Pesticides

A large number of synthetic organic pesticides (including insecticides, herbicides, and growth regulators) have been developed and applied in agricultural and urban settings. Some, such as the organochlorine insecticide DDT, were banned decades ago but still persist in soils and sediments and could still be released to groundwater systems. Most recently developed pesticides that have been approved for use are less persistent in natural environments; however, they may still have undesirable impacts on human health and groundwater suitability for various uses.

The environmental significance of pesticides in groundwater is difficult to determine precisely for several reasons (U.S. Geological Survey, 1999): (1) standards and guidelines are available for only a small number of individual pesticide chemicals and are generally not available for the equally important degradation products, (2) new pesticides are being developed continually, (3) environmental testing does not account for pesticide mixtures or breakdown products, which may be more potent than the original active ingredients, (4) only a limited suite of health and ecological effects have been tested, (5) concentrations much higher than those used in testing may be introduced to groundwater systems when pesticides are applied or after rains, and (6) some detrimental effects such as endocrine disruption and other subtle health effects have not been fully assessed. For these reasons, and because once contaminated, groundwater typically is slow to respond to changes in pesticide type and application methods, quantifying the existence of any detectable pesticides in Kentucky groundwater is important.

According to the 2000 agriculture sales data, atrazine, glyphosate, metolachlor, simazine, and 2,4-D are the top five pesticides sold in Kentucky. Alachlor and cyanazine have also been used extensively in the past. Glyphosate has not been measured in groundwater samples and so will not be discussed in this report. Toxicological information for pesticides was obtained from the Extension Toxicology Network and is available on the Web site ace.orst.edu/info/extoxnet.pips/.

2,4-D. The pesticide 2,4-D belongs to the chemical class of phenoxy compounds. Predominant uses are as a systemic herbicide to control broadleaf weeds in cultivated agriculture, pasture and range land, forest management, home and garden settings, and to control aquatic vegetation.

It has a low persistence in soils with a half-life of less than 7 days, and is readily degraded by microorganisms in aquatic environments. The EPA has established an MCL of 0.07 mg/L for 2,4-D.

The data repository contained 516 measurements of 2,4-D from 117 sites (Table 23). In BMU 3, 510 of 516 measurements (98.8 percent) were reported as less than a detection limit. No site yielded groundwater with 2,4-D concentrations above the MCL. Only three sites had detectable levels of 2,4-D (Fig. 108). All sites where 2,4-D was detected are springs; no 2,4-D was found in well samples. No cumulative data distribution plots or further analyses were performed because there were so few measurements above the detection limit of the analytical method.

Table 23. Summary of 2,4-D values (mg/L).

Measurements	516
Maximum	< 0.0009
75th percentile	< 0.000335
Median	< 0.0001
25th percentile	< 0.0001
Minimum	0.00001
Interquartile range	na
Sites	117
MCL	0.07
Sites > 0.07	0

< means analytical result reported as less than the stated value

In summary, the pesticide 2,4-D was detected at three of 117 sites; all detections were in groundwater from springs. No samples had 2,4-D concentrations greater than the MCL of 0.07 mg/L. The observed occurrences, coupled with the short half-life, suggest that 2,4-D degrades in the time it takes to travel from application site to water wells. Rapid runoff can transport 2,4-D to springs, however, where the water might be consumed or used for other domestic purposes.

