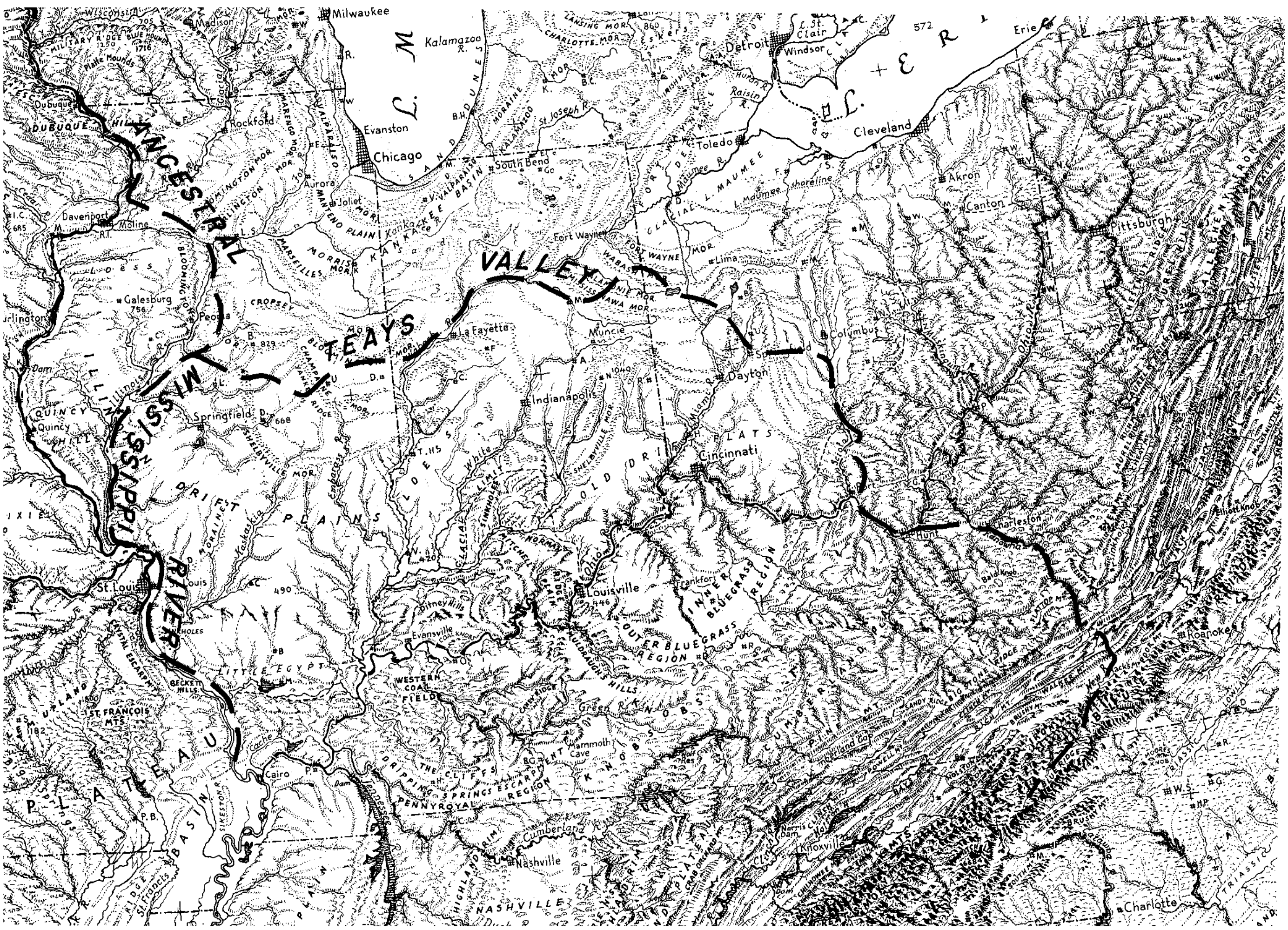
HYDROGEOLOGY OF THE LAFAYETTE (TEAYS) BEDROCK VALLEY SYSTEM NORTH-CENTRAL INDIANA



STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER

HYDROGEOLOGY OF THE LAFAYETTE (TEAYS) BEDROCK VALLEY SYSTEM, NORTH-CENTRAL INDIANA

By Thomas M. Bruns and William J. Steen

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER

Water Resource Assessment 2003-7

Printed by Authority of the State of Indiana
Indianapolis, Indiana: 2003

STATE OF INDIANA
Frank O'Bannon, Governor

DEPARTMENT OF NATURAL RESOURCES
John Goss, Director

DIVISION OF WATER
Michael W. Neyer, Director

For sale by Division of Water, Indianapolis, Indiana

Contents

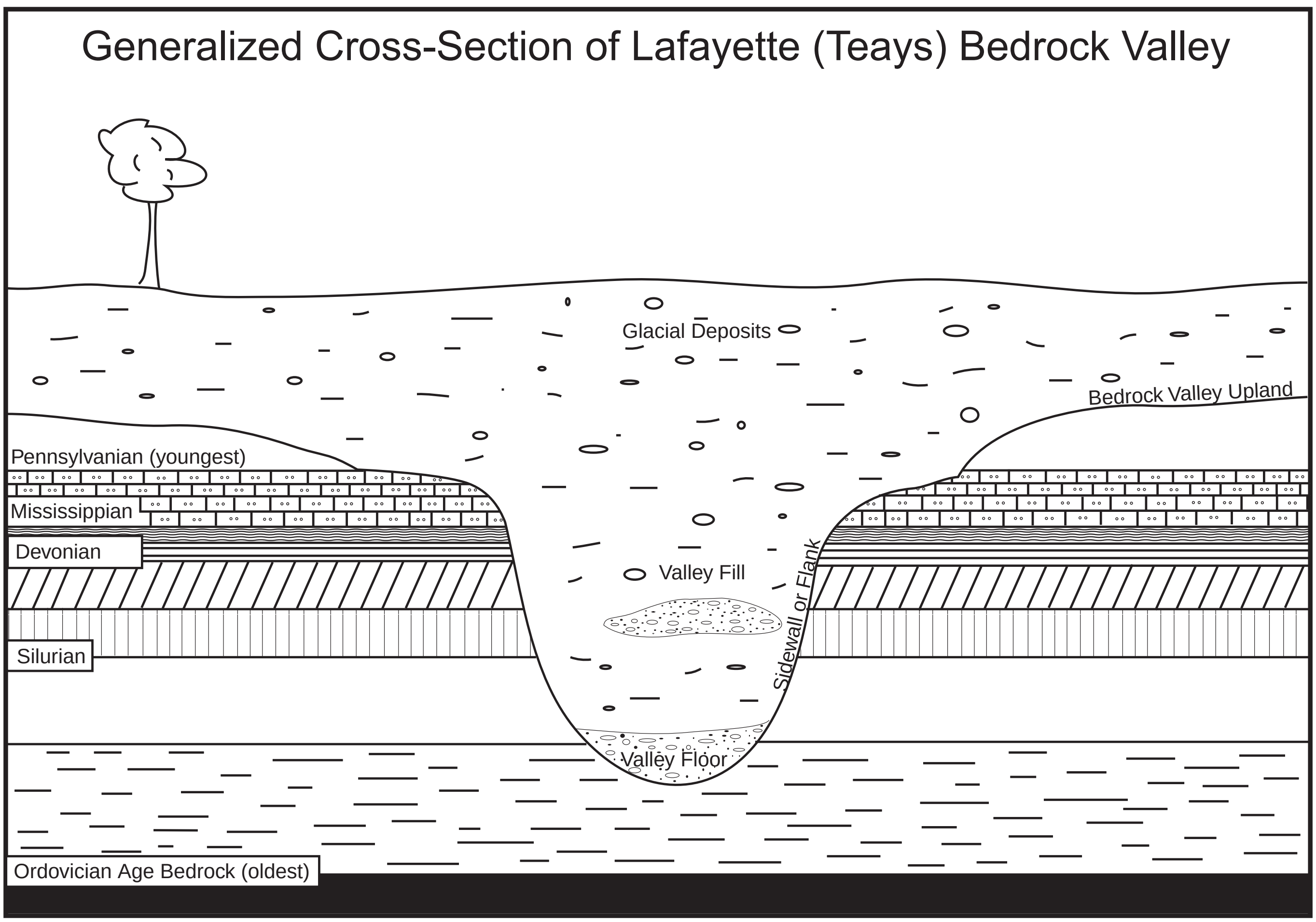
Illustrations, Tables, and Appendices

Forward

This report was completed and scheduled for publication in 1990; but due to unforeseen circumstances, was not published. The decision was made to publish the report at this time because it contains much valuable information about the Teays (Lafayette) Bedrock Valley System that is not available to the public in any other report.

Introduction

One of Indiana's most intriguing geologic features lies buried in north-central Indiana beneath up to 400 feet of glacial drift. The Teays Valley, a major drainage system that originated in West Virginia, has aroused the interest of the general public as well as scientists for more than one hundred years. Early reference to the Teays in Indiana dates back to the 1890s, when the location of the valley was of prime interest to oil and gas drillers who sought to avoid the "deep drive" or "Loblolly" area where they faced the expense and time-consuming job of setting 400 feet of well casing. In the 1980s the Teays Valley and its ground water characteristics became increasingly important to nearby communities looking for additional well field sites to meet future water demands. Long regarded by area residents as an "underground river" with unlimited supplies of ground water, this valley has been recognized as an extremely significant feature that merited detailed study in order to dispel the myths surrounding its origin and water potential, and to define the geologic composition and water-bearing capabilities of the material filling the valley. Figure 1 on the following page shows the general location of this Teays Valley study.



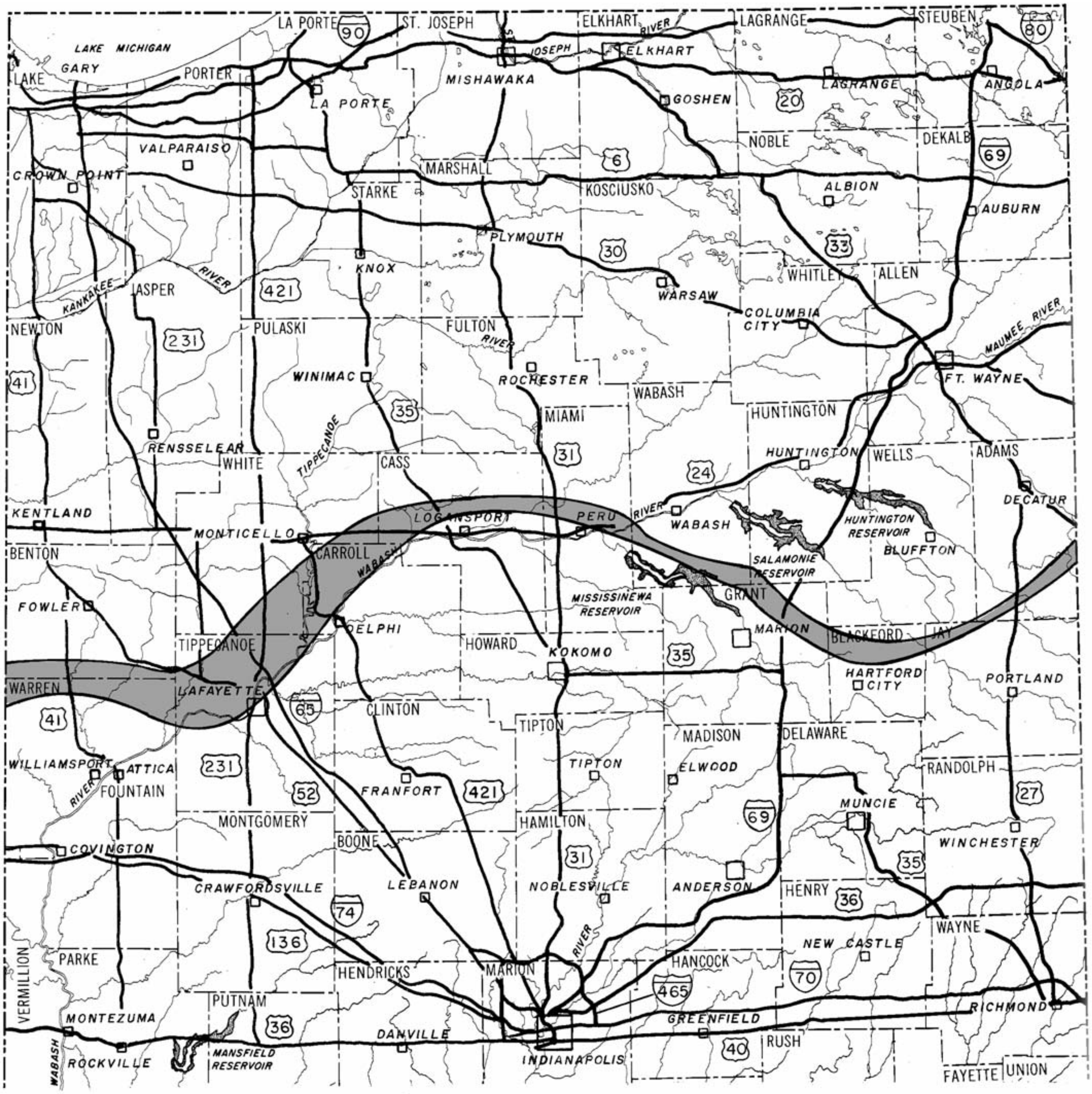


Figure 1. Location of the Lafayette (Teays) Bedrock Valley

In 1976, a combined effort by the Indiana Department of Natural Resources, Division of Water and the Indiana Geological Survey was initiated to provide accurate scientific information on the location, depth, geologic history, and hydrogeology of the buried bedrock valley. This report provides an analysis of these characteristics, with particular emphasis on the availability and occurrence of ground water. Over the past twenty years the need for ground water information has grown with the expanding water demands of cities and towns, industry, agricultural interests, and individual homeowners. A number of large water users have already used the basic data gathered during the study of the Teays Bedrock Valley, and this information has been used to locate new high-capacity wells. The deposits filling the buried valley will continue to be of significant interest to those seeking to develop new sources of ground water.

Work by both the Indiana Geological Survey (Bleuer, 1989) and the Division of Water suggests that the all-encompassing label "Teays" is a misnomer when discussing the location and characteristics of the valley in Indiana. The terminology "Lafayette (Teays) Bedrock Valley" as proposed by Bleuer recognizes the importance of the various major tributaries to the Teays and the impacts of the advances and retreats of various ice sheets on the course of the valley. Therefore, the term "Lafayette (Teays) Bedrock Valley" will be used hereafter in all references to the buried bedrock valley formerly attributed to the Teays River drainage system in Indiana.

Purpose and Scope

This report is intended to provide a detailed evaluation of the ground-water resources of the Lafayette (Teays) Bedrock Valley in Indiana and to make information available that can be useful to develop new sources of water to meet north-central Indiana's water requirements. Recognizing the need for a detailed study of the Teays, the Ground-Water Section of the Division of Water and the Geology Section of the Indiana Geological Survey initiated a project proposal in 1975 that sought to answer many of the questions regarding the Lafayette (Teays) Bedrock Valley. The project involved a coordinated effort to:

- assemble all available water well records, seismic data, oil and gas well data, stratigraphic test hole information, and bedrock outcrop data;
- obtain new geophysical data where necessary to define the configuration of the valley and its location;
- process and field-verify new water well and petroleum exploration well records;
- drill a series of deep test holes in the valley with the ultimate goal of assessing the glacial stratigraphy and general ground-water potential;
- reappraise existing maps and interpretations in light of new data; and
- prepare a series of publications describing the morphology, glacial stratigraphy, ground-water potential, and other characteristics of the Lafayette (Teays) Bedrock Valley system.

Geography of the Project Area

The Lafayette (Teays) Bedrock Valley is present beneath portions of 11 counties in north-central Indiana and extends from Adams County at the Ohio state line westward through the state and crosses into Illinois in southern Benton County (Figure 2 and Plate 1). The valley, which enters Indiana about two miles southeast of the community of Salem in Adams County and leaves the state just south of Ambia in Benton County, traverses a distance of about 165 miles in the state. Although it exhibits a general east-west orientation, it contains two major arcing curves before resuming a westward direction in Tippecanoe County (Figure 1). Major communities near the valley are Berne, Geneva, Hartford City, Marion, Peru, Logansport, Monticello, Delphi, Lafayette, and West Lafayette.

Physiography

The Lafayette (Teays) Bedrock Valley crosses the portion of the state that lies within the Tipton Till Plain as defined by Malott, 1922 (Figure 3). The till plain is typified by a flat to slightly rolling surface that contains several narrow arcing moraines in the eastern half of the state. These areas are a result of the glacial ice lobes, which came out of the Lake Erie area some 20,000 years ago.

The only significant surface relief in this portion of the state occurs where streams have cut deep narrow valleys into the surface of the glacial deposits. Several of these streams and rivers, such as the Wabash, Mississinewa, and Salamonie originate near and are parallel to the arcing terminal moraine ridges. The most noticeable changes in elevation in the area underlain by the Lafayette (Teays) Bedrock Valley occur near the Mississinewa and Wabash Rivers where 100 feet of relief or greater is present.

Near the Indiana-Ohio state line, where the Lafayette (Teays) Bedrock Valley enters the state, the land surface elevation is about 815 feet mean sea level (msl). The highest surface elevations in the area underlain by the Lafayette (Teays) Bedrock Valley are in the range of about 925 (msl) and occur near the small community of Balbec in Jay County. The lowest land surface elevation is present near Lafayette in the Wabash River Valley where the elevation is about 520 feet (msl); it is in this area that the Lafayette (Teays) Bedrock valley begins its trend westward toward the Illinois state line. Near the Indiana-Illinois state line the present-day surface elevation is about 725 feel (msl), or approximately 200 feet higher than the land surface at Lafayette.

Geologic Setting

As the Lafayette (Teays) Bedrock Valley traverses the state from east to west, increasingly younger bedrock formations are encountered (Figure 4). Starting at the Ohio state line, the bedrock present in the base of the valley is of Ordovician Age, with

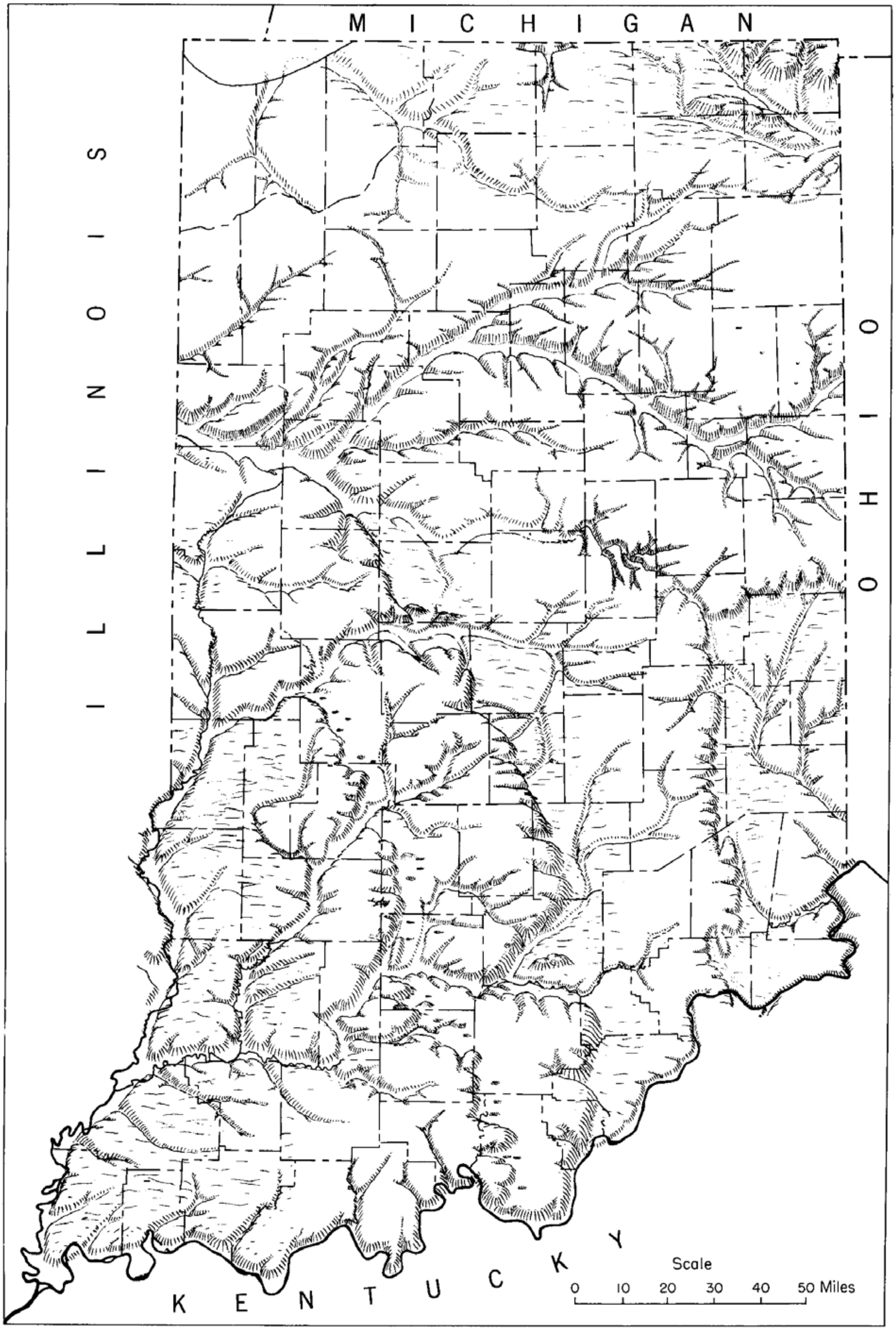


Figure 2. Physiographic diagram of Indiana showing topography at the close of the Pliocene (from Wayne, 1956)

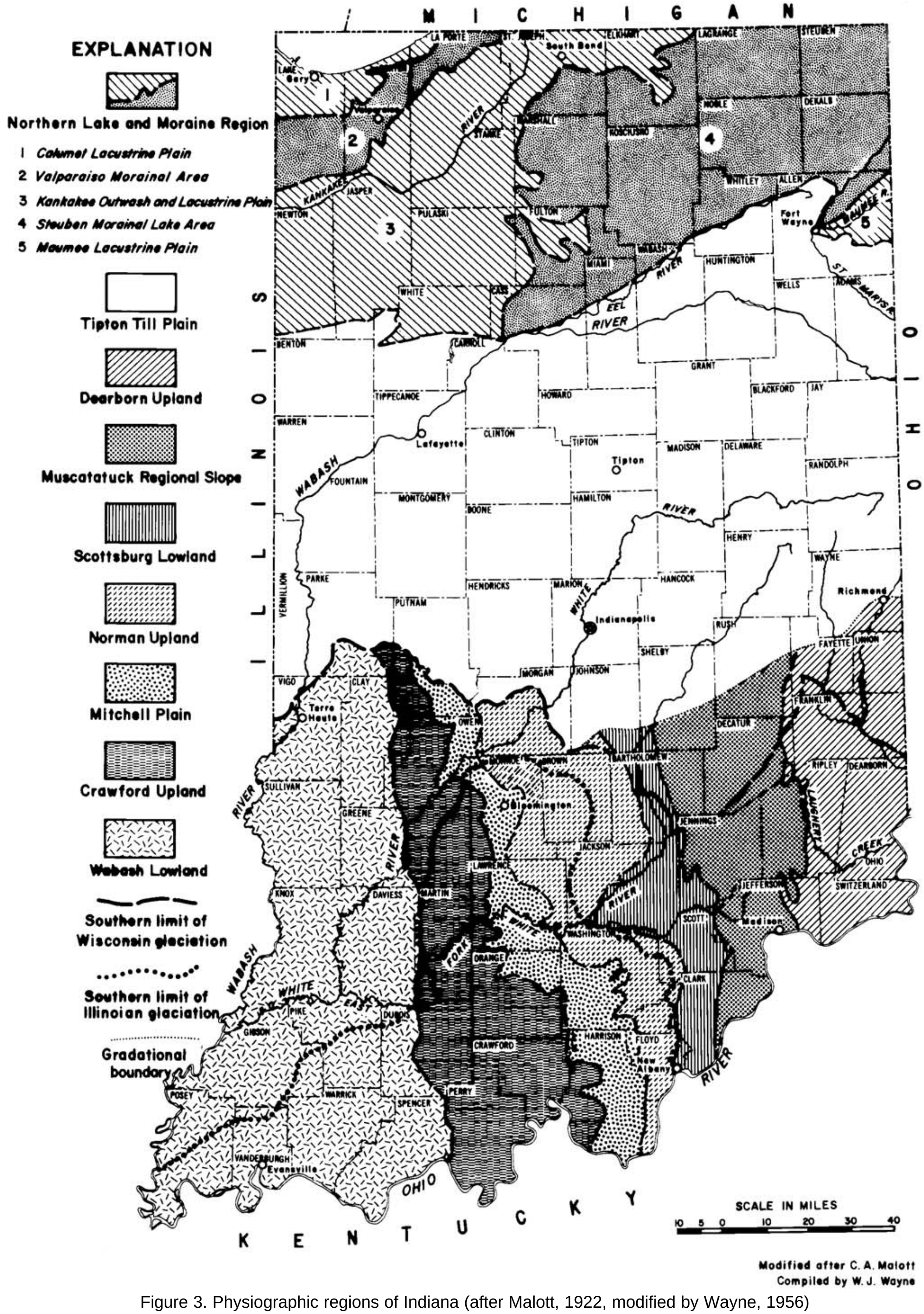


Figure 3. Physiographic regions of Indiana (after Malott, 1922, modified by Wayne, 1956)

younger Silurian bedrock forming the uplands and sidewalls of the valley. Westward into Jay, Blackford, Grant and Wabash Counties progressively younger bedrock is present in the sidewall and upland areas. Near the center of the state the Silurian bedrock still forms the valley floor and sidewall materials, but the younger Devonian limestones and shales form the uplands adjacent to the valley. In the western third of the state, lower Mississippian siltstones and shales are the major bedrock types present in the valley and sidewalls; scattered areas of Pennsylvanian sandstone, shale, and thin coal seams are present in the uplands. Contained within and overlying the Lafayette (Teays) Bedrock Valley are various types of glacial deposits. These materials consist of sand and gravel, varying textures and colors of glacial till, brownish-red to gray silt, and fine-grained lake deposits. These deposits are extremely variably in continuity and thickness, and radical changes may occur in short distances. The materials filling the valley commonly range between 200 to 425 feet thick, with a typical thickness greater than 300 feet. Wisconsinan age glacial deposits overlie essentially the entire valley, with Illinoian age and older deposits occurring at depth (Figure 5).

Bedrock Geology

Most of the following bedrock description is taken from Hill and Hartke, 1982. In the eastern portion of the state beginning at the Ohio state line, the subcrop (bedrock that occurs immediately below the glacial deposits) within the Lafayette (Teays) Bedrock Valley is composed of alternating layers of shale and limestone of Ordovician age (Figure 4). These rocks of the Maquoketa Group are found only in the deepest portions of the valley; they are present as far west as southern Wabash County.

In the area near the state line in Adams and Jay Counties, the Salamonie Dolomite forms the sidewall and upland flanks (Figure 4) of the Lafayette (Teays) Bedrock Valley. These rocks consist of dense to fine-grained, argillaceous, cherty dolomite. The Pleasant Mills Formation of Silurian Age, which stratigraphically overlies the Salamonie Dolomite, is also present in the area away from the valley. It becomes a prominent component of the upland bedrock surface near the valley in western Jay County and into Blackford and Grant Counties. The Pleasant Mills Formation consists mostly of dolomite and limestone with interbedded shale units.

In southwestern Wabash County and eastern Miami County, the Salamonie Dolomite and Pleasant Mills Formation form the floor of the bedrock valley with younger bedrock of the Wabash Formation occurring in the sidewall and adjoining upland areas. Westward into the central portion of the state in Grant, Wabash, Miami, Cass and Carroll Counties the Wabash Formation is present in the upland areas, flanks, and deeper portions of the Lafayette (Teays) Bedrock Valley. The lower part of the Wabash Formation consists of the Mississinewa Shale Member, a somewhat argillaceous, dense dolomitic siltstone. The upper part of the Wabash Formation consists of, in ascending order: the Liston Creek Limestone, a fine-grained cherty limestone; Kokomo Limestone Member; and the Kenneth Limestone Member.

In west-central Carroll County, Devonian bedrock forms the subcrop in the uplands and flanks adjoining the Lafayette (Teays) Bedrock Valley. Where the valley enters northern Tippecanoe County, bedrock of the Wabash Formation is present beneath the main valley (Figure 4). In much of northern Tippecanoe County, the bedrock present in the main valley floor is the Devonian Muscatatuck Group, consisting of the Traverse and Detroit River Formations comprised mostly of dolomite. The New Albany Shale of Devonian and early Mississippian Age, however, forms the subcrop under the Lafayette (Teays) Bedrock Valley in most of Tippecanoe County and eastern Warren County. The New Albany Shale, which is typically a black to brown carbonaceous shale, is expected to be dominantly soft greenish-gray shale further to the west.

In Benton and Warren Counties, which adjoin Illinois, the Borden Group of early Mississippian Age forms the subcrop in the area traversed by the valley. These rocks consist mainly of quartz-rich siltstone and shale, with occasional intervals of fine-grained sandstone and limestone. Pennsylvanian bedrock, composed of sandstone, shale, and lenticular coal seams form portions of the upland subcrop away from the main valley. Most of the bedrock units present in the sidewall and valley flanks are of the Borden Group of lower Mississippian age.

Preglacial History

The present day landscape of north-central Indiana bears little resemblance to that which existed when the Teays River flowed through the state. Prior to the "Ice Age" the terrain near the valley was similar in appearance to much of present-day south-central Indiana, with bedrock exposed in many places and deep narrow valleys entrenched into a hard bedrock surface. Tributary streams eroded valleys across an irregular bedrock terrain, eventually feeding into the main drainage systems that ultimately discharged into the Lafayette (Teays) Bedrock Valley. Major tributary streams include the Anderson, Metea, Wildcat, and Tippecanoe Valleys (Figure 2).

