State Summary for Pennsylvania

Information on population density, use of domestic-water supply, land use, and distribution of the 11 selected contaminants (arsenic, atrazine, benzene, deethylatrazine (CIAT), manganese, nitrate (data for nitrate consists of analyses for nitrite plus nitrate, as N, by the laboratory), perchloroethene (PCE), radon, strontium, trichloroethene (TCE), and uranium) for domestic well data for Pennsylvania is shown in figures PA1–PA16. The percentage of samples greater than U.S. Environmental Protection Agency (USEPA) human-health benchmarks for National Water-Quality Assessment (NAWQA) Program major-aquifer studies that included Pennsylvania and had at least 10 samples is given in table PA1. The areal extent of some NAWQA major-aquifer studies goes beyond the State boundary (fig. PA4). All data associated with a major-aquifer study are provided and are used in contaminant summaries even if the sampled well was located outside the State boundary. The "Selected References" section at the end of this summary lists previous Pennsylvania studies that are relevant to the 11 contaminants.

In Pennsylvania, the largest areas with the highest population density are located in the southwestern and southeastern parts of the State (fig. PA1). For Pennsylvania, about 30 percent of the domestic (private) supply is obtained from ground water (Fleeger, 1999), and about 15 percent of the public supply is obtained from ground water. The population (by census-block group for 1990) using a domestic-water supply from ground water was widespread throughout the State, with the exception of the north-central part and major population centers where less than 250 people per census block group were using ground water as a domestic water supply (fig. PA2). Although Pennsylvania is a heavily populated State, it also contains many forested and agriculture lands. Most of the forested areas are located in the northern part of the State, and the agriculture lands are distributed throught the State with the heaviest concentration in the southeastern part of the State (fig. PA3).

Nine major-aquifer studies in six principal aquifers (Early Mesozoic basin aquifer, glacial aquifers, Northern Atlantic Coastal Plain aquifer system, Pennsylvanian aquifers, Piedmont and Blue Ridge crystalline aquifers, and Valley and

Table PA1. Percentage of samples with concentrations greater than U.S. Environmental Protection Agency human-health benchmarks for National Water-Quality Assessment (NAWQA) Program major-aquifer studies that included Pennsylvania and had at least 10 samples.

Study-Unit code for NAWQA major-aquifer study	Principal aquifer	Contaminant	Number of samples	Percentage of samples with concentrations greater than human-health benchmark
delrsus1	Early Mesozoic basin aquifers	Radon	25	[1]100/8.0
delrsus3	Glacial aquifers	Radon	12	[1]100/0.0
lsussus2	Piedmont and Blue Ridge crystalline-rock aquifers	Radon	22	[1]95/41
delrsus2	Valley and Ridge aquifers	Radon	27	[1]89/15
potosus2	Early Mesozoic basin aquifers	Radon	22	86/4.5
lsussus1	Valley and Ridge aquifers	Radon	20	[1]80/5.0
almnsus2	Glacial aquifers	Radon	30	[1]77/0.0
almnsus1	Pennsylvanian aquifers	Radon	30	[1]53/0.0
podlsus2	Northern Atlantic Coastal Plain aquifer system	Radon	15	[1]13/0.0
almnsus1	Pennsylvanian aquifers	Manganese	30	27
almnsus2	Glacial aquifers	Manganese	30	13
lsussus1	Valley and Ridge aquifers	Manganese	26	12
delrsus3	Glacial aquifers	Manganese	12	8.3
lsussus2	Piedmont and Blue Ridge crystalline-rock aquifers	Nitrite plus nitrate	26	31
delrsus2	Valley and Ridge aquifers	Nitrite plus nitrate	27	7.4
podlsus2	Northern Atlantic Coastal Plain aquifer system	Nitrite plus nitrate	16	6.2
lsussus1	Valley and Ridge aquifers	Nitrite plus nitrate	26	3.8
almnsus1	Pennsylvanian aquifers	Nitrite plus nitrate	30	3.3
delrsus1	Early Mesozoic basin aquifers	Arsenic	25	8.0

[1]First number is the percentage greater than 300 picocuries per liter (proposed Maximum Contaminant Level), and second number is the percentage greater than 4,000 picocuries per liter (alternate proposed Maximum Contaminant Level).

Ridge aquifers) were conducted in Pennsylvania (fig. PA4). No samples were collected in Pennsylvania from the Northern Atlantic Coastal Plain aquifer system (fig. PA4). The Early Mesozoic basin aquifers (known locally as Piedmont Mesozoic basin aquifers) consist of lowland areas underlain by carbonate rocks (limestone, dolomite, and marble) and by clastic sedimentary rocks and are located in the southeastern part of Pennsylvania. Locally, the Early Mesozoic basin aquifers contain bodies of igneous rocks, such as basalt flows and diabase dikes and sills (Trapp and Horn, 1997). The rocks include beds of sandstone, arkose, and conglomerate that originally had considerable effective porosity between grains, but after compaction and cementation, are now poorly interconnected so only a small amount of water moves between pores. Ground water moves primarily along joints, fractures, and bedding plains and is more or less continuous in each aquifer, but the hydraulic connection across confining units between individual aquifers is poor (Trapp and Horn, 1997).

Several glacial aquifers occur near the land surface throughout Pennsylvania and consist of aquifers in unconsolidated sand and gravel deposits of Quaternary age. Most of the individual aquifers that compose the system are not hydraulically connected, and were formed mostly from sediments deposited by continental glaciers or by meltwater from glaciers, or from alluvium in valleys of major streams (Trapp and Horn, 1997). Most of the productive aquifers contain water under mostly unconfined conditions. Well yields are quite variable in the glacial systems because of variable thicknesses, coarseness of material, and the extent of the deposits.

The Pennsylvanian aquifers occur in western Pennsylvania and are most productive in consolidated sandstone deposits (Trapp and Horn, 1997). The Pennsylvanian aquifers are in the principal coal-bearing formations and consist of cyclic sequences of sandstone, shale, conglomerate, clay, coal, and minor limestone. The most productive aquifers are in sandstone deposits, and typical well yields range from 30 to 300 gallons per minute, with some wells yielding as much as 600 gallons per minute (Trapp and Horn, 1997).

The Piedmont and Blue Ridge crystalline-rock aquifers occur in southeastern Pennsylvania and are mostly in dense, almost impermeable bedrock consisting of metamorphic and igneous rocks of many types that yield water primarily from secondary porosity and permeability provided by fractures (Trapp and Horn, 1997). The crystalline bedrock often is covered by a thick to thin layer of regolith that is everywhere more porous than the bedrock. Well yields for all crystalline rocks are small with one study indicating an average yield of about 18 gallons per minute (Trapp and Horn, 1997).

The Valley and Ridge aquifers occur in the east-central part of Pennsylvania and consist of permeable rocks of primarily sandstone, shale, and carbonates within a sequence of folded and faulted sedimentary formations of Paleozoic age (Trapp and Horn, 1997). A thick sequence of carbonate rocks contains the most productive aquifers with yields as much as 850 gallons per minute for some wells.

Water-quality data for 11 selected contaminants (table 2) in samples from domestic-water supplies were compiled and summarized. The concentrations relative to USEPA human-health benchmarks (table 2, fig. PA5) and the number of major-aquifer studies with concentrations greater than human-health benchmarks were both considered in evaluating the potential concern to human health. This analysis assumes that current USEPA benchmarks (U.S. Environmental Protection Agency, 2006) are the most relevant and accurate measure of human-health risk.

Radon, manganese, nitrate, and arsenic had concentrations greater than USEPA human-health benchmarks (table PA1). Radon had the greatest potential human-health concern because it had the largest percentage of samples with concentrations greater than the human-health benchmark of 300 picocuries per liter (pCi/L). All the radon concentrations (100 percent) in two major-aquifer studies (delrsus1 and delrsus3) in the Early Mesozoic basin aquifers and glacial aquifers, respectively, were greater than 300 pCi/L, which is the proposed Maximum Contaminant Level (MCL) for radon (table PA1). Two of the samples (about 8 percent) in the delrsus1 major-aquifer study had radon concentrations greater than the alternative proposed MCL of 4,000 pCi/L. Radon concentrations were greater than the proposed MCL in about 95 percent of the samples from the lsussus2 major-aquifer study in the Piedmont and Blue Ridge crystalline aquifers; 89 percent of the samples from the delrsus2 major-aquifer study in the Valley and Ridge aquifers; 86 percent of the samples from the potosus2 major-aquifer study in the Early Mesozoic basin aquifers; 80 percent of the samples from the lsussus1 major-aquifer study in the Valley and Ridge aquifers; 77 percent of samples from the almnsus2 major-aquifer study in the glacial aquifers; and 53 percent of samples from the almnsus1 major-aquifer study (table PA1). About 41 and 15 percent of the samples from two of the studies (lsussus2 and delrsus2, respectively) had radon concentrations greater than the alternative proposed MCL. U.S. Geological Survey (USGS) State data also showed radon concentrations to be greater than the human-health benchmark of 300 pCi/L in most of the samples collected, and concentrations were greater than the alternative proposed MCL in many samples in the southeast corner of the State (fig. PA13). Radon-222 is a decay product of radium-226, and radon concentrations greater than the human-health benchmark are widespread and can be attributed to natural sources in the soil and rock material in Pennsylvania.

Manganese concentrations were greater than the human-health benchmark (Lifetime Health Advisory (HA) of 300 µg/L) in about 27 percent (almnsus1) of the samples collected for a study in the Pennsylvanian aquifers (table

PA1). About 13 percent (almnsus2) and 8 percent (delrsus3) of the samples collected for two studies in the glacial aquifers system had manganese concentrations greater than the human-health benchmark. About 12 percent of the samples collected for a study (lsussus1) in the Valley and Ridge aquifers had manganese concentrations greater than the human-health benchmark. Median concentrations in three studies (alumsus1, almnsus2, and lsussus1) were within an order of magnitude of the human-health benchmark. USGS State data (fig. PA10) showed several additional areas in Pennsylvania to have a group of samples with concentrations greater than their human-health benchmark, and several people could be using domestic-water supplies in the areas on the basis of water-use data.