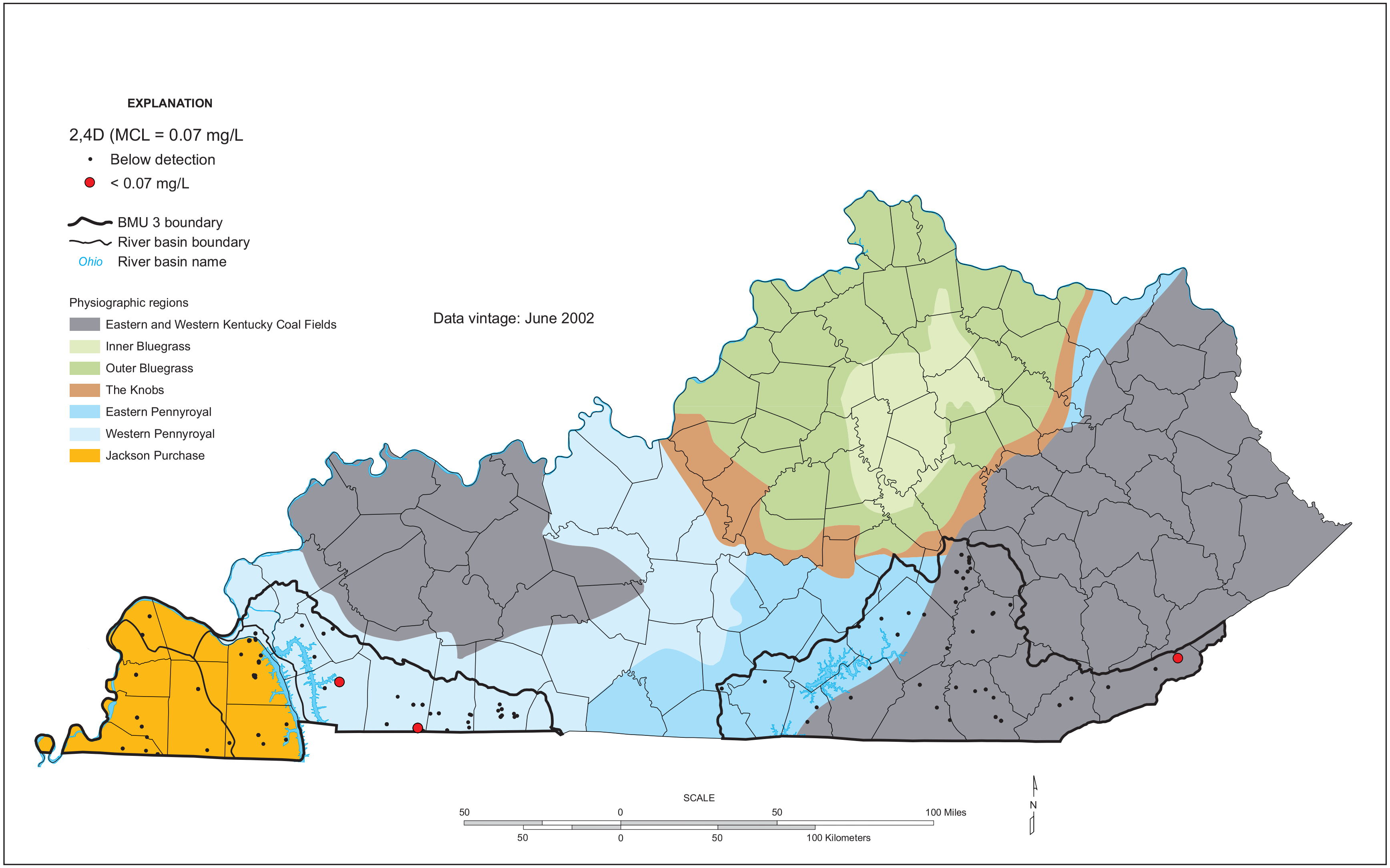

Figure 108. Locations of sites where 2,4-D was measured and ranges of 2,4-D values. No sites exceeded the MCL.

Alachlor. Alachlor belongs to the chemical class of analines. Predominant uses are the control of annual grasses and broadleaf weeds in field corn, soybeans, and peanuts. It has a low persistence in soils and half-life of about 8 days. It is moderately mobile in sandy and silty soils and breaks down rapidly in natural water because of microbial activity. The breakdown is significantly slower under reducing conditions. The EPA has set an MCL of 0.002 mg/L for alachlor.

The data repository contained 2,413 results of analyses from 107 sites (Table 24). Of the 2,413 measurements, 1,078 were reported from a single site, and 1,543 of the measurements (63.9 percent) were reported as less than a detection limit.

Cumulative data distributions were not plotted because of the small number of measurements above analytical detection limits.

The site distribution is relatively even but sparse throughout the project area. Two sites in the Lower Cumberland River watershed of the Western Pennyroyal Region yielded groundwater with alachlor concentrations above the MCL (Fig. 109). Twenty sites, most of them in the Lower Cumberland River watershed of the Western Pennyroyal Region, had detectable levels of alachlor.

Table 24. Summary of alachlor values (mg/L).

Measurements	2,413
Maximum	0.01200
75th percentile	0.00010
Median	< 0.00006
25th percentile	< 0.00006
Minimum	< 0.00002
Interquartile range	na
Sites	107
MCL	0.002
Sites > 0.002	2

< means analytical result reported as less than the stated value

Only three of the sites where alachlor was detected are water wells; the remainder are springs or are part of a karst system. Nearly all of the alachlor measurements that were above detection limits were from

