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Assessment of Groundwater Quality in a Remediated Abandoned Feedlot, Henderson County, Kentucky: Data Report

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Assessment of Groundwater Quality in a Remediated Abandoned Dairy Feedlot, Henderson County, Kentucky: Data Report

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Abstract

A three-phase project investigated the influence of past and present agricultural practices on groundwater resources in the Western Kentucky Coal Field. Phase III concentrated on an abandoned dairy feedlot that had been remediated. Results of phase III analyses are presented in this report.

Introduction

This report covers the third and final phase of an investigation of the influence of past and present agricultural practices on groundwater resources in the Western Kentucky Coal Field. Phase I (Beck and others, 2010a) of this project concentrated on water and soil quality associated with present agricultural practices (row crop, pasture, etc.) on a farm in Henderson County, Ky. Phase II (Beck and others, 2010b) focused on groundwater and soil quality in monitoring wells and soil cores associated with a long-abandoned dairy feedlot. This phase III report summarizes data collected at the abandoned feedlot, including groundwater- and soil-quality data, groundwater elevations, rain data, gamma-ray logs of monitoring wells, slug-test data, and X-ray fluorescence data. The abandoned dairy feedlot is on a farm in an upland bedrock setting in the Western Kentucky Coal Field. Funding for this research was provided in part by the University of Kentucky's College of Agriculture through the Senate Bill 271 Research and Education Program. Previous reports generated by this research describing water- and soil-quality monitoring were submitted to the UK College of Agriculture. This report covers work completed between January 1, 2002, and October 31, 2008.

Study Site

The abandoned feedlot is on a 540-acre farm (referred to as the Keach farm) in north-central Henderson County approximately 5 mi west of downtown Henderson (Fig. 1) in the Wilson 7.5-minute quadrangle (Johnson, 1973). The Keach farm is located in an upland bedrock setting with moderately thick loess (17 to 35 ft) of Pleistocene age overlying bedrock (shale and channel-fill sandstone) of Pennsylvanian age. Upland bedrock settings in the Western Kentucky Coal Field are characterized by broad ridges with shallow wide valleys. The two dominant loess-derived soil series are Memphis and Loring. Memphis soils are well drained, whereas Loring soils are well to moderately drained and typically have a fragipan (layer of semiconsolidated soil particles that retard water infiltration) between 26 and 42 in. below land surface (Converse and Cox, 1967).

Abandoned Feedlot Remediation

In November 2001, the abandoned dairy feedlot (Fig. 2) was remediated by removing 518 yd³ of organic-rich soil from the area (Fig. 3). The organic-rich soil was removed to a depth of 1 to 3 ft below land surface (Fig. 4), transported to a nearby pasture, and spread to a thickness of less than 1 in. (Fig. 5). The excavated feedlot

