ORIGIN AND RATIONALE OF CRITERION USED IN DESIGNATING FLOODWAYS

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The minimum criterion of "no more than one foot" for the permissible rise in the 100-year flood elevation for designated floodways was selected in the mid 1950s as one of the criteria governing reasonable and wise use of flood plains.

This paper presents the origin, use, and rationale of this criterion; the criterion currently used by each State and the rationale for some; findings of a limited study of occupance and growth practices in the floodway fringe areas; and related pertinent information.

The rationale in selecting this minimum criterion was to designate a floodway that was a compromise between prohibiting encroachments into the flood plain while permitting economical land use and protecting against unreasonable invasion of private property rights.

This minimum criterion is currently the national policy, as established by Executive Branch and Congressional actions.

Forty-one (41) States are using the "no more than one foot" criterion.

Nine (9) States have adopted and two others are in the process of adopting a more-stringent criterion, varying from zero to 0.5 foot.

Floodway limits are based on the assumption that the rise in water surface will not be greater than one foot at any point. Therefore, the rise will be a smaller amount at many locations. A brief analysis of flood insurance and other floodway studies shows:

a. Mean increase in water surface was about 0.7 foot.
b. Increase at many points was less than 0.4 foot.
c. Average width of floodway was about 55 percent of the 100-year flood plain width.

Development and building practices may, but seldom will, lead to filling the floodway fringe with structures and other fill that completely block flow through the fringe area. To permit a better understanding by individuals and the public, a limited-effort study was made to obtain data concerning past and present practices. That study, a judgement evaluation by experienced hydraulic engineers of conditions in floodway fringe areas of 56 communities in 25 States, shows:

a. Flow blockage or reduction in fringe areas averages 25 percent, although varying from zero to 100 percent.
b. The portion of the fringe areas occupied by structures, etc., is often greater than the degree of flow blockage.

Modifying the theoretical mean increase in water surface (0.7 foot) by the average degree of flow blockage (25 percent) indicates the actual mean increase could be more in the order of 0.2 foot. These amounts should be weighed realistically in the engineering perspective of judgement applied in hydrologic and hydraulic computations.

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INTRODUCTION

The criterion of "no more than one foot" for the permissible rise in flood elevation for designated floodways was selected in the mid 1950s as one of the criteria governing reasonable and wise use of flood plains. During the following two decades it has been widely used and generally accepted as the upper limit of this criterion. The Federal Insurance Administration (FIA) has made it a part of the "minimum criteria" the Congress directed be established. However, there is no known paper or report stating the rationale or the reasons for accepting this criterion as appropriate and reasonable as the upper limit.

This paper reviews the origin, use, and rationale of this criterion; the criterion currently used by each State and the rationale for those using more-stringent criterion; the average rise in water surface elevations and the average width of the designated floodways throughout reaches of streams in FIA flood insurance studies; and the occupance and growth practices in the floodway fringe areas that have affected water surface elevations.

ORIGIN OF CRITERION

From the evidence at hand in the early 1950s there was little doubt that in the United States most of the major flood disasters in recent decades were the result of urban expansion into flood hazard areas with too little regard to the existing natural hazard. As a result, many groups were noting that the nation's traditional approach to flood damage reduction was not adequate. They were suggesting that the response programs include not only dams and other protective structures to correct existing problems but also non-structural measures which would prevent the reoccurrence of the same problems from uncontrolled development into new areas.

The use of flood plain regulations (zoning ordinances, subdivision regulations, building codes, etc.) as one element of non-structural measures and as a partner with flood control structures to reduce flood damage potential and encourage wise use of flood plains was initiated in 1953 by the Tennessee Valley Authority (TVA). In cooperation with respective states, reports outlining flood problems were prepared and technical assistance and guidance were made available to communities as those communities grappled with their flood problems.

There are two objectives of flood plain regulations. First, they are to assure the retention of the required floodway area without unduly raising flood heights. Second, they are to encourage sound land use in the flood plain that is consistent with the flood hazard and the community land-use needs.

The main channel portion of the natural floodway with the adjacent lowlands, and, in certain cases, secondary channels and swales that become effective during flood periods, carry the greater portion of the flood flow. Shallow overflow areas and backwater areas, which may form the greater portion of the flood plain, are relatively less effective in their flood carrying capacity.

Because of the importance of a floodway for the passage of floodwaters, it is well to define the limits of a designated floodway on each stream and take such legal action as may be required to guarantee that improvements either subject to flood damage or having a detrimental effect on the hydraulic capacity are not permitted in such areas. Engineers can outline the floodway required for hydraulic flows, but in establishing the designated floodway limits, the technical requirements must often be modified by practical, economic, social, and related considerations.

The designated floodway to be reserved by zoning or the establishment of encroachment lines should be adequate for the passage of the selected flood without unduly raising water surface elevations. Criteria for determining such floodways should be those that will prohibit unwise encroachments into the flood plain while permitting economical land use and protecting against unreasonable invasion of private property

rights. The floodway should represent a compromise between the desire to prevent the shifting of costs resulting from flood plain occupance from individuals to the community and the desire to permit individual landowners as much freedom as is reasonable in the use of their lands.

Most of the nation's flood plains contain so many natural advantages to man that a no-development policy was not considered either desirable or acceptable because there are acceptable social and economic uses of the land in relation to the hazards involved. However, experience through centuries of indiscriminate and hazardous development of flood plains had indisputably shown that reasonable controls over such developments were a must. Consideration for such controls involved the development of reasonable and acceptable criteria.

Two of the major criteria were the magnitude of flooding and the permissible degree of flood plain development. For the first of these a "regional flood" based on flood experiences in the immediate region was selected. Developed at a time before the highly theoretical and largely misunderstood flood frequency designation came into common use, this was somewhat higher than the statistically derived 100-year flood minimum standard selected in 1966 as part of the national program.

