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 (extoxnet.orst.edu) and the Environmental Protection Agency Integrated Risk Information System (www.epa.gov/iris).

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 because the nervous system can be damaged from exposure at higher levels.

The data repository contained 1,054 2,4-D analyses from 232 sites in the project area (Table 23). No value exceeded the MCL of 0.07 mg/L. The maximum reported concentration was 0.0276 mg/L, found in a spring in the Outer Bluegrass Region of BMU 2. The second highest value was 0.0011 mg/L, and more than 99 percent of all reported concentrations were 0.001 mg/L or less. Only 21 percent of all measured 2,4-D concentrations exceeded analytical detection limits; 29 percent of all sites had detectable 2,4-D concentrations. Detectable concentrations of 2,4-D were found in 40 percent of the sampled wells and 22 percent of the sampled springs. There was no significant variation in 2,4-D concentrations with well depth.

Sample-site density was greatest in the Western Pennyroyal Region and lowest in the Knobs and Outer Bluegrass Regions (Fig. 150). Sites where 2,4-D exceeded analytical detection were predominantly in the limestone terrain of the Western Pennyroyal and Inner Bluegrass Regions.

Because of the narrow range of values and the small number of sites where concentrations exceeded analytical detection limits, no further analysis was performed.

In summary, concentrations of 2,4-D do not exceed the MCL in the project area, and are typically less than 0.001 mg/L. Detectable amounts of 2,4-D are found most commonly in wells and springs in the limestone terrain of the Western Pennyroyal and Inner Bluegrass Regions. The presence of 2,4-D at some sites in the project area indicates that some pesticides are entering the groundwater system.

Table 23. Summary of 2,4-D values (mg/L). MCL: 0.07 mg/L.

	BMU 1	BMU 2	BMU 5
Values	493	447	114
Maximum	0.0011	0.0276	< 0.0009
75th percentile	< 0.0001	< 0.0009	< 0.0001
Median	< 0.0001	< 0.0001	< 0.0001
25th percentile	< 0.0001	< 0.0001	< 0.0001
Minimum	0.00	< 0.0001	< 0.0001
Sites	67	118	47
Sites > 0.07 mg/L	0	0	0
Sites where detected	7	51	11

< means analytical result reported as less than the stated analytical detection limit

