

FLOOD PROTECTION IN INDIANA.

W. K. HATT.

Organized effort to study the causes and to lessen the effect of floods in Indiana begins with the appointment of the Indiana Flood Commission by Governor Ralston on April 20, 1914.

This commission is composed of one member from each congressional district and the personnel is as follows:

Mr. E. W. Shirk, Peru, Chairman.
 Professor W. K. Hatt, Purdue University, Lafayette, Chief Engineer.
 Mr. Frank C. Ball, Muncie.
 Mayor Benjamin Bosse, Evansville.
 Mr. William Cronin, Terre Haute.
 Mr. Stephen B. Fleming, Ft. Wayne.
 Mr. J. H. Frederick, Kokomo.
 Mr. S. J. Gardner, New Albany.
 Mr. Victor M. O'Shaughnessy, Lawrenceburg.
 Mr. Joseph C. Schaf, Indianapolis.
 Mr. W. N. Showers, Bloomington.
 Dr. Chas. K. Stoltz, South Bend.
 Mr. Herman Trichler, Brookville.

The commission met first in Indianapolis, on April 30, 1914.

The purpose of this commission is to consider the extent of damages due to floods in the State of Indiana, and to report to the Governor what measures should be taken to provide relief in the future.

The commission expects to issue its final report in 1915. This report will contain a full presentation of the history of floods in Indiana, a summary of the causes of floods, a collection of available data on rainfall, river discharge and topography, a discussion of flood protection works and a discussion of the principles of legislation to provide for flood relief.

This present pamphlet is an abstract of the forthcoming report of the commission, prepared in non-technical style for general information.

FLOOD OF MARCH, 1913.

The appointment of this commission was the direct result of the flood of March, 1913, in which 467 lives were lost and over \$160,000,000.00 of property destroyed in the United States. The memory of this catastrophe is still fresh in the minds of the people of Indiana, in which State thirty-nine lives were lost, and over \$18,000,000 of property destroyed.

The total loss in the flood of March, 1913, can never be known. The interruption of transportation and of business, the destruction to farm lands by cutting of banks of rivers and covering of bottom lands with gravel, the loss of productive capacity of manufacturing plants, and the sickness following exposure, are not susceptible of exact computation.

Professor Beede of Indiana University reports a total damage of approximately one-half million dollars in seven counties in the lower White River basin, in which also nearly eight thousand acres of agricultural land were denuded of soil and some sixteen thousand acres of river bottoms were covered with soil and silt. He estimates the loss to agricultural land in this region as nearly \$250,000.00.

The loss reported by county auditors to county roads and bridges alone, was over \$3,000,000.00. Other tangible losses that have been determined are shown in Table 1. It is probable that the loss during the flood of March, 1913, in Indiana, may be estimated at over \$25,000,000.00.

Indeed the catastrophe was so general over the Ohio Valley that it excited the sympathy and support of the entire nation. The Governor of the State of Indiana received \$———— in subscriptions for the relief of flood sufferers in this State.

PART OF DAMAGES SUSTAINED IN THE FLOOD OF MARCH, 1913.

1. County highways and bridges.....	\$2,825,240 00
2. Railroads—steam	5,299,810 00
3. Electric railways	788,000 00
4. Buildings and personal property.....	8,104,250 00
5. Telephone and telegraph.....	17,510 00
6. Crops	735,700 00
7. Livestock	149,380 00
8. Farm lands	264,700 00
9. Suspension of business.....	582,000 00
Total	\$18,766,590 00

Counties not included in (1)—Cass, Clinton, Fayette, Floyd, Miami, Sullivan.

Railroads not included in (2)—Central Indiana R. R., Chicago and Wabash R. R., Cincinnati, Hamilton & Dayton R. R., Toledo, Peoria & W. R. R., Toledo, St. L. & W. R. R.

Electric lines not included in (3)—Marion and Bluffton Traction Co., Bluffton, Geneva & Celina Traction Co., Central Indiana Lighting Co., Indianapolis Street Railway Co., Louisville and Southern Traction Co., Louisville and Northern Railway and Light Co., Vincennes Traction Co., Washington Street Railway Co.

(5) Includes Indianapolis Telephone Company only.

Counties in flood districts not included in (4), (6), (7), and (9)—Adams, Blackford, Cass, Clark, Clay, Clinton, Fayette, Floyd, Fountain, Franklin, Gibson, Grant, Greene, Harrison, Howard, Huntington, Jay, Jefferson, Ohio, Parke, Perry, Putnam, Randolph, Ripley, Scott, Sullivan, Switzerland, Tippecanoe, Vanderburg, Vermillion, Vigo, Wabash, Warrick, Wells, White, Whitley.

