U.S. Geological Survey

GROUND WATER ATLAS of the UNITED STATES
Illinois, Indiana, Kentucky, Ohio, Tennessee

HA 730-K

by Orville B. Lloyd, Jr., and William L. Lyke

Contents of HA 730-K, published in 1995

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The Atlas publication is intended for use as an introduction to the Nation's ground water resources, and as a teaching tool. For more information on how to purchase a copy of the printed Atlas please refer to the order form. ordering the print product.

Pertinent references are listed for each described aquifer to assist those needing additional information. Appropriate map scale is indicated by the representative fraction appearing over the scale bars. Interpretations concerning the appropriate use of these illustrations may be obtained from the Office of Ground Water, U.S. Geological Survey, 12201 Sunrise Valley Dr., Reston, VA, 20192.

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Hydrologic Atlas 730-K
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REGIONAL SUMMARY

INTRODUCTION

This report provides a summary of ground-water conditions and problems in Illinois, Indiana, Kentucky, Ohio, and Tennessee, which compose Segment 10 of the Grou
Segment 10 consists of parts of seven physiographic provinces (fig. 1)‹ the Coastal Plain, Blue Ridge, Valley and Ridge, Appalachian Plateaus, Interior Low Plat

SOURCE OF GROUND WATER

The upper part of the rock mass that underlies Segment 10 generally contains fresh ground water, whereas the intermediate and lower parts generally contain salt
The source of the freshwater in Segment 10 is precipitation, primarily rain and snow. Long-term average annual precipitation in Segment 10 ranges from about 36
Long-term average annual runoff ranges from about 10 inches in some of the northern parts of the area to about 30 inches in some parts of central and southeaste
Most of the precipitation that percolates downward and becomes ground-water recharge circulates through the shallow aquifers; only a small part enters the deep
Saltwater is present at depths of 500 feet or less in much of Segment 10, particularly in aquifers in Paleozoic rocks. The source of the saltwater is assumed to

PRINCIPAL AQUIFERS

The rocks that underlie Segment 10 are divided into the different geohydrologic units (aquifers and confining units) shown in figures 4 and 5. These aquifers an
Throughout Segment 10, the rocks that compose aquifers and confining units generally are divided into three types according to their degree of consolidation‹the
Unconsolidated, coarse-grained deposits of Quaternary age (primarily of glacial origin) compose principal aquifers that cover the Paleozoic rocks throughout mos
Semiconsolidated rocks of Cretaceous and Tertiary age compose principal aquifers in the Mississippi Embayment section of the Coastal Plain Province (figs. 1 and

GEOLOGIC SETTING

To a large extent, the geology of the area controls the occurrence, movement, availability, and quality of the ground-water resources. Thus, a basic understandi
Precambrian igneous, metamorphic, and sedimentary rocks are at the land surface in the Blue Ridge Province in eastern Tennessee. Elsewhere in Segment 10, Precam
A thick sequence of consolidated sedimentary rocks of Paleozoic age overlies the Precambrian rocks. These sedimentary rocks are primarily siltstone, shale, sand
The distribution of the Paleozoic rocks in the area is controlled by the position of the arches, domes, structural basins, and associated faults. The oldest Pal
The Paleozoic rocks are covered by sedimentary rocks of late Mesozoic and Cenozoic age in the Mississippi Embayment section of the Coastal Plain Province in the
In the northern part of Segment 10, the Paleozoic rocks are covered by Quaternary deposits, which consist of different combinations of clay, silt, sand, and gra
The distribution of the different geologic units at depth is shown by the geologic sections in figure 8. From this perspective, the effects of arches, domes, st

FRESH GROUND-WATER WITHDRAWALS

Ground water is a reliable source of freshwater for about 15 million people, or 44 percent of the total population, in the five-State area of Segment 10. Public
Fresh ground-water withdrawals during 1990 in Segment 10 are illustrated by county in figure 9. The total withdrawal values shown in figure 9 account for all ca

CENTRAL LOWLAND AQUIFERS

INTRODUCTION

The aquifers of the Central Lowland Physiographic Province consist of unconsolidated sand and gravel deposits of Quaternary age (fig. 11) and consolidated sands
The geologic and hydrogeologic nomenclature used in this chapter differs from State to State because of independent geologic interpretations and varied distribu
The Central Lowland Province in Segment 10 is characterized by a low-relief surface formed by glacial till, outwash plains, and glacial-lake plains. Long, low,
The depth to which freshwater circulates in the consolidated rocks depends on a number of factors, including the per-meability of the aquifers in the consolida
Unconsolidated glacial deposits of Quaternary age overlie the consolidated Paleozoic rocks throughout most of the Central Lowland Province in Segment 10. Howeve
The unconsolidated Quaternary deposits are saturated with freshwater throughout the segment. The water moves through the void spaces between the mineral grains

SURFICIAL AQUIFER SYSTEM

Some of the most productive aquifers in the Central Lowland Province in Segment 10 consist of Quaternary sand and gravel deposits (fig. 11). These deposits, whi
The range in thickness of the Quaternary deposits in the northern part of Segment 10 is shown in figure 14. The thickness of the deposits ranges from less than
Most of the principal sand and gravel deposits that are known to constitute aquifers are shown in figure 11. These coarse-grained deposits have been divided int

