PRELIMINARY ENGINEERING GEOLOGY REPORT OF DAM SITES ON THE EAST FORK OF THE MUSCATATUCK RIVER IN SCOTT, JENNINGS, AND JEFFERSON COUNTIES, INDIANA

by

JOHN D. WINSLOW

Indiana Department of Conservation
GEOLOGICAL SURVEY
Report of Progress No. 20

1960

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Harold W. Handley, Governor

DEPARTMENT OF CONSERVATION
E. Kenneth Marlin, Director

GEOLOGICAL SURVEY
John B. Patton, State Geologist
Bloomington

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1816

Printed by authority of the State of Indiana

BLOOMINGTON, INDIANA

September 1960

For sale by Geological Survey, Indiana Department of Conservation, Bloomington, Ind.
Price $1.00

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PRELIMINARY ENGINEERING GEOLOGY REPORT OF DAM SITES ON THE EAST FORK OF THE MUSCATATUCK RIVER IN SCOTT, JENNINGS, AND JEFFERSON COUNTIES, INDIANA

By John D. Winslow

ABSTRACT

Preliminary engineering geology investigations have been made of four proposed dam sites and their reservoir areas in the valley of the East Fork of the Muscatatuck River and its tributaries, Big Camp and Big Graham Creeks, in northern Scott County, southern Jennings County, and western Jefferson County, Ind. In this report the geologic column of the area has been divided, according to engineering characteristics, into five units. The bedrock consists of (in ascending order) unit 1, the Osgood Formation and the Laurel Limestone of Silurian age; unit 2, the Waldron Shale and the Louisville Limestone of Silurian age and the Geneva Dolomite and the Jeffersonville Limestone of Devonian age; unit 3, the North Vernon Limestone of Devonian age; and unit 4, the Devonian portion of the New Albany Shale. These rocks are overlain at most places by unit 5, the unconsolidated materials that range in character from red residual limestone soils to glacial till.

The bedrock formations stratigraphically below the North Vernon Limestone (units 1 and 2) are essentially sound rock and offer few problems to dam and reservoir construction except the possibility of a small amount of leakage. The Jeffersonville Limestone (the top formation of unit 2) includes a gray limestone bed that contains a few solution channels, but otherwise it is sound rock. Most of the solution channels and sinkholes in the area have been formed in the North Vernon Limestone (unit 3), and serious leakage from the reservoir probably would occur through this formation if it were not extensively grouted. The New Albany Shale (unit 4) weathers quickly where it is exposed at the surface, and spillways on the New Albany Shale must be designed to prevent the rapid erosion of the shale under the attack of running water. The red residual limestone soils (of unit 5) have high liquid limits, but these materials would make a satisfactory impermeable clay core of an earth dam. The other unconsolidated materials (glacial till, outwash silt and sand, and loess) overlying the bedrock are thin but sufficient in quantity to provide fill material for earth dams. Quarries could be opened in the limestone formations at any of the dam sites to supply concrete aggregate and fill material.

INTRODUCTION

This report is the result of reconnaissance field investigations of the engineering geology made to provide basic geologic information for appraisal of previously selected dam sites in the valleys of the East Fork of the Muscatatuck River, Big Camp Creek, and Big Graham Creek in Scott, Jennings, and Jefferson Counties, Ind. These investigations were made at the request of the Indiana Flood Control and Water Resources Commission to determine the feasibility of proposed flood control structures and to obtain information necessary to the planning of detailed foundations and leakage studies.

This report is based upon data collected during field investigations made in May, June, and July 1958. The work has entailed the mapping of the rock formations and the study of the engineering properties of the unconsolidated materials.

LOCATIONS

The flood control dam and reservoir sites studied are along the East Fork of the Muscatatuck River and its tributaries, Big Camp Creek and Big Graham Creek, in northern Scott County, southern Jennings County, and western Jefferson County, about 11 miles south of Vernon, Ind. (fig. 1). Geologic mapping was confined to the drainage basins of these streams within the area that will be affected by the proposed reservoir. The area lies between the parallels 38°45' and 38°52'30" north latitude and the meridians 85°30' and 85°45' west longitude. The area occupies parts of the Deputy and Volga $7\frac{1}{2}$-minute quadrangle maps published by the U. S. Geological Survey (pl. 1).

DEFINITIONS

The definitions of foundation engineering terms used in this report are as follows:

Field moisture content (w). Moisture content, as percentage of dry weight, of a soil in situ.

Atterberg limits. Arbitrary limits, liquid limit and plastic limit, adopted to mark the boundaries between the liquid, plastic, and nonplastic states of a soil-water suspension.

Liquid limit (L_w). Moisture content, as percentage of dry weight, that marks the boundary between the liquid and plastic states of a soil-water suspension.

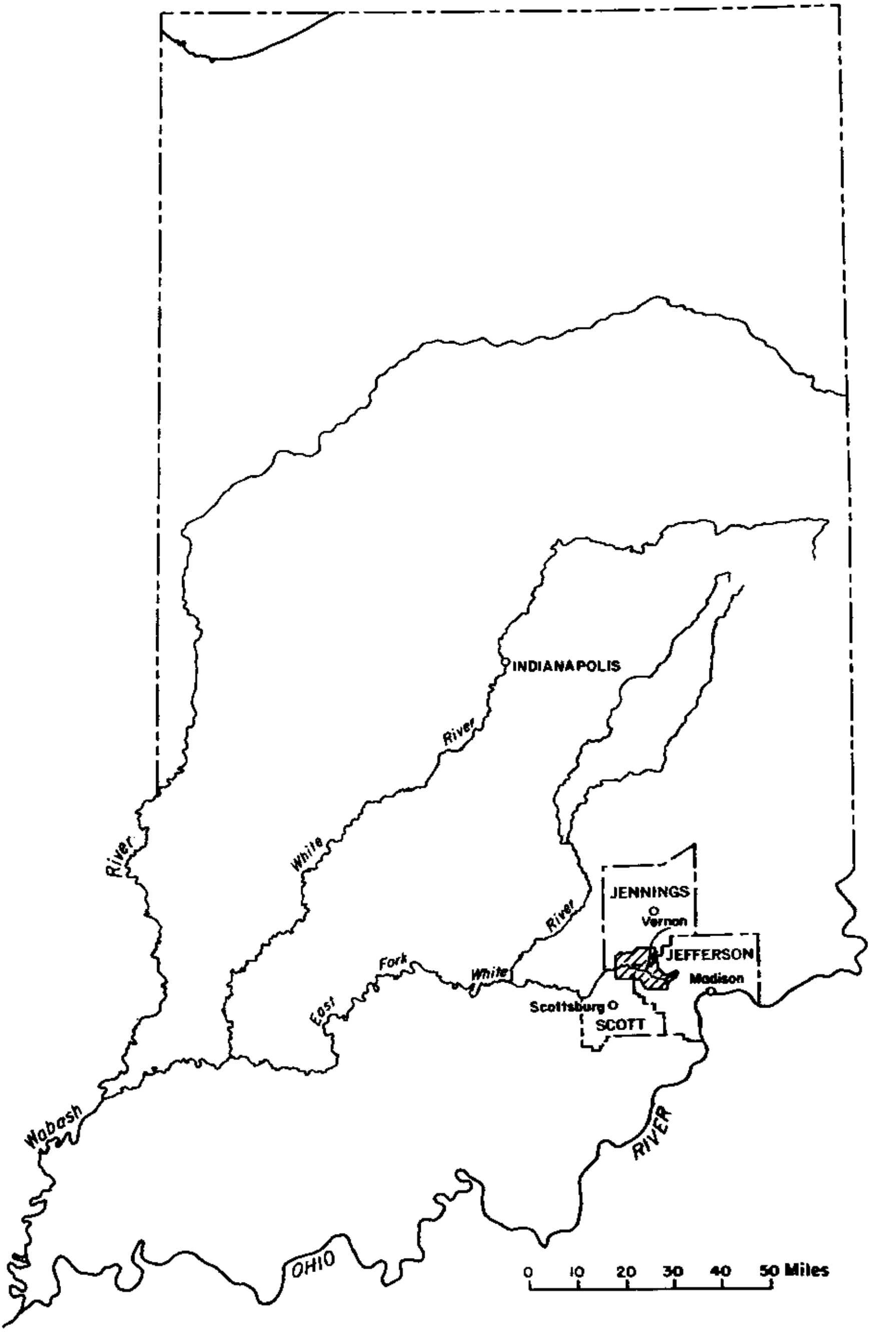


Figure 1.--Map of Indiana showing the area of investigation.

Plastic limit (P_w). Moisture content, as percentage of dry weight, that marks the boundary between the plastic and nonplastic states of a soil-water suspension.

Plasticity index (I_w) — $L_w - P_w$. Indicates the range of moisture content at which the soil-water suspension is in the plastic state.

Liquidity index (I_l) — $\frac{w - P_w}{I_w}$. When the liquidity index is negative, the field moisture content is less than the plastic limit, and the soil-water suspension is nonplastic. When the liquidity index is positive but is less than 1.0, the soil-water suspension is in the plastic state. When the liquidity index is greater than 1.0, the moisture content is higher than the liquid limit, and the soil-water suspension is in the liquid state.

METHOD OF INVESTIGATION

The study of aerial photographs preceded fieldwork to provide information with regard to drainage features, relief, and general soil patterns. Aerial photographs also were used to locate probable bedrock exposures and to discern readily accessible routes to them. Numerous geologic sections were measured along stream beds and valley walls where the rocks were best exposed. The altitude of the contacts between the geologic units that were mapped was determined either from topographic maps of the area or by hand level that used stream level as a reference datum. Steep slopes, dense vegetation, and the variable, but high, level of the streams during the period of fieldwork detract from the accuracy of the altitude determinations.

