Excess Water

Excess water, as the term is applied in this report, is not meant to suggest that there is yet another phase of the water resource discussed previously. Excess water describes aspects of the water resource which, because of the general prevalence and relative importance in the State of Indiana, merit separate discussion. The term is used to include the subjects of flooding, drainage, and soil erosion with consequent sedimentation. The use of the term *excess water* does not by any means suggest that the overall water resource of the state is excessive, but rather that "too much" water occurs at a particular place at a particular time, causing flooding, drainage problems, soil erosion, or problems of sedimentation.

FLOODS

The natural stream systems in Indiana have evolved in post-glacial periods under the influence of prevailing climatic, geologic, and hydrologic factors. In the typical case, each stream is characterized in its various reaches by a channel which, under the cumulative influence of the above-cited factors, is of such size and capacity as to convey within its banks a rate of flow roughly equivalent to that which may be expected to occur once or twice per year, on the average.

Flows in excess of the bank-full capacity of the channel, which spread out over the normally dry lands adjacent to the stream, known as flood plains, are referred to as floods or flooding.

The source of flood water is direct surface runoff, as opposed to the ground-water contribution to streamflow. Indeed, many hydrologists feel that the ground-water contribution to streams is generally inhibited, if not actually reversed, during the periods of high stream stages caused by floods.

Direct surface runoff to streams and lakes, results when precipitation occurs at rates in excess of the infiltration capacity of the land surface on which it falls. A flood results when precipitation events produce surface runoff at rates which exceed the capacity of the receiving stream.

The relative magnitude of flood events and their occurrence in time are directly influenced by the relative magnitude and time distribution of runoff-producing precipitation events. Since such precipitation events are highly variable in both time and space, so are floods. Thus, floods may occur at irregular intervals on an individual stream, on a reach of a single stream, or over a wide geographic area.

Major precipitation events, large enough to produce floods, are rarely predictable with any substantial degree of accuracy for more than a day or so in advance, and hence the prediction of floods suffers the same constraints. It is possible, once the storm event has occurred, to predict with relatively high accuracy both the magnitude and timing of resulting flooding on the major streams. The National Oceanic and Atmospheric Administration routinely performs such forecasting services.

For the purposes of planning, the application of probability theory to long-term gaging station records of streamflow produces estimates of flood magnitude and frequency. Such estimates are expressed in terms of the peak rate of flood flow which may be expected to be equalled or exceeded once in some specified interval of time. For example, the "100-year flood" is that flood whose peak rate of discharge is expected to be equalled or exceeded once in one hundred years, on the average. It also is expressed as that flood that has a one percent chance of occurrence at any time.

While floods in Indiana may occur at any time of the year, the prevailing climatic conditions are such that the great majority of floods occur during the period from January through June.

A general discussion of floods would not be complete without pointing out that flooding may be greatly, and usually adversely, affected by the activities of man. All construction that results in a relatively impervious surface, such as that of houses, buildings, sidewalks, roads, streets, and parking lots, causes increased surface runoff. Inadequate bridges and culverts restrict streamflow capacity and cause increased flood stages. Land filling operations may produce the same effect by restricting the floodway. The indiscriminate dumping of trash and debris in floodways not only restricts floodway capacity but may wash into the stream channels to create debris jams.

Flood Damages

Presumably, floods were not a concern prior to the settlement and economic development of the state. As the flood plains were converted to agricultural pursuits, to commercial and industrial enterprises, and to the building of homes, floods resulted in economic and social losses. The adverse impacts of floods include erosion, deposition of infertile sediments, losses of crops, interruption to transportation, communication, and commerce, loss of industrial production, property damage, human suffering, and, on occasion, the loss of human lives.

Unobstructed flood plains reduce the rates of flood flows and flood stages by providing temporary flood water storage. Thus unobstructed flood plains help reduce the damages caused by flood flows.

Neither the total area of the flood plains of Indiana nor the extent of social and economic losses from floods are known with precision. However, the general location of major Indiana flood plains is indicated on Figure 35. Numerous studies have been made in the past on most of the larger streams of the state, primarily by federal agencies, which have included estimates of average annual flood damages, exclusive of the loss of life. In the course of this study, rather extensive efforts were made to collect available information with a view toward at least developing a reasonable portrayal of the flood damage situation across the state.

The results of these studies are summarized in Table 22, which indicates an order of magnitude of estimated average annual flood damages within the major drainage basins. The damage data were adjusted to reflect January 1978 price and cost levels and are segregated as to agricultural and urban damages.

Table 22
The order of magnitude of the estimated average annual flood damages within selected drainage basins.

Stream	*Urban Damages in 1978 Dollars*	*Rural Damage in 1978 Dollars*	*Flood Plain Acres*
Iroquois River	0	136,000	100,800
Kankakee River	0	3,700,000	81,700
Little Calumet River	17,935,000	183,000	3,800
Maumee River	8,424,000	171,000	19,600
Ohio River and Minor Tributaries	819,000	3,673,000	183,200
St. Joseph River	775,000	21,000	2,800
Wabash River	15,243,000	75,801,000	1,316,700
Total	43,176,000	83,531,000	1,708,600

Estimated flood damages represent the Ohio, Elkhart, Kankakee, Maumee, Wabash, and Great Lake Basin studies prepared by the U.S. Army Corps of Engineers and the U.S. Soil Conservation Service. All figures derived from these studies were updated to reflect January 1978 dollar values.

