Application of Geology to Land Use Planning, Clinton County, Indiana

Ellen E. Otto, Tennessee Valley Authority
Engineering Geology Section, Chattanooga, Tennessee 37401

Terry R. West, Dept. of Geosciences
Purdue University, West Lafayette, Indiana 47907

Introduction

To provide a suitable base for developing a land use plan for Clinton County, Indiana, detailed data on the significant physical and cultural aspects of the area have been compiled for easy access (5). This inventory of physical and cultural characteristics provides planners with a detailed overview of the County, presented in map, table and text format. These materials can be used singly or in combination for various land use evaluations, the procedure depending upon the interaction of that use with the environment. Information is presented in an appropriate format which can be understood and interpreted by specialists and non-specialists alike.

Setting

In the current study, Clinton County, Indiana was chosen because of its location adjacent to a fast-growing sector of the state. Located approximately 40 miles northwest of Indianapolis and 20 miles east of Lafayette it is bordered by Boone, Hamilton and Tippecanoe Counties which are experienceing major population growth. By providing a suitable information base for Clinton County prior to expansion, land use planning can proceed in an orderly manner and geologic factors can be included in the decision making process.

The physiography of Clinton County is a result of Wisconsin age glacial deposition. The County is contained within the Tipton Till Plain division of the Central Lowlands Physiographic Province. This till plain, of youthful topography, is characterized by a gently undulating to moderately rolling surface. The maximum relief, caused by stream dissection, occurs within one mile of the major drainages. The valley flats commonly are less than one-half mile wide. Away from the drainage channels there has been little modification of the surface by Holocene drainage development.

Local relief is greater in the northern part of the county because of dissection associated with the larger drainage channels in that sector. The land surface displays a regional slope to the northwest, toward the base level set by the Wabash River. Maximum total relief is approximately 300 feet, with a maximum local relief of about 70 feet occurring along portions of the South Fork Wildcat Creek. Bluffs 20 to 50 feet are common along most of the other drainage channels.

Methodology

A review of literature concerned with urban planning, land use development, and engineering and environmental geology was undertaken to determine those physical characteristics which were most valuable to land use planning. The topics included for study were those pertaining to Clinton County and suited for presentation in a map format.

Topics selected to convey general information about the county include generalized topography, bedrock geology, bedrock topography, drainage channels and watershed boundaries. Topics useful for land use planning included surficial geology, glacial drift thickness, gravel resources, soil association, piezometric surface, well yield, transportation systems, present land use and depth to seasonal high water table. Some of these topics were combined into a single map for convenience of presentation.

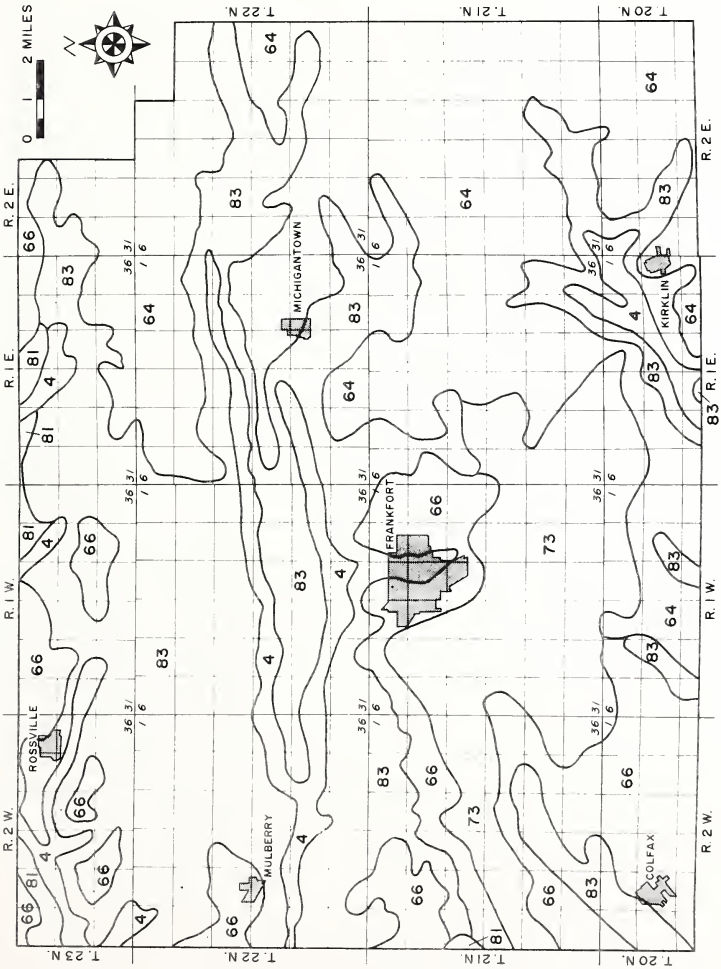
Map sources of information for the various topics ranged in scale from 1:24,000 to 1:500,000. A uniform scale was needed which would result in a base map of manageable size, yet convey sufficiently detailed information to be useful. A scale of 1 inch = 1 mile or 1:63,360 was chosen. To achieve this scale, the fourteen USGS 7½ minute topographic quadrangle maps which comprise Clinton County were reduced to 38% of their original size, combined into a mosaic, and the base map prepared from that mosaic. This produced a map with dimensions of 17½″ x 17″ page size convenient for presentation. The final scale after reduction was approximately 1:150,000. The Depth to Seasonal High Water Table Map was presented at the original scale of 1:63,360 because of its considerable detail and the useful information it provides at that scale.