About 31 percent of samples from the lsussus2 major-aquifer study in the Piedmont and Blue Ridge crystalline aquifers had nitrate concentrations greater than the human-health benchmark (MCL of 10 milligrams per liter (mg/L) as N) (table PA1). Two of 27 samples (about 7 percent) and 1 of 26 samples (about 4 percent) from the delrsus2 and lsussus1 major-aquifer studies in the Valley and Ridge aquifers, 1 of 16 samples (about 6 percent) from the podlsus2 major-aquifer study in the Northern Atlantic Coastal Plain aquifer system, and 1 of 30 samples (about 3 percent) from the almnsus1 major-aquifer study in the Pennsylvanian aquifers had nitrate concentrations greater than the human-health benchmark. Median nitrate concentrations for six of the major-aquifer studies were within an order of magnitude of the human-health benchmark (fig. PA5). USGS State data (fig. PA11) showed several areas in eastern Pennsylvania to have a group of samples with nitrate concentrations greater than their human-health benchmark, and the geographic extent is better defined using USGS State data than NAWQA data. The nitrate concentrations greater than human-health benchmark appear coincident with agricultural land use, and many people could be using domestic-water supplies in these areas.

Two of 25 samples (8 percent) collected from the delrsus1 major-aquifer study in the Early Mesozoic basin aquifers had arsenic concentrations greater than the human-health benchmark (MCL of 10 micrograms per liter (µg/L)) (table PA1). Median arsenic concentrations from this major-aquifer study also were within an order of magnitude of the human-health benchmark (fig. PA5). USGS State data (fig. PA6) showed several samples in Pennsylvania with arsenic concentrations greater than the human-health benchmark, but samples generally were randomly dispersed (except in the northeast corner) with samples that had concentrations less than the human-health benchmark.

NAWQA data did not show any benzene (fig. PA8), PCE (fig. PA12), strontium (fig. PA14), TCE (fig. PA15), or uranium (fig. PA16) concentrations greater than USEPA human-health benchmarks. However, a few samples for each constituent had concentrations greater than USEPA human-health benchmarks in the USGS State data.

For the entire Pennsylvania data set, atrazine (fig. PA7) and CIAT (fig. PA9) did not have concentrations greater than USEPA human-health benchmarks for either NAWQA or USGS State data. CIAT is a degradation product of atrazine and does not have a human-health benchmark; however, for this report, the MCL for atrazine is used as a benchmark for CIAT because their toxicities are considered equivalent.

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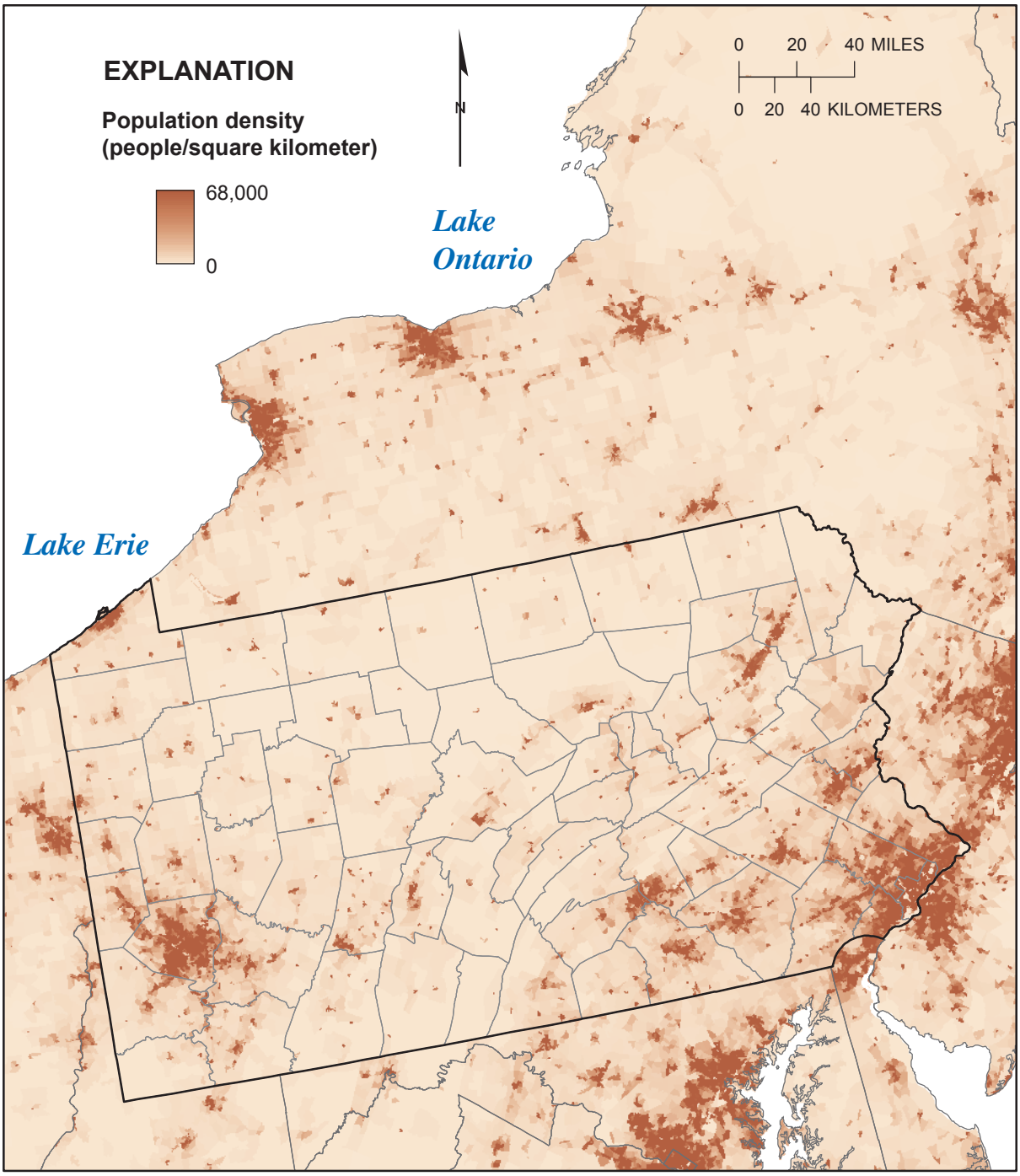
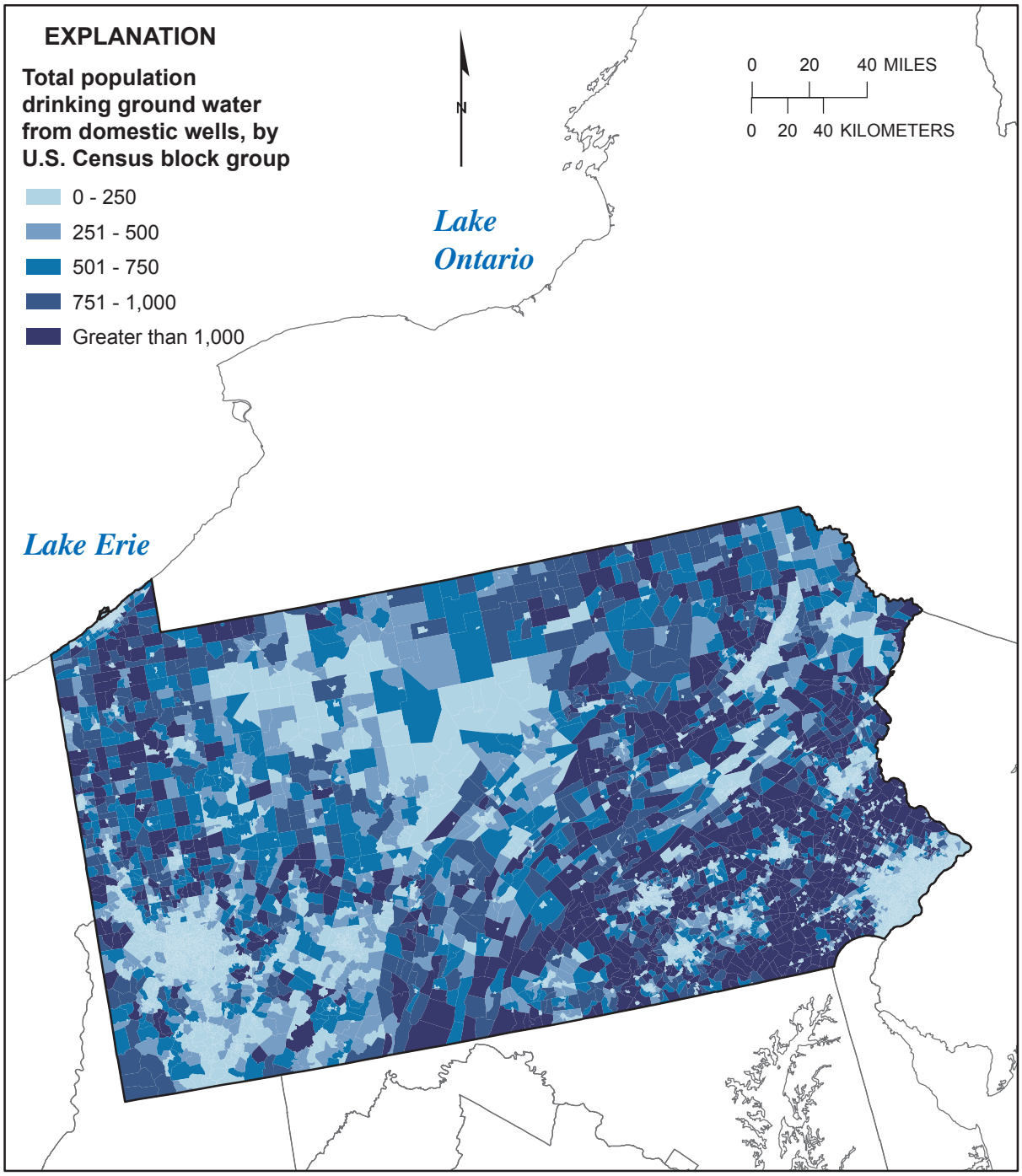


Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Figure PA1. Population density for Pennsylvania and nearby States. (Data from Hitt, 2003.)



