Ground-Water-Quality Data in Pennsylvania— A Compilation of Computerized [Electronic] Databases, 1979-2004

By Dennis J. Low and Douglas C. Chichester

In cooperation with the Pennsylvania Department of Environmental Protection

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Contents

Figures

Tables

Conversion Factors, Datums, and Abbreviations

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
gallon per day (gal/d)	0.003785	cubic meter per day
	Radioactivity	
picocurie per liter (pCi/L)	0.037	becquerel per liter
	Temperature	
degree Fahrenheit (^oF)	$^oC=5/9$ (^oF-32)	degree Celsius

Horizontal coordinate information is referenced to either the North American Datum (NAD 1927) or the North American Datum of 1983 (NAD 83).

Water-Quality Units

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as mass (milligrams) of solute per unit volume (liter) of water. One-thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million. Bacterial concentrations are reported in units of colonies per 100 milliliters (col/100 mL). Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C). Turbidity is reported in nephelometric turbidity units (NTU).

Radioactivity Units

A commonly used unit of measure for radioactivity is the picocurie. One Curie is the activity of one gram of radium-226, which is equal to 3.7×10^{10} atomic disintegrations per second; a picocurie is 10^{-12} Curies, which is about equal to 2.2 atomic disintegrations per minute. Activity refers to the decay of a radioactive substance, which is measured by the number of particles emitted by a radionuclide per unit of time. The rate of decay is proportional to the number of atoms of a radioactive substance present, and inversely proportional to its half life, which is the time necessary for the substance to lose half its radioactivity. Activity is defined as being equal to n x l, where n is the number of atoms of a radionuclide and l is the decay constant. The decay constant, l, is equal to the natural logarithm of 2 divided by the half-life of the radionuclide.

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Abstract

This study, by the U.S. Geological Survey (USGS) in cooperation with the Pennsylvania Department of Environmental Protection (PADEP), provides a compilation of ground-water-quality data for a 25-year period (January 1, 1979, through August 11, 2004) based on water samples from wells. The data are from eight source agencies—Borough of Carroll Valley, Chester County Health Department, Pennsylvania Department of Environmental Protection-Ambient and Fixed Station Network, Montgomery County Health Department, Pennsylvania Drinking Water Information System, Pennsylvania Department of Agriculture, Susquehanna River Basin Commission, and the U.S. Geological Survey. The ground-water-quality data from the different source agencies varied in type and number of analyses; however, the analyses are represented by 12 major analyte groups: biological (bacteria and viruses), fungicides, herbicides, insecticides, major ions, minor ions (including trace elements), nutrients (dominantly nitrate and nitrite as nitrogen), pesticides, radiochemicals (dominantly radon or radium), volatile organic compounds, wastewater compounds, and water characteristics (dominantly field pH, field specific conductance, and hardness).

A summary map shows the areal distribution of wells with ground-water-quality data statewide and by major watersheds and source agency. Maps of 35 watersheds within Pennsylvania are used to display the areal distribution of water-quality information. Additional maps emphasize the areal distribution with respect to 13 major geolithologic units in Pennsylvania and concentration ranges of nitrate (as nitrogen). Summary data tables by source agency provide information on the number of wells and samples collected for each of the 35 watersheds and analyte groups.

The number of wells sampled for ground-water-quality data varies considerably across Pennsylvania. Of the 8,012 wells sampled, the greatest concentration of wells are in the southeast (Berks, Bucks, Chester, Delaware, Lancaster, Montgomery, and Philadelphia Counties), in the vicinity of Pittsburgh, and in the northwest (Erie County). The number of wells sampled is relatively sparse in south-central (Adams, Cambria, Cumberland, and Franklin Counties), central (Centre, Indiana, and Snyder Counties), and north-central (Bradford, Potter, and Tioga Counties) Pennsylvania. Little to no data are available for approximately one-third of the state. Water characteristics and nutrients were the most frequently sampled major analyte groups; approximately 21,000 samples were collected for each group. Major and minor ions were the next most-frequently sampled major analyte groups; approximately 17,000 and 12,000 samples were collected, respectively. For the remaining eight major analyte groups, the number of samples collected ranged from a low of 307 samples (wastewater compounds) to a high of approximately 3,000 samples (biological).

The number of samples that exceeded a maximum contaminant level (MCL) or secondary maximum contaminant level (SMCL) by major analyte group also varied. Of the 2,988 samples in the biological analyte group, 53 percent had water that exceeded an MCL. Almost 2,500 samples were collected and analyzed for volatile organic compounds; 14 percent exceeded an MCL. Other major analyte groups that frequently exceeded MCLs or SMCLs included major ions (17,465 samples and a 33.9 percent exceedence), minor ions (11,905 samples and a 17.1 percent exceedence), and water characteristics (21,183 samples and a 20.3 percent exceedence). Samples collected and analyzed for fungicides, herbicides, insecticides, and pesticides (4,062 samples), radiochemicals (1,628 samples), wastewater-compounds (307 samples), and nutrients (20,822 samples) had the lowest exceedences of 0.3, 8.4, 0.0, and 8.8 percent, respectively.

Introduction

Ground-water-quality data have been collected in Pennsylvania for more than 100 years. Unfortunately, most data are confined to paper copies, and it is prohibitively expensive to compile the data. However, with the advent of computers and increased storage capacities, most recent (since about 1980) data now reside in electronic databases making access less expensive. By compiling the electronic data from local, state, and Federal agencies, it may be possible to identify areas where (1) data are sparse and further studies of ground-water quality

may be needed, and (2) ground water contains analytes of concern at elevated concentrations.

In 2001, the Pennsylvania Department of Environmental Protection (PADEP) re-oriented its resource management and planning strategy to a watershed, as opposed to political boundary, approach. With this watershed-focused approach, PADEP established 35 watershed teams (fig. 1 and table 1) to address 17 indicators of environmental improvement at a watershed scale.

Pennsylvania is a physiographically and geologically diverse state. Over 200 different geologic formations or members are recognized by the Pennsylvania Topographic and Geologic Survey (PAGS). For this study, geologic formations were consolidated into 13 major aquifer categories based on dominant rock type or geolithologies (table 2). Even with this simplified categorization, however, geology extends beyond watershed and political boundaries (fig 2).

Purpose and Scope

This report provides geologic, hydrologic, and geographic information regarding electronically available ground-water-quality data in the Commonwealth of Pennsylvania on watershed and statewide scales from January 1, 1979, through August 11, 2004. This report presents ground-water-quality data from eight local, state, or Federal source agencies in a standard electronic format. The geographic distribution of the data also are presented in a standard electronic format, most commonly by watershed. Ancillary information, including local well numbers, and major geolithologic units are included by well for each source agency. More detailed information, specifically the aquifer sampled and the original scientific or data report in which the water-quality data were released, is provided for individual wells sampled as part of various U.S. Geological Survey (USGS) studies or investigations.

Nitrate nitrogen was identified as an analyte of interest to better evaluate the potential of an electronic database for visually displaying ground-water-quality data. Nitrate nitrogen was selected because (1) it is widespread in Pennsylvania, (2) it is commonly analyzed for, and (3) it has a maximum contaminant level (MCL). As a result, maps were generated summarizing nitrate nitrogen concentrations by watershed and geology.

Data-Compilation Methods

The compiled ground-water-quality data varies by (1) number of constituents, (2) frequency of sample collection, (3) source agency, and (4) geographic distribution. For example, the Borough of Carroll Valley collects water-quality data on bacteria and nutrients from selected wells within the Borough once every 10 years. The PADEP Ambient and Fixed Station Network (FSN) collects water-quality data (major ions, minor ions, trace elements, and nutrients) from across the state at individual wells. The frequency of this collection varies from one time only to multiple samples spread out over a period of years. Although the USGS collects ground-water-quality samples across the state, the geographic distribution may vary from several wells at a field research site to major river basins. A specific contaminant of concern such as arsenic may lead to a geographic distribution relating to land use or other factors. Geographic distribution of data collection also may be restricted to specific geologic formations and members.