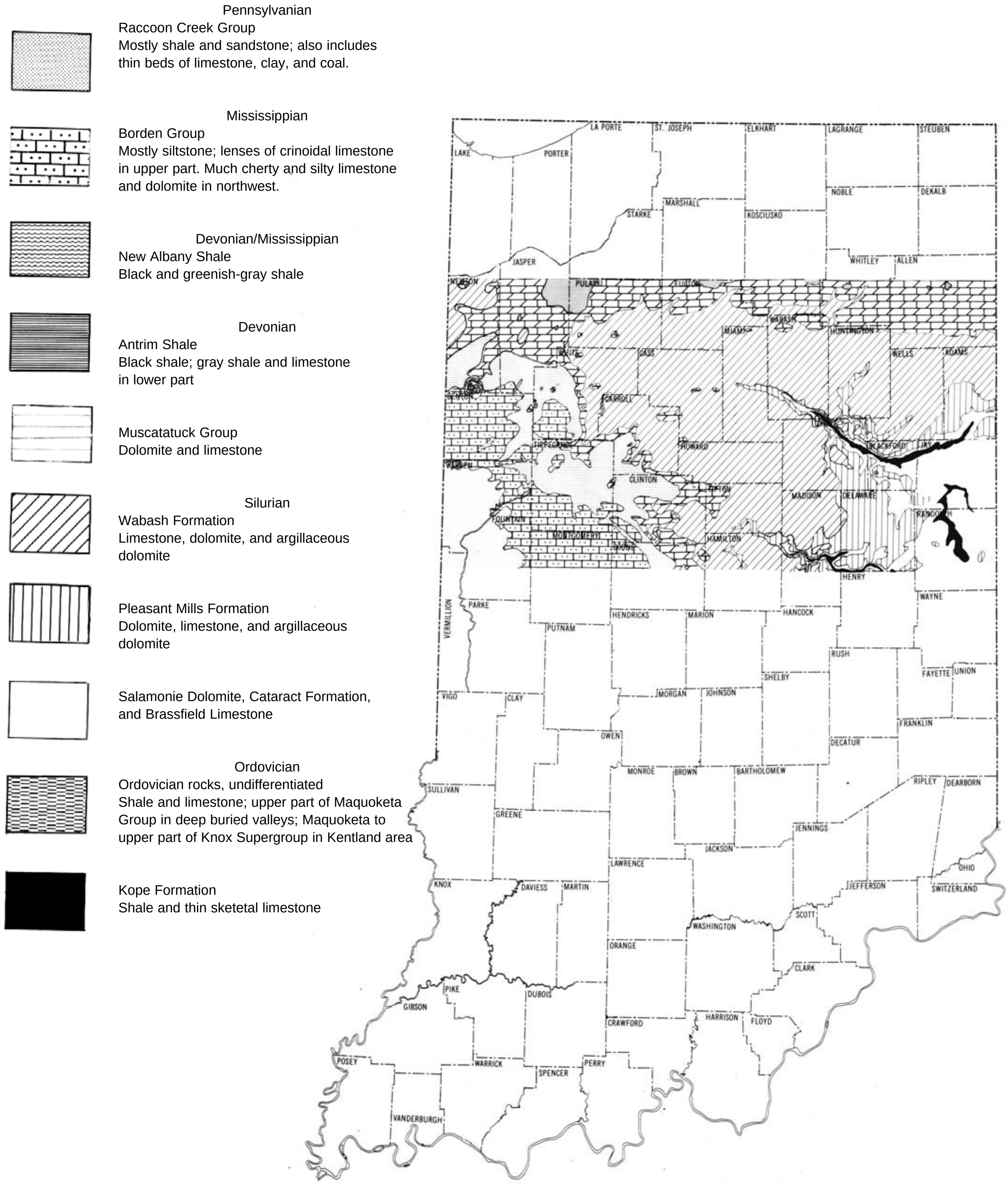


Figure 4. Bedrock geology of Lafayette (Teays) Bedrock Valley area (prepared by Indiana Geological Survey for this study)

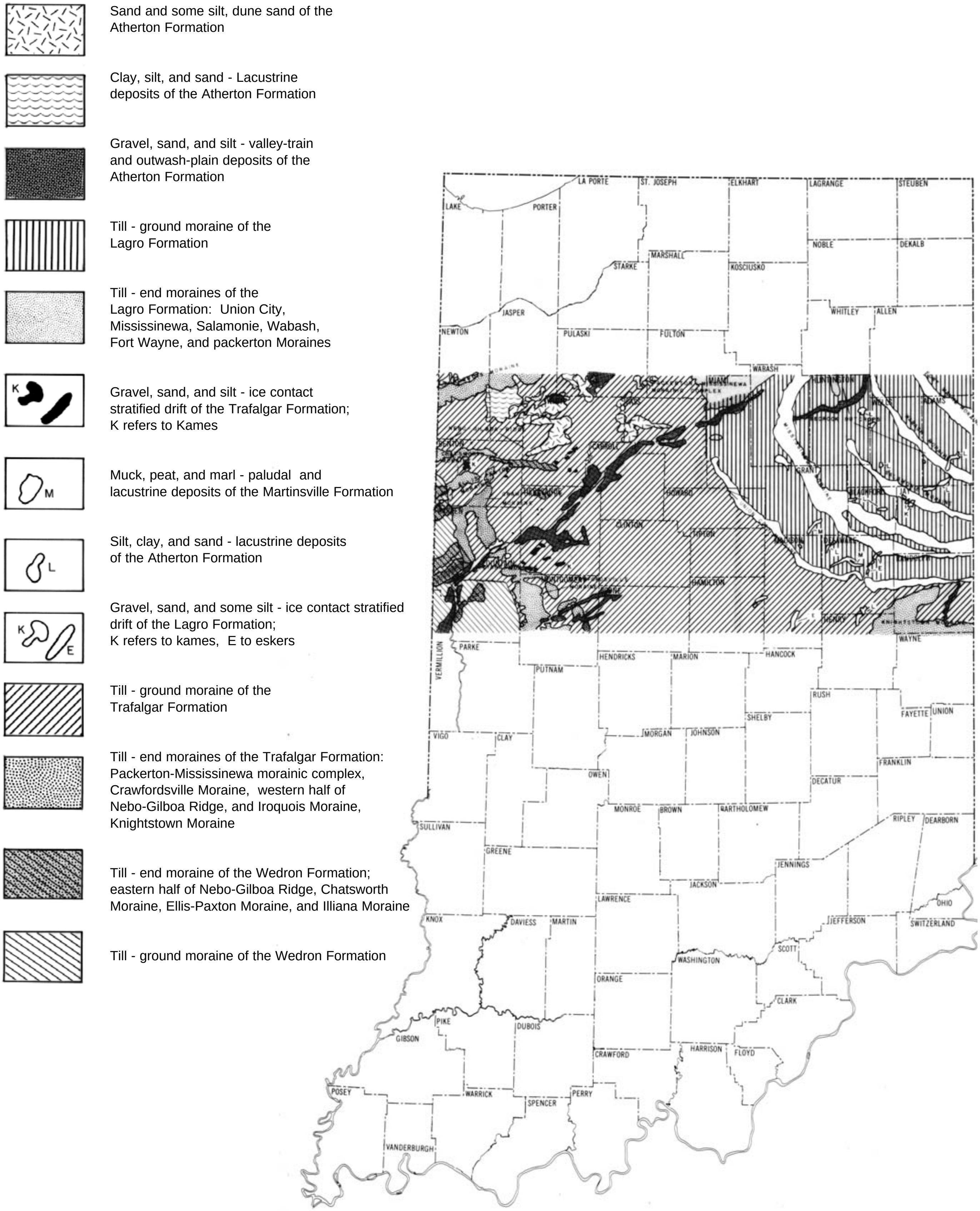


Figure 5. Glacial deposits of Lafayette (Teays) Bedrock Valley area (prepared by Indiana Geological Survey for this study)

In much of east-central Indiana the valley is gorge-like and confined to a width of one mile or less (Plate 1). In places the valley is over 300 feet below the surrounding bedrock uplands. In other areas, such as at Lafayette, the valley broadens to a width of several miles where the Anderson, Metea, Wildcat, and Tippecanoe bedrock valleys join with the Lafayette (Teays) Bedrock Valley. The Borden bedrock escarpment became a major barrier to further westward development of these streams. The reentrant condition that is present here is in many respects similar to the entrance of the East Fork White River Valley into the Borden escarpment west of Brownstown in Jackson County.

The origin of the bedrock valley (in north-central Indiana), while subject to considerable debate, appears to have had its headwaters east of the Appalachian Mountains (Bleuer, 1989) (See cover of this report). Some sources would place the headwaters as far east as North Carolina. From its headwaters it flowed westward through West Virginia, Ohio, Indiana, and finally into Illinois where it joined with the ancestral Mississippi River. Wright (1890) first used the name Teays to describe a high level abandoned valley in West Virginia located near the community of St. Albans, west of Charleston, east of Huntington.

The Teays Bedrock Valley up to St. Albans was essentially the same as the present day Kanawha and New River Valleys; however, westward it departed from the path parallel to the Kanawha and flowed via the abandoned valley southwesterly toward Huntington, West Virginia. From Huntington to Wheelersburg, Ohio the course of the Teays River is thought to be generally the same as that of the present-day Ohio River, as revealed by high-level terraces and abandoned valley remnants (Norris and Spicer, 1958). From this point on the Ohio River northwest of Franklin Furnace, Ohio the Teays took a more northward direction turning northwest toward Piketon, Ohio. It generally followed the course of the present day Scioto River Valley toward Richmondale, Ohio where it again exited the present Scioto Valley, only to subsequently re-enter about five miles south of Chillicothe, Ohio (Walker and others, 1965, Ohio Division of Water). North of Chillicothe near South Bloomfield, Ohio the valley began a new and significant trend as it left the essentially unglaciated part of its course. From this point westward to its confluence with the ancestral Mississipi River Valley in west-central Illinois, the valley is obscured by thick deposits of glacial drift. Its presence and location is only defined by available records of oil and gas wells, stratigraphic test holes, water wells, and seismic data, except in some circumstances such as at Richvalley-Peru where the present valley of the Wabash River reflects the modifications by the buried bedrock valley.

With few exceptions, evidence of this once extensive drainage system is now obliterated by thick deposits of glacial materials. Westward from South Bloomfield, Ohio the valley can be traced northwest toward London and Springfield, Ohio, and beneath the St. Mary's River Reservoir near Celina, Ohio. Through much of this portion of Ohio the Lafayette (Teays) Bedrock Valley assumes a gorge-like morphology, with valley walls descending rapidly into the deeper parts of the valley. This condition continues to the Indiana border where it enters east-central Adams County about eight miles east of Berne.

Glacial Geology

In eastern Indiana where the bedrock valley is present, from place to place the flat landscape is interrupted by a series of arcing and parallel end moraines that provide a degree of topographic variability to an otherwise monotonous expanse of till plain (Hill and Hartke, 1982) (Figure 5). From west to east the moraines consist of the subdued Union City Moraine, the Mississinewa Moraine, which overlies the Lafayette (Teays) Bedrock Valley, the Salamonie Moraine, the Wabash Moraine, and the Fort Wayne Moraine. These moraines are of the Ontario-Erie Lobe of the Laurentide Ice Sheet, of Wisconsinan Age; and are part of the Lagro Formation that is typically composed of a silt loam to silty clay till and is finer-grained than the underlying Trafalgar Formation. The Lagro Formation was deposited during late Woodfordian time, from 15,000 years before present (B.P.) to 14,000 years B.P. (N.K. Bleuer, oral communication, 1982). The Trafalger Formation, a silty, pebbly till, was deposited in the central part of the state and overlies the bedrock valley. In the western part of the state underlain by the bedrock valley, older morainal deposits are present that are attributed to the Lake Michigan Lobe, which dates to 17,000 to 18,000 years B.P. (N.K. Bleuer, personal communication, 1982). These moraines, as noted earlier, are capped in places by the Trafalgar Formation. Thus the surficial deposits in the areas underlain by the bedrock valley are of Wisconsinan Age.

In the central segment of the valley, the predominant surficial glacial feature is a level to slightly undulating glacial till plain as expressed by the Trafalgar Formation. The Tipton Till Plain is the predominant physiographic province, and only in Cass County, where a portion of the Packerton-Mississinewa Moraine complex edges into the area adjacent to the buried Lafayette (Teays) Bedrock Valley, does a change in the normal surficial glacial sequence occur.

The Trafalgar Formation, a Wisconsinan Age sandy loam to loam till, is the most extensive unit in the west-central portion of the state and is generally present in the form of a ground moraine. The Trafalgar Formation is of eastern derivation and caps portions of the older morainal systems including the Nebo-Gilboa Ridge and Chatsworth Moraine. The lack of typical arcuate terminal moraines coupled with extensive (up to 50 miles long) fluted forms, relict sub-ice channel features, and numerous ice-

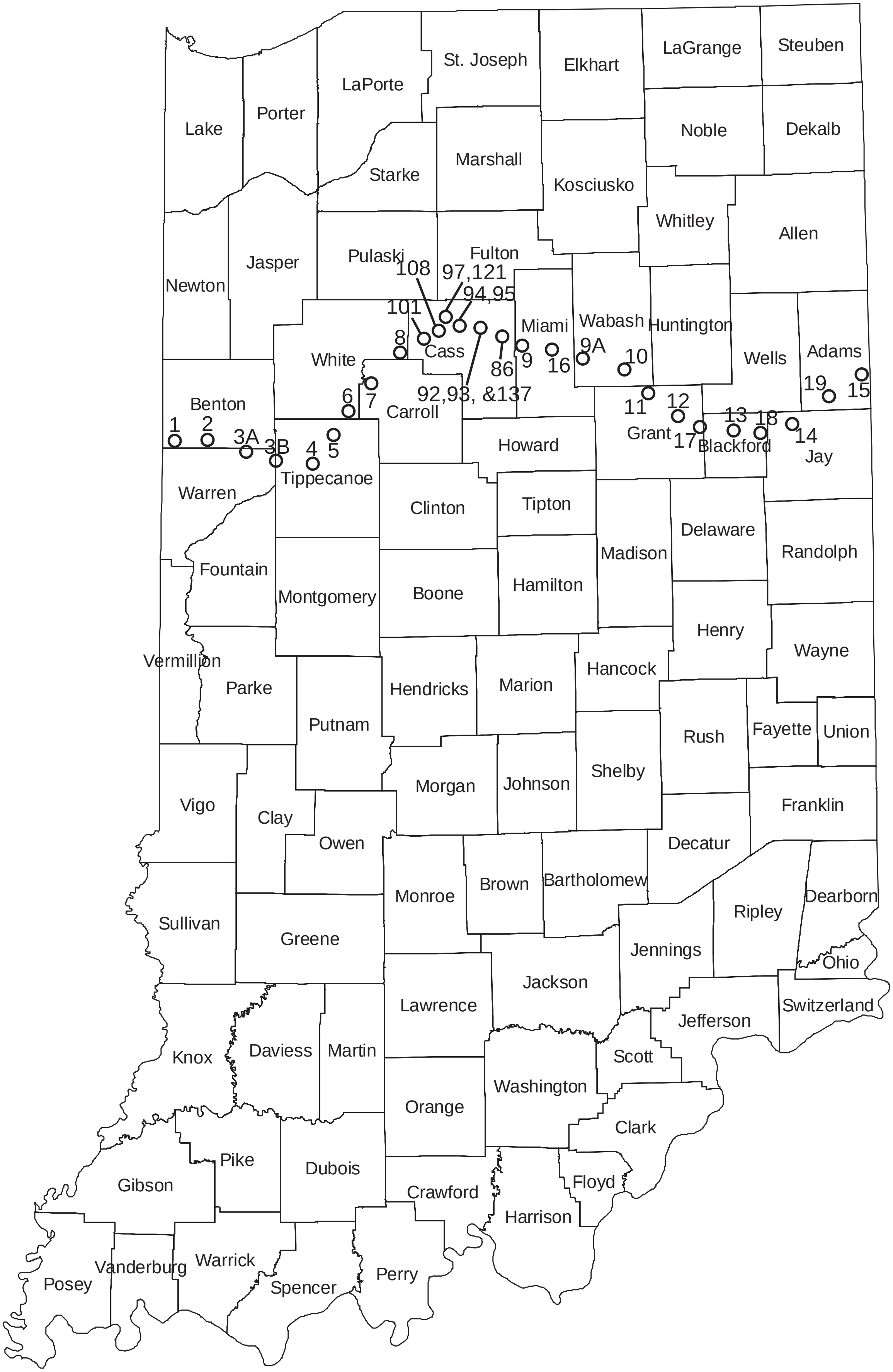


Figure 6. Location of test holes drilled for Lafayette (Teays) Bedrock Valley study and Logansport study of U.S. Geological Survey, 1981

flow indicators suggest that the glacial ice advance responsible for deposition of the Trafalgar Till was non-lobate in this part of Indiana. Because of the complex interrelationships, overlaps, and variation in composition of the glacial deposits, the interested reader is directed to the various studies by Bleuer (1974, 1975, 1989) and Hill and Hartke (1982).

The deposits of the Tipton Till Plain and the various morainal deposits have essentially obscured all evidence of the existence of the Lafayette (Teays) Bedrock Valley in the western part of the state. This area is generally characterized by a flat to gently rolling ground moraine that is locally dissected by the Wabash River, Tippecanoe River and other major streams. Several Wisconsinan end moraines are present in Warren and Benton Counties; they include the Nebo-Gilboa Ridge, Chatsworth Moraine, Ellis-Paxton Moraine, Illiana Moraine, and Crawfordsville Moraine. Only the Crawfordsville Moraine is not attributed to a Lake Michigan Lobe ice sheet (Hill and Hartke, 1982). That moraine defines the western limit of the most recent advance of the Ontario-Erie Lobe into west-central Indiana and is breached by the Wabash River along the Warren-Fountain County line.

In the eastern part of the state, streams of consequence including the Mississinewa, Salamonie, Wabash, and St. Mary's River mark the distal ends of the Mississinewa, Salamonie, Wabash, and Fort Wayne Moraines. These ice margin streams drain much of the northeastern portion of the state.

In none of the test holes drilled for this project was there any indication that the materials filling the valley were anything other than of Pleistocene Age (Figure 6). Any pre-glacial materials present in the valley had either been removed or reworked by glacial deposition.

The complex interrelationships of the glacial deposits that overlie and fill the Teays Valley are discussed by Bleuer (1989) in a report entitled "Historical and Geomorphic Concepts of the Lafayette Valley System (So-Called Teays Valley) in Indiana".

Lafayette (Teays) Bedrock Valley
Fill Composition and Ground-Water Potential

In any review of the ground-water potential of the Lafayette (Teays) Bedrock Valley system in Indiana, one quickly becomes aware of the widely held perceptions of the general public regarding the availability of ground water within the buried valley. The history of the valley dating back to the 1890s is replete with stories concerning the encounters that drillers have had with the thick glacial deposits filling the valley. Terms such as "deep drive" and "Loblolly" were often used to refer to the thick drift conditions in the valley in east-central Indiana. From the layman's viewpoint, these thick deposits contain an unlimited amount of water, and hardly any discussion of the Lafayette (Teays) Bedrock Valley is entered into without mention of an underground river and the connotation of the amount of water that goes with it.

What are the facts regarding the occurrence of ground water within the Lafayette (Teays) Bedrock Valley? To begin with, water in the valley is not part of an underground river. The water present is found within granular deposits of sand and gravel. The movement of the water within these deposits is only a slow trickle, generally at a rate of movement of less than five feet per day. Also, the valley is not a discharge point for the regional ground water as some believe, nor does ground water flow down the valley like a river as has been suggested. Water-level maps prepared for the area surrounding the valley reveal that no discernible effect is exerted by the valley's water-bearing formations on the regional ground water flow pattern (Plate 2). Water in the ground-water systems typically passes slowly through the valley-fill deposits and discharges some distance away at the land surface into the major streams and rivers of the area.

One of the major objectives of this study was to determine the ground-water potential within the Lafayette (Teays) Bedrock Valley and the prospects for finding appreciable amounts of water. The data gathered suggests conditions ranging from poor to excellent, depending upon the specific area and the volume of water needed. The valley in eastern Indiana presents a mixture of conditions varying from poor to excellent for obtaining wells yielding 500 to 1,000 gallons per minute (gpm) or more. Yields in the central segment of the state range typically from fair to good, and the western third of the state exhibits generally good to excellent conditions for obtaining high-capacity wells.

In the following pages a review of the expected ground water prospects is given for various segments of the Lafayette (Teays) Bedrock Valley across the state, starting at the Ohio state line and proceeding westward to Illinois. Cross-sections for each area accompany the discussion to illustrate the geologic and hydrologic conditions present. Figure 6 shows the location of test holes used for this study.

Lafayette (Teays) Bedrock Valley
Ohio State Line to Geneva

Ground-water conditions are generally good to excellent in many parts of this segment of the Lafayette (Teays) Bedrock Valley. Both an intermediate level and a basal sand and gravel aquifer are present within and above the bedrock valley. The intermediate zone, which occurs at a depth of about 100 to 150 feet, appears in most areas to offer the greater potential for obtaining wells yielding 500 to 1,000 gallons per minute (gpm).

Wells drilled into the valley can generally be expected to encounter an upper zone of till, silt, or clay for the first 100 to 150 feet of drilling before encountering the thicker sand and gravel aquifers. Locally, near Geneva, thick deposits of sand are found in the deeper portions of the valley with gravel being a minor component of the valley fill.

Near the Ohio-Indiana state line, as can be seen from Cross-Section A-A' (Plate 1, Figure 7), the valley is quite narrow with the deeper portion less than one mile in width. In Test Hole (T.H.) #15 (Figure 6), a particularly coarse zone of sand and gravel is present at a depth from about 107 to 155 feet. Less important sand and gravel aquifers are found at various points below this level to a depth of slightly over 300 feet. The bedrock is encountered at a depth of 323 feet, or elevation 492 feet mean sea level (msl). From this point near the state line, the Lafayette (Teays) Bedrock Valley turns southwest toward Berne (Figures 1 and 2) where it is joined by a prominent tributary valley leading south from the Town of Monroe. The tributary valley extends to Decatur and has been called the Decatur Valley in some discussions.

The valley broadens near the point of juncture with the tributary and increases beyond the typical width of one mile. In this area the valley contains locally thick deposits of sand or sand and gravel (Cross-Section B-B') (Plate 1, Figure 8). East of Berne where the well fields for the cities of Decatur and Berne are located, (and to the southwest at Geneva) an excellent sand and gravel aquifer is encountered at a depth beginning at about 100 feet below land surface. Wells in the Decatur field encountered a zone of very course gravel and boulders that created very difficult drilling conditions and, for this reason, the wells were terminated at a depth of about 150 feet, even though usable sand and gravel formation was present to a depth of about 180 feet. The wells reportedly are capable of yielding 1500 gpm or more each. In T.H. #19, (Figures 6 and 8) a sand and gravel zone beginning at a depth of about 175 to 180 feet, and a basal sand and gravel within the deeper part of the bedrock valley, appears to have the capability to yield larger volumes of water, although the effects of barrier boundaries (such as bedrock valley walls) and the availability of recharge could alter the usability on a long-term basis.

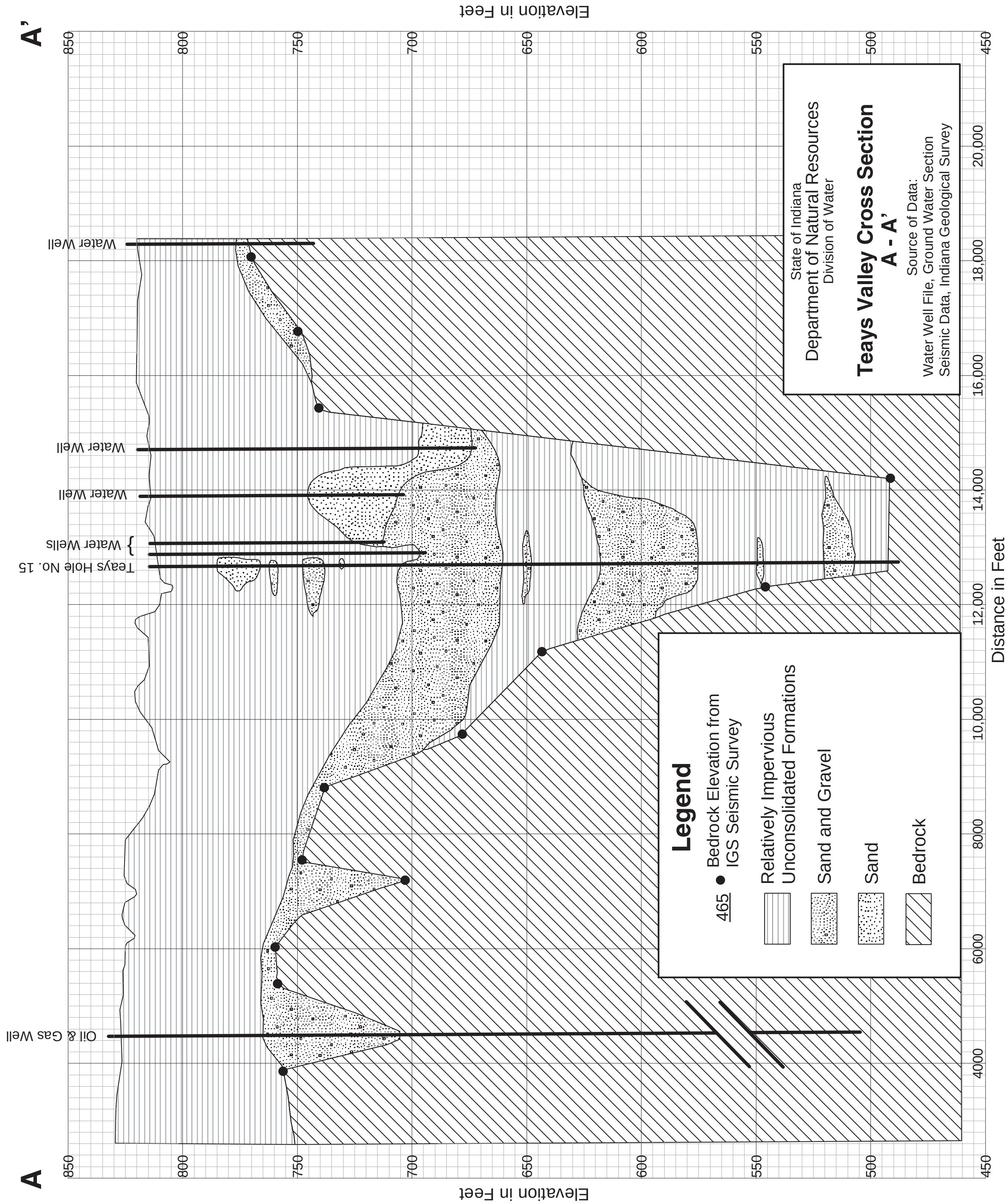
The valley takes a southwesterly path (Figures 1 and 2) from its juncture with the tributary valley, proceeding to a point about two miles southwest of Geneva where it begins trending westward into Jay County. In the Geneva area a thick deposit of sand, containing some gravel, locally fills the deeper portions of the valley; however, the potential of this zone does not appear to be as good as the aquifer occurring at a depth of 100 feet and greater.

Lafayette (Teays) Bedrock Valley
Geneva to Balbec

Water well data and other information concerning the materials filling the bedrock valley in this portion of the state are limited. However, it appears that moderately good prospects exist for the development of wells yielding 500 gpm or more. A basal sand and gravel unit is present in many places that has a reported composite thickness that approaches 100 feet of sand, and sand and gravel that includes some thin clay layers. An intermediate aquifer generally occurs at depths of 180 to 200 feet is encountered in T.H. #14 (Figure 6). Locally, shallower zones appear to offer reasonable prospects for the development of moderate (100 to 300 gpm) capacity wells.

The intermediate zone appears to offer the greatest potential for the development of wells capable of meeting the needs of most municipal, industrial, or irrigation users. In T.H. #14 (Cross-Section C-C') (Plate 1, Figure 9), the intermediate zone extends from about 195 to 270 feet, with a basal sand and gravel occurring at a depth from about 310 to 390 feet. Near the small community of Balbec, a well drilled for oil and gas encountered four prospective sand and gravel zones within the bedrock valley at depths of 50, 90, 180 and 380 feet. These potential aquifers vary from 15 to 50 feet in thickness.

Again, although prospects appear reasonably good in some parts of this segment of the valley, little data are available on the composition of the fill materials, and therefore the nature and the potential of the aquifers remains largely a matter of specula-



A
A'
Elevation in Feet
Distance in Feet
Oil & Gas Well
Teays Hole No. 15
Water Wells
Water Well
Water Well
Water Well
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
A - A'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 7

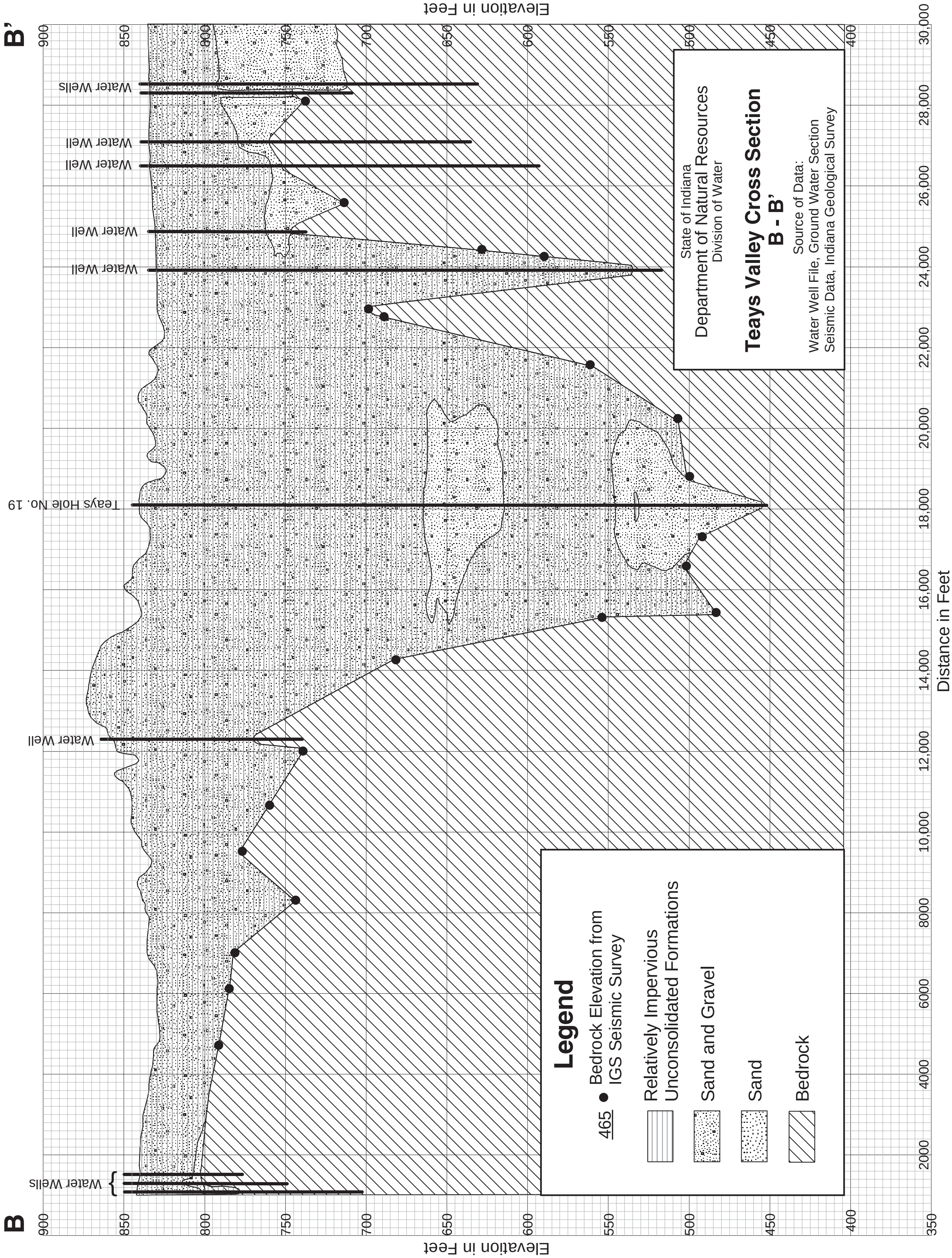

B
B'
Elevation in Feet
Distance in Feet
Water Wells
Water Well
Teays Hole No. 19
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
B - B'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey
900
850
800
750
700
650
600
550
500
450
400
350
2000
4000
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000

Figure 8

tion. Poor aquifer conditions were encountered in the drilling of T.H. #18 (Appendix A) at the Blackford-Jay County line with only a thick fine sand being encountered, and a well drilled at a nearby farm did not encounter any water-bearing materials to a depth of 339 feet.

Lafayette (Teays) Bedrock Valley
Balbec to Jadden

Ground-water availability is highly variable in this segment of the bedrock valley, ranging from little or no potential for the development of appreciable amounts of water (250 gpm +), to areas where excellent development prospects are present. In general, available information is so limited for this segment of the valley regarding the valley fill materials that any comments on the water-bearing capabilities are at best speculative.

In the eastern part of this segment of the valley, near the Blackford-Jay County line, the prospect for the presence of significant aquifers appears to be quite limited, with some portions of the valley being filled with till and thick deposits of silt or fine sandy materials. As shown in T.H. #18 (Figure 6), only a few thin streaks of sand and gravel are noted in the upper portions of the materials filling the valley, with fine-grained silt, clays, and till comprising the upper 240 feet of this hole. From a depth of 240 feet downward to the bedrock surface at a depth of 390 feet (elevation 465 feet msl), only local zones of sand and gravel occur in the thick sand section.

North of Hartford City conditions are substantially better than in the area of T.H. #18. In T. H. #13 (Figure 6) large amounts of sand and gravel are present in two separate major aquifer zones. As can be seen from Cross-Section D-D' (Plate 1, Figure 10) a thick sand and gravel zone occurs at a depth of 85 to 200 feet, with a second zone (basal) occurring from 370 to 420 feet. Bedrock is present at a depth of 422 feet, or elevation 463 msl. Either of these aquifer zones should be more than capable of supplying 1,000 gpm or more to properly designed wells.

This segment of the valley, as with the areas to the east, is overlain by till and in places by units of silt and lacustrine clay. In T.H. #13 reddish-brown clay was noted at several intervals beginning at about 220 feet. This clay is usually a significant diagnostic unit within the valley and denotes a major change in the depositional environment of the fill materials. In many cases this reddish clay marks the point below which sand and gravel become a minor component of the materials filling the deeper portions of the valley.

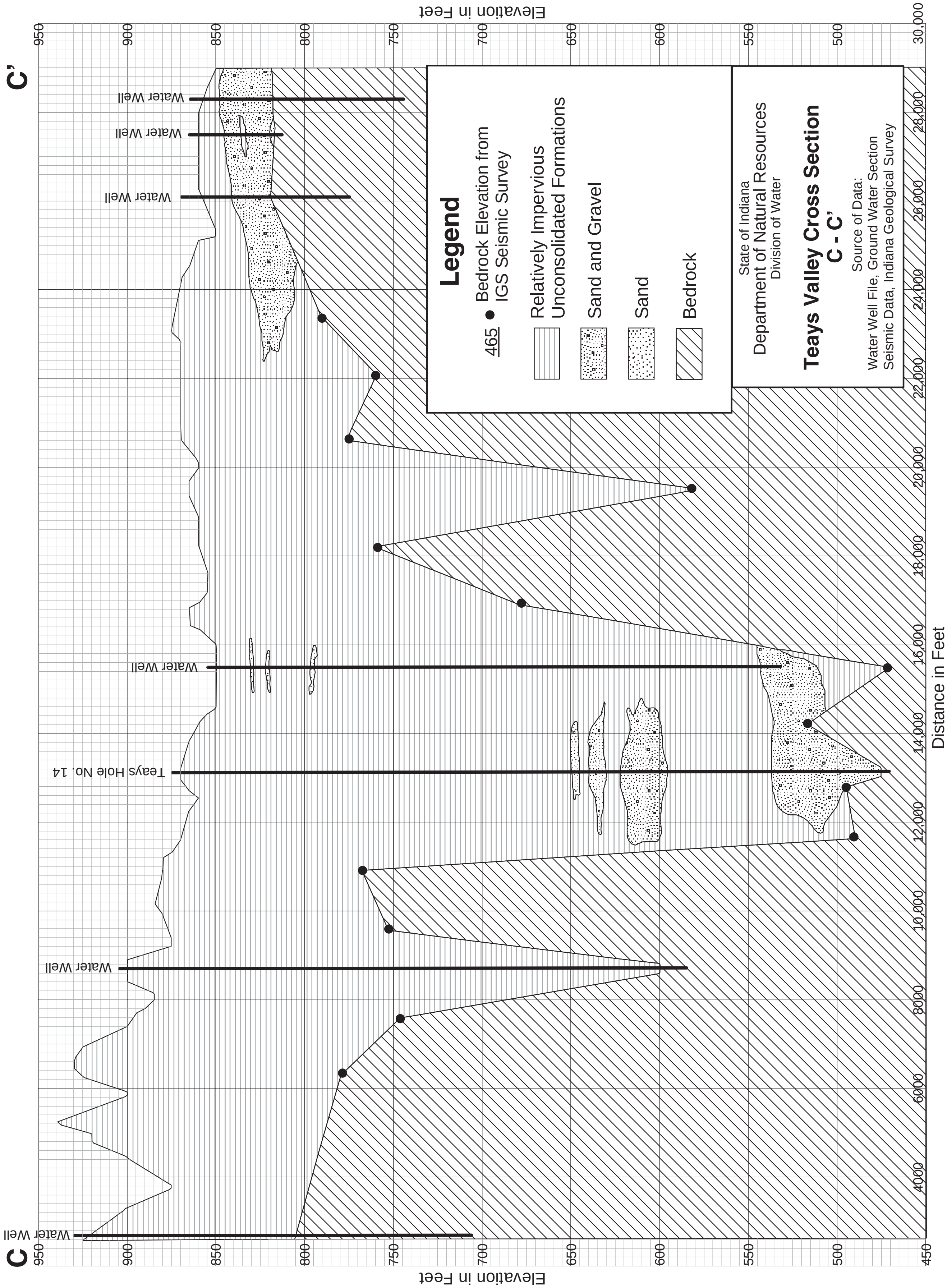
Northwest of Hartford City, near the small community of Jadden, a basal sand and gravel aquifer is present in the valley at a depth from about 390 to 430 feet (T.H. #17, Appendix A); however, it is expected that recharge to this aquifer would be limited and it is doubtful that conditions would be favorable for the development of wells of any particular sustained capability. This basal sand and gravel unit is noted in several of the test wells drilled during the study. No other zones of water-bearing significance are recorded in T.H. #17, drilled at the Blackford-Grant County line (Figure 6).

