position of the aquifer close to land surface render it particularly susceptible to contamination. As has been documented in numerous reports (Denver, 1993; Bachman and Ferrari, 1995; Duffield Associates, Inc., 1994 and Ritter, 1987), the chemical quality of water in these systems has been adversely affected by both point and non-point sources of contamination associated with a variety of land uses.

Because most of the water in deeper confined aquifer systems passes through the shallow systems, any contamination of the near surface aquifers has the potential for affecting the quality of water in confined aquifers.

The need for a well-planned and clearly-defined assessment of ground-water quality has been demonstrated to support resolution of complex issues and for making decisions to ensure compatibility between economic development and preservation of water quality for existing and future New Castle County residents and businesses.

Systematic characterization and monitoring of New Castle County's ground-water quality and levels will improve the quality of ground-water management, protection, and development. In addition, it will result in improved access to and exchange of ground-water information among state, county, federal, and local governmental agencies and other water-user groups.

Monitoring the quality of ground water is essential to developing an understanding of southern New Castle County's ground-water resources. Development of a baseline survey of existing ground-water quality is an important first step in the implementation of a monitoring network. It can be used to determine the overall status of the resource and to identify temporal and spatial changes resulting from natural as well as anthropogenic (human-induced) factors. A baseline survey will enable County, State, and local officials to more properly manage land use and ground-water development and use, and provide a baseline for long-term planning

Purpose and Scope

The primary purpose of Phase III of the investigation was to implement the ground-water quality monitoring network for southern New Castle County which was designed and developed in Phase I. As a result of the implementation process, the Delaware Geological Survey (DGS) identified monitoring locations, drilled fourteen new monitoring wells, identified specific parameters to be tested, and established a sampling schedule. This report is based on water-quality samples collected by the Delaware Geological Survey during the summer of 1996 from 45 water supply and observation wells. Summary results are presented for each aquifer system.

Location and Geologic Setting

The area of investigation includes that portion of southern New Castle County in the Atlantic Coastal Plain Physiographic Province. The area is bounded on the north by the Chesapeake and Delaware Canal. The eastern, western, and southern portions of the study area are bounded by the Delaware River, and the Delaware-Maryland and New Castle-Kent County boundaries, respectively (Figure 1). The study area covers more than 200 square miles and includes eleven watersheds. The Delaware River basin portion of the area includes Appoquinimink River, Blackbird Creek, Cedar Swamp, and the Smyrna River watersheds. The Chesapeake Bay basin includes Back Creek, Bohemia Creek, Sassafras River, and the Cypress Branch watersheds. The monitoring program incorporates a watershed-based approach to collection and presentation of data.

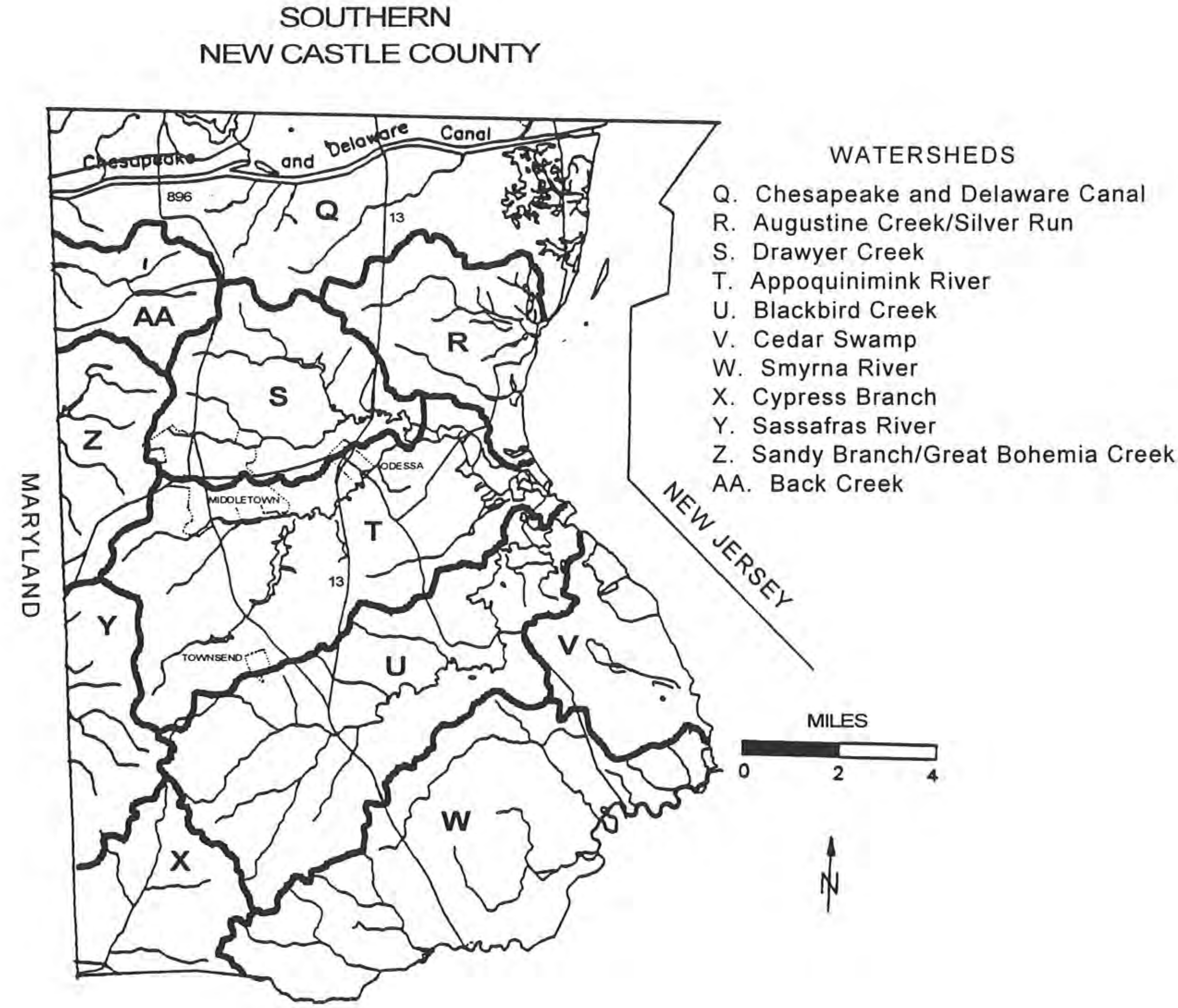

Figure 1. Location of study area.

The area is underlain by unconsolidated gravels, sands, silts, and clays that range in age from Lower Cretaceous through Holocene. Thickness of sedimentary rocks range from approximately 600 to 700 ft near the Chesapeake and Delaware Canal to approximately 2,300 ft in southeastern New Castle County. Within this area, the Columbia Formation overlies the truncated edges of older geologic units that dip in a seaward direction. Ground water is withdrawn from the water-table or unconfined aquifers (Columbia and underlying water-table portions of the Englishtown and Mt. Laurel formations and the Rancocas group) as well as from confined aquifers within several of these older units, including the Potomac, Magothy, Englishtown, Mt. Laurel, and Vincentown formations (Figure 2 and Figure 3).

Previous Work

Several investigations have been conducted pertaining to the water quality of southern New Castle County. The most recent of these reports include Bachman and Ferrari (1995), Denver (1993), and Ritter (1987). Bachman and Ferrari (1995) concluded that "considerable degradation" of water quality has occurred in the aquifers in southern New Castle County.

Naturally occurring dissolved iron has degraded water quality in the confined portions of the aquifer system. Iron concentrations exceeded the U. S. Environmental Protection Agency's (USEPA) Secondary Maximum Contaminant Level (SMCL) of 300 µg/L in many instances in the Englishtown-Mt. Laurel aquifer system and in the Rancocas aquifer. Dissolved iron values consistently exceeded the SMCL value in the Magothy and Potomac aquifers (Bachman and Ferrari, 1995).

Prior to this study, Bachman and Ferrari (1995) conducted the only study with regards to radon in the ground water in southern New Castle County. They reported radon values above a proposed Maximum Contaminant Level (MCL) of 300 pCi/L occurred exclusively in the Englishtown-Mt. Laurel aquifer system and the Rancocas aquifer. Woodruff et al., (1992) looked at the radon potential of the glauconitic sediments in the study area and concluded that radon appears to occur where the underlying geology contains glauconite.

Elevated nitrate concentrations in the unconfined aquifer have been documented in southern New Castle County (Bachman and Ferrari, 1995; Denver, 1993; and Ritter, 1987). Hamilton and others (1993) reported that nitrate concentrations of less than 0.2 mg/L are probably present as a result of natural factors whereas ground water with nitrate concentrations greater than about 0.4 mg/L have been affected by human activity. Bachman and Ferrari (1995) reported elevated nitrate concentrations in the unconfined portion of the Englishtown-Mt. Laurel aquifer system, in the unconfined portion of the

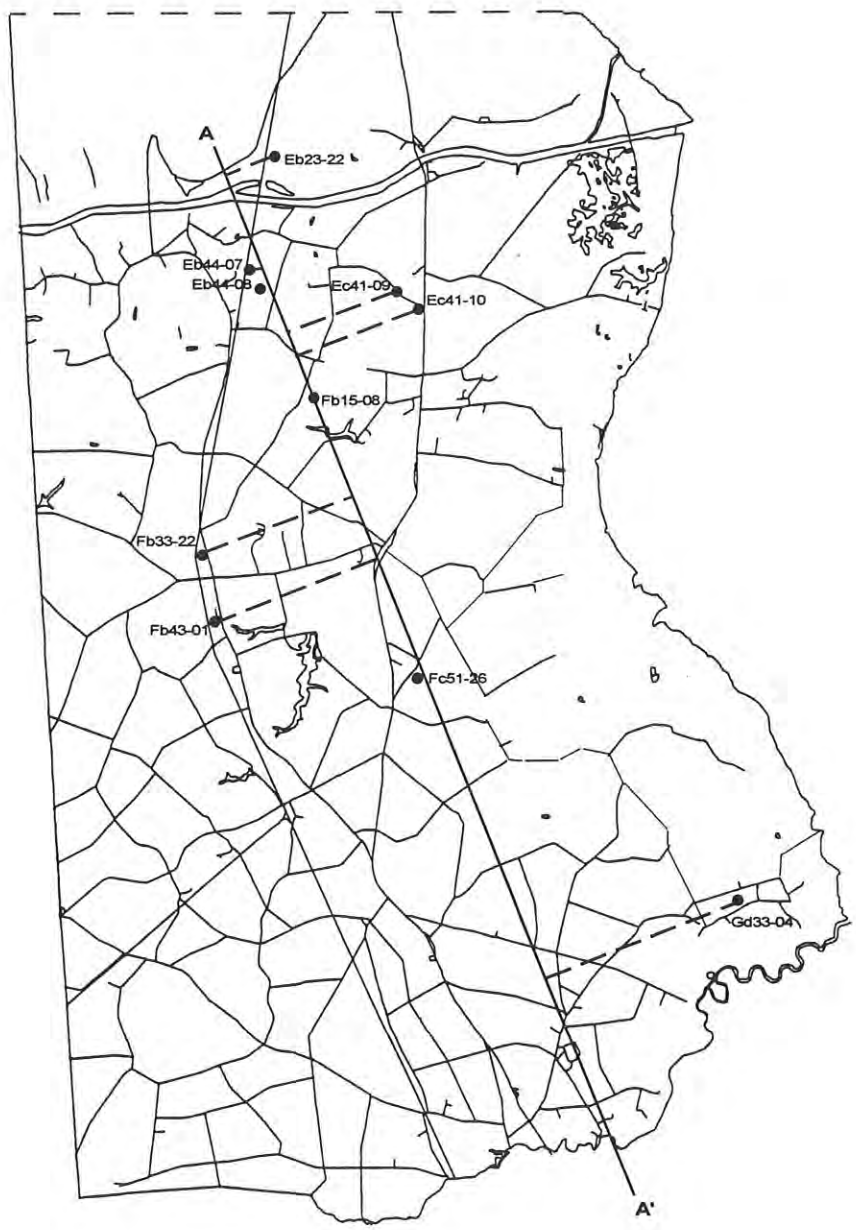

Figure 2. Location of wells shown on cross section in Figure 3.

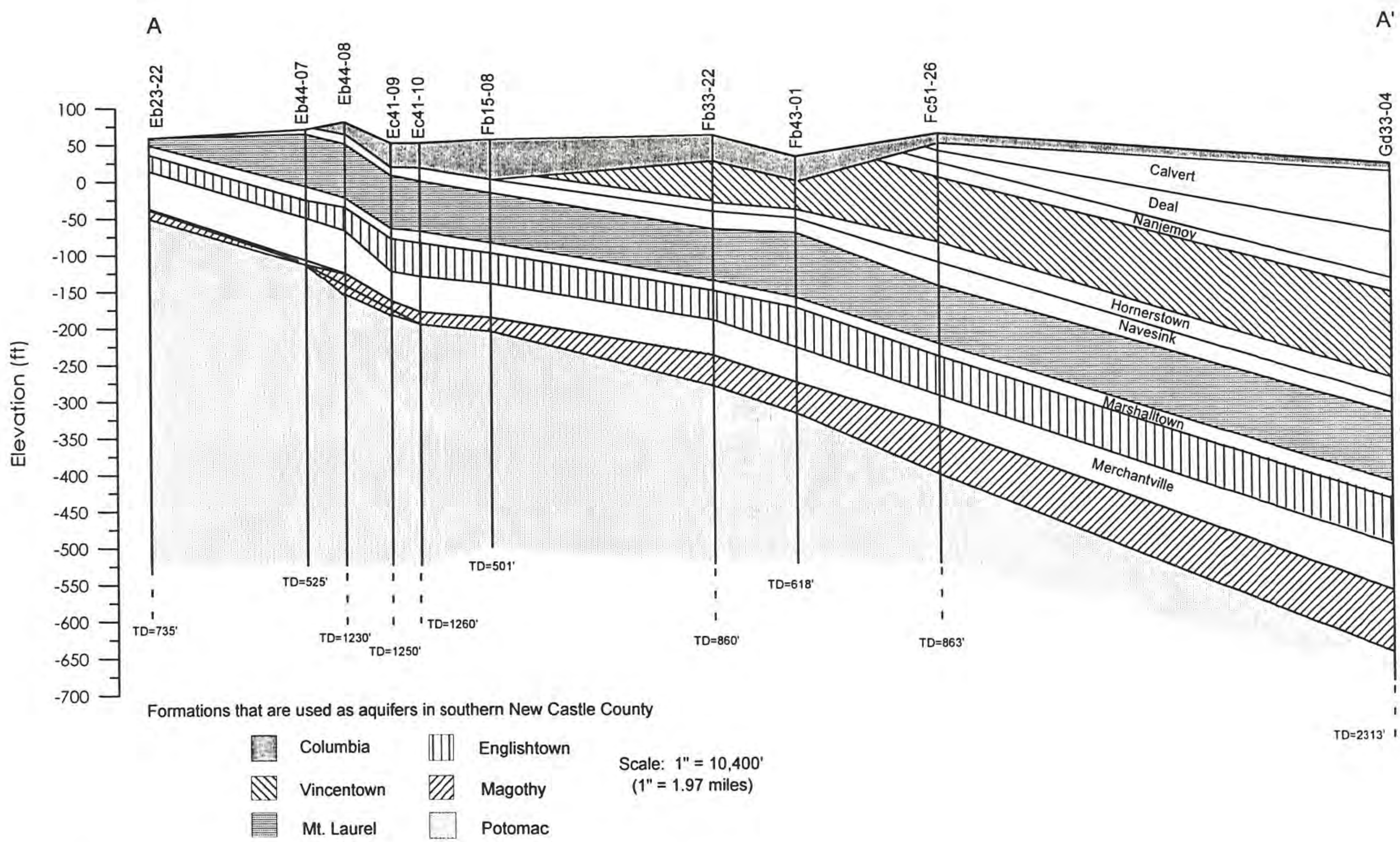

Figure 3. Geologic cross section of southern New Castle County. A-A' line is shown on Figure 2.

Rancocas aquifer and in the Columbia aquifer. Although the elevated nitrate levels were greater than 0.4 mg/L in the Englishtown-Mt. Laurel aquifer system and in the Rancocas aquifer (indicating the effect of human activities) they were below the USEPA MCL of 10 mg/L. This was not the case for the Columbia aquifer, however, where concentrations exceeded 10 mg/L in 22 percent of the samples (Bachman and Ferrari, 1995) and in several samples collected by Ritter (1987). Elevated levels in the confined portions of the entire aquifer system have gone undetected.

There have been two investigations in southern New Castle County in which testing for herbicides have been completed. Denver (1993) conducted an investigation in an agricultural land use area near Vandyke in southwestern New Castle County. Sixteen wells were installed in the shallow water-table aquifer at this site. Denver (1993) reported that " . . . triazine herbicides were detected at least once in water from about half of the wells . . .." Denver (1993) reported that "concentrations of most herbicide detections by laboratory analyses were at or near a concentration of 0.1 µg/L" (ppb). Detected concentrations were low and all were less than the USEPA's maximum contaminant and health advisory levels. Ritter (1987) conducted an investigation in the Appoquinimink River watershed and reported that approximately one half (12) of the monitoring wells located in the shallow water-table aquifer had detectable atrazine concentrations above 1.0 ppb and in March 1985, water from eight wells had concentrations at or above the USEPA's MCL of 3.0 ppb.

METHODS OF STUDY

Well Network

Forty-five wells were sampled throughout southern New Castle County (Figure 4 and Appendix A) as outlined in Phase I of this project (Baxter and Talley, 1996). The number of wells sampled varies from the original number proposed in Phase I due primarily to the inability to locate previously drilled wells in remote locations.

Fourteen shallow water-table wells were installed throughout the study area by the DGS (Appendix B). Boreholes were augured using the DGS drill rig and 8-inch augers. Two-inch diameter wells were installed down the center of the augers and gravel packed and sealed according to Department of Natural Resources and Environmental Control (DNREC) regulations. All wells were completed with a locking cap and well cover which was finished flush with the ground surface. Wells were constructed using polyvinyl chloride (PVC) casing and slotted screen. Wells were developed by surging and/or with compressed air. Equipment was cleaned between each purging to ensure against contamination.

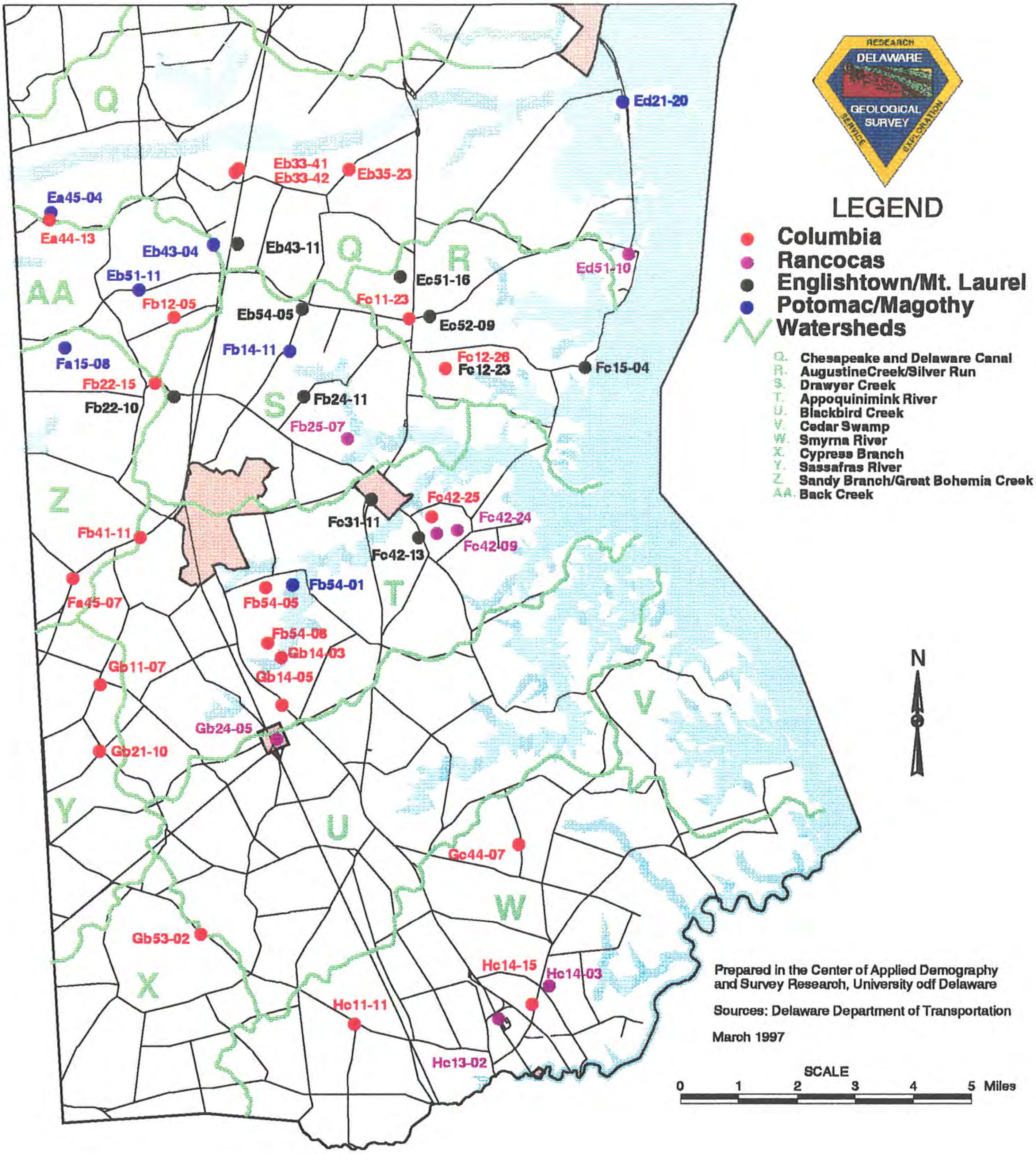

Figure 4. Map showing wells sampled during Phase III.

Water-Sample Collection and Analysis

Ground-water samples were collected primarily during August and September 1996. Samples were collected by means of pumps installed in existing wells and a small-diameter Grundfos Redi-Flo2 submersible pump in monitor wells. Wells were purged until pH, temperature and specific conductance stabilized. Three monitor wells, drilled as part of the Appoquinimink Study (Ritter, 1987), were bailed due to their small casing diameters. They were bailed until five casing volumes were removed and prior to sampling.

Field measurements of temperature, pH, specific conductance, and dissolved oxygen were performed at each well prior to sample collection. Temperature, pH, and specific conductance were measured with the YSI Model 3560 Water-Quality Monitoring System. Dissolved oxygen was determined using the Winkler titration method.

Samples collected for dissolved metals were filtered through a 0.45-micron filter and acidified with approximately 4 milliliters of nitric acid or until the pH was below 2.0. All of the samples were placed in individual baggies, chilled on ice and delivered within hours to the appropriate laboratories: New Castle County Department of Public Works (NCC), Delaware Department of Agriculture (DDA), Delaware Division of Public Health (DPH), or Artesian Laboratories, Inc. Radon samples were collected using a syringe and sampling device designed by the U. S. Geological Survey (USGS) and shipped overnight to the USGS National Laboratory in Denver, Colorado, where analyses were performed.

Results of chemical analyses are stored in a relational database management system at the DGS. Radon results are also stored in the National Water Information System (NWIS) database operated by the USGS.

Statistical analyses were performed using Microsoft Excel and Piper diagrams (Piper, 1944). Piper diagrams are trilinear plots showing the relative concentrations of the major ions generally found in natural waters and are often used in water-analysis interpretation. Piper diagrams for this report were generated using a program written by A. Scott Andres of the DGS.

Quality Assurance and Quality Control

The quality assurance/quality control (QA/QC) program included the planned and systematic procedures necessary to provide adequate confidence that the data generated during a project will satisfy quality requirements. The QA/QC plan for Phase III addressed aspects of sample collection and analysis needed to produce reliable data.

Types and Frequency of Quality-Assurance and Quality-Control Measures

Well casings and screens were kept wrapped in plastic sleeves until installation to prevent contact with materials (soil, grass, etc.) that could contaminate the borehole. Vegetation and soil were removed from the well site before drilling to prevent contamination of the borehole with organic material and possibly pesticides. Drilling and purging equipment used during well installation and development was cleaned prior to use at each site as a precaution against cross contamination.

Other precautions against contamination while in the field included wearing protective gloves while sampling and placing a protective covering around the sampling area so equipment did not come in contact with the ground once the decontamination process had started.

Types of QA/QC water samples included blanks and duplicates. Blank samples are a measure of bias and are taken to ensure the data-collection process has not contaminated samples. There are many types of blank samples, each designed to isolate a different part of the data collection process including, for example, sampling storing, and transporting samples.

