Floodway Analysis and Mapping for Flood Risk Analysis and Mapping

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1. Introduction

This document provides guidance for floodway analysis, and all the components that accompany it. A floodway is a tool to assist communities in balancing development within the floodplain against the resulting increase in flood hazard. A regulatory floodway is defined as the channel of a river or other watercourse and the adjacent land area that is reserved from encroachment in order to discharge the base flood without cumulatively increasing the water-surface elevation by more than a designated height. NFIP regulations and Standard SID 69 and 70 state: *"Floodway surcharge values must be between zero and 1.0 ft. If the state (or other jurisdiction) has established more stringent regulations, these regulations take precedence over the NFIP regulatory standard. Further reduction of maximum allowable surcharge limits can be used if required or requested and approved by the communities impacted.", and "If a stream forms the boundary between two or more states and/or tribes, either the 1.0-foot maximum allowable rise criterion or existing floodway agreements between the parties shall be used."* The portions of the floodplain beyond the floodway are called the floodway fringe. The community is responsible for maintaining the floodway to mitigate flood hazards; the community must not allow any activities causing a rise in the Base Flood Elevation (BFE) in the regulatory floodway.

The baseline model for the allowable surcharge is the model used to determine the BFEs the first time a floodway was adopted for the reach. Unless it is demonstrated that the model should be revised for reasons other than encroachments into the floodplain, all subsequent revisions to the floodway are limited to the maximum allowable surcharge above the elevations determined in the base model. That way, as hydraulic models are updated to reflect encroachments into the floodway fringe, the cumulative effect of those and future encroachments is limited to the maximum allowable surcharge. If the model is revised for reasons other than encroachments into the floodplain (such as increased discharges, shift in channel, modeling software advancements), the revised model, excluding any revisions attributable to loss of conveyance areas resulting from floodplain encroachment, is the base model for future floodway analyses.

Regulatory floodways are not normally delineated in coastal high-hazard areas (i.e., Zones V1-30, VE, and V). The computation of regulatory floodways on riverine flooding sources in coastal floodplains is based on the base flood discharge and elevations of the riverine flooding source only. The regulatory floodway must be terminated at the boundary of the V1-30, VE, or V Zone, or where the mean high tide exceeds the 1% annual-chance riverine flood elevation, whichever occurs further upstream.

2. The Floodway and Why It Is Important

Perhaps the most important function of a natural floodplain is to convey floodwaters from upstream to downstream. The portion of the floodplain that conveys most of the floodwaters is called the floodway. Obstructions placed in the floodplain block the flow of water and can cause increased flood heights upstream from the obstruction and increased velocities of floodwaters adjacent to and downstream from the obstruction. Preserving the capacity of floodplains to convey floodwaters through the designation and preservation of a floodway has been an important concept in floodplain

management from the very beginning. Preserving the floodway limits the impact of development from occurring in the floodplain that will increase flood heights and damages to upstream and downstream properties, and it avoids allowing excess velocities resulting in stream stability and damages to downstream properties. The NFIP and nearly all state and local floodplain management programs have incorporated the concept of a floodway to convey floodwaters in their floodplain management requirements.

2.1. The Regulatory Floodway

The NFIP defines "regulatory floodway" as the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. This designated height is one foot for most NFIP communities. FEMA will develop a floodway for a community as part of a Flood Insurance Study. Floodways are usually shown on the community's Flood Insurance Rate Map (FIRM), but for many older studies a separate Flood Boundary and Floodway Map (FBFM) was published.

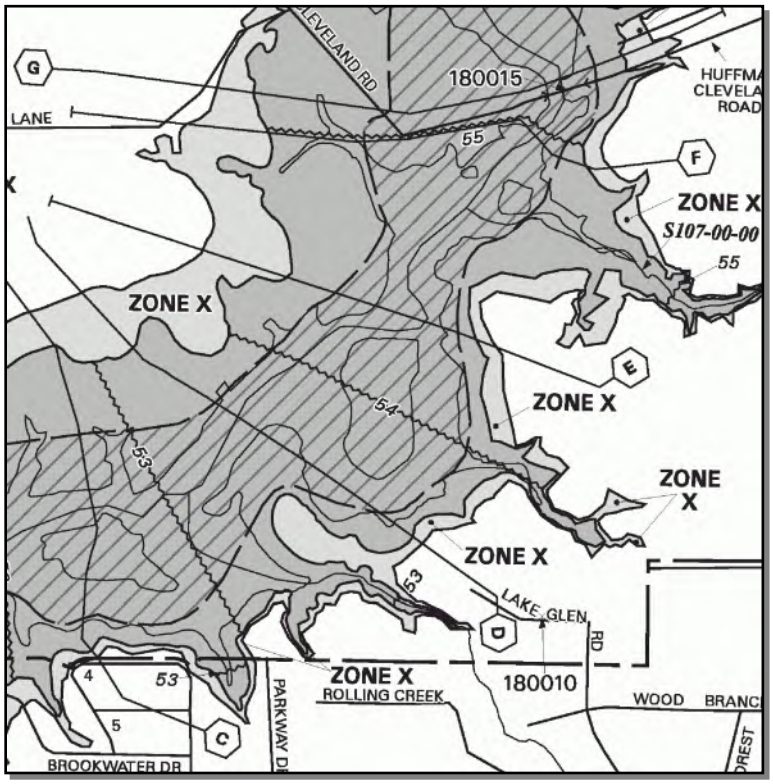


Figure 1. An example of a Flood Insurance Rate Map showing the floodway, cross section locations, and base flood elevations

An example of a FIRM with a floodway is shown in Figure 1. The cross hatched area in Figure 1 within the floodplain is the floodway. The locations of the cross sections are shown and identified by a letter and the base flood elevations are identified by numbers representing the elevation. The dark shaded area outside the floodway is the 1% annual-chance floodplain or Special Flood Hazard Area and the light shaded areas (labeled Zone X) are the 0.2% annual-chance floodplain.

Communities that participate in the NFIP that have been provided with floodway data by FEMA are required to adopt a floodway that causes no more than one foot increase in the base flood elevation at any point in the community. The increase in base flood elevation from the "no floodway" to "with floodway" condition is called the surcharge. Most communities adopt the floodway provided by FEMA

although they can adopt an alternative floodway provided it meets the one-foot criteria. Once a community adopts a floodway, it must prohibit development in that floodway unless it has been demonstrated through engineering analyses that there will be no increase in flood stage. Some states and communities have adopted more restrictive floodway standards than those adopted by FEMA.

> 44 CFR 59.1 Definitions: *"Regulatory Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.*

Designation of a floodway allows for part of the floodplain to be developed while at the same time preserving much of the ability of the floodplain to convey flood discharges. The area within the floodplain but outside the floodway is called the floodway fringe. The allowable one-foot rise in flood stage or surcharge is a compromise intended to balance the rights of the property owner to develop their property against the need to protect adjacent and upstream property owners from increased flood heights and increased flood damages. If FEMA did not allow for some increase in flood stage when designating a floodway, the floodway could comprise most of the floodplain and development in the floodplain would be severely limited.

> 44 CFR 60.3(d): *When the Administrator has provided a notice of final base flood determinations within zones A1-30 and/or AE on the community's FIRM …and has provided data from which the community shall designate its regulatory floodway, the community shall:*
> *(1) …*
> *(2) Select and adopt a regulatory floodway based on the principle that the area chosen for the regulatory floodway must carry the waters of the base flood, without increasing the water surface elevation of that flood more than one foot at any point;*

Code of Federal Regulations (CFR) 60.3 was published in the NFIP regulations on October 26, 1976. However, the floodway was being used in the NFIP for floodplain management prior to 1976 because there is reference to floodways in the "The Flood Disaster Protection Act of 1973". Figure 2 shows a cross section of the floodplain and distinguishes between the floodway and floodplain width.

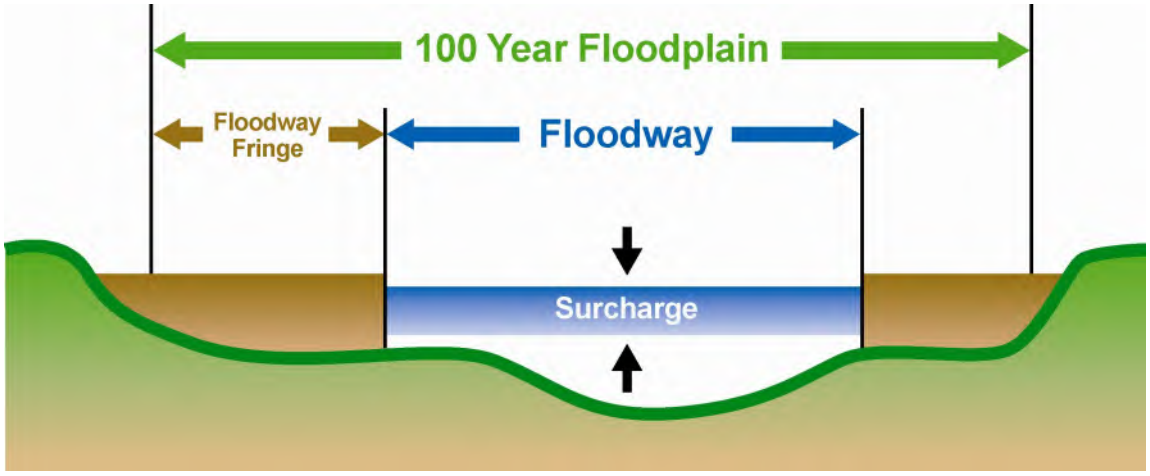


Figure 2. Cross section of a floodplain showing the floodway, floodway fringe, and surcharge

Implications of allowing a one-foot rise: NFIP regulations allow up to a one-foot rise in flood stage when designating the floodway. The floodway boundary is mapped to the edge of the encroachment determined in the floodway analysis, but the surcharge caused by encroachment can result in flooding beyond the extents of the floodway boundary and the identify floodplain boundary. If development occurs outside of the floodway in the floodway fringe and there is an increase in flood stage, there will be an increase in potential flood damages to adjoining and upstream property. In densely populated areas with existing development, even the allowable one-foot increase in depth of flooding could significantly add to flood damages to adjoining and upstream property. Damages can also occur during the base flood to new buildings in the floodway fringe that are elevated or floodproofed to the base flood elevation. Additional areas may be flooded that are not shown on the FIRM as floodplain and not subject to the community's floodplain management ordinance. In these situations, the community may wish to adopt a more restrictive floodway (surcharge less than one foot) to prevent this increase in damages.

2.2. Requirements for Development in the Floodway

Once a community has adopted a floodway, it must prohibit development in the floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed using standard engineering practice that the development will not result in any increase in flood levels during the base flood. FEMA defines "any" as meaning a zero increase (greater than 0.00 feet). This analysis is usually called a "no-rise" or "zero-rise" analysis and results in a "no-rise" or "zero-rise" certification by a qualified register professional engineer. Remember that considerable encroachment into the floodplain was already allowed when the floodway was designated by the community. Although some communities or states perform the hydrologic and hydraulic analyses themselves, most require the permit applicant to obtain the services of a qualified registered professional engineer to perform the analysis and provide the certification. The process for meeting this requirement is described in Section 5. Unless the engineering analysis demonstrates that there will not be an increase in the base flood elevation as a result of the development, the permit must be denied.

> 44CFR 60.3(d)(3): *Prohibit encroachments in the floodway, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community during occurrence of the base flood discharge.*

2.3. Variances

If a permit applicant requests a variance to allow for development in the floodway that would cause an increase in flood stage, the variance request must be denied. NFIP variance criteria at 44 CFR 60.6(a)(1) specifically prohibit the issuance of variances by communities for development in a floodway that cause any increase flood levels during the base flood. Granting this type of variance could violate other NFIP variance criteria since variances also cannot result in increased flood heights, additional threats to public safety, extraordinary public expense, create nuisances, or cause fraud or victimization of the public.

> 44 CFR 60.6(a) Variances: (*1) Variances shall not be issued by a community within any designated regulatory floodway if any increase in flood levels during the base flood discharge would result.*

By designating a floodway, a community greatly simplifies the administration of its floodplain management regulations. Floodplain permits outside of the floodway can be issued without delays for costly hydraulic analyses. Property owners have a greater certainty as to what areas of their properties they can develop and what areas they cannot and can plan accordingly.

2.4. The Importance of Protecting the Floodway

The primary benefit to designating a floodway and regulating development within that floodway is to preserve a portion of the floodplain to convey flood waters from upstream or downstream. Without these requirements, development over time would encroach into the floodway and obstruct the flow of floodwaters thus increasing upstream flood elevations. Limiting development in floodways provides important benefits to the community.

2.4.1. PREVENTING INCREASES IN DAMAGES TO UPSTREAM BUILDINGS

Floodway requirements are different from most other NFIP requirements which are intended to protect individual buildings from flood damages. The primary reason for designating a floodway and limiting development in that floodway is to prevent encroachments in the floodplain from blocking flood flows and impacting flood stages. Without floodway requirements, encroachments into the floodplain would eventually increase flood stages to the point where upstream flood damages are significantly increased. Before floodway requirements were adopted by communities it was common for floodplain encroachments such as bridges and their approaches or fill in the floodplain to cause increases of several feet in flood stage potentially increasing flood damages.

2.4.2. LIMITING DEVELOPMENT IN THE MOST HAZARDOUS AREAS OF THE FLOODPLAIN

Since floodways include the stream channel and the adjacent areas of the floodplain, they tend to include the most hazardous areas of the floodplain with the greatest depths and velocities of floodwaters and amount of debris. Most of these areas are not only hazardous, but they are expensive to develop due the costs of meeting elevation requirements and designing buildings to withstand flood forces. The floodway also will generally flood more frequently than other parts of the floodplain. These areas pose a threat to public safety and are best avoided. If floodways were developed, the likely result would be buildings isolated by deep and fast flood waters that may jeopardize the safety of any building occupants as well as that of public safety employees conducting search and rescue operations.

2.4.3. PROTECTING NATURAL FUNCTIONS OF FLOODPLAINS

Floodways also protect important natural functions of the floodplain that benefit the community and its citizens. In addition to conveying floodwaters, floodways and the adjoining floodplains (floodway fringe) provide flood storage and reduce flood velocities and peak flows. When left in natural vegetation, they also protect water quality and reduce sedimentation in the river or stream. Floodways often contain wetlands and generally provide critical riparian fish and wildlife habitat including habitat for threatened or endangered species. Floodways can provide linear corridors and greenways that allow for the migration of wildlife. Floodway requirements can be combined with

other regulatory programs such as those designed to protect water quality to achieve multiple objectives. Floodways that provide open space in densely populated areas are an amenity that can increase the value of adjoining property and enhance the tax base of the community.

2.4.4. APPROPRIATE USES OF FLOODWAYS

There are a number of economic uses that can be conducted in floodways that do not impact flood stages. Where possible these uses should be encouraged.