HYDROGEOLOGIC SETTING

The lateral extent, thickness, and hydraulic characteristics of each of the numerous sand and gravel aquifers and clay and silt confining units that make up the
The sand and gravel aquifers of the surficial aquifer system are present in different hydrogeologic settings. Aquifers that consist of glacial deposits are in b
The occurrence and movement of the ground water is somewhat different in the four hydrogeologic settings shown in figures 15 through 18. In the buried bedrock v
In the glacial outwash plain setting (fig. 16), the sand and gravel aquifers commonly are at the land surface and receive recharge directly from precipitation.
Parts of the hydrogeologic setting in figure 17 are similar to the settings illustrated by figures 15 and 16. The upper sand and gravel aquifer in figure 17A is
The sand and gravel deposits in the Mississippi River Valley (fig. 18) are somewhat isolated from direct recharge but have a direct hydraulic connection to the
Published reports on the sand and gravel deposits of the surficial aquifer system indicate that individual units range from less than 1 to about 300 feet in thi

GENERALIZED GROUND-WATER MOVEMENT

Although ground water in the surficial aquifer system is under water-table, or unconfined, conditions in many places, artesian, or confined, conditions exist in
A local example of the configuration of the potentiometric surface of the surficial aquifer system and its relation to inter-stream recharge areas and stream-va

AQUIFER HYDRAULIC CHARACTERISTICS AND WELL YIELDS

In parts of central and southern Ohio, the buried Teays Valley is filled with laminated clay and silt that are not aquifer material. Further to the north and we
The transmissivity of the surficial aquifer system varies through a wide range but generally is much larger than the transmissivity of underlying bedrock. Trans
If all other factors remain the same, yields of wells completed in an aquifer are directly proportional to the transmissivity of the aquifer. The largest yields

GROUND-WATER QUALITY

The quality of water in the sand and gravel aquifers of the surficial aquifer system is similar throughout Illinois, Indiana, and Ohio. The quality of the groun
Water in the surficial aquifer system typically is a calcium magnesium bicarbonate type, is hard, and has large concentrations of iron (fig. 23). The water typi

FRESH GROUND-WATER WITHDRAWALS

Approximately 2 billion gallons of fresh ground water was withdrawn each day during 1985 from all the aquifers in the Central Lowland Province in Segment 10. Of

PENNSYLVANIAN AQUIFERS

HYDROGEOLOGIC SETTING

Sandstone and limestone beds of Pennsylvanian age that are aquifers in the Central Lowland Province in Segment 10 lie beneath the surficial aquifer system in pa
Small to moderate supplies of water are obtained from the Pennsylvanian aquifers in places where little water is available from the overlying Quaternary deposit
Most of the water in the Pennsylvanian aquifers is under confined conditions because the aquifers commonly are inter-bedded with siltstone, shale, and clay and
The thickness of Pennsylvanian rocks that is saturated with freshwater ranges from less than 100 feet to more than 300 feet (fig. 29). The thickest parts of the
The sandstones and limestones that are the most productive aquifers in the Pennsylvanian rocks have a distinct stratigraphic (vertical) and areal distribution.

GROUND-WATER QUALITY

The quality of water obtained from the upper parts of the Pennsylvanian aquifers generally is similar throughout the area. However, pronounced water-quality cha
Mixing of freshwater with the saltwater results in a water that is a sodium chloride type, such as the water represented by figure 32B. The change in water from

WELL YIELDS AND FRESH GROUND-WATER WITHDRAWALS

Yields of wells completed in the Pennsylvanian aquifers have been reported to range from less than 1 to about 100 gallons per minute. The average well yield is
Fresh ground-water withdrawals from the Pennsylvanian aquifers are relatively small. Withdrawals from these aquifers during 1985 were less than 4 percent of the

MISSISSIPPIAN AQUIFERS

HYDROGEOLOGIC SETTING

Mississippian rocks that are aquifers in the Central Low-land Province in Segment 10 lie beneath Quaternary deposits and Pennsylvanian rocks in parts of western
Freshwater circulates to depths greater than 1,000 feet below sea level in west-central Illinois; consequently, all the Mississippian rocks that are directly ov
The distribution of wells that obtain water from the Mississippian aquifers is similar to that of wells completed in the Pennsylvanian aquifers. The Mississippi
Water in the Mississippian aquifers primarily moves through openings such as bedding planes, fractures, and solution channels. Generally, the water is under con

GROUND-WATER QUALITY
A summary of the results of chemical analyses of water from wells completed in the Mississippian aquifers in Greene County, Ind., on the eastern side of the Ill
Water quality and well-depth data from the Mississippian and the Pennsylvanian aquifers in Greene and Sullivan Counties, Ind., indicate that small increases in

