

# Groundwater uranium and radon can be anticipated in certain geologic settings

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Major findings about uranium in the glacial, Cambrian-Ordovician, and New England Crystalline aquifers from the NAWQA regional studies:

1. Uranium concentrations in ground water are related to natural sources of uranium in aquifer materials; this can be used to anticipate high-concentration areas.

2. Uranium concentrations in samples from the New England Crystalline are generally higher than in the glacial and Cambrian - Ordovician aquifer systems; all concentrations are generally less than 10 ug/L

3. Uranium in the Cambrian-Ordovician aquifers is generally low (<5 ug/L); though other radionuclides may not be.

4. The Columbia Plateau glacial aquifers and glacial aquifers of west-central United States, had the highest uranium concentrations.

Uranium concentrations in ground water sampled from monitoring and water-supply wells correlate strongly with uranium-bearing aquifer materials in the glacial, Cambrian-Ordovician, and New England Crystalline aquifers. Geologic data can therefore be used to anticipate where this naturally occurring element could be elevated.

Radionuclide concentrations differ by Principal Aquifer (Table 1). The median uranium concentration in the three Principal Aquifers in this study are below 1 microgram per liter (mg/L), but the 75th and 90th percentiles vary. Viewed this way, uranium is highest in New England Crystalline aquifers (Table 1) and lowest in the Cambrian - Ordovician aquifer. The median <sup>222</sup>radon concentration is near the USEPA proposed MCL of 300 picocuries per liter (pCi/L) in the glacial and Cambrian - Ordovician aquifers but is 7 times higher (2,144 pCi/L) in New England Crystalline aquifers where 25% of wells sampled exceed the proposed USEPA alternative MCL (AMCL) of 4,000 pCi/L (Table 1).

Maps of generalized bedrock geology, Wisconsin glacial lobes (Fig. 1), their advance directions, and their composition, were used to delineate important

sub-aquifers within the glaciated terrain of the U.S. Analysis of the bedrock lithology and the glacial lobe data identified groups that might relate to radionuclide occurrence in ground water (King and Beikman, 1974; Schumann, 1993).

Uranium was highest in ground-water samples in the glacial aquifers underlying parts of North and South Dakota, Minnesota, and Nebraska, as well as Washington,

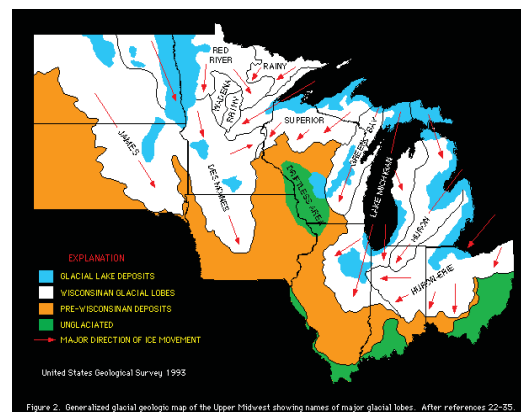


Figure 1. Wisconsin glacial lobes and ice directions

and the New England crystalline aquifers. It was lowest (< 5 micrograms per liter, ? g/L) in samples from the Cambrian-Ordovician aquifers underlying parts of Minnesota, Michigan, and Wisconsin. About 10 percent of wells (monitoring and supply wells) sampled in glacial sediments containing Cretaceous shale or western basalts had concentrations above the current U.S. Environmental Protection Agency (USEPA) drinking-water standard (maximum contaminant level, MCL) of 30 ug/L (Figure 2).

Domestic wells in selected granitic aquifers in Maine and New Hampshire also had samples above the uranium MCL (4%).

| Table 1. Summary of uranium and <sup>222</sup> radon by Principal Aquifer in the glaciated northern United States |     |         |                  |                  |        |                  |                  |         |
|-------------------------------------------------------------------------------------------------------------------|-----|---------|------------------|------------------|--------|------------------|------------------|---------|
| Principal Aquifer                                                                                                 | N   | Maximum | 90 <sup>th</sup> | 75 <sup>th</sup> | Median | 25 <sup>th</sup> | 10 <sup>th</sup> | Minimum |
| <b>Uranium, ? g/L</b>                                                                                             |     |         |                  |                  |        |                  |                  |         |
| New England Crystalline                                                                                           | 113 | 428.9   | 12.8             | 2.9              | < 1    | < 1              | < 1              | < 1     |
| Glacial                                                                                                           | 874 | 162.3   | 7.6              | 2.1              | < 1    | < 1              | < 1              | < 1     |
| Cambrian -- Ordovician                                                                                            | 73  | 5       | 3                | 1                | < 1    | < 1              | < 1              | < 1     |
| <b><sup>222</sup>Radon, pCi/L</b>                                                                                 |     |         |                  |                  |        |                  |                  |         |
| New England Crystalline                                                                                           | 107 | 215,210 | 12,000           | 4,899            | 2,144  | 1,200            | 573              | < 80    |
| Glacial                                                                                                           | 609 | 8,056   | 888              | 523              | 313    | 208              | 150              | < 80    |
| Cambrian -- Ordovician                                                                                            | 70  | 2,700   | 920              | 616              | 370    | 230              | 181              | < 80    |