Several sources of information were used in preparation of the topical maps. The USGS 7½ minute quadrangle provided information for the 50-foot contour-interval, generalized topography map, for drainage channels and watershed boundaries and for the transportation systems map. Pipeline locations for the transportation map were obtained from the "Map of Indiana Showing Oil, Gas and Products Pipelines" (4). Present land use was modified from a published report of consultants (3) with floodplain limits modified from the Danville Geologic Quadrangle (7) using 1939 black and white airphotos at a scale of approximately 1:21,000.

Bedrock geology was obtained from the Danville Geologic Quadrangle (7), and combined with bedrock topography as modified from a bedrock topography map of northern Indiana (1). Modifications were made based on logs of wells drilled to bedrock which are recorded with the Indiana Department of Natural Resources (DNR), Division of Water, Indianapolis, Indiana.

Surficial geology was modified from the preliminary and published sheets of the Danville Geologic Quadrangle (7). These modifications were accomplished using airphoto interpretation. Glacial drift thickness, depicted with a 50-foot contour interval was added to the map. Drift thickness was based on wells penetrating bedrock (DNR information) and on published information (6).

Well records from the Dept. of Natural Resources, Division of Water were used to produce the potential well-yield map and the piezometric surface map



SOIL ASSOCIATIONS

4. Genesee-Shoals-Eel: Nearly level, well drained, loamy Genesee, moderately well drained, loamy Eel, and somewhat poorly drained, loamy Shoals in alluvial deposits.

64. Crosby-Brookston: Nearly level, somewhat poorly drained, clayey Crosby and very poorly drained, loamy Brookston in glacial till.

66. Fincastle-Ragsdale-Brookston: Nearly level, somewhat poorly drained, silty Fincastle in wind-blown silts and glacial till, very poorly drained, silty Ragsdale in wind-blown silts and loamy Brookston in glacial till.

73. Raub-Ragsdale: Nearly level, somewhat poorly drained, silty Raub in wind-blown silts and glacial till and very poorly drained, silty Ragsdale in wind-blown silts.

81. Miami-Russell-Fincastle: Sloping, well drained, loamy Miami in glacial till, silty Russell in wind-blown silts and glacial till and nearly level, somewhat poorly drained, silty Fincastle in wind-blown silts and glacial till.

83. Miami-Crosby: Sloping, well drained, loamy Miami and nearly level, somewhat poorly drained, clayey Crosby in glacial till.

Base from published USGS 7.5' topographic quadrangles; Soil association boundaries from Agricultural Experimental Station and Cooperative Extension Service, Purdue University and the Soil Conservation Service, United States Department of Agriculture (1971).

Figure 1. General soil associations of Clinton County, Indiana.

Table 1. Summary of the soil associations in Clinton County, Indiana. Data from the Agricultural Experiment Station and the Cooperative Extension Service, Purdue University and the Soil Conservation Service, USDA (1971).