WELL YIELDS AND FRESH GROUND-WATER WITHDRAWALS
The reported yields of wells completed in the Mississippian aquifers range from less than 1 to more than 100 gallons per minute; the average well yield is about
The specific capacity (well yield divided by water-level drawdown during pumping) of wells completed in the Mississippian aquifers generally ranges from 0.03 to
Fresh ground-water withdrawals from the Mississippian aquifers during 1985 were less than 3 percent of the total ground water withdrawn in Illinois. Withdrawals

SILURIANDEVONIAN AQUIFER

HYDROGEOLOGIC SETTING
Dolomites and limestones of Silurian and Devonian age constitute one of the principal consolidated-rock aquifers throughout a large area in the Central Lowland
The SilurianDevonian aquifer has been referred to by a number of different names. It is known as the carbonate aquifer in Ohio, the SilurianDevonian aquifers in
The Devonian rocks are less important hydrologically than the Silurian rocks because much of the lower part of the section of Devonian rocks has been removed fr
In northern Illinois, freshwater is present at depths greater than 1,000 feet below sea level, which is much deeper than the bottom of the SilurianDevonian aqui
Most of the freshwater part of the SilurianDevonian aquifer is directly overlain by unconsolidated deposits of Quaternary age that compose the surficial aquifer
Ground water generally is under confined conditions in the SilurianDevonian aquifer. The water moves through fractures, bedding planes, and solution cavities in

WELL YIELDS
The yields of wells completed in the SilurianDevonian aquifer range from less than 5 to more than 1,000 gallons per minute. Yields of 5 to 15 gallons per minute
Large well yields in Ohio are possible in the west-central and northwestern parts of the State (fig. 42). Middle and Upper Silurian dolomites are the major wate
The estimated yield of wells completed in the SilurianDevonian aquifer in northern Illinois is shown in figure 43. Well yields in the area are highly variable a

GROUND-WATER QUALITY
The chemical quality of water from the freshwater parts of the SilurianDevonian aquifer generally is adequate or can be treated and made adequate, for most purp
An example of the major dissolved constituents in water from the SilurianDevonian aquifer is shown in figure 45. In samples from western Ohio, calcium, magnesiu

FRESH GROUND-WATER WITHDRAWALS
Total fresh ground-water withdrawals from the SilurianDevonian aquifer in Illinois, Indiana, and Ohio were about 488 million gallons per day during 1985. About
The volume of water withdrawn for some of the ground-water use categories changes significantly from State to State (fig. 47). Ground-water withdrawals from the

CAMBRIANORDOVICIAN AQUIFER SYSTEM
The aquifers in rocks of Cambrian and Ordovician age and the confining units that separate and overlie them are collectively known as the CambrianOrdovician aqu
The CambrianOrdovician aquifer system is complex and multilayered; major aquifers are separated by leaky confining units. Large withdrawals in the Chicago, Ill.
The CambrianOrdovician aquifer system contains freshwater in a large area in northern Illinois (fig. 48). The freshwater flow systems within individual aquifers
Water in the CambrianOrdovician aquifer system primarily is under confined conditions and moves through primary and secondary openings in the rocks. The primary
Parts of three principal aquifers, which consist of consolidated rocks of Ordovician and Cambrian age, are present in northern Illinois‹the St. PeterPrairie du

ST. PETERPRAIRIE DU CHIENJORDAN AQUIFER
The St. PeterPrairie du ChienJordan aquifer lies beneath the Maquoketa, the Galena, and the Platteville Groups, which primarily are shale, dolomitic shale, and
The top of the St. PeterPrairie du ChienJordan aquifer is more than 500 feet above sea level in the northernmost part of Illinois and about 2,500 feet below sea
The St. PeterPrairie du ChienJordan aquifer is about 250 feet thick along the northern boundary of Illinois and about 1,250 feet thick in west-central Illinois.
Before substantial volumes of ground water were withdrawn from the CambrianOrdovician aquifer system, water levels in the St. PeterPrairie du ChienJordan aquife

IRONTONGALESVILLE AQUIFER
The IrontonGalesville aquifer is separated from the overlying St. PeterPrairie du ChienJordan aquifer by dolomite and poorly sorted, fine-grained clastic rocks
The IrontonGalesville aquifer consists of the Ironton and the Galesville Sandstones of Cambrian age. These units are lithologically similar and generally consi
The sandstones of the IrontonGalesville aquifer were not deposited to the southwest of a line that marks the limit of the aquifer in west-central Illinois (fig.
The top of the IrontonGalesville aquifer slopes from about 250 feet above sea level in northernmost Illinois to about 2,500 feet below sea level in the west-cen
Estimated water levels (hydraulic head) for the IrontonGalesville aquifer before the development of substantial ground-water supplies from the CambrianOrdovicia

MOUNT SIMON AQUIFER
The Mount Simon aquifer underlies the northern part of Illinois and the northwestern part of Indiana in Segment 10. It is separated from the IrontonGalesville a
The Mount Simon aquifer consists of sandstone that contains water with a wide range of concentrations of dissolved solids (fig. 57). In Segment 10, only the upp
solids concentrations increase with depth (fig. 50) and toward the south and east. The line that shows dissolved-solids concentrations of 10,000 milligrams per
The top of the Mount Simon aquifer ranges from slightly above sea level to more than 2,000 feet below sea level (fig. 58). The depth to the top of the aquifer d
The thickness of the Mount Simon aquifer in northern Illinois ranges from slightly less than 1,000 feet in northernmost Illinois to more than 2,500 feet southwe
Estimated hydraulic heads (water levels) in the Mount Simon aquifer before substantial ground-water supplies were developed from the CambrianOrdovician aquifer