| WELL | AQUIFER | CODE | AQUIFER NAME                                                                |
|------|---------|------|-----------------------------------------------------------------------------|
|      |         | PMG  | Pacific Mountains Glacial                                                   |
|      |         | CPG  | Columbia Plateau Glacial                                                    |
|      |         | WCG  | West-Central Glacial (Dakota, James, Des Moines, eastern Red River lobes)   |
|      |         | NCG  | North-Central Glacial (Red R., Wadena, Rainy, L. Superior, Green Bay lobes) |
|      |         | PWG  | Pre-Wisconsinan Glacial                                                     |
|      |         | ECG  | East-Central Glacial                                                        |
|      |         | COS  | Cambrian-Ordovician Sedimentary (Lakes Michigan, Huron, and Erie lobes)     |
|      |         | NEG  | New England Glacial                                                         |
|      |         | NEC  | New England Crystalline                                                     |

(a)

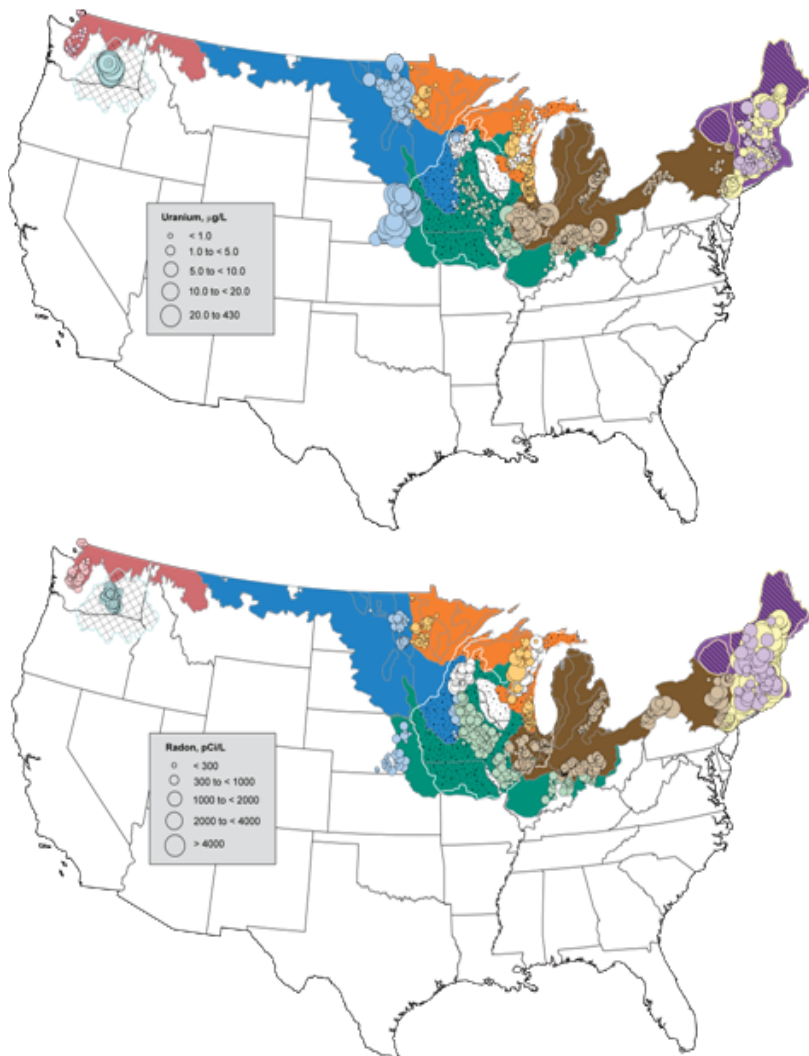


Figure 2a-b. Principal Aquifer and sub-aquifer groups with (a) uranium and (b) <sup>222</sup>radon in ground water. New England Crystalline underlies Northeastern Glacial aquifer. The Cambrian – Ordovician Sandstone aquifer underlies the Midwest Glacial aquifer. The Columbia Plateau Glacial aquifers are outside the extent of Pleistocene glaciation.