The second criterion was selected on the basis indicated earlier in this paper with the thought of attaining the most judicious balance between utilizing the flood plains with their many advantages and avoiding the hazards inherent in flood plains. The decision was to preserve a floodway to accommodate nature's flood waters and require the elevation or flood proofing of structures outside the floodway. The floodway was to be the channel and that portion of adjacent flood plains necessary to carry the selected flood without increasing flood elevations significantly. By general acceptance among professionals in the field "significantly" had come to be considered no more than one foot. The question explored here is how the definition of "significant increase" became synonymous with "no more than one foot".

During the evolution of TVA's flood plain management program in the mid-1950s, the first consideration for designating floodways was quite simple. All of the flood plain of the selected flood was included, except those shallow areas and embayments into small drains or gulleys where there was ponding but little, if any, flow. The reasoning was to have zero or no perceptible increase in flood heights.

However, existing uses, development needs, physical characteristics and general economics of flood plains; local and regional economy; various constraints; private property rights, and other pertinent considerations were discussed with many disciplines. Urban planners, engineers, economists, lawyers, geographers, administrators, officials of several States and several communities, and related departments of a few universities and Federal agencies were consulted. These discussions and suggestions and the limited experience in the program indicated that the "Zero" approach could result in inefficient use of the flood plain. The need for a reasonable, intermediate approach to flood plain use was suggested.

The concept which evolved from this process was an intermediate approach that allowed encroachment onto the flood plain, providing it would not cause an unreasonable increase in flood heights. The criterion which evolved as being a reasonable amount was no more than one foot. The full number "one" did not suggest an accuracy or degree of guidance that a fraction or fractions of a foot might connote. It related realistically to the engineering judgement applied in hydrologic and hydraulic computations. It was to be a minimum criterion intended as a regional standard, recognizing that there were urbanizing areas where the existing development, physical conditions, or other elements might demand a more-stringent evaluation and a much smaller rise might be appropriately considered. The criterion appeared to be reasonable and justifiable and was assumed to be acceptable.

For a short time another intermediate step was considered. It would apply the criterion of "one foot or less" to TVA's maximum probable flood, a large flood related to the design of flood control structures. However, it was soon determined that a more reasonable and understandable compromise was to relate the criterion to the selected flood (then the TVA's experience-based Regional Flood and later translated nationally into the theoretical and statistically determined 100-year flood).

A few of the first flood plain regulations adopted in the Tennessee Valley contained floodways and provisions to "meet the needs of the stream to carry the abnormal flows of water in time of floods", or "to carry flood waters with the practical minimum of interference", or "contained without increasing the height of the flood appreciably", or "to carry flood waters with the practical minimum of interference".

TVA in the late 1950s started to design floodways using the "one foot or less" criterion. The floodway design was explained to and discussed with State and local officials and representatives. The floodways were suggested for consideration of the respective communities. Final, negotiated floodways evolving from these were a part of the adopted ordinance but neither the text nor the maps contained the criterion. One of the first communities in the Tennessee Valley to adopt a flood plain regulations ordinance with specific wording regarding the one-foot criterion was Maryville, Tennessee. That city adopted a formal ordinance in 1960 with floodway map that stated "confining flow to floodway indicated would increase the Regional Flood profile height by less than one foot". Later that year Alcoa, Tennessee, adopted similar regulations.

In subsequent years, scores of communities in the Tennessee Valley and many hundreds of other cities throughout the nation have adopted floodways based on this criterion. As flood plain regulations became better understood and were accepted nationally, the criterion for designating floodways was widely accepted and implemented. Many states have established the criterion in their legislation and/or programs.

The Federal Insurance Act of 1968 established a national flood insurance program (NFIP). It directed the Federal Insurance Administration (FIA) to establish minimum criteria for flood plain regulations that local governments must adopt as one of the requirements for eligibility. One of those criteria established by FIA was the "no more than one foot" for the permissible rise in the water surface elevation of the base flood in designating floodways.

CRITERION OF FEDERAL AND PROFESSIONAL GUIDELINES

Criterion expressed in the American Society of Civil Engineers (ASCE) guide and national policy criteria adopted by various Federal Agencies are quoted in the chronological order in which they were established.

Cooperative Program in Tennessee Valley

Tennessee Valley Authority, Late 1950s: "Confining flows to floodway indicated would increase the regional flood profile height by less than one foot," and "holding the increase in elevation to a foot or less".

ASCE Guide For The Development Of Flood Plain Regulations, Sept. 1962

"The designated floodway to be reserved by zoning or the establishment of encroachment lines should be adequate for the passage of the major floods or a flood of a specific size without unduly raising upstream surface elevations. Its size must be based on sound hydraulic and economic criteria and on computations uniformly applied throughout the length of the stream being studied."

"Final selection of the limits of a designated floodway will often be strongly influenced by non-engineering factors. Flood plain lands are frequently quite valuable to the future growth of a city because of their location in relation to major developments. For that reason, it is often considered economical and advisable to restrict the floodway and make a little more land available for concentrated development, even though the action may result in somewhat higher stages for any given flood flows. The engineers should determine and advise concerning the effects on flood stages of certain sizes of floodways so that the other effects can, in turn, be determined and evaluated in comparison with possible benefits."

Guidelines for Executive Order 11296

August 1967 Proposal - Guidelines 4 (Floodways), last paragraph: "One percent probability flood by a significant amount, generally considered one foot".

September 1969 - Guideline 7: "Use the 100-year frequency flood as the design" and Appendix 5, 2nd paragraph: "no more than one foot".