GROUND-WATER QUALITY
Most of the data on the quality of water from the CambrianOrdovician aquifer system in northern Illinois are from wells that are open to more than one aquifer i
Water from 74 wells completed in the CambrianOrdovician aquifer system in northern Illinois had concentrations of dissolved solids that ranged from about 260 to
The composite water that represents the CambrianOrdovician aquifer system is a calcium magnesium bicarbonate type in northern Illinois (fig. 61). Toward the sou

FRESH GROUND-WATER WITHDRAWALS
Major areas of ground-water withdrawal from the CambrianOrdovician aquifer system in northern Illinois are shown in figure 62. The areas of largest withdrawal a
About 260 million gallons per day were withdrawn from the CambrianOrdovician aquifer system in northern Illinois during 1980. Of this amount, 68 percent, or abo
As a result of withdrawals in the Chicago, Ill., and Milwaukee, Wis. areas, the potentiometric surface of the CambrianOrdovician aquifer system had declined mor
Fresh ground-water withdrawals from the CambrianOrdovician aquifer system totaled 315 million gallons per day during 1985. About 197 million gallons per day was

INTERIOR LOW PLATEAUS AQUIFERS

INTRODUCTION
The Interior Low Plateaus aquifers in Segment 10 consist of the same two general categories of rocks as those in the Central Lowland Province‹unconsolidated san
The major hydrogeologic difference between the Interior Low Plateaus and the Central Lowland Provinces is the restricted distribution of the Quaternary deposits

SURFICIAL AQUIFER SYSTEM
The sand and gravel deposits of Quaternary age along the Ohio River compose the principal aquifers in unconsolidated rocks in the Interior Low Plateaus Province
The distribution and approximate thickness of the Quaternary deposits in the Interior Low Plateaus Province are shown in figure 68. Typically, the lower two-thi
The saturated thickness of the Quaternary deposits increases from east to west along the Ohio River. In Kentucky, the saturated thickness is about 35 feet in Le

AQUIFER CHARACTERISTICS AND WELL YIELDS
Aquifer-test data from Kentucky indicate that median values of transmissivity for different areas of the surficial aquifer system along the Ohio River range fro

GROUND-WATER QUALITY
Chemical analyses of water from selected wells completed in the surficial aquifer system in the Louisville, Ky., area are shown in figure 69. These data are exa
The water typically is hard and is a calcium magnesium bicarbonate sulfate type (fig. 69) with large concentrations of iron. Large dissolved-solids concentratio
The distance of wells from rivers and streams and the type of underlying bedrock affect the chemical characteristics of the water from wells completed in the su
FRESH GROUND-WATER WITHDRAWALS
During 1985, about 113 million gallons per day was withdrawn from wells completed in the surficial aquifer system in the Interior Low Plateaus Province in Segme
The history of withdrawals in the Louisville area in Jef-ferson County, Ky., is an example of how the need for ground water can change through time (fig. 71). F
Water levels in the surficial aquifer system in the Louisville area have risen in response to the decrease in ground-water withdrawals. The hydrograph shown in

PENNSYLVANIAN AQUIFERS

HYDROGEOLOGIC SETTING
Sandstones of Pennsylvanian age are the principal aquifers in consolidated rocks throughout most of the northwestern part of the Interior Low Plateaus Province
The Pennsylvanian rocks are folded into a syncline (fig. 74) that plunges to the north and northwest into the Illinois Basin. Sandstones of the Caseyville and t
The Pennsylvanian sandstones, like those in the Central Lowland Province, are part of repeating sequences of coal-bearing rocks deposited during sedimentary cyc

Part of the precipitation that falls on the exposed Pennsylvanian rocks percolates downward to the water table to recharge the aquifers in these rocks. The wate
In most places, the freshwatersaltwater interface in the Pennsylvanian aquifer is at depths of less than 500 feet below land surface. The deepest occurrence of

AQUIFER CHARACTERISTICS AND WELL YIELDS
Limited data from wells completed in the Pennsylvanian aquifers in Kentucky indicate well yields range from 0.5 to 150 gallons per minute and average about 25 g
Large water-level declines might result from small to moderate ground-water withdrawals in some of the Pennsylvanian aquifers. Such declines are most probable i

GROUND-WATER QUALITY
Sparse data indicate that the aquifers in Upper Pennsylvanian rocks contain hard water that is a calcium magnesium bicarbonate type. The calcium and magnesium i
The quality of the ground water from the sandstone aquifer in Lower Pennsylvanian rocks in the Interior Low Plateaus generally is suitable for most uses. The wa

FRESH GROUND-WATER WITHDRAWALS
Only small quantities of freshwater are withdrawn from the sandstone aquifers in Pennsylvanian rocks in the Interior Low Plateaus Province in Segment 10. Total