Trip blanks, source solution blanks, and equipment blanks were used extensively during Phase III. Trip blanks were used to isolate potential contamination while transporting the samples. Source solution blanks were used to determine if any contamination, if present, was coming from the distilled water obtained from the DGS lab and used during the sampling process. Equipment blanks were used primarily to determine if adequate decontamination of equipment was taking place in the field.

Duplicates are used to estimate sample variability. Duplicate samples are a group of samples collected in a manner such that the samples are thought to be essentially identical in composition; they were used extensively throughout this round of sampling.

QA/QC results are listed in Appendices C, D, and E. In addition to the project QA/QC program, all laboratory facilities involved in analyzing the samples routinely conduct internal QA/QC programs.

RESULTS

Thirty-three parameters were measured on most of the wells during the first quarter (Phase III) of the of the southern New Castle County Ground-Water Monitoring Network (Appendix F). Measurements included those made in the field at each well (pH, eH, temperature, specific conductivity and dissolved oxygen) as well as laboratory analyses of inorganics, radon, four herbicides and one insecticide (throughout this report, herbicides and insecticides will be referred to collectively as pesticides). Radon was sampled at selected wells from each aquifer system and pesticides were sampled only in wells screened in the shallow water-table aquifer.

Median values for the majority of the parameters tested are within the limits established by the USEPA. However, all four aquifer systems (Potomac-Magothy, Englishtown-Mt. Laurel, Rancocas, and Columbia) had at least some results above the limits established for pH, iron and manganese by the USEPA. Fifty-nine percent of the results were outside the SMCL set for pH (6.5-8.5), 35% were greater than the SMCL set for iron (0.3 mg/L), and 26% were greater than the SMCL set for manganese (0.05 mg/L). Exceedence of an SMCL does not pose a health risk to the public.

Seven parameters are discussed for each aquifer. Manganese and pH are discussed because, as mentioned above, a fair percentage of the results exceeded the SMCL values. Nitrate and pesticide concentrations are discussed for each aquifer system because they can be used to gauge anthropogenic effects on the environment. Chloride is a relatively easy analysis to perform (Hem, 1970) and can be used to indicate intrusion of brackish water and, to some extent, effects of application of road deicing salts and wastewater effluent. Iron, a naturally occurring metal, and radon, a naturally occurring gas, are also discussed.

Basic statistical analyses were performed on results from each aquifer and are presented at the end of each aquifer discussion (Tables 1, 2, 3, and 4). Relative concentrations of major ions were plotted using Piper diagrams (Piper, 1944). Analyses were performed using the average of environmental and quality control samples where duplicates were taken.

Analysis by Aquifer

Potomac-Magothy Aquifer System

Of the 45 wells sampled, seven were screened in the Potomac-Magothy aquifer system (Figure 4). The Potomac and Magothy are generally mapped as separate aquifers. However, because they are mineralogically similar and both environments are anoxic, they are considered a single aquifer system for water-quality analyses (Bachman and Ferrari, 1995; Hamilton et al., 1991).

The Potomac-Magothy aquifer system can be categorized as having primarily calcium-magnesium-bicarbonate-type water with few a wells yielding sodium-bicarbonate-type water (Figure 5). The results of this study and the results presented by Bachman and Ferrari (1995) are presented in Figure 6 for comparative purposes. Figure 6 indicates relative agreement between results of both studies.

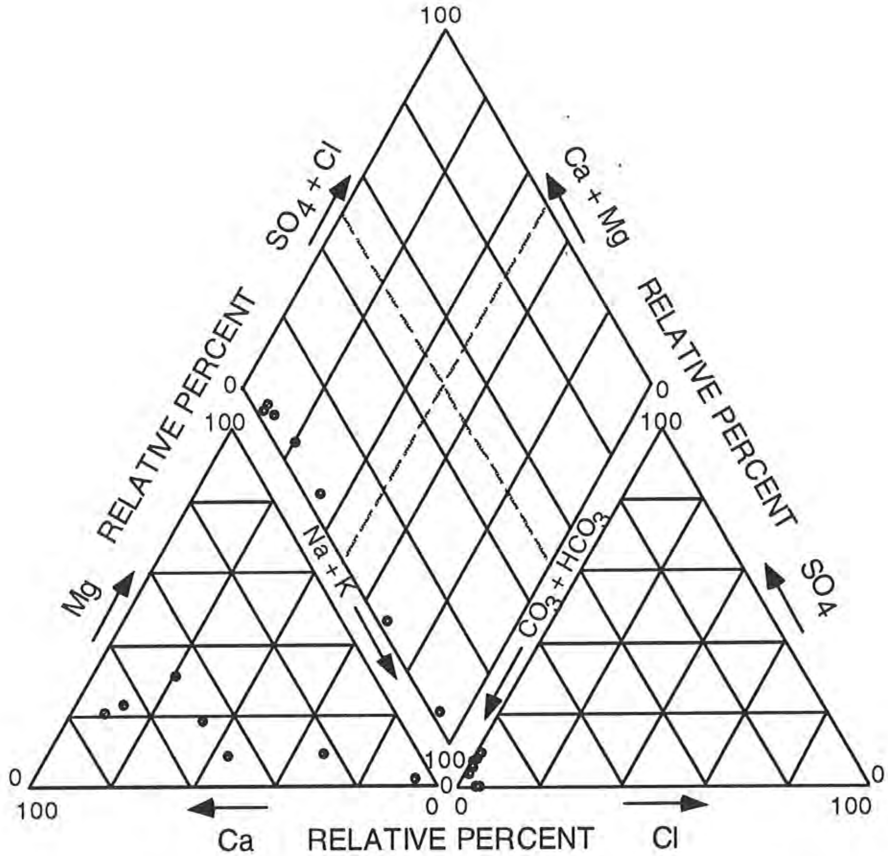

Figure 5. Piper diagram for Potomac-Magothy aquifer system.

Values for pH were within the SMCL range (6.5-8.5) with the exception of one sample that had a pH slightly below 6.5. Two samples had manganese values greater than the SMCL of 0.05 mg/L. This was not surprising since manganese is typically found in iron-bearing water (Hem, 1970).

Nitrate values are consistently low with 92.5% of the samples having values <0.4 mg/L indicating the deeper, confined aquifers are not being influenced by human activity. The one exception (Ed21-20) had a nitrate value of 2.65 mg/L. Although 2.65 mg/L is well below the USEPA Maximum Contaminant Level (MCL) of 10 mg/L, it was considered unusual because the nitrate value for this well was measured at <0.020 mg/L in 1991 (Bachman and Ferrari, 1995). We do not feel that this indicates the beginning of aquifer degradation but rather the well is beginning to fail. This conclusion is based on the fact that nitrate is generally not found under natural conditions with low dissolved oxygen and high iron as is the case with the sample drawn from this well (Scott Andres, personal communication).

Chloride values were very low with all seven samples having concentrations less than 2 mg/L. These low values indicate that, at this time, salt-water intrusion does not appear to be a problem in this aquifer system near the C & D Canal (Ea45-05, Eb43-04, Eb51-11) or in the vicinity of the Delaware Bay (Ed21-20).

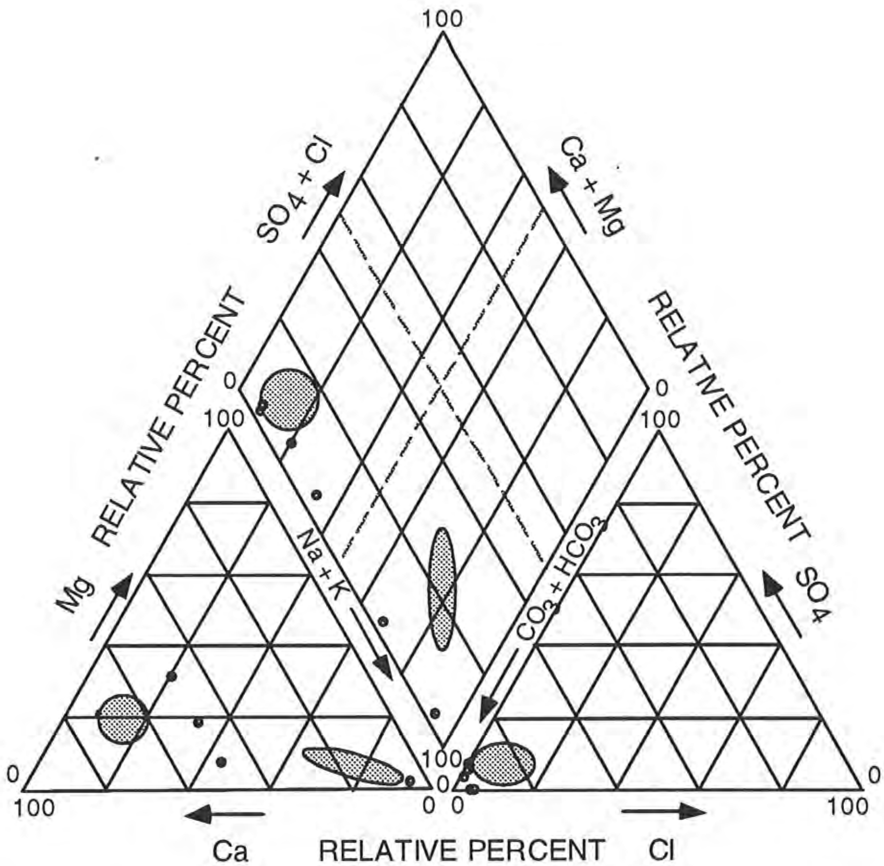

Figure 6. Comparative Piper diagram for Potomac-Magothy aquifer system. Small circles represent results from this study and shaded regions represent Bachman and Ferrari (1995) data.

Pesticides were not analyzed in the Potomac-Magothy aquifer system. It is highly unlikely that they would be found in these deeper, confined units. Therefore, resources were concentrated on the shallow, unconfined portions of the Englishtown-Mt. Laurel, Rancocas and Columbia aquifers.

Iron was detected at values greater than the SMCL (>0.3 mg/L) in all seven of the Potomac-Magothy samples. This was expected since pyrite and siderite are dominant minerals in these units (Benson and Spoljaric, 1996) and produce iron through dissolution.

Radon was detected in three wells that were tested in the Potomac-Magothy aquifer system. Concentrations ranged from 120 to 200 pCi/L. The detection levels, however, were below the proposed MCL of 300 pCi/L and were among the lowest values reported in the study area. Lower values of radon were expected in this aquifer system because the Potomac and Magothy formations do not contain glauconitic sediments which are believed to be a source of radon in the study area (Woodruff, et al., 1992). Statistical analyses for the parameters tested in the Potomac-Magothy aquifer system are presented in Table 1.

Table 1. Statistical Summary for Potomac-Magothy Aquifer System

Constituent	Number of analyses	Minimum	25th Percentile	Median	75th Percentile	Maximum	Number of samples exceeding water-quality criteria
Specific Conductance (μS/cm)	7	103	131	137	160	236	
Dissolved Oxygen (mg/L)	7	0	0	0	1.95	3.9	
pH (standard units)	7	6.43	6.69	6.77	7.21	7.63	1 sample > SMCL of 6.5-8.5
Bicarbonate (mg/L)	7	63.4	81.7	92.7	104.2	131.7	
Ammonia (mg/L as N)	7	0.02	0.03	0.08	0.15	0.21	
Nitrate (mg/L as N)	7	<0.4	<0.4	<0.4	<0.4	2.7	0 samples > MCL of 10 mg/L
Total Organic Carbon (mg/L)	7	0.0	0.0	0.0	0.0	0.0	
Calcium (mg/L)	7	1.88	11.5	15.0	23.8	36.3	
Magnesium (mg/L)	7	0.43	3.2	4.2	4.6	6.4	
Sodium (mg/L)	7	3.4	3.9	4.5	25.0	39.2	
Potassium (mg/L)	7	0.4	0.8	1.3	1.6	1.8	
Chloride (mg/L)	7	1.4	<2.0	<2.0	<2.0	<2.0	0 samples > SMCL of 250 mg/L
Sulfate (mg/L)	7	<0.05	<0.05	<0.05	<0.05	<0.05	0 samples > SMCL of 250 mg/L
Fluoride (mg/L)	7	0.11	0.18	0.22	0.26	0.29	
Silica (mg/L)	7	3.7	4.2	4.4	6.9	10	
Iron (mg/L)	7	0.39	2.6	3.5	5.0	9.2	7 samples > SMCL of 0.30 mg/L
Manganese (mg/L)	7	<0.02	<0.02	0.04	0.1	0.21	2 samples > SMCL of 0.05 mg/L
Phosphorous (mg/L)	3	<0.05	<0.05	<0.05	<0.05	<0.05	
Zinc (mg/L)	7	<0.02	<0.02	0.03	0.1	0.22	0 samples > SMCL of 5 mg/L
Lead (mg/L)	7	<0.002	<0.002	0.003	0.003	0.003	0 samples > MCL of 0.05 mg/L
Copper (mg/L)	7	<0.01	<0.01	<0.01	<0.01	0.02	0 smaples > SMCL of 1 mg/L
Radon (pCi/L)	3	120	135	150	175	200	0 samples > proposed MCL of 300 pCi/L
Alachlor (μg/L)	0						
Cyanazine (μg/L)	0						
Metolachlor (μg/L)	0						
Atrazine (μg/L)	0						
Carbofuran (μg/L)	0						

Englishtown-Mt. Laurel Aquifer System

Ten wells sampled were screened in the Englishtown-Mt. Laurel aquifer system (Figure 4). This aquifer system can be categorized as having primarily calcium-magnesium-bicarbonate type water (Figure 7). One sample plots as a sodium-bicarbonate type. Of interest is the contrast between the Piper diagrams of this study and those of Bachman and Ferrari (1995) (Figure 8) with the latter showing two distinct water types. This difference is most likely due to sample size; over three times as many samples (35) were drawn from the confined and unconfined portions of the Englishtown-Mt. Laurel aquifer system by Bachman and Ferrari resulting in a greater range of results.

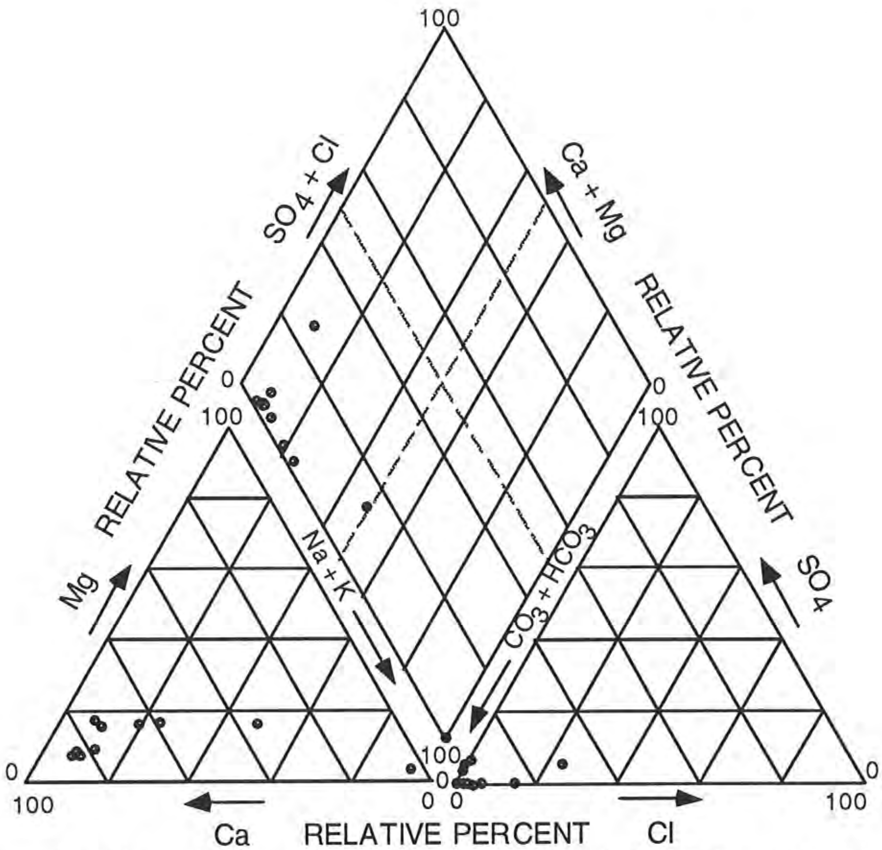

Figure 7. Piper diagram for the Englishtown-Mt. Laurel aquifer system.

Two samples had values outside the SMCL range for pH (6.5-8.5). These samples were slightly more acidic than 6.5. Three samples were above the SMCL for manganese (0.05 mg/L). Again, this is not unexpected since the Englishtown-Mt. Laurel aquifer system is irony in the confined portion of the system (Bachman and Ferrari, 1995).

Fifty percent of the nitrate values reported were >0.4 mg/L indicating the aquifer system is being influenced by human activity. However, values were well below the MCL of 10 mg/L with the highest reported value being 3.5 mg/L (Eb54-05). Wells Eb54-05 and

Eb43-11 had significantly lower nitrate values than in 1991 when they were sampled by Bachman and Ferrari (1995).

Chloride concentrations were <2.0 mg/L in 70% of the samples from the Englishtown-Mt. Laurel aquifer system. The highest reported value was 19 mg/L from

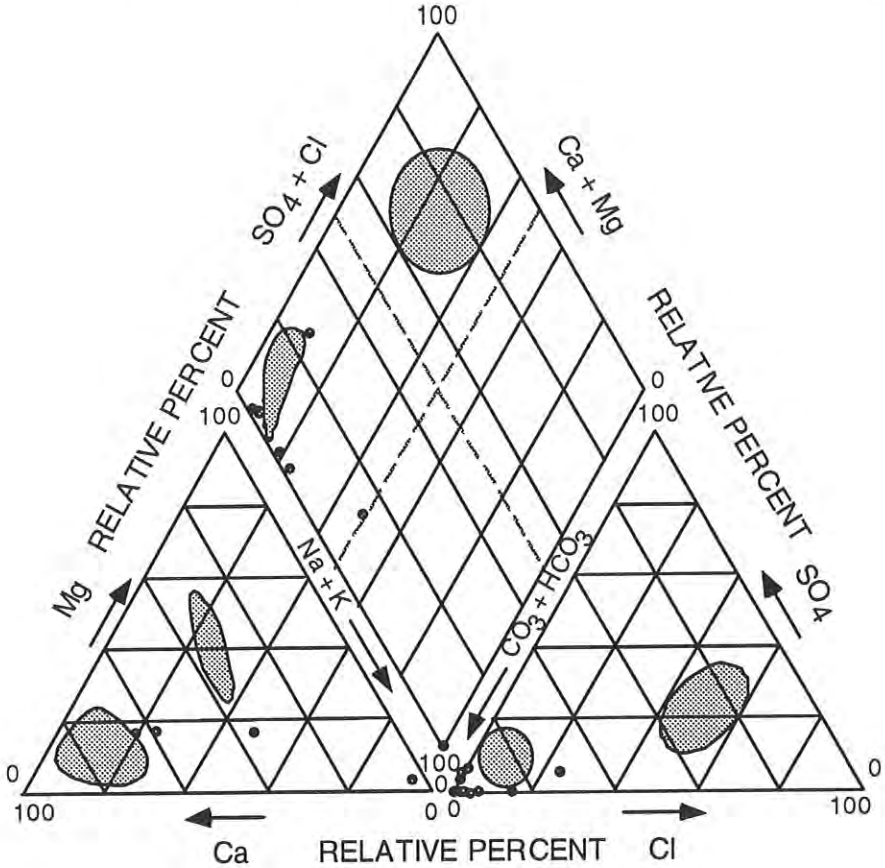

Figure 8. Comparative Piper diagram for Englishtown-Mt. Laurel aquifer system. Small circles represent results from this study and shaded regions represent Bachman and Ferrari (1995) data.

well Fc12-23. Although high in comparison to other wells in this aquifer system, it is far below the SMCL of 250 mg/L set for chloride.

Two wells (Eb43-11 and Eb54-05) were sampled for pesticides. Detectable amounts of alachlor and atrazine were measured in both wells that are located in the subcrop area of the Englishtown-Mt. Laurel aquifer system. However, the reported values were well below the MCL for these two pesticides. Non-detectable concentrations were reported in both wells for cyanazine, metolachlor and carbofuran.

Four of the ten wells (40%) sampled had iron values greater than the SMCL of 0.3 mg/L. This is consistent with the mineralogy of the Englishtown Formation, which contains the iron-bearing minerals pyrite, siderite, and goethite (Benson and Spoljaric, 1996). The observation that only 40% of the wells had values above the SMCL is because the Englishtown-Mt. Laurel aquifer system is dominated by chemical processes that act upon the calcium-carbonate found in the system more so than the processes that control dissolution and precipitation of the iron-bearing minerals (Bachman and Ferrari, 1995).

Radon occurred in all of the samples screened in the Englishtown-Mt. Laurel aquifer system at values greater than the proposed MCL of 300 pCi/L. Concentrations ranged from 420 to 1,200 pCi/L. The Englishtown and Mt. Laurel formations are glauconitic units (Benson and Spoljaric, 1996) so higher radon values would be expected. Statistical analyses for the Englishtown-Mt. Laurel aquifer system are presented in Table 2.

Table 2. Statistical Summary for Englishtown-Mt. Laurel Aquifer System

Constituent	Number of analyses	Minimum	25th Percentile	Median	75th Percentile	Maximum	Number of samples exceeding water-quality criteria
Specific Conductance (μS/cm)	10	137	187	199	213	228	
Dissolved Oxygen (mg/L)	10	0	0	1	5.3	8.4	
pH (standard units)	10	6.05	6.61	7.48	7.6	7.78	2 samples > SMCL of 6.5-8.5
Bicarbonate (mg/L)	10	30.9	62.2	108.6	143.4	166.6	
Ammonia (mg/L as N)	10	0.02	0.03	0.09	0.11	0.15	
Nitrate (mg/L as N)	10	<0.4	<0.4	1.1	2.1	3.5	0 samples > MCL of 10 mg/L
Total Organic Carbon (mg/L)	10	0.0	0.0	0.0	1.1	2.4	
Calcium (mg/L)	10	0.1	31.9	40.4	43.4	53.4	
Magnesium (mg/L)	10	0.02	2.4	4.1	5.7	15.8	
Sodium (mg/L)	10	4.0	4.3	4.7	11.8	74.8	
Potassium (mg/L)	10	0.07	0.8	1.4	1.8	18.2	
Chloride (mg/L)	10	0.18	2.0	2.0	3.3	19	0 samples > SMCL of 250 mg/L
Sulfate (mg/L)	10	<0.05	<0.05	<0.05	<0.05	<0.05	0 samples > SMCL of 250 mg/L
Fluoride (mg/L)	10	0.13	0.14	0.19	0.35	0.43	
Silica (mg/L)	10	5.3	7.7	8.7	10.8	13.9	
Iron (mg/L)	10	0.05	0.11	0.23	0.41	2.2	4 samples > SMCL of 0.30 mg/L
Manganese (mg/L)	10	0.02	0.02	0.02	0.06	0.24	3 samples > SMCL of 0.05 mg/L
Phosphorous (mg/L)	10	<0.05	<0.05	<0.05	<0.05	<0.05	
Zinc (mg/L)	10	0.02	0.02	0.02	0.07	0.18	0 samples > SMCL of 5 mg/L
Lead (mg/L)	10	<0.002	<0.002	<0.002	0.003	0.004	0 samples > MCL of 0.05 mg/L
Copper (mg/L)	10	<0.01	<0.01	<0.01	<0.01	<0.01	0 samples > SMCL of 1 mg/L
Radon (pCi/L)	7	420	488	500	855	1200	7 samples > proposed MCL of 300 pCi/L
Alachlor (μg/L)	2	0.09	0.09	0.1	0.1	0.1	0 samples > MCL of 2 μg/L
Cyanazine (μg/L)	2	0	0.008	0.015	0.023	0.03	0 samples > MCL of 1 μg/L
Metolachlor (μg/L)	2	0	0	0	0	0	0 samples > MCL of 100 μg/L
Atrazine (μg/L)	2	0.07	0.233	0.395	0.558	0.72	0 samples > MCL of 3 μg/L
Carbofuran (μg/L)	2	0	0.008	0.015	0.023	0.03	0 samples > MCL of 40 μg/L

Rancocas Aquifer

Seven wells sampled for water quality were screened in the Rancocas aquifer (Vincentown and Hornerstown formations). This aquifer can be categorized as being primarily a calcium-magnesium-bicarbonate system with a few samples (29%) plotting as calcium-magnesium-chloride type (Figure 9). These results are consistent with those of Bachman and Ferrari (1995) (Figure 10) who reported that water of mixed types were most commonly found in this aquifer.