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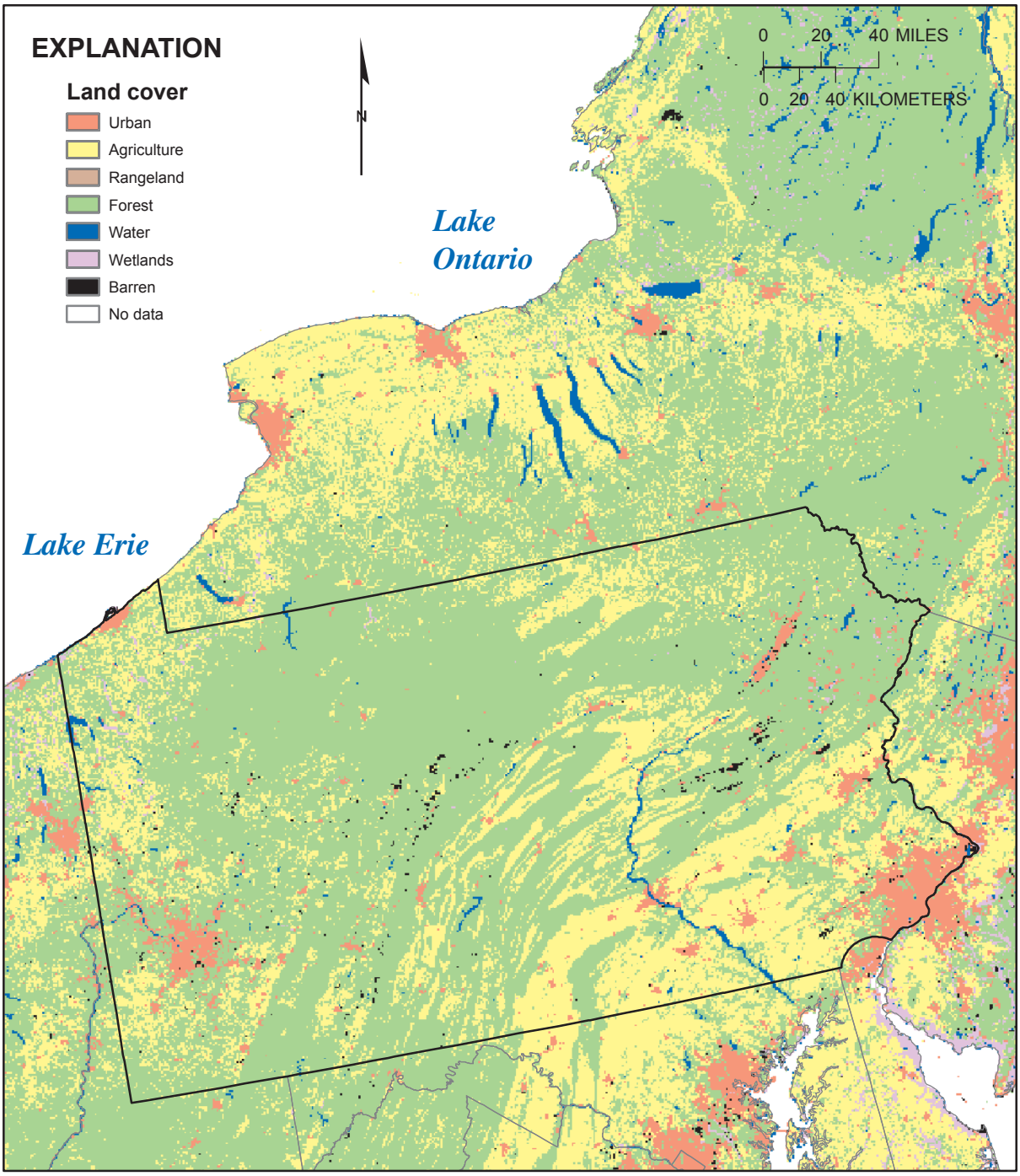
Standard Parallels 29°30' and 45°30', central meridian -96°

Figure PA2. Population using domestic-water supply (from ground water) for Pennsylvania. (Data from 1990 U.S. Census block group, Kerie Hitt, U.S. Geological Survey, written commun., 1997.)



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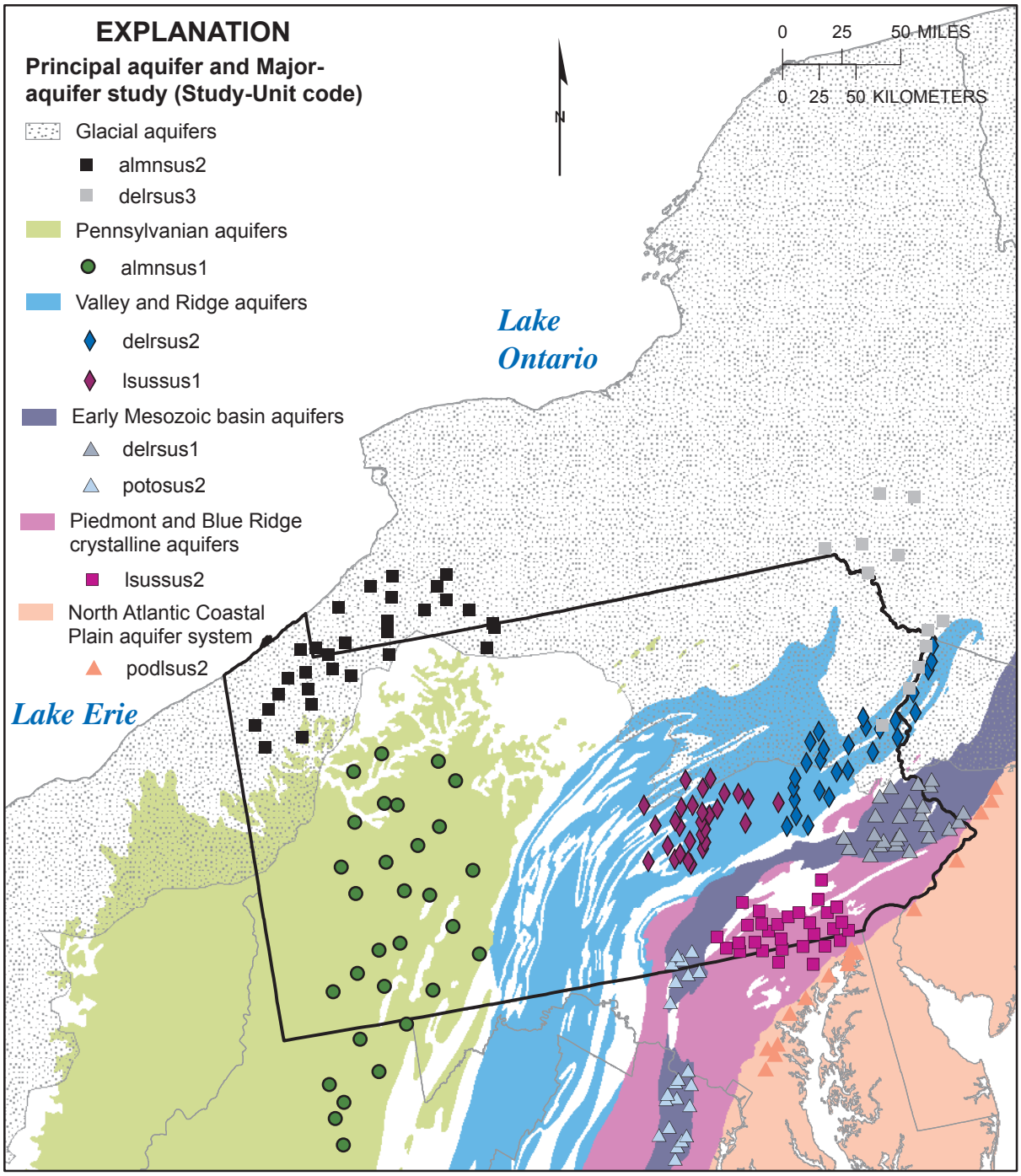
Standard Parallels 29°30' and 45°30', central meridian -96°

Figure PA3. Land use/land cover for Pennsylvania and nearby States. (Data from Naomi Nakagaki, U.S. Geological Survey, written commun., 2005.)



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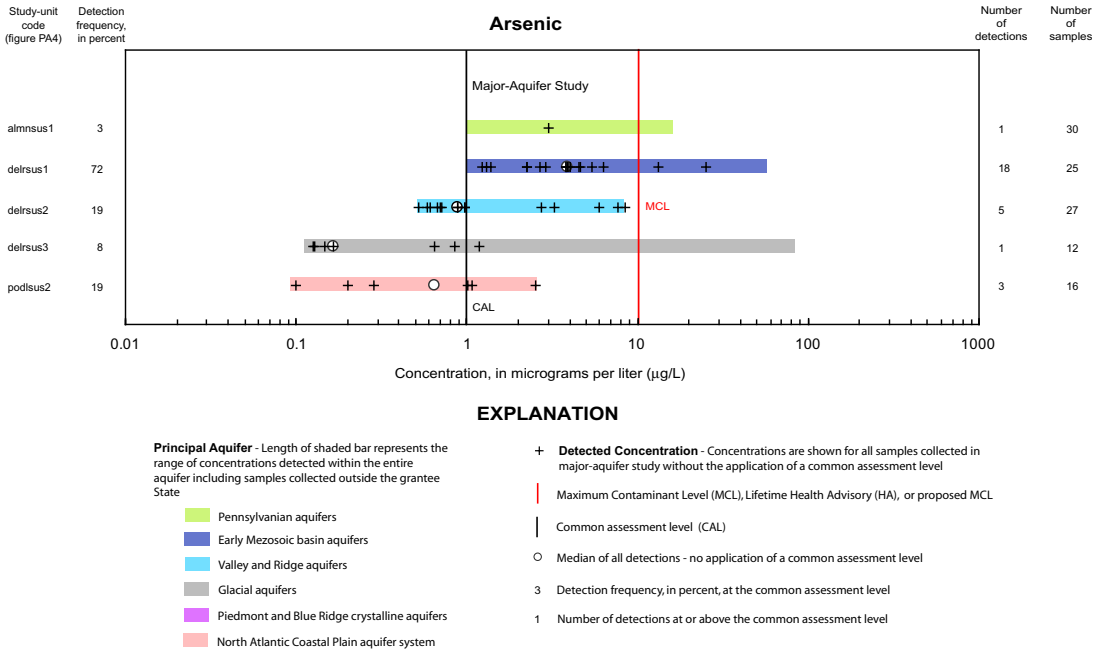
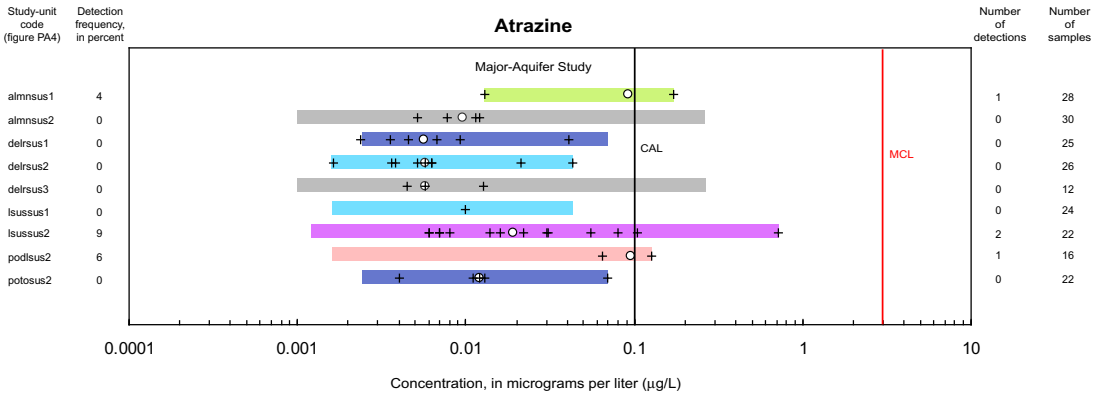
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

Figure PA4. Location of domestic wells sampled for National Water-Quality Assessment (NAWQA) major-aquifer studies that included Pennsylvania.