MISSISSIPPIAN AQUIFERS

HYDROGEOLOGIC SETTING
A large part of the Interior Low Plateaus Province in Segment 10 is underlain by limestone aquifers in Mississippian rocks (fig. 78). These aquifers have been c
In most places, the Mississippian aquifers are covered by regolith, which mostly consists of weathered material, or residuum (fig. 80). This material consists o
The conceptual flow system in the Mississippian aquifers is shown in figure 80. Precipitation infiltrates the land surface and percolates downward to the water
Freshwater circulates through the limestone aquifers to depths as great as 500 feet below land surface (fig. 81). However, most of the circulation is at depths
The altitude and configuration of the potentiometric surface and the general direction of ground-water movement in the Mississippian aquifers (the Ste. Geneviev
Water in the Mississippian aquifers generally moves in a direction perpendicular to the potentiometric contours, as shown by the arrows in figure 82. However, t

EFFECTS OF DISSOLUTION
An idealized diagram of some of the common types of features that develop on the land surface where Mississippian limestones are exposed and are partially disso
An excellent example of the extent and interconnection of large solution cavities that form as a result of the dissolution of limestone by circulating freshwate
The solution openings in the limestone are so well developed in the Mammoth Cave area that most surface runoff enters the rocks through sinkholes and moves thro
The presence or absence of solution openings affects aquifer recharge and discharge in the Mammoth Cave area and is reflected by the water levels in wells compl

AQUIFER CHARACTERISTICS, YIELDS OF WELLS, AND DISCHARGES OF SPRINGS
The hydraulic characteristics of the Mississippian aquifers vary greatly over short distances. For example, the ability of limestone with large, interconnected
The data in table 1 indicate that the yields of wells completed in the Mississippian aquifers vary greatly. Well yields commonly range from 2 to 50 gallons per
The discharges of 31 selected springs that issue from Mississippian aquifers in the western part of the Interior Low Plateaus Province in Tennessee range from a
The distribution of discharges for six large springs in Kentucky is shown in figure 90. These springs issue primarily from the St. Louis Limestone. These discha

GROUND-WATER QUALITY
The quality of water in the Mississippian aquifers in Kentucky is somewhat different from that in Tennessee (fig. 91). The range of concentrations and the media
Water-quality data from wells and springs in the Mississippian aquifers in Kentucky indicate that the water is either a calcium magnesium bicarbonate type or a
Water with the large concentrations of sulfate is from wells that penetrate anhydrite and gypsum beds in the deeper parts of the Mississippian aquifers in Kentu
Contaminated and turbid water are problems that can plague the users of water from wells and springs in limestone aquifers. Sinkholes are sometimes used to dis

FRESH GROUND-WATER WITHDRAWALS
Total fresh ground-water withdrawals during 1985 from the Mississippian aquifers in the Interior Low Plateaus part of Segment 10 were about 64 million gallons p

DEVONIAN, SILURIAN, AND ORDOVICIAN AQUIFERS

HYDROGEOLOGIC SETTING
Carbonate rocks of Devonian, Silurian, and Ordovician age, which are primarily limestone with some dolomite, are the principal aquifers in large areas of centr
The majority of the carbonate-rock aquifers are in Ordovician rocks. The Middle Ordovician High Bridge and Stones River Groups and the Lexington Limestone and
The depth of freshwater in the limestone and dolomite aquifers can vary greatly, but wells completed in these aquifers generally range from 50 to 200 feet deep
The occurrence and movement of ground water in the limestone and dolomite aquifers in Devonian, Silurian, and Ordovician rocks are much like those in the Missis
Confining units, such as beds of shaly limestone and bentonite, affect the depth to which freshwater circulates (fig. 97). Thin bentonite zones, which consist o
Ground water in the limestone and dolomite aquifers moves from upland recharge areas where water-level altitudes are high to low-lying discharge areas where the

YIELD OF WELLS AND DISCHARGES OF SPRINGS
The yields of wells completed in the limestone and dolomite aquifers in rocks of Devonian, Silurian, and Ordovician age vary considerably throughout the area. T
Spring discharge also is extremely variable. Discharges reported for 89 springs that issue from aquifers in the Silurian and Ordovician rocks in the south-centr

GROUND-WATER QUALITY
The quality of the water in the limestone and dolomite aquifers in Ordovician rocks in Kentucky and Tennessee is shown in figure 99; sparse data indicate that t
The water from Ordovician aquifers in Kentucky is a hard, calcium magnesium bicarbonate type (fig. 100). The abundance of these dominant ions results primarily
The quality of the water from wells completed in the Ordovician aquifer in Kentucky (fig. 100A) and from springs that issue from the same aquifer (fig. 100B) is
As with the Mississippian aquifers, contaminated and turbid waters are common problems for the users of water from the limestone and dolomite aquifers in Devoni

FRESH GROUND-WATER WITHDRAWALS
More fresh ground water is withdrawn from the limestone and dolomite aquifers in Devonian, Silurian, and Ordovician rocks in Tennessee than in Kentucky. About 2