May 1972 - Guidelines (3): "The 100-year flood as the basic flood"; "needed to convey a basic flood, with not more than one foot rise in flood-water elevation"; under regulatory principle, "required to pass a regulatory flood, which equates to a basic flood, with no significant increase in the profile" and "A significant amount is generally taken as falling within the range of zero to one foot".

FIA Regulations Minimum Criteria

June 1969-1909.1: "Floodway means the area of the flood plain reasonably required to carry and discharge flood waters," and "Flood plain area having special flood hazards generally means the maximum area of the flood plain which is likely to be flooded at least once every 100 years."

September 1971 - 1910.3 (d) (4): "floodway must be designed to carry the waters of the 100-year flood without increasing the water surface elevation of that flood more than one foot at any point."

Proposed Revision of March 1975 - 1909.1: "Floodway means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the 100-year flood without cumulatively increasing the water surface elevation more than one foot at any point."

October 1976 - 1909.1: '"Base flood means the flood having a one percent chance of being equalled or exceeded in any given year," and 1910.3 (d) (2): "regulatory floodway must be designed to carry the waters of the base flood, without increasing the water surface elevation of that flood more than one foot at any point." Elsewhere the wording "cumulatively increasing" is used.

Guidelines for Executive Order 11988

February 1978 - Glossary: "Base flood is that flood which has a one percent chance of occurring in any given year (also known as a 100-year flood)" and "to provide for the discharge of the base flood so the cumulative increase in water surface elevation is no more than a designated amount (not to exceed one foot as set by the NFIP)". Part I, Introduction: "to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of flood plains".

CRITERION OF STATE AND LOCAL PROGRAMS

Most States and hundreds of communities have adopted this criterion or a more-stringent one as a part of their flood plain regulations program. A survey of all States was made by correspondence and a few were visited for discussion of details. Each was requested to submit a copy of their respective legislation, operating procedures, and statements used to justify their particular criteria.

The accompanying table shows pertinent findings for each State. The following discusses these findings and the criterion used by different States, and quotes from the few statements that have been used to justify criterion. The discussion is divided into two sections, one for those States using "no more than one foot" and the other for those using a more-stringent criterion.

States using "no more than one foot" criterion

Forty-one (41) States are using the "no more than one foot" criterion, as shown in Table 1. Some use the term "one foot" and others use the term "FIA" or "FIA criteria" or "FIA requirements". Only nine have included specific criteria in the State Legislation. In other States the legislation has authorized or mandated a specific agency to determine and adopt specific criteria for the implementation of the program outlined.

The majority of these States, twenty-nine (29) in number, do not have special legislation nor programs and have not formally adopted criteria. Those States are permitting or encouraging and assisting local governments to adopt flood plain regulations that meet the FIA requirements. Seven of them refer to the floodway criterion as "one foot".

None of these States have formal statements setting forth the rationale used in selecting and justifying the criterion. Informal records and statements indicate most of them have adopted and/or used this criterion for one or more of the following reasons:

1. It seems a reasonable medium between no-development and uncontrolled development of the flood plain.

2. It has been used elsewhere for years and apparently is acceptable to officials, the public, and individual owners.

3. It is a minimum criterion (maximum amount for permissible rise).

4. Others have studied this in greater detail and adopted this criterion.

5. Federal agencies have suggested this criterion.

6. It is a part of the minimum criteria established by FIA.

STATE	No more than one foot				More-stringent			No amount stated		
	Amount stated		FIA stated by		Stated by			by		Using
	Legis-lation	Rules	Legis-lation	Rules	Legis-lation	Rules	Amount	Legis-lation	Rules	Amount
abama								X	X	FIA
aska								X	X	FIA
izona								X	X	1
kansas			X							
lifornia								X	X	FIA
lorado						*		X	X	1
nnecticut								X	X	1
laware								X	X	FIA
orida			X							
orgia								X	X	FIA
waii								X	X	FIA
aho								X	X	FIA
linois						X	0.1			
diana						X	0.1			
wa		X								
nsas								X	X	1
ntucky								X	X	1
uisiana								X	X	FIA
ine			X							
ryland						X	* *			
ssachusetts						*		X	X	FIA
chigan						X	0.1			
nnesota						X	0.5			
ssissippi								X	X	FIA
ssouri								X	X	FIA
ntana						X	0.5			
braska		X								
vada								X	X	FIA
w Hampshire								X	X	FIA
w Jersey						X	0.2			
w Mexico			X							
w York			X							
rth Carolina	X									
rth Dakota								X	X	FIA
io						X	0.5			
lahoma								X	X	FIA
egon								X	X	FIA
nnsylvania			X							
ode Island								X	X	FIA
uth Carolina								X	X	FIA
uth Dakota								X	X	FIA
nnessee								X	X	1
xas			X							
ah								X	X	FIA
rmont								X	X	FIA
rginia								X	X	1
shington				X						
st Virginia			X							
sconsin						X	0.1			
oming								X	X	FIA
TOTALS	1	2	8	1	0	9*		29	29	

* Two are in process of adopting more-stringent

* * Approximately zero but not expressed in terms of permissible rise

North Carolina's criterion was developed by a committee composed of representatives of State government, the State's Institute of Government, the Tennessee Valley Authority, the Corps of Engineers, and the U.S. Geological Survey during their work on a draft of the State's Act that was enacted in 1971. The one foot criterion represented the consensus of the committee, based on their experience and judgement.

