# Some Applications of Geology to the Location of Dam Sites in Indiana

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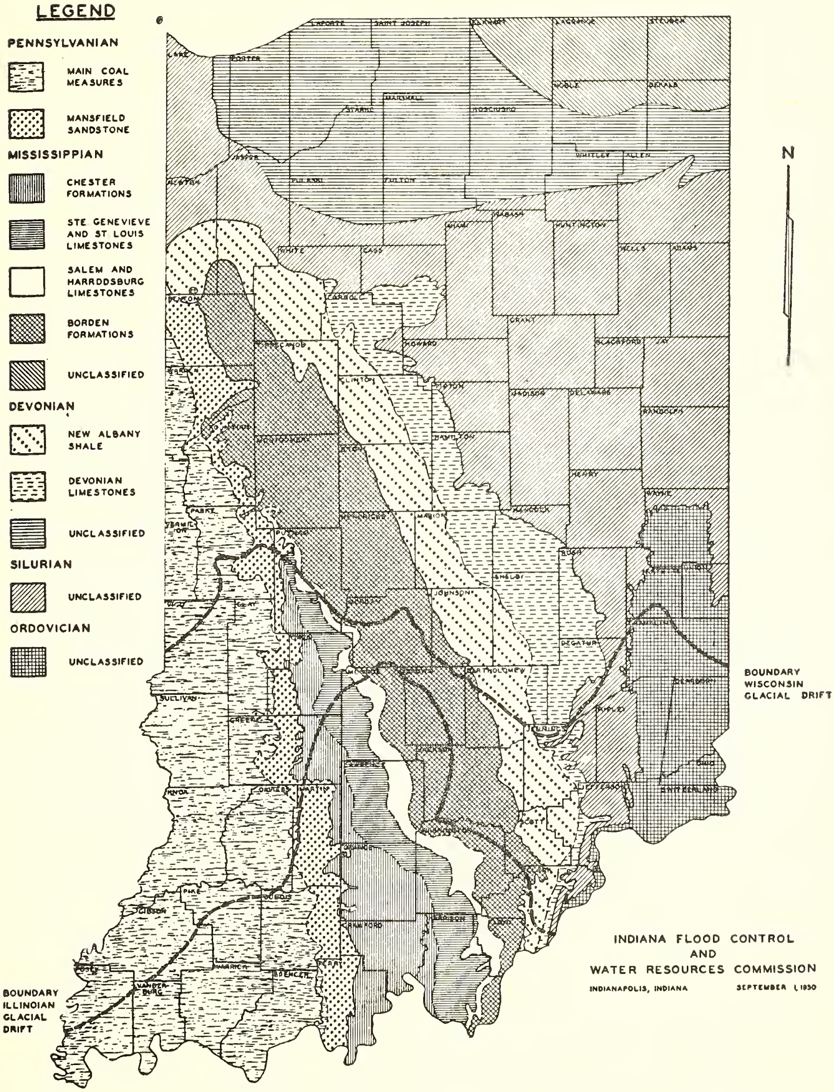
The greatly increased interest and activity in collecting and controlling surface waters by impounding for flood control, water supply, hydroelectric development, and recreational purposes has made geology an increasingly important factor in engineering work in Indiana. The purpose of this report is to describe some of the general and specific geologic conditions in Indiana which will affect the economics, effectiveness, and safety of dam sites. The observations incorporated herein are primarily those made by the writer while on the technical staff of the Indiana Flood Control and Water Resources Commission from 1947 to 1950. Over fifty suggested sites and numerous completed sites were observed and studied during this period. Reports covering many of these investigations are in the files of the Indiana Flood Control and Water Resources Commission in Indianapolis.

Numerous requisites for a satisfactory reservoir have been set forth by various writers. Very few dam sites in Indiana are ideal from strictly a geologic point of view. All rock at the surface has been attacked by the various weathering agencies, and this weathering has not affected the rocks uniformily. Joints, bedding planes, and miscellaneous fractures are to be found in the rock. Solution openings occur in carbonate rocks and may extend for considerable distances. Porous sands and gravels are common in unconsolidated deposits. The geologist, therefore, is primarily concerned with determining the tightness of the retaining basin, the foundation of the dam and associated structures, available materials of which to construct the dam, and amount and character of materials which will be deposited by streams flowing into the reservoir. The identification of earth materials at the site of a proposed dam and reservoir is one of the simplest tasks of a geologist assigned to a project. On the other hand, the geologist has a very responsible job when it comes to the correct interpretation of the results obtained.