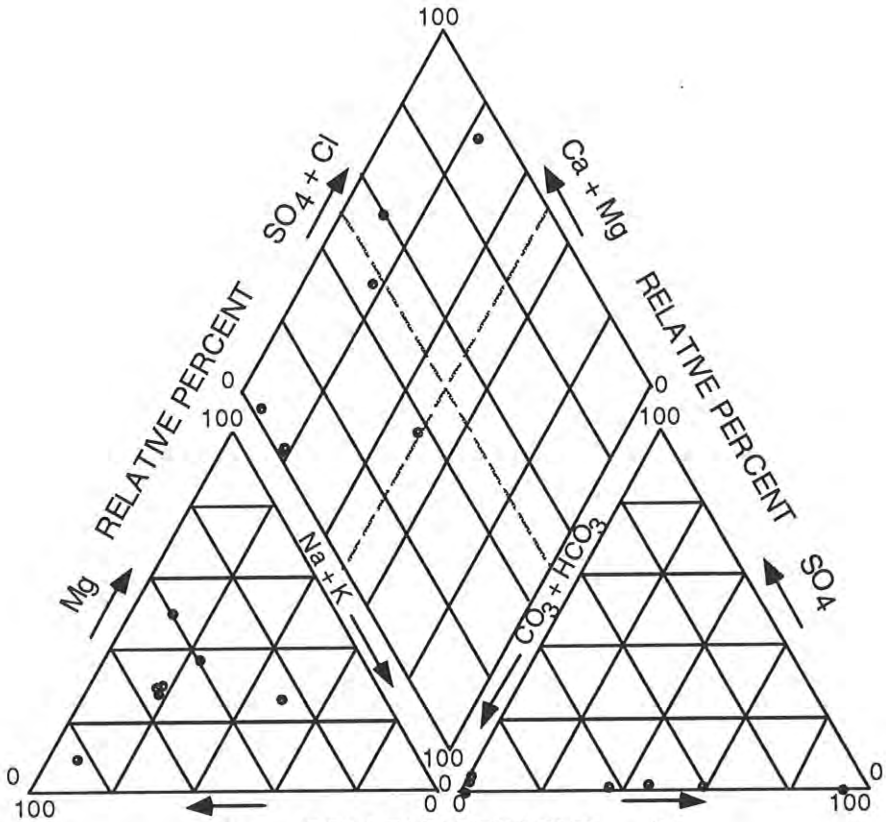

Figure 9. Piper diagram for the Rancocas aquifer.

Four samples had pH values that were more acidic than the SMCL set by the USEPA. The aquifer from which these four samples were drawn is hydraulically connected to the shallow water-table aquifer. Due to various processes, precipitation entering the water-table aquifer becomes acidic recharge water as it flow to the Rancocas aquifer (Bachman and Ferrari, 1995; Denver, 1986). One sample exceeded the SMCL for manganese in this aquifer.

Nitrate values greater than the background level of 0.4 mg/L were reported in 57% of the samples. Of those wells with levels >0.4 mg/L, only one domestic well (Ed51-10) had a nitrate level (0.80 mg/L) well below the MCL of 10 mg/L. The remaining wells were monitor wells located on property surrounding Water Farm #1 near Odessa (Fc42-09 and Fc42-24) and Burris Extractive Use Facility near Odessa (Fb25-07). Fc42-09 (13 mg/L) and Fb25-07 (9.9 mg/L) are located at or near areas where crops (soybeans and corn) were grown. Fertilizers used during the growing season are the most likely source of nitrates. Fc42-24 (7.0 mg/L) is located in a field treated with spray irrigation.

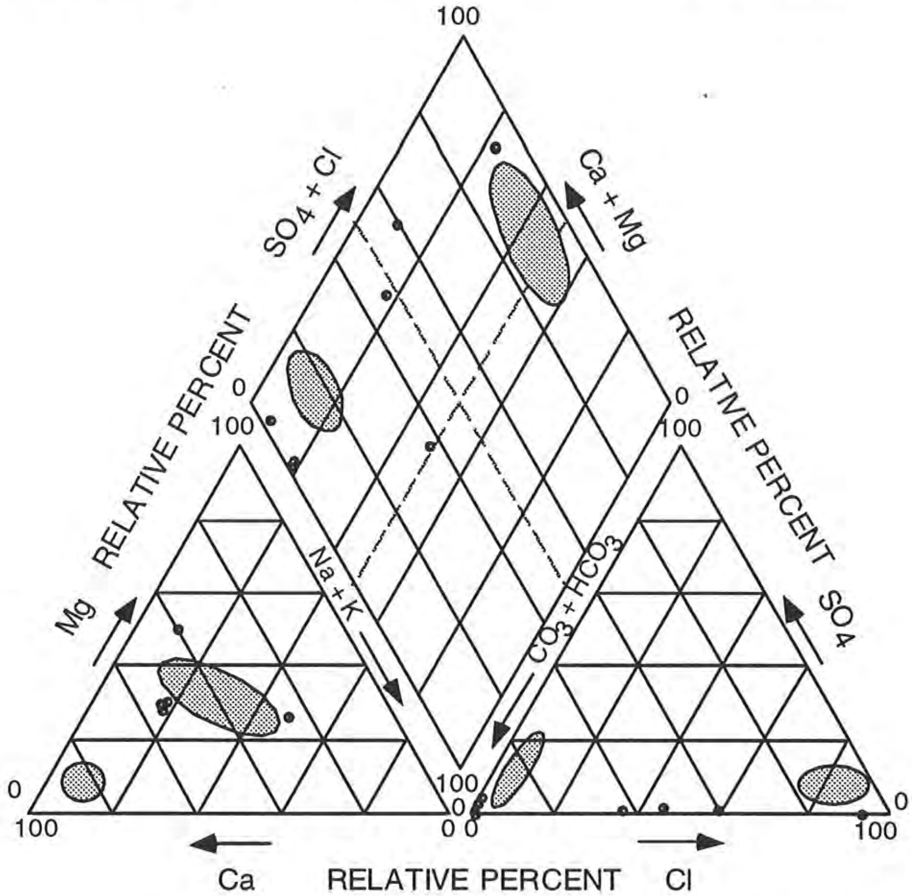

Figure 10. Comparative Piper diagram for Rancocas aquifer. Small circles represent results from this study and shaded regions represent Bachman and Ferrari (1995) data.

Chloride concentrations were less than 2 mg/L in 86% of the wells sampled in the Rancocas aquifer system. One well (Fc42-09) had a concentration of 18.5 mg/L, which is well below the SMCL for chloride (250 mg/L).

Three wells screened in the Rancocas aquifer (Ed51-10, Fb25-07, Fc42-24) were tested for pesticides. Only one (Fc42-24) had a detectable level of atrazine (0.14 µg/L) which is below the MCL of 3.0 µg/L. Non-detectable concentrations were reported for alachlor, metolachlor, cyanazine, and carbofuran in all three wells.

Two of the seven wells (28.6%) sampled had iron values slightly greater (0.42 and 0.44 mg/L) than the SMCL of 0.3 mg/L. In the unconfined portions of this aquifer system, this relatively low iron percentage may be due to relatively higher amounts of dissolved oxygen (DO) in this aquifer. Higher DO concentrations hinder the dissolution of iron resulting in lower concentrations in ground water.

Sixty percent of the wells sampled for radon in the Rancocas aquifer had values above the proposed MCL of 300 pCi/L. Concentrations range from 230 to 850 pCi/L. Again, the concentrations are most likely due to the presence of glauconitic sediments (Woodruff et al., 1992). Statistical analyses for the Rancocas aquifer are presented in Table 3.

Table 3. Statistical Summary for the Rancocas Aquifer

Constituent	Number of analyses	Minimum	25th Percentile	Median	75th Percentile	Maximum	Number of samples exceeding water-quality criteria
Specific Conductance (μS/cm)	7	146	187	202	222	294	
Dissolved Oxygen (mg/L)	7	0	5.75	6.3	9.25	13.7	
pH (standard units)	7	4.08	4.81	4.92	7.59	7.76	4 samples > SMCL of 6.5-8.5
Bicarbonate (mg/L)	7	2.3	2.3	3.5	158.30	182.9	
Ammonia (mg/L as N)	7	0.01	0.06	0.11	0.13	0.19	
Nitrate (mg/L as N)	7	<0.4	<0.4	0.8	8.5	13	1 sample > MCL of 10 mg/L
Total Organic Carbon (mg/L)	7	0.0	0.0	0.0	0.0	1.2	
Calcium (mg/L)	7	11.6	16.0	16.6	36.3	48.5	
Magnesium (mg/L)	7	3.61	5.9	10.3	12.2	12.7	
Sodium (mg/L)	7	4.0	4.7	6.3	7.0	34.3	
Potassium (mg/L)	7	0.54	0.89	1.1	6.9	12.8	
Chloride (mg/L)	7	1.2	1.3	1.9	2.0	18.5	0 samples > SMCL of 250 mg/L
Sulfate (mg/L)	7	<0.05	<0.05	<0.05	<0.05	<0.05	0 samples > SMCL of 250 mg/L
Fluoride (mg/L)	7	0.12	0.21	0.27	0.40	0.59	
Silica (mg/L)	7	5.36	6.41	6.70	10.1	13.8	
Iron (mg/L)	7	0.03	0.09	0.18	0.30	0.44	2 samples > SMCL of 0.30 mg/L
Manganese (mg/L)	7	0.02	0.02	0.02	0.02	0.11	1 samples > SMCL of 0.05 mg/L
Phosphorous (mg/L)	7	<0.05	<0.05	<0.05	<0.05	<0.05	
Zinc (mg/L)	7	0.02	0.02	0.02	0.06	0.09	0 samples > SMCL of 5 mg/L
Lead (mg/L)	7	<0.002	<0.002	<0.002	<0.002	0.003	0 samples > MCL of 0.05 mg/L
Copper (mg/L)	7	<0.01	<0.01	<0.01	<0.01	0.14	0 samples > SMCL of 1 mg/L
Radon (pCi/L)	5	230	250	360	465	840	3 samples > proposed MCL of 300 pCi/L
Alachlor (μg/L)	3	0	0.01	0.02	0.03	0.03	0 samples > MCL of 2 μg/L
Cyanazine (μg/L)	3	0	0	0	0	0	0 samples > MCL of 1 μg/L
Metolachlor (μg/L)	3	0	0	0	0.005	0.01	0 samples > MCL of 100 μg/L
Atrazine (μg/L)	3	0	0.005	0.01	0.075	0.14	0 samples > MCL of 3 μg/L
Carbofuran (μg/L)	3	0	0.005	0.01	0.03	0.05	0 samples > MCL of 40 μg/L

Columbia Aquifer

Twenty-one wells screened in the Columbia Formation were sampled (one well, Eb35-23, was sampled twice resulting in 22 analyses shown in the summary table). Recent studies have not looked extensively at the water quality in the Columbia aquifer in the study area which is why this aquifer was so heavily sampled during this investigation. Seven of the 21 wells were pre-existing; 14 new monitor wells were drilled throughout the study area by the DGS.

The Columbia aquifer can be characterized predominantly as a calcium-magnesium-bicarbonate system with a few samples (9%) plotting as sodium-potassium-bicarbonate-type water (Figure 11). When compared to a recent study completed by Denver (1993) (Figure 12) a noticeable difference is apparent; mainly that sulfate and chloride were present in lower concentrations than the samples collected by Denver (1993). This difference may be because Denver (1993) concentrated sampling in the southwest portion of the study area sampling wells located adjacent to roads that were more susceptible to contamination from road deicing salts.

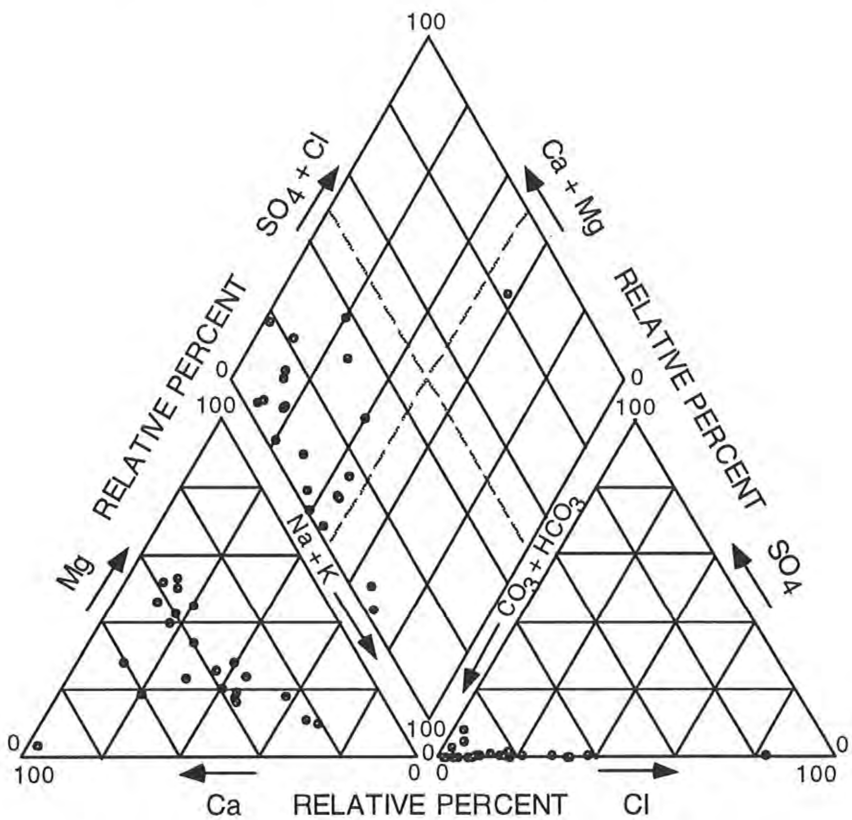

Figure 11. Piper diagram for the Columbia aquifer.

The majority of samples that had values outside the SMCL range for pH were drawn from the Columbia aquifer. This is to be expected since water entering the aquifer in the form of precipitation has a natural pH of 3.5 to 4.5 (Denver, 1986). The SMCL for manganese was exceeded in six samples drawn from the Columbia aquifer. Columbia sediments are typically stained with limonite (iron-hydroxide). It would not be uncommon to find dissolved manganese in the iron-bearing water of the Columbia aquifer.

Nitrate values above background (0.4 mg/L) were found in 95.5% of the samples. Two samples (Fb22-15 and Fb54-05) were equal to or greater than the MCL of 10 mg/L (10.0 mg/L and 12.0 mg/L, respectively). Both of these wells are shallow monitoring wells

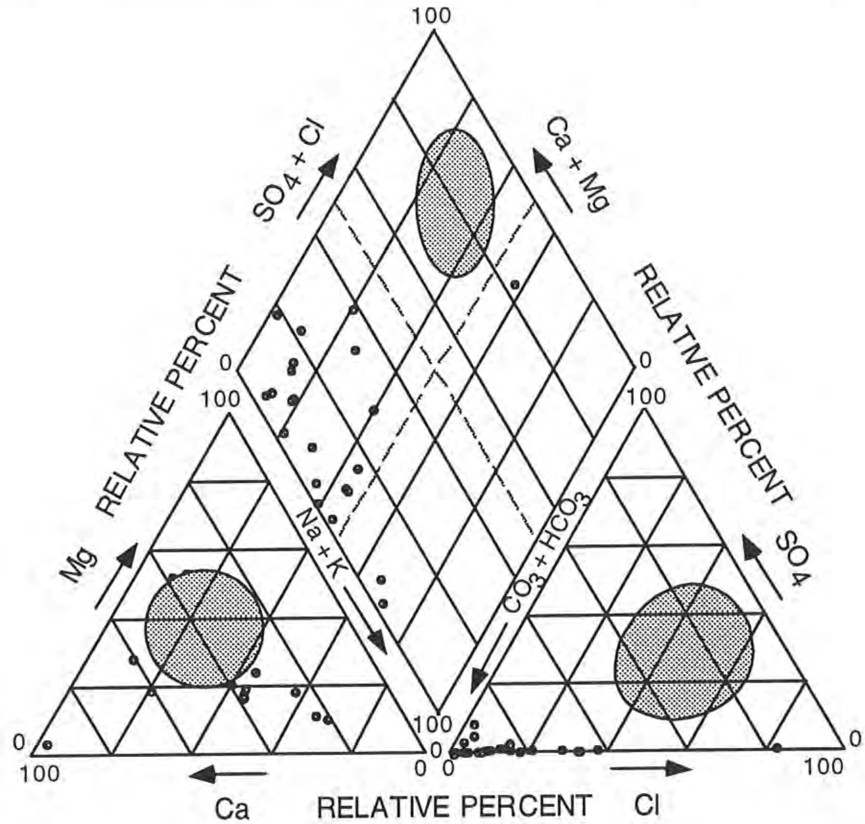

Figure 12. Comparative Piper diagram for Columbia aquifer. Small circles represent results from this study and shaded regions represent Denver (1993) data.

located immediately adjacent to cornfields. One well (Fc42-25) had a nitrate value of 7 mg/L while the remaining 18 wells with detectable nitrate levels had reported values much less than the MCL of 10 mg/L.

Chloride concentrations were less than 2.0 mg/L in 82% of the samples. The highest reported value was 6.4 mg/L from well Hc11-11 which is located in a slightly depressed area near the edge of a road.

Eighteen wells screened in the Columbia aquifer were sampled for pesticides. Non-detectable to trace amounts of alachlor, cyanazine, metolachlor, atrazine, and carbofuran were reported for all wells tested. The reported values were well below the

MCLs. One well (Gb11-07) had an atrazine concentration (3.04 μg/L) above the MCL of 3.0 μg/L.

Only two of the 21 wells (9.5%) screened in the Columbia aquifer had iron values greater than the SMCL of 0.3 mg/L. The highest reported value (15.1 mg/L) was from a monitor well (Gc44-07) located in the southeastern portion of the study area (Figure 4). A large range in iron values is not unusual given the "sporadic" occurrence of iron in the Columbia Formation (Johnston, 1973).

Fifteen wells screened in the Columbia aquifer were sampled for radon (Eb35-23 was sampled twice). Fifty-six percent of the samples had concentrations greater than the proposed MCL of 300 pCi/L with values ranging from 150 to 2,600 pCi/L. The highest values were from monitor well Eb35-23 which was drilled in a valley located in the subcrop area of the Mt. Laurel Formation. Statistical analyses for the Columbia aquifer are presented in Table 4.

Table 4. Statistical Summary for the Columbia Aquifer

Constituent	Number of analyses	Minimum	25th Percentile	Median	75th Percentile	Maximum	Number of samples exceeding water-quality criteria
Specific Conductance (μS/cm)	22	22	155	182	380	3530	
Dissolved Oxygen (mg/L)	19	0	0	5.1	7.85	14.2	
pH (standard units)	22	4.74	5.18	5.49	6.02	7.23	20 samples > SMCL of 6.5-8.5
Bicarbonate (mg/L)	22	2.3	5.2	14.5	32.7	159.7	
Ammonia (mg/L as N)	22	0.02	0.03	0.09	0.13	0.97	
Nitrate (mg/L as N)	22	0.2	1.00	2.6	3.7	12	2 samples > MCL 10 mg/L
Total Organic Carbon (mg/L)	22	0	0	0	0.99	4	
Calcium (mg/L)	22	1.4	11	14.7	37.2	168	
Magnesium (mg/L)	22	0.66	5.0	7.8	12.2	51.5	
Sodium (mg/L)	22	1.46	5.0	8.8	16.8	545	
Potassium (mg/L)	22	0.43	0.75	0.93	1.3	20.2	
Chloride (mg/L)	22	0.38	0.63	0.71	1.09	6.4	0 samples > SMCL of 250 mg/L
Sulfate (mg/L)	22	<0.05	<0.05	<0.05	<0.05	0.07	0 samples > SMCL of 250 mg/L
Fluoride (mg/L)	22	0.11	0.14	0.16	0.22	1.4	
Silica (mg/L)	22	2.6	4.9	5.9	8.4	27.4	
Iron (mg/L)	22	0.02	0.06	0.09	0.18	15.1	3 samples > SMCL of 0.30 mg/L
Manganese (mg/L)	22	0.02	0.02	0.02	0.07	1.41	6 samples > SMCL of 0.05 mg/L
Phosphorous (mg/L)	22	<0.05	<0.05	<0.05	<0.05	<0.05	
Zinc (mg/L)	22	0.02	0.02	0.02	0.04	0.07	0 samples > SMCL of 5 mg/L
Lead (mg/L)	22	<0.002	<0.002	<0.002	<0.002	<0.002	0 samples > MCL of 0.05 mg/L
Copper (mg/L)	22	0.01	0.01	0.01	0.01	0.21	0 samples > SMCL of 1 mg/L
Radon (pCi/L)	16	150	244	315	405	2600	9 samples > proposed MCL of 300 pCi/L
Alachlor (μg/L)	19	0.01	0.03	0.04	0.08	0.47	0 samples > MCL of 2 μg/L
Cyanazine (μg/L)	19	0.0	0.01	0.01	0.03	0.09	0 samples > MCL of 1 μg/L
Metolachlor (μg/L)	19	0.0	0.01	0.02	0.05	0.1	0 samples > MCL of 100 μg/L
Atrazine (μg/L)	19	0.0	0.07	0.35	0.68	3.04	1 sample > MCL of 3 μg/L
Carbofuran (μg/L)	19	0.0	0.01	0.02	0.03	0.05	0 samples > MCL of 40 μg/L

SUMMARY

Median values of the major ions from the first round of sampling are in general agreement with the median values from previous studies of Bachman and Ferrari (1995) and Knobel (1985). Results indicate ground water in southern New Castle County is being influenced by natural as well as human activity.

Under natural conditions, sodium and bicarbonate usually comprise the largest percentage of major ions found in water of the unconfined aquifers whereas greater proportions of calcium, magnesium, chloride, and sulfate may indicate agricultural or anthropogenic influences (Denver, 1986, 1993). With few exceptions, the water in the Columbia aquifer and unconfined portions of the Rancocas and Englishtown-Mt. Laurel aquifers can be classified as being primarily calcium-magnesium-bicarbonate type water indicating an anthropogenic/agricultural influence. Nitrate levels above those found under natural conditions and detectable levels of pesticides were detected in the majority of samples from the water-table aquifers.

Fifty-nine percent of the results fell outside the SMCL range set for pH (6.5-8.5). All four aquifer systems had at least one sample that fell below the suggested range. A total of three samples from the Potomac-Magothy and the Englishtown-Mt. Laurel aquifer systems had values slightly below a pH of 6.5. Twenty-four samples collected from the Rancocas and Columbia aquifers had pH values between 4.0 and 6.0. These two aquifers are shallow and receive acidic recharge from precipitation which has a pH of 3.5 to 4.5 on the Delmarva Peninsula (Bachman and Ferrari, 1995; Denver, 1986).

Manganese concentrations exceeded the SMCL (0.05 mg/L) in 26% of the samples. Manganese, like iron, is a common metallic element found in the earth's crust. Water percolating through soil and rock can dissolve minerals containing iron and manganese and hold them in solution. Iron and manganese are chemically similar and manganese is typically found in iron-bearing water (Hem, 1970; Driscoll, 1989). All four aquifer systems had at least one sample that exceeded the SMCL. This would be expected since all four systems contain some degree of iron-bearing minerals (Benson and Spoljaric, 1996; Denver, 1986).

Nitrate concentrations greater than background (0.4 mg/L) were detected in the majority (66.6%) of the total number of wells sampled (Figure 13). However, only two shallow monitor wells had concentrations exceeding the MCL of 10 mg/L. The shallow, water-table aquifer had the largest percentage of samples (92.5%) exceeding the background level followed by the unconfined portions of the Rancocas (71.4%) and Englishtown-Mt. Laurel (50.0%) aquifer systems. The Potomac-Magothy aquifer system had the lowest number of samples (one) with detections greater than or equal to 0.4 mg/L. Nitrates in this well are most likely due to failure of the well.

Chloride concentrations were at expected levels in all aquifers tested. This indicates that the confined aquifers are not, at this time, being affected by salt-water intrusion.