Elsewhere in this segment of the bedrock valley, units of sand and gravel are present above the main portion of the valley-fill materials, which would appear to offer reasonable prospects for the location of wells yielding moderate amounts of water, generally less than 500 gpm. A basal sand and gravel is present in many places, but because of the apparent lack of continuity of this formation and limitations in recharge, it is doubtful that this aquifer would offer significant potential for ground water development except as previously noted in the areas north of Hartford City near T.H. #13 (Appendix A). In general the prospects for encountering aquifers with the capability of meeting the needs of wells supplying 500 gpm or more is uncertain in this section of the bedrock valley.

Lafayette (Teays) Bedrock Valley
Jadden to La Fontaine

This segment of the valley appears to have only fair to moderately good prospects for the development of wells yielding 500 gpm or more. An extensive but shallow aquifer system overlies much of the valley in this portion of the state. Depths to the top of this aquifer vary from 60 to 120 feet; and typical aquifer thicknesses range from 20 to 50 feet. Locally, as much as 100 feet of sand and fine gravel are present.

As can be seen from Cross-Section E-E' (Plate 1, Figure 11) the flank areas of the bedrock valley are appreciably wider than in the sections to the east; however, the central deeper part of the valley remains, as elsewhere, a mile or less in width.



C
C'
Elevation in Feet
Distance in Feet
Water Well
Teays Hole No. 14
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
C - C'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 9

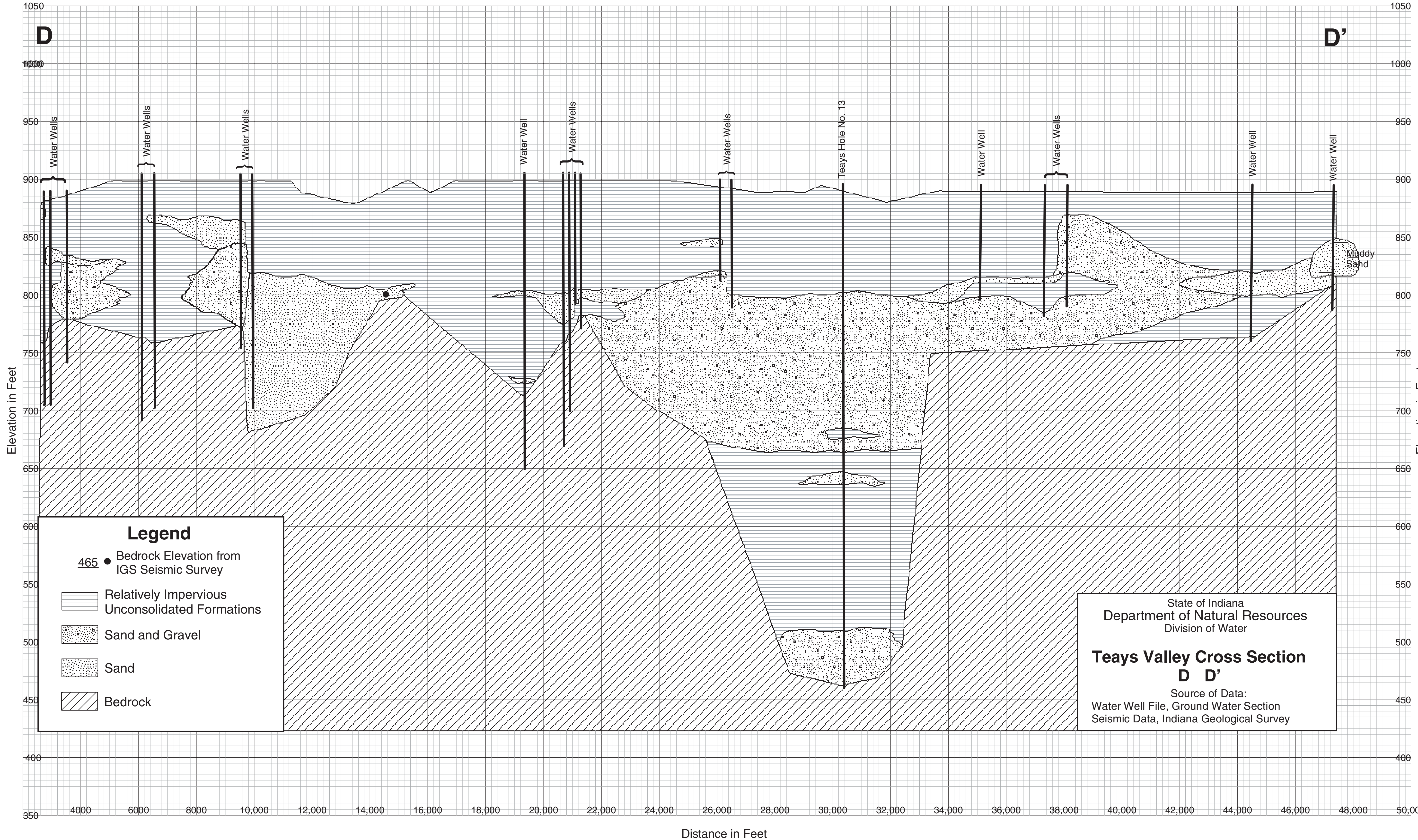

D
D’
Water Wells
Water Wells
Water Wells
Water Well
Water Wells
Water Wells
Teays Hole No. 13
Water Well
Water Wells
Water Well
Water Well
Muddy Sand
Elevation in Feet
Distance in Feet
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
D D’
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 10

A basal sand and gravel is present in a number of places in the deepest part of this segment of the valley; however, this aquifer lacks continuity and is capped by considerable thicknesses of overlying till, clay, and silt units. For these reasons this system would probably not support any significant level of pumpage.

In the area of Marion's "Northeast" well field, the shallow aquifer, as described earlier, merges with the basal aquifer to form the greatest known thickness of sand and gravel in the Marion area. Sand and gravel having saturated thicknesses or 100 feet or greater are present in a small area. Similar thicknesses also occur in the NE SE, of Section 27, T. 25N, R. 8E (northwest of the intersection of County Roads 200N and 400E). The potential for thicker deposits of sand and gravel appears to be greatest over the flanks of the valley, rather than in the main part of the valley where the deposits of glacial drift are in excess of 400 feet thick. In T.H. #11 and T.H. #12 (Figure 6), which terminated at 426 (470 feet msl) and 405 feet (460 feet msl) respectively, an appreciable amount of the brownish-red clay was encountered within the main bedrock valley. In these test wells both the shallow aquifer and basal sand and gravel units are present; however, neither appears to offer significant ground-water development potential (Appendix A).

In the La Fontaine area a thick "dirty sand" was recorded in many places, and it may be associated with the extensive shallow aquifer that is present in much of this segment of the valley, and from which La Fontaine obtains its water supply. According to N.K. Bleuer (oral communication, 1986), the shallow deposit of sand and gravel occurs below the base of the Wisconsinan till which overlies the valley in this area. The new "North Well Field" for the city of Marion is located in the aquifer along the Grant-Wabash County line (Figure 2 and Plate 1).

In the vicinity of the old Marion well field, in downtown Marion near the Mississinewa River, reasonably thick sand and gravel units are present in the NW SW of Section 5, T. 24N, R. 8E (southeast of the intersection of State Roads 15 and 18). Wells in this unit reach a depth of about 150 feet, with saturated thicknesses of 70 feet or more reported in some exploratory holes. This aquifer is apparently associated with a small tributary valley that runs parallel to, but that is separated by a low bedrock divide from, the main tributary bedrock valley in which the "Northeast" well field is located. The tributary valleys coalesce northeast of Marion and join the main Lafayette (Teays) Bedrock Valley in the vicinity of Section 27, T. 25N, R. 8E (northeast of the intersection of County Roads 200N and 300E)(Figure 2).

Lafayette (Teays) Bedrock Valley
La Fontaine to Richvalley Areas

This portion of the Lafayette (Teays) Bedrock Valley appears to offer only poor to moderate prospects for development of wells yielding 500 gpm or more. In some areas ground water is available in such limited quantities that it has been a problem to secure enough water for even residential use.

Locally, shallow zones of sand and gravel (50 to 100 feet in depth), positioned over and adjacent to the deeper part of the valley appear to offer moderate prospects for the development of wells yielding in the range of 300 to 500 gpm each. However, the materials filling the main part of the bedrock valley do not appear to offer favorable prospects for the occurrence of significant deposits (15 feet or greater) of sand and gravel. In several places, the valley contains a thick deposit of brown silty clay. Generally, significant water-bearing sand and gravel deposits are not found below this brown silty clay.

As may be noted from Cross-Section F-F' (Plate 1, Figure 12), an upper sand and gravel is present in places, and locally attains moderate thickness. In T.H. #10 a sandy, fine- to medium-grained gravel containing clay layers is present from approximately 55 to 110 feet in depth. No significant deposits of sand and gravel are present below that point until a depth of about 290 feet, where forty feet of silty sand and gravel is encountered. In this segment, the valley broadens slightly (Cross-Section F-F') indicating a possible change in the bedrock lithology. From one valley wall to the other, the valley approaches a width of about three miles; however, the main deep part of the valley remains about one mile in width, as it does in much of the valley to the east.

Southeast of the City of Wabash, a narrow northeast to southwest trending tributary valley is present (Figure 2 and Plate 1) that contains, in places, moderately thick deposits of water-bearing sand and gravel. It is within this valley that the old city wells for Wabash were first drilled. However, over the years additional water was required by the city, and a new well field was developed about three miles southwest of Wabash in a second tributary valley leading to the Teays. This tributary valley runs parallel to, but west of, the tributary valley in which the old city wells were located. This short tributary valley contains an excellent sand and gravel aquifer, which in places is in excess of 100 feet in thickness. Wells in this aquifer are rated at greater than 1,000 gpm each. This "Smith Well Field" tributary valley enters the Lafayette (Teays) Bedrock Valley in Section 33, T. 27N, R. 6E (northwest of the intersection of County Road 400W and State Road 124), approximately 3 miles south of Wabash.

Exclusive of the localized conditions outlined above, ground-water prospects within the main Lafayette (Teays) Bedrock Valley from La Fontaine to Richvalley are expected to be only marginal at best for the development of significant supplies of ground water. Although only a limited amount of data are available for this segment of the valley, the potential for an intermediate level aquifer and a consistent basal sand and gravel aquifer does not appear promising. The upper level aquifer, when present in thicknesses of fifteen feet or more, may yield in the range of from 300 to 500 gpm to properly constructed wells.

Lafayette (Teays) Bedrock Valley
Richvalley Area to U.S. 31 Near Peru

This portion of the Lafayette (Teays) Bedrock Valley exhibits some of the greatest potential for the development of ground water of any segment in the state. The intersection of the present day Wabash River valley with the buried bedrock valley has resulted in a noticeable broadening of the Wabash River topographic valley and in the deposition of large amounts of sand and gravel. In places these outwash sand and gravel deposits extend from near the surface to depths approaching 200 feet. While locally these materials may contain clay layers, zones of till, silt, and cemented deposits of broken stone, cobbles, and gravel, the probability of encountering an aquifer exceeding 40 feet in thickness is excellent. This segment of the valley is oriented in an east to west direction, departing from the northwesterly trend, which had prevailed from the Jadden, Marion, La Fontaine to Richvalley area (Figure 2). The valley is much wider than to the east, and in this segment widths up to two miles prevail, as compared to a width of less than one mile in most other areas.

Well yields in the range of 500 to 1,000 gpm or greater can be expected for properly constructed wells for much of this segment of the bedrock valley. Peru obtains its water supply from wells completed in outwash sand and gravel deposits which are positioned above the Lafayette (Teays) Bedrock Valley. The old city wells were about 110 to 115 feet in depth and yielded in the range of 1,200 to 1,500 gpm. New wells drilled at the north edge of Peru on the south side of the bedrock valley are capable of yielding 2,000 gpm each. These wells, 136 feet and 157 feet in depth, are two of the most productive wells tapping the valley aquifer.

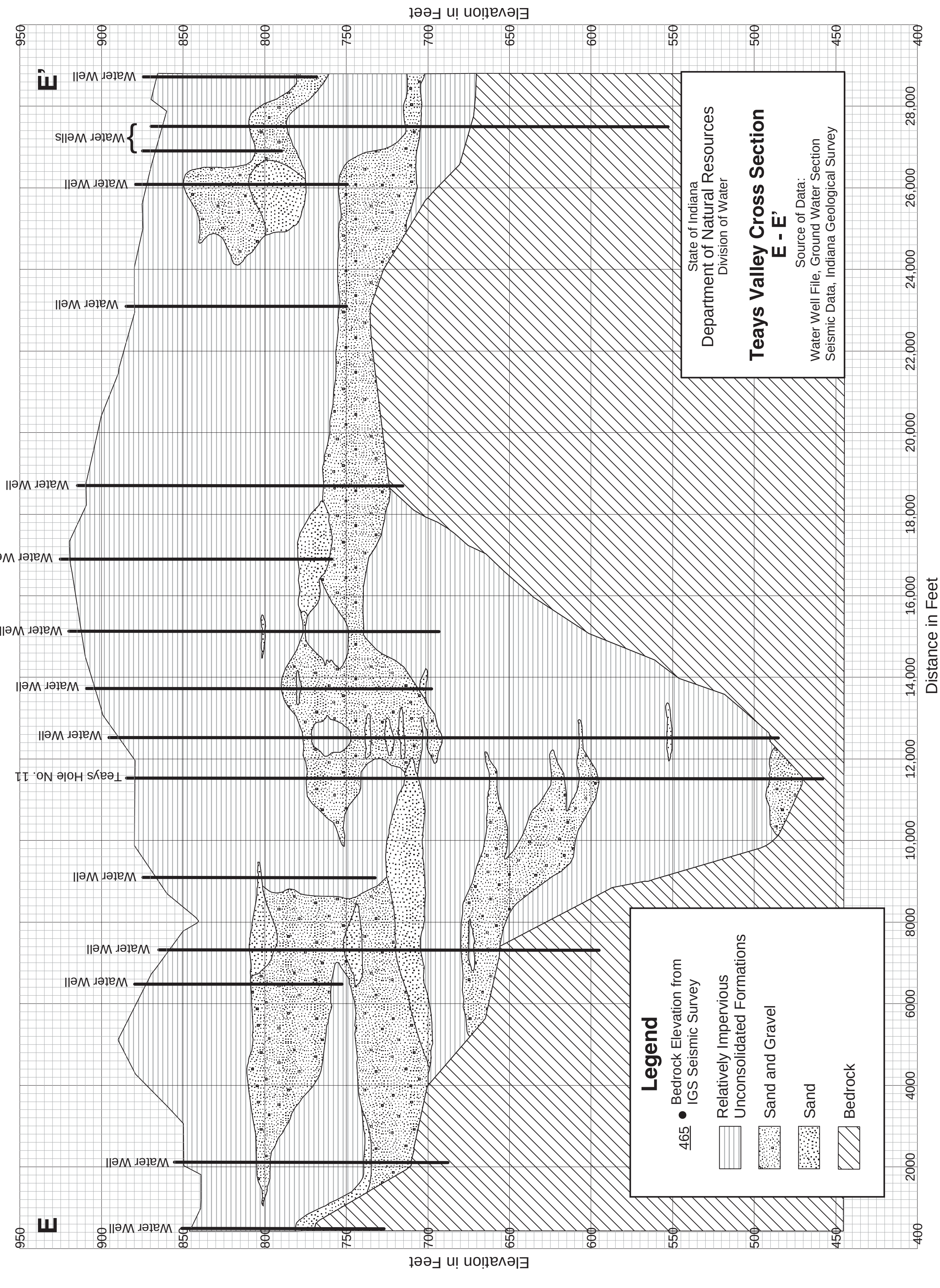
Layers of cemented gravel, broken limestone and cobbles are common in the valley segment near Peru, and these deposits have led in some instances to the completion of wells at a shallower depth rather than risking the loss of equipment or broken casing in attempting to drill deeper into the cobbley deposits. Available data including T. H. #16 (Figure 6 and Appendix A) and test wells drilled for Peru at the new well field confirm the presence of sand and gravel at depth below these zones, and the potential of these deeper sand and gravels in the Lafayette (Teays) Bedrock Valley should not be excluded. In Cross-Section G-G' (Plate 1, Figure 13) the character and variation in fill materials in the valley can be seen.

Northeast of the community of Richvalley a narrow northeast to southwest trending tributary valley contains deposits of sand and gravel that locally approach 100 feet in thickness. It is questionable whether these narrow deposits would have much potential as a significant water supply source; however, the area is noted for future examination and possible test drilling.

Throughout much of the Richvalley to Peru segment of the valley, sand and gravel is the major component of the materials overlying and filling the deeper portions of the valley, and deposits of till do not cover these materials as they do to the east. However, in the extreme western portion of the area, the bedrock valley departs from its parallel course with the Wabash River valley, and takes a more northwesterly trend. In that area a thick sequence of till, silt, and clay overlies the sand and gravel aquifers contained within the valley. Land surface elevations above the valley also increase as the buried valley trends northwestward away from the present day Wabash River valley and into the hilly area that lies to the north. The total thickness of materials filling the valley increases dramatically, changing from 200 feet or less near Peru, to over 325 feet to the northwest in the higher ground. A notable change in aquifer conditions also occurs in the bedrock valley near U.S. 31. A substantial drop in ground-water potential occurs as the sand and gravel becomes confined between layers of glacial till and other fine-grained deposits. While reasonably thick units of sand and gravel are present beneath the clay cover, these confined aquifers are less easily recharged and are thinner than the more productive water table aquifer found between Peru and Richvalley. The confined aquifers to the north of the Wabash valley can generally be expected to yield less than 500 gpm to properly constructed wells.

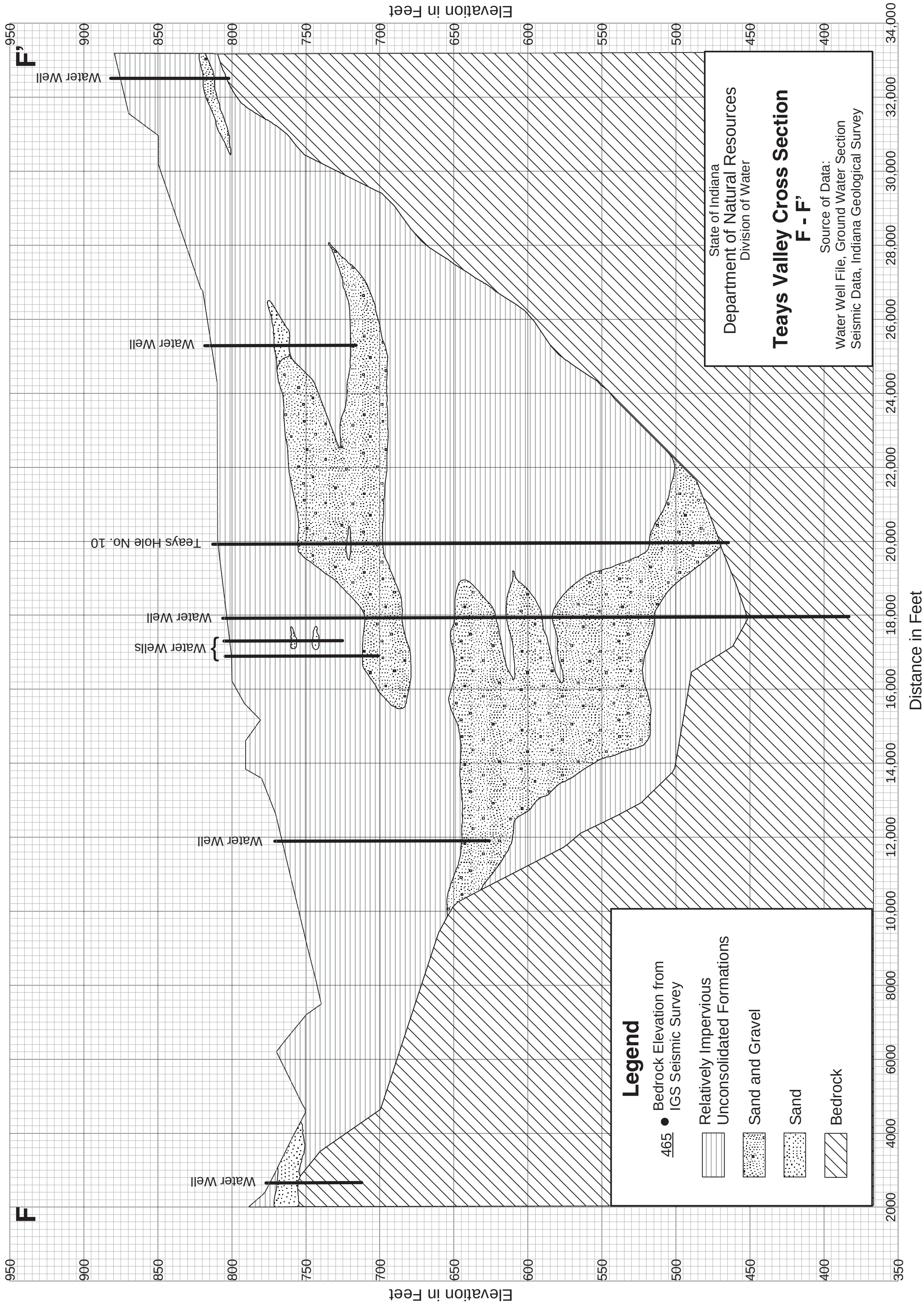
Lafayette (Teays) Bedrock Valley
U.S. 31 near Peru to Logansport (S.R. 17)

This segment of the Lafayette (Teays) Bedrock Valley offers generally good to excellent prospects for the development of wells having the capability of yielding 500 gpm or greater. In the area near U.S. 31, till comprises a major part of the overlying valley fill materials. Aquifers within and above the valley have a lesser capability as noted earlier, as compared to the mid-



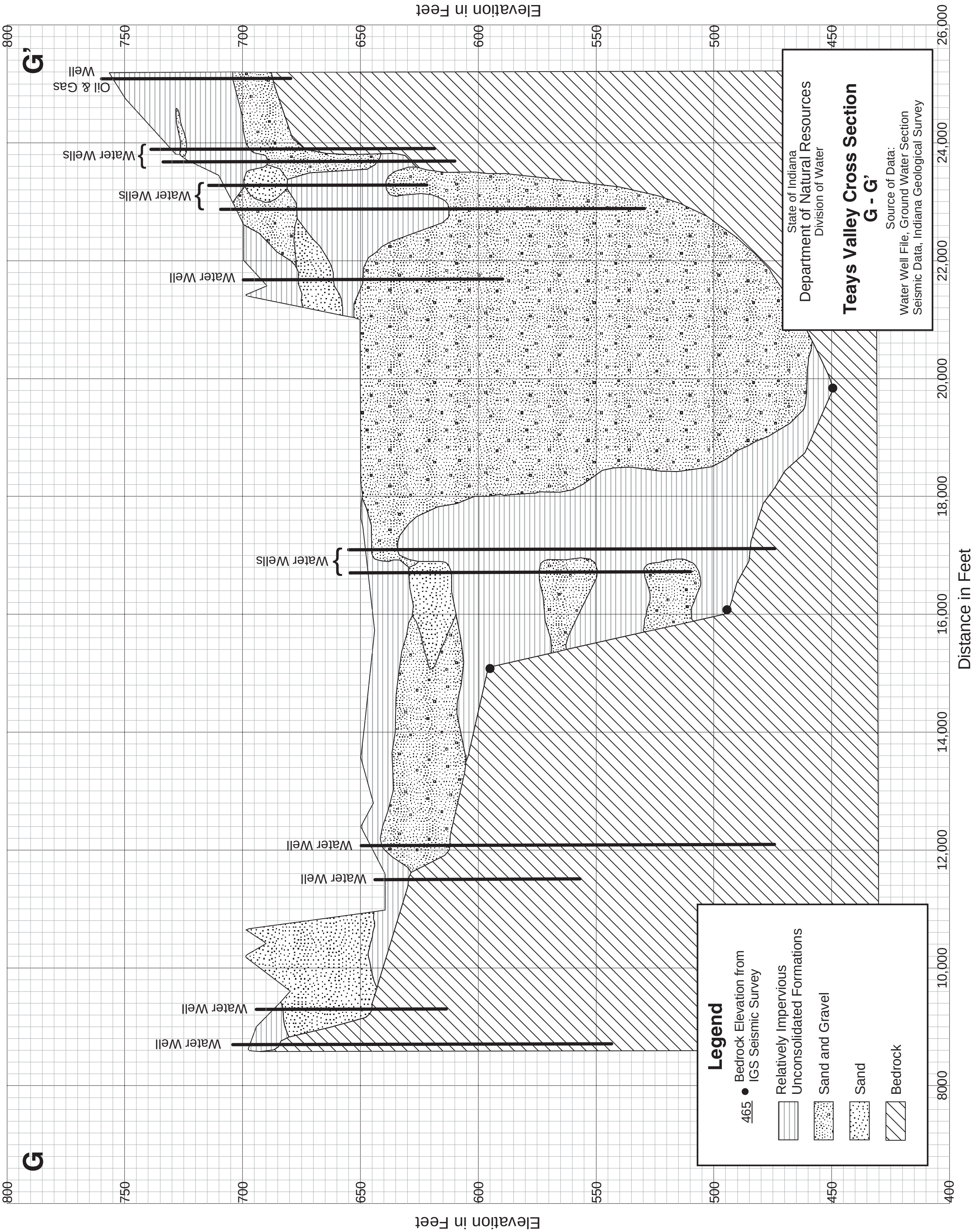
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
E - E'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
E
E'
Water Well
Water Wells
Teays Hole No. 11
Elevation in Feet
Distance in Feet

Figure 11



F
F'
Elevation in Feet
Distance in Feet
Water Well
Water Wells
Teays Hole No. 10
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
F - F'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock

Figure 12



State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
G - G'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
G
G'
Oil & Gas Well
Water Wells
Water Well
Elevation in Feet
Distance in Feet

Figure 13

dle portion of this segment where the valley underlies the present-day Eel River, or to the west where a basal and intermediate sand and gravel aquifer are present.

The configuration of the topography of the valley throughout this area is substantially different from the canyon-like conditions, which prevailed further to the east. The upland areas and valley flanks are more subdued in character, and changes in elevation are less precipitous at the edge of the valley. The elevation of the valley bottom is less than 450 feet msl in the deepest part, and the valley is generally about one and one-half miles in width, with wider areas at the intersections with major tributary valleys (Cross-Section H-H', Plate 1, and Figure 14).

In the eastern portion of this segment of the valley, a very rocky, possibly cemented sand and gravel, is present in the T.H. #9 (Figure 6 and Appendix A) at a depth from 277 to 305 feet. This zone occurs only a short distance above the bedrock surface that is encountered at a depth of 324 feet. Another sand and gravel zone separated by about 10 feet of clay overlies this zone, and occurs at depth from 211 to 267 feet. A third potential aquifer was noted in T.H. #9 from about 116 to 149 feet in depth. Westward in the Eel River valley an intermediate level aquifer occurs at a depth from 75 to 100 feet below ground level, extending downward to a depth of about 150 feet. Also, a near-surface deposit of outwash sand and gravel is present in the Eel River valley to a depth of about 50 feet. The materials filling the deeper portions of the valley contain few zones of water-bearing sand and gravel. A reddish-brown clay similar to that noted in the Marion area is the primary material filling the lower part of the valley. This clay denotes the blockage of the valley during the early part of the glacial period (N.K. Bleuer, oral communication, 1984).

The bedrock valley is coincident with the present day Eel River valley for several miles before it departs to the west and is buried again beneath a thick cover of till northeast of Logansport. In that area, and for one to two miles to the west, no significant deposits of sand and gravel were noted in test wells drilled by the U.S. Geological Survey (USGS) in a 1976 study (Gillies, 1981). Further west, a 50- to 60- foot thick sand and gravel deposit is present in the deeper parts of the valley, along with scattered thinner aquifers at shallower depths. These zones were noted in USGS test wells #93, #94, #95, and #137 (Figure 6). Near highway S.R. 17, north of Logansport, the deeper materials filling the bedrock valley become finer, and more clay-rich deposits replace the coarser sand and gravel deposits noted to the east. In a tributary valley in the SW, NW, of Section 35, T.28N, R.2E (northeast of the intersection of County Roads 500E and 440 N), an exceptionally thick section of sand and gravel is encountered in USGS test hole #137, marking this area as one that bears further ground-water evaluation.

In general, the west-central segment of this part of the bedrock valley appears to offer reasonably good prospects for the siting of wells yielding 500 gpm or more. An intermediate level aquifer is present beneath the Eel River valley and should present good prospects for the development of high-capacity wells.

Lafayette (Teays) Bedrock Valley
<u>Logansport (S.R. 17) to Lake Cicott (U.S. 24)</u>

The direction of the Lafayette (Teays) Bedrock Valley through this segment is generally westward with a slight arcing curve that begins in the section between highways U.S. 31 and S.R. 17 and continues on to the Lake Cicott area near U.S. 24 (Figures 1 and 2). From U.S. 31 to S.R. 17 the valley has a slight southeast to northwest flexure, while westward from S.R. 17 to Lake Cicott the valley is marked by a northeast to southwest trend. Westward from the Lake Cicott area the valley assumes a pronounced southwesterly direction as it approaches the Cass-White county line.

The availability of ground water in this segment of the bedrock valley is generally good with some areas having excellent potential. Three potentially productive zones are present which could yield 500 gpm or more to properly designed wells. These zones are highly variable in thickness and lateral extent, and it is difficult to predict which zone might offer the greatest prospect at any given point for water-supply development. In test hole #121 drilled by the U.S. Geological Survey for the Logansport area ground-water study, all three zones were present in sufficient thickness to merit attention for the development of wells requiring 500 gpm or more. Typically, the upper zone, which occurs from 30 to 60 feet below ground level, contains very coarse sand and gravel and could yield 500 gpm or more to properly constructed large-diameter wells.

The next significant aquifer occurs at a depth of about 100 feet and may exceed 30 feet in thickness. In the areas where the aquifer is of greatest thickness, the yield to a properly constructed well could exceed 1,000 gpm. The final potential zone, a basal sand and gravel, fills the deepest part of the bedrock valley and is by far the most consistent of the three potential zones. However, this aquifer locally contains a number of clay layers, zones of cemented gravel, boulders, and broken limestone, all of which may impact its capability to yield water. In USGS test hole #121, the basal sand and gravel unit from about 208 to 312 feet in depth, represents a potentially excellent source of ground water. Wells completed in this zone should yield in excess of

1,000 gpm. In test well (USGS) #97, which is located slightly over one mile to the south, the basal sand and gravel is fifty feet in thickness and contains scattered clay units and boulder zones that could impact its yield capabilities. The valley through this area is broader than in sections to the east (Cross-Section I-I') (Plate 1, Figure 15. Near the intersection of some of the tributary valleys with the main valley, the width increases to about two miles; however, the deeper part of the valley is generally about one mile in width. Of note in USGS test holes #97 and #108 (copy of drilling log in Appendix A) was the presence of sizeable amounts of wood near the top of the basal sand and gravel unit. Carbon-14 dating placed the age of this organic material at about 21,500 B.P. (N.K. Bleuer, oral communication, 1984), thus indicating that much of the fill material in this part of the valley is of Wisconsinan Age.

Westward in this segment of the bedrock valley, the intermediate level aquifer at about 100 feet depth increases to thicknesses greater than 30 feet and is separated in places by a clay layer which could affect its water development potential. This aquifer locally presents an excellent prospect for the development of wells yielding from 500 to 1,000 gpm. In the area north of Lake Cicott, irrigation wells completed in this aquifer yield in excess of 1,000 gpm.