- Agriculture and forestry uses that do not involve buildings or use of fill.
- Back yards, lawns, gardens, parking areas and play areas. Often subdivisions can be designed so that there are building sites on each lot that are outside of the floodplain or at least the floodway and that all floodway areas are preserved.
- Private or public open space and recreation uses such as golf courses, campgrounds, picnic grounds, boat launching ramps, wildlife and nature reserves, and similar uses. When in public ownership, floodways can provide corridors for trail systems for hiking, jogging, biking, or horse-back riding. Often these uses enhance the value of adjoining properties.
- Industrial and commercial uses such as parking lots and loading areas and airport landing strips for light airplanes that do not involve buildings or use of fill.

If these uses require fill or construction of buildings, the developer will have to demonstrate through an engineering analysis that the use will cause no rise in flood stages. Some of these uses such as campgrounds or parking lots may not be suitable for areas subject to flash floods or areas that flood frequently.

2.5. Legal Basis for Floodways

Floodway regulations have withstood numerous challenges that they are an unconstitutional taking of private property without just compensation. The challengers generally have argued that floodway requirements are so restrictive that the owner is precluded from making an economic use of their property. In nearly all cases the concept of the floodway has been upheld in the Courts as an appropriate use of the community's floodplain management authority. The important point to remember is that floodway requirements are intended to prevent the actions of one property owner from causing increased flood damages to adjacent or upstream property owners. No property owner has a right to a use that would create a nuisance to adjacent properties.

The NFIP floodway requirements are not a prohibition on development within the floodway. They establish a performance standard (no increase in flood stages) that is intended to avoid increasing damages to adjacent and upstream property owners. If the development can be designed to meet the performance standard, it can be permitted in the floodway provided that the development meets other NFIP floodplain management requirements. Floodway requirements may increase the cost of development or limit the size of the development and the developer may decide that the development is no longer practicable and may choose to abandon the project or decide on an

alternative location for the development for economic reasons. However, this is an economic decision made by the developer and does not result in a taking under the law.

There are also public policy interests in controlling development in what is generally the most hazardous part of the floodplain. There can be increased costs to the community costs in providing services to floodway development. More importantly there are significant threats to public safety for any inhabitants in the floodway and the need for search and rescue and other emergency operations can place an additional burden on an already overwhelmed community. For these reasons as well as to provide increased protection to adjoining and upstream property owners, some states and communities adopt more restrictive (surcharge less than one foot) floodway standards. The following sections provide guidance and requirements associated with floodway determinations.

2.6. More Restrictive State and Local Floodway Standards

Several states have adopted floodplain management laws and regulations that are more restrictive than NFIP minimum requirements. Communities in these states must comply with both NFIP minimum criteria and the more restrictive state requirements. In addition, many communities have adopted more restrictive floodways or placed added restrictions on floodway development.

2.6.1. MORE RESTRICTIVE ENCROACHMENT STANDARDS

In accordance with 44 CFR 60.1(d), any floodplain management regulations adopted by a state or a community which are more restrictive than the criteria set forth in the minimum NFIP standards are encouraged and shall take precedence. The most common state requirement is an encroachment standard that is more restrictive than the NFIP one-foot rise criteria for designating floodways. Typically, these states limit the increase in flood stages caused by designating the floodway to zero or to an amount such as 0.1 foot or 0.5 foot. Provided that the state has legally enforceable laws or regulations, FEMA recognizes these state standards and maps floodways in communities in these states using the more restrictive state standard. For rivers or streams that border two states, one of which has a more restrictive floodway standard, the one-foot surcharge is used unless the states have mutually agreed on a lesser criterion.

Provided that an individual community has a legally enforceable law or regulation for a more restrictive floodway, it can also request the more restrictive floodway be placed on their FIRM. FEMA's policy is to map a floodway for the community using the one-foot surcharge and do an additional floodway analysis using the community's more restrictive standard and provide those floodways to the community. The Mapping Partner conducting the study must consult with the appropriate FEMA Regional Office to determine the appropriate floodway to be placed on the FIRM. For rivers or streams that border two communities, if one community has a more restrictive floodway standard, the one-foot surcharge is used for the maps unless the communities have mutually agreed on a lesser criterion.

Information on contacting the FEMA Regional Offices can be found at https://www.fema.gov/about/contact.

2.6.2. STATE FLOODWAY REGULATORY PROGRAMS

Several states directly regulate all or most development in floodways. These states have engineering staffs that perform floodway analyses and review and approve permits for floodway development. Both a state permit and a permit from the community may be required for a floodway or floodplain development in these states. If your community is located in one of these states, contact the responsible state agency for information on the state requirements.

2.6.3. FLOODWAYS THAT PRESERVE FLOODPLAIN STORAGE

The FEMA floodway is intended to limit the impacts of encroachments into the floodplain on the hydraulics of the river or stream – the requirement prevents increases in flood elevations on upstream or adjoining properties from exceeding the one-foot standard. The FEMA floodway usually does not account for the effects of loss of storage on the hydrology of the river or stream and on downstream flood heights due to increased peak discharges. In some situations loss of storage may not make much of a difference on flood stages; however, on smaller streams, particularly those with wide floodplains that contain areas such as wetlands that store large amounts of floodwaters it could be a significant factor in increasing flood stages. Without these upstream storage areas, floodwaters will concentrate more quickly increasing peak discharges of floodwaters. The result will be increases in flood heights in downstream areas. Under certain conditions the increase in downstream flood heights can be much greater than the upstream hydraulic impacts of the encroachments. Some communities address storage by incorporating loss of storage into their hydrologic and hydraulic models and develop a "storage" floodway. Other communities designate wider floodways in areas of the floodplain that provide storage such as wetlands. For communities wishing to consider higher standards the downstream impacts caused by loss of storage can be identified through the use of unsteady regulatory models.

A community can also address this issue by limiting the amount of fill that can be placed in the floodplain, adopting wetlands ordinances, requiring large lot zoning, or requiring that compensatory storage be provided as the floodplain is developed. Compensatory storage ordinances require developers that fill in the floodplain to compensate for the loss of storage by creating new storage elsewhere on the property that is comparable to the storage that was lost.

2.6.4. ALTERNATIVE FLOODWAY CRITERIA

Some communities use other criteria to designate their floodways. Typically, these criteria include in the floodway those areas that are frequently flooded, have flood depths greater than a specified depth, or areas where floodwaters exceed a certain velocity. Their grounds for using these criteria for designating their floodways are that these areas are generally not suitable for development or are too hazardous and a threat to the safety of the public. The severity of the hazard is a function of the combination of the depth of flooding and the velocity of the floodwaters. Even very shallow flood depths of 1-2 feet can be hazardous in areas of high flood velocities. For example, floodwaters of 2 feet deep with velocities of five feet per second would be hazardous to even an adult. Numerous agencies, including the U.S. Bureau of Reclamation in ACER Technical Memorandum No. 11, *Downstream Hazard Classification Guidelines* (1988), have developed guidance that can be used to

help identify the most hazardous areas of the floodplain based on depth and velocity magnitudes. To meet NFIP minimum requirements these floodways must also not cause an increase in the water surface elevation of the base flood of more than one foot at any point in the community.

Another alternative is to designate a resource based floodway. Such a floodway must at a minimum include the FEMA one foot floodway but can include areas that protect other important natural floodplain functions. For example, the floodway could be expanded to include adjacent wetlands, key riparian habitat, a setback to protect water quality, and similar areas. Communities that adopt resource based floodways need to clearly explain the basis and purpose of their floodway designation in their ordinance. Resource based floodways work best when combined with restrictions on the uses allowed in floodways discussed in the next section.

2.6.5. RESTRICTIONS ON USES ALLOWED IN FLOODWAYS

In addition to establishing more restrictive standards for designating floodways, some states and communities limit the types of development that can occur in floodways. Generally, these states and communities have determined that public safety issues created by locating buildings in the floodway far outweigh any economic benefits of allowing the development. For example, several states prohibit the placement of all buildings in the floodway or limit the floodway to open space uses. One state prohibits new residential buildings in the floodway with exceptions for certain farm residences. Along streams with relatively narrow floodways it may also be possible to prohibit most alterations of the floodway with an allowance for any necessary road and bridge crossings.

2.6.6. REGULATING TO A BASE FLOOD ELEVATION THAT INCLUDES THE ONE FOOT SURCHARGE

One of the major concerns regarding the NFIP floodway requirements is that they can result in up to a one-foot increase in flood stage for the base flood within the community. The result is that even buildings that are elevated or floodproofed to above the base flood elevation (BFE) can eventually sustain flood damage during the base flood. Furthermore, buildings developed outside the Special Flood Hazard Area maybe susceptible to flooding over time. Several states require that any increase in flood stage that would result from the designation of a floodway be added to the BFE and the buildings be protected to the increased elevation. In some instances, states or communities add freeboard on top of the base flood elevation to account for uncertainties in the base flood elevation, provide an increased level protection, or compensate for the increase in flood stages that result from floodway encroachments.

2.6.7. COMMUNITY RATING SYSTEM (CRS)

Communities that adopt regulatory floodways that are more restrictive than NFIP minimum requirements or apply more restrictive requirements within their floodways can receive credits under the NFIP's Community Rating System (CRS). The CRS provides discounts on flood insurance premiums in those NFIP communities that implement floodplain management programs that go beyond the minimum requirements of the NFIP. Contact your State or FEMA Regional Office regarding the CRS or refer to the CRS page on the FEMA website at https://www.fema.gov/flood-insurance/rules-legislation/community-rating-system for additional information.

3. How Floodways are Delineated in FEMA Flood Insurance Studies

Flood insurance studies are conducted on behalf of FEMA by a Mapping Partner that could be a private consultant, a federal agency, a state agency, a special district such as a flood control or watershed district, or a community. States, communities, or special districts that cooperate with FEMA during the flood insurance study process can become a Cooperating Technical Partner (CTP) to FEMA. Flood Insurance Studies are conducted in accordance with FEMA's Guidelines and Standards for Flood Risk Analysis and Mapping using standard engineering models. Most detailed studies along rivers and streams have been prepared using HEC-RAS or, its predecessor, HEC-2 developed by the U.S. Army Corps of Engineer's Hydrologic Engineering Center in Davis, California. Other FEMA approved hydrologic and hydraulic models that can be used can be found on the Flood Hazard Mapping pages on FEMA's web site www.fema.gov/national-flood-insurance-program-flood-hazard-mapping.

There are two main components to a flood insurance study that take place prior to the mapping of the floodplain and delineating the floodway, and these involve defining the hydrology and hydraulics of the stream being studied.

4. Hydrology

A detailed hydrologic analysis is conducted to determine the flood discharges that will occur during the base flood and other representative floods including the 10-year (10% annual-chance), 25-year (4% annual-chance), 50-year (2% annual-chance), and 500-year (0.2% annual-chance) floods at a location under existing conditions. Flood discharge is the quantity of floodwaters that will pass a particular location for that frequency flood measured in cubic feet per second. Flood discharges can be found in the Summary of Discharges table in the Flood Insurance Study (FIS) report. Flood flow frequencies are determined using data from stream gages if there is one on the stream being studied and procedures described in Bulletin 17C, *Guidelines For Determining Flood Flow Frequency* (2018) or subsequent editions. If stream gage data are not available, flood discharges are determined using regression equations developed by the U.S. Geological Survey or other agencies or approved rainfall-runoff computer models that combine rainfall or snowmelt with characteristics of the watershed to obtain the flood discharges. For more information, see Guidance Document No. 71: Guidance for Flood Risk Analysis and Mapping: General Hydrologic Considerations and Guidance Document No. 91: Guidance for Flood Risk Analysis and Mapping: Hydrology: Rainfall-Runoff Analyses.

An example of a flood frequency curve for a gaging station is shown in Figure 3. This curve relates the magnitude of the flood discharges to the percent chance of exceedance. The data shown in Figure 3 include the annual peak data collected at the gaging station, the solid curve representing the computed frequency curve and the dashed lines showing confidence limits that depict the uncertainty in the computed curve. For the stream in Figure 3, the 1% annual-chance or 100-year discharge is 82,000 cubic feet per second (cfs).

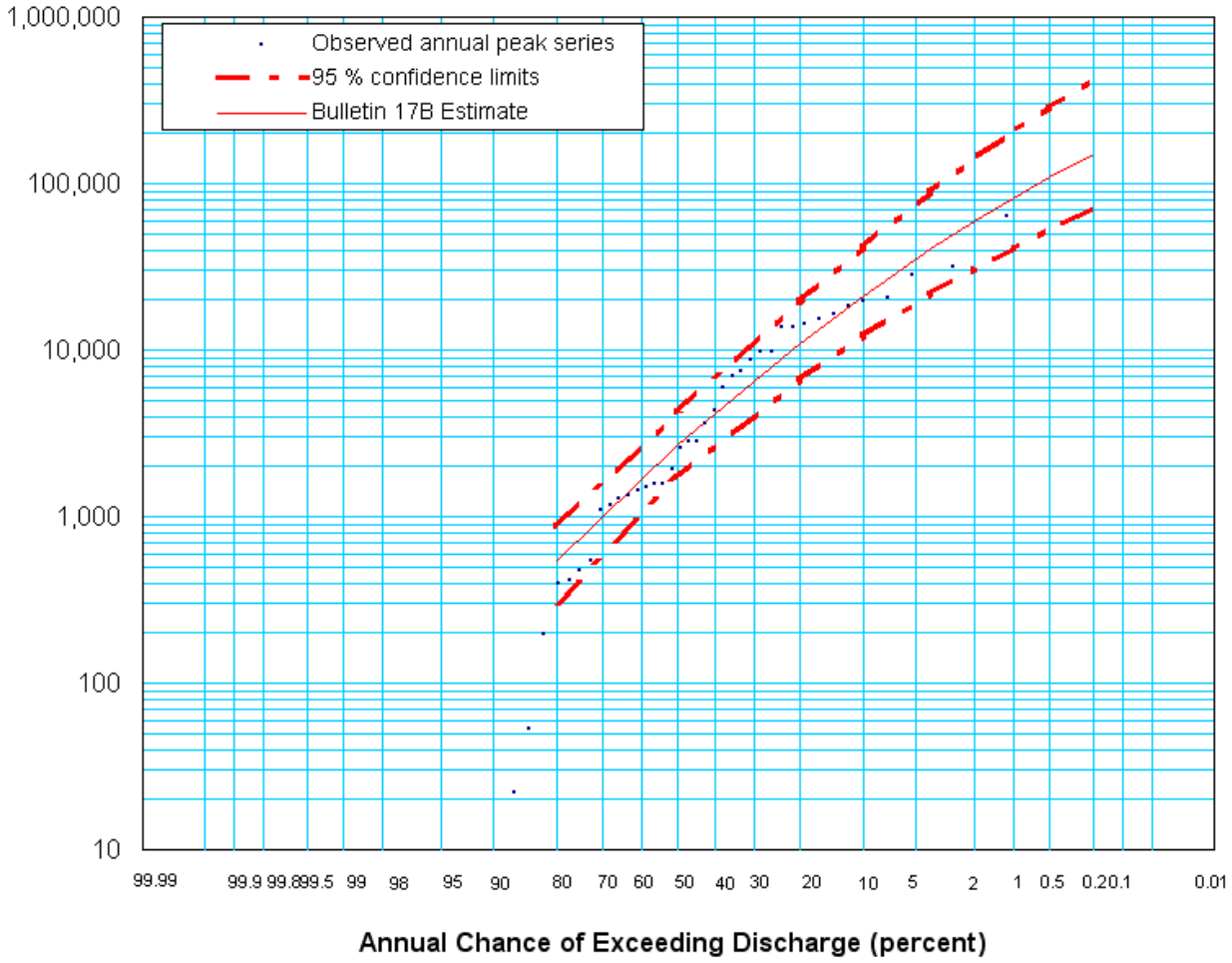


Figure 3. Flood frequency curve for a gaging station that relates the magnitude of the flood discharges to the percent chance of exceedance

5. Hydraulics

Once the flood discharges are determined, a hydraulic analysis is conducted to provide estimates of the elevations of the various frequency floods and to designate the floodway. Often a one dimensional HEC-RAS or its predecessor HEC-2 are used to conduct this analysis although there are other FEMA approved models that are appropriate. The hydraulic analysis creates a computer model of the floodplain using the flood discharges, 1D cross sections or 2D mesh of the river or stream, and characteristics of the channel and overbank areas such as their roughness coefficients, slope, and location and size of any obstructions such as bridges and culverts.