Assn. no. 1	Pct. in county 2	Pct. PD SPD 3	Pct. Allu-vial 4	Pct. muck 5	Pct. I-IV land 6	Yield estimates in bushels or tons (hay): I-IV soils corn 7	All soils: Corn 8	All soils: Soy-bean 9	All soils: Wheat 10	All soils: Hay 11	Pct. poten. incr. 12	Avg. prod. index 13	Index potential for: Water eros. (1-4) 14	Index potential for: Wind eros. (1-3) 15	Index potential for: Irri-gation (1-4) 16	Avg. pct. OM 17	Pct. suited for septic 18	Land use (pct. of assn.): Crop land 19	Land use: Pas-ture 20	Land use: For-est 21	Land use: Idle 22	Land use: Ur-ban 23
4	6.17	15	80	0	96	116	114	40	47	3.8	44	69	1.4	1.0	1.2	2.0	16	59	10	21	4	6
64	29.90	86	2	1	99	117	117	41	52	3.8	41	65	1.7	1.0	1.0	2.7	5	80	5	6	4	5
66	14.60	81	2	0	99	133	132	47	53	4.4	40	79	1.9	1.0	1.0	2.9	8	81	6	4	4	5
73	11.08	78	1	0	100	142	142	50	57	4.7	38	87	1.6	1.0	1.0	4.0	20	96	1	0	2	1
81	.98	30	5	0	90	108	104	37	45	3.4	35	51	2.7	1.0	1.1	2.0	39	65	14	14	3	4
83	37.24	42	7	1	95	104	102	36	45	3.4	38	50	2.4	1.0	1.0	2.1	26	66	17	8	4	5
Weighted Avg.*		63	9	1			116	41	50	3.8	40	64	2.0	1.0	1.0	2.6	16	75	9	7	4	5

General: Calculations were made to represent average values for each association across its entire area in Indiana. In a particular county, values may be somewhat different. Except for cols. 6 and 7, calculations consider use of all soils in the association. Individual soils may have values well above or below the averages reported here. Weighted averages (*) are calculated taking into account the area of each association within the county.

Notes by columns:

3. Natural soil drainage: PD (poorly drained), SPD (somewhat poorly drained). Others considered were moderately well and well drained.
4. Subject to periodic flooding unless protected by dikes or levees.
5. Organic areas in low landscape positions with or without surface outlets.
6. Percent tillable, Classes I-IV by SCS Land Capability Classification.
7. Present average yield on Classes I-IV (better row-crop soils) without irrigation.

8-11. Present average yields on Classes I-VII (all soils) without irrigation. For yields on Class I-IV only, multiply values in col. 7 by .35 for soybeans, by .40 for wheat and divide by 30 for hay (tons).

12. Percent potential increase over yields in cols. 8-11 with excellent management in best growing seasons.
13. Productivity index = average gross return minus production and conservation costs (highest index = 100).

14-16. Col. 14, 1 (slight) to 4 (severe); col. 15, 1 (slight) to 3 (severe); col. 16, 1 (low) to 4 (high) response for grains.

17. Muck soils (usually over 30% organic matter) not included in calculation. No percent OM given for Assn. 108.
18. Soils with slight and moderate limitations by SCS system. Rest have severe limitations.

19-23. Land use calculated from Indiana soil and water conservation needs inventory data for 1958.

Percent of Land by Slope Groups
(Gradient by groups: A 0-2%, B 2-6%, C 6-12%, D 12-18%, E 18-25%, F 25-35%, G > 35%)

Assn.					
4	A= 90	B= 4	C= 2	>C= 4	
64	A= 84	B= 12	C= 3	>C= 1	
66	A= 80	B= 16	C= 3	>C= 1	
73	A= 84	B= 14	C= 2		
81	A= 39	B= 34	C= 16		
	D= 4	E= 2	F= 2	G= 3	
83	A= 52	B= 32	C= 10		
	D= 3	E= 1	F= 1	G= 1	

for the County. The piezometric surface map was presented at a 50-foot contour interval.

The map showing soil associations was prepared from map information of the Agricultural Experimental Station/Cooperative Extension Service, Purdue University (2). The Depth to Seasonal High Water Table Map was prepared from advanced field sheets provided by the Clinton County office of the Soil Conservation Service and through detailed photo interpretation of the 1939 black and white airphotos of the County.

Results

The maps, tables and text of the complete report can be used for various phases of land use planning in Clinton County, Indiana (5). The maps can be used individually or in combination to make evaluations, depending upon the type of land use anticipated. For this discussion, general interpretations of various topical mpas are presetned as they relate to specific land uses. The purpose is to illustrate the value of the mapped information during initial phases of land use evaluations. The information is generalized and can only provide a starting point for planning. Because of the extreme variability of actual physical conditions and the small scale at which information was gathered, specific site investigations should also be performed before site selection is finalized.

