

**In cooperation with Kentucky Natural Resources and Environmental
Protection Cabinet—Department for Environmental Protection—
Division of Waste Management**

**Ground-Water Levels and Precipitation Data
at the Maxey Flats Low-Level Radioactive
Waste Disposal Site Near Morehead,
Kentucky, October 1988—September 2000**

Open-File Report 02-357

U.S. Department of the Interior
U.S. Geological Survey

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By Douglas D. Zettwoch

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**In cooperation with Kentucky Natural Resources and
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Louisville, Kentucky
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U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

For additional information write to:

District Chief, Kentucky District
U.S. Geological Survey
9818 Bluegrass Parkway
Louisville, KY 40299-1906
<http://www.dky/sv.er.usgs.gov>

Copies of this report can be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225-0286

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CONVERSION FACTORS AND VERTICAL DATUM

CONVERSION FACTORS

Multiply	By	To obtain
inch	2.54	centimeter
foot	0.3048	meter
mile	1.609	kilometer
acre	0.004047	square kilometer
gallon	3.785	liter

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$$

VERTICAL DATUM

Sea level: In this report “sea level” refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Elevation, as used in this report, refers to distance above or below sea level.

Ground-Water Levels and Precipitation Data at the Maxey Flats Low-Level Radioactive Waste Disposal Site Near Morehead, Kentucky, October 1988–September 2000

By Douglas D. Zettwoch

Abstract

The U.S. Geological Survey, in cooperation with the Kentucky Natural Resources and Environmental Protection Cabinet—Department for Environmental Protection—Division of Waste Management, has an ongoing program to monitor water levels at the Maxey Flats low-level radioactive waste disposal site near Morehead, Kentucky. Ground-water-level and precipitation data were collected from 112 wells and 1 rain gage at the Maxey Flats low-level radioactive waste disposal site during October 1988–September 2000. Data were collected on a semi-annual basis from 62 wells, continuously from 6 wells, and monthly or bimonthly from 44 wells (13 of which had continuous recorders installed for the period October 1998–September 2000). One tipping-bucket rain gage was used to collect data at the Maxey Flats site for the period October 1988–September 2000.

INTRODUCTION

The Maxey Flats low-level radioactive waste disposal site began operation as a commercial radioactive waste-disposal facility in May 1963. The U.S. Geological Survey (USGS) involvement began in 1962 with a well inventory of the Maxey Flats area. In 1973, the Kentucky Cabinet for Human Resources (KCHR) reported the detection of radionuclides outside the disposal trenches. In 1974, the USGS began collecting water-level and

precipitation data to assess the basic hydrologic system at the Maxey Flats site (Zehner, 1979 and 1983). Collection of these data continued through September 30, 2000 (table 1). Commercial disposal operations at the facility ceased in December 1977 because of increased concern about the migration of radionuclides from the site. The Maxey Flats site was placed on the U.S. Environmental Protection Agency's (USEPA) Superfund National Priority List in 1986, and remediation plans were developed for the site.

The Maxey Flats low-level radioactive waste disposal site encompasses approximately 280 acres near the edge of a flat-topped ridge. The ridge is underlain by fractured shale and sandstone beds of the Nancy Member and the Farmers Member of the Borden Formation of Mississippian age. The only appreciable ground-water flow in the strata beneath the site occurs through fractures, and flow patterns are difficult to delineate (Wilson and Lyons, 1991).

Remediation of the site began in 1995 and included the pumping of leachate from trench sumps, solidifying the leachate, and storing the material in a concrete bunker on site. From 1997 to 2000, over 700,000 gallons of leachate were pumped from the trenches (Hampson, 2000). Also during this period, construction began on cut-off trenches to the north and east of the burial site to intercept any recharge to or leakage from the trench area. Long-term water-level monitoring of wells and trench sumps is being used to help determine the effectiveness of this remediation.