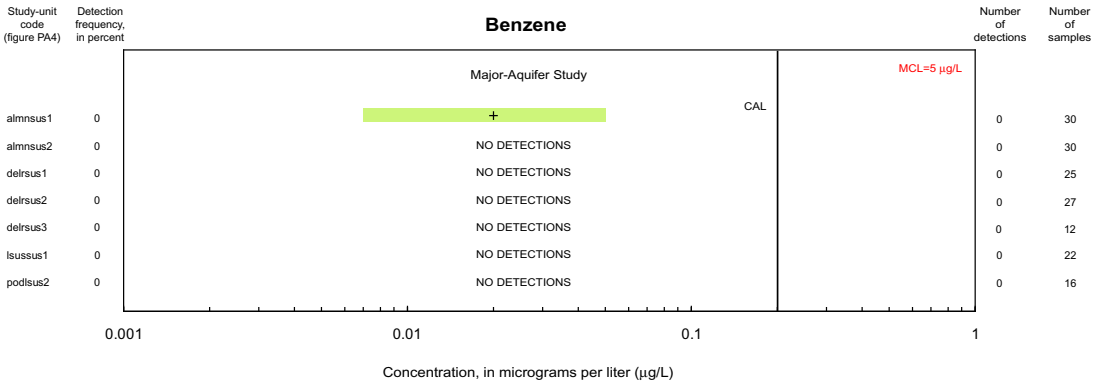


Figure PA5. Statistical summary for 11 selected contaminants by major-aquifer study using domestic-well data from National Water-Quality Assessment (NAWQA) studies for Pennsylvania (includes studies for which at least 10 analyses were available).

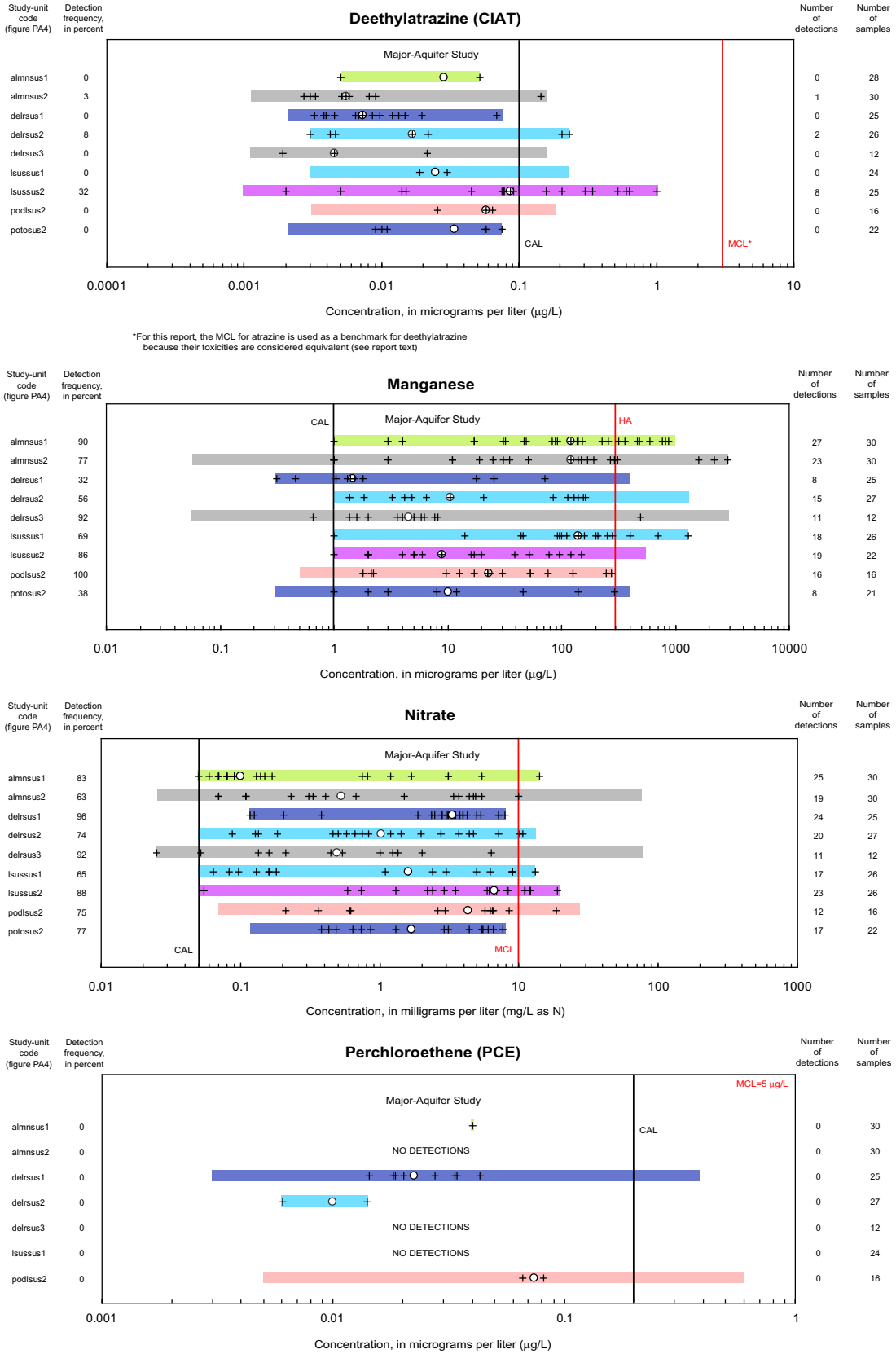


Figure PA5. Statistical summary for 11 selected contaminants by major-aquifer study using domestic-well data from National Water-Quality Assessment (NAWQA) studies for Pennsylvania (includes studies for which at least 10 analyses were available).—Continued

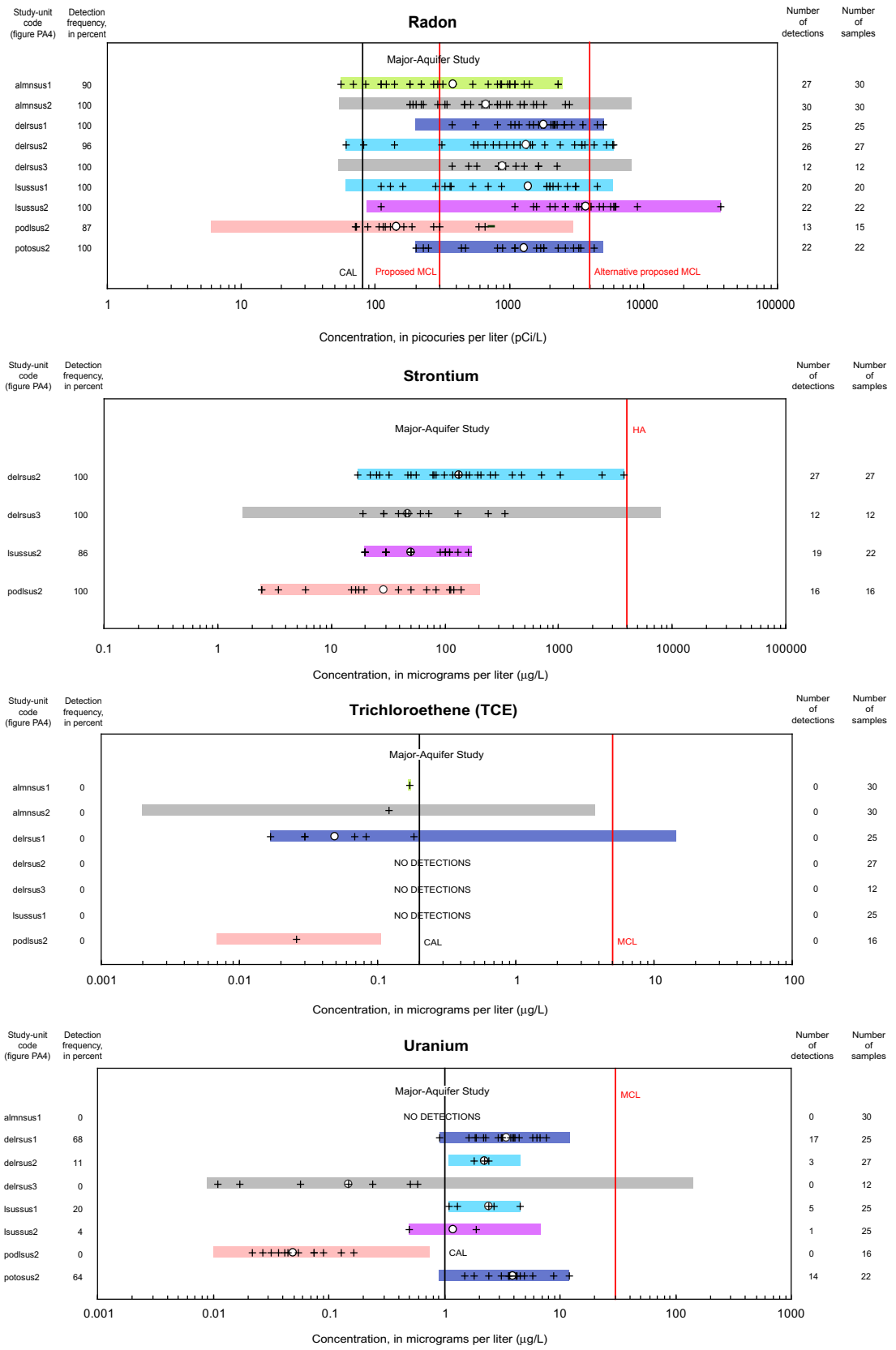
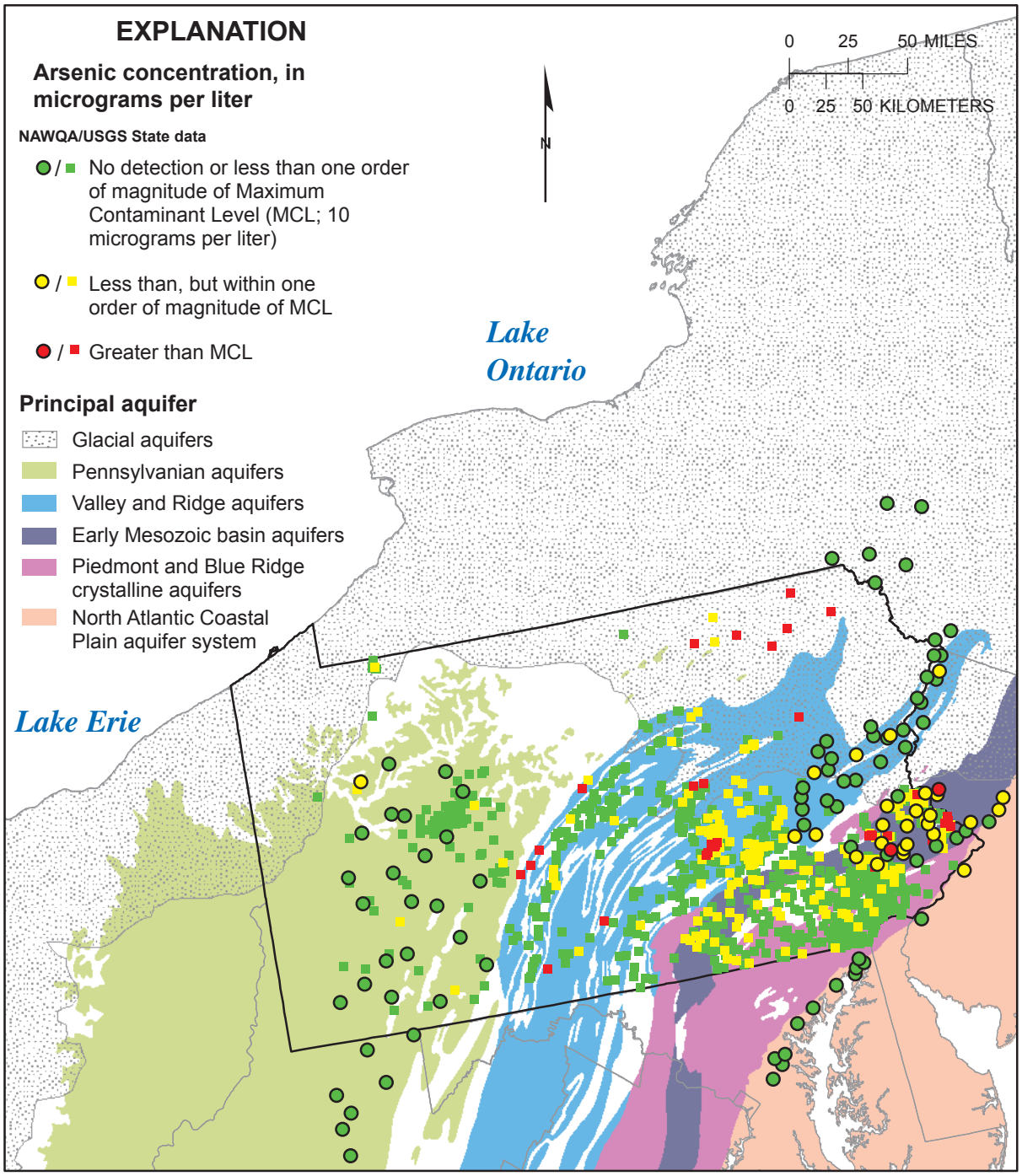