The geologist is not concerned with the methods by which the dam is constructed, except in relation to the local geological conditions, but is primarily interested in the load that the dam will form and the depth to which it is to be constructed in order to stop possible leakage. The most common type of dam site in Indiana lies in a narrow part of a valley where the rock of the abutments of the site is more or less visible, but in the bottom of the valley bedrock is hidden by alluvium and outwash. The first problem for the geologist is to determine the depth to bedrock in the valley. If the stream is aggrading the depth of alluvial fill may be very great, whereas if the stream is still degrading its bed the alluvium over which it runs is probably very thin. Limestones and sandstones found in Indiana should be sufficiently competent to support a dam. On the other hand, many shales and clays may not be able to

GENERALIZED GEOLOGICAL MAP




ADAPTED FROM GEOLOGICAL MAP OF INDIANA. INDIANA DEPARTMENT OF CONSERVATION. DIVISION OF GEOLOGY. PUBLICATION NO. 112. 1932.

FIGURE I

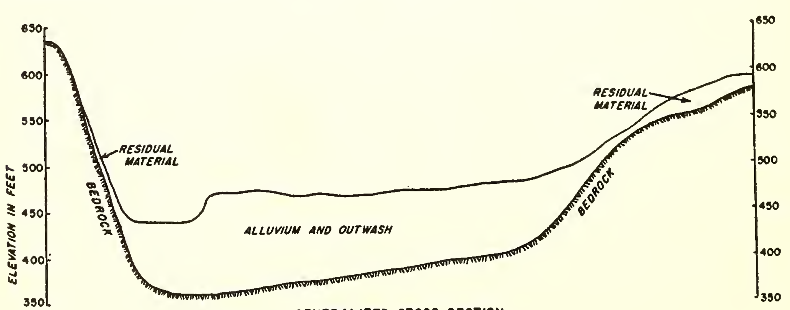
resist the load of man-made structures imposed upon them or their equilibrium might be disturbed if overlying material are removed. Examples of such disturbances have been observed along some of the highways within the state and it is not unreasonable to expect a repetition of this phenomena at dam sites if care isn't exercised in the selection of the site.

Requirements concerning leakage for dams vary according to the use intended for the resulting reservoir and the effect upon the dam itself. Leakage should not be serious where the impounding rocks are sandstone, shale, siltstone, or till. Where limestones, sands, and gravels are present serious leakage may occur. The seriousness of this leakage is due not only to the occurrence of voids in these latter earth materials but also because such openings might enlarge under the increased pressure due to impounding of water in the reservoir.

Since some method must be provided by which excess waters may pass a dam, the geologist is concerned with the erosive effect of the earth materials in and along the spillway site and the route of the spillway waters.

Approximately five-sixths of the total area of Indiana has been subjected to glaciation (Figure 1). Consequently, glacial deposits, including both glacial drift and glacial outwash, are the most common earth materials encountered along Indiana's streams.

Since the heterogenity of glacial materials and the complexity of their arrangement are well known many geologic conditions enter into engineering problems for dam and reservoir sites in glaciated areas. In addition to avoiding glacial deposits containing bodies of porous sand and gravel, the problems of providing a foundation for a dam and an opportunity for building a safe and ample spillway to dispose of surplus water are also important requisites. Ordinarily, glacial till can be expected to support an earth and rock filled dam. On the other hand, because glacial materials are generally unconsolidated, spillways must be lined with concrete, which necessarily adds to the expense of the installation.




GENERALIZED CROSS SECTION
OF
EAST FORK OF WHITE RIVER VALLEY
NEAR SHOALS, INDIANA
*ADAPTED FROM U.S. CORPS OF ENGINEERS DATA*

FIGURE 2

Streams in or adjacent to glaciated areas often carried glacial meltwaters and glacial debris. Many such streams are filled to a great depth with unconsolidated deposits. Lower Wabash River, both forks of White River (Figure 2), both forks of Whitewater River, and numerous smaller streams are examples. Opportunities for leakage under and around a dam constructed across such a valley probably would be great. The installation of costly cores of impervious materials would be necessary to prevent the loss of water and damage to the dam itself. However, with everything else being satisfactory these latter valleys could be used for dry dams for flood control purposes similar to those in the Miami Valley of Ohio.

Many of the streams in the glaciated area are young, geologically speaking. Their valleys are frequently narrow and shallow. Consequently, their capacities for storing waters are quite limited. This factor must be taken into consideration when planning a reservoir for flood control or water supply purposes.