Table 1. Status of wells as of September 30, 2000, at the Maxey Flats low-level radioactive waste disposal site near Morehead, Kentucky

Well name	U. S. Geological Survey site number	Period of record (year-month/year)	Status of well as of 09-30-00
UA1	381548083340001	1976–August 1999	Measurement discontinued
UA2	381549083340001	1976–August 1999	Measurement discontinued
UA3	381549083335901	1976–August 1999	Measurement discontinued
UB1A	381533083341701	1977–August 1995	Measurement discontinued
UB2	381533083341702	1977–August 1995	Measurement discontinued
UB3	381534083341801	1977–August 1995	Measurement discontinued
UB4	381533083341802	1977–August 1995	Measurement discontinued
UE1	381538083342001	1984–September 2000	Continuous water-level recorder
UE2	381538083342002	1984–September 2000	Continuous water-level recorder
UE3	381538083342003	1984–September 2000	Continuous water-level recorder
UE7	381537083342101	1984–August 1999	Measurement discontinued
UE8	381536083342201	1984–September 2000	Continuous water-level recorder
UE9	381540083341901	1984–April 1999	Destroyed
UE11	381539083341901	1984–September 2000	Measured bimonthly
UF1	381540083341801	1985–September 2000	Continuous water-level recorder
UF2	381541083341701	1985–September 2000	Continuous water-level recorder
UF3	381542083341601	1985–August 1999	Measurement discontinued
UF4	381543083341601	1985–August 1999	Measurement discontinued
UF5	381543083341501	1985–September 2000	Continuous water-level recorder
UF6	381544083341401	1985–August 1999	Measurement discontinued
UF8	381544083341201	1985–August 1999	Measurement discontinued
UF9	381543083341101	1985–August 1999	Measurement discontinued
UF10	381542083341001	1985–September 2000	Continuous water-level recorder
UF11	381542083340901	1985–April 1987	Measurement discontinued
UF12	381541083340801	1985–April 1999	Measurement discontinued
UF13	381541083340701	1985–October 1995	Measurement discontinued
UF14	381540083340601	1985–April 1999	Measurement discontinued
UF15	381539083340501	1985–April 1999	Measurement discontinued
UF16	381539083340401	1985–April 1999	Measurement discontinued
UF17	381538083340301	1985–April 1999	Measurement discontinued
UF18	381538083340201	1985–October 1998	Measurement discontinued
UF19	381537083340301	1985–April 1999	Measurement discontinued
UF20	381536083340401	1985–April 1999	Measurement discontinued
UF21	381535083340401	1985–April 1999	Measurement discontinued
UF22	381534083340501	1985–April 1999	Measurement discontinued
UF23	381534083340601	1985–September 2000	Continuous water-level recorder
UF24	381533083340601	1985–April 1999	Measurement discontinued

Table 1. Status of wells as of September 30, 2000, at the Maxey Flats low-level radioactive waste disposal site near Morehead, Kentucky—*Continued*

Well name	U. S. Geological Survey site number	Period of record (year–month/year)	Status of well as of 09-30-00
UF25	381532083340702	1985–April 1999	Measurement discontinued
UF26	381531083340801	1985–September 2000	Continuous water-level recorder
UF27	381530083340901	1985–April 1999	Destroyed
UF28	381539083340901	1985–April 1999	Destroyed
UF29	381529083341001	1985–April 1999	Destroyed
UF30	381528083341101	1985–April 1999	Destroyed
UF31	381527083341101	1985–April 1999	Destroyed
UF32	381526083341201	1985–April 1999	Destroyed
UF33	381525083341201	1985–April 1999	Destroyed
UF34	381534083341301	1985–April 1999	Destroyed
UF35	381523083341301	1985–April 1999	Destroyed
UF36	381523083341401	1985–October 1998	Destroyed
UF37	381524083341601	1985–September 2000	Continuous water-level recorder
UF38	381525083341701	1985–October 1998	Destroyed
UF39	381525083341801	1985–October 1998	Destroyed
UF40	381526083341901	1985–April 1999	Destroyed
UF41	381526083342001	1985–April 1999	Destroyed
UF42	381527083342101	1985–April 1999	Destroyed
UF43	381530083342701	1985–April 1999	Measurement discontinued
UF44	381531083342601	1985–April 1999	Measurement discontinued
UF45	381532083342501	1985–September 2000	Continuous water-level recorder
UF46	381533083342401	1985–April 1999	Measurement discontinued
UF47	381534083342401	1985–October 1996	Destroyed
UF48	381534083342301	1985–April 1999	Measurement discontinued
UF49	381535083342201	1985–August 1999	Measurement discontinued
UG1	381540083341601	1985–October 1998	Measurement discontinued
UG2	381539083341501	1985–June 1997	Destroyed
UG3	381539083341401	1985–June 1997	Destroyed
UG4	381538083341401	1985–June 1997	Destroyed
UG5	381539083341301	1985–June 1997	Destroyed
UG6	381540083341401	1985–June 1997	Destroyed
UG7	381541083341501	1985–September 2000	Continuous water-level recorder
UG8	381540083341201	1985–June 1997	Destroyed
UG9	381540083341301	1985–June 1997	Destroyed
UG10	381541083341401	1985–June 1997	Destroyed
UG11	381542083341501	1985–September 2000	Continuous water-level recorder
UG12	381542083341301	1985–September 2000	Continuous water-level recorder
UG13	381542083341201	1985–June 1997	Destroyed

