State Summary for Washington

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 Washington is shown in figures WA1–WA16. The percentage of samples with concentrations greater than U.S. Environmental Protection Agency (USEPA) human-health benchmarks for National Water-Quality Assessment (NAWQA) Program major-aquifer studies that included Washington and had at least 10 samples is given in table WA1. The areal extent of some NAWQA major-aquifer studies goes beyond the State boundary (fig. WA4). 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 list previous Washington studies that are relevant to the 11 contaminants.

In Washington, the area with the highest population density is located in the western part of the State (fig. WA1). About 50 percent of the combined domestic (private) and public drinking-water supply is obtained from ground water. The population (by census-block group for 1990) using a domestic-water supply from ground water was greatest in the southwestern and central parts of the State (fig. WA2). In general, the population density in Washington is low except in urban centers (fig. WA1). Most of the land use in Washington is forest lands, agricultural, and rangeland (fig. WA3).

Two major-aquifer studies in two principal aquifers (Northern Rocky Mountains Intermontane Basin aquifer system and glacial aquifers) were conducted in Washington (fig. WA4). The Northern Rocky Mountains Intermontane Basin aquifer system is located in the northeastern part of the State and consists of several unconsolidated-deposit aquifers in clay and fine sand to coarse sand and gravel deposits. Permeability is decreased in areas where increasing proportions of clay are intermixed with the coarse grained deposits, and faulted valley margins can affect ground-water movement (Whitehead, 1994). Well yields can range from only a few gallons per minute to 3,000 gallons per minute (Whitehead, 1994).

Several glacial aquifers occur near the land surface in the northern and western parts of Washington and are contained in unconsolidated sand and gravel deposits of Quaternary age, some as much as several hundred feet thick (Whitehead, 1994). Most of the individual aquifers that compose the system were formed mostly from sediments deposited by continental glaciers or by meltwater from glaciers, and the aquifers readily receive, store, transmit, and discharge water. Well yields are quite variable in the glacial systems because of variable thicknesses, coarseness of material, and the extent of the deposits. The most productive glacial aquifers in Washington are in sand and gravel deposits in Okanogan County, and yield from less than 10 to 1,000 gallons per minute (Whitehead, 1994).

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. WA5) and the number of major-aquifer studies with concentrations greater than human-

Table WA1. 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 Washington 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
nroksus1	Northern Rocky Mountains Intermontane Basins aquifer system	Radon	29	[1]100/0.0
pugtsus1	Glacial aquifers	Radon	29	[1]48/0.0
nroksus1	Northern Rocky Mountains Intermontane Basins aquifer system	Arsenic	29	10
pugtsus1	Glacial aquifers	Manganese	29	3.4
pugtsus1	Glacial aquifers	Nitrite plus nitrate	29	3.4

[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).

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, arsenic, manganese, and nitrate had concentrations greater than USEPA human-health benchmarks (table WA1). 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). Radon concentrations were largest in the nroksus1 major-aquifer study in the Northern Rocky Mountains Intermontane Basins aquifer system, with concentrations greater than the proposed Maximum Contaminant Level (MCL) of 300 pCi/L in 100 percent of the samples (table WA1). Median radon concentrations were about 700 pCi/L in the nroksus1 major-aquifer study (fig. WA5). Radon concentrations also were greater than the proposed MCL of 300 pCi/L in about 48 percent of the samples from the pugtsus1 major-aquifer study in the glacial aquifers. None of the radon concentrations in either major-aquifer study were greater than the alternative proposed MCL of 4,000 pCi/L. Additionally, U.S. Geological Survey (USGS) State data showed radon concentrations greater than 300 pCi/L in areas in central and eastern Washington that were not sampled for NAWQA studies (fig. WA13). 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 Washington.

Arsenic had the next largest potential concern to human health. Arsenic concentrations were larger than the human-health benchmark (MCL of 10 micrograms per liter (µg/L)) in about 10 percent of the samples from the nroksus1 major-aquifer study in the Northern Rocky Mountains Intermontane Basins aquifer system (table WA1). Median arsenic concentrations were within an order of magnitude of the human-health benchmark (fig. WA5). USGS State data showed that the same general area in the Northern Rocky Mountains Intermontane Basins aquifer system had arsenic concentrations greater than the human-health benchmark (fig. WA6). No samples from the pugtsus1 major-aquifer study in the glacial aquifers were analyzed for arsenic; however, USGS State data showed that arsenic concentrations in the glacial aquifers in northwestern Washington could be greater than the human-health benchmark (fig. WA6).

NAWQA data showed that the manganese concentration in one sample (about 3 percent) from the pugtsus1 major-aquifer study in the glacial aquifers in northwestern Washington was greater than the human-health benchmark (Lifetime Health Advisory (HA) of 300 µg/L) (fig. WA10). The USGS State data set contained more samples than the NAWQA data set, and USGS State data better defined the geographical extent of the manganese concentrations in this area (fig. WA10). USGS State data also showed manganese concentrations greater than the human-health benchmark in eastern and south-central Washington, for which no manganese data were available in the NAWQA data set.

NAWQA data showed that the nitrate concentration in one sample (3 percent) from the pugtsus1 major-aquifer study in the glacial aquifers in northwestern Washington was greater than the human-health benchmark (MCL of 10 milligrams per liter (mg/L) as N) (fig. WA11). Median nitrate concentrations were within an order of magnitude of the human-health benchmark (fig. WA5). NAWQA data did not show any nitrate concentrations greater than the human-health benchmark in the Northern Rocky Mountains Intermontane Basin aquifer system (fig. WA11). USGS State data showed nitrate concentrations greater than the human-health benchmark in both the glacial aquifers principal aquifer and the aquifers in the south-central part of the State (fig. WA11). These nitrate concentrations appear coincident with agricultural land use, and many people could be using domestic-water supplies in these areas on the basis of water-use data.

NAWQA data showed that neither PCE nor TCE concentrations were greater than human-health benchmarks in the glacial aquifers and the Northern Rocky Mountain Intermontane aquifer system. However, PCE and TCE concentrations were greater than human-health benchmarks (MCL of 5 µg/L for both contaminants) in three samples from the USGS State data set (figs. WA12 and WA15, respectively). The PCE and TCE concentrations were in two proximal samples in east-central Washington and one sample in south-central Washington.

For the entire Washington data set, no concentrations of atrazine (fig. WA7), benzene (fig. WA8), CIAT (fig. WA9), strontium (fig. WA14), and uranium (fig. WA16) were 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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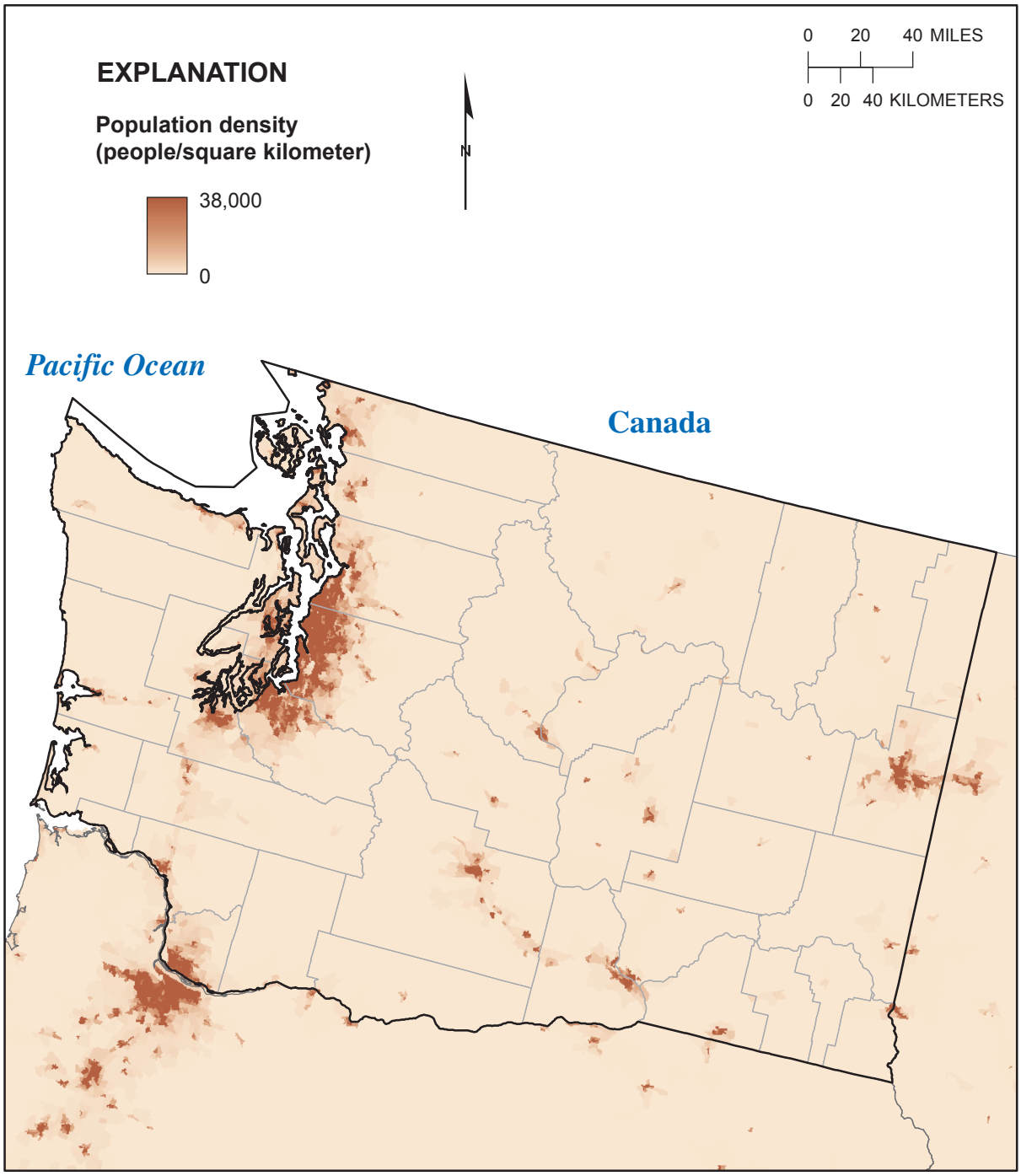

Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Figure WA1. Population density for Washington and nearby States. (Data from Hitt, 2003.)