An appraisal of flood damages was made by determining the area flooded by different events. This involved a study of historical flood events to determine their magnitude and frequency. The area affected by each flood and the resulting physical damage were converted to monetary amounts. (Physical damage is the reduction of yields to agricultural products, or the actual resources that must be repaired or replaced in houses, businesses, roads, bridges, and other structures.) The monetary damage for each flood is evaluated with the frequency of the floods to determine the average damage, in dollars, that can be expected annually. This is referred to as average annual dollar damage.

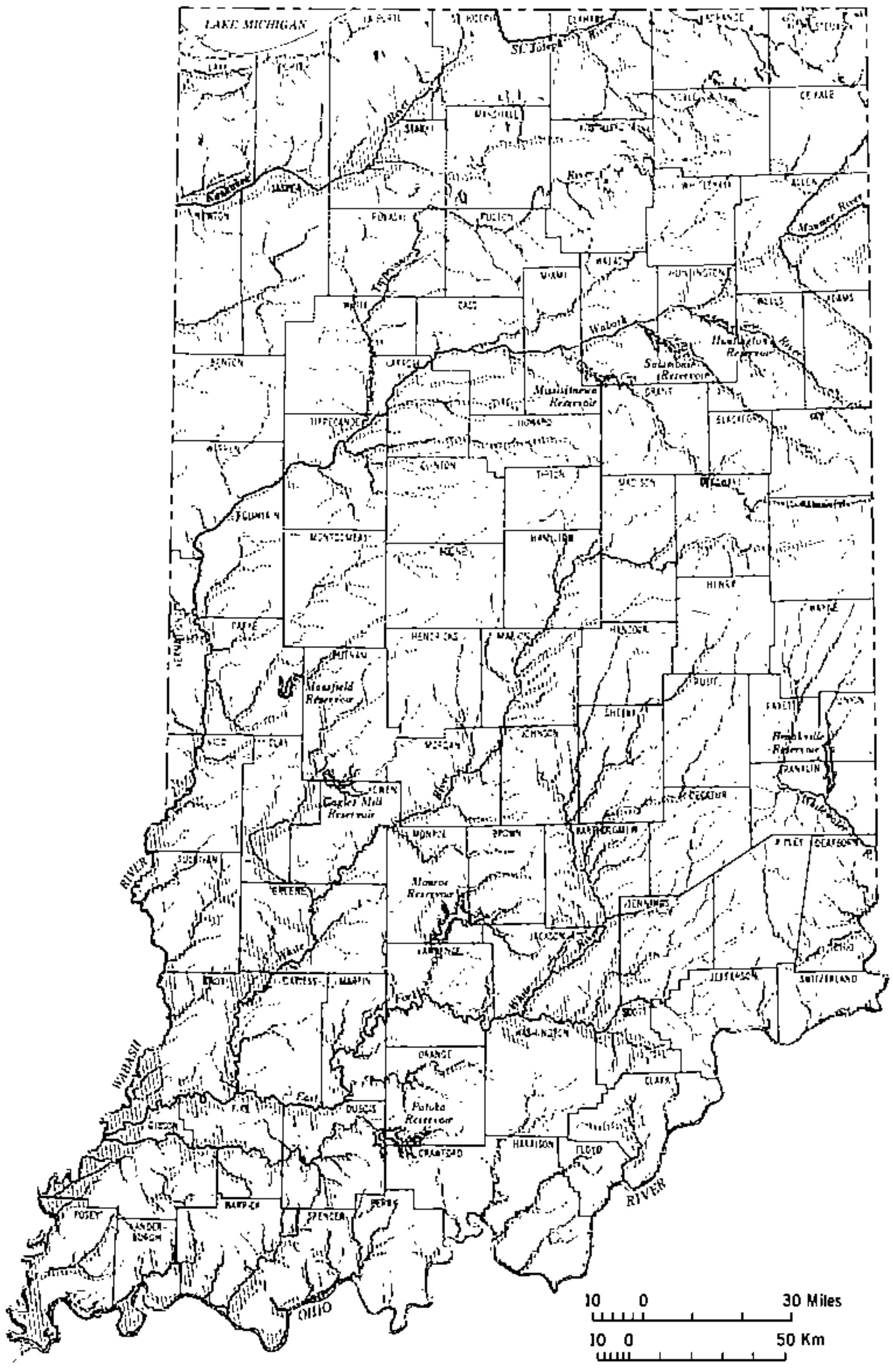

Figure 35
Map of Indiana showing the location of flood plains.

It is emphasized that these estimates do not include all flood plain areas, and that the dollar values shown are not represented to be absolute. Rather, they reflect the best estimates now available and are intended to serve to provide at least an impression of the relative magnitude of flood damages, both statewide and among the major drainage basins.

The areas prone to major urban flood damage are the Little Calumet River drainage basin, the Maumee River of the Great Lakes basin, and the upper West Fork White River area of the Wabash River basin. These three areas sustain about 81 percent of the slightly more than $43 million in urban flood damages.

Nearly ninety-one percent, or approximately $75.8 million, of the average annual rural flood damages are sustained in the Wabash River basin. The Kankakee River and the Ohio River basins are next in order, with average annual rural damages on the order of $3.7 million each.

Flood Projects and Programs

The extent of flooding and resultant damages have provided the impetus for many federal, state, and local projects and programs over the years.

The federal government, through the United States Army Corps of Engineers, began water resource development projects in Indiana during the 1800s. To date over $238 million have been expended by the corps of engineers on Indiana water projects, all of which were built in whole or in part for flood control purposes. Figure 36 indicates the location and stage of development of these projects.