For 1D models, cross sections of the stream channel and the adjacent overbank areas are developed at regular intervals along the channel using ground surveys, detailed topographic maps or digital elevation data. A cross section is vertical slice of the channel and overbank areas taken perpendicular to the direction of flow. See Figure 4 for an example of a surveyed cross section. Cross sections must be located close enough together to reflect changes in the shape and slope of the

channel and overbank areas. For example, cross sections are taken to reflect changes in the width of the floodplain, bridge and road crossings (several cross sections are required to model a bridge), changes in floodplain land use, and other factors that may impact flood flows. The more changes there are in the floodplain the more cross sections that are required for the hydraulic model. See the FIRM in Figure 1 for examples of cross section locations.

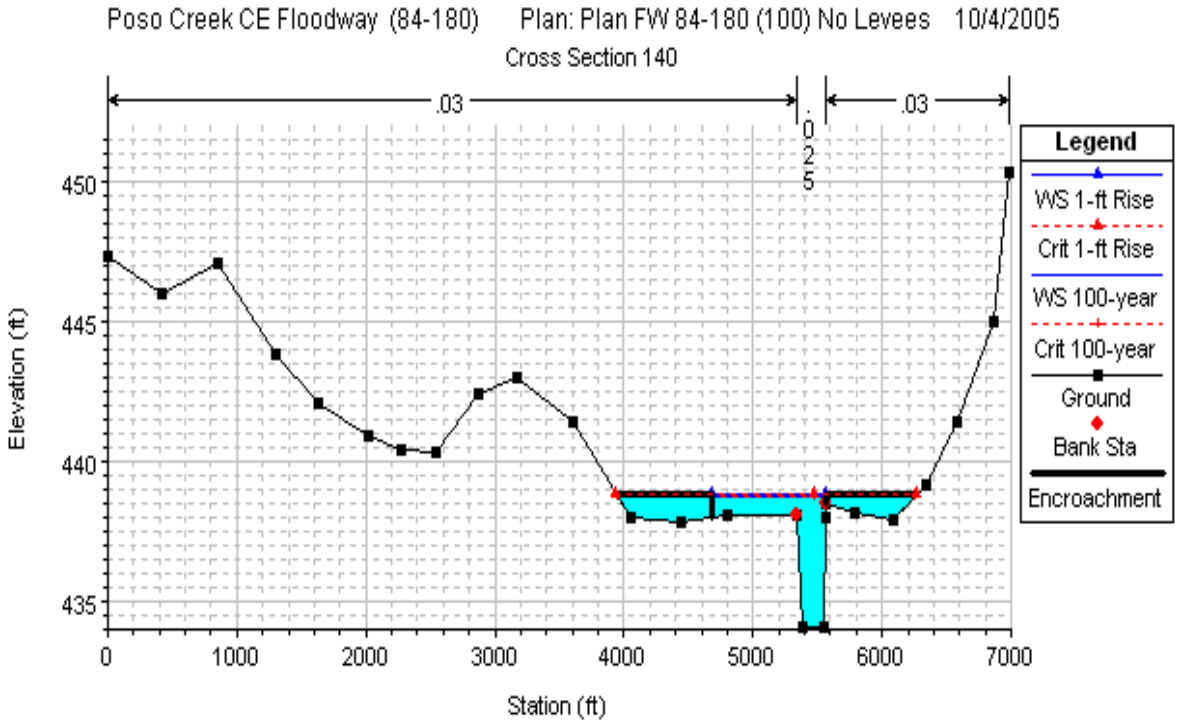


Figure 4. Surveyed cross section

Roughness coefficients (called Manning's "n") are determined for the channel and overbank areas of each cross section. Roughness coefficients measure the friction in the channel and overbank areas and are a significant factor in measuring the effectiveness of that portion of the channel or overbank area in conveying flood waters. For example, floodwaters will flow more smoothly and at higher velocities over a paved surface than if the area were heavily forested.

Within the model, the flood discharges are routed through the model and the result of the hydraulic analysis is a base flood elevation and a floodplain boundary at each cross section. The floodplain boundary is then interpolated between the cross sections using available topographic information. See Figure 5 for a flood profile from an FIS Report.

Guidelines and Specifications for Flood Hazard Mapping Partners [April 2003]

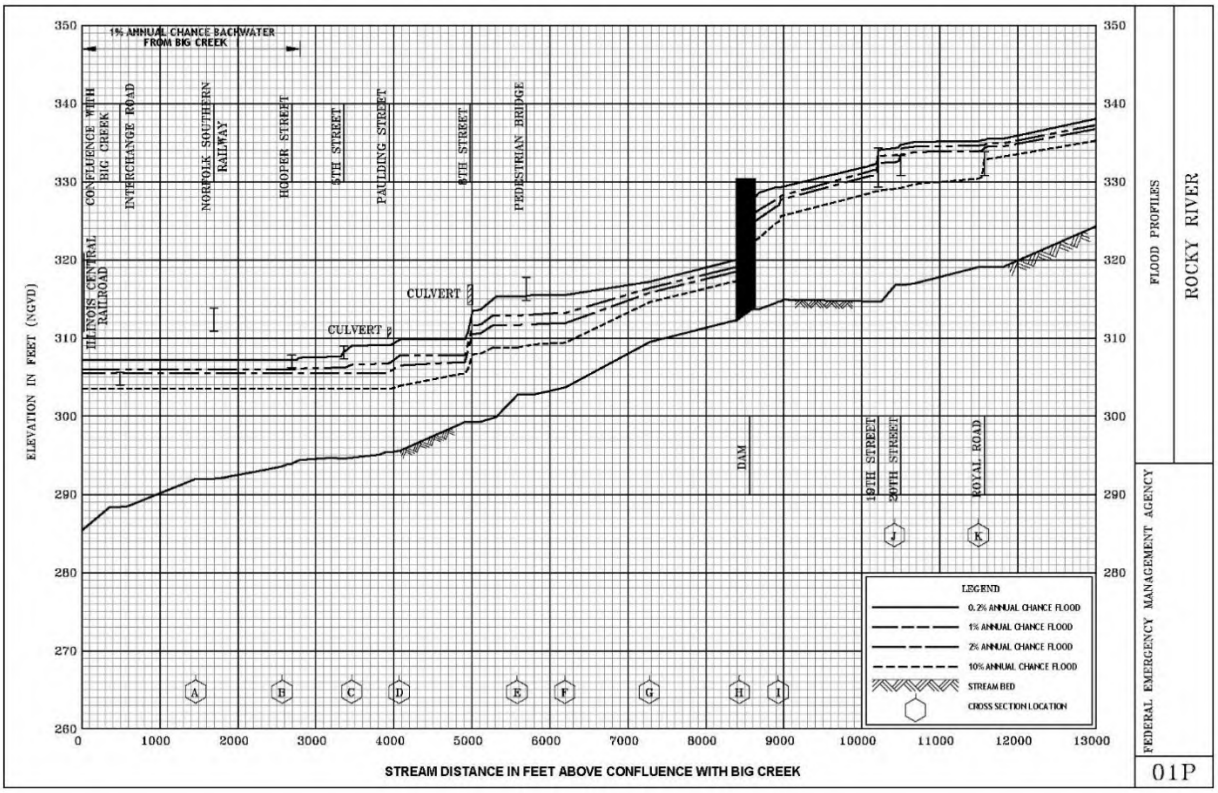


Figure 5. Flood Profile from a Flood Insurance Study. Note that in addition to the elevations of various frequency floods, the Flood Profile shows the locations of the cross sections and of bridges, culverts, and other water control structures

For 2D models, a flood is typically routed through a mesh or grid that calculates flow in multiple directions. Each mesh is comprised of elements such as a 10 foot by 10 foot square representing a typical elevation. These types of analyses and models are often capable of providing much more detailed output than a 1D analysis. Profiles can also be generated or extracted along the stream centerline for these 2D studies, but the water surface elevations (WSELs) along the profile may vary significantly from nearby mesh elements – particularly where wide overbank areas convey much of the flow. Figure 6 provides an example of a 2D-modeled floodplain that illustrates this point, where approximating the BFE using the WSELs along the profile baseline would produce an inaccurate estimate at locations farther away from the profile baseline.

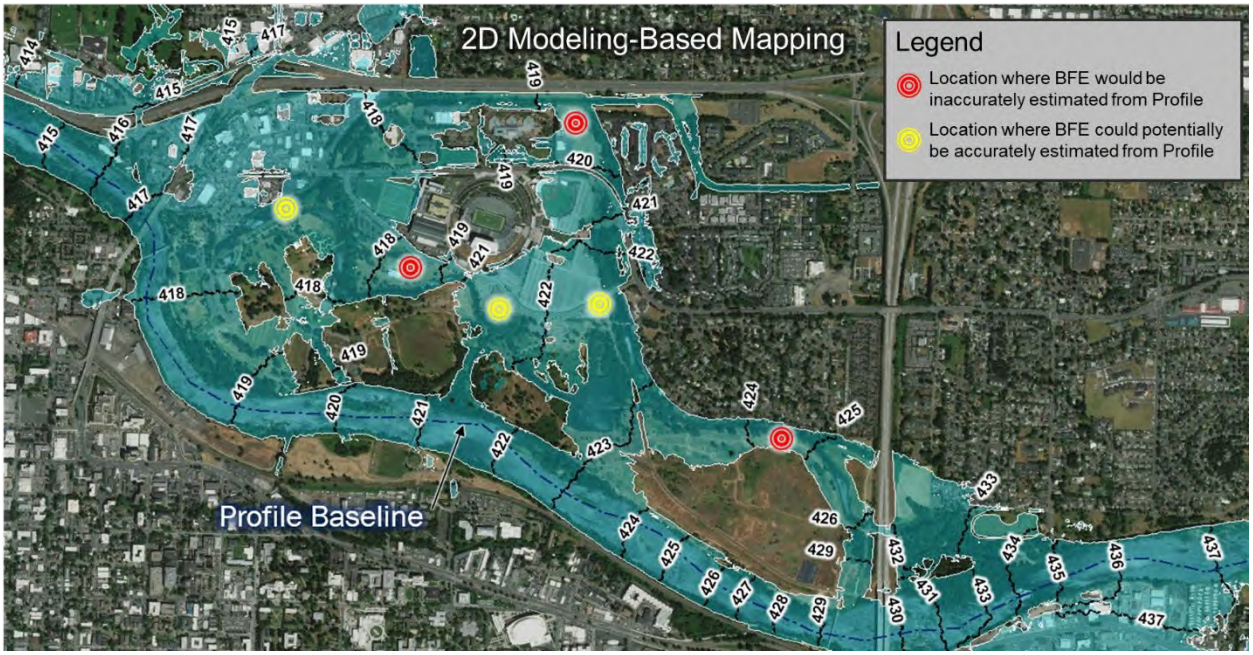


Figure 6. Example of challenge with using a Flood Profile to estimate floodplain BFEs in a 2D-modeled area

5.1. Floodway Analysis

The next step in conducting the hydraulic analysis is to develop the floodway. The Mapping Partner performing the hydraulic analysis shall determine the floodway using a procedure based on equitable consideration of encroachment of both overbanks. Equitable consideration should be based on physical considerations only, not land value. The procedure used to establish equitable distribution of encroachment may vary based on the model type. For example, floodway analyses based on 1D modeling typically establish equitable consideration via equal reduction of conveyance (described in Section 5.1.1) on opposite sides of the stream (also called equal degree of encroachment), while 2D or hybrid 1D, 2D models typically use an equal unit discharge or depth times velocity (DxV) value to accomplish equitable distribution on either overbank (see Section 5.3.2). Alternative approaches may be used for both modeling types, but the FEMA Project Officer and impacted communities should be involved in the method selection process.

The purpose of encroaching based on equitable consideration is to ensure that like-situated properties are treated equally. This does not mean that that the flood fringe will be an equal width on both sides of the stream. Since the stream channel meanders across the floodplain, the amount of conveyance in the overbank areas will usually vary. Reducing the amount of conveyance by an equal amount in both overbank areas usually is the fairest way to treat property owners. Additional consideration may also be given to areas that have been developed previous to a floodway being identified. See Figure 7 for a standard floodway schematic from an FIS Report.

As the floodway encroachment boundaries are identified, the study assumes that the entire floodplain outside of the floodway has been filled or otherwise obstructed and does not convey flood waters. For this reason, once a floodway has been designated encroachment analyses are no longer required for development outside of the floodway. Having a floodway considerably reduces the administrative burden of regulating floodplain development since hydraulic studies do not have to be undertaken for individual development proposals.

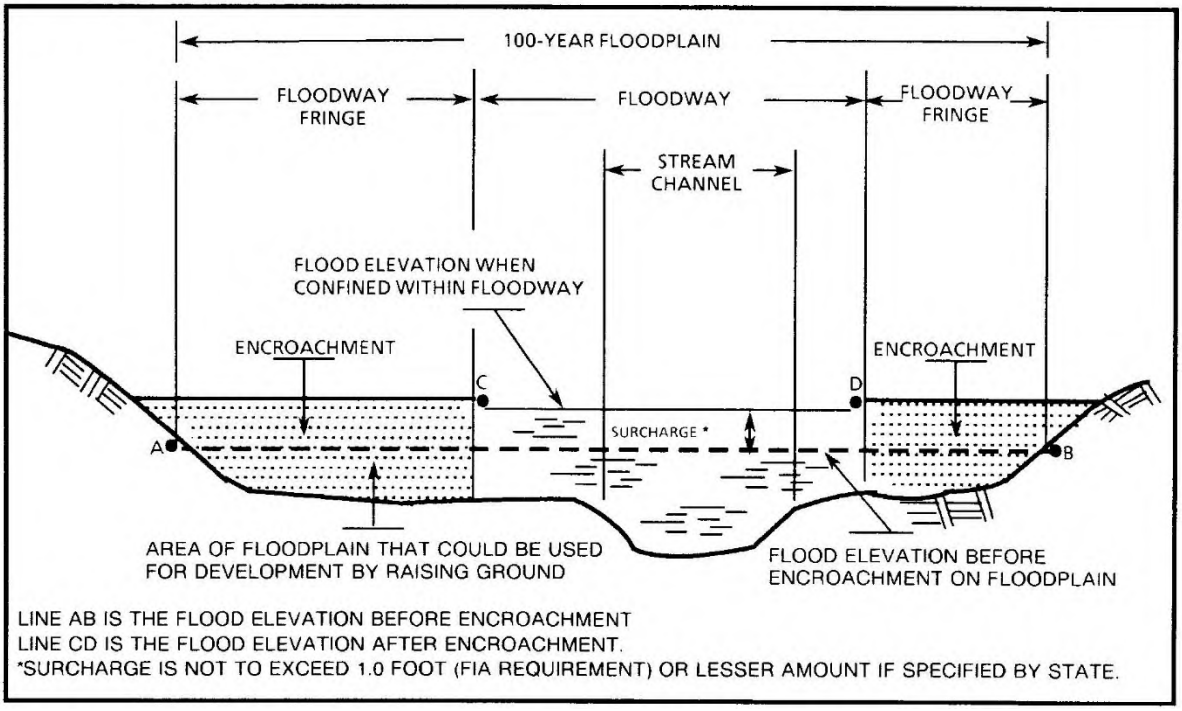


Figure 7. Cross section of the floodplain showing the floodway, floodway fringe and surcharge. The model assumes that the entire floodplain outside of the floodway is filled or otherwise obstructed.

