2007

# Groundwater Quality in Kentucky: Iron

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## Introduction

Iron is one of the most abundant elements in rocks and soils, and one of the most common problems in groundwater supplies. Rainwater seeping through soils and bedrock dissolves iron and carries it to wells and springs. In deep groundwater systems that lack oxygen, iron occurs as dissolved ferrous ion and the water is clear. Under oxidizing conditions such as in shallow groundwater systems or where the water is exposed to air at a tap or faucet, however, iron converts to a ferric form when it combines with oxygen to form reddish-brown rust particles. In addition to natural sources, elevated iron concentrations in water are also associated with acid drainage from coal mining.

Small amounts of iron are essential to human health because it is needed to transport oxygen in the blood. Iron is considered a secondary or aesthetic contaminant in water, however, because rust can clog pipes and valves, and iron will stain kitchen appliances and clothing. At concentrations greater than 1 mg/L (or parts per million) iron gives water an objectionable taste. Iron in water also causes problems for many industrial uses such as food processing, paper manufacturing, and brewing (Illinois Department of Public Health, 1999). For these reasons, the Environmental Protection Agency has set a secondary maximum contaminant level for iron of 0.3 mg/L.

## Iron Concentrations in Groundwater

### *Data Sources*

Results of iron analyses for this report were compiled from the Kentucky Groundwater Data Repository, maintained by the Kentucky Geological Survey. The repository was established in 1990 to archive and disseminate groundwater data collected by various agencies in Kentucky. Major data sources for the repository include the Kentucky Division of Water, the Kentucky Geological Survey, the U.S. Geological Survey, the National Uranium Resource Evaluation Program, and the Environmental Protection Agency.

The database contained 23,942 analyses of iron from 6,356 wells and springs throughout Kentucky as of November 2004. Of the analyses, 10,001 were identified as total iron (unfiltered groundwater), 7,669 were identified as dissolved iron (filtered groundwater), and the rest were unspecified. Analytical results for groundwater samples collected from known or suspected contaminated sites, identified by regulatory program names such as the Resource Conservation and Recovery Act, Solid Waste, and Underground Storage Tank, were not included in this report because they are not representative of regional groundwater quality. Samples from wells deeper than 1,000 ft were excluded because such deep wells are not likely to be used for domestic or industrial water supplies.

### *Variations in Iron Concentrations*

The maximum iron concentration in each of Kentucky's geologic regions far exceeds the cosmetic and aesthetic level of 0.3 mg/L (Table 1). In the Eastern Kentucky Coal Field, Outer Bluegrass, and Western Kentucky Coal Field Regions, even the median value exceeds the secondary maximum contaminant level. More than 60 percent of all sampled sites produced groundwater with more than 0.3 mg/L of iron, and approximately 50 percent of all iron concentrations were greater than 0.3 mg/L (Fig. 1).

| Region | No. of Measurements | 25th Percentile Value (mg/L) | Median Value (mg/L) | 75th Percentile value (mg/L) | Number of Sites | Percent of Sites > 0.3 mg/L |
|---|---|---|---|---|---|---|
| Eastern Ky. Coal Field | 11,779 | 0.11 | 0.48 | 2.3 | 2,138 | 75 |
| Eastern Pennyroyal | 811 | 0.03 | 0.13 | 0.58 | 399 | 55 |
| Inner Bluegrass | 725 | 0.01 | 0.06 | 0.19 | 162 | 45 |
| Outer Bluegrass | 2,029 | 0.07 | 0.45 | 2.7 | 613 | 65 |
| Knobs | 429 | 0.02 | 0.16 | 1.4 | 193 | 56 |
| Western Pennyroyal | 3,604 | 0.02 | 0.08 | 0.25 | 1,026 | 40 |
| Western Ky. Coal Field | 1,704 | 0.09 | 0.43 | 3.3 | 677 | 66 |
| Jackson Purchase | 2,861 | 0.08 | 0.42 | 4.1 | 1,148 | 50 |

**Table 1.** Summary of iron concentrations.

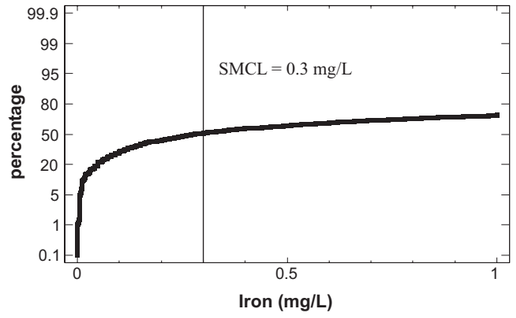


Figure 1. Cumulative percentage plot of measured iron concentrations. Higher values were excluded to better show the region of interest.

The map shows sites where iron in groundwater has been measured, with different symbols to show concentration ranges. Sites that have been sampled more than once may have more than one symbol, and symbols may overlap if the sites are close to each other. The Eastern Kentucky Coal Field, Outer Bluegrass, and Western Kentucky Coal Field Regions have the largest percentage of sites where iron concentrations exceed the secondary maximum contaminant level, whereas the Inner Bluegrass, Western Pennyroyal, and Jackson Purchase Regions have the smallest percentage of such sites.