Table 1. The 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management.

Watershed number	Watershed name
1	Central Penn
2	Upper West Branch
3	Susquehannock/Genessee
4	Lower North Branch Susquehanna
5	Big Bend
6	Bradford/Tioga
7	Upper Susquehanna
8	Wyoming Valley
9	Lackawanna
10	Upper Delaware
11	Brodhead/Toby/Tunk
12	Upper Schuylkill/Middle Lehigh
13	Lower Lehigh
14	Delaware River/Tohickon Creek
15	Delaware Common Tributaries/Neshaminy
16	Middle Schuylkill
17	French/Manatawny
18	Perkiomen Creek
19	Wissahickon Creek/Schuylkill River
20	Darby/Chester/Ridley/Crum Creeks
21	Christina River/Elk/North East River/ Brandywine Creek/White Clay
22	Pennypack/Tacony
23	Lower Susquehanna East
24	Lower Susquehanna West
25	Potomac
26	Juniata
27	Kiski-Conemaugh
28	Youghiogheny
29	Monongahela
30	Ohio
31	Allegheny
32	Moraine
33	Middle Allegheny
34	Upper Allegheny
35	Lake Erie/French & Oil Creek

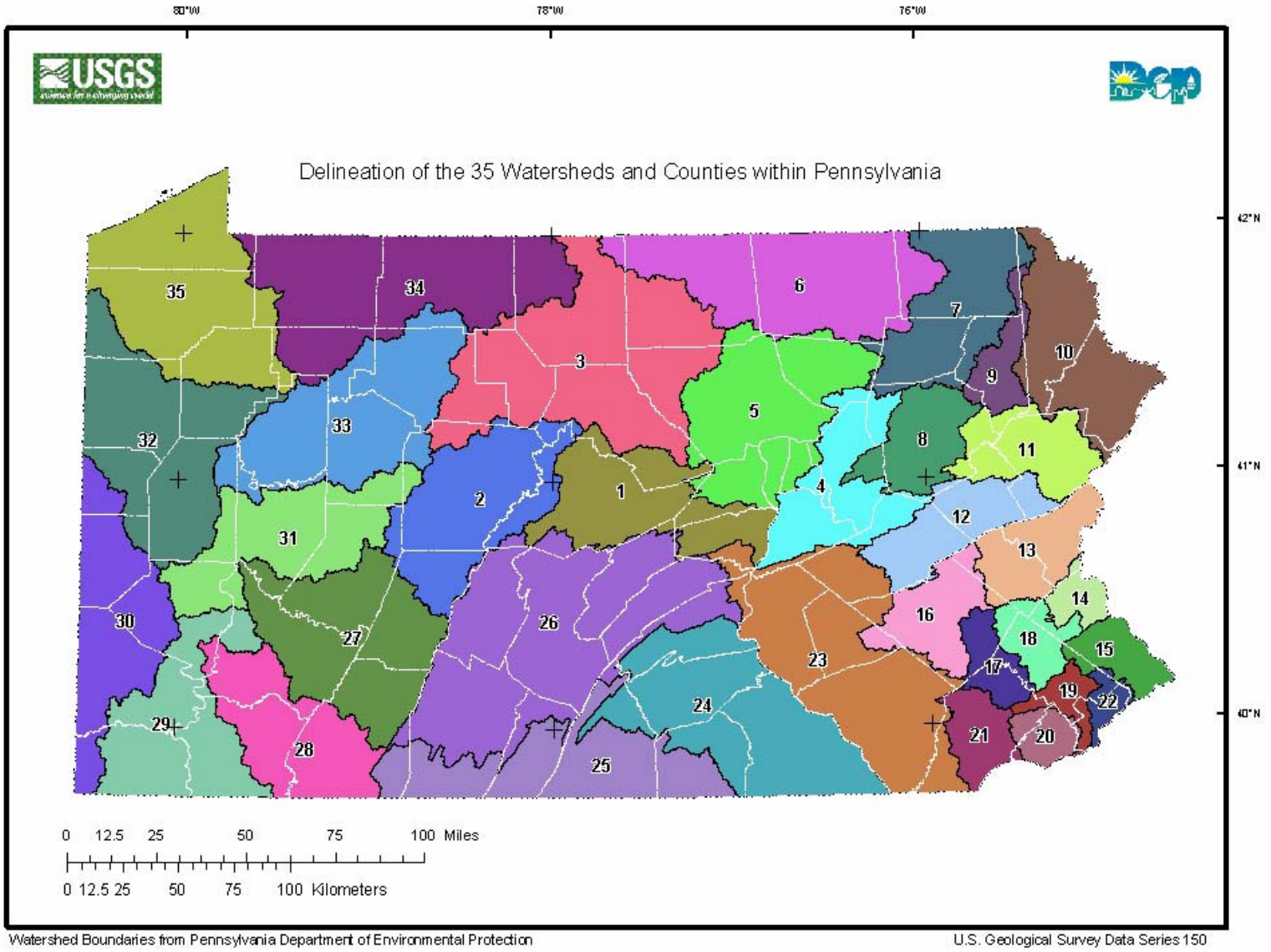

Figure 1. The 67 counties in Pennsylvania and boundaries of the 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management (see table 1 for watershed names). (modified from Pennsylvania Department of Environmental Protection, 2005)