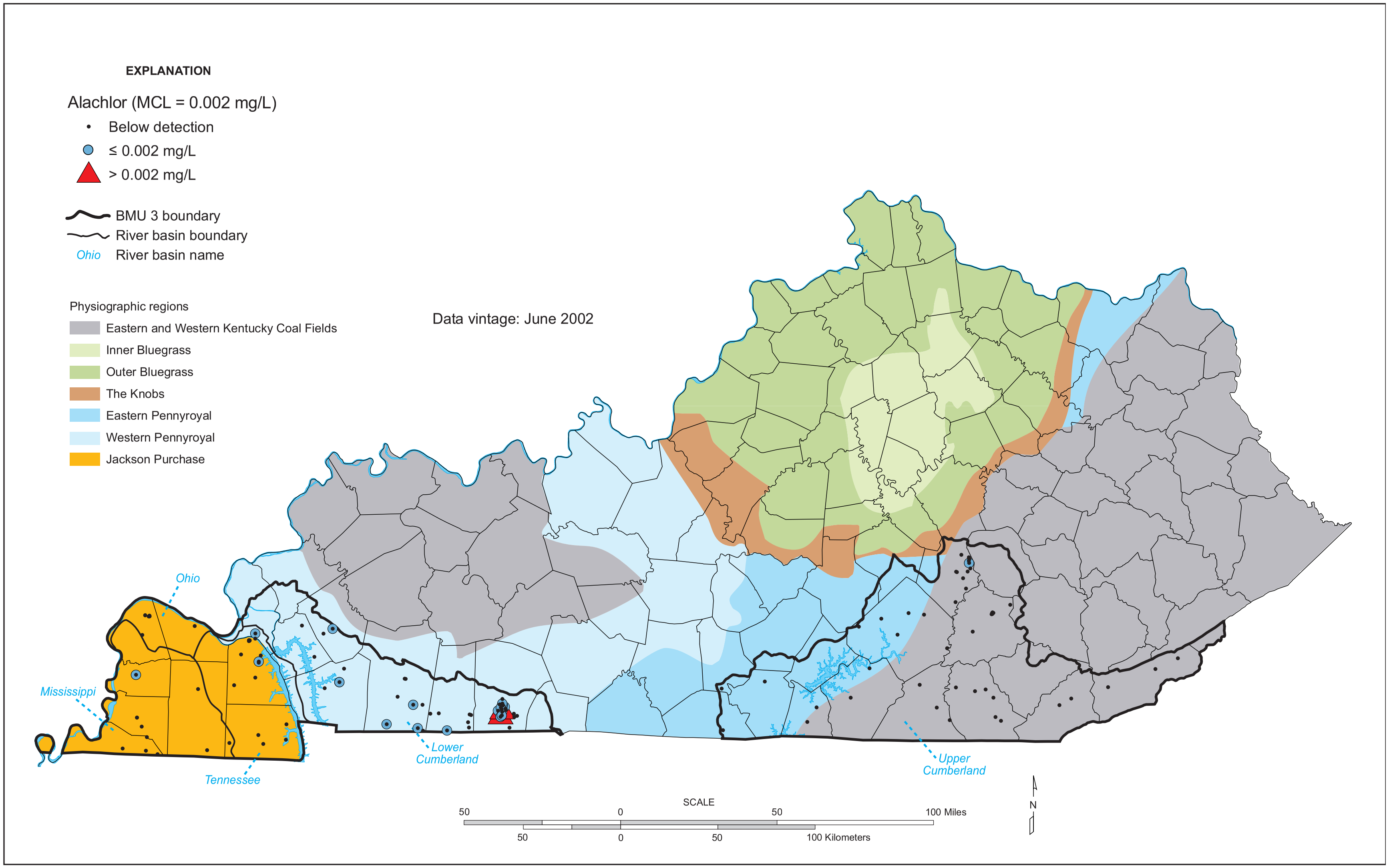

Figure 109. Locations of sites where alachlor was measured and ranges of alachlor values.

springs rather than wells (Fig. 110). An analysis of the relation between well depth and alachlor concentration was not possible because very few well samples had both detectable alachlor and a recorded well depth.

In summary, alachlor exceeded the MCL at two sites. It was detected at 20 of 107 sites, most of which were springs in karst systems. Alachlor apparently degrades before reaching most water wells, but can be transported through springs rapidly enough to persist at potentially harmful levels.

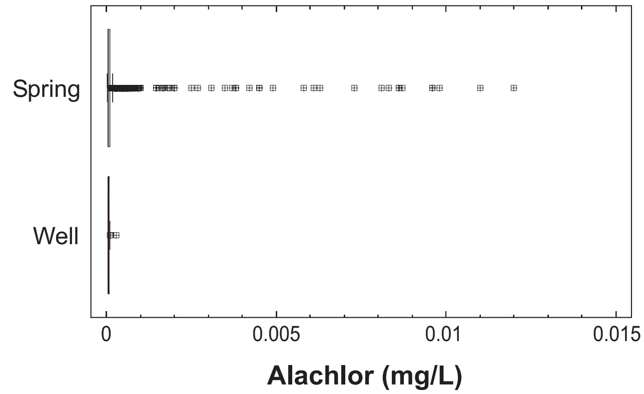

Figure 110. Comparison of alachlor values in wells and springs.

Atrazine. Atrazine belongs to the chemical class of triazines. Predominant uses are to control broadleaf and grassy weeds in corn, sorghum, and other crops and in conifer reforestation plantings. It is highly persistent in soils, moderately soluble in water, and not readily sorbed to sediments. The EPA has set an MCL of 0.003 mg/L for atrazine.

The data repository contained 638 analytical reports of atrazine from 62 sites (Table 25). In BMU 3, 400 of 638 measurements were reported as less than a detection limit. Atrazine concentrations were above analytical detection limits at 21 sites and exceeded the MCL at four sites.

Table 25. Summary of atrazine values (mg/L).

Measurements	638
Maximum	0.039
75th percentile	0.00042
Median	< 0.0003
25th percentile	0.00006
Minimum	0.00002
Interquartile range	0.0004
Sites	62
MCL	0.003
Sites > 0.003	4

< means analytical result reported as less than the stated value

Few sites in the Upper Cumberland River watershed were sampled for atrazine (Fig. 111), and none of these sites had atrazine values above the MCL. Sample site distribution is sparse in the Lower Cumberland River watershed and Jackson Purchase Region. All sites where atrazine exceeded the MCL are located in the carbonate terrain of the Western Pennyroyal Region, in the Lower Cumberland River watershed.