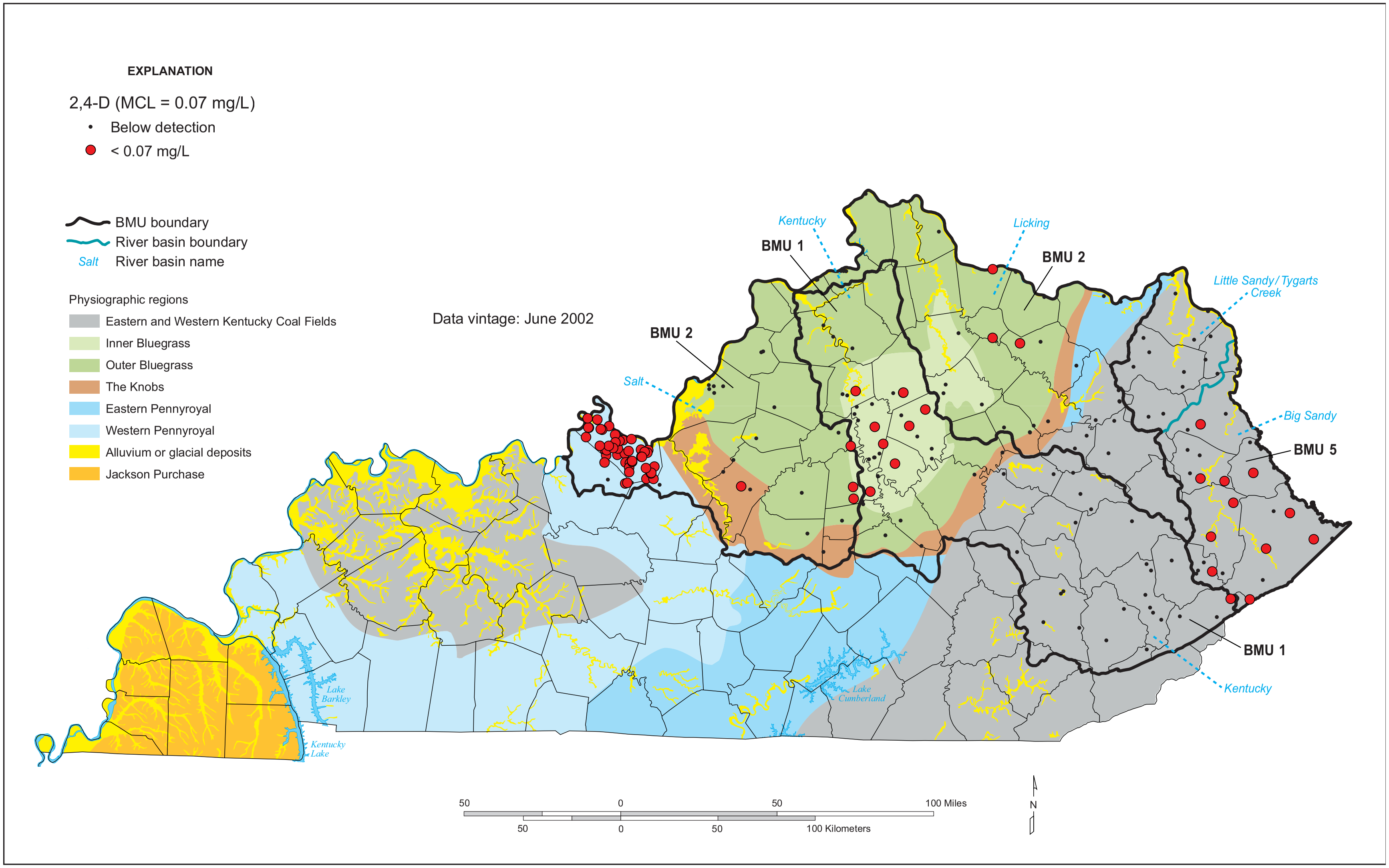

Figure 150. Locations of sampled sites and ranges of 2,4-D values. No values exceeded the MCL. Superimposed symbols indicate that values recorded at different sampling times fell into different ranges.

Alachlor. Alachlor belongs to the chemical class of analines. Predominant use is 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 found alachlor to pose a risk for skin and eye irritation on short-term exposure, and to potentially cause damage to the liver, kidney, spleen, and the lining of the nose and eyelids, and possibly cause cancer on long-term exposure. For these reasons, the EPA has set an MCL of 0.002 mg/L for alachlor.

The data repository contained 1,130 measurements of alachlor from 196 sites in the project area (Table 24). No values exceeded the MCL. Fifteen analyses exceeded detection limits; 10 sites produced water that had detectable alachlor.

Sample density was greatest in the Eastern Kentucky Coal Field and Inner Bluegrass Regions, and lowest in the Outer Bluegrass and Western Pennyroyal Regions (Fig. 151).

Of the reported concentrations that exceeded analytical detection, 12 were samples from springs and three were samples from wells. No further analysis was performed because of the small number of detected alachlor concentrations.

In summary, alachlor was detected at only 5 percent of the sampled sites, and none of the measured concentrations exceeded the EPA MCL of 0.002 mg/L. Alachlor use is probably very limited in the project area because corn, soybeans, and peanuts are not produced in this part of Kentucky. The presence of alachlor at some sites in the project area indicates that some pesticides are entering the groundwater system.

Table 24. Summary of alachlor values (mg/L). MCL: 0.002 mg/L.

	BMU 1	BMU 2	BMU 5
Values	574	420	136
Maximum	0.0004	0.000721	0.00027
75th percentile	< 0.00005	< 0.00005	< 0.00004
Median	< 0.00004	< 0.00004	< 0.00004
25th percentile	< 0.00004	< 0.00004	< 0.00004
Minimum	< 0.00002	< 0.00002	< 0.00002
Sites	70	77	49
Sites > 0.002 mg/L	0	0	0
Sites where detected	2	8	0

< means analytical result reported as less than the stated analytical detection limit

