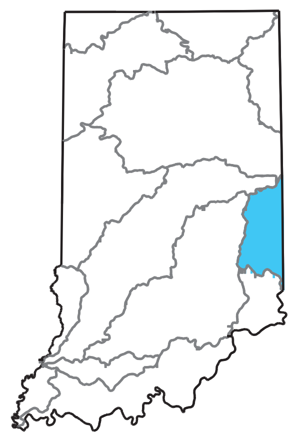


WHITEWATER RIVER BASIN

By M. Catharine Woodfield

General Description

The Whitewater River water-management basin is located in southeastern Indiana. The basin extends approximately 75 mi along the Indiana-Ohio State line. Its maximum width is approximately 30 mi, south of the Brookville Reservoir (fig. 66). The basin encompasses an area of 1,425 mi^2 and includes all of Wayne and Union Counties, most of Fayette and Franklin Counties, and parts of Randolph, Henry, Decatur, and Dearborn Counties. The largest cities in the basin are Richmond and Connersville.

Previous Studies

The most comprehensive study of the Whitewater River basin's ground-water resources was done by the Indiana Department of Natural Resources (1988). Information on ground-water quality and availability, a potentiometric-surface map, and an aquifer-system map were included in this study. Wolf (1969) presented information on the hydrogeology of the unconsolidated water-bearing units and bedrock aquifers, including data on the thickness and permeability of the aquifers, well yields, ground-water discharge to streams, and water quality. Reports on ground-water availability, quality, bedrock topography, and piezometric surface for Union and Fayette Counties were prepared by Clark (1992) and Reynolds (1993), respectively.

Several authors have reported on the ground-water resources for the entire State of Indiana. Harrell (1935) wrote a comprehensive report on the ground-water resources for each county in Indiana. Bechert and Heckard (1966) delineated ground-water provinces on the basis of well yields and sources of ground water. Clark (1980) examined the different types of aquifers and their potential yields.

A detailed description of the unconsolidated materials for the entire basin was presented by Gooding (1963, 1966, 1973, and 1975). Gruver (1984) described the outwash deposits along the Whitewater River.

Physiography

Two physiographic units are included in the Whitewater River basin. The Tipton Till Plain, in the northern one-third of the basin, is characterized by gently rolling topography. In contrast, the southern two-thirds of the basin is characterized by bedrock-controlled rugged relief of the Dearborn Upland (fig. 67) (Schneider, 1966, p. 42).

The glaciated northern part of the basin (Tipton Till Plain) is underlain by a moderate thickness of glacial till (fig. 68), ranging from greater than 400 ft in a segment of the Lafayette Buried Bedrock Valley (fig. 7) to less than 50 ft near the southern boundary of the Tipton Till Plain. Headwater tributaries of the Whitewater River—namely, the West Fork, Greens Fork, Nolands Fork, and East Fork (fig. 66)—are incised into the Tipton Till Plain and have local relief of greater than 100 ft. Other geomorphic features of the Tipton Till Plain include moraines, kames, ice-channel fills (eskers), outwash plains, and valley trains. The predominant features are the moraines (fig. 67).

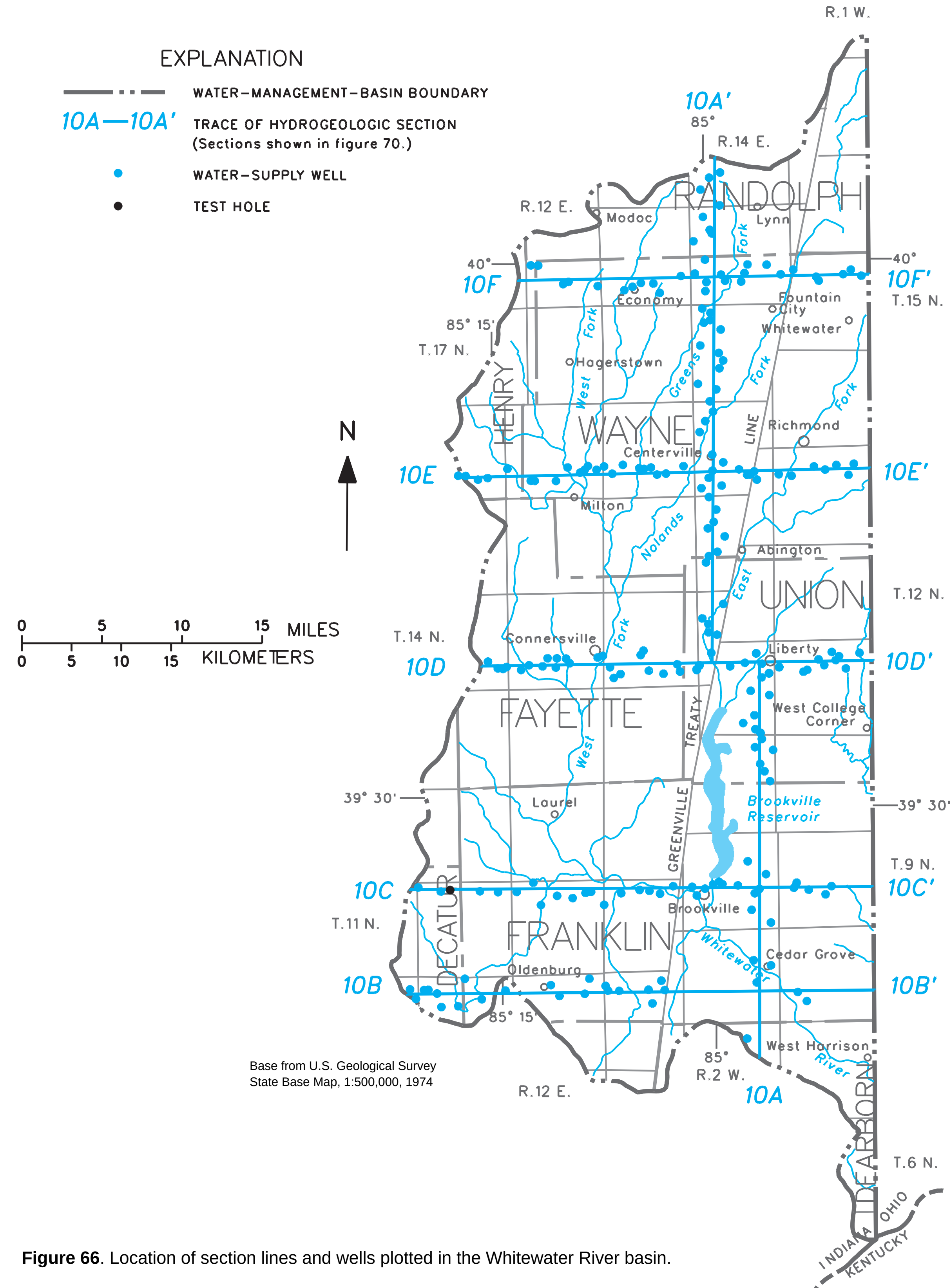
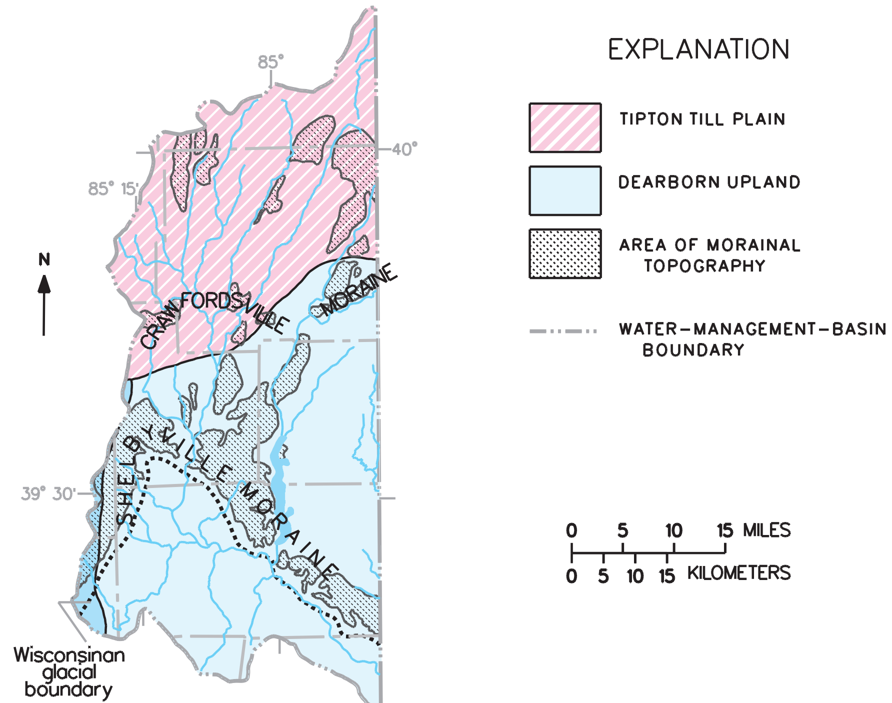