Lafayette (Teays) Bedrock Valley
<u>Lake Cicott (U.S. 24) to Delphi</u>

Ground water conditions are generally good in much of this segment of the bedrock valley. Both an intermediate and basal sand and gravel aquifer are present in many places in the valley, with the middle zone being the most commonly used. Only a few records are available to substantiate the presence of the basal sand and gravel in this area. However, in T.H. #7 and #8 (Figure 6 and Appendix A) the basal zone is 48 and 70 feet in thickness, respectively. The presence of a basal sand and gravel unit in this part of the bedrock valley is consistent with its occurrence to the east, beginning northeast of Logansport near the Eel River.

Wells drilled in the area underlain by the valley generally encounter a near-surface sand and gravel along with a brown sandy clay. Till or other fine-grained deposits comprise the major component of the fill materials within the valley with "intra-till" sand and gravel units beginning at a depth of about 50 to 100 feet. Most of the sand and gravel zones encountered are in the range of 10 to 20 feet thick. Locally some irrigation wells are completed at depths of about 130 to 150 feet and obtain water from the thicker "intra-till" sand and gravel aquifers. The basal sand and gravel aquifer in T.H. #7 and #8 lies at a depth of about 190 and 180 feet, respectively. The basal zone extends downward to the bedrock surface, with thin layers of clay contained within it. It would appear that this zone has the potential for development of larger volumes of water (500 to 1000 gpm). As can be seen from Cross-Section J-J' (Plate 1, Figure 16), both the intermediate aquifer and basal unit are present in the profile. Unlike the portion of the valley to the east where the valley walls are clearly defined and there is a pronounced change in elevation, the position of the valley in this section is indistinct.

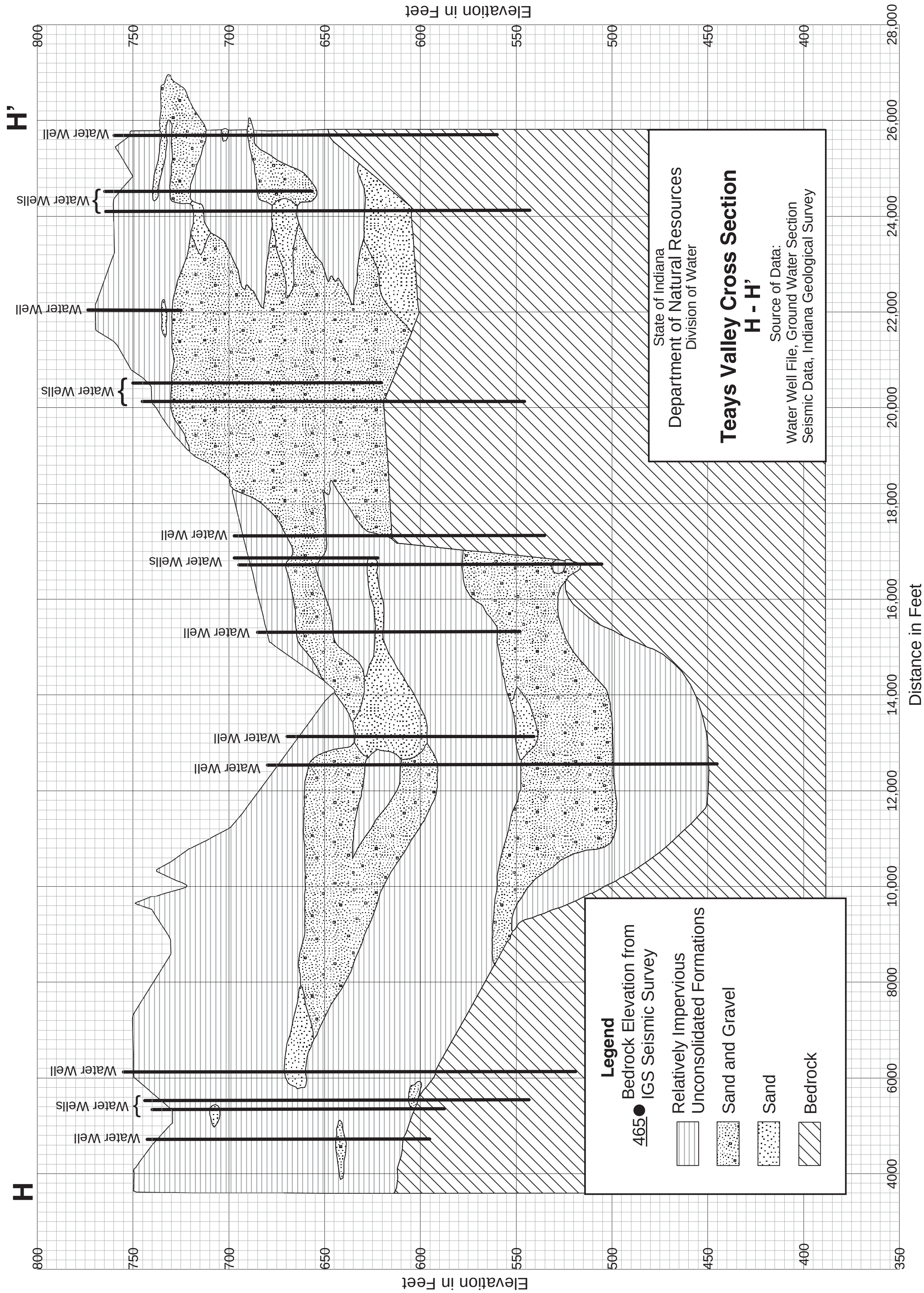
The position of the main thalwag of the bedrock valley is not well documented in this section (Plate 1). The classically-accepted route of the valley is from Lake Cicott southwestward toward Delphi; but a case could be made for a more westerly direction from Lake Cicott into the Monticello area and down a well-defined valley leading southward from Monticello. Major tributary valleys enter the Monticello area from the northeast, and a significant buried valley is present beneath Monticello; however, they do not explain the size and maturity of the valley south of Monticello. From Lake Cicott westward a poorly defined trough in the bedrock surface may actually be the main course of the valley. Because data on the bedrock surface west of Lake Cicott to Monticello are limited, no definitive information is available to prove or disprove the possibility of a westerly direction to the Lafayette (Teays) Bedrock Valley.

The presence of the more easily eroded New Albany Shale may be a major factor in the lack of a clearly defined bedrock valley in this section.

Lafayette (Teays) Bedrock Valley
<u>Delphi to I-65 at Lafayette</u>

The Lafayette (Teays) Bedrock Valley is subdued and indistinct in this part of the state and continues the diffused condition that was present in the area between Lake Cicott and Delphi. The valley typically spans a distance of several miles from wall to valley wall.

The availability of ground water is generally good to excellent in this segment of the valley. In most areas, properly constructed large-diameter wells should be capable of yielding 500 gpm or more. However, localized areas exist where the "intra-



H
H’
Water Well
Water Wells
Elevation in Feet
Distance in Feet
800
750
700
650
600
550
500
450
400
350
4000
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
H - H’
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey
Legend
465● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock

Figure 14

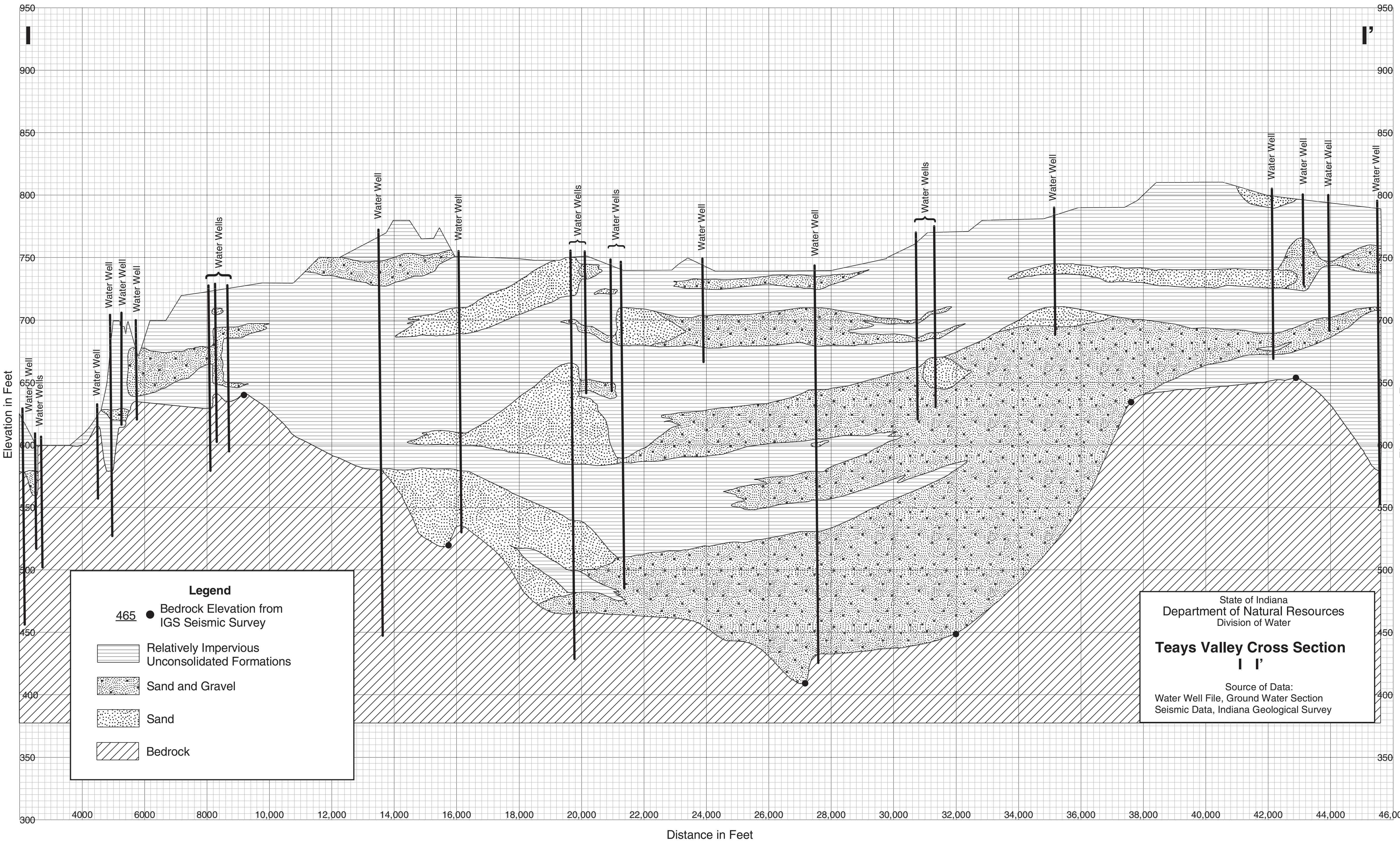
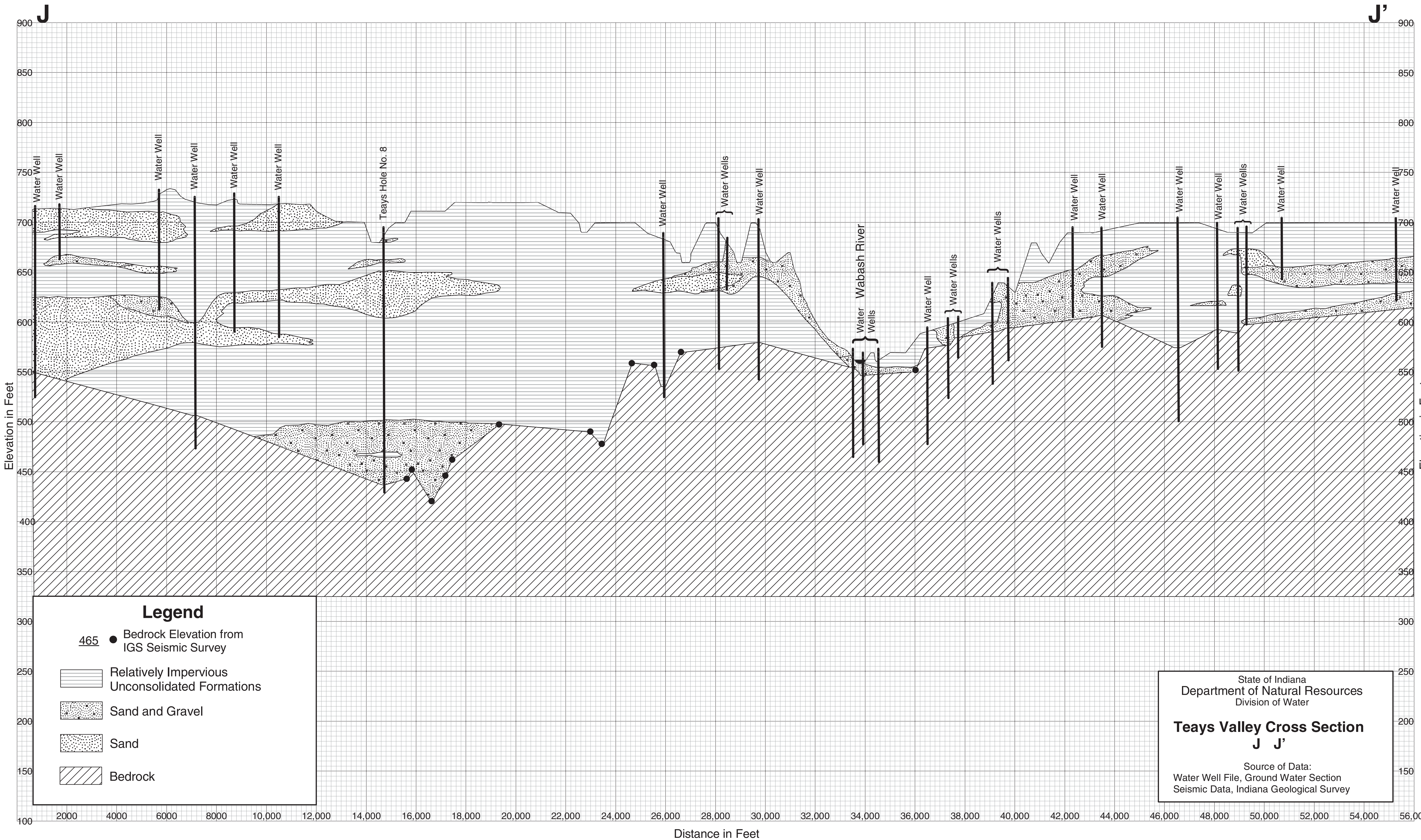

I
I'
Elevation in Feet
Distance in Feet
Water Well
Water Wells
Legend
465 Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
I I'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 15



J
J'
Water Well
Water Wells
Teays Hole No. 8
Wabash River
Water Wells
Elevation in Feet
Distance in Feet
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
2000
4000
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
32,000
34,000
36,000
38,000
40,000
42,000
44,000
46,000
48,000
50,000
52,000
54,000
56,000
Legend
465 Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
J J'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 16

till" sand and gravel aquifers are thin or absent (Cross Section K-K') (Plate 1, Figure 17), and in these areas the production capability could be substantially less. A basal sand and gravel aquifer is present in T.H. #6 and similar valley fill materials are noted in other wells drilled to the bedrock surface in the area. In T.H. #6 the basal aquifer is present from about 167 to 246 feet. However, it contains cemented zones, occasional layers of clay, broken limestone, and boulders, all of which could affect its capability as an aquifer. It appears that the basal zone may be a viable aquifer for users requiring moderate amounts of water (up to 500 gpm). In the Delphi area, between the Tippecanoe and Wabash Rivers, the water level in the deeper aquifers is typically in the range of 70 to over 100 feet below ground level. Locally, thick sand and gravel deposits are present at a shallow depth, but because of the deep water levels these zones either do not contain water or the available drawdown is such that yields would be substantially affected. For this reason the deeper aquifers are more commonly used. In the valley of the Tippecanoe River, surficial outwash sand and gravel deposits are present where the Lafayette (Teays) Bedrock Valley system underlies the river. These outwash materials may extend to a depth of 60 feet before encountering a clay layer. Sand and gravel deposits occur below the clay separator and extend to the bedrock surface. Near I-65 and the Wabash River the outwash sand and gravel deposits become thicker and more prominent, and the potential for high-capacity wells is substantially increased. A clay-separating unit is also present in this area below the outwash deposits, and the deeper sand and gravel appears to be thicker and more productive than the one to the northeast toward Delphi. The Lafayette (Teays) Bedrock Valley at this point is about four miles in width.

Lafayette (Teays) Bedrock Valley
I-65 at Lafayette to Green Hill

In this segment of the Lafayette (Teays) Bedrock Valley the valley abruptly changes direction from a south-southwest direction at Lafayette to a westerly trend. Most wells drilled to the bedrock in this area encounter black or brown shale of Devonian - Mississippian Age (New Albany Shale). The valley here is characteristically six to seven miles in width, as it approaches the Mississippian (Knobstone) Escarpment. In addition, several major tributary valleys enter the valley in this area. These tributary valleys enter from the northwest to the southeast and intersect the main valley at the point where it turns to the west (Figure 2).

Throughout this segment of the bedrock valley, the modern Wabash River has cut its valley into the glacial sediments filling the larger, pre-existing Lafayette (Teays) Bedrock Valley. The Wabash River follows the trend of the bedrock valley from a point about five miles northeast of Lafayette to a point six miles south of Otterbein, near the small community of Green Hill, a distance of about twenty-two river miles. South of Green Hill, the Wabash flows southwest over shallow bedrock wheras the bedrock valley continues its westward trend. Cross-Section L-L' (Plate 1, Figure 18) illustrates the relationship between the Wabash and Lafayette (Teays) Bedrock Valleys. The Wabash valley is incised approximately 150 to 200 feet into the sediments that filled the valley, leaving about 100 to 150 feet of sediment between the bed of the Wabash River and the bedrock floor of the bedrock valley.

Cross-Section L-L' illustrates the nature of the sediments filling the valley in this area. Thick sand and gravel aquifer zones are separated by equally thick layers of clay or till. These layers appear to be laterally continuous across the valley. Logs of deep wells commonly report thick sand and gravel zones immediately overlying the bedrock surface. This basal aquifer zone, up to 100 feet thick, is commonly used for a water supply.

Over much of this segment of the valley, thick, near-surface sand and gravel deposits are reported. The upper zones may be 50 to 60 feet thick, or can be split up into multiple, thinner zones by intervening clay layers. Thinner layers of sand and gravel, five to twenty feet thick, are often reported scattered throughout the section. Although not shown on the cross-section, these thin zones are common, but of limited areal extent. As many as four or five of these sand and gravel zones are reported on well logs. While these shallower sand and gravel units are sometimes used as domestic water supplies, they are often dry because of deep water levels and the relatively high topographic position. Test Hole #4 located in T. 23 N., R. 5 W., Section 21 (northeast of the intersection of County Road 500W and State Road 43) contains several of these thin zones in addition to the thick basal aquifer (Appendix A).

The ground-water availability throughout this segment of the bedrock valley is generally excellent. Several high-capacity municipal and industrial wells in Lafayette and West Lafayette have reported yields over 2,000 gpm. Many well logs report yields in excess of 500 gpm. These high-capacity wells are large-diameter, 6- to 48-inch, and range in depth from 65 to 230 feet deep.

Water levels in this area vary considerably, depending largely on the elevation and well depth. Generally, shallow wells, up to 140 feet deep, have water levels of around 50 feet or less, while deeper wells, over 175 feet deep, commonly have static water levels greater than 90 feet. Overall, water levels range from 5 to 130 feet below ground level.

Lafayette (Teays) Bedrock Valley
Green Hill to Little Pine Creek

In this section the courses of Lafayette (Teays) Bedrock Valley and the present-day Wabash River diverge as the Wabash heads southwest. The bedrock valley here gently bends to the northwest and then returns to a west trend. In the eastern portion of this segment the valley is broad, five to six miles across, as in the previously described segment. Beginning just to the west of Otterbein, the valley narrows abruptly to two to three miles across. This narrower portion of the valley is similar to areas in eastern Indiana where the former Teays River flowed over more resistant rock and hence, cut a narrower valley. The sudden narrowing of the valley also represents a change in bedrock to a more resistant bedrock type.

Although data for this segment are less plentiful than for the segment to the east previously described, it appears that there are thick continuous sand and gravel bodies capable of yielding significant quantities of water. Cross-section M-M' (Plate 1, Figure 19) depicts the general conditions in this segment. There appears to be a surficial clay layer of variable thickness covering the area. Thick sand and gravel deposits are encountered at variable depths with interspersed clay layers. Some of these clay layers are thick and may be continuous over a wide area. These clay layers may locally inhibit recharge to the deeper aquifers. Thin sand and gravel layers of limited continuity are present within the clays and may be utilized for domestic water supplies. Test Hole 3-B located in T. 23 N., R. 6 W., Section 22 (northeast of the intersection of County Line Road and Baseline Road) encountered a thick clay sequence from the ground surface to 127 feet (Appendix A and Cross-section M-M', Figure 19). Two thin intra-till sand and gravel zones are encountered within this upper clay. From 127 to 238 feet are mostly sand and gravel with thin clay layers. Shale bedrock is present at 238 feet. Sand and gravel zones up to 128 feet thick are reported on well logs from this area.

Properly constructed wells in this area should be able to produce enough water for most needs. Two high-capacity wells have reported yields of 300 to 1,000 gpm. Domestic wells generally yield from 15 to 40 gpm. Well depths in this area range from 40 to 250 feet, with most wells in the 90 to 180 foot range. Static water levels in this segment are extremely variable, ranging from 19 to 150 feet. In general the deepest wells have deep static levels. The shallow water levels found in shallower aquifers suggest that water is perched in the higher sand and gravel zones by low permeability clay layers.

Lafayette (Teays) Bedrock Valley
Little Pine Creek to Mud Pine Creek

The valley here continues its westward trend following the Benton-Warren county line. The valley width remains approximately two to three miles in the eastern portion of this segment, but about three miles northwest of Pine Village the valley width constricts to less than two miles. At the western edge of this segment, along Mud Pine Creek, the valley widens abruptly to four to five miles across. Two miles southeast of Oxford a major tributary enters the valley. This tributary, trending northeast-southwest can be traced for five miles at which point it divides into a north and east trending branch, each several miles long.

Compared to the previously described valley segments to the east, this segment appears to have a much thicker till and clay cap and less sand and gravel. Cross-section N-N' (Plate 1, Figure 20) shows the general sediment profile in this segment. The main aquifer is the thick basal sand and gravel zone. Thin sand and gravel beds occur within the thick clay sequence and may be used for small-capacity water supplies. In Test Hole 3-A near the eastern edge of this segment, clays and silts extend from ground level to 110 feet depth (Appendix A). No sand and gravel zones significant enough to be a potential aquifer are present within this upper clay unit. The basal zone aquifer, 173 feet of sand and gravel deposits, is present from 110 feet to 283 feet; and limestone bedrock is present at 283 feet.

Ground-water conditions in this segment are good. Small-diameter domestic wells usually yield 10 to 50 gpm, and yields up to 100 gpm have been reported. Two large diameter high-capacity wells drilled by Oxford in the bedrock valley south of town reported yields of 200 and 500 gpm each.

The basal aquifer should be capable of yielding 1,000 gpm to properly constructed wells. Water levels are usually between 25 and 60 feet, although one well had a reported water level of 110 feet and two wells were reportedly flowing wells. The thick, largely untapped, basal sand and gravel zone represents a major water-supply source in this portion of Indiana.

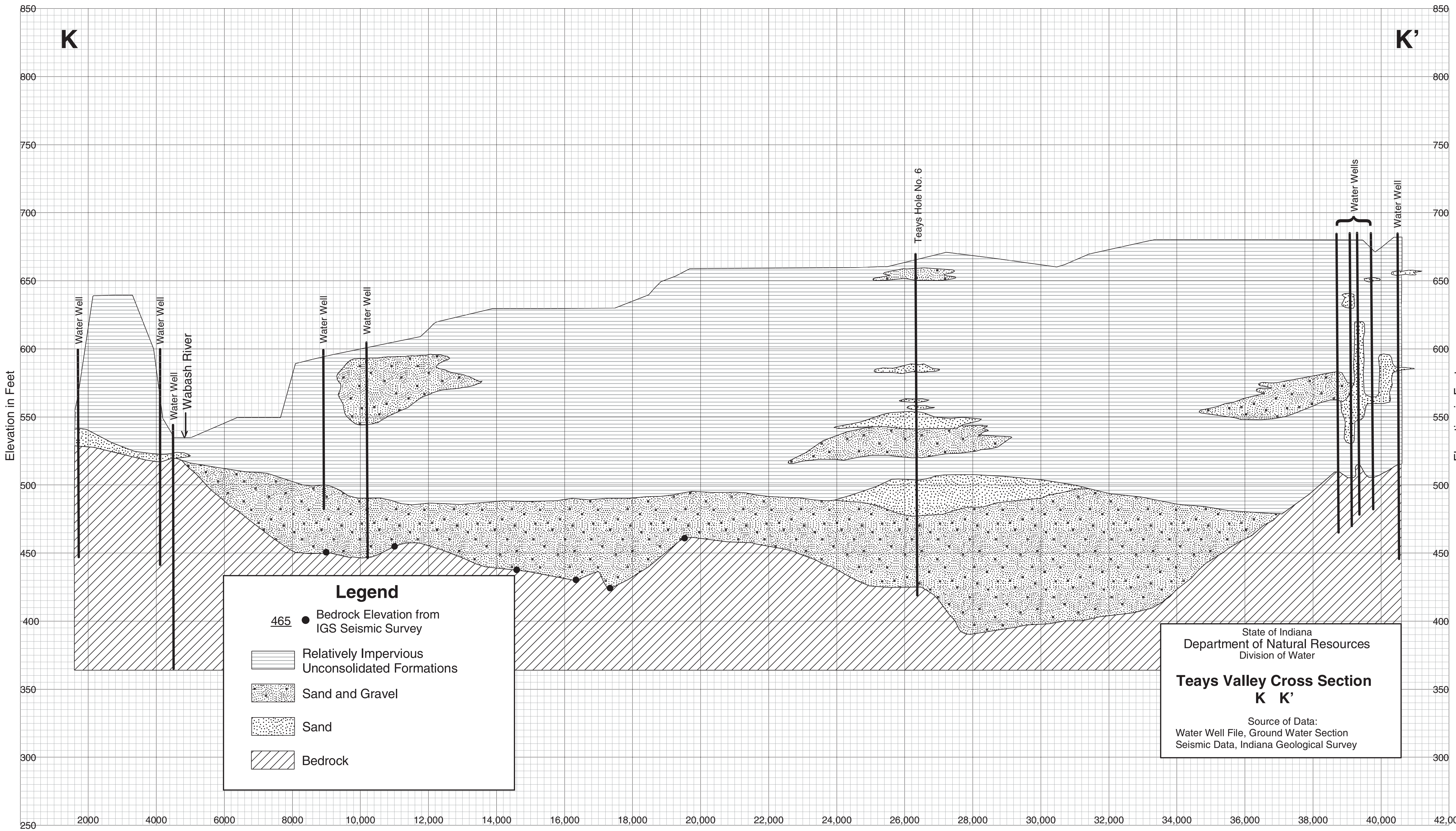
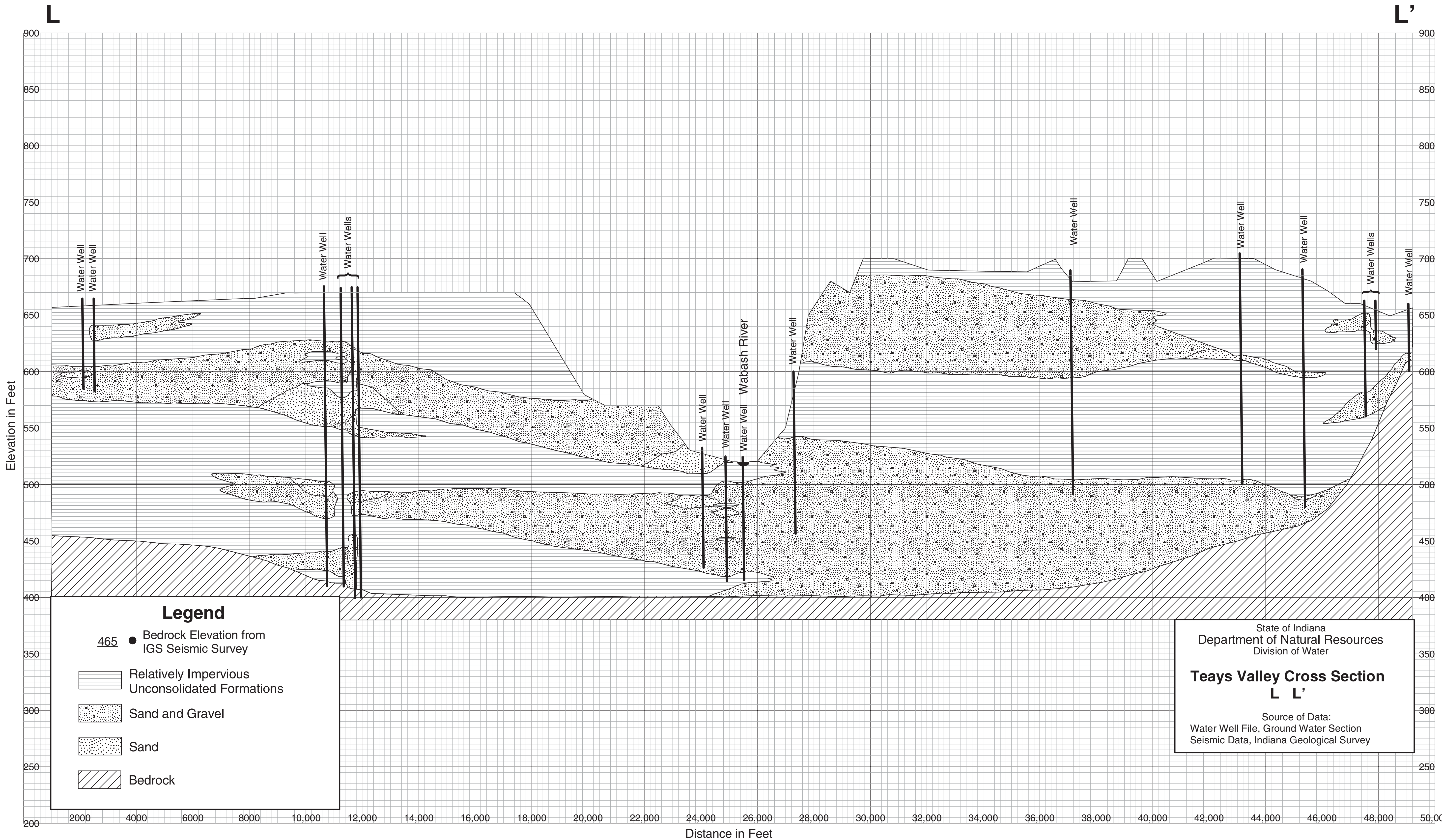

K
K'
Elevation in Feet
Distance in Feet
Water Well
Water Well
Water Well
Wabash River
Water Well
Water Well
Teays Hole No. 6
Water Wells
Water Well
850
800
750
700
650
600
550
500
450
400
350
300
250
2000
4000
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
32,000
34,000
36,000
38,000
40,000
42,000
Legend
465 Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
K K'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 17



L
L'
Elevation in Feet
Distance in Feet
Water Well
Water Wells
Wabash River
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
L L'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 18

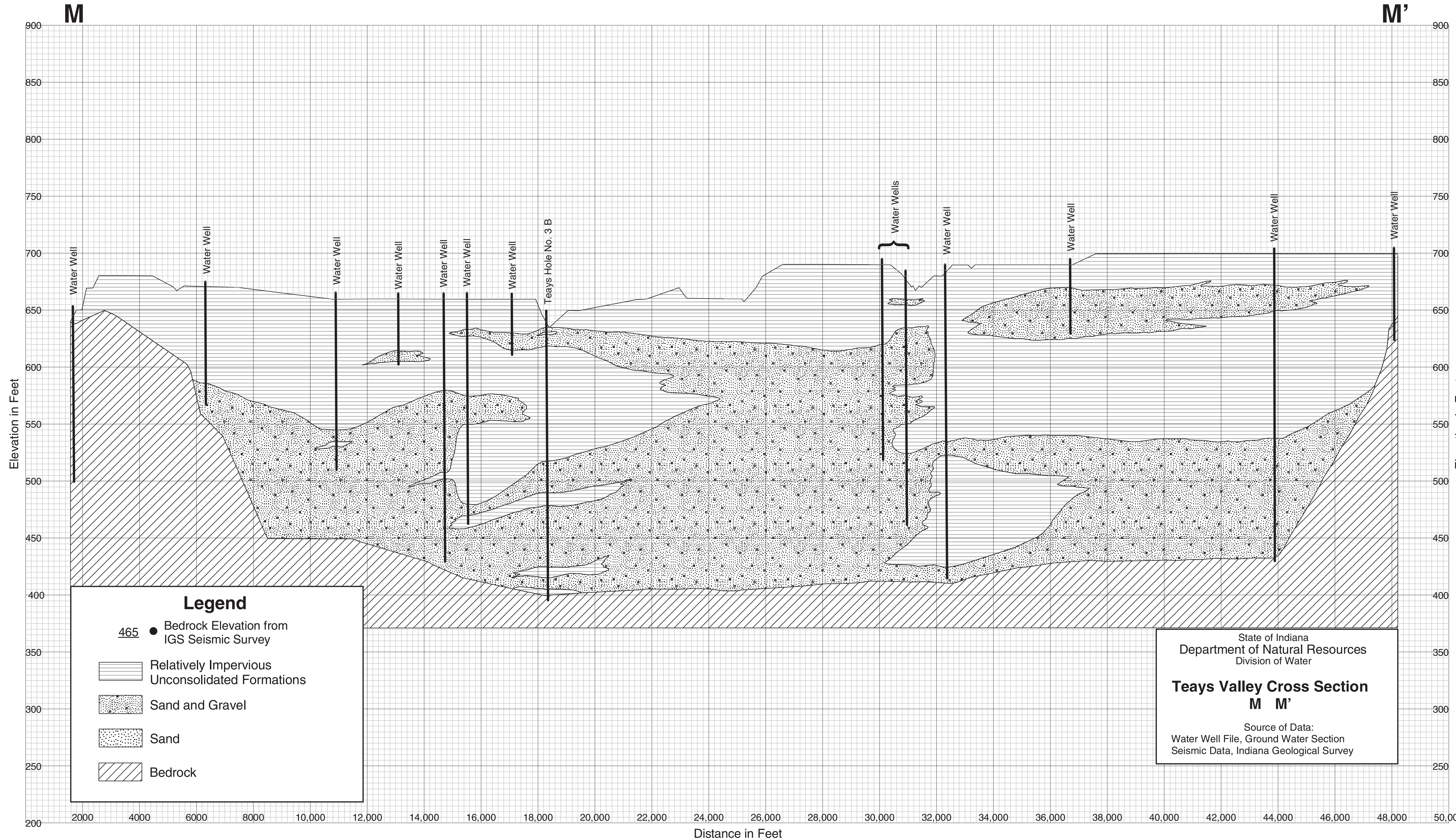

M
M’
Elevation in Feet
Distance in Feet
Water Well
Water Wells
Teays Hole No. 3 B
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
M M’
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 19

