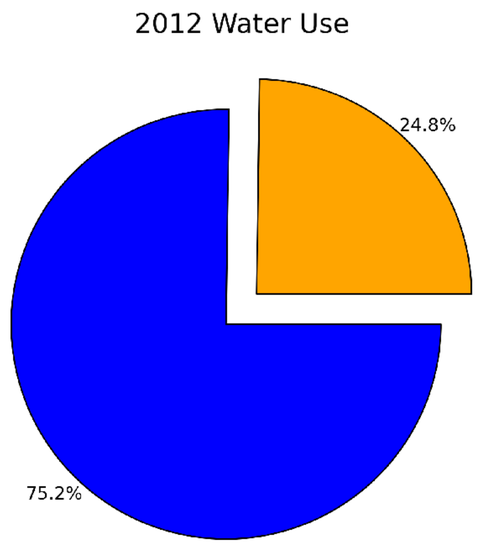
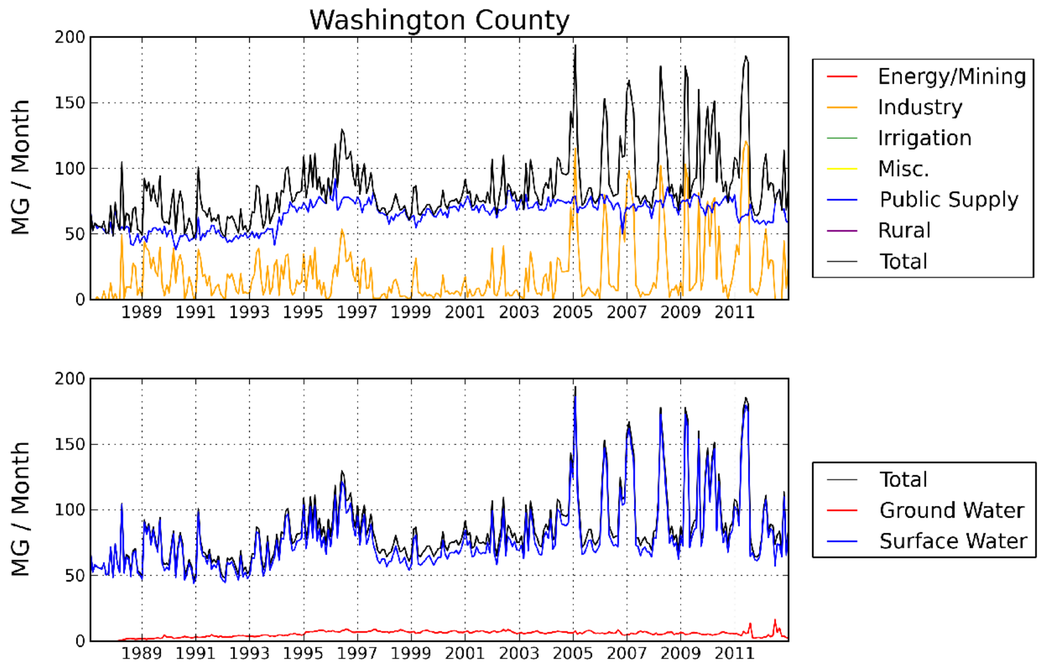
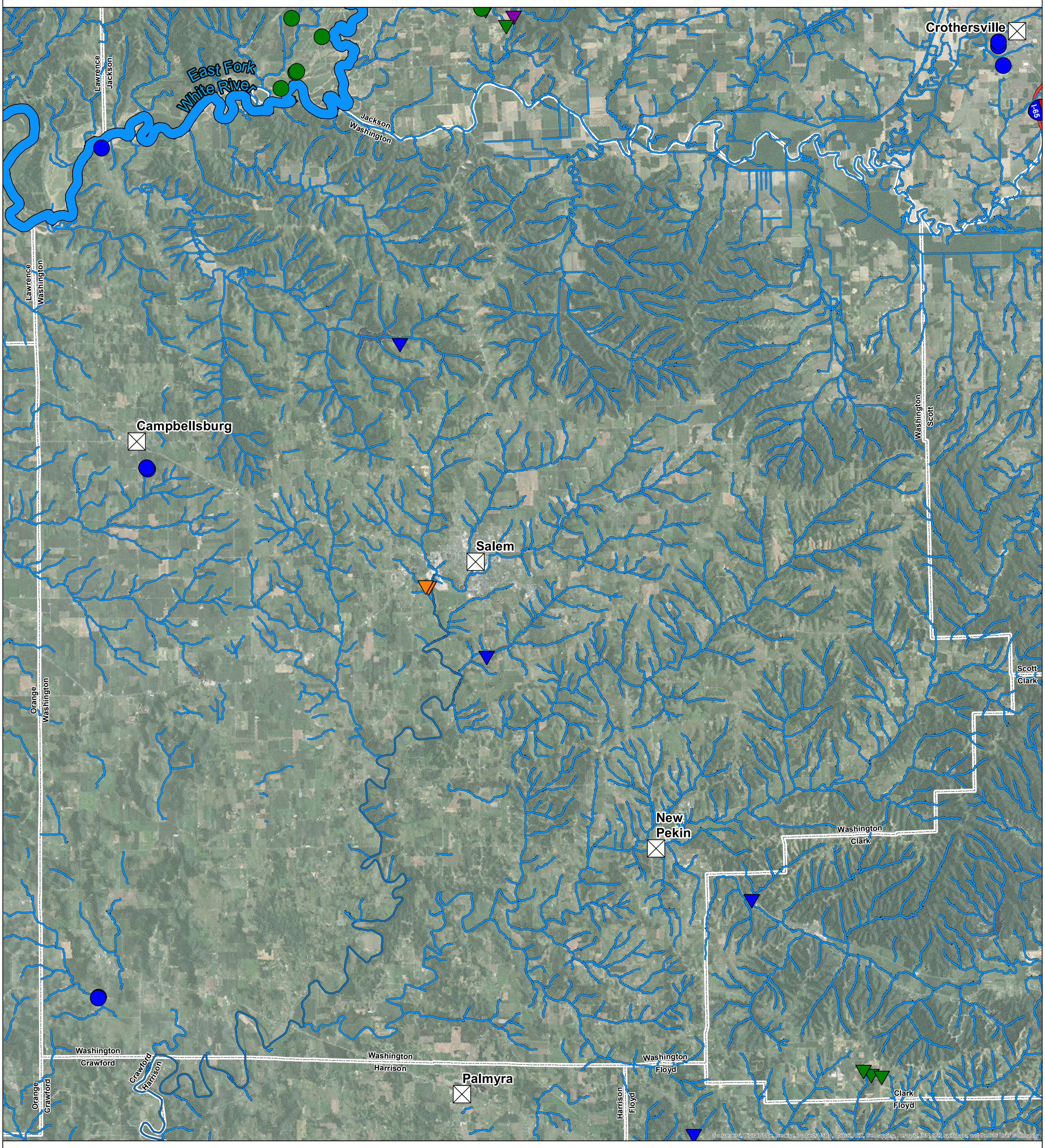


