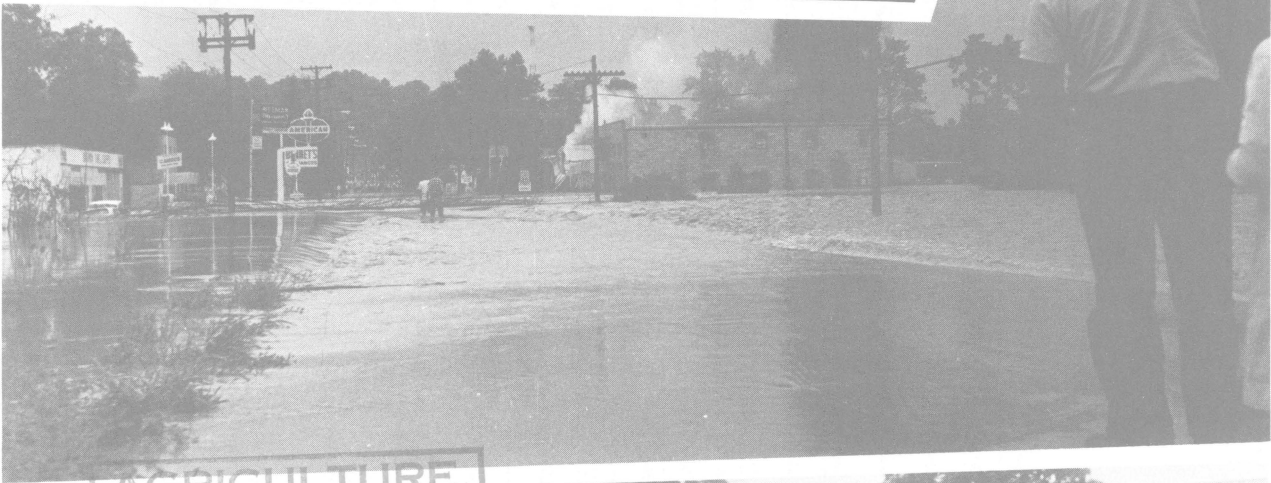
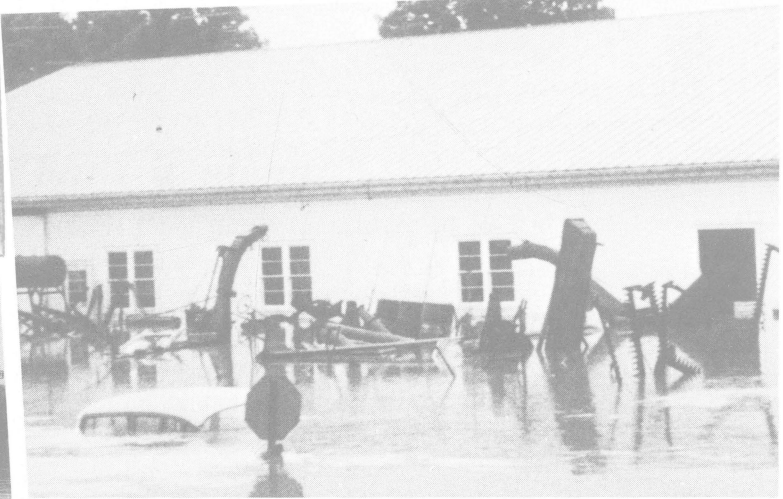


# FLOODS and FLOOD PLAINS



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# FLOODS AND FLOOD PLAINS

By Byron H. Nolte  
Extension Agricultural Engineer

## *Why read this bulletin?*

*Damage to property, human suffering, and loss of life resulting from floods have been increasing in spite of the Federal expenditure of over \$7 billion between 1936 and 1966, along with state programs and local efforts. The increase in flood damages has been due to the rapid building of flood damageable improvements in flood plains. The growth of improvements in flood plains has been taking place faster than flood control works have been built to protect them.*

*The two thirds of Ohio which drains to the Ohio River has an estimated average annual flood damage of \$17 million. This damage represents annual costs from \$2 to \$6 per capita in the various watersheds. Estimates are not available for streams that drain to Lake Erie, but losses are expected to be similar.*

## *What's it about?*

*This bulletin explains flood flows, the chance of future floods, the location and extent of flood plains, flood losses, factors bearing on the flood plain problem, and alternative ways of dealing with the flood problem. By selecting appropriate alternatives, a flood plain management program can be tailored to fit your community.*

# FLOODS and FLOOD PLAINS

Most creeks or rivers flow in a definite channel bordered on one or both sides by a flat area or valley floor. This valley floor is called the *flood plain*. In Ohio, there are over 44,000 miles of streams with adjoining flood plains. These areas are called flood plains because they are occasionally covered with flood waters.

## Streams and Floods

A river channel has only a moderate or small amount of water flowing in it on most days. On a few days each year there is usually enough rain or snowmelt to raise the river to fill the channel but not overtop its banks. The great flows which cause the large floods occur only once in a while, generally a long while. The river channel is shaped mostly by the more frequent moderate flood flows, and it is large enough to carry these. Overflow of the flood plain is caused by the rare major floods that cannot be carried within the channel.

Figure 1 shows the cross section of a river and the flows that can be expected at different intervals of time. The Figure 1A sketch shows the river at average flow. On about 90 days of a year, on the average, there is no more water than is shown.

It takes a big rain to produce enough surface runoff to fill the channel to the top of the banks. Such rains occur about two times each year. The level of the water, or bankful flow, is shown in Figure 1B.