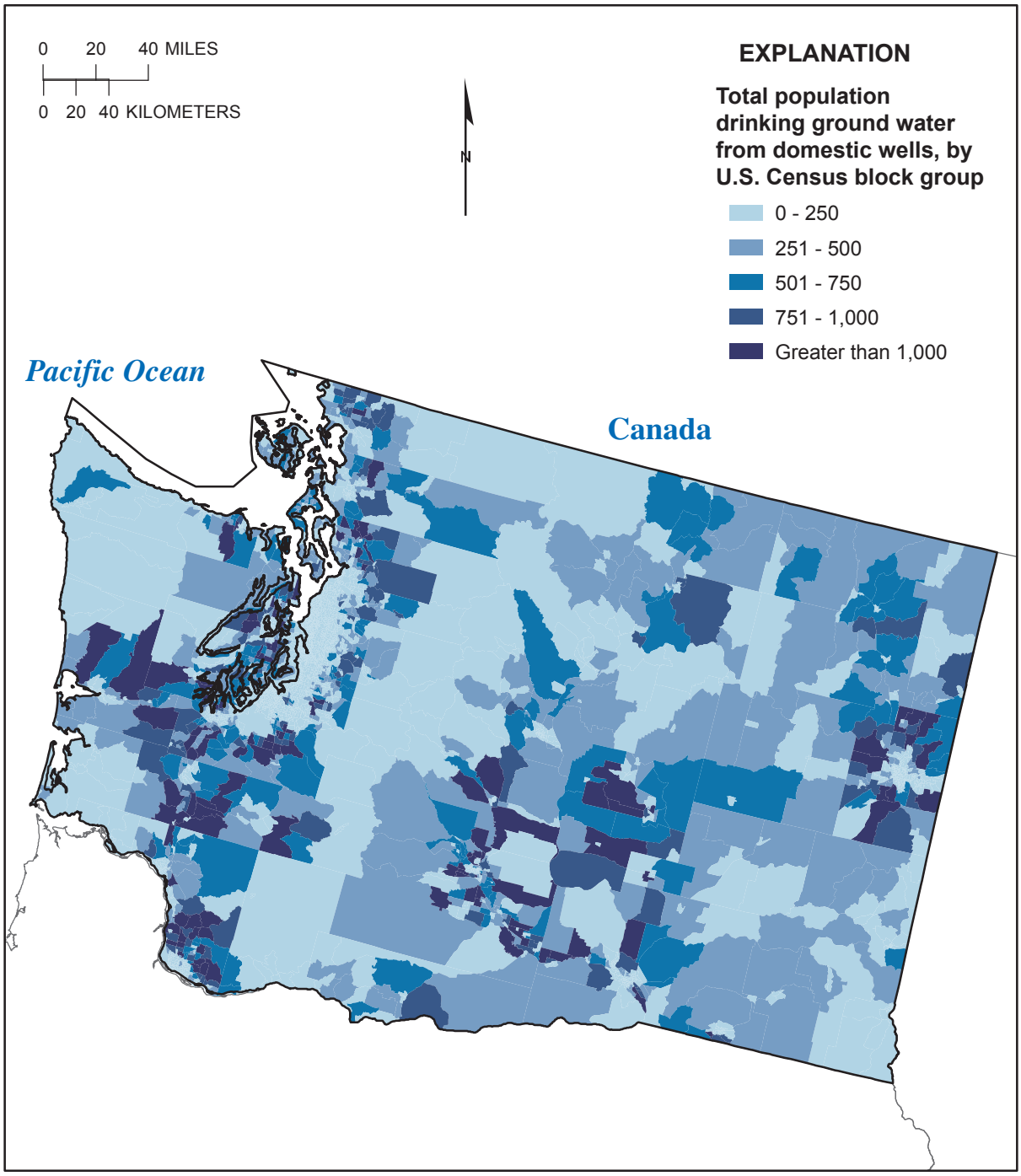

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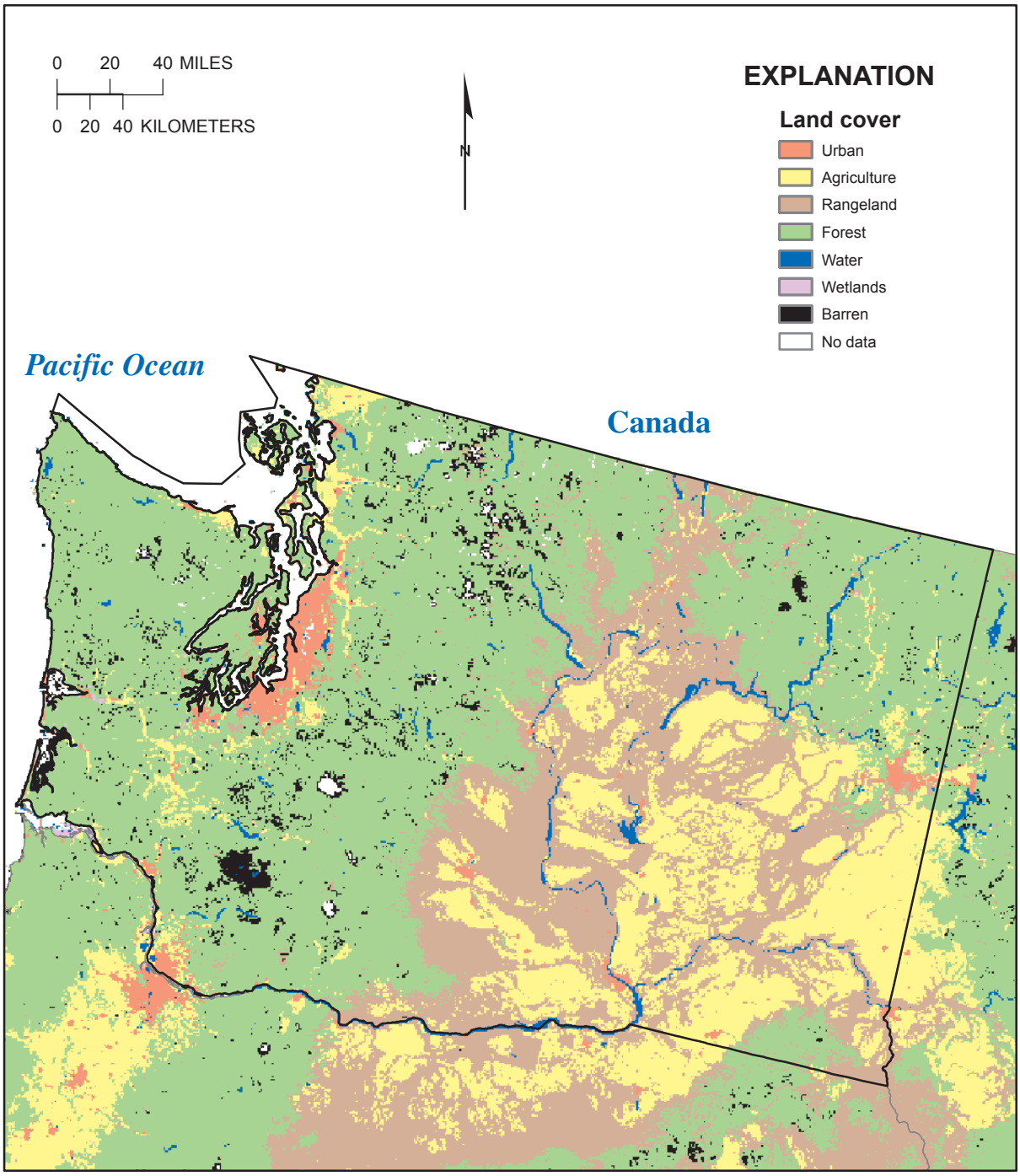
Figure WA2. Population using domestic-water supply (from ground water) for Washington. (Data from 1990 U.S. Census block group, Kerie Hitt, U.S. Geological Survey, written commun., 1997.)



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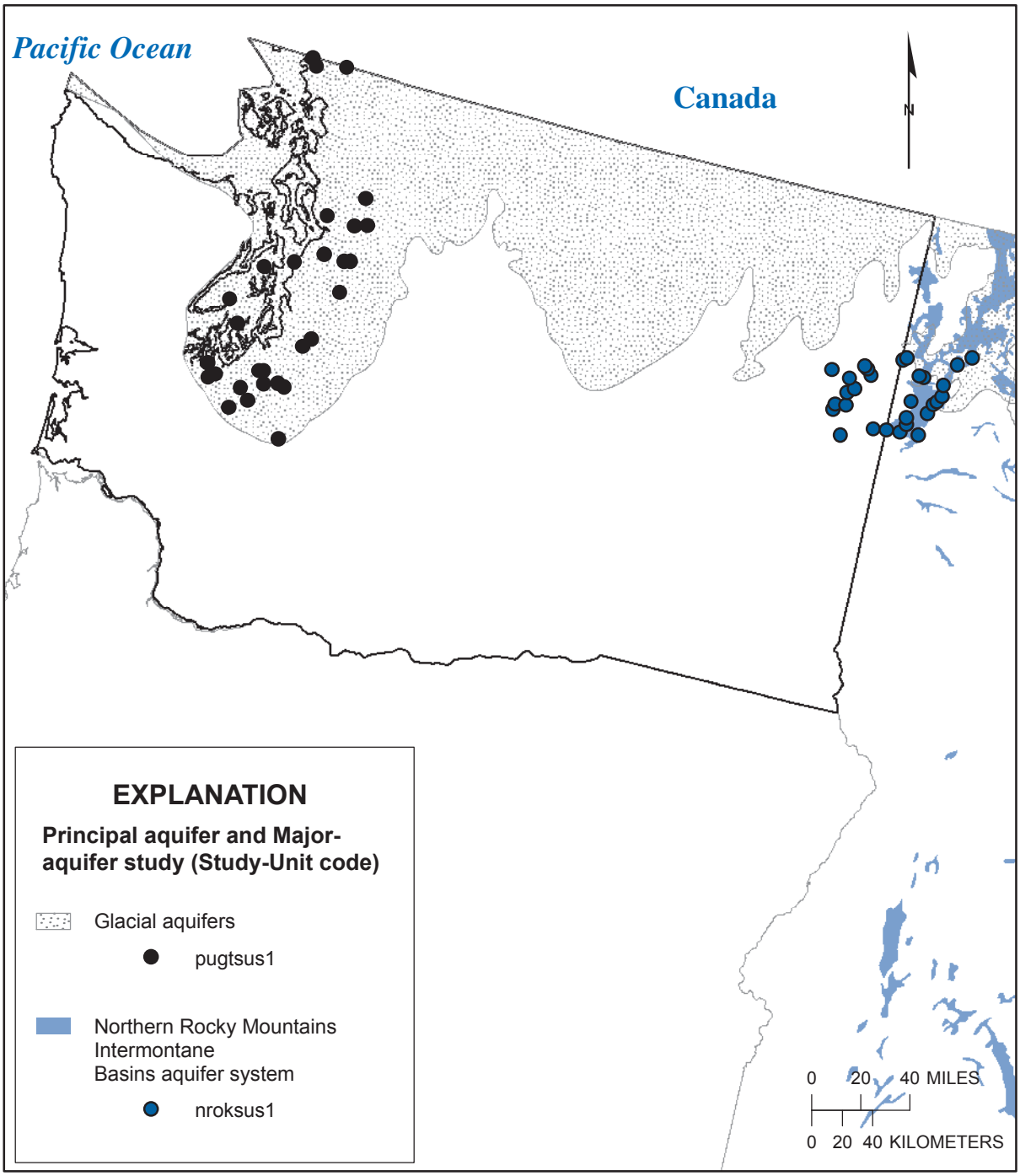
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

Figure WA3. Land use/land cover for Washington and nearby States. (Data from Naomi Nakagaki, U.S. Geological Survey, written commun., 2005.)