Average Daily Use: 2.9 MGD





Water Resources and Use in Washington County

Data Sources: U.S. Geological Survey and Indiana Department of Natural Resources

Withdrawal Location

WELL INTAKE

- Energy/Mining
- Industry
- Irrigation
- Misc.
- Public Supply
- Rural Use

River

7Q2 Flow (MGD)

- <10 MGD
- 10 - 50 MGD
- 50 - 100 MGD
- 100 - 500 MGD
- > 500 MGD

- Major Lakes
- Interstate
- County
- City

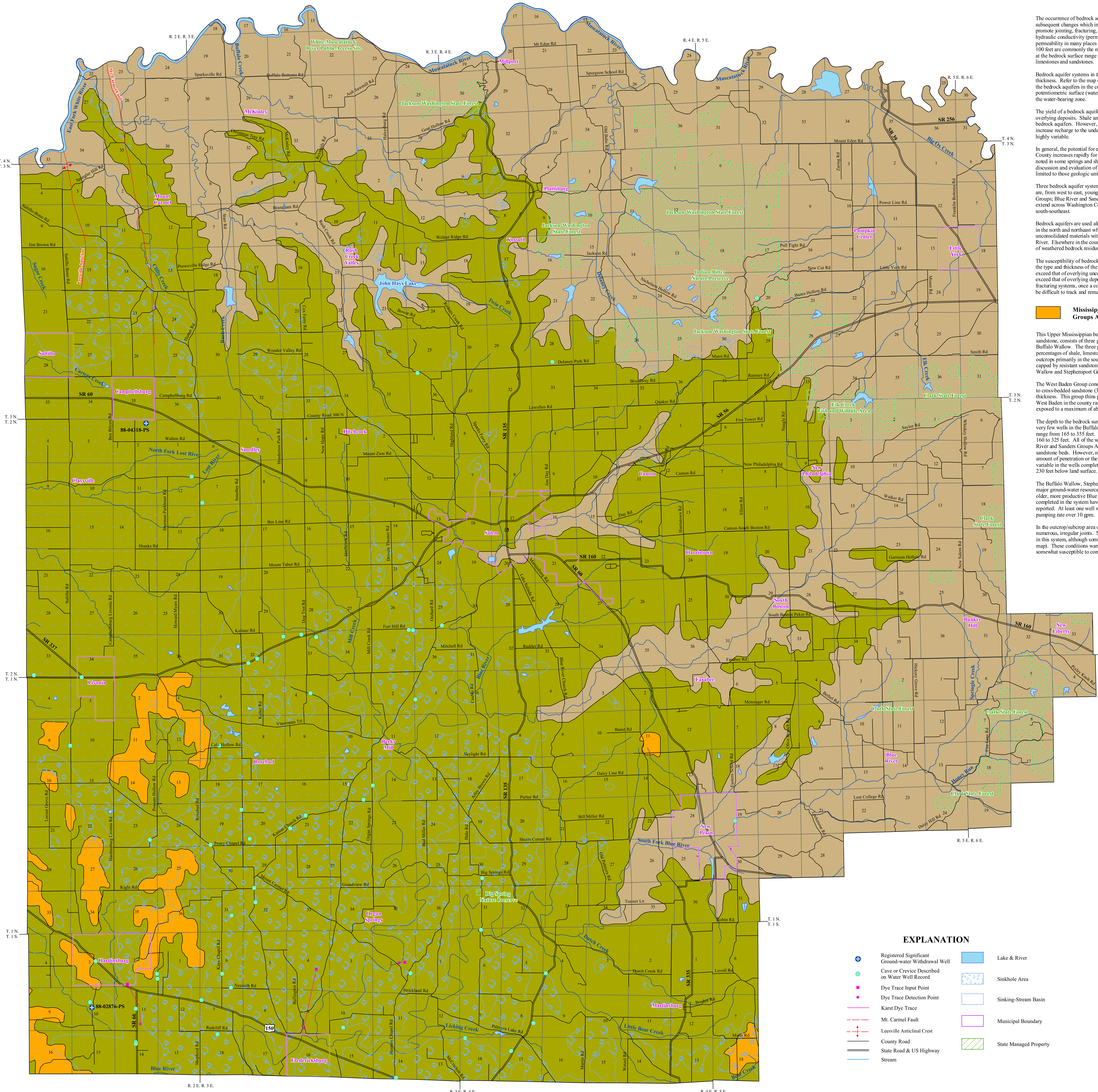
INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