Six test auger holes (pl. 1) were drilled to determine the character and thickness of the flood-plain deposits in the Muscatatuck Valley. Four of the holes were drilled at regular intervals across the flood plain of the valley in the western part of the area to obtain a profile of the rock floor of the valley and to obtain some idea of the continuity of the flood-plain deposits. Exposures, sample sites, and auger holes that are mentioned in the text are shown on the map (pl. 1) and are listed in table 1.

The Atterberg limits and the natural moisture content were determined for representative samples of the unconsolidated materials collected at road-cut exposures. Standard ASTM specifications (American Society for Testing Materials, 1958) were followed in the determination of the liquid and plastic limits, except that the samples were not air-dried prior to sieving. The standard ASTM specifications require soil samples to be air-dried prior to sieving

Table 1.—*Locations of exposures, measured sections, quarries, sample sites, and auger holes*

Location No.	Field No.	Location			Nature of data and reference
		Sec.	T.	R.	
1 - - - -	26	NE¼SE¼ 33	5N	7E	Sample site (table 2)
2 - - - -	22	SW¼SW¼ 35	5N	7E	Exposure (p. 25)
3 - - - -	18	SE¼SE¼ 35	5N	7E	Exposure (pl. 2B)
4 - - - -	79	NE¼SE¼ 15	5N	8E	Sample site (table 2)
5 - - - -	97	NE¼SE¼ 21	5N	8E	Quarry (p. 23; pl. 4)
6 - - - -	80	SE¼NE¼ 22	5N	8E	Exposure (pl. 3B)
7 - - - -	81	NW¼SE¼ 27	5N	8E	Sample site (table 2)
8 - - - -	38	SE¼NW¼ 33	5N	8E	Measured section (p. 27)
9 - - - -	39	SE¼SW¼ 33	5N	8E	Measured section (p. 27)
10 - - - -	H-5	NW¼NW¼ 2	4N	7E	Auger hole (table 3)
11 - - - -	H-6	NW¼SW¼ 2	4N	7E	Auger hole (table 3)
12 - - - -	H-1	NE¼SE¼ 4	4N	7E	Auger hole (table 3)
13 - - - -	4	NE¼SE¼ 4	4N	7E	Sample site (table 2)
14 - - - -	5	SE¼SE¼ 4	4N	7E	Sample site (table 2; pl. 5B)
15 - - - -	H-2	NW¼SE¼ 4	4N	7E	Auger hole (table 3)
16 - - - -	H-3	NE¼SW¼ 4	4N	7E	Auger hole (table 3)
17 - - - -	H-4	NW¼SW¼ 4	4N	7E	Auger hole (table 3)
18 - - - -	--	SE¼ 9	4N	7E	Quarry (pl. 5A)
19 - - - -	--	SW¼NE¼ 4	4N	8E	Quarry (p. 23)
20 - - - -	--	SW¼NE¼ 4	4N	8E	Exposure (pl. 2A)
21 - - - -	40	SW¼SW¼ 4	4N	8E	Measured section (p. 28)
22 - - - -	--	SW¼NE¼ 7	4N	8E	Quarry (p. 23)
23 - - - -	82	SW¼NW¼ 13	4N	8E	Sample site (table 2; p. 19)
24 - - - -	--	NE¼NE¼ 17	4N	8E	Quarry (p. 23)
25 - - - -	31	NW¼NW¼ 17	4N	8E	Exposure (pl. 3A)

to the less-than-0.420-mm-grain size fraction that is used to obtain the Atterberg limits. The author feels that this is a poor procedure because the several clay minerals reabsorb moisture at different rates, and reabsorption is not complete in the 5-to-10-minute period normally needed to make the limit tests (based on White, 1958). In addition, some iron and aluminum hydroxides may not rehydrate at all. These problems can be circuited by preserving the natural moisture content and by sieving the samples in the manner described below.

For the present investigation the natural moisture content of the soils was retained by inserting the samples in polyethylene bags at the time of collection. In the laboratory the test samples were prepared for sieving to the less-than-420-mm size fraction by mixing distilled water with the moist material until the consistency of the soil approached that of the liquid limit. Then the sample was gently pushed through a 40-mesh sieve. The Atterberg limits by this method are 10 to 30 percent higher than those obtained by standard ASTM specifications, and the plasticity index is slightly greater. The author believes that these results are more representative of the engineering properties of the unconsolidated materials in the field.

PREVIOUS WORK

The principal references of detailed work on the geology of the area are the reports by Cox (1876) and Dawson (1941). Geologic maps are not included in either of these reports, but numerous geologic sections, as observed in surface exposures of rock formations, are described in detail. In addition, Dawson's report contains a map showing contour lines on the upper surface of the Devonian limestone sequence. A discussion of the geomorphology of the Muscatatuck Regional Slope and the Scottsburg Lowland are contained in Malott's (1922) and Wayne's (1956) descriptions of the physiography of Indiana. The Field Conference Guidebooks of Esarey, Malott, and Galloway (1947) and Murray (1955) describe the general stratigraphy of southeastern Indiana. The quarries of the area and analyses of most of the formations exposed in them are tabulated in part by Murray (1955) and in Patton's (1949) report on crushed stone in Indiana.

CLIMATE

The area of this investigation has a humid climate, and precipitation is distributed fairly evenly over the year. The annual average mean temperature and precipitation are 55.1° F. and 43.6 inches respectively. The annual average mean temperature and precipitation as computed from U. S. Weather Bureau records (Climatological Data, Annual Summary, Indiana, 1956) for the nearby cities of Madison, North Vernon, and Scottsburg are shown below.

Annual average mean temperature and precipitation for Madison, North Vernon, and Scottsburg, Ind.

City	Period of record (yr)	Average temperature (° F.)	Average precipitation (in.)
Madison ----	62	56.2	43.66
North Vernon -	70	54.3	48.47
Scottsburg ---	62	54.7	43.56

TOPOGRAPHY

The area of investigation lies principally within the physiographic region designated the Muscatatuck Regional Slope (Malott, 1922, p. 86). The west border of the area is marginal between the Muscatatuck Regional Slope and the Scottsburg Lowland, the latter province being represented by the wide portion of the Muscatatuck River Valley and the more gentle lowland topography of the western part of the area.

The Muscatatuck Regional Slope dips southwestward about 15 feet per mile. This dip is slightly less than the average southwesterly dip (20 feet per mile) of the rock formations. The dip of the rocks, as well as the relative hardness and solution characteristics of the rocks, appears to have controlled the base levels of the streams. The projected upland surface slopes southwestward from a maximum altitude of about 730 feet in the eastern part of the area to a level of about 650 feet in the western part. The lowest point is about 540 feet and is along the Muscatatuck River at the west edge of the mapped area. The maximum local relief is about 140 feet near Lick Branch Church, sec. 13, T. 4 N., R. 8 E., where the upland surface is at an altitude of about 720 feet and stream level is about 580 feet.

DRAINAGE

Big Camp Creek and Big Graham Creek join near Deputy, western Jefferson County, to form the East Fork of the Muscatatuck

River. These three streams and their tributaries drain all the region. The gradients of the three streams are, respectively, about 6 feet, 7.5 feet, and 1 foot per mile of stream length. The lower gradient of the East Fork of the Muscatatuck River reflects the extension of the Scottsburg Lowland up the valley to the confluence of Big Camp and Big Graham Creeks.

The storage characteristics of a drainage basin reflect the geology of the basin. A drainage basin that comprises a large percentage of porous and fairly permeable deposits will have good storage characteristics because a high percentage of the precipitation will infiltrate into the ground and will be released later at a much slower rate as ground-water discharge to the stream rather than as direct surface runoff. The flood flows of such a basin will be lower and the drought flow higher than that of a drainage basin that has poor storage characteristics.

The storage characteristics of the Muscatatuck basin in the area of this report are poor because the infiltration capacity of the soils is low and most precipitation runs off directly to the streams, either over the land surface or through solution channels in the limestone. Some flooding follows each moderate to severe storm and in periods of drought the flow of the stream is very low. At the U. S. Geological Survey gaging station on the East Fork of the Muscatatuck River 1½ miles west of Deputy, the average discharge (1948-55) for the 296-square-mile drainage basin is 364 cubic feet per second (cfs). The maximum and minimum recorded flows are 28,000 cfs (January 24, 1949) and 0.0 cfs respectively. During each of the climatic years (April to March 31) 1953-54, 60 days of 0.0-cfs flow were recorded.

If specified amounts of stream flow are plotted against the percentage of time that such flows are equalled or exceeded, a flow-duration curve, such as shown in figure 2, is formed. The flow-duration curve provides an indication of the future performance of the stream (the reliability of the indication being roughly proportionate to the length of the period of record) and reflects the storage characteristics of the basin. If the flow-duration curve has a gentle slope (such as curve 2, figure 2), the storage characteristics of the basin are good. The 90-percent point on the duration curve is called the low-flow index of the basin. The low-flow index represents essentially the ground-water discharge to the stream which sustains the flow of the stream during drought periods.

The steepness of the flow-duration curve, as determined from records at the gaging station on the East Fork of the Muscatatuck River near Deputy for the years 1949-55 (curve 1, fig. 2) reflects rapid surface drainage, rapid subsurface drainage through solution channels in the carbonate bedrock (limestone and dolomite), and the

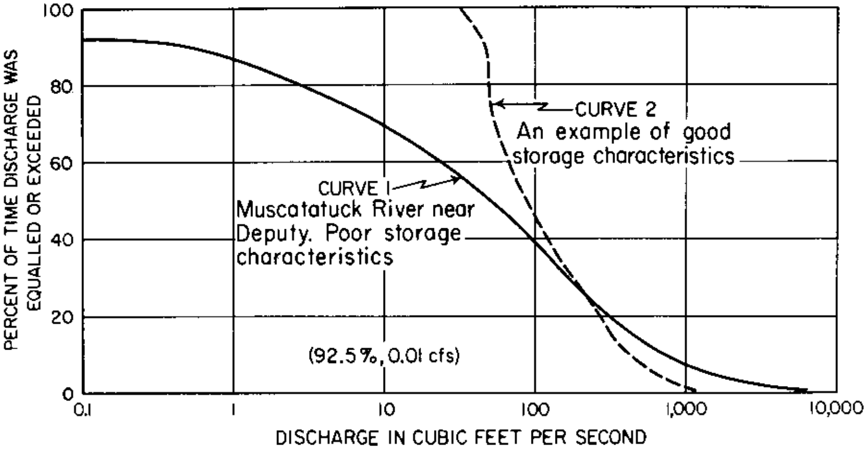


Figure 2.--Flow-duration curve, Muscatatuck River near Deputy, Ind. Drainage area 296 square miles. Period of record 1949-55. Data from Surface Water Branch, U. S. Geological Survey.

thin cover of unconsolidated material over the bedrock. In addition, the clay subsoil that has been formed on the loess deposits and on the carbonate rocks is dense and relatively impermeable so that the infiltration capacity of the soil probably is very low. The low-flow index of the stream is less than 1.0 cfs; this fact indicates that the contribution of ground-water discharge to streamflow is very small.