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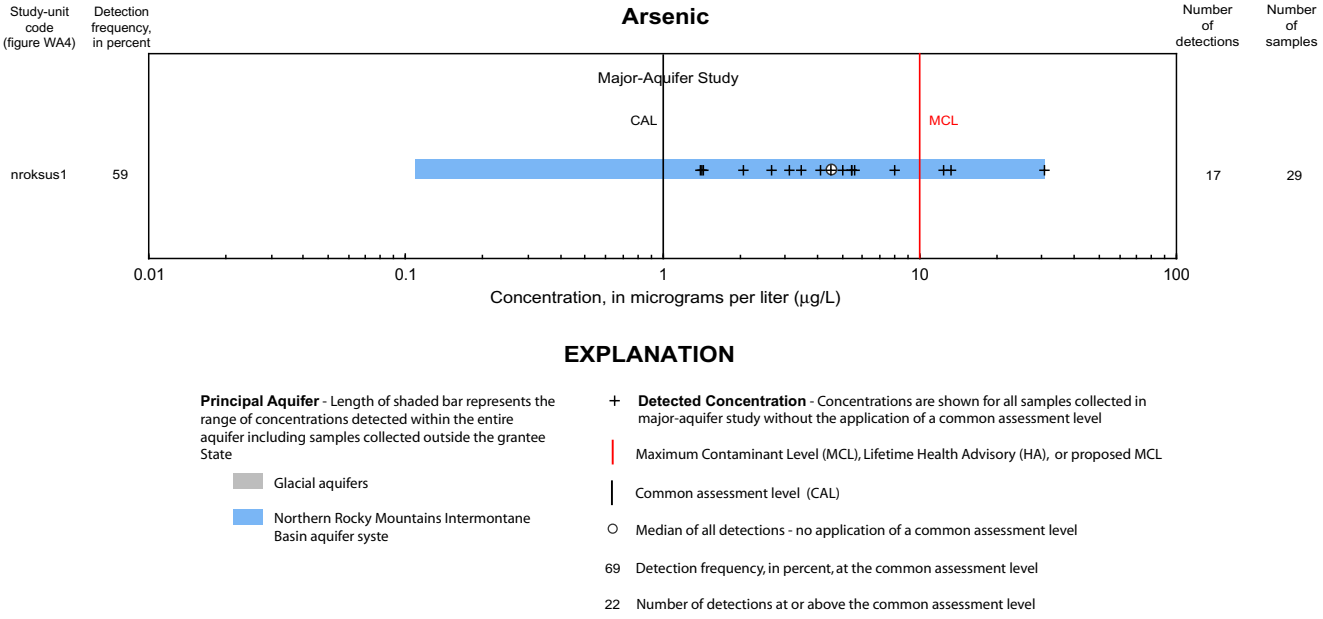
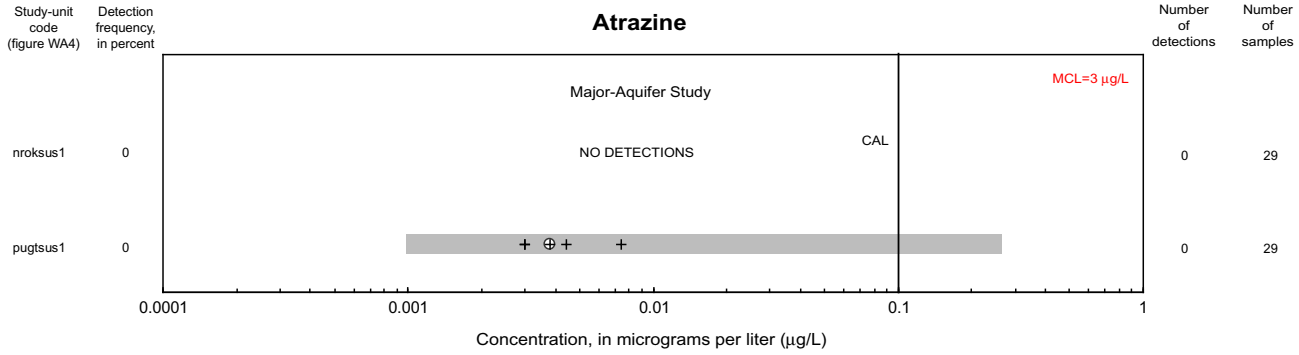
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

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

Figure WA4. Location of domestic wells sampled for National Water-Quality Assessment (NAWQA) major-aquifer studies that included Washington.





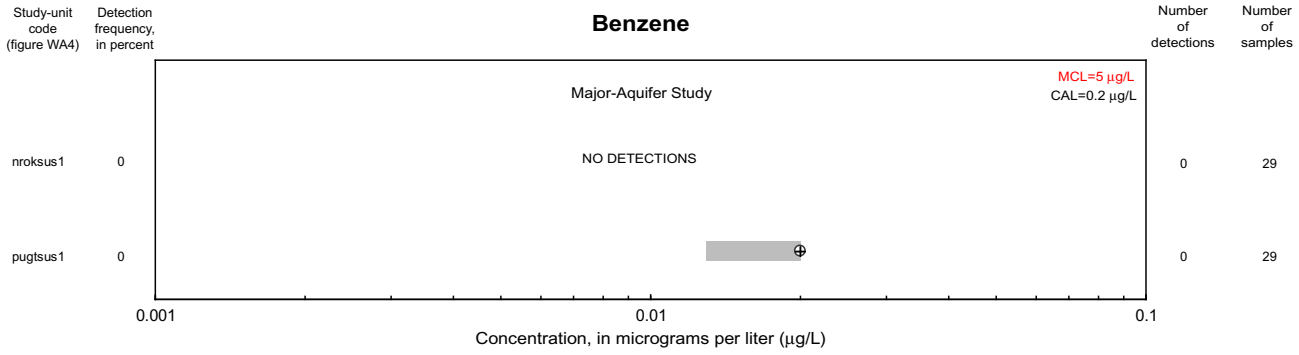
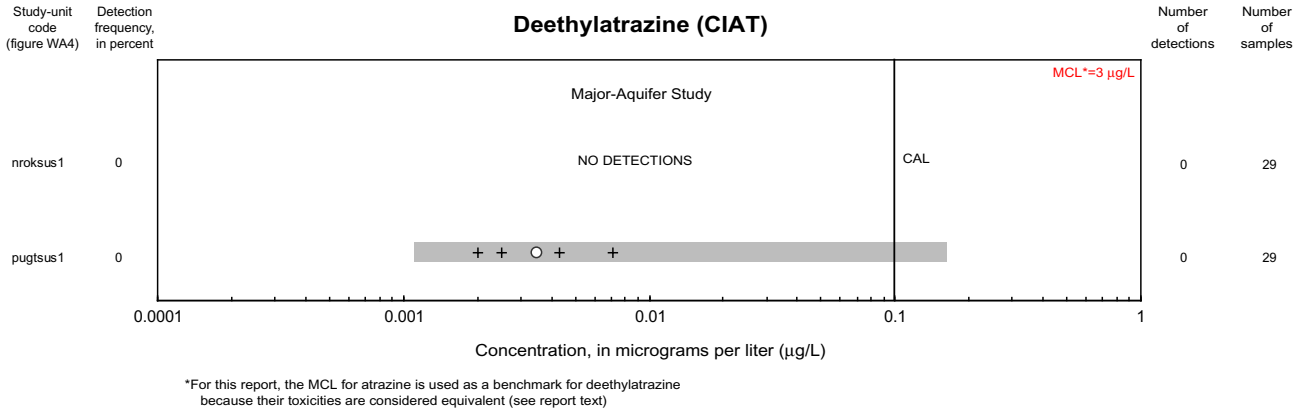
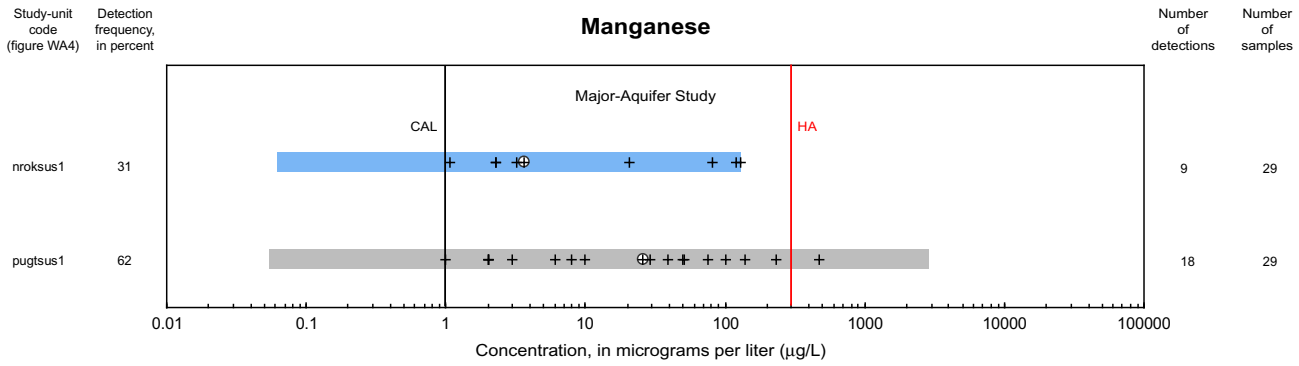
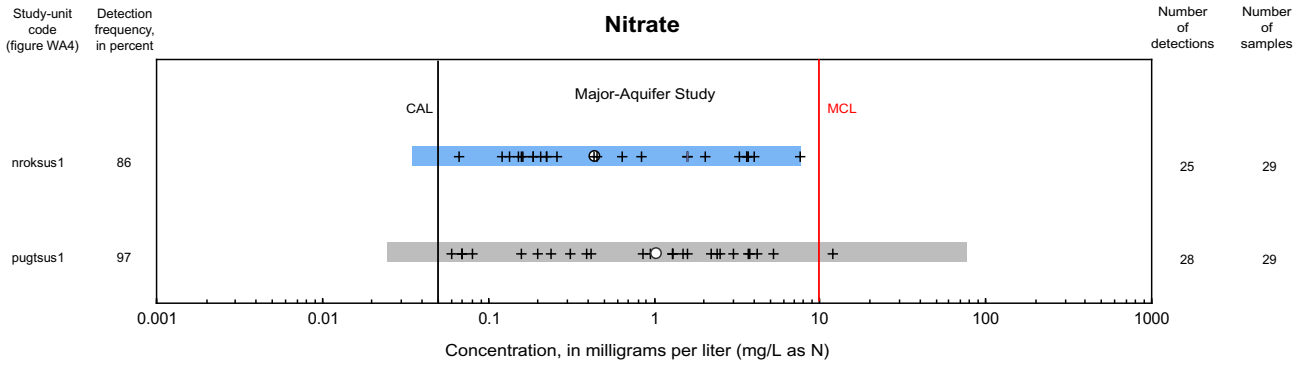