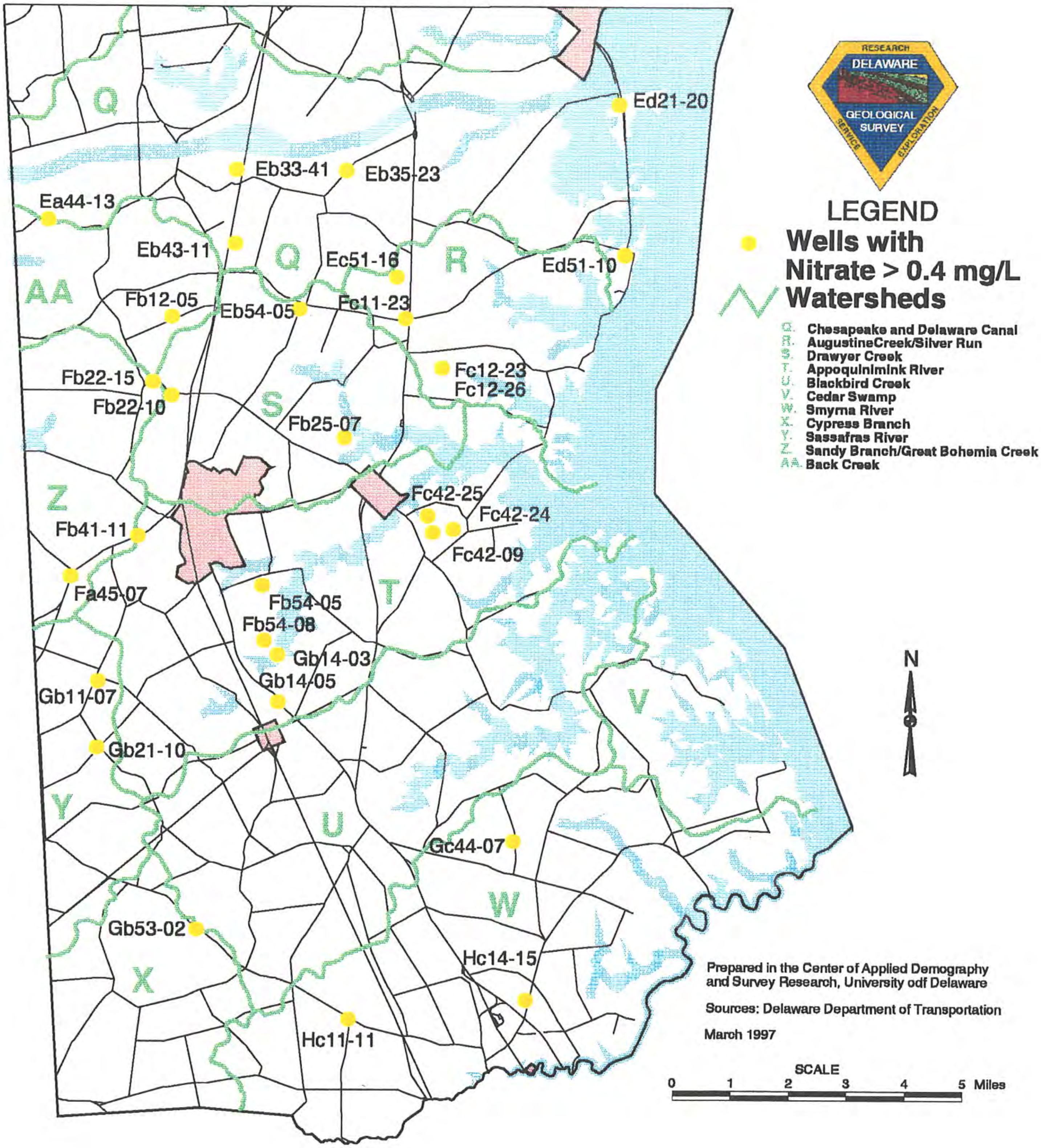

Figure 13. Map showing wells with nitrate values >0.4 mg/L.

Iron concentrations >0.3 mg/L were detected in 35% of the total number of wells sampled (Figure 14). The largest concentrations occurred in wells screened in the Potomac-Magothy aquifer system followed by those screened in the confined portion of the Englishtown-Mt. Laurel aquifer system. These results were not unexpected since these aquifers are comprised of sediments containing the iron-bearing minerals pyrite and siderite which exist under anoxic conditions.

Twenty-four samples were tested for atrazine, alachlor, metolachlor, carbofuran and cyanazine. Although 75% of the samples showed detectable levels of at least one of the pesticides (primarily atrazine), only one sample had an atrazine concentration above the MCL of 3 μg/L. The vast majority of the samples with detections had concentrations well below the MCLs for pesticides.

Radon was present at concentrations greater than the proposed MCL (300 pCi/L) in samples drawn from the Columbia aquifer (53%), Rancocas aquifer (60%), and the Englishtown-Mt. Laurel aquifer system (100%) (Figure 15). Radon concentrations in the Potomac-Magothy aquifer system were consistently below the proposed MCL. It must be made clear that the 300 pCi/L is a *proposed* MCL and the average radon concentration in public water systems is generally within the range of 100 to 1,000 pCi/L (Bachman and Ferrari, 1995). A ground-water value of 200 pCi/L is equivalent to 0.02 pCi/L in the air and is considered negligible (Hurlburt, 1989).

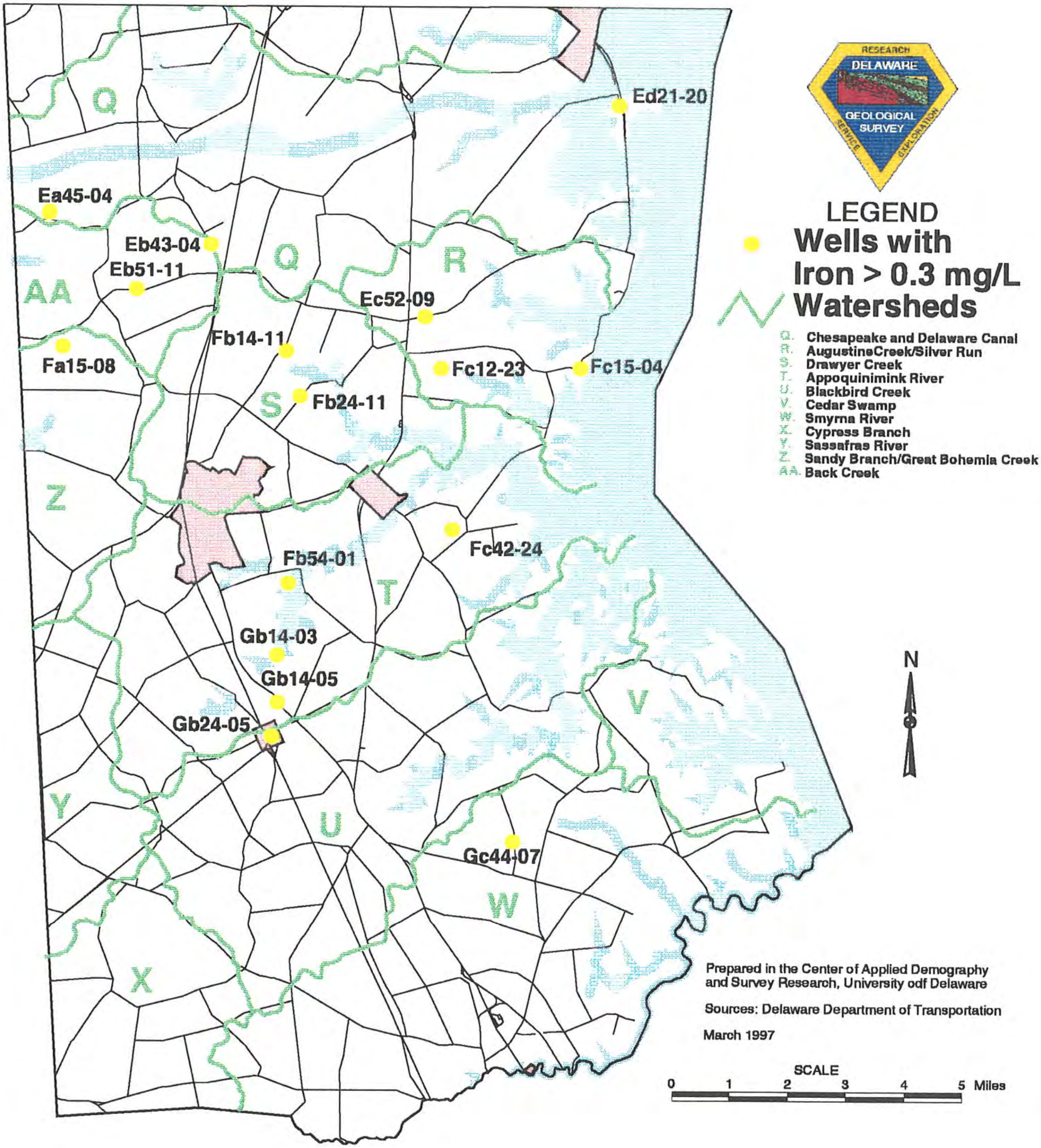

Figure 14. Map showing wells with iron concentrations >0.3 mg/L.

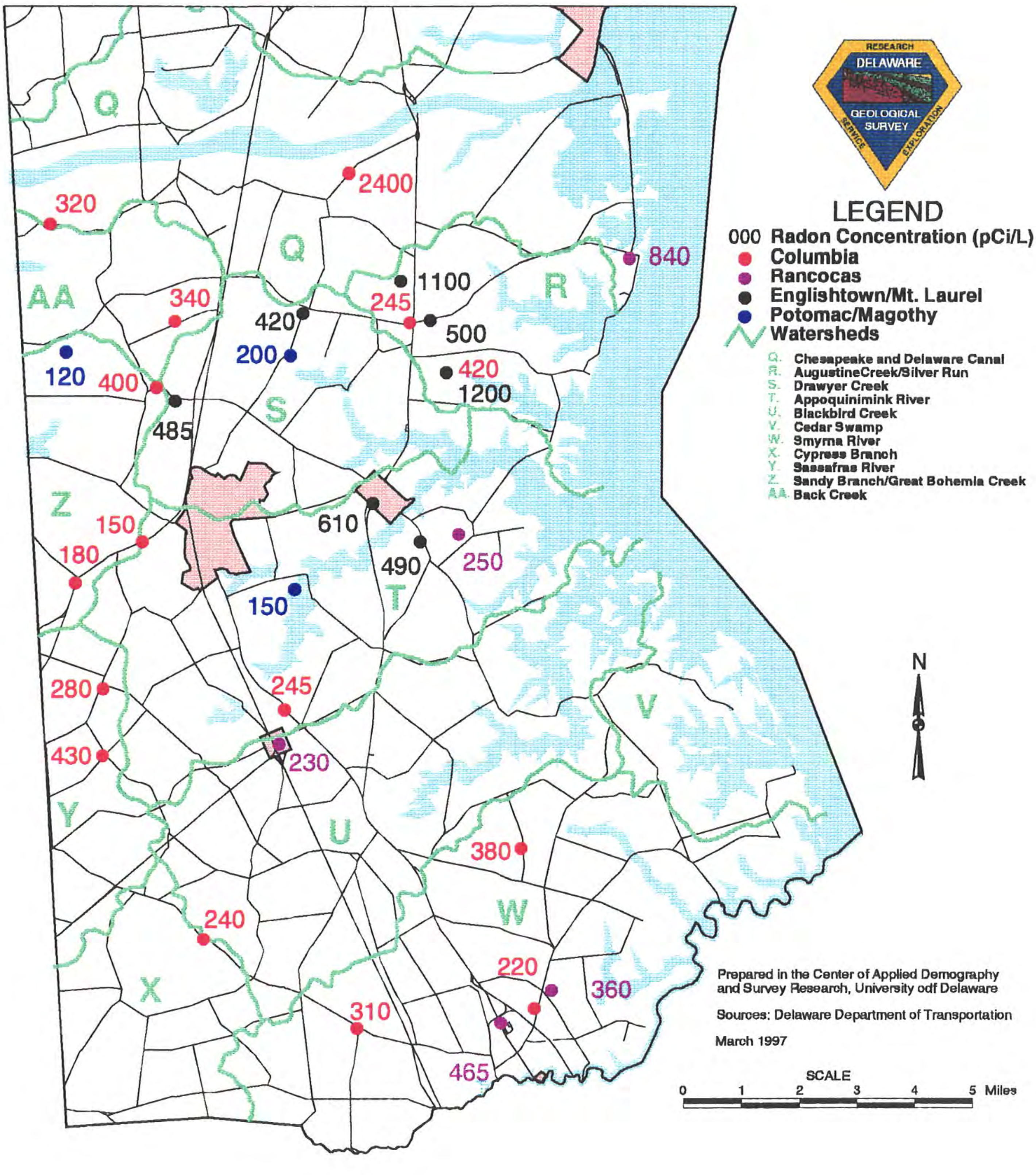

Figure 15. Map showing radon concentrations.

RECOMMENDATIONS

We recommend continuation of the southern New Castle County ground-water monitoring network as outlined in Appendix A. In order to conduct time-series analyses of ground-water quality, more than just a "snapshot" of the ground water is needed. Sampling during all seasons of the year over several years will provide the data necessary for a comprehensive understanding of the ground-water quality and will help in determining the sources of contamination. We recommend continued sampling of shallow, water-table wells and public wells on a quarterly basis and a yearly schedule for wells screened in the deeper, confined aquifers.

Flexibility is built into the sampling schedule to allow for modifications in the number of analyses as well as the number of wells sampled. New Castle County Department of Public Works, WRA, DGS, DDA, DNREC and DPH should evaluate the number of parameters tested on a yearly basis. New wells may be added or existing wells removed from the network to obtain the most efficient coverage of southern New Castle County.

The process of systematically assessing water quality in southern New Castle County began in Phase III and has provided the baseline from which future results can be compared to determine the impacts of specific land uses. The database will enable use of consistent and reliable data to examine temporal variability on short- and long-term time frames. Continued testing will provide a tool that will enable State and local officials to effectively manage ground-water development and use.

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APPENDIX A
Sampling Schedule Summary

		pH (field)	pH (lab)	Temp	Spec. Cond.	Ca	Mg	Na	Alk	SO_4	Cl	SiO_2	Fe	Mn	K	Cu
	Ea45-04	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Eb43-04	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Eb51-11	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Ec51-16	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Ec52-09	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Fa15-08	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
Public	Fb14-11	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
Wells	Fb24-11	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
(deep)	Fb54-01	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Fc12-23	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Fc15-04	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Fc31-11	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Fc42-13	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Gb24-05	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Hc13-02	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Hc14-03	DGS	DPH	DGS	DGS	ART	ART	NCC	DPH	NCC	DPH	ART	DPH	NCC	NCC	NCC
	Eb33-41	DGS	Current	DGS	DGS	ART	ART	Current	NCC	NCC	Current	ART	NCC	NCC	NCC	NCC
	Eb33-42	DGS	Current	DGS	DGS	ART	ART	Current	NCC	NCC	Current	ART	NCC	NCC	NCC	NCC
Monitor	Fc42-09	DGS	Current	DGS	DGS	ART	Current	Current	Current	Current	Current	Current	NCC	NCC	NCC	NCC
Wells	Fc42-24	DGS	Current	DGS	DGS	ART	Current	Current	Current	Current	Current	Current	NCC	NCC	NCC	NCC
(shallow)	Fc42-25	DGS	Current	DGS	DGS	ART	Current	Current	Current	Current	Current	Current	NCC	NCC	NCC	NCC
	Fb25-07	DGS	Current	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Fb12-05	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
Appoquinimink	Fb54-05	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
Study Wells	Fb54-08	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Gb14-03	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Eb43-11	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
DGS/USGS Wells	Eb54-05	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
(deep & shallow)	Ed21-20	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Ed51-10	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Fb22-10	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Ea44-13	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Eb35-23	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Fa45-07	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Fb22-15	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Fb41-11	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Fc11-23	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
New	Fc12-26	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
Monitor Wells	Gb11-07	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
(shallow)	Gb14-05	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Gb21-10	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Gb53-02	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Gc44-07	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Hc11-11	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC
	Hc14-15	DGS	NCC	DGS	DGS	ART	ART	NCC	NCC	NCC	NCC	ART	NCC	NCC	NCC	NCC

Key:

(shaded) Quarterly analysis

(unshaded) Initial analysis to begin in the Summer of 1996. Any detects in the initial analysis would warrant further sampling. If there are no detects, yearly sampling is sufficient.

DDA = Delaware Department of Agriculture

DGS = Delaware Geological Survey

DPH = Delaware Division of Public Health

NCC = New Castle County Department of Public Works

ART = Artesian Laboratories, Inc.

USGS = U.S. Geological Survey, National Water-Quality Laboratory, Arvada, CO

Current= Required or currently being tested by owner/operator of facility

APPENDIX A
Sampling Schedule Summary

		Pb	Zn	Fl	Radon	DO	TOC	TDS	Total Phos.	Ortho-Phos.	Ammonia Nitrogen	Nitrate Nitrogen	Nitrite Nitrogen	Pest.
	Ea45-04	NCC	NCC	NCC	-	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Eb43-04	NCC	NCC	NCC	-	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Eb51-11	NCC	NCC	NCC	-	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Ec51-16	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Ec52-09	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Fa15-08	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
Public	Fb14-11	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
Wells	Fb24-11	NCC	NCC	NCC	USGS*	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
(deep)	Fb54-01	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Fc12-23	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Fc15-04	NCC	NCC	NCC	-	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Fc31-11	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Fc42-13	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Gb24-05	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Hc13-02	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Hc14-03	NCC	NCC	NCC	USGS	DGS	ART	DPH	NCC	NCC	NCC	DPH	NCC	-
	Eb33-41	NCC	NCC	NCC	USGS*	DGS	ART	Current	Current	NCC	Current	Current	NCC	DDA
	Eb33-42	NCC	NCC	NCC	-	DGS	ART	Current	Current	NCC	Current	Current	NCC	-
Monitor	Fc42-09	NCC	NCC	NCC	-	DGS	ART	Current	Current	NCC	Current	Current	Current	-
Wells	Fc42-24	NCC	NCC	NCC	USGS	DGS	ART	Current	Current	NCC	Current	Current	Current	DDA
(shallow)	Fc42-25	NCC	NCC	NCC	-	DGS	ART	Current	Current	NCC	Current	Current	Current	-
	Fb25-07	NCC	NCC	NCC	USGS*	DGS	Current	Current	NCC	NCC	NCC	NCC	NCC	DDA
	Fb12-05	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
Appoquinimink	Fb54-05	NCC	NCC	NCC	-	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
Study Wells	Fb54-08	NCC	NCC	NCC	USGS*	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Gb14-03	NCC	NCC	NCC	-	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	-
	Eb43-11	NCC	NCC	NCC	-	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
DGS/USGS Wells	Eb54-05	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
(deep & shallow)	Ed21-20	NCC	NCC	NCC	-	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	-
	Ed51-10	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Fb22-10	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	-
	Ea44-13	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Eb35-23	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Fa45-07	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Fb22-15	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Fb41-11	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Fc11-23	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
New	Fc12-26	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
Monitor Wells	Gb11-07	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
(shallow)	Gb14-05	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Gb21-10	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Gb53-02	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Gc44-07	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Hc11-11	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA
	Hc14-15	NCC	NCC	NCC	USGS	DGS	ART	NCC	NCC	NCC	NCC	NCC	NCC	DDA

APPENDIX B

WELL COMPLETION REPORTS

MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 108634 LOCAL ID 17
Owner NCC DEPT. of Public Works
Address 2701 CAPITAL TRAIL
City NEWARK State DE Zip 19711
Telephone Number 302-366-7850
Consulting Firm/Supervising Geologist (If applicable) DGS
Telephone Number 302-831-8261
Well Contractor DGS - BOUNDS
Date of Completion 7-11-96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [x] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.
Ea44-13
Lat. - 39°31'26"
Lon. - 75°46'02"
Elkton Quadrangle
Chesapeake Drainage Basin

WELL CONSTRUCTION

Total depth drilled: 18.0'
Depth to water 8.11'
Surveyed Top of Casing Elevations
______ (Inner) ______ (Outer) Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.0
Casing bottom		7.0'
Casing diameter		2.0"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		7.0'
Screen bottom		17.0'
Screen diameter		2.0"
Screen material		PVC

Type of Grout cement/bentonite from 0 to 6.0
Gravel pack interval from 6.0' to 17.0'
Aquifer/Formation screened in: Cls
Type of samples (ditch, split spoon, etc.)

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top Soil	0.0	0.5'
Sand, orange with brown mottling fine silty moist c-gravel pieces throughout - drilling eased up from 6.0 - 6.5'	0.5	4.4'
Sand, orange fine grading to coarse near 9.4'. Slightly silty. wet about 8.0-9.4	4.4'	9.4'
Sand orange wet m-c two fines	9.4'	14.4'
Same as 9.4-14.4 bit siltier with some large pieces of gravel	14.4'	18.0'

Samples Logged By: Stefanie BAXTER (Name)
Research Assoc. (Title) DGS (Company)

Well Drilled By: R. BOUNDS DGS (Company Name)

[illegible] 7/29/96
(Signature of Driller in Charge) (Date)

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [x]
PAGE 1 OF 1 PAGES

White - Water Supply • Canary - Other • Pink - Owner • Goldenrod - Contractor

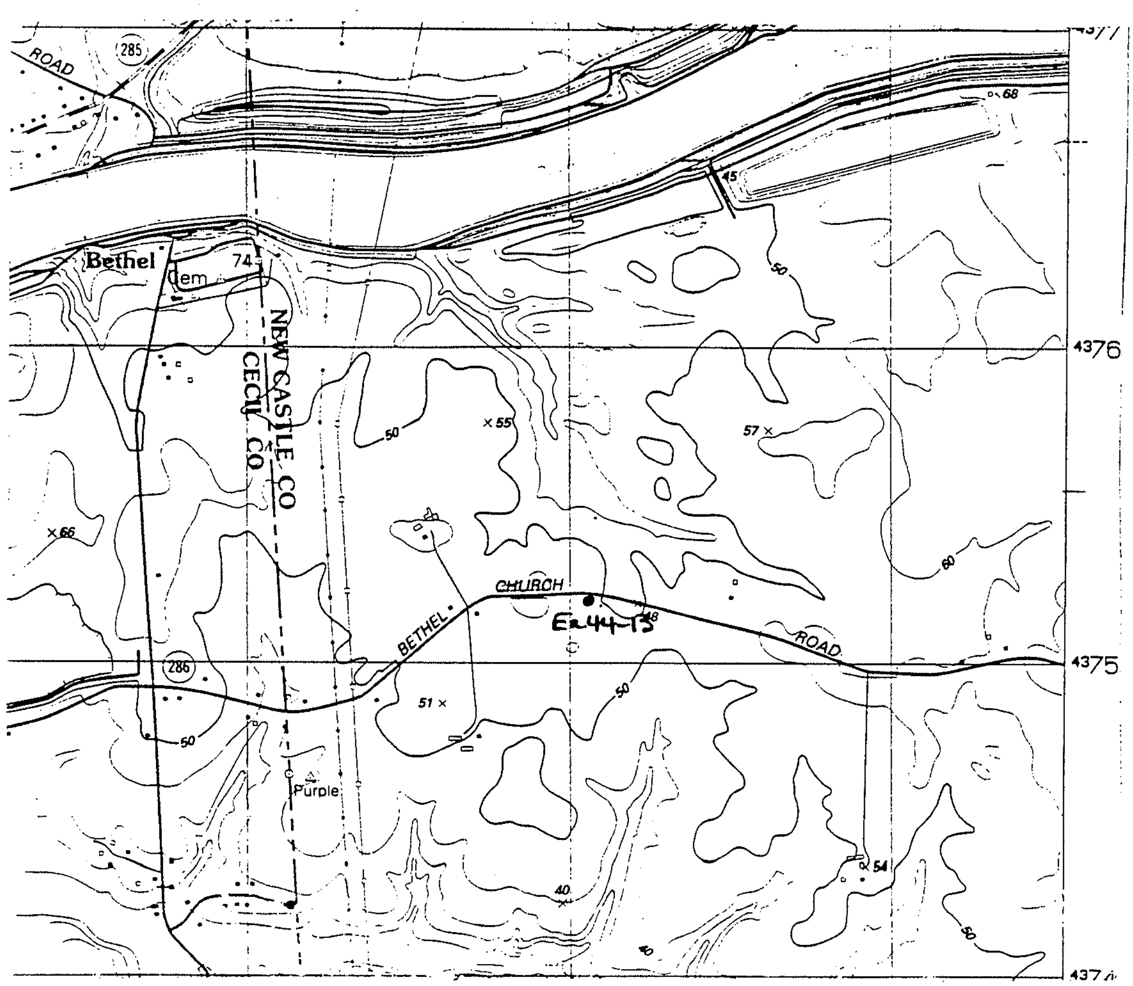
DOCUMENT NO. 40-08/87/02/03 - EC 81

Date Filed 10-22-96

NOTES Ea44-13

CORE SAMPLES 87395-87393

LOCATION MAP



MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 108633 LOCAL ID 16
Owner NCC DEPT. of Public Works
Address 2701 Capital Trail
City Newark State DE Zip 19711
Telephone Number 302-366-7850
Consulting Firm/Supervising Geologist (If applicable) DGS
Telephone Number 302-831-8261
Well Contractor DGS- BOUNDS
Date of Completion 7-11-96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

WELL CONSTRUCTION

Total depth drilled: 16.0'
Depth to water 6.15'
Surveyed Top of Casing Elevations
____ *Inner* ____ *Outer* Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.0
Casing bottom		5.0'
Casing diameter		2.0"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		5.0'
Screen bottom		15.0'
Screen diameter		2.0"
Screen material		PVC

Type of Grout cement/bentonite from 0 to 3.5'
Gravel pack interval from 3.5' to 15.0'
Aquifer/Formation screened in: Clg
Type of samples (ditch, split spoon, etc.)

