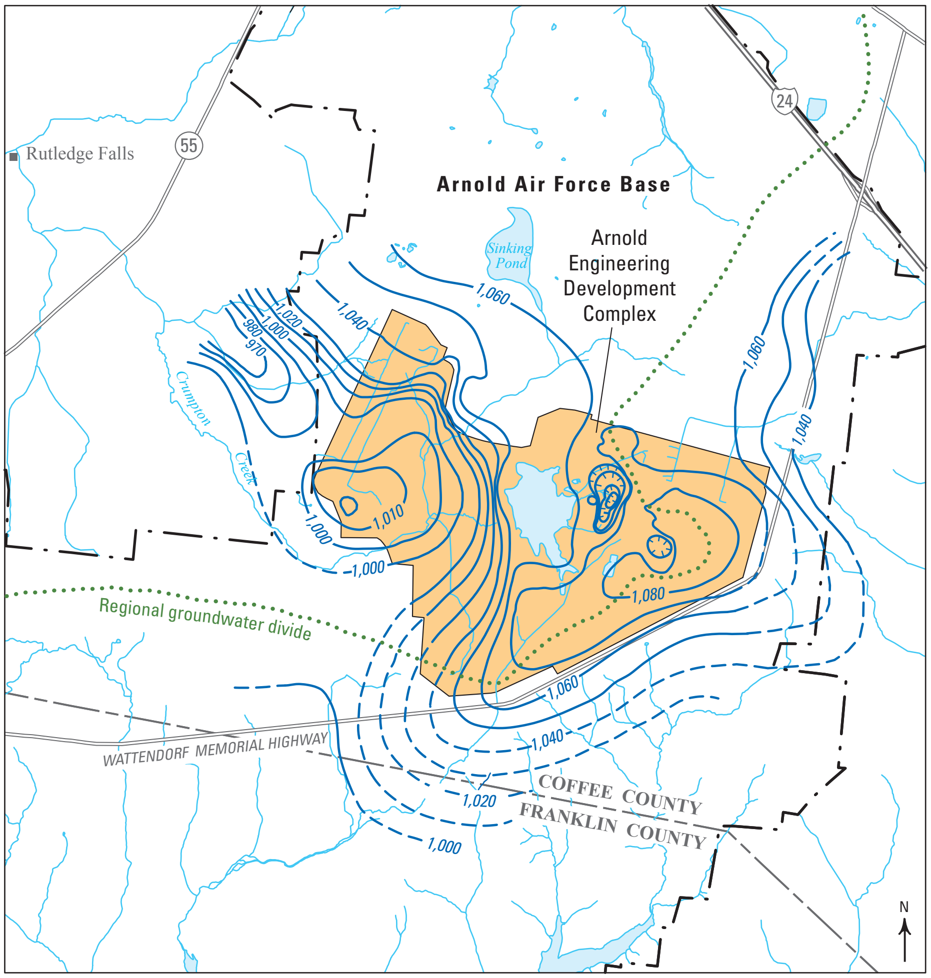
Prepared in cooperation with the United States Air Force, Arnold Air Force Base

Potentiometric Surfaces of the Arnold Engineering Development Complex Area, Arnold Air Force Base, Tennessee, May and September 2011



Scientific Investigations Report 2015–5165

U.S. Department of the Interior
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Cover. See figure 6 of this report.

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By Connor J. Haugh and John A. Robinson

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SALLY JEWELL, Secretary

U.S. Geological Survey
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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviations

AAFB	Arnold Air Force Base
AEDC	Arnold Engineering Development Complex
SWMU	solid waste management units

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Abstract

Arnold Air Force Base occupies about 40,000 acres in Coffee and Franklin Counties, Tennessee. The primary mission of Arnold Air Force Base is to provide risk-reduction information in the development of aerospace products through test and evaluation. This mission is achieved in part through test facilities at Arnold Engineering Development Complex (AEDC), which occupies about 4,000 acres in the center of Arnold Air Force Base. Arnold Air Force Base is underlain by gravel and limestone aquifers, the most productive of which is the Manchester aquifer. Several volatile organic compounds, primarily chlorinated solvents, have been identified in the groundwater at Arnold Air Force Base. In 2011, the U.S. Geological Survey, in cooperation with the U.S. Air Force, Arnold Air Force Base, completed a study of groundwater flow focused on the Arnold Engineering Development Complex area. The Arnold Engineering Development Complex area is of particular concern because within this area (1) chlorinated solvents have been identified in the groundwater, (2) the aquifers are dewatered around below-grade test facilities, and (3) there is a regional groundwater divide.

During May 2011, when water levels were near seasonal highs, water-level data were collected from 374 monitoring wells; and during September 2011, when water levels were near seasonal lows, water-level data were collected from 376 monitoring wells. Potentiometric surfaces were mapped by contouring altitudes of water levels measured in wells completed in the shallow aquifer, the upper and lower parts of the Manchester aquifer, and the Fort Payne aquifer. Water levels are generally 2 to 14 feet lower in September compared to May. The potentiometric-surface maps for all aquifers indicate a groundwater depression at the J4 test cell. Similar groundwater depressions in the shallow and upper parts of the Manchester aquifer are within the main testing area at the Arnold Engineering Development Complex at dewatering facilities.

Introduction

Arnold Air Force Base (AAFB) occupies about 40,000 acres in the eastern part of the Highland Rim physiographic region in Coffee and Franklin Counties, Tennessee (fig. 1). The primary mission of AAFB is to provide risk-reduction information in the development of aerospace products through test and evaluation. This mission is accomplished in part through test facilities at the Arnold Engineering Development Complex (AEDC), which occupies about 4,000 acres in the center of AAFB (fig. 1). The AEDC test facilities include aerodynamic and propulsion wind tunnels, rocket and turbine engine test cells, space environmental chambers, ballistic ranges and other specialized units.

The AAFB is underlain by unconsolidated gravel and limestone aquifers of the Highland Rim aquifer system. The most productive aquifer is the Manchester aquifer, the primary source of domestic drinking water in the area. Groundwater contamination in the Manchester aquifer, in and near the AAFB, has been well documented in numerous investigations (CH2M HILL, 1999a, 1999b, 2001; Williams, 2003). Several synthetic volatile organic compounds, primarily chlorinated solvents, have been identified in groundwater samples collected at several solid waste management units (SWMUs) at AAFB. Groundwater contaminants have moved downgradient from three SWMU sites creating groundwater contamination plumes that extend to regional discharge points outside the AAFB boundary. At each of the SWMU sites, pump and treat remediation wells were operating in 2011 to prevent further migration of groundwater contaminants offsite. Groundwater is also withdrawn at about 20 dewatering locations associated with below-grade testing facilities in the AEDC area, the largest and deepest of which is the J4 test cell (fig. 1) (CH2M HILL, 2001; fig. 9 in Haugh, 2006). The J4 test cell is about 100 feet in diameter and extends about 250 feet below land surface. Because of its depth, dewatering at the J4 test cell has depressed water levels in

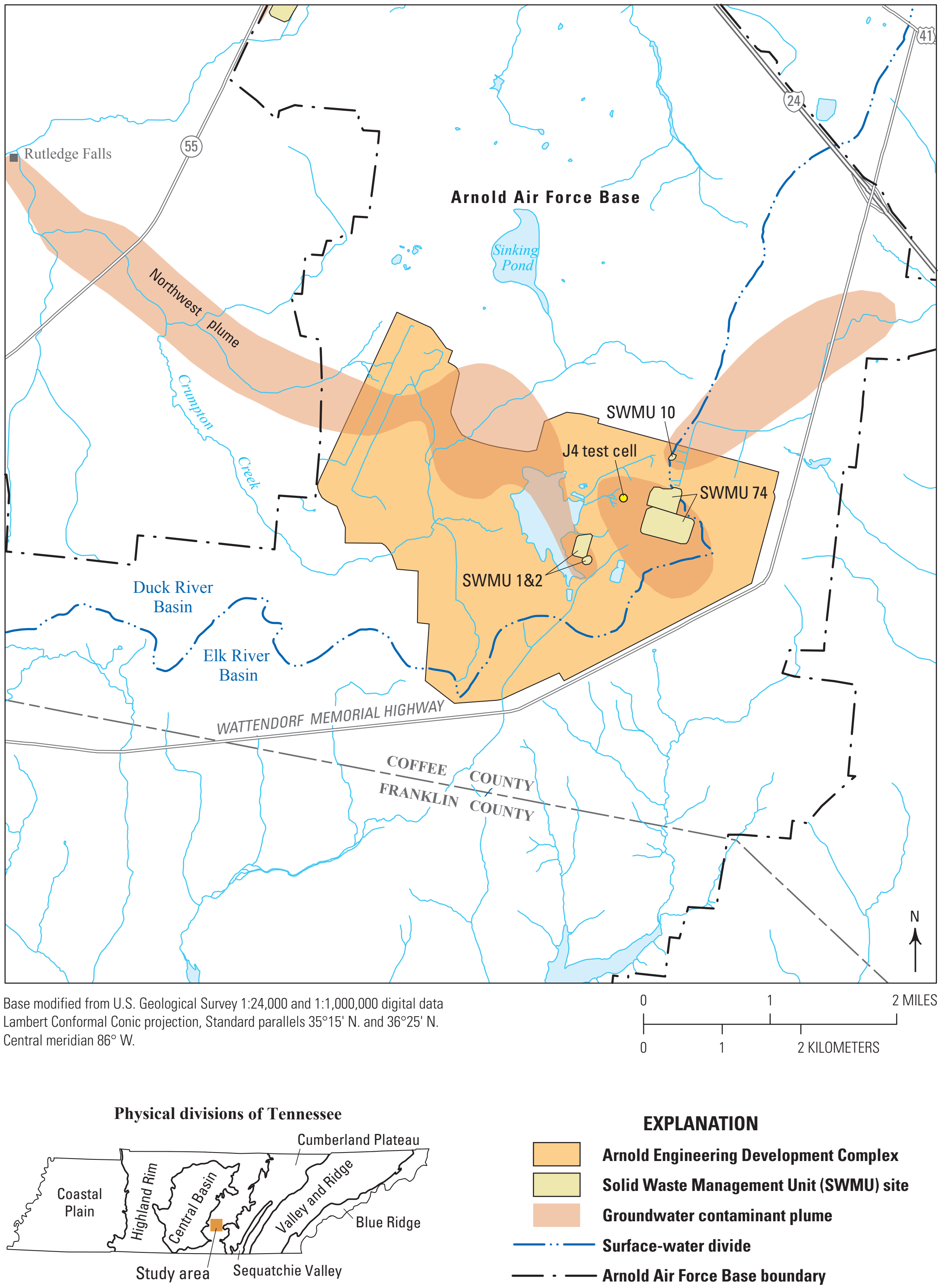


Figure 1. Location of study area at Arnold Air Force Base, Coffee and Franklin Counties, Tennessee (physical divisions modified from Miller, 1974).

all the aquifers of the Highland Rim aquifer system (Haugh, 1996). Because most of the groundwater contamination and groundwater withdrawals at AAFB are in the AEDC area, the U.S. Geological Survey, in cooperation with the U.S. Air Force, AAFB, completed a study of groundwater flow focused on the AEDC area. The AEDC area is of particular concern because within this area (1) there are several SWMUs, (2) the aquifers are dewatered around below-grade test facilities, and (3) there is a regional groundwater divide.

Purpose and Scope

The objectives of the study were to (1) map the potentiometric surfaces within the shallow aquifer, upper and lower parts of the Manchester aquifer, and Fort Payne aquifer in the AEDC area during seasonal high and low water-level periods; and (2) provide more detailed information on groundwater-flow directions in the AEDC area.

This report presents seasonal high and low potentiometric surfaces of the AEDC area based on synoptic water-level measurements made in existing monitoring wells in May and September 2011. Additionally, the report presents continuous hydrographs for six wells completed in the Manchester aquifer. These hydrographs allow the time period of the synoptic water-level measurements to be seen in the context of seasonal changes in water levels. The aquifer potentiometric maps will help further understand groundwater-flow paths in the AEDC area and supplement previously published regional potentiometric-surface maps from May and October 2002 (Robinson and others, 2005) and May 1991 (Mahoney and Robinson, 1993), and potentiometric-surface maps local to the AEDC area from July 1994 (Haugh, 1996).