The United States Department of Agriculture through the Soil Conservation Service, acting pursuant to the Small Watershed Program (Public Law 83-566), provides technical assistance and construction funds for watershed protection and flood protection projects in small watersheds. Over $22 million in federal funds have been invested on these small watershed projects in Indiana. By 1978, eight small watershed projects were complete and twenty-one were authorized for construction. The location of the active small watershed projects in Indiana is shown on Figure 37.

The Soil Conservation Service is also involved with the ninety-two county soil and water conservation districts in Indiana. The Soil Conservation and Domestic Act (under Public Law 74-46) empowers the Soil Conservation Service to provide technical and advisory assistance to individuals, groups, and other governmental agencies for soil and water management.

In addition, the Soil Conservation Service provides technical and financial assistance to Resource Conservation and Development Areas in planning and installing of measures such as flood prevention, sediment, and erosion control. Five Resource Conservation and Development Areas encompass thirty-one Indiana counties.

In addition to those projects and programs for structural methods of flood control, there are three flood plain management programs in force whose primary thrust is to mitigate damages in existing situations and to avert future damages.

Indiana Flood Control Act The first of these is the 1945 Indiana Flood Control Act, whereby the construction of places of abode within floodways is prohibited and all other construction within such floodways is subject to prior permit by the Natural Resources Commission. In acting upon applications for permit, the commission must consider whether the proposed construction will (1) adversely affect the capacity and efficiency of the floodway, (2) create an unreasonable hazard to the safety of life or property, and (3) have unreasonably detrimental effects upon fish, wildlife, or botanical resources.

Indiana Flood Plain Management Act The second flood plain management program is based upon the 1973 Indiana Flood Plain Management Act. The act requires that, on and after July 1, 1974, any local ordinance adopted in Indiana that contains flood plain management rules and regulations must receive the approval of the Natural Resources Commission prior to becoming effective. The commission's minimum standards for the regulation of flood hazard areas are: (1) Natural Resources Commission possesses primary regulatory jurisdiction over the floodways of Indiana, (2) developments in the floodway fringe areas must be provided with a flood protection grade of at least two feet above the 100-year frequency flood, and (3) nonconforming uses in flood hazard areas may be expanded on a one time only basis, provided that expansion and improvements are less than forty percent of the premarket value exclusive of the land. The counties and communities with flood plain management ordinances approved by the Natural Resources Commission are shown in Figure 38.

National Flood Insurance Program The third flood plain management program is the National Flood Insurance Program as established by the Flood Insurance Act of 1968 and strengthened by the 1973 Flood Disaster Protection Act. The program is designed to provide low cost, subsidized, flood insurance to participating communities. In 1978, 319 communities and 53 counties were participating in either the regular or emergency phase of the program, as shown in Figure 39. The regular phase of the National Flood Insurance Program includes a detailed engineering study of flood