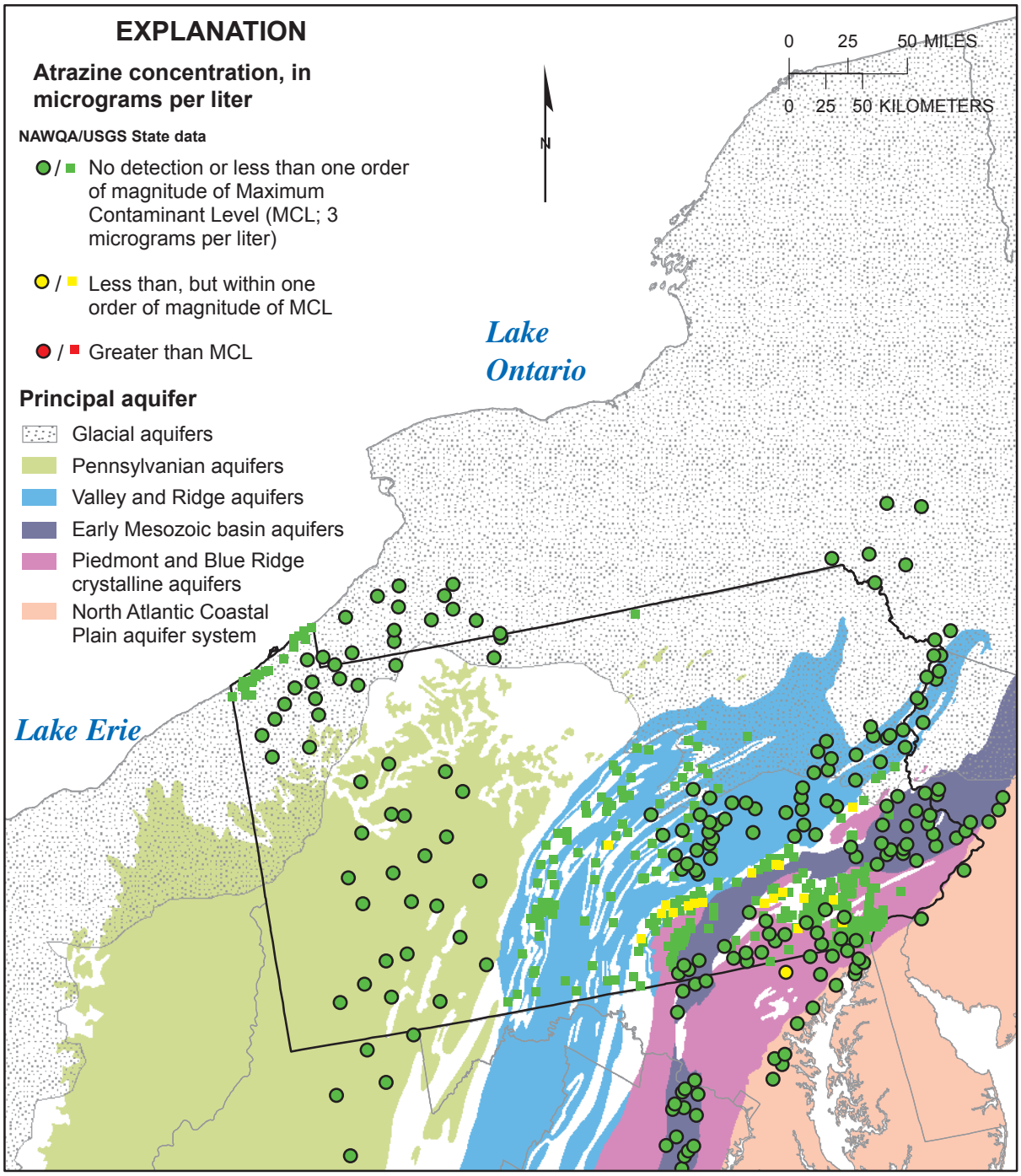
Figure PA5. Statistical summary for 11 selected contaminants by major-aquifer study using domestic-well data from National Water-Quality Assessment (NAWQA) studies for Pennsylvania (includes studies for which at least 10 analyses were available).—Continued



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

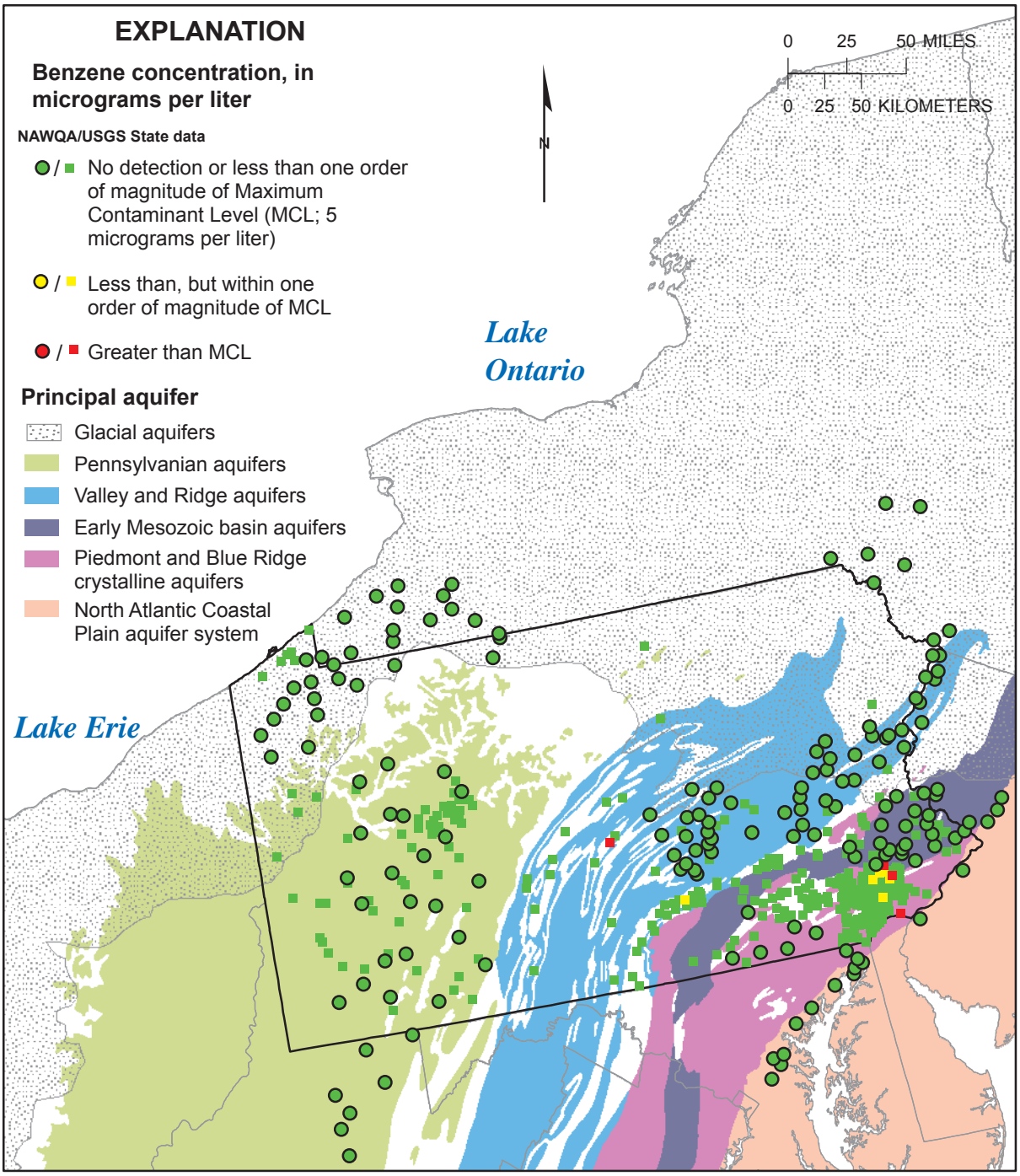
Figure PA6. Concentration of arsenic in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

