Geologic Guidelines for Statewide and Regional Land-Use Planning in Indiana[1]

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Abstract

Effective land-use planning attempts to evaluate the impact of change before changes take place. Geologic data are essential to this process. The Indiana Geological Survey's recently completed 1:250,000 scale mapping of the state makes geologic information on a statewide basis available, but most planners are not qualified to interpret geologic data directly. Although they recognize the importance of these data to their work, the land-use implications of conventionally mapped geologic units usually must be explained to them.

In this report, each of the 38 geologic units shown on the statewide mapping is evaluated for 11 kinds of land use that range from undisturbed woodland to heavy industry. Taken into account in each rating are many factors; among them are frequency of flooding, position of the water table, slope stability, bearing strength, erodibility, septic tank performance, and many others. These factors should next be quantified so that the present ratings may be made more objective. Additional data will be needed on several of the mapped units.

Geology in Land-Use Planning

The eight Regional Geologic Maps prepared by the Indiana Geological Survey (see list below) provide information that is aimed at filling the needs of land-use planners and others who require a state-

List of Regional Geologic Maps

(unnumbered) Geologic map of Indianapolis 1° x 2° Quadrangle, Indiana and Illinois, showing bedrock and unconsolidated deposits. Scale, 1:250,000. By C. E. Wier and H. H. Gray, 1961.

No. 2. Geologic map of the 1° x 2° Danville Quadrangle, Indiana and Illinois, showing bedrock and unconsolidated deposits. Scale, 1:250,000. By W. J. Wayne, G. H. Johnson, and S. J. Keller, 1966.

No. 3. Geologic map of the 1° x 2° Vincennes Quadrangle and parts of adjoining quadrangles, Indiana and Illinois, showing bedrock and unconsolidated deposits. Scale, 1:250,000. By H. H. Gray, W. J. Wayne, and C. E. Wier, 1970.

No. 4. Geologic map of the 1° x 2° Chicago Quadrangle, Indiana, Illinois and Michigan, showing bedrock and unconsolidated deposits. Scale, 1:250,000. By A. F. Schneider and S. J. Keller, 1970.

No. 5. Geologic map of the 1° x 2° Muncie Quadrangle, Indiana and Ohio, showing bedrock and unconsolidated deposits. Scale 1:250,000. By A. M. Burger, J. L. Forsyth, R. S. Nicoll, and W. J. Wayne, 1971.

No. 6. Geologic map of the 1° x 2° Louisville Quadrangle, Indiana, showing bedrock and unconsolidated deposits. Scale 1:250,000. By H. H. Gray, 1972.

No. 7. Geologic map of the 1° x 2° Cincinnati Quadrangle, Indiana and Ohio, showing bedrock and unconsolidated deposits. Scale 1:250,000. By H. H. Gray, J. L. Forsyth, A. F. Schneider, and A. M. Gooding, 1972.

No. 8. Geologic map of the 1° x 2° Fort Wayne Quadrangle, Indiana, Michigan, and Ohio, showing bedrock and unconsolidated deposits. Scale 1:250,000. By G. H. Johnson and S. J. Keller, 1972.

Supp. Chart 1. Properties and uses of geologic materials in Indiana. By H. H. Gray, 1973.

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[1] Publication authorized by the State Geologist, Indiana Geological Survey.

wide overview of the properties and extent of near-surface bodies of earth materials. Both bedrock and unconsolidated deposits are shown by a two-layer mapping system, and the descriptions and diagrams that accompany the maps are intended to convey an understanding of the areal and vertical distribution, thickness, material content, and interrelationships of each of the 38 mapped geologic units. A supplementary chart provides additional related information. In preparing these publications, particular effort was made to insure that they would be understood by the non-geologist.

The principal use of these maps in the planning field is in preparing land-use suitability interpretations. Some of these interpretations may be made directly from the maps through the use of common knowledge or through association. For example, areas mapped as alluvial deposits (unit Qsa) are subject to flooding; sand and gravel must be searched for in kame and outwash deposits (units Qgk, Qgv, and Qgp); and dune sands (unit Qsd) are especially well suited to the growing of melons.