Figure 66. Location of section lines and wells plotted in the Whitewater River basin.



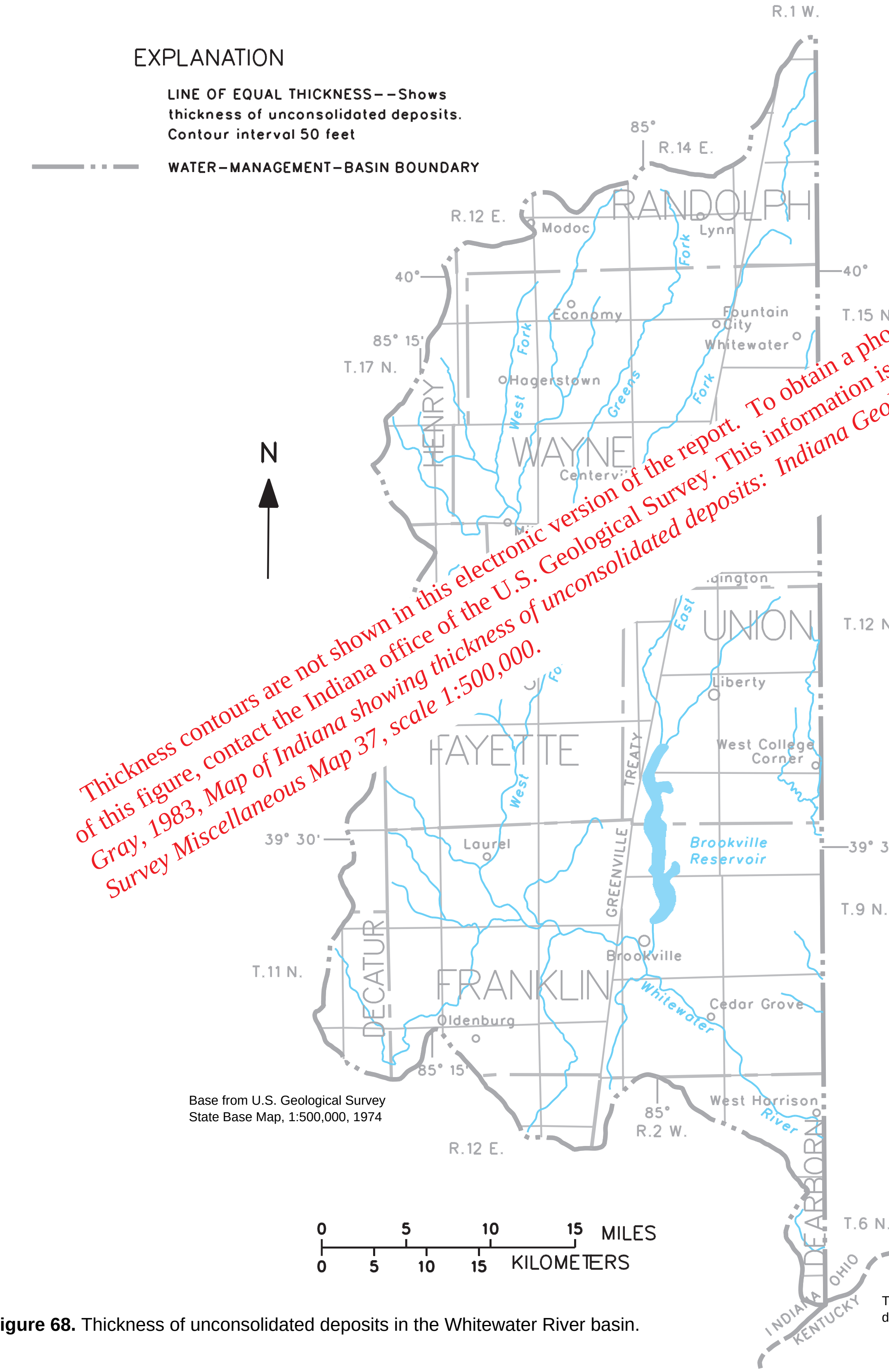
Base from U.S. Geological Survey
State Base Map, 1:500,000, 1974

Physiographic units from
Schneider, 1966, fig. 14.
Morainal areas from Gray, 1989

Figure 67. Physiographic units, moraines, and extent of glaciation in the Whitewater River basin.

The first and southernmost advance of the Erie Lobe (fig. 8) is marked by the segmented terminal Shelbyville Moraine (Wayne, 1965, p. 12). The Crawfordsville Moraine is a segmented recessional moraine marked by many kames and a large outwash plain (Wayne, 1965, p. 11). A segmented moraine deposited after the Crawfordsville Moraine (formerly called the Knightstown Moraine), covers most of the northern part of the basin and merges with the continuation of the Farmersville and Camden Moraines of Ohio (Wayne, 1965, p. 12). The boundary between the Tipton Till Plain and the Dearborn Upland is a broad arbitrary transitional zone where the glacial till is too thin to obscure the bedrock-surface relief of the Dearborn Upland (Schneider, 1966, p. 49).

The Dearborn Upland is a highly dissected bedrock plateau of rugged relief that is underlain by nearly flat-lying limestones and shales of Silurian and Ordovician age (Schneider, 1966, p. 42). The top of the plateau is covered by a cap of glacial till 15 to 50 ft thick (Schneider, 1966, p. 43). Large volumes of water from rapid ice melts have eroded deep valleys in this plateau, producing the major tributary valleys of the East and West Forks of the Whitewater River. These valleys have functioned as sluiceways for glacial meltwaters and extensive valley trains have developed within their courses. The valley-train deposits form a series of five to six outwash terraces that stand well above the present flood plains (Gooding, 1957, p. 1).



Base from U.S. Geological Survey
State Base Map, 1:500,000, 1974

Thickness of unconsolidated
deposits from Gray, 1983

Figure 68. Thickness of unconsolidated deposits in the Whitewater River basin.