(8) Includes loss only in 230 miles of East and West Forks of the White River through Morgan, Owen, Greene, Daviess, Knox, Jackson, Lawrence, and Martin counties.

First there are six main problems to be solved before our Indiana communities can protect themselves against floods.

FIRST PROBLEM.

Flood Flow.

First there must be proper information as to the amount of water carried safely in a channel. To determine this amount we must first know the rainfall that may reasonably be expected at a time not too remote, and the rapidity with which this rainfall runs down the watershed.

In considering flood protection in Indiana we are barred at the outset from a sure solution at present, first, on account of a lack of rainfall records over a sufficiently long time; second, by a lack of stream gaging to determine the amount of water which does run down our streams during heavy rains; and third, by a lack of surveys of watersheds.

In other words, a heavier storm than any that has been recorded in the last thirty years of our rainfall records, may come in the future, but our records do not serve to determine the probable extent of this storm.

Again, we have not gaged our streams to know the relation between the runoff and the rainfall. Such records as are gathered in other communities will not apply to our peculiar conditions, that is, two watersheds of equal area, one long, narrow and V-shaped, and the other broad and flat, will yield very different flows in the streams. Again, the character of the surface, whether of rocky formation or swamps or farmland, will change the conditions.

Therefore, to obtain an exact solution of our flood problems we must first of all get accurate surveys and determine the flow of our streams. This cannot begin too soon. For this reason, the Indiana Flood Commission recommends an early beginning of this work of surveys and stream gaging.

These surveys are most important for another purpose, namely, to determine if the water of the upper reaches of the rivers can be held back for a time in reservoirs. For instance in the case of the Wabash River at Logansport, which carries the floods from the upper Wabash, the Mississinewa, the Salamonie, and the Eel River, we would like to know if it is possible to find reservoir sites in the valleys of these tributaries, so that the flood flows may be controlled. Each tributary flood might be held back to the proper amount, and for the proper time, so as to let these flood flows by Logansport one by one.

For example, in Ohio, it was found that by reservoir control, flood protection could be obtained for the cities of the Great Miami Valley at a cost of \$17,000,000.00, whereas the total sum of the cost of the individual protection schemes gotten up by each city acting separately was over \$100,000,000.00. The study of reservoir protection for the Miami Valley was made by the use of the topographic maps of the State of Ohio from which reservoir sites were planned and preliminary estimates worked up. Later on, detailed surveys showed that the preliminary work was accurate to within one per cent. The topographic survey of Ohio is 87 per cent. complete, whereas the Indiana survey is only 9 per cent. complete. If we were fortunate enough to possess topographic maps of the State of Indiana, we could go ahead immediately to study flood protection in a more complete manner.

The topographic map of the State is not only necessary for complete flood protection studies, but it is of use in the following:

(1) As a preliminary map for planning extensive drainage projects, showing areas of catchment for water supply, sites for reservoirs, routes of canals, etc.

(2) For laying out highways, electric roads, railroads, aqueducts and sewerage systems, thus saving the cost of preliminary surveys.

(3) In improving rivers and smaller waterways.

(4) In determining and classifying water resources, both surface and underground.

(5) In determining routes, mileage, location of road-building material, and topography in country traversed by public highways.

(6) In classifying lands and in plotting the distribution and nature of the soils.

(7) As base maps for the plotting of information relating to the geology and mineral resources of the country.

Our first problem is therefore to gather reliable information as to stream flow and topography.

The Indiana Flood Commission, however, realizes that critical conditions exist in several cities which can not wait the ten or twelve or fifteen years required for the completion of such surveys. The commission has therefore made the best solution it can, and has studied all available records, has computed rainfall and runoff, and determined to the best of its ability, the amount of water which an Indiana city may expect to take care of during future flood time.

Briefly, the records of the heaviest storms in the Ohio Valley region have been studied and the relation between the drainage area and the inches of rainfall worked out for these storms. Several of these storms have been studied, notably those of October, 1910; January, 1913, and February, 1884. For instance, it was found that the center of the storm in January, 1914, was over Southwestern Kentucky; the center of the storm of March, 1913, was over a line from Mt. Carmel, Ill., to Richmond, Ind. It is reasonable to expect as a matter of chance, that similar storms in the future will be centered fifty to one hundred miles from its former center. Cities must therefore reasonably expect to take care of such storms.