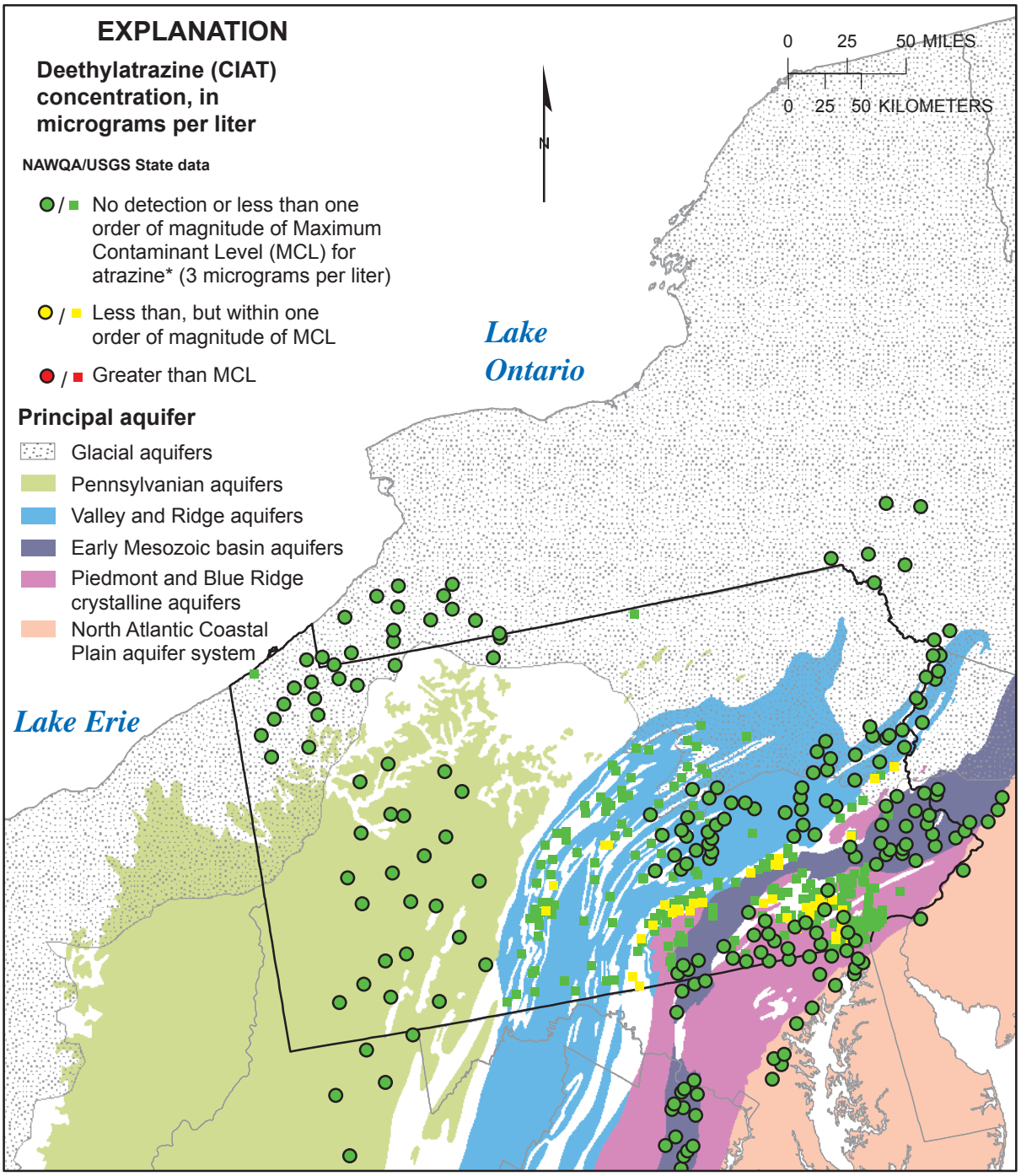
Figure PA7. Concentration of atrazine in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

Figure PA8. Concentration of benzene in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



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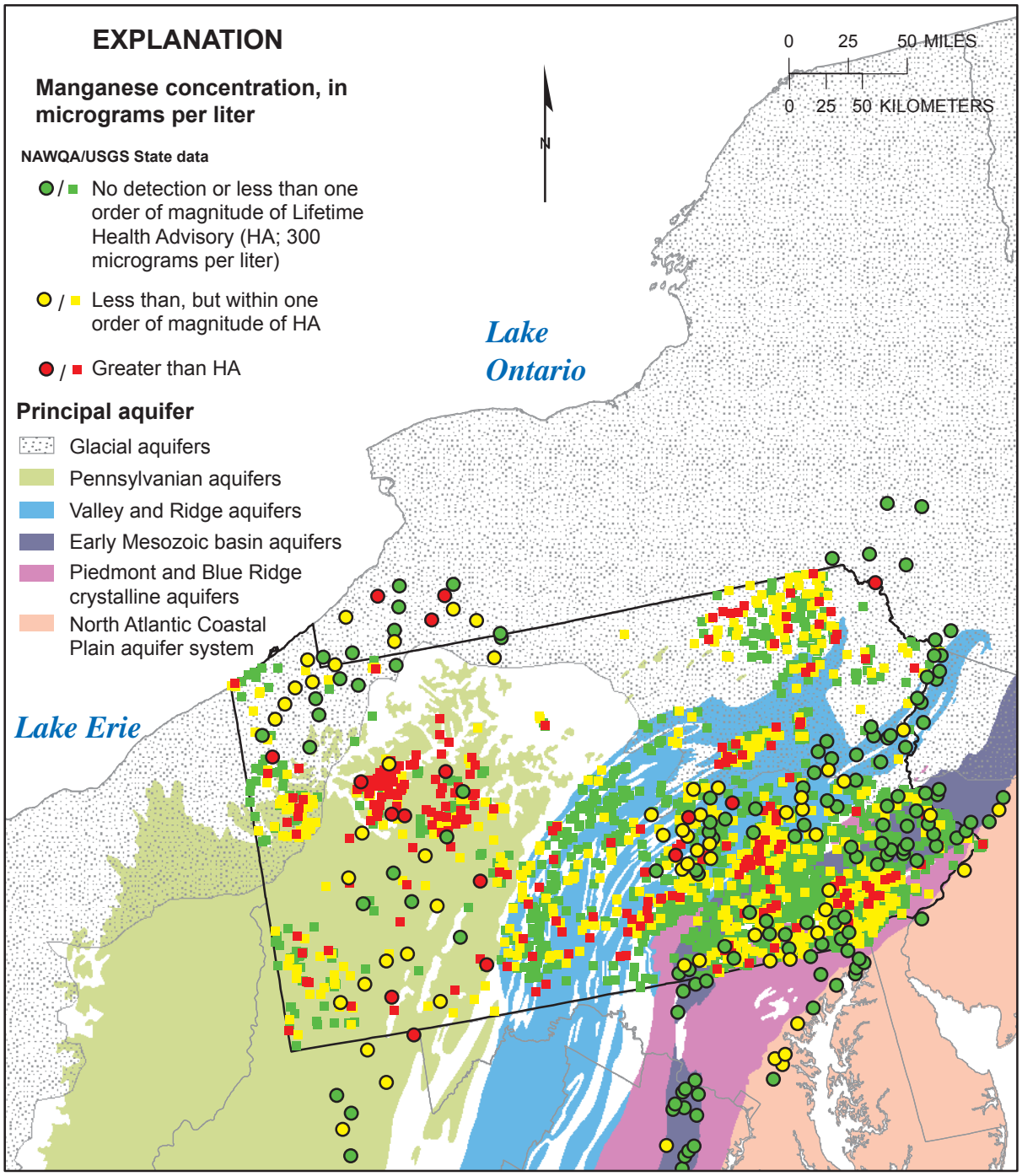
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

* For this report, the MCL for atrazine is used as benchmark for deethylatrazine because their toxicities are considered equivalent (see report text).

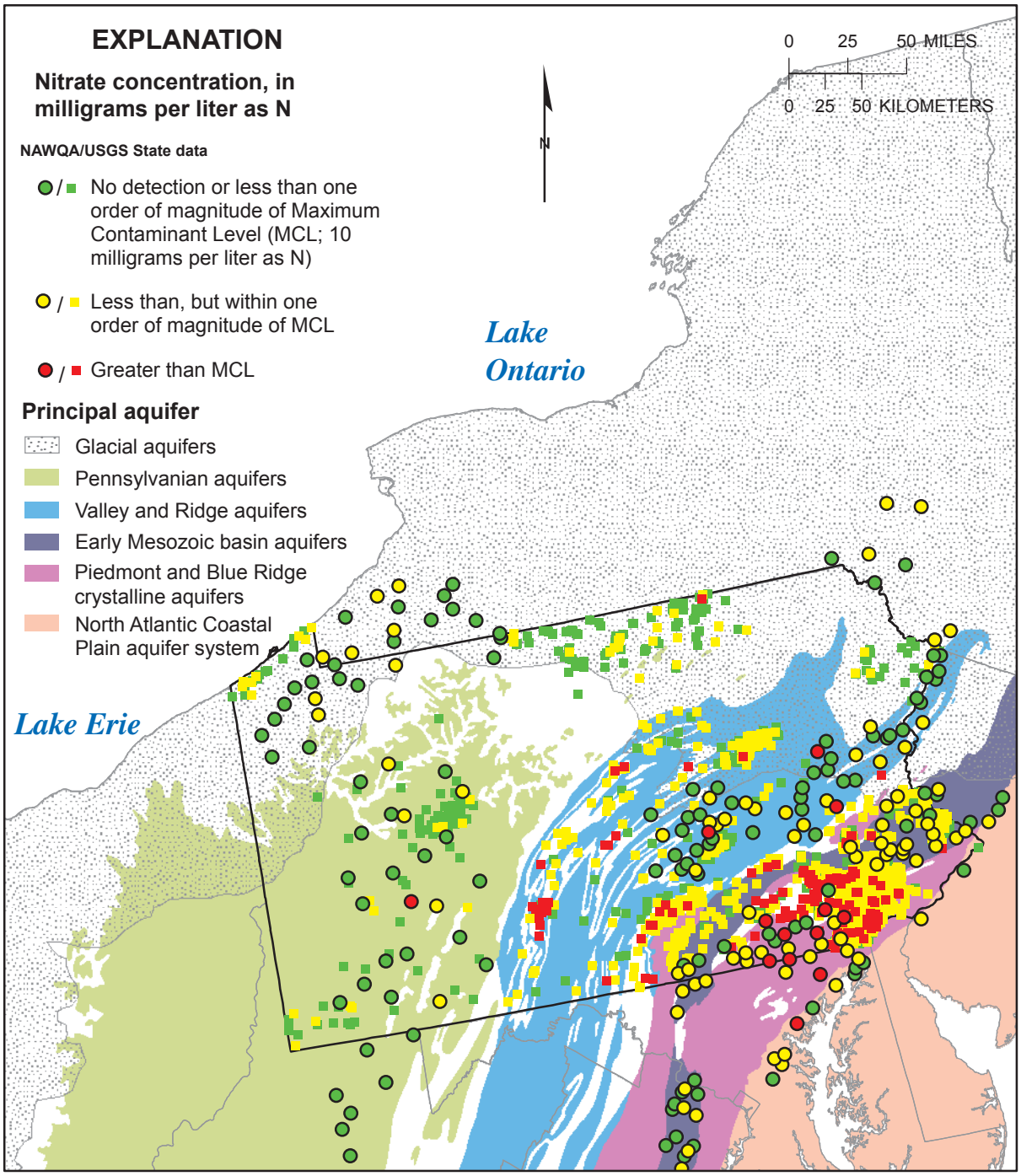
Figure PA9. Concentration of deethylatrazine (CIAT) in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