Surface-Water Hydrology

The Whitewater River, a major tributary of the Great Miami River in Ohio, drains 1,296 mi^2 in southeastern Indiana. Greens Fork, Nolands Fork, and the East and West Forks of the Whitewater River in southern Randolph County drain this basin to the Indiana-Ohio State line, near West Harrison, Ind. (fig. 66). The East Fork Whitewater River drains 352 mi^2 (312 mi^2 in Indiana), the West Fork drains 842 mi^2, and the main stem south of Brookville drains 145 mi^2 (142 mi^2 in Indiana) (Hoggatt, 1975, p. 78 and 94).

The Whitewater River water-management basin in Indiana also includes areas with headwater streams that drain into the Great Miami River in Ohio. These areas are in the northeastern, east-central, and southeastern parts of the basin and total more than 100 mi^2, accounting for the remainder of the basin's 1,425 mi^2 .

Greens Fork and Nolands Fork, headwater streams of the West Fork Whitewater River, originate in the northern part of the basin and flow south-southwest (fig. 66). The East Fork Whitewater River originates in Ohio and drains the northeastern part of the basin as it flows south-southwest. The average discharge of the East Fork Whitewater River at Brookville at drainage area 380 mi^2 (1954-88) is 396 ft^3/s (Glatfelter and others, 1989, p. 49). The West Fork Whitewater River abruptly turns to the southeast in Franklin County where it joins the East Fork Whitewater River at Brookville. The average discharge of the Whitewater River at Brookville at drainage area 1,224 mi^2 (1916-17 and 1924-88) is 1,266 ft^3/s; flow ranged from a daily mean discharge of 60 ft^3/s to an instantaneous peak of 81,800 ft^3/s (Glatfelter and others, 1989, p. 50). The Whitewater River flows to the southeast out of Indiana through Dearborn County into the southwest-flowing Great Miami River in Ohio, which empties into the Ohio River at the intersection of Indiana, Ohio, and Kentucky.

The Whitewater River basin includes several manmade lakes that are used for reservoirs, especially in the southern part of the basin where ground-water supplies are limited. The East Fork Whitewater River flows into Brookville Reservoir (fig. 66), Indiana's second deepest (Indiana Department of Natural Resources, 1988, p. 1) and largest normal capacity reservoir (Ruddy and Hitt, 1990, p. 100).

Geology

Bedrock Deposits

The major geologic structure in the Whitewater River basin is the Cincinnati Arch (fig. 4) (Malott, 1922, p. 128). The crest of the arch trends north-northwest and bisects the basin. On the crest of the arch the rocks are nearly horizontal; the rocks on the western side dip west-southwest at an average of 25 ft/mi into the Illinois Basin (fig. 4) (Gutschick, 1966, p. 10), and rocks on the eastern side dip east to northeast at a similar rate into the Appalachian Basin. Because of this geologic structure and erosional processes, rocks of Ordovician age are exposed in the center of the basin, whereas rocks of Silurian age are exposed in the northeastern corner and southwestern edge of the basin (fig. 69).

The oldest rocks in the basin, at depths of 1,500 to 2,000 ft, are Precambrian granite, basalt, and arkose (fig. 5). These rocks are overlain by Cambrian rocks consisting of sandstone, shale, limestone, and dolomite (Gray, 1987). Unexposed Ordovician rocks that overlie the Cambrian rocks in the basin are composed primarily of dolomite, limestone, and sandstone. These Cambrian and Ordovician bedrock units are too deep to serve as a practical source for water supply, and the ground water is not potable in most places because of excessive concentrations of dissolved solids.

The oldest exposed bedrock in the Whitewater River basin is the Ordovician Maquoketa Group (figs. 5 and 69). This group is a westward-thinning wedge of rocks, approximately 700 to 1,000 ft thick in the basin, which consists primarily of shale in its lower part and limestone with smaller amounts of shale in its upper part (Gray, 1972, p. 5). The formations contained within this group include the Kope, Dillsboro, and Whitewater Formations.

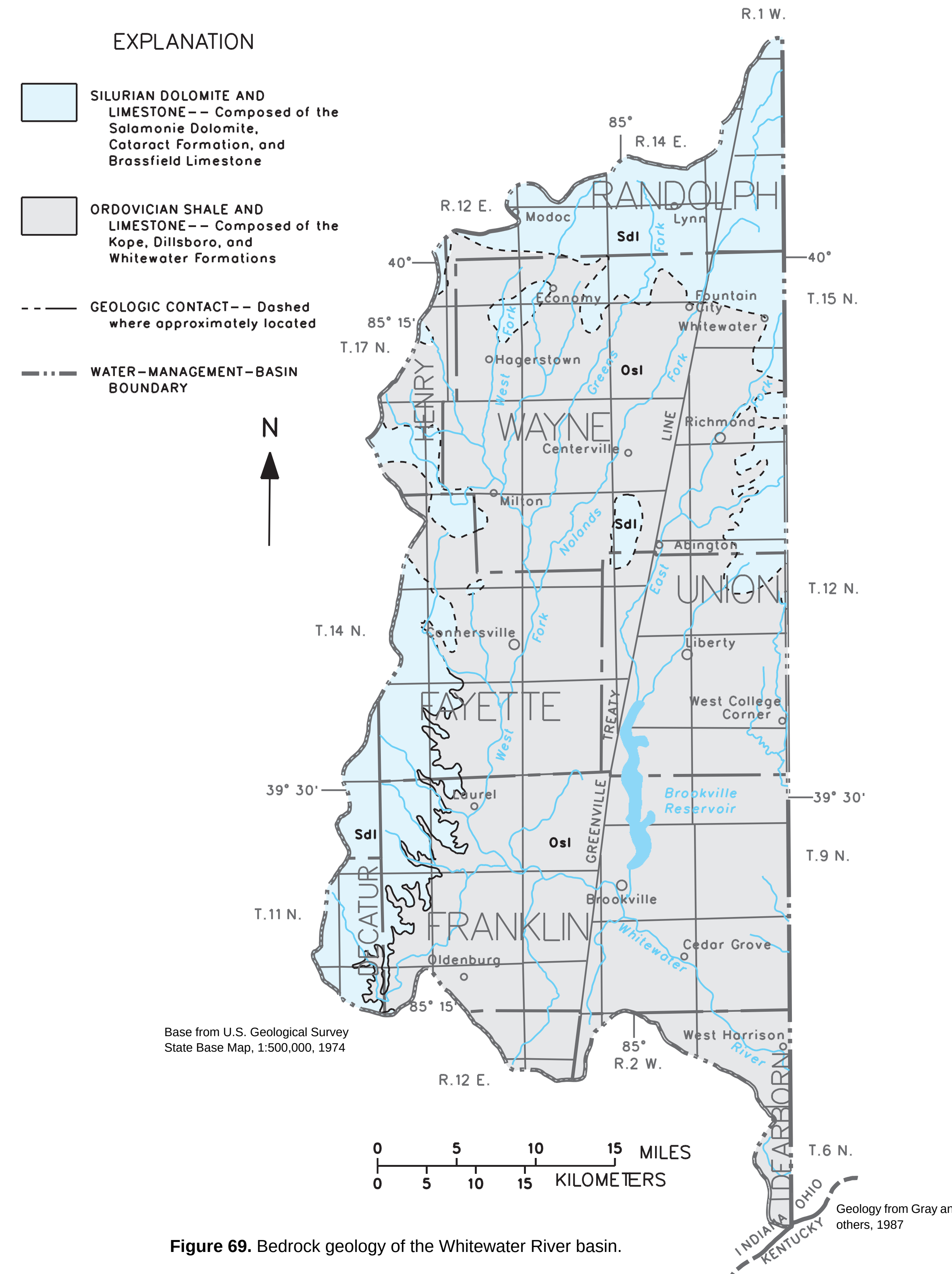


Figure 69. Bedrock geology of the Whitewater River basin.