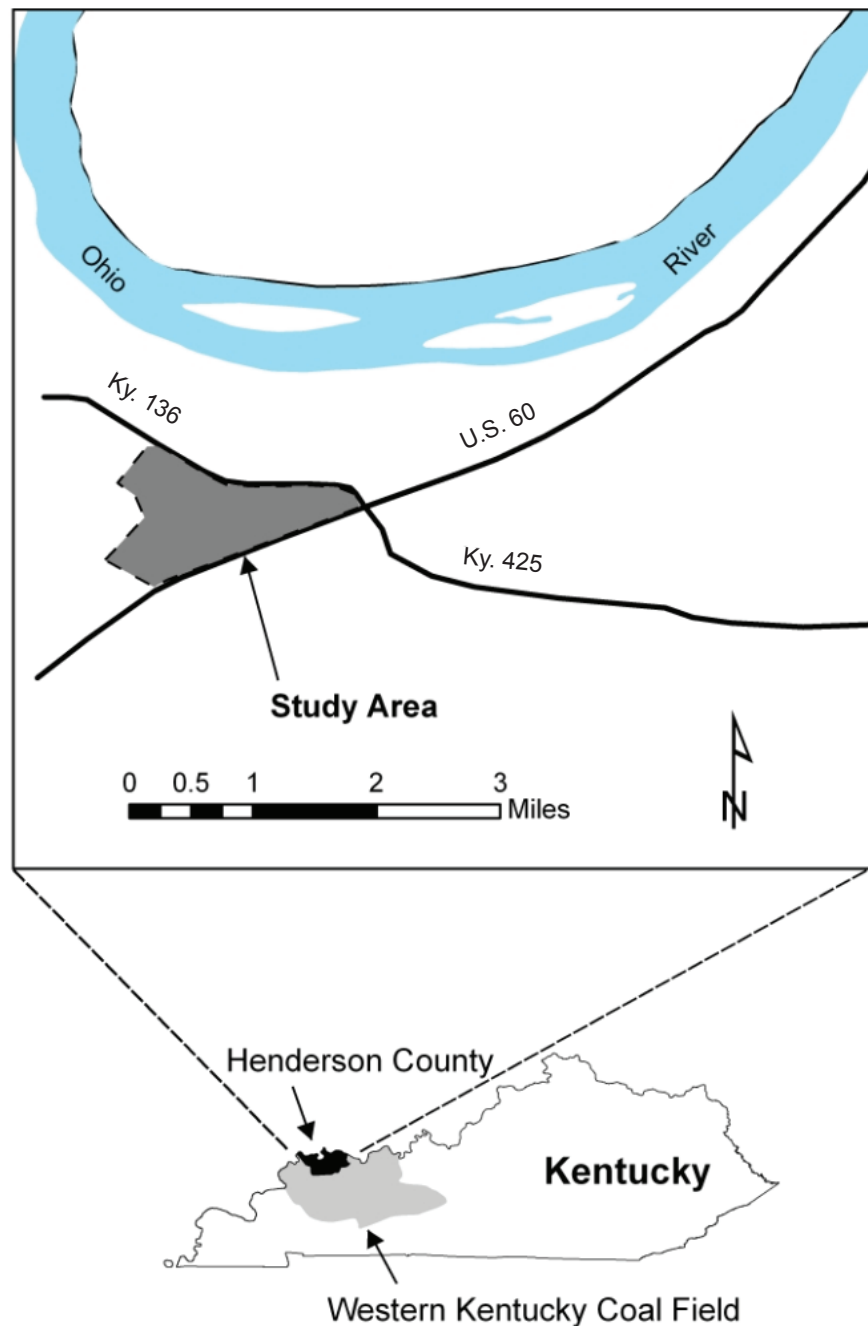


Figure 1. Location of the study site in Henderson County, Kentucky.

was filled with native soil and then leveled to original grade (Fig. 6).

Soil Core Descriptions

Soil cores were collected from the excavated feedlot after remediation to determine changes in soil quality over time. Five rounds of 12 soil cores were collected (60 total cores) from the excavated area (Fig. 3). Collection dates are listed in Table 1. All cores were collected to a depth of 8 ft below land surface. Cores were

identified with E (excavated), R1 through 5 (round 1-5), and core number (1-12). Coordinates, elevations, and measured depth for each core are presented in Table 2. Coordinates are in decimal degrees and based on the 1983 North American datum (NAD 83). Elevations are recorded as feet above sea level.

Soil Core Data

At the time of collection, soil cores were typically subdivided into 1-ft increments and placed in brown