Table 1. Status of wells as of September 30, 2000, at the Maxey Flats low-level radioactive waste disposal site near Morehead, Kentucky—*Continued*

Well name	U. S. Geological Survey site number	Period of record (year–month/year)	Status of well as of 09-30-00
UG14	381531083341301	1985–April 1999	Measurement discontinued
UG15	381530083341301	1985–April 1999	Measurement discontinued
UG16	381529083341401	1985–April 1999	Measurement discontinued
UG17	381535083341401	1985–April 1999	Measurement discontinued
UG18	381537083341101	1985–April 1999	Measurement discontinued
UG19	381534083341601	1985–April 1995	Measurement discontinued
UI1	381540083341611	1986–October 1998	Measurement discontinued
UI2	381540083341602	1986–October 1998	Measurement discontinued
UI3	381540083341603	1986–October 1998	Measurement discontinued
UI4	381540083341604	1986–October 1998	Measurement discontinued
UI5	381540083341605	1986–October 1998	Measurement discontinued
UI6	381540083341606	1986–October 1998	Measurement discontinued
UI7	381540083341607	1986–October 1998	Measurement discontinued
UI8	381540083341608	1986–October 1998	Measurement discontinued
UI9	381540083341609	1986–October 1998	Measurement discontinued
UI10	381540083341610	1986–October 1998	Measurement discontinued
UJ1	381542083341309	1986–October 1998	Measurement discontinued
UJ2	381542083341302	1986–October 1998	Measurement discontinued
UJ3	381542083341303	1986–October 1998	Measurement discontinued
UJ4	381542083341304	1986–October 1998	Measurement discontinued
UJ5	381542083341305	1986–October 1998	Measurement discontinued
UJ6	381542083341306	1986–October 1998	Measurement discontinued
UJ7	381542083341307	1986–October 1998	Measurement discontinued
UJ8	381542083341308	1986–October 1998	Measurement discontinued
UK1	381539083341902	1986–September 2000	Continuous water-level recorder
UK2	381538083341901	1986–September 2000	Continuous water-level recorder
UK3	381524083341701	1986–April 1999	Destroyed
UK4	381523083341601	1986–April 1999	Destroyed
UK5	381522083341501	1986–April 1999	Destroyed
UK6	381522083341401	1986–April 1999	Destroyed
UL1	381550083341001	1988–August 1999	Measurement discontinued
UL2	381547083341201	1988–August 1999	Measurement discontinued
UL3	381540083340201	1988–August 1999	Measurement discontinued
UL4	381543083340401	1988–August 1999	Measurement discontinued
11E	381534083342302	1974–August 1999	Measurement discontinued
Walker #8	381537083341001	1979–October 1998	Measurement discontinued
N2B	381540083342001	1984–September 2000	Continuous water-level recorder

Purpose and Scope

This report is one in a series of reports published by the USGS describing conditions at the Maxey Flats site. In this report, ground-water-level and precipitation data were collected from 112 wells and 1 rain gage at the Maxey Flats site during October 1988–September 2000. Data were collected on a semi-annual basis from 62 wells, continuously from 6 wells, and monthly or bimonthly from 44 wells (13 of which had continuous recorders installed for the period October 1998–September 2000). One tipping-bucket rain gage was used to collect data at the Maxey Flats site for the period October 1988–September 2000. All data are available for retrieval from the USGS National Water Information System (NWIS) data base.