5.1.1. ONE-DIMENSIONAL FLOODWAY ANALYSIS

For a one-dimensional floodway analysis, the encroachment boundaries are identified on each cross section within the model where a floodway is defined and then engineering judgment is used to interpolate the floodway boundary between the cross sections adhering to hydraulic principles, river morphology, and topography. Equal reduction of conveyance is typically used to establish equitable distribution of encroachment in both the left and right overbank. Equal reduction of conveyance means that that the conveyance on both sides of the stream is reduced by an equal percentage. The computer model in effect squeezes the floodplain by progressively eliminating the area of the cross section beginning at the edge of the floodplain until the allowable one foot surcharge (or community/state-designated surcharge amount) is reached at one of the cross sections. Usually several computer runs are made to come as close as possible to the maximum allowable one foot surcharge (or community/state-designated surcharge amount) at all of the cross sections.

In a 1-D analysis it is also possible to determine a floodway by manually locating floodway boundaries at each cross section and then running the computer model to determine if the floodway meets the one foot surcharge criteria. This method is used to develop a floodway when equal reduction of conveyance does not produce the desired results or to evaluate floodways proposed by communities to determine if they meet allowable one foot surcharge.

The requirement that the increase in the base flood elevation due to the floodway not exceed one foot (or community/state designated more restrict surcharge amount) at any point in the community generally results in many cross sections where the surcharge is less than the allowable surcharge. Usually the controlling factor is a single cross section where the stage increase is at the allowable surcharge. In some situations, it is possible to fill up to the bank of the stream without causing a one foot increase in flood stage. When this occurs the floodway boundary may be set at the bank station of the stream channel as defined in the model even though the allowable one foot increase in flood has not been reached.

5.1.2. TWO-DIMENSIONAL FLOODWAY ANALYSIS

For a floodway analysis complete using a 2D, or hybrid 1D, 2D model encroachment boundaries are identified as continuous polygons on either side of the model domain. Floodway analyses completed using a 2D model will typically use an encroachment screening procedure based on DxV contour values from the base flood analysis to establish equitable distribution of encroachment (discussed in Section 5.1.2.2). Unlike floodways generated from a 1D model, analyses based on a 2D model will have a continuous encroachment, removing the need to interpolate the floodway boundary between two locations.

If a floodway based on a 2D model is being used in an area where the floodway was previously determined by a one-dimensional model, the Mapping Partner should incorporate the encroachment stations into the 2D model to verify that the maximum allowable surcharge is not exceeded. Although modeling techniques and calculation sets vary between 1D and 2D methods, all floodways developed with 2D modeling platforms must have floodway widths that tie into any effective floodways at the limits of the study.

The procedure for setting up and evaluating surcharge encroachment in a 2D model varies from the common procedures used in a 1D analysis due to the added level of detail captured in the model domain. Subsection below describe guidance on setup and evaluation of a 2D floodway analysis, including establishing inflows, initial encroachment screening approaches, setting encroachments, and validating the surcharge results.

5.1.2.1 Managing Inflows

2D models can be used to model a variety of situations ranging from the evaluation of a single structure crossing to modeling the runoff characteristics of an entire watershed. To determine the appropriate setup for a floodway analysis for any 2D model, the first step is to determine the inflow source. Generally there are two main scenarios where a floodplain model may be used as a starting point for developing a 2D floodway model for a reduced area: riverine source inflow, and rain-on-grid

(ROG). The descriptions below give a brief overview of some of the common processes for converting the base floodplain model into a floodway model for these situations. Although different encroachment techniques and modeling platforms may be used, the underlying principles listed below will hold true.

Riverine Inflow Source: If the base model being used is a riverine inflow source model flow, the peak flow or flow hydrographs can be extracted from the base model and included as inflows into the floodway model at coincident locations in the floodway model. Where a steady-state solution is desired but the modeling software does not include an option for steady state analysis a quasi-unsteady state hydrograph can be considered as an inflow source. A quasi-unsteady hydrograph can be manually created by gradually increasing flow to avoid model instabilities until the peak flow matches the original hydrograph peak flow. Once the peak flow is reached, the peak flow is sustained until the entire study reach reaches equilibrium with the same constant peak flow. The quasi-unsteady hydrograph can simplify the floodway encroachment analysis by ensuring the same peak flow is achieved at all locations along the study reach contrary to the unsteady hydrograph inflow where applied encroachments will modify the peak flow moving downstream. However, the quasi-unsteady hydrograph introduces more volume into the model than the original hydrograph which may result in a wider floodway. Both approaches must use the same inflow approach as the base model for comparison to calculate and validate surcharges.

Rain on Grid (ROG) Source: Within a ROG model, it is possible there are no riverine inflow hydrographs, and instead, all flooding is a result of rainfall applied to a 2D mesh and allowed to congregate and propagate downstream along flow paths defined by the underlying terrain dataset. When a ROG model is used as the base flood comparison for a floodway analysis, the modeler has two options. They can elect to continue using the entire ROG domain to perform the floodway analysis or they can choose to reduce the ROG model to a smaller domain. Depending on the modeling software and domain size, one option may provide more advantages over the other. When the modeler elects to use a reduced domain, the direct flow along the stream and drainage basins to the main stem should be extracted and inputted into the river corridor project area. Flow hydrographs can be extracted from the ROG model along both main flooding sources and key tributaries at the confluence near the floodplain fringe and inserted into the floodway model as internal boundary conditions with lengths comparable to the flood extents introduced by the tributary. Consideration of back flow areas, or eddies, at each confluence area should be avoided when considering both the hydrograph extraction transect locations and the extents of the applied inflow boundary conditions to ensure the introduced flow from the contributing areas isn't reduced by the backwater effects. Peak discharges between the newly created riverine base scenario floodway model utilizing extracted flow hydrographs and the base ROG model should match within a certain reasonable percentage (commonly within a 5% difference) at incremental locations along the modeled reach. In some scenarios, this may be difficult to achieve due to decreases in total water volume caused by removing the direct flow from the ROG from the floodway model. To overcome this issue, the modeler may choose to try the use of the quasi-unsteady flow hydrograph approach to delineate the floodway as previously discussed.

5.1.2.2 Initial Encroachment Screening Approaches

Once the inflow sources for the 2D floodway analysis are set initial encroachments should be determined. Steady and unsteady floodway analyses completed using a 2D model will typically use an initial encroachment screening procedure based on the unit discharge or DxV values from the base flood results. This approach is a way to establish an equitable distribution of the initial encroachments, but the floodway shall still be evaluated against the maximum floodway surcharge criteria restricted by SID 69. In accordance with local or regional management objectives, the initial encroachments can be reduced to more conservative, lower maximum surcharge values. Aligning the floodway encroachments with hazard-based categories may make for a more tangible result when conveyed to the general public. The decision on initial encroachment screening should be made in conjunction with community representatives and the FEMA Project Officer.

Two commonly used initial screening or binning approaches to consider are the DxV approach and the Australian Flood Hazard Curves approach.

The DxV approach takes both the floods depth and velocity component to graphically show the higher conveyance areas within a calculated floodplain and consider an equitable reduction in flow from either side of the flood area for a single DxV area contour. Different values of DxV contour extents can be used to delineate and bin different floodway iterations to expedite the path to a final encroached floodway. DxV binned values associated with conceptual flood severity categories are presented in Guidance Document No. 14: Guidance for Flood Risk Analysis and Mapping: Flood Depth and Analysis Grids.

The Australian Flood Hazard Curves approach, presented in the *Australian Rainfall and Runoff, A Guide to Flood Estimation* (2019), covers in-depth studies used to create different flood risk categories associated with different vulnerabilities in a particular analyzed area. The Australian Flood Hazard Curve approach also takes into account DxV values but instead creates depth and flood velocity maximum thresholds for each hazard category where a DxV value would asymptotically approach each depth or velocity axis. This gives a slightly more conservative hazard contour extent than a DxV number for initial screening and integrates which downstream vulnerabilities to weigh for flood risk management.

5.1.2.3 Encroachment Types

The process for applying encroachments in a 2D model may vary depending on the software package used and preferences of the community. Three common encroachment approaches are described below. The final approach should be selected based a project area's unique flow characteristics with concurrence from the FEMA project manager, the engineer, and the local community impacted.

1. Raised Terrain at Floodway Fringe: The terrain is manually manipulated by raising terrain elevations substantially at the tested floodway fringe to confine all flow within the encroached floodway.

2. Nulled Computational Cells along Floodway Fringe: The computational mesh is manually manipulated to "turn off", or null, cells that are outside of the tested floodway fringe allowing

only the internal cells to convey the base flood during the floodway trial without any manipulation to their orientation from the base mesh configuration.

3. Lateral Weirs and Mesh Realignment along Floodway Fringe: A lateral weir structure is placed along the floodway fringe with cell faces realigned to the lateral weir alignment. The lateral weir alignment would keep flow from passing outside of the encroached area with an unconventionally high value weir coefficient designated for each lateral weir element. This realignment of the original base model mesh would need to be re-run for the base flood comparison to confirm results have not changed from the original model and would act a duplicate base model for comparison to the encroached lateral weir results for the floodway surcharge calculations and validation.

5.1.2.4 2D Floodway Validation

Once encroachment boundaries are set in the 2D floodway analysis floodway surcharge criteria must be evaluated. Elevations and surcharge must be reported in a format that is consistent with regulatory FIS and FIRM products. In order to achieve this consistency, and in order to align with floodway evaluation techniques upon which the CFR regulations were originally based, the use of 2D floodway "evaluation lines" is recommended. Evaluation lines in 2D floodway analysis may be thought of as virtual hydraulic cross sections similar to the physical cross sections used in 1D modeling and reported in the floodway data table. Evaluation lines should be placed on FIRMs where a detailed study included a floodway calculated based on 2D methods. Evaluation lines should also be used where a detailed study included a floodway calculated based on a hybrid 1D, 2D model where the cross sections do not cover the entire floodplain. In both cases, evaluation lines should be set at the critical locations as a reference point for floodway reporting and validating surcharge requirements. Where a 2D or hybrid 1D, 2D model was used but no floodway is calculated, evaluation lines should not be included.

Evaluation lines should typically represent a single water surface elevation and may have a contoured shape. While similar to a BFE line, an evaluation line is a separate line type used to report floodway or encroachment information and used to validate that the calculated floodway or encroachment modification meets the surcharge requirements. Evaluation lines should be reported in the S_XS database layer. On the FIRM, evaluation lines can be either lettered or unlettered, and will have water surface elevation reported, similar to a lettered and mapped cross section line in a 1D model. The combination of BFE lines stored in the S_BFE layer and evaluation lines stored in the S_XS layer will produce a credible water surface elevation grid that captures the variability in the model results and aligns with the requirements of SID 128 and guidance listed in Guidance Document No. 31: Guidance for Flood Risk Analysis and Mapping: Mapping Base Flood Elevations on Flood Insurance Rate Maps. Figure 8 below provides an example of how evaluation lines and contoured BFE lines may be used together on a FIRM to represent the modeled water surface. It is recommended that evaluation lines follow whole foot elevations if possible, and are placed in key locations. Additional guidance for evaluation lines placement is included below. Alternatives to this approach are allowed and should be coordinated with both the local community and FEMA Region.

Guidance for Evaluation Lines Placement

- The profile slope between any two evaluation lines or evaluation lines and BFE lines should be relatively constant.
- Spacing of evaluation lines should follow these general guidelines:
  - Gentle Gradient – If water surface elevations rise less than one foot per one inch of map distance, the evaluation lines should be plotted at every whole foot of elevation rise.
  - Moderate Gradient – If water surface elevations rise more than one foot, but less than five feet per one inch of map distance, the evaluation lines should be plotted at approximately one-inch intervals.
  - Steep Gradient – If water surface elevations rise five feet or more per one inch of map distance, the evaluation lines should be plotted at half-inch intervals of map distance or at five-foot intervals, whichever is greater (i.e., whichever results in a wider evaluation line spacing).
- Evaluation lines should be placed at key hydraulic locations to capture and report the resultant surcharge. Examples of key hydraulic locations will vary depending on the characteristics of the stream but will likely include:
  - Expansions and contractions in the floodplain
  - Upstream and downstream of existing structures
  - Upstream, downstream, and at the location of significant hydraulic controls
  - Where significant changes occur in the modeled topography
  - At divergence and confluence of split flow paths or divided flow paths
- Special care should be given to make sure that evaluation lines are placed where splits in the high conveyance areas of the floodplain occur. The DxV outputs from the base flood analysis should be used to assist in identifying these locations. Failure to capture these areas with appropriate evaluation line placement could result in significant changes in the overall floodway width.

General Rules for Plotting Evaluation Lines on FIRMs:

- The maximum rise between plotted evaluation lines should not exceed 10 feet.
- Evaluation lines may be shown similar to “lettered” cross sections on FIRMs. “Lettered” evaluation lines should not be further than two inches of map distance apart.
- Evaluation lines should be stored in the S_XS database layer and attributed similar to cross sections
- In general, evaluation lines should avoid complex areas such as confluences if possible.