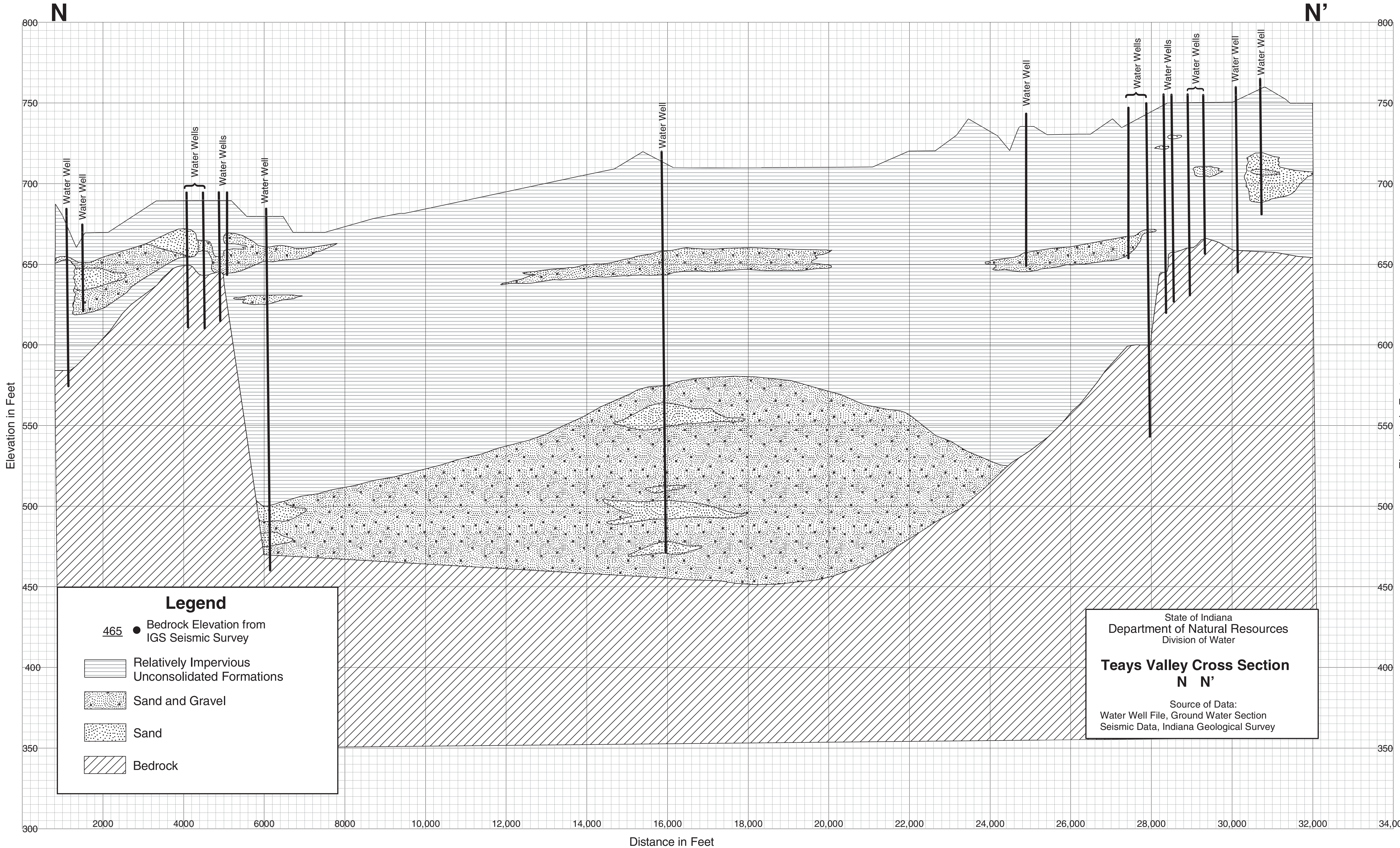

N
N'
Water Well
Water Well
Water Wells
Water Wells
Water Well
Water Well
Water Well
Water Wells
Water Wells
Water Wells
Water Well
Water Well
Elevation in Feet
Distance in Feet
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
N N'
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 20

Lafayette (Teays) Bedrock Valley
Mud Pine Creek to Indiana-Illinois State Line

In this segment the valley continues due west, straddling the Benton-Warren county line. The valley is much wider here than in the previous segment, averaging four to five miles. Data in this segment are sparse, but it appears that the sediment fill in the valley becomes progressively more clay rich to the west. The basal sand and gravel in the segment to the east discussed previously, is still present here and is still the main aquifer; but it is thinner and narrower and may be split by a clay layer. Cross-Section O-O' (Plate 1, Figure 21) clearly illustrates the thicker clay fill of this segment and the decreasing thickness of the basal sand and gravel aquifer. As before, thinner sand and gravel zones are present above the basal aquifer.

Two test holes were drilled in this segment. Test Hole 2 is located near the east edge of the segment in T. 24 N., R. 8 W., Section 31 (east of the intersection of U.S. 41 on County Road 1050, less than a mile west of Mud Pine Creek). From the surface to 100 feet there is a sequence of clay with thin layers of sand and gravel. The upper surface of the basal sand and gravel zone lies at a depth of 100 feet and extends downward to 303 feet with only one thin clay break near the top. The bedrock floor of the valley is encountered at 303 feet. Near the west edge of the segment, in T. 24 N., R. 9 W., Section 31 (north of the Benton/Warren County Line near County Road 900W) is Test Hole 1. At this location, clay extends down to 244 feet with scattered sand and gravel zones. The basal sand and gravel zone is found from 244 to 340 feet and is split by a 21 foot layer of sandy clay from 284 to 305 feet. Bedrock lies at 340 feet. Comparison of the two test holes shows the basal aquifer thinning to the west.

Ground-water availability in this segment is more limited than areas previously discussed due to thinner sand and gravel zones. Although most domestic wells provide adequate water (5 to 25 gpm), the area is poorly tested for high-capacity well volumes. One municipal well at Ambia reportedly produced 100 gpm, the highest documented well yield in this segment of the bedrock valley. It is expected that wells drilled into the basal sand and gravel aquifer should produce from 300-600 gpm.

Generalized Ground Water Availability of the Bedrock Aquifers Underlying the Lafayette (Teays) Bedrock Valley

In addition to the unconsolidated materials filling the Lafayette (Teays) Bedrock Valley, the bedrock underlying the valley also contains water-producing units. Because the bedrock supplies water for much of the area around the valley, the potential of obtaining water from the bedrock was evaluated. Many bedrock types are present along the path of the bedrock valley, and the availability of ground water varies with the bedrock type.

Ground-water availability of the bedrock occurring along the valley floor, flanks, and uplands of the Lafayette (Teays) Bedrock Valley is discussed from east to west and oldest to youngest. This discussion focuses primarily on the water-bearing characteristics of the bedrock. For detail on lithology and stratigraphy of the bedrock, refer to the Bedrock Geology section of this report under the heading of Geologic Setting. Figure 4 also provides a map showing the location of bedrock types in and near the bedrock valley.

Ordovician Age bedrock subcrops in the deepest portion of the valley in the eastern part of the state. To the west, progressively younger bedrock units of Silurian, Devonian, and Mississippian Age are present in the valley floor.

Ordovician Age Bedrock

The bedrock formations of Ordovician Age are generally not considered to be a potential source of ground water. Because of the typically shaley nature of this alternating limestone-shale bedrock, little water is usually encountered. However, in some of the test holes drilled for this study, substantial losses in drilling mud occurred where the Ordovician bedrock was encountered which would seem to indicate the potential for sizable volumes of ground water. Excluding these anomalous circumstances, the Ordovician bedrock (Maquoketa Group) is not expected to be a source of water, and dry wells are common.

Silurian Age Bedrock

Overlying the Ordovician bedrock are various formations of Silurian Age. These formations have varying degrees of water-bearing potential depending upon the physical properties and units present. In general the Silurian is considered as a significant aquifer for moderate to large volumes of ground water (150 to 600 gpm).

Silurian Aquifers

The Salamonie Dolomite is present in and near the bedrock valley in Adams, Jay, and Blackford Counties (Figure 4). This unit and the underlying Cataract Formation appear to be capable of yielding, in most cases, 75 to 300 gpm to properly constructed large-diameter wells. An occasional well in the range of 500 gpm may be obtained.

The Pleasant Mills Formation is present in and near the bedrock valley in portions of Jay, Blackford, Grant, Huntington, Wabash and Miami Counties (Figure 4). It is a moderate producer of ground water as denoted by various large-diameter wells drilled for industrial and municipal purposes. Yields of wells penetrating this formation and the underlying Salamonie Dolomite and Cataract Formation are in the range of 50 to 250 gpm. Some wells have yielded larger amounts where the Pleasant Mills Formation forms the subcrop, but such wells are an exception.

The Lower Wabash (Mississinewa Shale) is present in and near the Lafayette (Teays) Bedrock Valley in portions of Grant, Huntington, Wabash, and Miami Counties (Figure 4). This unit is not normally considered to be a good source of ground water; however, locally some wells penetrating this bedrock aquifer may yield up to 100 gpm. Well yields of 25 gpm or less can be expected to properly constructed large-diameter wells in most cases.

The rocks making up the Upper Wabash comprise the upper most bedrock units of Silurian Age that are found in and near the bedrock valley in much of Miami, Cass, White, and Carroll Counties (Figure 4). Wells drilled into these bedrock aquifers and the underlying deeper units of Silurian Age can be expected to yield limited to moderate amounts of ground water (75 to 250 gpm) to properly constructed large-diameter wells.

In the uplands away from the bedrock valley and its tributaries, where the bedrock topography assumes a more plain-like appearance (Plate 1), the yields of wells in the Silurian Aquifers appear to be more predictable and approach expected average maximum yields of 300 gpm on a more consistent basis. This may be due in part to the greater thickness of weathered bedrock containing numerous joints, fractures and solution enlarged zones.

Devonian Aquifers

Devonian Age bedrock of the Muscatatuck Group is present in and near the bedrock valley in Carroll, White and Tippecanoe Counties (Figure 4). Although the Muscatatuck subcrop is narrow (Figure 4), these rocks constitute a portion of the bedrock aquifer system present in the western part of the state. These formations are similar in water-bearing characteristics to the earlier mentioned Silurian age dolomites and limestone bedrock. Wells drilled into the Muscatatuck Group, and the deeper Silurian bedrock can be expected to yield limited to moderate (50 to 250 gpm) amounts of ground water.

Devonian-Mississippian Age

The New Albany Shale of Devonian-Mississippian Age is present in and near the bedrock valley in White, Carroll, Tippecanoe, Benton, and Warren Counties (Figure 4). The New Albany Shale is not normally considered as an aquifer, but some wells completed in it have yields up to 5 gpm.

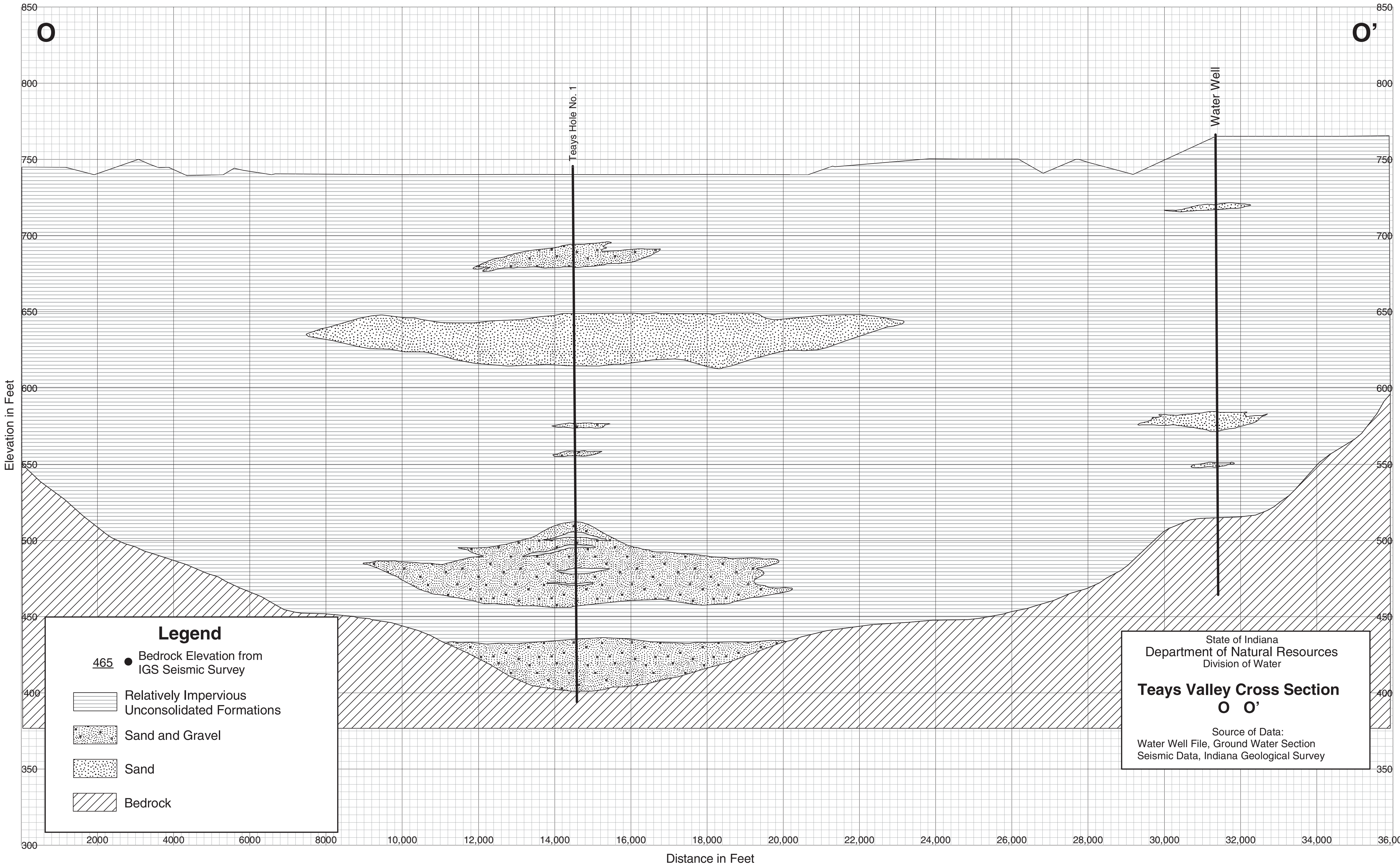
Mississippian Age

Rocks of the Borden Group of early Mississippian Age subcrop in and near the bedrock valley in portions of Tippecanoe, Warren and Benton Counties (Figure 4).

The Borden rocks are not normally considered to be a significant aquifer, and wells drilled into it often encounter little water. Wells drilled deep into the Borden bedrock formation run an increasing risk of encountering high levels of mineralized water, including sodium chloride (salt water) and other salts.

Pennsylvanian Age

Erosional remnants of the Pennsylvanian Age bedrock are present near the Lafayette (Teays) Bedrock Valley in Warren County at the higher elevations of the bedrock surface. These rocks constitute a minor aquifer source and wells typically yield from a



O
O’
Teays Hole No. 1
Water Well
Elevation in Feet
Elevation in feet
850
800
750
700
650
600
550
500
450
400
350
300
2000
4000
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
32,000
34,000
36,000
Distance in Feet
Legend
465 ● Bedrock Elevation from IGS Seismic Survey
Relatively Impervious Unconsolidated Formations
Sand and Gravel
Sand
Bedrock
State of Indiana
Department of Natural Resources
Division of Water
Teays Valley Cross Section
O O’
Source of Data:
Water Well File, Ground Water Section
Seismic Data, Indiana Geological Survey

Figure 21

few gallons per minute to a maximum of 25 gallons per minute to properly constructed large-diameter wells.

Ground-Water Flow
Potentiometric Surface

Many view the Lafayette (Teays) Bedrock Valley as an underground river with water moving down a stream channel to some unknown distant point. Nothing could be further from the truth. As shown earlier, the valley is filled with varying types of glacial deposits through which ground water moves.

Ground water flow, or movement of ground water, in the area underlain by the Lafayette (Teays) Bedrock Valley is generally in a direction toward the major rivers, which serve as the discharge points, or drains, for the various hydrologically connected aquifer systems. The movement of ground water is down gradient from areas of higher ground to areas of low ground, which normally are the major rivers.

The bedrock valley exerts no discernible influence on the regional ground-water flow system. The valley is not a discharge point for the regional ground-water system, nor does ground water flow through the valley like a river. Water is contained within the deposits filling the valley, and generally moves at a very slow rate, typically from less than one foot per day to a maximum of about ten feet per day toward the point of discharge laterally and/or upward into one of the major rivers. The water level map developed for the area surrounding the Lafayette (Teays) Bedrock Valley (Plate 2) shows a gradual but consistent decline in elevation as the water moves to the points of discharge.

Ground water discharged from the regional aquifer systems maintains flow in the streams even during the driest periods of the year. Essentially all streams and rivers in this area of the state are effluent, or gaining streams; they are receiving water from the ground water system rather than losing flow to it.

In the central and western part of the state underlain by the Lafayette (Teays) Bedrock Valley the Wabash River is the major discharge point for the ground-water system, along with various major tributary streams such as the Eel and Tippecanoe Rivers, and Wildcat Creek. In the area west of Lafayette and toward the Illinois state line, the ground-water flow is to the east and southeast toward the Wabash River.

Ground-Water Quality
Lafayette (Teays) Bedrock Valley

Only a limited number of chemical analyses are available for wells tapping aquifers in or above the Lafayette (Teays) Bedrock Valley; however, these analyses provide valuable insights into the general ground-water chemistry that can be expected from wells drilled into the bedrock valley aquifers. The chemical analyses tabulated in Table 1 are presented in east-to-west order.

General Chemical Analysis

In the eastern part of the state, the ground water for aquifers in the bedrock valley is hard and contains high levels of sulfate and iron. Sulfate content in the range of 100 to 600 milligrams per liter (mg/L) is common. Iron levels are typically in the range of 1 to 3 mg/L. Fluoride above 1 mg/L is present in much of this area, and levels up to 4 mg/L are noted, negating the need for supplemental fluoridation of waters for schools and other public uses. Other chemical constituents are fairly typical for much of Indiana, except for the sodium level, which is slightly elevated (See Table 1).

In the north-central part of the state, the available analyses for aquifers in the Lafayette (Teays) Bedrock Valley indicate lower hardness and sulfate levels relative to areas to the east. Fluoride levels are well below 1 mg/L and sodium is typically less than 50 mg/L. The iron content is generally in the range of 1 to 2 mg/L and the manganese level is often high enough to require removal. The levels of other constituents are fairly typical of ground water in Indiana.

In the western part of the state, the chemistry of waters contained within the aquifers of the bedrock valley is similar in composition to much of the ground water generally present in that portion of the state. Hardness levels are typically in the range of 300 mg/L or greater, and iron is in excess of 1 mg/L. All other constituents generally are at moderate levels, except for manganese whose elevated levels may require removal. Further to the west, the manganese levels are substantially lower.

In general, the chemical content of ground water from aquifers in or above the Lafayette (Teays) Bedrock Valley is considered satisfactory for most household, municipal, commercial, and irrigation uses without significant treatment. The water is typically above a hardness level of 300 mg/L and iron removal is required for aesthetic purposes in most cases. Manganese levels above 0.1 mg/L, common in the central and western portions of the state, require removal along with the iron present. Sulfate levels are substantially elevated in portions of the eastern part of the state and fluoride concentrations above 1 mg/L are common. Beyond these noted constituents most other components of the ground-water chemistry are of a moderate level and bear little consideration for further treatment.

Recharge
Lafayette (Teays) Bedrock Valley

Recharge to aquifers within the Lafayette (Teays) Bedrock Valley occurs in much the same manner as it does to any of the other aquifers in the state, namely by the downward percolation of local rainfall through the soil horizon and underlying formations. Recharge does not occur to these aquifers from remote sources such as Lake Michigan, Lake Superior, or the Appalachian Mountains, but from precipitation falling in the immediate area. Observation wells equipped with automatic, continuous, water-level recording devices positioned at various places throughout the state attest to the quick response of aquifers to localized rainfall events. This condition is particularly noticeable during certain periods of the year when local rain storms only a few miles in width cause significant water level rises in affected wells, while other wells outside of these storms paths show no change at all.

Available information on recharge to the Lafayette (Teays) Bedrock Valley aquifers indicates no departure from the expected normal recharge pattern. In fact the observation well in Benton County (Be #4), which is completed in a thick basal fill sand and gravel aquifer contained within the bedrock valley at the depth of 310 feet, exhibits a recharge pattern typical for observation wells in that area of the state and typical for aquifers having similar hydraulic characteristics.

Conclusions

It is perhaps an understatement to say that the Lafayette (Teays) Bedrock Valley is an important source of ground water for north-central Indiana. The work completed in the joint effort by the IDNR Division of Water and the Indiana Geological Survey, while generating significant amounts of new data, provided only a "snapshot" of the geologic and hydrologic characteristics of this unique major buried valley system. New ground-water development projects, completed after the project's test drilling, have provided verification of the highly productive nature of the aquifer systems contained in the Lafayette (Teays) Bedrock Valley.

In the eastern segment of the valley, the most prolific ground-water supplies are generally associated with the entrance of tributary valleys into the main-stem. In other locations within this area of the state, only minor amounts of ground water can be obtained, particularly in those segments containing thick sequences of reddish-brown clay.

Further west, in the stretch from Richvalley to Peru, is found some of the greatest potential for ground-water development. Exhumation of the buried valley, coupled with the addition of more recent sand and gravel deposits, has created a highly transmissive and easily recharged aquifer complex. Individual well yields in excess of 2,000 gpm have been obtained from this aquifer in Peru.

From Peru west to I-65 near Lafayette the aquifers contained in the bedrock valley offer good to excellent ground-water potential. In some areas, cementation of sand and gravel units reduces their productivity. This segment of the buried valley system is largely untapped at the present time and will be an important source of water for agricultural irrigation and public water supply purposes.

In the Lafayette and West Lafayette area, the superposition of the Wabash River valley on the underlying buried valley system has created ideal conditions for major ground-water development. The aquifer complex in this segment has been a significant factor in the economic development of the area. In July of 1988 up to 36 mgd of ground water was pumped from the aquifer system without any significant decline in water levels.

From West Lafayette to the Illinois State Line, the Lafayette (Teays) Bedrock Valley was virtually uncharted until this study. Today, it is clear that this area still holds some geologic "secrets." It is a complex area where overflow channels and classic stream course morphology lie buried beneath deposits from multiple glacial advances. To the communities of Otterbein and Oxford, the buried valley has become an essential source of high-quality ground water. And, as the valley exits Indiana, its geologic character appears to change once again, as do ground-water conditions.

The aquifers associated with the Lafayette (Teays) Bedrock Valley system will continue to be an important source of water for portions of north-central Indiana and can be expected to provide additional quantities of water for agricultural, industrial, and public water-supply needs.

Table 1. Teays Valley Chemical Analsis

County	Owner	Usage	Twp	Rng	Sec	Turb	pH	Hardness (CaCO3)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Iron (Fe)	Manganese (Mn)	Alkalinity (CaCO3)	Chloride (Cl)	Sulfate (SO4)	Phosp (PO4)	Flouride (F)	Nitrates (NO3)	Spc Cond	Diss Solids	Arsenic (As)	Other Paras	Well Data Depth	Geol Unit	Yield	Remarks	Date
Adams	Decatur	Muni	25N	14E	2		7.8	536	126	53	70	3	1.8	0.03	172	11	510	<0.1	1.6	<0.1					150	G	2100	#1- West Well	Apr-76
Adams	Decatur	Muni	25N	14E	2		7.6	636	157	59	79	3	2.2	0.04	162	10	630	<0.1	1.6	<0.1			<.01		151	G	2100	#2- East Well	Apr-76
Adams	Decatur	Muni	25N	14E	2		7.3	552	131	54	61	2.7	1.9	0.02	170	12	510	0.09	1.5	0.1					150	G	2100	#1- West Well	Jun-81
Adams	Decatur	Muni	25N	14E	2		7.3	684	160	69	69	2.8	2.4	0.04	176	11	670	0.1	1.5	0.1					151	G	2100	#2- East Well	Jun-81
Adams	Decatur	Muni	25N	14E	2		7.8	550	131	54	65	2.7	1.5	0.03	168	12	470	0.09	1.4	0.2					150	G	2100	#1- West Well	May-82
Adams	Decatur	Muni	25N	14E	2		7.7	676	165	64	72	2.7	2.2	0.05	160	11	630	0.12	1.5	0.5					151	G	2100	#2- East Well	May-82
Adams	Geneva	Muni	25N	14E	29		7.7	478	118	45	72	3	1.5	0.02	178	14	440	<0.1	1.6	0.3			<.01		131	S/G	550	#1- Downtown	Jul-74
Grant	Marion	Muni	25N	8E	27	10	7.4	436	96	48	40	2	1	0.03	328	5	170	<0.1	1.2	<0.1			<.01		236	S/G	2200	#1- NE Field	Jul-70
Grant	Marion	Muni	25N	8E	27	7	7.4	434	97	47	40	2	0.9	0.02	318	5	175	<0.1	1.1	<0.1					209	S/G	2118	#2- NE Field	Jul-70
Grant	Marion	Muni	25N	8E	27	8	7.4	430	97	46	39	2	1	0.03	312	5	180	<0.1	1.1	<0.1			<.01		184	S/G	1740	#3- NE Field	Jul-70
Grant	Marion	Muni	25N	8E	27	6	7.5	432	97	46	38	2	0.7	0.02	316	7	170	<0.1	1.1	<0.1			<.01		203	S/G	1810	#4- NE Field	Jul-70
Wabash	LaFontaine	Muni	26N	7E	27		7.7	340	72	39	38	2	1.7	0.04	342	3	88	0.1	1.6	1.3					89	S/G		#1	Mar-76
Wabash	LaFontaine	Muni	26N	7E	27		7.6	336	75	36	34	2	1.6	0.02	342	4	68	<0.1	1.4	0.7									
Wabash	Wabash	Muni	27N	6E	28	4	7.8	352	92	30	4	<1	1.4	0.04	315	3	26		0.4	0.1			<.01		203	S/G	1016	#1- Smith Field	May-69
Wabash	Wabash	Muni	27N	6E	28	10	7.1	331	86	28	5	2	1.6	0.05	321	2	23		0.3	0.1					187	S/G	1529	#2- Smith Field	Jan-67
Miami	Peru	Muni	27N	4E	22	15	7.3	474	136	33	5	2	1.8	0.2	340	21	110	<0.1	0.2	<0.1			<.01		118	S/G	1800	#3	Aug-70
Miami	Peru	Muni	27N	4E	22	2	7.2	600	163	47	45	4	0.6	0.2	332	94	215		0	1.2					117	S/G	760	#4	Aug-65
Miami	Peru	Muni	27N	4E	22	15	7.3	560	151	44	34	3	4.1	0.19	332	66	183	0.2	0.2	1.1					117	S/G	760	#4	Aug-70
Miami	Peru	Muni	27N	4E	22		7.5	440	118	35	5	2	1.6	0.13	318	10	115	<0.1	0.2	0.1					117	S/G	760	#4	Oct-76
Miami	Peru	Muni	27N	4E	22	30	7.4	628	175	46	59	4	2.7	0.2	334	133	220		0.2	1.1			<.01		135	S/G	2000	#5	Jun-71
Miami	Peru	Muni	27N	4E	22		7.6	544	152	40	33	4	1.8	0.23	338	64	178	<0.1	0.2	1.2					135	S/G	2000	#5	Oct-76
Miami	Peru	Muni	27N	4E	22		7.3	516					1.7		328	62	163				925				135	S/G	2000	#5	Feb-80
Miami	Peru- T.W.	Muni	27N	4E	22		7.8	408	104				1.8	0.1	329	4	69		0.6	8	700				152	S/G	695	TW #1priv.lab	Apr-81
Miami	Peru- T.W.	Muni	27N	4E	22		7.3	400	104	34	64	1.6	1.2	0.07	332	11	65	0.09	0.3	0.1					152	S/G	695	TW #1 (SBH)	Apr-81
Miami	Stokely	Ind	27N	4E	22		7.5	432	113	36	4.4	2.1	2	0.09	312	2.9	112		0.1	0.2	754	485		SiO_2 13 HCO_3 380	73	S/G	250	USGS Tmp 53	Aug-53
Tippe	Battleground	Muni	24N	4W	23	1	7.5	310	79	28	8	2	1.1	0.2	289	3	38		0.1	0								East Well	Oct-63
Tippe	Battleground	Muni	24N	4W	23		7.9	298	71	29	10	2	1.2	0.15	260	10	46	<0.1	0.3	<0.1			<.01					#1- South Well	Jul-75
Tippe	Battleground	Muni	24N	4W	23	2	7.5	316	79	28	11	3	1.1	0.19	310	4	25	<0.1	0.3	<0.1								#1- South Well	Oct-76
Tippe	Battleground	Muni	24N	4W	23	2	7.5	298	78	25	12	2	1.1	0.2	294	3	24		0	0								West Well	Oct-63
Tippe	Battleground	Muni	24N	4W	23		7.7	320	78	31	13	3	1.1	0.18	322	4	18	0.1	0.3	0.1			<0.1					#2- West Well	Jul-75
Tippe	Battleground	Muni	24N	4W	23	0.8	7.5	344	88	30	10	3	1.2	0.15	294	9	58	0.2	0.2	<0.1								#2- West Well	Oct-76
Tippe	Grn Meadows	PS	23N	5W	15	6	7.6	292	75	25	2	2	0.6	0.11	238	5	60	<0.1	0.2	<0.1			<.01		191	S/G	156		
Tippe	Carriage Est.	PS	23N	5W	9	10	7.5	336	80	33	18	2	1.4	0.05	350	3	20	0.2	0.5	0.1					138	S/G	350	#1 Well	May-76
Tippe	Lafayette	Muni				0.1	7.9	304	82	24	13	3	<0.1	0.15	246	25	60	<0.1	0.3	0.5			<0.1					#1 Well (old)	Apr-76
Tippe	Lafayette	Muni					7.7	280	75	22	10	3	0.9	0.29	212	20	56		0.3	0.3			<0.1					#2 Well (old)	Sep-69
Tippe	Lafayette	Muni				0.4	7.9	316	85	25	13	3	0.1	0.38	232	32	74	<0.1	0.2	0.8			<0.1					#3 Well (old)	Apr-76
Tippe	Lafayette	Muni				0.2	7.9	280	76	22	12	3	<0.1	0.24	210	25	66	<0.1	0.2	0.5			<0.1					#4 Well (old)	Apr-76
Tippe	Lafayette	Muni				0.1	7.6	304	80	25	14	3	<0.1	0.5	208	27	80	<0.1	0.2	2			<0.1	Pb <.02				#5 Well (old)	Mar-75
Tippe	Lafayette	Muni				0.2	7.6	376	101	30	18	3	0.1	0.3	306	35	64	<0.1	0.2	0.8			<0.1					#6 Well (old)	Apr-76
Tippe	Lafayette	Muni				0.4	7.4	436	115	36	38	5	0.4	0.09	342	64	91	<0.1	0.3	1.4								#7 Well (old)	Apr-76
Tippe	Lafayette	Muni				0.2	7.2	464	130	34	23	4	<0.1	<.02	356	41	99	<0.1	0.2	2.4								#8 Well (old)	Apr-76
Tippe	Lafayette	Muni				5	7.7	266	74	20	12	3	1	0.6	194	25	64	<0.1	0.3	0.1			<0.1	Pb <.02				#9 Well (old)	Mar-75
Tippe	Lafayette	Muni				25	7.6	282	78	21	12	3	2.1	0.13	216	18	61		0.2	0.1			<0.1					#12 Well (old)	Sep-71
Tippe	Lafayette	Muni				0.1	7.7	268	72	21	11	3	<0.1	0.4	196	24	69	<0.1	0.2	0.6								#13 Well (old)	Apr-76