Figure 2 summarizes total (unfiltered water) and dissolved (filtered water) iron concentrations. In this plot, boxes enclose the central 50 percent of the values from the 25th percentile value to the 75th percentile value. The median value is shown by a vertical line through the box, and lines extend from each edge of the box for a distance of 1.5 times the iron range represented by the central box. Extreme values are shown as individual squares. Total iron concentrations have a higher median value, higher 75th percentile value, and larger range of values in the central 50 percent of the reported concentrations. Unfiltered groundwater typically has a higher iron concentration than filtered water.

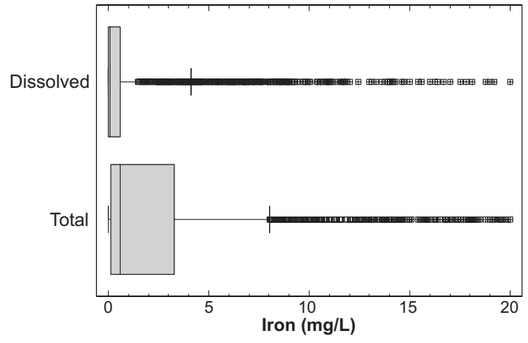


Figure 2. Comparison of total and dissolved iron concentrations. Higher values were excluded to better show the majority of the data.

A similar plot shows that groundwater from wells has a higher median iron concentration and a higher 75th percentile value than groundwater from springs (Fig. 3). Water from springs is more likely to contain dissolved oxygen than is well water, which will result in iron precipitating out of solution as rust particles.

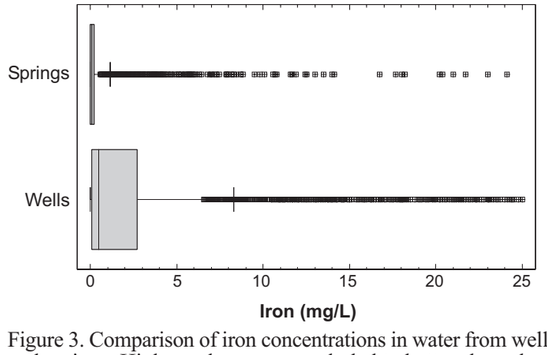


Figure 3. Comparison of iron concentrations in water from wells and springs. Higher values were excluded to better show the majority of the data.

The highest iron concentrations are found in water from shallow wells (Fig. 4). Many of the results from wells less than 200 ft deep that have iron concentrations of several hundred mg/L are total iron concentrations; that is, samples that may contain suspended particulate material that contains iron.

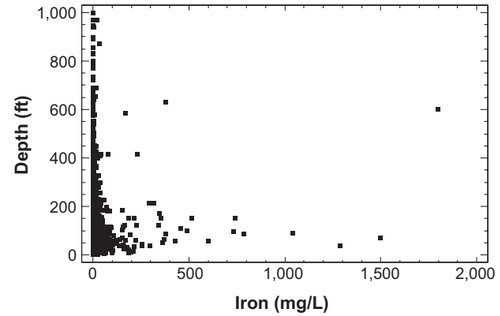


Figure 4. Plot of iron concentrations versus well depth.

## Water-Quality Concerns

Iron in Kentucky groundwater commonly exceeds the secondary maximum contaminant level. Iron is present to some degree in all of Kentucky's rock types. Therefore, sites where iron exceeds the SMCL occur across the state in all physiographic regions.

These findings should be viewed as general patterns. Individual wells or springs should be tested for the occurrence of iron and other potential contaminants before being used as drinking-water supplies. Citizens with concerns about the quality of water in private wells or springs should contact their local health department or the Groundwater Branch of the Kentucky Division of Water, a division of the Kentucky Natural Resources and Environmental Protection Cabinet. The Groundwater Branch can provide literature on maintaining private wells and springs and information on sampling for water-quality analysis.

Various treatment options, including aeration, filtration, use of a water softener, use of ion exchangers, ozonation, and chlorination, are available to reduce iron in groundwater supplies. Citizens who have high iron concentrations in their water supplies can consult with water-treatment companies to determine which method might work best in their particular situation.

## The Kentucky Interagency Groundwater Monitoring Network

This publication is a product of the Kentucky Interagency Groundwater Monitoring Network, which was established in 1998 by legislation (KRS 161.625) to collect groundwater-quality data, characterize groundwater resources, and distribute the resulting information. The network is assisted by an Interagency Technical Advisory Committee on Groundwater, which was also created by statute (KRS 151.629).

Additional information and a list of member agencies can be found at www.uky.edu/KGS/water/gnet/gnet.htm.

## References Cited

Illinois Department of Public Health, 1999, Environmental health fact sheet: Iron in drinking water: www.idph.state.il.us/envhealth/factsheets/ironFS.htm [accessed 5/12/05].