NORTH

0 1 2 4 Miles

Joseph E. Kernan, Governor
Department of Natural Resources
John Goss, Director

BEDROCK AQUIFER SYSTEMS OF WASHINGTON COUNTY, INDIANA



The occurrence of bedrock aquifers depends on the original composition of the rocks and subsequent changes which influence the hydraulic properties. Post-depositional processes which promote jointing, fracturing, and solution activity of exposed bedrock generally increase the hydraulic conductivity (permeability) of the upper portion of bedrock aquifer systems. Because permeability in many places is greatest near the bedrock surface, bedrock units within the upper 100 feet are commonly the most productive aquifers. In Washington County, rock types exposed at the bedrock surface range from relatively unproductive shales to moderately productive limestones and sandstones.

Bedrock aquifer systems in the county are overlain by unconsolidated deposits of varying thickness. Refer to the map of unconsolidated aquifer systems for more information. Most of the bedrock aquifers in the county are under confined conditions. In other words, the potentiometric surface (water level) in most wells completed in bedrock rises above the top of the water-bearing zone.

The yield of a bedrock aquifer depends on its hydraulic characteristics and the nature of the overlying deposits. Shale and glacial till act as aquitards, restricting recharge to underlying bedrock aquifers. However, fracturing and/or jointing may occur in aquitards, which can increase recharge to the underlying aquifers. Hydraulic properties of the bedrock aquifers are highly variable.

In general, the potential for encountering mineralized or saline ground water in Washington County increases rapidly for bedrock wells deeper than a few hundred feet. Mineralized water is noted in some springs and shallower wells, particularly in low-lying areas. Therefore, the discussion and evaluation of the ground-water potential of the bedrock aquifers is essentially limited to those geologic units lying above the expected limits of nonpotable water.

Three bedrock aquifer systems of Mississippian age are identified for Washington County. They are, from west to east, youngest to oldest: Buffalo Wallow, Stephensport, and West Baden Groups; Blue River and Sanders Groups; and Borden Group. The bedrock aquifer systems extend across Washington County generally as a series of bands trending north-northwest to south-southeast.

Bedrock aquifers are used almost exclusively in Washington County. One exception is an area in the north and northeast where adequate ground water is generally available from shallower unconsolidated materials within the floodplains of the East Fork White River and Muscatatuck River. Elsewhere in the county, unconsolidated materials are relatively thin, primarily consisting of weathered bedrock residuum.

The susceptibility of bedrock aquifer systems to surface contamination is largely dependent on the type and thickness of the overlying sediments. Just as recharge for bedrock aquifers cannot exceed that of overlying unconsolidated deposits, susceptibility to surface contamination will not exceed that of overlying deposits. However, because the bedrock aquifer systems have complex fracturing systems, once a contaminant has been introduced into a bedrock aquifer system, it will be difficult to track and remediate.

Mississippian -- Buffalo Wallow, Stephensport, and West Baden Groups Aquifer System

This Upper Mississippian bedrock aquifer system, composed primarily of shale, limestone, and sandstone, consists of three groups, from oldest to youngest: West Baden, Stephensport, and Buffalo Wallow. The three groups comprising this bedrock aquifer system differ in their percentages of shale, limestone, and sandstone. In Washington County this aquifer system outcrops primarily in the southwest corner of the county, where many of the ridge tops are capped by resistant sandstones (Sample Formation) of the West Baden Group. The Buffalo Wallow and Stephensport Groups are not present in the county.

The West Baden Group consists dominantly of shale and mudstone (40 percent) and thin-bedded to cross-bedded sandstone (35 percent); however, it has limestone beds (25 percent) of variable thickness. This group thins progressively eastward in Washington County. The thickness of the West Baden in the county ranges from 0 feet where the older Blue River Group rocks are exposed to a maximum of about 100 feet in the western part of the county.

The depth to the bedrock surface is typically less than 20 feet on the uplands. Well depths of the very few wells in the Buffalo Wallow, Stephensport, and West Baden Groups Aquifer System range from 165 to 355 feet. The amount of rock penetrated by a well typically ranges from about 160 to 325 feet. All of the wells penetrate through this aquifer system into the underlying Blue River and Sanders Groups Aquifer System. Most of the water will be found in the limestone and sandstone beds. However, no attempt has been made in this report to correlate yields with the amount of penetration or the individual geologic formations used. Static water levels are highly variable in the wells completed in this aquifer system. Reported water levels range from 40 to 230 feet below land surface.