Most of the background information presented in the “Study Area,” “Hydrogeologic Setting,” and “Groundwater Flow” sections is summarized from previously published reports (Haugh and Mahoney, 1994; Haugh, 2006). A more thorough description of the hydrogeology of the AAFB is presented in Haugh and Mahoney (1994) and Haugh (2006), and a description focused on the AEDC area is provided in Haugh (1996).

Study Area

The AAFB area lies on the eastern Highland Rim physiographic region of Tennessee (Miller, 1974) and is characterized by poorly drained, flat uplands and valley-dissected, sloping escarpments. A primary surface-water divide separating the Duck River and Elk River drainages bisects AAFB extending from the southwest to the northeast (fig. 1). Surface drainage to the north and west of this divide flows toward the Duck River and is impounded at Normandy Lake (8 miles to the northwest), whereas drainage to the east and south flows toward the Elk River and is impounded at Woods Reservoir (4 miles to the south). Land-surface altitudes range from about 1,120 feet (ft) at the crest of the Duck River-Elk River drainage divide to about 960 ft near Woods Reservoir.

Hydrogeologic Setting

The AAFB area is in a fractured carbonate terrane covered by regolith derived from the weathering of carbonate units of Mississippian age (fig. 2). The carbonate units that compose the regolith are as follows (in descending order): the St. Louis Limestone, the Warsaw Limestone, and the Fort Payne Formation (Wilson, 1976). Regolith in the AAFB area is typically 10 to 100 ft thick and consists primarily of clayey chert rubble and some silt and sand. Typically, the regolith grades upward from gravel-size chert rubble at the top of bedrock to clay-size chert particles, silt, sand, and clay at land surface (Burchett, 1977). Bedrock underlying the regolith consists of the Fort Payne Formation, which is an indurated siliceous limestone containing many chert nodules and platy chert stringers. The Fort Payne bedrock in the AAFB area ranges from less than 20 to greater than 240 ft thick. Over most of the AAFB area the bedrock is typically 60–80 ft thick. Bedrock is thinnest beneath the AEDC, where it is generally less than 20 ft thick, and thickens to the north and northeast (fig. 6 in Haugh, 2006). The upper part of the Fort Payne Formation bedrock contains many fractures and solution openings. Underlying the Fort Payne Formation is the Chattanooga Shale, which consists of 20–30 ft of fissile, black, carbonaceous shale. The Chattanooga Shale is considered to be the base of the fresh groundwater system in the study area (Haugh and Mahoney, 1994; Haugh, 1996).

The Highland Rim aquifer system is the groundwater system of interest in the study area and can be divided into three different zones or aquifers (Haugh and Mahoney, 1994): the shallow aquifer, the Manchester aquifer, and the Fort Payne aquifer (fig. 2). The Chattanooga Shale is the lower confining unit for the Highland Rim aquifer system (Brahana and Bradley, 1986). The aquifers differ from one another in permeability caused by the degree of weathering, amount of chert, and type of weathering product. The aquifers are not separated by confining units of any notable lateral extent; therefore, water is free to flow between these aquifers at most locations. The shallow aquifer is discontinuous beneath the AAFB; perched in some locations; and described as alluvial, residual silt, clay, sand, and clay-size chert particles in the upper part of the regolith. The Manchester aquifer, the primary source of drinking water in the area, can be subdivided into two parts: the upper part, which consists of chert rubble at the base of the regolith, and the lower part, which consists of solution openings in the upper part of the bedrock (Burchett and Hollyday, 1974). The Fort Payne aquifer consists of dense, cherty limestone in the Fort Payne Formation where solution openings are less developed. The base of the Fort Payne aquifer is the Chattanooga Shale (Haugh and Mahoney, 1994; Haugh, 1996).

Formations underlying the AAFB area have a general, regional dip towards the southeast (Wilson and Born, 1943) as a result of the tectonic uplift of the Nashville Dome. Superimposed on the regional structure are local folds and flexures. The AAFB is along an anticline in the Chattanooga Shale that is nearly coincident with the regional drainage

Stratigraphy	Thickness (feet)	Lithology	Hydrogeologic unit		Arnold Air Force Base unit designation	Remarks
Regolith derived from in place weathering of the St. Louis Limestone, Warsaw Limestone, or Fort Payne Formation	10–100	Clay, silt, and sand with some chert and rock fragments	Highland Rim aquifer system	Shallow aquifer	Shallow aquifer	Low producing wells, shallow groundwater circulation, low dissolved solids, and bicarbonate dominant anion
		Rock fragments, chert gravel, and rubble with some clay		Manchester aquifer, upper part	Intermediate aquifer	Good producing wells, rapid ground-water circulation, low dissolved solids, and bicarbonate dominant anion
Fort Payne Formation	20–240	Fractured and dissolutioned cherty limestone and siltstone		Manchester aquifer, lower part	Deep aquifer, upper part	
		Dark gray silt-stone; dense, cherty limestone; and bedded chert. Few fractures		Fort Payne aquifer	Deep aquifer, lower part	Low well yield, slow groundwater circulation, high dissolved solids, and high sulfates
Chattanooga Shale	20–30	Dark grayish black, fissile, carbonaceous shale		Chattanooga confining unit	Chattanooga confining unit	Confining unit. Base of fresh ground-water-flow system

Figure 2. Stratigraphy, lithology, and hydrogeologic units in the Arnold Air Force Base area, Tennessee (modified from Haugh and Mahoney, 1994).

divide (Haugh and Mahoney, 1994; Haugh, 1996). A high point in the anticline is at AEDC in the SWMU 74 area (fig. 1) (Haugh, 1996; Haugh, 2006).The primary set of fracture traces in these formations is oriented northwest to southeast. A secondary set of fracture traces is oriented northeast to southwest (Haugh and Mahoney, 1994). These fracture traces, particularly where they are oriented parallel to the geologic dip, potentially provide preferential pathways for groundwater flow through the bedrock. The anticline in the local geologic structure and fractures in the bedrock influence surface-water and groundwater flow directions in the AAFB area (Haugh and Mahoney, 1994; Haugh, 1996; Aycock and Haugh, 2001).

Groundwater Flow

The AEDC facility is along a regional groundwater divide, which runs northeast to southwest and generally coincides with the Duck River-Elk River surface-water divide (Haugh and Mahoney, 1994; Haugh, 1996). Overall, groundwater generally flows from the main groundwater divide area toward the northwest or toward the south or southeast, and discharges to the principal streams and reservoirs. Several troughs are present in the regional potentiometric surface. The most prominent trough trends northwest to southeast in the Crumpton Creek Basin (figs. 2 and 4 in Robinson and others, 2005). During seasonal water-level lows in October 2002, this trough extended upgradient, toward the northeast, to the Sinking Pond area (fig. 4 in Robinson and others, 2005). At the downgradient end of this trough is Big Spring at Rutledge Falls (fig. 1), which has a steady discharge of about 3.3 cubic feet per second (Williams and Farmer, 2003).

The primary human-induced stress on the groundwater system at AEDC is dewatering of the units of the Highland Rim aquifer system at the J4 test cell (fig. 1) (a deep excavation that is part of a rocket engine test facility). Locally, groundwater flows to the J4 test cell from all directions because water in the aquifers immediately surrounding the cell is continuously drained through a network of six wells that surround the test cell. About 105 gallons per minute of groundwater are pumped from the collection system, which extends to a depth of about 250 ft below land surface. The depressions in the potentiometric surfaces in all the Highland Rim aquifers at the test cell show anisotropy that results from preferential dewatering along zones of high permeability (Haugh, 1996). Dewatering also happens, in lesser amounts and at shallower depths, at about 20 other locations associated with test facilities at AEDC.

Potentiometric Surface

The groundwater-flow system was investigated by collecting continuous and synoptic water levels measurements in groundwater monitoring wells and constructing potentiometric-surface maps of the aquifers in the AEDC area. Continuous water-level data were collected at six wells completed in the Manchester aquifer (fig. 3). The hydrographs from these six wells allow the time periods for the synoptic water-level measurements (May and September 2011) to be seen in the context of seasonal changes in water levels. The hydrographs show water levels from October 2010 to March 2012 in order to include the seasonal changes before and after each synoptic water-level measurement period (fig. 4). Potentiometric surfaces were mapped by contouring altitudes of synoptic water levels measured in monitoring wells completed in the shallow aquifer, the upper and lower parts of the Manchester aquifer, and the Fort Payne aquifer. During May 2011, water-level data were collected from 374 monitoring wells. Water levels in the wells ranged from 968 to 1,097 ft above the National Geodetic Vertical Datum of 1929 (NGVD 29) in May 2011 when water levels were near seasonal highs as indicated by hydrographs for six wells completed in the Manchester aquifer (fig. 4). During September 2011, water-level data were collected from 376 monitoring wells. Water levels in the wells ranged from 962 to 1,090 ft above the NGVD 29 in September 2011 when water levels were near seasonal lows (fig. 4).

In the AEDC area, natural seasonal fluctuations of the potentiometric surface are related to seasonal changes in groundwater recharge and evapotranspiration. Groundwater levels are normally highest during the spring months after the winter period of high precipitation and low evapotranspiration. Water levels recede during the summer in response to diminishing precipitation and high evapotranspiration, and are lowest in the fall (Haugh and Mahoney, 1994; Robinson and others, 2005). The average difference in water levels from wells measured in May 2011 and September 2011 is about 5 ft. The largest seasonal variations in water levels are to the north and northeast of AEDC where the regolith thins and the bedrock thickens. Seasonal changes in the Manchester aquifer of 20 ft or more are typical in this area (monitoring wells 177 and 353, fig. 4).

During May 2011, water levels measured in wells completed in the shallow aquifer ranged from 1,044 to 1,097 ft; generally were highest near the southern boundary of the AEDC; and decreased to the north, west, and east. The potentiometric-surface map of the shallow aquifer indicates a groundwater depression at the J4 test cell (fig. 5). Similar groundwater depressions are present at dewatering facilities within the main testing area of the AEDC. The potentiometric-surface map also indicates potentiometric highs to the north of J4 and east of the main test area (fig. 5).

During May 2011, water levels measured in wells completed in the upper part of the Manchester aquifer ranged from 968 to 1,088 ft above the NGVD 29. The highest water levels are east of the main test area along the regional groundwater divide (fig. 6). Groundwater gradients are nearly flat along the groundwater divide northeast of AEDC and east of Sinking Pond. A prominent groundwater depression is present at the J4 test cell along with a smaller depression within the main test area. Most groundwater from SWMU 74 is captured by the J4 test cell or other dewatering facilities within the main test area. Groundwater in the area west of the divide generally flows to the west and northwest towards a trough in the potentiometric surface within the Crumpton Creek Basin. At the downgradient end of this trough are several springs near Rutledge Falls (fig. 1) (Haugh, 2006).

Water levels in the lower part of the Manchester aquifer ranged from 971 to 1,084 ft and showed a similar pattern as water levels in the upper part of the Manchester. The highest water levels are east of the main test area. A smaller groundwater depression is present at the J4 test cell, and no other depressions are indicated within the main test area (fig. 7).

During May 2011, water levels measured in wells completed in the Fort Payne aquifer ranged from 1,016 to 1,068 ft above the NGVD 29. With only 23 water-level measurements, well coverage in the Fort Payne aquifer is not as extensive as in the other aquifers. The most notable feature is an asymmetrical groundwater depression around the J4 test cell (fig. 8). Groundwater flow in the Fort Payne aquifer is dominated by fracture flow and moderately isolated from the overlying Manchester aquifer (Haugh and others, 1992; Haugh and Mahoney, 1994; Haugh, 1996) resulting in a more asymmetric depression around the J4 test cell than observed in the upper or lower parts of the Manchester aquifer.

The potentiometric-surface maps for all aquifers from September 2011 (figs. 9–12) are similar in overall shape to the May 2011 maps. Water levels generally are 2–14 ft lower in September than in May. In September 2011, the trough in the upper Manchester potentiometric surface extends farther upgradient and towards the northeast to the Sinking Pond area (fig. 10).

