DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
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PREPARED IN COOPERATION WITH
THE COMMONWEALTH OF KENTUCKY, UNIVERSITY OF KENTUCKY
KENTUCKY GEOLOGICAL SURVEY
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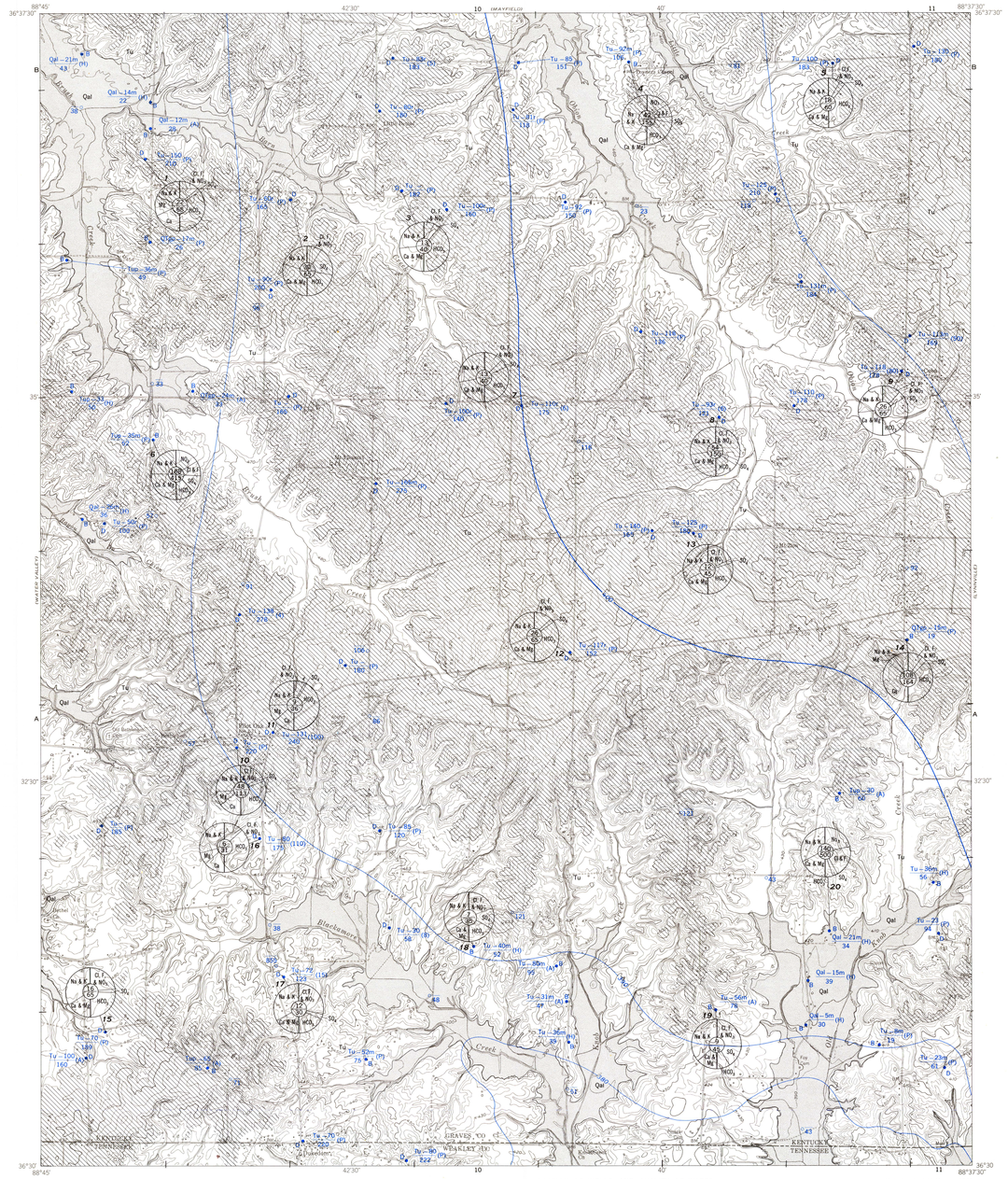
HYDROLOGIC INVESTIGATIONS
ATLAS HA-161