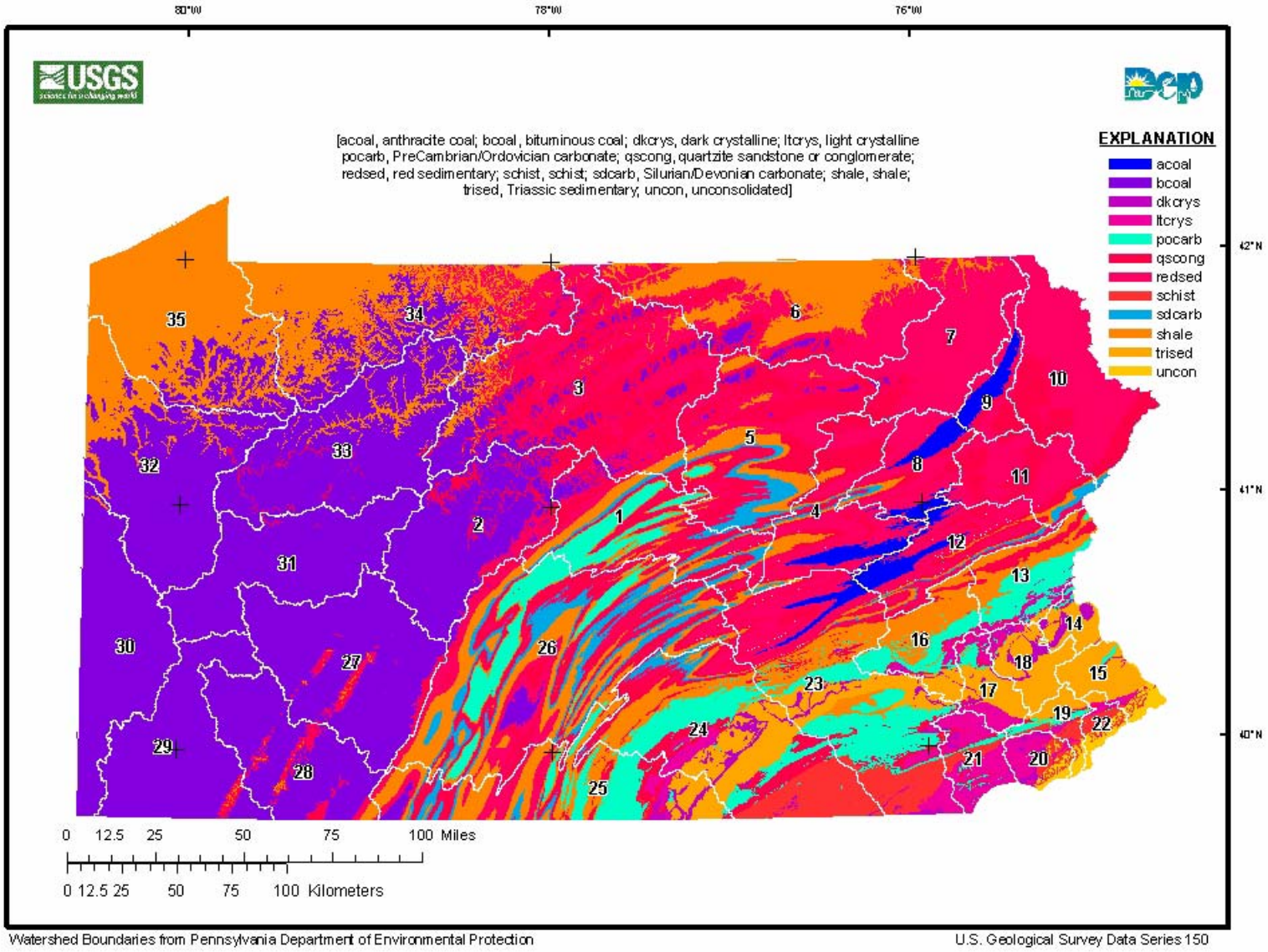

Figure 2. Dominant aquifer (excludes Glacial outwash or "ice") and boundaries of the 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management.

Table 2. The 13 dominant aquifer and rock-type categories used for this data compilation with abbreviations.

Dominant aquifer	Geo-Abbreviation	Dominant rock type.
Anthracite coal	acoal	Anthracite coal bearing
Bituminous coal	bcoal	Bituminous coal bearing
Dark crystalline	dkcrys	Intrusive crystalline rocks that are dark in color (for example, diabase)
Light crystalline	ltcrys	Intrusive crystalline rocks that are light in color (for example, granite)
PreCambrian/Ordovician carbonates	pocarb	Precambrian- through Ordovician-age limestones and dolomites (with or without minor siliciclastics)
Quartzite, sandstone, or conglomerate	qscong	Quartz rich, dominantly sedimentary rocks (for example, Tuscarora Formation)
Red sedimentary	redsed	Rocks that are dominantly red in color, excludes Triassic age sediments (for example, Catskill Formation)
Schist	schist	A strongly foliated crystalline rock, formed by dynamic metamorphism, that have a dominant cleavage plane due to well developed parallelism of the minerals (for example, Marburg Schist)
Silurian/Devonian carbonates	sdcarb	Silurian- through Devonian-age limestones and dolomites (with or without minor siliciclastics)
Shale	shale	Dark, fine-grained, sedimentary rocks (for example, Hamilton Group)
Triassic sedimentary	trised	Sedimentary rocks that are Triassic in age (for example, Gettysburg Formation)
Unconsolidated	uncon	Gravels, sands, and clays along the Delaware River (for example, Trenton Gravel)
Glacial outwash	ice	Dominantly sand and gravel that were deposited by glaciers or associated fluvial action (for example, outwash)

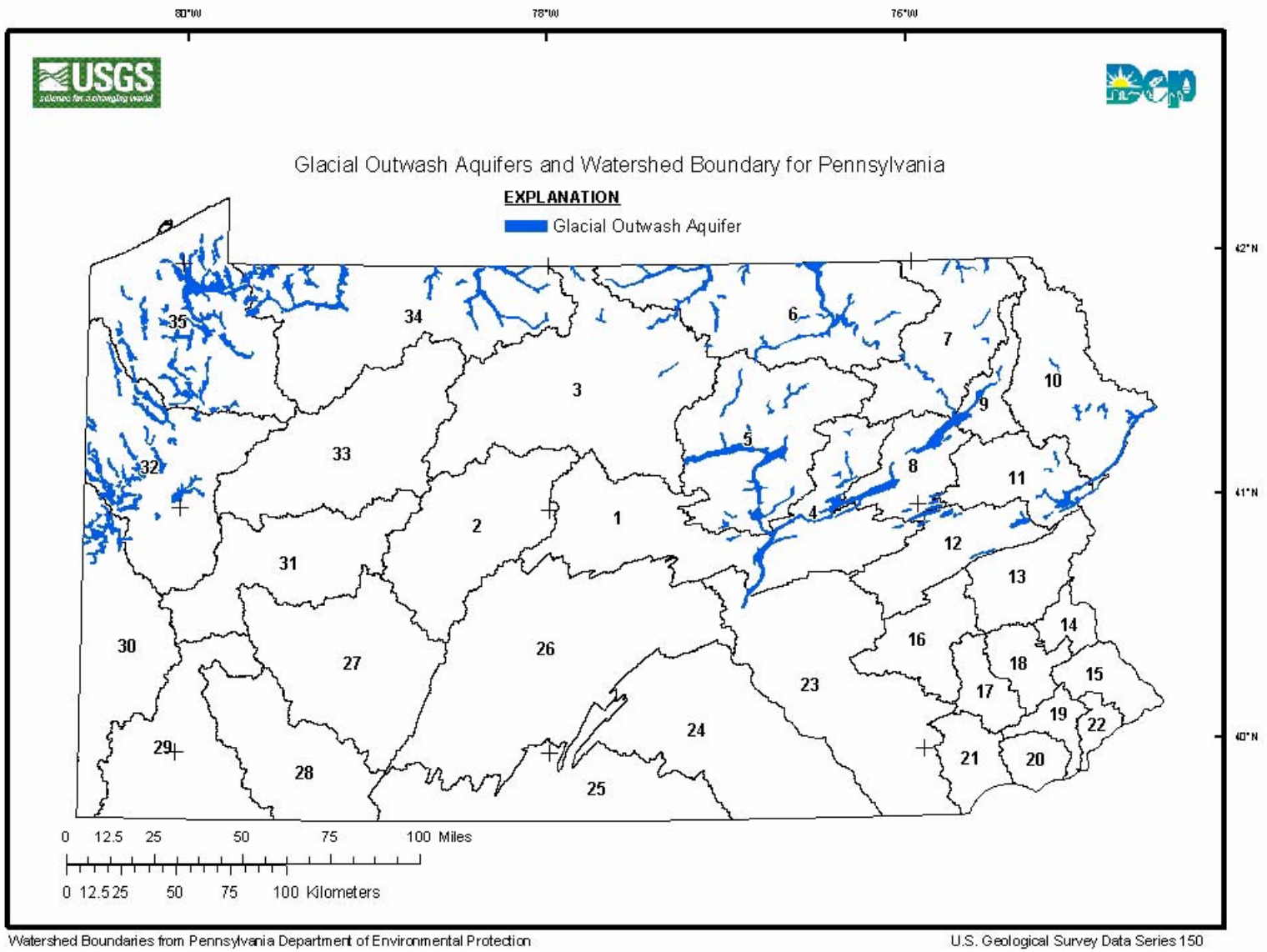

Figure 3. Glacial outwash or "ice" aquifers and boundaries of the 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management. (modified from Sevon and Braun, 2000)

Data Sources

Despite the widespread use of computers and related software, electronic archival or storage of ground-water-quality data is limited when compared to what is available in hard or paper copy. Many local and county agencies as well as universities contacted for this study maintain paper copies as the final repository format for ground-water-quality data. As a result, the sources of the collected data in this study are dominated by state and Federal agencies. Information on the source of the ground-water-quality data collected for this study and reasons for data collection are presented in table 3.