"About once every 2 years, on the average, the river will overflow the flood plain (Fig. 1C) to a depth equal to the depth of average flow shown in Figure 1A.

The great and rare flows cover the flood plain even deeper. But, as the sketches show, it would take the largest flood expected in a period of 50 years, on the average, to flood over the whole flood plain (Fig. 1E) to a depth equal to the height of the streambank exposed by average flow, as in Figure 1A.

The great, really catastrophic, flood may occur this year, next year, or the next. Within our lifetime we may actually experience a flood so unusual that it would occur only one in several generations. In fact, we have already gone through such an experience in the great flood of New England in the year 1955. So extraordinary was the rainfall that it might not be repeated in another 1,000 year." (1)\*

A similar rare flood occurred in north central Ohio on July 4-5, 1969, when from 4 to 15 inches of rain fell on a 21 county area. The disaster caused 41 deaths, much property loss, and over \$66 million estimated economic loss.

The chance of experiencing a great flood can be compared to playing bridge. Few of us have ever been dealt 13 cards of the same suit, yet we know such a hand might occur in the next game we play. So it is with floods. The very unusual event may occur tomorrow, but it is unlikely.

\* Numbers in parentheses refer to appended references.

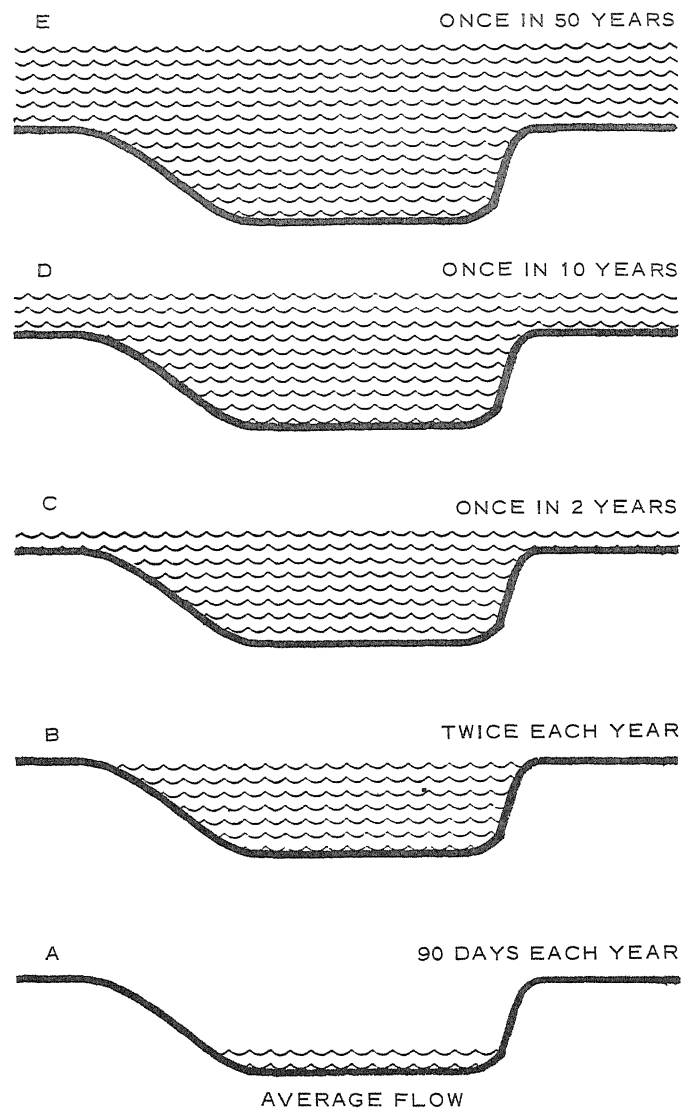


Figure 1. Amount of water in a river channel and how often that amount occurs on the average.

Reference (1)

Another way to express the flood hazard is to convert the average number of years between floods (return period) to an annual probability.

Average frequency of flood level	return period (years)	chance each year (annual probability)
Twice each year	½	200%
Once each year	1	100%
Once in 2 years	2	.50%
Once in 10 years	10	10%
Once in 25 years	25	4%
Once in 50 years	50	2%
Once in 100 years	100	1%

The per cent chance each year is equal to (1 divided by the return period) times 100. The per cent chance of a flood expresses the risk involved each year. This risk should be taken into account when private or public decisions are being made concerning flood plain land. The 100-year return period flood is often used for planning and design purposes. It has a one per cent chance of being equalled or exceeded in any year. Perhaps more significantly, there is about a 25 per cent chance it will be exceeded in the usual mortgage period.