The result of the study is equivalent to fixing a future expected rainfall as equal to that of the storm of March, 1913, plus one-third additional in the White River Valley, and one-fourth additional in the Wabash watershed. Small drainage areas are yet to be studied. The river dis-

charge resulting from the specified rainfall is determined from river gagings at selected points during the flood stages of March, 1913. Adjustments are made for various rainfall and channel slopes directly as the rainfall and as the one-fourth power of the slope.

To determine the area of channel or bridge opening to carry this flow, the commission suggests tentatively six feet per second as a flood velocity through an improved channel, and not over eight feet per second as a velocity through bridge openings. In any particular case, special study of channel conditions must be made. The Indiana Flood Commission has thus proceeded with the compilation of recommended bridge openings throughout the various parts of the State, as an approximate solution of our present difficulties. A survey of actual bridge openings through the State accompanies this study.

SECOND PROBLEM.

Design of Works.

The second problem is to design flood protection works to take care of the water which is recommended to be carried. This is not a difficult problem, involving only good engineering knowledge and judgment.

These flood improvements will consist in improvement of the channels of the rivers involving cleaning and straightening the river bed and lengthening the bridges, and removing obstructions, and secondly the building of levees to retain the flood heights. If proper surveys exist, reservoir control may be studied.

The Indiana Flood Commission has gathered together a number of plans that have been drawn for the Indiana cities, and it is in a position to assist communities that desire advice on the nature of flood protection works.

THIRD PROBLEM.

Construction Work.

After complete information has been gathered, and the best engineering skill has been operating, a third and most important step must be taken. There must be some organization to finance and build flood protection works. In other words some legislative action must be taken, some so-called enabling legislation. In any community some agency must be created to determine the necessity of improvements, to direct their construction, and to establish an assessment roll for benefits and damages

within a district defined in advance. And this agency must be appointed and directed by the courts or by a State board.

This is the crucial problem. It involves the coördination of several, at present unrelated agencies, as for instance the city government, the county commissioners, and the railways.

Of what benefit is it to a city like Peru, to spend \$350,000.00 on a levee, if this scheme demands for its proper action the lengthening of a county or railway bridge, when the county commissioners or railway officials refuse to coöperate.

It must also be remembered that we all have gone ahead creating new obstructions in the flood plain and in the channel which interfere with the flow of our flood waters. Railways, cities and county commissioners are responsible for the conditions. Channel obstructions must be removed, and either the State or the Federal Government must take action. Some control must be exercised over present as well as future constructions in the channels.

FOURTH PROBLEM.

Valley Protection.

When we take a wider view than that of the specific problem of a single city, we must consider a flood protection scheme from the standpoint of the watershed as a whole. One city in Indiana has made flood protection plans which deflect the water around the city, and throw it around in increased volume on its neighboring down stream. Cities often content themselves with sluicing the water through the cities and pile them up on communities below. Here is again the problem of state action to protect the whole people. Fortunately this is not merely an action of control, but means a wider viewpoint that may disclose a cheaper and better method of protecting the whole valley.

FIFTH PROBLEM.

Maintenance.

After these works have been constructed, we have a fifth problem in their maintenance. It must be recollected that these works are built to protect against floods which happen only once or twice in a generation. Naturally such works as levees and reservoirs will tend to be neglected during this unused interval. If people construct dwellings and operate industries in a space supposedly protected by improperly maintained reser-

voirs, or levees, they are in jeopardy. In this case the State must exercise some power to protect the people and see that these works are maintained.

SIXTH PROBLEM.

Federal Action.

In considering the question of floods the view is successively of city, of county, of watershed, of State; and finally the rights and duties of the Federal Government come into view. Our present problem is to delimit and properly apportion the action and responsibility as between the States and the Federal Government. At present the Federal Government controls all openings and obstructions in navigable streams. The logic of the situation would extend this to the upper reaches, because what happens there will affect navigation below.

For instance, if, due to obstructions, bars pile up on bridges and soil is washed down and creates bars below, there is a real connection between the upper reaches and the lower parts of the river.

Again, the Weather Bureau is in the best position to take observations of rainfall, and the Geological Survey can best and does make the topographic surveys, and the stream gaging.

Thus in this problem, the complex question of the division of water control, as between the States and the Federal Government, is to be determined in the future. A watershed is a natural unit, and not a political unit. There should be some coördination between the States in the Ohio Valley, whose problems are very similar.