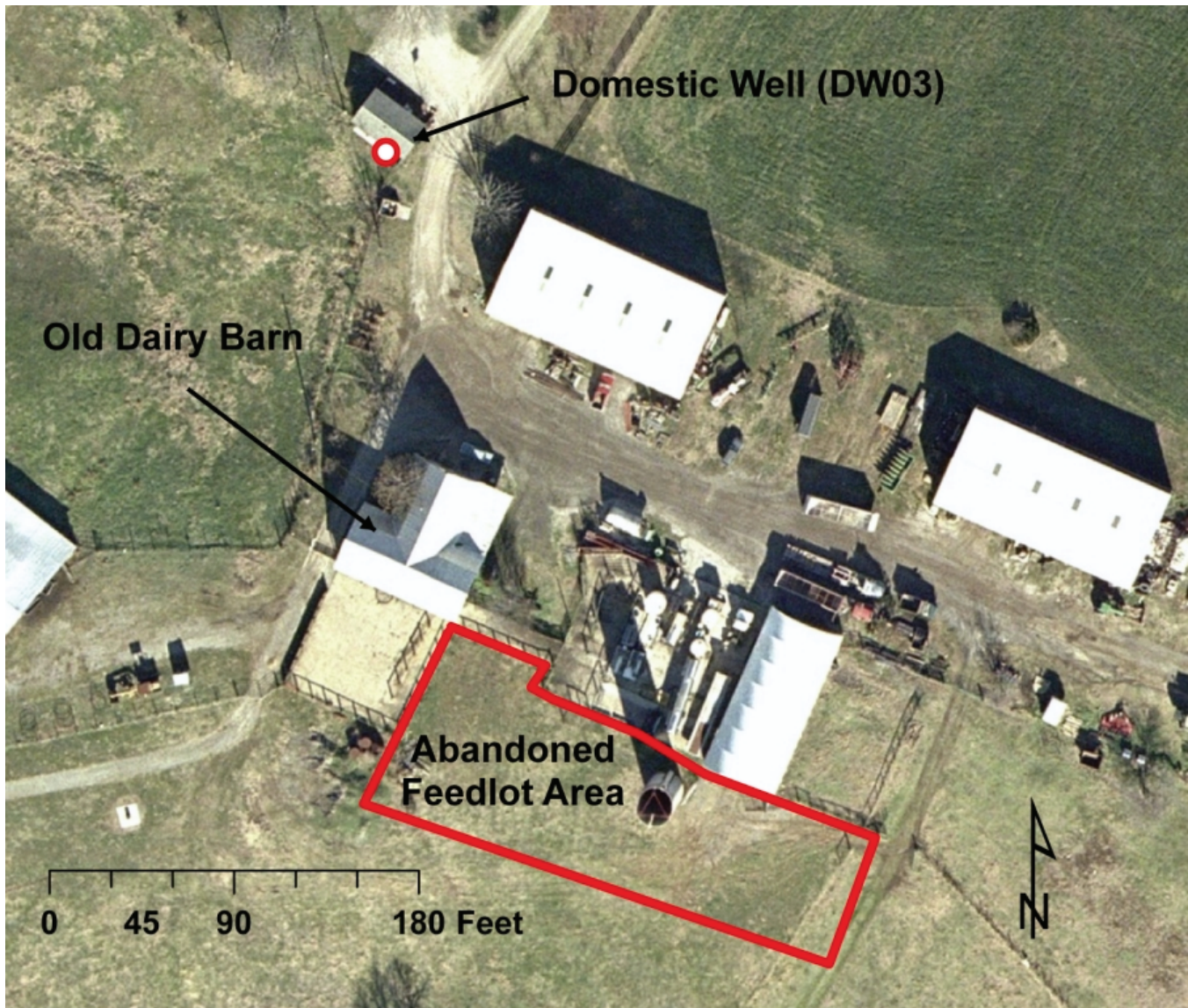


Figure 2. Approximate location of the abandoned dairy feedlot before excavation. A map of the entire Keach farm is presented in Beck and others (2010b).

paper bags to be transported to a freezer, where the samples remained until they were analyzed. Inorganic nitrogen (ammonium and nitrate) was analyzed in the University of Kentucky Department of Plant and Soil Sciences' Chemical and Physical Edaphology Laboratory. All other soil properties (pH, bioavailable phosphorus, potassium, calcium, magnesium, manganese, zinc, organic matter, and total nitrogen) were analyzed in the University of Kentucky Regulatory Services Laboratory. All analyses were performed in accordance with methods widely accepted in the literature. Table 3 presents the laboratory analyses performed and methods used.

When possible, chemical analysis was conducted for 1-ft intervals of core. Missing intervals indicate

that samples were not collected because of inadequate sample volume or because of cross-contamination during the coring process. Appendices A through E contain chemical data related to rounds 1 through 5, respectively (all appendices are available for download at kgs.uky.edu/kgsweb/olops/pub/kgs/water/IC20_12). Organic matter is calculated as percent carbon multiplied by 1.72, which gives the percentage of organic matter of the soil sample. Analyses are presented as lb/acre, parts per 2 million, and parts per million.

Well Descriptions

Data presented in this report were collected from eight monitoring wells installed in and around the aban-



Figure 3. Area of the abandoned feedlot that was remediated and locations of the post-remediation soil cores (white circles).

doned dairy feedlot and one domestic well (DW03) (Fig. 7). Construction and location details for wells DW03 and DW05 are presented in Beck and others (2010a), and for the remaining seven wells (DW06–DW12) in Beck and others (2010b).