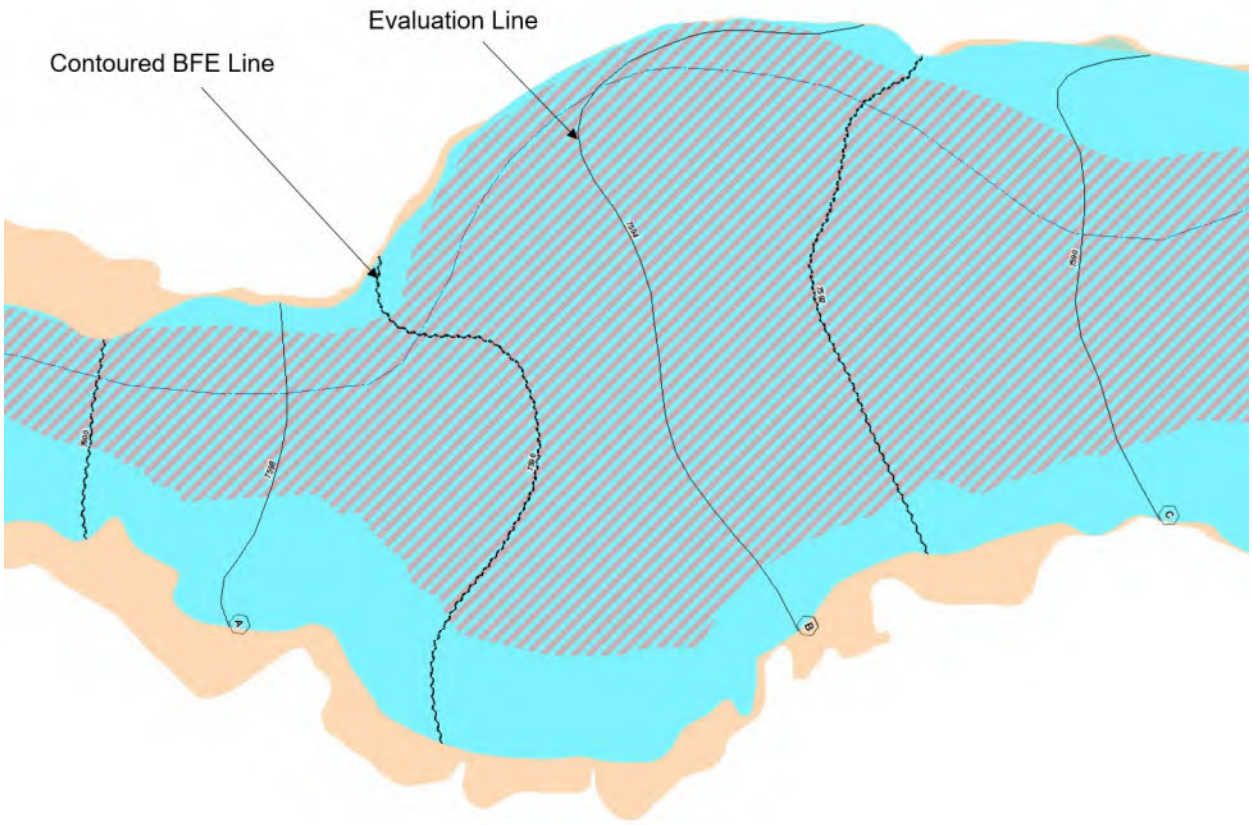


Figure 8: Example of Evaluation Lines and BFE Lines Used to Map Results of a 2D Based Floodway Analysis

Surcharge Evaluations and Averaging on Evaluation Lines

The final mapped floodway should follow the calculated boundaries in the 2D model. Surcharges should be calculated at each individual model cell or node as well as along evaluation lines. Surcharges at the individual model cells or nodes should reflect the difference between the floodway and base flood water surface elevations. Surcharges calculated on evaluation lines should be based on averaging of all cells or nodes that intersect the evaluation line and averaging should be done using a suitable weighting method. The appropriate averaging technique should be selected in coordination with the FEMA Project Officer and community officials. See Figure 9 for a sample schematic demonstrating the averaging approach utilizing a discharge-weighted technique.

A floodway based on averaging techniques along evaluation lines shall be allowed only if each of the following criteria are met:

1. The average surcharges for each evaluation line meet the requirements of SID 69.
2. No individual 2D cell results within the floodway domain (either along evaluation lines or elsewhere) have surcharges that are greater than 0.5 foot of the maximum allowable surcharge for the community.
3. The surcharges at all cells that intersect insurable structures meet the requirements of SID 69.

Some projects and communities, however, may choose to evaluate floodway compliance based on a calculation of surcharges at each individual model cell or node, rather than solely at evaluation lines. This "All Cells" evaluation approach is the most complete representation of the impacts of encroachment and therefore should be considered where a 2D floodway analysis is being conducted. In these situations, the surcharge at each model cell should be within the allowable surcharge range established in SID 69. For example, where the maximum surcharge allowed is 1-foot, this would mean surcharges at all model cells are less than 1-foot. Where a community elects to use an "All Cells" surcharge evaluation approach, evaluation lines (and the corresponding average surcharge along that evaluation line) should still be used to report floodway results in the floodway data table.

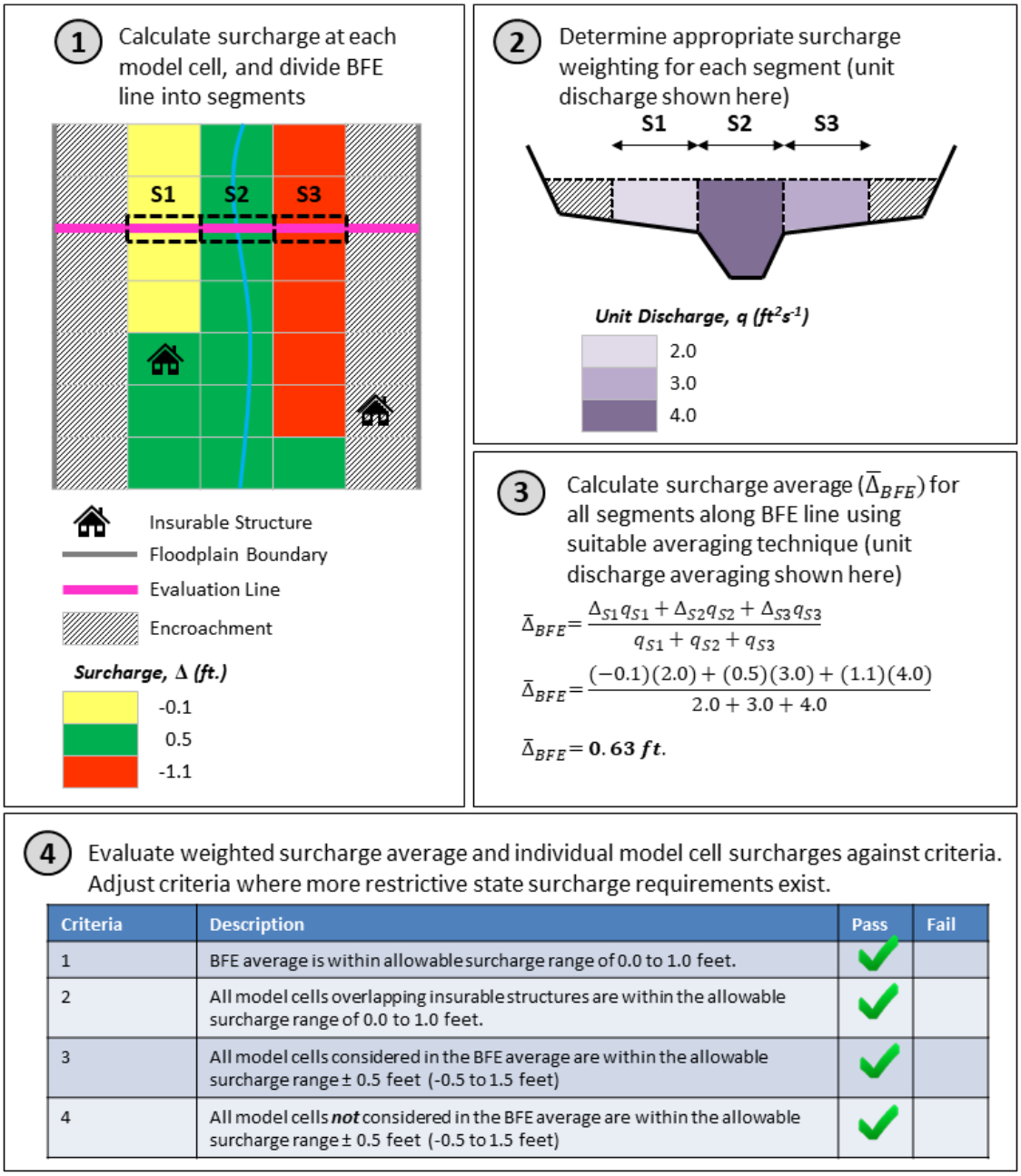
Surcharge calculated for each model element should use either the centroid point of each 2D grid cell or each node to compare the WSEL values between the encroached 2D floodway simulation and the accompanying unencroached base floodplain simulation. To ensure a direct comparison, it is important that the base floodplain model and the encroached floodway model share the same grid cell alignment, allowing the cell centroid and/or node points to align with each other. Any variation in cell alignment in the base model should be carried forward into the floodway model as well. If the modeling software being used allows for different interpolation methods for displaying and reporting results, the method that most accurately represents the true calculated WSEL values should be used. Point evaluations should be used to ensure that modeled surcharges meet the criteria outlined between evaluation lines.

There may be some locations where small areas of dry elements in the floodplain analysis become wet with a floodway analysis, and showing a surcharge (since any water in the cell would be an increase) greater than the allowable amount. This surcharge would be allowable as long as the dry cells were already anticipated to be shown in the SFHA, and it can be shown that the calculated surcharge for these cells is actually less than the required allowable amount.

Special Considerations for Surcharge Averaging

In situations where the analyzed floodway contains one or more split flow paths, surcharge averages should be calculated independently for each segment of the evaluation line intersecting a separate split flow path. For example, if the floodway splits into two separate and distinct flow paths, two surcharge averages would be calculated, one for the segment intersecting the first split path and a second for the second intersecting the second split path.

When model results show a localized dry spot in the base flood and floodway results, but that spot is being mapped inside the SFHA, the evaluation line should continue across the dry spot. A null value should be considered for the portion of the evaluation line intersecting the dry spot when calculating the surcharge average.



Criteria	Description	Pass	Fail
1	BFE average is within allowable surcharge range of 0.0 to 1.0 feet.	✓	
2	All model cells overlapping insurable structures are within the allowable surcharge range of 0.0 to 1.0 feet.	✓	
3	All model cells considered in the BFE average are within the allowable surcharge range ± 0.5 feet (-0.5 to 1.5 feet)	✓	
4	All model cells ***not*** considered in the BFE average are within the allowable surcharge range ± 0.5 feet (-0.5 to 1.5 feet)	✓	

Figure 9: Example of surcharge averaging across an evaluation line for a floodway analysis performed using a 2D model

5.2. Steady State Floodway Analysis

Floodways based on 1D or 2D model techniques discussed in Section 5.1 are determined by modeling the floodway fringe as a non-conveyance area by encroaching the effective flow area. The technique of using artificially high roughness coefficients should not be used for floodway analyses based on steady flow conditions. The Mapping Partner should use the most recent existing conditions model, or base model discussed in Section 1.0 as the base for the floodway analysis

limiting surcharges to the maximum allowable above the original base conditions 1% annual-chance profile.

When flow is in the supercritical regime for man-made channels, or where velocity conditions are such that normal encroachment analyses are not possible or are inappropriate, the encroachment should be placed so that the allowable rise in water-surface elevation matches the target water surface without exceeding the target energy grade line.

5.2.1. BOUNDARY OF FLOODWAY ANALYSES

If a floodway exists at the upstream or downstream limit of study on the same stream as the study reach, the floodway for the study reach must be configured so that the floodway data at the revised stream limit of study match the floodway width at the limits of the effective study. See Section 6 of Guidance Document No. 45: Guidance for Flood Risk Analysis and Mapping: Contiguous Community Matching for more information about study tie-ins.

In case a discrepancy is identified between the floodway data table and floodway model, the Mapping Partner must document the magnitude of and reason for the mismatch and suggest remedies to the FEMA Project Officer. Once the data match, the floodway analysis is based on a starting water-surface elevation associated with the maximum allowable surcharge, or the water surface elevation resulting from application of a more restrictive requirement imposed by a state or other jurisdiction. That way, future (allowable) revisions to the downstream floodway should not create surcharges greater than the maximum allowable in the study reach.

If the study reach begins at the mouth of the stream, the Mapping Partner should start the encroachment analysis at a width yielding the maximum allowable surcharge, or the water surface elevation resulting from application of a more restrictive requirement imposed by a state or other jurisdiction, for a normal depth calculation using the same friction slope as the unencroached profile. If a floodway does not exist immediately downstream of the study reach, the Mapping Partner should start the analysis sufficiently beyond the limit of study so that differences in the starting conditions do not create surcharges greater than the maximum allowed within the study reach. That way, future floodway designations beyond the study limits should not create surcharges greater than the maximum allowable in the study reach.

5.2.2. STORAGE CONSIDERATIONS

Storage considerations in hydrologic and hydraulic modeling of the unencroached condition should be revised to reflect any encroachment into storage areas indicated by the floodway configuration for both steady and unsteady state analyses.

If designated storage areas behind structures are accounted for in the flood discharge computations by routing the base flood hydrograph, no encroachment is to be allowed; and the floodway encroachment should be equal to the base floodplain boundary of the storage area designating the storage area as part of the floodway. In this case, the Mapping Partner should use the same flood discharge for the unencroached and encroached conditions to determine the surcharge values.

However, if the storage capacity exists but is not accounted for in the routing base flood hydrograph, it can be encroached; the Mapping Partner should determine the flood discharges for the encroached condition downstream of the structure by routing the 1% annual-chance flood hydrograph through the reduced storage area. In this case, the flood discharge for the encroached profile may be greater than the flood discharge for the unencroached profile in the analysis.

5.2.3. TRIBUTARY, SPLIT AND DIVERTED FLOWS

For 1D models, the regulatory floodway on a tributary stream is based on the base (1% annual-chance) flood discharge and elevation of that stream only and normally should not include consideration of any backwater flooding from the main stem. Therefore, the floodway elevations in the lower reach of a tributary subject to backwater flooding may be lower than those used to plot the Flood Profiles. See Section 7 of Technical Reference No. 1: Flood Insurance Study (FIS) Report Technical Reference to see how this is portrayed in the FIS Report.

The Mapping Partner should re-compute flood flow values along each flow path associated with reaches with split and/or diverted flow situations, as described in Split Flow under Section 2.2.7, in Guidance Document No. 80: Guidance for Flood Risk Analysis and Mapping: Hydraulics: One-Dimensional Analysis, under encroached (floodway) conditions. If the primary flow path (originating reach) can safely carry the entire base flood flow without increasing flood heights more than the maximum allowable surcharge, only the primary flow path requires a floodway. If not, other flow paths require floodways.

The Mapping Partner should ensure that the overland flow segment on the mainstream remains open by determining a separate regulatory floodway for the overflow path, or by a note on the FIRM stating that the overflow area should remain unencroached until a detailed hydraulic analysis is performed to establish a regulatory floodway. The Mapping Partner must inform the FEMA Project Officer when overland flow paths lead into another jurisdiction where a regulatory floodway has not been computed, thus necessitating that the overflow area remains unencroached.