Figure WA5. Statistical summary for 11 selected contaminants by major-aquifer study using domestic-well data from National Water-Quality Assessment (NAWQA) studies for Washington (includes studies for which at least 10 analyses were available).







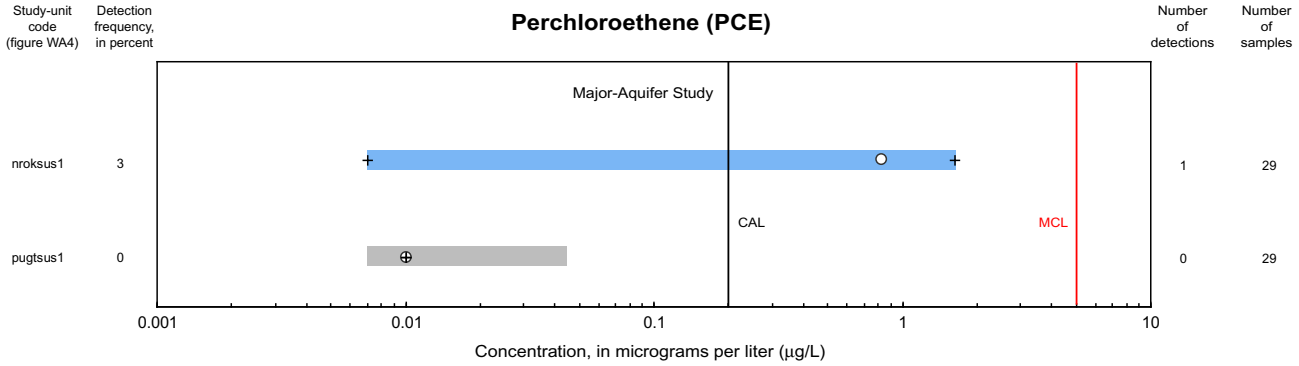
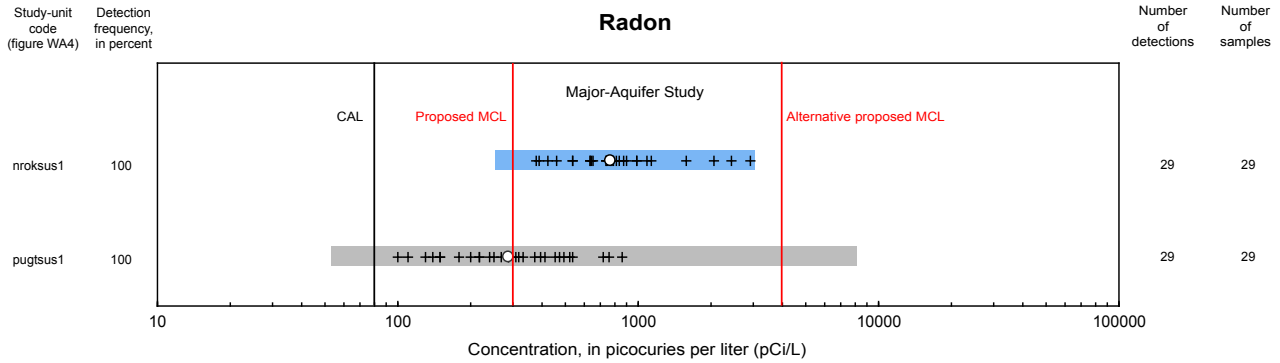
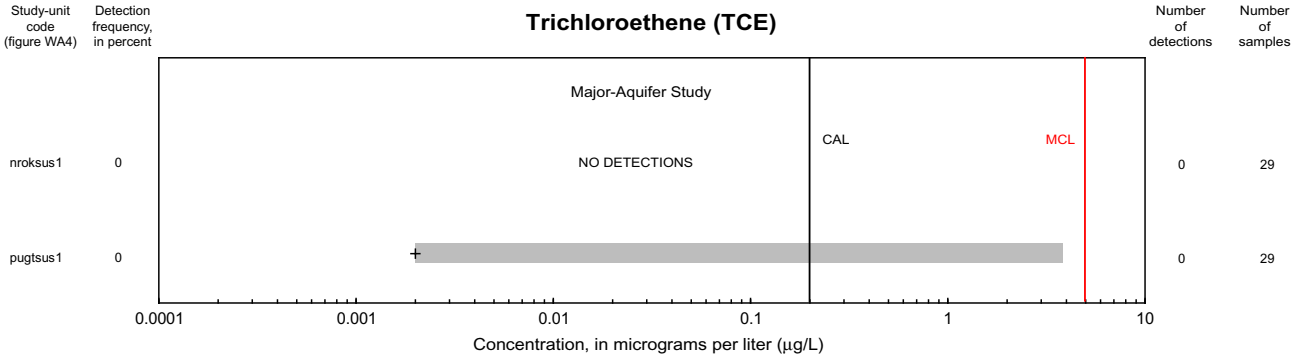


Figure WA5. Statistical summary for 11 selected contaminants by major-aquifer study using domestic-well data from National Water-Quality Assessment (NAWQA) studies for Washington (includes studies for which at least 10 analyses were available).—Continued.



There are no strontium data for Washington.



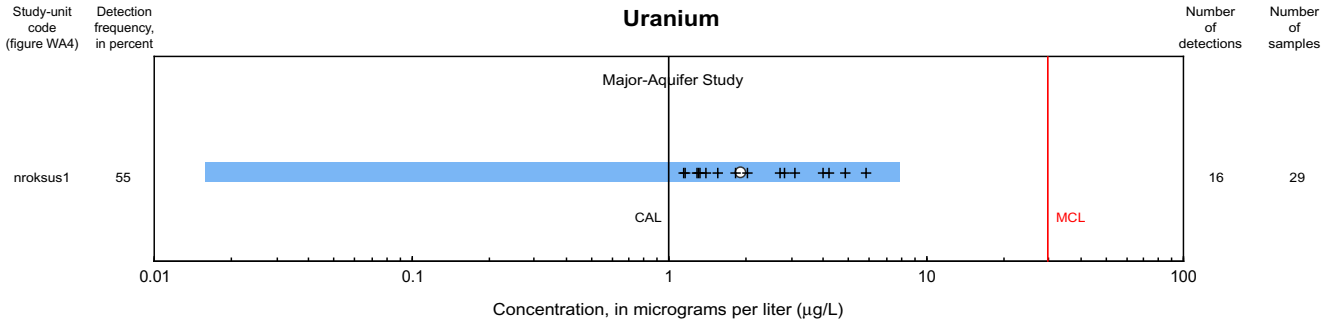
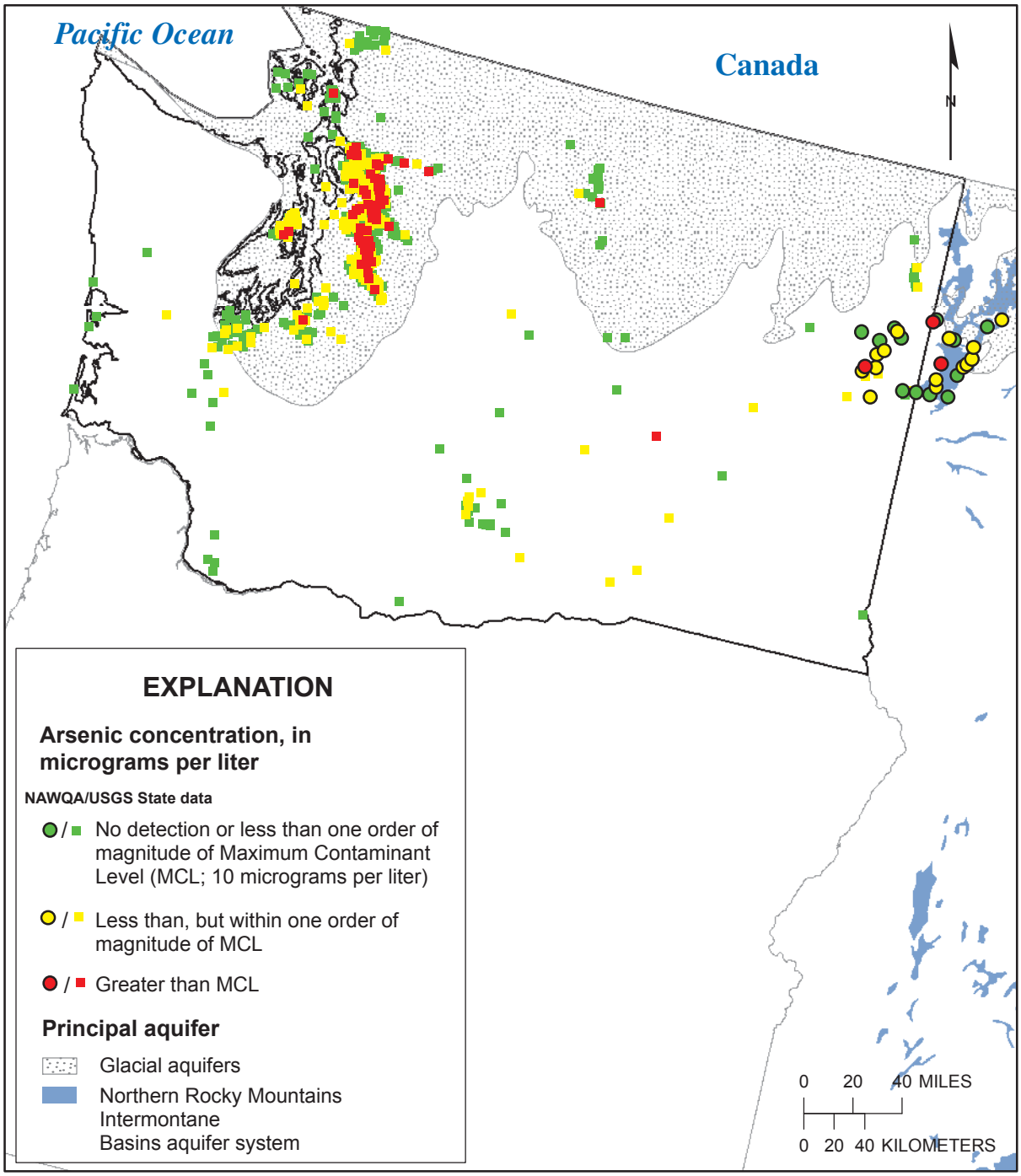