The loessial soils erode readily and probably are the source of much of the silt and clay that muddy the streams more or less continually. From appearance, the amount of suspended sediment in the streams is high, sufficiently so, perhaps, to warrant a study to determine the siltation rate of the proposed reservoir.

STRATIGRAPHY

For the purposes of the present report the several rock formations have been grouped into mappable units according to their engineering properties. These units are: (1) the Osgood Formation and Laurel Limestone of Silurian age, (2) the Waldron Shale and Louisville Limestone of Silurian age and the Geneva Dolomite and Jeffersonville Limestone of Devonian age, (3) the Devonian North Vernon Limestone, and (4) the Devonian portion of the New Albany Shale. A thin mantle of glacial drift and (or) Recent alluvium (unit 5) generally overlies the bedrock. The glacial drift consists of terrace deposits of sand, silt, and clay, thin glacial till, and loess.

The loess forms a blanket 2 to 5 feet thick over the area and contains most of the soil zones which have been formed. The Recent alluvium consists of silt and sand and local small pockets of organic material that accumulated and were buried later in temporary channels of the streams.

On the geologic map (pl. 1) flood-plain deposits along the East Fork of the Muscatatuck River are the only unconsolidated deposits shown. The unconsolidated materials elsewhere in the area have not been mapped because the surface material is predominantly loess and a detailed drilling program is necessary to determine the type and areal extent of the underlying unconsolidated materials (silt, sand, glacial till, and gravel).

Rock exposures are relatively common in road cuts and along the steep slopes of valley walls. Along the valley of the East Fork of the Muscatatuck River, where relief is low, rock exposures generally are limited to the points where stream meanders impinge against the valley walls at the edge of the flood plain.

The regional dip of the bedrock formations is southwesterly about 20 feet per mile. Owing to the southwesterly dip of the rocks, stratigraphically lower (older) formations are exposed at the surface progressively eastward. The older rocks, units 1 and 2, are less subject to solution because they are dolomitic. Thus reservoir leakage should not constitute a problem upstream from any of the dam sites considered. The regional joint pattern consists principally of two joint sets that bear N. 10° W. and N. 80° W.

The lithologic and physical aspects of the Silurian and Devonian formations in adjacent areas to the north and to the south are similar to those in the report area. Thus the engineering characteristics of the formations described in this report also will apply to a large extent to the same formations in adjacent areas. One must remember, however, that the geology in each locality will differ in some respect from that in a nearby locality owing to variations in the lithology of the rocks or in the attitude and position of the formations with respect to the land surface.

UNIT 1

The Osgood Formation and the Laurel Limestone are grouped as unit 1 in this report. The Osgood Formation, where it is exposed within the area of investigation, consists of interbedded gray calcareous shale and tan to tan-gray argillaceous dolomitic limestone. The overlying Laurel Limestone is relatively thin bedded, tan to tan gray, and dolomitic (pl. 2A). Many of the beds are argillaceous and look like similar beds in the Osgood Formation. Thin beds of chert are common in the Laurel. The Osgood Formation

A. LAUREL LIMESTONE EXPOSED UNDER BRIDGE IN THE SW¼NE¼ SEC. 4, T. 4 N., R. 8 E. (LOCATION 20).

B. SPRING ISSUING FROM THE NORTH VERNON LIMESTONE AT LOCATION 3 IN THE SE¼ SEC. 35, T. 5 N., R. 7 E. THE VERTICAL SOLUTION CHANNEL IS 2 TO 3 FEET WIDE, ABOUT 6 FEET LONG, AND AT LEAST 10 FEET DEEP. DISCHARGE AT THE TIME THE PHOTOGRAPH WAS TAKEN WAS ESTIMATED TO BE ABOUT 25 GPM. DURING AND SHORTLY AFTER PERIODS OF HEAVY RAINFALL DISCHARGE PROBABLY IS 500 GPM OR MORE.

LAUREL AND NORTH VERNON LIMESTONES

A. SWALLOW HOLE IN THE NORTH VERNON LIMESTONE AT LOCATION 25 IN THE SW¼ SEC. 17, T. 4 N., R. 8 E. THE ENTRANCE TO THE SOLUTION CHANNEL IS ABOUT 12 FEET WIDE AND 5 FEET HIGH.

B. NORTH VERNON LIMESTONE IN SPILLWAY OF A SMALL RESERVOIR AT LOCATION 6 IN THE EAST-CENTRAL PART OF SEC. 22, T. 5 N., R. 8 E. EARTH FILL OF THE DAM IS AT RIGHT OF PHOTOGRAPH.

NORTH VERNON LIMESTONE

crops out in the bed and along the lower valley walls of Big Camp Creek in the eastern part of the area. The Laurel Limestone is exposed principally along Big Camp Creek, but along the lower reaches of Big Graham Creek as much as 13 feet of the limestone is exposed above stream level. The top of the Laurel Limestone is above stream level at dam sites C and D.

Both formations should provide good foundations for engineering structures. Minor leakage may be expected through joints and cracks in these rocks, but no solution channels were observed. The upper part of the Laurel Limestone is the source of water to some domestic and stock wells, but the yield is small.

UNIT 2

Unit 2 in this report comprises the Waldron Shale, the Louisville Limestone, the Geneva Dolomite, and the Jeffersonville Limestone. The base of the unit has been taken arbitrarily as the base of the Waldron Shale, primarily for convenience in constructing the geologic map but also because the shale marks a break in the lithology of the section.

The Waldron Shale is 1 foot to 12 feet thick and looks like a crumbly gray to green-gray siltstone. The rock is actually calcareous shale. It is not fissile but breaks out in chunks. The formation weathers to a sticky whitish-gray clay.

The Louisville Limestone unconformably overlies the Waldron Shale. It is thin bedded to medium bedded, sugary, fine grained, tan to cream, and dolomitic and is 2 to 8 feet thick.

The Geneva Dolomite unconformably overlies the Louisville Limestone. It is massively bedded, soft (but dense), medium brown to chocolate brown, and sugary and contains numerous crystals and crystalline masses of calcite and some calcified corals.

The Jeffersonville Limestone in the area may be divided into two zones: (1) a basal zone that is a rather massively bedded soft medium- to chocolate-brown sugary dolomite that contains many fossil corals and (2) an upper zone that is thin- to medium-bedded gray to light-brown fossiliferous limestone or dolomite. Some thin, discontinuous chert beds are present in both zones. The contact between the Geneva Dolomite and the Jeffersonville Limestone is difficult to determine because the rocks are very similar in lithology and both contain fossil corals. The Geneva is the more dense and compact, but only slightly. The combined thickness of the two formations generally is 40 to 50 feet.

The engineering characteristics of several of the formations of unit 2 may present some problems with regard to dam construction and reservoir leakage. The Waldron Shale, in places where it is more a shale than an argillaceous limestone, may weather rapidly where it is exposed at the surface. Many minor seeps or springs (a few gallons per hour) were observed to flow from the contact between the Louisville Limestone and the Geneva Dolomite. Some joints and cracks in the Louisville Limestone and in the lower 4 feet of the Geneva Dolomite have been widened slightly by solution of the rock. A few small and relatively unimportant solution channels exist in both the Geneva Dolomite and in the basal zone of the Jeffersonville Limestone. No significant solution channels were observed in the vicinity of the dam sites, but this fact does not remove the possibility of their existence at these sites. The upper zone of the Jeffersonville Limestone contains some solution channels and sinkholes, but principally only where the rock is gray. Solution features are fewer and less prominent where the rock is tan or brown and more dolomitic.

UNIT 3

The North Vernon Limestone comprises the Speed, Silver Creek, and Beechwood Members. The Speed Member is thin bedded to medium bedded, fine grained to coarse grained, fossiliferous, gray to tan gray, and crystalline. Where the underlying Jeffersonville Limestone is similar in appearance the only readily available means of determining the contact between them is the presence of the fossil brachiopod, *Paraspirifer acuminatus*, in the upper beds of the Jeffersonville Limestone. The Silver Creek Member is homogeneous, argillaceous, thin bedded, fine grained, and light gray to chalky gray. The Beechwood Member is hard, coarse grained, fossiliferous, and crystalline. The combined thickness of these members ranges from about 10 feet to 25 feet within the area.