Some of Nebraska's flood plains are extremely flat and wide, such as those of the Platte River near Grand Island. In such flood plains the ratio of designated floodway width to projected flood depth is of such magnitude that establishment of a designated floodway in the usual manner seems impractical. For that reason, the State of Nebraska has amended its rules and regulations that called for a floodway using the "no more than one foot" criterion. They now include a maximum density of development requirement within those 100-year flood plains where the above conditions prevail, but such development (encroachments) on the flood plain, in the aggregate, must not raise the 100-year water surface elevations more than one foot. A smaller designated floodway is encouraged, but not required, with the density requirement applied to the floodway fringe. The allowable density will vary with the respective physical conditions, based generally on compensating flows throughout cross-sectional areas. Grand Island, Wood River, and North Platte are three Nebraska communities that have adopted such flood plain regulations.

Connecticut establishes encroachment lines along both sides of streams, thus creating a floodway between them. State Statutes directs the Water Resources Commission to establish encroachment lines and states that the establishment by the Commissioner is to be "based upon his findings of the effect of such proposed encroachments upon the flood-carrying and water storage capacity of the waterways and flood plains, flood heights, hazards to life and property, and the protection and preservation of the natural resources and ecosystems of the state, including but not limited to ground and surface water, animal, plant and aquatic life, nutrient exchange, and energy flows with due consideration given to the results of similar encroachments constructed along the reach of waterway." In implementing this policy, the allowable backwater (permissible rise) is likely to vary, depending on the location and type of encroachment. In some cases it may be reduced to nothing. The State further advises "One foot of water surface increase has generally been the upper limit allowable".

States Using a More-Stringent Criterion

A more-stringent criterion has been adopted by nine States and two other States are in the process of adopting more-stringent criteria. Those States are:

Colorado*	Massachusetts*	New Jersey
Illinois	Michigan	Ohio
Indiana	Minnesota	Wisconsin
Maryland	Montana	

* In process of adopting

Officials of these States state that terrain and other conditions warrant a more-stringent criterion and that local communities and the public are willing to accept the stricter controls. Some States encourage and approve a variable, though stricter than the State minimum, criterion where respective conditions warrant and citizens approve.

Each State presents its criterion in a different manner. The rationale or justification for the criterion has not been well documented -- in fact, the only information pertaining to this was submitted by the States during this study. From that information, statements outlining the rationale and justification for the respective States have been prepared.

Criterion and rationale justifying same are presented in the following:

Colorado

Criterion - The Colorado Water Conservation Board, as directed by State legislation, adopted in February 1975 a "Model Flood Plain Regulation" for local area regulations. The model states that the floodway zone "is the designated flood plain less the low hazard zone" and that the "low hazard zone means the area of the flood plain in which the waters of an intermediate regional flood will not attain a maximum depth greater than one and one-half feet". In addition, the low hazard zone may be used for any lawful purpose provided that "use shall not cause an enlargement of the flood plain so as to cause damages to or on lands other than those owned by the user". The Colorado Land Use Commission also has interests and legislated authority relative to flood plain management and the flood insurance program. A Colorado Attorney General's opinion states that the State regulations were the minimum standard for counties and that counties could not have regulations which were less restrictive than those of the State.

Some local governments have chosen to use different criteria. Presently, five types of criteria are being used in state reviews and/or local regulations. One permits a rise of no-more-than-one foot. Another permits a rise of no-more-than-0.5-foot. A third one is more stringent, with the floodway including the designated flood plain less the low hazard areas with depths of less than 18 inches. A fourth is the same as the third except that low hazard areas are those with depths less than 12 inches. The fifth one includes the entire designated flood plain in the floodway. Uniform procedures and criterion for all have been drafted and in October 1978 were being reviewed. These include only the stringent criterion of "those areas in which the waters of a base flood are eighteen (18) inches or more in depth".

Rationale - The general rationale is to prevent any appreciable rise in water surface elevations. Those portions of the flood plain where the flood hazard is low and the flood water storage is less effective can be used with little effect on flood elevations. Areas with flood depths less than 1.5 feet (18 inches) do not generally have appreciable flow nor storage. Procedures now being reviewed state "low hazard" areas are not included in designated floodways.

Illinois

Criterion - The regulatory floodway limits "define the outer portions of the flood plain which do not significantly contribute to conveyance or to valley storage". The program administration interprets the wording "significantly" to mean anything greater than zero, but its practical interpretation is 0.1 foot for computer purposes.

Rationale - "During the development of the flood plain regulations program, extensive analysis of existing flood plain regulation programs, case law, and the economics of the effects of the various possible regulation requirements was completed. Results of this analysis led to the State's requirement that the total encroachment should be limited to the extent that an insignificant increase in the regulatory flood stage be produced.

"The major reasons for the insignificant stage rise requirement is the topography of the State and the existing case law. The overbank flood plain of most of the streams in the State is quite flat. A small increase in the flood profile can significantly extend the width of the flood plain. It seemed unreasonable economically to allow any significant increase in the flood stage that subjects previously "safe" structures to flood waters. Even more important in the final decision process was the existing case law relating to drainage. Cases were reviewed and interpreted to dictate the insignificant stage rise decision. This decision allows the flood plain to be developed in a wise manner but prevents construction that singularly or cumulatively creates flooding problems for others.

"Consideration was given also to the State's local governments' ordinances and the programs of the surrounding States. In the review of those ordinances and in discussions with local staffs, a feeling developed that strict State regulations were desired. Additionally, the State has entered into agreements with Indiana and Missouri establishing a procedure for coordination of flood plain definition studies of interstate streams. Similar agreements with Iowa and Wisconsin are being considered. Having compatible standards facilitates the execution of and compliance with such agreements."

Indiana

Criterion - In the general case, the floodway shall consist of that area lying between the lines describing the sweep and extent of moving floodwaters of the regulatory flood. In order to prevent unreasonable and detrimental affects, the floodway on streams shall include not only the area covered by moving floodwaters of the regulatory flood but so much of the adjacent flood hazard area as is necessary to ensure that the peak regulatory flood discharge will not be significantly increased by reason of loss of natural valley storage. This is generally interpreted as no more than 0.1 foot for computer purposes.