The Buffalo Wallow, Stephensport, and West Baden Groups Aquifer System is not regarded as a major ground-water resource in this county, thus most drillers prefer to finish the wells in the older, more productive Blue River and Sanders Groups Aquifer System. Most domestic wells completed in the system have been tested between 0 and 10 gpm and a few dry holes have been reported. At least one well was tested as high as 25 gpm. However, very few wells can sustain a pumping rate over 10 gpm.

In the outcrop/subcrop area of this aquifer system the rock is predominantly shallow and contains numerous, irregular joints. None of the very few water well records describes caves or crevices in this system, although some karst features (sinkholes) are noted on topographic maps (see map). These conditions warrant considering the aquifer system in Washington County to be somewhat susceptible to contaminants introduced at and near land surface.

Mississippian -- Blue River and Sanders Groups Aquifer System

This Middle Mississippian age aquifer system outcrops primarily in the western two thirds of the county. The older Sanders group is exposed roughly in a diagonal from the northwest corner to the southeast corner of Washington County and is found along the lower valley walls of the southern portion of Blue River and its larger tributaries. The Sanders Group consists in ascending order of the Harrodsburg and Salem limestone formations. These are primarily limestone but contain some dolomite. The Blue River Group includes in ascending order the St. Louis, Ste. Genevieve, and Paoli limestone formations. These formations are primarily limestone, but they may contain significant amounts of gypsum, anhydrite, shale, chert, and calcareous sandstone. The Blue River Group outcrops/subcrops primarily on the plateaus and lowland of the western portion of the county and generally on the uplands further east.

The combined thickness of the Blue River and Sanders Groups ranges from 0 feet where they are eroded in the eastern third of Washington County, to over 400 feet in the southwestern part of the county. The formations thicken as they dip to the west-southwest. Limestones within the Blue River Group are especially noted for development of karst features on the land surface where the bedrock is quite shallow. Some of the karst features in the county include caves, sinkholes, collapsed sinkholes, sinking streams, stream rises, and springs. These features are produced by the action of ground water dissolving the limestone, primarily along planes or zones of weakness. Weak zones include vertical or nearly vertical joints, nearly horizontal bedding planes between limestone units, and zones within the formations that are more easily dissolved. Most of the permeability (a measure of the ability of the rock to transmit water) of these limestones results from the joints that developed after the rock was formed and their subsequent enlargement by the dissolving action of water.

Some well records describe cavities or solution channels up to 15 feet in height (see map for location of these wells). Not surprisingly, the yields of wells tapping this aquifer system are quite variable. Yields should vary roughly in proportion to the number, size, depth, and degree of interconnection of joints and solution channels. However, the effects of those variables at any specific location cannot be predicted with any degree of accuracy. Where the rock is overlain by sand and gravel, or broken limestone such as in a river valley or on the uplands of the central portion of the county (Mitchell Plateau), somewhat higher sustained yields are believed possible. The Division has records for over 600 wells in this aquifer system in the county. The depth to solid bedrock is typically between 20 and 60 feet on the uplands of the central portion of the county (Mitchell Plateau), but may be as much as 80 feet where broken limestone and clay are present due to extensive weathering and/or karstification. Isolated sand and gravel seams up to 5 feet thick may be present in the valley bottoms of Lost River and/or Blue River. Additionally, isolated thin sand and gravel seams may be present in the outwash terraces along the major forks of Blue River, particularly the South Fork Blue River. However, these terraces are unlikely to have much saturated thickness. Well depths range from about 25 to 325 feet, with most wells completed at depths of about 85 to 150 feet. Reported test rates for water wells vary between 0 and 200 gpm. The registered significant ground-water withdrawal facilities with wells completed in this system are reported to have pumping capacities ranging from 50 to 120 gpm. Most domestic wells completed in the system have been tested between 1 and 30 gpm and a few isolated dry holes have been reported. Reported water levels range from 0 to 225 feet below land surface, but are typically between 30 and 80 feet.

In Washington County, the Blue River and Sanders Groups Aquifer System is considered a very dependable ground-water source. Water quality is generally good, except for several wells reporting a sulfur odor, which may be due to chemical reactions associated with gypsum deposits in the Blue River Group. Because the rock is generally quite shallow, and contains numerous fractures, open joints, and solution channels, the aquifer system is considered very susceptible to contamination from the land surface.