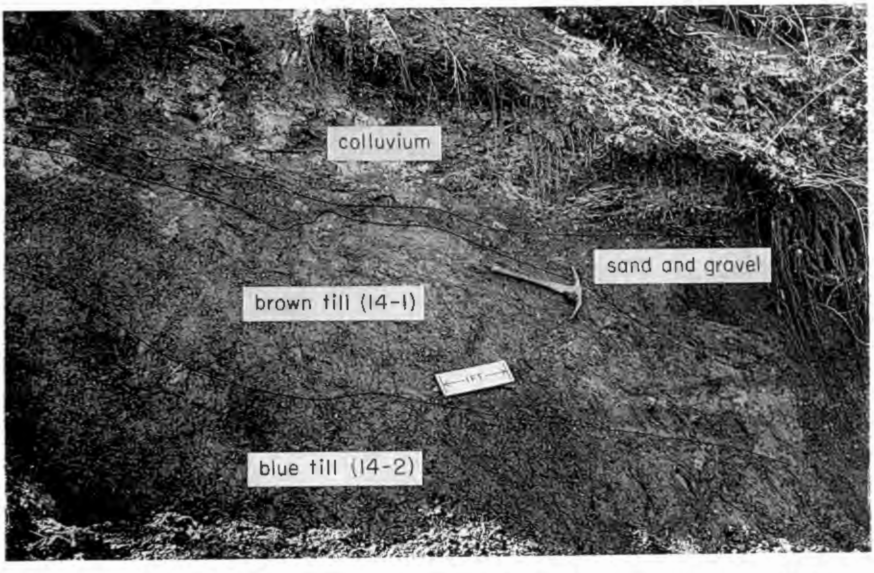
Almost all the numerous solution channels and sinkholes in the area of investigation have been formed in the North Vernon Limestone. A smaller, but significant, number of these solution features also have been formed in the gray portions of the Jeffersonville Limestone. Most of the photographs in this report (pls. 2, 3, 4, and 5) are included to stress the solubility of these gray limestones and to point out the problem of controlling leakage through them, should they be below reservoir level. In the western part of the area, where the gray limestones are near or below drainage, solution channels can be expected to exist below streambed level.

A. LAUREL CAVE, LOCATION 5, IN THE EAST-CENTRAL PART OF SEC. 21, T. 5 N., R. 8 E. A LARGE SPRING ISSUES FROM THE UPPER PART OF THE JEFFERSONVILLE LIMESTONE. LINE AT RIGHT SIDE OF PHOTOGRAPH MARKS THE CONTACT BETWEEN THE JEFFERSONVILLE AND NORTH VERNON LIMESTONES. THE SPRING DRAINS SINKHOLES IN THE NORTH VERNON LIMESTONE TO THE NORTH AND WEST.

B. LAUREL CAVE, LOCATION 5, IN THE EAST-CENTRAL PART OF SEC. 21, T. 5 N., R. 8 E. SMALL FALL IN THE UPPER PART OF THE JEFFERSONVILLE LIMESTONE IN LAUREL CAVE ABOUT 100 FEET FROM ENTRANCE.

LAUREL CAVE

A. NEW ALBANY SHALE EXPOSED IN AN ABANDONED QUARRY (LOCATION 18) IN THE SOUTHEAST CORNER SEC. 9, T. 4 N., R. 7 E.



B. GLACIAL TILL OVERLAIN BY TERRACE DEPOSITS AND COLLUVIAL MATERIAL IN THE SOUTHEAST CORNER SEC. 4, T. 4 N., R. 7 E. (LOCATION 14). THE GLACIAL TILL SAMPLES, 14-1 AND 14-2, WERE COLLECTED AT THIS EXPOSURE.

NEW ALBANY SHALE AND GLACIAL TILL

UNIT 4

Unit 4 of this report is the New Albany Shale. This formation is a fissile black bituminous shale which weathers quickly to a mass of rust-red to light-gray shale chips where it is exposed at the surface (pl. 5A). It is the uppermost rock unit of the section, and it may be more than 70 feet thick in the uplands and ridges of the central and western parts of the area.

Spillway structures may be founded on the New Albany Shale. If so, either the following precautions must be taken or their need must be investigated:

1. Care must be taken to prevent the weathering of the shale before concrete is poured on the cleaned surface.
2. The shale will erode quickly under attack of rapidly moving water, and this factor must be considered in the design of spillway structures to be founded on the shale.
3. Because of the southwesterly regional dip and the soft fissile character of the shale, the weight or thrust of engineering structures may possibly cause the formation of slippage planes within the shale.
4. In many areas where the shale is thin (20 feet or so) sinkholes appear to have been formed in the shale. The sinkholes are actually in the North Vernon Limestone, and the shale has slumped into them. Test drilling should be carried to the limestone surface and perhaps beyond to assure a sound foundation. Leakage through the formation, except in the sinkhole areas, should be minor.

UNIT 5

Unit 5, as shown on the geologic map (pl. 1), represents only the Recent alluvium that forms the flood-plain deposits along the East Fork of the Muscatatuck River and tributaries in the western part of the area. The unconsolidated deposits elsewhere are mantled by loess deposits and are exposed principally only in road cuts and along the cut banks of streams. The moisture content and Atterberg limits of representative samples of clay zones in such exposures are shown in table 2 and on figure 3. Auger holes were drilled in the western part of the area to determine the thickness and the character of the unconsolidated material overlying the bedrock along the flood plain of the Muscatatuck River. The unconsolidated materials comprise five types of deposits: (1) residual clay and silty clay soils on the shale and carbonate bedrocks; (2) glacial till (sandy pebbly clay); (3) terrace deposits (sand, silt, gravel, and clay); (4) loess (windblown silt, clay, and fine sand); and (5) river alluvium that consists of silt, sand, and fine gravel.

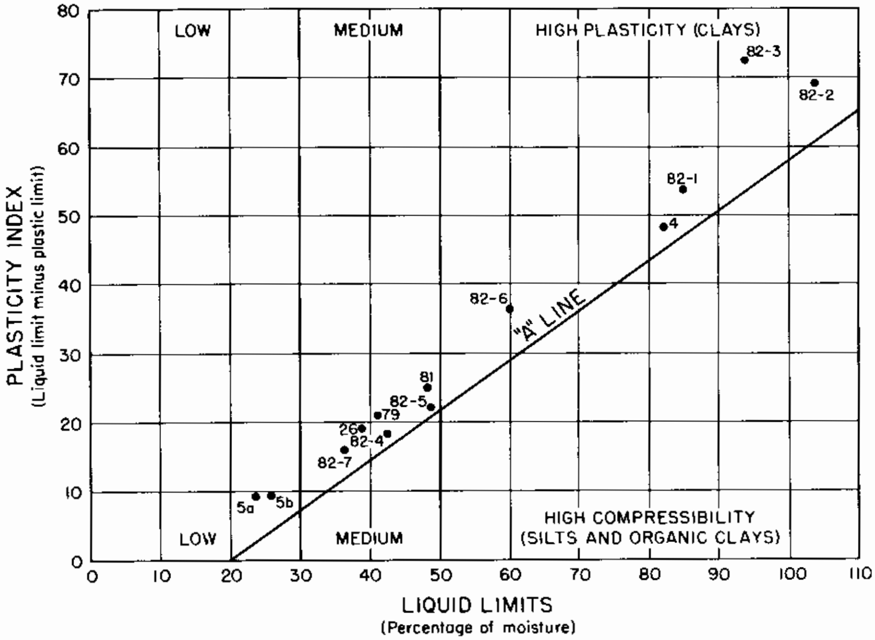


Figure 3.--Plasticity chart showing character of representative unconsolidated materials. Modified from Casagrande, 1947, fig. 5. Samples plotted above the "A" line are plastic clays and below the "A" line compressible silts. The degree of plasticity or compressibility is determined by the liquid-limit value: <30 percent is low; 30 percent to 50 percent is medium; and >50 percent is high. (See table 2 for location and description of soil samples.)

The range of the engineering properties of the unconsolidated materials at one place is indicated by the samples taken at location 23 (table 2), which represent the soil profile at that exposure. The field description of the soil profile is given below.

Soil profile at location 23, sec. 13, T. 4 N., R. 8 E.

Sample No.	Material	Thickness Ft	Thickness in
23-1	Silt loam, yellow-brown; A_1 zone of loessial soil	0	4
23-2	Silty clay loam, yellow-brown; A_2 zone of loessial soil	1	6
23-3	Silty clay loam, chocolate-brown; B_1 zone of loessial soil	1	8
23-4	Clay, chocolate-red; some manganese staining; some small soft iron concretions	3	9
23-5	Clay, sandy to silty, yellow-brown; mottled with gray; some manganese staining; some chips of New Albany Shale (terrace deposit)	2	7
23-6	Clay, chocolate-red; some manganese staining (residual limestone soil)	2	9
23-7	Clay, mottled yellow-brown and rust-brown (residual limestone soil)	0	6

The soils that are formed on the New Albany Shale are silty clay loams. The soil zone generally is thin, and the lower part of the clay subsoil is a mass of more or less disintegrated shale chips that will not compact well if they are used as fill material.

The soils that are formed on the carbonate rocks are thicker and more clayey and are characterized by significantly high natural moisture contents, liquid limits, and plastic limits and by a considable plastic range or index. The liquidity index probably ranges from plus to minus depending upon the precipitation and the season of the year. Samples 23-6 and 23-7, taken from the clay zone of the soil formed on the Jeffersonville Limestone, exhibit high plasticity and, as with most soils with a liquid limit above 50 percent, may present some problems. Much of the locally available fill material for dams built at sites C and D would be similar; however, mixing it with the siltier material of the upper soil zones should reduce the plasticity.

Table 2.—*Engineering characteristics of unconsolidated materials*

[Sample sites are shown on plate 1.]