Most land-use suitability interpretations, however, require the evaluation of a large number of geologically related factors. Among these are frequency of flooding, soil and rock permeability, position of the water table, erosion hazard, slope stability, erodibility, topographic relief, ease of excavation, engineering properties such as unconfined compressive strength and liquid and plastic limits of the soil, and many others. Few of these factors are primary properties of the geologic material itself. Most are derivative of these properties or derivatives of the derivatives. Many of the factors are interrelated, some are difficult to evaluate, and all are important for some geologic materials and some uses but unimportant to others. Thus the evaluation process is complex.

Few land-use planners are well qualified to make these evaluations without assistance. The planning process is essentially a political one and the geologic, biologic, sociologic, and economic input to the process must usually be prvided by specialists. Geologic data may (at least in part) be provided by soil scientists, engineers, or hydrologists as well as geologists, but the geologist brings an ecumenical outlook and an appreciation of the inevitability of change through time that are of value to the planning process.

Geologic Land-Use Suitability Interpretations

The accompanying tables (Tables 1 and 2) present suitability interpretations of mapped geologic units for selected kinds of land use. They are to be used in conjunction with the Regional Geologic Maps and Supplementary Chart 1, and they are to be regarded as preliminary for two reasons. First, they represent qualitative and somewhat subjective assessments that can be improved by quantification, and second, they relate to mapping that ultimately may be replaced by more detailed work. For example, far more elaborate land-use suitability interpretations are available for the 20 or so counties in Indiana that are covered by modern soil mapping of the Soil Conservation Service. When this series is completed for the entire state, as is projected some

TABLE 1. *Suitability interpretations of mapped unconsolidated deposits in Indiana for selected general uses.*

Geologic unit	Summary description[1]	Area: Square miles	Area: Percent of state	Woodland, undisturbed	Woodland, logged	Grassland, undisturbed	Grassland, pastured	Row crops	General recreation	Isolated dwellings	Grouped dwellings	Subdivision development[2]	General urban	Heavy industry
Qm	Made, modified land[3]	200	tr.	A	B	B	B	D	B	B	C	C	D	C
Qsa	Alluvium; silt, sand	2500	7	A	B	A	A	A	B	D	D	D	D	D
Qmp	Muck, peat	500	1	A	D	A	C	B[5]	D	D	D	D	D	D
Qgm	Muck over gravel	500	1	A	B	A	B	B[5]	D	D	D	D	D	D
Qsd	Dune sand	700	2	A	C	A	C	C[6]	D	B	C	D	D	C
Qs	Sheet sand	400	1	A	B	A	B	C	D	D	D	D	D	D
Qsb	Beach sand	200	tr.	A	B	A	B	C[6]	C	B	B	B	B	C
Ql	Windblown silt (loess)	1300	4	A	B	A	A	B	B	A	B	B	B	B
Qcl	Lake clay	1200	3	A	B	A	B	C	C	C	D	D	D	D
Qsl	Lake silt	300	1	A	B	A	A	B	B	B	C	C	C	D
Qgv	Valley-train sand, gravel	2200	6	A	B	A	B	B	B	B	B	B	B	B
Qgp	Outwash-plain sand, gravel	1500	4	A	A	A	A	A	B	B	B	B	B	B
Qgk	Kame gravel	300	1	A	B	A	B	C	B	A	B	C	C	C
Qsi	Old alluvium; silt, clay	100	tr.	A	B	A	B	B	B	A	B	B	B	B
Qgt	Mixed gravel and till	30	tr.	A	B	A	B	C	B	B	C	C	D	D
Qts	Thin sand over clay	100	tr.	A	B	A	B	B	B	C	C	D	D	C
Qt	Wisconsinan till	11700	32	A	A	A	A	A	A	A[7]	A[7]	A[7]	A[7]	B[7]
Qte	Wisconsinan moraine till	4200	12	A	B	A	A	A	A	A[7]	A[7]	A[7]	A[7]	B[7]
Qtl	Wisconsinan lake-bottom till	200	tr.	A	B	A	A	A	B	C	D	D	D	D
Qti	Illinoian till	3500	10	A	B	A	B	B	B	A	B	B	B	B
Qtk	Kansan till[4]	—	—	—	—	—	—	—	—	—	—	—	—	—