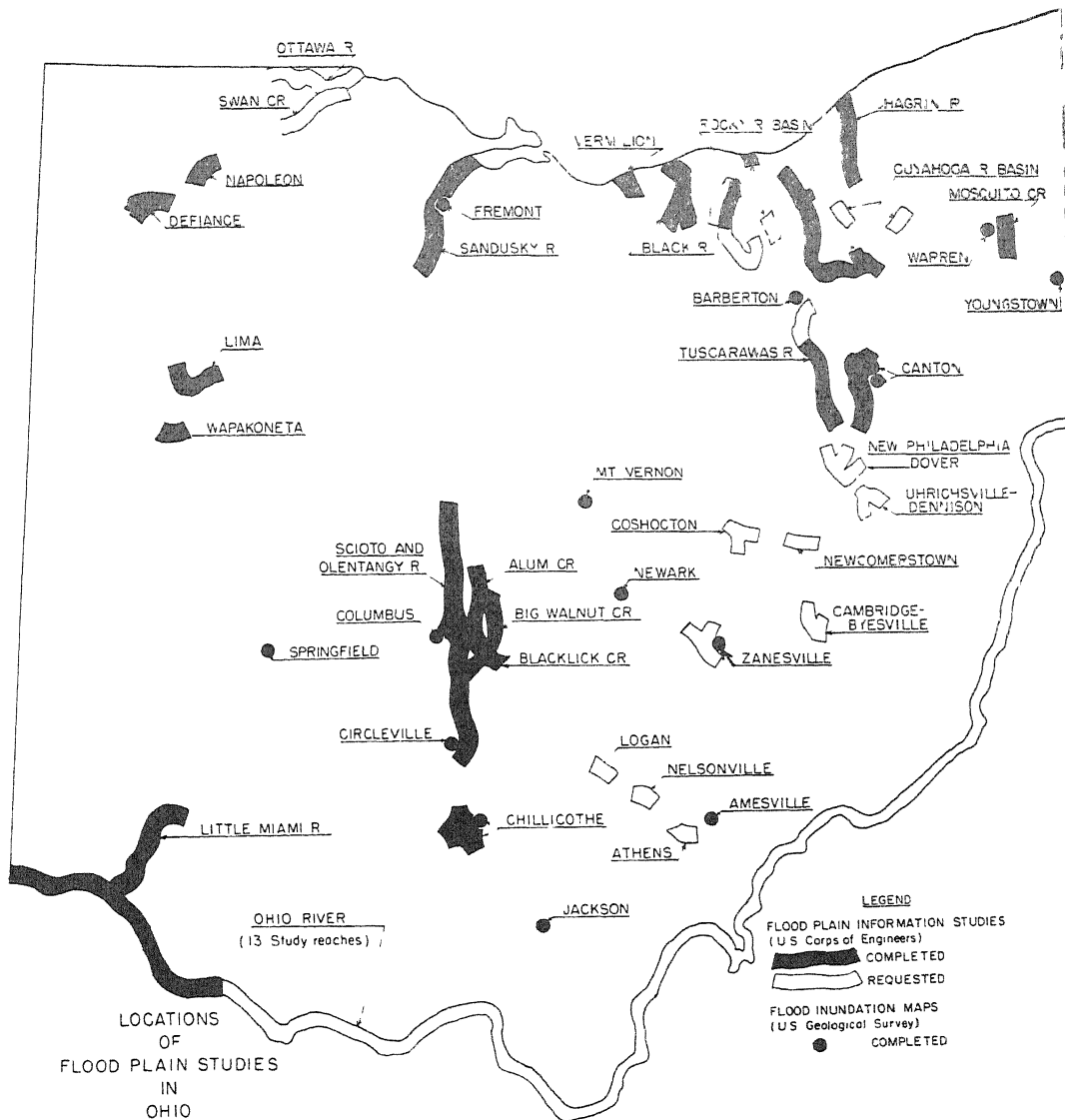


Figure 2.

Reference Ohio Division of Water

### Identifying Flood Plains

Having learned the flood plain definition, one can travel across the land and observe and mark approximate boundaries of flood plains. This task can be done more quickly and accurately with the use of topographic maps, soil survey maps, and stream flow data. In some areas flood plains are already mapped (Figure 2) for a particular flood frequency.

The U.S. Geological Survey has completed reports called "Hydrologic Atlases" of past floods where severe damage has been done. The 14 reports available include maps of the flooded area, profiles giving elevation of flood waters, information on damages, and probable frequency of future floods. In addition, the U.S. Geological Survey has delineated approximate flood plain boundaries on about 10 per cent of the topographic maps covering the state of Ohio and more "Flood-Prone Area Maps" are being prepared.

The U.S. Army Corps of Engineers has completed 24 flood plain information studies in Ohio, covering 570 miles of streams. These reports have detailed flood level and frequency information which can be used as a basis for planning flood plain land use. More reports are being prepared.

In the Great Miami Watershed, the Miami Conservancy District, 38 E. Monument Ave., Dayton, Ohio 45402 has prepared a flood hazard atlas which provides flood level and frequency information around their five flood control reservoirs and along the streams downstream from the reservoirs.

Flood profile charts, urban flood maps, technical flood information and reports of the Corps of Engineers and the Geological Survey are available through the Ohio Division of Water, 65 South Front Street, Columbus, Ohio 43215. Flood plain studies are continuing and additional reports become available each year. These reports provide information on flood plain areas and the hazard involved in using the land. The purpose of these reports is to furnish technical information for the purpose of developing flood plain zoning or other regulations to control development of flood plain areas and to provide flood hazard information for private land users, developers and financiers.

Local sources of flood plain information include the county Extension office, soil and water conservation district, county engineer, conservancy districts and planning agencies.

UNITED STATES  
ESTIMATED ANNUAL FLOOD LOSSES  
1902-1964

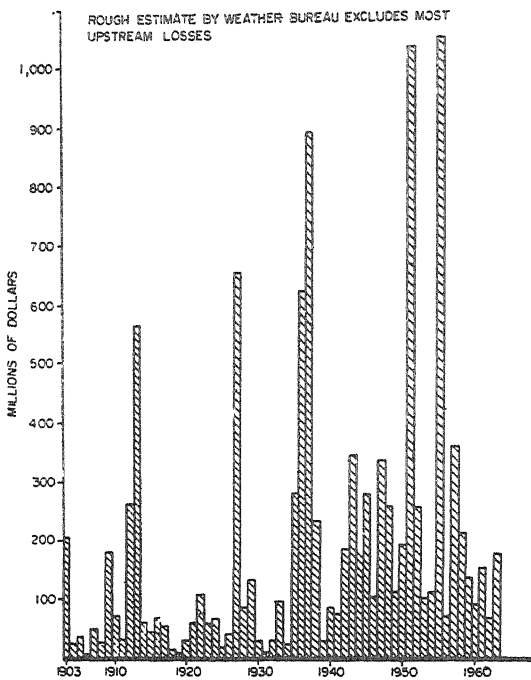


Figure 3.