Location and sample No.	Location			Field moisture content (w)[1]	Liquid limit (L_w)	Plastic limit (P_w)	Plasticity index (I_w)	Liquidity index (I_i)	Sample description
	Sec.	T.	R.						
1 - - -	33	5N	7E	23.0	39.1	20.0	19.1	+.16	Clay, light blue-gray with some brown mottling and organic material. "B" zone of poorly drained flood-plain deposits.
4 - - -	15	5N	8E	10.9	41.2	20.4	20.8	-.45	Sandy clay, brown. "B" zone of loessial soil.
7 - - -	27	5N	8E	16.1	48.3	23.2	25.1	-.28	Clayey sand, brown. "B" zone of terrace-soil.
13 - - -	4	4N	7E	25.3	82.2	34.1	48.1	-.18	Sandy clay, mottled brown and yellow. "B" zone of terrace-deposit soil.
14-1 - - -	4	4N	7E	9.0	25.5	16.3	9.2	-.79	Silty to sandy clay till, moderately pebbly, brown, oxidized.
14-2 - - -				8.5	23.5	14.2	9.3	-.61	Silty to sandy clay till, moderately pebbly, blue-gray.
23-1 - - -	13	4N	8E	9.4	36.5	20.2	16.3	-.66	Sandy silt loam, brown. "A" zone of soil.
23-2 - - -				17.8	59.8	23.2	36.6	-.15	Clayey silt loam, brown.
23-3 - - -				19.4	48.4	26.2	22.2	-.31	Sandy clay, brown.
23-4 - - -				19.1	42.4	24.0	18.4	-.27	Clayey sand, chocolate-red. Some small soft iron concretions.
23-5 - - -				18.4	93.7	21.3	72.4	-.04	Sandy silty clay, yellow-brown mottled with gray. Some shale chips.
23-6 - - -				46.5	103.7	34.6	69.1	+.17	Clay, chocolate-red. Residual limestone soil.
23-7 - - -				29.4	84.7	30.9	53.8	-.03	Clay, mottled yellow-brown to rust-brown. Residual limestone soil.

---

[1] Percentage of dry weight.

Table 3.—*Logs of auger holes drilled to determine the thickness and the character of unconsolidated materials*

[Drilling sites are shown on plate 1.]

Location No.	Location	Material	Depth in ft	
			from	to
10	sec. 2, T. 4 N., R. 7 E., 300 ft south of the East Fork of the Muscatatuck River	Clayey silt, brown	0	7
		Silty clay, brown	7	9
		Clay, wet, light-gray mottled with brown	9	12
		Silty clay, brown	12	14
		Sandy clay with some pebbles, brown	14	19
		Bedrock	19	
11	sec. 2, T. 4 N., R. 7 E.	Sandy clay, brown	0	7
		Sandy clay with some pebbles, blue-gray (glacial till)	7	10
		New Albany Shale	10	
12	sec. 4, T. 4 N., R. 7 E.	Silty clay, brown	0	5
		Silty sandy clay, brown	5	8
		Silty sandy clay and some pebbles, mottled brown and gray with a few carbonaceous streaks (possibly glacial till)	8	15
		Bedrock	15	
15	sec. 4, T. 4 N., R. 7 E., 0.24 mile west of location 12	Plastic sandy clay, brown	0	3
		Clayey sand, brown	3	8
		Slightly clayey sand, wet, brown	8	13
		Soupy silty sand, brown	13	20
		Fine to medium gravel (as much as 1 in. in diameter)	20	22
		No sample; presumed to be silty sand; wet	22	26
		No sample; presumed to be silty sand with some gravel; wet	26	29
		Limestone	29	
16	sec. 4, T. 4 N., R. 7 E., 0.25 mile west and 5 to 10 ft higher than location 15	Clayey sand, brown	0	8
		Soupy clayey sand, brown	8	29
		Coarse gravel (as much as 1.5 in. in diameter) and sand	29	32
		Limestone	32	
17	sec. 4, T. 4 N., R. 7 E., 0.3 mile west of location 16 on east side of bridge	Clayey sand, wet, brown	0	12
		Soupy silty sand and some clay, brown	12	27
		Clayey sand and some gravel, wet, brown	27	32
		Boulder	32	32.5
		Sand and fine gravel, stratified	32.5	[a]35
		Bedrock	35	

[a] A few inches of light-gray clay containing chips of New Albany Shale immediately above bedrock.

The glacial till, samples 14-1 and 14-2, is dense and compact and will make excellent fill material if the deposits are extensive. Glacial till is known to be present in the area, however, only from the road cut from which the samples were taken (exposure 14) (pl. 5B) and from auger hole 11. The till probably is a thin and discontinuous deposit.

The terrace deposits predominantly are sand and silt and contain only minor amounts of gravel and clay. The average thickness of these deposits probably is about 20 feet.

The river alluvium shown on the map (pl. 1) is restricted to the flood plain of the East Fork of the Muscatatuck River where the deposits are extensive and relatively uniform. There are alluvial deposits, however, in most of the valleys, and in places these deposits may be 20 to 30 feet thick. The sand and fine gravel probably are quite permeable.

"Forest beds" or pockets of organic material that have resulted from the burial of vegetal material in abandoned stream channels in the valley bottoms were observed at several places along Big Camp and Big Graham Creeks. These deposits, especially if thick, are highly compressible and may be quite plastic.

Leakage through the unconsolidated materials that form the rim of the reservoir should be insignificant; however, seepage through silt, sand, and gravel beneath the dam or spillway structure or along the abutments may cause piping (removal of fine-grained material from beneath the dam or from within the dam itself), which would eventually lead to failure of the structure.

BURIED VALLEYS

In most glaciated areas there are preglacial and Pleistocene valleys that have been filled by the deposits of later ice advances. The principal dangers of buried valleys to reservoir projects are leakage, slump of the unconsolidated material on slopes, and settlement. During the field investigation of the area, the writer looked for evidences of buried valleys. None were found, and because rock was exposed almost continually at stream level along valley walls, the probability of the existence of buried valleys that were cut below the present level of the major streams is small. Rock exposures in the upper valley walls are not continuous, and whereas at most places the rock is only thinly covered by regolith and slumped material, at other places small buried valleys 50 to 70 feet deep (below the upland surface) may exist. Where buried valleys intersect the rim of the reservoir, except at the dam or spillway site, leakage probably will be minor owing to the relatively fine-grained character of the material and the distance to a point of discharge.

Relatively thick unconsolidated material may exist somewhere in the vicinity of Paris Crossing. Cox (1876, p. 172) reported 38 to 42 feet of unconsolidated material encountered in a well dug "at Paris Crossing. . . on lands elevated some 60 to 70 feet above the bed of Graham Creek." The lower 7 to 10 feet of the well contained some organic material--"limbs, twigs, and roots of trees." The direction and distance of this well site from Paris Crossing are not known. The logs of wells reviewed by the writer (files, Ground Water Branch, U. S. Geological Survey, Indianapolis, Ind.) in the course of the investigation indicate 6 to 15 feet of unconsolidated material overlying the bedrock at Paris Crossing. The greatest thickness of unconsolidated material reported in the area is 60 feet (beneath the upland surface) in the SW¼NE¼, sec. 13, T. 4 N., R. 8 E.

LOCAL CONSTRUCTION MATERIALS

LIMESTONE AND DOLOMITE

Limestone quarries can be opened in the vicinity of the dam site to provide coarse and fine aggregate for concrete and fill material. Four small abandoned quarries, originally operated to supply local building needs, are in the area: on the road south of Paris in the SW¼NE¼ sec. 4, T. 4 N., R. 8 E., in the Jeffersonville Limestone (location 19); east of State Route 3 and south of the east-west road in the NE¼SE¼ sec. 21, T. 5 N., R. 8 E., in the North Vernon Limestone (location 5); south of the east-west road through Deputy, just east of State Route 3, in the NE¼NE¼ sec. 17, T. 4 N., R. 8 E., in the North Vernon Limestone (location 24); and southwest of the south bridge abutment near the center of sec. 7, T. 4 N., R. 8 E., in the Jeffersonville and North Vernon Limestones (location 22). The opening of new quarries near the dam sites probably will prove more economical than to reopen and develop the small quarries listed above. All the limestones and dolomites should meet the specifications for concrete aggregate. The Jeffersonville Limestone may contain some chert in places, but the injurious laminated rock present elsewhere in the middle part of this formation was not observed in the area of investigation.

SAND AND GRAVEL

Some sand is available in the alluvial material in the beds of the major streams, but a test-drilling program will be required to determine the amount. Considerable silt and clay-sized material must be expected with the sand. Gravel in mineable quantities is essentially nonexistent in the area, and any gravel found is likely to contain shale chips (from the New Albany Shale) and a rather high proportion of chert (derived originally by weathering and glacial erosion from the Laurel Limestone and to some extent from the Jeffersonville Limestone).

EARTH FILL

Most of the earth fill for dam construction probably can be obtained from the unconsolidated materials overlying the bedrock in the upland areas. The red residual limestone soils are essentially impermeable and probably would provide a good material for the core of an earth dam. The material would be difficult to work, however, because the natural moisture content of these clays is generally higher than the plastic limits. The clay subsoil of the loess and terrace deposits, as well as glacial till, is somewhat more permeable but will be more readily emplaced and compacted. The thickness of the unconsolidated materials probably averages between 10 and 20 feet.

DAM SITE DESCRIPTIONS

Four prospective dam sites are considered in this report: sites A and B on the East Fork of the Muscatatuck River, site C on Big Graham Creek about 1 mile northeast of its confluence with Big Camp Creek, and site D on Big Camp Creek about half a mile east of its confluence with Big Graham Creek.

DAM SITES A AND B

Dam site A is about 1 mile downstream from dam site B, but because the geologic terrane and the associated hazards are the same for both, the sites are discussed together. The axis of dam site A runs northwestward from sec. 13 to the central part of sec. 3, T. 4 N., R. 7 E., then generally northward to the northeastern part of sec. 34, T. 5 N., R. 7 E., and then northeastward to the northwest corner of sec. 35, T. 5 N., R. 7 E. The axis of dam site B runs northwestward from sec. 13 to the northwestern part of sec. 11, T. 4 N., R. 7 E., and then generally northward to the central part of sec. 35, T. 5 N., R. 7 E. Generalized cross sections of dam sites A and B and the lines of cross section are shown on plate 1. The two sites share the same axis between B' and A'''.