The Kope Formation is a 300- to 400-ft-thick sequence, 95 percent of which consists of bluish- to brownish-gray shale (Shaver and others, 1986, p. 72). Exposed along the entrenched valleys of the lower reaches of the Whitewater River, this shale contains a thick basal dark-brown to nearly black shale. The upper contact between the Kope and the Dillsboro Formations is transitional; it is marked by a comparatively sharp upward increase in the proportion of limestone (Gray, 1972, p. 14).

In the Whitewater River basin, the Dillsboro Formation is an approximately 400-ft-thick sequence of shale with interbedded limestone (Shaver and others, 1986, p. 37). The Dillsboro is conformably overlain by the Whitewater Formation, which is a bluish-gray rubbly limestone interbedded with calcareous shale (Shaver and others, 1986, p. 168). The Whitewater Formation is disconformably overlain by the Silurian Brassfield Limestone.

Laferriere and others (1986, p. 1) noted that the disconformity between the Whitewater Formation and the Brassfield Limestone contains evidence of a complex erosional and depositional history. The disconformity is clearly defined by an abrupt vertical lithologic change (Laferriere and others, 1986, p. 4).

The Silurian Brassfield Limestone generally is a medium- to coarse-grained fossiliferous limestone that contains small amounts of shale and fine-grained dolomite (Shaver and others, 1986, p. 20). The Salamonie Dolomite, which unconformably overlies the Brassfield Limestone, is an impure dolomite that includes finer-grained clayey limestone, dolomitic limestone, and shale. Along the eroded edges of the unit in southeastern Indiana, the thickness ranges from 0 to 60 ft.

Unconsolidated Deposits

The Whitewater River basin is divided into three distinct areas of surficial unconsolidated deposits (Gray, 1989). The Jessup Formation of pre-Wisconsinan age is present in the southern one-third of the basin and is from an eastern source. The Trafalgar Formation of Wisconsinan age was deposited during several events by glaciers from a northeastern source and covers the central and northern parts of the basin. Buried pre-Wisconsin till is found beneath the Trafalgar Formation within the basin. Ice from two advances separated by a brief retreat deposited this pre-Wisconsinan till sequence (Gooding, 1966).

Pre-Wisconsinan loam to sandy-loam tills of the Jessup Formation are present in the southern part of the basin (Gray, 1989). Classically this formation has been referred to as the Illinoian drift. Gooding (1963) describes the drift in this area as consisting of calcareous oxidized till; noncalcareous, cherty, grayish-brown till; and calcareous sand and gravel. Minor deposits of outwash and alluvium are present within this area. The upland areas are capped by a silt complex composed of poorly stratified and poorly sorted sand and silt. These sediments are composed of weathering products and windblown silt (loess) (Gray, 1989).

The Trafalgar Formation in the central part of the basin is underlain by loam till and covered by a surficial layer of loess that ranges in thickness from 20 to 40 in. (Gray, 1989). The Wisconsinan glacial boundary and the Shelbyville Moraine (fig. 67) mark the southern edge of this unconsolidated material. Gooding (1975) described unnamed till units in the area as consisting of calcareous, brown to yellow-brown oxidized till along vertical joints, and gray unoxidized till. These units also contain some discontinuous and thin buff-colored calcareous sands and gravels. Extensive outwash material lies along the Whitewater River valley. Alluvium underlies the modern flood plain of the Whitewater River.

The northern one-third of the basin contains a thick sequence of older tills separated by buried soils and covered by Wisconsinan tills of the Trafalgar Formation (Gray, 1989). The northernmost part, an area of morainal topography, includes layers of ablation till, and dead-ice landforms. Within the headwater valleys of the Whitewater River and its major tributaries are linear, complex sequences of mixed drift, till, and stratified drift that appear to be collapse features. Further southward along the Whitewater River valley are a series of terraces composed of valley-train outwash (Gruver, 1984, p. 10). The outwash material contains large volumes of commercially extractable sand and gravel. The flood plain along the Whitewater River consists of Holocene alluvium of silt, sand, and gravel. The Crawfordsville Moraine marks the southernmost part of the northern region (fig. 67).

Within the northern part of the basin (western Wayne County and eastern Henry County) is a buried bedrock valley (fig. 7) that Bleuer (1989, p. 3) refers to as the New Castle Valley section of the Lafayette Bedrock Valley (formerly called the Teays Valley). This major preglacial drainageway originally flowed northwest, but it was blocked by ice and filled with glacial till. The valley is filled in places with more than 400 ft of unconsolidated deposits (fig. 68) consisting of clay interbedded with smaller amounts of sand and gravel. The valley is shown in Rs. 12 and 13 E. of section 10E–10E′, fig. 70).

Aquifer Types

Six hydrogeologic sections (10A–10A′ to 10F–10F′, fig. 70) were produced for this atlas to show the hydrostratigraphy of the Whitewater River basin. Hydrogeologic section 10A–10A′ bisects the basin and is oriented south to north (except for a 3 mi segment in the middle of the section that is oriented east-west and is also part of section 10B–10B′). The southern part of section 10A–10A′ crosses the lower reaches of the Whitewater River and roughly parallels the east side of the Brookville Reservoir, whereas the northern part of the section crosses Nolands Fork and Greens Fork. The remaining hydrogeologic sections (10B–10B′ to 10F–10F′) are oriented west to east and are approximately perpendicular to the surficial drainage of the basin (fig. 66). The west-east sections are spaced at intervals of approximately 8 to 12 mi. The average density of the 226 logged wells plotted along the hydrogeologic sections is 1.2 wells per mile.

Both the unconsolidated and bedrock deposits in the Whitewater River basin contain aquifers. The unconsolidated aquifers are composed of outwash in valley trains, intertill lenses of sand and gravel, and recently deposited alluvium. The bedrock aquifers are in the Silurian carbonate rocks and in an upper weathered zone in the Ordovician shale and limestone. Five aquifer types are mapped in the Whitewater River basin (fig. 71) and are summarized in table 12. The table includes information on the thickness, range of yields, and common aquifer names used by other authors.

Unconsolidated Aquifers

The unconsolidated aquifers, which contain the largest supply of ground water in the basin, consist of complexly interbedded glacial deposits. For simplicity, these sand and gravel aquifers are subdivided into three distinct aquifer types (fig. 71): discontinuous zones of sand and gravel, buried sand and gravel, and surficial sand and gravel.

Numerous layers of discontinuous sand and gravel aquifers underlie the northern two-thirds of the basin (fig. 71). Sand and gravel layers range from 2 to 50 ft in thickness and are not areally extensive. Hydrogeologic sections 10A–10A′ and 10D–10D′ to 10F–10F′ (fig. 70) show this type of aquifer material. Wells in areas of discontinuous sand and gravel are typically drilled and screened in the first significant water-bearing zone; however, some wells tap multiple zones.