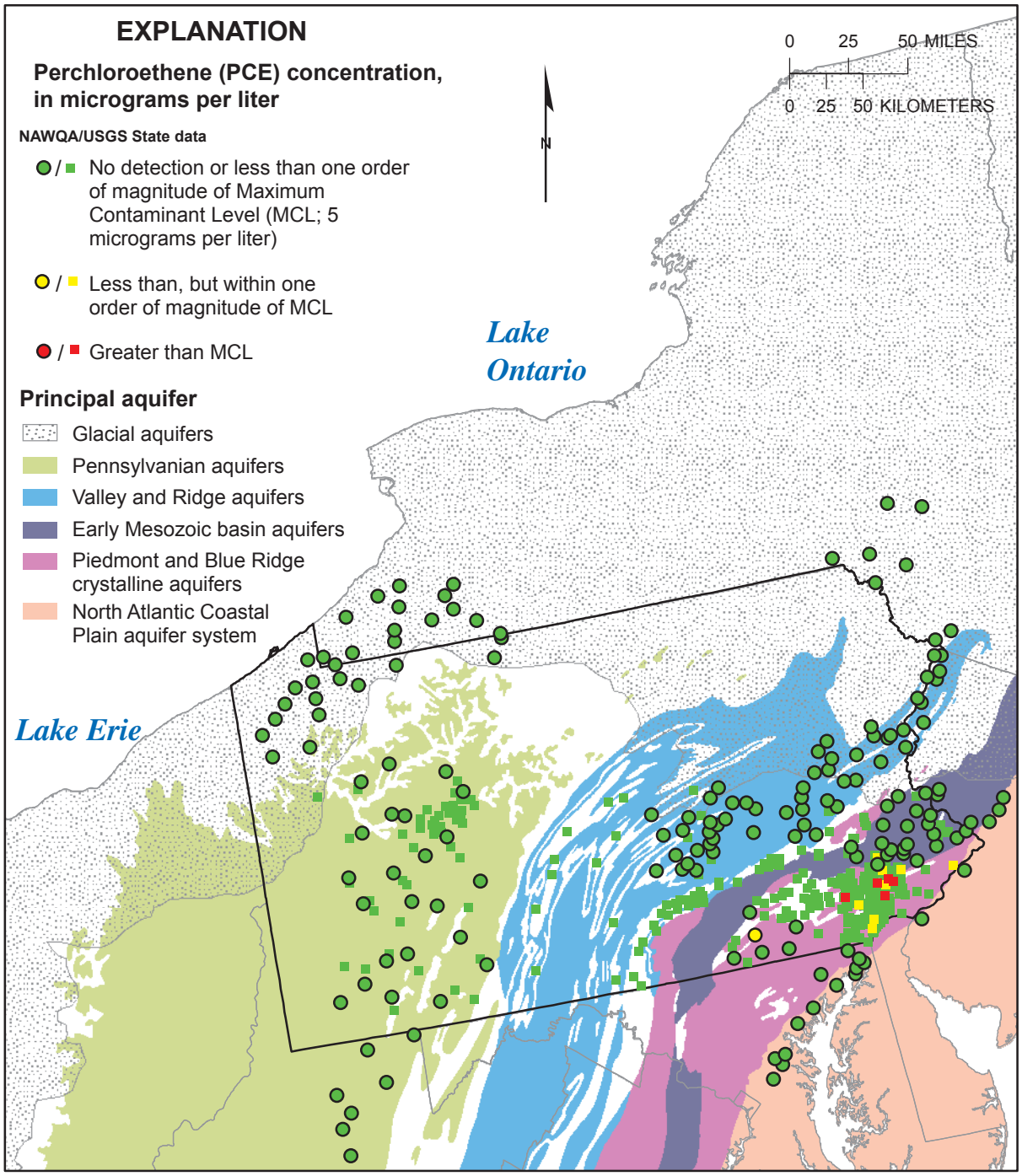
Figure PA10. Concentration of manganese in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

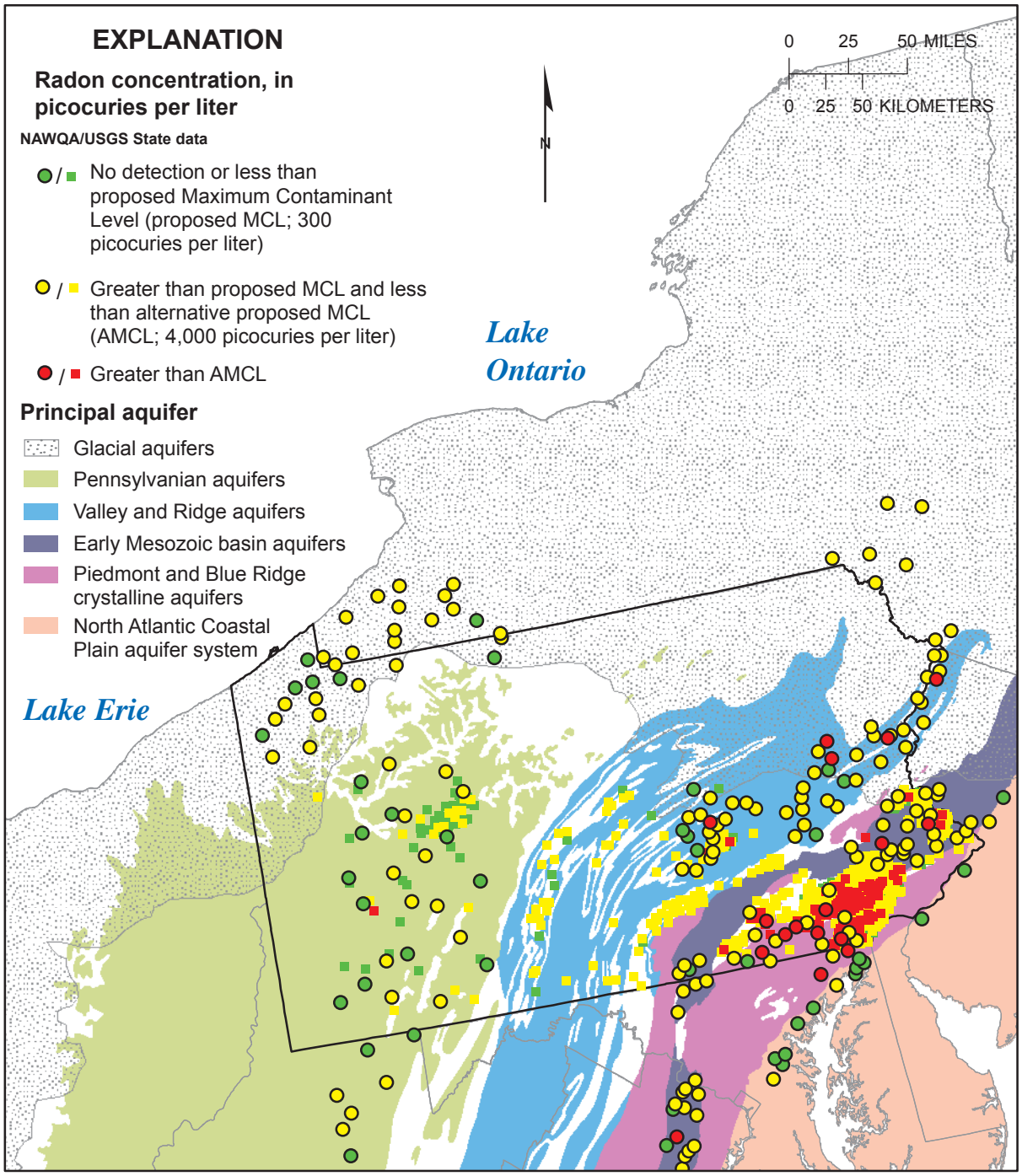
Figure PA11. Concentration of nitrate in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