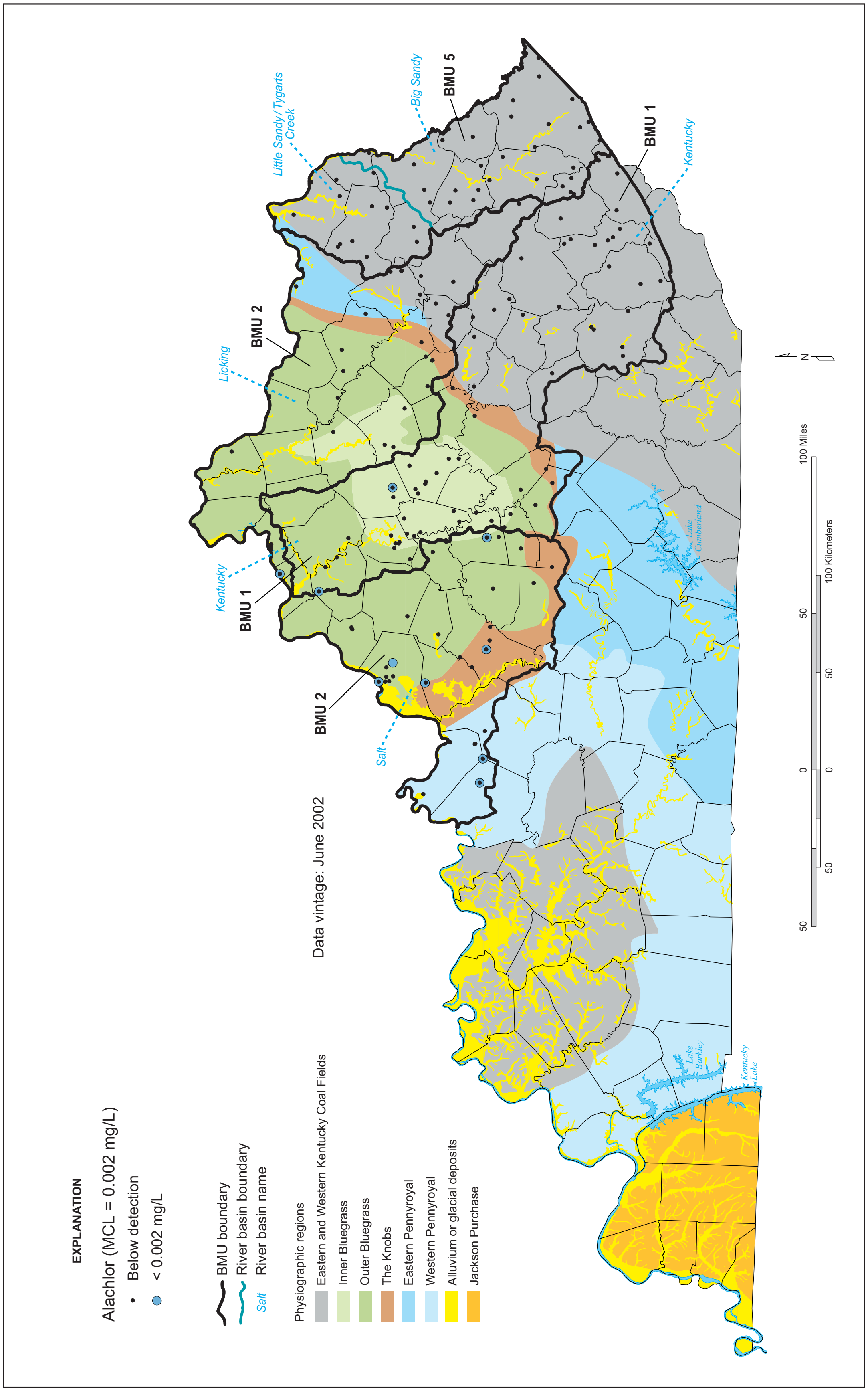

Figure 151. Locations of sampled sites and ranges of alachlor values. No values exceeded the MCL. Superimposed symbols indicate that values recorded at different sampling times fell into different ranges.

Atrazine. Atrazine belongs to the chemical class of triazines. Predominant use is 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. Atrazine can cause a variety of acute health effects from exposures at higher levels. These effects include congestion of heart, lungs, and kidneys; hypotension, antidiuresis; muscle spasms; weight loss; and adrenal degeneration. Atrazine also has the potential to cause cardiovascular damage, retinal and some muscle degeneration, and mammary tumors from a lifetime exposure at levels above the MCL.

The data repository contained 804 reports of atrazine concentrations from 137 sites in the project area (Table 25). Only 97 of the 804 measurements exceeded analytical detection limits, and only one site, a spring in the Western Pennyroyal Region of the Salt River watershed, yielded groundwater with an atrazine concentration greater than the MCL. Atrazine was detected at 33 of 137 sites in the project area.