About every 10 years, as part of their Act 537 Sewage Facilities Program (Carl Bower, Borough of Carroll Valley, oral commun., 2004), the Borough of Carroll Valley (CV) evaluates the effectiveness of the community's onlot septic systems. This is done by collecting water-quality samples from domestic wells for analysis of nitrate as nitrogen and bacteria (fecal and total coliform). Carroll Valley tries to obtain a representative sample from about 10 percent of the domestic wells.

Since 1984, the Chester County Health Department (CCDH) has required that recently drilled and completed domestic wells be sampled and tested for a fixed group of analytes. Although the number of analytes tested is extensive, only a small part of the data is stored electronically (water characteristics, major ions, and nutrients).

PADEP is charged with determining the ambient ground-water quality of water in Pennsylvania. PADEP addresses this effort through the FSN. The FSN consists of a large number of wells in selected basins generally in the eastern or western parts of Pennsylvania.

Since February 1, 1997, the Montgomery County Health Department (MCHD) has required that recently drilled and completed domestic wells be sampled and tested for a fixed group of analytes. These analytes include bacteria, water characteristics, major ions, minor ions, nutrients, trace elements, volatile organic compounds, and wastewater compounds.

PADEP also is responsible for assessments of ground-water quality for community and non-community water systems to determine whether ground water meets the primary drinking-water standards. One method utilized by PADEP to meet this directive is through the Pennsylvania Drinking Water Information System (PADWIS). Through PADWIS, raw (unfiltered) ground-water samples are collected from non-private wells and submitted to private water-quality labs for analysis. The resulting data are then reviewed and entered into PADWIS.

The Pennsylvania Department of Agriculture (PennAg) has long been interested in monitoring for pesticides in ground water. As a result, PennAg has sampled wells in agricultural areas to determine occurrence and distribution of pesticides in ground water; the most recent sampling was directed at an assessment of concentration trends.

The Susquehanna River Basin Commission (SRBC) issues permits for large supply wells (wells that yield more than 100,000 gallons per day). Water-quality data is a part of the data that SRBC collects.

The U.S. Geological Survey (USGS) has collected data through various water-resources and water-quality studies. Much of the water-quality data collected by the USGS was obtained from analysis of water samples from domestic wells.

Table 3. Data sources and reason(s) for data collection.

Data Sources	Source abbreviation	Reason for data collection
Borough of Carroll Valley	CV	Act 537 (sewage facilities program)
Chester County Health Department	CCDH	Permitting of domestic wells
Pennsylvania Department of Environmental Protection—Ambient and Fixed Station Network	FSN	Monitoring of ground-water quality by ground-water basin
Montgomery County Health Department	MCHD	Permitting of domestic wells
Pennsylvania Drinking Water Information System	PADWIS	Permitting of public and non-community wells (self-reporting system)
Pennsylvania Department of Agriculture	PennAg	Pesticides in ground water
Susquehanna River Basin Commission	SRBC	Permitting of public, industrial, and commercial water-supply wells
U.S. Geological Survey	USGS	Various water-resources and water-quality studies

Mandatory Latitude and Longitude in Data Files

Water-quality data collected from January 1, 1979, through August 11, 2004, were obtained from the source government agencies in a variety of electronic formats but were dominated by Microsoft Excel or .dbf4 type files (.dbf4 or dBase files are simple sequential files of fixed-length records. .dbf file formats commonly are understood by Windows spreadsheets and organizers.). Although the number of analytes varied by source agency and the objective(s) of historical studies, each data set was required to have (1) a site-specific identifier such as a local name or well number, (2) a geographic reference, and (3) an analyte of interest. The CV data set lacked latitudes and longitudes but contained street addresses and parcel numbers. The parcel and address information was combined with an available Geographic Information System (GIS) parcel coverage to assign latitudes and longitudes. The wells comprising the MCHD data set contained a mixture of latitudes, longitudes, and street addresses. The GIS parcel coverage from Montgomery County was not available; therefore, wells lacking latitudes or longitudes were removed from the data set.

Assigning a Geolithology to Wells

Utilizing previous work (Barker, 1984; Low and others, 2002), the geologic formations represented on PAGS Map 1 (Berg and others, 1980) were condensed into 13 geolithologic units (table 2), and a GIS coverage was developed. A second GIS coverage that contained attributes for the 35 watersheds was obtained from PADEP (fig. 1). On the basis of their geographic distribution, the wells in each data set were brought into the various GIS coverages and assigned a specific geolithologic unit and watershed.

Clean-up of Data Records and Bulk Processing

The data sets from MCHD and CCDH included a large segment of text embedded with quantified results. A substantial effort at hand editing was involved to separate the text from the quantified results. In many of these cases, qualitative results were converted into numeric remark codes such as “sample exceeded the MCL for lead,” or “an analyte was sampled for but not detected.”

To efficiently combine the water-quality data sets and the GIS data sets, a series of SAS Institute Inc. (SAS) programs were developed. The SAS programs not only merged the water-quality and GIS data sets by site identifier but also were written to identify which samples contained an analyte that exceeded a U.S. Environmental Protection Agency (USEPA) maximum contaminant level (MCL) or secondary maximum contaminant level (SMCL). Because of the size of some files generated by the SAS program, the data sets were exported as .dbf4 files and hand edited for possible errors prior to conversion to Microsoft Excel format where additional editing took place. Additional GIS coverages were then developed from the Microsoft Excel data files to show the distribution of wells by data source across the state and for individual major watershed.

Categories of Analytes

The source-agency data files are subdivided into 12 analyte groups described below. These analyte groups represent subfiles or folders. Some source agency files, such as the CV, consisted of two subfiles—bacteria and nutrients. Others, like the USGS, consisted of 11 subfiles. Because some source agencies such as the USGS collect a large amount of pesticide data, it was necessary to further divide this analyte group into fungicides, herbicides, and insecticides.

Analyte Group Abbreviations and Descriptions

- Micro—Bacteria, viruses, and other micro-organisms group. Total coliform and fecal coliform are the most common bacteria analyzed. Enteric and coliphage are the most common viruses analyzed. Clostridium and enterococci are some of the other micro-organisms analyzed.

  Source agency—CV: Total and fecal bacteria; 124 samples.
  Source agency—MCHD: Total, fecal, and *Escherichia coli* (*E. coli*) bacteria; 971 samples.
  Source agency—PADWIS: Total, fecal, and *E. coli* bacteria; 360 samples.
  Source agency—PennAg: Total and *E. coli* bacteria; 269 samples.
  Source agency—USGS: 11 methods or organisms including viruses; 1,264 samples.
- Field—Water characteristics group. pH and specific conductance are the most common analytes.

  Source agency—CCDH: Turbidity and pH; 833 samples.
  Source agency—FSN: lab pH, lab alkalinity, and total hardness; 10,590 samples.
  Source agency—MCHD: pH; 971 samples.
  Source agency—SRBC: 4 parameters or analytes; 681 samples.
  Source agency—USGS: 16 parameters or analytes; 8,132 samples
- Fungus—Fungicide group. Chlorothalonil and cis-1,3-Dichloropropane are the most common analytes.

  Source agency—USGS: 10 analytes (including filtered and unfiltered); 1,196 samples.
- Herb—Herbicide group. Atrazine, Alachlor, and Cyanazine are among the most common analytes.

  Source agency—USGS: 107 analytes (including filtered and unfiltered); 1,319 samples.
- Insec—Insecticide group. Carbaryl, Dieldrin, and Lindane are among the most common analytes.

  Source agency—USGS: 87 analytes (including filtered and unfiltered); 1,280 samples.
- Major—Major cations and anions group. Chloride, calcium, and iron are among the most common analytes.