Groundwater-Quality Data

Groundwater-quality data were collected from seven water wells between January 2002 and October 2008. Data for wells DW03 and DW05 were collected between June 2002 and October 2008. Data for wells DW03 and DW05 were collected between January 2002 and May 2002 and are presented in Beck and others (2010a). Field measurements collected during sampling were pH, specific conductance, temperature, dissolved oxygen, and oxidation-reduction potential; sampling and

collecting were in accordance with U.S. Geological Survey guidelines (U.S. Geological Survey, 1980). All wells, except for well DW03, were purged and sampled using a 2-in.-diameter submersible Grundfos Redi-Flo pump.¹ The pump and tubing were rinsed thoroughly with distilled water between purging and sampling. Well DW03 was purged using the existing submersible pump.

Field measurements (specific conductance, pH, temperature, and dissolved oxygen) were recorded using a Horiba U-10 water-quality monitoring system with a flow-through chamber. Oxidation-reduction potential was recorded using an Orion ORP electrode and field meter. Measurements were recorded after each well was purged and field measurements had stabilized. All instruments were calibrated daily during sampling using procedures prescribed by the manufacturers.

¹The use of trade or product names is for descriptive purposes only and does not imply endorsement by the Kentucky Geological Survey.



Figure 4. (A) The abandoned feedlot before excavation began, looking northeast. (B-C) During excavation, both looking west. (B) shows the area where the soil was excavated to 1 ft below land surface. The foreground area in (C) was excavated to 3 ft below land surface.

All laboratory analyses were performed in accordance with either U.S. Environmental Protection Agency methods or methods widely accepted in the literature. Sample splits were prepared in the field and transported to the laboratory in sterilized bottles. For dissolved-constituent analysis, filtration was performed in the field using high-capacity in-line filters (0.45- μm pore size). If sample preservation was required by analysis protocol, the samples were preserved at the time of col-