Groundwater from springs yields more high-atrazine measurements than does groundwater from wells, and springs are the only sites where atrazine concentrations exceed the 0.003 mg/L MCL (Fig. 112). Atrazine concentrations above analytical detection limits have been found in wells as deep as 200 ft, but no groundwater from wells had an atrazine concentration greater than the MCL (Fig. 113).

In summary, four sites in the project area produced groundwater that exceeded the MCL for atrazine; 21 of 62 sites produced groundwater with atrazine concentrations greater than the analytical detection limit. Springs are more likely than wells to have relatively high atrazine levels, and shallow wells are more likely than deep wells to have relatively high atrazine concentrations. The data suggest that atrazine in the subsurface is degraded to the low levels observed in wells. Rapid runoff from fields to springs allows high atrazine concentrations to contaminate springs, however.

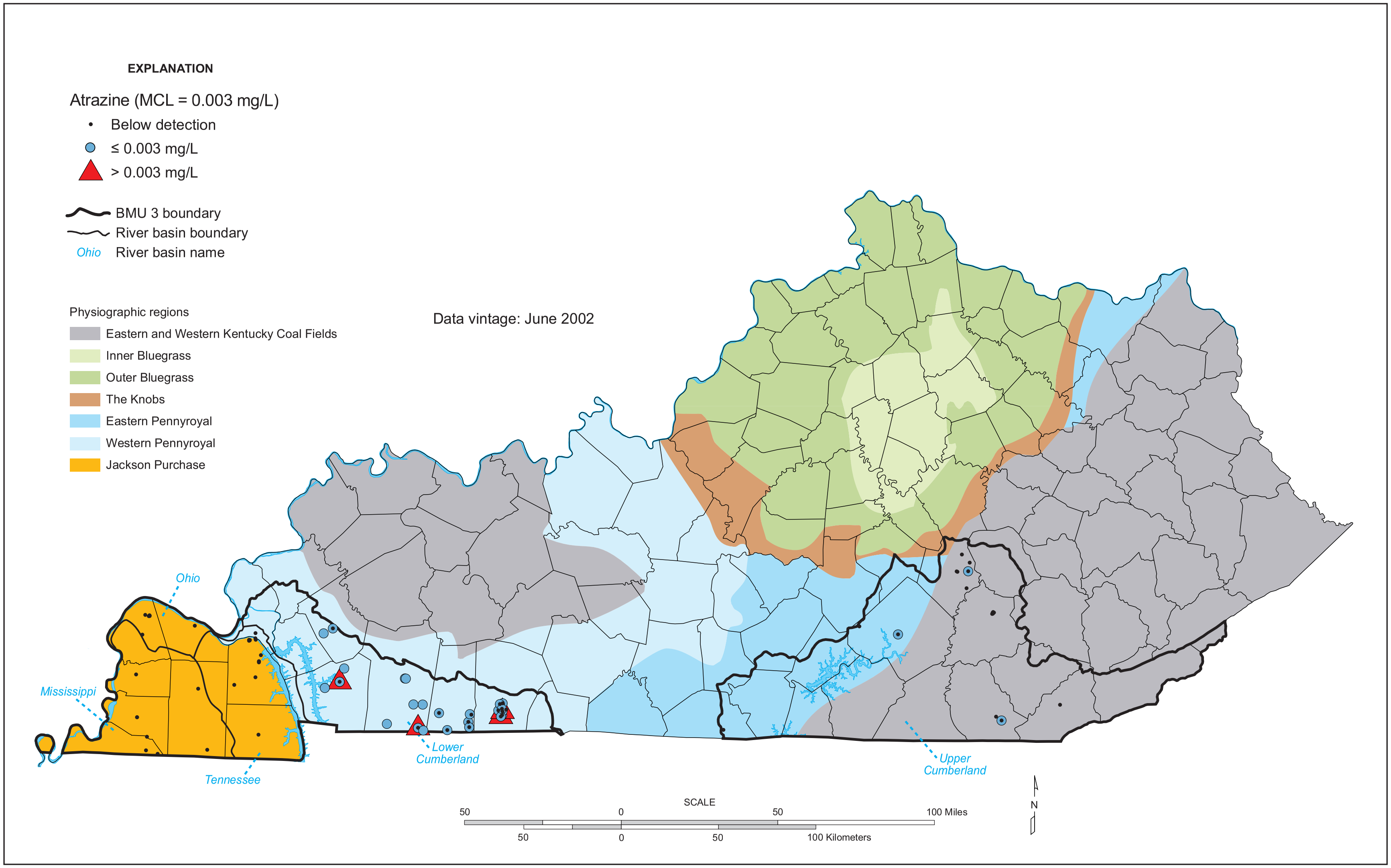

Figure 111. Locations of sites where atrazine was measured and ranges of atrazine values.