Rationale - "There were three main reasons for this selection (zero increase floodway). The first was that, because of the flat characteristic of our State, a one-foot increase in stage would in many cases

considerably increase the extent of the flood plain. The second reason was simply to retain Commission jurisdiction over a large area. The third reason is simply that there are few topographical restraints on development in Indiana, so there is no real need to view flood plains as the only developable area.

"There were those on the staff who argued for a less restrictive standard. Their main points were that overall encroachment of a floodway fringe to the point that stages are increased by one foot is extremely unlikely. Also, broad Commission jurisdiction simply places an unnecessary burden on Indiana citizens (especially on the outer edges of that area). This consideration can be partitularly burdensome because the floodway classification still carries the prohibition on housing."

Maryland

Criterion - Although the State leaned toward more-stringent criteria the no-more-than-one-foot criterion was used by communities until the summer of 1978. This was revised, effective August 1978. The revised criteria for changes in stream channels or flood plains are based on the 100-year frequency flood but do not include a reference to permissible rise in water surface elevations. The new criteria for encroachment on flood plains states "Proposed flood plain encroachments shall not increase the tractive force or the stream power by more than 5 percent during the passage of the 100-year frequency flood event". The Regulations' definitions state "Stream power means the multiplicative product of the mean stream channel velocity, in feet per second, and the slope of the hydraulic energy gradient, in feet per foot" and "Tractive force means the multiplicative product of the depth of flow in the stream channel, in feet, and the slope of the hydraulic energy gradient, in feet per foot". The criteria also state that no encroachment shall decrease the natural meander width of the channel nor allow increase of risk of flooding to other property.

Rationale - Maryland has a flood plain management program, including the regulation of flood plain land use. The State experimented with the floodway concept, using the permissible-rise-in-water-surface-elevation criterion, but in the summer of 1978 abandoned the concept as impractical and unworkable for the State's requirements. Also, the imposition of that type of criterion could cause increased flooding on other properties that were not previously subject to flooding. Different, more-stringent criteria were eventually selected and adopted 11 August 1978. They refer to the changes in relationship of water velocities and depths to the hydraulic energy gradients and to changes in natural meander width of channel. Encroachments on flood plains are not permitted to increase the "stream power" (velocity x hydraulic energy gradient) or the "tractive force" (channel flow depth x hydraulic energy gradient) more than five percent. Neither are they permitted to decrease the natural meander width of the stream channel.

Massachusetts

Criterion - Neither the State legislation nor the authorized Environmental Quality Engineering Department's regulations contain a

specific criterion. The FIA minimum criteria are being used. However, the Department's usual practice (under the State's Wetlands Protection Act) is to require development to provide for compensating storage and be developed in such a way that no measurable rise will be experienced. Resolutions have been submitted to the Commission (of the Department), recommending Massachusetts adopt a zero water surface increase, as measured by existing methods as operating standards. The recommended criterion was under consideration in the fall of 1978.

Michigan

Criterion - Michigan's Act No. 167, P.A. of 1968 created a Water Resources Commission "to protect and conserve the water resources, to have control over the alteration of the water courses and the flood plains of all rivers and streams, with powers to make rules and regulations governing the same" and "to prohibit the obstruction of the floodways". State procedures (General Rules) state in the definition of floodway "...reasonably required to carry and discharge a 100-year flood". They also contain the definition "harmful interference means causing an unnaturally high stage or unnatural direction of flow on a river or stream which causes, or may cause, damage to property, a threat to life, a threat to personal injury, or a threat to water resources". Criteria for determining permissibility of encroachments in the floodway or floodway fringe includes "does not cause harmful interference". Implementation of State procedures has indicated the flood insurance studies are to show floodways based on "no more than 0.1 foot". If communities want to use some other floodway, the State will assess proposals on the "harmful interference" basis, but in no case can the allowable increase exceed 1.0 feet over the elevation of the unencroached flood level.

Rationale - Michigan's approach is somewhat different. A large floodway is designated and encroachments in it are permitted under certain conditions. State procedures state in the definition of floodway ".... reasonably required to carry and discharge a 100-year flood". They also contain the definition "Harmful interference means causing an unnaturally high stage or unnatural direction of flow on a river or stream which causes, or may cause, damage to property, a threat to life, a threat of personal injury, or a threat to water resources". Criteria for determining permissibility of encroachments in the floodway or floodway fringe includes "does not cause harmful interference".

The State feels it is reasonable to either permit or deny a proposed encroachment based on its impact and not on an arbitrary allowable increase that may or may not be harmful. Seldom will an acceptable flood plain encroachment increase the flood plain elevation 1.0 feet, however there have been some instances where it has been approached. These instances are in rural areas with non-damageable property upstream or in areas where all affected upstream property owners have signed formal letters of nonobjection to the increase.

Implementation of State procedures has indicated the flood insurance studies are to show floodways based on "no more than 0.1 foot". If communities want to use some other floodway, the State will assess

proposals on the harmful interference basis. This floodway delineation gives the community and the State some flexibility when planning or assessing future needed public or private facilities within the floodway. The State can still assess a floodway encroachment based upon the harmful interference criteria with the added control that in no case can the allowable increase exceed 1.0 feet over the elevation of the unencroached flood level.