An area with buried sand and gravel aquifers (fig. 71) that range in thickness from 2 to 50 feet is in the northwestern part of the basin. The layers of buried sand and gravel are more continuous (greater than 15 mi^2) than the discontinuous sand and gravel lenses. The buried sand and gravel is shown in hydrogeologic sections 10A–10A′, 10E–10E′, and 10F–10F′ (fig. 70). In many places, water-bearing zones of discontinuous sand and gravel are encountered above or below the more continuous aquifer. These multiple layers of sand and gravel deposits are separated by as little as 10 feet to as much as 50 feet of glacial till. Sand and gravel layers at different elevations represent deposition of outwash during various advances and retreats of the ice during Wisconsinan and pre-Wisconsinan glaciations.

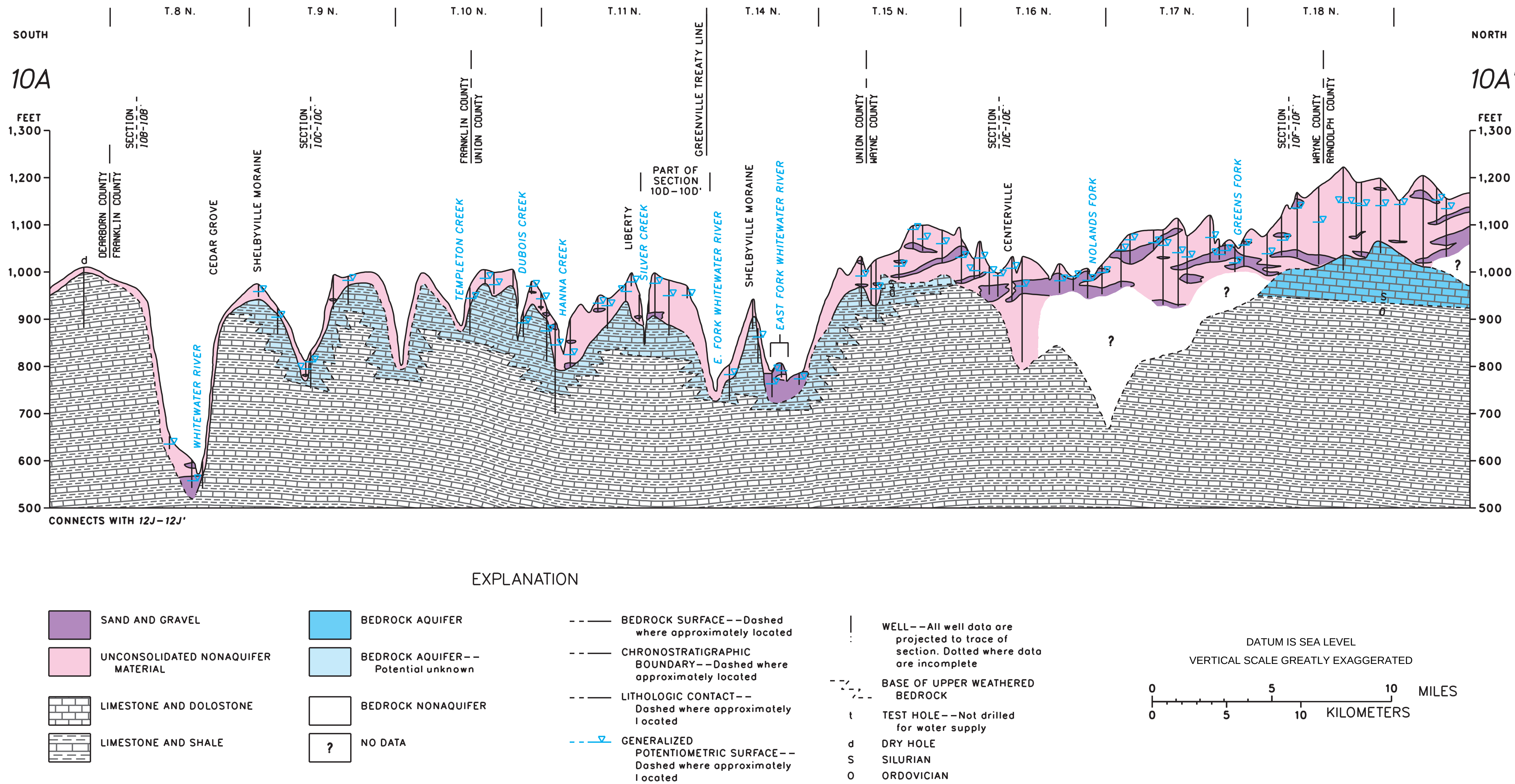


Figure 70. Hydrogeologic sections *10A–10A′* to *10F–10F′* of the Whitewater River basin.

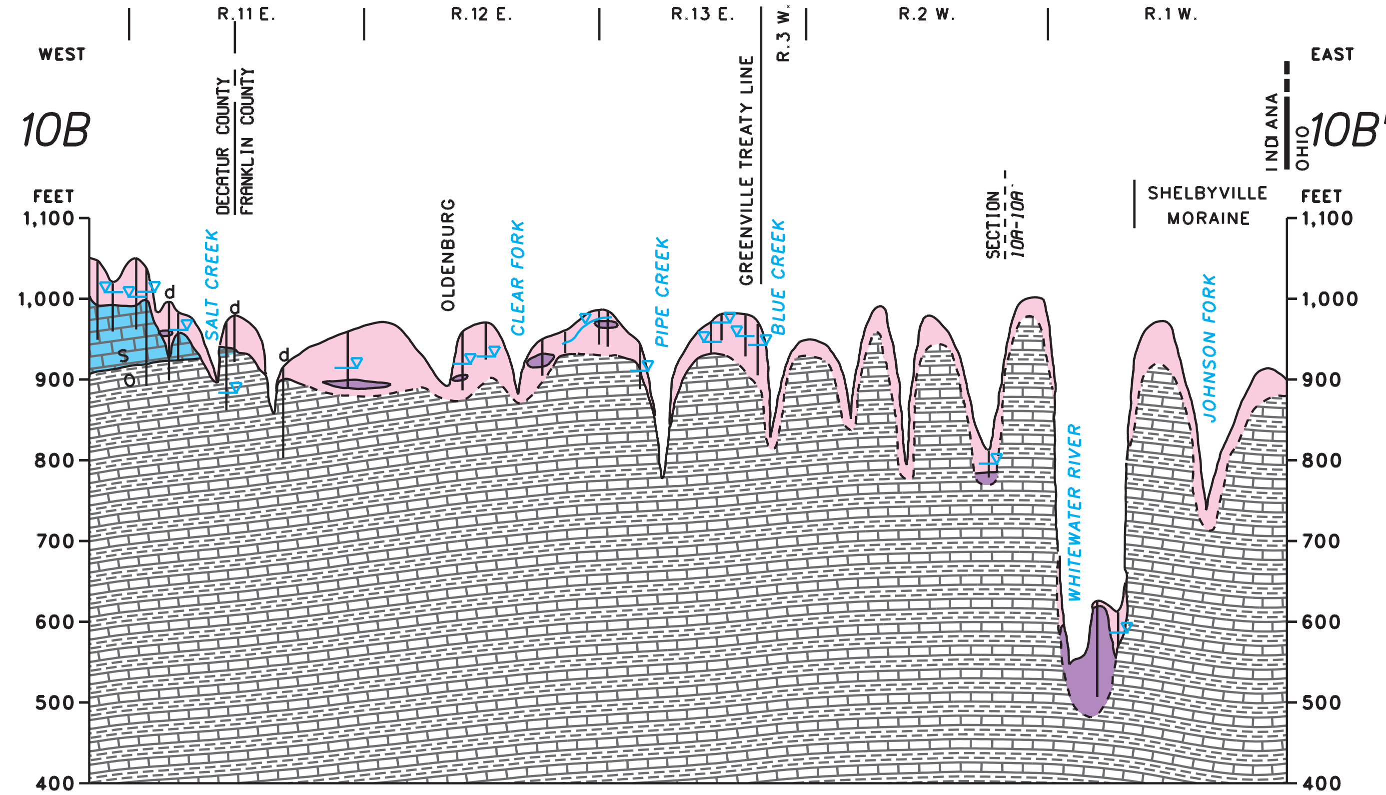
Figure 70. Hydrogeologic sections *10A–10A′* to *10F–10F′* of the Whitewater River basin—Continued.