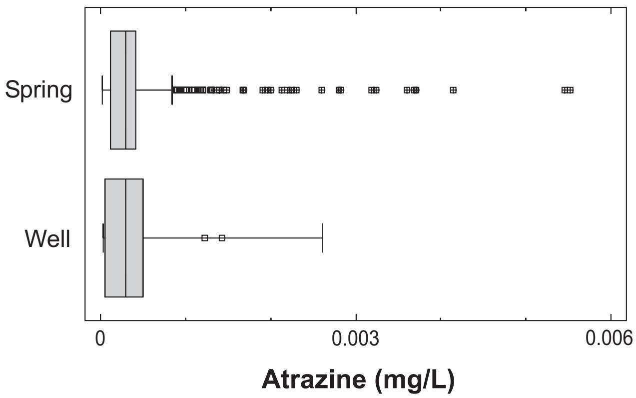

Figure 112. Comparison of atrazine values from wells and springs.

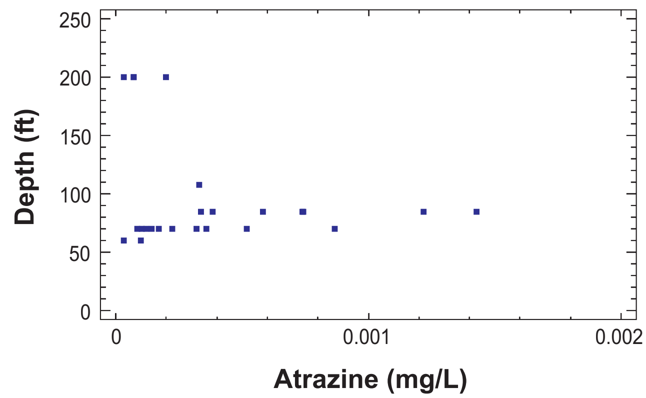

Figure 113. Atrazine concentrations versus well depth. Only results that exceeded analytical detection limits are shown.

Cyanazine. Cyanazine belongs to the chemical class of triazines. It is used mainly to control annual grasses and broadleaf weeds in corn. It has low to moderate persistence in soils and is rapidly degraded by microbial activity. Cyanazine has a half-life of 2 to 14 weeks, depending on soil type, and is stable in water. There is no MCL for cyanazine. The Division of Water has set a health advisory limit (HAL) of 0.001 mg/L.

The data repository contained 489 reports of cyanazine analyses at 97 sites (Table 26). Only four measurements at three sites exceeded analytical detection limits. Groundwater from springs in the Lower Cumberland River watershed of the Western Pennyroyal Region accounted for all the samples in which cyanazine was present at detectable concentrations (Fig. 114). One spring in the Lower Cumberland River watershed of the Western Pennyroyal Region produced groundwater with a cyanazine concentration that exceeded the HAL of 0.001 mg/L. Because of the very small number of cyanazine detections, no further analysis was performed.

Table 26. Summary of cyanazine values (mg/L).

Measurements	489
Maximum	0.00440
75th percentile	< 0.00010
Median	< 0.00005
25th percentile	< 0.00004
Minimum	< 0.00004
Interquartile range	na
Sites	97
HAL	0.001
Sites > 0.001	1

< means analytical result reported as less than the stated value

In summary, cyanazine is rarely detected in the project area. The highest concentrations were observed in springs in the Lower Cumberland River watershed of the Western Pennyroyal physiographic region.