The horizontal gradient between wells AEDC–353 and AEDC–201/AEDC–305 reverses seasonally. Water levels in well AEDC–353 were higher than water levels in wells AEDC–201 and AEDC–305 in spring of 2011 and 2012; however, the opposite was true in the fall of 2010 and 2011 (fig. 4). The seasonal change in groundwater gradient between wells AEDC–201/AEDC–305 and AEDC–353 is the result of the groundwater trough in the Crumpton Creek Basin extending farther to the northeast toward the Sinking Pond area during periods of seasonally low water (figs. 10 and 11). This seasonal change in the potentiometric surface and groundwater gradients may affect the movement and shape of the northwest plume (fig. 1). A similar change in gradient between these two areas was noted in the 2002 potentiometric-surface maps (Robinson and others, 2005). Despite seasonally changing gradients in the upper parts of the Crumpton Creek Basin, groundwater in this area eventually flows toward the groundwater trough in the Crumpton Creek Basin (figs. 4, 6, 7, 10, and 11).

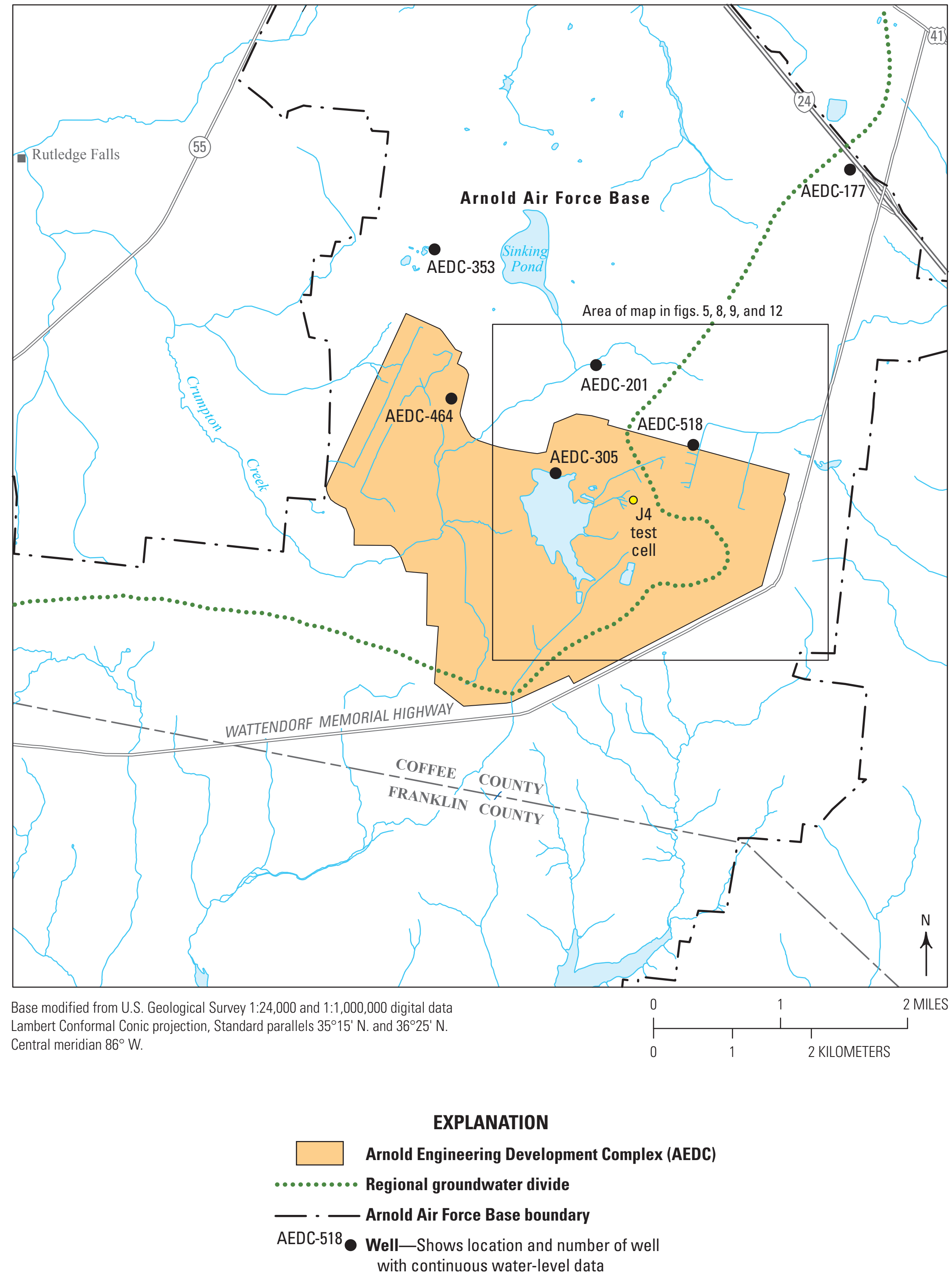


Figure 3. Location of selected Manchester aquifer monitoring wells with continuous water-level data in the Arnold Air Force Base area, Tennessee.

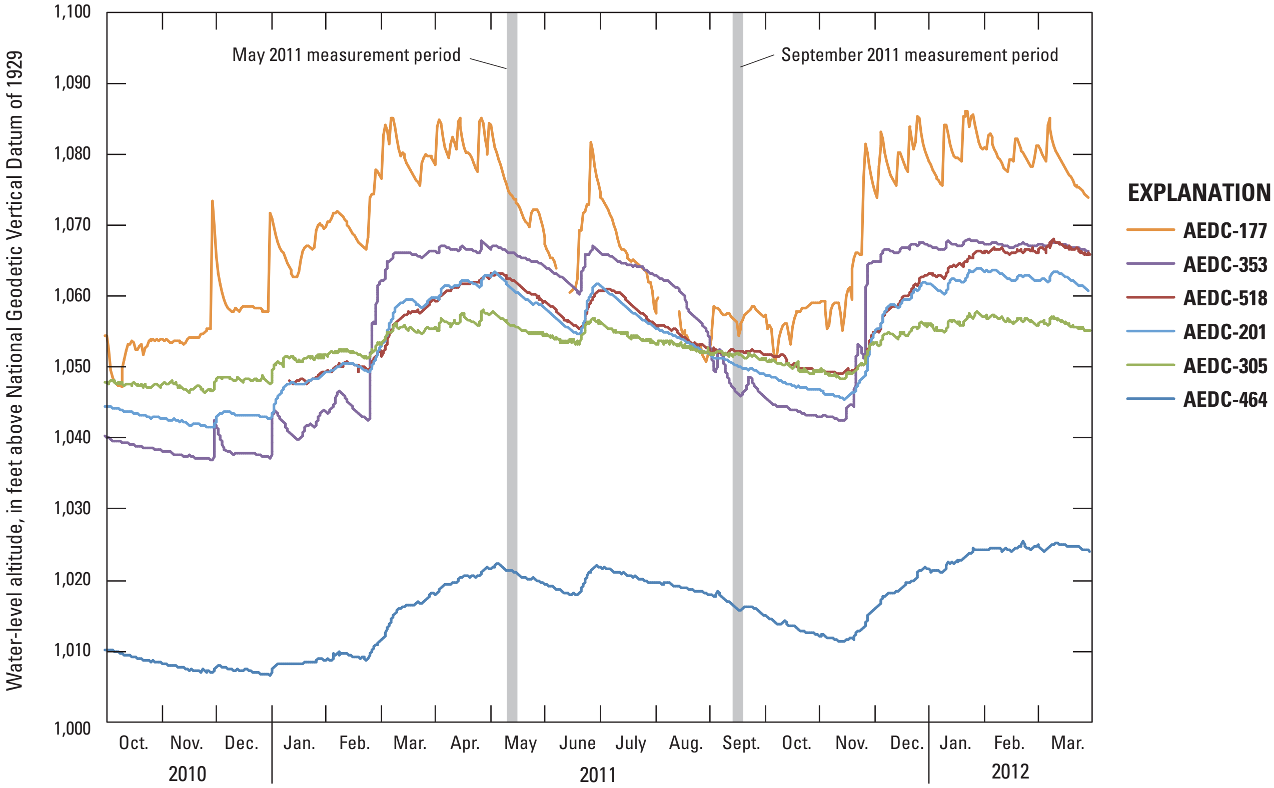


Figure 4. Water-level altitudes in Manchester aquifer monitoring wells 177, 201, 305, 353, 464, and 518 at Arnold Air Force Base area, Tennessee, from October 2010 through March 2012. See figure 3 for well locations.

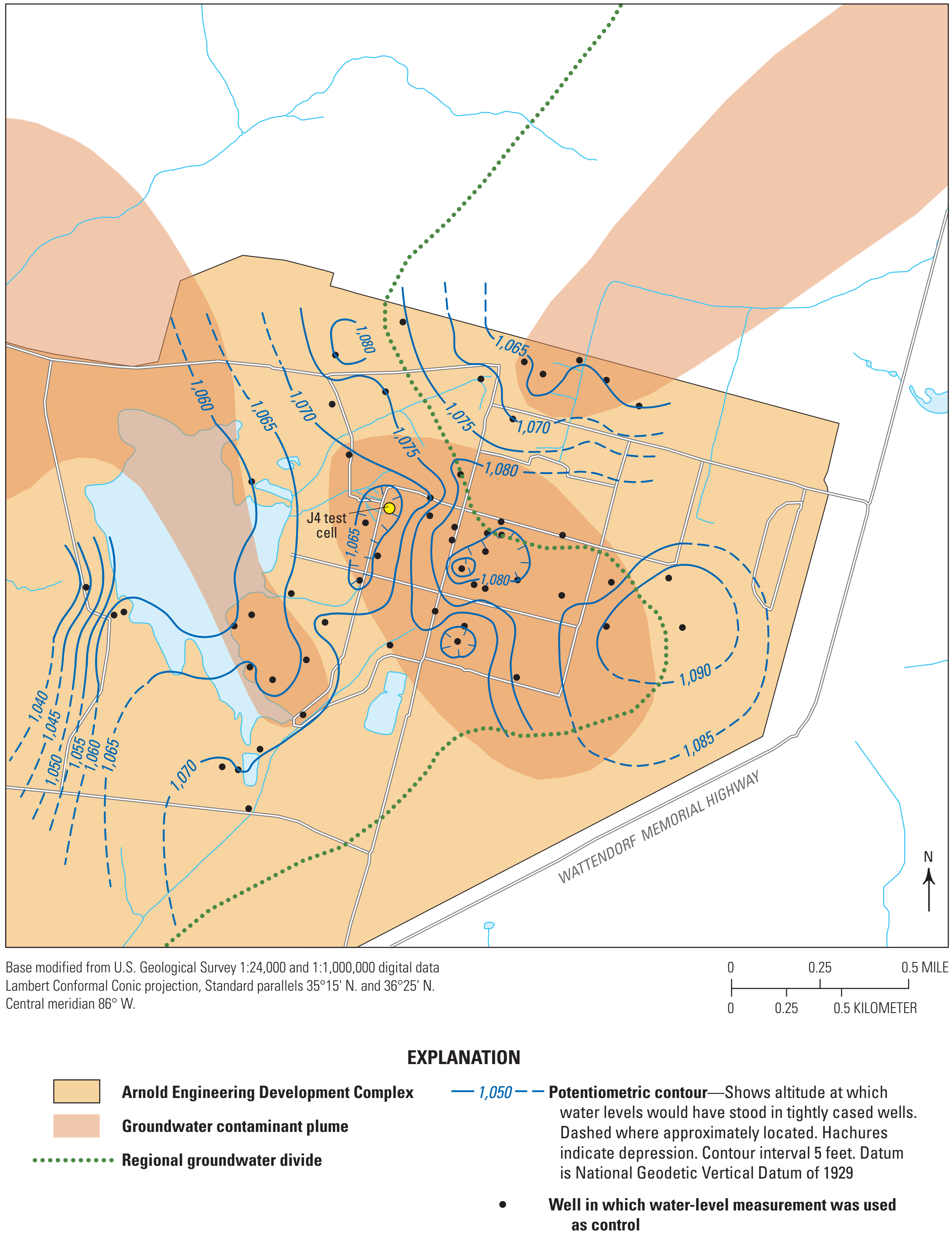
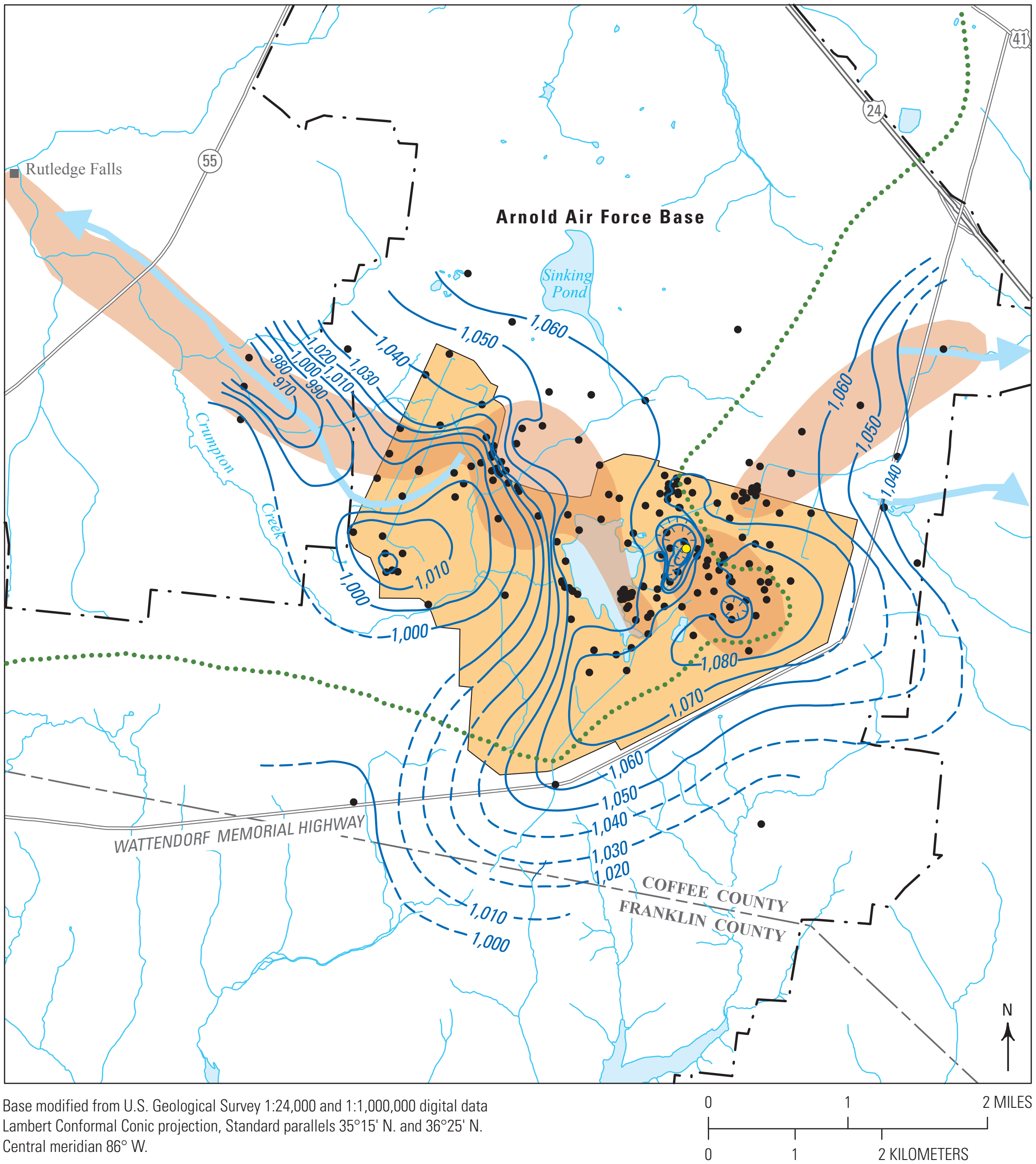