A map of the general soil associations of Clinton County (Figure 1) provides an overview of the soil types, textures, drainage characteristics, slope and parent material types. This map, used in combination with data from the Agricultural Experiment Station/Cooperative Extension Service for each soil association, (Table 1) can provide information about yields for various crops, productivity of the soil, potential for wind or water erosion, percent of land surface suited for septic systems and the current type of land use found predominantly within a particular soil association. The descriptions of the soil association also include soils formed on floodplains, but these areas are excluded from development owing to the potential for flooding.

Because the soil is directly involved with many aspects of land use, a map showing more detail than the general soils map can be very useful for planning. A detailed map at a scale of 1:63,360 was prepared using one characteritic of the soil, the depth to seasonal high water table, as the mapping unit (5). Soil wetness and drainage characteristics are important in determining what uses are acceptable for specific soils. For examle, soils with a depth to seasonal high water table of 0-1 foot would not be suited for a use as septic filter fields because of the need for a dry, permeable soil for absorption. Other uses, such as basement construction, would require special construction designs, such as waterproofing, and possibly drainage in soils with a high water table. The detail provided by this map can supply valuable information for many land uses and designate areas where corrective design would be needed to overcome wetness problems.

An important resource for urban development is a supply of sand and gravel. The map of the surficial geology and glacial drift thickness (Figure 2) shows areas of potential supply. Valley train and kame deposits have a good