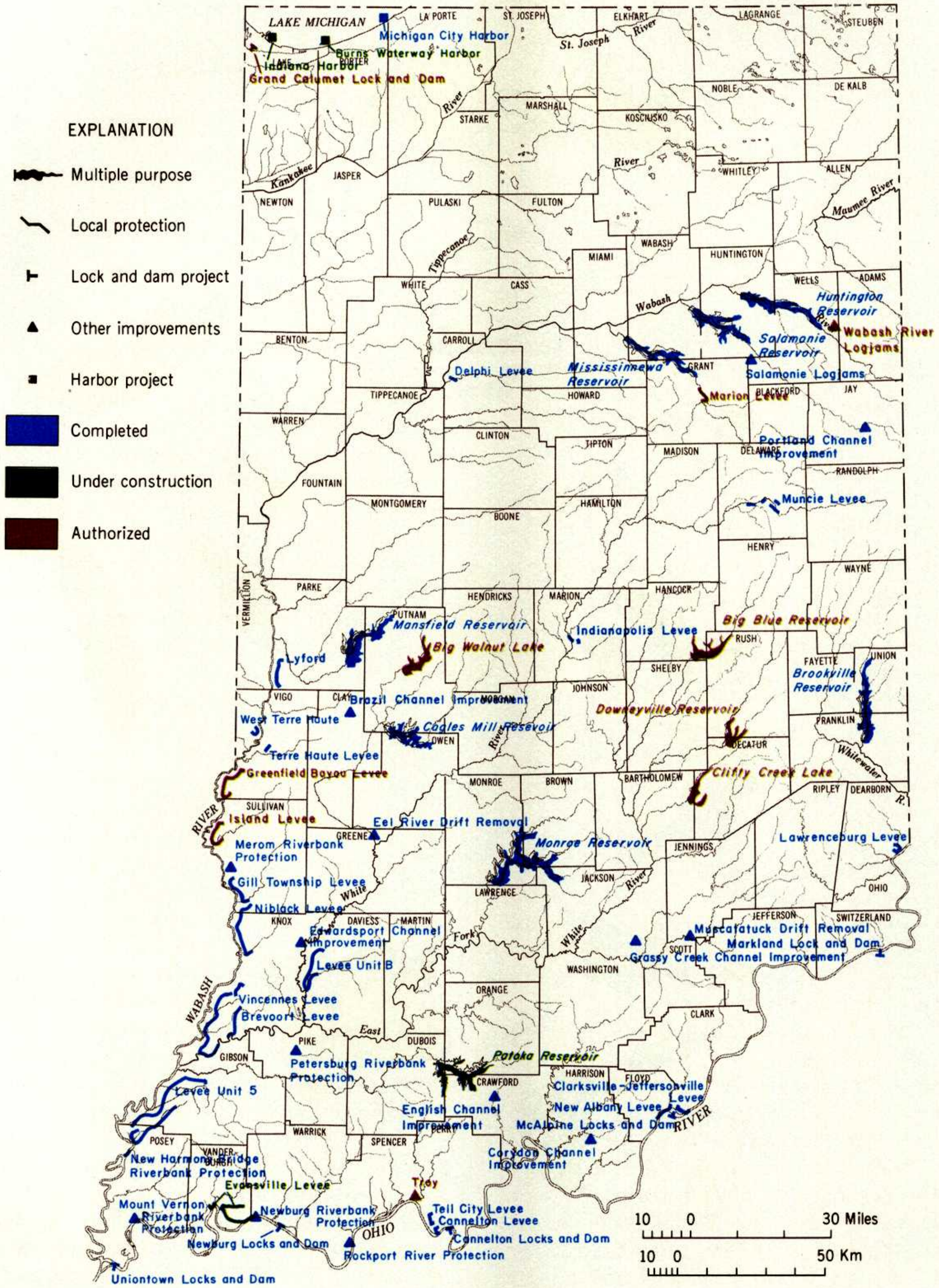

Figure 36
Map of Indiana showing the location and state of development of the U.S. Army Corps of Engineers water resource management projects.

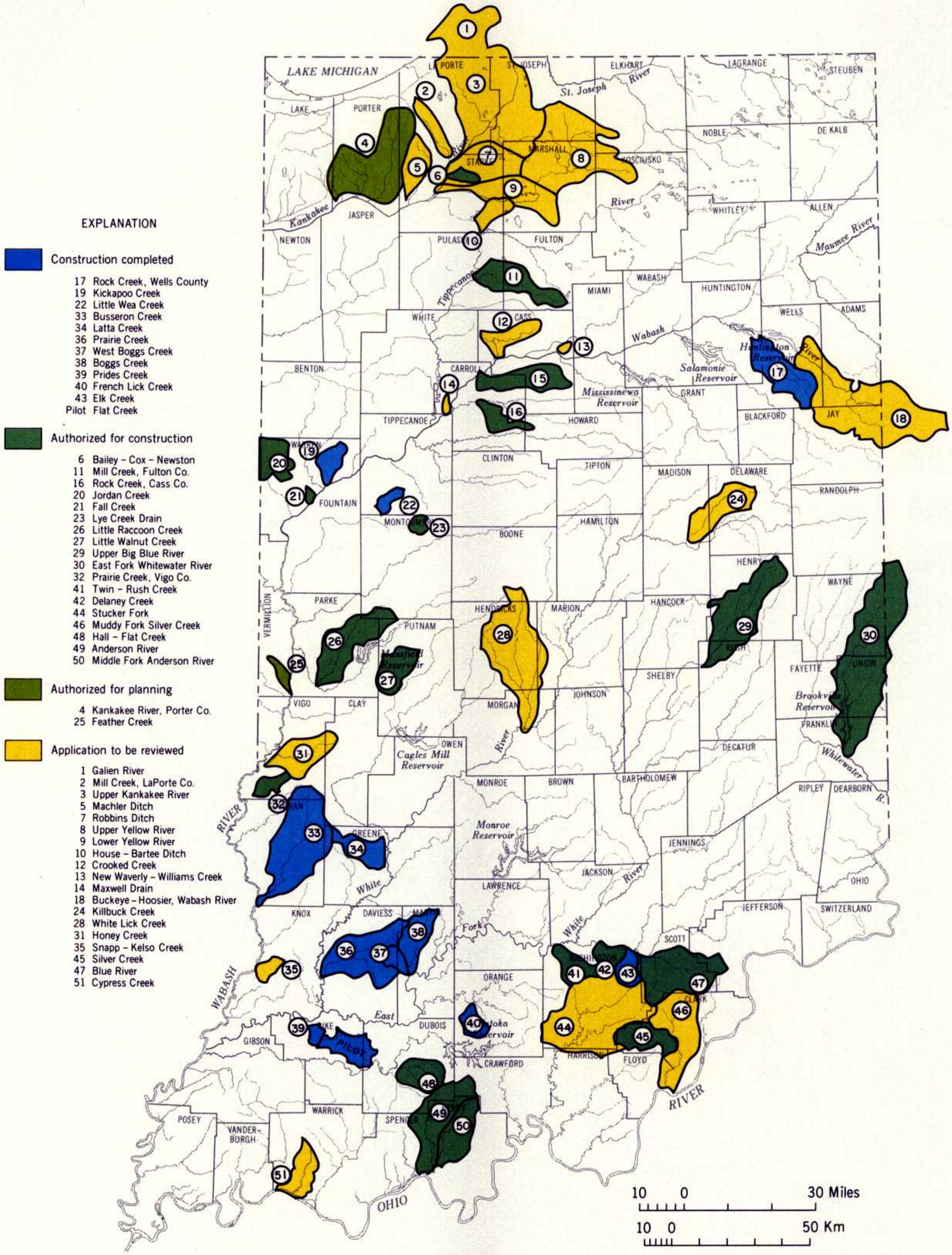

Figure 37
Map of Indiana showing the location and status of small watershed programs.