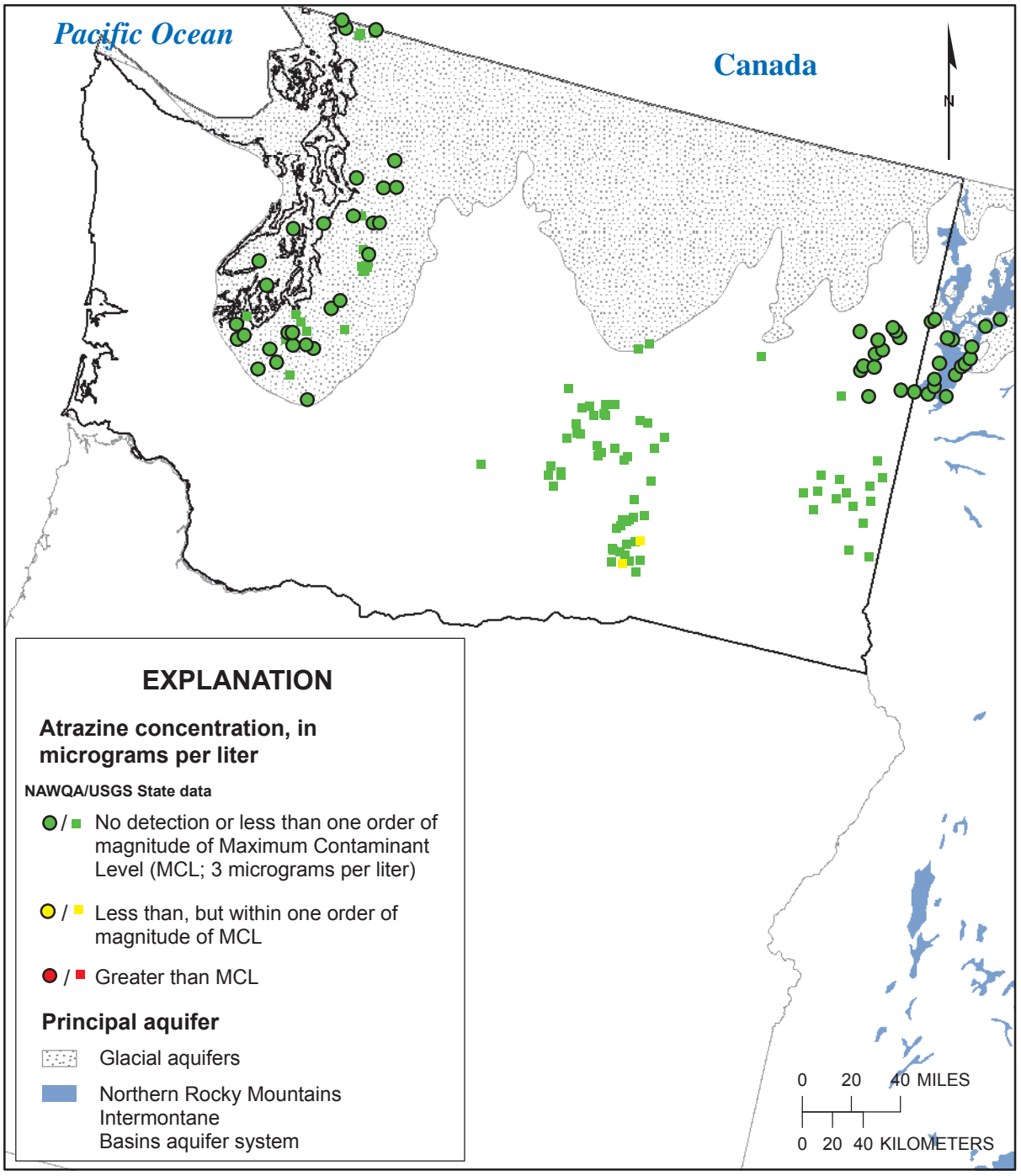
Figure WA5. Statistical summary for 11 selected contaminants by major-aquifer study using domestic-well data from National Water-Quality Assessment (NAWQA) studies for Washington (includes studies for which at least 10 analyses were available).—Continued.



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 WA6. Concentration of arsenic in samples from domestic wells in Washington 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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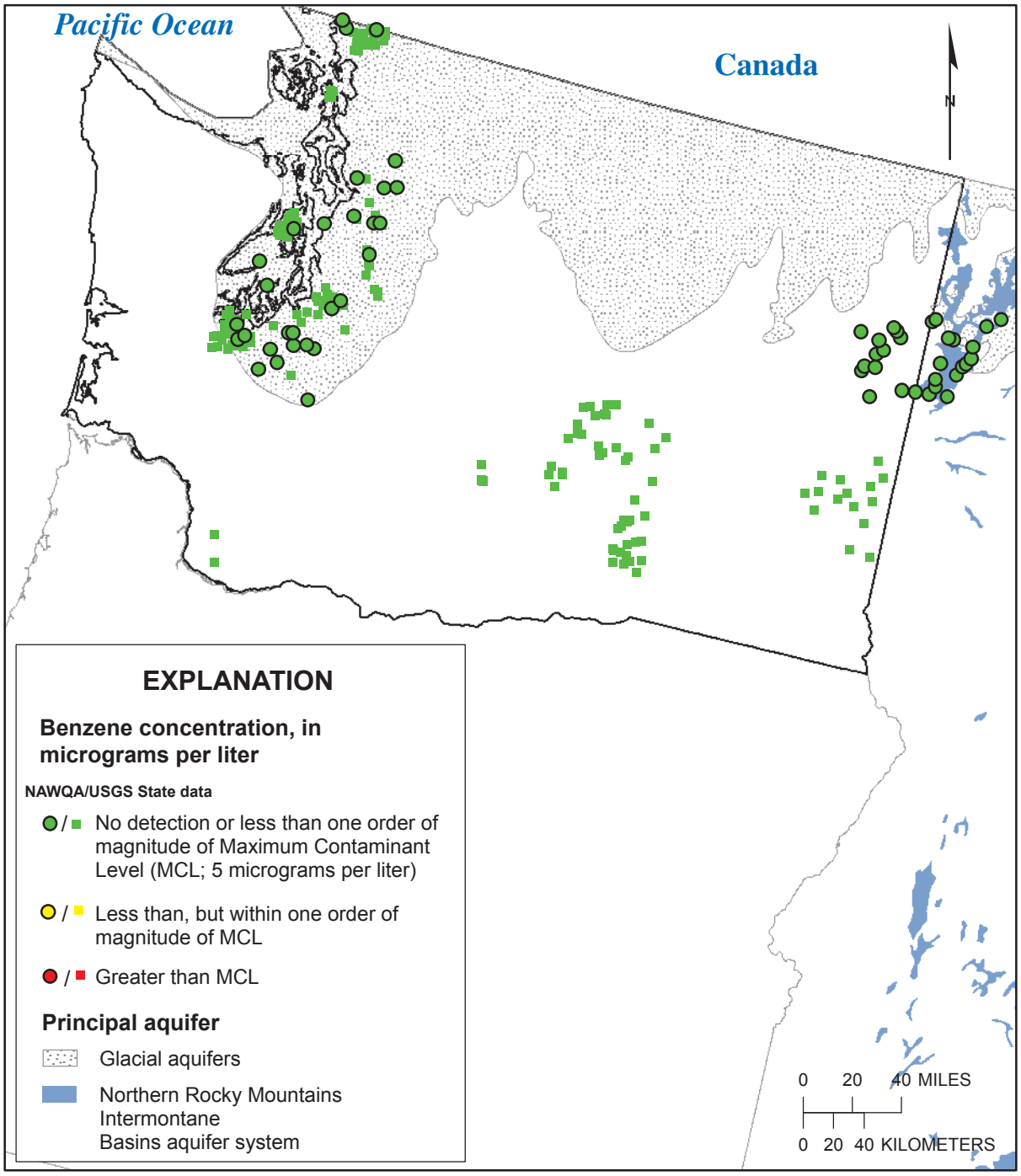
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