Figure 5. Potentiometric surface of the shallow aquifer in the Arnold Engineering Development Complex area, Tennessee, May 2011.



EXPLANATION

- **Arnold Engineering Development Complex**
- **Groundwater contaminant plume**
- **Regional groundwater divide**
- **Arnold Air Force Base boundary**
- **Groundwater trough**—Arrow indicates groundwater-flow direction
- *1,050* **Potentiometric contour**—Shows altitude at which water levels would have stood in tightly cased wells. Dashed where approximately located. Hachures indicate depression. Contour interval 10 feet. Datum is National Geodetic Vertical Datum of 1929
- **Well in which water-level measurement was used as control**
- **J4 test cell**

Figure 6. Potentiometric surface of the upper part of the Manchester aquifer in the Arnold Engineering Development Complex area, Tennessee, May 2011.

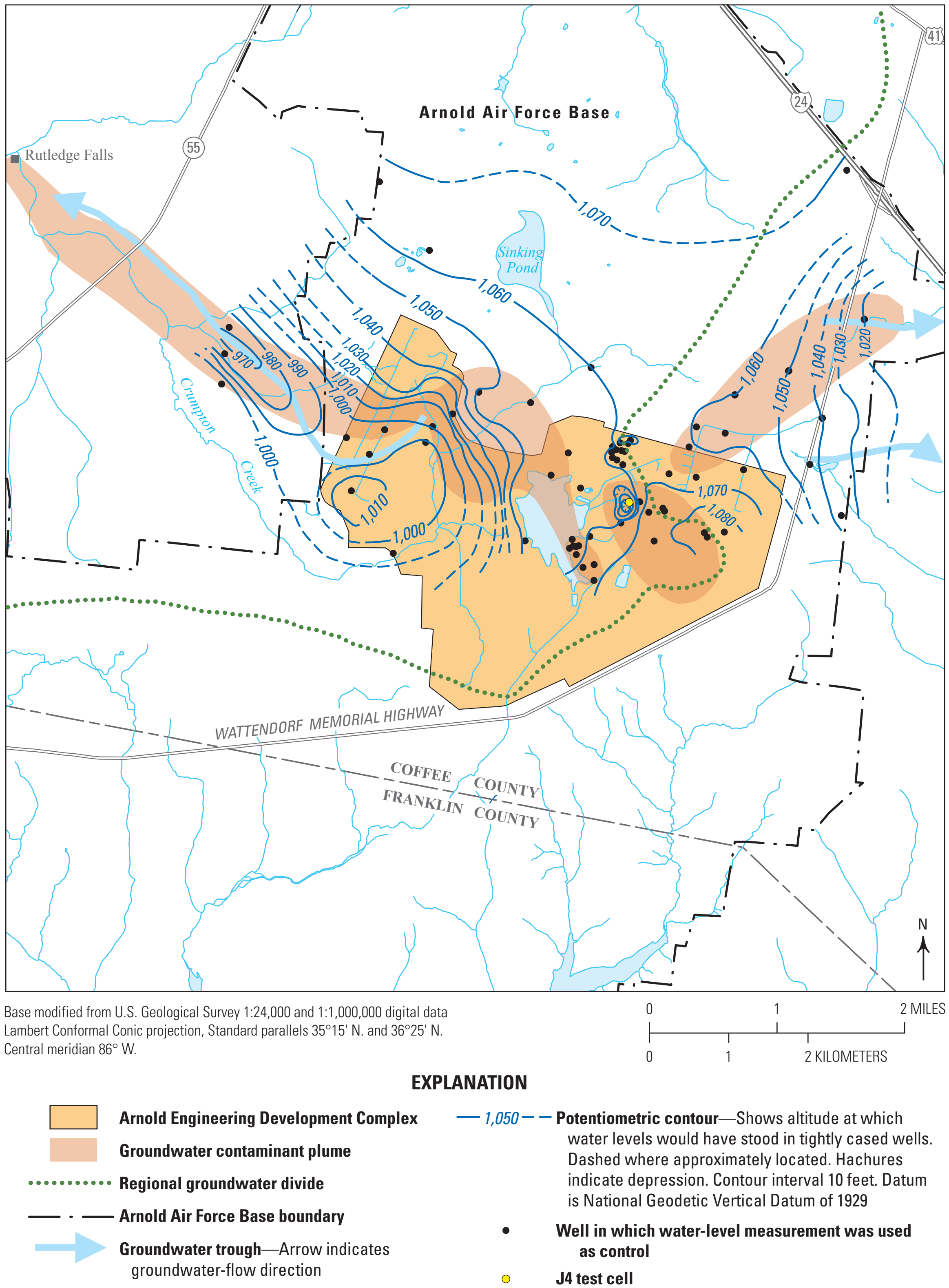
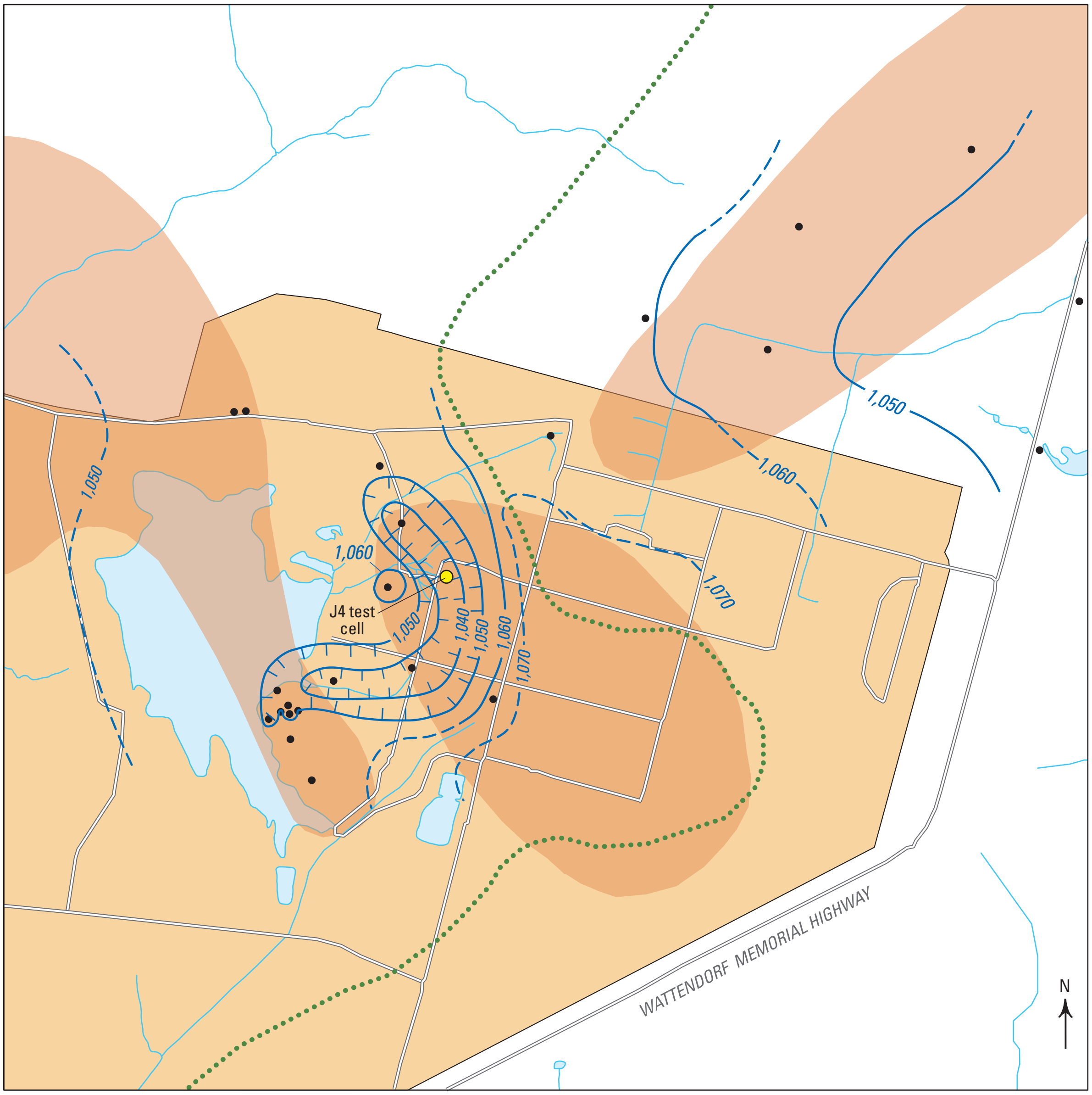


Figure 7. Potentiometric surface of the lower part of the Manchester aquifer in the Arnold Engineering Development Complex area, Tennessee, May 2011.



Base modified from U.S. Geological Survey 1:24,000 and 1:1,000,000 digital data
Lambert Conformal Conic projection, Standard parallels 35°15′ N. and 36°25′ N.
Central meridian 86° W.