Mississippian -- Borden Group Aquifer System

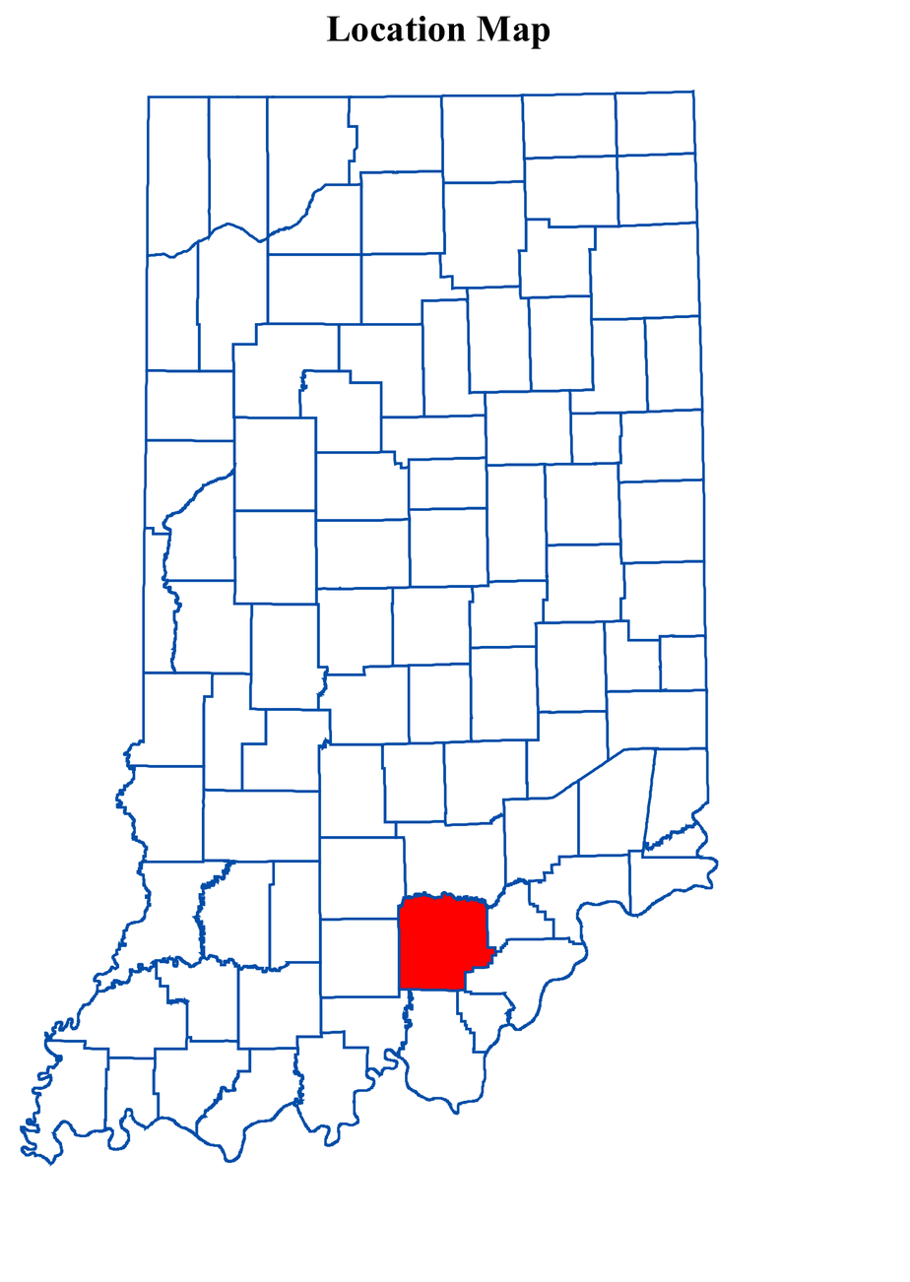
The outcrop/subcrop area of the Mississippian age Borden Group Aquifer System includes the eastern third of Washington County, especially the valleys of East Fork White River, Muscatatuck River, and their tributaries. This bedrock aquifer system is composed mostly of siltstone and shale, but fine-grained sandstones are common. Carbonates are rare, but do occur as discontinuous interbedded limestone lenses, mostly in the upper portion of the group.

The Borden Group in Washington County is up to 600 feet thick. Well depths in the Borden Group Aquifer System range from 26 to 220 feet. However, most wells are completed at depths of 50 to 100 feet. Reported static water levels in the wells completed in this aquifer system range from 0 to 80 feet below land surface, but are commonly between 15 and 40 feet.

Because the Borden Group is generally not very productive, it is typically used only where overlying deposits do not contain an aquifer. The Borden Group is often described as an aquitard and yields of wells completed in it are usually quite limited. Many wells, however, are able to produce sufficient water for domestic purposes by relying on extra well-bore storage created by drilling relatively large diameter and relatively deep wells. Most domestic wells completed in the group have reported testing rates of less than 5 gpm and many dry holes have been reported. A few wells have been tested at rates greater than 50 gpm in the New Pekin area along the South Fork Blue River. The higher capacity wells likely occur along significant bedrock fractures. Overlying alluvium in the river valley may help recharge the fractures. However, it is doubtful that many wells could sustain high pumping rates for very long. There have been several dry holes reported within a few hundred feet of these higher capacity wells. Overall, there is little chance for development of high-capacity wells in the Borden Group Aquifer System in Washington County.

The Borden Group is composed primarily of fine-grained materials that limit the movement of ground water to fractures, joints, and along the bedrock surface. This, along with the overlying, typically fine-grained clay materials, puts most of the Borden Group Aquifer System at low risk to contamination from the surface or near surface. However, in areas where coarse-grained alluvium overlies the fractured and jointed rock, there is a high risk of contamination from surface or near-surface sources.

Location Map



EXPLANATION

- Registered Significant Ground-water Withdrawal Well
- Cave or Crevice Described on Water Well Record
- Dye Trace Input Point
- Dye Trace Detection Point
- Karst Dye Trace
- Mt. Carmel Fault
- Leesville Anticlinal Crest
- County Road
- State Road & US Highway
- Stream
- Lake & River
- Sinkhole Area
- Sinking-Stream Basin
- Municipal Boundary
- State Managed Property

Map generated by Jennifer Mc Millan
IDNR, Division of Water, Resource Assessment Section
March 2004