System	Series	Formation	Section	Thickness, in feet	Lithology	Topography and geologic setting	Hydrology
QUATERNARY	Pleistocene and Recent	Alluvium		0-30'	Brown, tan, and gray sand, silt, and gravel, locally cemented with iron oxide. Very fine- to very coarse-grained sand containing a few pebbles of chert and quartz, commonly silty and clayey, and subangular to rounded chert gravel in a sandy to clayey matrix.	Stream-laid deposits in the valley floors of the regional drainage system. The alluvium beneath the flood plain in the lower reaches of the larger streams may be as thick as 30 feet but thins to less than 10 feet in many smaller tributary valleys.	Water bearing in availability area 1. The alluvium yields adequate domestic supplies of ground water (500 gallons per day) to large-diameter bored and dug wells commonly less than 30 feet deep. The stream valleys intersect the underlying main zone of saturation in the southern part of the quadrangle and the alluvium there is water bearing throughout the year. In the northern and western parts of the quadrangle the alluvium is underlain by clay in the upper part and contains discontinuous beds of clay and may furnish only small supplies in some places, especially during periods of low rainfall when the smaller perched bodies of water are not replenished. A chemical analysis of one sample of the water from the alluvium shows the water is hard in places but contains only negligible amounts of iron. The nitrate content is extremely high in this sample (188 parts per million), possibly due to pollution. More than 45 parts per million of nitrate is considered harmful in water fed to infants as it may cause methemoglobinemia ("blue baby" disease) which is sometimes fatal.
	Pleistocene	Loess		0-15'	Brown to gray noncalcareous unstratified silt, in part sandy and clayey, containing some dark-brown iron-oxide nodules.	Windborne deposits which mantle the uplands and drape down hillsides. As thick as 15 feet in uplands; eroded thin or removed in places.	Yields little or no water to wells. Probably transmits some water from rainfall into underlying aquifers.
	Pliocene(?)	Gravel and sand		0-100'	Reddish-brown to tan gravel, sand, and some clay, locally cemented. Very fine- to very coarse-grained micaceous and crossbedded sand containing small lenses and laminae of gravel in upper part and iron-stained subangular to rounded pebbles and cobbles of chert gravel, commonly abundant. The middle part of the unit consists of very fine- to medium-grained clean sand and sandy clay containing a few very coarse grains of quartz. Mostly gravel and clayey sand in basal part of the formation.	Continental deposits which blanket the upland, particularly in the northern part of the quadrangle, and cap ridges in the deeply dissected area in the southern part. The middle sandy unit is apparently restricted to a broad irregular band that trends northeast across the quadrangle. The Pliocene(?) deposit, exposed in hillsides, roadcuts, and valley walls, may be as thick as 100 feet and rests unconformably on sediments of Eocene age.	Water bearing in places in availability area 2 where ground water is perched above clay in local areas (see fig. 3). The basal part of the gravel is commonly water bearing where it rests on clay in the underlying Eocene formations. The sandy middle unit is commonly perched in the interbedded sand unit where it is underlain by clay in the Pliocene(?) gravel. Large-diameter bored or dug wells ranging in depth from about 20 to 30 feet generally obtain adequate domestic supplies from the perched water; however, many of the perched bodies may be small and not dependable for a perennial supply. In one sample the water is moderately hard and contains 2.4 parts per million of iron. More than 0.30 parts per million of iron, considered to be the objectionable limit, imparts a disagreeable taste to the water and may stain laundry and plumbing fixtures.
TERTIARY	Eocene	Sand and clay		150-180'	Brown, gray, and white sand and dark- to light-gray, tan, and pink clay. The upper part is generally very clayey and silty with fine- to medium-grained lenses of crossbedded, somewhat micaceous, sand, locally cemented with iron oxide. Lignitic clay is common and thin to thick-bedded silty and lignitic clay. The lower 100 feet is predominantly medium- to coarse-grained micaceous clean sand.	Coastal plain deposits underlying the Pliocene(?) gravel and exposed in many valley floors in the quadrangle. The deposits, 650 feet or more thick, contain several beds of sand that evidently dip at about 20 to 25 feet per mile toward the southwest. Clay seems to be more abundant in the upper part of the formation in the northwestern part of the quadrangle. The sediments of Eocene age rest unconformably on the underlying Porters Creek Clay.	Water bearing in the entire quadrangle. The main zone of saturation is as thick as 600 feet or more and furnishes an abundant supply of ground water to both large-diameter bored wells and small-diameter drilled or jetted wells. Yields as great as 100 gallons per minute are presently being obtained; larger yields are probably available from properly constructed wells. Most wells are finished in the upper thick section of sand at depths ranging between 150 to 300 feet. In the northwestern part of the quadrangle, discontinuous beds of clay may cause small perched bodies of water to be tapped by large-diameter bored wells; tap the perched water and obtain adequate domestic supplies. The water in the Eocene sand is commonly very soft but probably contains objectionable amounts of iron in a few places. The rare occurrence of harmful concentrations of nitrate in the water may be due to pollution in local areas.
				250'±	Brown, gray to white sand and dark-gray to olive-gray to white clay. Upper part is commonly fine-grained, micaceous, somewhat lignitic sand, containing thin discontinuous beds and laminae of sandy clay, grading down into thick beds of fine- to coarse-grained, slightly lignitic sand.		
				225'±	Brown to gray sand and clay. Sand is fine- to coarse-grained, thin- to thick-bedded, micaceous, and lignitic. Clay is silty and sandy, interbedded with sand in upper part. Coarse sand in basal part in deep test hole south of Pilot Oak.		
	Paleocene	Midway	Porters Creek Clay	300'±	Dark-gray to black, micaceous, commonly massive clay containing thin beds of fine-grained glauconitic sand in upper part. Slightly glauconitic in some zones. Gray to greenish-gray, very glauconitic clayey sand or sandy clay at base.	Marine deposit concealed beneath the sediments of Eocene age at depths greater than 700 feet. The Porters Creek Clay is underlain by the McNairy Formation of Cretaceous age. The depth to the Cretaceous sediments may be as great as 1,000 feet. The unconsolidated Cretaceous sediments rest on an eroded Paleozoic rock floor.	Not significant as an aquifer. The Porters Creek Clay retards descending water in the overlying sand of Eocene age and confines water in the underlying sand of Cretaceous age. Cretaceous sands, as much as 300 feet and composed of sand and clay, have not been tapped for water supplies in this area. Little is known of the occurrence of confined ground water in the deeper aquifer. The confined water should rise in wells to altitudes estimated to range from about 350 to 400 feet above sea level. The water probably is hard or very hard and possibly contains objectionable concentrations of iron and dissolved solids.