The FEMA Project Officer may approve, as an alternative, that the Mapping Partner determine the regulatory floodway on the main channel downstream of the overflow area by determining the floodway profile with the total flow (including the flow lost as overflow). The Mapping Partner should compare the water-surface elevations from the floodway profile to the water-surface elevations of the 1% annual-chance Flood Profile reflecting existing conditions (whose discharges in the main channel have been reduced because of flow lost as overflow) to determine surcharges. If the calculated surcharge is less than or equal to the allowable surcharge, the regulatory floodway is depicted on the main channel only.

Otherwise, a separate regulatory floodway should be defined for the overflow path. The Mapping Partner should add a note to the Floodway Data Table or the FIRM to identify the segment of floodway where the surcharge was computed using the reduced flow. The floodway should be revised when the diverted flow does not occur anymore, and the flow is fully carried by the main stem.

2D and hybrid 1D-2D models that solve the dynamic wave equation have inherent splits and diverted flows, and accurately calculate internal flood flow distribution. These splits and diverted flows should be evaluated using the information in the model as-is, including when a floodway encroachment causes the blockage of a minor split flow path.

5.2.4. NEGATIVE SURCHARGE VALUES

For 1D models, surcharge values must be between zero and the maximum allowable value in the respective community. Negative values in output data generally indicate excessive changes in velocity, conveyance capacity, or floodway width at or downstream of the cross section with the negative surcharge. Furthermore, 1D models do not provide sufficient information in the lateral flow direction to indicate when a negative surcharge is a product of flow redistribution, as discussed below in relation to 2D models. 1D floodway configurations should be revised until all surcharge values are between zero and the maximum allowable value. Reasons for deviating from this practice should be coordinated with the FEMA Project Officer.

For 2D models, surcharge values along evaluation lines should average (via a suitable weighting method) between zero and the maximum allowable value in the respective community (see Figure 9 for an example schematic). Negative averaged surcharges often indicate the same issues as presented with 1D models. In those instances, they should be resolved. However, they could also be indicative of a change in direction of flow or flow redistribution within the model domain. This may be allowable, provided that change does not create a surcharge above allowable values elsewhere. Areas of negative surcharge should also be evaluated to ensure that they do not cause other undesirable or un-equitable results, such as causing a significant increase in erosion hazard compared to un-encroached conditions. Individual cells should also be evaluated to verify, if possible, they are not impacting insurable structures. If insurable structures may be impacted but the negative surcharges are not believed to create an adverse condition, the FEMA Project Officer should be consulted to ensure appropriate documentation. The aerial imagery or building footprint files used to identify insurable structures should be documented for community visibility.

5.3. Unsteady State Floodway Analysis

Both 1D and 2D unsteady floodway analyses should use a methodology based on equitable consideration of both overbanks. Use of an alternative method must be approved by the FEMA Project Officer and agreed to by the communities involved.

Steady state models do not consider lost storage in both effective and ineffective flow areas and its impacts on flow rates and timing. However, for unsteady state models, encroachment into the floodway fringe would impact flow rates; the degree depends on the amount of storage lost. Encroachments result in storage decreases in both off-channel storage modeled with an elevation-storage curve, and in non-conveyance areas modeled with artificially high roughness coefficients. Input data for the elevation-storage curve or the values of roughness coefficients should be revised to reflect the lost storage.

5.3.1. ONE-DIMENSIONAL UNSTEADY FLOODWAY ANALYSIS

The loss of storage in the floodway fringe of an unsteady model makes it likely that the peak discharge in the floodway model will be larger than that in the unencroached analyses. The flow rate increases are likely to cause elevation increases downstream even if the base flood is fully within the channel. If surcharges increase when unsteady state modeling is used for a reach with a previously determined steady-state floodway, the unsteady state floodway width should be increased to meet the maximum allowable surcharge limit, or other more restrictive requirements of a state or other jurisdiction.

The equal conveyance reduction method can be performed in unsteady state modeling through an iterative process. In general, the Mapping Partner should follow procedures described in the HEC-RAS User's Manual (HEC, 2016) to perform unsteady flow floodway analyses. The procedure uses a steady flow encroachment analysis to establish an approximate floodway and import the encroachment stations to the unsteady flow model to verify that the surcharge is within the maximum allowable limit. The Mapping Partner should incorporate peak flows from unsteady flow runs to the steady flow model to estimate the encroachment stations. When rerunning the steady flow model with encroachment stations, Mapping Partners should adjust downstream boundary conditions to reflect increases of water-surface elevation due to encroachment.

An alternative method is to perform floodway analysis using an unsteady state model directly. The Mapping Partner should use the base flood hydrograph as the inflow hydrograph and determine encroachment stations by the equal conveyance reduction method.

Equal storage reduction may be applied in the floodway determination for streams with flooding dominated by storage. In such systems, the difference between the equal conveyance reduction method and equal storage reduction method is usually not significant. The equal storage reduction method is simpler in both concept and application and could be considered as an alternative approach for floodway determination.

5.3.2. TWO-DIMENSIONAL UNSTEADY FLOODWAY ANALYSIS

When an unsteady flow hydrograph is routed downstream and constrained within the floodway, it moves water downstream at a different rate and with a given surcharge when compared to the unconstrained floodplain. If the floodway fringe is encroached, the water that previously inundated the floodway fringe areas is pushed downstream due to reduction of storage and may result in increased flow rate and water-surface elevation on the downstream floodplain. The Mapping Partners must use a FEMA approved modeling platform. They should work with their FEMA Project Officer when project decisions and assumptions stray from the guidance outlined in this document and coordinate with the communities to get an approved floodway configuration.

5.4. Levees and Floodways

For some communities, regulatory floodways may have already been delineated for levee-impacted areas along a flooding source. The presence and hydraulic significance of a levee along a flooding

source with a regulatory floodway can affect which base model is encroached to define the floodway, the placement of the floodway boundary on the map, and the stakeholders included in the floodway coordination. FEMA has developed an approach for modeling and delineating the regulatory floodway in levee-impacted areas. This approach is outlined in Guidance Document No. 95: Guidance for Flood Risk Analysis and Mapping: Levee Guidance.

5.5. Alternative Floodway Alignments

The standard methodologies for designating floodways work well for most rivers and streams. However, there are unusual situations where it may not be possible to designate a typical one foot flood rise floodway using the standard FEMA approved models or where one would make little practical sense. Typical situations where this could occur are floodplains where flood waters escape into an adjoining watershed, streams with beds that are perched above the surrounding ground level, and extremely shallow floodplains where the flow areas are not adjacent to the channel of the river or stream. The FEMA Regional Offices generally address these situations on a case by case basis in consultation with the State and the local governments affected with the overall goal of maintaining sufficient flow areas to prevent increases in flood stage of one foot or greater no matter where the water goes.

5.6. Floodways and Restudies

FEMA periodically conducts restudies of floodplains in communities where the current FIRM does not adequately reflect the current flood hazard. Restudies are generally done when physical conditions change in the watershed sufficiently to impact on flood stages, to reflect new flood control structures, to incorporate better climate data, or take advantage of new mapping and study technologies. When a restudy is done for a river or stream where a floodway has been designated, the Mapping Partner conducting the study is directed to maintain the existing floodway configuration wherever possible. If conditions have changed significantly, a new floodway may have to be developed, particularly if a wider floodway is required to meet the one foot rise criteria due to increased flood discharges. To the degree possible the new floodway will reflect the effects of the encroachments that have occurred since the original floodway was designated to ensure that flood stages do not increase more than the one-foot provided for in the original flood insurance study.

5.7. Community Adoption of a Floodway

When FEMA provides floodway data to the community, the community is required to adopt a regulatory floodway that causes no more than a one foot increase at any point in the community. There is no requirement that the community adopt the floodway on the FIRM as its regulatory floodway. However, most NFIP communities do use the floodway on the FIRM rather than do the hydraulic analyses necessary to develop their own floodway. The community, FEMA and the Mapping Partner should work collectively to develop a floodway that meets the community's needs. If the community uses their own floodway in lieu of the FEMA floodway, it must be in all instances wider than the FEMA floodway or the community must demonstrate that the floodway meets the allowable one foot surcharge criteria. In either situation the community must consult with the FEMA Region prior to adoption of the floodway.

5.8. Floodway Development by State and Federal Agencies

State and federal agencies also undertake development that could impact on floodways. For example, State highway departments construct roads, highways, and bridges using federal or states funds. Some of these state or federal agencies may be willing to apply for and obtain local permits and most will at least coordinate with the community to make sure that their actions are consistent with the requirements of the local floodplain management ordinance. Even if the agency maintains that it is exempt from local permits it must still comply with floodway requirements comparable to those in your floodplain management ordinance.

Federal agencies are subject to Executive Ordinance 11988, Floodplain Management which requires at a minimum that their actions be consistent with NFIP minimum requirements. All federal agencies have adopted regulations that comply with Executive Order 11988 and should be applying floodway requirements to actions that they undertake or fund. State highway departments will be subject to Federal Highway Administration requirements each time they construct a bridge or road using federal funds. States also will have floodplain management regulations that will meet NFIP minimum requirements that will apply to their actions.

If a state or federal agency is undertaking development in a floodway in your community, you should contact that agency to assure that they have undertaken the hydraulic analyses necessary to assure that the development will not cause an increase in the base flood elevation within your community. If you need assistance, please contact your NFIP State Coordinator or your FEMA Regional Office (https://www.fema.gov/about/contact).

6. Floodway Coordination

The Mapping Partner should coordinate with the community when developing floodways. Title 44 CFR Part 60, Section 60.3 states:

… the community shall

60.3 (d) (2) **Select** and adopt a regulatory floodway based on the principle that the area chosen for the 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. This section is related to the amount of surcharge. Due to concerns about encroachments impacting existing development some communities may opt for floodways with no surcharge or a less amount than the one-foot minimum standard.

FEMA typically starts with a procedure based on equitable consideration of encroachment of both overbanks to determine the floodway. However, because the floodway is the community's tool to mitigate flood losses by restricting encroachments into the floodplain, Mapping Partners must coordinate all regulatory floodway determinations with community officials, as well as the NFIP State Coordinator and FEMA, as early as possible in the study process.

Some communities may wish to propose a floodway alignment that is not based on equitable consideration of encroachment (i.e. sometimes this is called a planning floodway). The approach for defining the floodway should be incorporated into the communities' ordinances to support the variance from the equitable consideration floodway. Although generally the community should treat like situated property owners equally, there can be competing community needs that can be met if the community designates a floodway based on criteria other than equitable consideration of encroachment:

- The floodway can be drawn to minimize the inclusion of existing development. For example, there may be a developed or partially developed subdivision that would fall within an equitable consideration of encroachment floodway. Since developed areas often do not effectively convey floodwaters, floodways may need to be wider when these areas are included.

- The floodway can be drawn to accommodate proposed land uses. For example, the community may have approved a subdivision in an area or extended sewer, water, streets or other infrastructure to an area. There may be a need for a new bridge crossing and there may be other anticipated needs.

- The floodway can be drawn to be compatible with the communities land use plans or zoning. For example, one side of the river or stream may be zoned for agriculture or other low density use or be in parkland.

- The floodway can be drawn to include high hazard areas including areas subject to deep flooding or high velocity floodwaters or areas that emergency vehicles could not access during a flood.

- The floodway can be drawn in a way that will prevent legal challenges by ensuring that all existing parcels in the community have a building site.

Community designated floodways can be designed to meet the planning needs of the community provided the community has a sound rationale for establishing the proposed floodway boundaries.

Evaluating a community designated floodway can require trial and error in order to meet the allowable one foot surcharge which may increase study costs. For this reason, the Mapping Partner needs to obtain prior approval from the FEMA Regional Office. Information on contacting the FEMA Regional Offices can be found at https://www.fema.gov/about/organization/regions. Where communities have adopted a regulatory floodway, the Mapping Partner must use the configuration of the adopted floodway to the extent practical to compute floodway data along restudied streams. If the surcharge values are greater than the maximum allowable above the base condition, the Mapping Partner must inform the FEMA Project Officer and community. In such cases, the Mapping Partner must coordinate a revised configuration with the community and the FEMA Project Officer.

Where communities have not adopted a regulatory floodway or where the scope of work calls for a revised configuration, the Mapping Partner must coordinate the floodway configuration with the community and FEMA Project Officer. The Mapping Partner must discuss options for determining the floodway with community officials and the FEMA Project Officer. Those discussions should include:

- The establishment of the base condition for this floodway determination and future floodway revisions;
- The effects of high velocities on fill, and structures and preferences the community may have for restricting encroachments into high velocity areas or encroachments that may result in high velocities elsewhere;
- The restrictive nature of the regulatory floodway and means to distribute the restrictions evenly, such as determining the limits through equitable consideration on both sides of the channel;
- The use of public land such as parkland to offset restrictions in other parts of the floodplain;
- The benefits of adopting more restrictive surcharge criteria for existing development within the community.

The agreed upon approach must be fully documented in the hydraulics report including the reasoning leading to the encroachment methods and minutes of coordination meetings. Meeting minutes must include the date, time, and location of the meeting and a list of attendees. If the community cannot agree upon an approach, the Mapping Partner must consult the FEMA Project Officer for direction.

If more than one community is affected by the floodway, all affected communities must be included in the discussions. In the case that one of the communities sharing the same reach has a more stringent allowable maximum surcharge, the Mapping Partner must describe any differences in maximum allowable surcharge values and facilitate an agreement among the communities as to the maximum surcharge and the floodway configuration to be applied to the shared reaches. That agreement must be fully documented including the date, time, and location of the meeting, and signed by all parties in attendance. If such an agreement cannot be reached, the Mapping Partner must seek guidance from the FEMA Project Officer.

If the state or community in which the mapping project is being performed has established more stringent regulations for the maximum allowable rise in water-surface elevations, through legally enforceable statutes, these regulations take precedence over the NFIP regulatory standard. In the case of streams that form the boundary between two or more states, the 1.0-foot maximum allowable rise criterion should be used unless the states have previously agreed on a lesser rise criterion. The Mapping Partner must obtain written approval of the Regional Project Officer before computing or mapping a second regulatory floodway based on a criterion established by the community.

When the floodway has been established for either or both upstream or downstream communities, the Mapping Partner must coordinate with all involved communities to create a smooth transition of floodway surcharges and ensure the surcharges are within the maximum allowable limit.

7. Floodway Boundary Mapping

In a 1D model, floodways are delineated at the encroachment stations (limits of conveyance) at cross sections and interpolated between. Data available when the floodway analysis is completed should be used, as possible, to assist with the interpolation of the floodway boundary between consecutive cross sections. Data that can assist with these decisions includes aerial photos, knowledge about riparian vegetation or lack thereof, and identification of river mechanics features such as erosion and deposition areas. For 2D models, floodway are delineated by connecting the adjacent nodes or grid elements to establish a continuous boundary along both overbanks in a 2D model. For more information, see Section 5 of Guidance Document No. 60: Guidance for Flood Risk Analysis and Mapping: Riverine Mapping and Floodplain Boundaries.

Where the floodway is mapped differently than the model results to meet state requirements, the Mapping Partner should document the state requirements and the location(s) where discrepancies occur.