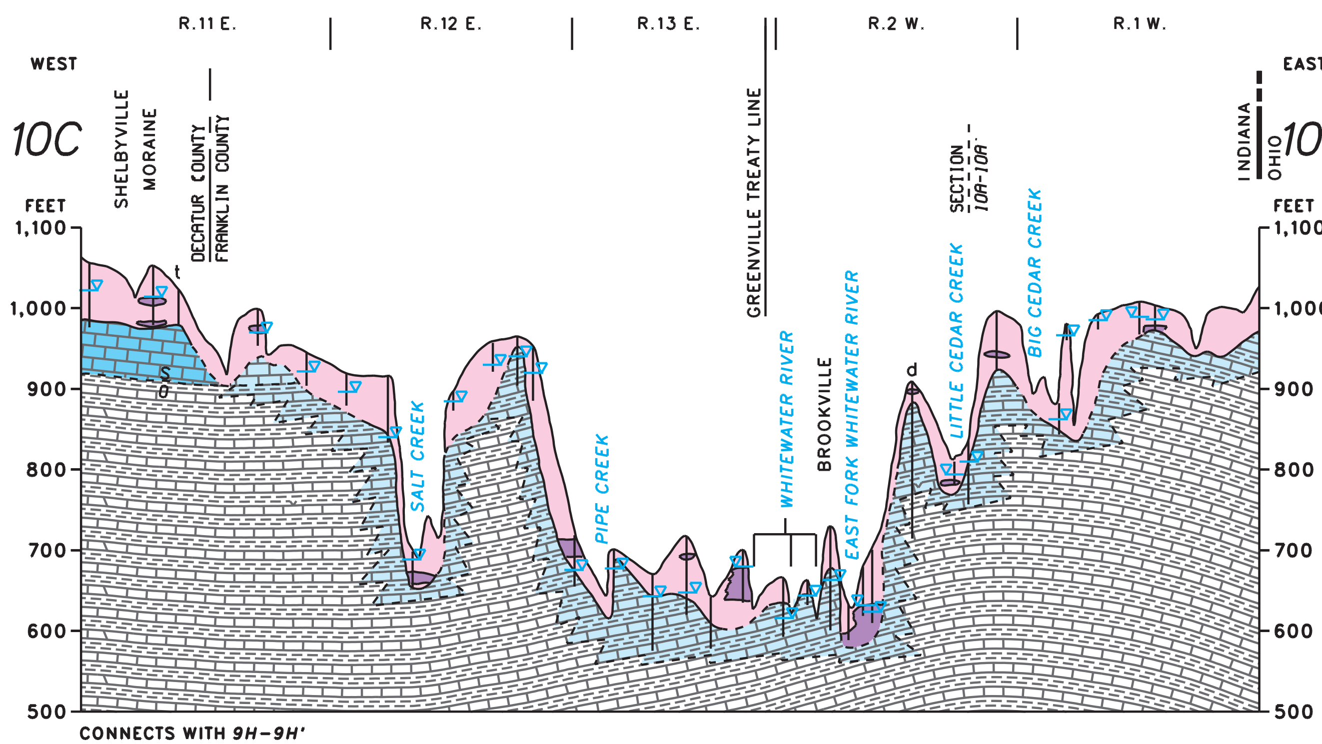
DATUM IS SEA LEVEL

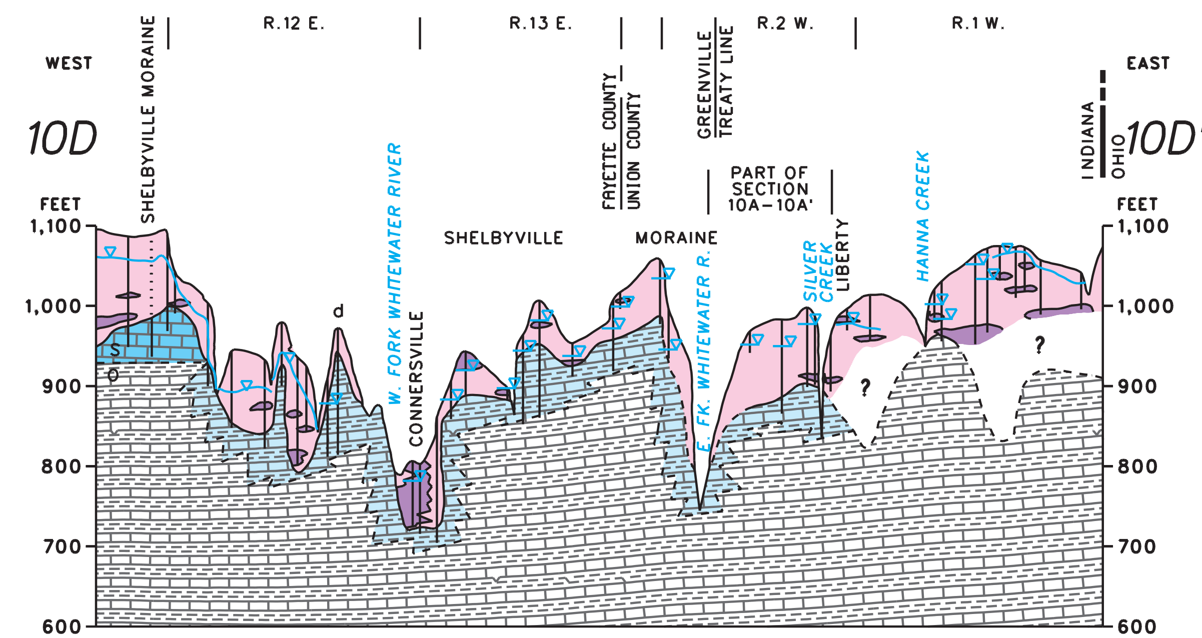
VERTICAL SCALE GREATLY EXAGGERATED

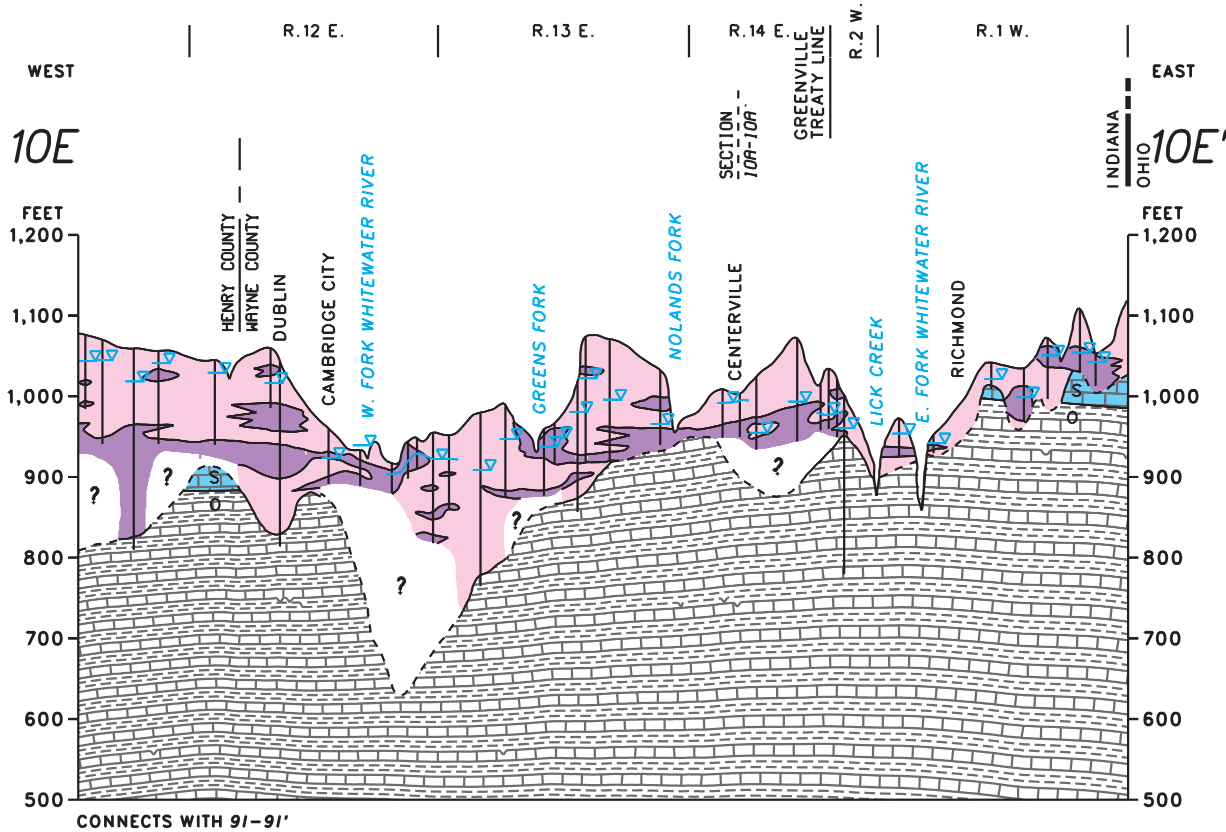
0 5 10 MILES

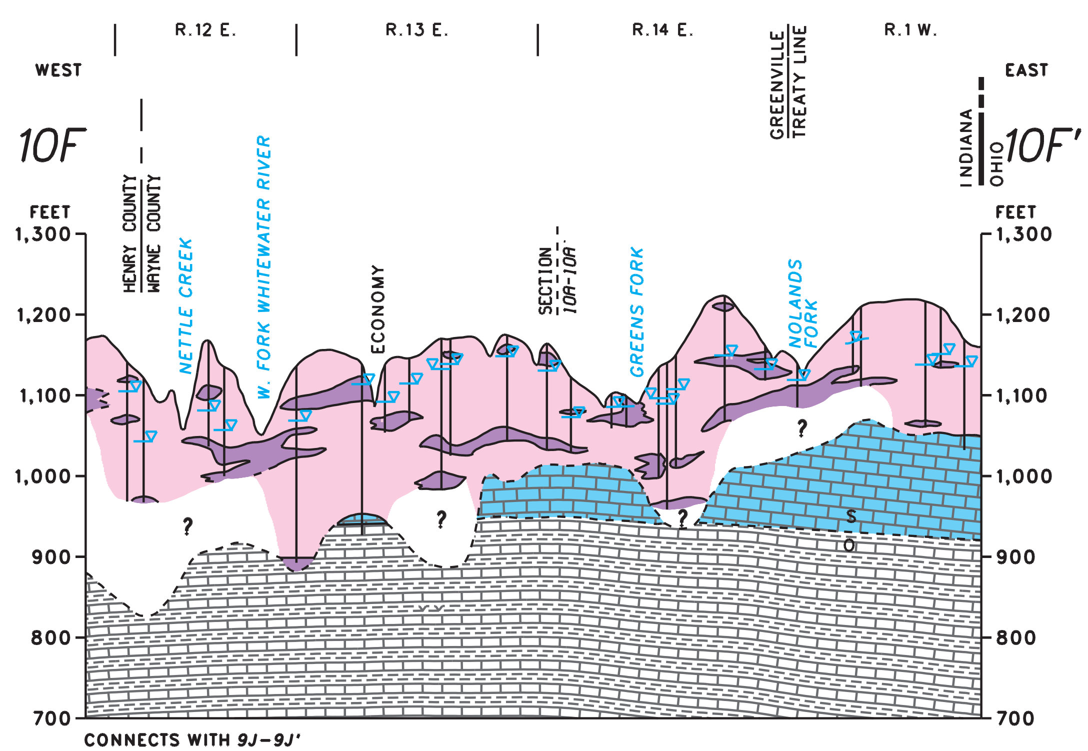
0 5 10 KILOMETERS











The New Castle Valley Section, a southeastern tributary of the Lafayette Bedrock Valley (Bleuer, 1989) (fig. 7) is located along the northwestern edge of the basin. The bedrock valley is shown beneath Nolands Fork in section 10A–10A′ (fig. 70) and beneath the West Fork Whitewater River in section 10E–10E′ (fig. 70). The buried bedrock valley is overlain by a confining layer of clay and contains discontinuous and buried sand and gravel layers and lenses. The extent of the aquifers within the buried bedrock valley is not known because wells within this area penetrate to a depth of only 200 ft or less, whereas the valley extends to a depth of 400 ft or more (fig. 68).

Surficial sand and gravel aquifers are present in the valleys of the Whitewater River and its major northern tributaries (fig. 71). These surficial aquifers are shown on all the hydrogeologic sections except 10F–10F′ (fig. 70). The principal water-bearing materials are extensive sand and gravel outwash deposits that were deposited as valley fill during the various periods of glacial advance and retreat, and more recently, as alluvium. Ground-water yields from these surficial sand and gravel aquifers are the highest measured for the entire basin (table 12).

