Indiana Floods

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Floods are frequent in Indiana, local ones occurring somewhere nearly every season, and widespread ones occurring every few years. The following discussion is a companion to the study of "Drouths in Indiana" in *The Proceedings* for two years ago. The frequency of floods reflects four main conditions: (1) The abundant rainfall yields much water which must either soak in, evaporate, or run off. During the cooler months there is little evaporation, and the soil is often soaked, with the result so that there is much runoff. (2) Much of Indiana's rainfall occurs in considerable concentration. (3) In much of Indiana the runoff channels are inadequate in size and number to carry off the water of hard rains. This is partly a temporary condition resulting from the geologically recent glaciation. In the central and northern glaciated two-thirds of the State, natural drainage is incomplete or inadequate; much of that area is poorly drained because the stream courses have not yet been well developed or eroded to sufficient size. Each century the drainage of that region is becoming a little more adequate to carry off the excess rainfall, but insufficient time has elapsed since the glacier melted away to permit valleys to extend to all parts of the area and to provide adequate drainage channels. That region still is in the stage known as "physiographic youth" or (in parts of northern Indiana which are almost entirely undrained) "physiographic infancy". In the unglaciated section and that covered by the older Illinoian ice sheet (approximately the southern third of the State) although natural drainage courses are numerous and the relief is in most places "physiographically mature", nevertheless floods are rather frequent because of three special conditions. One of these is that rain frequently comes with notable intensity. Another condition favoring floods is the fact that the lower courses of several of the streams, notably the Wabash and the White, were partly filled by alluvial deposits as a result of special conditions prevailing during the Glacial Period, when these rivers were excessively loaded with glacial materials. Their wide, fertile alluvial plains are inviting to farmers, but partly because of the meandering, clogged streams, they are relatively often flooded.

The third main reason why there are many floods in Indiana and the fourth why southern Indiana, despite its numerous valleys, has many floods, are that changes produced by man have taxed the streams beyond their natural capacity. Deforestation has greatly increased runoff as have extensive drainage operations by open ditches and by tiles. Indiana has many miles of drainage ditches, 20,787 miles according to the 1930 Census of Drainage. Moreover, detailed estimates of tile drainage indicate that there are in the State a total of many thousand miles of small tile in addition to the 10,439 miles of large tile such as storm sewers, reported by the Census. These tile rapidly bring to the open ditches vast amounts of runoff water which otherwise would have stayed longer on or in the ground. This increased percentage and rapidity of runoff and the flooding caused thereby, and also the extensive erosion of cultivated hillsides have carried large amounts of soil and other materials from the higher levels into the stream channels, partly clogging them, thus reducing their capacity for rapid transportation of water. Consequently in times of high water, the rivers must spread beyond their normal channels.

Another human interference with runoff, which is of at least local importance, is the restriction to natural stream flow imposed by numerous graded roads and railroads crossing valleys, and by bridges constructed with a view toward saving money even though such bridges do impede the flow of streams. It does seem foolish, to those who have little considered the hazard, to build a large, long, and high bridge over a comparatively small stream, and to refrain from damming the valley by a high road grade. But repeatedly in Indiana, short, relatively inexpensive bridges and road grades in valleys have been seriously damaged by floods, with the result that replacement or extensive repair has required a total financial outlay greater than would have been required for an adequate bridge and a properly opened, graded road across the bottom land. The inconvenience and loss caused to citizens by the closure of roads for such replacement or repair of inadequate bridges and grades is a cost which is hard to estimate, but which is quite considerable in a region where population is as numerous and travel as extensive as in modern Indiana.

Floods vary greatly in magnitude, and the damage they cause varies with magnitude and with season of occurrence, and especially with the extent of human adjustments to them. Where flooded areas contain few people and little constructed property, floods may do little damage. In this article an effort is made to summarize the occurrence of floods of four magnitudes—local, moderate, widespread, and great—and also to point out methods of reducing the damage that future floods of similar intensities will cause. Under the latter head, flood predicting is mentioned. Details on occurrence are given following a brief discussion of types, causes, and ways of reducing the damage.

Local floods are caused by excessive local rainfall. A rain of two or three inches may cause a local flood upon relatively flat land, such as a city site, if it falls within an hour or two, as sometimes happens. The frequency of rainfalls of such an amount in Indiana is discussed elsewhere, where data on the maximum rainfalls which have occurred in various short periods from five minutes to six days are also mapped and discussed. A local rainfall of several inches within a day or two is sure to cause some local flooding not only of poorly drained areas, but also of those with small valleys.

Floods of a small river basin, for example the East Fork of the White River, are caused by several days of heavy rainfall over a large part or all of its basin. The larger the area drained, the more widespread or excessive the rains must be in order to cause a flood of the main stream.