Samples Logged By: Stefanie Baxter *(Name)*
Research Assoc. *(Title)* DGS *(Company)*

Well Drilled By: DGS - BOUNDS *(Company Name)*

Ward C. Bounds 7/29/96
(Signature of Driller in Charge) *(Date)*

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [X] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.
Eb35-23
Lat. - 39° 32' 10"
Lon. - 75° 40' 16"
Saint Georges Quadrangle
Chesapeake + Delaware Canal Drainage Basin

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top Soil	0.0	0.5'
Sand, f-c, orange-brown, some large gravel pieces scattered throughout, silty, moist	0.5'	4.2'
Sand, clayey, f-c, green near top changing to orange near bottom gravel pieces throughout wet at 6.0'.	4.2'	9.2'
Sand, med, mostly orange with some green sand a bit of clay, wet.	9.2'	14.2'
Sand, med, scattered pieces of ironstone, orange + dark green color slightly silty, wet	14.2'	16.0'

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [X]
PAGE 1 OF 1 PAGES

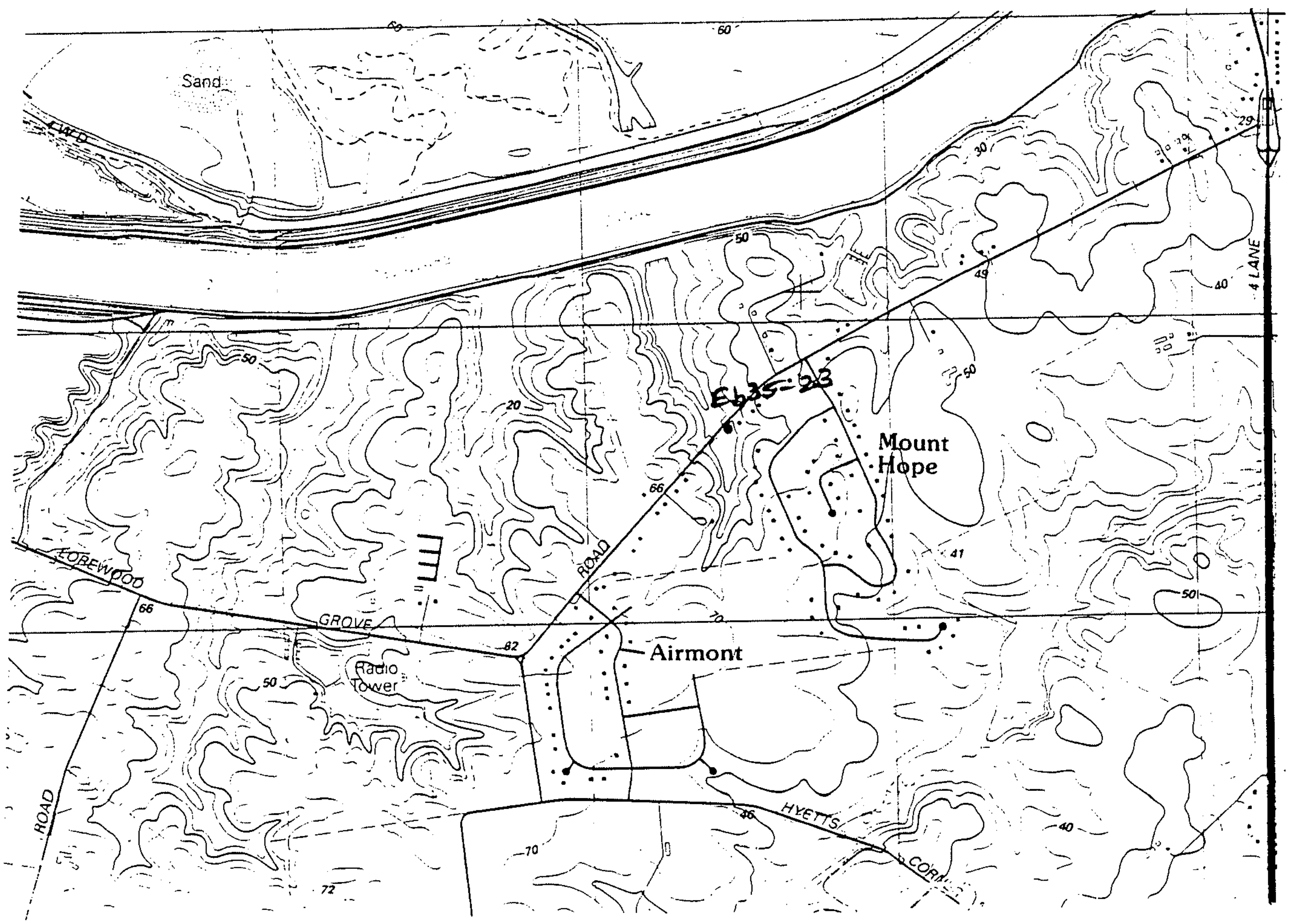
Date Filed 10-22-96

NOTES Eb35-23

CORE SAMPLES 87352-87355

Developed 7/29/96

LOCATION MAP



MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 106882 LOCAL ID 5
Owner NCC Dept. of Public Works
Address 2701 Capitol TRAIL
City Newark State DE Zip 19711
Telephone Number 302-366-7850
Consulting Firm/Supervising Geologist (If applicable) DGS-Roland BOUNDS
Telephone Number (302)-831-8261
Well Contractor DGS-BOUNDS
Date of Completion 5/21/96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [X] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.
Fa45-07
Lat.-39°26'05"
Lon.-75°45'28"
Cecilton Quadrangle
Chesapeake Drainage Basin

WELL CONSTRUCTION

Total depth drilled: 25'
Depth to water 14.92'
Surveyed Top of Casing Elevations
______ (Inner) ______ (Outer) Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		6
Casing bottom		14'
Casing diameter		2"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		14'
Screen bottom		24'
Screen diameter		2"
Screen material		PVC

Type of Grout Cement/bentonite from 11.3 to 0
Gravel pack interval from 24' to 11.3'
Aquifer/Formation screened in: Columbia
Type of samples (ditch, split spoon, etc.) split spoon

Samples Logged By: Stefanie BAXTER (Name)
RESEARCH Assoc. (Title) DGS (Company)

Well Drilled By: DGS (Company Name)

Roland E Bounds (Signature of Driller in Charge) 6/17/96 (Date)

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top soil	0.0'	1.5'
Clayey silt, traces of sand, brown-orange, very moist	1.5'	3.9'
Sand, f-c, trace of silt, orange thin lens of gravel at 7.5'	3.9'	8.9' *
Sand, f-M, clean, trace of silt, orange brown	8.9'	10.4'
Lens of manganese-stained sand w/ traces of Mica	10.4'	10.6'
Thin lenses of very fine sandy silt	10.6'	10.9'
Gravel lens	10.9'	11.0'
Sand, f-M, clean, orange, gravel lens at 12.9'	11.0	13.9'
Sand, M-C, orange very wet w/ gravel lenses at 14.0 + 16.9'	13.9'	18.9'
Sand, M-C, w/ gravel, orange, very wet, w/ manganese specks from 18.9' to 22.9'	18.9'	24.0'

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [X]
PAGE 1 OF ____ PAGES

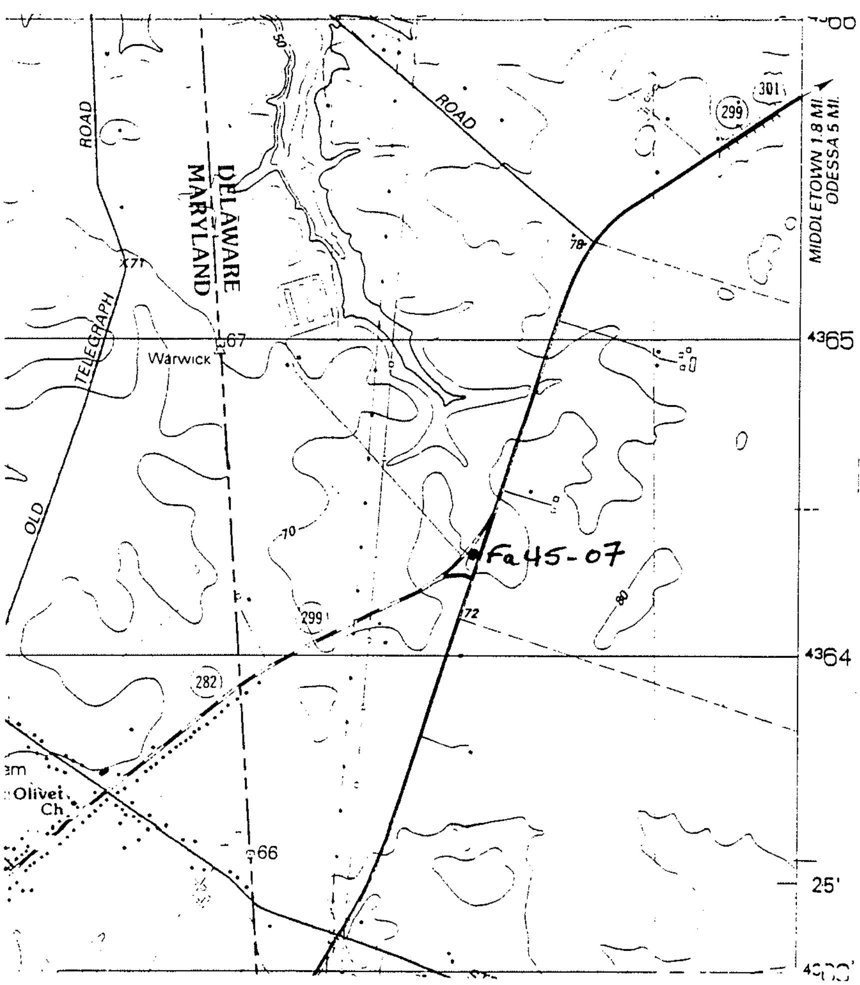
Date Filed 10-22-96

NOTES Fa45-07

CORE SAMPLES 87362-87366

Developed 8/6/96

LOCATION MAP



MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 106874 LOCAL ID 2
Owner NCC Dept. of Public Works
Address 2701 Capitol Trail
City Newark State DE Zip 19711
Telephone Number 302-366-7850
Consulting Firm/Supervising Geologist (If applicable) DGS
Telephone Number 831-2833
Well Contractor DGS _ Bounds
Date of Completion 6-25-96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

WELL CONSTRUCTION

Total depth drilled: 24.2'
Depth to water 6.29'
Surveyed Top of Casing Elevations
_____ (Inner) _____ (Outer) Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.0'
Casing bottom		14.0'
Casing diameter		2.0"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		14.0'
Screen bottom		24.0'
Screen diameter		2.0"
Screen material		PVC

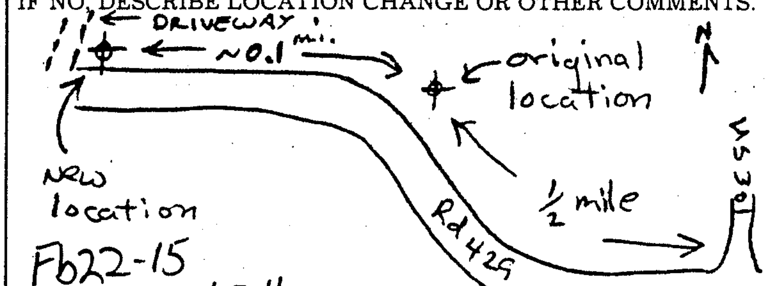
Type of Grout bentonite/cement from 0.0' to 12.0'
Gravel pack interval from 12.0' to 24.0'
Aquifer/Formation screened in: Clg
Type of samples (ditch, split spoon, etc.) ditch

Samples Logged By: Stefanie BAXTER (Name)
Research Assoc. (Title) DGS (Company)

Well Drilled By DGS (Company Name)

Roland E. Bounds 6/26/96
(Signature of Driller in Charge) (Date)

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [ ] NO [X]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.



Fb22-15
Lat. - 39°29'59"
Lon. - 75°43'55"
Appoquinimink Creek Dr. Basin
ARMSTRONG CORNER
Middletown Quadrangle

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top Soil	0.0	0.5'
Sand, fine, yellow-brown, slightly silty w/ gravel & coarse sand from 1.0'-2.0'.	0.5'	4.2'
Sand, M-C, brown-orange w/ a few heavy minerals. wet. Clayey at top, silty towards bottom.	4.2	9.2
Sand f-M orange wet, few mica flakes, fairly clean.	9.2	17.2
Sand, M-C, orange traces of gravel wet.	17.2	19.2
Sand, Coarse, orange-brown, fairly clean, trace of silt w/ scattered large gravel pieces.	19.2	24.2

SUPPLEMENTAL DRILLERS LOG ATTACHED? YES [ ] NO [X]
PAGE 1 OF ___ PAGES

White - Water Supply • Canary - Other • Pink - Owner • Goldenrod - Contractor

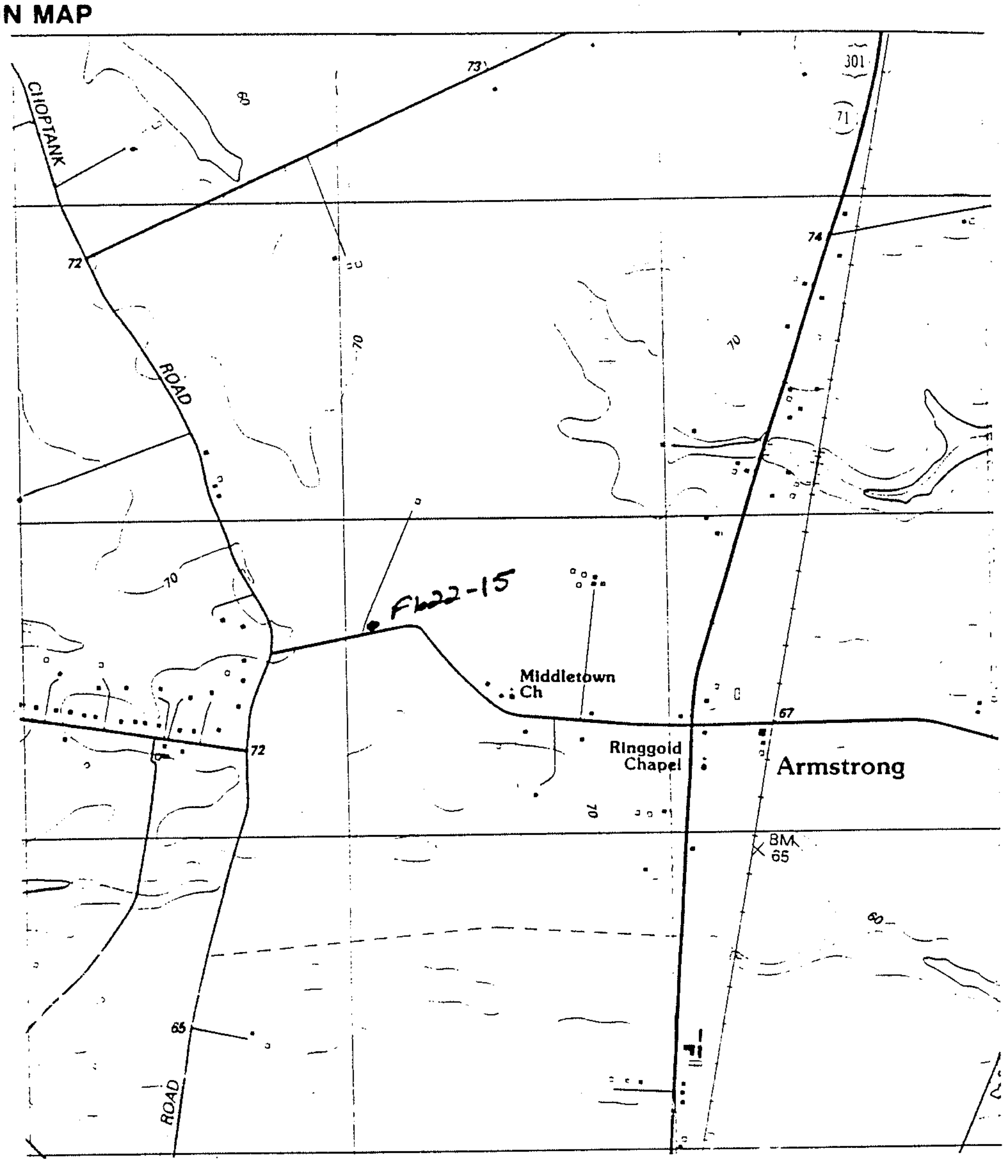
DOCUMENT NO. 40-08/87/02/03 - EC 81

Date Filed 10-22-96

NOTES Fb22-15

CORE SAMPLES 87102-87106

LOCATION MAP



DGS 1-84

MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 106881 LOCAL ID 4
Owner NCC Dept of Public Works
Address 2701 Capital Trail
City Newark State DE Zip 19711
Telephone Number 302-366-7850
Consulting Firm/Supervising Geologist (If applicable)
DGS-Roland Bounds
Telephone Number 302-831-8261
Well Contractor DGS-Bounds
Date of Completion 5-30-96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [X] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.
Fb41-11
Lat. - 39° 26' 39"
Lon. - 75° 44' 11"
Middletown Quadrangle
Appoquinimink Creek Drainage Basin

WELL CONSTRUCTION

Total depth drilled: 23'
Depth to water 11.5'
Surveyed Top of Casing Elevations
______ Inner ______ Outer Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.0
Casing bottom		13.0'
Casing diameter		2"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		13.0'
Screen bottom		23.0'
Screen diameter		2"
Screen material		PVC

Type of Grout Cement/bentonite from 11.0' to 0.0
Gravel pack interval from 11.0' to 23.0'
Aquifer/Formation screened in: Columbia
Type of samples (ditch, split spoon, etc.)
Split spoon

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top soil	0.0'	1.0'
Silty sand med, moist, moderate brown color	1.0'	3.2'
Silty sand f-M mod. brown, moist	3.2'	4.0'
Sand, f-c mod. brown w/ a bit more orange color fairly clean, traces of silt, wet	4.0'	5.7
Sand, f-c, mod. brown, fairly clean, moist	5.7'	8.0'
Sand, f-M, very clean, mod. brown, very moist	8.0'	9.0'
Sand, f-c, light brown to tan, clean, very wet	9.0'	19.0'
Sand, m-vc, tan, very clean, very wet	19.0'	24.0

Samples Logged By: Stefanie Baxter (Name)
Research Assoc. (Title) DGS (Company)

Well Drilled By: DGS (Company Name)

Roland E. Bounds (Signature of Driller in Charge) 6/17/96 (Date)

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [X]
PAGE 1 OF ______ PAGES

White - Water Supply • Canary - Other • Pink - Owner • Goldenrod - Contractor

DOCUMENT NO. 40-08/87/02/03 - EC 81

Date Filed 10-22-96

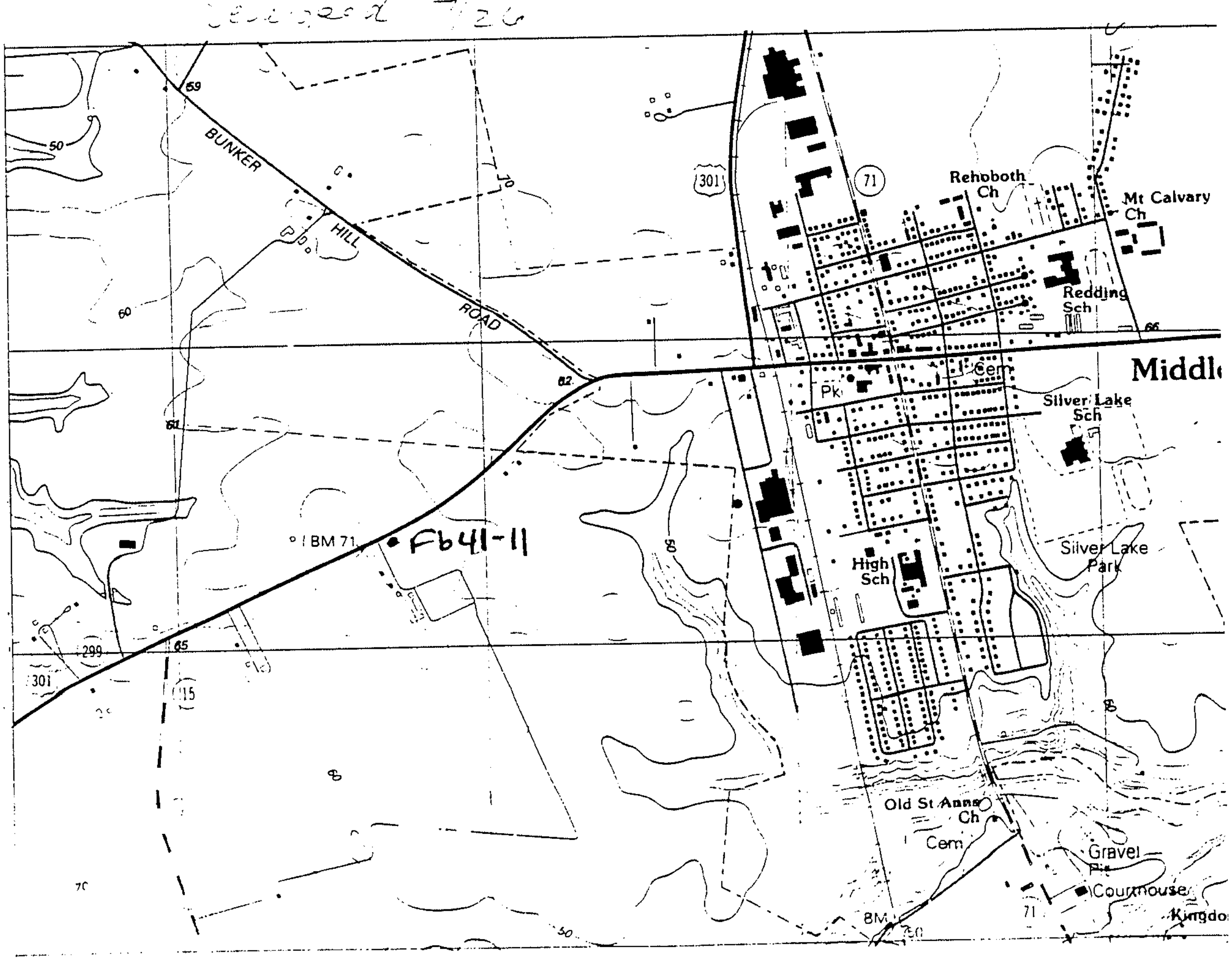
NOTES Fb41-11

CORE SAMPLES 87383-87386 AND

26304-26306

Developed 7/26/96

LOCATION MAP



DGS/1-84

MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 106883 LOCAL ID 8
Owner NCC Dept. of Public Works
Address 2701 Capitol Trail
City Newark State DE Zip 19
Telephone Number 302-362-7850
Consulting Firm/Supervising Geologist (If applicable) DGS
Telephone Number 302-831-2833
Well Contractor DGS/ BOUNDS #68
Date of Completion 5-1-96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

WELL CONSTRUCTION

Total depth drilled: 39.5'
Depth to water 27.5'
Surveyed Top of Casing Elevations
______ Inner ______ Outer Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top	0	
Casing bottom	29.0'	
Casing diameter	2"	
Casing material	PVC	

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top	29.0'	
Screen bottom	39.0'	
Screen diameter	2.0"	
Screen material	PVC	

Type of Grout cement bentonite mix from 0 to 23'
Gravel pack interval from 23.0' to 39.0'
Aquifer/Formation screened in: Columbia
Type of samples (ditch, split spoon, etc.) split spoon + ditch

Samples Logged By: S. Baxter (Name)
Research Associate (Title) DGS (Company)

Well Drilled By: Del. Geol. Survey (Company Name)

Roland C. Bounds 5/10/96
(Signature of Driller in Charge) (Date)

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [X] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.