Sample density is greatest in the Inner Bluegrass Region of the Kentucky River watershed (Fig. 152). Twenty-seven springs and five wells produced water with detectable amounts of atrazine. Because of the narrow range of values and the small number of sites where concentrations exceeded analytical detection limits, no further analysis was performed.

In summary, one site produced water that had an atrazine concentration greater than the MCL of 0.003 mg/L. Atrazine was detected at 27 springs and five wells in the project area, most of which were in the limestone terrain of the Inner and Outer Bluegrass and Western Pennyroyal Regions. Atrazine use is probably very limited in the project area because the types of crops atrazine is used on are not grown in this part of the state. The presence of atrazine in the project area indicates that some pesticides are entering the groundwater system.

Table 25. Summary of atrazine values (mg/L). MCL: 0.003 mg/L.

	BMU 1	BMU 2	BMU 5
Values	428	300	76
Maximum	0.001039	0.004753	0.00194
75th percentile	< 0.0003	< 0.0003	< 0.0003
Median	< 0.00006	< 0.00006	< 0.0003
25th percentile	< 0.00005	< 0.00005	< 0.00005
Minimum	0.000005	0.000018	< 0.00004
Sites	60	63	14
Sites > 0.003 mg/L	0	1	0
Sites where detected	12	18	3

< means analytical result reported as less than the stated analytical detection limit