0 0.25 0.5 MILE
0 0.25 0.5 KILOMETER

EXPLANATION

Arnold Engineering Development Complex

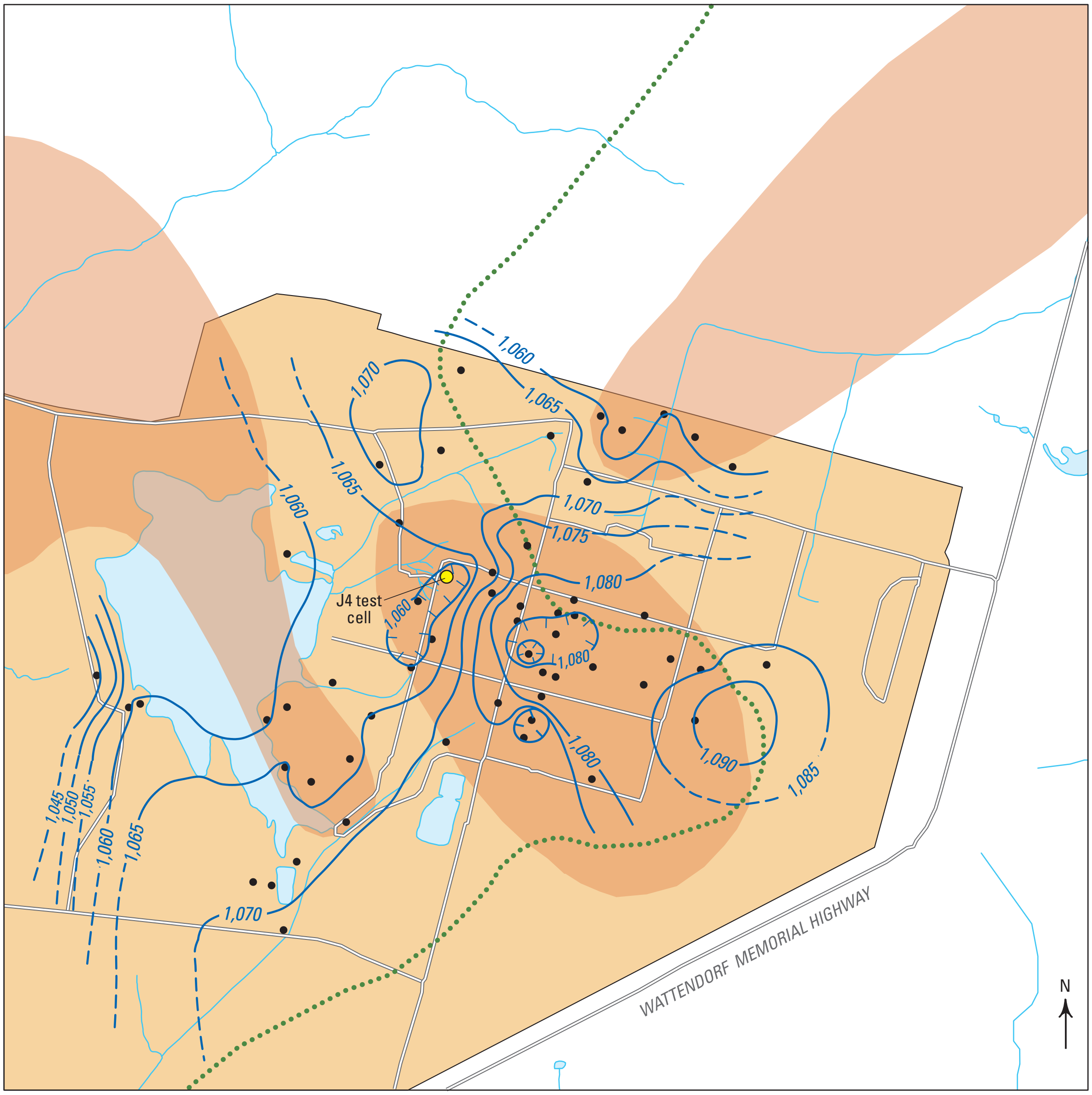
Groundwater contaminant plume

Regional groundwater divide

1,050 — **Potentiometric contour**—Shows altitude at which water levels would have stood in tightly cased wells. Dashed where approximately located. Hachures indicate depression. Contour interval 10 feet. Datum is National Geodetic Vertical Datum of 1929

Well in which water-level measurement was used as control

Figure 8. Potentiometric surface of the Fort Payne aquifer in the Arnold Engineering Development Complex area, Tennessee, May 2011.



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0 0.25 0.5 MILE
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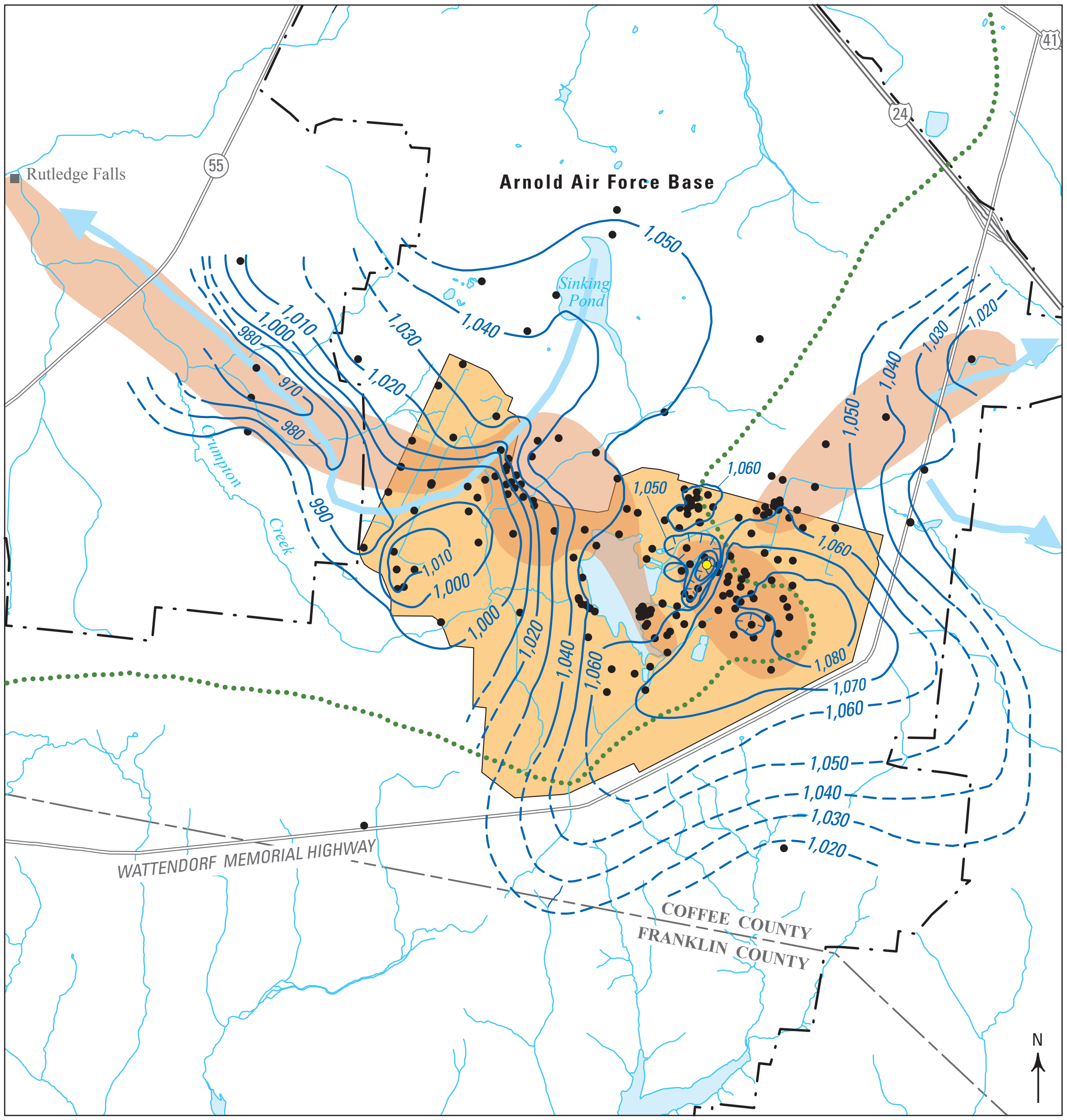
EXPLANATION

- **Arnold Engineering Development Complex**
- **Groundwater contaminant plume**
- **Regional groundwater divide**
- 1,050 **Potentiometric contour**—Shows altitude at which water levels would have stood in tightly cased wells. Dashed where approximately located. Hachures indicate depression. Contour interval 5 feet. Datum is National Geodetic Vertical Datum of 1929
- **Well in which water-level measurement was used as control**

Figure 9. Potentiometric surface of the shallow aquifer in the Arnold Engineering Development Complex area, Tennessee, September 2011.

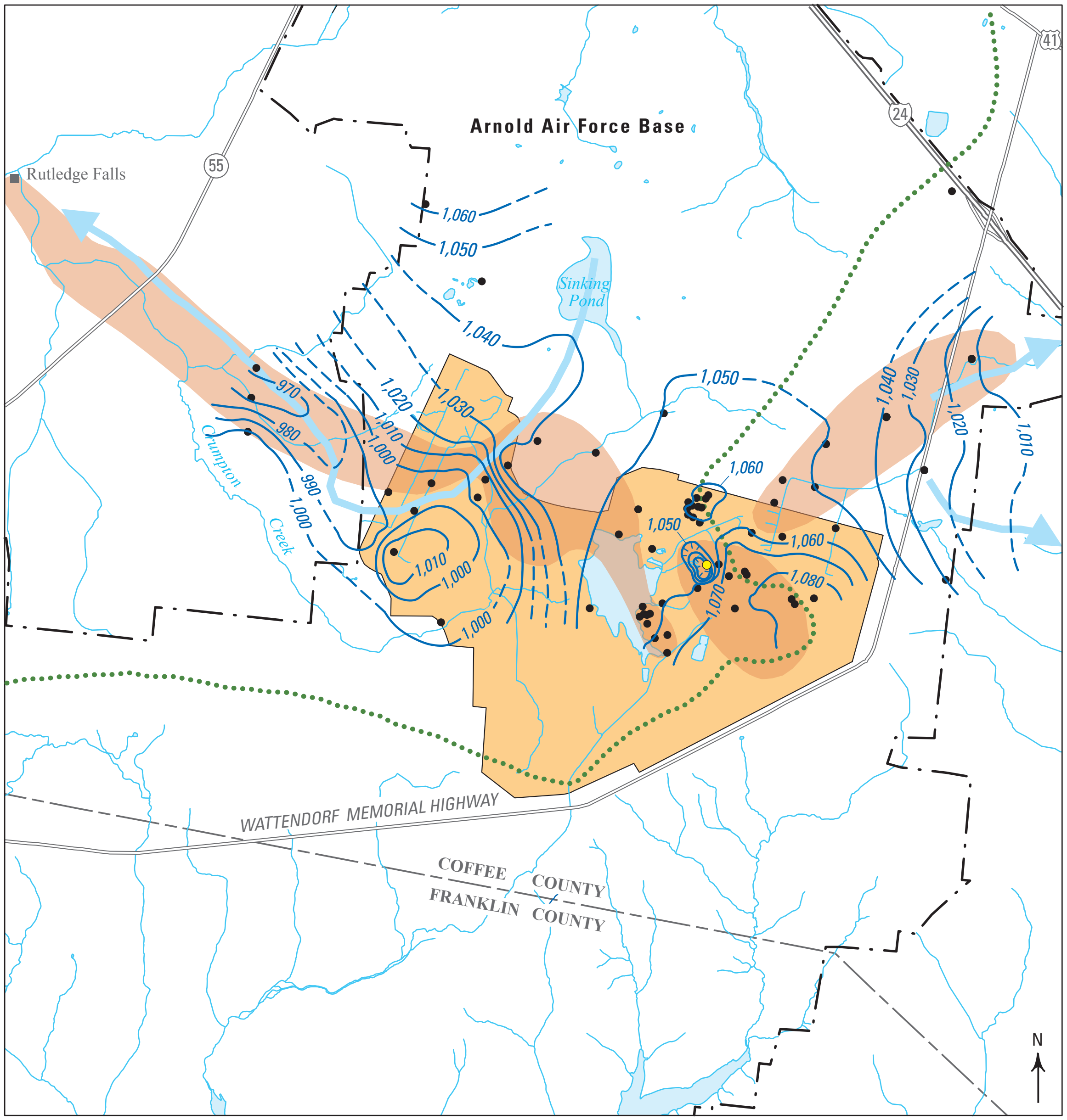


Base modified from U.S. Geological Survey 1:24,000 and 1:1,000,000 digital data
Lambert Conformal Conic projection, Standard parallels 35°15' N. and 36°25' N.
Central meridian 86° W.