Flood Losses

Reference (2)

The Indians and early settlers usually were not troubled by floods because their residences were only temporary. When flood waters rose, they moved out of the way. With permanent settlement this is not practical.

While flood plains make up only 5 per cent of the nation's land area, a large proportion of the population and tangible property is located in these areas.

Damage to property, human suffering, and loss of life resulting from floods have been increasing (Figure 3) in spite of decades of effort and the Federal expenditure of over seven billion dollars for flood control works since 1936. This losing battle has caused public officials, technical experts, and others throughout the Nation to take a critical look at the reasons for it.

The increase in flood damages has been due to the rapid growth of flood damageable improvements in the flood plains of streams, lake shores and seacoasts. This growth has taken place at a rate greater than flood control works have been built.

In 1966 the President sent Congress a report by the Task Force on Federal Flood Control Policy. It documented past flood losses (Figure 3). The Water Resources Council estimates that the annual flood damage potential will increase from \$1.7 billion in 1966 to \$5 billion in 2020 (Figure 4). This potential loss is  $\frac{2}{5}$  in downstream areas and  $\frac{3}{5}$  in upstream areas. If construction programs for flood damage abatement continue with past trends the \$5 billion potential damage by 2020 will be reduced to \$2 billion. No estimate is available on damage reduction that might be achieved by flood plain management. (8)

In Ohio, flood losses appear to have followed the national pattern. One need only recall the May, 1968, flood in southeast Ohio, and the July, 1969, flood in north central Ohio to recognize the tremendous losses that continue to occur. Estimated losses from the 1969 flood include: 41 lives; destruction of 32 dwellings, 108 mobile homes, 32 farm buildings, and 104 small businesses; and \$66 million economic loss.

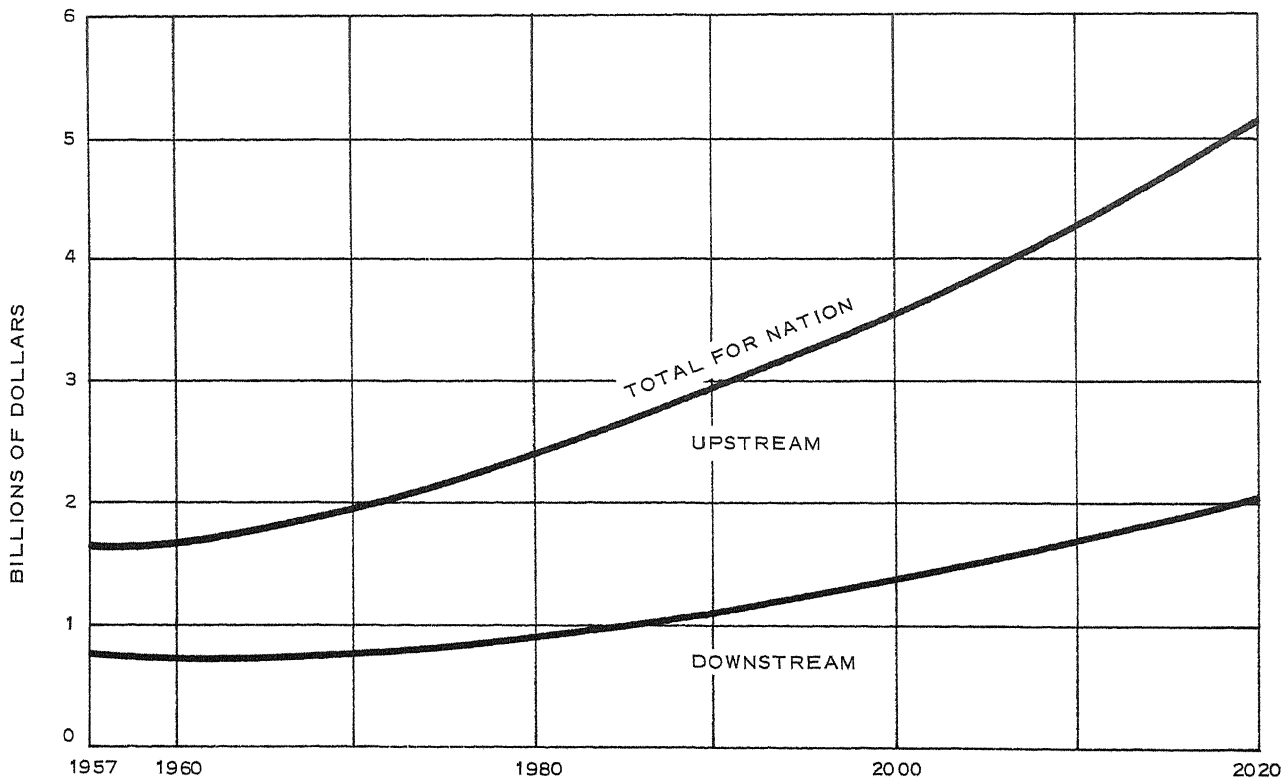


Figure 4. Projections of potential flood damages without flood plain management or new flood protection works, 1957-2020.

