Cooperative Planning in Use of Flood Plains

Corps of Engineers Report on Rouge River at Farmington, Michigan

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•THIS PAPER describes cooperative planning for utilization of the Rouge River flood plain at Farmington. Items covered include the purpose and need for the study, the procedures used and analyses made, and the selection and presentation of data.

The objectives of flood plain information studies are as follows: (1) To compile specific information on floods, potential flood hazards, and areas subject to inundation. (2) To encourage optimum and prudent use of flood plains. (3) To disseminate and publicize available information for the guidance of all. (4) To reduce future Federal expenditures to alleviate flood problems arising from improper flood-plain use.

These objectives are applicable to all such studies, but the reasons for initiating studies are not always the same. At Farmington, the local officials had been concerned for some time about their lack of power to control filling and other improper use of the flood plain. In this and adjacent areas, filling of flood plains and other areas is advancing at an accelerated rate due to the disposal of enormous quantities of soil from extensive expressway construction programs and the normal need of an expanding population for refuse disposal areas. In the northwest sector of the Detroit metropolitan area, two expressway projects alone are contributing about 5.5 million cu yd of excavated materials to the disposal problem.

The Farmington City Council became concerned when it found itself without adequate power to prevent conflicting uses of the Rouge River flood plain within the Farmington City Limits. This consisted primarily of filling operations and housing developments. The Council members realized that without proper controls, the best use of the land could not be guaranteed and eventually someone would be injured.

Their concern appears valid in view of the valley's flooding history and the flashy nature of the river. Although there has been a U. S. Geological Survey Gaging Station on the river at Farmington only since March 1958, it was fortunate that four notable floods within the past 30 yr could be defined through newspaper and U. S. Weather Bureau records. These floods occurred as the result of storms in 1933, 1947, 1956, and 1962. The first three of these were the result of storms producing 2.3, 3.0, and 3.65 in. of rain. However, the 1962 flood was caused by a rainfall of only 0.7 in. and an ice-choked channel.

All floods in this part of the Rouge River generally follow the same pattern; the peak discharge occurs 4 to 12 hr after the beginning of rainfall; the duration of valley flooding is usually less than 24 hr.

This pattern is constantly undergoing change because of the urbanization taking place in the valley above Farmington and by changes taking place in the valley at Farmington. The net effect is a shortening of the runoff period and a restriction of the flood plain.

The river at Farmington is a major tributary of the Rouge River and is known as the Upper Rouge River. The Rouge River flows into the Detroit River at Detroit from a basin of 464 square miles.

Farmington, by 1940, had grown to 1,510. By 1950, the population was 2,325; and by 1960, it had increased to 6,881. Although the city development was primarily along the plateau at one side of the valley of the Rouge River, the city now occupies both

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plateaus and the valley as well. At present, the land use in the flood plain is equally divided between residential areas, open idle lands, and park land.

The basin above Farmington, with an area of 17.5 square miles, is a moderately wooded rural area, but numerous isolated residential subdivisions have been developed in recent years. Upstream of the city, the stream flows in a well-defined fairly narrow valley and has a slope of about 30 ft per mile. Below the city, the slope flattens to about 12 ft per mile. The channel, through the city, is about 40 ft wide and is entrenched only a few feet below the valley floor. The flood plain averages about 500 ft in width and is well defined with banks ranging from 20 to 50 ft in height.

The study area extends along the river only from city limit to city limit, a distance of about 2½ miles. Hydrologic studies, however, were not limited to that area.