[1] For further description, see Regional Geologic Maps and Supplementary Chart 1.
[2] Rated with sanitary sewers; reduce rating one step if sewers are not available.
[3] Ratings for reclaimed strip-mined land in southwestern Indiana. Not rated in northwest where materials are variable and in part unknown.
[4] Unit has only minimal exposure at land surface, has little direct effect on land use, and is not rated.
[5] Drainage required. Suited also to specialty crops, such as onions.
[6] Raise rating one step for certain specialty crops, such as melons.
[7] Reduce rating one step in northeastern Indiana where till is clay-rich.
A—Mostly suitable; few limitations in most parts of area.
B—Partly suitable; widespread moderate limitations or local severe limitations.
C—Partly unsuitable; widespread severe limitations, but only moderate limitations in some places.
D—Mostly unsuitable; severe limitations in most parts of area.

TABLE 2. *Suitability interpretations of mapped bedrock units in Indiana for selected general uses.*

Geologic unit	Principal lithology[1]	Area: Square miles	Area: Percent of state	Woodland, undisturbed	Woodland, logged	Grassland, undisturbed	Grassland, pastured	Row crops	General recreation	Isolated dwellings	Grouped dwellings	Subdivision development[2]	General urban	Heavy industrial
IP$_5$	Shale, sandstone[3]	—	—	—	—	—	—	—	—	—	—	—	—	—
IP$_4$	Shale, sandstone, limestone[3]	—	—	—	—	—	—	—	—	—	—	—	—	—
IP$_3$	Shale, sandstone, limestone	30	tr.	A	B	A	A	B	A	A	B	B	B	B
IP$_2$	Shale, sandstone, coal	200	tr.	A	B	A	A	B	A	A	B	B	B	B
IP$_1$	Shale, sandstone	600	2	A	B	A	B	C	B	B	C	C	C	C
M$_6$	Shale, sandstone, limestone	300	1	A	C	B	C	D	B	B	C	C	C	C
M$_5$	Limestone, sandstone, shale	400	1	A	B	A	B	C	B	B	C	C	C	C
M$_4$	Shale, sandstone, limestone	300	1	A	B	A	B	C	B	B	C	C	C	C
M$_3$	Limestone	900	3	A	B	A	A	B	A	A	B	B	B	B
M$_2$	Limestone	500	1	A	B	A	A	B	A	A	B	B	B	B
M$_1$	Siltstone, shale	900	3	A	C	B	C	D	B	B	C	C	C	C
DM/D$_2$	Black and gray shale	<30	tr.	A	B	A	B	C	B	B	C	C	C	C
D/D$_1$	Limestone, dolomite	<30	tr.	A	B	A	B	C	B	A	B	B	B	B
S$_2$	Limestone, dolomite[3]	—	—	—	—	—	—	—	—	—	—	—	—	—
S/S$_1$	Limestone, dolomite	30	tr.	A	B	A	B	C	B	A	B	B	B	B
O/O$_2$	Shale, limestone	800	2	A	C	B	C	D	B	B	C	C	C	C
O$_1$	Limestone[3]	—	—	—	—	—	—	—	—	—	—	—	—	—

[1] For further description, see Regional Geologic Maps and Supplementary Chart 1.
[2] Rated with sanitary sewers; reduce rating one step if sewers are not available.
[3] Unit has only minimal exposure at land surface, has little direct effect on land use, and is not rated.

A—Mostly suitable; few limitations in most parts of area.
B—Partly suitable; widespread moderate limitations or local severe limitations.
C—Partly unsuitable; widespread severe limitations, but only moderate limitations in some places.
D—Mostly unsuitable; severe limitations in most parts of area.

10 years hence, many of the interpretations presented here will become obsolete.

In the meantime, however, the planners must proceed with their work, and for their use I have evaluated each of the 38 geologic units that are shown on the Regional Geologic Maps through the use of letter ratings for each of 11 general kinds of land use. The rating A indicates that few problems arise in connection with that kind of use; D at the opposite end of the rating spectrum indicates that in most places the mapped unit is poorly suited for that particular use.