This is because stream valleys are prepared to carry away the normal amounts of runoff and hence large basins normally have developed large drainage channels. Indeed, as the valleys were carved out by the runoff water itself, especially that of times when more than the normal amount occurred, floods seldom occur unless there is considerably more than the normal amount of runoff. The chief exception to this rule occurs when special conditions interfere with runoff. Examples are the partial blocking of valleys by ice, road grades, or levees, and by an unnatural increase in runoff such as that caused by drainage projects. (The sudden release by warm rain of previous precipitation accumulated as snow, although an important cause of floods in some regions, is of minor import in Indiana.)

Widespread floods (the third magnitude) which occur once every few years are the result of excessive rainfall over a large area. Such floods are much more important than are the more restricted floods just mentioned, chiefly because they affect larger areas, even though they may not cause any more damage in any particular small area than are caused by local floods.

The final category here considered are the "great floods", the worst in a generation or a century. These are due to excessive rainfall over a large area, and their height is little affected by anything man has done. Floods as great as any which have occurred in recent years certainly have occurred in most regions before there was any appreciable amount of deforestation or artificial drainage, or before man-made obstructions to the valleys were constructed. In other words, although the frequency and severity of local and ordinary floods clearly are affected in several ways by human action, the "great" floods are meteorological phenomena that are almost completely uninfluenced by man. They come whenever sufficiently excessive rain falls, they require such large amounts of precipitation that the soil even of forested land, the reservoirs, and other catchment basins are filled to overflowing, and the levees are inadequate to hold the streams in place. For example, the record-breaking flood of the Ohio River in January, 1937, resulted from a rainfall of eight inches or more falling during a three-weeks' period over much of the Ohio Basin (from Ohio, Tennessee, and Kentucky to southern Indiana) following heavy rains in late December and early January. The January rainfall averaged 15.4 inches in Kentucky, 14.7 in Tennessee, 9.8 in Indiana, and 9.4 in Ohio. For each of these states, those totals set new January records. For the 30 days December 27, 1936—January 25, 1937, 33 Indiana Weather Bureau stations each received more than 15 inches of precipitation. Five of them received from 20 to 22.38 inches.

Experts have calculated that the several dams on the Upper Ohio River and its tributaries did not reduce the height of the great 1937 flood of the lower Ohio River more than one or two per cent, an almost negligible amount. This was because vast amounts of rain fell after the reservoirs were filled.

Thus, it appears that not only are these great floods not in any way the fault of man but that he can do almost nothing appreciably to reduce their frequency or height. Levees merely somewhat increase the height of the flood, at least until the levee is broken. It is, however, clearly possible to reduce the damage which floods cause.

Methods of Reducing Flood Damage

Four chief ways of reducing flood damage are: (1) Reduce the number and severity of floods by retarding runoff in the upper stretches by increasing absorption by the soil (as by reforestation, strip farming, and contour plowing), and by creation of storage reservoirs. As already remarked, this method is entirely ineffectual after sufficient rainfall has fallen to saturate the soil and to fill the reservoirs. (2) "Improve" the stream channels by removing obstructions to stream flow to reduce locally the flood height. This procedure, however, increases the height of the flood farther down the valley. Its effect is opposite to the first procedure, that of retarding runoff. (3) Build barriers (levees) against the flood to confine the high water to areas bordering the normal course of the river. Levees increase the height of the flood (except in the protected area), by confining the water to a narrower channel. Moreover if the flood overflows or breaks the levee, the resulting damage may well be distinctly greater than would have occurred if there had been no levee. This is partly because levees give a false sense of security and thus encourage improper land use. Deposition along the stream bed between the retaining levees commonly causes the stream to flow at an ever higher level, with the result that progressively higher levees are required to confine the stream. Furthermore, insofar as levees are effective in preventing any flooding of the bottom lands, they also prevent the deposition of silt there, and consequently inhibit the upbuilding and natural fertilization of the bottom lands. In other words, a system of levees which prevents any flooding of the adjacent flood plain results in serious injury to the flood plain by causing the confined river to flow at an increasingly higher elevation above the flood plain. This seriously interferes with the natural drainage of the bottom land, and at the same time the lack of flooding means the absence of natural fertilization; flood plains are valuable primarily because they are relatively fertile.[1] (4) The fourth and most effective way of reducing flood damage is by making adequate allowance for and adjustment to floods. Flood prediction is one aspect. Studies of the flooding effects of various amounts of rainfall and other conditions are essential. The predicting of the height and time of the crest of a flood is done both on the basis of observations further upstream and by deductions from meteorological and surface conditions. Structures necessarily placed near streams, such as bridges, and some roads, should be constructed in such a way as to withstand floods, and at the same time not to be a significant contributing factor. To do this efficiently requires knowledge of the flood conditions which are to be expected. It is of special importance that the areas subject to flood have their use restricted in such a way that a minimum amount of damage will be done by the flood. Permanent residences, for example, should be prohibited, at least those which are not cheaply replaceable; only such livestock and so forth as can be readily removed should be allowed. In general, areas which are frequently flooded should be devoted to forest growth for which they are especially well adapted and useful, now that timber has become valuable. If farmed, such low land should be planted in some crop which is relatively little subject to flood damage. Farmers who plant these areas should reside on considerably higher land and should be able to accept the financial risk of losing an occasional crop in order to harvest higher yields from rich land most of the time.