Reference (8)

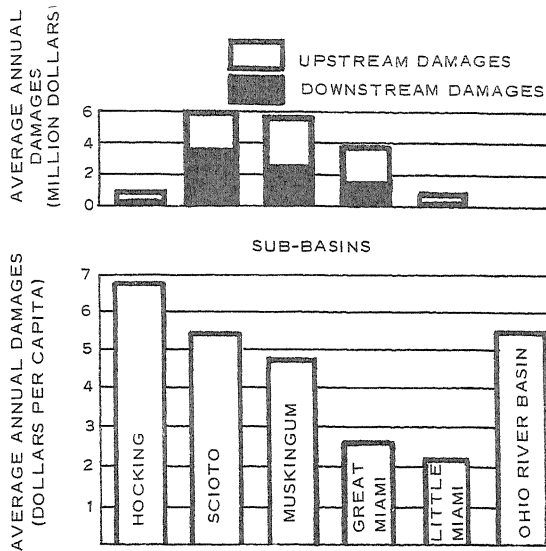


Figure 5. Average annual flood damages under 1965 conditions of development in watersheds draining to the Ohio River. The Ohio River Basin data is included for comparison. (The Ohio River Basin includes major portions of Ohio, Indiana, Kentucky, West Virginia and parts of other states.)  
Reference (6)

Average annual flood damages in the southern  $\frac{2}{3}$  of Ohio are shown in Figure 5. The Hocking, Scioto, Muskingum, Great Miami and Little Miami River basins have an estimated total average annual flood damage of \$17 million. This damage represents over \$6 per capita in the Hocking, over \$5 per capita in the Scioto, over \$4 per capita in the Muskingum, and over \$2 per capita in the Great and Little Miami River basin. Estimates are not presently available for the northern Ohio streams that drain to Lake Erie, but losses are expected to be similar.

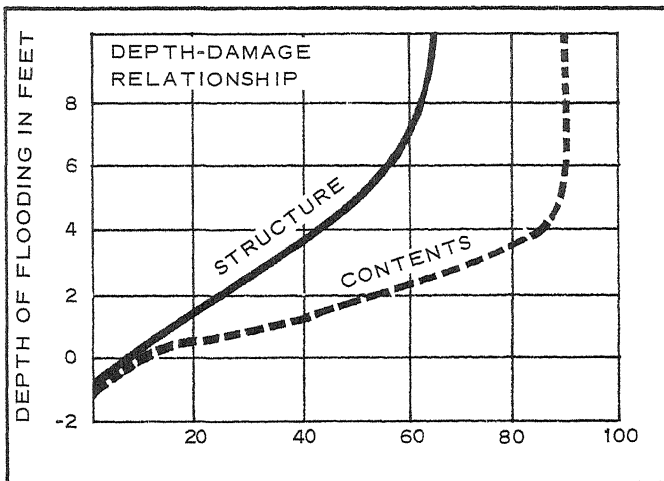


Figure 6. The damage from flood waters 2 feet above flood level is about 25 per cent of the value of a single family residence. The same flood will cause damage equal to nearly 60 per cent of the value of contents in the same structure.  
Reference (7)

On an individual property, as for a watershed, damages are measured in dollars, time and lives. Losses may be tangible and intangible, direct and indirect. An example of tangible losses alone in a one-story, single-family dwelling is given in Figure 6. Only two feet of flooding on the first floor "costs" about 25 per cent of the value of the house and nearly 60 per cent of the

value of the contents. The loss in commercial houses and manufacturing plants can be more or less, depending on the nature of the business. Losses due to a flood in agricultural areas depends upon the crop, time of year, depth and duration of flooding, and flow velocity. Figure 7 illustrates the effect that time of year and watershed area can have on the frequency of floods.

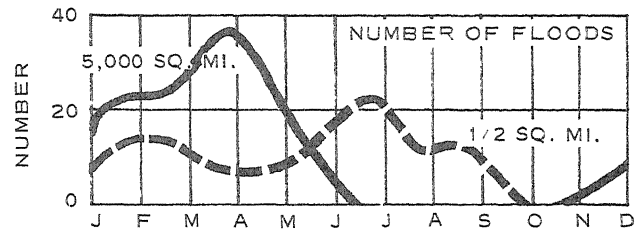


Figure 7. The greatest number of maximum annual flood events for small watersheds occurs in the growing season. Local, high-intensity storms are the cause. For larger watersheds, major floods occur in late winter and early spring seasons. On wet soils, storms covering a large area and of long duration combine to cause these floods, even though the storms may be of low intensity.  
Reference (4)

### Factors Bearing on the Flood Plain Problem

The flood plain problem can be described in terms of physical extent, economic relationships, and individual and social responsibility.

Typically, a river uses some portion of its flood plain about once in 2 to 3 years. At average intervals of 25 to 100 years, a river may inundate most of its flood plain to a considerable depth. Although flood records permit estimation of frequency of various flooding levels, it is not possible to forecast the year a flood will occur on any given stream.

Use of flood plains involving periodic damage from floods is not, in itself, a sign of unwarranted or inefficient economic development. It may well be that the advantages of flood plain location outweigh the intermittent cost of damage from floods. Further, there are some kinds of activity which can only be conducted near a watercourse.