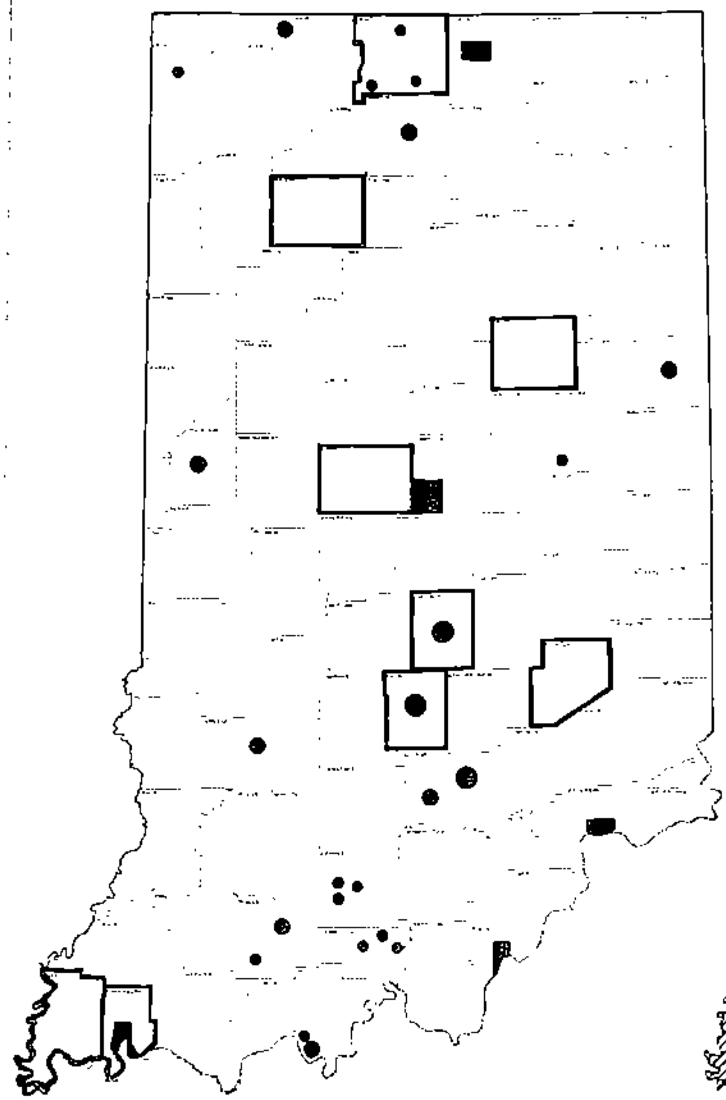

Figure 38
The communities and counties with floodplain management approved by the Natural Resources Commission.

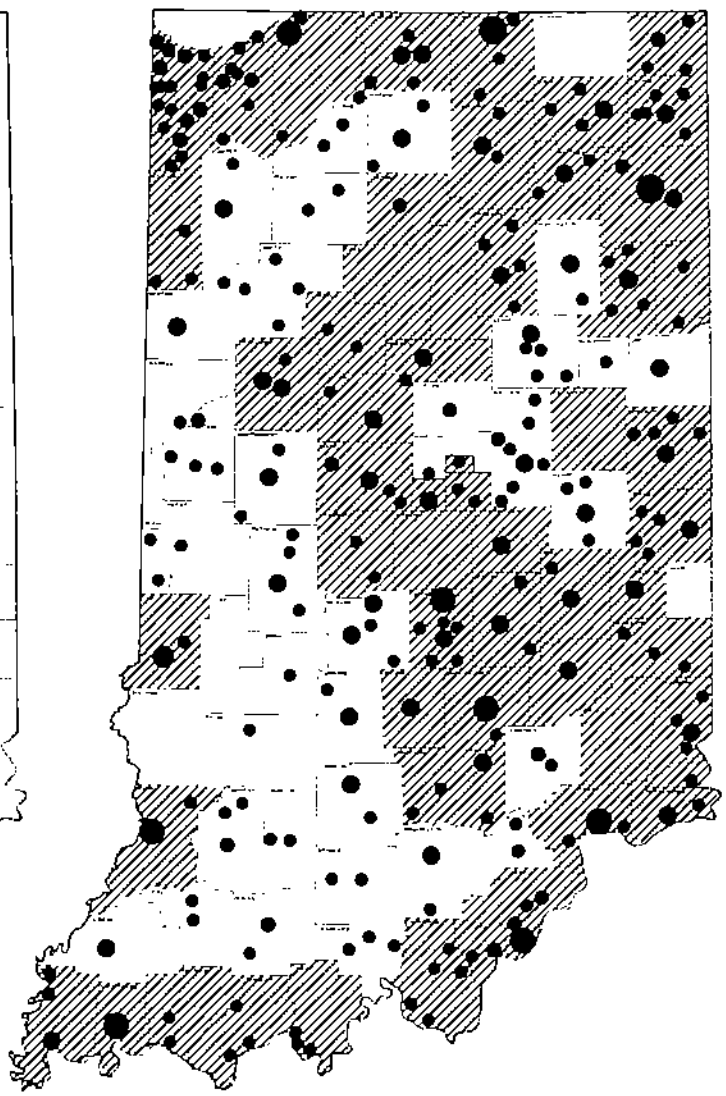

Figure 39
Map of Indiana showing the location of communities and counties participating in the National Flood Insurance Program.

prone areas and the adoption of flood plain ordinances by the participating community. The emergency phase of the program includes only the mapping of flood prone areas. The National Flood Insurance Program provides affordable flood insurance in flood prone communities in return for enactment of flood plain management rules and regulations. The regulations can be in the form of zoning ordinances, building codes, subdivision control regulations, and others, which will provide sound flood plain management in those areas designated by the study to be flood prone. In 1978, eleven communities had adopted regulations based upon detailed Flood Hazard Studies with an additional ninety studies underway.

AGRICULTURAL DRAINAGE

Cash receipts for crops in Indiana during 1977 were a record two billion dollars. Indiana ranked fifth in the nation in receipts from crops. Approximately eighty-eight percent of these crop receipts are derived from corn and soybeans which are grown under cultivation on high value land. Much of this land must be drained to achieve this level of production.