The effects of glaciation are further noticed because of derangments and modifications of drainage systems which existed prior to the advance of the ice sheets. In the region of Wisconsin glaciation drainage lines have been developed in a thick blanket of glacial drift which was deposited over an irregular and eroded bedrock surface. Preglacial and interglacial bedrock valleys are present, though usually hidden from view. Great streams, like Wabash, Mississinewa, Salamonie, Eel, Tippecanoe, Iroquois, and many others intermittently encounter bedrock and glacial drift at many places along their routes (3). Usually at the places where a stream encounters bedrock narrow outlets occur which require

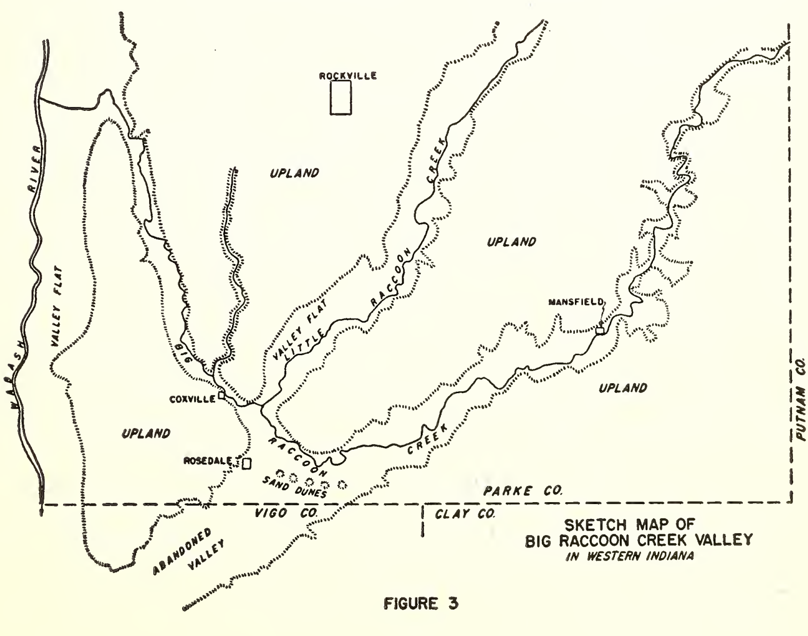
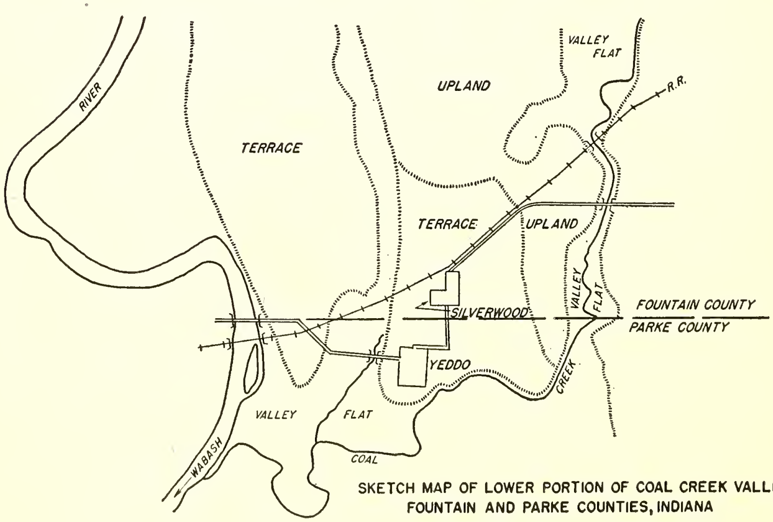



FIGURE 3

relatively small and economical dams, with foundations able to sustain the structure. However, at relatively short distances away it is just as common to find glacial materials at low levels because of the low elevation of the dissected bedrock surface. It is the geologist's responsibility to determine the character and extent of such sediments and whether or not impounded waters can be retained in the proposed basin. To avoid leakage of water from the basin of the reservoir the reservoir either must be lined or located at such a place that leakage into the ground is resisted by natural conditions. Inasmuch as the cost of lining a large reservoir is prohibitive, the latter qualification is a prime requisite. Unless the dam and the adjoining rocks are impervious to water serious leakage may occur.