Fc11-23
Lat.-39°29'58"
Lon.-75°39'02"
Middletown Quadrangle
Chesapeake + Delaware Canal Drainage Basin

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top soil	0.0	0.5
Clayey silt, yellow-brown; orange + brown mottling. moist - very moist	0.5	4.5
SAME	4.5	6.7
gravel	6.7	9.0
gravel with Alternating layers of clayey sand. Sand is fine to med, orange-brown + moist. Sand is fairly clean at 9.5	9.0	9.5
Orange clean very wet sand + gravel. Sand is fine to coarse	9.5	14.5
Sand + gravel Some gravel up to 1.5" in length; orange very moist. gravel end at 19.0'	14.5	19.5
Sand, very clean, fine-med, yellow-brown.	19.5	39.5

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [X]
PAGE 1 OF 1 PAGES

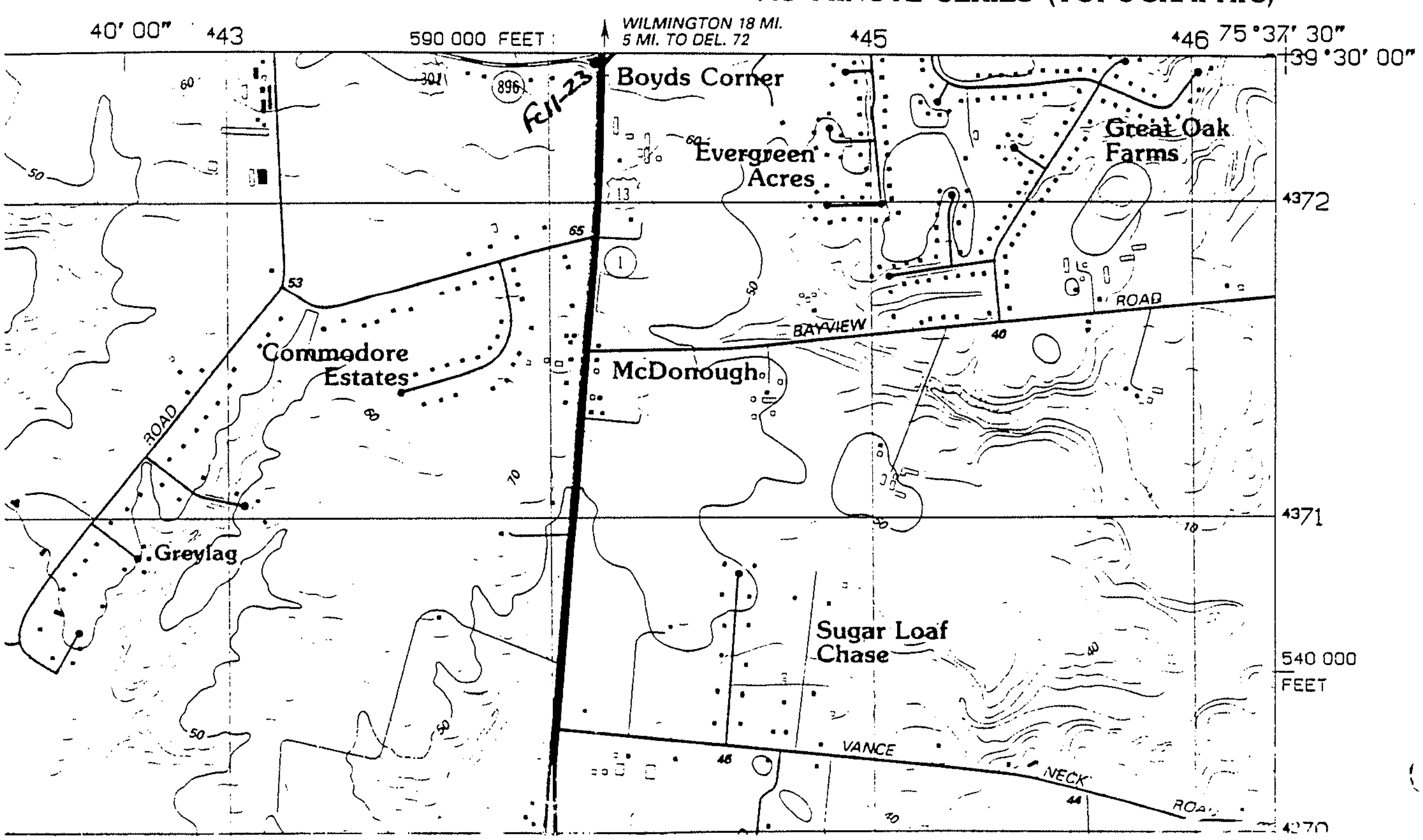
Date Filed 10-22-96

NOTES Fc11-23

CORE SAMPLES 87372-87379 + 26301

LOCATION MAP

MIDDLETOWN QUADRANGLE
DELAWARE-NEW CASTLE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 168632 LOCAL ID 15
Owner NCC Dept. of Public Works
Address 2701 Capitol Trail
City Newark State DE Zip 19711
Telephone Number 302-831-8261
Consulting Firm/Supervising Geologist (If applicable) DGS
Telephone Number 302-831-8261
Well Contractor DGS - BOUNDS
Date of Completion 7/16/96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

WELL CONSTRUCTION

Total depth drilled: 29.5
Depth to water 20.0'
Surveyed Top of Casing Elevations
______ Inner ______ Outer Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.0'
Casing bottom		18.0'
Casing diameter		2.0"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		18.0'
Screen bottom		28.0'
Screen diameter		2.0"
Screen material		PVC

Type of Grout Cement/bentonite from 0.0 to 16.0
Gravel pack interval from 16.0 to 28.0
Aquifer/Formation screened in: Clg
Type of samples (ditch, split spoon, etc.)

Samples Logged By: Stefanie BAXTER (Name)
Research Assoc. (Title) DGS (Company)

Well Drilled By: DGS - BOUNDS (Company Name)

Roland E. Bounds 7/29/96
(Signature of Driller in Charge) (Date)

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [X] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.

Fc12-26
Lat. - 39°29'13"
Lon. - 75°38'20"
Middletown Quadrangle
Chesapeake + Delaware Canal Drainage

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top Soil	0.0	0.5'
Clayey sand, f, yellow brown, slightly moist	0.5'	4.5
Sand, M-C with gravel from 5.0-6.0'. Yellow brown fairly clayey, slightly moist	4.5'	9.5'
Sand, M-C with gravel throughout. yellow brown slightly clayey, a bit moister at 14.0-14.5'	9.5'	14.5'
Sand, M-C orange, ironstone from 16.0-16.5'. Heavier throughout, pieces of gravel, slightly clayey, very moist	14.5'	19.5'
Sand, coarse with large pieces of gravel orange, silty wet at 20.0'	19.5'	24.5'
Same as above interval only green sand/clay from 28.5-29.5'. Mostly clay at base w/ gravel	24.5'	29.5'

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [X]
PAGE 1 OF ____ PAGES

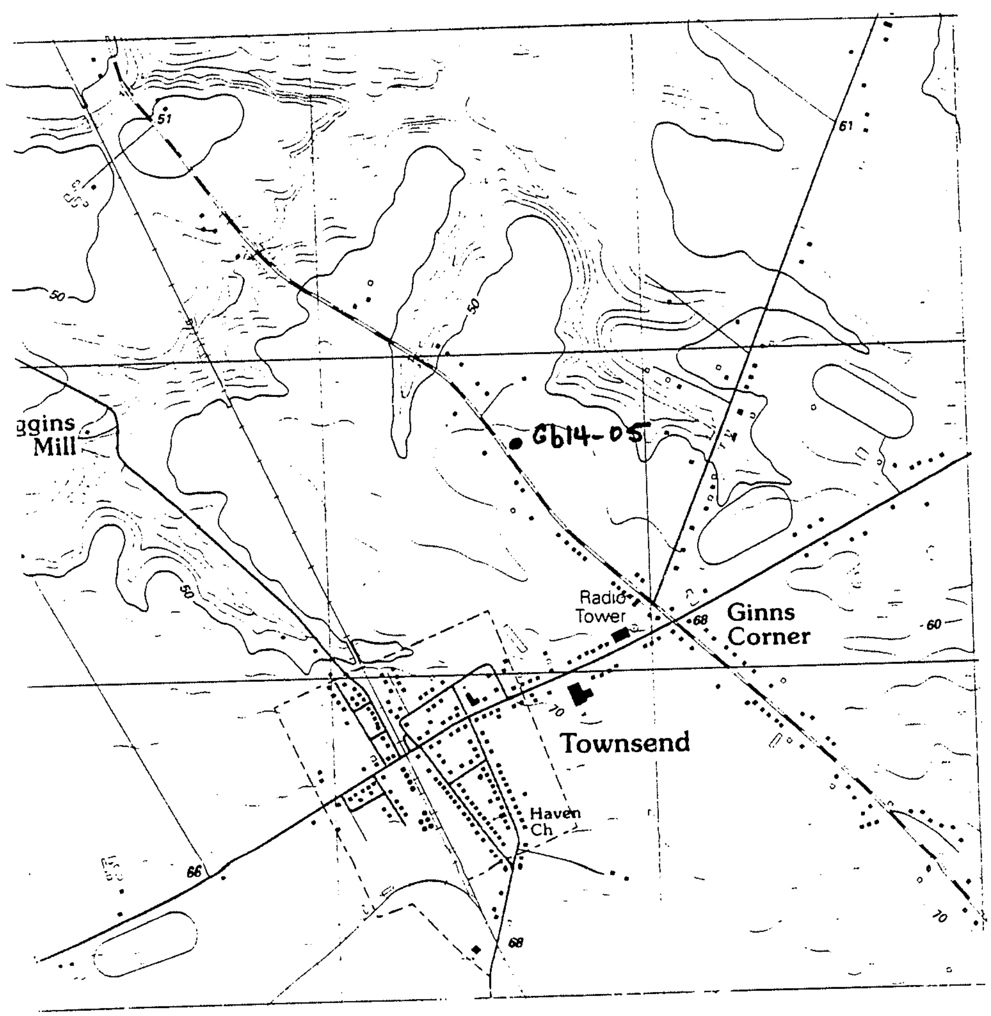
Date Filed 10-22-96

NOTES Gb14-05

CORE SAMPLES 87348-87351

Developed 8/6/96

LOCATION MAP



MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 106885 LOCAL ID 10
Owner NCC Dept of Public Works
Address 2701 Capital Trail
City Newark State DE Zip 1971I
Telephone Number 302-366-7850
Consulting Firm/Supervising Geologist (If applicable) DGS
Telephone Number 302-831-2833
Well Contractor DGS - BOUNDS
Date of Completion 6/27/96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

WELL CONSTRUCTION

Total depth drilled: 18.7'
Depth to water 4.0'
Surveyed Top of Casing Elevations
_____ Inner _____ Outer Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.0'
Casing bottom		5.0'
Casing diameter		2.0"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		5.0'
Screen bottom		15.0'
Screen diameter		2.0"
Screen material		PVC

Type of Grout bent./cement from 0.0 to 3.5
Gravel pack interval from 3.5 to 15.0
Aquifer/Formation screened in: Cls
Type of samples (ditch, split spoon, etc.) ditch

Samples Logged By: Stefan Baxter (Name)
Research Assoc. (Title) DGS (Company)

Well Drilled By: DGS (Company Name)

Roland E. Bounds (Signature of Driller in Charge) 6/27/96 (Date)

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [X] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.

Gb21-10
Lat. - 39°23'24"
Lon. - 75°44'56"
Middletown Quadrangle
Chesapeake Drainage Basin

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top soil	0.0	0.5'
Sand, f-m, orange-brown, trace of clay, moist, with gravel from 2.3-2.9'	0.5	3.7'
Sand, m-c, buff, wet, clean.	3.7'	8.7'
Sand, coarse w/ gravel, buff, wet, clean.	8.7'	10.7'
Sand, coarse, orange, trace of gravel, wet.	10.7'	13.7'
Sand, m-c, w/ clay, orange, wet. Abrupt change at 15.7' to black clay w/ gravel	13.7'	15.7'
Clay, dense, black-grey, moist	15.7'	18.7'

SUPPLEMENTAL DRILLERS LOG ATTACHED? YES [ ] NO [X]
PAGE 1 OF _____ PAGES

White - Water Supply • Canary - Other • Pink - Owner • Goldenrod - Contractor

DOCUMENT NO. 40-08/87/02/03 - EC 81

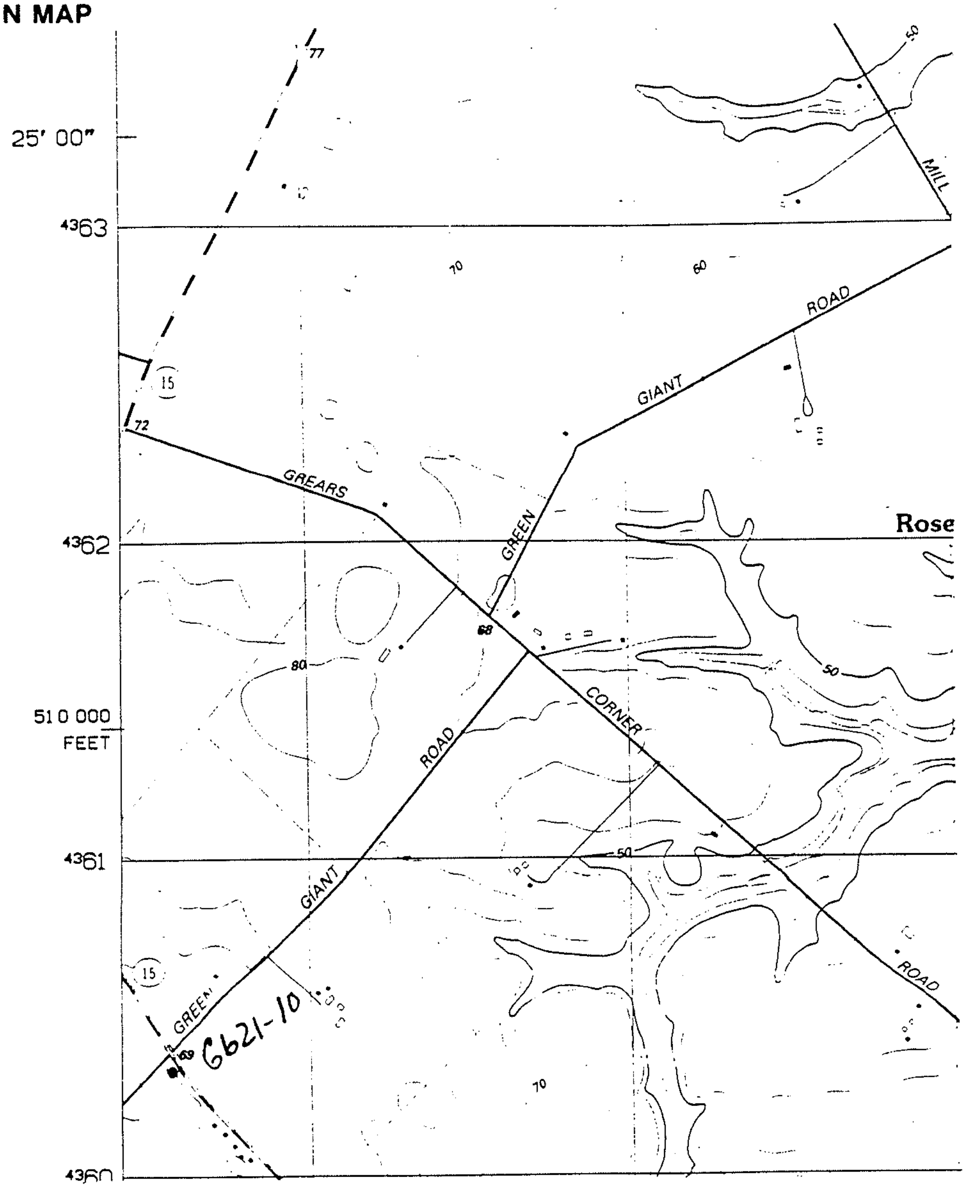
Date Filed 10-22-96

NOTES Gb21-10

CORE SAMPLES 87356-87361

Developed 7/31/96

LOCATION MAP



DGS/1-84

MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 106890 LOCAL ID 12
Owner NCC Dept of Public Works
Address 2701 Capitol Trail
City Newark State DE Zip 1974
Telephone Number (302) - 366 - 7850
Consulting Firm/Supervising Geologist (If applicable) DGS
Telephone Number 831-2833
Well Contractor DGS - BOUNDS
Date of Completion 6/18/96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

WELL CONSTRUCTION

Total depth drilled: 24'
Depth to water 3.57'
Surveyed Top of Casing Elevations
_____ (Inner) _____ (Outer) Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.0'
Casing bottom		14.0'
Casing diameter		2.0"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		14.0'
Screen bottom		24.0'
Screen diameter		2.0"
Screen material		PVC

Type of Grout Cement/bentonite from 0.0 to ~~8.7~~ 9.3'
Gravel pack interval from 9.3' to 24.0'
Aquifer/Formation screened in: unconfined
Type of samples (ditch, split spoon, etc.) split spoon

Samples Logged By: Stefanie Baxter (Name)
Research Assoc. (Title) DGS (Company)

Well Drilled By: DGS (Company Name)

[signature] 6/24/96
(Signature of Driller in Charge) (Date)

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [x] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.

Gb53-02
Lat. - 39°20'38"
Lon. - 75°42'58"
Clayton Quadrangle
Blackbird Creek Drainage Basin

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top Soil	0.0	0.4'
Sand, clayey, f-m tacky, moist yellow-brown w/ a few lt. grey lenses of clay.	0.4'	3.9'
Sand, m-c, tan and orange, small amount of silt w/ a few heavy minerals, moist.	3.9'	5.9'
Sand, f-m, silty, tan and lt. grey wet,	5.9'	8.9'
Silty clay, grey, trace of sand	8.9'	10.6'
Clay, grey, moist w/ a trace of sand.	10.6'	10.9'
Silt, red-orange with a trace of fine sand, wet	10.9'	13.9'
Sand, m-c, orange silty, wet	13.9'	18.9'
Sand, coarse, clean w/ just a trace of silt.	18.9'	23.9'

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [ ]
PAGE 1 OF _____ PAGES

White - Water Supply • Canary - Other • Pink - Owner • Goldenrod - Contractor

DOCUMENT NO. 40-08/87/02/03 - EC 81

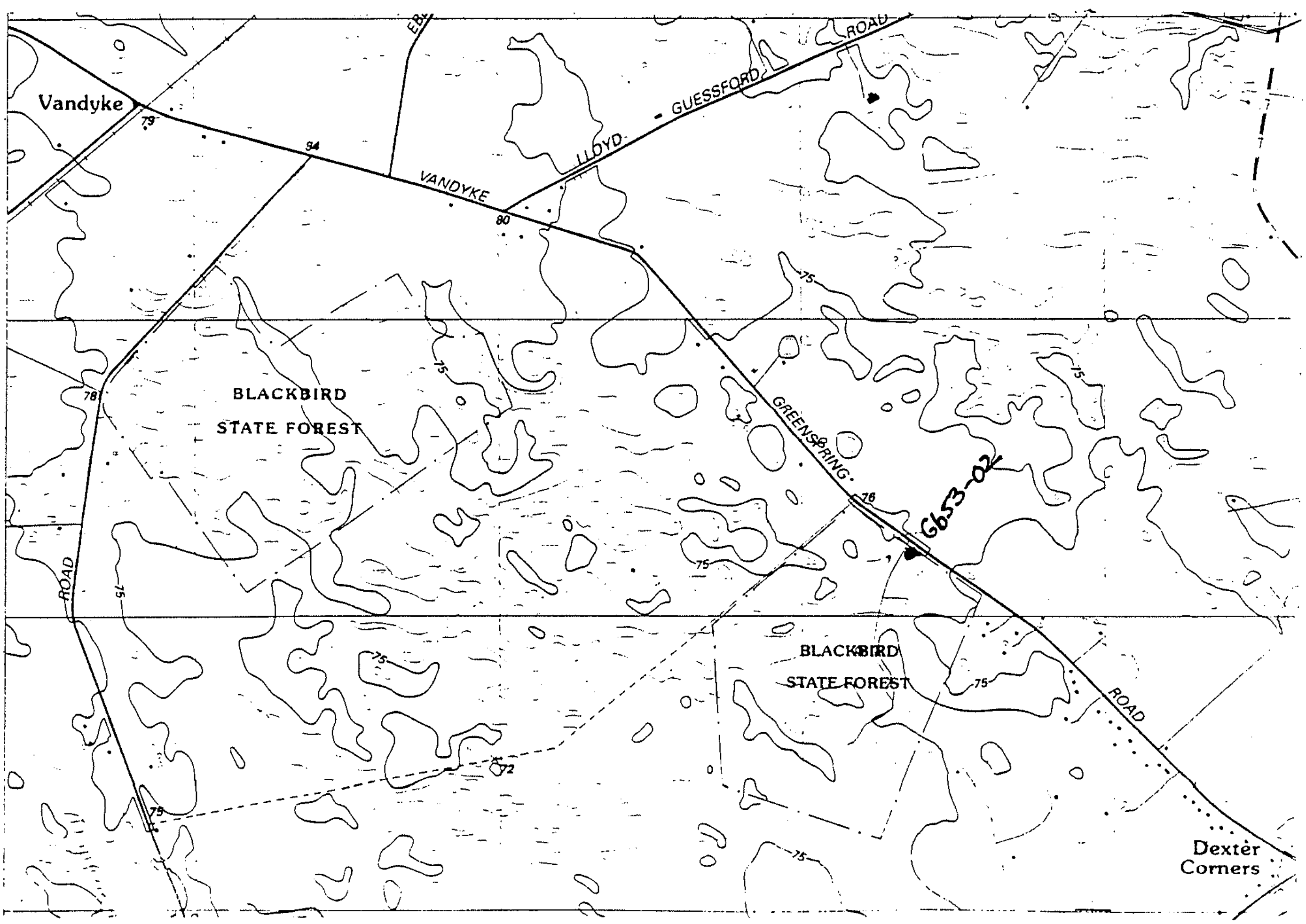
Date Filed 10-22-96

NOTES Gb53-02

CORE SAMPLES 87335-87342

Developed 7/31/96

LOCATION MAP



MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 108635 LOCAL ID 18
Owner NCC Dept. of Public Works
Address 2701 Capitol Trail
City Newark State DE Zip 19711
Telephone Number 302-366-7850
Consulting Firm/Supervising Geologist (If applicable) DGS
Telephone Number 302-831-8261
Well Contractor DGS - BOUNDS
Date of Completion 7-9-96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

WELL CONSTRUCTION

Total depth drilled: 14.5'
Depth to water 7.6'
Surveyed Top of Casing Elevations
_____ (Inner) _____ (Outer) Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.0'
Casing bottom		7.0'
Casing diameter		2.0"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		7.0'
Screen bottom		12.0'
Screen diameter		2.0"
Screen material		PVC

Type of Grout cement/bentonite from 0.0 to 4.7
Gravel pack interval from 4.7 to 12.0
Aquifer/Formation screened in: Columbia
Type of samples (ditch, split spoon, etc.)

Samples Logged By: Stefanie Baxter (Name)
Research Assoc. (Title) DGS (Company)

Well Drilled By: DGS (Company Name)

Roland E. Bounds (Signature of Driller in Charge) 7/24/96 (Date)

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [✓] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.