Preparation of a flood-plain study is basically a data collection process. The essential elements are those that make it possible to illustrate the extent to which river flows of specific magnitudes and frequencies occupy the flood plain. These elements usually consist of but are not necessarily limited to the following four elements: (1) Good maps of the area, preferably good contour maps, showing as much of the area culture as possible. Aerial maps provide the best base for illustrating the hazards of occupying the flood plain for the reason that individual buildings and other natural features can be seen and identified by the layman. (2) Flood marks from one or more recent major floods are needed to provide a check on hydraulic computations and to lend confidence to computed flood profiles. In the Detroit metropolitan area, local units of government have had difficulty in formulating flood plain regulations that will stand up in court. In the light of these experiences, it is evident that if the reports are to be useful, the basic data for the computations must be authentic and well documented. To provide good solid data on prior flooding, as many people living adjacent to the river as possible are interviewed. Photos of past floods and record descriptions of high water marks are collected, and other physical factors affecting past floods are studied. (3) Information concerning the rainfall and runoff of specific floods is extracted from published records and is supplemented by data extracted from local newspapers. (4) It is also important when studying past floods to determine whether or not changes have taken place that would affect the runoff or the stage-discharge relationship of the stream at a specific point. Included in these determinations are the past and future area development factors at the study site and removed therefrom.

When hydraulic computations are necessary in order to define the flood plain, field surveys may be required to provide the necessary basic data. Usually it is necessary to obtain cross-sections of the stream at more or less regular intervals and occasionally of the entire width of the valley. This is an expensive operation; but at Farmington, the use of aerial photos acquired from a local source reduced the cost. The locations of the cross-sections were spotted on the photos thereby eliminating the need for horizontal control. Vertical control was established by running from existing U. S. Geological Survey bench marks to six newly established ones.

To further document high water profiles, a device was installed at five locations along the stream within the study area. This homemade device is a crest-stage gage designed to record the crest stage of a flood. Credit for the device goes to the U. S. Geological Survey and the Michigan Water Resources Commission. These recorders are fabricated from 2-in. pipes cut to the length required by the site. A ¾-in. square stick, the length of the pipe gage, is inserted in the pipe and held with standard pipe caps. A bolt in the lower cap is set so that the head is even with the lip of the pipe cap—the zero point of the gage. Several holes are drilled in the lower end of the pipe to allow the water to flow in. The gage is charged from the upper end of the pipe with one teaspoon of powdered cork and ¼ teaspoon of dry detergent. The peak flood stage is recorded in the pipe by a ring of cork particles that cling to the stick in the gage. The flood stage elevation is found by adding the distance from the end of the stick to the cork ring and the elevation of the gage zero. Some care is required in setting these gages to see that the bottom will not be inundated by every minor stream rise.

It is Corps of Engineers' practice to encourage local governmental units to furnish and install the crest-stage gages and the adjacent bench marks, and to maintain them. This has been successful in most cases. It was also found that because it is usually necessary to mount the gages in relatively exposed locations, damage including vandalism is a factor and frequent inspections are necessary.

Certain computations are generally required in order to portray flood-plain limits. These cannot be made without the types of data previously described. These computations are usually in two stages; first, analysis of the pertinent hydrologic factors concerning the floods to be studied; second, development of the hydraulic computations that are determinations of the stream's capacity to carry the flood flow.

The hydrologic studies usually involve a detailed analysis of the rain, snow, and runoff conditions to determine the characteristics of the watershed and all factors contributing to runoff at a given location. These data make it possible to develop a unit-hydrograph, the flow-versus-time curve for a given point on the stream for a given amount of rainfall. The unit-hydrograph provides the tool for determining such flood characteristics as time of concentration, the nature of the rise of the flood, duration, and flood magnitude. It is also the tool that makes it possible to predict the magnitude of floods caused by any selected runoff including the flood produced by the most severe storm considered to be meteorologically possible in the area. The flood produced by this extreme storm is required in flood plain reports to serve as a warning regarding what could happen.