A thorough classification of all the land of Indiana as to its suitability for various uses should be made. Land should be used in the ways believed by competent authorities to be the most advantageous from the viewpoint of the general good over a long period. It has been suggested that such wise use might advantageously be encouraged by flexible taxation. For example, wisely used rural land could be taxed lightly; land which was used with moderate suitability could be taxed moderately; land which is used in a way clearly contrary to the better interests of the community and nation could be taxed heavily. Land subject to frequent flooding certainly should not be used in the ways in which much of it is now used. Merely because it is poor for residential purposes, and hence cheap, is no justification for having much of the low land of Indiana's cities occupied by numerous poor dwellings. Likewise, merely because it is convenient to live near to one's fields is no justification for having permanent and costly farmsteads in places that are subject to flood, with consequent loss of property and perhaps lives. Despite the strong American rebellion against restrictions of freedom of action, such restrictions are becoming increasingly necessary.

The modern availability of communication and transportation, while improving some possibilities of adjustment to floods, for example, prompt removal of livestock, has made for a wider knowledge of human suffering in flooded areas which leads to mental suffering by sympathetic people elsewhere. Moreover, the people of neighboring areas are adversely affected financially by sharing the losses caused by the floods. They do so in many ways, partly through voluntary contributions for relief, partly through being compelled to pay higher taxes to raise money appropriated for relief and rehabilitation, and partly because of the higher prices they must pay for certain services and goods as a result of the flood. Hence there is real justification and social desirability for enacting and enforcing regulations to prevent permanent residence in areas subject to serious flooding and to restrict the use of those areas in such a way as to cause

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[1] Because of these well-recognized drawbacks to levees, the world's most expensive levee system, that along the lower Mississippi River, is being seriously questioned, even partially abandoned. This is despite the urgent political pressure imposed by people taking a short view of the matter, who insist that levees are essential. One phase of the partial abandonment of the Mississippi levee system takes the form of deliberate breaks in the levee with the result that large prescribed areas are flooded, thus temporarily checking the rise in the river level, and reducing the prospect that an undesired break will occur elsewhere in the levee. In the areas thus deliberately flooded, the flood damage is relatively slight because the use of those areas is restricted in such a way as to render flood damage small.

a minimum of anguish and loss not only to the local people but to numerous others.

Floods of the White River

Five especially high floods of the White River were those of 1828, 1847, August 1875, March 1913, and January 1930. The floods of February, 1916, January, 1937, and April, 1939, also were high. The floods of 1930, 1913, and 1875 reached approximately the same heights as did those of 1828 and 1847, both of which apparently were somewhat higher than the more recent ones. The earlier floods caused much less damage, however, as relatively few people resided in the valley in 1828 or 1847. The flood of 1875 did more damage than that of 1913, except in Indianapolis, because it occurred in late July and early August, and destroyed most corn, while the 1913 flood occurred in March before corn was planted. The increase in bridges and road grades in the valley, which had occurred between 1913 and 1930, resulted in greater damage by the later flood. Moreover, a considerable share of the corn crop of 1929 on the bottom land had not been harvested prior to the January, 1930, flood, because much of the land had been almost continuously too wet to permit the use of wagons. Hence the 1930 flood caused greater destruction along much of the valley than did the 1913 flood. The chief exception was in Indianapolis, where the 1913 flood did much the greater damage, several millions of dollars worth in the western and southwestern parts of the urban district. The 1913 flood is estimated to have taken the lives of 200 people in Indiana (on other rivers as well as the White) and to have driven 200,000 people from their homes. The estimated number of persons driven from their homes in Indianapolis was 35,000; at Rushville, the entire business district was inundated.

Floods on the Wabash River

The lower Wabash River carries the drainage from two-thirds of Indiana as well as from a small part of Illinois. The upper Wabash, above the mouth of the White River, is a much smaller stream, draining less than a third of the State, only a little more than is drained by the White River (11,481 versus 11,155 square miles). Moreover, the upper Wabash Basin has less runoff than the White, both because it receives less rainfall, especially during the cooler months, and because much of it is relatively level, in contrast with the "well-drained" character of much of the White River Basin. In this discussion it is therefore desirable to distinguish between the upper and lower Wabash, the latter including that below the mouth of the White River.