Nonaquifer material, consisting mostly of sandy and pebbly clay, covers the southern part of the basin. Although no aquifer material is mapped in this area, large-diameter domestic wells are constructed in marginal water-bearing zones using an upper fractured clay zone or thin sand and gravel lenses within the clay as a source of water. Areas underlain by nonaquifer material can best be seen in hydrogeologic section 10B–10B′ (fig. 70).

Bedrock Aquifers

The Silurian carbonate bedrock aquifer forms an important aquifer in the northeastern and in the southwestern margins of the basin (fig. 71). This aquifer ranges in thickness from a few feet to more than 100 ft and is shown in all hydrogeologic sections (fig. 70). The carbonate bedrock aquifer is composed of thick-bedded limestone with thin interbedded shales. Most wells screened in these carbonate rocks receive water from the top few feet of the weathered bedrock and(or) intersect bedrock fractures or joints at depth. The fractures and joints were probably produced by the tectonic stresses that upwarped the Cincinnati Arch and by the overriding of glaciers at various times. Zones of moderate to high permeability along bedding planes and disconformities between successive rock strata, such as the Silurian-Ordovician unconformity, also increase well yields. Lateral changes in permeability can result from facies changes and fracture density. Ground-water yields from the carbonate bedrock aquifer are generally greater in the northern part of the basin where yields are usually more than 10 gal/min (Indiana Department of Natural Resources, 1988, p. 44); overall, well yields are generally sufficient for domestic use, although attempts to construct wells occasionally result in dry holes.