  Source agency—FSN: 11 analytes; 10,591 samples.
  Source agency—MCHD: 4 analytes; 971 samples.
  Source agency—SRBC: 8 analytes; 724 samples.
  Source agency—USGS: 31 analytes (including filtered and unfiltered); 5,175 samples.
- Minors—Minor cations, anions, and trace elements group. Aluminum, arsenic, and lead are common analytes.

  Source agency—FSN: 8 analytes (trace elements); 7,675 samples.
  Source agency—MCHD: 4 analytes (trace elements); 75 samples.
  Source agency—PADWIS: 12 analytes; 36 samples.
  Source agency—SRBC: 6 analytes (trace elements); 706 samples.
  Source agency—USGS: 41 analytes (including filtered and unfiltered); 3,413 samples.
- Nuts—Nutrient group. Nitrate, nitrite, and total organic carbon are among the most common analytes.

  Source agency—CV: Nitrate; 124 samples.
  Source agency—CCDH: Nitrate; 849 samples.
  Source agency—FSN: 5 analytes; 10,594 samples.
  Source agency—MCHD: Nitrate; 971 samples.
  Source agency—PennAg: Nitrate, nitrite; 269 samples.
  Source agency—SRBC: Nitrate, orthophosphate, and total organic carbon; 707 samples.
  Source agency—USGS: 27 analytes (including filtered and unfiltered); 7,315 samples.
- Pest—Pesticide group. Atrazine, Cyanazine, and Simazine are among the most common analytes.

  Source agency—PADWIS: Carbofuran, and 2,4-D; 2 samples.
  Source agency—PennAg: 10 analytes; 273 samples.
- Radio—Radiochemicals (radionuclides) group. Radon-222 and uranium are the most common analytes.

  Source agency— PADWIS: 6 analytes; 19 samples.
  Source agency—USGS: 16 analytes (including filtered and unfiltered); 1,609 samples.
- Voa—Volatile organic compounds group. Benzene, toluene, styrene, and xylenes are among the most common analytes.

  Source agency—MCHD: 25 analytes; 971 samples.
  Source agency—PADWIS: 27 analytes; 183 samples.
  Source agency—USGS: 104 analytes (including filtered and unfiltered); 1,280 samples
- Waste—Wastewater and pharmaceuticals group. Methylene blue active substance and caffeine are among the most common analytes.

  Source agency—MCHD: Trihalomethanes; 5 samples.
  Source agency—USGS: 54 analytes (including filtered and unfiltered); 304 samples.

Formats, Naming Conventions, and Abbreviations Used in Data Files

The data format is Microsoft Excel 2003 (Excel); supporting documents are in Portable Document Format (PDF). Each folder is identified by the source agency. For example, the folder titled MCHD contains files compiled from the Montgomery County Health Department. Within each folder are a series of files. Each file is organized by analyte group. For example, the Excel file titled MCHD.Voa.xls contains the water-quality data for volatile organic compounds collected by the Montgomery County Health Department. Also included in this file are ancillary data such as local well number, site identifier (site ID), latitude, longitude, and geolithologic unit. Information regarding an exceedence of a USEPA MCL or SMCL is presented in an adjacent column and cell. Analyte results for MCHD and CCDH also contain numeric qualifiers. Data files from the USGS also contain analyte remark codes such as less than, estimated, and missing, as well as information on the study for which the samples were collected. The USGS data files also contain a seven or eight length alphanumeric code that details a specific geologic formation or unit.

MCHD.Comments.Micro.pdf is a PDF file that provides supporting information on the water-quality measurements (in this case about bacteria and viruses), including analytes, definitions, and USEPA contaminant levels on samples collected by or for the Montgomery County Health Department.

USGS.CrossReferenceNumbers is an Excel table that presents the abbreviated author and report citation for the scientific or data report in which the data were originally published. This allows the interested reader a means to locate the study and determine the purpose for which the data were collected. It is an aid in locating the complete citation listed in the Selected References, which also lists the abbreviated report citation in bold. USGS.MicroReport is an Excel file that lists the abbreviated citations for bacteria and virus studies and includes local well numbers, site IDs, latitudes, longitudes, watersheds, geolithologic units, and geologic formations.

Maps and Tables Summarizing the Ground Water-Quality Data

The maps generated for this study (accessed through hyperlinks in the Appendix) are PDF images. The 35 images titled Basin1_Wells through Basin35_Wells show the distribution of wells with available water-quality data by watershed and source agency. The 35 images titled Basin1_QWNO3 through Basin35_QWNO3 show the distribution of nitrate data (NO3) by watershed and source agency. The 12 images pre-fixed by “Statewide” show the distribution of wells with water-quality data by source agency.

Summary tables (accessed through hyperlinks in the Appendix) are included within each source-agency file. For example, SRBC.Summary.pdf (table 4) presents information on the number of (1) wells sampled by major river basin, (2) wells sampled by watershed, (3) samples collected by analyte group, and (4) samples that exceeded USEPA contaminant levels.

Statewide Summary Map

Figure 4 shows the distribution of the 8,012 wells from the eight source agencies. The greatest concentration of wells with water-quality data are in watersheds 17, 18, 21, and 23 of southeastern Pennsylvania (Chester, Lancaster, and Montgomery Counties). The part of watershed 35 that has been extensively sampled is Erie County. About half of the watersheds in Pennsylvania have fewer than 100 wells with water-quality data; watershed 9 contains no ground-water-quality data.

Summary Maps for 35 Watersheds

Figure 5 shows the distribution by county and watershed from the PDF image Basin35_Wells. Almost all 246 wells sampled for ground-water-quality data in watershed 35 were the result of USGS studies specifically related to Erie County. Similar images for all 35 watersheds can be viewed through the hyperlinks in the Appendix.

Summary Maps for Nitrate Nitrogen Concentrations in Ground Water for 35 Watersheds

Figure 6 shows the distribution of 461 wells by county in watershed 24 (from the PDF image Basin24_QWNO3). Of the 565 nutrient samples collected and analyzed, 31 samples (5.5 percent) exceeded the USEPA MCL of 10.0 mg/L for nitrate. Results were averaged for wells that were sampled more than once. About 50 percent of the wells visited and sampled are the result of USGS studies. Similar images for all 35 watersheds can be viewed through the hyperlinks in the Appendix.

Summary Tables by Source Agency

Table 4 is a summary of the ground-water-quality data collected by the SRBC and contained within the various Excel data spreadsheet files listed for the SRBC in the Appendix. Similar summary files for the other source agencies also are available through hyperlinks in the Appendix. Each summary table presents information on the number of wells sampled, the number of samples collected, the number of exceedences for USEPA MCL and SMCL analytes. The summary data are organized by PADEP watershed and major analyte group.