* Age undetermined. Estimates of age range from Pliocene or older to Pleistocene.

FIGURE 2.—GENERALIZED COLUMNAR SECTION AND WATER-BEARING CHARACTER OF GEOLOGIC FORMATIONS



Base by Tennessee Valley Authority and U.S. Geological Survey, 1955

The Carter Coordinate System letters and numbers used to designate five-minute divisions of latitude and longitude are shown along the margins; tick marks indicate one-minute divisions.

FIGURE 1.—MAP SHOWING AVAILABILITY OF GROUND WATER. LOCATION OF WELLS, AND QUALITY OF WATER

Hydrology by J. H. Morgan, 1963

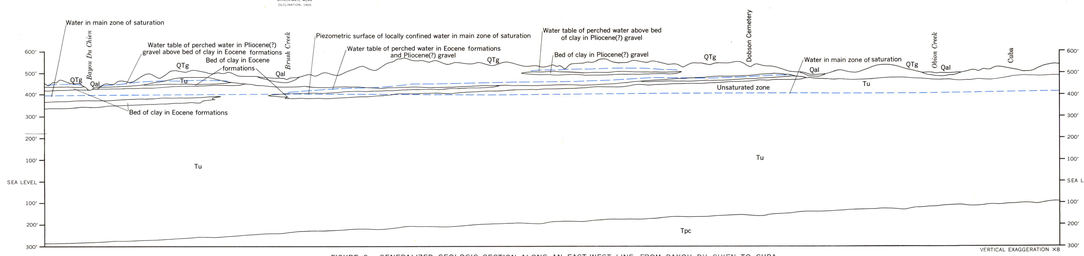


FIGURE 3.—GENERALIZED GEOLOGIC SECTION ALONG AN EAST-WEST LINE FROM BAYOU DU CHIEN TO CUBA

EXPLANATION

The water-availability areas on this map show the occurrence and availability of ground water in the shallowest aquifer that may yield adequate amounts of water for a domestic supply. As considered in this report an adequate domestic supply will deliver approximately 500 gallons per day from a well equipped with a power pump and pressure-distribution system. The shallowest aquifer is underlain by deeper aquifers whose depths and water-bearing properties are described in the generalized columnar section (fig. 2)

Qal

AREA 1

Water in Quaternary alluvium

The alluvium is water bearing in area 1 at depths commonly less than 20 feet below the flood plain. In the western and northern parts of the quadrangle, the stream valleys are underlain by clay in the upper part of the Eocene formations. Ground water is perched in the alluvium above these clays and may furnish only small supplies in some places. Where the stream valleys intersect the underlying main zone of saturation in the southern part of the quadrangle along Blackamore, Knob, and Old Knob Creeks, the saturated zone extends below the alluvium into the underlying sediments and the alluvium is water bearing throughout the year. In the upper reaches of the streams, always in areas of some, small bodies of ground water may be perched above discontinuous beds of clay but are probably too small for the development of a satisfactory water supply.