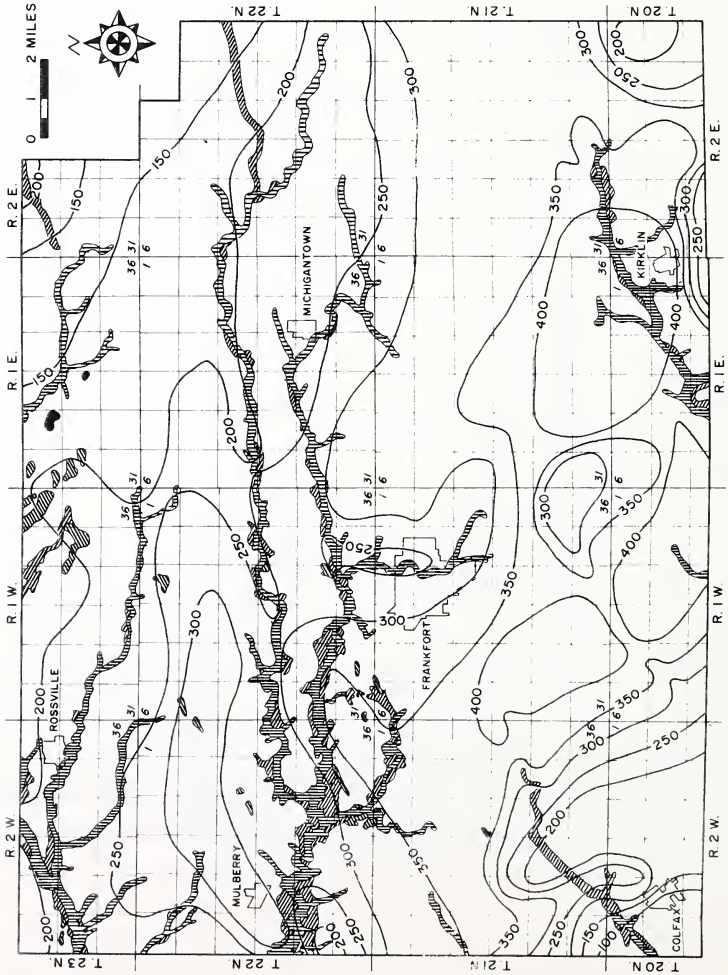
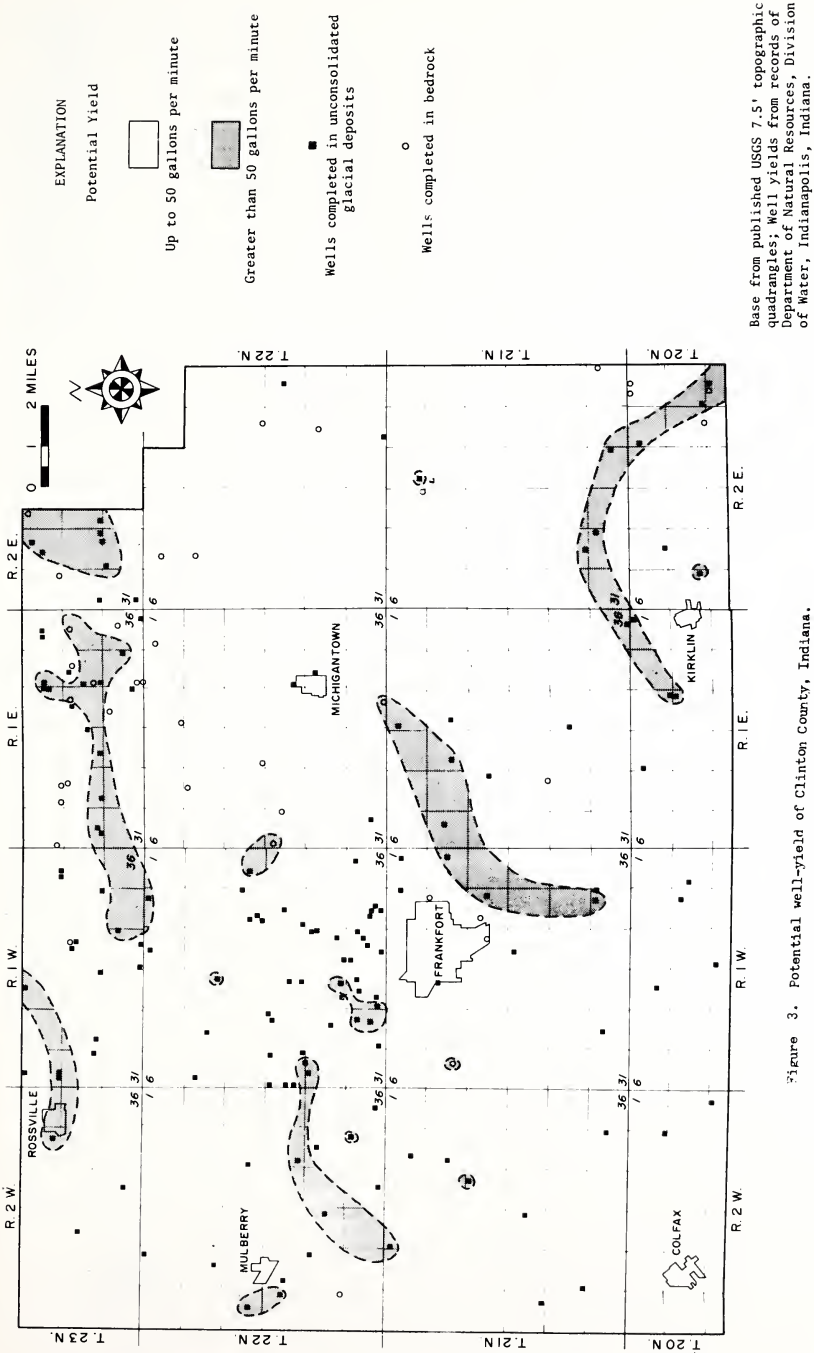


Figure 2. Surficial geology and glacial drift thickness showing sand and gravel resources of Clinton County, Indiana.



Base from published USGS 7.5' topographic quadrangles; Well yields from records of Department of Natural Resources, Division of Water, Indianapolis, Indiana.

Figure 3. Potential well-yield of Clinton County, Indiana.