Minnesota

Criterion - The State's 1973 legislation states "not to prohibit but to guide development of the flood plains" without "unduly restricting the capacity of the flood plain to carry and discharge the regional flood" and the regional flood is defined elsewhere as the 100-year flood. The State's regulations state "the limits of the floodway shall be designated so that permissible encroachments on the flood plain will not cause an increase in stage of the regional flood of more than 0.5 foot in any one reach or for the cumulative effect of several reaches of a watercourse". However, more-stringent criteria are encouraged where appropriate and many communities are using zero or 0.1 foot or 0.2 foot.

Rationale - Minnesota's "regulations specify that the designation of a floodway can cause a stage increase of no more than 0.5 feet with any increase from 0.0 to 0.5 being legally enforceable. The decision to define 0.5 as the maximum was apparently a compromise between the prevailing philosophies of 1.0 foot and 0.0 allowable rise. It was felt that 0.0 foot was unworkable in mathematical modeling and that 1.0 foot was excessive in view of the topographic conditions in Minnesota. Thus, a maximum of 0.5 foot was adopted."

Montana

Criterion - "The delineations of a designated floodway shall be based on the channel of the watercourse or drainway and those portions of the adjoining flood plain which are reasonably required to carry the discharge of the flood of one hundred (100) year frequency without any theoretical measurable increase in flood heights. In areas having appreciable urban development on the flood plain, the outer boundary lines of the floodway may generally follow the riverward limits of development provided that (a) the calculated elevation of the flood of one hundred (100) year frequency would not be increased more than five-tenths (0.5) foot as a result of the theoretical additional construction of the floodway, (b) floodway lines are compatible with local land use plans, and (c) the flood fringe does not contain appreciable areas with flood velocities greater than three (3) feet per second or flood depths greater than three (3) feet."

Rationale - State legislation states the purpose of the Act is to guide, manage, and regulate development of the flood plains consistent with "sound land and water use management practices which will prevent and alleviate flooding threats to life and health and reduce private and public economic losses". It is also to "ensure that regulations and minimum standards adopted under this Act, insofar as possible, balance the greatest public good with the least private injury".

New Jersey

Criterion - New Jersey statute, N.J.S.A. 58: 16A-52, directs the Water Policy and Supply Council to study and delineate floodways and flood hazard areas and the Council on 30 October 1974, by Resolution, ruled that "floodways to be delineated under the NFIP shall be based on the principle that the area chosen for the floodway must be designed to carry the waters of the 100-year flood without increasing the water surface elevation of the 100-year flood more than two tenths of one foot (0.2 ft.) at any point".

Rationale - The "no more than one foot" criterion "would have allowed a considerable amount of additional encroachment along streams where the 100-year flood elevation prior to additional encroachment was well above the general level of construction. It should be realized that large urban areas of New Jersey are frequently damaged by flooding". And application of that criterion "would only aggravate an already serious problem in New Jersey". The Water Policy and Supply Council stated "WHEREAS Section 1910.3(d) (4) of Title 24, Subchapter B - National Flood Insurance Program recommends establishment of floodways which would increase the 100-year flood water surface elevation up to one foot which is considered to be excessive along New Jersey streams due to their extensive urbanization;" and resolved that floodways be delineated by the criterion of "no more than 0.2 foot at any point".

Ohio

Criterion - State has no legislative criterion. State program up until April 1978 was based on 0.5 foot rise for determining regulatory floodways. FIA then informed the State that future FIA studies would use the one-foot criterion. State will "however, continue to work closely with Ohio's communities to assure that future FIA studies give consideration to local flood problems. Where local conditions warrant a more-restrictive floodway criteria, we will actively encourage the community to go with the 0.5 foot rise standard".

Rationale - Ohio's flood plain management efforts prior to April 1978 were "based upon the 0.5-foot rise for determination of the regulatory floodway. This 0.5-foot rise limit was adopted after our review of the flood plain management efforts of other midwestern states". However, because this was not legislative criteria, the FIA studies prepared after April 1978 have been based on the one-foot criterion. The State advises that "where local conditions warrant a more restrictive floodway criteria, we will actively encourage the community to go with the 0.5-foot rise standard. For those communities which express an interest in enforcing the 0.5-foot standard, we will ask that the additional 0.5-foot floodway be computed, mapped, and presented along with the one-foot standard".

Wisconsin

Criterion - "Wisconsin's standards allow no increase in flood elevations in excess of 0.1 foot. In essence, it is a zero increase standard, but 0.1 foot is used as a rational means of measurement."

Rationale - "Our rationale is that floodway lines are to be developed based on existing conditions as reflected by encroachments that are in place at the time a study is done. The Wisconsin law requires communities to zone their flood plains to prevent future encroachment. Any further encroachment after the zoning ordinance is effective will cause increased elevations and flooding which will adversely affect upstream property owners."

EFFECTS OF FRINGE DEVELOPMENT ON ELEVATIONS

The permissible rise in flood elevations is based on the assumption that the floodway fringe (flood plain outside of the floodway) is completely filled with structures or earth fill to the elevation of the selected flood , or is closed off by levees or walls, so that all flood waters pass down the floodway. However, development and building practices seldom lead to such conditions, except for levees and for bridges with confined openings.

No useful data or studies were found relative to the degree-of-development or degree-of-flow-blockage in floodway fringes.

The degree-of=development or physical blockage of the overflow section is not necessarily, and often is not, the same as the degree-of-flow-blockage. Some development is of the type that nearly offsets the detrimental effects of the fill or structures on flow. Paved streets paralleling the stream channel, grassed lawns, and paved parking areas are examples of developments that generally improve the natural flow conditions. Oblong structures that have the long dimension paralleling the direction of flow offer much less obstruction to flow. In most situations the degree-of-flow-blockage will be considerably less than the degree-of-development. Also, development on only one side of the stream often occurs although the flood plain on the other side is conducive to development.