Large-diameter bored and dug wells, and a few small-diameter bored wells, ranging in depth from about 20 to 40 feet, yield adequate domestic supplies of ground water from the alluvium. Although many of these wells are equipped with only a hand bailer, properly constructed wells will yield enough water for a power-pump installation. Wells in the alluvium could be deepened into the underlying saturated zone and obtain larger yields

Tu

AREA 2

Water in Eocene sands

(Diagonal ruling shows areas where the measured water level in wells is more than 100 feet below land surface)

The Eocene sands contain abundant quantities of ground water in the main zone of saturation, the shallowest source for a dependable ground-water supply in area 2. The water ranges in depth from only a few feet below the land surface in the stream valleys in the southern part of the quadrangle to depths greater than 100 feet in the area shown by the diagonal ruling. Several shallower bodies of ground water are perched in the upper part of the Eocene formations and in the Pliocene(?) gravel (fig. 3). Although these small perched bodies of water yield adequate domestic supplies in some places, wells should reach into the underlying main zone of saturation for large dependable yields. The Eocene formations consist of several thick beds of sand in the main zone of saturation which extends downward to the underlying Porters Creek Clay at depths greater than 700 feet. The depth to the water table can be determined from either the water-level contours or from the well data for the deeper wells in this area

Small-diameter drilled or jetted wells penetrate deeply into the main zone of saturation and obtain water through well screens placed in coarse sand. Yields as great as 100 gallons per minute presently are being obtained. Large-diameter wells generally are bored or dug in areas where the water table is at shallow depths and penetrate only a few feet of the saturated zone; these wells yield adequate domestic supplies but could be deepened to obtain larger yields

Area boundary

○ 81

Test hole

Figure below line is depth of test hole

● B

Water well

D, *Drilled or jetted well, generally with well screen on lower end*

B, *Bored or dug well, generally 36-inch concrete casing or 8-inch soil pipe open at the bottom*

Tu – 130m
180 (110)

- Aquifer (see below)
- Water level in well, in feet below land surface; m, if measured; r, if the reported water level corresponds to a shallower perched water table
- Yield in gallons per minute, or adequacy (see below)
- Depth of well, in feet below land surface

AQUIFER SYMBOLS

Qal ..... Alluvium of Quaternary age

QTp ..... Perched water in gravel and sand of Pliocene(?) age

Tup ..... Perched water in sand of Eocene age

Tu ..... Sand of Eocene age

YIELD OR ADEQUACY

(S) ..... Gallons per minute where known

(P) ..... Well reported adequate for power pump for domestic and/or stock supply

(H) ..... Well reported adequate for hand pump or bailer

(A) ..... Abandoned

—410—

Water-level contour

Shows altitude of water level in main zone of saturation. Contour interval 10 feet; datum is mean sea level. Depth to water is difference in feet between altitude of water-level contour and land surface. The water is confined where clay occurs at, or below, the altitude of the contour. Water-level measurements taken in September 1963

QUALITY

Cl, F, Na & K, NO3, SO4, Ca & Mg, HCO3, 18

Chemical composition of dissolved solids

Figure between circular diagram and well symbol refers to analysis number in table at end of text. Figure above line at center of circular diagram is carbonate hardness (calcium magnesium hardness as $CaCO_3$) in parts per million; figure below line is dissolved solids in parts per million. Hardness of water is classified by the U.S. Geological Survey as follows: 0-60 parts per million, soft; 61-120 parts per million, moderately hard; 121-180 parts per million, hard; 181 parts per million or more, very hard. Dissolved solids in partial analyses are computed from specific conductance and are only approximate values. Areas of the segments of each circle are proportional to the mineral component in the dissolved solids in the water. Percentages are computed from equivalents per million of the anions and cations. Calcium and magnesium are shown as one segment in partial analyses. Nitrate shown separately if present in amounts greater than 45 parts per million

EXPLANATION

Qal ..... Alluvium of Quaternary age

QTg ..... Gravel and sand of Pliocene(?) age

Tu ..... Sand and clay of Eocene age, undifferentiated

Tpc ..... Porters Creek Clay of Paleocene age

AVAILABILITY OF GROUND WATER IN THE CUBA QUADRANGLE KENTUCKY–TENNESSEE

An abundance of ground water for domestic, municipal, and industrial supplies is available in the water-bearing geologic formations in the Cuba quadrangle. This valuable resource has been only partially exploited and will furnish sufficient amounts of water for industrial developments and future public demands.