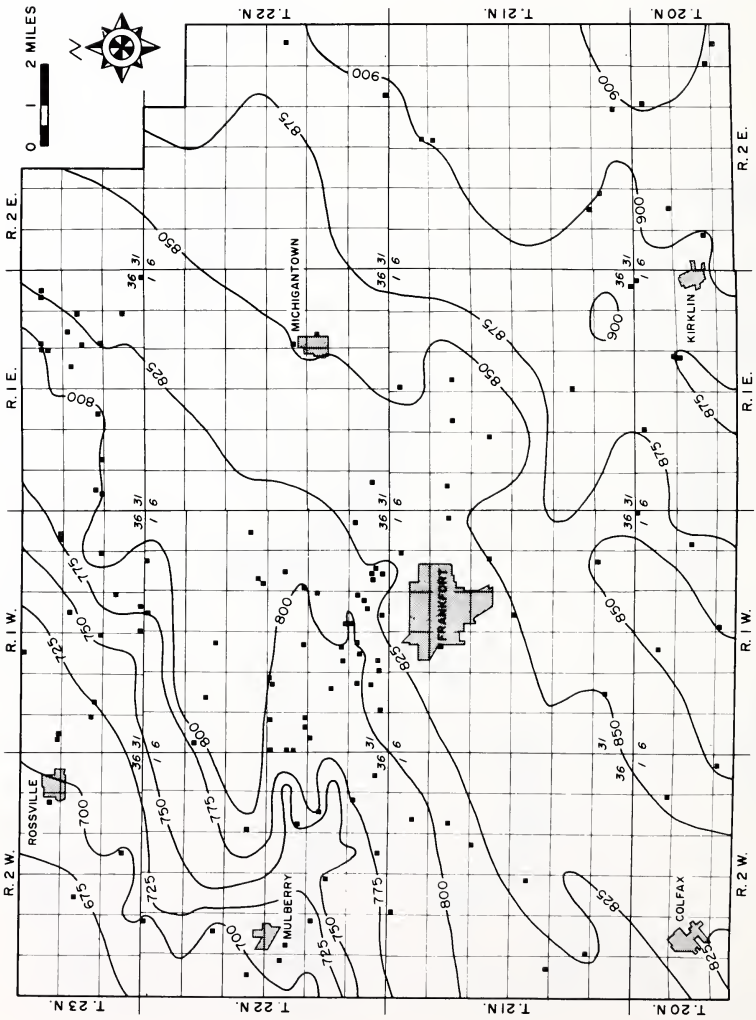


Figure 4. Piezometric surface of Clinton County, Indiana.

potential for sand and gravel production, with a moderate source available from alluvial deposits.

The drift thickness contous on the surface geology map show that bedrock is not found within 50 feet of the surface, therefore, no bedrock will be encountered during normal foundation construction. This is an important consideration in estimating costs for excavation.

Development of industry or residential areas requires a good source of water. In Clinton County, that source is ground water. A map of the potential well-yield (Figure 3) shows areas where yields of 0-50 gpm and yields of over 50 gpm may be expected. The areas are generalized and yields cannot be guaranteed. However, the map does provide a starting point in the search for an adequate water supply for commercial or domestic use.

The map of the piezometric surface (Figure 4) shows the elevations to which the ground water will rise under artesian pressure. Using this map in combination with topographic map information (available from the 7½ minute quadrangles of the county) depth to the static water surface in a well can be determined. The actual aquifer may be deeper, with the static water level reaching a higher elevation because of the artesian conditions. However, the position of the piezometric surface can provide information regarding how much lift will be needed to pump water to the surface.

The general direction of ground water flow can also be determined from the piezometric surface map as flow occurs perpendicular to the contours and in the down-slope direction. Flow direction becomes important in the location of water supply wells which should be upgradient from likely sources of contamination, such as septic filter fields. Also a sanitary landfill shoud not be sited where the regional ground water flow is through the fill material.

Along with information and maps of the physical characteristics of Clinton County, the cultural or man-made features also provide an important aspect for the land use planner. It is necessary to know where past development has taken place so patterns of growth can be determined and suitable areas for new development can be located.

A map of transportation systems (Figure 5) locates the pipelines, transmission lines, railroads and highways of the county. Developing industry will wish to locate near ready access to one or more of these transportation systems depending upon the specific needs. Frankfort is an important railway center with lines extending to all parts of the state. Rapid access statewide is also provided by Interstate 65 which crosses the southwestern part of the county. Other state and federal highways provide ready access to nearby cities of Lafayette, Kokomo, Lebanon and Indianapolis, as well as other parts of the state. The transportation map is also helpful in planning residential areas so easy access to the development will be possible.