| Table 2. Percent of drinking water and monitoring wells with uranium and <sup>222</sup> radon greater than the enforceable or proposed USEPA maximum contaminant level (MCL or AMCL), by aquifer category and well type |                       |                    |                      |                       |                     |                   |                    |                      |                       |                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|--------------------|----------------------|-----------------------|---------------------|-------------------|--------------------|----------------------|-----------------------|---------------------|
| Principal Aquifer or sub aquifer                                                                                                                                                                                        | Drinking water wells: |                    |                      |                       |                     | Monitoring wells: |                    |                      |                       |                     |
|                                                                                                                                                                                                                         | Uranium               |                    | <sup>222</sup> radon |                       |                     | Uranium           |                    | <sup>222</sup> radon |                       |                     |
|                                                                                                                                                                                                                         | N                     | Percent > 30 ? g/L | N                    | Percent > 4,000 pCi/L | Percent > 300 pCi/L | N                 | Percent > 30 ? g/L | N                    | Percent > 4,000 pCi/L | Percent > 300 pCi/L |
| PMG                                                                                                                                                                                                                     | 31                    | 0                  | 57                   | 0                     | 46                  | 5                 | 0                  | 17                   | 0                     | 65                  |
| CPG                                                                                                                                                                                                                     | --                    | --                 | 44                   | 0                     | 89                  | 46                | 9                  | 39                   | 0                     | 72                  |
| WCG                                                                                                                                                                                                                     | 52                    | 12                 | 35                   | 0                     | 40                  | 116               | 11                 | 41                   | 0                     | 73                  |
| NCG                                                                                                                                                                                                                     | 76                    | 0                  | 74                   | 0                     | 34                  | 93                | 0                  | 31                   | 0                     | 32                  |
| ECG                                                                                                                                                                                                                     | 70                    | 0                  | 123                  | 0                     | 45                  | 209               | 0                  | 209                  | 0                     | 53                  |
| PWG                                                                                                                                                                                                                     | 59                    | 0                  | 88                   | 0                     | 41                  | 8                 | 0                  | 83                   | 0                     | 66                  |
| COS                                                                                                                                                                                                                     | 73                    | 0                  | 74                   | 0                     | 66                  | --                | --                 | --                   | --                    | --                  |
| NEG                                                                                                                                                                                                                     | 67                    | 0                  | 61                   | 2                     | 92                  | 55                | 0                  | 29                   | 0                     | 93                  |
| NEC                                                                                                                                                                                                                     | 113                   | 4                  | 107                  | 30                    | 94                  | --                | --                 | --                   | --                    | --                  |

<sup>222</sup>Radon, also naturally occurring and related to aquifer materials, was highest in the New England crystalline aquifers, where 25% of samples from domestic wells exceeded the proposed USEPA Alternate MCL of 4,000 picocuries per liter (pCi/L) (Table 2).

<sup>222</sup>Radon was significantly lower in samples from the glacial and Cambrian-Ordovician aquifers but still exceeded the proposed USEPA MCL of 300 pCi/L in about half of these samples (Table 2: Figure 2).

Although uranium and <sup>222</sup>radon concentrations can vary markedly from well-to-well, this study provides a broad regional basis for predicting where these contaminants are likely to occur in public and private wells in the northern United States.

#### Reference:

Ayotte, J.D., Flanagan, S.M., and Morrow, W.S., 2007, Occurrence of Uranium and <sup>222</sup>Radon in Glacial and Bedrock Aquifers in the Northern United States, 1993–2003: U.S. Geological Survey Scientific Investigations Report 2007–5037, 84 p.

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The USGS has recently released two reports on arsenic, uranium, and radon in parts of the glacial and bedrock aquifer systems in the northern U.S.

Access these reports online at:  
<http://pubs.usgs.gov/sir/2007/5036/> and  
<http://pubs.water.usgs.gov/sir2007-5037/> .  
Printed copies are also available upon request from Denver at  
<http://infotrek.er.usgs.gov/pubs/>

These studies are part of the National Water-Quality Assessment (NAWQA) Program, which is currently conducting regional assessments in 9 principal aquifers. (<http://water.usgs.gov/nawqa/studies/praq/>)

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