"Principles of national efficiency require, however, that the benefits of flood plain occupation exceed all associated costs, not merely those borne by the individual or enterprise which so locates. Total associated, or full social, costs include —

- Immediate expenses of development,
- Damages to be endured by the occupant or the expense of protective measures undertaken to reduce the frequency and extent of flood damage,
- Damages forced on others as a result of encroachment, and public costs involved in disaster relief and rehabilitation.

Flood plain occupation in which benefits do not exceed the estimated total costs, or which yields lower returns than other uses such as recreation and wildlife conservation, is undesirable, because it causes an eventual net loss to society. Any public policy which encourages submarginal development adds to those losses." (2)

Flood damages are a direct consequence of flood plain investment actions, both private and public. Floods are an "act of God"; flood damages result from the acts of men. Those who occupy the flood plain should be individually responsible for the results of their actions.

Attempts to resolve the problem of rising flood losses within the framework of the Nation's traditional value system should focus on promoting sound investment decisions by individuals, local governments, states and the nation. They should concentrate on bringing the moral, legal, and fiscal responsibilities of all parties involved into effective alignment.

"Policies now governing the national flood control program fail to achieve the necessary integration and equitable apportionment of responsibilities. Principal shortcomings are —

- (a) There is inadequate recognition of the nature of the flood threat and the limitations of engineering works;
- (b) A river control approach is championed to the virtual exclusion of other applicable means such as flood proofing and land regulation which must be applied in the main by non-Federal interest in conformity with community plans, and which should be practices whether or not protection is available, but particularly when it is not feasible; and
- (c) Individual beneficiaries from engineering protection works do not, in many instances, bear an adequate share of the costs.

This latter factor, combined with the bias in favor of

river control alternatives, has relieved many individual flood plain occupants of responsibility, in a fiscal sense, for the consequences of their actions. Under existing policies flood plain property owners in unprotected areas may bear only a portion of the cost, their price being exacted when damage occurs. Some shoulder the full losses; others rely on public relief and assistance in rehabilitation. No matter how serious their encroachment on the watercourse, the occupants bear few of the costs resulting from encroachment. They bear a minor fraction, through payment of general taxes, of the public cost of relief and rehabilitation. The general public, by bearing all or a major part of the cost of flood protection works and lessening the individuals' damage costs, further subsidize their use of the flood plain. Principles of economic efficiency and social equity thereby are violated." (2)

National policy on flood damage reduction is continually changing. The "National Flood Insurance Act of 1968" sets up procedures for flood insurance. Land use and control measures must be adopted with enforcement provisions before continuing insurance is available.

### Alternatives

It is clear that flood control measures which provide control over the river are not solving flood plain land use and flood loss problems. Control over the land must be exercised along with other measures to reach an optimum solution in reducing flood losses. The alternatives available, both corrective and preventive, for flood control and flood damage prevention are illustrated in Figure 8.

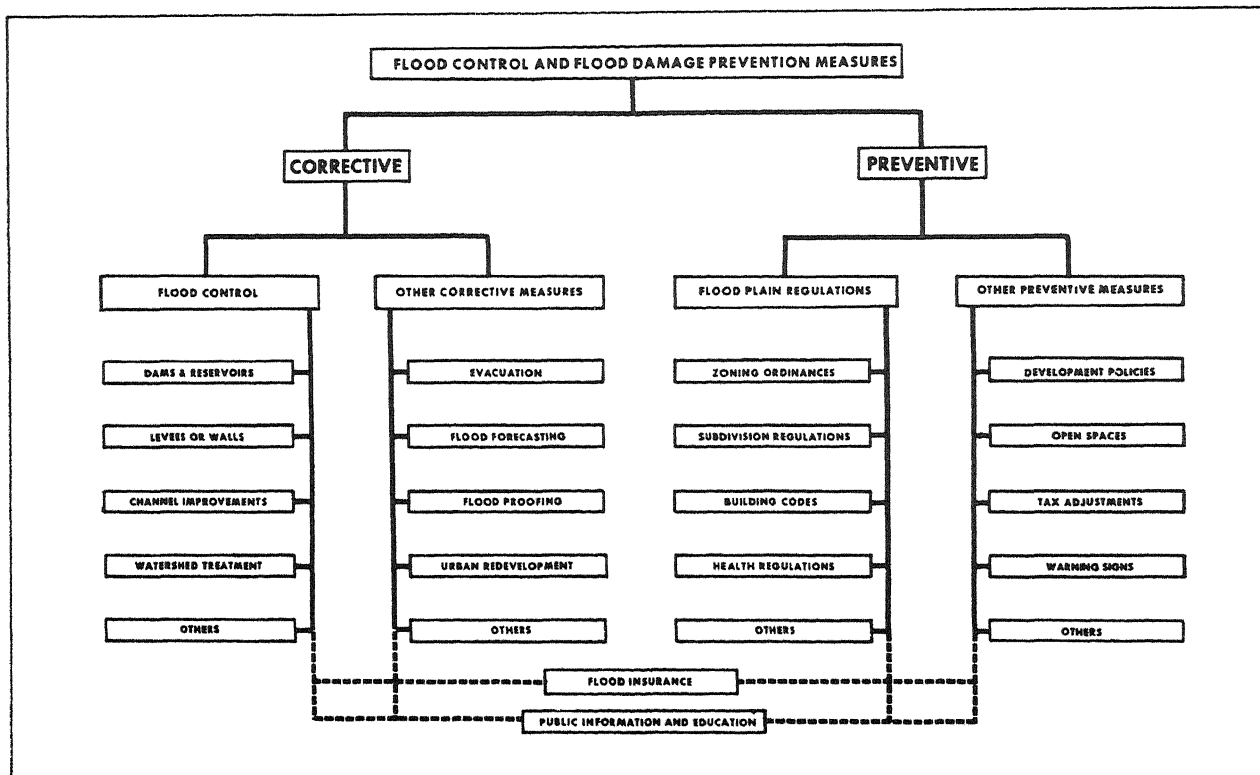


Figure 8. Alternatives for controlling flood losses (corrective), and measures for preventing flood damages (preventive).