The map of present land use (Figure 6) shows areas of urban development, industry, parks and institutions and agricultural areas. Industrial development would be best suited in areas where industry is already located, assuming the physical characteristics are suited for that type of development. Also the pattern of urban development can be determined from this map. Recent "strip

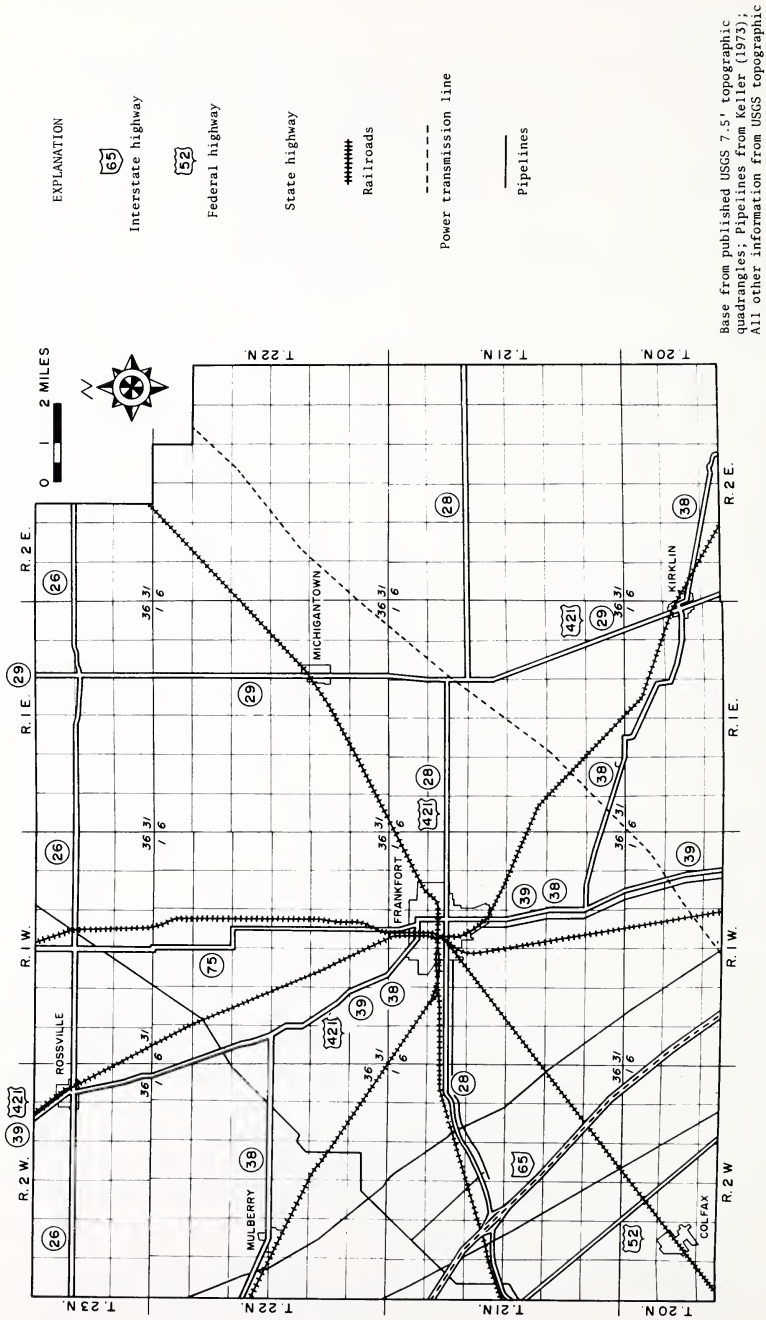


Figure 5. Transportation systems of Clinton County, Indiana.