Tippe	Lafayette	Muni	23N	4W	17	2	7.3	332	88	27	14	2	0.2	0.16	268	19	59	0.1	0.2	0.4			0.002	Pb<.02	98	S/G	2641	#1 New Well	Jun-78
Tippe	Lafayette	Muni	23N	4W	17		7.3	336	93	25	8	1.5	0.96	0.2	278	13	60	0.09	0.2	0.1					98	S/G	2641	#1 New Well	Nov-82
Tippe	Lafayette	Muni	23N	4W	17	5	7.4	328	86	27	8	2	0.6	0.21	268	10	55	0.1	0.2	0.1			0.002	Pb <.02	101	S/G	2676	#2 New Well	Jun-78
Tippe	Lafayette	Muni	23N	4W	17		7.5	342	90	28	8	1.5	0.74	0.19	276	14	61	0.09	0.2	0.1					101	S/G	2676	#2 New Well	Nov-82
Tippe	Lafayette	Muni	23N	4W	17	15	7.3	336	84	31	7	2	1.4	0.13	286	12	43	0.1	0.2	0.1			0.002	Pb <.02	100	S/G	2597	#3 New Well	Jun-78
Tippe	Purdue Univ.	PS				0.04	7.3	402	105	34	9	3	<0.1	0.06	290	26	95		0.1	2.5								#1 Well	Sep-71
Tippe	Purdue Univ.	PS				0.5	7.5	348	86	32	6	3	0.2	0.14	266	10	76	<0.1	0.2	0.2				Pb .05				#1 Well	Aug-76
Tippe	Purdue Univ.	PS				1	7.4	382	94	35	5	3	0.3	0.11	286	6	80		0.1	0.4								#4 Well	Sep-71
Tippe	Purdue Univ.	PS				20	7.4	348	93	28	7	4	2.4	0.19	238	13	90		<0.1	0.5								#5 Well	Sep-71
Tippe	Purdue Univ.	PS				0.7	7.5	352	86	33	4	2	0.6	0.14	268	5	83		0.1	0.3								#7 Well	Dec-70
Tippe	Purdue Univ.	PS				3	7.6	360	91	32	8	3	0.6	0.16	264	16	83	1.5	0.1	0.6				Pb .04				#8 Well	Aug-76
Tippe	Purdue Univ.	PS				0.7	7.6	380	99	32	6	3	0.3	0.2	278	18	82	<0.1	0.1	1.2				Pb .04				#11 Well	Aug-76
Tippe	Purdue Univ.	PS				20	7.5	338	85	31	3	3	1.1	0.17	258	<1	75		<0.1	<0.1								#12 Well	Sep-71
Tippe	Purdue Univ.	PS				0.7	7.6	344	86	31	5	3	0.4	0.15	260	12	72	1.6	0.2	0.1				Pb .04				#14 Well	Aug-76
Tippe	W. Lafayette	Muni				0.5	7.2	332	87	28	13	2	<0.1	0.11	250	24	66	<0.1	0.2	0.1								#2 Well	Nov-77
Tippe	W. Lafayette	Muni				15	7.2	354	90	32	9	2	1.4	0.15	284	16	59	0.1	0.2	<.01								#3 Well	Nov-77
Tippe	W. Lafayette	Muni				3	7.1	364	94	32	12	2	0.4	0.12	277	21	73	<0.1	0.2	0.4								#4 Well	Nov-77
Tippe	W. Lafayette	Muni				10	7.2	317	85	26	11	2	1.2	0.18	240	15	73	<0.1	0.2	<0.1								#5 Well	Nov-77
Tippe	W. Lafayette	Muni				2	7.2	363	93	32	12	3	0.6	0.13	286	21	65	0.3	0.2	0.5								#6 Well	Nov-77
Tippe	W. Lafayette	Muni				1	7.2	352	92	30	12	3	0.4	0.09	279	9	65	12	0.3	0.1								#7 Well	Nov-77
Tippe	W. Lafayette	Muni				20	7.4	332	82	31	6	2	1.9	0.09	298	3	39	0.1	0.3	<0.1								#8 Well	Mar-77
Tippe	Otterbein	Muni	24N	6W	34		7.7	280	66	28	22	2.5	2	0.02	326	5	5	0.09	0.5	0.1					260	S/G	643	10" at tower	Mar-81
Tippe	Otterbein	Muni	24N	6W	34		7.8	250	66	21	22	2.3	2	0.03	300	5	5		0.5		360		0.002		260	S/G	643	10" at tower	Nov-80
Tippe	Otterbein	Muni	24N	6W	34		7.6	280	65	28	23	2.3	1.3	0.03	329	5	5	0.09	0.5	0.1					260	S/G	643	10" at tower	Mar-82
Benton	Otterbein	Muni	24N	6W	33	5	7.6	400	97	38	15	2	1	0.1	339	13	78		0.2	0.2								#1 Well	Aug-60
Benton	Otterbein	Muni	24N	6W	33	10	7.4	442	106	43	21	2	1.1	0.2	350	32	80		0.3	0.3			<.01					#2 Well	Aug-70
Benton	Otterbein	Muni	24N	6W	33	0.7	7.2	448	107	44	18	3	1.9	0.05	338	23	115		0.2	0.2								#3 Well	Nov-65
Benton	Oxford	Muni	24N	7W	31		7.6	284	63	31	24	2.6	1.7	0.02	334	3	8		0.5	0.1	640	420	0.003		211	S/G	750	#1 New Well	Aug-79
Benton	Oxford	Muni	24N	7W	31		7.6	282	63	30	24	2.5	1.6	0.02	346	3	10		0.5	0.1	640	420	0.002		211	S/G	750	#1 New Well	Aug-79
Benton	Oxford	Muni	24N	7W	31		7.7	296	67	31	27	2.5	2.3	0.05	346	7	5	5	0.5	0.1					211	S/G	750	#1 New Well	Jun-82
Benton	Ambia	Muni	24N	10W	35		7.8	280	62	30	22	4	1.7	0.06	326	<1	1	0.6	0.7	0.4					125	S/G		#1 Well	Jul-73
Benton	Ambia	Muni	24N	10W	35		8.1	282	60	32	21	4	1	0.04	320	3	1	<0.1	0.6	0.1			<.01						Jan-69

Table 1 continued...

REFERENCES

Ault, C.H., 1989, Map of Indiana showing directions of bedrock jointing: Indiana Geological Survey, Miscellaneous Map 52

Bleuer, N.K., 1974, Distribution and significance of some ice-disintegration features in west-central Indiana: Indiana Geological Survey, Occasional Paper 8

_____, 1975 The Stone Creek Section, a historical key to the glacial stratigraphy of west-central Indiana: Indiana Geological Survey, Occasional Paper 11

_____, 1989, Historical and geomorphic concepts of the Lafayette bedrock valley system (so-called Teays Valley) in Indiana: Indiana Department of Natural Resources, Geological Survey Special Report 46, 11 p.

_____, 1991, The Lafayette Bedrock Valley System (Teays-Mahomet drainage system) in Indiana: concept, form, and stratigraphy, in a symposium volume on the geology and hydrology of the Teays-Mahomet bedrock valley system edited by W.N. Melhorn and J.P. Kempton: Geological Society of America Special Paper 258, p. 51-77

Bleuer, N.K., Melhorn, W.N., Steen, W.J., and Bruns, T.M., 1991, Aquifer systems of the buried Marion-Mahomet trunk valley (Lafayette Bedrock Valley System) of Indiana, in Melhorn, W.N., and Kempton, J.P., eds., Geology and hydrogeology of the Teays-Mahomet Bedrock Valley System: Geological Society of America Special Paper 258, p. 79-89

Bownocker, J.A., 1899, A deep preglacial channel in western Ohio and eastern Indiana: American Geologist, v.23, p. 178-182, map

Brown, R.T., 1881, Fountain Country: Geology, geography, etc: Indiana Department of Geology and Natural History, 11th Annual Report, p. 89-125, map

Bruns, T.M., and Steen, W.J., 1980, Hydrogeology and ground-water availability in the preglacial Teays Valley, west-central Indiana: Geological Society of America, Abstracts with Programs, v. 12, p. 221

_____, 1983, Hydrogeology of the Teays valley fill, north-central Indiana: Geological Society of America Abstracts with Programs, v. 15, p 535

Bruns, T.M., Logan, S.M., and Steen, W.J., 1985, Maps showing bedrock topography of the Teays Valley, western part, central part, and eastern part, north-central Indiana: Indiana Department of Natural Resources, Geological Survey Miscellaneous Maps 42, 45, and 44

Burger, A.M., Keller, S.J. and Wayne, W.J., 1966, Map showing bedrock topography of northern Indiana: Indiana Geological Survey Miscellaneous Map No. 12, scale 1:500,000

Capps, S.R., 1910, The underground waters of north-central Indiana: U.S. Geological Survey Water-Supply Paper 254, 279 p., 7 pls., 12 figs.

Coffey, G.N., 1961, Major preglacial, Nebraskan, and Kansan glacial drainages in Ohio, Indiana, and Illinois: Ohio Journal of Sciences, v. 61, p. 295-313

Eveland, H.E., 1952, Pleistocene geology of the Danville region: Illinois Geological Survey Report of Investigation 159, 32 p., 1 pl., 14 figs.

Fidlar, M.M., 1943, the preglacial Teays Valley in Indiana: Journal of Geology, v. 51, p. 411-418, 2 figs.

Fowke, Gerard, 1925, The genesis of the Ohio River: Indiana Academy of Science Proceedings, v. 34, p. 81-102, 3 figs.

Gillies, D.C., 1981, Ground-water potential of the glacial deposits near Logansport, Cass County, Indiana: U.S. Geological Survey Water-Resources Investigations 81-7,98 p.

Gorby, S.S., 1886, Geology of Tippecanoe County: Indiana Department of Geology and Natural History, 15th Annual Report, p. 61-96

Harrell, M., 1935, Groundwater in Indiana, Indiana Department of Conservation, Division of Geology, Publication 133, 504 p.

Hartke, E.J., 1982, Environmental geology of Grant County, Indiana- an aid to planning: Indiana Department of Natural Resources, Geological Survey, Special Report No. 23, 25 p., 1 pl.

Hill, J.E., and Hartke, E.J., 1982, Geologic materials as potential confinements for hazardous wastes in Indiana: Indiana Geological Survey, Interim Report prepared for the Indiana State Board of Health

Horberg, Leland, 1945, A major buried valley in east-central Illinois and its regional relation ships: Journal of Geology, v. 53, P. 349-359, 4 figs., 1 table

Horberg, Leland, 1950, Bedrock topography of Illinois: Illinois Geological Survey Bulletin 73, 1 p., 2 pls., 23 figs., 9 tables

Janssen, R.E., 1953, The Teays River, ancient precursor of the East: Science Monthly, v. 77, p. 306-314, 1 fig., 4 illus.

Leverett, 1902, Glacial formations and drainage features of the Erie and Ohio Basins: U.S. Geological Survey Monograph 41, 802 p., 25 pls., 8 figs.

Maarouf, Abdelrahman, and Melhorn, Wilton N., 1975, Hydrogeology of glacial deposits in Tippecanoe county, Indiana: Purdue University Water Resources Research Center Technical Report No. 61, 107 p., 4 pls.

Malott, C.A., 1922, The physiography of Indiana, in Handbook of Indiana Geology, Indiana Department of Conservation, Publication 21, p. 59-256

McGrain, 1950, Thickness of glacial drift in north-central Indiana: Indiana Flood Control and Water Resources Commission Circular 1 (map and text (1951)

Noel, S.D., 1978, Subsurface stratigraphy and water resources of Cass County, Indiana: Purdue University Water Resources Research Center Technical Report 102, 94 p., 1 pl.

Norris, S.E., 1951, Map showing contours on the bedrock surface in west-central Ohio, in Goldthwait, R.P., The 1952 field conference of Friends of the Pleistocene.

Norris, S.E., and Spicer, H.C., 1958, Geological and geophysical study of the preglacial Teays Valley in west-central Ohio: U.S. Geoleological Survey Water-Supply Paper 1460-E, 232 p.

Rosenshein, J.S., 1958, Groundwater resources of Tippecanoe County, Indiana: Indiana Department of Conservation, Division of Water Resources, Bulletin 8, 38 p.

Rosenshein, J.S., and Cosner, O.J., 1956, Groundwater resources of Tippecanoe County, Indiana: Appendix, Basic Data, Indiana Department of Conservation, Division of Water Resources, Bulletin 8, 67 p.

Stout, Wilber, and Schaaf, Downs, 1931, Minford silts of southern Ohio: Geological Society of America Bulletin, v. 42, p. 663-672

Thornbury, W.D., 1948, Preglacial and interglacial drainage of Indiana abs.): Geological Society of America Bulletin, v. 69, p. 1359

Thornbury, W.D., 1958, The geomorphic history of the Upper Wabash Valley: American Journal of Science, v. 256, p. 449-469

Thornbury, W.D., and Deane, H.L., 1955, The geology of Miami County, Indiana: Indiana Geological Survey Bulletin 8, 49 p., 8 pls., 1 fig.

VerSteeg, Karl, 1936, The buried topography of western Ohio: Journal of Geology v. 44, p. 918-939, 3 fig.

_____, 1938, Thickness of the glacial drift in western Ohio: Journal of Geology v. 46, p. 654-659, map

Walker, A.C., Schmidt, J.J., Stein, R.B., Pree, H.L., and Bailey, N.G., 1965, Ground-Water for industry in the Scioto River Valley: Ohio Department of Natural Resources, Division of Water, Buried Valley Investigation No. 1, 29 p., 3 pls.

Wayne, W.J., 1952b, Pleistocene evolution of the Ohio and Wabash Valleys: Journal of Geology, v. 60, p. 575-585, 5 figs.

Wayne, W.J., 1956, Thickness of drift and bedrock physiography of Indiana north of the Wisconsin glacial boundary, Indiana Geological Survey Report of Progress 7, 70 p.

Wayne, W.J., 1958, Map No. 10 - Glacial geology of Indiana: Indiana Department of Conservation, Geological Survey Atlas of Mineral Resources of Indiana, 1 map

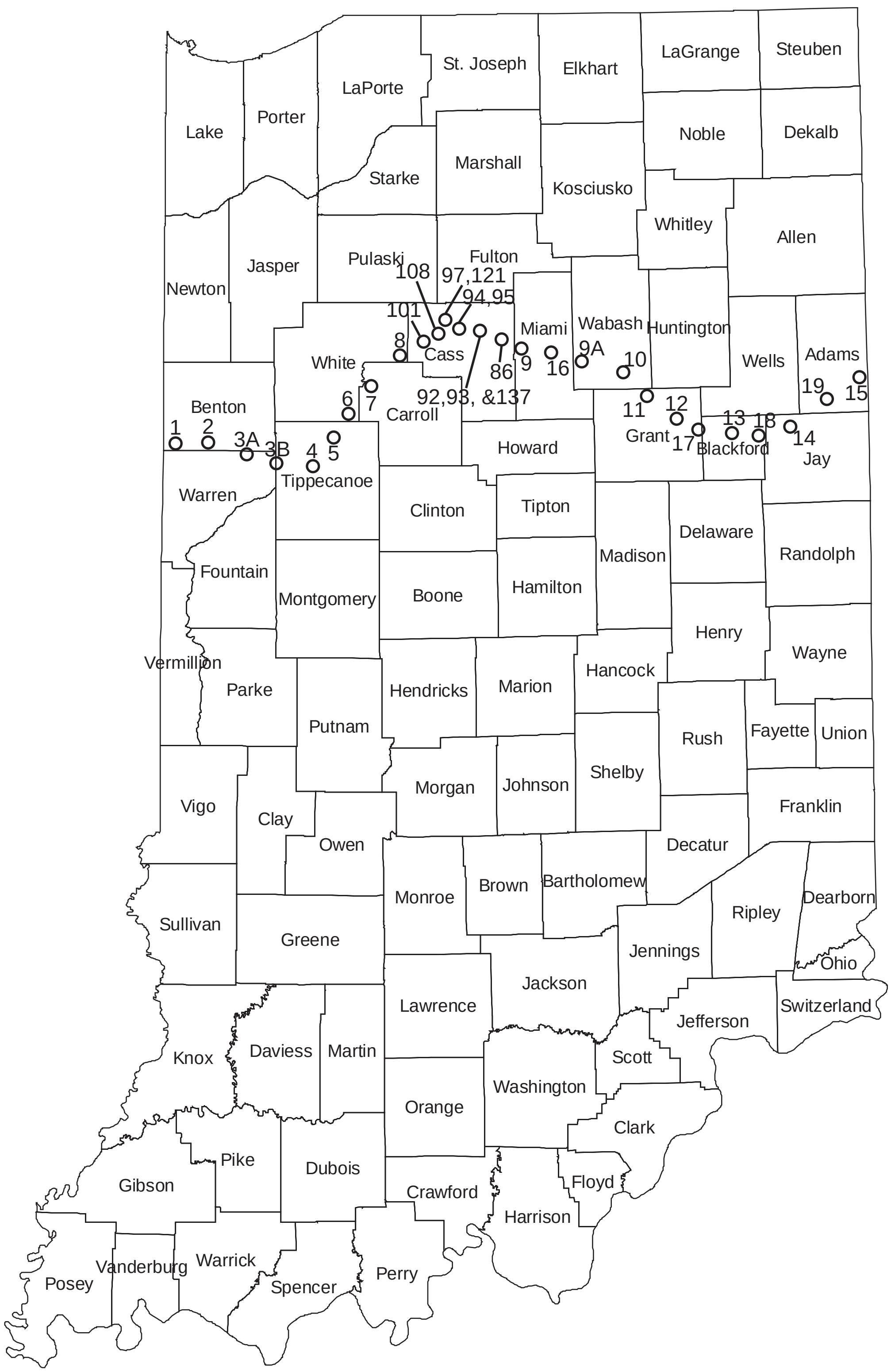
Wayne, W.J., and Thornbury W.D., 1951, Glacial geology of Wabash County, Indiana: Indiana Geological Survey Bulletin 5, 39 p., 7 pls., 1 fig.

Wright, G.F., 1890, The glacial boundary in western Penn., Ohio, Kentucky, Indiana, and Illinois.: U.S. Geological Survey Bulletin, No. 58, p. 112

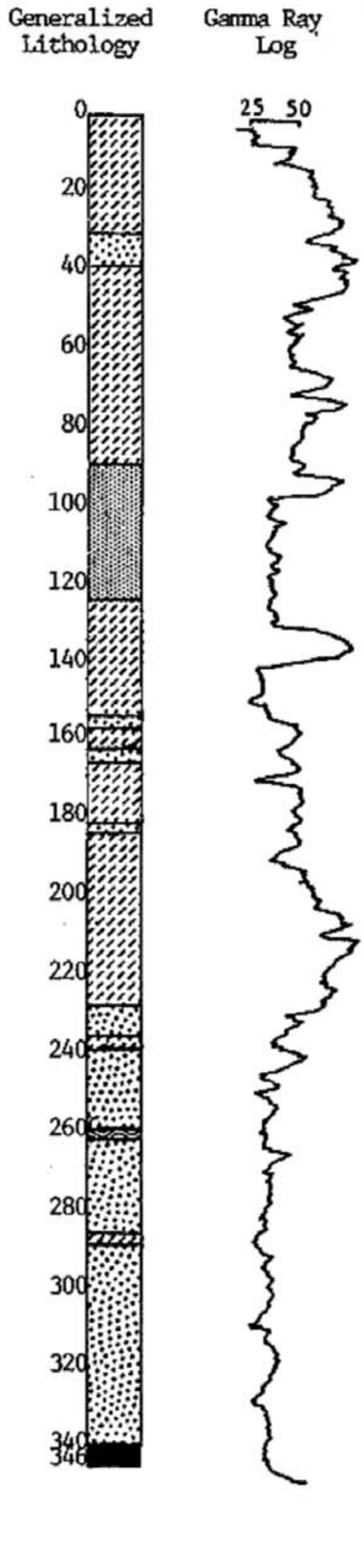
APPENDIX A

GEOLOGIC DESCRIPTIONS OF TEAYS VALLEY TEST HOLES

The following test hole information is a summation and tabulation of the data at sites for which driller's logs, gamma ray logs are available. The location of each test hole is depicted below and in Figure 6 of the text.

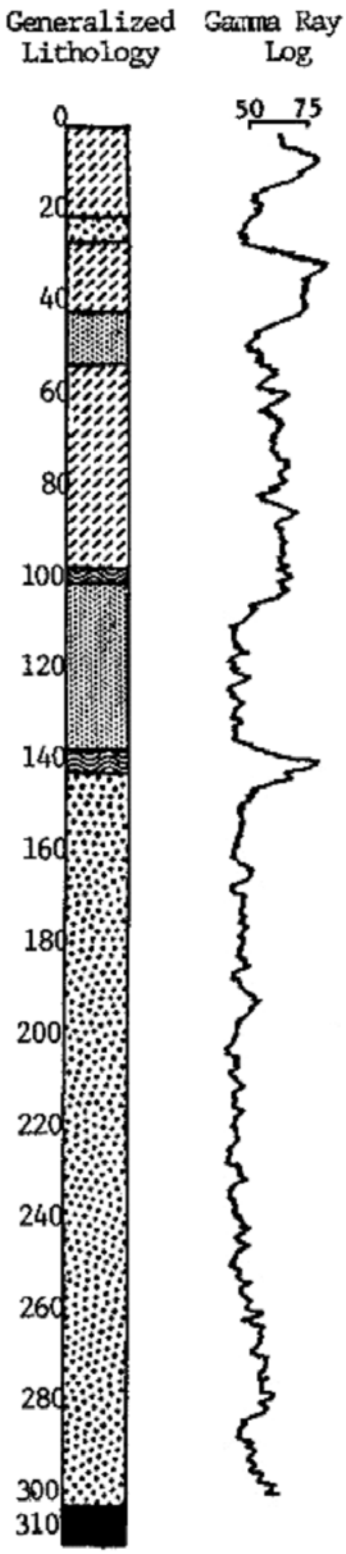


I.D.N.R. Test hole #1 – Ambia site; SW¼ of NW¼, Section 31, T. 24 N., R. 9 W. Hickory Grove Township, Benton County, Elevation: 742 feet. Total depth is 346 feet. Drilled by Ortman Drilling, Inc., September 6, 1978.



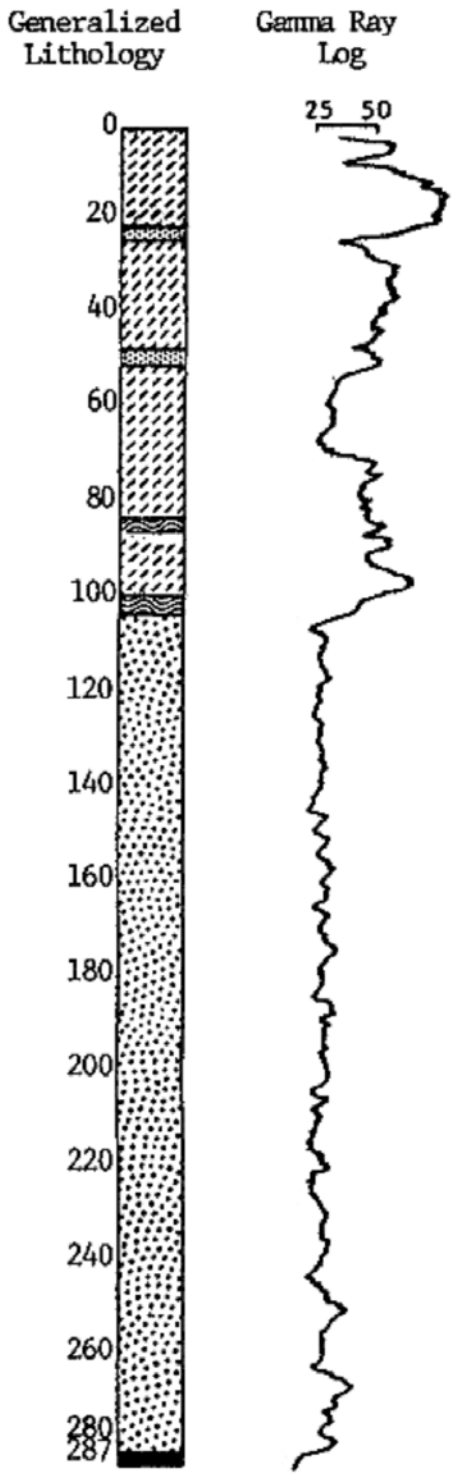
Driller's Log	Interval
Black dirt	0-2
Brown clay	2-8
Gray clay (sticky)	8-38
Soft gray clay	38-45
Gray fine to med. gravel	45-59
Gray clay (very sticky)	59-63
Gray clay	63-77
Soft gray sticky clay	77-90
Very fine silty sand	90-125
Soft sticky sand gray clay	125-155
Gravelly gray clay	155-163
Sand and fine-med. gravel	163-166
Gray clay	166-182
Sand and fine gravel	182-184
Gray clay, some gravel	184-189
Sticky gray clay	189-210
Sticky gray clay	210-228
Sand and med. gravel	228-235
Brown clay	235-239
Sand & dirty gravel	239-243
Clay	243-244
Sand & fine med. gravel	244-259
Greenish brown clay	259-262
Brown sand & med. gravel	262-284
Sandy gravelly gray clay	284-305
Sandy fine to med. gravel	305-340
Brown weathered bedrock	340-342
White putty stone	342-346

I.D.N.R. Test hole #2 – Mud Pine Creek site; NE¼ of SE¼, Section 31, T. 24 N., R. 8 W., Grant Township, Benton County. Elevation: 710 feet. Total depth is 310 feet. Drilled By Ortman Drilling, Inc., September 5, 1978. Used as U.S. Geological Survey Observation Well Benton #4.



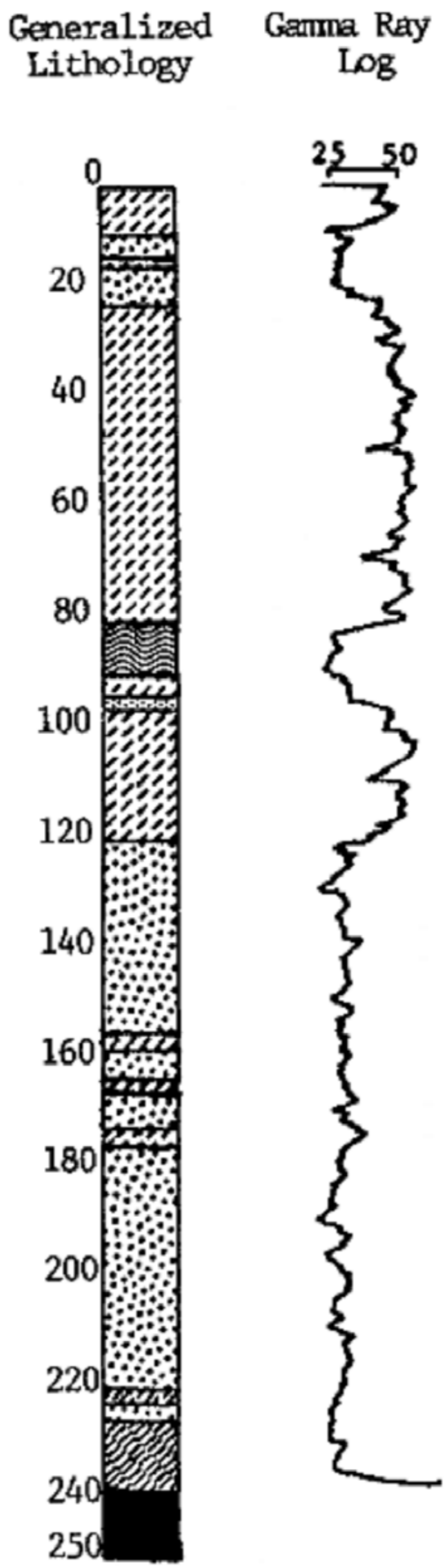
Driller's Log	Interval
Black dirt and gray clay	0-20
Red, med. sand and gravel	20-25
Gray clay	25-41
Gray med. gravel and broken stone	41-52
Gray clay with some gravel	52-97
Gray clay	97-100
Fine silty sand	100-137
Gray clay	137-142
Fine to med. sand & gravel	142-255
Sandy gravel with some broken stone	255-303
Blue gray stone	303-310

I.D.N.R. Test hole #3A – Pine Village site; SE¼ of NE¼, Section 4, T. 23 N., R. 7 W., Adams Township, Warren County. Elevation: 693 feet. Total depth is 287 feet. Drilled by Ortman Drilling, Inc., September 7, 1978.



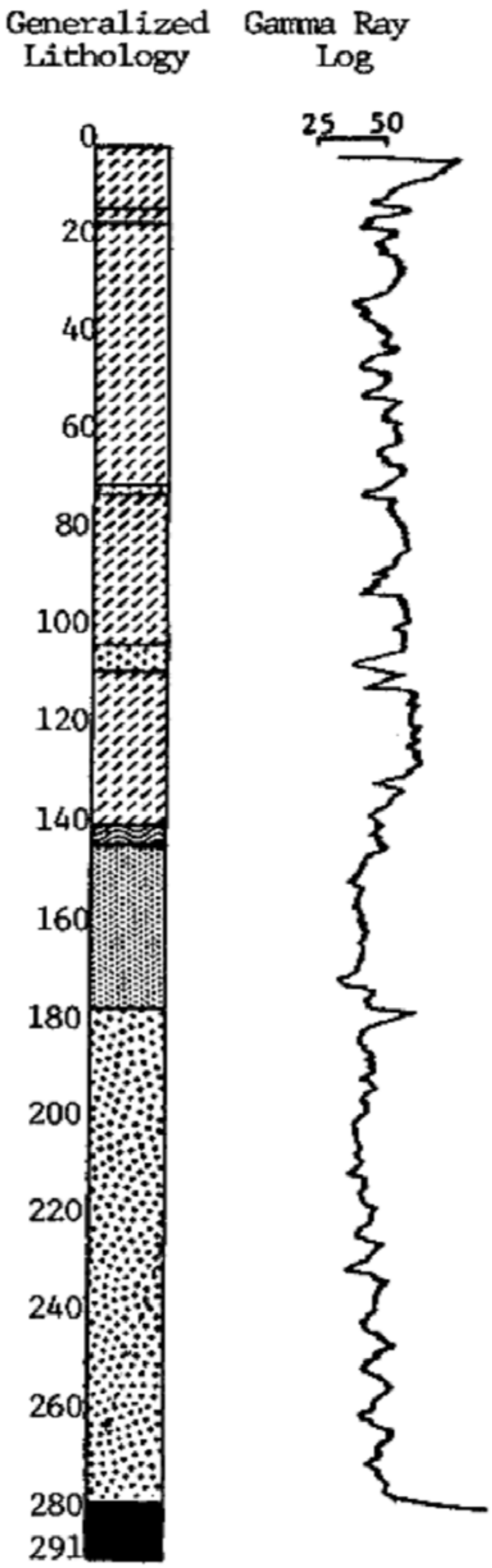
Driller's Log	Interval
Black dirt	0-2
Sandy yellow clay	2-12
Gray clay	12-22
Sand	22-24
Gray clay	24-33
Gray clay	33-40
Gray clay	40-49
Brown clay	49-51
Very fine silty sand	51-69
Brownish gray clay	69-82
Sand	82-83
Sticky gray clay	83-88
Gravelly silty gray clay	88-90
Gray clay	90-98
Silty brown gray clay	98-100
Brown silty with some sand	100-110
Sandy fine to med. brown gravel	110-120
Fine-med. sand	120-138
Med. to coarse sand and gravel	138-283
Yellow limestone	283-285
Gray limestone	285-287

I.D.N.R. Test hole #3b – Green Hill site; NW¼ of SW¼, Section 22, T. 23 N., R. 6 W., Shelby Township, Tippecanoe County. Elevation: 645 feet. Total depth is 250 feet. Drilled by Ortman Drilling, Inc., September 14, 1978.



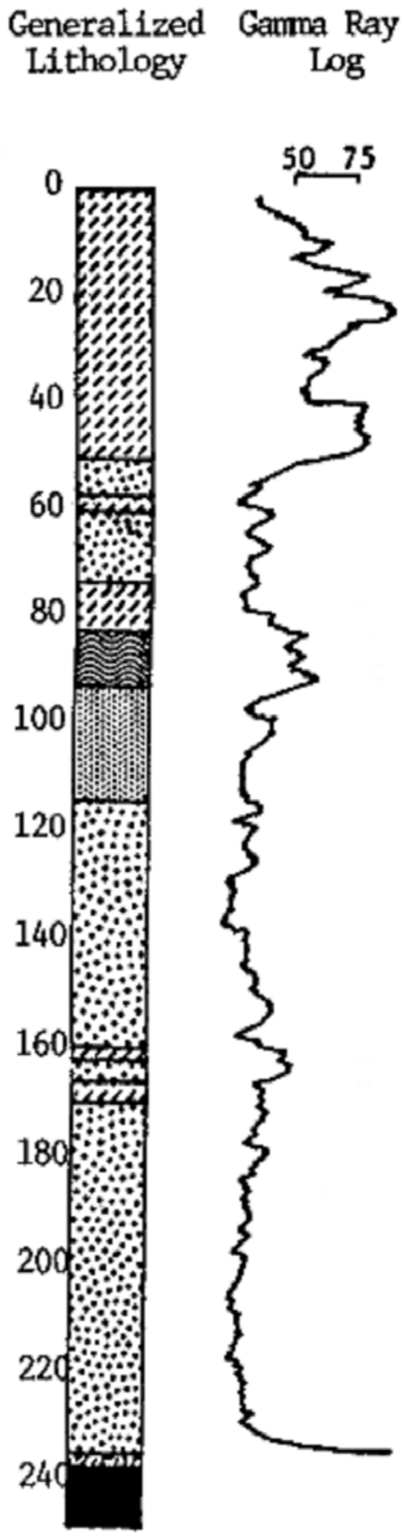
Driller's Log	Interval
Gravelly brown clay	0-5
Gray clay	5-9
Loose fine-med. sand and gravel	9-13
Sandy gray clay	13-15
Loose med. sand & gravel	15-22
Gray to brown clay	22-80
Silt	80-90
Very fine silty sand	90-95
Gray clay	95-117
Soft sandy brownish gray clay	117-127
Fine to med. sand	127-149
Sand fine to med. gravel	149-155
Sand and fine gravel with clay	155-165
Sand and fine to med. gravel	165-175
Sand and fine gravel with clay	175-200
Fine to med. gravel with sand	200-220
Dirty sand	220-228
Yellow fine-med. gravel and broken stone	228-238
Blue shale	238-250

I.D.N.R. Test hole #4 – West Lafayette site; SE¼ of NE¼ of Section 21, T. 23 N., R. 5 W., Wabash Township, Tippecanoe County. Elevation: 682 feet. Total depth is 291 feet. Drilled by Ortman Drilling, Inc., September 7, 1978.