Reference (6)

Land use controls, often known as "Flood Plain Regulations", can be used to accomplish flood plain management. These controls do not attempt to reduce or eliminate flooding but are designed to mold the flood plain development in such a manner as to lessen the damaging effects of floods. Flood plain regulations imply the adoption and use of legal tools, by communities, to control the extent and type of future development which will be permitted in the valleys. For these controls to be effective, it is necessary that the public understand the general flood problem, the degree of risk, and the methods available to control use of the land. There are various ways to accomplish flood plain management. Here are eight alternatives that may be used alone or in combination:

1. *Designated floodways and encroachment lines*

"A designated floodway is the area of channel and those portions of the flood plains adjoining the channel which are reasonably required to carry floodwaters. Encroachment lines are the lateral boundaries of the floodway, one on each side of the river. No construction or land filling should be permitted between these lines if these works will interfere with the floodwaters."

2. *Zoning.*

"Zoning is the legal tool that is used to implement and enforce the detailed plans resulting from the planning program. It is used by townships, counties, cities and villages (municipal corporations) to control and direct the use and development of land and property within their jurisdiction. Zoning insures the safekeeping of property for the public health and welfare and the best use of available land. Division of communities into various zones should be the result of a comprehensive planning program for the entire area. Designated floodways may be zoned for the purpose of passing floodwaters and for other limited uses that do not conflict with that primary purpose. The ordinance may also establish regulations for the floodplain areas outside the floodway. These include designating elevations below which certain types of development cannot be constructed." (3)

In Ohio the zoning power granted by Sections 303.02, 519.02 and 713.07 of the Ohio Revised Code do not mention use of these powers to restrict or regulate construction or

occupancy in flood plains, but flood plain zoning can be done for the more general purpose of promoting the public health and safety.

In 1967, Section 1521.14 of the Ohio Revised Code was adopted to require all departments, agencies and political subdivisions of the state to consult with the Ohio Division of Water before doing any construction in locations that may be subject to flooding. Criteria have been drafted to define hazardous use of flood plains. Local governments have the responsibility and authority to develop and administer flood plain regulations.

3. *Subdivision regulations*

"A subdivision can be defined in a broad sense as a tract of land divided into lots for the purpose of sale or building development. Subdivision regulations are used by local governments to specify the manner in which land may be divided. They may state the required width of streets, requirements for curbs and gutters, size of lots, elevation of land, freedom from flooding, size of floodways, and other points pertinent to the welfare of the community. Not only can public health and welfare benefit, but various municipal costs such as maintenance of streets and utilities can be reduced during flood periods. Subdivision regulations provide an efficient means of controlling construction in presently undeveloped flood-plain areas. The following typical provisions which could be added to regulations would be helpful to flood damage prevention:"

- "Show extent of the flood plain on subdivision maps,
- Show floodway limits or encroachment lines,
- Prohibit fill in channel and floodway that would restrict flow,
- Require that subdivision roads be above the elevation of a selected flood level,
- Require that each lot contain a building site with an elevation above a selected flood level." (3)

Planning commissions with plat approval authority may require developers to get a letter from the Ohio Division of Water evaluating the flood hazard and making recommendations for reducing the flood hazard.



This lot was probably dry when the buyer inspected it.



#### 4. *Building codes*

"A building code is a set of regulations adopted by a local governing body. It sets forth standards for the construction of buildings and other structures for the purpose of protecting the health, safety, and general welfare of the public. A well-written and properly enforced building code can effectively reduce damages to buildings in the flood plain. A few of the requirements which should be specified in a building code to reduce flood damages are:"

"Prevent flotation of buildings from their foundations by requiring proper anchorage,  
Establish basement elevations and minimum first floor elevations consistent with potential floods,  
Require structural strength to withstand water pressure or high velocity of flowing water,  
Restrict the use of materials which deteriorate rapidly when exposed to water,  
Prohibit equipment that might be hazardous to life when submerged, such as chemical storage, boilers, or electrical equipment."

#### 5. *Development policies*

"Wise day-to-day policy and action decisions to prevent construction of streets and utility systems in undesirable areas will deter development in flood plains. Street improvements, schools, and other public facilities located elsewhere wield a "soft-sell," negative influence on flood-plain exploitation and a positive leadership toward the higher ground." (3)

#### 6. *Open Spaces*

Flood plain areas are adapted to open space uses since areas adjacent to streams have a natural attraction. Parks, playgrounds, picnic areas and agricultural crop production can utilize land which is not suitable for permanent structures required for homes, business and industries.

#### 7. *Tax Adjustments*

Tax adjustments for land dedicated to agriculture, recreation, conservation and open spaces could help preserve existing floodways. Unless such concessions are made, agricultural land around urban areas will become more valuable each year as parts of it are developed. This process tends to cause tax evaluations of the agricultural land to rise to the point where the land can no longer be used for farming or other open uses. Ohio laws have not been enacted to provide that tax adjustments be made for flood plain land on a regular basis.