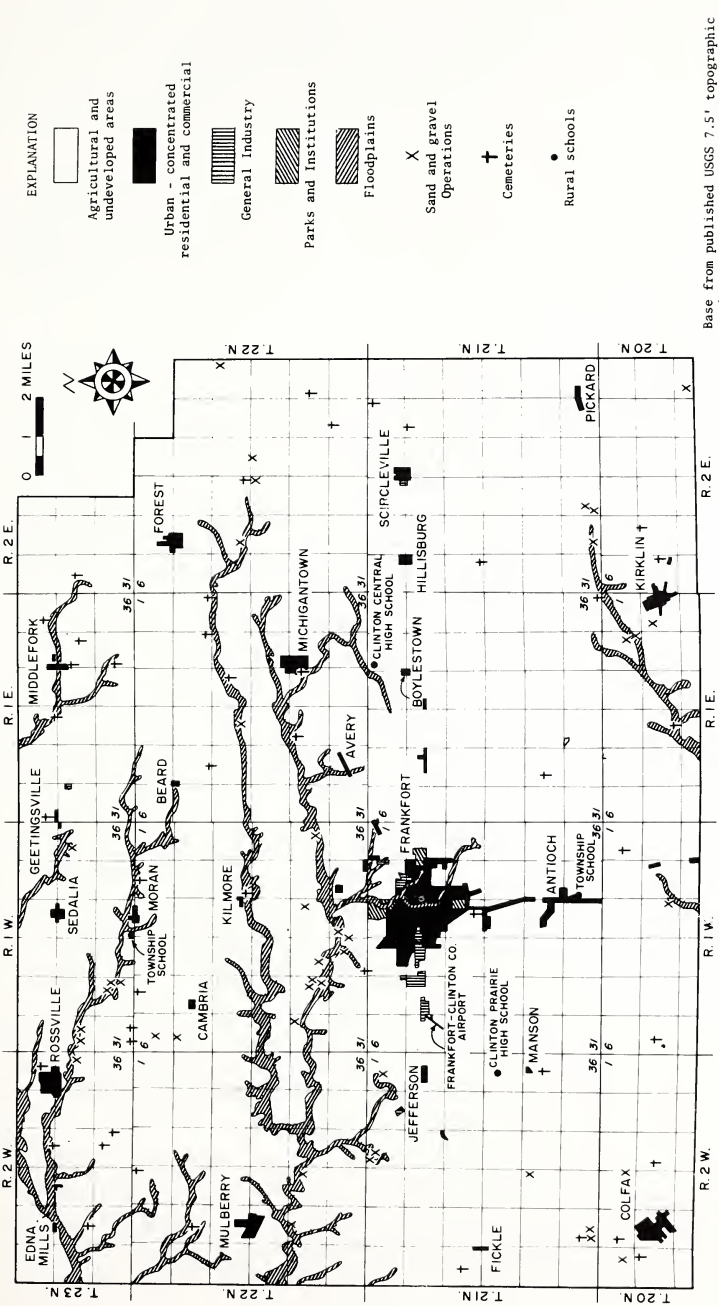


Figure 6. Present land use of Clinton County, Indiana.

development" has taken place along the major highways with residential housing expanding in a linear fashion from the major towns. An example, is the pattern of growth of south of Frankfort to Antioch along state road 38, 39. This type of "strip development" if not planned, results in problems of extending municipal services for a great distance to serve a limited number of people. Development along a transportation route also limits access to lands beyond this "strip" for future development.

The land use map also delineates floodplains, those areas which should not be used for development except for agriculture, open space or perhaps certain recreational uses which would not be greatly affected by occasional flooding. Cemeteries are located on the land use map because of the need to avoid these areas for most types of development.

Conclusion

A brief overview has been presented to show some specific uses of the various maps of physical and cultural aspects of Clinton County, Indiana. Using the extensive inventory of the County (5), planners can make more appropriate decisions related to land use. Before any final land use decisions are made, a more detailed on-site investigation would be required. However, the information in this report provides a proper starting point for analysis, streamlines the procedure and insures the consideration of geologic and other physical factors in the decision-making process.

Literature Cited

1. BURGER, A. M., S. J. KELLER and W. J. WAYNE, 1966. Map showing bedrock topography of northern Indiana. Misc. Map 12, Ind. Geol. Surv., Bloomington, Indiana, scale 1:500,000.
2. COOPERATION EXTENSION SERVICE/AGRICULTURAL EXPERIMENT STATION and the SOIL CONSERVATION SERVICE, USDA, 1971. General soil map and interpretation table for Clinton County, Indiana. Purdue Extension Publ. AY-50-12, scale 1:190,080.
3. HUFF, CARPENTER, ROSS ASSOCIATES, 1974. Frankfort-Clinton County comprehensive plan. South Bend, Indiana.
4. KELLER, S. J., 1973. Map of Indiana showing oil, gas and products pipelines. Misc. Map 18, Ind. Geol. Surv., Bloomington, Indiana, scale 1:500,000.
5. OTTO, E. E., 1977. Engineering and environmental geology of Clinton County, Indiana. M.S. Thesis, Purdue University, West Lafayette, Indiana. 118 p.
6. WAYNE, W. J., 1956. Thickness of drift and bedrock physiography of Indiana north of the Wisconsin glacial boundary. Report of Progress 7, Ind. Geol. Surv., Bloomington, Indiana, 70 p.
7. WAYNE, W. J., G. H. JOHNSON, and S. J. KELLER, 1966. Geologic map of the Danville 1° x 2° Quadrangle, Indiana and Illinois, showing bedrock and unconsolidated deposits Regional Geol. Map No. 2, Ind. Geol. Surv., scale 1:250,000.