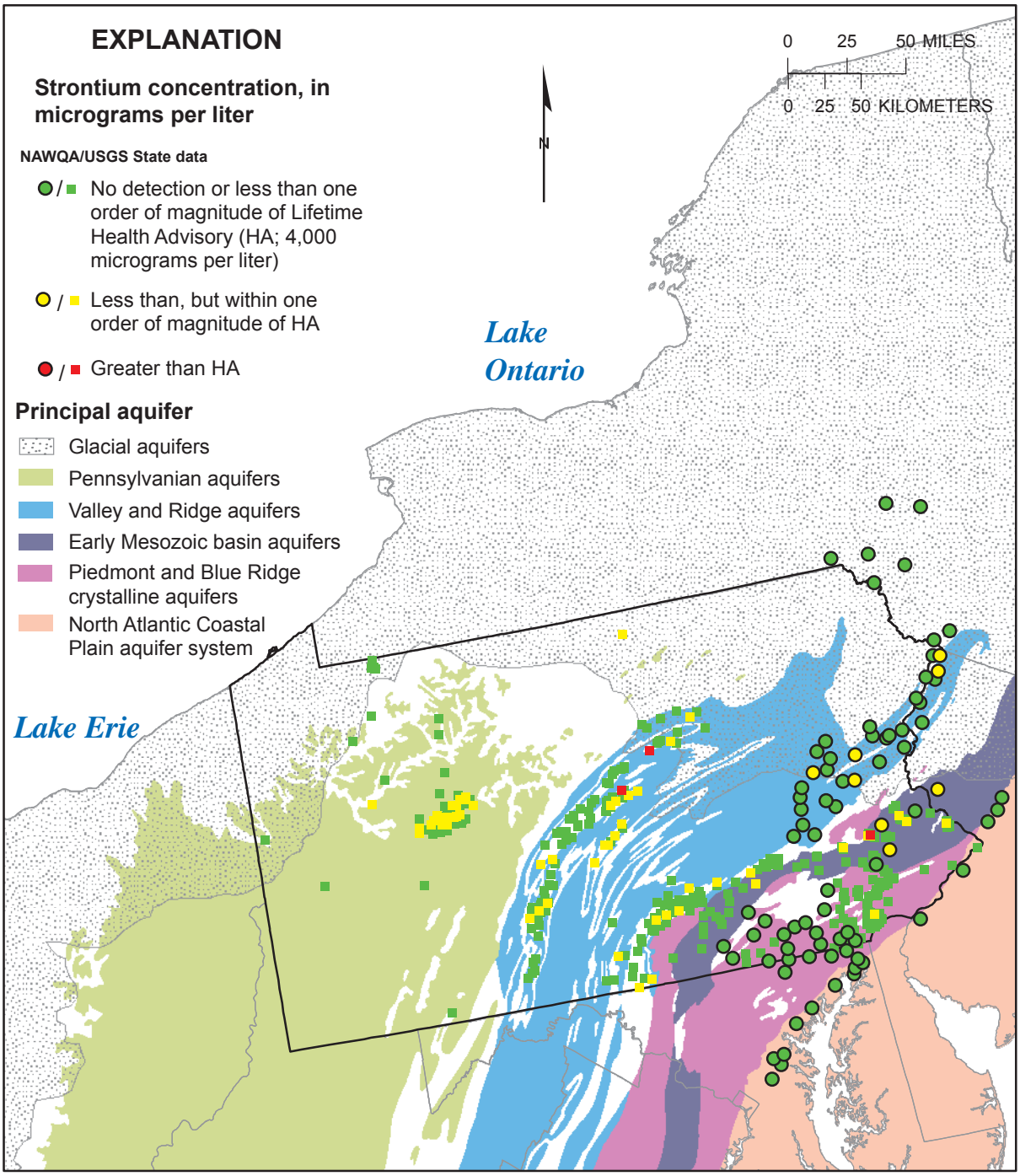
Figure PA12. Concentration of perchloroethene (PCE) in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

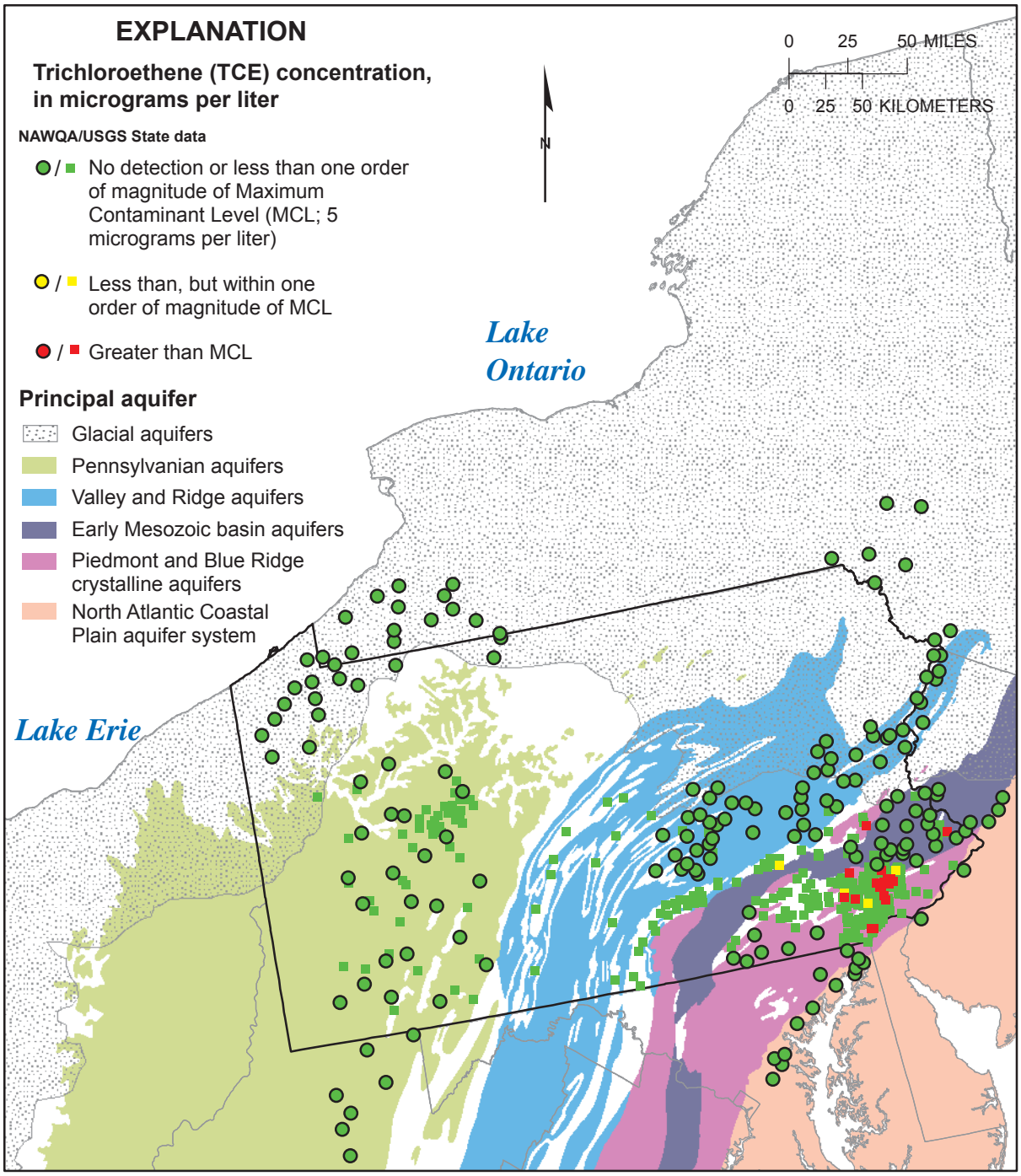
Figure PA13. Concentration of radon in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

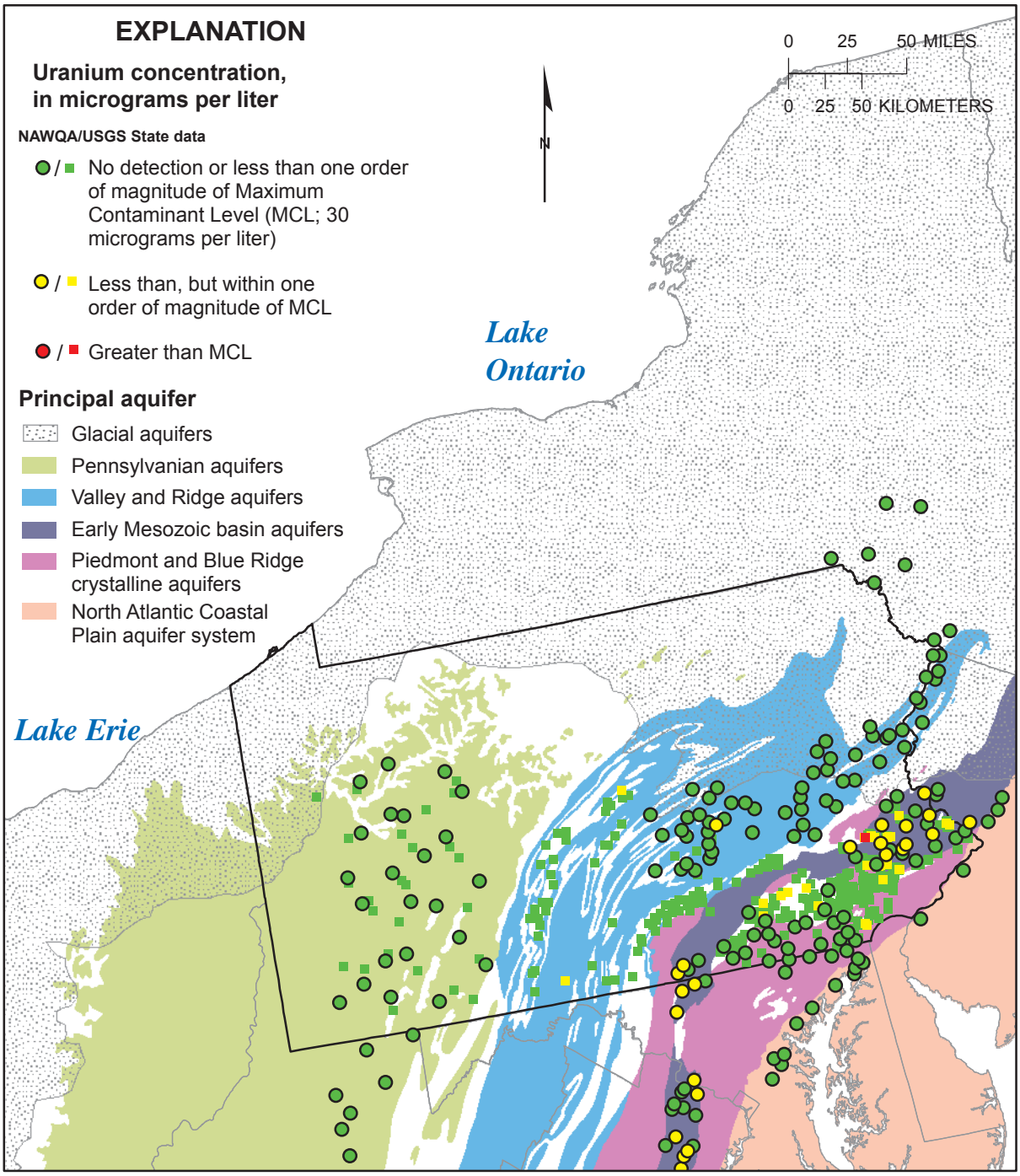
Figure PA14. Concentration of strontium in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

Figure PA15. Concentration of trichloroethene (TCE) in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Principal aquifer data from U.S. Geological Survey, 2003

Figure PA16. Concentration of uranium in samples from domestic wells in Pennsylvania and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).