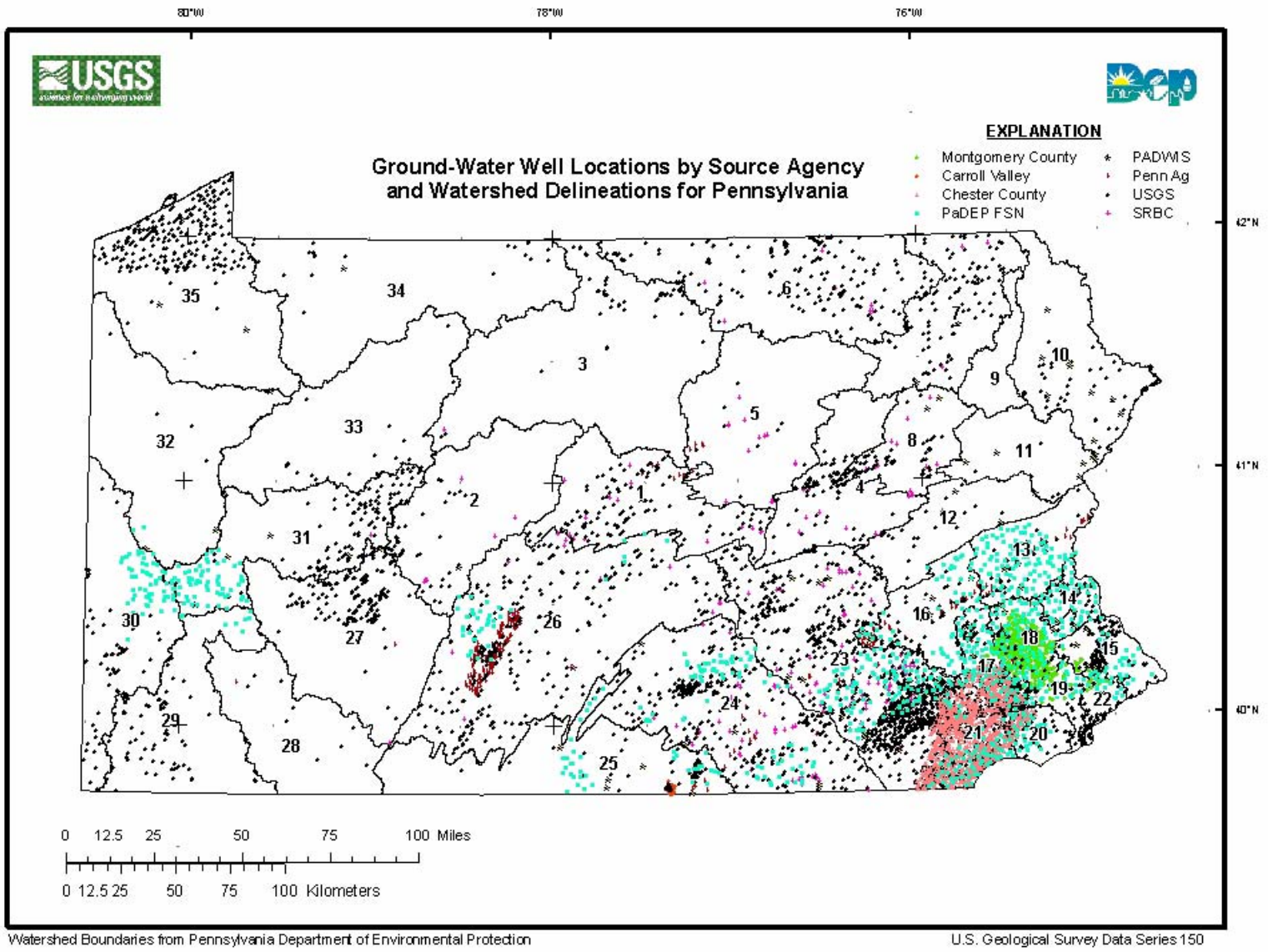

Figure 4. Well locations with ground-water-quality data compiled from eight source agencies representing the period 1979-2004 for Pennsylvania.

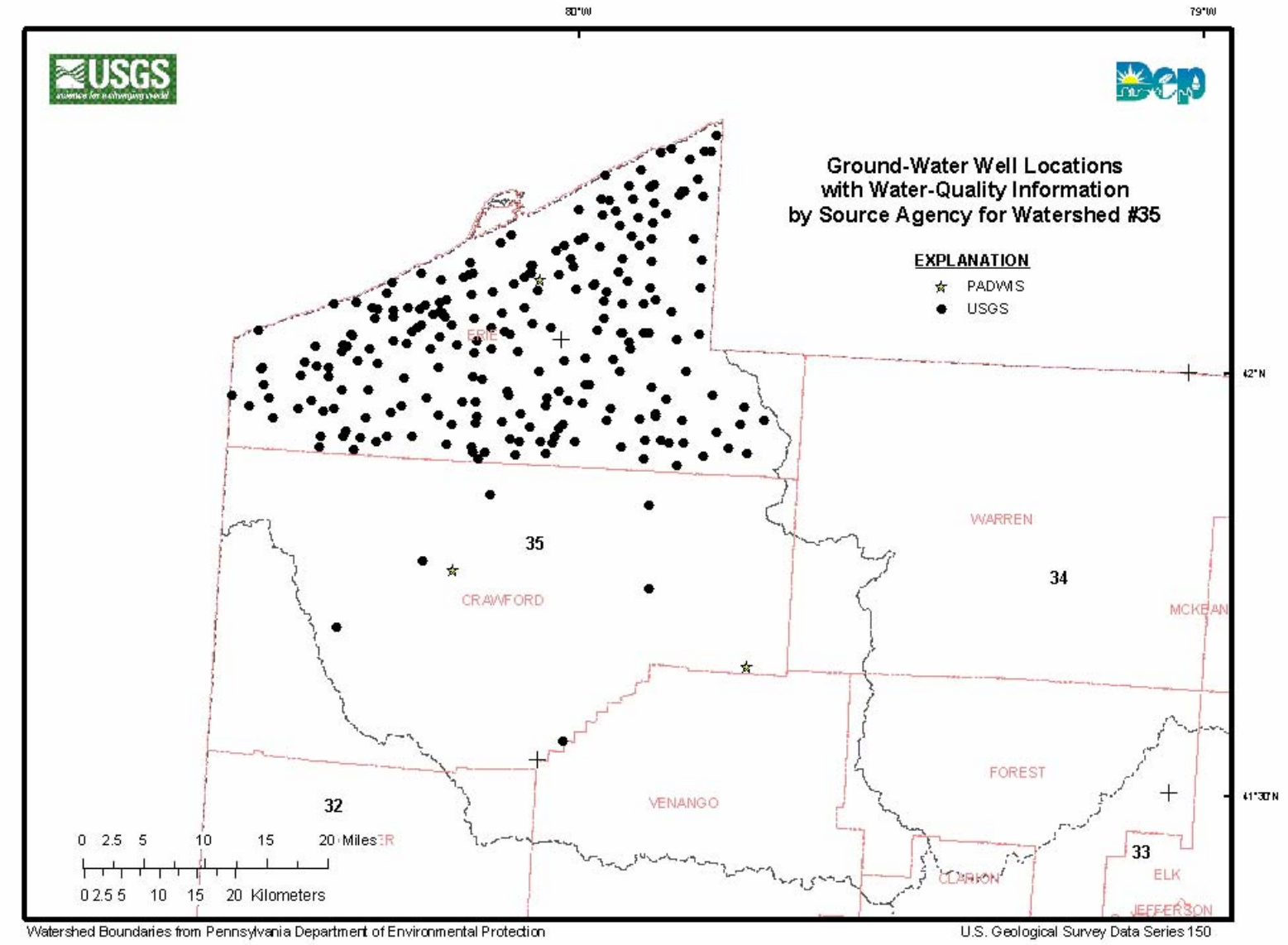

Figure 5. Well locations of water-quality data compiled from two source agencies (Pennsylvania Drinking Water Information System and U.S. Geological Survey) for Watershed Number 35, Lake Erie/French & Oil Creek, northwestern Pennsylvania.