There are numerous examples in Indiana of deranged drainage lines which appear to offer excellent opportunities for impounding surface waters. Big Raccoon Creek (Figure 3) is one of the most striking examples. The course of this stream was altered during or just after glacial times. From its junction with the Wabash River upstream to Rosedale the stream occupies a deep and relatively narrow valley which was tributary to its preglacial ancestor. At Coxville the constricted valley is associated with a thick deposit of sandstone, overlying Coal III and partly digging below it for a short distance. Immediately upstream from Rosedale the valley widens suddenly and spectacularly where it meets a valley which was a discharge route of glacial meltwaters. The drainage divide at this point is barely forty feet above the flood plain of the stream. It would be possible to locate a dam in the vicinity of Coxville, but a long, high dike or levee would be required to cross the low point in order to impound water in Big Raccoon Creek valley here. Other constrictions in Big Raccoon Creek valley occur near




SKETCH MAP OF LOWER PORTION OF COAL CREEK VALLEY, FOUNTAIN AND PARKE COUNTIES, INDIANA

FIGURE 4

Mansfield. However, a buried valley, which represents part of the former route of Big Raccoon Creek, is present. Although this valley has not been traced in detail, it is known to contain a quantity of sand and gravel.

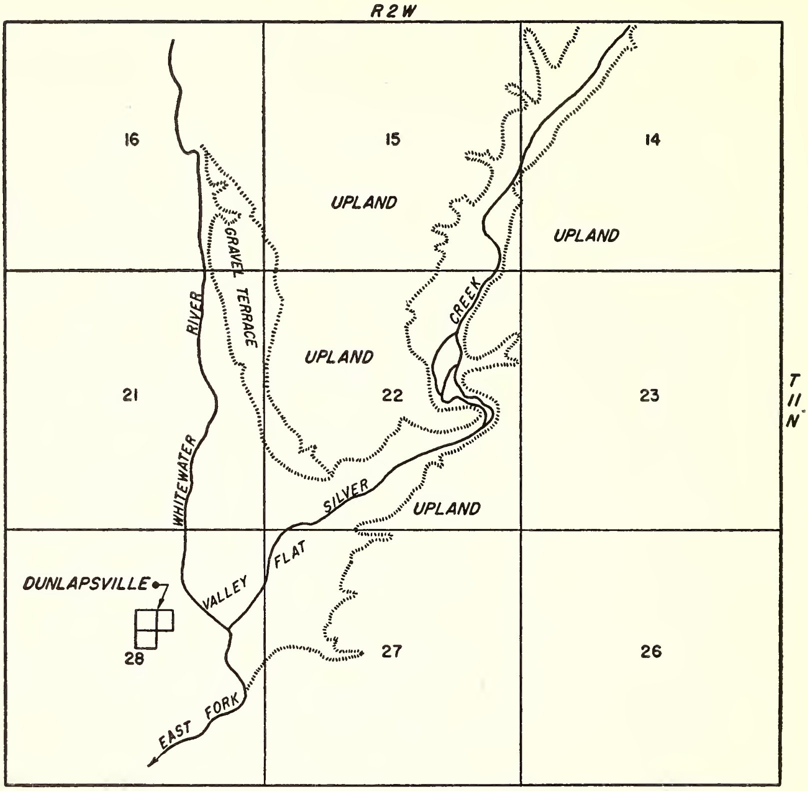
The character of the valley of Coal Creek near Silverwood also is unusual (Figure 4). The stream flows through a narrow rock-walled valley a short distance east of Silverwood, but immediately upstream the valley widens many times. The shape of the valley is made even more unusual by the rectangular cul-de-sac which extends in a southwesterly direction. This anomaly has been carved out of soft sands and undoubtedly marks a former route of Coal Creek. Test holes for coal immediately north of Silverwood have revealed an extension of this valley and confirm its significance.

The situation on the lower part of Silver Creek valley, a tributary of East Fork of Whitewater River in Union County, is not greatly unlike that described on Coal Creek. Silver Creek is a relatively short stream but occupies a rather broad valley. This stream even assumes braided characteristics as it nears the junction with East Fork of Whitewater River (Figure 5). About one and one-fourth miles upstream from this confluence the stream encounters a bedrock ridge of Upper Ordovician strata. The valley narrows abruptly as it crosses the ridge and then widens again just a few hundred yards down stream. Gravels from one-eighth to one-fourth inch in diameter were observed at the base of the little neck, or spur, of land near its junction with the upland mass between Silver Creek and East Fork of Whitewater River. Records of borings made for the Indiana Department of Conservation confirm the presence of a sand and gravel filled valley across this long, narrow spur which is only about 700 feet wide at its narrowest part.