EXPLANATION

- **Arnold Engineering Development Complex**
- **Groundwater contaminant plume**
- **Regional groundwater divide**
- **Arnold Air Force Base boundary**
- **Groundwater trough**—Arrow indicates groundwater-flow direction
- 1,050 **Potentiometric contour**—Shows altitude at which water levels would have stood in tightly cased wells. Dashed where approximately located. Hachures indicate depression. Contour interval 10 feet. Datum is National Geodetic Vertical Datum of 1929
- **Well in which water-level measurement was used as control**
- **J4 test cell**

Figure 10. Potentiometric surface of the upper part of the Manchester aquifer in the Arnold Engineering Development Complex area, Tennessee, September 2011.



Base modified from U.S. Geological Survey 1:24,000 and 1:1,000,000 digital data
Lambert Conformal Conic projection, Standard parallels 35°15' N. and 36°25' N.
Central meridian 86° W.

0 1 2 MILES
0 1 2 KILOMETERS

EXPLANATION

Arnold Engineering Development Complex

Groundwater contaminant plume

Regional groundwater divide

Arnold Air Force Base boundary

Groundwater trough—Arrow indicates groundwater-flow direction

1,050 **Potentiometric contour**—Shows altitude at which water levels would have stood in tightly cased wells. Dashed where approximately located. Hachures indicate depression. Contour interval 10 feet. Datum is National Geodetic Vertical Datum of 1929

Well in which water-level measurement was used as control

J4 test cell

Figure 11. Potentiometric surface of the lower part of the Manchester aquifer in the Arnold Engineering Development Complex area, Tennessee, September 2011.

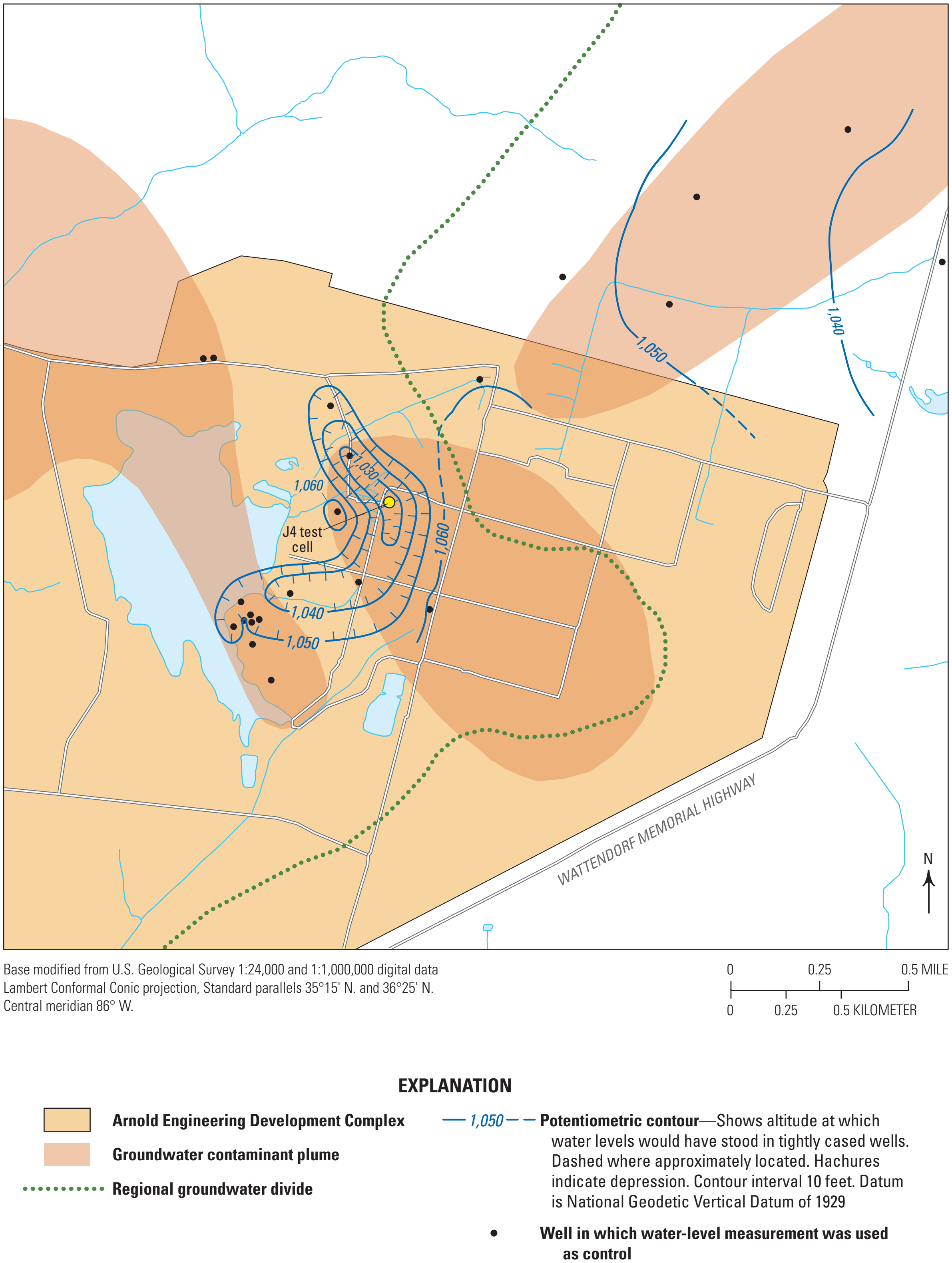


Figure 12. Potentiometric surface of the Fort Payne aquifer in the Arnold Engineering Development Complex area, Tennessee, September 2011.

Summary

Arnold Air Force Base (AAFB) occupies about 40,000 acres in Coffee and Franklin Counties, Tennessee. The primary mission of AAFB is to provide risk-reduction information in the development of aerospace products through test and evaluation. This mission is accomplished in part through test facilities at the Arnold Engineering Development Complex (AEDC), which occupies about 4,000 acres in the center of AAFB. The AAFB is underlain by gravel and limestone aquifers, the most productive of which is the Manchester aquifer. Several volatile organic compounds, primarily chlorinated solvents, have been identified in the groundwater at AAFB. In 2011, the U.S. Geological Survey, in cooperation with the U.S. Air Force, AAFB, completed a study of groundwater flow focused on the AEDC area. The AEDC area is of particular concern because within this area (1) chlorinated solvents have been identified in the groundwater, (2) the aquifers are dewatered around below-grade test facilities, and (3) there is a regional groundwater divide.

Analysis of the groundwater-flow system in the AEDC area was completed by measuring groundwater levels in monitoring wells and constructing potentiometric-surface maps of the four aquifers. During May 2011, water-level data were collected from 374 monitoring wells. Water levels in the wells ranged from 968 to 1,097 feet above the National Geodetic Vertical Datum of 1929 in May 2011. During September 2011, water-level data were collected from 376 monitoring wells. Water levels in the wells ranged from 962 to 1,090 feet above the National Geodetic Vertical Datum of 1929 in September 2011. Potentiometric surfaces were mapped by contouring altitudes of water levels measured in wells completed in the shallow aquifer, the upper and lower parts of the Manchester aquifer, and the Fort Payne aquifer. Water levels are generally 2–14 feet lower in September compared to May.

Potentiometric-surface maps for all aquifers indicate the presence of a groundwater depression at the J4 test cell. Similar groundwater depressions are present in the shallow and upper Manchester aquifers at dewatering facilities within the main testing area of the AEDC. The J4 test cell is the deepest and largest of all the dewatering facilities and the only one to affect water levels in all four aquifers. The highest water levels in all the aquifers are east of the main test area along the regional groundwater divide, which roughly coincides with the Duck River-Elk River surface-water divide. Groundwater gradients are nearly flat along the groundwater divide northeast of AEDC and east of Sinking Pond. Most groundwater from solid waste management unit 74 is captured by the J4 test cell or other dewatering facilities within the main test area. Groundwater in the area west of the divide that is not captured by dewatering facilities generally flows to the west and northwest towards a trough in the potentiometric surface within the Crumpton Creek Basin. Groundwater gradients between the area just west of the main test area and the area around Sinking Pond varied seasonally and may affect the movement and shape of the northwest plume.

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Appendix

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352255086030001	AEDC-1	SH	1,077.0	1,073.6
352252086025602	AEDC-3	SH	1,081.7	1,081.0
352246086024402	AEDC-5	SH	1,080.4	1,080.6
352239086022801	AEDC-7	SH	1,091.0	1,090.4
352246086031301	AEDC-30	SH	1,064.1	1,061.0
352249086030901	AEDC-81	SH	1,066.6	1,064.4
352241086025901	AEDC-82	SH	1,079.4	1,078.6
352254086025501	AEDC-83	SH	1,083.6	1,082.5
352255086024702	AEDC-84	SH	1,081.1	1,080.8
352242086025202	AEDC-85	SH	—	1,083.2
352246086021702	AEDC-86	SH	1,091.6	1,089.2
352241086033203	AEDC-93	SH	1,062.1	1,061.8
352319086031701	AEDC-114	SH	1,080.3	—
352241086035601	AEDC-166	SH	1,060.7	1,058.7
352318086024302	AEDC-171	SH	1,066.4	1,061.5
352304086031403	AEDC-275	SH	1,069.5	1,065.0
352258086030004	AEDC-280	SH	1,070.3	1,067.7
352311086031703	AEDC-284	SH	1,073.4	1,070.8
352313086030803	AEDC-287	SH	1,075.4	1,069.1
352315086025103	AEDC-290	SH	1,072.4	1,066.6
352309086024503	AEDC-293	SH	1,070.3	1,066.0
352254086031101	AEDC-307	SH	1,061.5	1,060.4
352221086033001	AEDC-310	SH	1,068.8	1,068.3
352213086033202	AEDC-311	SH	1,073.6	1,070.7
352245086040102	AEDC-319	SH	1,043.9	1,043.8
352241086035501	AEDC-321	SH	1,063.5	1,062.6
352301086025401	AEDC-324	SH	1,081.1	1,078.5
352253086023601	AEDC-325	SH	1,083.6	1,082.9
352324086030501	AEDC-336	SH	1,076.0	1,067.9
352318086023301	AEDC-407	SH	1,064.2	1,059.6
352316086024003	AEDC-410	SH	1,061.6	1,055.8
352315086022802	AEDC-411	SH	1,063.8	1,057.2
352312086022202	AEDC-419	SH	1,065.1	1,059.1