High floods on the upper Wabash (based on data for Terre Haute for 1905-1939) occurred in January, 1907, March, 1913, August, 1915, February, 1916, November, 1921, April, 1922, September-October, 1926, June and December, 1927, January, 1930, May, 1933, July, 1938, and March, 1939. The highest of these floods was that of 1913 when on March 27, the crest was 17.3 above flood stage. The next highest floods were on May 16, 1933, and March 16, 1939, when the crests were 11 feet above flood stage. In 1907, (January 23) the crest was 10.7 feet above flood; in 1922 (April 19) it was 10.4 feet; in 1916 (February 2) it was nine feet; it was about seven feet above flood stage on December 5, 1927, October 7, 1926, and July 4, 1938. The highest water (1905-1939) during June was only four feet above flood stage (June 1, 1927) while August had no flood in these years, the highest water level being two feet below flood stage. At Vincennes, the crest of the January, 1930, flood was higher than that of March, 1913, flood, but this greater height in 1930 is believed to have been due to the presence of levees which held, whereas the levees of 1913 failed to hold. Floods which did especial damage in the Wabash Valley were those of 1913, 1930, and 1937. In 1913, for example, two-thirds of the city of Logansport was submerged, some of it to a depth of 15 feet. At Lafayette, the river reached 22 feet above flood stage and was three miles wide. At Peru, Kokomo, and numerous lesser places along the river, many citizens were compelled to flee.

Floods on the Ohio River

The Ohio River is scarcely in Indiana, because when Kentucky was established, its northern boundary was the north bank of the river. The U. S. Supreme Court has, however, ruled that the boundary between Indiana and Kentucky is along what was the north bank in 1816, when Indiana was admitted to statehood, instead of along the present north bank. Since the river shifts continually, small parts of the river now are within Indiana. During floods, of course, considerable stretches of Indiana's bottom lands are covered.

The Ohio can carry such a vast volume of water that a serious flood scarcely could be caused by its Indiana tributaries. Moreover as floods on the Ohio affect other states more conspicuously than they do Indiana, discussions of Ohio floods have been made almost solely by non-Hoosiers. Cincinnati, the largest city on the Ohio proper, has been much affected by that river, and therefrom have come many valuable data as to floods.

The Ohio has, on the average, several floods a decade (62 floods in 67 years, 75 in 100 years) but few of them attain heights much in excess of flood stage, as when that stage is reached, the river is much wider and straighter than normal, and flows much more rapidly, and hence carries off much more water. Flood stage does not commence until the water attains a level about 50 feet above low water level at Cincinnati and Louisville, and about 35 feet at Evansville.

The 1937 flood was the highest on record, reaching a level of approximately 80 feet above low water level at Cincinnati, 87.4 feet at Louisville and 87 feet at Dam 43 (located 25 miles below Louisville) and 54 feet at Evansville. Never before in the United States, Devereaux declares, has a river flood attained a level as much as 80 feet above low water stage. The second highest flood of record of the Ohio River was in 1773, estimated to have attained a height of 76 feet at Cincinnati.

Four-fifths of the floods of the Ohio River are caused, Devereaux estimates, by heavy precipitation over the upper parts of the Ohio and its tributaries, while one-fifth are caused by excessive precipitation in the region near Cincinnati and along the local tributaries.

The Ohio River floods have caused heavy damage to several Indiana river cities and towns. The 1937 flood, which at the crest, January 26 at Cincinnati, January 27 at Louisville, and January 31-February 1 at Evansville, reached heights of 28, 30 and 19 feet above flood stage, respectively, caused millions of dollars of damage in Indiana (especially at Evansville, more than two-thirds of which was under water, while 90,000 people fled from their homes). Jeffersonville was 90 per cent flooded and 13,000 people fled from their homes. Several lesser places were badly damaged, one of which, Leavenworth, has been largely abandoned in favor of a new town site on the upland.

The Ohio floods occur predominantly during the first three months of the year. Of the 18 greatest floods of 1832-1939, January had five, February seven, March, four, the other nine months only two. Of the 28 chief floods at Evansville, 1883-1939, only two had their crests after April 5, (April 23, May 20) and only two before New Year's Day (December 15, 30). March and January each had eight, February seven, April four, December two.

Thus a flood which attains a height of at least seven feet above flood stage at Evansville occurs in nearly half of the years, and in about one-eighth of each of the Januaries, Februaries and Marches.