Conditions similar to those described on the valleys of Big Raccoon, Coal, and Silver Creeks occur on Bean Blossom Creek near its junction with West Fork of White River. Bean Blossom Creek crosses a bedrock ridge at Mt. Tabor, in western Monroe County, through a narrow valley. Immediately upstream and down stream from this site the valley widens abruptly, suggesting modification of this drainage system due to glaciation. It has been reported by Mr. L. R. Gray of Gosport, Indiana, that a water well in the southwest quarter of section 3, T. 10 N., R 2 W., was drilled 207 feet deep without encountering bedrock. The entire section consisted of sand and blue mud. The deep hollows to the west and southwest also contain fine sand and clay. Thus, it would appear that the preglacial valley of Bean Blossom Creek lies immediately north of its present channel at Mt. Tabor.

The conditions in Mill Creek valley in Owen and Putnam Counties, which were described by the writer (2) at an earlier date, are also similar to the streams and valleys just described.

The possible hazards which accompany the location of a dam site in a limestone terrain have long been recognized. In Putnam, Owen, Monroe, Lawrence, Greene, Orange, Washington, Harrison and Crawford counties, Indiana, there is an area of approximately 2000 square miles with limestone at or near the surface. According to the late Dr. C. A.




SKETCH MAP OF PORTION OF SILVER CREEK VALLEY
IN
UNION COUNTY INDIANA

FIGURE 5

Malott[1] 680 square miles are wholly characterized by sinkholes and 100 percent underground drainage, 350 square miles are karst valley areas, while 750 square miles are characterized by occasional to numerous sinkholes and partial underground drainage. There are also 150 square miles in Jennings, Jefferson and Clark Counties, Indiana, characterized by sinkholes, some swallowed drainage, and occasional caverns.

The Middle Mississippian limestones, particularly the St. Louis and Ste. Genevieve formations, are notoriously cavernous and are generally considered risky as retainers for impounded waters. However, karst features are common in other Mississippian formations. Only the thin Rockford, Floyds Knob, Reelsville, Vienna, and Clore limestones of the Mississippian limestone formations are without conspicuous solution

[1] Personal communication, 1950.

features. Masses of limestone in the form of bioherms are present occasionally in the Borden Group, a series of formations generally considered as among the most impervious and impermeable rocks in Indiana. Such a limestone deposit exists in the narrow ridge between Salt and Allens Creeks in southeastern Monroe County. This limestone is well jointed and contains a small cavernous opening. A reservoir located at this point might be subject to serious leakage unless the height of the dam were restricted.

Several streams, including Indian creek in Lawrence and Martin Counties, Lost River, Blue River, and Big Indian Creek in Harrison County, flow long distances across these limestone terrains. Swallow holes, subterranean cut-offs, springs, caverns, and other features evidencing movement of ground waters and solution work abound along these streams and their tributaries offering warnings of unsatisfactory conditions for extensive impounding of surface waters. Low dams with small reservoirs in limestone areas can frequently be successful retainers for small local water supplies because of the alluvial and residual clays which usually cover the valley floor and flood plain.

Caverns and sinkholes are also common in Devonian and Silurian limestone formations, particularly the Jeffersonville limestone, along the upper part of Muscatatuck River and its tributaries. Meek Cave, located six miles southwest of North Vernon, is an example.

No attempt will be made here to describe the multitude of conditions found along all of Indiana's streams. Such is not the purpose of this report. Rather an attempt has been made to point out certain types of problems which are present and the outstanding features which characterize them. Dams and reservoirs in Indiana have been or will be constructed under a variety of geological conditions. No two sites will be alike. Each site must be studied and analyzed individually, keeping in mind the purpose desired and the limitations imposed thereon. Consequently, geology will continue to be an important factor in engineering. Dams for water supply, flood control, and hydroelectric power are desirable and necessary for the development of Indiana. By proper application of geologic data to sound engineering practices not only can many costly construction problems be avoided, but also chances of disastrous dam failures, such as the classical example of the St. Francis Dam in California in 1928 (1), can be in a large part prevented.

## Literature Cited

1. LONGWELL, C. R. 1928. Lessons from the St. Francis Dam. Science, n. ser., 68:36-37.

2. MCGRAIN, PRESTON. 1949. Geological features of the proposed Cagle's Mill flood control reservoir, Ind. Acad. Sci., Proc. 1948, 58:163-172.

3. ———— 1951. Thickness of glacial drift in north central Indiana, Ind. Flood Control and Water Resources Commission, Circular No. 1.