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352248086025401	AEDC-424	SH	1,074.1	1,073.7
352247086023201	AEDC-426	SH	—	1,081.8
352232086024402	AEDC-476	SH	1,080.8	1,079.4
352245086025201	AEDC-486	SH	1,082.7	1,082.6
352234086032201	AEDC-589	SH	1,065.8	1,063.3
352246086022702	AEDC-591	SH	1,082.7	1,083.5
352300086033202	AEDC-662	SH	1,059.6	1,057.3
352218086033401	AEDC-663	SH	1,069.7	1,068.0
352226086032301	AEDC-668	SH	1,069.0	1,068.9
352219086033701	AEDC-670	SH	1,073.0	1,067.8
352233086033201	AEDC-673	SH	1,066.1	1,066.5
352236086030701	AEDC-680	SH	1,072.2	1,071.7
352244086032503	AEDC-772	SH	1,066.4	1,064.2
352239086033504	AEDC-773	SH	1,060.2	1,059.1
352240086031901	AEDC-774	SH	1,071.1	1,064.7
352231086032802	AEDC-775	SH	1,062.1	1,062.0
352244086023601	AEDC-820	SH	1,084.5	1,084.7
352253086024701	AEDC-827	SH	1,078.6	1,080.5
352253086025002	AEDC-828	SH	1,082.0	1,082.4
352245086025001	AEDC-832	SH	1,083.1	1,083.0
352250086025002	AEDC-834	SH	1,079.4	1,078.2
352239086021501	AEDC-jar-002	SH	1,096.6	Dry
352237086025501	AEDC-PZ10001	SH	1,064.1	1,070.1
352240086025401	AEDC-PZ10006	SH	1,072.1	1,067.4
352256086030001	AEDC-2	UMN	1,068.4	1,065.9
352252086025601	AEDC-4	UMN	1,079.4	1,078.4
352246086024401	AEDC-6	UMN	1,086.9	1,086.7
352239086022802	AEDC-8	UMN	1,087.7	1,087.4
352251086022701	AEDC-10	UMN	1,081.5	1,081.4
352246086031302	AEDC-64	UMN	1,043.0	1,040.7
352241086033202	AEDC-92	UMN	1,056.3	1,054.1
352233086032302	AEDC-97	UMN	1,065.1	1,066.5
352317086033601	AEDC-98	UMN	1,055.5	1,051.6
352301086040402	AEDC-99	UMN	1,051.6	1,048.2
352322086031201	AEDC-102	UMN	1,070.7	1,067.1
352323086030901	AEDC-104	UMN	1,073.4	1,068.3
352319086030903	AEDC-109	UMN	1,071.2	1,068.4

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352319086031402	AEDC-112	UMN	1,069.8	1,066.0
352323086031302	AEDC-116	UMN	1,068.5	1,065.2
352319086030904	AEDC-120	UMN	1,068.6	1,063.0
352317086031401	AEDC-121	UMN	1,070.9	1,066.7
352304086032902	AEDC-124	UMN	1,060.4	1,058.5
352249086030902	AEDC-154	UMN	1,048.9	1,046.0
352242086030001	AEDC-156	UMN	1,078.7	1,078.0
352254086025502	AEDC-158	UMN	1,079.2	1,077.9
352242086025201	AEDC-160	UMN	1,078.9	1,078.2
352255086024703	AEDC-162	UMN	1,079.2	1,078.6
352246086021703	AEDC-164	UMN	1,082.9	—
352237086050303	AEDC-182	UMN	998.4	998.0
352237086050304	AEDC-183	UMN	999.8	999.4
352253086011902	AEDC-199	UMN	1,037.4	—
352354086032502	AEDC-201[1]	UMN	1,059.8	1,049.8
352411086045101	AEDC-213	UMN	1,045.2	1,034.8
352302086053201	AEDC-214	UMN	1,013.9	988.2
352420086024101	AEDC-215	UMN	1,061.6	1,051.2
352414086011001	AEDC-216	UMN	1,022.6	1,014.1
352246086040201	AEDC-217	UMN	1,046.9	1,044.9
352213086035001	AEDC-218	UMN	1,075.1	1,070.1
352123086053701	AEDC-223	UMN	993.4	979.2
352130086040501	AEDC-224	UMN	1,061.6	—
352115086022901	AEDC-226	UMN	1,024.2	1,021.2
352307086041201	AEDC-232	UMN	1,028.8	1,029.5
352247086031501	AEDC-267	UMN	1,064.9	1,060.3
352258086031202	AEDC-269	UMN	1,048.2	1,045.5
352256086031602	AEDC-271	UMN	1,070.4	1,065.9
352301086030601	AEDC-272	UMN	1,042.3	1,038.9
352304086031402	AEDC-274	UMN	1,051.4	1,048.2
352301086025501	AEDC-276	UMN	1,078.6	1,075.9
352258086030003	AEDC-279	UMN	1,058.5	1,055.7
352311086031702	AEDC-283	UMN	1,065.8	1,062.0
352313086030802	AEDC-286	UMN	1,071.2	1,064.7
352315086025102	AEDC-289	UMN	1,067.6	1,059.8
352309086024502	AEDC-292	UMN	1,067.6	1,060.1
352254086040002	AEDC-299	UMN	1,054.7	1,052.0

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352311086035902	AEDC-301	UMN	1,052.6	1,049.1
352320086042201	AEDC-312	UMN	1,027.8	1,025.4
352244086040102	AEDC-314	UMN	1,049.4	1,048.5
352244086035901	AEDC-315	UMN	1,051.6	1,049.3
352244086035902	AEDC-316	UMN	1,052.0	1,051.0
352241086035502	AEDC-317	UMN	1,056.0	1,053.4
352317086023801	AEDC-322	UMN	1,061.4	1,054.2
352246086023101	AEDC-327	UMN	1,081.6	1,082.8
352324086030402	AEDC-331	UMN	1,070.7	1,063.5
352325086031001	AEDC-332	UMN	1,070.8	1,063.8
352321086031302	AEDC-333	UMN	1,067.9	1,062.3
352320086031202	AEDC-334	UMN	1,068.6	1,062.0
352343086051601	AEDC-342	UMN	1,018.2	1,015.4
352441086044502	AEDC-354	UMN	1,063.7	1,046.0
352436086041201	AEDC-355	UMN	—	1,043.6
352458086034702	AEDC-356	UMN	—	1,046.7
352507086034501	AEDC-358	UMN	—	1,052.7
352234086032101	AEDC-364	UMN	1,065.2	1,062.9
352236086033201	AEDC-365	UMN	1,058.1	1,056.5
352240086033302	AEDC-366	UMN	1,055.9	1,053.7
352244086032502	AEDC-367	UMN	1,061.2	1,059.6
352319086031702	AEDC-368	UMN	1,066.5	1,062.6
352326086031501	AEDC-369	UMN	1,064.4	1,058.3
352314086030801	AEDC-370	UMN	1,066.9	1,060.3
352315086022801	AEDC-412	UMN	1,062.1	1,063.4
352318086024301	AEDC-413	UMN	1,061.4	1,052.6
352312086022201	AEDC-420	UMN	1,062.7	1,054.0
352317086023701	AEDC-421	UMN	1,061.2	1,052.4
352334086043302	AEDC-450	UMN	1,023.4	1,019.6
352403086050401	AEDC-451	UMN	1,039.7	1,029.5
352321086023502	AEDC-452	UMN	1,061.3	1,052.2
352319086034002	AEDC-453	UMN	1,054.5	1,050.8
352319086030202	AEDC-454	UMN	1,070.7	1,061.7
352318086022501	AEDC-455	UMN	—	1,053.0
352246086040202	AEDC-456	UMN	1,047.3	1,045.0
352305086035401	AEDC-457	UMN	1,054.0	1,050.4
352300086033201	AEDC-458	UMN	1,056.7	1,053.9

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352330086034501	AEDC-460	UMN	1,053.0	1,049.3
352344086045801	AEDC-461	UMN	1,033.6	1,026.7
352327086045101	AEDC-462	UMN	995.2	994.1
352357086040801	AEDC-463	UMN	1,053.1	—
352340086043601	AEDC-464[1]	UMN	1,020.1	1,015.9
352352086014511	AEDC-465	UMN	1,056.4	1,043.3
352309086043101	AEDC-467	UMN	999.3	998.2
352328086050704	AEDC-469	UMN	996.7	962.3
352232086024401	AEDC-470	UMN	1,072.2	1,070.2
352352086043801	AEDC-471	UMN	1,040.3	1,032.3
352306086044601	AEDC-472	UMN	—	1,002.0
352342086021201	AEDC-473	UMN	1,062.2	1,050.8
352328086050702	AEDC-474	UMN	996.8	995.3
352220086023601	AEDC-487	UMN	1,082.4	1,079.7
352333086012801	AEDC-488	UMN	1,041.4	1,029.5
352226086030201	AEDC-498	UMN	1,082.2	—
352334086052101	AEDC-499	UMN	1,002.6	1,001.7
352344086041101	AEDC-501	UMN	1,051.2	1,043.3
352356086034901	AEDC-502	UMN	1,057.3	—
352334086052102	AEDC-503	UMN	1,002.5	999.6
352339086035402	AEDC-504	UMN	1,053.1	1,049.4
352321086023401	AEDC-518[1]	UMN	1,061.2	1,052.2
352328086050705	AEDC-523	UMN	996.7	995.1
352327086050702	AEDC-524	UMN	996.9	995.7
352327086050701	AEDC-525	UMN	996.3	994.9
352303086052402	AEDC-561	UMN	1,015.2	1,010.5
352318086051502	AEDC-563	UMN	995.6	993.5
352242086035703	AEDC-599	UMN	1,052.9	1,050.5
352347086062902	AEDC-602	UMN	1,002.5	1,000.7
352358086062702	AEDC-604	UMN	971.0	969.8
352410086062502	AEDC-606	UMN	967.8	966.9
352449086063201	AEDC-607	UMN	—	1,004.6
352413086054001	AEDC-615	UMN	1,037.7	1,023.0
352241086042801	AEDC-620	UMN	1,002.7	1,001.7
352256086024802	AEDC-624	UMN	1,079.1	1,078.2
352246086022701	AEDC-626	UMN	1,081.5	—
352242086035701	AEDC-635	UMN	1,058.4	1,057.0

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352314086013501	AEDC-650	UMN	1,039.4	1,031.0
352312086020801	AEDC-652	UMN	1,063.4	1,056.0
352327086021701	AEDC-654	UMN	1,061.5	1,052.4
352331086023601	AEDC-658	UMN	1,062.1	1,052.0
352232086035803	AEDC-660	UMN	1,058.9	1,055.5
352329086023101	AEDC-665	UMN	1,062.6	1,052.1
352226086032201	AEDC-667	UMN	1,068.6	1,067.1
352219086033702	AEDC-669	UMN	1,070.4	1,068.8
352213086033201	AEDC-671	UMN	1,074.8	1,071.3
352221086033002	AEDC-672	UMN	1,069.4	1,067.1
352220086034701	AEDC-675	UMN	1,068.2	1,064.3
352314086013504	AEDC-677	UMN	1,040.2	1,031.8
352314086013503	AEDC-678	UMN	1,040.1	1,031.8
352237086030701	AEDC-679	UMN	1,072.9	1,072.4
352318086045101	AEDC-700	UMN	1,007.4	1,003.6
352323086044702	AEDC-701	UMN	1,000.7	998.6
352333086043401	AEDC-703	UMN	1,015.3	1,013.4
352333086043402	AEDC-704	UMN	1,014.8	1,012.5
352309086034403	AEDC-707	UMN	1,054.4	1,050.9
352243086033401	AEDC-710	UMN	1,054.5	1,052.7
352231086032801	AEDC-712	UMN	1,060.3	1,059.3
352239086033503	AEDC-714	UMN	1,056.1	1,053.7
352237086031501	AEDC-719	UMN	1,066.8	1,069.0
352243086031801	AEDC-720	UMN	1,064.1	1,059.7
352240086031801	AEDC-721	UMN	1,066.1	1,062.0
352249086052201	AEDC-723	UMN	1,019.9	1,010.5
352256086052301	AEDC-724	UMN	1,019.6	1,011.9
352256086051501	AEDC-725	UMN	1,019.0	1,010.0
352250086051702	AEDC-727	UMN	1,007.9	Dry
352319086023901	AEDC-747	UMN	1,061.2	1,052.4
352318086023302	AEDC-748	UMN	1,062.1	1,062.4
352320086023501	AEDC-749	UMN	1,061.1	1,052.2
352320086023301	AEDC-750	UMN	1,061.0	1,052.1
352322086023301	AEDC-751	UMN	1,061.5	1,052.7
352316086024002	AEDC-776	UMN	1,060.9	1,052.3
352316086024001	AEDC-777	UMN	1,061.5	1,054.1
352329086044302	AEDC-779	UMN	996.0	994.9