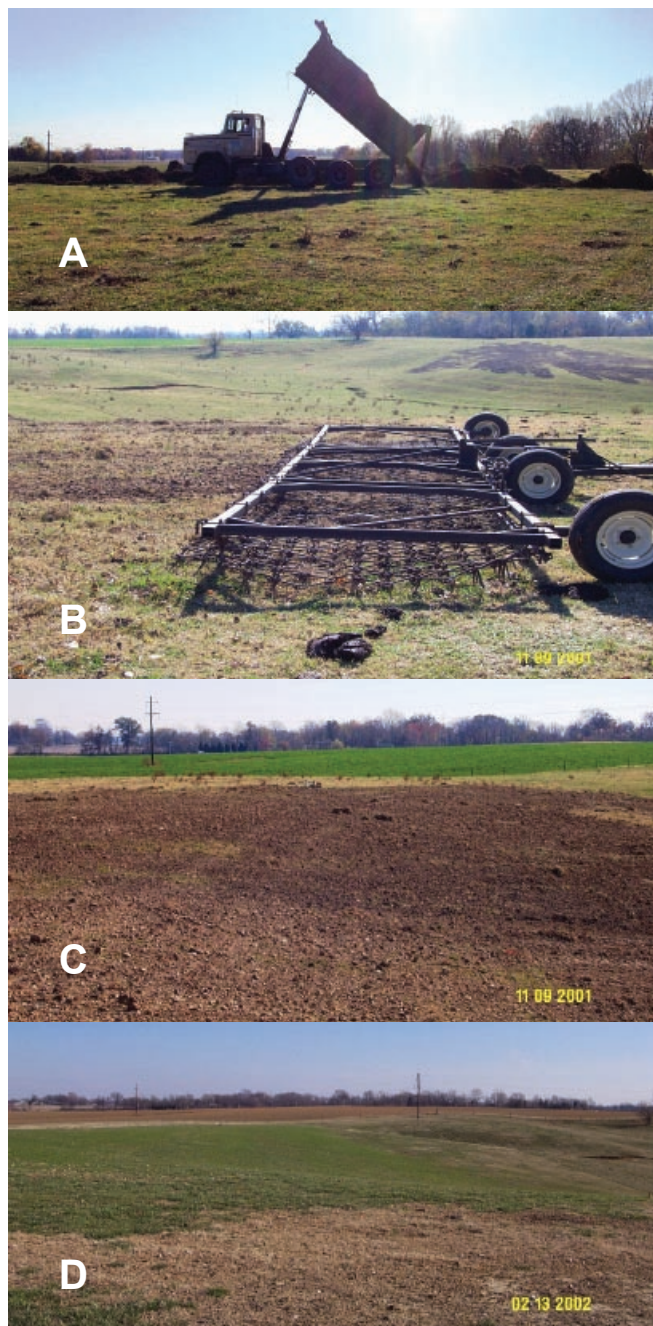


Figure 5. Pasture where the excavated organic-rich soil was spread. (A) After being dumped (looking southwest), (B) the organic-rich soil was thinly spread with a bulldozer and then raked (looking south) before being planted with grass. (C) Looking east, just before grass was planted. (D) Looking east, 3 months after grass was planted.

lection, and kept at a temperature of 4°C until delivered to the appropriate laboratory.

Water analyses were performed in four laboratories: Kentucky Geological Survey, Kentucky Division of Environmental Services, University of Waterloo En-



Figure 6. (A) The excavated feedlot being filled with native soil, looking north. (B) Soil being spread back to original grade (looking southwest). (C) After remediation was completed, looking northeast.

Core Round	Date Collected
1	9/10/02
2	6/9/03
3	6/2/04
4	5/31/05
5	6/13/06

Environmental Isotope Laboratory (Ontario, Canada), and KGS Western Kentucky office. Table 4 lists the analyses performed, methods used, and required sample preservation for KGS, Division of Environmental Services, and University of Waterloo laboratories. Table 5 lists the analyses performed, methods used, and required sample preservation for the Western Kentucky office laboratory. Because funding and goals changed during the project, the list of analytes changed also. Therefore, not all analytes listed in Tables 4 and 5 will appear throughout the water-quality data tables.

Groundwater Data Format

Data presented here are from wells DW03, DW05, and DW06 through DW12. All data tables are formatted similarly. The “<” symbol indicates a concentration below the indicated method detection limit. Data were checked for accuracy, and suspect laboratory results were analyzed again to verify reported values.

Appendix F contains field-measurement data (pH, specific conductance, dissolved oxygen, temperature, and oxidation-reduction potential) for all wells. Problems occasionally occurred with field instruments, and when identified, the resulting measurements were not included.

Appendix G contains inorganic anion, pesticide, and nitrogen isotope data. Nitrate-nitrogen and chloride samples were analyzed using two different methods, which are identified in Tables 4 and 5. Shaded cells in the nitrate-nitrogen, chloride, and bromide columns indicate that the samples were analyzed using an ion selective electrode. Nitrogen isotope ratios ($^{15}\text{N}/^{14}\text{N}$) were analyzed from the groundwater nitrate molecule and are represented as $\text{NO}_3\text{-}\delta^{15}\text{N}$.

Groundwater-Elevation Data

Groundwater-level elevations were manually measured during each sampling event and periodically between sampling events. A downhole electronic water-level indicator that measures the depth to water from a consistent measuring point was used. Groundwater-level elevations for wells DW03, DW05, and DW06 through DW12 are presented in Appendix H. Elevations are reported in feet above sea level.

Rainfall Data

Rainfall data were collected on site from January 1, 2002, through December 31, 2004, and from January 1, 2008, through October 31, 2008. Data from January 1, 2005, to December 31, 2007, were downloaded from the University of Kentucky College of Agriculture’s Agricultural Weather Center Web site (www.agwx.ca.uky.edu). From January 1, 2002, to December 31, 2004, data

Table 2. Coordinates, elevations, and measured depths for each soil core collected from the excavated feedlot.

Core ID	Latitude	Longitude	Elevation (ft)	Measured Depth for Round 1 (in.)	Measured Depth for Round 2 (in.)	Measured Depth for Round 3 (in.)	Measured Depth for Round 4 (in.)	Measured Depth for Round 5 (in.)
1	37.799534	-87.670652	434.95	100	98	98	101	101
2	37.799514	-87.670586	434.88	94	98	99	100	102
3	37.799486	-87.670682	434.57	100	100	96	99	98
4	37.799462	-87.670616	434.36	98	98	89	100	101
5	37.799416	-87.670640	433.83	97	95	98	102	98
6	37.799462	-87.670479	434.82	99	95	100	102	102
7	37.799428	-87.670378	435.04	100	98	caved in	101	97
8	37.799351	-87.670230	433.49	96	100	96	101	90
9	37.799318	-87.670134	432.14	99	97	98	101	98
10	37.799308	-87.670382	434.87	97	91	98	97	96
11	37.799279	-87.670278	431.46	99	94	99	98	98
12	37.799243	-87.670177	429.57	99	100	97	99	98

Table 3. Analytical methods for soil samples.