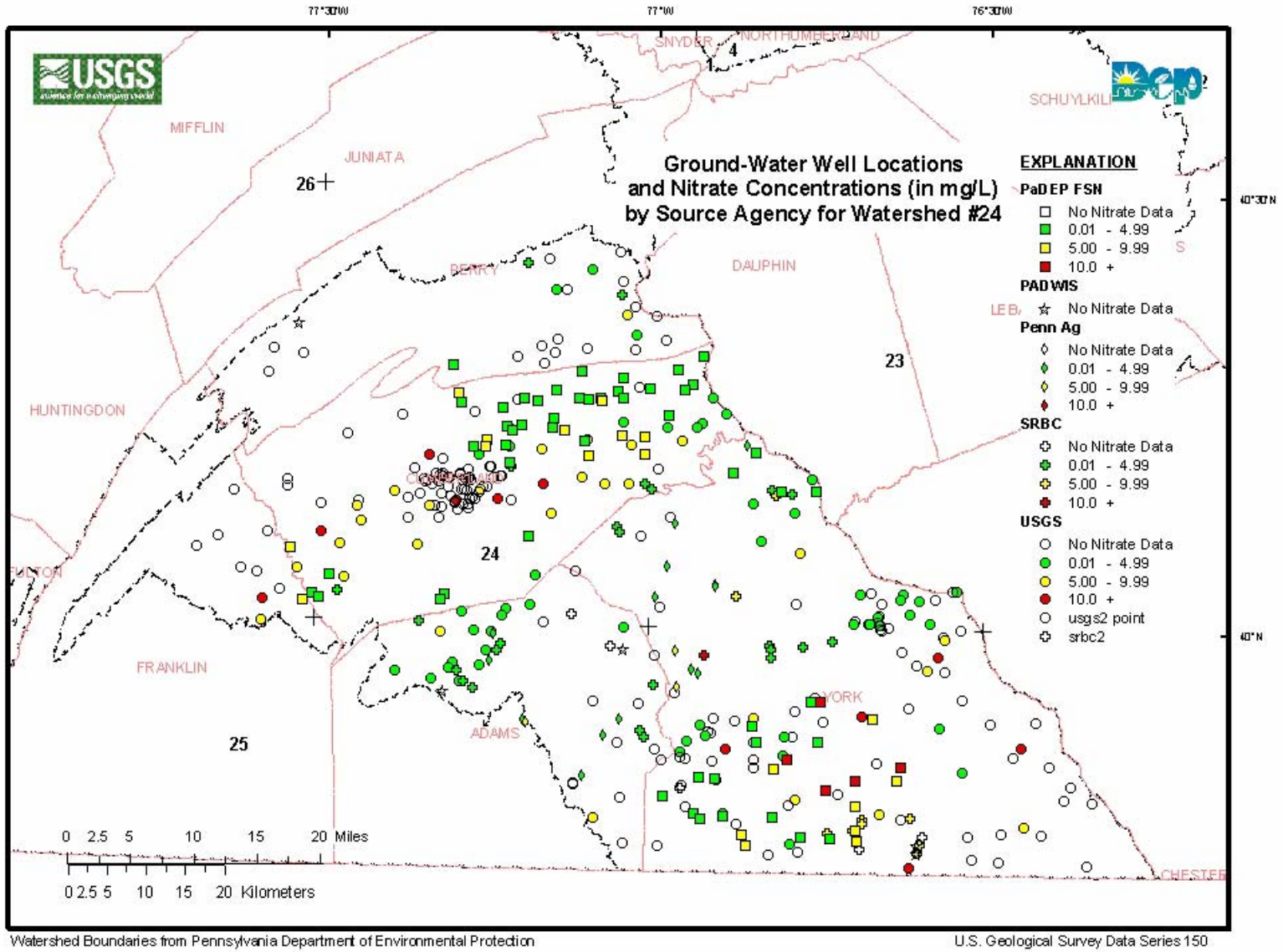

Figure 6. Ranges of concentration for nitrate nitrogen in ground water for Watershed Number 24, southcentral Pennsylvania.

Table 4. Summary table of Susquehanna River Basin Commission (SRBC) ground-water-quality studies by major river basins in Pennsylvania.

[2/ 0, number of samples collected/number of samples that exceeded a U.S. Environmental Protection Agency Maximum or Secondary Maximum Contaminant Level]

Pennsylvania Department of Environmental Protection watershed	Wells	Major ions	Minor and trace elements	Nutrients	Water characteristics (field measurements)
Ohio and St. Lawrence River Basins					
31	1	2/ 0	2/ 0	2/ 0	2/ 0
Delaware River Basin					
12	6	13/ 4	14/ 4	13/ 0	13/ 8
Lower Susquehanna River Basin					
23	123	289/ 73	278/ 27	236/ 34	267/ 27
24	61	147/ 14	145/ 22	138/ 3	144/ 23
26	18	40/ 3	39/ 6	31/ 3	33/ 2
Upper Susquehanna River Basin					
1	23	39/ 9	38/ 5	36/ 0	37/ 1
2	10	35/ 15	35/ 5	28/ 0	33/ 7
3	1	2/ 0	3/ 0	2/ 0	2/ 0
4	14	21/ 12	21/ 5	21/ 0	21/ 7
5	24	44/ 12	41/ 3	41/ 0	43/ 10
6	17	33/ 23	32/ 8	28/ 0	31/ 0
7	3	7/ 0	6/ 1	7/ 0	6/ 1
8	28	52/ 22	52/ 7	49/ 1	49/ 17

Summary

This study, by the U.S. Geological Survey (USGS) in cooperation with the Pennsylvania Department of Environmental Protection (PADEP) Bureau of Watershed Management, provides detailed ground-water-quality data from January 1, 1979, to August 11, 2004, on 8,612 wells for 35 watersheds throughout Pennsylvania. Eight source agencies—Borough of Carroll Valley (CV), Chester County Health Department (CCDH), Pennsylvania Department of Environmental Protection-Ambient and Fixed Station Network (FSN), Montgomery County Health Department (MCHD), Pennsylvania Drinking Water Information System (PADWIS), Pennsylvania Department of Agriculture (PennAg), Susquehanna River Basin Commission (SRBC), and USGS provided the data in various electronic formats that were suitable for editing and compiling. The resulting ground-water-quality data were divided, by source agency, into 12 analyte groups—micro-organisms, major ions, minor ions and trace elements, nutrients, pesticides (USGS pesticide data were further subdivided into fungicides, herbicides, and insecticides), radiochemicals, volatile organic compounds, wastewater compounds, and water characteristics.

For each source agency, Microsoft Excel files and Portable Document Format files were created. The Excel files (for example, CV.Micro.xls) contain the edited ground-water-quality data, whereas the PDF files (for example, SRBC.Summary.pdf) contain a summary of the results by watershed and analyte group. As a result of the large number of independent studies conducted by the USGS, additional Excel files were created. These Excel files (for example, USGS.MicroReport.xls) contain an abbreviated reference to the original citation listed in Selected References. This allows the interested reader a means to locate the study and determine the purpose for which the ground-water-quality data were collected.

A series of PDF images were created to show the 35 watersheds within Pennsylvania, the 13 geolithologic units that were used to represent the complex geology of Pennsylvania, and the distribution of 8,612 wells with ground-water-quality data. An additional 35 images were created to show the distribution of the 8,612 wells by watershed, another 35 were images created to show the distribution and range of nitrate (as nitrogen) concentrations in the 35 watersheds.

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Joseph J. Lee, Jr. and Patrick Bowling of the Pennsylvania Department of Environmental Protection Bureau of Watershed Management provided technical assistance and review of the report along with Dennis W. Risser, Kim L. Otto, and Kevin J. Breen from the USGS.