Gc44-07
Lat.-39°21'58"
Lon.-75°36'47"
Smyrna Quadrangle
Smyrna River Drainage Basin

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top Soil	0.0	0.5
Clay, brown, traces of sand, M-C.	0.5	4.5'
Sand, M-C with gravel. Top is light grey changing to dark grey/black near 8.0'. Odor in black area. Wet at 9.0-9.5'.	4.5'	9.5'
Clay w/ M-C sand throughout grey, wet.	9.5'	14.5'

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [✓]
PAGE 1 OF 1 PAGES

White - Water Supply • Canary - Other • Pink - Owner • Goldenrod - Contractor

DOCUMENT NO. 40-08/87/02/03 - EC 81

Date Filed 10-22-96

Gc44-07

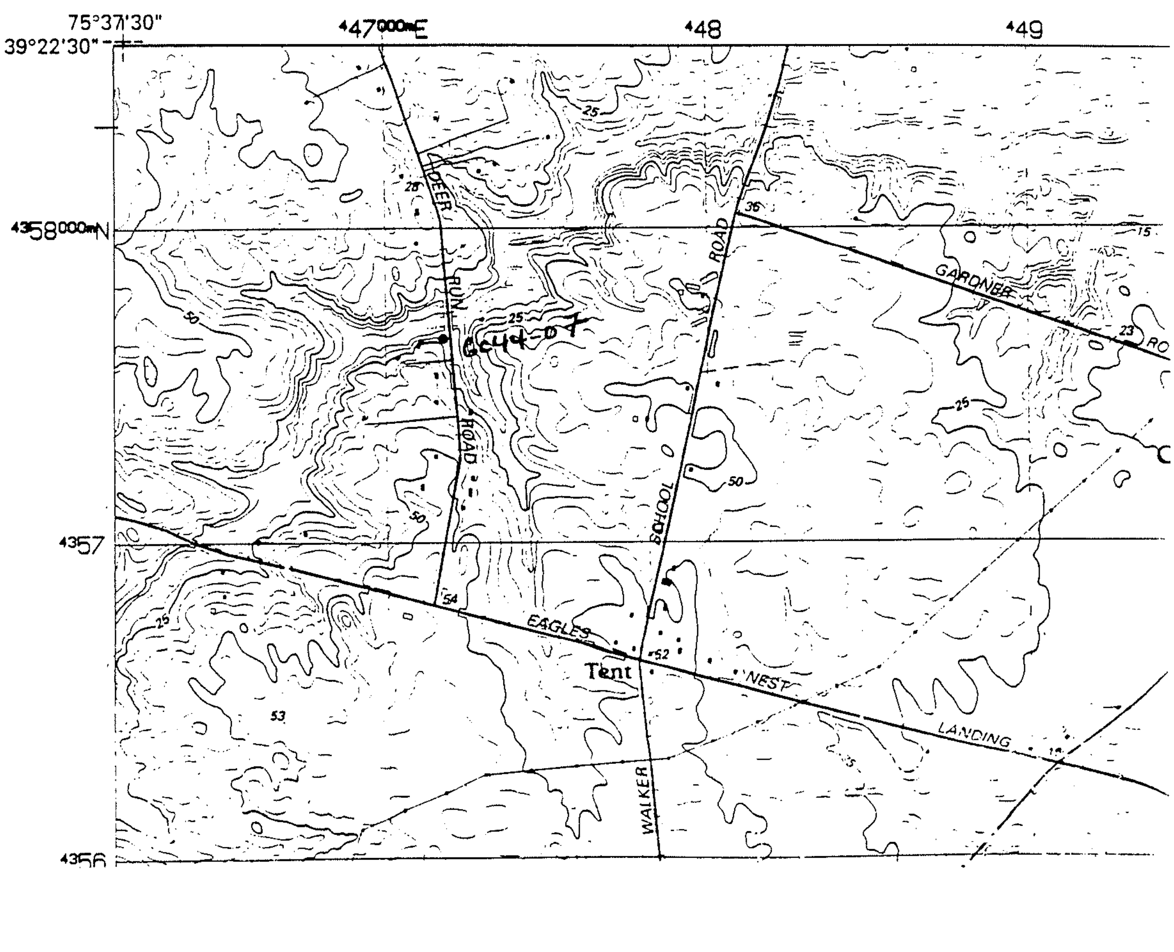
NOTES

CORE SAMPLES 87343-87347

Developed 7/29/96

LOCATION MAP

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



DGS/1-84

MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 106888 LOCAL ID 13
Owner NCC Dept. of Public Works
Address 2701 Capitol Trail
City Newark State DE Zip 19711
Telephone Number 302-366-7850
Consulting Firm/Supervising Geologist (If applicable)
DGS - R. Bounds
Telephone Number 302-831-8261
Well Contractor DGS Bounds
Date of Completion 6-13-96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

WELL CONSTRUCTION

Total depth drilled: 14.4'
Depth to water 3.75'
Surveyed Top of Casing Elevations
______ Inner ______ Outer Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.0'
Casing bottom		4.4'
Casing diameter		2"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		4.4'
Screen bottom		14.4'
Screen diameter		2"
Screen material		PVC

Type of Grout Cement / bentonite from 0.0 to 3.6'
Gravel pack interval from 3.6' to 14.4'
Aquifer/Formation screened in: Columbia
Type of samples (ditch, split spoon, etc.)
split spoon

Samples Logged By: Stefanie Baxter (Name)
Research Assoc. (Title) DGS (Company)

Well Drilled By DGS (Company Name)

Roland E. Bounds (Signature of Driller in Charge) 6/17/96 (Date)

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [X] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.

Hc11-11
Lat.- 39°19'19"
Lon.- 75°39'57"
Clayton Quadrangle
Smyrna River Drainage Basin

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top soil	0.0	1.0
Clay, brown-yellow w/ traces of fine sand, moist	1.0	2.0
Sand, clayey, light brown, moist	2.0	4.2
Sand, f-m, light grey with a trace of silt, fairly clean, moist w/ coarse to gravel sized pieces, orange at 6.0'	4.2	6.2
Sand, m-c light grey and tan, trace of silt, very moist	6.2	14.2
Sand, m-c, light grey to white, clean, few heavy minerals with bands of sand, m-c orange, very clean at 15.7 + 15.9'	14.2	16.2

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [ ]
PAGE 1 OF ______ PAGES

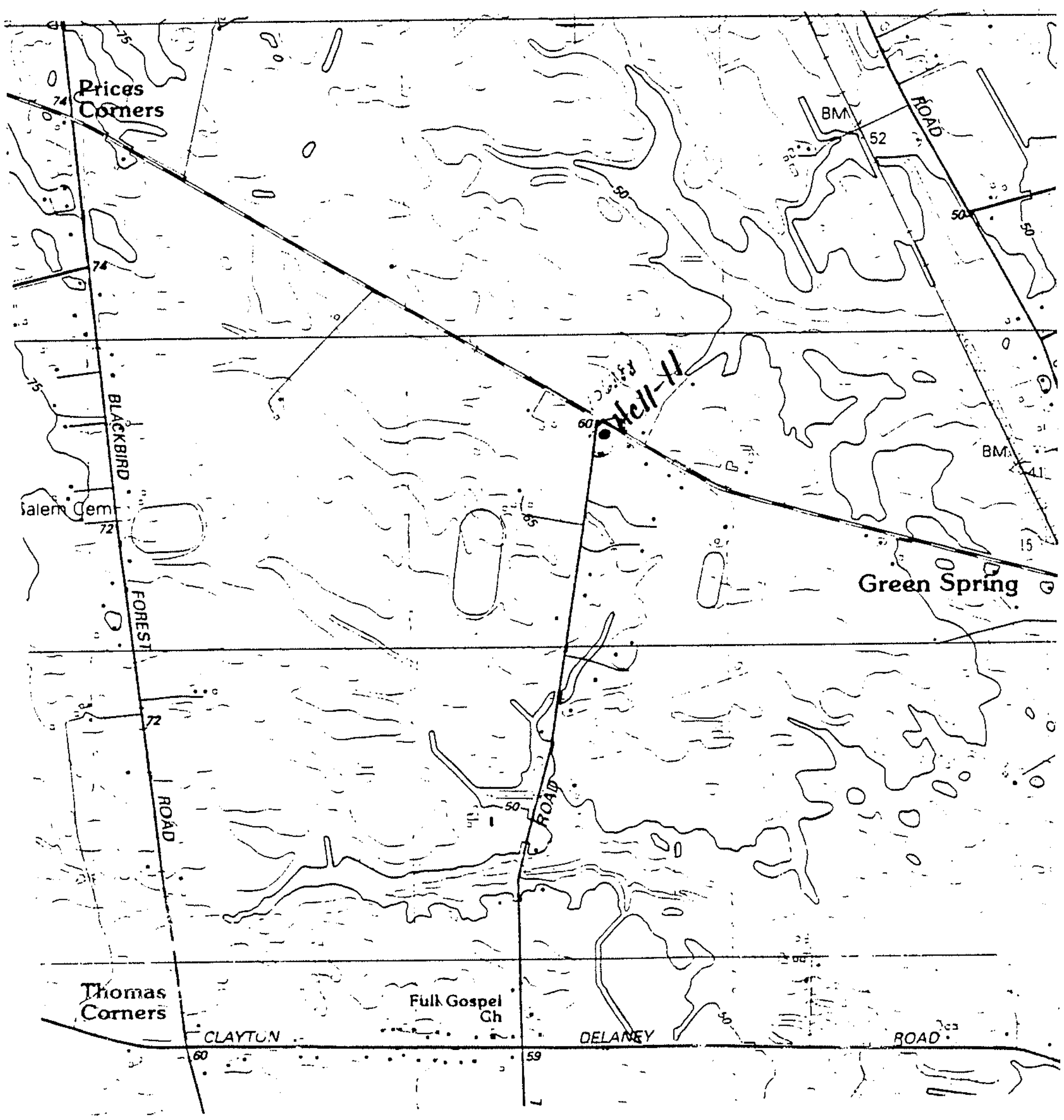
Date Filed 10-22-96

NOTES Hcl1-11

CORE SAMPLES 87367-87371

Developed 7/31/96

LOCATION MAP



DGS/1-84

MAIL TO:
WATER SUPPLY BRANCH
DIVISION OF WATER RESOURCES
P.O. BOX 1401
DOVER, DELAWARE 19903

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT MUST BE RETURNED WITHIN 30 DAYS AFTER CONSTRUCTION DATE.

MONITOR / OBSERVATION WELL COMPLETION REPORT

PLEASE PRINT OR TYPE

PERMIT NO. 106889 LOCAL ID 14
Owner NCC Dept. of Public Works
Address 2701 Capital Trail
City Newark State DE Zip 19711
Telephone Number 302-366-7850
Consulting Firm/Supervising Geologist (If applicable)
DGS
Telephone Number 302-831-8261
Well Contractor DGS - BOUNDS
Date of Completion 5-22-96
Name of DNREC Contact Person B. Venables
Drilling Method HSA

WELL CONSTRUCTION

Total depth drilled: 13.9'
Depth to water 4.51'
Surveyed Top of Casing Elevations
_____ Inner _____ Outer Ft. above Sea Level

CASING SEQUENCE

	Inner casing	Outer casing
Casing top		0.01
Casing bottom		3.9'
Casing diameter		2"
Casing material		PVC

SCREEN SEQUENCE

	Inner casing	Outer casing
Screen top		3.9'
Screen bottom		13.9'
Screen diameter		2"
Screen material		PVC

Type of Grout cement/bentonite from 2.6 to 0.0
Gravel pack interval from 2.6 to 13.9
Aquifer/Formation screened in: Columbia
Type of samples (ditch, split spoon, etc.)
split spoon

Samples Logged By: Stefanie BAXTER (Name)
Research Assoc. (Title) DGS (Company)

Well Drilled By: DGS (Company Name)

Roland E. Bounds (Signature of Driller in Charge) 6/17/96 (Date)

IS COMPLETED WELL LOCATED AS SHOWN ON APPLICATION FORM? YES [X] NO [ ]
IF NO, DESCRIBE LOCATION CHANGE OR OTHER COMMENTS.

Hc14-15
Lat. - 39° 19' 36"
Lon. - 75° 36' 32"
Smyrna Quadrangle
Smyrna River Drainage Basin

DRILLERS LOG DESCRIP.	TOP OF STRATA	BOTTOM
Top Soil	0.0	0.5'
Sand, f-m, light brown w/ some gravel, slightly silty, moist	0.5	1.9'
Sand, grades from f-c, yellow brown traces of silt, fairly clean, gravel at 3.9	1.9	3.9
Coarse gravel	3.9	4.5
Sand m-vc with gravel orange-brown, slightly silty, very wet	4.5	13.9
Sand, vc, orange, wet, white + orange mottled clay at 15.7' And 15.9'	13.9	15.9

SUPPLEMENTAL DRILLERS LOG ATTACHED?
YES [ ] NO [X]
PAGE 1 OF _____ PAGES

White - Water Supply • Canary - Other • Pink - Owner • Goldenrod - Contractor

DOCUMENT NO. 40-08/87/02/03 - EC 81

Date Filed 10-22-96

Hc14-15

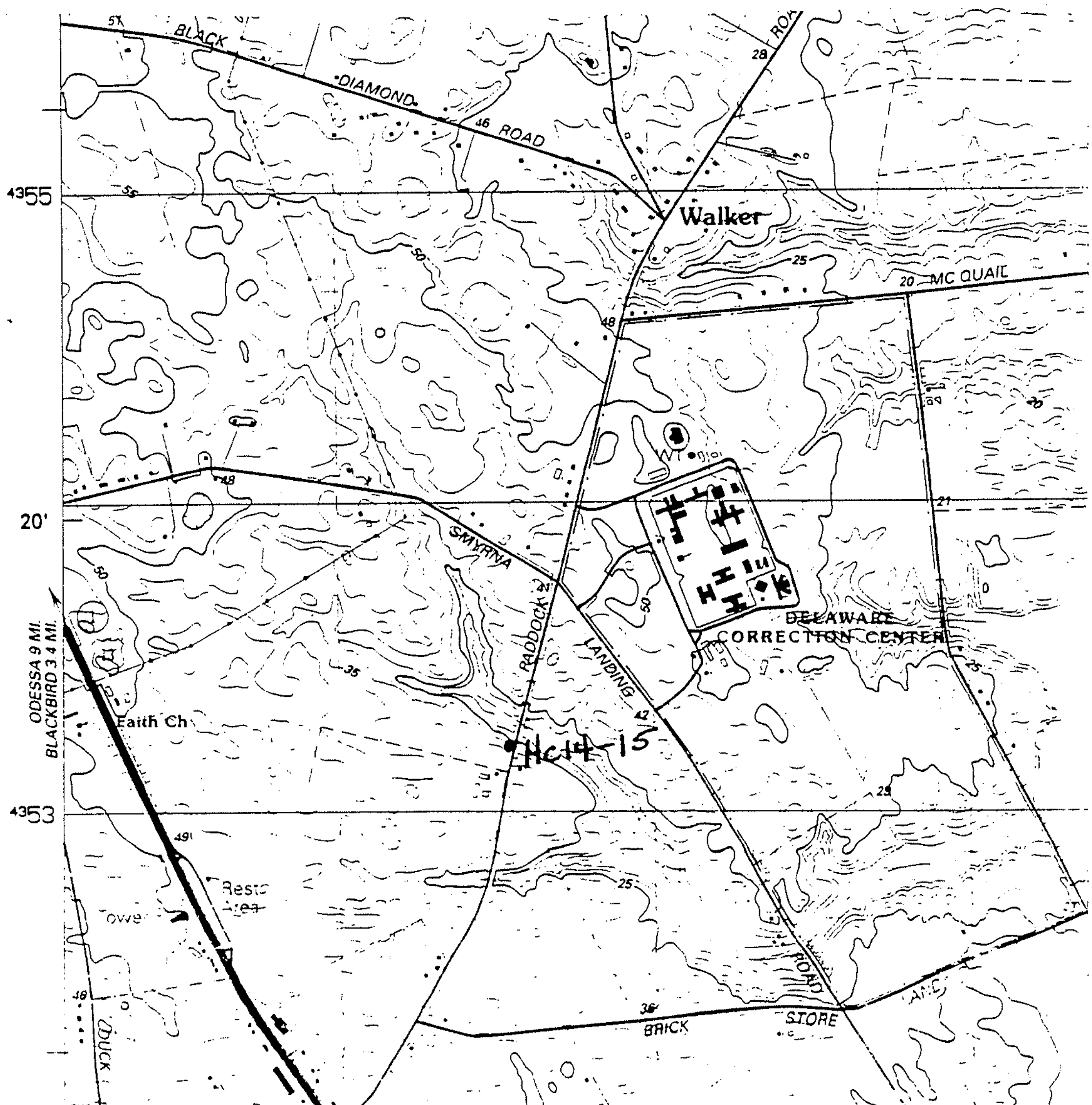
NOTES

CORE SAMPLES 87380-87382 AND

26302-26303

Developed 7/29/96

LOCATION MAP



DGS/1-84

APPENDIX C
Results of Quality Assurance and Quality Control

DGSID	Date	Analysis Result Duplicate 1	Analysis Result Duplicate 2	Average Value	Difference in given units
		pH (standard units)			
Ed21-20	9/17/96	6.98	7.3	7.14	0.32
Fb22-10	9/24/96	7.76	7.82	7.79	0.06
Fc11-23	9/16/96	6.02	6.33	6.175	0.31
Fc31-11	9/10/96	7.23	7.6	7.415	0.37
Gb14-05	9/9/96	6.74	6.79	6.765	0.05
Hc13-02	9/10/96	7.68	7.66	7.67	0.02
		Total Organic Carbon (TOC) mg/L			
Ed21-20	9/17/96	**1**	**1**	1	0
Fb22-10	9/24/96	**1**	**1**	1	0
Fc11-23	9/16/96	1.9	**1**	1.45	0.9
Gb14-05	9/9/96	**1**	**1**	1	0
Hc13-02	9/10/96	**1**	**1**	1	0
		Calcium (mg/L)			
Ed21-20	9/17/96	12.4	12	12.2	0.4
Fb22-10	9/24/96	0.103	0.08	0.0915	0.023
Fc11-23	9/16/96	12.1	12.2	12.15	0.1
Gb14-05	9/9/96	22.3	19.8	21.05	2.5
Hc13-02	9/10/96	36.6	36.6	36.6	0
		Magnesium (mg/L)			
Ed21-20	9/17/96	2.91	2.83	2.87	0.08
Fb22-10	9/24/96	0.049	**0.004**	0.0265	0.045
Fc11-23	9/16/96	10.4	10.4	10.4	0
Gb14-05	9/9/96	6.49	5.87	6.18	0.62
Hc13-02	9/10/96	11.8	11.9	11.85	0.1
		Silica (mg/L)			
Ed21-20	9/17/96	3.74	3.6	3.67	0.14
Fb22-10	9/24/96	13.9	13.9	13.9	0
Fc11-23	9/16/96	6.26	6.28	6.27	0.02
Gb14-05	9/9/96	4.76	5.21	4.985	0.45
Hc13-02	9/10/96	6.19	6.21	6.2	0.02
		Sodium (mg/L)			
Ed21-20	9/17/96	39.6	38.8	39.2	0.8
Fb22-10	9/24/96	58.6	58.2	58.4	0.4
Fc11-23	9/16/96	4.53	4.61	4.57	0.08
Gb14-05	9/9/96	83.7	77.2	80.45	6.5
Hc13-02	9/10/96	6.25	6.29	6.27	0.04

DGSID	Date	Analysis Result Duplicate 1	Analysis Result Duplicate 2	Average Value	Difference in given units
			Alkalinity (mg/L)		
Hc13-02	9/10/96	115	115	115	0
Gb14-05	9/91996	29.45	28.5	28.975	0.95
Fc11-23	9/16/96	3.8	3.8	3.8	0
Ed21-20	9/17/96	76	76	76	0
Fb22-10	9/25/96	43.7	43.7	43.7	0
Fc31-11	9/10/96	87	120	103.5	33
			Sulfate (mg/L)		
Ed21-20	9/17/96	**0.05**	**0.05**	0.05	0
Fb22-10	9/24/96	**0.05**	**0.05**	0.05	0
Fc11-23	9/16/96	**0.05**	**0.05**	0.05	0
Gb14-05	9/9/96	**0.05**	**0.05**	0.05	0
Hc13-02	9/10/96	**0.05**	**0.05**	0.05	0
			Chloride (mg/L)		
Ed21-20	9/17/96	1.4	1.45	1.425	0.05
Fb22-10	9/24/96	0.2	0.15	0.175	0.05
Fc11-23	9/16/96	0.38	0.4	0.39	0.02
Gb14-05	9/9/96	0.4	0.35	0.375	0.05
Hc13-02	9/10/96	0.68	0.9	0.79	0.22
			Iron (mg/L)		
Ed21-20	9/17/96	2.54	2.91	2.725	0.37
Fb22-10	9/24/96	0.25	0.18	0.215	0.07
Fc11-23	9/16/96	**0.02**	**0.02**	0.02	0
Gb14-05	9/9/96	1	1	1	0
Hc13-02	9/10/96	0.22	0.22	0.22	0
			Manganese (mg/L)		
Ed21-20	9/17/96	0.05	0.05	0.05	0
Fb22-10	9/24/96	**0.02**	**0.02**	0.02	0
Fc11-23	9/16/96	0.06	**0.02**	0.04	0.04
Gb14-05	9/9/96	**0.02**	**0.02**	0.02	0
Hc13-02	9/10/96	0.03	**0.02**	0.025	0.01
			Potassium (mg/L)		
Ed21-20	9/17/96	1.78	1.78	1.78	0
Fb22-10	9/24/96	0.07	0.07	0.07	0
Fc11-23	9/16/96	0.74	0.71	0.725	0.03
Gb14-05	9/9/96	0.91	0.9	0.905	0.01
Hc13-02	9/10/96	12.8	12.8	12.8	0

Boldface type indicates levels below the minimum detection limit for the indicated parameter

APPENDIX C
Results of Quality Assurance and Quality Control

DGSID	Date	Analysis Result Duplicate 1	Analysis Result Duplicate 2	Average Value	Difference in given units
			Copper (mg/L)		
Ed21-20	9/17/96	**0.01**	**0.01**	0.01	0
Fb22-10	9/24/96	**0.01**	**0.01**	0.01	0
Fc11-23	9/16/96	**0.01**	**0.01**	0.01	0
Gb14-05	9/9/96	**0.01**	**0.01**	0.01	0
Hc13-02	9/10/96	**0.01**	**0.01**	0.01	0
			Lead (mg/L)		
Ed21-20	9/17/96	0.004	**0.002**	0.003	0.002
Fb22-10	9/24/96	0.003	**0.002**	0.0025	0.001
Fc11-23	9/16/96	**0.002**	**0.002**	0.002	0
Gb14-05	9/9/96	0.003	**0.002**	0.0025	0.001
Hc13-02	9/10/96	0.004	**0.002**	0.003	0.002
			Zinc (mg/L)		
Ed21-20	9/17/96	0.22	0.22	0.22	0
Fb22-10	9/24/96	**0.02**	0.02	0.02	0
Fc11-23	9/16/96	0.03	0.05	0.04	0.02
Gb14-05	9/9/96	0.06	0.06	0.06	0
Hc13-02	9/10/96	**0.02**	**0.02**	0.02	0
			Flouride (mg/L)		
Ed21-20	9/17/96	0.23	0.13	0.18	0.1
Fb22-10	9/24/96	0.13	0.13	0.13	0
Fc11-23	9/16/96	0.18	0.14	0.16	0.04
Gb14-05	9/9/96	0.12	0.12	0.12	0
Hc13-02	9/10/96	0.49	0.47	0.48	0.02

DGSID	Date	Analysis Result Duplicate 1	Analysis Result Duplicate 2	Average Value	Difference in given units
			Ammonia (mg/L)		
Ed21-20	9/17/96	0.02	0.04	0.03	0.02
Fb22-10	9/24/96	0.02	0.01	0.015	0.01
Fc11-23	9/16/96	0.03	0.04	0.035	0.01
Gb14-05	9/9/96	0.03	0.03	0.03	0
Hc13-02	9/10/96	0.13	0.15	0.14	0.02
			Nitrite (mg/L)		
Ed21-20	9/17/96	0.04	0.03	0.035	0.01
Fb22-10	9/24/96	0.04	0.04	0.04	0
Fc11-23	9/16/96	0.03	0.02	0.025	0.01
Gb14-05	9/9/96	0.03	0.02	0.025	0.01
Hc13-02	9/10/96	0.03	0.03	0.03	0
			Nitrate(mg/L)		
Ed21-20	9/17/96	2.5	2.8	2.65	0.3
Fb22-10	9/24/96	3.2	2.6	2.9	0.6
Fc11-23	9/16/96	3.5	3.5	3.5	0
Gb14-05	9/9/96	0.67	0.87	0.77	0.2
Hc13-02	9/10/96	0.2	0.3	0.25	0.1
			Total Dissolved Solids (mg/L)		
Ed21-20	9/17/96	312	307	309.5	5
Fb22-10	9/24/96	66	69	67.5	3
Fc11-23	9/16/96	74	195	134.5	121
Gb14-05	9/9/96	88	67	77.5	21
Hc13-02	9/10/96	418	458	438	40

Boldface type indicates levels below the minimum detection limit for the indicated parameter

APPENDIX D

Pesticide Quality Control Sample Duplicates and Blanks

Pesticide	DGSID	Date	Analysis 1 Result (ppb)	Analysis 2 Result (ppb)	Average Value (ppb)	Difference in given units
Alachlor						
	Eb43-11	9/12/96	0.10	0.10	0.10	0.00
	Fc43-11	9/16/96	0.27	0.17	0.22	0.10
	Gb14-05	9/9/96	0.00	0.02	0.01	0.02
	Field Blank	7/31/96	0.02	0.14	0.08	0.12
	Field Blank	8/1/96	0.07	0.07	0.07	0.00
	Trip Blank	9/9/96	0.01	0.04	0.03	0.03
Cyanazine						
	Eb33-41	9/12/96	0.00	0.00	0.00	0.00
	Eb54-05	9/19/96	0.00	0.03	0.02	0.03
	Gb11-07	9/9/96	0.09	0.09	0.09	0.00
	Field Blank	7/31/96	0.03	0.03	0.03	0.00
	Field Blank	8/1/96	0.02	0.03	0.03	0.01
	Trip Blank	9/9/96	0.01	0.01	0.01	0.00
Metolachlor						
	Eb35-23	9/19/96	0.00	0.00	0.00	0.00
	Fb41-11	9/17/96	0.02	0.08	0.05	0.06
	Field Blank	7/31/96	0.15	0.19	0.17	0.04
	Field Blank	8/1/96	0.15	0.09	0.12	0.06
	Field Blank	9/9/96	0.11	0.06	0.09	0.05
	Trip Blank	9/9/96	0.01	0.06	0.04	0.05
Atrazine						
	Eb35-23	9/19/96	0.34	0.35	0.35	0.01
	Fb12-05	9/17/96	0.46	0.39	0.43	0.07
	Gb11-07	9/9/96	3.04	2.81	2.93	0.23
	Field Blank	7/31/96	0.06	0.10	0.08	0.04
	Field Blank	8/1/96	0.06	0.08	0.07	0.02
	Field Blank	9/9/96	0.10	0.11	0.11	0.01
Carbofuran						
	Ed51-10	9/16/96	0.05	0.01	0.03	0.04
	Fa45-07	9/12/96	0.03	0.01	0.02	0.02
	Fc11-23	9/16/96	0.03	0.02	0.03	0.01
	Gb14-05	9/9/96	0.04	0.02	0.03	0.02
	Field Blank	7/31/96	0.03	0.02	0.03	0.01
	Field Blank	8/1/96	0.02	0.01	0.02	0.01