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This map was created from several existing shapefiles. Township and Range Lines of Indiana (line shapefile, 20020621), Land Survey Lines of Indiana (polygon shapefile, 20020621), Selected Subsurface Dye Traces in Parts of Southern Indiana (line shapefile, 20000225), Input and Detection Points for Selected Subsurface Dye Traces in Parts of Southern Indiana (point shapefile, 20001124) and County Boundaries of Indiana (polygon shapefile, 20020621), were all from the Indiana Geological Survey and based on a 1:24,000 scale, except the Bedrock Geology of Indiana (polygon shapefile, 20020318), which was at a 1:500,000 scale. Draft road shapefiles, System1 and System2 (line shapefiles, 2003), were from the Indiana Department of Transportation and based on a 1:24,000 scale. Populated Areas in Indiana 2000 (polygon shapefile, 20021000) was from the U.S. Census Bureau and based on a 1:100,000 scale. Structural Features of Indiana (line shapefile,20020718) was from the Indiana Geological Survey and based on various scales. Streams27 (line shapefile, 20000420) was from the Center for Advanced Applications in GIS at Purdue University. Managed Areas 96 (polygon shapefile, various dates) was from IDNR. Sinkhole Areas and Sinking-Stream Basins in Part of Southern Indiana (polygon shapefile, 20001124) were also from the Indiana Geological Survey, but based on a 1:126,720 scale.

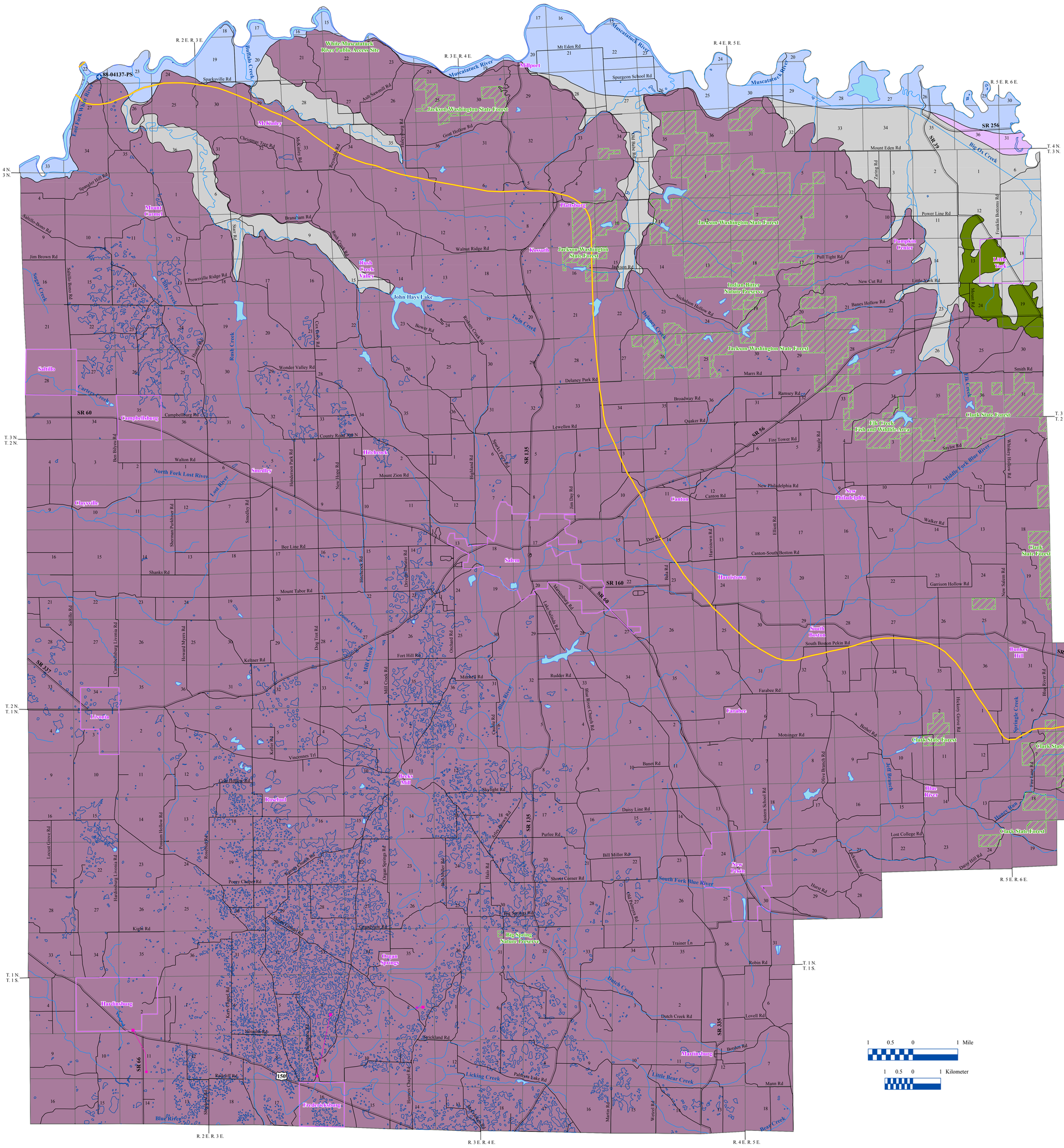
Bedrock Aquifer Systems of Washington County, Indiana

by

Glenn E. Grove
Division of Water, Resource Assessment Section

March 2004

UNCONSOLIDATED AQUIFER SYSTEMS OF WASHINGTON COUNTY, INDIANA



Five unconsolidated aquifer systems have been mapped in Washington County: the Dissected Till and Residuum / Unglaciated Southern Hills and Lowlands; the Alluvial, Lacustrine, and Backwater Deposits; the Scottsburg Lowland Till Subsystem; the White River and Tributaries Outwash; and the White River and Tributaries Outwash Subsystem. The first system includes relatively thin deposits left by continental ice sheets as well as eroded residuum (a product of bedrock weathering). The next four systems comprise sediments deposited by, or resulting from, glaciers, glacial meltwaters, and post-glacial precipitation events. Boundaries of these aquifer systems are commonly gradational and individual aquifers may extend across aquifer system boundaries.