The bedrock section as measured at location 2 (pl. 1) on the north bank of the East Fork of the Muscatatuck River in the NW¼SW¼ sec. 35, T. 4 N., R. 7 E., consists of 3+ feet of Jeffersonville Limestone (unit 2) overlain by 17 feet of North Vernon Limestone (unit 3). The base of the measured section was stream level at a time of moderate flow. During the time of low flow, perhaps 15 feet of Jeffersonville Limestone would be exposed. The top of the Jeffersonville is at an altitude of about 545 feet. The proposed spillway altitude for both dam sites is 610, and 620 feet and 630 feet are the altitudes of the flood pool and the top of the dam respectively.

The bedrock along the axes of both sites would be the New Albany Shale (unit 4) except across the flood plain of the East Fork of the Muscatatuck River where the underlying rock is Jeffersonville and North Vernon Limestones. The New Albany Shale is relatively impermeable and need not be considered as far as leakage is concerned. The bearing capacity of the rock should be sufficient for all necessary foundations; however, many sinkholes have been formed in the North Vernon Limestone beneath the shale, and in time the shale has slumped into them. Test drilling to the limestone surface would determine the presence of this hazard. Spillway structures for both sites probably would be founded on the New Albany Shale. The shale is soft and fissile and is readily eroded by moving water. There are many sinkholes and springs in the upper part of the Jeffersonville Limestone and in the North Vernon Limestone at the north side of the valley in the northern part of secs. 34 and 35, T. 5 N., R. 7 E. (pl. 2B). These solution features pose danger of severe leakage and possible undermining of the dam. A test-drilling program should not be limited only to the area where the limestone directly underlies the unconsolidated deposits, but the test drilling should extend along the axis of the dam where the New Albany Shale is less than 30 feet thick, especially between A' and A'' and between B and B'. The danger of springs being formed beneath the dam, owing to the hydrostatic pressure of the reservoir, is a distinct possibility.

The unconsolidated materials overlying bedrock provide a source of fill all along the dam. Because of the variation in character of these materials, test drilling should be done in advance to assure proper quality. Limestone quarries might be opened preferably to the east of the dam sites where the rock thickness is sufficiently great above drainage to avoid water problems as well as to keep the amount of necessary overburden removal to a minimum.

There is no preferable location for the spillway of either dam. The spillway would be founded on the New Albany Shale, and the exact location of the spillway would be based upon economic considerations related to the depth and length of the spillway excavation and the basic design.

Some leakage from the reservoir may be expected, especially through the North Vernon Limestone. A strong effort should be made to control leakage through the limestone; otherwise, in the course of time, leakage would increase owing to the enlargement of the solution channels in the rock.

DAM SITES C AND D

Dam sites C and D are on Big Graham Creek and Big Camp Creeks respectively, a short distance above the confluence of the two streams. Cross sections C-C' and D-D' (pl. 1) in sec. 33, T. 5 N., R. 8 E., and sec. 4, T. 4 N., R. 8 E., lie near, but not on, the axes of the two proposed dam sites.

The bedrock at both sites is similar and consists of the Laurel Limestone in the bed of the stream, overlain by Waldron Shale, Louisville Limestone, Geneva Dolomite, Jeffersonville Limestone, North Vernon Limestone, and New Albany Shale. The controlling factor determining the spillway altitude for the two dam sites is the extent of solution features in the upper part of the Jeffersonville Limestone. Numerous sinkholes have been formed in the North Vernon Limestone, and many of these sinkholes presumably extend into the underlying Jeffersonville Limestone. The lower part of the Jeffersonville and the formations beneath it are believed to be comparatively free of solution channels, and thus leakage through these rocks probably would be minor. The Laurel Limestone may be sufficiently permeable to permit some seepage. If so, corrective measures may be necessary to prevent the formation of solution channels in the course of time.

The spillway altitude of a dam at site C cannot be placed higher than about 600 feet without the possibility of serious leakage through the top of the Jeffersonville Limestone at conservation pool level. In the south bank of Big Graham Creek and along State Route 3 to the south, the following composite geologic section was measured above stream level (part of section was covered):

Measured section at location 9, sec. 33, T. 5 N., R. 8 E.

		Thickness (ft)	Altitude of top formation exposed (ft)
2.	Jeffersonville Limestone and Geneva Dolomite, undifferentiated	38	615
	Louisville Limestone	6	577
	Waldron Shale	4	571
1.	Laurel Limestone	16	567

In the north bank of Big Graham Creek, the following composite geologic section was measured above stream level (part of section was covered):

Measured section at location 8, sec. 33, T. 5 N., R. 8 E.

		Thickness (ft)	Altitude of top formation exposed (ft)
2.	Jeffersonville Limestone	17	607
	Geneva Dolomite	18	590
	Louisville Limestone	5	572
	Waldron Shale	4	567
1.	Laurel Limestone	3	563

The spillway altitude of a dam at site D cannot be placed higher than about 610 feet without the possibility of serious leakage through the top of the Jeffersonville Limestone. In the north bank of Big Camp Creek below State Route 3 about half a mile west of dam site D, the following composite geologic section was measured above stream level:

Measured section at location 21, sec. 4, T. 4 N., R. 8 E.

		Thickness (ft)	Altitude of top of formation (ft)
3.	North Vernon Limestone	22	645
2.	Jeffersonville Limestone	28	623
	Geneva Dolomite (mostly covered)		
	Louisville Limestone	26	595
	Waldron Shale (mostly covered)		
1.	Laurel Limestone	13	569

Limestone quarries might be opened at either site C or D in the limestone that forms the valley walls. Fine-grained fill material is available in the upland areas, but these deposits are likely to be rather thin (10 to 20 feet thick) and to have some variability in character.

Spillway locations for the two dams would be limited to the dam sites themselves unless extensive excavation is done through one of the ridges that would form the reservoir rim.

CONCLUSIONS

Discussion of the relative merits of the several dam sites pertains to two areas because the geologic setting and problems are the same for dam sites A and B and for dam sites C and D.

Sites A and B have potentially serious problems with regard to leakage through solution channels in the upper part of the Jeffersonville Limestone and in the North Vernon Limestone and with regard to rapid erosion of the New Albany Shale below the spillway structure. The latter problem is a matter of design, but the problem of leakage through solution channels can require an extensive test-drilling and pressure-grouting program for correction not only along the axis of the dam but also along the reservoir rim upstream to the point where the base of the North Vernon Limestone would be above water level. Both dams would be long and relatively high but sufficient fill material, although relatively thin, is available within a reasonable distance of the sites. Several adequate spillway sites exist at low points in the reservoir rim both north and south of the dam sites.

Leakage problems should be minor at sites C and D if the spillway altitude is 5 to 10 feet below the top of the Jeffersonville Limestone. Both dams would be short. Fill material is available in the upland areas, but because of the thinness of the unconsolidated materials overlying the bedrock, borrow pits may be large. The spillways for both dams either would be situated close to the dam sites or would require extensive excavation in bedrock. The spillway altitude of dam site D would be about the same as those of dam sites A and B, and the spillway altitude of dam site C would be 10 feet or more lower. The combined storage of dam sites C and D would be considerably less than that for either dam site A or B.

The geologic terrane along the outcrop of the Silurian and Devonian formations in areas to the north and south is similar to that described in this report. For this reason dam and reservoir sites in these areas would have a similar suite of geologic features and most of the engineering characteristics listed above.

LITERATURE CITED

American Society for Testing Materials, 1958, Book of standards; Part 4, Cement, concrete, mortars, road materials, waterproofing, soils, p. 1099-1228, illus., tables.

Casagrande, Arthur, 1947, Classification and identification of soils: Am. Soc. Civil Engineers Proc., v. 73, no. 6, p. 783-810, pt. 1, 6 figs., 4 tables.

Cox, E. T., 1876, Seventh annual report of the Geological Survey of Indiana, made during the year 1875: Indianapolis, 601 p., 2 pls., 1 fig., 4 maps.

Dawson, T. A., 1941, The Devonian formations of Indiana; Part 1, Outcrop in southern Indiana: Indiana Div. Geology, 48 p., 4 pls., 20 figs.

Esarey, R. E., Malott, C. A., and Galloway, J. J., 1947, Silurian and Devonian formations in southeastern Indiana: Indiana Div. Geology Field Conf. Guidebook 1, 22 p., 2 pls.

Malott, C. A., 1922, The physiography of Indiana, *in* Handbook of Indiana geology: Indiana Dept. Conserv. Pub. 21, pt. 2, p. 59-256, 3 pls., 51 figs.

Murray, H. H., 1955, Sedimentation and stratigraphy of the Devonian rocks of southeastern Indiana: Indiana Geol. Survey Field Conf. Guidebook 8, 73 p., 7 pls.

Patton, J. B., 1949, Crushed stone in Indiana: Indiana Div. Geology Rept. Progress 3, 47 p., 1 pl.

U. S. Weather Bureau, 1956, Climatological data, annual summary, Indiana.

Wayne, W. J., 1956, Thickness of drift and bedrock physiography of Indiana north of the Wisconsin glacial boundary: Indiana Geol. Survey Rept. Progress 7, 70 p., 1 pl., 10 figs.

White, W. A., 1958, Water sorption properties of homoionic clay minerals: Illinois Geol. Survey Rept. Inv. 208, 46 p., 16 figs., 4 tables.