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

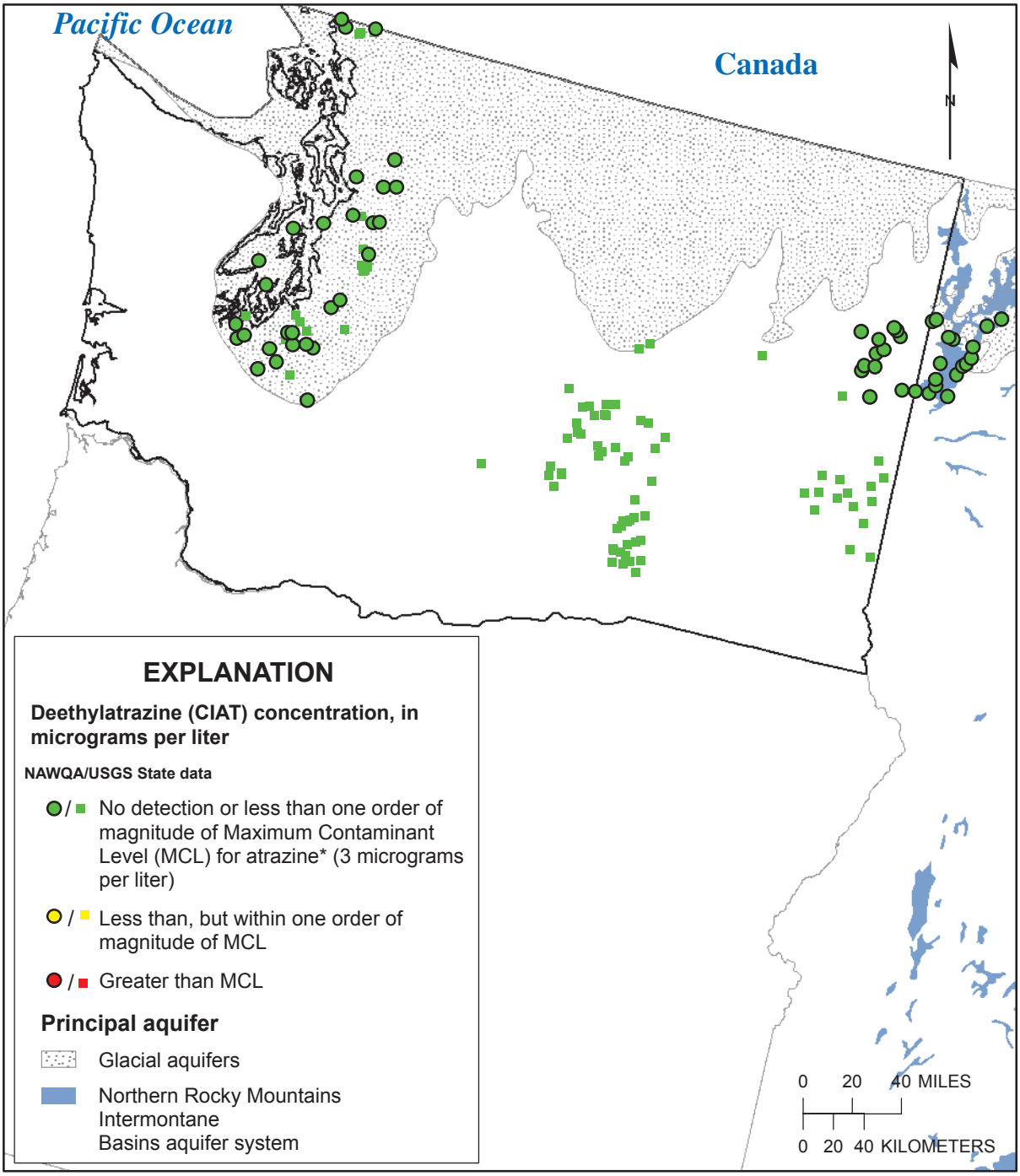
Figure WA7. Concentration of atrazine in samples from domestic wells in Washington and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey(USGS) State data in the National Water Information System (NWIS)).



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 WA8. Concentration of benzene in samples from domestic wells in Washington 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)).

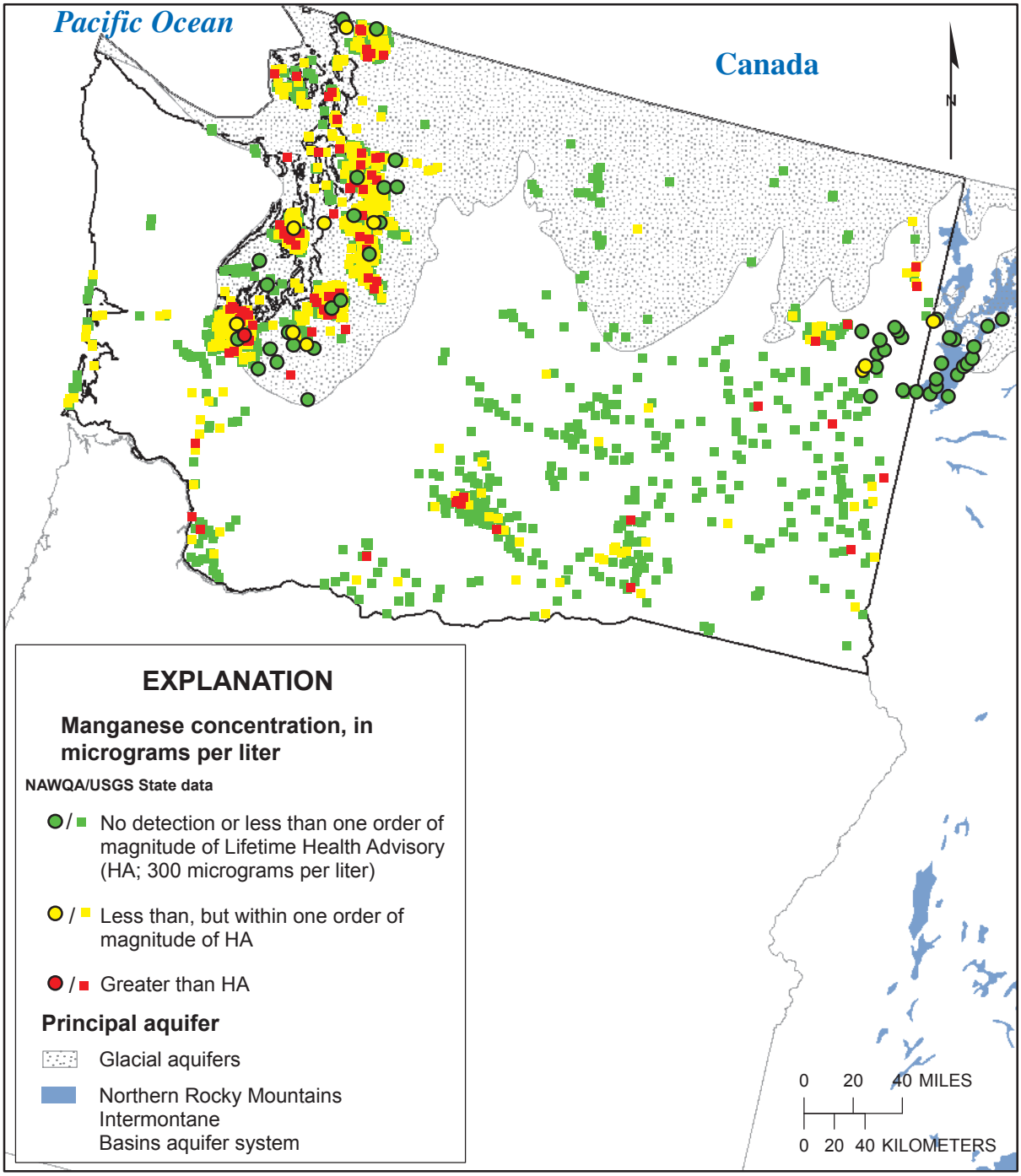


Base information from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard Parallels 29°30' and 45°30', central meridian -96°

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

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

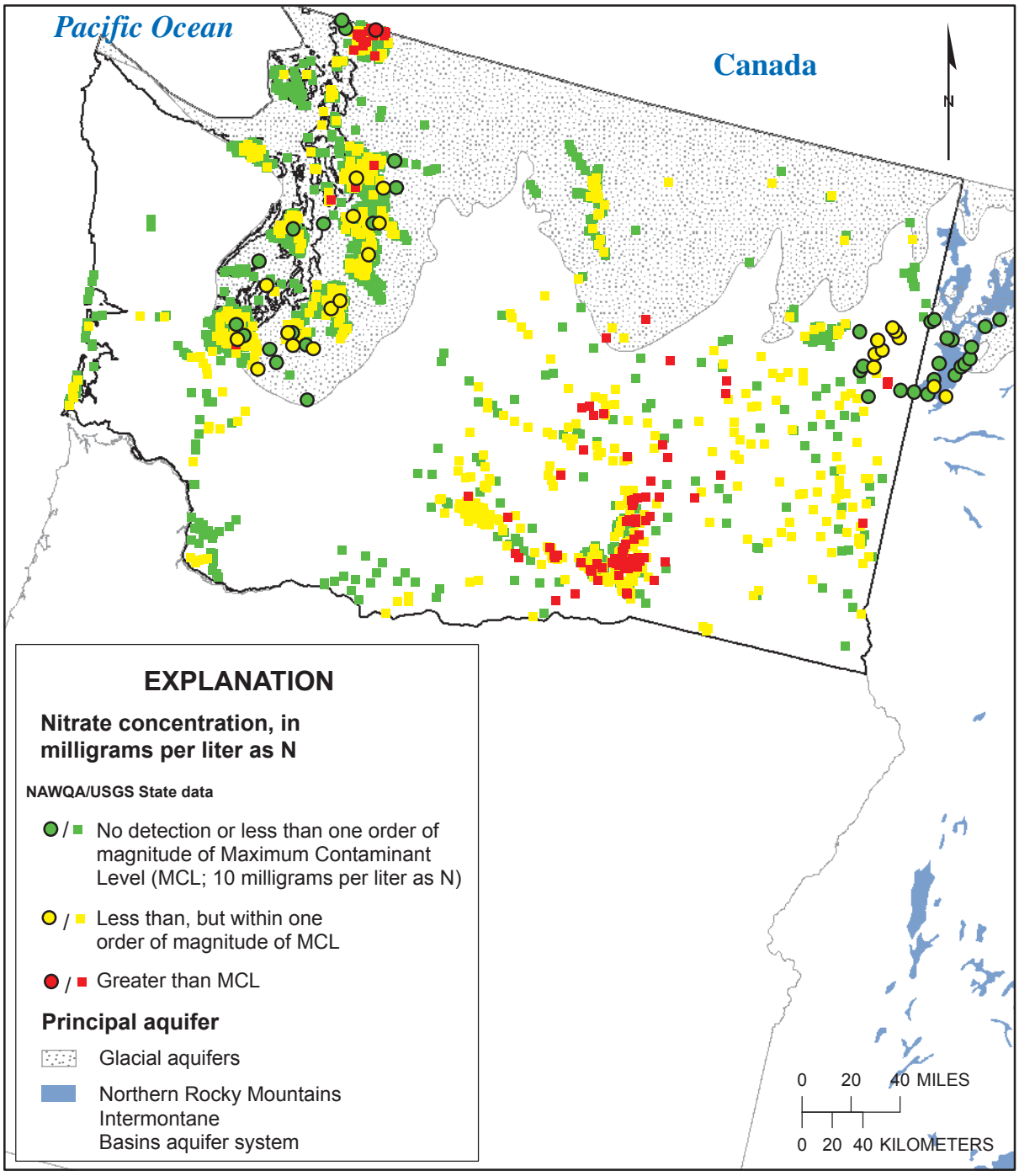
Figure WA9. Concentration of deethylatrazine (CIAT) in samples from in Washington and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