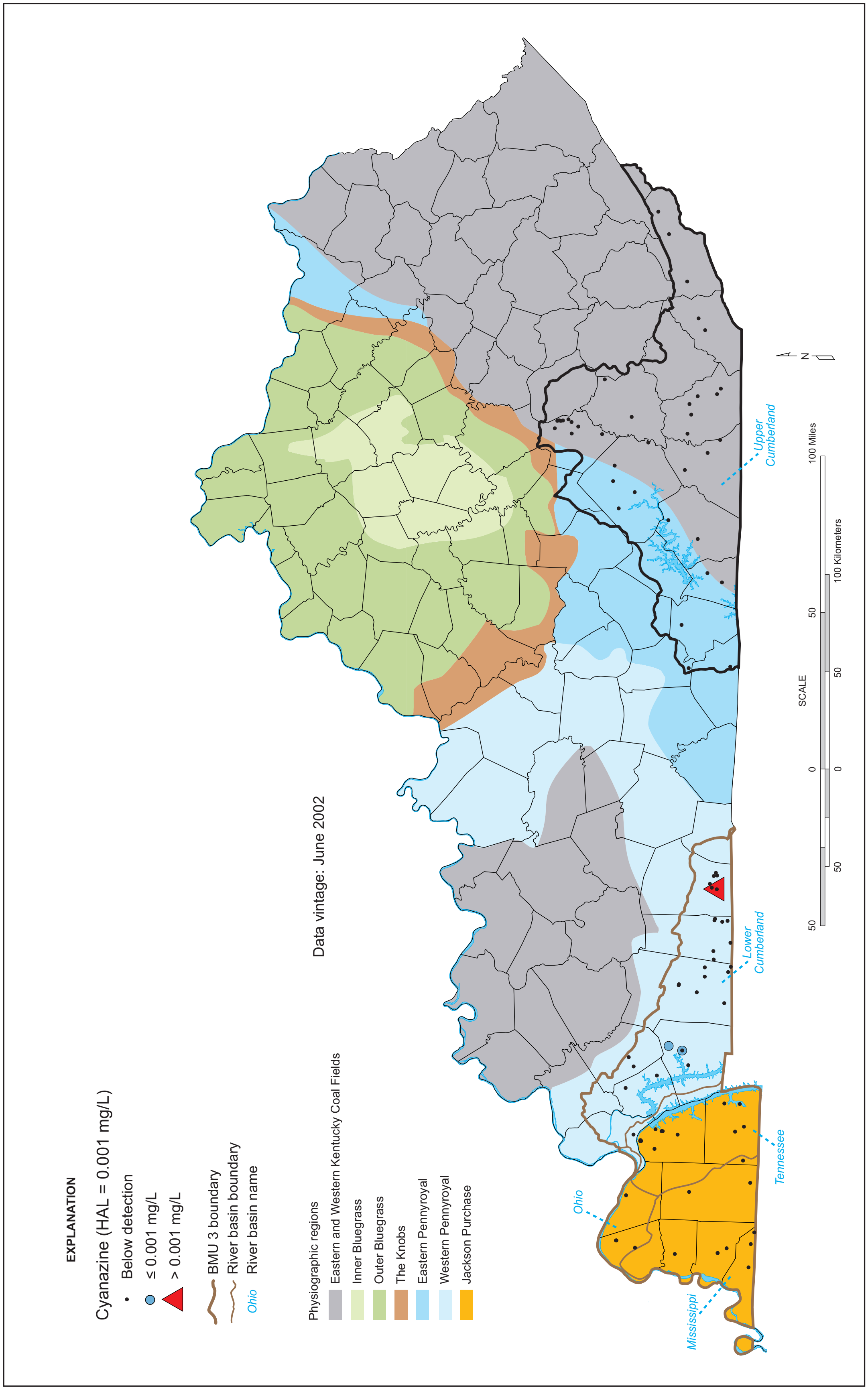

Figure 114. Locations of sites where cyanazine was measured and ranges of cyanazine values.

Metolachlor. Metolachlor belongs to the chemical class of amides. It is predominantly used to control broadleaf and grassy weeds in field corn, soybeans, peanuts, grain sorghum, potatoes, pod crops, cotton, safflower, stone fruits, and nut trees, highway rights-of-way, and woody ornamentals. It is moderately persistent in soils with a half-life of 15 to 70 days, and is highly persistent in water. There is no MCL for metolachlor; the Division of Water has set a health advisory limit of 0.1 mg/L.

The data repository contained 2,650 metolachlor measurements from 100 sites (Table 27). Most measurements were below analytical detection (1,247 of 2,650). No sites produced groundwater that exceeded the HAL for metolachlor. Thirty-one of 100 sites produced water that had metolachlor concentrations above the analytical detection limit. One of these sites is in the Upper Cumberland River watershed and one is in the Jackson Purchase Region. The remainder are in the Lower Cumberland and Tennessee River watersheds of the Western Pennyroyal Region (Fig. 115).

The highest metolachlor concentrations were observed in groundwater from springs (Fig. 116). Metolachlor has been detected in wells as deep as about 200 ft (Fig. 117).

Table 27. Summary of metolachlor values (mg/L).

Measurements	2,650
Maximum	0.0296
75th percentile	0.00039
Median	0.00011
25th percentile	< 0.00008
Minimum	0.000001
Interquartile range	na
Sites	100
HAL	0.1
Sites > 0.1	0

< means analytical result reported as less than the stated value

In summary, more than half of the groundwater samples analyzed for metolachlor had concentrations that were below detection limits. No sample was found to exceed the HAL of 0.1 mg/L. The highest metolachlor concentrations were found in springs and shallow wells. Metolachlor is apparently degraded before reaching intermediate and deep groundwater systems, but can persist long enough to be detected in shallow wells and springs.