The thickness of unconsolidated sediments in Washington County is quite variable. In much of the county the unconsolidated materials overlying bedrock are less than 30 feet thick. However, along the northern and northeastern county boundary, particularly in the floodplains of the Muscatatuck and East Fork White Rivers, the thickness of unconsolidated deposits commonly ranges from 40 to 75 feet. A thickness of over 90 feet is present in glaciated upland areas around the town of Little York, where sequences of glacial outwash, till, and lacustrine deposits have been stacked above a deep part of a buried bedrock valley. Sand and gravel aquifers exist within thicker unconsolidated materials in the main valley of the East Fork White River and are expected to be present at the base of the thicker unconsolidated materials in the main valley of the Muscatatuck River.

Regional estimates of aquifer susceptibility to contamination from the surface can differ considerably from local reality. Variations within geologic environments can cause variation in susceptibility to surface contamination. In addition, man-made structures such as poorly constructed water wells, unplugged or improperly abandoned wells, and open excavations, can provide contaminant pathways that bypass the naturally protective clays.

Dissected Till and Residuum / Unglaciated Southern Hills and Lowlands Aquifer System

The Dissected Till and Residuum / Unglaciated Southern Hills and Lowlands Aquifer System, which covers about 93 percent of Washington County, has the most limited groundwater resources of the unconsolidated aquifer systems in the county. Unconsolidated materials of this aquifer system predominantly consist of thin, eroded bedrock residuum and (in the glaciated northeastern part of the county) pre-Wisconsin tills and thin outwash terraces. On the uplands of the central portion of the county the residuum and broken limestone are generally between 25 and 50 feet thick, but near Campbellsburg and Smedley the residuum is over 80 feet thick in places. On long steep slopes the residuum is commonly less than 10 feet thick. Also included in this aquifer system, in many of the stream bottoms, are relatively thin deposits of alluvium, colluvium, and lacustrine materials. Thin dune sands of Wisconsin age are also present in this system east of Buffalo Creek.

Total thickness of this system in Washington County typically ranges from about 10 to 50 feet. Because the unconsolidated materials covering the bedrock are so thin in most places, the aquifer elevations closely match the elevation of the bedrock surface. The bedrock surface varies in elevation from about 530 feet above mean sea level (m.s.l.) near the East Fork White River at the northwestern corner of the county to as much as 1000 feet m.s.l. west of the town of New Philadelphia.

There is little potential for water production in the Dissected Till and Residuum / Unglaciated Southern Hills and Lowlands Aquifer System in Washington County and several dry holes have been reported. Nearly all wells penetrating this unconsolidated aquifer system in the county are developed in the underlying bedrock. However, in places large-diameter bored (bucket-rig) wells may produce water from thin sands within the predominantly clay and silt materials of this aquifer system. Because of the generally low permeability of the near-surface materials, this system is not very susceptible to contamination from surface sources.

Alluvial, Lacustrine, and Backwater Deposits Aquifer System

In Washington County the Alluvial, Lacustrine, and Backwater Deposits Aquifer System is made up of deposits in the valleys of larger tributaries to the East Fork White and Muscatatuck Rivers. A portion of the main Muscatatuck River valley is also included in this system.

The unconsolidated deposits in this aquifer system come from two sources. The first source is alluvium, and perhaps some old outwash, deposited by the streams along with colluvium eroded from the valley walls and upland areas. The second source is glaciolacustrine deposits that were formed in bodies of relatively stagnant lake water, and are marked by soft silt and clay. These lake deposits were formed when the valley of the East Fork White River was choked with coarser material carried by glacial meltwater. Thick deposits of this material effectively dammed tributary streams, creating lakes. Thick deposits of silt, sometimes called "slackwater clay," mark the former locations of these glacial lakes. These lacustrine deposits are often noted on Quaternary geology maps and soil maps.

The three forks of the Blue River (West Fork, Middle Fork, and South Fork) all carried pre-Wisconsin outwash. However, the valley filling was not significant or has been mostly eroded over time. In many locations these streams run on bedrock, and bedrock outcrops along their banks. The South Fork Blue River has small isolated terraces of thin sand and gravel, mixed with clay. However, these deposits are too thin to be included in the Alluvial, Lacustrine, and Backwater Deposits Aquifer System.

The total thickness of unconsolidated deposits (mostly clay and silt) in this aquifer system varies considerably, from about 25 feet to more than 50 feet. The thickness of permeable sand or gravel zones is typically less than 5 feet, but in a few isolated places may exceed 10 feet. Most of the permeable zones are fine-grained sand. The overall scarcity of productive zones of sand and gravel in this aquifer system is apparent from the number of water wells completed in the underlying bedrock aquifers. Very few data are available. However, it is expected that many wells drilled in this system (especially bucket-rig wells) may yield sufficient water for domestic needs.