The size of the total farm business in Indiana, as well as the type of farming in any area, is greatly determined by the quality of its soils. The part of the soil that is plowed or cultivated is not the only portion of the soil that is important in the cultivation of a plentiful crop. The roots of a corn plant extend several feet into the soil beyond the area normally cultivated. The depth to which roots go in a soil depends partly on the water level in the soil profile. There are always some roots in the subsoil. These subsoil roots need water, oxygen, and nutrients just as do roots in the surface soil.

Soil bacterial action is essential for the transformation of soil components to forms available to plants. The presence of air in the soil is essential for soil bacterial growth. These bacteria change organic matter into organic acids which in turn dissolve the elements in the soil that furnish plant food. The roots of plants and the soil bacteria must have oxygen. Free water in the soil creates unfavorable conditions for plant growth because oxygen is excluded when the pore space is filled with water. Drainage provides air space in the soil, thus facilitating plant growth.

Soils were formed when various geologic materials such as glacial till, limestone, or wind-blown silt underwent physical, chemical, and biological changes as water moved through them. The soil that resulted depended on the kind of geologic material, the climate, kind of vegetation, the topography, and the length of time the soil had been forming. Indiana has a great variety of geologic materials resulting from different glaciers. A high percent of the glaciated area has a relatively level topography and is made up of rather impervious materials resulting in restricted natural drainage.

The productivity and water movement in any soil is determined by the properties of the different soil layers that extend down to the unweathered material from which the soil is formed. Some of the properties, such as texture (relative amounts of sand, silt, and clay), natural drainage, and the content of slowly soluble minerals, are fixed and change very slowly. Where the natural drainage is inadequate farms must supplement this drainage by the addition of various types of open channels and subsurface or tile drains.

The degree of artificial drainage to soils is determined by the amount of natural, external drainage (runoff) and the amount of internal drainage (percolation). Most waterlogged soils have dull, gray, poorly oxidized subsoils. Most well drained soils have brown subsoil which resulted from the oxidation of the soil minerals.

Agricultural drainage removes excess water (also known as free water or gravitational water) from or below the surface of the farmland in order to create favorable soil conditions for plant growth. The process of removing free water from the surface is referred to as surface drainage and the removal of free water from the subsoil is known as subsurface drainage. An adequate drainage system considers both surface and subsurface (tile) drainage.

A "legal drain" is a natural or artificial open channel or subsurface drain, or a combination of the two, that has been established under the Indiana drainage statute. These are sometimes called a public ditch, court drain, county ditch, or ditch of record. The county drainage board (county commissioners or appointed board) is responsible for construction, reconstruction, and maintenance of legal drains. Petitions for drainage construction or reconstruction are filed with the board, which determines whether they are practical or beneficial. The board determines assessments against property owners based on benefits they realize for the project. A "mutual drain" means a tile or open drain running through the lands of two or more owners and established by their mutual consent and not under the drainage statute. Indiana has more than thirty-six thousand miles of mutual drains. In 1976 alone, approximately thirty-five million feet of subsurface drains were installed at a cost of $17.5 million. More than 500 miles of legal drains occur in each of thirty-five Indiana counties.

The extent to which agricultural lands require drainage in order to maximize the agricultural yields is dependent upon the soil wetness characteristics of the individual soils. The wetness characteristics of Indiana soil associations are shown on Figure 40. These wetness characteristics are divided into three general categories. Soil associations with a *slight* degree of wetness represent soils with less than thirty acres per one hundred acres requiring drainage in order to maximize the agricultural yield. Soil associations with a slight degree of wetness are generally deep, well drained soils located on gently sloping to sloping topography as shown in the background of Figure 41-A. The *moderate* wetness characteristics represent soil associations with thirty to sixty-nine acres per one hundred acres requiring drainage. Soil associations with moderate wetness characteristics are generally deep and very poorly to somewhat poorly drained on nearly level topography as shown in the foreground