The most important aquifer (water-bearing geologic formation) is the sand in the Eocene formations which contains a large body of ground water in the main zone of saturation, that part of the formation completely saturated with water. Less important aquifers include small bodies of ground water above beds of clay called "perched water," and the confined water in the deeper McNairy Formation of Cretaceous age.

The depth to the main zone of saturation in the Eocene formations ranges from only a few feet below the land surface in the southeastern part of the quadrangle to as much as 165 feet beneath the higher uplands north of Kentucky Highway 94. The formations extend to depths as great as 700 feet or more and contain several thick beds of saturated sand, suitable for development by means of screened wells. The water table, the upper surface of the saturated zone, slopes gently to the west except in the southeastern part of the quadrangle where the stream valleys are sufficiently deep to discharge the ground water toward the south.

The town of Cuba, the larger dairy farms, and several commercial water wells in this area obtain water from the Eocene sands. As much as 30,000 gallons of water per day have been pumped from a single commercial water well and hauled to fill cisterns. The latter are used for storage of water by a few of the smaller farms. The more productive wells presently yield about 100 gallons per minute but larger yields can be obtained from wells designed and constructed to pump a greater quantity of water.

Discontinuous beds of clay above the water table commonly retard descending water in the Eocene sands, in the Pliocene(?) gravel, and, in some places, in the alluvium. These small bodies of perched water occur throughout the quadrangle where clay beds are continuous over areas large enough to retain the water. Several of the perched bodies of ground water will sustain withdrawals for a perennial domestic supply.

Because an abundant quantity of good-quality ground water is available at shallow depths, the McNairy Formation of Cretaceous age probably will not be developed as a source of ground water in the Cuba quadrangle in the near future. The deeper aquifer has not been tapped by water wells in this area and little is known of the occurrence of its confined water. However, in Calloway and Marshall Counties where the aquifer is nearer the land surface and where overlying aquifers are inadequate for large supplies of ground water, several towns obtain their water supply from the McNairy Formation.

The shallowest water-bearing formation that will yield a dependable supply of ground water is shown on the water-availability map (fig. 1). As an example, the color pattern for area 2 just north of Bayou Du Chien in the west-central part of the quadrangle indicates that the shallowest source for a large dependable supply is the main zone of saturation which is greater than 100 feet below the land surface. Several wells, however, terminate in shallow perched water in the area as shown by aquifer symbols in the well data. The explanation states that the large-diameter bored wells tapping the perched water yield adequate domestic supplies and that large supplies can be obtained from the underlying main zone. The depth to the perched water can be determined from well data, whereas the depth to the main zone is the difference in feet between the water table, shown by the water-level contours, and the land surface. In the higher upland near Bayou Du Chien the difference is about 120 feet. Deeper wells in the quadrangle indicate the depths to coarse sand, suitable for construction of screened wells.

The quality of the water in the main zone of saturation is considered to be excellent for many uses. The concentration of dissolved solids rarely exceeds 60 or 70 parts per million and the water is commonly very soft. However, greater concentrations of dissolved solids, present in the water from a few bored wells, contain harmful amounts of nitrate that are possibly due to pollution; bored and dug wells are susceptible to pollution unless properly sealed. The water is slightly acidic and is considered somewhat corrosive. Objectionable amounts of iron are probably the result of slightly acidic water reacting with steel casing and pump equipment. Large concentrations of iron are rarely present in water from wells that have concrete or plastic casing. The confined water in the deeper McNairy Formation is probably less acidic than the shallow water but may be very hard and contain iron in excessive concentrations. The temperature of the water, ranging from about 58° to 62°F., could make it useful as a coolant.

The following table shows the iron content in parts per million and the hydrogen-ion concentration, expressed as pH, of the water analyses shown by circular diagrams on figure 1. A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 indicate acidity. Corrosiveness of water generally increases with decreasing pH.

Analysis number	1	2	3	4	5	6	7	8	9	10
Iron content	21.0	9.0	2.4	0.14	0.06	0.13	15.0	5.8	4.1	39.0[1]
pH	6.3	6.9	–	6.5	6.3	6.7	6.0	6.2	6.5	6.5

Analysis number	11	12	13	14	15	16	17	18	19	20
Iron content	5.2	5.6	1.3	2.4	0.94	0.23	0.15	0.42	0.14	0.19
pH	7.0	6.7	6.2	6.6	6.4	5.8	5.7	5.7	5.4	–

[1] In sediment and solution when analyzed

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By
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For sale by U. S. Geological Survey, price 50 cents