APPALACHIAN PLATEAUS AQUIFERS

INTRODUCTION
The part of the Appalachian Plateaus Physiographic Province included in Segment 10 is present in the eastern parts of Ohio, Kentucky, and Tennessee (fig. 102).
Aquifers in the Appalachian Plateaus Physiographic Province can be divided into two categories‹the surficial aquifer system in unconsolidated deposits and the a

HYDROGEOLOGIC UNITS

SURFICIAL AQUIFER SYSTEM
The surficial aquifer system consists of sand and gravel deposits of glacial and alluvial origin. Some of the glacial material was deposited directly by the ice
The aquifers of the surficial aquifer system are of two types‹alluvium that is in present-day stream valleys and glacial out-wash or valley-train deposits in bu

PENNSYLVANIAN AQUIFERS
Pennsylvanian aquifers in the Appalachian Plateaus Province mostly consist of sandstone and limestone that are parts of repeating sequences of beds deposited du
Upper Pennsylvanian aquifers mostly are present in the Pennsylvanian Monongahela and Conemaugh Groups but also can include sandstones of the Dunkard Group of Pe
Middle and Lower Pennsylvanian aquifers crop out throughout most of the Appalachian Plateaus Province in Segment 10 and are the most widespread source of ground

MISSISSIPPIAN AQUIFERS
Mississippian aquifers in the Appalachian Plateaus Province in Segment 10 consist mostly of limestone and sandstone. Fractured chert of the Fort Payne Formation
The Black Hand and the Berea Sandstones (fig. 103) are the primary Mississippian aquifers in Ohio. Although the Berea is Devonian age in part, it is included in

GROUND-WATER OCCURRENCE AND MOVEMENT

SURFICIAL AQUIFER SYSTEM
Sand and gravel aquifers of the surficial aquifer system in Ohio are the most productive aquifers in the Appalachian Plateaus Province in Segment 10 because the
Aquifers that consist of fine sand and silt also are common in Ohio but generally are less permeable than aquifers that consist of coarse sand and gravel. Yield

AQUIFERS IN CONSOLIDATED ROCKS
Aquifers in consolidated rocks are an important source of ground water, especially where wells penetrate fractures that store and transmit water, where sandston
Water in the consolidated-rock aquifers of the Appalachian Plateaus Province is primarily in fractures in sandstones and shales and in fractures or bedding plan
Sandstone, limestone, and conglomerate are the dominant water-yielding rocks that compose Upper Pennsylvanian aquifers, but beds of fractured coal locally provi
Middle and Lower Pennsylvanian rocks generally contain more sandstone and conglomerate than Upper Pennsylvanian rocks. Some of the Middle and Lower Pennsylvania

Mississippian aquifers are mostly in limestones, except in Ohio where they are mostly in sandstones. Slightly acidic water that moves along fractures, bedding p

GROUND-WATER QUALITY
The quality of ground water from the aquifers in the Appalachian Plateaus Province in Segment 10 generally is suitable, with minimal treatment for most uses. Ch

SURFICIAL AQUIFER SYSTEM
Water from the surficial aquifer system in the Appalachian Plateaus Province in Ohio is predominantly a calcium bicarbonate type. The water generally has larger

AQUIFERS IN CONSOLIDATED ROCKS
The principal factors that govern the chemical quality of ground water in the aquifers in consolidated rocks are aquifer mineralogy and residence time (the amou
Chloride concentrations can be large in water from aquifers in consolidated rocks beneath valley bottoms because of deep circulation of the water to zones at or
Water from the Pennsylvanian and the Mississippian aquifers in Ohio generally is either a calcium magnesium bicarbonate type or a calcium sodium bicarbonate typ
In Kentucky, water from wells completed in the Middle and Lower Pennsylvanian aquifers commonly is a calcium sodium bicarbonate type (fig. 110B). Water from the
Saltwater, defined in this Atlas as water that has a dissolved-solids concentration of more than 1,000 milligrams per liter, generally is at depths greater than
Sparse data indicate that water from Pennsylvanian aquifers in Tennessee ranges from soft to hard, is a mixed type (no anion or cation is dominant), and contain

EFFECTS OF COAL MINING AND RECLAMATION ON GROUND-WATER QUALITY
Surface coal mining and reclamation activities can affect the quality of ground water. Changes in ground-water quality that can occur as a result of mining and
The ground-water flow system in coal mining areas generally is controlled by underclays that typically are present beneath each of several coal beds (fig. 111B)
The quality of the water in the aquifers can be altered by mining activity. In this example, water in the top aquifer undergoes many water-quality changes as a

FRESH GROUND-WATER WITHDRAWALS
Ground water is an important source of freshwater in the Appalachian Plateaus Province of Segment 10. Ohio withdrew the largest quantity of ground water during
The distribution of ground-water withdrawals by county during 1985 (fig. 113) shows that Ohio withdrew the largest quantity of ground water and had the most cou
Despite their generally lower yields, the aquifers in consolidated rocks are important sources of water. In Ohio, Upper Pennsylvanian aquifers provide domestic
During 1985, most of the ground water withdrawn in Ohio (51 percent of total withdrawals) was used for public supply (fig. 114); withdrawals for domestic and co