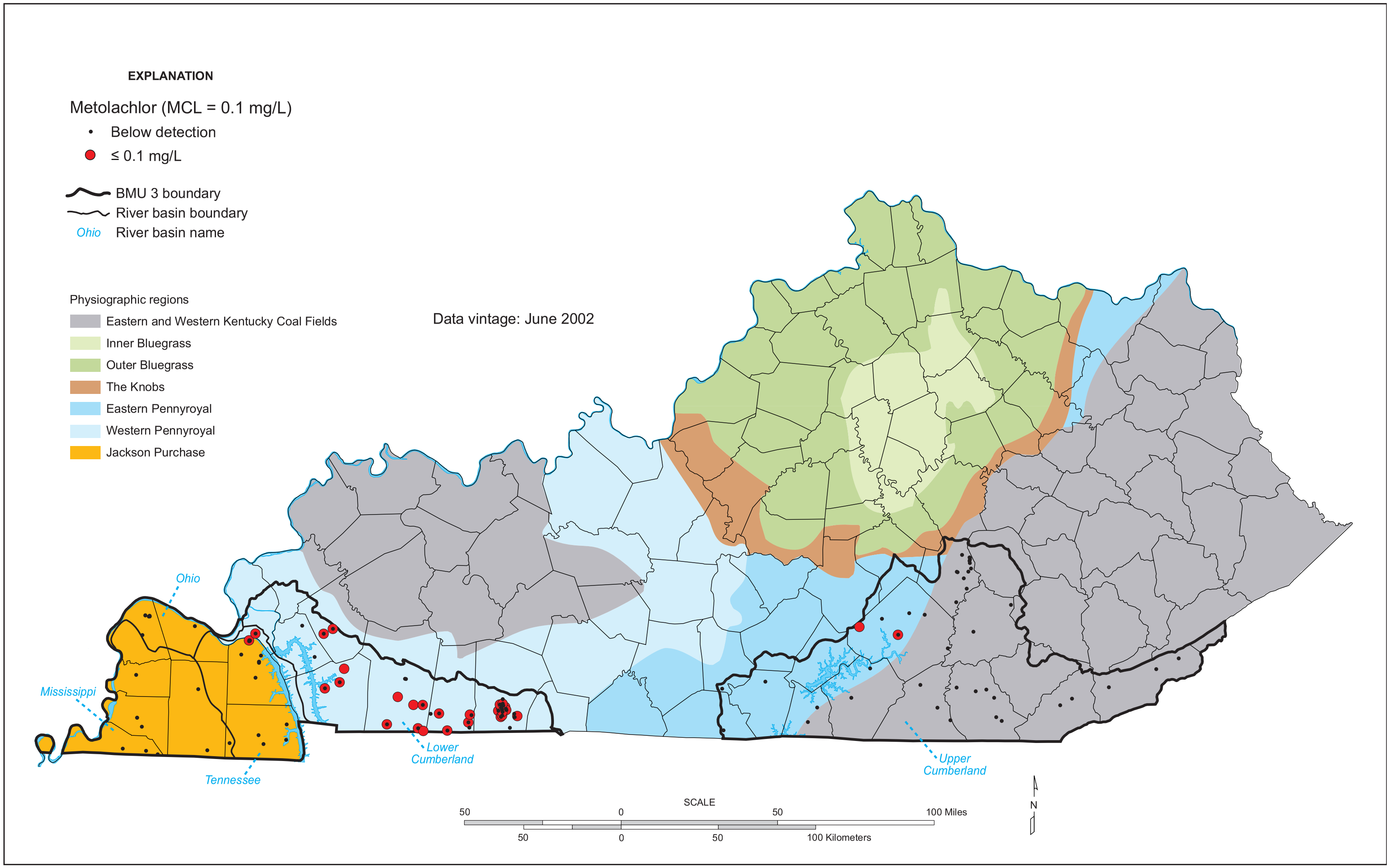

Figure 115. Locations of sites where metolachlor was measured and ranges of metolachlor values.

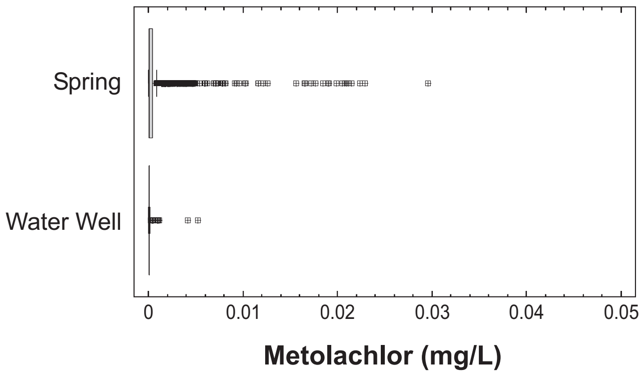

Figure 116. Comparison of metolachlor values in wells and springs.

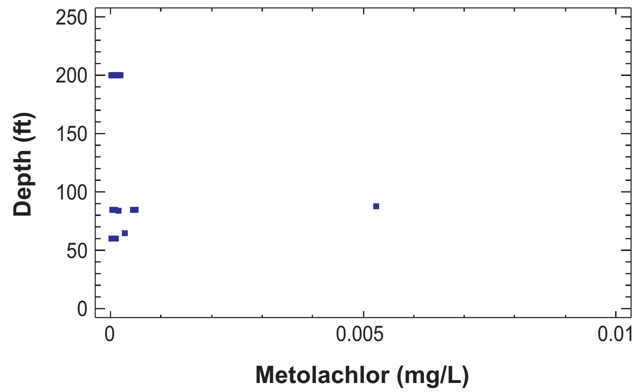

Figure 117. Metolachlor values versus well depth. Only values greater than analytical detection limits are shown.

Simazine. Simazine belongs to the chemical class of triazines. It is predominantly used to control broadleaf weeds and annual grasses in fields where berry fruits, nuts, vegetables, and ornamental crops are grown, and on turfgrass. It is moderately persistent in soils, with a half-life of about 60 days, and is moderately persistent in water, with a half-life that depends on the amount of algae present. The MCL for simazine is 0.004 mg/L.