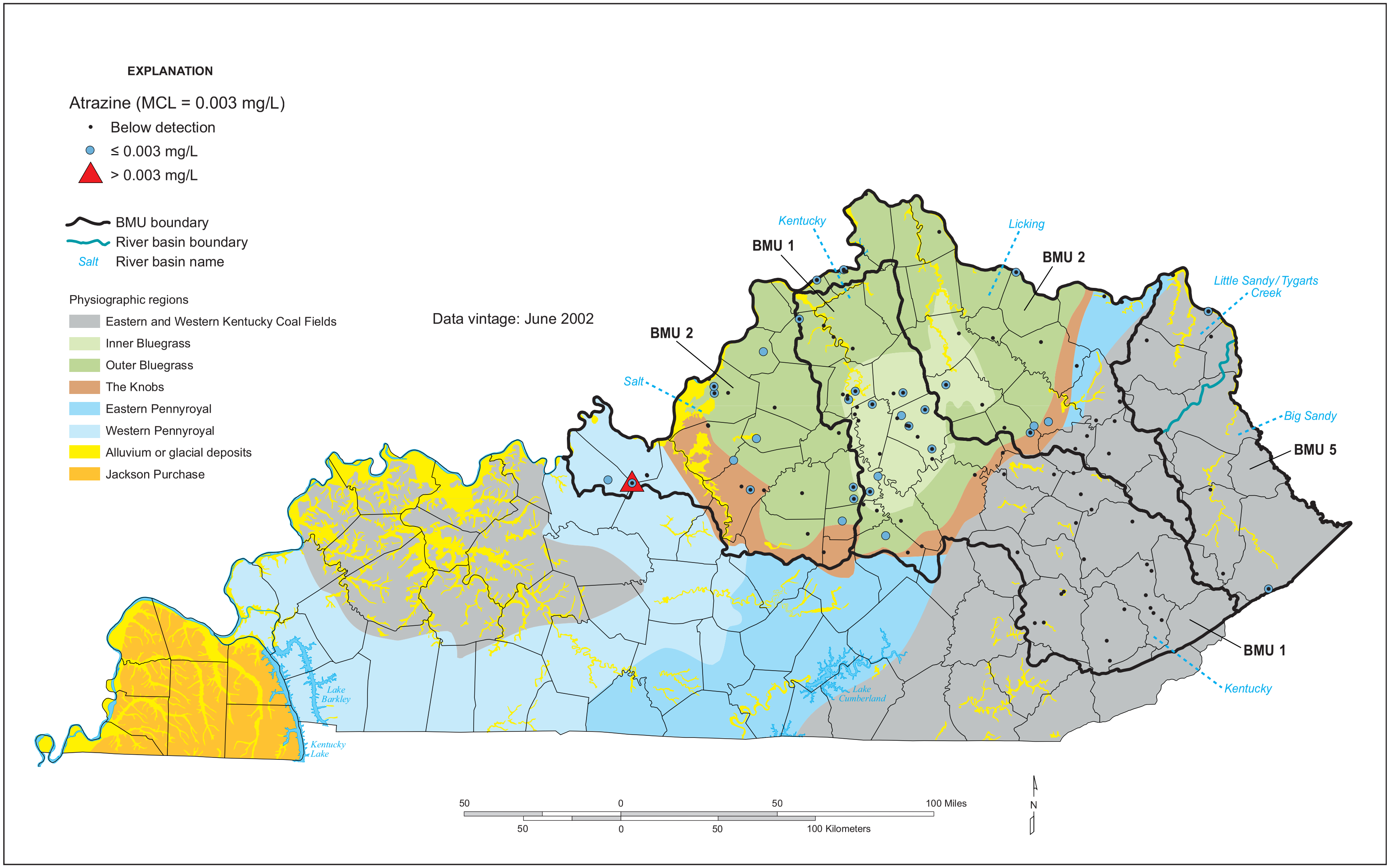

Figure 152. Locations of sampled sites and ranges of atrazine values. Superimposed symbols indicate that values recorded at different sampling times fell into different ranges.

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 EPA MCL for cyanazine; however, DOW has set a health advisory limit (HAL) of 0.001 mg/L.

The data repository contained 776 results of cyanazine analyses from 170 sites in the project area (Table 26). Only one value exceeded analytical detection limits; this site also exceeded the HAL. Because only one cyanazine concentration was greater than analytical detection, no further analyses were performed.

As with the other pesticides, sample-site density was greatest in the Eastern Kentucky Coal Field and Inner Bluegrass Regions, and lowest in the Outer Bluegrass and Western Pennyroyal Regions (Fig. 153).

In summary, only one of 170 sites in the project area produced water that had detectable cyanazine. Cyanazine use is probably very limited in the project area because the types of crops cyanazine is used on are not grown in this part of the state. The presence of cyanazine in the project area indicates that some pesticides are entering the groundwater system.

Table 26. Summary of cyanazine values (mg/L). HAL: 0.001 mg/L.

	BMU 1	BMU 2	BMU 5
Values	492	374	128
Maximum	< 0.001	< 0.001	0.00126
75th percentile	< 0.00005	< 0.00005	< 0.00005
Median	< 0.00005	< 0.00004	< 0.00004
25th percentile	< 0.00004	< 0.00004	< 0.00004
Minimum	< 0.00004	< 0.00004	< 0.00004
Sites	68	74	47
Sites > 0.001 mg/L	0	0	1
Sites where detected	0	0	1

< means analytical result reported as less than the stated analytical detection limit