Location and Description of Study Area

The Maxey Flats site is located about 10 miles northwest of Morehead, Ky., in Fleming County. The site is located on a “flat” surrounded on the east, west, and south by steep wooded hillsides and is connected to a ridge on the north. Elevation differences range from 1,050 feet above sea level on top of the flat to 700 feet above sea level at the stream valleys below.

The site, including a recently acquired buffer zone, now encompasses 650 acres of State-owned land. The actual disposal area is contained on about 50 acres on top of Maxey Flats. Most of the monitoring wells surround this restricted area, with a few clusters of wells inside this area (see fig. 1) (Steve Hampson, Kentucky Water Research Institute, written commun., 1998).

Geohydrology

A detailed description of the geohydrology of the study area has been documented in previous studies by Zehner (1979 and 1983) and Wilson and Lyons (1991). The following is an overview of the geohydrologic system at the Maxey Flats site.

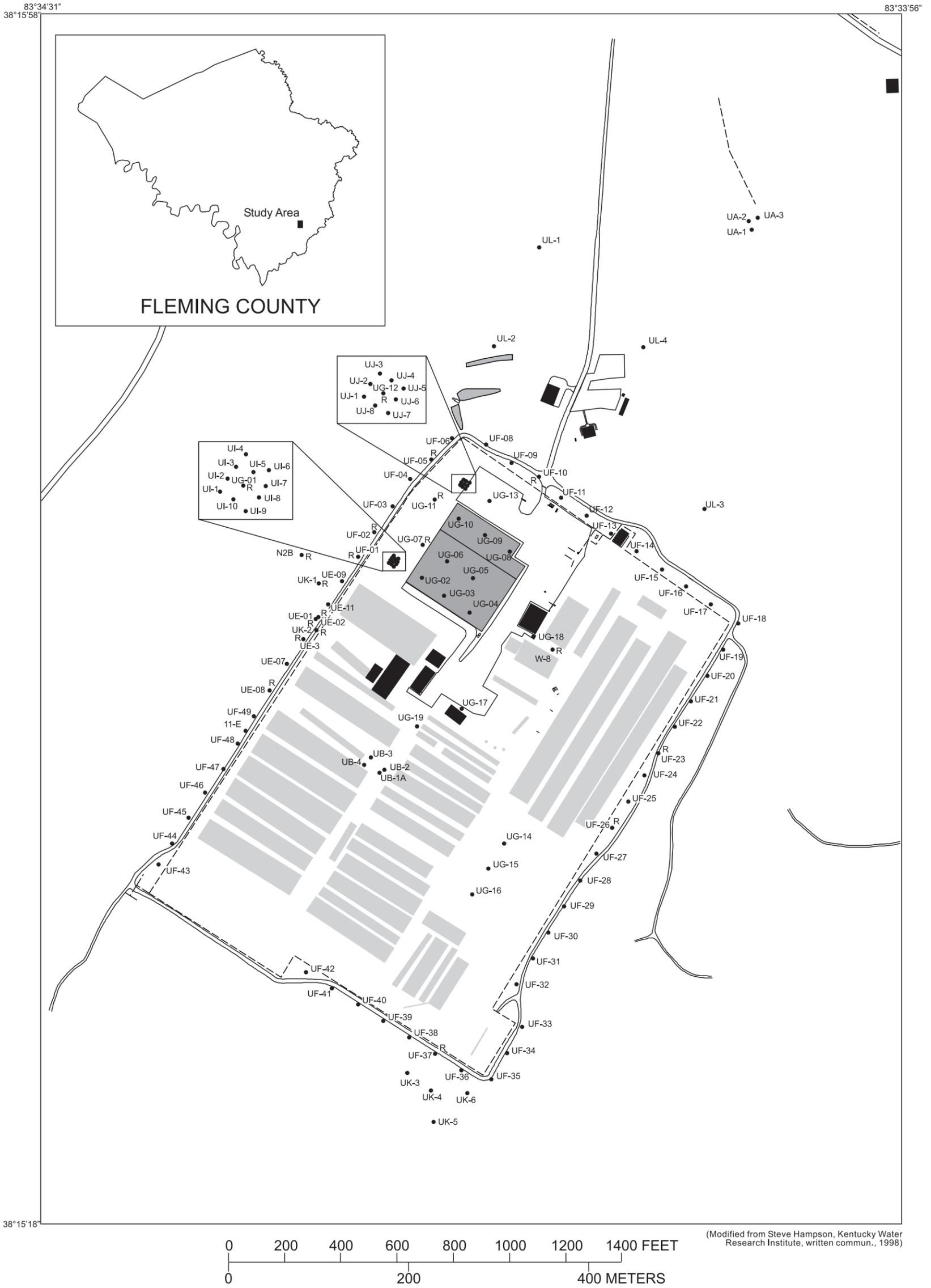
The stratigraphic units underlying the Maxey Flats site consist, from oldest to youngest, of the upper part of the Crab Orchard Group of Silurian age; the Ohio Shale of Devonian age; and the Bedford Shale, the Sunbury Shale, and the lower part of the Borden Formation of Mississippian age (fig. 2). The New Albany Shale, of Devonian and Mississippian age, is stratigraphically equivalent to the Ohio, Bedford, and Sunbury Shales (Wilson and Lyons, 1991).