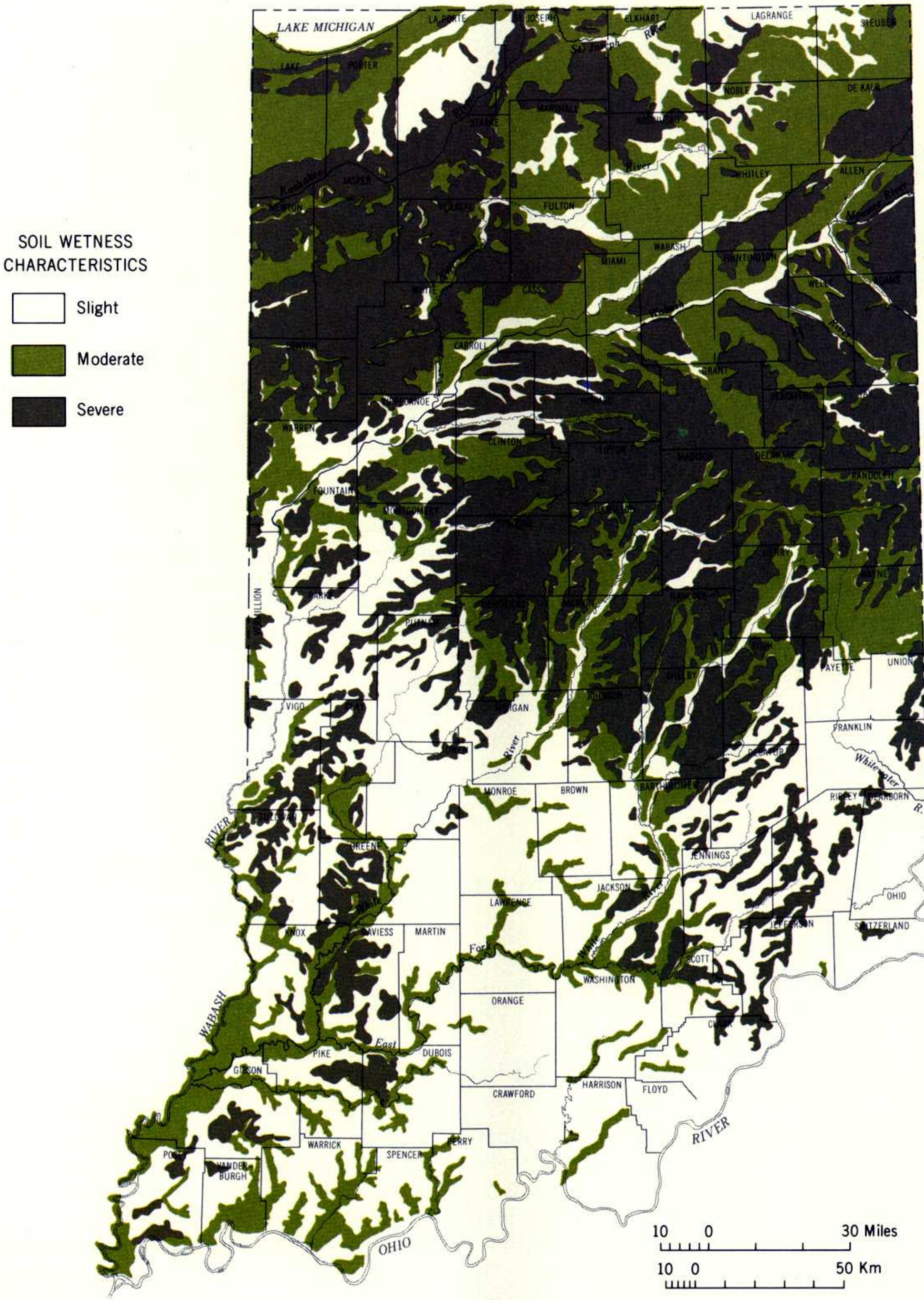

Figure 40
Map showing wetness characteristics of Indiana soil associations.

Figure 41-A
Deep, well drained soils located on gently to moderately sloping landscape are shown in the background. Deep and very poorly to somewhat poorly drained soils on nearly level ground are shown in the foreground.

Figure 41-B
Soils that are deep and very poorly to somewhat poorly drained are located on nearly level to depressional landscape.

(Photographs courtesy of the U.S. Soil Conservation Service)

of Figure 41-A. The *severe* wetness characteristics represent those soil associations with over seventy acres per one hundred acres requiring drainage to maximize agricultural yields. Soil associations with severe wetness characteristics are usually deep and very poorly to somewhat poorly drained on nearly level and depressional landscapes as shown on Figure 41-B. It should be noted that not all soils within each soil association require drainage to maximize agricultural yields and that existing land use was not considered when evaluating the wetness characteristics of the soil associations.

The *Indiana Farm Drainage Guide* has been prepared by the United States Soil Conservation Service and Purdue University to provide technical data on drainage for agricultural production. The guide provides drainage recommendations for all Indiana soils and design and construction information for various drainage methods. It lists the drainage practices needed for optimum field crop production for each soil type.

URBAN RUNOFF

During periods of moderate to heavy precipitation removal of excess water from urban areas is a necessity. Urban areas, by their developed nature, have less pervious ground surface and hence a high amount of runoff. This runoff has higher flow rates than in natural conditions. Without proper storm water drainage, much damage and inconvenience results. Problems of storm water removal, although widespread in Indiana, are generally local in nature and affect the individual urban area.

However, urban runoff problems may have widespread impacts when the storm water and sanitary sewer systems are combined. During periods of high urban runoff the capacity of the local sewage treatment plant is often exceeded and a direct combined storm water and sewage is discharged into streams. The results of the sewage treatment bypass caused by excess storm runoff is a significant degradation of water quality of the receiving waters.

SOIL EROSION

Soil erosion, in minute and almost imperceptible amounts, is a part of the weathering process naturally occurring over the past several hundreds of thousands of years. This process has resulted in our varied landscapes from the high relief areas of Brown County to the lowlands of Scott County. The normally slow, natural process of soil erosion, however, has in many areas been greatly accelerated by land disturbing activities of urban growth and the intensive cropping practices of a highly productive modern day agriculture.

Soil losses from croplands may annually range from a few tons per acre to several hundred tons per acre on exposed, strongly sloping land areas. When soil losses exceed the natural, regenerative capabilities of the soil, productivity declines.

As erosion occurs, soil is transported by wind and direct surface runoff and is ultimately deposited in streams and lakes. Sediment and other associated pollutants degrade water quality and aquatic life. The expense of removing sediment from drainageways, stream channels, and reservoirs is exorbitant.

The potential for severe soil erosion exists in many areas throughout Indiana. The Soil Conservation Service and the State Soil and Water Conservation Committee have assessed the soil erosion potential resulting from rain falling on land left in a fallow condition within Indiana. The methodology for estimating the average annual soil loss is described within Appendix Six. The estimates of soil erosion are based upon soil associations. Not all the soils within each association are subject to erosion. The four categories of erosion potential are *low, medium, high,* and *very high.*

The soil associations with *low* erosion potential represent soils that are deep and very poorly to somewhat drained on nearly level and depressional land as shown in Figure 42-A.