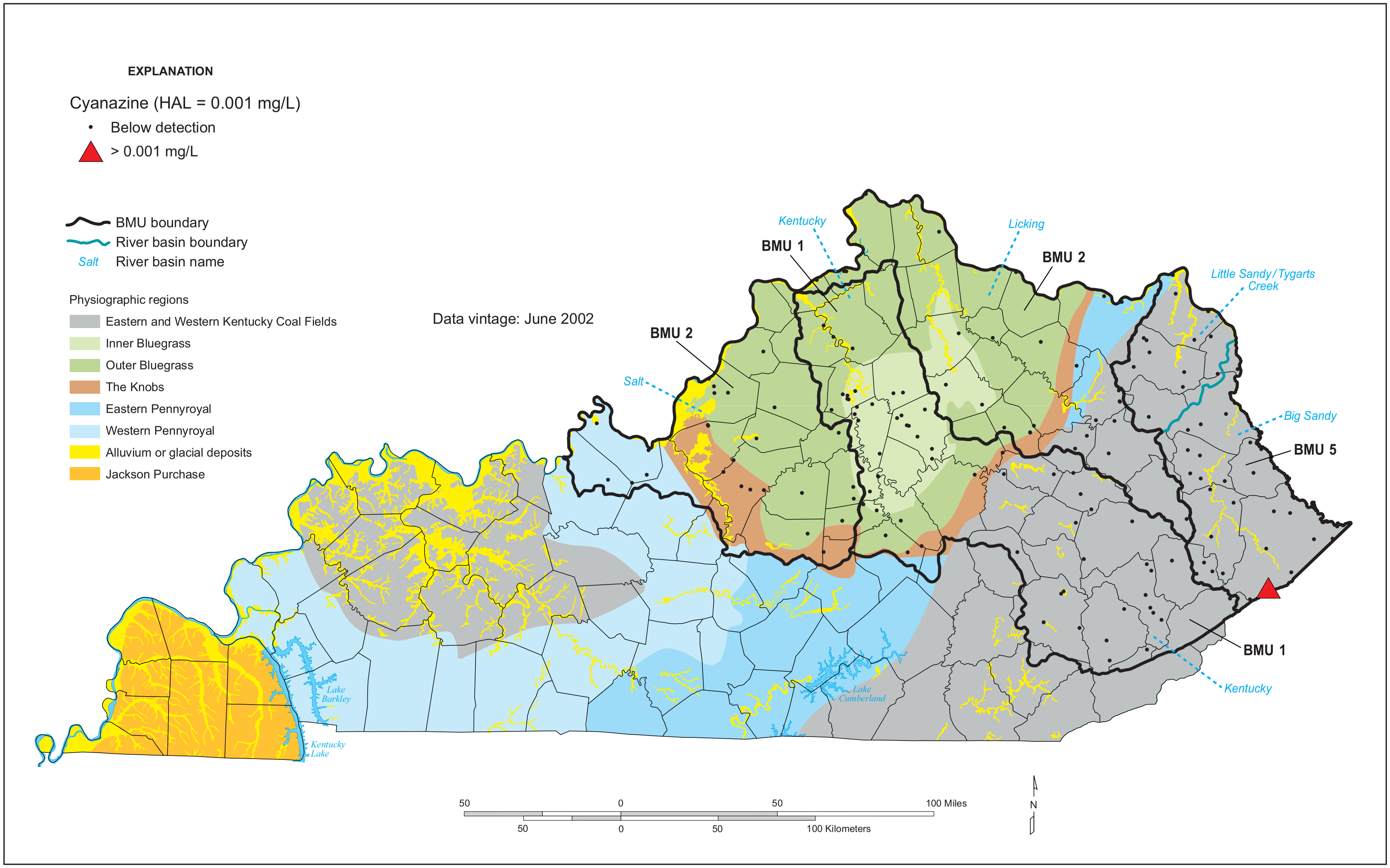

Figure 153. Locations of sampled sites and ranges of cyanazine values. Superimposed symbols indicate that values recorded at different sampling times fell into different ranges.

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, 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; DOW has set a health advisory limit of 0.1 mg/L.

The data repository contained 1,125 metolachlor concentrations from 192 sites in the project area (Table 27). No values exceeded the HAL; 64 measurements from 15 springs and two wells exceeded analytical detection limits.

Sample-site distribution is most dense in the Eastern Kentucky Coal Field and Inner Bluegrass Regions (Fig. 154). Because of the very small number of sites where metolachlor exceeded analytical detection limits, no further analysis was performed.

In summary, metolachlor is probably not used much in the project area. It is rarely detected in groundwater, and is more common in springs than in wells. The presence of metolachlor in the project area indicates that some pesticides are entering the groundwater system.

Table 27. Summary of metolachlor values (mg/L). HAL: 0.1 mg/L.

	BMU 1	**BMU 2**	**BMU 5**
Values	572	418	135
Maximum	< 0.004	0.000908	< 0.0002
75th percentile	< 0.00005	< 0.00005	< 0.00005
Median	< 0.00005	< 0.00004	< 0.00004
25th percentile	< 0.00004	< 0.00004	< 0.00004
Minimum	0.000004	0.000008	0.000022
Sites	69	75	48
Sites > 0.1 mg/L	0	0	0
Sites where detected	7	9	1

< means analytical result reported as less than the stated analytical detection limit