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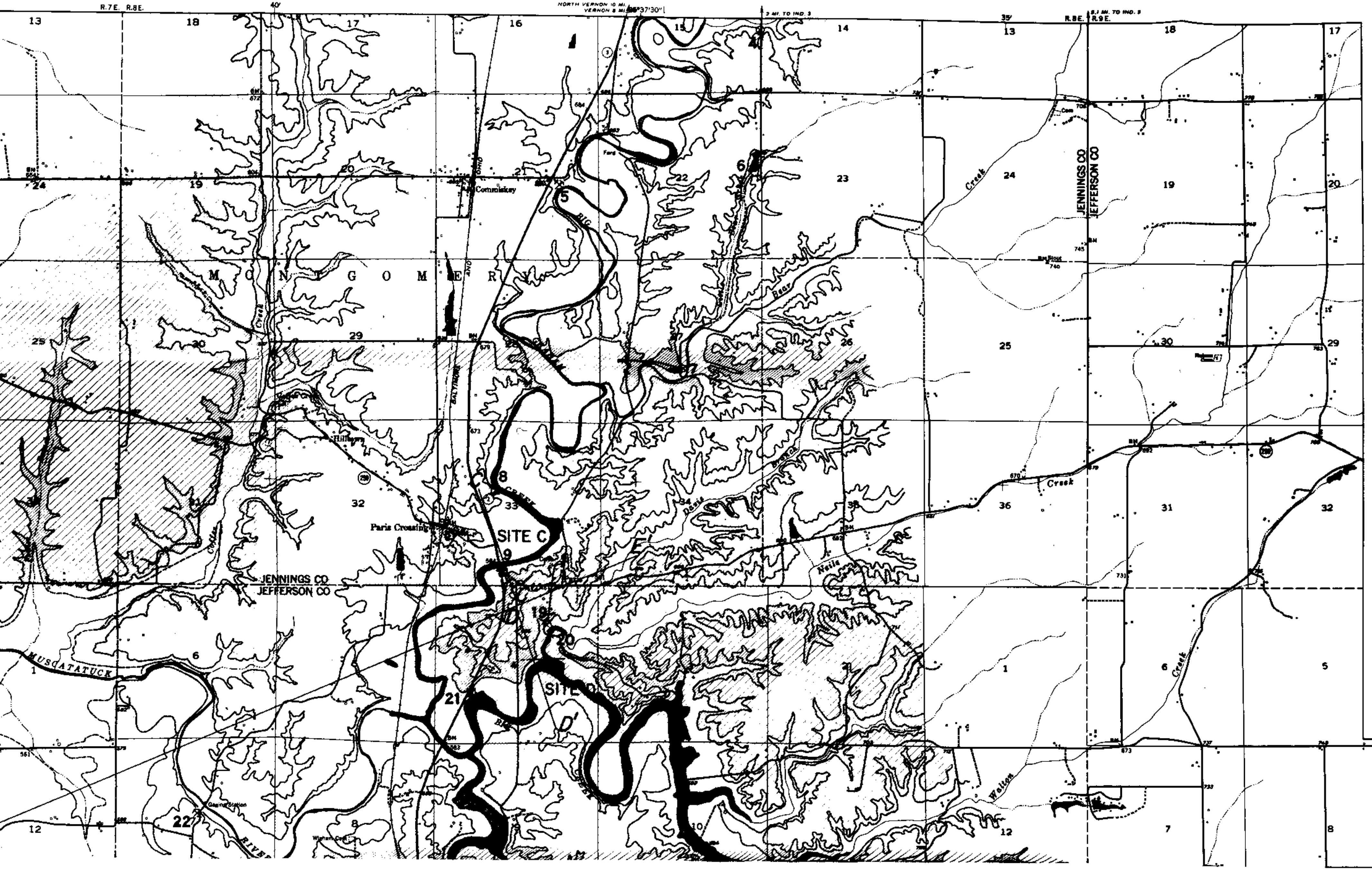
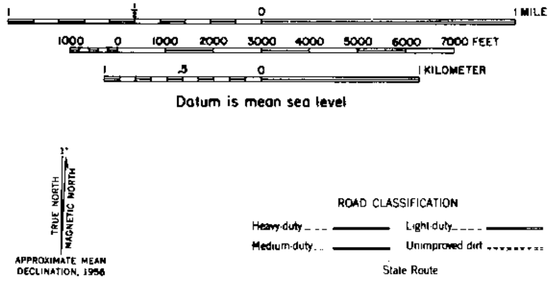


AGE	FORMATION OR TYPE OF DEPOSIT	THICKNESS IN FEET	MAP SYMBOL	UNIT NO.*	LITHOLOGIC DESCRIPTION
PLEISTOCENE	Alluvium	0–40		5	Recent floodplain deposits; principally water deposited sand, silt, and clay, but also containing some gravel and organic deposits
	Loess	0–10	SHOWN ON CROSS SECTIONS ONLY		Wind deposited silt
	Terrace deposits	0–20			Sand, silt, clay, and some gravel
	Glacial till	0–15			Silty to sandy clay with some pebbles
DEVONIAN	New Albany Shale	70+		4	Black, fissile, bituminous shale; weathers rapidly to a mass of small, thin, light gray to tan chips
	North Vernon Limestone	10–25		3	Gray to gray-brown, fine-grained to coarsely crystalline, fossiliferous limestone. Numerous sinkholes and other solution features
	Jeffersonville Limestone	50–70		2	Gray to chocolate brown, sugary to crystalline dolomitic limestone; contains thin chert beds. Numerous corals occur in the lower part of the formation
	Geneva Dolomite				Chocolate brown sugary dolomite; contains white calcite masses and many fossil corals
SILURIAN	Louisville Limestone				Tan to yellow-tan, finely crystalline, dolomitic limestone
	Waldron Shale				Light blue-gray calcareous shale or argillaceous limestone
	Laurel Limestone	50–60	■	1	Light gray to tan; thin-bedded, dolomitic and argillaceous limestone
	Osgood Formation				Light gray to tan, thin-bedded, calcareous shale and limestone

*Numbers refer to unit descriptions in text.



Datum is mean sea level

×2
Exposure

⊗4
Sample site

⚒18
Quarry

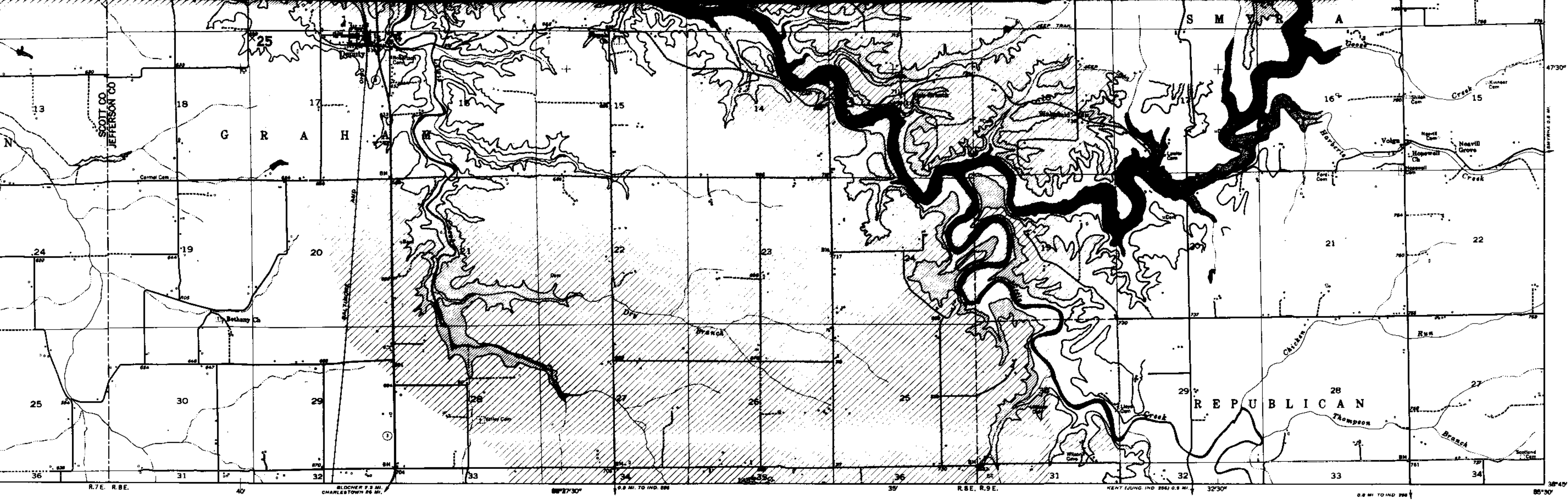
○10
Auger hole

■21
Measured section
Numbers refer to table I.

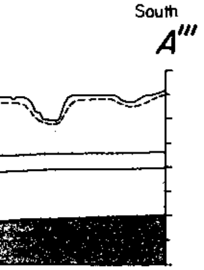
Determinate contact between bedrock units

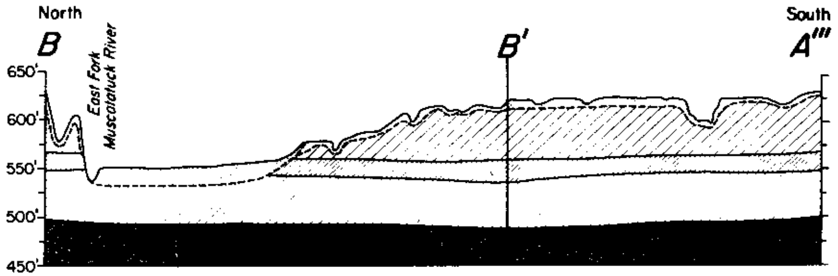
Indeterminate contact between floodplain deposits and bedrock units

Vertical exaggeration of cross sections, 20 times

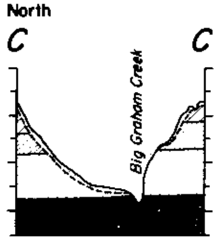


INDEX MAP SHOWING MAPPED AREA





DAM SITE B



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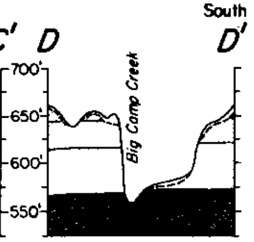