The soil associations with *medium* erosion potential represent soils that are deep and somewhat poorly drained on nearly level to slightly sloping topography as shown in Figure 42-B.

The soil associations with a *high* erosion potential represent soils that are deep and well drained and located on moderately to steeply sloped land, as shown in Figure 42-C. Severe erosion losses would be expected to occur on very steep land that is bare and left exposed for a prolonged period of time. However, much of this land in rural areas is protected by grassland and woodland uses and generally would not be found in a fallow condition.

Soil associations with a *very high* erosion potential represent those land areas with the most serious soil loss potential if not maintained under good protective cover. The soils are usually deep, well drained, and associated with very steep slopes, as shown in Figure 42-D.

Figure 42-A
Deep soils with low erosion potential are located on nearly level to depressional land.

(Photographs courtesy of the U.S. Soil Conservation Service)

Figure 42-B
Soils that are somewhat poorly drained and located on nearly level to slightly sloping landscape have a "medium" erosion potential.

Figure 42-C
Soils with "high" erosion potential are deep, well drained, and occur on moderate to steeply sloping land.

Figure 42-D
Soil associations that are usually deep, well drained, and occur on very steep slopes have a "very high" erosion potential.

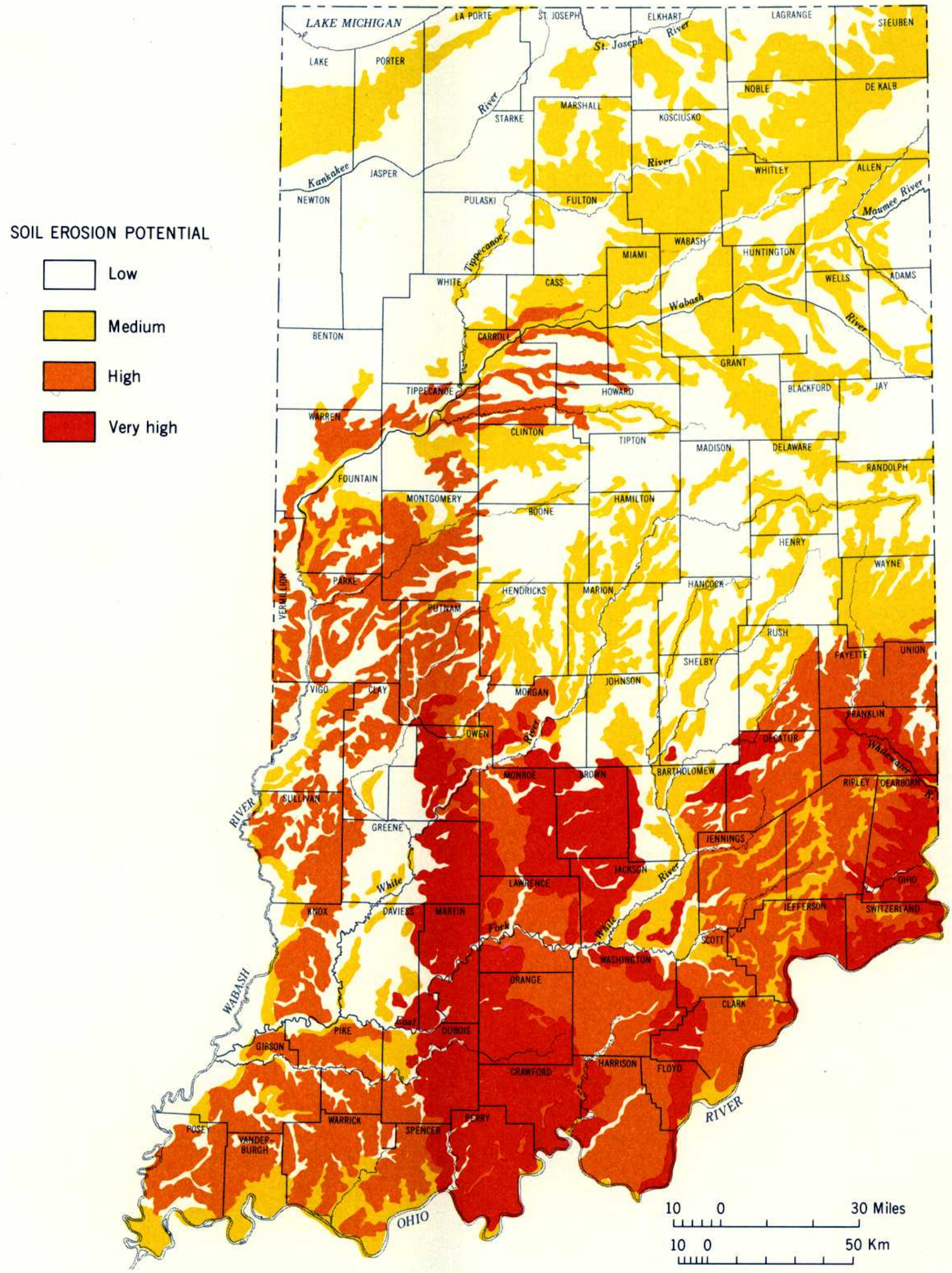

Figure 43
Map showing soil erosion potential of Indiana soil associations.

The assessment of the potential soil loss for land in fallow condition does not imply that the sloping lands of southern Indiana are losing more soil than other parts of the state. Many of these lands have adequate cover (trees and grass) and supplemental conservation practices to protect the land from erosion. Many farms throughout the state being intensively cropped on gentle and moderate slopes, without adequate conservation practices, are losing more soil to erosion than the more steep woodland and pasture areas. The general location of soil associations subject to erosion is shown on Figure 43.