Floodway limits determined by computer models are based on the assumption that the rise in water surface elevations will not be greater than one foot at any point. This means that the rise will be less at many points in order that the cumulative amount at any point will not exceed the maximum allowance.

To obtain an understanding of the average rise that may occur throughout reaches of streams as well as other flood plain relationships, the Corps of Engineers made a brief analysis of readily available data. Data for 2390 cross sections were taken from flood insurance studies and other floodway studies made by the Corps. Results showed, for the nation:

1. Mean increase in water surface was about 0.7 foot.
2. Increase at many points was, therefore, less than 0.4 foot.
3. Average width of 100-year floodway was about 55 percent of the width of the 100-year flood plain.

The Corps is refining this analysis to see what variation there is for different regions and for various sizes of drainage areas (DA). Preliminary results indicate that on a DA basis the floodway-flood plain relationship shown above probably is representative. Those refinements are not expected to be completed before late 1978.

When the mean increase of 0.7 foot from the above study is modified for the degree-of-flow-blockage the actual mean increase could be generally much less. If one assumes that the degree is 75 percent, the mean

increase could be in the order of 0.5 foot. For a degree of 50 percent it could be about 0.4 foot and for 25 percent it could be only about 0.2 foot.

Need For Data Regarding Flow-Blockage

It is necessary to know what is happening in the floodway fringe areas to properly understand the effect on water surface elevations. It is also critical to remember that there can be, and in a relatively few locations there will be, full development of a type that completely blocks flow and storage in overflow sections. Impressions of many working closely with this have continued to question the degree of development and of flow-blockage that is occurring or can be expected to occur in the fringe areas.

One regional source states that in most cases the flow-blockage in fringe areas is not total, but it would be hard to specify a percentage of blockage. This argument has been used in justifying "our half-foot rise criteria as being an insubstantial rise".

The public's understanding, as well as the individual's, is a crucial element in establishing a criterion. Acceptance is a major ingredient in a reasonable compromise between land owners' rights, local and regional economy, and public costs of flood plain use. Referring to a criterion of "one foot" is misleading where the fringes are not completely developed. Some will think such a criterion permits too great an effect on flood heights, whereas the actual effect is probably far less than indicated.

The Little Rock District of Corps of Engineers says: "In regard to the amount of permissible rise in base flood elevations, it appears that local officials are tending to accept the 1-foot criterion more readily than a lesser amount. The obvious immediate advantage of a narrower floodway and the greater amount of land for development in the floodway fringe seems to outweigh a higher flood elevation at some possible future date. In addition, some local officials also may have some doubts that future development will be so complete that the full amount of the permissible rise will be realized. One Missouri city in this District has recently requested a restudy of their Type 15 study to increase a 0.5-foot permissible rise as originally requested to 1.0-foot."

A big topic of conversation about floodways centers about the effect of floodway fringe filling on peak discharges downstream. At least two States, Illinois and Indiana, are concerned that flood plain filling might remove existing natural flood-control reservoirs from river systems and increase downstream peaks. Others wonder if localized constrictions built in the flood plain might impound additional water upstream and reduce downstream flooding. There are no conclusive studies to evaluate the factors involved.

Effective implementation of flood plain regulations that include this criterion will probably bring about a change in development practices

for the fringe areas. Some say it will be a severe change, leading to full development of a type that approaches full blockage of flows. Others say that knowledge of the flood hazard and/or additional costs of meeting criteria for developing will deter development and tend to offset the real estate interests desire to develop "right up to the floodway limits".

Effective flood plain regulations throughout the nation have not been in effect long enough to determine empirically whether or not and how development patterns and practices in floodway fringes will change. However, as a point of departure it is practical to obtain an understanding of past and present practices. Such an in-depth study would be costly and time consuming. However, data obtained from a minimum-effort study would be quite useful. Some data are needed to check the impressions of experts and to guide all concerned with these programs.

Corps of Engineers Data

The Corps of Engineers has for several decades been working with States and local communities in studying and developing solutions for flood problems and water resources development. During recent years the program has encouraged and assisted local communities to recognize flood hazards and limit use of flood hazard areas. Hundreds of flood plain information reports were prepared. The Corps has also prepared hundreds of flood insurance studies for the FIA. These activities and experiences have made certain staff members in each of the Corps' 47 District and Division Offices knowledgeable of occupancy and growth practices in flood plains.

The Corps was cooperative in furnishing useful information pertaining to the nationwide practices. Nearly all of the District Offices throughout the nation selected and reported on one or more communities where data and maps were available. The communities selected are somewhat typical although not as representative as could be obtained if funds and manpower were available for an in-depth study of a greater number of communities. Nevertheless, the results of this nationwide contribution are meaningful and interesting.

The evaluation of conditions in floodway fringes in the selected communities was in accordance with these general guidelines:

a. Based on a review of maps, aerial photos, and if possible, a brief field inspection of the floodway fringe areas, determine the overall "portion occupied" and the "effective flood conveyance reduction" (flow-blockage) of the floodway fringe area. This is a judgement evaluation. Based on these judgements, tabulate the results using the sample format showing estimates of 0 or .25 or .50 or .75 or all.

b. For the portion occupied, consider all types of structures that are in place. Note that even in cases where an area is fully developed, streets, open parking lots, etc., represent unoccupied space. Many areas have buildings on fill

but the entire lot may not be raised to the 100-year flood elevation. Therefore, only consider the portion that is filled.

c. For the effective flood conveyance reduction (flow-blockage), the area occupied, type of development, alignment of streets, height of streets (embankments), etc., all contribute to a certain hydraulic conveyance condition. The estimate of the effective flood conveyance reduction should be a judgement of current flow conditions as compared to an open floodway fringe (no buildings). For the purpose of this exercise, the open condition would be considered as a "0" reduction.

d. It may be possible to note changes in the development in floodway fringe areas since the communities' adoption of flood plain regulations. Any comments on that change will be helpful.