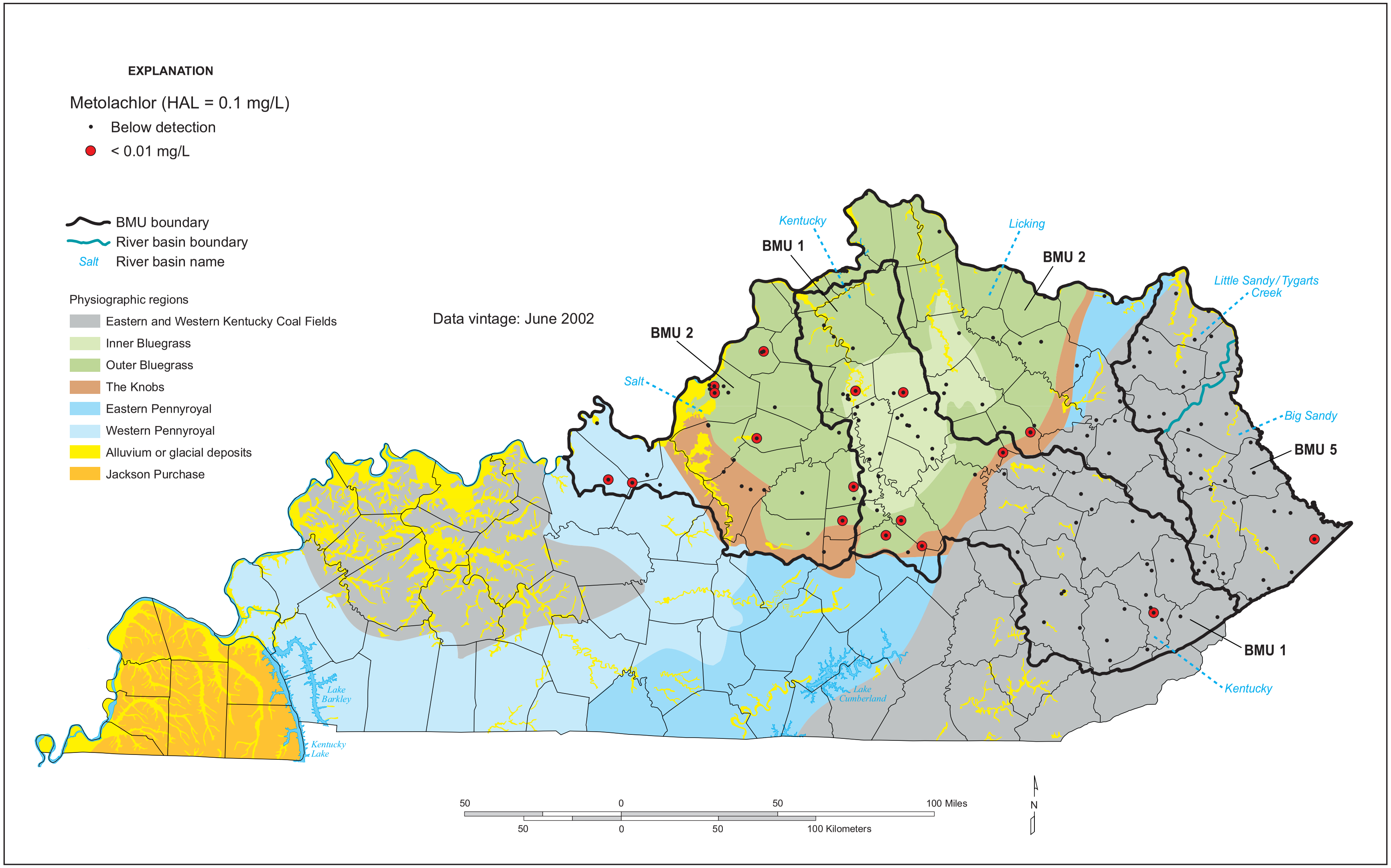

Figure 154. Locations of sampled sites and ranges of metolachlor values. No values exceeded the HAL. Superimposed symbols indicate that values recorded at different sampling times fell into different ranges.

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 EPA MCL for simazine is 0.004 mg/L. At levels above 0.004 mg/L, long-term exposure to simazine can cause tremors; damage to testes, kidneys, liver, and thyroid; and gene mutations. There is some evidence that simazine may have the potential to cause cancer from a lifetime exposure at levels above the MCL.

The data repository contained 1,193 simazine measurements from 191 sites in the project area (Table 28). No measurement exceeded the MCL of 0.004 mg/L. Groundwater from 15 springs and one well had simazine concentrations that exceeded analytical detection limits.

Sample-site distribution is most dense in the Eastern Kentucky Coal Field and Inner Bluegrass Regions (Fig. 155). Because of the very small number of sites where simazine exceeded analytical detection limits, no further analysis was performed.

In summary, simazine is probably not used much in the project area. It is rarely detected in groundwater. When found, it is more common in springs than in wells. The presence of simazine in the project area indicates that some pesticides are entering the groundwater system.

Table 28. Summary of simazine values (mg/L). MCL: 0.004 mg/L.