The data repository contained 690 simazine measurements from 99 sites (Table 28). More than 95 percent of the measurements (658 of 690) were below analytical detection limits. Simazine was detected at three wells and 12 springs (Fig. 118). Simazine in groundwater exceeded the MCL at one spring in the Lower Cumberland River watershed of the Western Pennyroyal Region. Simazine concentrations did not vary with well depth. Because of the small number of simazine detections, no further analysis was performed.

Table 28. Summary of simazine values (mg/L).

Measurements	690
Maximum	0.0045
75th percentile	< 0.0003
Median	< 0.0001
25th percentile	< 0.00004
Minimum	< 0.00002
Interquartile range	na
Sites	99
MCL	0.004
Sites > 0.004	1

< means analytical result reported as less than the stated value

In summary, simazine concentrations exceeded the MCL at one site and were detected at 15 of 99 sites. Twelve of these sites are springs and three are wells. This suggests that rapid transport can carry simazine to springs more readily than to water wells.

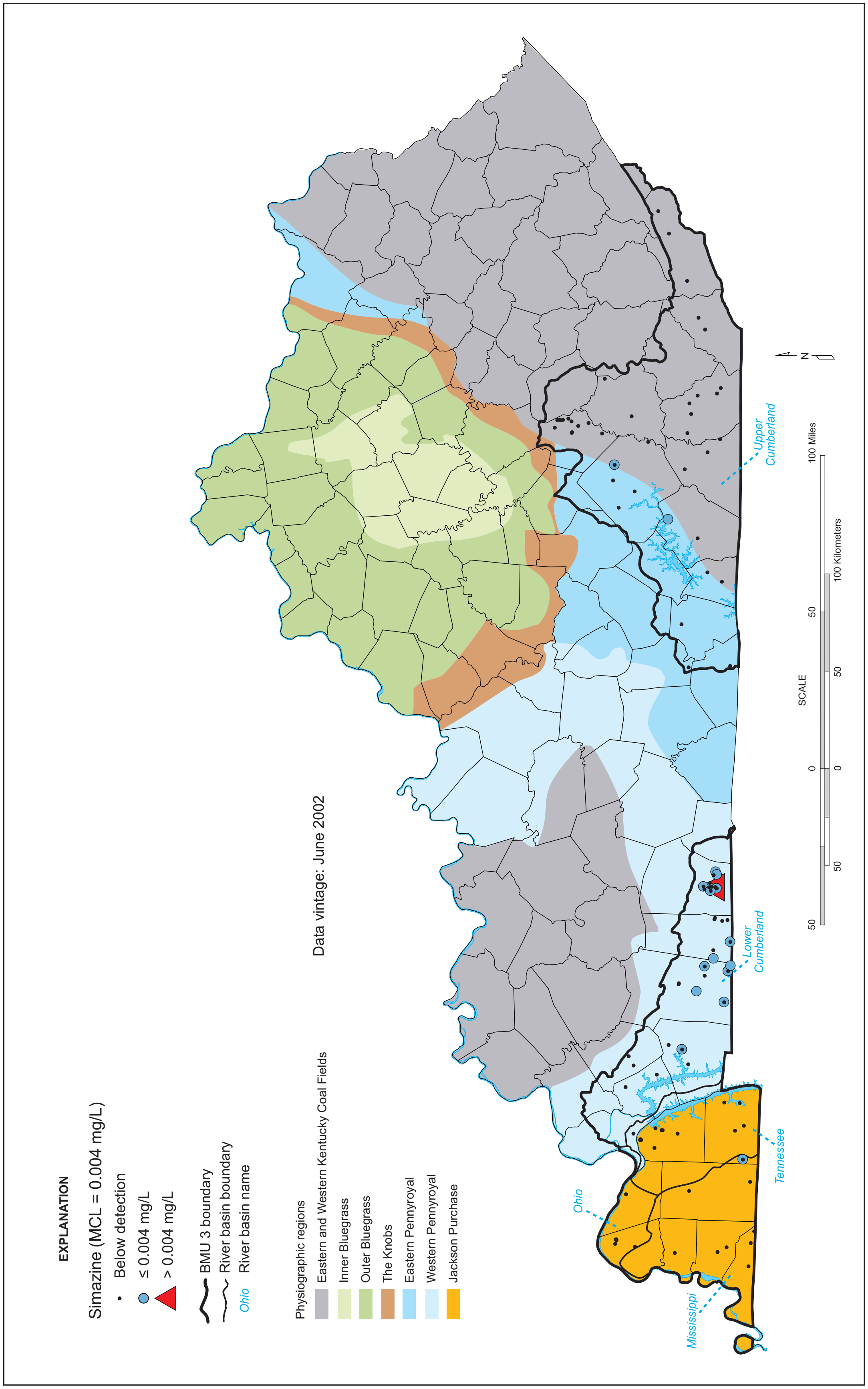

Figure 118. Locations of sites where simazine was measured and ranges of simazine values.