#### 8. *Warning Signs*

These signs carry no enforcement, but serve to inform prospective buyers that a flood hazard exists. Such signs may be used to mark previous high-water levels. In 1967, the Ohio Division of Water was authorized to conspicuously mark

past and probable flood heights on publicly owned facilities so as to assist in creating public awareness and knowledge of flood hazards. As of the date of this writing (October, 1971) no signs have been posted under this authority.

Individual decisions and actions concerning private flood plain use should take the risk into account and should be consistent with public policy. The various preventive measures for effecting community flood plain management just outlined can also be applied by an individual to his property.

### Discussion

While this bulletin stresses the flood plain management aspect of the flood damage problem, it should be apparent that a unified effort to decrease flood losses is needed. A unified effort would include both flood control and flood damage prevention measures.

The land use regulations are the weakest part of Ohio's effort to decrease flood losses. Local regulation has done little of the job. An increased effort will be required to reverse the trend of increasing flood losses.

A 1969 study of regulation of areas subject to flooding by the University of Wisconsin found that all 50 states have municipal zoning and 23 used the words "flood", "flood plain regulation" or "flood control" in the statutes. The number of states authorizing regulation of flooded areas is increasing. Sixteen states enacted new laws from 1959 to 1968. These laws used financial pressure, structure prohibition in channels without approval, regulations for floodway areas and regulation of flood plain areas.

Increased use and development of flood plains adds to potential flood damages. In addition, building and filling in flood plains can raise flood levels and cause even more damage (Figure 9).

Lee (5) has prepared the following list of expected benefits from sound flood plain management practices:

Protection of human life.

Reduction of rescue and relief efforts, generally undertaken at the expense of the general public.

Reduction in business interruptions, factory closing, disruption of transportation routes, interference with utility services and other factors that result in loss of wages, sales and production.

Minimization of damage to public facilities on the flood plains.

Elimination of the sale, to unwary buyers, of flood-prone lots.

Maintenance of a more stable tax base and the preservation of property values for developments on and adjacent to the flood plains. This is accomplished by minimizing development of future flood blight areas along the stream.

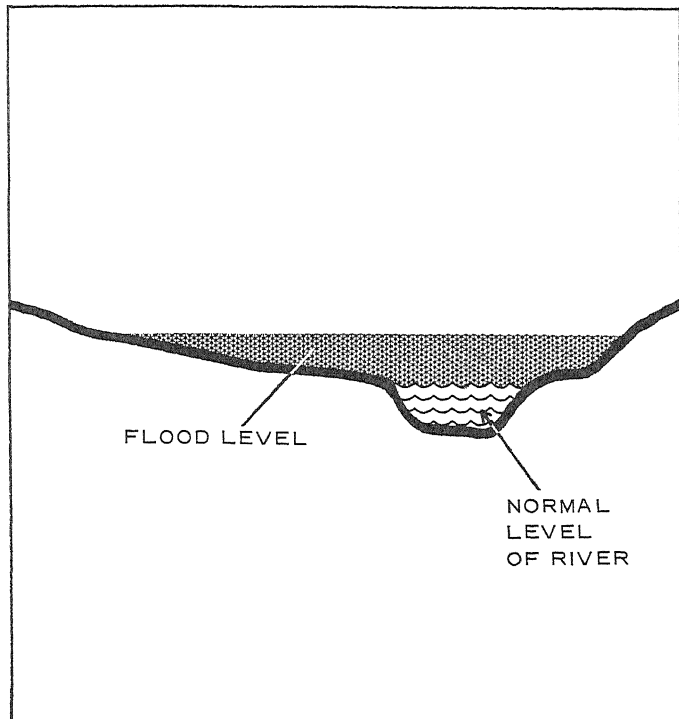
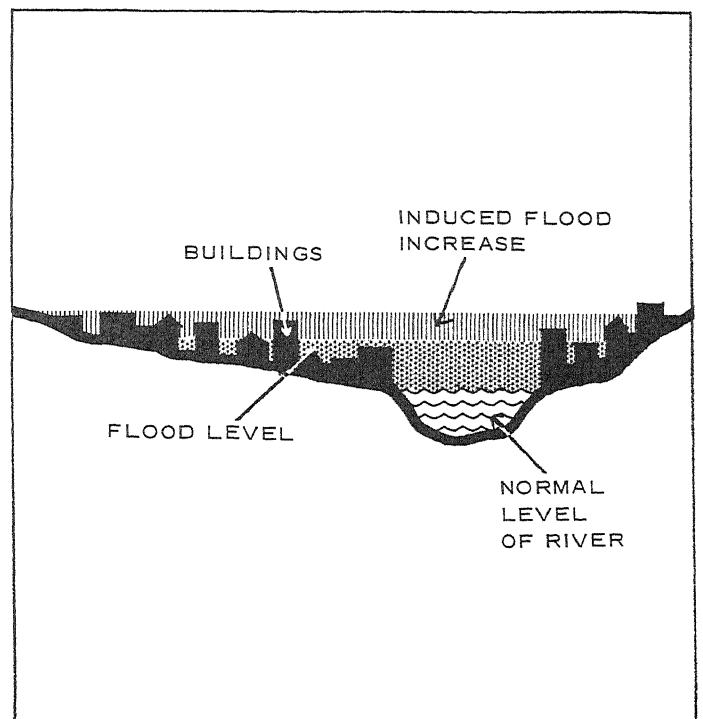


Figure 9. Without structures or other encroachments in the flood plain, this represents the level which the river has a 1 per cent chance of reaching during any year.



With encroachments, the 1 per cent chance flood would reach this higher level and increased width.

Reference (7)

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