VALLEY AND RIDGE AQUIFERS

INTRODUCTION
The Valley and Ridge Physiographic Province is characterized by a sequence of folded and faulted, northeast-trending Paleozoic sedimentary rocks that form a ser
The arrangement of the northeast-trending valleys and ridges and the broad expanse of the Cambrian and the Ordovician rocks in eastern Tennessee are the result
The general hydrogeologic characteristics of the entire Valley and Ridge Province are fairly consistent. However, unique characteristics can be attributed to lo

HYDROGEOLOGIC UNITS
The principal aquifers in the Valley and Ridge Province of Segment 10 consist of carbonate rocks that are Cambrian, Ordovician, and Mississippian in age (fig. 1

GROUND-WATER MOVEMENT
Ground water in the Valley and Ridge aquifers primarily is stored in and moves through fractures, bedding planes, and solution openings in the rocks. These type
In the carbonate rocks, the fractures and bedding planes have been enlarged by dissolution of part of the rocks. Slightly acidic water, especially that circulat
Ground-water movement in the Valley and Ridge Province in eastern Tennessee is localized, in part, by the repeating lithology created by thrust faulting and, in

WELL YIELDS AND SPRING DISCHARGE
Yields of wells completed in the principal Valley and Ridge aquifers range from about 1 to 2,500 gallons per minute (table 7). The largest yields (2,500 gallons
The discharges of springs that issue from the principal Valley and Ridge aquifers in eastern Tennessee vary greatly; measured discharges range from about 1 to 5

GROUND-WATER QUALITY
The chemical quality of water in the freshwater parts of the Valley and Ridge aquifers is similar for shallow wells and springs (fig. 119). The water is hard, i
In places where the residuum that overlies the carbonate rocks is thin, the Valley and Ridge aquifers are susceptible to contamination by human activities. The

FRESH GROUND-WATER WITHDRAWALS
Fresh ground-water withdrawals from the aquifers in the Valley and Ridge Province in eastern Tennessee were about 82 million gallons per day during 1985 (fig. 1

BLUE RIDGE, OZARK PLATEAUS, AND SOUTHEASTERN COASTAL PLAIN AQUIFERS

BLUE RIDGE AQUIFERS
The Blue Ridge Physiographic Province in Segment 10 is in easternmost Tennessee (fig. 121). Rocks that underlie the province range in age from Precambrian to Or
Ground water in the Blue Ridge Physiographic Province generally is present in fractured bedrock. The bedrock, which consists of sedimentary, metasedimentary, a
Locally, regolith and stream-valley alluvium also can provide ground water. The bedrock is overlain by regolith that ranges from 1 to 150 feet thick. Alluvium
Ground water from the Blue Ridge aquifers is used primarily for domestic supplies. Well yields from these aquifers are adequate for domestic, livestock, and sm

GROUND-WATER OCCURRENCE
Ground-water occurrence in the Blue Ridge aquifers is determined by the number, size, and degree of interconnection of fractures. Rocks in the Blue Ridge Provin
The saturated regolith that overlies the bedrock and the alluvium in major stream valleys store ground water and release it slowly into the bedrock fractures. T
Ground-water circulation in the Blue Ridge aquifers is localized. Most of the ground water moves along short, shallow flow paths. Precipitation recharges the re

GROUND-WATER QUALITY
The chemical quality of the water in the Blue Ridge aquifers generally is suitable for most uses. Water from wells completed in sandstone aquifers (fig. 123) ty

OZARK PLATEAUS AQUIFER SYSTEM
Because only a small part of the Ozark Plateaus aquifer system is within Segment 10 (fig. 124), the aquifer system is only briefly summarized here. A complete d
The principal aquifers in consolidated rocks of the Ozark Plateaus aquifer system consist of limestone and minor dolomite of Mississippian through Ordovician ag
Water in the limestone and dolomite aquifers of the Ozark Plateaus aquifer system primarily is stored in and moves through fractures and bedding planes because
Yields of wells completed in the Ozark Plateaus aquifer system in Illinois generally are less than 25 gallons per minute but might be several hundred gallons pe
Water from wells completed in the Ozark Plateaus aquifer system is hard and is a calcium magnesium bicarbonate type. Dissolved-solids concentrations generally r

SOUTHEASTERN COASTAL PLAIN AQUIFER SYSTEM
The part of the Southeastern Coastal Plain aquifer system within Segment 10 is restricted to small areas in portions of six counties in western Tennessee (fig.
The Southeastern Coastal Plain aquifer system is divided into four regional aquifers, which consist mostly of semicon-solidated sand, separated by three regiona
Water enters the Black Warrior River aquifer in upland re-charge areas and moves westward and southwestward, down the dip of the sand beds, to discharge to stre
Although the Black Warrior River aquifer is moderately permeable, the aquifer is thin, and its transmissivity is accordingly moderate. Estimated transmissivity
Water from the Black Warrior River aquifer is hard to moderately hard and is a calcium bicarbonate type. Dissolved-solids concentrations in water from the aquif