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

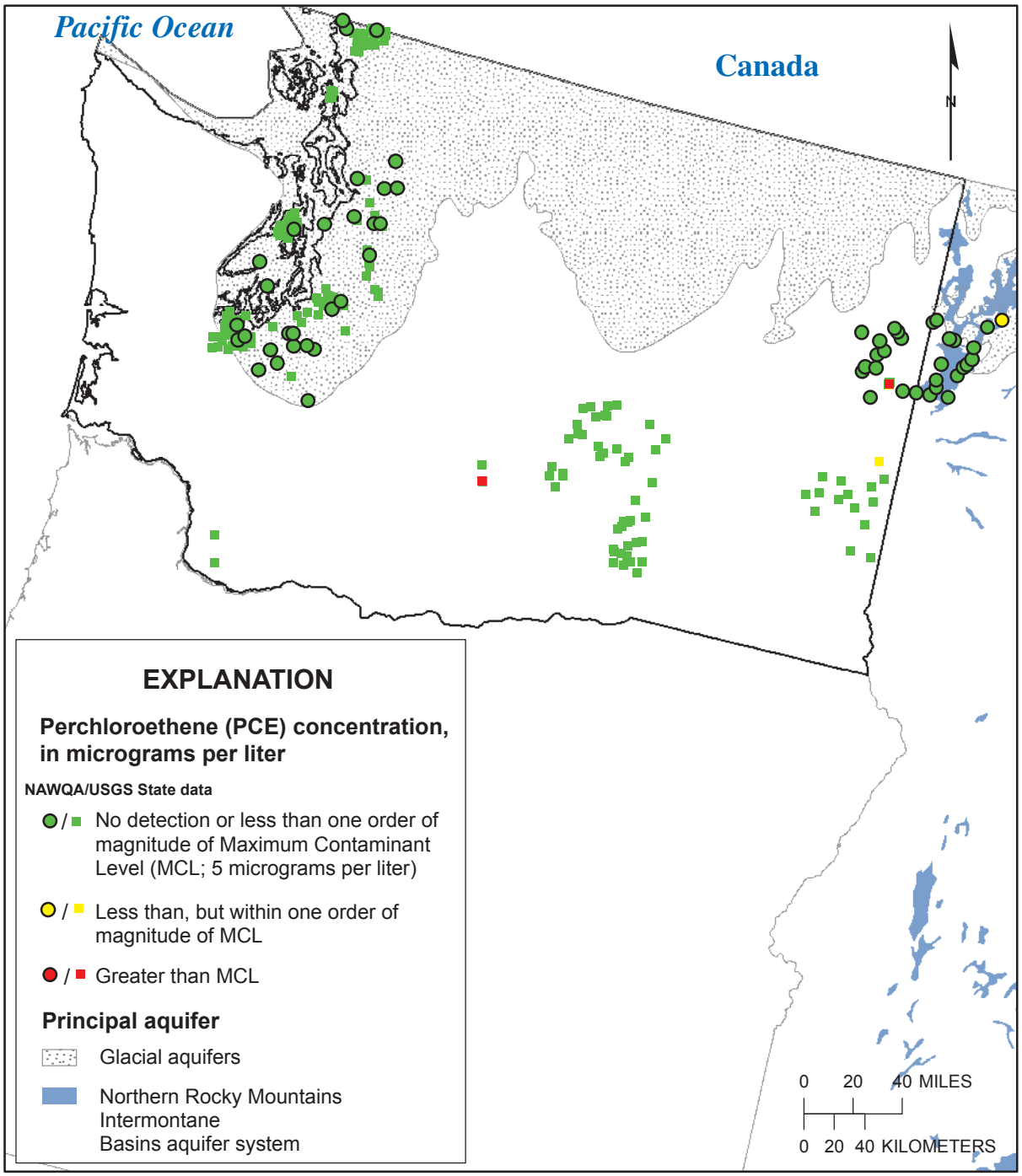
Figure WA10. Concentration of manganese in samples from domestic wells in Washington and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



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

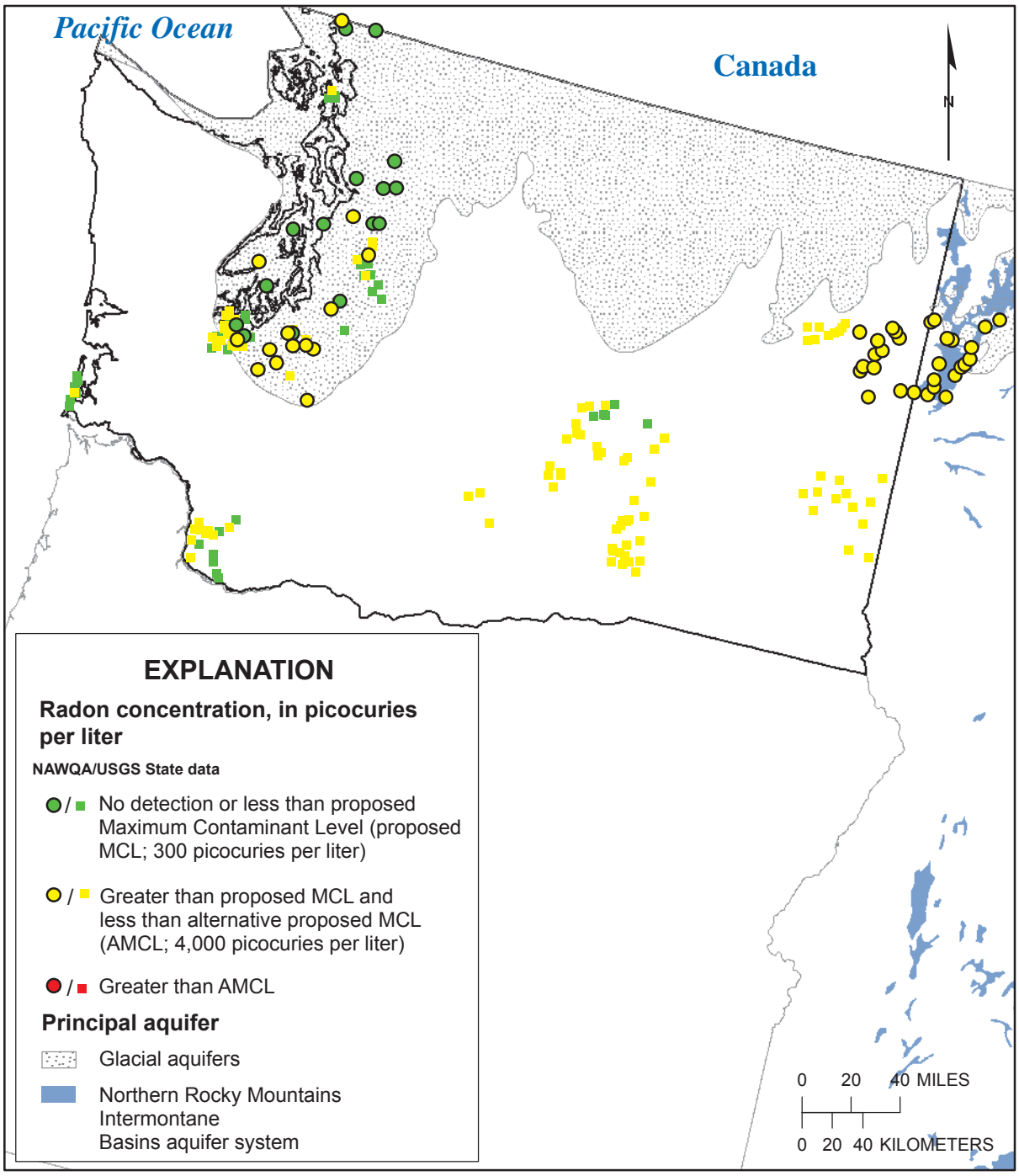
Figure WA11. Concentration of nitrate in samples from domestic wells in Washington and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS)).