The next step involves obtaining the hydraulic relationships of the river channel. The basic data are the cross-sections, bridge openings, and other features previously discussed. All these data are integrated in a step-by-step solution of the basic hydraulic equations developed by Bernoulli and Manning. Since this is a trial and error computation, the electronic computer becomes a very useful tool. The collected high water marks are used at this time to provide a check on the computations. The assumptions made regarding roughness and bridge opening coefficients are adjusted until the computed profile matches the historical profile as defined by the flood marks. It is necessary to build-in the physical changes that have taken place since the date of the reconstituted flood. At this point, the work has resulted in an up-to-date mathematical model of the stream permitting computation or profiles for various hypothetical floods with considerable confidence.

One other step is required before the efforts can result in meaningful data for the city planner. To give the city planner a basis for reasoned judgment regarding prudent use of the flood plain or of various levels of the flood plain, the city planner should know how often the various levels of inundation can be expected. This requires that an analysis be made to produce the relationship of flood discharges to time. This relationship expresses the average intervals that can be expected between floods of similar magnitudes. This is neither a prediction nor a prognostication. It is simply a statistical analysis of available data by the best methods known today.

Another feature studied, on request, is the effect of specific fills or obstructions proposed for the flood plain. In the case of Farmington, a determination of the effect on the several flood profiles of a definite proposed fill was requested. This was done and the results were presented in the report.

All of the data developed in this study were presented to the City of Farmington for use in developing and supporting flood-plain use regulations. The data were presented, when possible, in such a manner as to be useful to the engineer and understandable to the layman.

Flood outlines were presented on an aerial mosaic of the area and on detailed contour maps. The topographic maps show cross-sections, gages, bench marks, streets and buildings, and other features of interest. A profile also was furnished. The profile of record was shown as observed and as it would be under present-day conditions.

The report prepared as a means of making the collected and developed data available to the people concerned was really two reports in one.

The main report was intended to be a concise, readable narrative bringing together data on the character of the flood-plain area; descriptions of developments having an effect on flood flows; words of caution regarding possible damage to structures already in the flood plain; discussion of ordinances in effect that pertain to flood plain use; and a description of the extent of the flood problems and the hazards. The report also presented a discussion of development factors that affect the flood flows, means to reduce damages by flood fighting and flood warning, and a general discussion of flood flows and probabilities. It also furnished maps showing the extent to which flows of various magnitudes occupy the flood plain.

Experience gained since the beginning of this program indicates the advisability of emphasizing in the reports the need for flood-plain planning regarding use. To provide this type of guidance, a general information section is included covering such flood-plain regulation and management items as channel encroachment lines, zoning ordinances, building codes, flood proofing, urban redevelopment, open spaces and recreation areas, and warning signs.

The report data make it possible to stake out on the ground the outlines of the several floods developed during the course of the study. These data and the computations were documented for use by the engineer and technician in a technical appendix. This appendix is intended to supplement and expand the information contained in the main report. It contains a section on the vertical control used and established for the study area. Another section lists the crest-stage gages, a description of each, and a discussion of their maintenance and operation. The appendix also tabulates and describes the high water marks, cross-section, and bridge data. Of course, considerable detail is presented regarding the climatological and hydrologic data. It is also important to tabulate numerical results from backwater computations and to present examples regarding their possible use in locating flood outlines on the ground. The appendix, however, only summarizes because the statistics and computations may be consulted by responsible persons in the Office of the District Engineer.

The maps presented with the report are intended to illustrate the areas inundated by floods of selected magnitudes. If possible, an aerial mosaic is used in the main report because it usually provides a more impressive means of showing the extent to which the flood plain is inundated. More conventional maps are made a part of the appendix.

When all field surveys had been made, all studies and computations completed, the results assembled, and the narrative written, the resulting report was reviewed within the Corps of Engineers and by the Michigan Water Resources Commission. When the review was completed, the report was produced in quantity and was presented to the city council by the Detroit District and the Water Resources Commission jointly. The results of the work were discussed, existence of backup data was emphasized, and the hazards of uncontrolled flood-plain development were pointed out. Less than two months after receiving the report, the City of Farmington used the data as the basis for flood-plain use regulations.