8. Floodway Data Table

For each floodway determined under the scope of work, the Mapping Partner must create a Floodway Data Table (FDT). The FDT developed as part of this analysis must contain an entry for each lettered cross section or evaluation line in the model to fully document the floodway analysis (this does not imply that all cross sections or evaluation lines will be shown in the FDT published in the FIS Report). For more information about the contents and appearance of the FDT see Section 5 of the FIS Report Technical Reference.

For 1D analyses, existence of high ground in the middle of a cross section would reduce the floodway width, computed as distance between two encroachment stations. In such a case, the width of floodway should be the width as mapped and a note should be added to the FDT to explain the difference.

When creating a FDT based on a HEC-RAS unsteady flow floodway analysis, the Mapping Partner should use floodway parameters (floodway width, section area, mean velocity of with-floodway and without-floodway water-surface elevation) associated with the maximum discharge at each cross section or evaluation line from the unsteady floodway run.

When a 2D or hybrid 1D-2D model is used by the Mapping Partner, they should create evaluation lines as described in Section 5.1 to report the appropriate parameters in the FDT at key locations. The Mapping Partner should use the appropriate template from the FIS Report Technical Reference to ensure users are aware that the values reported in the FDT are based on a 2D or 1D-2D hybrid model. .

9. Deliverable Products

The floodway analysis and mapping must be submitted as part of the hydraulics and floodplain submittal described in Section 6.7 and Section 6.11 of Technical Reference No. 4: Data Capture Technical Reference, and Section 9 of Technical Reference No. 3: Flood Insurance Rate Map (FIRM) Database Technical Reference. The Mapping Partner must submit files via the MIP; other media may be acceptable if coordinated with FEMA.

10. Floodway Analysis Review

The reviewing Mapping Partner will be responsible for performing hydraulic and floodway reviews as described below. The reviewing Mapping Partner is responsible for determining whether the proposed analyses are reasonable. Section 9 of Guidance Document No. 52: Guidance for Flood Risk Analysis and Mapping: General Hydraulics Considerations provides requirements and criteria that should be used to determine if the hydraulic and floodway analyses are reasonable.

11. Evaluating Proposals for Floodway Development

Once a community has designated a floodway it must prohibit development within that floodway unless it has been demonstrated through hydrologic and hydraulic analyses that the development will not cause an increase in flood stages at any point in the community. Some communities maintain their own in-house engineering expertise and perform these analyses themselves. Most require that the permit applicant hire a qualified registered professional engineer to conduct the analysis and submit it to the community for review and approval. This analysis is usually called a "no-rise" or a "zero-rise" analysis and results in a "no-rise certification" if the analysis demonstrates that there will not be any increase in the base flood elevation due to the development. This section provides guidance on conducting and reviewing the "no-rise" analysis.

11.1. The Types of Development that Must Be Evaluated

The NFIP broadly defines development to include nearly all man-made changes to the floodplain. Permits are required for all development to determine whether the development is subject to the floodplain management requirements in the community's ordinance. For development other than buildings the primary purpose of the permit review is to determine whether the development is in the floodway and, if it is, whether it will cause any increase in flood stage.

> 44 CFR 59.1 Definitions: *Development means any man-made change to improved or unimproved real Estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations or storage of equipment and materials.*

It is important to note that development includes additions to buildings that are less than substantial improvements. These additions can obstruct flood flows and increase flood stages. In addition, development includes the storage of equipment and materials. Activities such as the stock-piling of sand or gravel or the storage of heavy machinery in the floodway can be as much of an obstruction of flood flows during the base flood as the permanent placement of fill or construction of a building. Unless you as a community can be absolutely sure that these equipment or materials will be removed from the floodway prior to a flood, you must determine that they will not cause any increase in flood stage before you can permit the use.

Communities can exercise some discretion and common sense in determining which development requires permits or a hydraulic analysis. For example, you can exclude on-going activities such as gardening and most forms of agriculture from your permitting requirements. These activities generally do not change the existing grade of the ground in the floodway and will not obstruct flood flows. Any related activities such as construction of levees that involve placement of fill are covered in the definition of development and will require permits.

11.1.1. EXEMPTIONS FOR MINOR PROJECTS

There are other developments within the floodway that will require permits but can be allowed once the community determines that they are not an obstruction to floodwaters. Small projects that do not increase the natural grade, such as the paving of a driveway or parking area at the existing grade can be permitted. There are other minor projects that probably will not increase flood stages. For example, small isolated obstructions such as a mailbox, a pitcher's mound, or a single telephone pole can be permitted without requiring a no-rise certification. There is almost no likelihood that these minor projects by themselves or in combination could cause a measurable increase flood stage.

Common sense can also be exercised when evaluating proposals to place fences in the floodway. Most types of fences such as barbed wire or chain link fences are likely to be knocked over by floodwaters and debris long before flood heights approach the elevation of the base flood. Debris will build up on these fences and the force of the water will push or bend the fence over. More substantial fences such as solid wood privacy fences on small streams may obstruct flood flows and will need to be evaluated. If in doubt, you have two choices. You can require the fence be constructed in a manner that will assure that it will be knocked over and not obstruct flood flows during the base flood (for example by requiring shallow embedment of the fence posts) or you can require that the permit applicant obtain the services of a registered professional engineer to design the fence or conduct a no-rise analysis.

If in doubt as to whether on obstruction will increase flood stages, the community should require that the permit applicant conduct a hydraulic study to demonstrate that there will be no rise in flood stage.

11.2. Meeting the No-Rise Criteria

Once you determine that a development will take place in the floodway, the next step is to demonstrate that the development will not cause any increase in flood stage. FEMA defines "any" as meaning a zero increase. It does not mean that you can allow a 0.1 foot or even a 0.01 foot increase – it means nothing greater than 0.00 feet. If you do not limit the increase to zero, the small increases in flood heights from individual developments will cumulatively have significant impacts on flood stages and flood damages. Under NFIP minimum requirements it is assumed that there will be no cumulative increases since the permissible increase for any single encroachment is zero.

There a number of ways a permit applicant can meet the no-rise criteria contained in the community's floodplain management regulations.

11.2.1. REDESIGN THE DEVELOPMENT TO AVOID THE FLOODWAY

The best way to meet the no-rise criteria is to design or redesign the development so that no obstructions are placed in the floodway. For example, when planning a subdivision, the plot can be laid out so that the floodway areas are included in common open space or as backyards to buildings that will be located outside of the floodway or even better outside of the floodplain.

11.2.2. REPLACE AN EXISTING BUILDING, BRIDGE, OR CULVERT

There are also situations where you may allow the replacement of an existing building or bridge or culvert in the floodway without requiring a hydraulic study and a no-rise certification. For example, the demolition of a building and the replacement of the building with a new building can be permitted provided that the new building is contained within the footprint of the demolished building. If you go outside of the footprint of the demolished building or change the location of the building, the effect on flood flows may change and you will have to conduct a hydraulic analysis and demonstrate that there will be no increase in flood stages. The replacement building will of course have to comply with the other requirements of your ordinance. Your community may wish to limit the replacement of buildings in the floodway. Although the new building should be protected from flood damages during the base flood, it will be isolated by floodwaters and search and rescue operations may be required.

It may also be possible to replace a bridge or culvert with an identical or larger bridge or culvert and not cause an increase. However, new bridges and culverts are seldom identical to those that they replace since design standards will change. Unless the new bridge or culvert is identical to the one it replaces or the waterway opening is increased with no other change to the cross section or 2D mesh, you will have to conduct a hydraulic analysis and demonstrate that there will be no increase in flood stage. In situations where the new bridge or culvert is identical to the one it replaces but the road is raised from its existing elevation it may still affect upstream flood levels due to the reduced weir flow capacity over the road Usually a hydraulic analysis will be required to design the bridge or culvert anyway so the no-rise certification can be provided. Remember that replacement of a bridge or culvert may provide an opportunity to solve an existing upstream or downstream flood problem.

11.2.3. SPAN THE FLOODWAY

For bridges on smaller streams it is sometimes possible to span the floodway with a waterway opening sufficient in size to pass the base flood without causing an increase. This bridge could meet the no-rise criteria depending on the design of the bridge abutments. Generally, however, a hydraulic analysis would be conducted anyway as part of the bridge design and a no-rise certification can be obtained as part of that analysis.

11.2.4. DEMONSTRATE THAT THERE WILL BE NO-RISE IN FLOOD STAGE THROUGH A HYDRAULIC STUDY

In some situations, it may be possible to demonstrate that a development will cause no increase in flood stage by conducting a hydraulic analysis. Guidance for conducting hydraulic analysis and making a no-rise certification can be found in Section 11.3 below. Generally, you can expect that development in the floodway will cause an increase in flood stage. If the floodway has been properly computed and displayed on the map, nearly all areas within floodway should effectively convey floodwaters. When an increase occurs, it will be necessary to modify the development proposal so that it no longer causes an increase in flood stage or to compensate for the increase. Most communities require the permit applicant to hire an engineer to do the analysis and provide a no-rise certification.

11.2.5. LIMIT THE DEVELOPMENT TO THE "HYDRAULIC SHADOW" OR "CONVEYANCE SHADOW" OF ANOTHER OBSTRUCTION

There are also situations where the development can be limited to the hydraulic shadow of a building or other obstruction such as an isolated area of high ground that was in existence at the time the floodway was designated. This should be only done for small projects such as building additions or accessory buildings. The conveyance shadow includes the areas immediately upstream and downstream of an existing building or other obstruction. Flood waters are already flowing around the existing obstruction so that the new development will not affect the existing flood flows. (See Figure 10.)

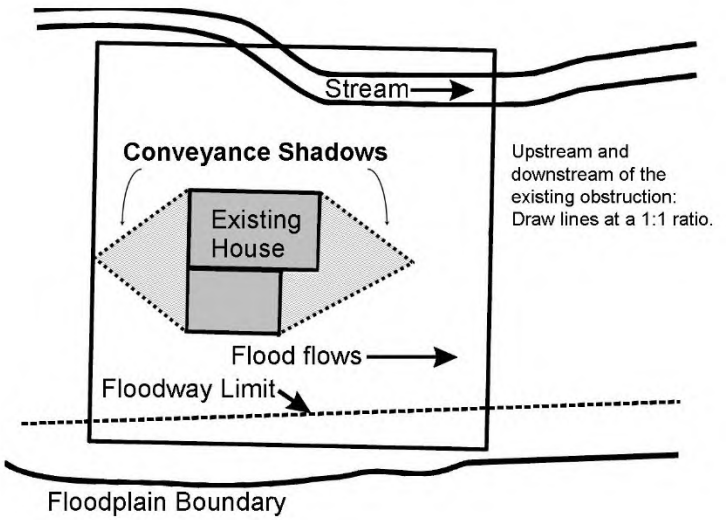


Figure 10. Limiting development to the hydraulic shadow of an existing building or other obstruction

Generally, the conveyance shadow is determined by drawing lines at a 1:1 ratio upstream and downstream of the obstruction. This method may not be sufficient if the building is located in an area with complex 2D flow characteristics. Building additions or small accessory structures built entirely within the conveyance shadow can be permitted without the engineering analysis needed for a no-rise certification. The addition or accessory building must meet all other floodplain management requirements in your ordinance.

11.2.6. COMPENSATE FOR ANY RISE

If a development is in the floodway and will cause an increase in flood stage, it may possible to compensate for the rise by physically modifying the floodway to replace the flood conveyance that would be lost as a result of the development. Typical ways that this is done include:

- Modifications to the channel or overbank areas of the cross section or 2D mesh, or channel improvements to compensate for the loss of conveyance. Channel improvements are frequently done as part of bridge design and construction. Modifications to the channel and overbank areas and channel improvements must be permanent changes to the floodway. The community must assume responsibility for maintaining the modification or improvement or negotiate a maintenance agreement with the permit applicant. A floodway revision as provided for in 44 CFR 64.7 will be required if floodway boundaries or base flood elevations change.

- Removal of an existing comparable obstruction such as a building or bridge. However, you must usually conduct a hydraulic analysis to demonstrate that the net result will be no increase in flood stage during the base flood.

- Expanding the floodway to replace the conveyance lost due to the obstruction. It may also be possible to expand the floodway to compensate for the encroachment. This is usually done to compensate for loss of conveyance from bridge piers or pilings. Unless the area is in public

ownership, expanding the floodway will generally require a floodway revision to assure that the area remains available for conveyance of floodwaters.

Each of these alternatives will require a hydraulic analysis to demonstrate the result of the compensation is that there will be no increase in flood stage during the base flood.

11.2.7. FLOODWAY REVISION

It may be possible to revise the floodway boundaries so that the development is no longer in the floodway while still meeting the allowable one foot surcharge. You can sometimes narrow the floodway at the location of the development or shift the floodway alignment so that that the development is no longer in the floodway while still meeting the one foot surcharge limitation. Usually this will require the surveying of additional cross sections to more accurately model the floodway at the location of the development. If you want to do this, you must obtain a floodway revision as provided for in 44 CFR 64.7 of NFIP regulations. Floodway revisions must be applied for by the community since it is the community's adopted floodway that is being changed. Procedures for obtaining floodway revisions are described in Section 13. The floodway revision must be obtained prior to proceeding with the development.

11.3. How a No-Rise Certification is Developed

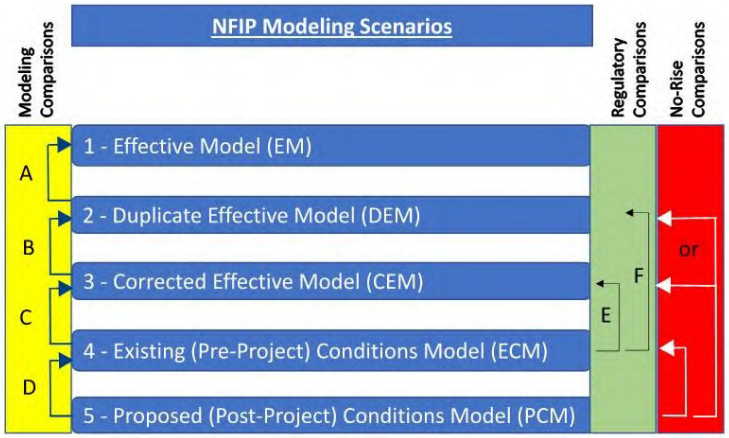
NFIP minimum criteria prohibit encroachments in the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the encroachment will not cause any increase in flood levels in the community during the base flood discharge. FEMA defines "any" as meaning a zero increase. It does not mean that you can allow a 0.1 foot or even a 0.01 foot increase – it means 0.00 feet. Otherwise the cumulative effects of all of the developments in the floodway could significantly increase flood stages. There should be no cumulative effects since the permissible increase for any single development is zero.

This hydrologic and hydraulic analysis is commonly called a no-rise or zero-rise analysis and results in a no-rise certification. A few states and communities perform the no-rise analysis themselves, but most require the permit applicant to hire a qualified registered profession engineer to perform the analysis and provide the no-rise certification.

Some communities require that the registered professional engineer submit the no-rise certificate on a form such as the example in Figure 12. Other communities allow the engineer to submit the certification in a letter. Either way is acceptable provided that all of the necessary information is included. The no-rise certification must be accompanied by documentation to support the finding that there will be no increase in flood stage including the results of the hydraulic study.