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ISSN 0075-5583

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INFORMATION CIRCULAR 13
SERIES XII, 2007

https://doi.org/10.13023/kgs.ic13.12

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Information Circular 13
Series XII, 2007
https://doi.org/10.13023/kgs.ic13.12

# IRON CONCENTRATIONS IN WELLS AND SPRINGS IN KENTUCKY

## EXPLANATION

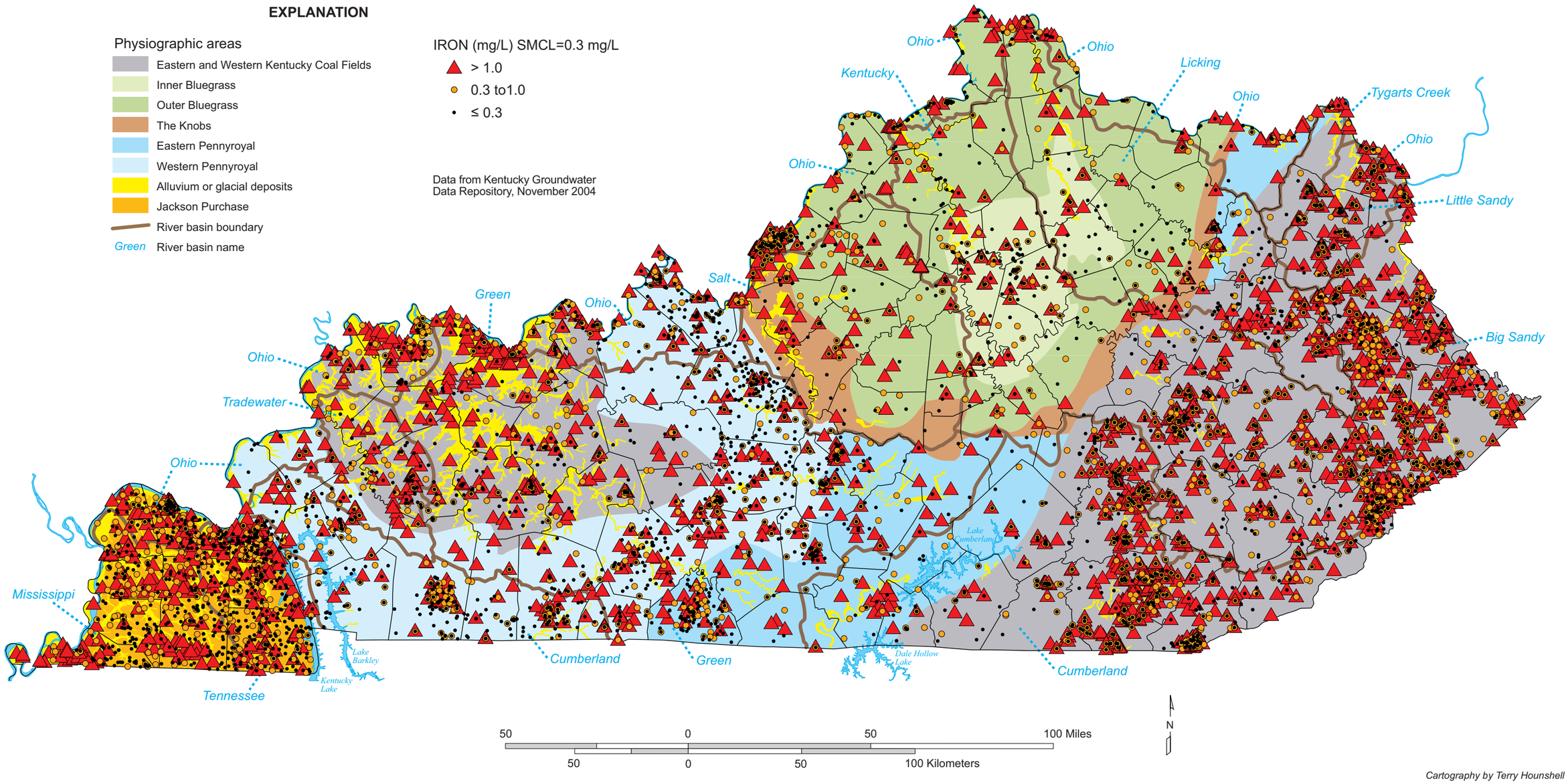
Physiographic areas

- Eastern and Western Kentucky Coal Fields
- Inner Bluegrass
- Outer Bluegrass
- The Knobs
- Eastern Pennyroyal
- Western Pennyroyal
- Alluvium or glacial deposits
- Jackson Purchase
- River basin boundary
- *Green* River basin name

IRON (mg/L) SMCL=0.3 mg/L

- ▲ > 1.0
- ● 0.3 to1.0
- • ≤ 0.3

Data from Kentucky Groundwater Data Repository, November 2004




*Cartography by Terry Hounshell*