Analyte	Method	Laboratory
pH	glass electrode in a 1:1 soil:water suspension	UK Regulatory Services
bioavailable phosphorus, calcium, potassium, magnesium, manganese, zinc	Mehlich III extraction (Mehlich, 1984)	UK Regulatory Services
organic matter and total nitrogen	dry combustion (Bradstreet, 1965; Nelson and Sommers, 1996)	UK Regulatory Services
inorganic nitrogen (ammonium and nitrate)	Colorimetry (Technicon Corp., 1965) and Greiss-Ilosvay method (Keeney and Nelson, 1982)	Chemical and Edaphology Laboratory

were collected on-site by a tipping-bucket rain gage connected to a Telog pulse-recording data logger. From January 1, 2008, to October 31, 2008, data were collected on-site by a tipping-bucket rain gage connected to a RainWise RainLog data logger; the data loggers did not record data unless a pulse from the tipping bucket was sent to the recorders. Therefore, there are records only for those days with rainfall.

Rainfall data are found in Appendix I. The first column is the date of measurement in mm/dd/yy format. The second column is the amount of daily rainfall in inches. The third column is cumulative rainfall. The data tables are categorized by year and the cumulative totals are zeroed at the beginning of each year.

Gamma-Ray Logs

In April 2006, personnel from the Indiana Geological Survey used a Widco Logger 1200 portable logger to record gamma-ray logs for wells DW01, DW02, DW06, DW07, DW08, DW09, DW10, and DW12. Log and well identification information is presented in Table 6. Gamma-ray logs are presented in Appendix J.

Slug-Test Data

On May 9, 2006, and June 7, 2006, slug tests were performed on wells DW07, DW08, DW09, DW10, and DW12 (Fig. 7). The slug was constructed out of 2-in.-diameter PVC pipe and filled with sand. The slug was measured to displace 0.925 gal of water. Water-level measurements were recorded every second with a submersible pressure transducer as the slug was dropped into the well and as the slug was removed from the well.