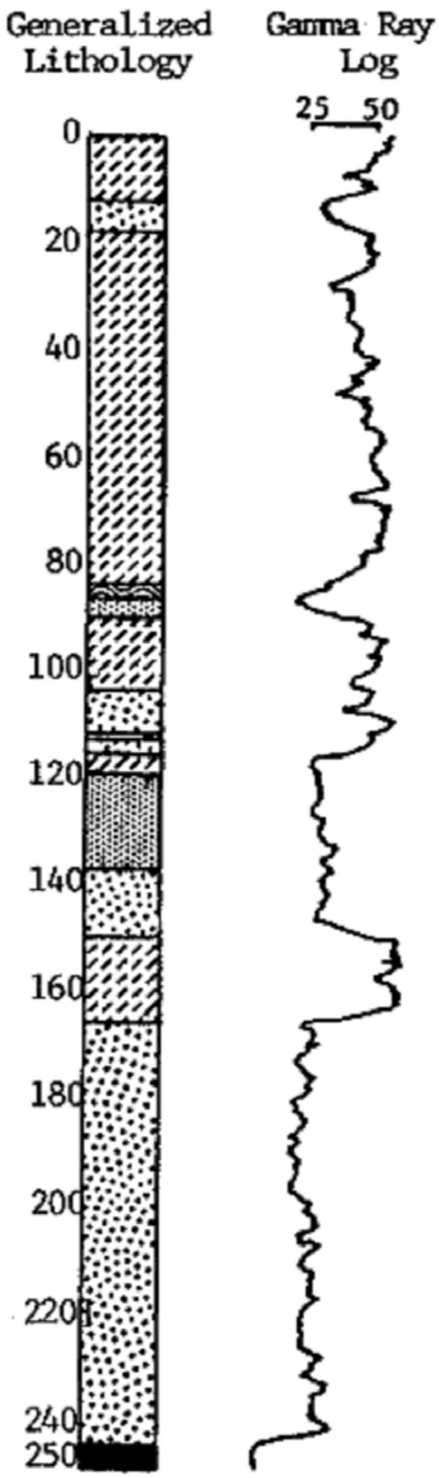
Driller's Log	Interval
Brown clay	0-5
Brown to gray clay, some sand	5-14
Sand and fine gravel	14-16
Gray clay with some boulders	16-43
Sandy gravelly clay	43-46
Sandy clay	46-71
Sand and gravel	71-72
Brownish gray clay	72-103
Very sandy fine yellow gravel	103-108
Brownish gray clay	108-140
Very fine silty sand	140-160
Fine to med. sand	160-177
Sandy, tight med. to coarse gravel	177-190
Cemented sand and fine gravel	190-264
Boulders and med. to coarse cemented gravel (sandy)	264-278
Soft blue shale	278-287
Hard bedrock	287-291

I.D.N.R. Test hole #5 – North Lafayette site; SE¼ of SE¼, Section 36, T. 24 N. R. 5 W., Wabash Township, Tippecanoe County. Elevation: 677 feet. Total depth is 240 feet. Drilled by Ortman Drilling, Inc., September 8, 1978.



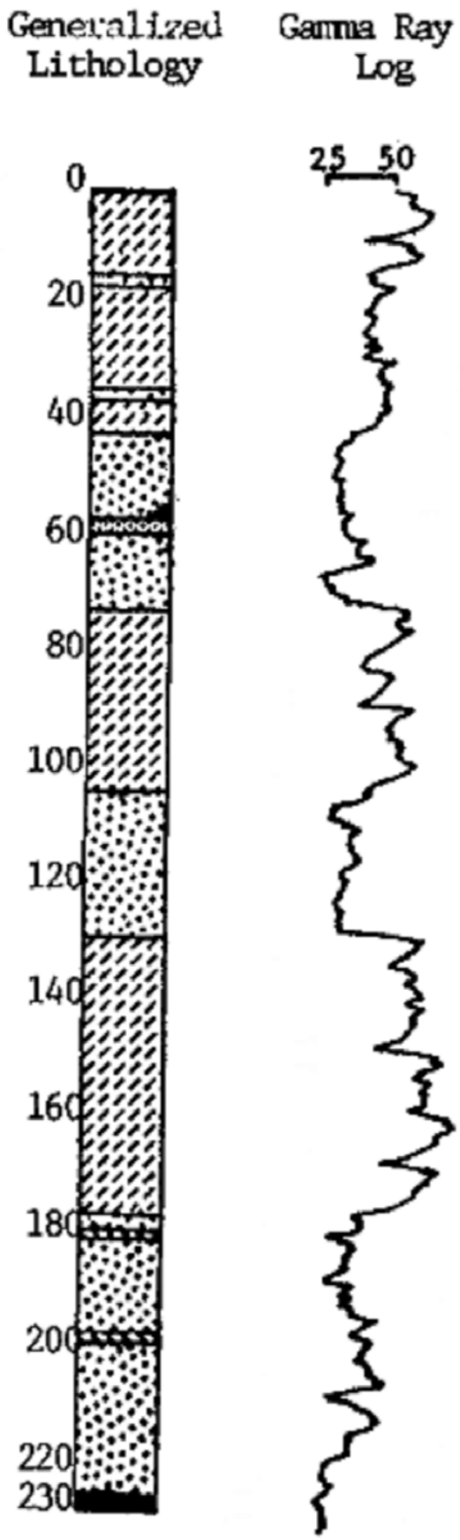
Driller's Log	Interval
Black dirt	0-2
Brown clay	2-8
Gray clay	8-51
Sandy fine to med. gravel	51-57
Gravelly gray clay	57-60
Sandy fine to med. gravel	60-78
Gray clay	78-94
Very fine to fine brown silty sand	94-116
Brown sandy fine gravel	116-117
Brown sand	127-147
Brown sandy fine-med. gravel	147-152
Gray sandy fine gravel	152-160
Gravelly greenish to gray clay	160-175
Gray sandy fine gravel	175-185
Med. to coarse gravel, sand some cementing	185-235
Pink clay	235-236
Brown shale	236-240

I.D.N.R. Test hole #6 – Battleground site; SE¼ of SE¼, Section 35, T. 25 N., R. 4 W., Prairie Township, White County. Elevation: 668 feet. Total depth is 250 feet. Drilled by Ortman Drilling, Inc., September 13, 1978.



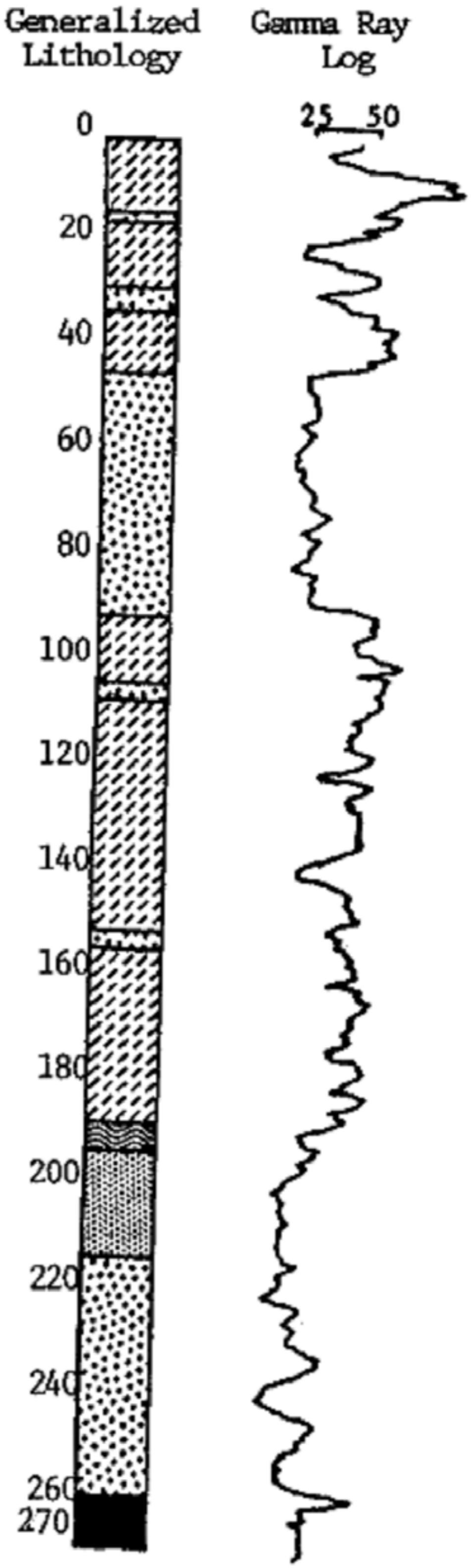
Driller's Log	Interval
Black dirt and yellow clay	0-7
Greenish-brown to gray clay	7-12
Brown to gray sand and gravel	12-18
Gritty gray clay	18-64
Pink clay	64-85
Dirty fine sand	85-90
Gray clay	90-112
Gray clay with layers of sand and gravel	112-117
Fine-very fine sand	117-130
Very sandy fine gravel	130-150
Silty gritty gray clay	150-167
Fine brown sand	167-178
Brown fine to medium sand	178-198
Medium to coarse gravel and broken stone	198-245
White limestone	245-250

I.D.N.R. Test hole #7 – Yeoman site; SW¼ of SE¼, Section 34, T. 26 N., R. 3 W., Tippecanoe Township, Carroll County. Elevation: 660 feet. Total depth is 230 feet. Drilled by Ortman Drilling, Inc., September 13, 1978.



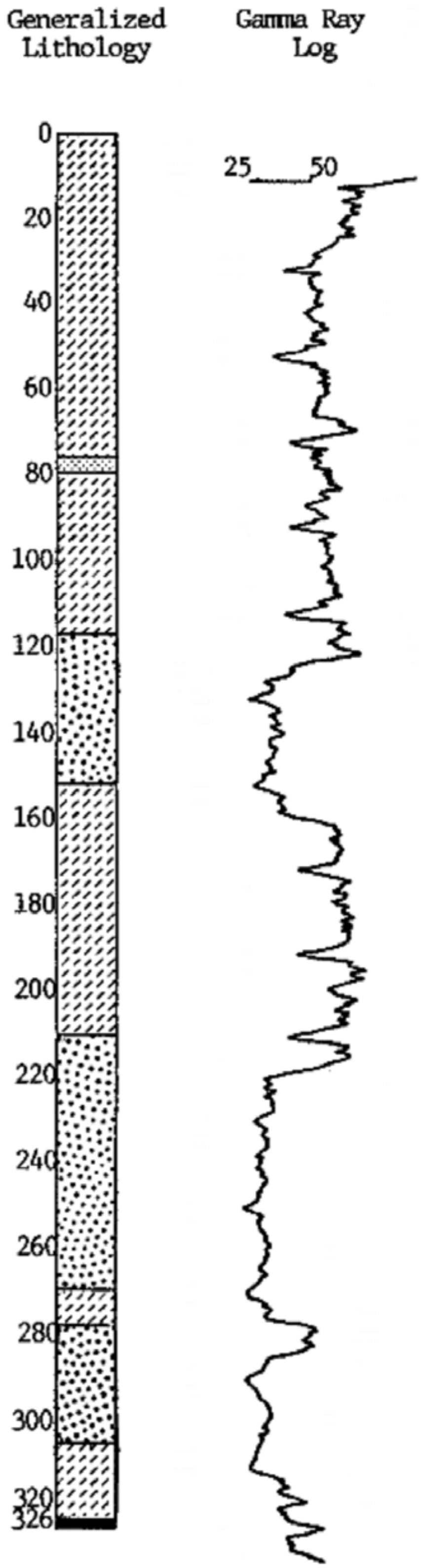
Driller's Log	Interval
Yellow clay	0-10
Gray clay	10-15
Sandy gravel	15-16
Sandy gray clay	16-34
Sand	34-35
Sandy gray clay	35-42
Very sandy fine gravel	42-60
Soft gray clay	60-66
Fine to med. sand	66-72
Slightly gritty gray clay	72-80
Thin alternating gray clay and sand	80-83
Slightly gritty gray clay	83-104
Sand	104-115
Sandy fine to med. gravel	115-130
Slightly gritty gray clay	130-177
Sand and gravel	177-179
Clay	179-180
Coarse-vcrs. gravel with broken stone	180-195
Clay streaks & gravel	195-202
Med.-vcrs. gravel and broken stone	202-225
White limestone	225-230

I.D.N.R. Test hole #8 – Burnettsville site; NW¼ of NE¼, Section 36, T. 27 N., R. 2 W., Jackson Township, White County. Elevation: 698 feet. Total depth is 270 feet. Drilled by Ortman Drilling, Inc., September 12, 1978.



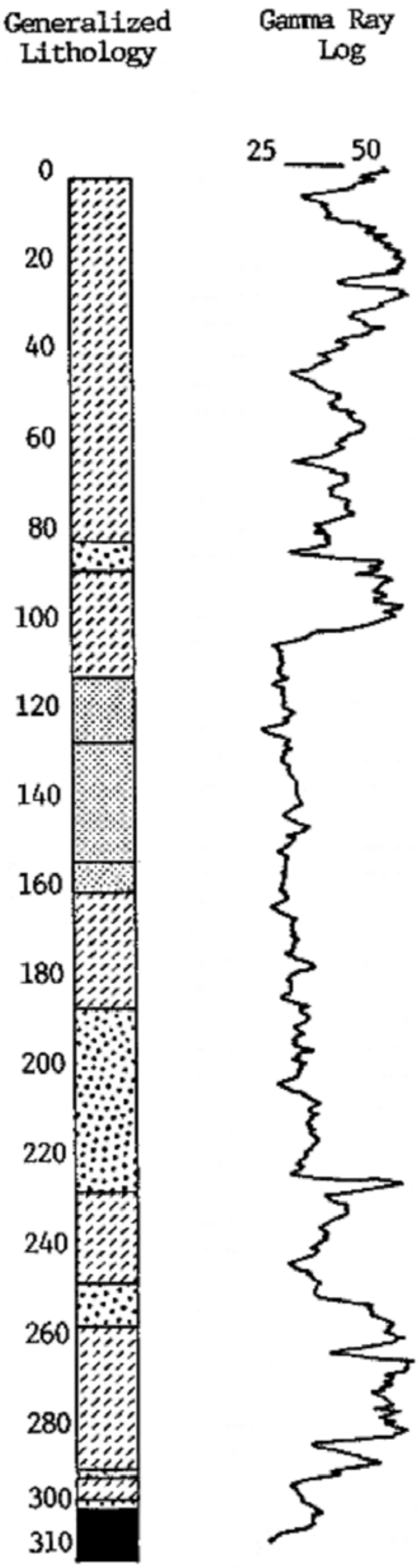
Driller's Log	Interval
Dark brown muck	0-5
Sandy gray gravel and clay	5-15
Greenish brown gravelly clay	15-20
Sandy clay with gravel	20-26
Sandy gray clay	26-30
Sandy gravel	30-33
Gray clay	33-44
Sandy fine to med. loose gravel	44-85
Sandy fine gravel	85-92
Gray clay with sand streaks	92-114
Pink-brown clay	114-129
Sand & fine gravel	129-130
Brownish gray clay, some sand	130-153
Sandy fine gravel	153-155
Brownish gray clay	155-159
Sandy gravel	159-160
Gritty brownish gray clay, some sand and gravel	160-190
Sandy silt - fine	190-210
Sandy fine gravel	210-215
Med. to very coarse gravel	215-232
Brown soft clay	232-237
Very coarse gravel and broken stone	237-260
Blue-gray limestone	260-270

I.D.N.R. Test hole #9 – Peru Airport site; SW¼ of NW¼, Section 13, T. 27 N., R. 3 E., Jefferson Township, Miami County. Elevation: 770 feet. Total depth is 326 feet. Drilled by Ortman Drilling, Inc., October 16, 1978.



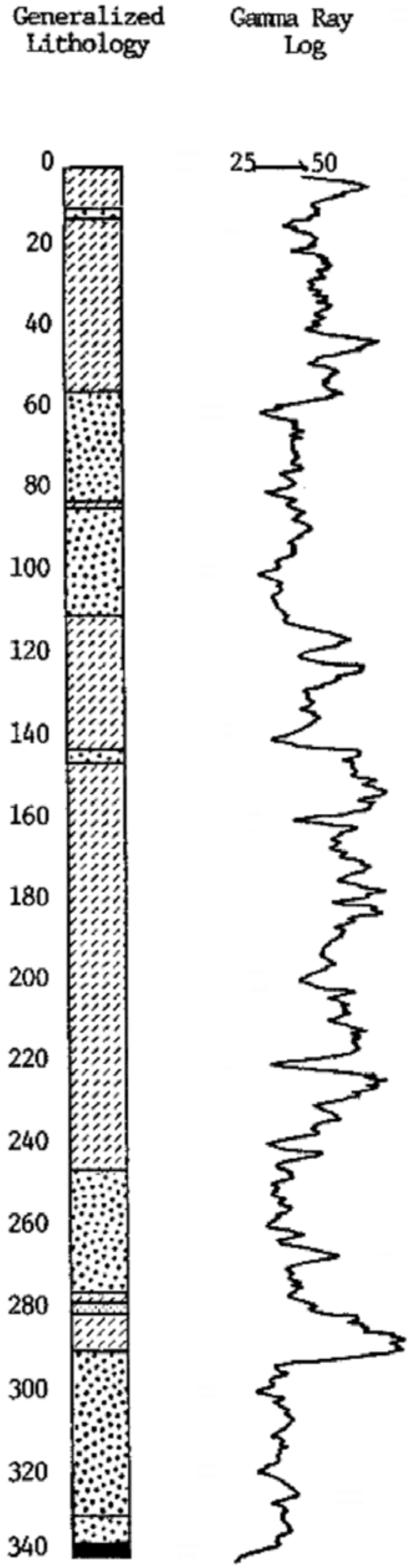
Driller's Log	Interval
Brown clay	0-9
Gray clay	9-19
Brown clay	19-25
Gray clay	25-40
Gravelly clay	40-43
Gray clay	43-77
Fine gray sand	77-80
Gray clay	80-115
Clay and gravel	115-117
Tight angular gravel with broken stone	117-123
Sandy fine-med. gravel	123-153
Slightly gritty gray clay	153-212
Tight fine-med. gravel and broken stone	212-240
Gravel with clay stringers	240-248
Sandy fine-med. gravel with broken stone	248-270
Reddish brown smooth clay	270-278
Cemented sand and gravel	278-305
Sandy brown clay	305-324
Blue gray limestone	324-326

I.D.N.R. Test hole #9A – Richvalley site; NW¼ of SE¼, Section 30, T. 27 n., R. 6 E., Noble Township, Wabash County. Elevation: 770 feet. Total depth is 310 feet. Drilled by Ortman Drilling, Inc., October 17, 1978.



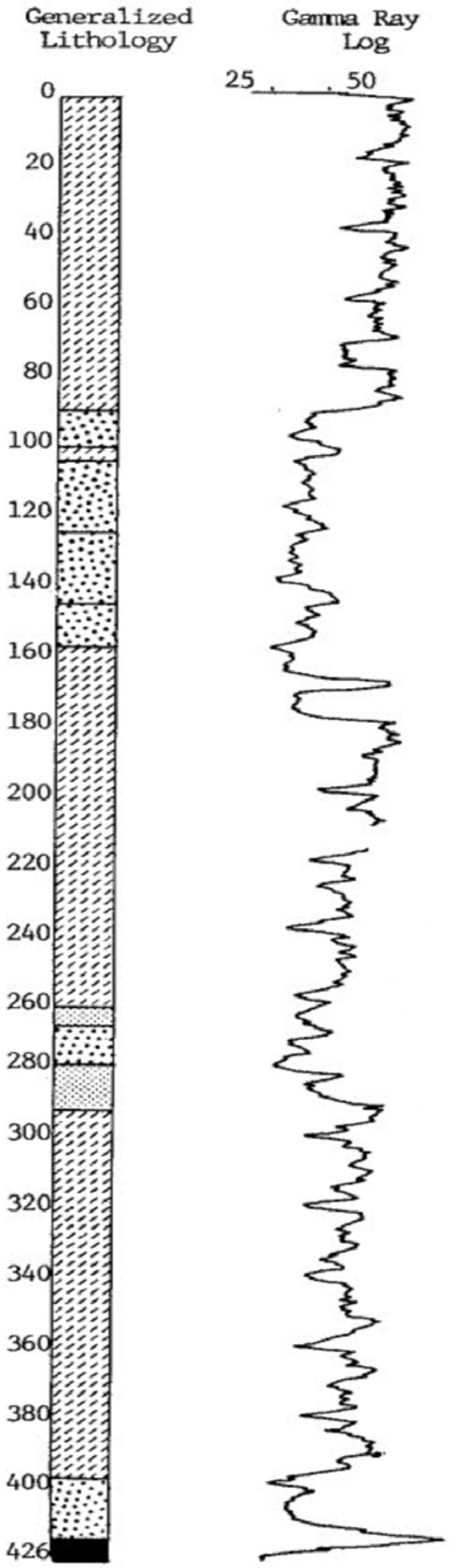
Driller's Log	Interval
Yellowish brown sandy clay	0-14
Sticky gray clay	14-34
Sandy brown clay	34-48
Sandy gray clay, some gravel streaks	48-82
Sandy fine-med. gravel -clay	82-88
Smooth brown clay	88-106
Gritty brown clay	106-112
Cemented sand	112-127
Fine gravel, brown silty sand, red-brown clay	127-153
Fine-med. sandy gravel broken stone	153-160
Layers red-brown clay and sand	160-187
Sandy fine-med. gravel broken stone	187-228
Red-brown clay streaks gravel & broken stone	228-248
Sandy fine-med. gravel, clay	248-258
Red brown clay	258-289
Sand and gravel	289-290
Red-brown clay streaks gravel & broken stone	290-297
Blue-gray limestone	297-308
White limestone	308-310

I.D.N.R. Test hole #10 – Treaty site; SE¼ of SE¼, Section 18, T. 26 N., R. 7 E., Liberty Township, Wabash County. Elevation: 805 feet. Total depth is 340 feet. Drilled by Ortman Drilling, Inc., October 18, 1978.



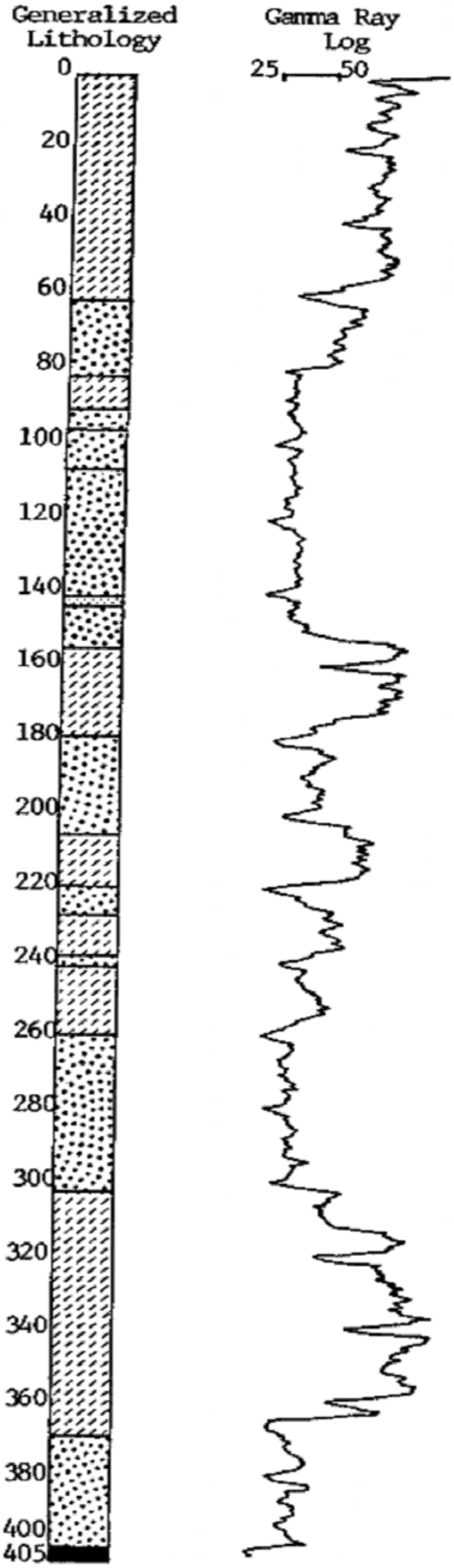
Driller's Log	Interval
Yellow clay	0-11
Brown silty clay-med. gravel	11-13
Sandy gritty gray clay	13-55
Dirty fine sand and fine-med. gravel	55-83
Sandy gray clay	83-85
Sandy fine gravel	85-87
Sandy fine-med. gravel	87-95
Coarse sand with clay stringers	95-105
Sandy fine gravel	105-111
Red-brown clay	111-114
Gray clay, layers silt and sand	114-149
Red-brown soft sticky clay	149-197
Red-brown clay, layers sand	197-219
Limestone boulder, gray	219-221
Brown clay with rocks and gravel	221-245
Fine-med. gravel with broken stone	245-265
Brown clay	265-267
Cemented fine sand, gravel, clay	267-278
Grayish-brown silty gray clay	278-291
Cemented fine med. gravel, sand, stone	291-334
Sand and gravel	334-336
Blue gray stone	336-340

I.D.N.R. Test hole #11 – LaFontaine site; NE¼ of NW¼, Section 8, T. 25 N., R. 8 E., Washington Township, Grant County. Elevation: 885 feet. Total depth is 426 feet. Drilled by Ortman Drilling, Inc. October 13, 1978.



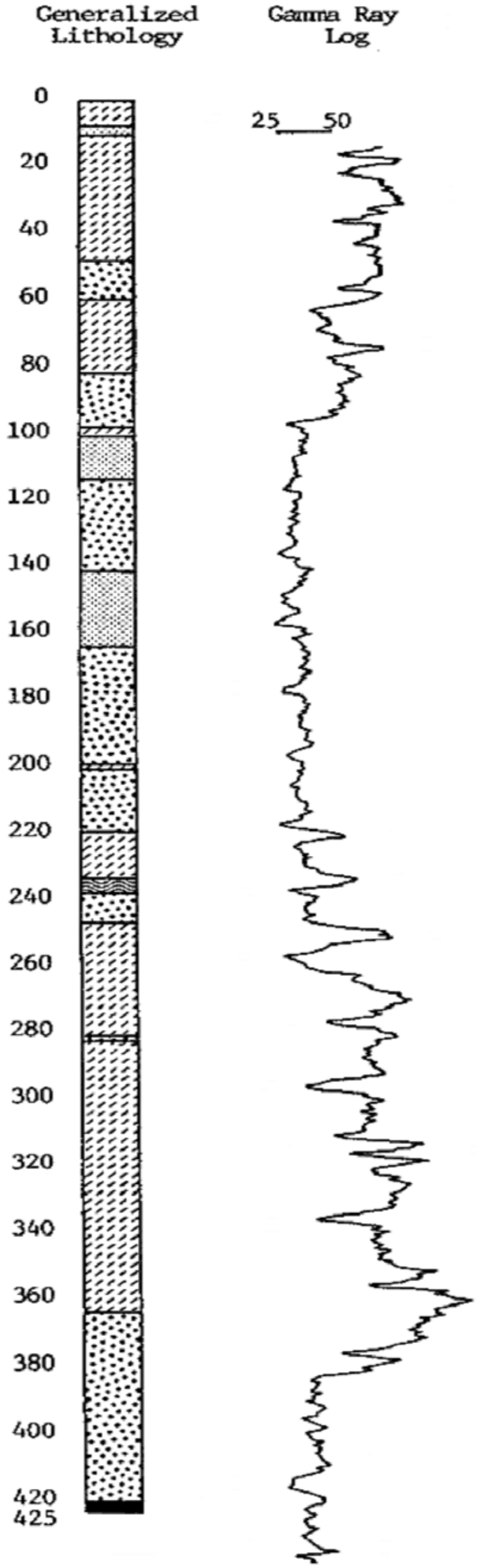
Driller's Log	Interval
Brown clay	0-15
Gray clay	15-90
Sandy silty brown gravel	90-101
Sandy brown clay	101-104
Broken stone and gravel with clay stringers	104-110
Sandy brown fine to med. gravel	110-144
Gray clay	144-145
Gray sandy gravel and broken stone	145-157
Soft gray clay with layers gravel	157-168
Sticky gray clay	168-170
Very fine and	170-179
Gray clay-smooth, sticky	179-204
Gray clay	204-223
Gravel	223-227
Gray silty clay	227-241
Gray clay	241-262
Sandy fine to med. gravel	262-269
Brown clay	269-270
Tight gravel and broken stone	270-277
Loose fine-med. sand and gravel	277-290
Soft red-brown smooth clay	290-353
Brown clay and sand	353-374
Brown clay with sand streaks	374-395
Fine sand and gravel	395-413
Blue gray shale	413-418
Gray limestone	418-426

I.D.N.R. Test hole #12 – Van Buren site; NE¼ of NE¼, Section 36, T. 25 N., R. 8 E., Washington Township, Grant County. Elevation: 860 feet. Total depth is 405 feet. Drilled by Ortman Drilling, Inc., October 12, 1978.



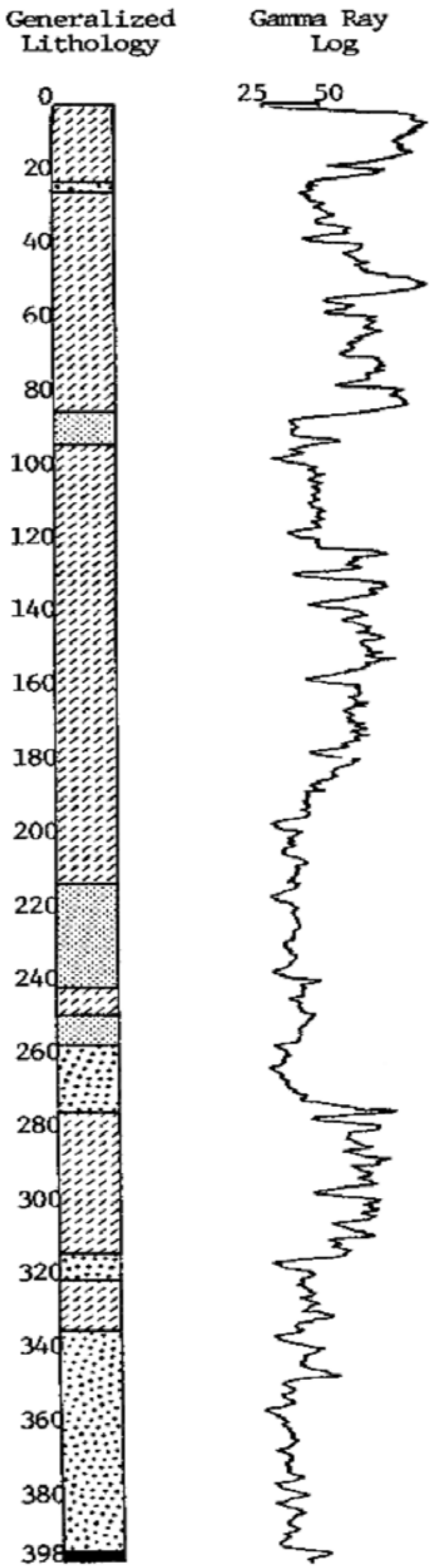
Driller's Log	Interval
Brown clay	0-10
Gray clay	10-57
Dirty sand & gravel	57-62
Sandy med. gravel	62-81
Gritty silty gray clay	81-85
Gritty silty sand-some gravel	85-105
Sandy fine to med. gravel	105-156
Brown smooth clay	156-176
Sandy silt	176-180
Very sandy fine to med. gravel	180-206
Gritty red-brown clay	206-221
Sandy fine-med. angular gravel	221-228
Soft reddish-brown clay	228-239
Sand and gravel	239-241
Gritty soft red-brown clay-some sand and gravel	241-260
Tight angular sand, gravel & broken stone	260-303
Brown clay	303-305
Gray clay	305-370
Fine gravel & sand	370-400
Blue gray shale	400-405

I.D.N.R. Test hole #13 – Hartford City site; SW¼ of SW¼, Section 25, T. 24 N., R. 10 E., Washington Township, Blackford County. Elevation: 885 feet. Total depth is 425 feet. Drilled by Ortman Drilling, Inc., October 11, 1978.