	BMU 1	BMU 2	BMU 5
Values	602	440	151
Maximum	0.000119	0.002528	0.000689
75th percentile	< 0.0003	< 0.0003	< 0.0003
Median	< 0.00005	< 0.00004	< 0.00004
25th percentile	< 0.00004	< 0.00004	< 0.00004
Minimum	0.00001	0.000017	0.00003
Sites	69	74	48
Sites > 0.004 mg/L	0	0	0
Sites where detected	7	7	2

< means analytical result reported as less than the stated analytical detection limit

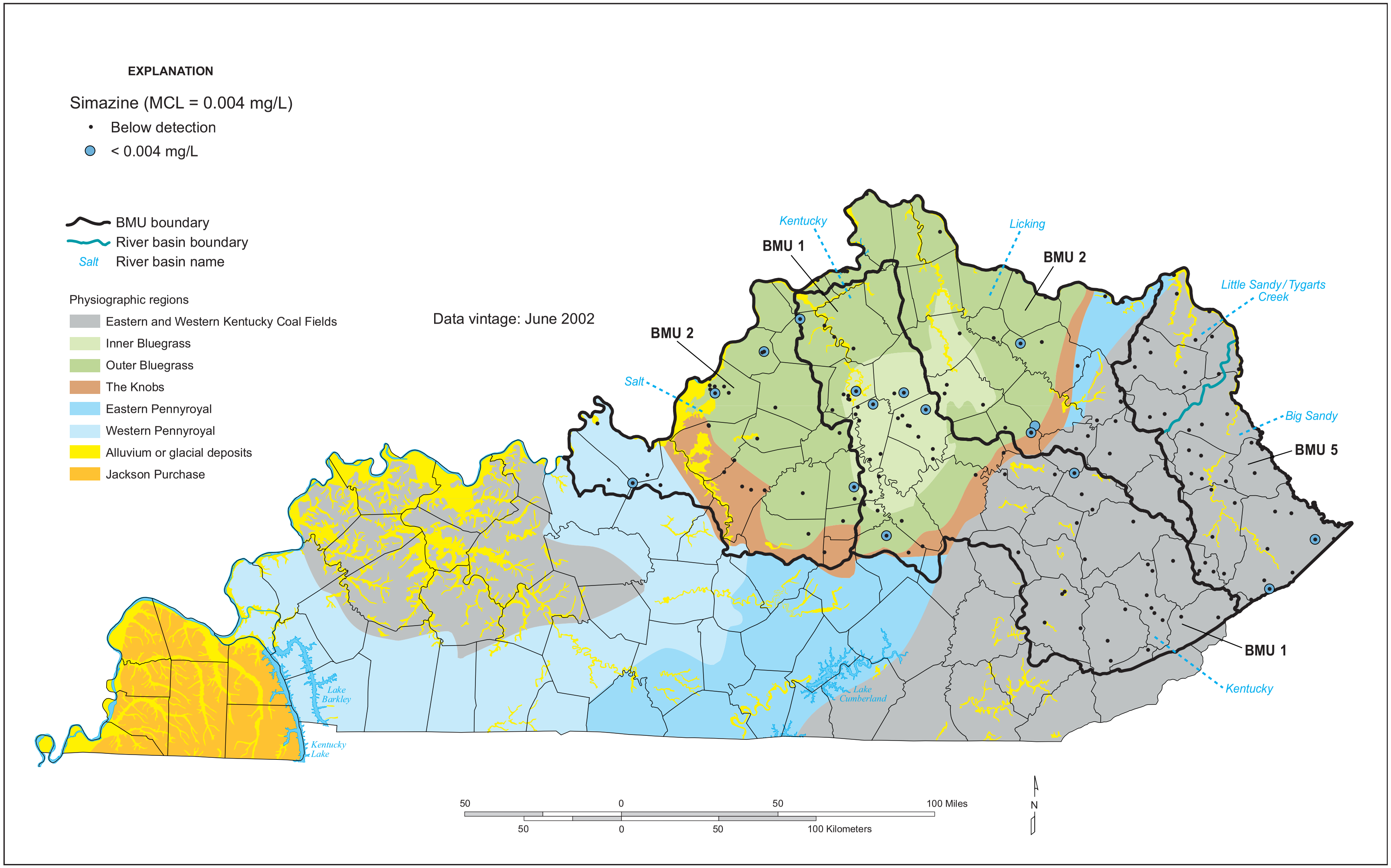

Figure 155. Locations of sampled sites and ranges of simazine values. No values exceeded the MCL. Superimposed symbols indicate that values recorded at different sampling times fell into different ranges.