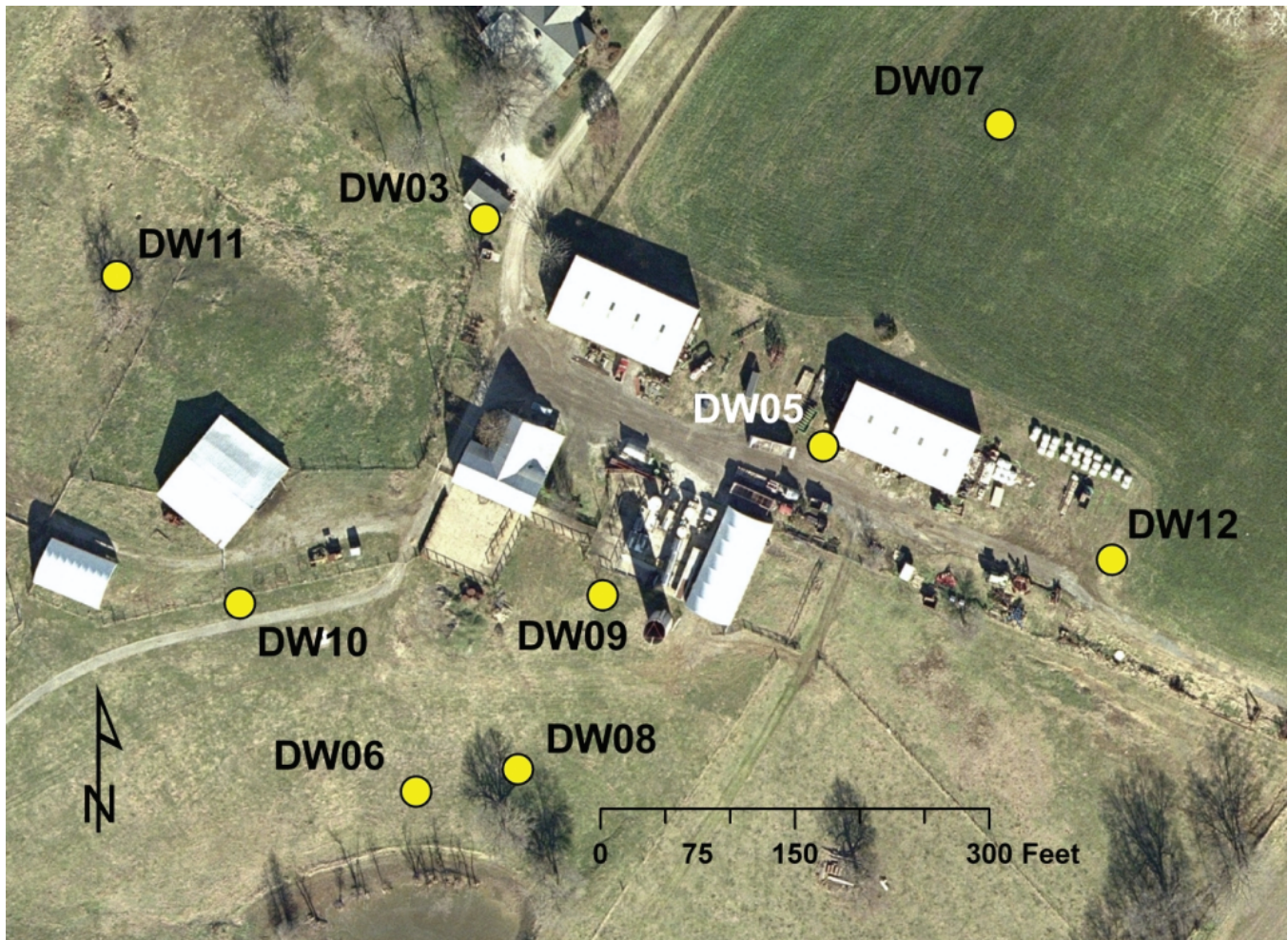


Figure 7. Locations of wells DW03, DW05, DW06, DW07, DW08, DW09, DW10, DW11, and DW12 (yellow circles).

Table 4. Analyses, methods, and preservatives used by Kentucky Geological Survey, Division of Environmental Services, and University of Waterloo laboratories.

<i>Analyte</i>	<i>Method</i>	<i>Preservative</i>	<i>Laboratory</i>
chloride bromide sulfate nitrate-nitrogen	SW846-9056	4°C	Kentucky Geological Survey
pesticides	ELISA	4°C	Kentucky Geological Survey
nitrogen-15	Flatt and Heemskerk (1997)	filtered, HgCl ₂	University of Waterloo

Table 5. Analyses, methods, and preservatives used by Western Kentucky office laboratory.

<i>Analyte</i>	<i>Method</i>	<i>Preservative</i>
chloride	Orion Research Inc. (1996a)	4°C
nitrate-nitrogen	Orion Research Inc. (1996b)	4°C
bromide	Cole-Parmer Instrument Co. (no date)	4°C

Table 6. Gamma-ray log ID and corresponding well numbers.	
<i>Log ID</i>	<i>Well No.</i>
06-3001	DW06
06-3002	DW08
06-3003	DW09
06-3004	DW10
06-3005	DW12
06-3006	DW07
06-3007	DW02
06-3008	DW01

Data for the May 9 and June 7 slug tests are presented in Appendices K and L, respectively.

X-Ray Fluorescence Data

Four soil cores to bedrock were collected using the Kentucky Geological Survey's Giddings soil probe. Two cores (K8-1 and K8-2) were collected less than 10 ft from well DW08 and the other two (K9-1 and K9-2) less than 10 ft from well DW09. Two-in. sections were removed from the cores on 1-ft intervals, crushed, and fused with lithium metaborate to produce a glass disc. The discs were analyzed using an X-ray fluorescence spectrometer at the Kentucky Geological Survey. XRF data are expressed in three different formats: (1) oxides plus loss on ignition, (2) oxides minus loss on ignition, and (3) elemental percentages. XRF data for cores K8 and K9 are presented in Appendices M and N, respectively.

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