MISSISSIPPI EMBAYMENT AQUIFER SYSTEM

INTRODUCTION
The aquifers that compose the Mississippi embayment aquifer system (fig. 126) are located in the southwestern part of Segment 10 on the eastern side of the Miss

HYDROGEOLOGIC UNITS
Six aquifers and two confining units compose the Mississippi embayment aquifer system in Segment 10 (fig. 127). The Mississippi River Valley alluvial aquifer, w
The aquifers in the Mississippi embayment aquifer system are defined on the basis of changes in lithology and hydraulic head (water level) between aquifers. Som
Extensive and massive beds of sand characterize the Mississippi embayment aquifer system. These beds thin and pinch out along the updip limit of the Mississippi
The tops of the aquifers in Tertiary and Cretaceous rocks slope toward the axis of the Mississippi Embayment; for example, the top of the lower Wilcox aquifer (

MISSISSIPPI RIVER VALLEY ALLUVIAL AQUIFER
The Mississippi River Valley alluvial aquifer is present only along the Mississippi River in Segment 10. The alluvial aquifer consists primarily of Quaternary s
The Mississippi River Valley alluvial aquifer is capable of sustaining well yields of several thousand gallons per minute because it is hydraulically connected

UPPER CLAIBORNE AQUIFER
The upper Claiborne aquifer is the uppermost hydrogeo-logic unit of the Mississippi embayment aquifer system. Locally, it is overlain by the Mississippi River V

The upper Claiborne aquifer consists of interbedded fine sand, silt, clay, and some lignite; thicker sand beds are common near the base of the aquifer. Sands of

MIDDLE CLAIBORNE AQUIFER

The middle Claiborne aquifer is a major source of ground water in the Mississippi embayment aquifer system in Segment 10. This aquifer primarily consists of the
The thickness of the middle Claiborne aquifer is variable (fig. 132). Sands of the middle Claiborne aquifer are derived from continental sources and are thick
The middle Claiborne aquifer is in direct hydraulic connection with the underlying lower Claiborneupper Wilcox aquifer in Tennessee and Kentucky. No confining u

LOWER CLAIBORNEUPPER WILCOX AQUIFER

The lower Claiborneupper Wilcox aquifer in Illinois and Kentucky consists of the upper part of the Wilcox Formation (fig. 127). In Tennessee, the aquifer consis
The lower Claiborneupper Wilcox aquifer thickens from a featheredge at its updip limit to more than 400 feet in southwestern Tennessee (fig. 133). The aquifer c

MIDDLE WILCOX AQUIFER

The middle Wilcox aquifer primarily consists of the Wilcox Formation in Illinois and Kentucky and the Fort Pillow Sand in Tennessee (fig. 127). The aquifer is t
Sediments of continental origin, which compose the middle Wilcox aquifer, consist of thin, interbedded, fine sand, silt, and clay, all with low permeability. Sa

LOWER WILCOX AQUIFER

The lower Wilcox aquifer directly underlies the middle Wilcox aquifer and is the lowermost aquifer in Tertiary rocks in the Mississippi embayment aquifer system
The thickness of the lower Wilcox aquifer increases from a featheredge at the eastern limit of its outcrop to a maximum of more than 300 feet in parts of Dyer,
The lower Wilcox aquifer consists of sands deposited in fluvial conditions similar to those in the floodplain of the present-day Mississippi River. These sands
The lower Wilcox aquifer is underlain by a thick sequence of marine clay beds known as the Midway confining unit (fig. 127). This confining unit hydraulically s

MCNAIRYNACATOCH AQUIFER

The McNairyNacatoch aquifer is in Upper Cretaceous rocks and is the lowermost hydrogeologic unit included in the Mississippi embayment aquifer system (fig. 127)

GROUND-WATER MOVEMENT

The principal aquifers in the Mississippi embayment aquifer system that are used for water supply in Segment 10 are the middle Claiborne, the lower Wilcox, and
Regional ground-water movement in the aquifers of the Mississippi embayment aquifer system generally is from aquifer outcrop areas toward the axis of the Missis

HYDRAULIC CHARACTERISTICS OF PRINCIPAL AQUIFERS

Yields from the Mississippi embayment aquifer system in Segment 10 tend to be greater for wells completed in the aquifers in Tertiary rocks than for those compl
Transmissivity is a measure of the ease with which water can move through an aquifer. The larger the transmissivity, the more readily water can move through the

GROUND-WATER QUALITY

The chemical quality of water from the aquifers in the Mississippi embayment aquifer system generally is suitable for most uses. The areal distribution of const
Dissolved-solids concentrations usually are less than 250 milligrams per liter in water from most of the aquifers in the Mississippi embayment aquifer system. H

FRESH GROUND-WATER WITHDRAWALS

Total ground-water withdrawals from the aquifers of the Mississippi embayment aquifer system in Kentucky and Tennessee were about 311 million gallons per day du
Ground water is the major source of water for public supply throughout the Coastal Plain Province in Segment 10. During 1985, withdrawals for public supply and
Shelby County, Tenn., which includes the city of Memphis, withdrew about 196 million gallons per day of freshwater during 1985. As shown in figure 140,

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