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

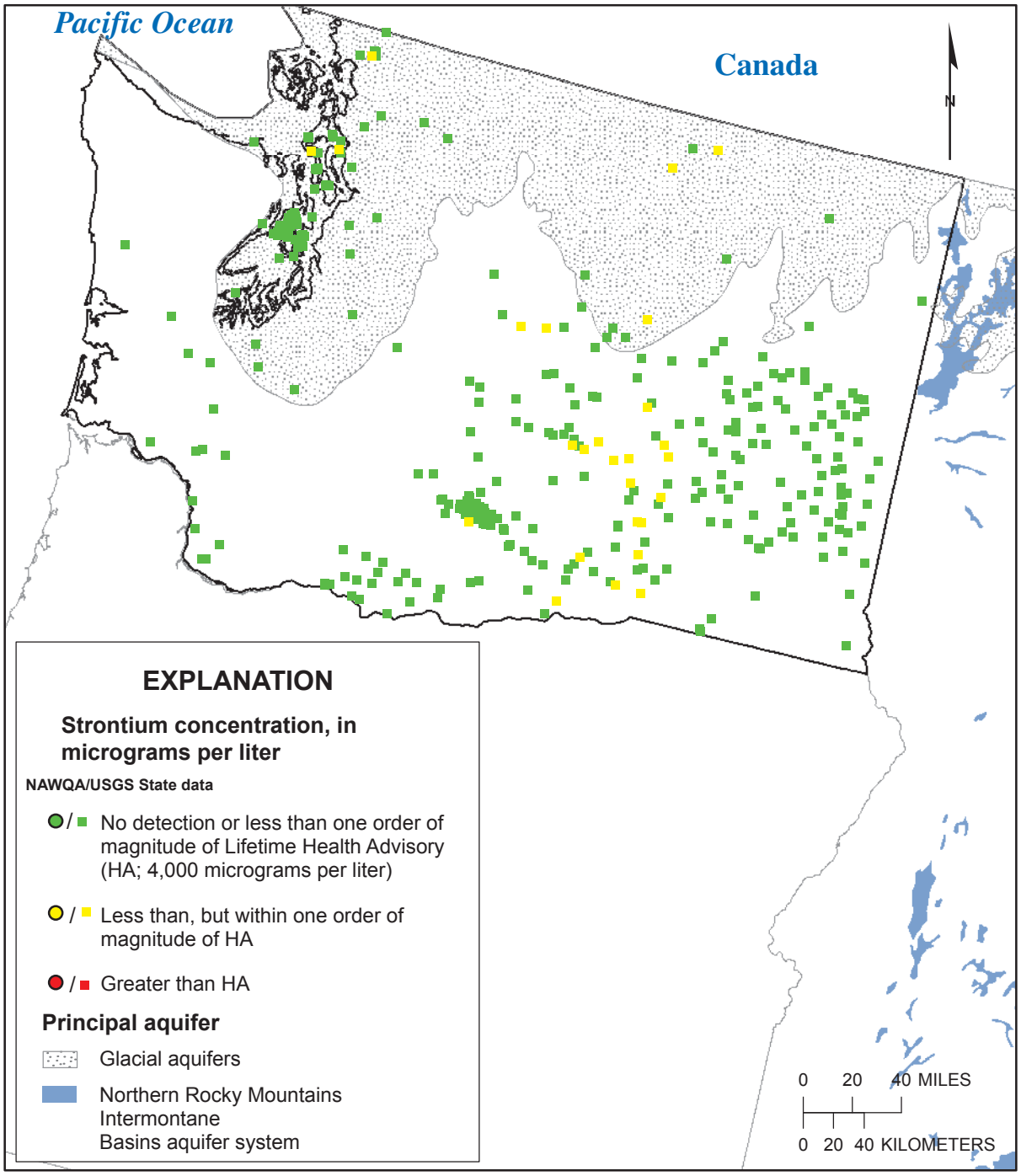
Figure WA12. Concentration of perchloroethene (PCE) in samples from in Washington and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological Survey (USGS) State data in the National Water-Information System (NWIS)).



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

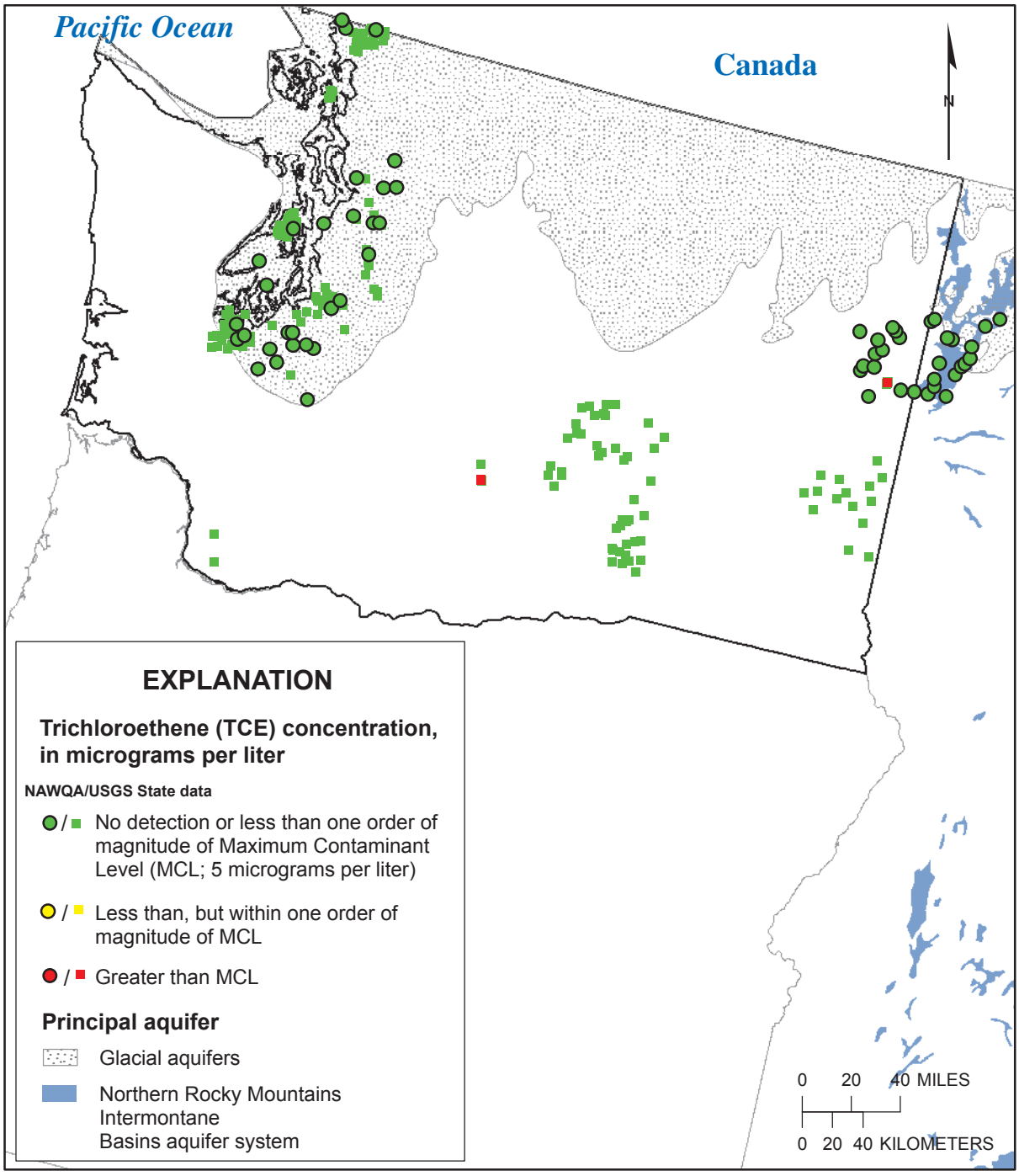
Figure WA13. Concentration of radon in samples from domestic wells in Washington and nearby States (from National Water-Quality Assessment (NAWQA) studies and U.S. Geological (USGS) Survey State data in the National Water Information System (NWIS)).



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

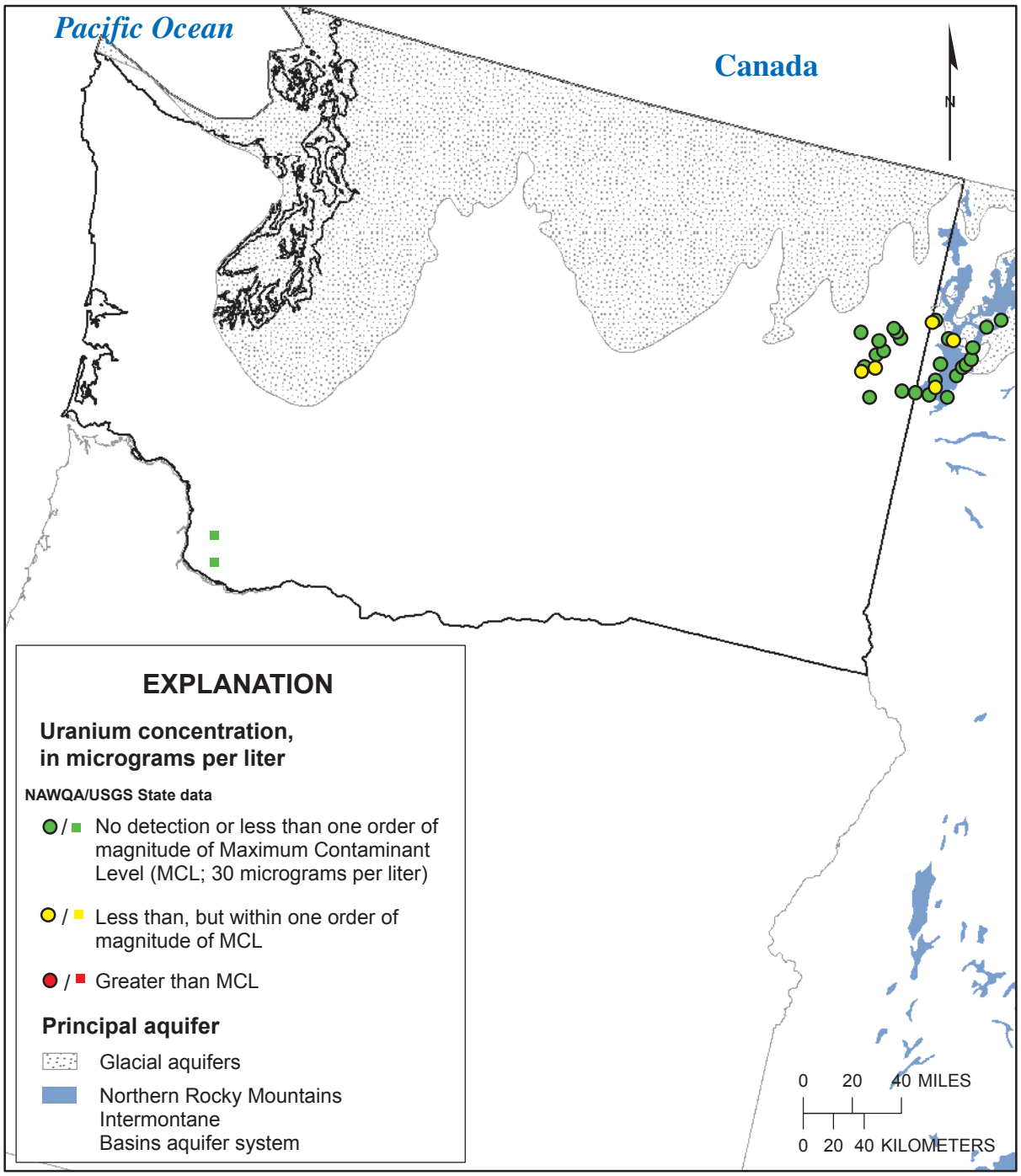
Figure WA14. Concentration of strontium in samples from domestic wells in Washington (from U.S. Geological Survey (USGS) State data in the National Water Information System (NWIS). No additional data were available from National Water-Quality Assessment (NAWQA) studies).



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 WA15. Concentration of trichloroethene (TCE) in samples from domestic wells in Washington 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 WA16. Concentration of uranium in samples from domestic wells in Washington 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)).