This aquifer system is marked by thick deposits of soft silt and clay that have low susceptibility to surface contamination.

Scottsburg Lowland Till Aquifer Subsystem

The Scottsburg Lowland Till Aquifer Subsystem is present in one small area in northeastern Washington County. The unconsolidated deposits overlying bedrock consist of dominantly pre-Wisconsin glacial materials that range in thickness from 30 to more than 95 feet. Very few data points are available for this aquifer system in the county, thus boundaries with other aquifer systems are transitional and largely based on surface topography. In places, this system is also covered by younger lacustrine deposits of Wisconsin age.

In Washington County this aquifer system is expected to be a better resource than the Dissected Till and Residuum Aquifer System. Potential aquifer materials within the glacial till include discontinuous intratill sand and gravel units. The Division of Water has only one water well record for this system, and the well driller described a seam of gravel 8 feet thick. Typical well yields would be expected to be sufficient for domestic uses.

The Scottsburg Lowland Till Aquifer Subsystem has a low susceptibility to surface contamination because intratill sand and gravel aquifers in this system are generally overlain by fine-grained material (till), loess, and/or lacustrine deposits.

White River and Tributaries Outwash Aquifer System

The White River and Tributaries Outwash Aquifer System occupies the valley of the East Fork White River and portions of the Muscatatuck River valley in Washington County. This system contains large volumes of sand and gravel that filled the main river valleys. As the glaciers melted (far upstream), the sediment contained within them was delivered to these valleys in quantities too large for the streams to transport. As a result, the increased sediment load was stored in the valleys as vertical and lateral accretionary deposits. As long as the retreating glaciers continued to provide sediment in quantities too large for the streams to transport, the main valleys continued to be filled. This valley-filling process formed the most prolific aquifer system in the county.

Based on only two water well records and limited seismic data, the unconsolidated deposits (mostly sand and gravel) of this system in the East Fork White River valley are known to be up to 85 feet thick. West of the confluence of the Muscatatuck River, little or no clay is present above the sand and gravel. It is likely most of the sand and gravel is saturated, because the ground water level is expected to be 5 to 15 feet below the land surface. The two wells completed in this system are for the town of Campbellsburg. The wells are 61 and 65 feet deep and penetrate 49 to 53 feet of saturated aquifer materials and wells yield about 350 gallons per minute (gpm).

The Muscatatuck River valley was blocked by valley-train outwash deposits of the East Fork White River during Wisconsin glacial events. This resulted in a thick accumulation of fine-grained sediments (silt, clay, and fine-grained sand) over the pre-Wisconsin sediments in the Muscatatuck valley. Because few water well records are available, the boundaries of this portion of the system are somewhat subjective. The system is limited to the deepest part of the bedrock valley. Seismic data indicate the unconsolidated material exceeds 100 feet in thickness in Jackson County; however, it is generally less than 75 feet thick in Washington County. Below as much as 40 or 50 feet of silt and clay, in the deepest part of the bedrock valley, are likely relatively thick sand and gravel outwash deposits of pre-Wisconsin age.

The elevation of the modern Muscatatuck River floodplain is approximately 525 feet m.s.l. upstream where the river enters Washington County and approximately 515 feet m.s.l downstream at its confluence with the East Fork White River. The elevation of the floodplain where the East Fork White River leaves the county is approximately 505 feet m.s.l. The elevation of the bottom of the aquifer system, in the deepest parts of the bedrock valley, may range from 430 to 415 feet m.s.l.

The White River and Tributaries Outwash Aquifer System is by far the most productive in Washington County and has the potential to consistently meet the needs of high-capacity water users. Large-diameter well yields of 300 to 1500 gpm have been obtained in this system in other counties. The system could support considerably more development than is utilized by the existing facilities. The only registered significant groundwater facility in the county currently using this aquifer system is the town of Campbellsburg.

White River and Tributaries Outwash Aquifer Subsystem

This aquifer system (subsystem) is generally located adjacent to and parallel to the White River and Tributaries Outwash Aquifer System. It typically occupies a higher topographic position and has considerably thinner sand and gravel units than the main outwash aquifer system. Commonly the sand and gravel is covered by a layer of clay, till, lacustrine, or loess deposits. The boundaries of this portion of the system are very subjective. Because of a lack of water well data, the system boundaries are based primarily on limited seismic data. This system occupies a very small portion of the northeastern corner of Washington County.

This system is not expected to be as productive as the White River and Tributaries Outwash Aquifer System. Based on well data from nearby counties, well yields in this subsystem would be expected to be sufficient for most domestic uses. Larger diameter wells in the thickest sand and gravel may yield 70 to 300 gpm.

In Washington County the subsystem is not very susceptible to surface contamination because of moderately thick units of clay and silt overlying the water-bearing sand and gravel.

EXPLANATION

- Registered Significant Ground-water Withdrawal Well
- Dye Trace Input Point
- Dye Trace Detection Point
- Karst Dye Trace
- Stream
- County Road
- State Road & US Highway
- Approximate Southern Limit of Older Glacial Deposits
- USGS Closed Contour (Mostly Karst Depressions)
- Municipal Boundary
- State Managed Property
- Lake & River

Location Map

Map generated by Jennifer Mc Millan
IDNR, Division of Water, Resource Assessment Section
March 2004

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Unconsolidated Aquifer Systems of Washington County, Indiana

by

Glenn E. Grove
Division of Water, Resource Assessment Section

March 2004

Washington County