Shale and limestone of the Ordovician Maquoketa Group are present as subcrop or are exposed in the entrenched valleys in most of the basin from the northwest to the southeast (fig. 69). The Ordovician bedrock consists predominantly of nearly flat-lying interbedded layers of thick shale and thin limestone. These rocks form the bedrock surface across more than two-thirds of the basin and underlie the carbonate bedrock elsewhere. Because of the high shale content, permeability of these rocks is low. The small amount of water that does circulate through these rocks is within small joints and fractures at or near the bedrock surface. An upper weathered zone in the shale and limestone bedrock was mapped as "aquifer—potential unknown" in the central part of the basin (fig. 71). In this part of the basin, the shale and limestone are at the bedrock surface and are commonly used as a water supply. Areas where the shale and limestone bedrock is rarely used were not mapped as an aquifer even though bedrock could possibly provide ground water in these areas. Wells drilled into the shale and limestone can be seen in all six hydrogeologic sections, although most of the wells are shown in sections 10A–10A′, 10C–10C′, and 10D–10D′ (fig. 70). Most wells penetrate less than 100 feet into the upper weathered bedrock and yield less than 10 gal/min; dry holes are not uncommon. The upper weathered-bedrock aquifer is generally used if no other aquifer is available.

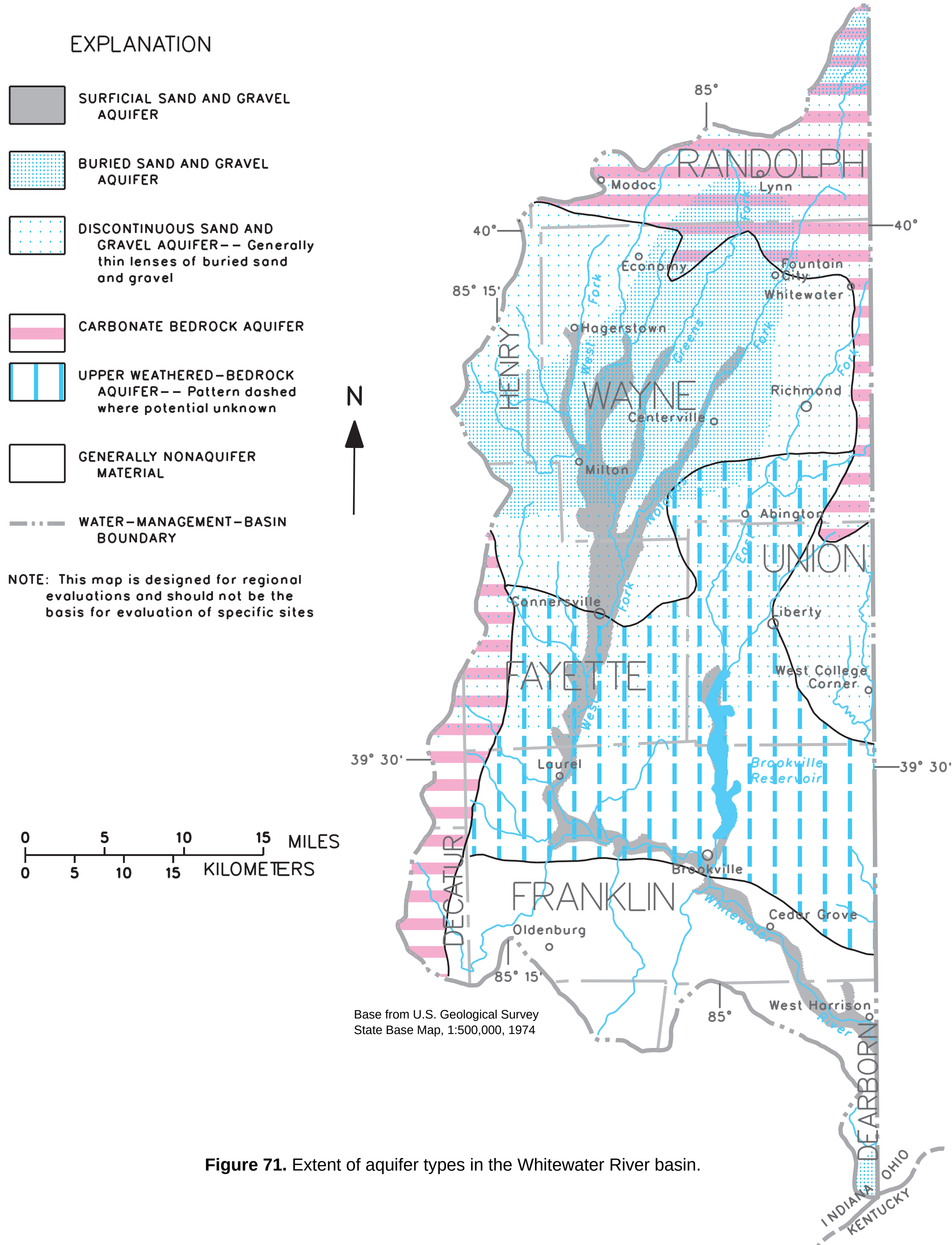


Figure 71. Extent of aquifer types in the Whitewater River basin.

Table 12. Characteristics of aquifer types in the Whitewater River basin
[<, less than; locations of aquifer types shown in fig. 71]

Aquifer type	Thickness (feet)	Range of yield (gallons per minute)	Common name(s)
Discontinuous sand and gravel	2- 50	0- 150	Fayette-Union and Wayne-Henry Aquifer Systems[1]
Buried sand and gravel	2- 50	5- 150	Centerville Subsystem[1]
Surficial sand and gravel	30- 150	50- 1,200	Whitewater Valley Aquifer System[1]
Carbonate bedrock	0- 100	0- 60	Silurian Bedrock Aquifer System[1]
Upper weathered bedrock	<100	0- 10	Ordovician Bedrock Aquifer System[1]

[1]Indiana Department of Natural Resources, 1989.

Summary

The Whitewater River basin encompasses 1,425 mi^2 in southeastern Indiana. The basin is composed of two physiographic units; the undulating Tipton Till Plain in the north and the rugged Dearborn Upland in the south. Silurian carbonate rocks are at the bedrock surface on the western, northern, and northeastern edges of the basin, whereas Ordovician shale and limestone are at the bedrock surface in the remaining three-quarters of the basin. The bedrock is covered with as much as 400 ft of loam to sandy-loam till, loess, outwash, and alluvium.

Five different aquifer types are delineated in the Whitewater River basin: discontinuous sand and gravel; buried sand and gravel; surficial sand and gravel; carbonate bedrock; and an upper weathered zone in shale and limestone. The unconsolidated aquifers produce the largest supply of ground water for the basin; typical well yields range from approximately 10 gal/min within the discontinuous zones to several hundred gallons per minute in the surficial sand and gravel aquifers along the Whitewater River. The carbonate bedrock aquifer is a secondary supply of ground water, mostly for domestic use. Wells in the carbonate bedrock aquifer yield from 0 to 60 gal/min; the larger yields are obtained in the northern part of the basin where one or more fractures or joints are intersected. The upper weathered-bedrock aquifer is generally used if no other aquifer is available. Well penetration into the weathered zone is usually less than 100 ft, and most well yields are less than 10 gal/min. No aquifer is mapped in the southern part of the basin. Most ground water in this area is obtained from low-permeability unconsolidated deposits.

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