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352337086043301	AEDC-781	UMN	1,031.1	1,026.2
352343086042002	AEDC-782	UMN	1,050.8	1,015.3
352239086023801	AEDC-784	UMN	1,078.3	1,078.6
352236086024501	AEDC-785	UMN	1,064.2	1,062.3
352233086023301	AEDC-786	UMN	1,083.8	1,082.1
352233086025301	AEDC-787	UMN	1,080.1	1,078.9
352327086042801	AEDC-789	UMN	1,031.3	1,027.2
352331086043001	AEDC-790	UMN	1,031.0	1,026.9
352326086043001	AEDC-791	UMN	1,013.9	1,011.8
352328086043201	AEDC-792	UMN	1,017.1	1,015.1
352324086043301	AEDC-793	UMN	1,001.9	1,000.9
352330086043901	AEDC-795	UMN	998.1	997.0
352338086042301	AEDC-796	UMN	1,050.8	1,043.1
352327086043401	AEDC-797	UMN	1,005.6	1,004.1
352323086042601	AEDC-801	UMN	1,014.9	1,012.1
352322086042201	AEDC-802	UMN	1,028.8	1,025.5
352243086033302	AEDC-803	UMN	1,054.7	1,052.8
352243086033304	AEDC-804	UMN	1,054.7	1,052.9
352243086033303	AEDC-805	UMN	1,057.6	1,056.5
352239086033401	AEDC-806	UMN	1,056.2	1,054.0
352239086033402	AEDC-807	UMN	1,056.2	1,054.0
352239086033403	AEDC-808	UMN	1,057.7	1,055.9
352241086033101	AEDC-809	UMN	1,056.7	1,054.6
352241086033102	AEDC-810	UMN	1,056.8	1,054.6
352241086033103	AEDC-811	UMN	1,058.3	1,056.7
352242086033001	AEDC-812	UMN	1,057.0	1,054.9
352242086033002	AEDC-813	UMN	1,057.0	1,054.9
352242086033003	AEDC-814	UMN	1,058.2	1,056.7
352240086033303	AEDC-815	UMN	1,058.3	1,056.7
352241086033204	AEDC-816	UMN	1,058.3	1,056.8
352243086033402	AEDC-817	UMN	1,052.8	1,050.2
352242086033501	AEDC-818	UMN	1,055.1	1,052.6
352253086023602	AEDC-821	UMN	1,081.8	1,082.1
352300086022701	AEDC-822	UMN	1,078.3	1,074.9
352303086023901	AEDC-824	UMN	1,077.1	1,073.4
352248086024501	AEDC-826	UMN	1,079.4	1,079.2
352253086025001	AEDC-829	UMN	1,080.1	1,077.4

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352248086025501	AEDC-830	UMN	1,078.4	1,077.3
352246086025201	AEDC-831	UMN	—	1,077.9
352245086025001	AEDC-832	UMN	—	1,083.0
352250086025001	AEDC-833	UMN	1,078.4	1,077.8
352250086051902	AEDC-835	UMN	1,019.5	1,009.7
352250086051901	AEDC-836	UMN	1,023.0	Dry
352300086023301	AEDC-874	UMN	1,080.2	1,078.1
352324086052602	AEDC-559A	UMN	996.7	993.9
352326086021702	AEDC-653UD	UMN	1,057.3	1,050.5
352244086032501	AEDC-708UD	UMN	1,060.8	1,059.3
352243086033305	AEDC-709LD	UMN	—	1,044.8
352243086033306	AEDC-709UD	UMN	1,055.0	1,053.1
352232086032802	AEDC-711UD	UMN	1,062.2	1,060.6
352239086033505	AEDC-713UD	UMN	1,056.0	1,053.7
352240086033305	AEDC-715UD	UMN	1,055.7	1,053.4
352240086033203	AEDC-716UD	UMN	1,056.6	1,054.5
352240086033002	AEDC-717UD	UMN	1,057.3	1,055.2
352237086033102	AEDC-718UD	UMN	1,057.3	1,056.3
352314086032401	AEDC-jar-001	UMN	1,062.4	1,058.8
352243086022901	AEDC-jar-003	UMN	1,081.6	1,082.4
352246086025801	AEDC-no num1	UMN	—	1,077.9
352423086042501	AEDC-PZ-BKG-1	UMN	1,054.7	1,043.9
352322086030601	AEDC-22	LMN	1,066.6	1,059.1
352321086031303	AEDC-29	LMN	1,057.7	1,050.9
352233086032301	AEDC-96	LMN	1,068.1	1,065.9
352323086031001	AEDC-105	LMN	1,070.4	1,063.1
352319086030902	AEDC-110	LMN	1,055.4	1,048.9
352319086031401	AEDC-113	LMN	1,067.2	1,061.5
352319086030701	AEDC-118	LMN	1,067.5	1,060.7
352316086031301	AEDC-119	LMN	1,066.4	1,059.7
352304086032901	AEDC-125	LMN	1,059.2	1,059.3
352249086030903	AEDC-155	LMN	1,064.5	1,062.8
352254086025503	AEDC-159	LMN	1,077.6	1,075.9
352242086025301	AEDC-161	LMN	1,078.9	1,078.2
352255086024701	AEDC-163	LMN	1,077.5	1,077.6
352246086021701	AEDC-165	LMN	1,083.8	1,083.6
352515086011702	AEDC-177[1]	LMN	1,068.7	1,036.3

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352237086050302	AEDC-181	LMN	998.9	998.3
352509086051102	AEDC-185	LMN	1,067.9	1,061.9
352253086011901	AEDC-198	LMN	1,036.2	1,029.7
352354086032501	AEDC-200	LMN	1,059.8	1,049.9
352258086030002	AEDC-278	LMN	1,063.3	1,059.6
352313086030801	AEDC-285	LMN	1,066.0	1,059.4
352309086034401	AEDC-305[1]	LMN	1,054.5	1,051.9
352324086030401	AEDC-330	LMN	1,070.5	1,063.2
352320086031201	AEDC-335	LMN	1,067.9	1,061.4
352441086044501	AEDC-353[1]	LMN	1,065.2	1,046.0
352352086014510	AEDC-428	LMN	1,055.6	1,041.8
352334086043301	AEDC-459	LMN	1,028.4	1,043.2
352328086050701	AEDC-468	LMN	997.0	996.0
352318086033501	AEDC-494	LMN	1,055.7	1,051.3
352339086035401	AEDC-505	LMN	1,053.6	1,049.2
352321086023501	AEDC-520	LMN	1,061.3	1,052.2
352324086052601	AEDC-559	LMN	996.4	994.2
352303086052401	AEDC-560	LMN	1,017.8	1,016.6
352318086051501	AEDC-562	LMN	993.9	991.0
352316086031101	AEDC-598	LMN	1,066.3	1,059.7
352242086035702	AEDC-600	LMN	1,053.2	1,050.6
352347086062901	AEDC-601	LMN	1,001.2	999.5
352359086062701	AEDC-603	LMN	970.6	970.5
352410086062501	AEDC-605	LMN	972.0	972.8
352244086022601	AEDC-619	LMN	1,082.9	1,083.3
352256086024801	AEDC-623	LMN	1,080.3	1,086.8
352246086022703	AEDC-625	LMN	1,081.5	1,082.6
352312086020802	AEDC-651	LMN	1,063.6	1,056.1
352329086023102	AEDC-664	LMN	1,058.6	1,056.4
352226086032302	AEDC-666	LMN	1,068.5	1,067.0
352310086024501	AEDC-732	LMN	1,067.7	1,060.1
352329086044301	AEDC-778	LMN	1,002.0	1,000.7
352323086044701	AEDC-780	LMN	1,003.4	1,000.7
352343086042001	AEDC-783	LMN	1,050.7	1,040.5
352308086023201	AEDC-875	LMN	1,065.5	1,057.7
352413086010703	AEDC-647-106.0	LMN	1,019.6	1,011.8
352413086010701	AEDC-647-116.0	LMN	1,019.6	1,011.8
352413086010706	AEDC-647-74.5	LMN	1,019.6	1,011.6

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352413086010708	AEDC-647-76.5	LMN	1,019.7	1,012.2
352413086010707	AEDC-647-81.0	LMN	1,019.9	1,012.0
352413086010705	AEDC-647-84.3	LMN	1,020.0	1,011.9
352413086010709	AEDC-647-88.0	LMN	1,020.0	1,012.1
352413086010702	AEDC-647-99.6	LMN	1,019.6	1,012.1
352333086012807	AEDC-648-117.5	LMN	1,040.4	1,034.0
352333086012803	AEDC-648-54.1	LMN	1,040.3	1,028.4
352333086012804	AEDC-648-59.5	LMN	1,040.2	1,029.2
352333086012805	AEDC-648-63.3	LMN	1,040.3	1,028.4
352352086014503	AEDC-649-100	LMN	1,055.0	1,041.5
352352086014504	AEDC-649-111.5	LMN	1,058.4	1,056.1
352352086014505	AEDC-649-123.5	LMN	1,025.1	1,015.8
352352086014506	AEDC-649-127.5	LMN	1,024.1	1,016.1
352352086014507	AEDC-649-131.5	LMN	1,023.9	1,014.3
352352086014501	AEDC-649-47	LMN	1,054.7	1,041.2
352352086014502	AEDC-649-51	LMN	1,055.1	1,041.2
352326086021702	AEDC-653UD	LMN	1,057.3	1,050.5
352314086013505	AEDC-655UD	LMN	1,041.7	—
352342086021207	AEDC-656-59.0	LMN	1,061.1	1,049.7
352342086021205	AEDC-656-65.5	LMN	1,061.2	1,049.9
352342086021209	AEDC-656-70.0	LMN	1,061.1	1,049.8
352342086021210	AEDC-656-79.5	LMN	1,060.3	1,050.6
352342086021203	AEDC-656-88.0	LMN	1,060.4	1,051.8
352342086021208	AEDC-656-94.0	LMN	1,060.4	1,051.2
352342086021204	AEDC-656-99.5	LMN	1,060.4	1,051.2
352244086032501	AEDC-708UD	LMN	1,060.8	1,059.3
352243086033306	AEDC-709UD	LMN	1,055.0	1,053.1
352232086032802	AEDC-711UD	LMN	1,062.2	1,060.6
352239086033505	AEDC-713UD	LMN	1,056.0	1,053.7
352240086033305	AEDC-715UD	LMN	1,055.7	1,053.4
352240086033203	AEDC-716UD	LMN	1,056.6	1,054.5
352240086033002	AEDC-717UD	LMN	1,057.3	1,055.2
352237086033102	AEDC-718UD	LMN	1,057.3	1,056.3
352246086031303	AEDC-31	FP	1,036.6	1,035.3
352241086033201	AEDC-91	FP	1,047.9	1,045.8
352242086030002	AEDC-157	FP	1,062.1	1,060.9
352256086031601	AEDC-270	FP	1,067.8	1,063.2
352304086031401	AEDC-273	FP	1,033.3	1,029.5

Table 1–1. Water-level altitudes for the Arnold Engineering Development Complex area, Tennessee, May and September 2011.—Continued

[USGS, U.S. Geoligical Survey; AEDC, Arnold Engineering Development Complex. NGVD 29, National Geodetic Vertical Datum of 1929. Hydrogeologic unit: FP, Fort Payne aquifer; LMN, lower part of Manchester aquifer; SH, shallow aquifer; UMN, upper part of Manchester aquifer. —, no data]

USGS site identification	AEDC well number	Hydro-geologic unit	Water-level altitude, in feet above NGVD 29	
			May 2011	September 2011
352311086031701	AEDC-282	FP	1,053.7	1,049.3
352315086025101	AEDC-288	FP	1,067.4	1,059.2
352319086033801	AEDC-481	FP	1,053.4	1,049.3
352318086034001	AEDC-551	FP	1,053.6	1,049.8
352333086012808	AEDC-648-140.5	FP	1,016.2	1,011.5
352352086014509	AEDC-649-184.5	FP	1,053.5	1,047.3
352326086021703	AEDC-653LD	FP	1,055.8	1,049.4
352314086013506	AEDC-655LD	FP	1,048.1	—
352342086021206	AEDC-656-142.5	FP	1,053.2	1,045.5
352330086023603	AEDC-657LD	FP	1,061.7	1,051.9
352244086032505	AEDC-708LD	FP	1,036.9	1,035.0
352243086033305	AEDC-709LD	FP	1,046.0	1,044.8
352232086032803	AEDC-711LD	FP	1,052.7	1,051.1
352239086033501	AEDC-713LD	FP	1,046.5	1,045.1
352240086033304	AEDC-715LD	FP	1,055.5	1,053.3
352240086033201	AEDC-716LD	FP	1,046.1	1,044.6
352240086033003	AEDC-717LD	FP	1,051.0	1,049.2
352237086033103	AEDC-718LD	FP	1,057.3	1,056.3

[1]Well with continuous water-level measurements (see fig. 4).

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