Space does not permit analysis in detail of the reasons underlying each evaluation, but some understanding of the process may be gained from two examples. The lake clays (unit Qcl, Table 1) are among the more troublesome geologic units in many kinds of land use. The soils are wet, poorly drained, and difficult to drain because they are topographically low, and soft and incompetent. These properties pose some restrictions in agricultural use, but for more demanding uses, the options are very severely circumscribed. Isolated dwellings may perch on slightly elevated and thus better drained sites, but most urban areas located on the lake clays are so soggy that they can almost be flooded by a heavy dew. Sanitary sewers are absolutely essential in such areas; septic tanks will not work because of the wetness and impermeability of the soil. Runoff is high and stormwater is difficult to manage. Basements are impracticable. Industrial use is limited by the low strength of the material. In some places the clay will not properly support buried utility lines. Thus for most urban and suburban uses, unit Qcl gets low ratings.

Unit Qti (Table 1) is Illinoian till. It is intended that this unit (and most others) be mapped only where the deposit is thicker than about 5 feet, but in hilly areas the till is patchy and here and there bedrock may be exposed or at such shallow depth as to impede trenching for utility lines. On the plus side, the till itself is readily excavated, and in many places where wetness is a problem, adequate drainage may be arranged. Its strength is sufficient for most uses, and it does not readily cave into excavations. It is, however, of low permeability and a fragipan is widely present in the soil zone, so that septic tank tile field performance is poor. In some areas slopes are steep and very susceptible to erosion. Thus unit Qti receives good ratings for isolated dwellings but must be downgraded somewhat for most types of agricultural and urban use.

All geologic units get good ratings for undisturbed woodland and undisturbed grassland. This is, for one thing, an indication of the minimal demands that these uses place on the land. This should be readily understood; these were the uses of the land chosen by natural selection, so to speak, and they are uses to which the land was well adjusted. The effects of these uses—for example, the low erosion rate and the high water-storage factor—can be a reference or base line against which to measure the added stresses that are put on the land by other, more demanding uses. For some uses and some geologic units, these added stresses are slight; for others, they are severe. The ratings reflect these stresses as well as the inherent adaptability of the land to each use.

More Study Needed for Some Geologic Units

These evaluations can be made more useful and more objective through quantification of the factors that have gone into the ratings and codification of the rating process. Before this objective can be attained, however, more study will be required for many of the geologic units—particularly the unconsolidated deposits, to which geologists traditionally pay scant attention. More extensive than any of the bedrock units in terms of surface expression, and therefore in terms of importance in land use, are eight units among the unconsolidated deposits (Tables 1, 2). In order of areal extent, these are Wisconsinan till (unit Qt), Wisconsinan moraine till (Qte), Illinoian till (Qti), alluvial silt and sand (Qsa), valley-train outwash (Qgv), outwash-plain deposits (Qgp), windblown silt (Ql), and lake clay (Qcl). In all, 85 percent of Indiana is covered by unconsolidated deposits.

Particular additional attention must be directed at the Wisconsinan till (Table 1). This unit covers 12,000 square miles, or about one-third of the state. Together with the Wisconsinan moraine till, which is not a distinct unit in a material sense and which is only loosely differentiated in a topographic sense, the figure rises to 44 percent of the state. In many geologic reports this unit is dismissed at just plain till, yet it ranges in texture from sticky clay to silt loam to sandy silt loam and has widely varying characteristics. Some is cohesive and stiff; some is loose; some has moderate permeability; some has near zero permeability. Furthermore, the till is stratified; thus the surface till layer may be only a few feet thick, and its characteristics may not be a good guide to what lies below. The evaluation of important land-use factors such as foundation conditions, suitability to sanitary landfill, and groundwater availability depend on a far better understanding of this unit than presently we have.

Summary

Geologic information is of importance in land-use planning, but geologic data usually must be summarized and simplified for the planner's use. This is best done by a geologist. The charts herein presented help to provide for the planner's needs on a regional or statewide basis. The ratings are preliminary and are subject to revision as additional data become available and as the rating process becomes more quantified.