Control Type	Date	Alachlor (ppb)	Atrazine (ppb)	Carbofuran (ppb)	Cyanazine (ppb)	Metolachlor (ppb)
Field Blanks						
	7/22/96	0.01nd	nd	0.0nd	0.0nd	0.0nd
	7/29/96	nd	0.06	0.01nd	0.01nd	0.04nd
	7/31/96	0.02nd	0.06	0.03nd	0.03nd	0.15
	7/31/96	0.14	0.1	0.02nd	0.03nd	0.19
	8/1/96	0.07	0.06	0.02nd	0.02nd	0.15
	8/1/96	0.07	0.08	0.01nd	0.03nd	0.09
	9/9/96	0.01nd	0.1	0.04nd	0.01nd	0.11
	9/9/96		0.11			0.06
	9/12/96	0.02nd	0.06	0.02nd	0.01nd	0.01nd
	9/19/96	0.02nd	0.02nd	0.02nd	0.01nd	0.04nd
Trip Blanks						
	7/22/96	0.01nd	0.01nd	0.0nd	0.0nd	0.0nd
	7/29/96	nd	0.07	0.01nd	0.01nd	0.11
	7/30/96	0.04nd	0.07	0.01nd	0.01nd	0.03nd
	9/9/96	0.01nd	0.11	0.01nd	0.01nd	0.01nd
	9/9/96	0.04nd			0.01nd	0.06
	9/17/96	0.02nd	0.01nd	0.03nd	0.0nd	0.1

Note: "nd" indicates no detection and an empty space indicates not tested

APPENDIX E
Radon Quality Control
Duplicate Samples

DGSID	Date	Duplicate 1 (pCi/L)	Duplicate 2 (pCi/L)	Average Value	Difference in given units
Eb35-23	*	2600	2200	2400	400
Eb54-05	9/19/96	420	400	410	20
Ed51-10	9/16/96	840	810	825	30
Fa45-07	9/12/96	180	200	190	20
Fb12-05	9/17/96	340	360	350	20
Fb22-10	9/24/96	500	470	485	30
Fb41-11	9/17/96	150	150	150	0
Fc11-23	9/16/96	250	240	245	10
Fc12-26	9/16/96	420	510	465	90
Gb11-07	9/9/96	280	270	275	10
Gb14-05	9/9/96	250	240	245	10
Hc13-02	9/10/96	450	480	465	30

* Eb35-23 was sampled on 7/30/1996 and 9/19/1996

APPENDIX F
Results of Water-Quality Analyses

DGSID	Date	Aquifer	Watershed	Temperature (Celsius)	pH (lab)	pH (field)	eH	Specific Conductance in µS/cm	Oxygen, dissolved mg/L	Water Level (feet bls)
Ea44-13	7/29/96	clg	Q	17.1	5.34	5.15	219	173	0.0	7.43
Ea45-04	8/6/96	m	Q	14.0	6.20	6.43	-51	103	0.0	
Eb33-41	9/12/96	clg	Q	13.3	7.78	6.00		180		
Eb33-42	8/15/96	clg	Q	13.3	6.54	5.39	213	79	0.0	20.38
Eb35-23	7/30/96	clg	Q	18.0	6.12	6.15	162	667		2.26
Eb35-23	9/19/96	clg	Q	18.9	6.85	6.03	174	652	5.1	2.08
Eb43-04	8/6/96	m	Q	14.0	6.80	6.90	-53	137	0.0	
Eb43-11	9/12/96	ml	Q	17.2	6.96	6.14	147	137	8.4	
Eb51-11	8/6/96	m	AA	13.6	6.50	6.74	-73	140	3.9	
Eb54-05	9/19/96	ml	S	18.2	6.71	6.05	173	228	4.9	
Ec51-16	8/7/96	ml	R	13.0	6.80	6.86	115	166	0.0	
Ec52-09	8/7/96	ml	R	13.4	7.40	7.48	-114	200	0.0	
Ed21-20	9/17/96	m	Q	16.9	7.14*	7.63	-172	236	0.0	
Ed51-10	9/16/96	rng	Q	13.9	5.41	4.78	167	294	6.3	
Fa15-08	8/6/96	m	Z	13.9	6.40	6.63	-64	128	3.9	
Fa45-07	9/12/96	clg	Z	16.5	7.33	6.39	141	602	3.7	14.15
Fb12-05	9/17/96	clg	AA	16.2	5.61	4.90	237	128	9.0	9.47
Fb14-11	8/14/96	ptg	S	15.3	6.50	6.77	-76	134	0.0	
Fb22-10	9/24/96	ml	S	15.9	7.79*	7.58	111	216	2.0	
Fb22-15	7/29/96	clg	S	14.2	5.25	4.93	260	168	8.2	5.24
Fb24-11	8/8/96	ml	S	13.8	7.40	7.47	2	195	5.8	
Fb25-07	7/25/96	rng	S	14.5	5.16	4.83	269	146	9.3	11.20
Fb41-11	9/17/96	clg	T	16.8	6.49	6.39	173	3530	6.3	11.26
Fb54-01	8/13/96	ptg	T	17.5	7.20	7.51	-142	179	0.0	
Fb54-05	7/22/96	clg	T	15.6	5.61	5.86		183	0.0	32.43
Fb54-08	7/22/96	clg	T	14.6	5.16	4.74		22	0.0	23.02
Fc11-23	9/16/96	clg	R	14.1	6.17*	5.27	232	160	12.0	26.95
Fc12-23	8/7/96	ml	R	13.5	6.50	6.52	69	197	0.0	
Fc12-26	9/16/96	clg	R	15.3	6.26	5.38	190	263	7.1	22.96
Fc15-04	8/14/96	ml	R	14.2	7.60	7.60	-76	222	0.0	
Fc31-11	9/10/96	ml	T	14.1	7.60	7.63	-88	204	5.4	
Fc42-09	7/24/96	vt	T	17.2	4.38	4.08	296	186	9.2	31.12
Fc42-13	8/7/96	ml	T	14.1	7.60	7.78	-112	184	0.0	
Fc42-24	7/24/96	vt	T	13.5	5.14	4.92	254	188	13.7	25.88
Fc42-25	7/24/96	clg	T	18.4	5.19	4.92	262	161	9.3	7.48
Gb11-07	9/9/96	clg	Y	15.7	6.27	5.35	264	274		12.09
Gb14-03	7/18/96	clg	T	13.4	7.29	7.23	97	233	0.0	14.30
Gb14-05	9/9/96	clg	T	20.1	6.765*	5.29	309	575	7.5	5.62
Gb21-10	8/1/96	clg	Y	15.4	5.57	5.59	249	138	0.0	2.20
Gb24-05	8/14/96	rng	U	14.6	7.30	7.76	-140	202	0.0	
Gb53-02	8/1/96	clg	U	13.1	6.07	5.95	205	150	6.1	3.28
Gc44-07	7/31/96	clg	W	18.5	6.41	6.60	-130	268	0.0	2.42
Hc11-11	8/1/96	clg	W	20.6	5.12	4.92	251	415	0.0	1.00
Hc13-02	9/10/96	rng	W	15.0	7.65*	7.63	-88	204	5.4	
Hc14-03	8/13/96	rng	W	14.7	7.50	7.55	-77	239	6.1	
Hc14-15	7/31/96	clg	W	20.4	6.24	5.85	224	153	14.2	4.19

KEY

clg = Columbia

m = Magothy

rng = Rancocas Group

ptg = Potomac

vt = Vincentown

ml = Mt. Laurel

KEY

* = averaged value

nd = no detection

blank = not tested

APPENDIX F

Results of Water-Quality Analyses

DGSID	Total Organic Carbon (mg/L)	Calcium, dissolved mg/L as Ca	Magnesium, dissolved mg/L as Mg	Sodium, dissolved mg/L as Na	Silica dissolved mg/L as SiO_2	Alkalinity as $CaCO_3$ mg/L	Sulfate dissolved mg/L as SO_4
Ea44-13	nd	15.4	4.83	17.7	3.41	3.8	<0.05
Ea45-04	nd	10.7	4.17	3.75*	10	52	<0.05
Eb33-41	2.0	13.2	3.84	10.9	5.45	14.3	<0.05
Eb33-42	3.2	9.25	2.84	5.98	5.97	10.45	<0.05
Eb35-23	nd	53.1	15.1	70.3	3.53	55.1	<0.05
Eb35-23	nd	39.1	7.48	9.15	10.2	49.4	<0.05
Eb43-04	nd	36.3	6.4	3.33*	4.14	108	<0.05
Eb43-11	1.5	26.4	2.01	4.22	8.24	25.6	<0.05
Eb51-11	nd	26.3	4.6	2.68*	6.69	76	<0.05
Eb54-05	nd	53.4	15.8	74.8	5.3	31.4	<0.05
Ec51-16	nd	40.6	2.34	4.23*	8.09	80	<0.05
Ec52-09	nd	52	3.01	4.22*	9.14	125	<0.05
Ed21-20	nd	12.2*	2.87*	39.2*	3.67*	76*	<0.05*
Ed51-10	nd	16.1	10.3	34.3	13.8	2.85	<0.05
Fa15-08	nd	21.2	4.66	2.81*	7.16	65	<0.05
Fa45-07	nd	47.1	24.8	62.9	2.79	131	<0.05
Fb12-05	nd	10.8	8.73	6.66	6.76	2.85	<0.05
Fb14-11	nd	15	3.54	12.55*	4.22	69	<0.05
Fb22-10	nd	0.052*	0.025*	58.4*	13.9*	43.7*	<0.05*
Fb22-15	nd	13.9	11.4	3.28	6.53	3.8	<0.05
Fb24-11	2.4	43	2.7	3.77*	11.4	100	<0.05
Fb25-07	nd	15.8	5.23	5.05	6.7	1.9	<0.05
Fb41-11	nd	168	51.5	545	2.71	96.9	<0.05
Fb54-01	nd	1.88	0.4324	45.9*	4.43	95	<0.05
Fb54-05	2.0	9.89	6.41	4.29	4.86	13.3	<0.05
Fb54-08	2.1	1.4	0.658	1.9	8.42	9.5	<0.05
Fc11-23	0.95*	12.15*	10.4*	4.57*	6.27	3.8*	<0.05*
Fc12-23	nd	38.8	5.25	5.83*	11.2	75	<0.05
Fc12-26	nd	31.5	21	7.89	8.21	21.8	<0.05
Fc15-04	nd	43.5	7.1	9.3*	9.53	138	<0.05
Fc31-11	1.5	40.1	5.73	3.91*	6.48	104*	<0.05
Fc42-09	1.2	11.6	6.52	7.04	7.48	1.9	<0.05
Fc42-13	nd	29.6	5.41	14.45*	7.55	115	<0.05
Fc42-24	nd	16.6	12.6	4.3	5.36	1.9	<0.05
Fc42-25	nd	10.4	9.72	3.76	4.89	3.8	<0.05
Gb11-07	nd	24.4	13.7	10.6	5.91	10.45	<0.05
Gb14-03	1.0	102	2.52	1.46	8.66	18.4	<0.05
Gb14-05	nd*	21.05*	6.18*	80.45*	4.985*	28.975*	0.065*
Gb21-10	nd	11.6	6.06	8.39	8.4	7.6	<0.05
Gb24-05	nd	48.5	3.61	4.29*	12.8	117	<0.05
Gb53-02	nd	13.4	5.45	9.12	5.67	28.5	<0.05
Gc44-07	4.0	43.7	12.5	8.36	27.4	19	<0.05
Hc11-11	nd	17.2	8.05	46.6	11.4	1.9	<0.05
Hc13-02	nd*	36.6*	11.85*	6.51*	6.2*	127*	<0.05*
Hc14-03	nd	35.9	12.7	8.75*	6.62	150	<0.05
Hc14-15	nd	10.7	3.44	14.1	2.58	5.7	<0.05

KEY

* = averaged value

nd = no detection

blank = not tested

APPENDIX F
Results of Water-Quality Analyses

DGSID	Chloride dissolved mg/L as Cl	Iron dissolved mg/L as Fe	Manganese dissolved mg/L as Mn	Potassium dissolved mg/L as K	Copper dissolved mg/L as Cu	Lead dissolved mg/L as Pb	Zinc dissolved mg/L as Zn	Flouride dissolved mg/L as F
Ea44-13	1.06	<0.02	<0.02	0.75	<0.01	<0.002	<0.02	1.40
Ea45-04	<2	9.20	0.21	0.82	<0.01	0.003	0.03	0.11
Eb33-41	1.1	0.05	<0.02	12.20	<0.01	<0.002	<0.02	0.22
Eb33-42	0.58	0.19	<0.02	0.90	<0.01	<0.002	<0.02	0.52
Eb35-23	0.62	0.09	0.07	1.23	<0.01	<0.002	0.05	0.13
Eb35-23	0.8	0.19	0.26	9.90	<0.01	<0.002	0.05	0.14
Eb43-04	<2	2.40	0.04	1.46	0.02	<0.002	<0.02	0.25
Eb43-11	0.5	0.05	<0.02	0.53	<0.01	<0.002	0.08	0.24
Eb51-11	<2	3.50	<0.02	0.35	<0.01	<0.002	<0.02	0.22
Eb54-05	3.7	0.08	0.24	18.20	<0.01	<0.002	0.12	0.14
Ec51-16	4	<0.05	<0.02	0.78	<0.01	<0.002	<0.02	0.16
Ec52-09	<2	0.51	0.06	0.77	<0.01	<0.002	<0.02	0.14
Ed21-20	1.425*	2.725*	0.05*	1.78*	<0.01*	0.003*	0.22*	0.18*
Ed51-10	1.15	0.03	<0.02	1.91	0.14	<0.002	0.09	0.12
Fa15-08	<2	5.40	0.14	0.77	<0.01	0.003	0.06	0.17
Fa45-07	0.65	0.08	<0.02	1.94	<0.01	<0.002	<0.02	0.27
Fb12-05	1.2	0.09	<0.02	1.11	<0.01	<0.002	<0.02	0.12
Fb14-11	<2	4.60	<0.02	1.66	<0.01	0.003	0.14	0.27
Fb22-10	0.175*	0.215*	<0.02*	0.07*	<0.01*	<0.002*	<0.02*	0.13*
Fb22-15	0.71	0.04	<0.02	0.93	<0.01	<0.002	0.07	0.16
Fb24-11	<2	0.35	0.11	1.31	<0.01	<0.002	<0.02	0.43
Fb25-07	1.15	0.11	<0.02	0.98	<0.01	<0.002	0.06	0.18
Fb41-11	4.3	0.15	<0.02	20.20	<0.01	<0.002	0.07	0.16
Fb54-01	<2	0.39	<0.02	1.26	<0.01	<0.002	<0.02	0.29
Fb54-05	0.89	0.09	<0.02	0.94	0.21	<0.002	<0.02	0.21
Fb54-08	0.7	0.18	<0.02	0.53	<0.01	<0.002	<0.02	0.22
Fc11-23	0.39*	<0.02*	0.04*	0.725*	<0.01*	<0.002*	0.04*	0.16*
Fc12-23	19	2.20	<0.02	1.54	<0.01	<0.002	0.18	0.22
Fc12-26	0.55	0.06	0.52	1.08	<0.01	<0.002	<0.02	0.17
Fc15-04	<2	0.43	<0.02	11.00	<0.01	0.004	<0.02	0.39
Fc31-11	<2	0.25	0.04	1.73	<0.01	<0.002	<0.02	0.42
Fc42-09	18.5	0.06	0.11	1.12	<0.01	<0.002	0.05	0.27
Fc42-13	<2	0.21	<0.02	1.77	<0.01	0.003	<0.02	0.15
Fc42-24	1.94	0.42	<0.02	0.54	<0.01	<0.002	<0.02	0.32
Fc42-25	0.44	0.06	<0.02	0.76	<0.01	<0.002	<0.02	0.20
Gb11-07	0.75	0.07	0.11	0.84	<0.01	<0.002	0.04	0.11
Gb14-03	2.8	1.00	0.20	0.43	<0.01	<0.002	<0.02	0.33
Gb14-05	0.375*	1*	<0.02*	0.905*	<0.01*	0.0025*	0.06*	0.12*
Gb21-10	2.6	0.18	0.05	0.72	<0.01	<0.002	0.04	0.13
Gb24-05	<2	0.44	<0.02	0.79	<0.01	<0.002	<0.02	0.23
Gb53-02	0.7	0.06	<0.02	8.70	<0.01	<0.002	<0.02	0.14
Gc44-07	0.7	15.10	1.41	1.34	<0.01	<0.002	<0.02	0.21
Hc11-11	6.4	0.18	<0.02	0.46	<0.01	<0.002	<0.02	0.15
Hc13-02	1.19*	0.18*	0.025*	12.8*	<0.01*	0.003*	<0.02*	0.48*
Hc14-03	<2	0.18	<0.02	11.80	<0.01	<0.002	<0.02	0.59
Hc14-15	0.7	0.05	<0.02	0.92	<0.01	<0.002	<0.02	0.14

KEY

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nd = no detection

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APPENDIX F
Results of Water-Quality Analyses

DGSID	Total Phosphate dissolved mg/L as P	Ortho Phosphate dissolved mg/L as P	Ammonia dissolved mg/L as NH_4	Nitrite dissolved mg/L as N	Nitrate dissolved mg/L as N	Radon pCi/L	Total Dissolved Solids mg/L
Ea44-13	<0.05	<0.05	0.08	0.015	5.80	320	302
Ea45-04			0.12	0.02	<0.4		80
Eb33-41	<0.05	<0.05	0.04	0.04	2.30		179
Eb33-42	<0.05	<0.05	0.19	0.03	0.20		275
Eb35-23	<0.05	<0.05	0.10	<0.01	3.60	2600	498
Eb35-23	<0.05	<0.05	0.02	0.03	3.80	2200	88
Eb43-04			0.21	0.02	<0.4		121
Eb43-11	<0.05	<0.05	0.02	0.02	2.10		88
Eb51-11			0.18	<0.01	<0.4		96
Eb54-05	<0.05	<0.05	0.02	0.03	3.50	410*	96
Ec51-16	<0.05	<0.05	0.15	<0.01	2.10	1100	122
Ec52-09	<0.05	<0.05	0.09	<0.01	<0.4	500	114
Ed21-20	<0.05*	<0.05*	0.03*	0.035*	2.65		310*
Ed51-10	<0.05	<0.05	0.06	0.03	0.80	825*	82
Fa15-08			0.08	<0.01	<0.4	120	96
Fa45-07	<0.05	<0.05	0.02	0.02	3.60	180	112
Fb12-05	<0.05	<0.05	0.02	0.02	3.70	350*	65
Fb14-11	<0.05	<0.05	0.02	0.05	<0.4	200	85
Fb22-10	<0.05*	<0.05*	0.015*	0.04*	2.9*	485*	69.75*
Fb22-15	<0.05	<0.05	0.09	<0.01	10.00	400	198
Fb24-11	<0.05	<0.05	0.04	0.03	<0.4		157
Fb25-07	<0.05	<0.05	0.11	<0.01	9.90		89
Fb41-11	<0.05	<0.05	0.03	0.02	2.30	150*	110
Fb54-01	<0.05	<0.05	0.02	0.02	<0.4	150	119
Fb54-05	0.05	<0.05	0.36	<0.01	12.00		3270
Fb54-08	0.06	<0.05	0.30	0.02	0.86		6671
Fc11-23	<0.05*	<0.05*	0.035*	0.025*	3.55*	245*	134.5*
Fc12-23	<0.05	<0.05	0.10	0.02	1.80	1200	158
Fc12-26	<0.05	<0.05	0.03	0.03	3.20	465*	210
Fc15-04	<0.05	<0.05	0.08	0.04	<0.4		128
Fc31-11	<0.05	<0.05	0.11	0.04	0.2	610	121
Fc42-09	0.09	<0.05	0.19	<0.01	13.00		93
Fc42-13	<0.05	<0.05	0.11	0.02	<0.4	490	129
Fc42-24	<0.05	<0.05	0.12	0.02	7.00	250	88
Fc42-25	<0.05	<0.05	0.12	<0.01	7.00		62
Gb11-07	<0.05	<0.05	0.02	0.03	2.90	275*	92
Gb14-03	<0.05	<0.05	0.71	<0.01	0.42		416
Gb14-05	<0.05*	<0.05*	0.03*	0.025*	0.77*	245*	79.5*
Gb21-10	<0.05	<0.05	0.09	<0.01	1.50	430	116
Gb24-05	<0.05	<0.05	0.01	0.02	<0.4	230	141
Gb53-02	<0.05	<0.05	0.12	<0.01	0.65	240	71
Gc44-07	<0.05	<0.05	0.97	0.03	0.42	380	228
Hc11-11	<0.05	<0.05	0.13	0.015	1.40	310	292
Hc13-02	<0.05*	<0.05*	0.14*	0.03*	0.25*	465*	349*
Hc14-03	<0.05	<0.05	0.06	0.02	<0.4	360	157
Hc14-15	<0.05	<0.05	0.13	<0.01	2.30	220	59
	KEY						
	* = averaged value						
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APPENDIX F

Results of Water-Quality Analyses

DGSID	Alachlor (ppb)	Cyanazine (ppb)	Metolachlor (ppb)	Atrazine (ppb)	Carbofuran (ppb)
Ea44-13	0.03nd	0.03nd	0.02nd	0.49	0.01nd
Ea45-04					
Eb33-41	0.13	0.00nd*	0.02nd	0.54	0.01nd
Eb33-42					
Eb35-23	0.07	0.02nd	0.02nd	0.31	0.01nd
Eb35-23	0.03nd	0.01nd	nd*	0.35*	0.03nd
Eb43-04					
Eb43-11	0.1*	0.00nd	nd	0.07	0.03nd
Eb51-11					
Eb54-05	0.09	0.015nd*	nd	0.72	0.00nd
Ec51-16					
Ec52-09					
Ed21-20					
Ed51-10	0.00nd	0.00nd	nd	nd	0.03nd*
Fa15-08					
Fa45-07	0.02nd	0.04nd	0.06	1.1	0.02nd*
Fb12-05	0.08	0.01nd	0.01nd	0.43*	0.05nd
Fb14-11					
Fb22-10					
Fb22-15	0.36	0.06	0.04nd	1.63	0.02nd
Fb24-11					
Fb25-07	0.02nd	0.00nd	0.01nd	0.01nd	0.00nd
Fb41-11	0.02nd	0.04nd	0.05nd*	1.35	0.02nd
Fb54-01					
Fb54-05	0.06	0.01nd	0.05	0.16	0.00nd
Fb54-08	0.04nd	0.01nd	0.07	0.06	nd
Fc11-23	0.22*	0.01nd	0.03	0.4	0.03nd*
Fc12-23					
Fc12-26	0.08	0.03nd	0.05	0.82	0.02nd
Fc15-04					
Fc31-11					
Fc42-09					
Fc42-13					
Fc42-24	0.03nd	0.00nd	0.00nd	0.14	0.01nd
Fc42-25					
Gb11-07	0.47	0.09*	0.1	2.93*	0.02nd
Gb14-03					
Gb14-05	0.01nd*	0.00nd	nd	0.01nd	0.03nd*
Gb21-10	0.02nd	0.02nd	0.00nd	0.08	0.02nd
Gb24-05					
Gb53-02	0.01nd	0.01nd	0.01nd	nd	0.01nd
Gc44-07	0.04nd	0.02nd	0.01nd	0.01nd	0.02nd
Hc11-11	0.04nd	0.01nd	0.02nd	0.04nd	0.04nd
Hc13-02					
Hc14-03					
Hc14-15	0.03nd	0.01nd	0.02nd	0.09	0.02nd

KEY

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