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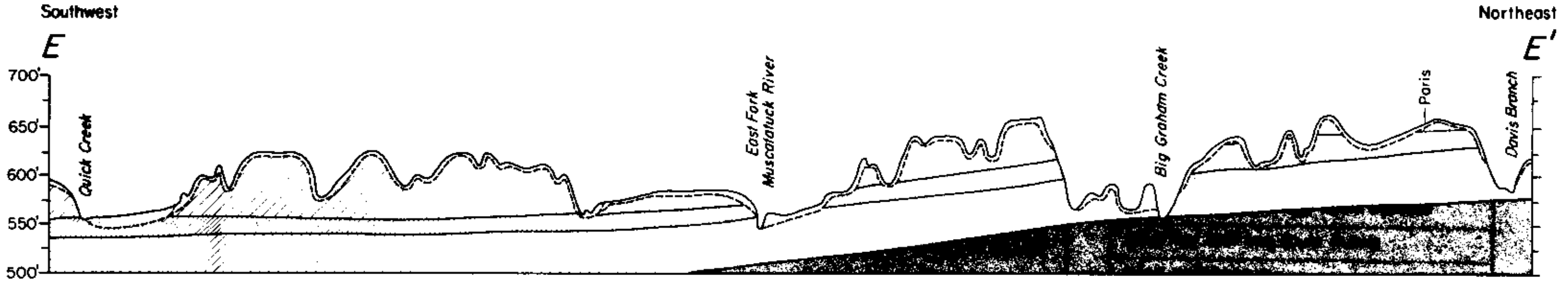


SOUTHWEST-NORTHEAST CROSS SECTION

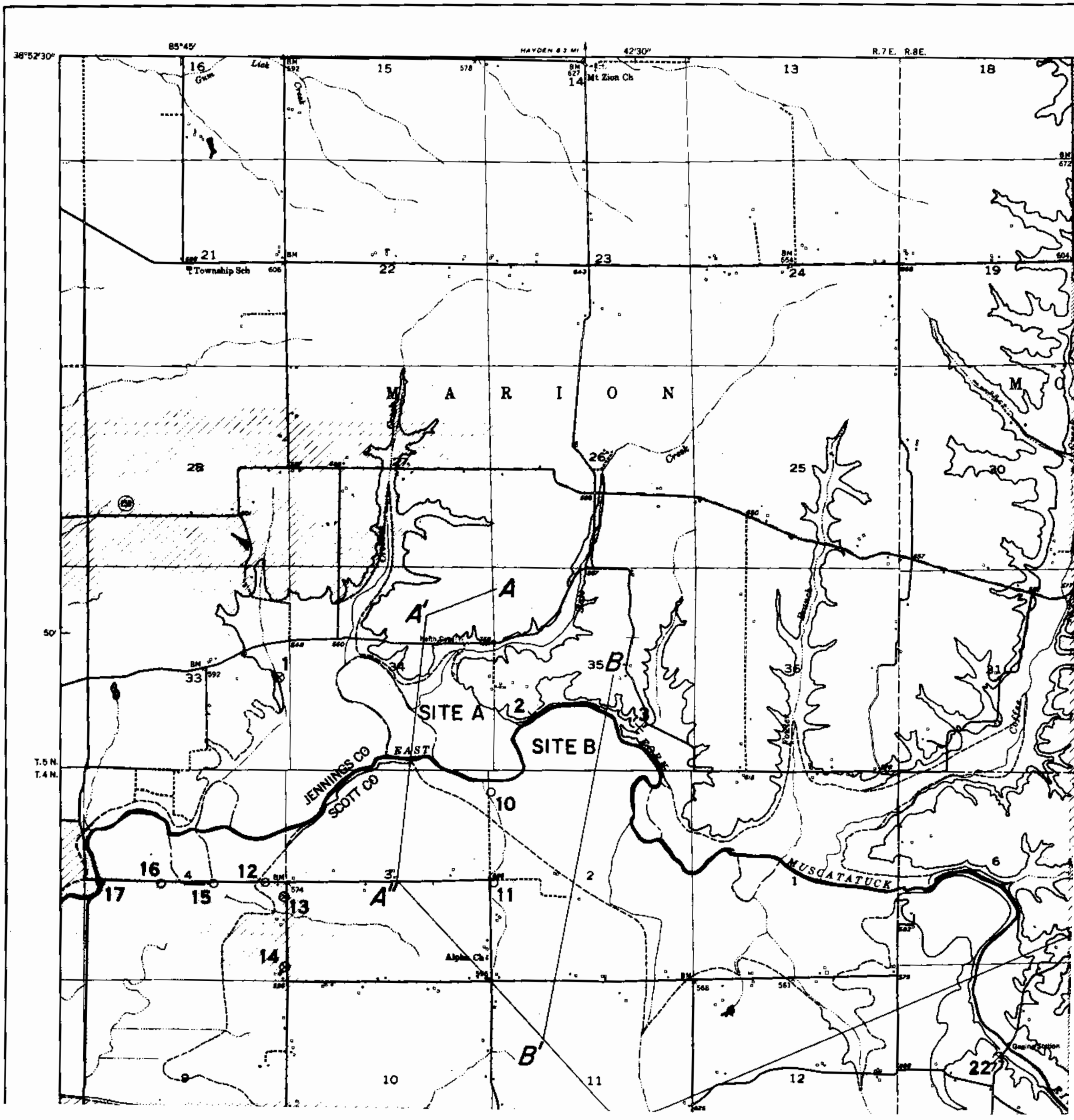
PROPOSED DAMSITES AND RESERVOIR AREAS ON EAST FORK OF MUSCATATUCK RIVER IN SCOTT, JENNINGS, AND JEFFERSON COUNTIES, INDIANA

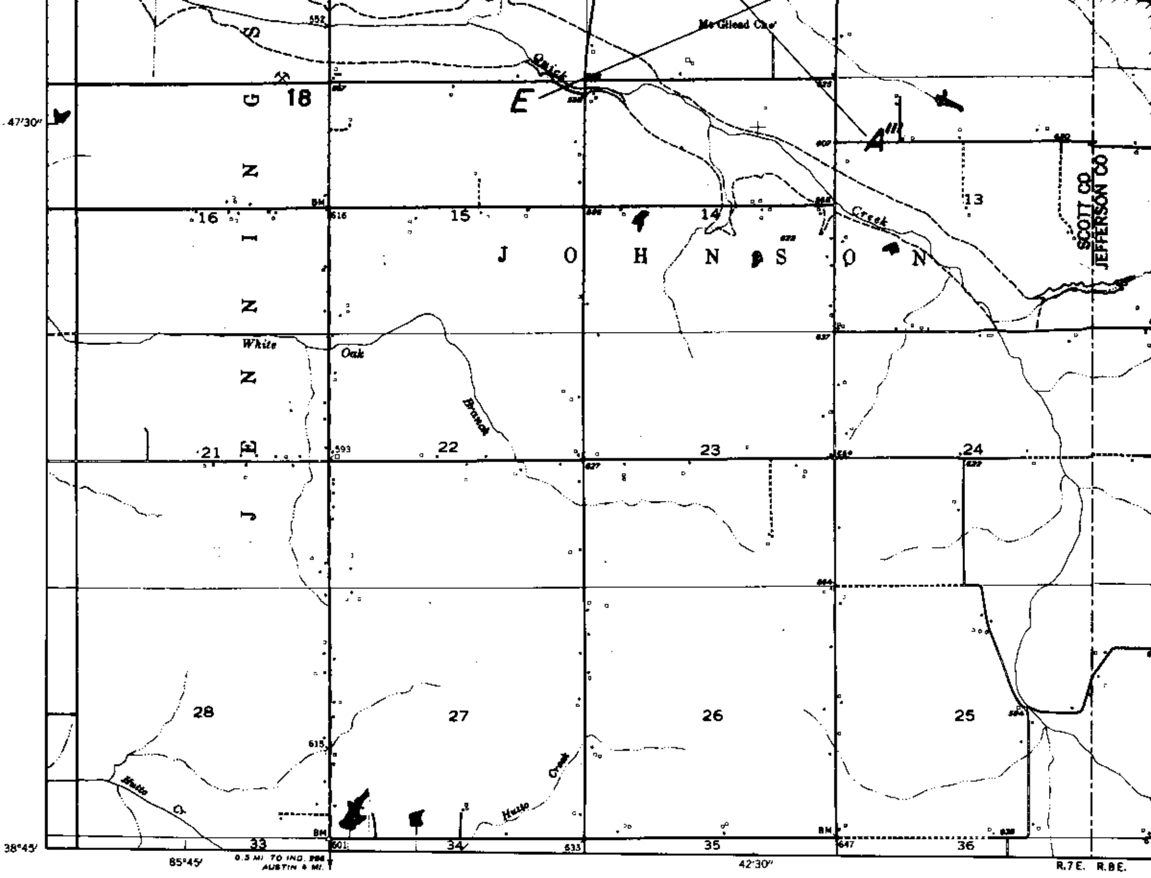
Geologic mapping, September 1958
Drafted by John E. Peace

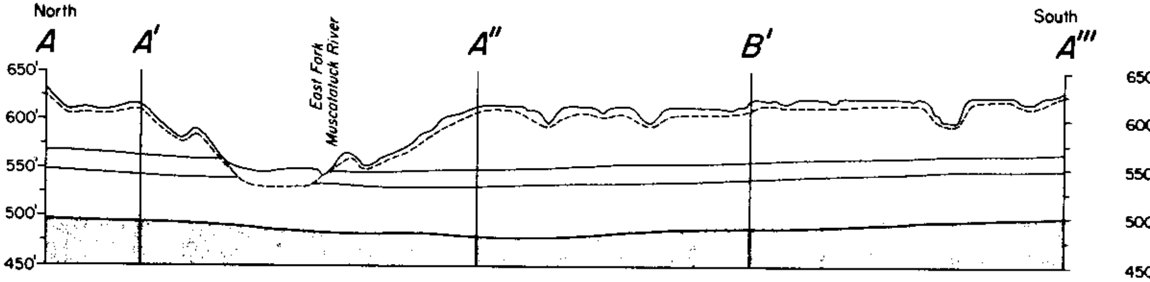
By John D. Winslow

1960

GEOLOGICAL SURVEY
JOHN B. PATTON, STATE GEOLOGIST







DAM SITE A

Base from U. S. Geological Survey topographic quadrangle maps, scale 1:24,000.

GEOLOGIC MAP OF PROPOSED DA