The lower part of the Borden Formation at the Maxey Flats site consists of the Farmers Member and the Nancy Member. The Farmers Member underlies the Nancy Member and is composed of interbedded sandstone and minor amounts of shale. In the study area, the average thickness of the Farmers Member is 36 feet. The upper part of the Farmers Member is extensively jointed (Zehner, 1983). The lower part of the Farmers Member is also jointed but to a lesser degree than the upper part; the lower part of the Farmers Member contains shale in thin beds ranging from less than 1 inch to a few inches in thickness.

The Nancy Member caps the Maxey Flats ridge and consists mostly of shale, with minor amounts of siltstone, and sandstone. The upper part of the Nancy Member is composed of weathered olive- to orange-gray shale and unweathered bluish- to greenish-gray shale. In some parts of the site, the weathered and unweathered shale are separated by a discontinuous, yellowish-brown siltstone bed, which averages about 1.5 feet in thickness (McDowell and others, 1971). A second siltstone bed, averaging about 1 to 2 feet in thickness, occurs at a lower elevation in the unweathered shale of the Nancy Member. Most of the monitoring wells at the site are completed at or near the top of this lower siltstone unit.

All strata of the Nancy Member contain weathered joints and fractures that vary in size, spacing, and interconnectivity. The occurrence and movement of ground water at the site is mostly within these interconnected joints and bedding-plane fractures (Zehner, 1983). The fracture porosity and permeability of the stratigraphic units are sufficient to transmit water in small quantities, but not to sustain a modern domestic water supply (100 gallons per day) (Hall and Palmquist, 1960).

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EXPLANATION

- | | | | |
|---|----------|--|-------------------------------|
|  | Trench |  | Fence |
|  | Bunker |  | Well and identifier |
|  | Building |  | Well with continuous recorder |

Figure 1. Locations of wells at the Maxey Flats low-level radioactive waste disposal site near Morehead, Kentucky.

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Previous Studies

Concern about the migration of radionuclides from the Maxey Flats site in northeastern Kentucky has led to several extensive hydrogeologic and water-quality studies. The USGS, in cooperation with the Kentucky Natural Resources and Environmental Protection Cabinet—Department for Environmental Protection—Division of Waste Management (KNREPC–DWM) and the KCHR, has collected data at the site since 1974. An extensive ground-water data-collection network has been maintained by the USGS and the KNREPC–DWM to obtain information needed to define the hydrologic setting at the site. The geohydrology has been described by Zehner (1979 and 1983), and data collected as part of the continuing investigation of ground-water conditions has been documented by Lyverse (1987), Wilson and Lyons (1991) and (Steve Hampson, Kentucky Water Research Institute, written commun., 1998).

Acknowledgments

The author would like to thank the cooperators of this study, KNREPC–DWM, and site personnel for their assistance in facilitating the collection of the data presented in this report.

SYSTEM	SERIES	FORMATION	
MISSISSIPPIAN	Lower	Borden Formation	Nancy Member
			Farmers Member
			Henley Bed
		Sunbury Shale	
?	?	?	Bedford Shale
DEVONIAN	Upper	New Albany Shale	Ohio Shale
SILURIAN	Lower and Middle	Upper part of Crab Orchard Group	

Figure 2. Generalized stratigraphic column for the Maxey Flats low-level radioactive waste disposal site near Morehead, Kentucky [modified from McDowell, 1981].