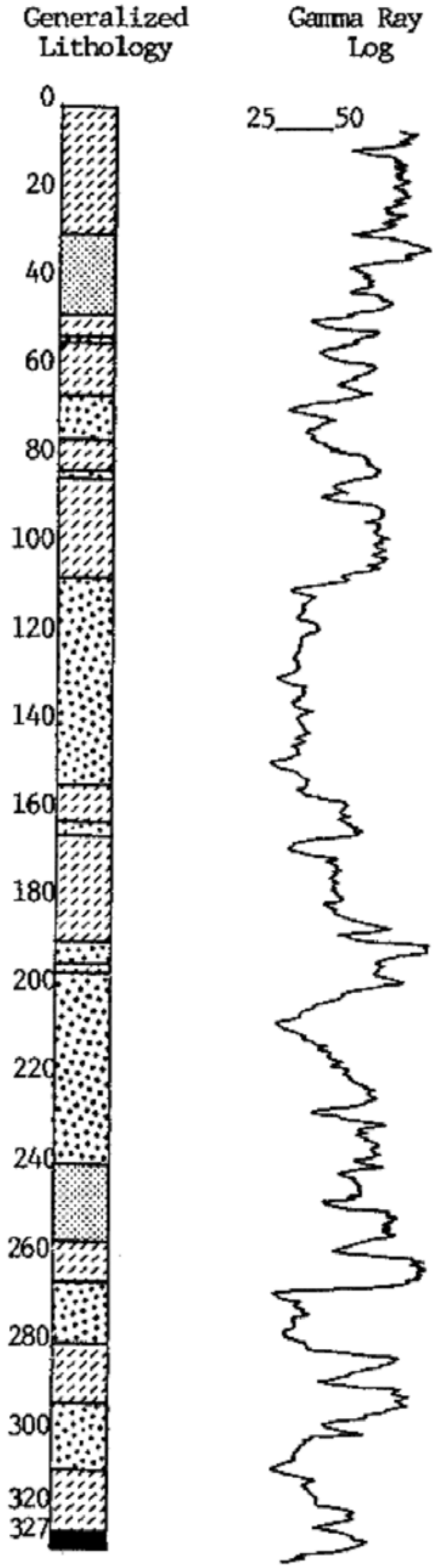
Driller's Log	Interva.
Top soil and dark gray clay	0-4
Greenish gray clay	4-8
Dirty med. coarse sand	8-11
Brownish gray-gray clay	11-49
Sandy fine gravel with clay stringers	49-59
Silty sandy brown gray clay	59-82
Sandy fine-med. gravel	82-90
Sand and gravel with clay stringers	90-98
Silty clay	98-101
Sand and fine-med. gravel	101-200
Clay	200-202
Sandy fine gravel with clay stringers	202-207
Coarse sand and med. gravel, angular	207-220
Red silty clay	220-235
Brown gritty clay	235-239
Sand and gravel	239-248
Reddish brown clay with sand and gravel streaks	248-253
Reddish brown smooth clay	253-282
Sand, gravel & boulders	282-284
Gray brown silty clay	284-312
Brown sticky clay	312-368
Coarse sand and fine to med. gravel	368-422
Limey light green shale	422-425

I.D.N.R. Test hole #14 – Domestic site; NW¼ of SW¼, Section 8, T. 24 N., R. 13 E., Jackson Township, Jay County. Elevation: 870 feet. Total depth is 398 feet. Drilled by Ortman Drilling, Inc. October 9, 1978.



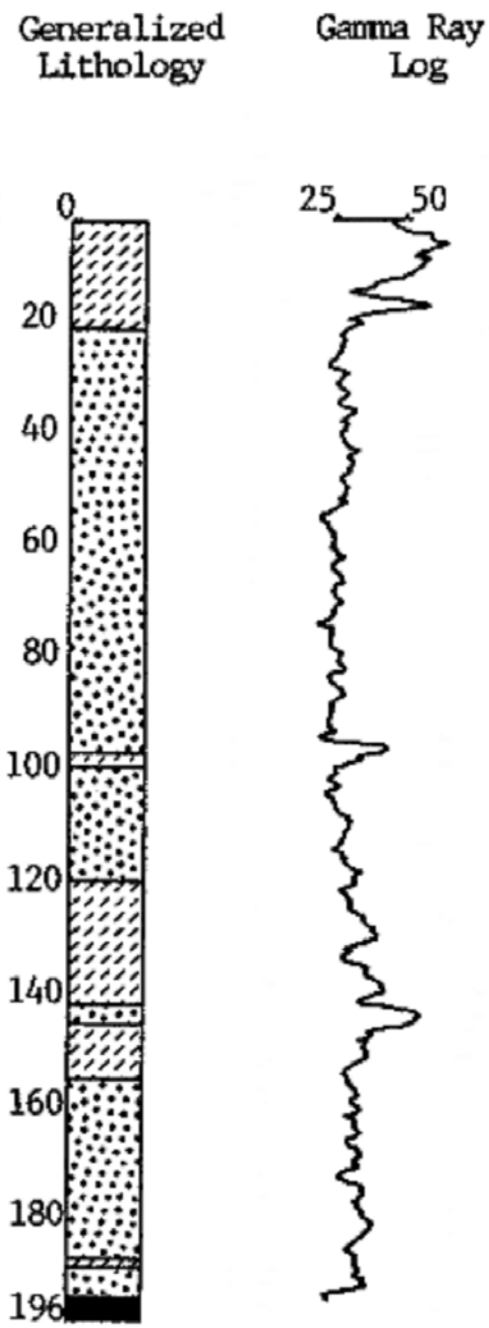
Driller's Log	Interval
Sandy yellowish clay	0-5
Brown to gray clay	5-18
Gray clay	18-19
Sandy silt	19-21
Fine silty sand and gravel	21-24
Silty clay	24-29
Gray clay	29-51
Gray clay	51-60
Gray clay	60-83
Fine silty sand	83-92
Alternate layers clay and sand	92-94
Very gritty gray clay	94-112
Brownish gritty clay	112-117
Very sandy gray clay	117-122
Gray gritty clay	122-129
Very sticky gray clay, some silt	129-212
Silty fine sand	212-220
Fine sand, some gravel and silt	220-240
Fine sand with clay stringers	240-248
Sandy gravel	248-274
Very silty brown clay	274-313
Med. gravel and broken stone, tight	313-320
Fine-med. gravel and silty clay	320-333
Fine-med. gravel and broken stone	333-345
Med.-course gravel and broken stone	345-394
Blue-green limestone and shale, alternating layers	394-398

I.D.N.R. Test hole #15 – State line site; NW¼ of NE¼, Section 27, T. 26 N., R. 15 E., Blue Creek Township, Adams County. Elevation: 815 feet. Total depth is 327 feet. Drilled by Ortman Drilling, Inc., October 10, 1978.



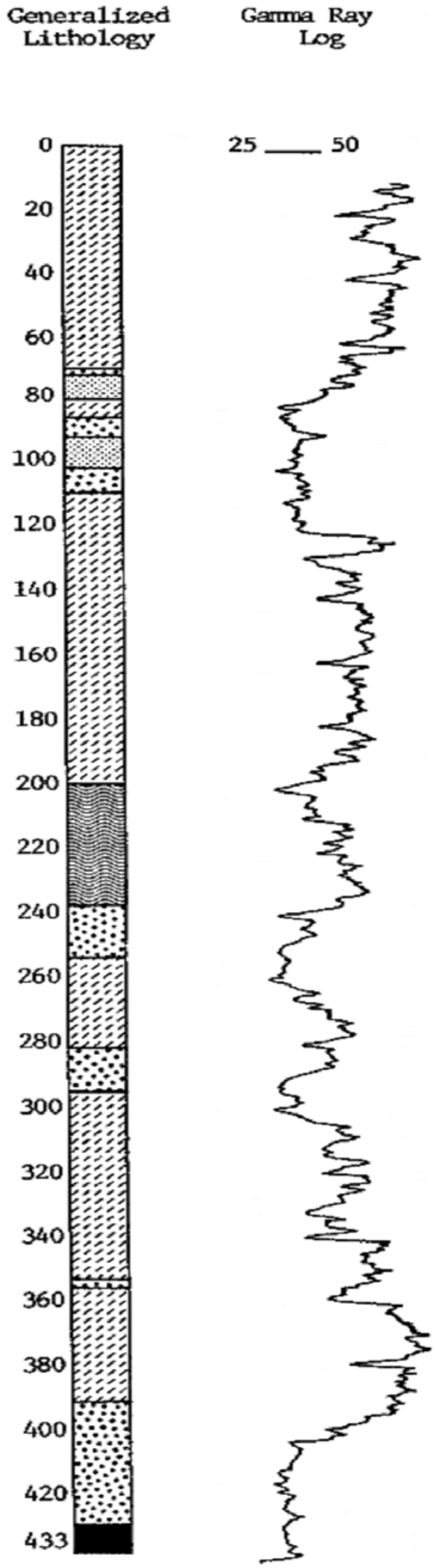
Driller's Log	Interval
Brown-brownish gray clay	0-10
Gray clay	10-30
Fine black and gray sand with gravel	30-47
Gray clay	47-53
Alternating gray clay with sand and gravel	53-76
Reddish brown clay	76-83
Coarse sand and fine gravel	83-85
Gritty reddish-brown clay	85-107
Very coarse gravel and broken stone	107-154
Sandy brown clay	154-163
Sand and gravel	163-166
Reddish to brown gritty clay	166-183
Gritty brown clay	183-190
Alternating clay, sand and gravel	190-195
Sticky brown clay	195-197
Fine sand and gravel	197-240
Silty sand	240-258
Brown sandy clay	258-263
Sticky brown clay	263-266
Sand and gravel	266-280
Brown clay	280-286
Sand and gravel	286-287
Brown clay	287-295
Sand and gravel	295-297
Fine sand and gravel	297-308
Laminated brownish gray clay	308-323
Limey shale	323-327

D.N.R. Test hole #16 – East Peru site; NE¼ of SW¼ of Section 19, T. 27 N., R. 5 E., Peru Township, Miami County. Elevation: 650 feet. Total depth is 196 feet. Drilled by Ortman Drilling, Inc. November 2, 1979.



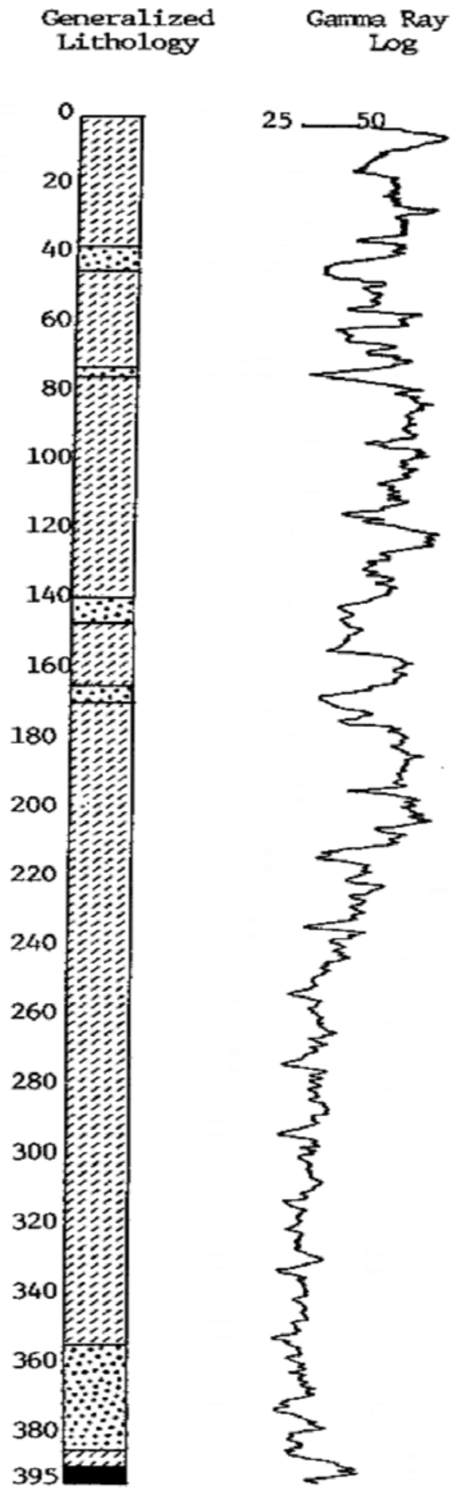
Driller's Log	Interval
Fill packed sand and gravel	0-2
Brown silt	2-8
Gray sand clay	8-11
Brown silty clay	11-18
Black-gray organic muck	18-19
Coarse gray sand & gravel	19-95
Reddish brown silty clay	95-98
Cemented sand & gravel	98-118
Gravelly brown clay	118-135
Gray-brown silty clay/ pebbles	135-140
Rocks and boulders	140-143
Gray silty gravelly clay	143-153
Coarse-med. sand and gravel	153-186
Coarse sand and gravel some clay	186-193
Hard gray limestone	193-196

I.D.N.R. Test hole #17 – Roll site; NE¼ of NE¼, Section 13, T. 24 N., R. 9 E., Monroe Township, Grant County. Elevation: 900 feet. Total depth is 433 feet. Drilled by Ortman Drilling, Inc. November 7, 1979.



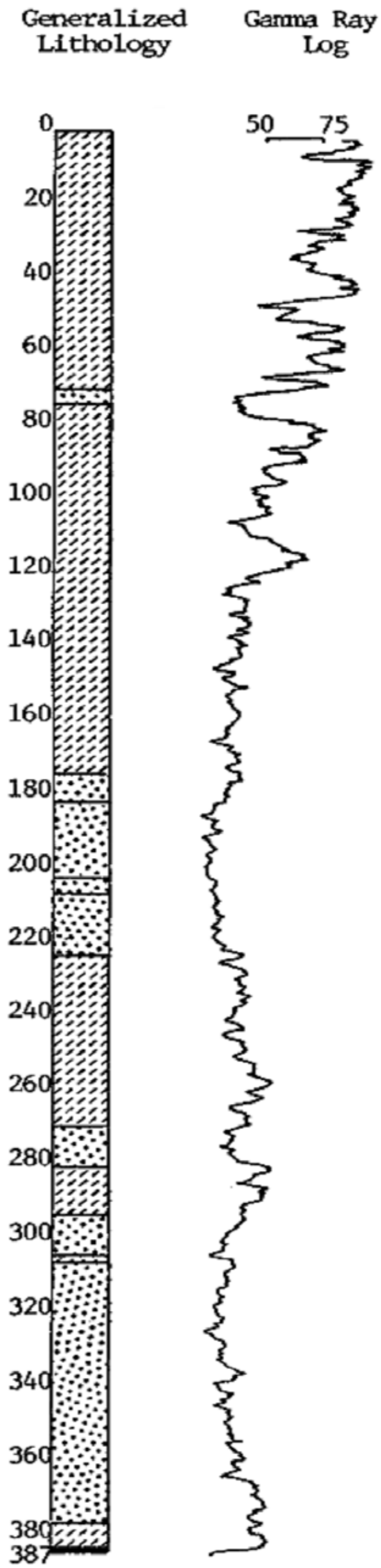
Driller's Log	Interval
Brown silty clay	0-5
Brown clay	5-11
Brownish-gray clay	11-38
Greenish-gray clay	38-40
Brownish gray-gray gritty clay	40-71
Clay and gravel	71-83
Silty fine sand, some gravel	83-103
Sand and gravel	103-110
Gray clay with some pebbles	110-121
Greenish brown-gray silty clay	121-133
Reddish brown clay	133-183
Soft gray clay	183-199
Reddish-brown gravelly clay, sand	199-238
Med. sand and gravel	238-254
Gray clay	254-255
Coarse sand & gravel	255-258
Alternate layers of brown clay, sand and gravel	258-295
Brownish gray clay	295-300
Reddish-brown clay	300-306
Brownish gray clay, some grit	306-322
Layers brown clay with sand & gravel	322-331
Brownish gray clay	331-347
Gritty gray clay	347-354
Sand & fine gravel	354-357
Gray-brownish gray clay	357-392
Fine-med. gravel, some sand	392-430
Blue gray shale & limestone	430-433

I.D.N.R. Test hole #18 – Pennville site; SE¼ of NE¼, Section 19, T. 24 N., R. 9 E., Harrison Township, Blackford County. Elevation: 855. Total depth is 395 feet. Drilled by Ortman Drilling, Inc. November 6, 1979.



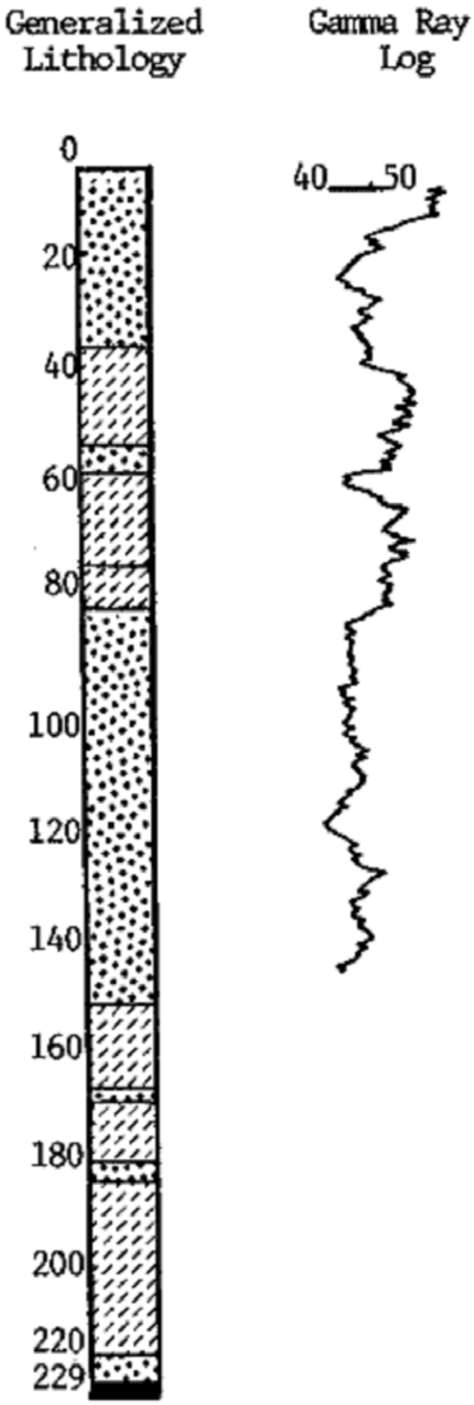
Driller's Log	Interval
Brown clay	0-7
Gravelly brown clay	7-10
Dirty red-gray sand and gravel	10-13
Gray clay	13-39
Fine-med. sand and gravel	39-46
Silty to sandy gray brown-gray clay	46-64
Brownish gray-gray clay with sand and gravel zones	64-140
Tight sand & gravel	140-147
Gray silty clay with sand and gravel layers	147-165
Fine med. tight angular gravel with shale chips	165-170
Sticky gray clay	170-206
Gray clay with thin sand and gravel layers	206-210
Sticky gray clay, some thin sand and gravel layers	210-351
Cemented sand and fine gravel	351-363
Gravelly gray clay	363-371
Cemented sand & fine gravel	371-380
Loose sand and fine gravel	380-384
Cemented sand and fine gravel	384-388
Gray clay with some pebbles	388-390
Alternate layers blue shale and blue-gray limestone	390-395

I.D.N.R. Test hole #19 – Berne site; SW¼ of SW¼, Section 10, T. 25 N., R. 14 E., Wabash Township, Adams County. Elevation: 840 feet. Total depth is 387 feet. Drilled by Ortman Drilling, Inc., November 5, 1979.



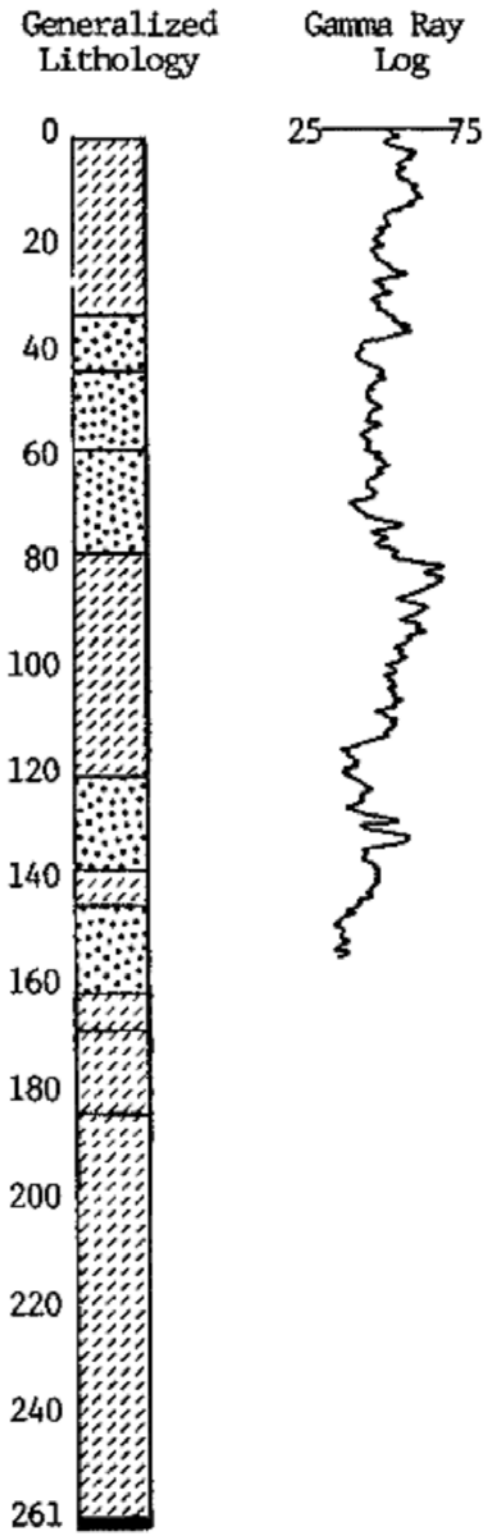
Driller's Log	Interval
Brown clay	0-14
Sticky gritty gray clay	14-43
Brownish gray-gray sandy clay	43-71
Silty fine sand	71-75
Silty brownish gray-gray clay	75-96
Silty gray clay	96-135
Sandy gravelly clay	135-175
Med.-coarse-very coarse gravel & boulders	175-224
Silty fine-med. sand with clay stringers	224-28
Reddish brown silt	282-295
Med. gravel	295-306
Gray silty clay	306-308
Med. tight gravel, some sand	308-378
Med. tight gravel, some silt	378-385
Alternate layers of blue-gray limestone	385-387

U.S.G.S. Logansport Test hole #86 – Twelve Mile site; NW¼ of NW¼, Section 7, T. 27 N., R. 3 E., Adams Township, Cass County. Elevation: 669 feet. Total depth is 229 feet. Drilled by Ortman Drilling, Inc., August 9, 1977.



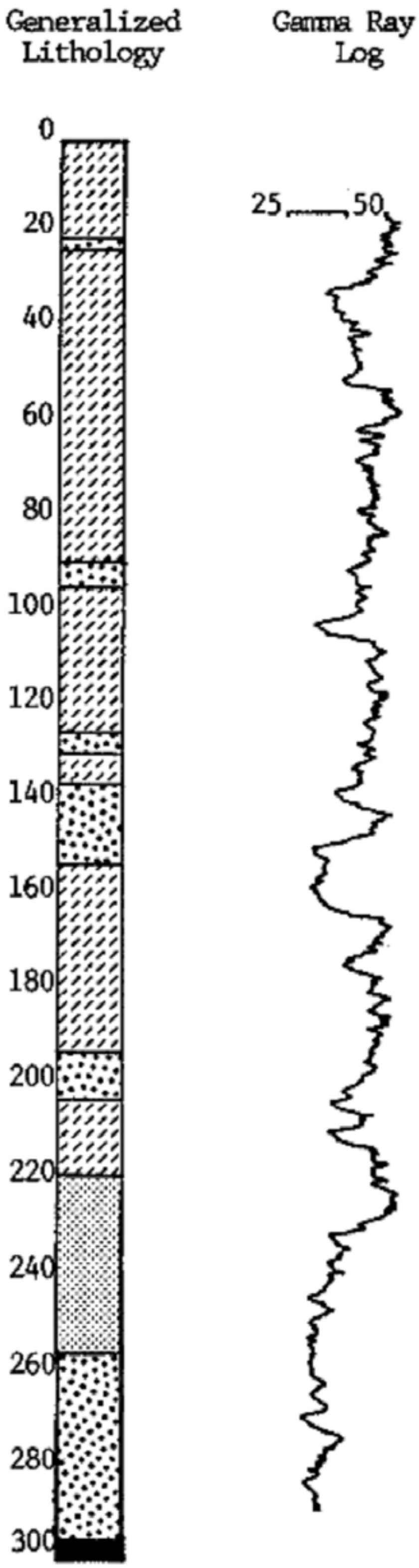
Driller's Log	Interval
Dirt	0-2
Sand and Gravel	2-32
Gray clay	32-52
Sand and Gravel	52-57
Brown clay	57-83
Very coarse gravel	83-126
Light gray clay	126-127
Med. sand and gravel	127-157
Brown clay	157-173
Sand and gravel	173-175
Sand, gravel & clay	175-186
Sand and gravel	186-190
Sand and gravel (60-70% gray clay)	190-222
Soft stone	222-227
Blue limestone	227-229

U.S.G.S. Logansport Test hole #92 – Logansport site; County Road 315 N.; SE¼ of SE¼, Section 3, T. 27 N., R. 2 E., Clay Township, Cass County. Elevation: 708 feet. Total depth is 265. Drilled by Ortman Drilling, Inc., August 11, 1977.



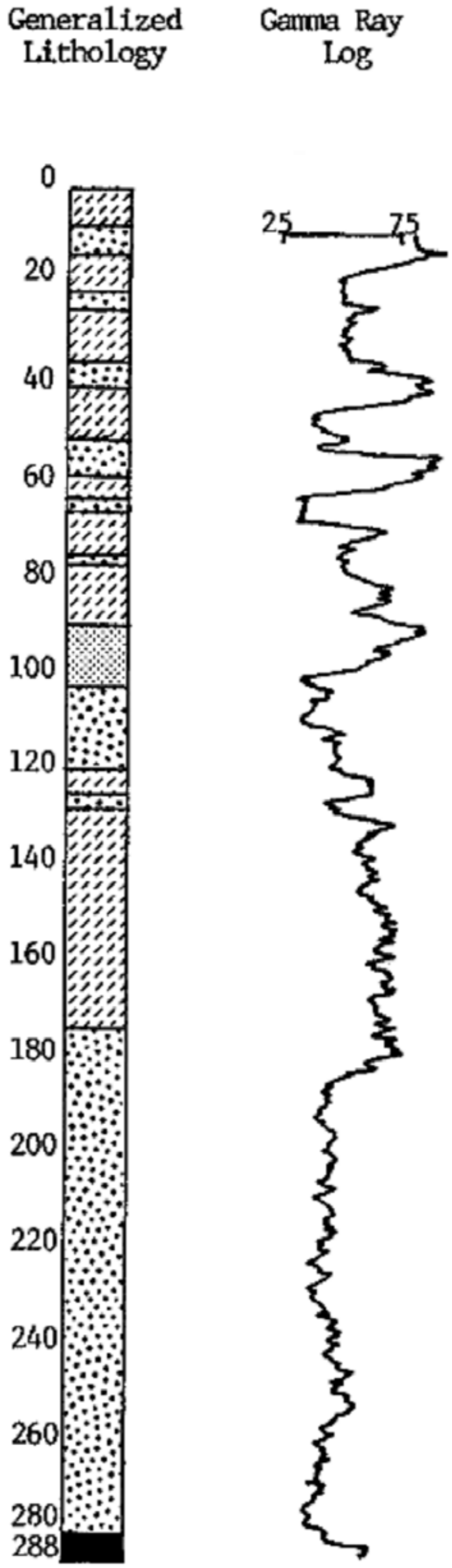
Driller's Log	Interval
Brownish gray clay	0-15
Soft gray clay	15-22
Gray clay	22-35
Med.-crs. sand & gravel	35-80
Gray brown clay	80-122
Sand and gravel-loose	122-135
Tight crs. sand and gravel	135-140
Clay	140-146
Med.-crs. sand and gravel	146-163
Light gray sand clay	163-170
Red clay	170-210
Sand, gravel & clay	210-225
Red clay	225-235
Sand, gravel, red clay and rocks	235-261
Blue limestone	261-

U.S.G.S. Logansport Test hole #94 – Logansport site; County Road 275 E.; NE¼ of SE¼, Section 5, T. 27 N., R. 2 E., Clay Township, Cass County. Elevation: 740 feet. Total depth is 300 feet. Drilled by Ortman Drilling, Inc., September 17, 1979.



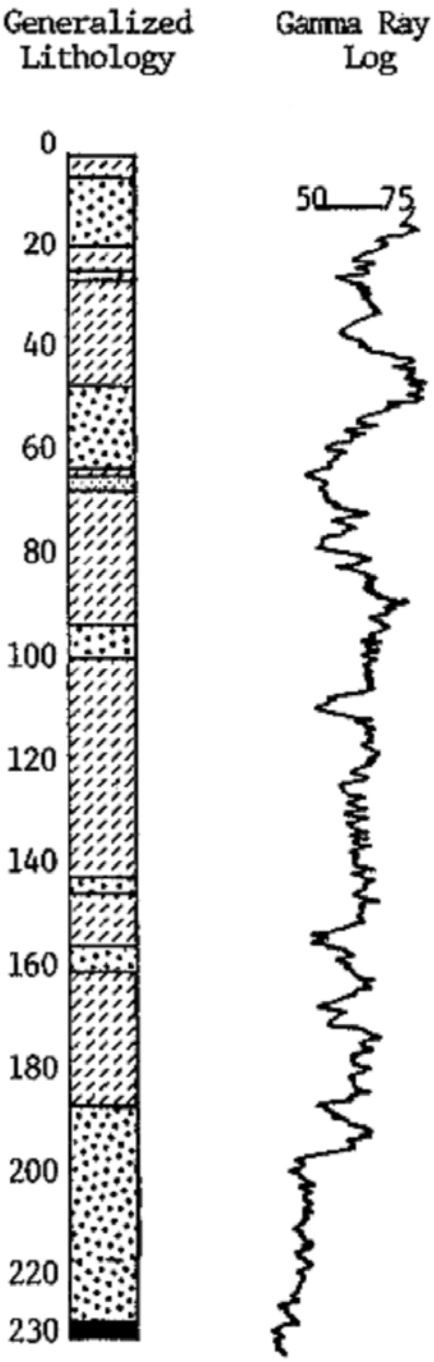
Driller's Log	Interval
Brown clay	0-14
Gray clay	14-21
Fine-med. gravel	21-23
Sandy gray clay	23-38
Sand and gravel	38-39
Med. gray clay "sticky"	39-51
Gray clay mixed with sand and gravel	51-63
Sandy gray clay-gritty	63-89
Fine-med. gravel	89-94
Greenish brown clay	94-97
Sandy med. gray clay	97-126
Sand-fine med. gravel	126-130
Gritty med. gray clay	130-136
Fine-med. gravel	136-153
Gritty light gray clay	153-163
Fine gravel with clay stringers	163-166
Gritty light gray clay	166-169
Fine gravel	169-170
Gritty brown clay	170-189
Fine gravel with clay stringers	189-193
Sand, fine gravel	193-196
Greenish brown clay	196-197
Fine-med. gravel	197-203
Gritty brown clay	203-219
Fine-med. silty sand	219-257
Limestone boulder	257-258
Broken stone-med. to coarse	258-296
Lt. brown limestone with putty stone	296-300

U.S.G.S. Logansport Test hole #101 – Lake Cicott site; SW¼ of SE¼, Section 15, T. 27 N., R. 1 W., Jefferson Township, Cass County. Elevation: 717 feet. Total depth is 288 feet. Drilled by Ortman Drilling, Inc., November 24, 1976.



Driller's Log	Interval
Black dirt	0-1
Brown clay	1-8
Med. sand and gravel (clean)	8-14
Gray clay	14-22
Med. gravel & sand	22-26
Gray clay	26-38
Med. coarse sand and gravel	38-42
Olive clay	42-47
Blue clay - smooth	47-53
Fine gravel (very sandy)	53-61
Smooth gray clay	61-65
Fine gravel & sand	65-68
Gritty gray clay	68-77
Med. to crs. gravel and sand	77-79
Gritty gray clay	79-91
Fine sand	91-105
Medium gravel (sandy)	105-122
Very gritty gray clay	122-127
Med. gravel (some sand)	127-130
Gritty gray clay	130-160
Gritty gray clay	160-176
Med.-coarse gravel, sand	176-215
Med.-coarse gravel, some clay	215-220
Med.-coarse gravel, broken stone, sand	220-282
Weathered limestone light gray	282-288

U.S.G.S. Logansport Test hole #108 – Lucerne site; NE¼ of NE¼, Section 18, T. 27 N., R. 1 E., Noble Township, Cass County. Elevation: 734 feet. Total depth is 230 feet. Drilled by Ortman Drilling, Inc., November 15, 1976.



Driller's Log	Interval
Black dirt	0-2
Gray clay	2-5
Med.-crs. sand & gravel	5-18
Gray clay	18-23
Fine sand and gravel	23-25
Gritty gray clay	25-46
Crs. sand and fine gravel	46-58
Med. to crs. gravel with sand	58-62
Gray gritty clay	62-63
Med. gravel with sand	63-66
Gritty gray clay	66-92
Med. to crs. gravel with sand	92-98
Pinkish brown clay (gritty)	98-100
Gray clay (gritty)	100-110
Light brown clay (gritty)	110-141
Fine to med. gravel with sand	141-144
Gritty gray clay	144-154
Med. gravel with sand	154-156
Gritty gray clay	156-157
Med. gravel with sand	157-159
Gritty gray clay	159-170
Wood	170-172
Gritty gray clay	172-175
Fine gravel, some clay	175-225
Fine gravel	225-227
Light yellowish-brown stone	227-230