Evaluations were made of conditions in floodway fringe areas along one or more streams in 45 communities that were distributed among 25 states. Size of the communities varied from small to very large, although only a portion of each larger one was included. A weighted average for each community was obtained by considering length of reach for each condition. The communities are listed alphabetically below:

Athens, GA
Camarillo, CA
Cape Girardeau, MO
Cherokee, IA
Danville, VA
DeKalb, IL
Durham, NC
Eagle, ID
Emporia, VA
Fox River Valley Gardens, IL
Franklin, TN
Gowanda, NY
Greensboro, NC
Greenville, NC
Grenada, MS
Gresham, OR
Healdsburg, CA
Honolulu, HI
Honolulu County, HI
Kansas City, MO
Kauai County, HI
Laurel, MD
Louisville, KY
Mapleton, OR
Meridian, MS
Ocoee, FL
Olathe, KS
Omaha, NB
Orlando, FL
Overland Park, KS
Paragould, AR
Petersburg, VA
Pittsburgh, PA
Pomeroy, WA
Raleigh, NC
Redmond, WA
Roanoke, VA
San Diego, CA
Scottsville, VA
Sonoma County, CA
St. Genevieve, MO
Sumter, SC
Velva, ND
West Logan, WV
West Seneca, NY

The weighted averages for the 45 communities varied from zero to 100 percent, as shown in the following table. Their average was 25 percent, and the median was 16 percent. The conveyance reduction (flow-blockage) was less than the portion occupied in at least one reach of stream in 21 or nearly one-half of the communities. The conveyance reduction was greater in a few reaches of streams. Three reasons for its being greater in some areas was highways crisscrossing the flood plain, fences of the type that quickly act as dams, and shopping centers.

Number of Communities with varying degree of flow-blockage

Degree of Flow-Blockage	<.125	.125	.143	.167	.25	.333	.5	.667	.75	All
Number of Communities	12	7	2	4	8	5	4	1	1	1

Tennessee Valley Authority Data

The Tennessee Valley Authority has for more than four decades been working with State and local governments in the Tennessee Valley, helping to solve their problems. Since the mid-1950s TVA has had a comprehensive flood plain management program, preparing flood plain information reports and providing assistance leading to solution of local flood problems. Those solutions included non-structural and structural measures. Through the years TVA has amassed a wealth of knowledge concerning occupancy and growth in flood plains throughout the Tennessee Valley.

TVA cooperated in furnishing information for 11 communities distributed among 4 states in the Tennessee Valley. The communities are listed alphabetically below:

Benton, KY	East Ridge, TN	Red Bank, TN
Bristol, VA	Huntsville, AL	Rockwood, TN
Cleveland, TN	Newport, TN	Sevierville, TN
Cleveland, VA	Paris, TN	

The weighted average for the 11 communities varied from zero to 100 percent, as shown in the following table. Their average was 25 percent, the same as for the communities included in the Corps data. The median was 25 percent. The conveyance reduction (flow-blockage) was less than the portion occupied in at least one reach of stream in 8 or three-quarters of the communities.

Number of Communities with varying degree of flow-blockage

Degree of Flow-blockage	<.125	.125	.166	.25	.333	.375	.5
Number of Communities	2	1	1	3	2	1	1

Other Related Data

A 1977 study of flood plain occupancy in urban areas, using 21 case studies, indicated that 18 percent of those urban flood plains had been developed.[1] The study defined "developed" as those areas with net residential, commercial, industrial, public, transportation, communications, and utilities uses which involve conversion of vacant land to a built or paved condition. "Net" is defined as the land actually in a particular use and the immediately adjacent support area that is clearly related to the function.

The estimate approximates the portion of the flood plain occupied and the portion where flows may be blocked. But it does not divide the flood plain into floodway and fringe areas. For that reason, the estimate

[1] Sheaffer and Roland, Inc., Evaluation of the Economic, Social, and Environmental Effects of Flood Plain Regulations, (Washington: Department of Housing & Urban Development, 1978).

cannot be compared directly with the Corps and TVA data that pertain to the fringe areas only.

Nevertheless, it is interesting to note the close comparison of the 18 percent in the 1977 study and the 25 percent in the current Corps and TVA data.

Findings

These data and limited studies lead to the following findings. Some of the figures or percentages shown may not be as exact as could be obtained through a more-costly and time-consuming study, but they adequately indicate a relationship and range that is useful.

1. Mean increase in water surface elevations related to the designation of floodway limits in flood insurance studies is about 0.7 foot, although the maximum permissible is 1.0 foot.

2. The increase at many points is less than 0.4 foot.

3. Average width of the 100-year floodway is about 55 percent of the width of the 100-year flood plain.

4. Seldom is the floodway fringe developed in a manner that completely blocks flow and storage in those overflow sections, although regulations permit the total blockage.

5. Flow-blockage (reduction in hydraulic efficiency) in the floodway fringe areas varies from zero to 100 percent, with an average in the order of 25 percent, based on data from 56 communities distributed among 25 states.

6. The above average flow-blockage includes reaches of streams that are away from the urban areas of greatest growth. This means that the average through the denser urban areas will be somewhat greater - - possibly as much as 50 percent.

7. The portion of the floodway fringe that is occupied is often greater than the effect on the hydraulic efficiency.

8. Nationwide, there has been too little time following adoption of flood plain regulations to determine the effect of the regulations on occupance and growth practices in floodway fringes. However, many replies indicated that no great or radical changes, except where there were unusual or special conditions, have been noted to date.