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Appendix—Files of Comments, Data, and Map Images by Source

["Click" on filename in lists below to link to the file]

Borough of Carroll Valley

Comment Files	Data Spreadsheet Files	Map Image Files
Portable Document Format	Microsoft Excel Format	Portable Document Format
CV.Comments.Micro.pdf	CV.Micro.xls	Statewide_WellsCarrollValley.pdf
CV.Comments.Nuts.pdf	CV.Nuts.xls	
CV.Summary.pdf		

Chester County Health Department

Comment Files	Data Spreadsheet Files	Map Image Files
Portable Document Format	Microsoft Excel Format	Portable Document Format
CCDH.Comments.Field.pdf	CCDH.Field.xls	Statewide_WellsChesterCo.pdf
CCDH.Comments.Nuts.pdf	CCDH.Nuts.xls	
CCDH.Summary.pdf		

Pennsylvania Department of Environmental Protection Ambient and Fixed Station Network

Comment Files	Data Spreadsheet Files	Map Image Files
Portable Document Format	Microsoft Excel Format	Portable Document Format
FSN.Comments.Field.pdf	FSN.Field.xls	Statewide_WellsPaDEPFSN.pdf
FSN.Comments.Major.pdf	FSN.Major.xls	
FSN.Comments.Minor.pdf	FSN.Minor.xls	
FSN.Comments.Nuts.pdf	FSN.Nuts.xls	
FSN.Summary.pdf		

Montgomery County Health Department

Comment Files	Data Spreadsheet Files	Map Image Files
Portable Document Format	Microsoft Excel Format	Portable Document Format
MCHD.Comments.Micro.pdf	MCHD.Micro.xls	Statewide_WellsMontgomeryCo.pdf
MCHD.Comments.Field.pdf	MCHD.Field.xls	
MCHD.Comments.Major.pdf	MCHD.Major.xls	
MCHD.Comments.Minor.pdf	MCHD.Minor.xls	
MCHD.Comments.Nuts.pdf	MCHD.Nuts.xls	
MCHD.Comments.Voa.pdf	MCHD.Voa.xls	
MCHD.Comments.Waste.pdf	MCHD.Waste.xls	
MCHD.Summary.pdf		

Pennsylvania Drinking Water Information System

Comment Files	Data Spreadsheet Files	Map Image Files
Portable Document Format	Microsoft Excel Format	Portable Document Format
PADWIS.Comments.Micro.pdf	PADWIS.Micro.xls	Statewide_WellsPADWIS.pdf
PADWIS.Comments.Minor.pdf	PADWIS.Minor.xls	
PADWIS.Comments.Pest.pdf	PADWIS.Pest.xls	
PADWIS.Comments.Radio.pdf	PADWIS.Radio.xls	
PADWIS.Comments. Voa.pdf	PADWIS.Voa.xls	
PADWIS.Summary.pdf		

Pennsylvania Department of Agriculture

Comment Files	Data Spreadsheet Files	Map Image Files
Portable Document Format	Microsoft Excel Format	Portable Document Format
PennAg.Comments.Micro.pdf	PennAg.Micro.xls	Statewide_WellsPennAg.pdf
PennAg.Comments.Nuts.pdf	PennAg.Nuts.xls	
PennAg.Comments.Pest.pdf	PennAg.Pest.xls	
PennAg.Summary.pdf		

Susquehanna River Basin Commission

Comment Files	Data Spreadsheet Files	Map Image Files
Portable Document Format	Microsoft Excel Format	Portable Document Format
SRBC.Comments.Field.pdf	SRBC.Field.xls	Statewide_WellsSRBC.pdf
SRBC.Comments.Major.pdf	SRBC.Major.xls	
SRBC.Comments.Minor.pdf	SRBC.Minor.xls	
SRBC.Comments.Nuts.pdf	SRBC.Nuts.xls	
SRBC.Summary.pdf		

U.S. Geological Survey—Pennsylvania Water Science Center

Comment Files	Data Spreadsheet Files		Map Image Files
Portable Document Format	Microsoft Excel Format		Portable Document Format
USGS.Comments.Micro.pdf	USGS.Micro.xls	USGS.MicroReport.xls	Statewide_WellsUSGS.pdf
USGS.Comments.Field.pdf	USGS.Field.xls	USGS.FieldReport.xls	
USGS.Comments.Fungus.pdf	USGS.Fungus.xls	USGS.FungusReport.xls	
USGS.Comments.Herb.pdf	USGS.Herb.xls	USGS.HerbReport.xls	
USGS.Comments. Insec.pdf	USGS.Insec.xls	USGS.InsecReport.xls	
USGS.Comments.Major.pdf	USGS.Major.xls	USGS.MajorReport.xls	
USGS.Comments.Minor.pdf	USGS.Minor.xls	USGS.MinorReport.xls	
USGS.Comments.Nuts.pdf	USGS.Nuts.xls	USGS.NutsReport.xls	
USGS.Comments.Radio.pdf	USGS.Radio.xls	USGS.RadioReport.xls	
USGS.Comments.Voa.pdf	USGS.Voa.xls	USGS.VoaReport.xls	
USGS.Comments.Waste.pdf	USGS.Waste.xls	USGS.WasteReport.xls	
USGS.Summary.pdf	USGS.CrossReference Numbers.xls		

Pennsylvania Geology

Map Image Files
Portable Document Format
Statewide_Geology.pdf
Statewide_SurficialGeology.pdf

Pennsylvania Well Locations

Map Image Files
Portable Document Format
Statewide_Wells2.pdf

Pennsylvania Watersheds

Map Image Files
Portable Document Format

Statewide_Watershed.pdf	Basin11_Wells.pdf	Basin21_Wells.pdf	Basin31_Wells.pdf
Basin1_Wells.pdf	Basin12_Wells.pdf	Basin22_Wells.pdf	Basin32_Wells.pdf
Basin2_Wells.pdf	Basin13_Wells.pdf	Basin23_Wells.pdf	Basin33_Wells.pdf
Basin3_Wells.pdf	Basin14_Wells.pdf	Basin24_Wells.pdf	Basin34_Wells.pdf
Basin4_Wells.pdf	Basin15_Wells.pdf	Basin25_Wells.pdf	Basin35_Wells.pdf
Basin5_Wells.pdf	Basin16_Wells.pdf	Basin26_Wells.pdf	
Basin6_Wells.pdf	Basin17_Wells.pdf	Basin27_Wells.pdf	
Basin7_Wells.pdf	Basin18_Wells.pdf	Basin28_Wells.pdf	
Basin8_Wells.pdf	Basin19_Wells.pdf	Basin29_Wells.pdf	
Basin9_Wells.pdf	Basin20_Wells.pdf	Basin30_Wells.pdf	
Basin10_Wells.pdf			

Pennsylvania Watersheds and Nitrate Ranges

Map Image Files
Portable Document Format

Basin1_QWNO3.pdf	Basin11_QWNO3.pdf	Basin21_QWNO3.pdf	Basin31_QWNO3.pdf
Basin2_QWNO3.pdf	Basin12_QWNO3.pdf	Basin22_QWNO3.pdf	Basin32_QWNO3.pdf
Basin3_QWNO3.pdf	Basin13_QWNO3.pdf	Basin23_QWNO3.pdf	Basin33_QWNO3.pdf
Basin4_QWNO3.pdf	Basin14_QWNO3.pdf	Basin24_QWNO3.pdf	Basin34_QWNO3.pdf
Basin5_QWNO3.pdf	Basin15_QWNO3.pdf	Basin25_QWNO3.pdf	Basin35_QWNO3.pdf
Basin6_QWNO3.pdf	Basin16_QWNO3.pdf	Basin26_QWNO3.pdf	
Basin7_QWNO3.pdf	Basin17_QWNO3.pdf	Basin27_QWNO3.pdf	
Basin8_QWNO3.pdf	Basin18_QWNO3.pdf	Basin28_QWNO3.pdf	
Basin9_QWNO3.pdf	Basin19_QWNO3.pdf	Basin29_QWNO3.pdf	
Basin10_QWNO3.pdf	Basin20_QWNO3.pdf	Basin30_QWNO3.pdf	

Pennsylvania Watersheds 17 and 18 Geology and Nitrate Ranges

Map Image Files
Portable Document Format
Basin17_QWNO3GEO.pdf
Basin18_QWNO3GEO.pdf