Generally, the process for conducting the hydraulic analyses is the same as that used for applying for a FIRM or floodway revision (see Section 13).

- The registered professional engineer obtains a copy of the model used to develop the effective flood insurance study from FEMA. Data may be accessed through the Flood Risk Study Engineering Library (FRiSEL). FRiSEL is an online search portal that can be used to access data associated with FEMA flood risk mapping projects that have been uploaded through the Mapping Information Platform (MIP). FRiSEL provides users with a fast, intuitive search and navigation interface for locating, examining, and downloading engineering and support data. For more information on FRiSEL access, please reference Guidance Document No. 54: Guidance for Flood Risk Analysis and Mapping: Mapping Information Platform (MIP) Guidance. If the effective model is not accessible through FRiSEL, users may contact the FEMA Mapping and Insurance eXchange (FMIX) Customer Care Center using www.floodmaps.fema.gov/fhm/fmx_main.html.
- The engineer duplicates the results of the effective model (called the Duplicative Effective Model).
- The engineer makes any corrections to the effective model (called the Corrected Effective Model) such as technical errors in the effective modeling or the inclusion of any floodplain changes that occurred prior to the date of the effective model.
- The engineer develops a model for existing conditions that reflects any modifications that have occurred within the floodplain since the date of the effective model but prior to the proposed development (called the Pre-Project (Existing) Conditions Model). Generally, one or more additional cross sections or edits to the 2D mesh will be necessary to model the impacts of the proposed development and any modifications that are made to the channel or overbank areas to compensate for any loss of conveyance.
- The engineer modifies the Pre-Project Conditions model to reflect the proposed development while retaining the currently adopted floodway widths (called the Proposed Conditions Model).
- The engineer compares the results of the Proposed Conditions Model to the Existing (Pre-Project) Conditions Model, Corrected Effective Model, or Duplicate Effective Model, as applicable, to determine if there will be an increase in elevation of the base flood or floodway elevations at any existing or new cross section or evaluation line.



A – Assures the DEM reproduces the information (BFEs, floodways, etc.) from the EM

B – Identifies any changes (increases/decreases) to the EM which would impact existing properties/structures in the floodplain

C & E – Identifies any increases/decreases in BFEs which could indicate allowable fill in floodplain fringe (60.3.d.2) and floodplain (60.3.c.10), or potential violations.

D – Compares PCM to ECM showing impacts of proposed project on pre-project conditions.

F – Compares ECM to DEM identifying any increases/decreases in BFEs which could indicate allowable fill in floodplain fringe (60.3.d.2) or floodplain (60.3.c.10) or potential violations.

Figure 11. Modeling and Model Comparison Scenarios

Figure 11 illustrates various modeling scenarios, including model comparison approaches. No-rise comparisons would be made between the Proposed (Post-Project) Conditions Model and any of the other applicable models (Duplicate Effective Model, Corrected Effective Model, and/or Existing (Pre-Project) Conditions Model). No-rise determinations look at increases between the BFEs, and where needed to help evaluate any BFE increases, determinations could also look at any floodway elevation increases.

If there will not be an increase in either of the elevations, the engineer can prepare and submit the no-rise certification and the supporting technical documentation to the community (Figure 12). If there will be an increase, the development will have to be redesigned to avoid the floodway, compensation provided for the loss of conveyance, or there will need to be a floodway revision.

11.4. Evaluating "No-Rise" Analyses Submitted by Engineers

The community must prohibit development in the floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community during occurrence of the base flood discharge. It is the community's responsibility to make the determination that a development in the floodway will not cause any increase in flood stage. You cannot depend solely on registered professional engineer's no-rise certification and must review and approve the submission.

A certification by a registered professional engineer does not constitute a warranty or guarantee of performance, expressed or implied. Certification of data is a statement that the data is accurate to

the best of the certifier's knowledge. Certification of an analysis is a statement that the analysis has been performed correctly and in accordance with sound engineering practice. However, not all engineers are equally skilled or experienced in performing technical analyses and there is room for disagreements as to what constitutes standard engineering practice. Remember the registered professional engineer works for the permit applicant and not the community. The no rise certification is a valuable piece of information that you can use to help make your determination, but you are not obligated to accept the no-rise certification if you have reason to believe that it is not done correctly.

Communities that have city or county engineering departments or that contract for these services are encouraged to develop their own in-house engineering capability to evaluate proposals for floodway development and review no-rise certifications. If your community is part of a flood control or water management district, they may be willing to provide this service for their local governments. Some states that have their own state floodplain management regulations or that maintain engineering staffs that conduct Flood Insurance Studies may also be willing to perform this service for communities. If the development requires a floodway revision and you wish to approve the development, forward the revision request to FEMA and it will do the review as part of processing the request.

Procedure for "No-Rise" Certification **DRAFT Rev. 1a**

To be completed by community permit official: Floodplain Development Permit No._____

ENGINEERING "NO-RISE" CERTIFICATION

Community:_____ County:_____ State:___

Applicant:_____ Date:_____ Engineer:_____

Address:_____ Address:_____

Telephone:_____ Telephone:_____

SITE DATA:

1. Location: _____ 1/4; _____ 1/4; Section____; Range _____; Township:_____

Street Address:_____

2. Panel(s) No. of NFIP map(s) affected:_____

3. Type of development: Filling_____Grading_____Excavation_____Minor Improv_____
Substantial-Improv_____New Construction_____Other_____

4. Description of Development:_____
_____
_____
_____

5. Name of flooding source:_____

COMMENTS:_____
_____
_____
_____
_____
_____

This is to certify that I am a duly qualified engineer licensed to practice in the State of _____.
It is to further certify that the attached technical data supports the fact that the proposed development described above will not create any increase to the 100-year elevations on said flooding source above at published cross sections in the Flood Insurance Study for the above community dated _____ and will not create any increase to the 100-year flood elevations at unpublished cross-section in the vicinity of the proposed development.

Name:_____

Signature:_____ Date:_____

(Seal)

Title:_____ License No.:_____

R7-No Rise 12-02-03

Attachment B

Figure 12. Example of a No-Rise Certificate

Communities should look at the following when reviewing no-rise certifications.

- The registered professional engineer should be experienced in conducting hydrologic and hydraulic studies. You do not have to accept a certification if you do not feel that the engineer is qualified to conduct the analysis.
- The analyses must be conducted using the hydraulic model that was used to develop the flood insurance study if it is still available. The analysis should follow the same assumptions made when the effective hydraulic model was developed, unless shown to be invalid.
- The analyses should be consistent with basic hydraulic principles. For example, there needs to be smooth transitions in flood flows between cross sections where 1D models were used. Abrupt changes in floodway width for example should be avoided.
- If the development is located between existing cross sections in a 1D model, additional cross sections must have been surveyed at the site of the development to accurately model the impacts of the development. Where a 2D model is used, evaluation lines should be added if existing lines do not coincide with the site of the proposed development.
- The analysis should not include unrealistic land use or hydraulic assumptions. For example, if the analysis assumes that roughness coefficients used in the original flood insurance study are changed, the new roughness coefficients must reflect what is actually on the ground.
- There should be no cumulative impacts if other property owners undertake similar developments. It is important that there really is no increase in flood stage due to the development.
- When a 2D model is used, the water surface elevation grids for Existing Conditions and Proposed Conditions should be compared to ensure that the proposed development causes no local (point) rise on existing insurable structures.
- If the no-rise analysis depends on adding additional flow areas to compensate for the impacts of an encroachment, you must ensure that the flow area will be available in perpetuity and that the floodwaters can get to and use that flow area. You will want to require the applicant to apply for a floodway revision and adopt the revised floodway as part of your ordinance.

Again, if you have doubts about the submission, contact your state or FEMA Regional Office for assistance (https://www.fema.gov/about/contact).

If the analysis depends on a change in floodway boundaries to achieve “no-rise” and a floodway revision will be required see Section 13, Obtaining a Revision to Floodway Boundaries. If you approve the request and forward a request for a floodway revision to FEMA, FEMA will review the hydraulic analysis when it reviews the request.

Generally, you must maintain documentation in your files of the hydraulic analysis, the no-rise certification, and your determination indefinitely. FEMA or your state will ask to see the documentation on your next Community Assistance Visit (CAV), and you will need the documentation if your floodway is ever revised.

12. Encroachment Requirements for Rivers and Streams without Floodways

FEMA may also issue a FIRM that include rivers or streams where FEMA has conducted a detailed study and established base flood elevations, but not designated a floodway. Generally, these Studies are conducted in less densely populated areas where it is difficult to justify the expense of conducting an engineering study that would include a floodway. These areas are subject to the requirements at 44 CFR 60.3(c)(10) which requires a hydraulic analysis to ensure that each development in the floodplain does not increase base flood levels by more than one foot at any point in the community. The requirement at 44 CFR 60.3(c)(10) essentially applies the same standard to these areas as would apply if a floodway were designated (the maximum one foot rise in flood stage). The main difference is that the hydraulic analyses are conducted on a case-by-case basis for each proposed development in the floodplain. Most communities pass on the cost of performing this analysis to the permit applicant. The advantage of having a floodway designated is that is that the community can review and permit development outside of the floodway without requiring a hydraulic analysis and without passing the costs of that analysis on to the permit applicant.

The requirement in 63.3(c)(10) only applies along rivers, streams, and other watercourses where FEMA has provided base flood elevations. The requirement does not apply along lakes, bays and estuaries, and the ocean coast. Generally, this type of data is provided as interim data and the intent is to eventually re-map these areas to add floodways when funding becomes available and the amount of development warrants the added cost to develop floodways.

Sometimes a decision is made not to designate a floodway on a stream because hydraulic conditions on the river or stream do not lend themselves to modeling a floodway using standard methodologies. Generally, FEMA, the state, and the community agree to an alternative management scheme for the stream that achieves the same purpose as designating a floodway or performing an encroachment analyses under 60.3(c)(10).

> **44 CFR 60.3(c)(10):** *Require until a regulatory floodway is designated, that no new construction, substantial improvements, or other development (including fill) shall be permitted within zones A1-30 and AE on the community's FIRM, unless it is demonstrated that the cumulative effect of the proposed development when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than one foot at any point within the community.*

12.1. Ways to Meet the 60.3(c)(10) Requirement

Section 60.3(c)(10) of NFIP regulations requires a hydraulic analysis to ensure that each development in the floodplain does not increase base flood levels by more than one foot at any point in the community. One of the concerns that have been expressed about implementing the requirement has been the cost of performing a hydraulic analyses for a small development such as a single home. The costs of this analysis must be considered as part of the cost of developing in the floodplain. The potential adverse impacts of development in the floodplain on upstream and adjacent property owners can be significant and must be evaluated before the development is allowed to occur. However, there are several ways a community can avoid or minimize these costs:

- **Stay out of the floodplain entirely.** Usually limited detail studies without floodways are provided in rural areas or less densely populated areas where parcels are large and there is a choice of building sites. In these cases, it is often in everyone's best interest to design the development so that the building sites are located outside of the floodplain. The floodplain is preserved, and the permit applicant avoids the added costs of performing the hydraulic analysis and of developing in the floodplain.
- **Limit development to backwater areas.** It may also be possible to limit the development to backwater areas that are not effective flow areas. Most floodplains have irregular boundaries and include backwater areas that provide storage of floodwaters but play little or no role in the conveyance of floodwaters. The velocity of floodwaters in these areas may be zero or close to zero. There may also be floodplain areas that are separated from the river or stream by a railroad or road embankment or a substantial levee that is at or near the base flood elevation that parallels the river or stream. Areas behind these obstructions also may not convey flood flows. These areas are not taken into account as flow areas when the hydraulic model is developed of the floodplain. Development of these areas will not increase flood stages. A qualified engineer can apply basic hydraulic principles to identify these areas. The remainder of the floodplain is sometimes referred to as a natural floodway.
- **Establish setbacks:** Finally, it may be possible to develop a standard setback or an algorithm for establishing setbacks along smaller streams in your community that would serve the same purpose as 44 CFR 60.3(c)(10). You may already have adopted a setback to preserve a natural stream buffer to protect water quality. Back-up your setback or algorithm with engineering calculations to show that development will cause no more than a one foot rise in flood stage. Be conservative. Test the setback or algorithm on a reasonable number of cross-sections given the variety of stream conditions in your community. If you choose this alternative, check with your state or FEMA Regional Office first.

If you adopt either the second or third alternative and feel that permit applicants may challenge your setbacks or other requirements, you can always allow the applicant the option of hiring an engineer and submitting a (c)(10) analysis if they disagree. Most permit applicants are likely to comply with your requirement as long as it is reasonable rather than to go to the expense of paying for a hydraulic analysis.

12.2. Performing a 60.3(c)(10) Analysis

In those floodplains where FEMA has provided the community with base flood elevations, but no floodway, the community must prohibit development unless it is demonstrated that the cumulative effect of the proposed development when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than one foot at any point within the community.

When evaluating the proposed encroachment into the floodway, you must assume that other like situated property owners will want to develop their properties in the same manner as the permit applicant and that eventually their properties will be developed. You must take their rights to develop into account when evaluating a proposed encroachment to determine if it will cause rise in flood stage for the base flood. For example, if the permit applicant wants to build a house on fill that extends 100 feet into the floodway, you must assume that the property owners across the stream encroach into the floodway an equal amount. You must also make the same assumption for upstream and downstream property owners on both sides of the river or stream. You need to extend your hydraulic analysis far enough upstream and downstream to capture the cumulative impacts of all of this development.

13. Obtaining a Revision to Floodway Boundaries

Generally, you must apply for and obtain a floodway revision from FEMA any time you want to make a change in the FEMA-designated floodway boundaries even if the change is so small that it would not be visible on your FIRM. Applicants for floodway revisions usually want to narrow the width of the floodway or shift the location or alignment of the floodway to allow for a development. Procedures for obtaining a floodway revision can be found in NFIP regulations at 44 CFR 65.7 Floodway Revisions.

Requests for floodway revisions must come from the community. It is your floodway that you have legally adopted as part of your floodplain management ordinance. You probably held a public hearing and met other due process requirements when you designated your floodway and usually will have to meet the same requirements to adopt a floodway revision. You are not obligated to revise your floodway merely because a permit applicant can demonstrate that it is possible to narrow the floodway or change the floodway alignment. Remember that when you revise a floodway boundary, you may impact on other property owners in your community. They usually will have an interest in maintaining the current floodway alignment and must be notified before you propose a Floodway Revision to FEMA.

13.1. Procedures for Applying for a Floodway Revision

Applications for floodway revisions are submitted using FEMA's MT-2 Forms. The MT-2 Forms and the accompanying instructions can be downloaded from FEMA's web site (https://www.fema.gov/flood-maps/change-your-flood-zone/paper-application-forms/mt-2).

> **44 CFR 65.7 Floodway Revisions.** *(a) General: Floodway data is developed as part of FEMA Flood Insurance Studies and is utilized by communities to select and adopt floodways as part of the floodplain management program required by Sec. 60.3 of this subchapter. When it has been determined by the community that no practicable alternatives exist to revising the boundaries of its previously adopted floodway, the procedures below shall be followed.*

You are under no obligation to request a floodway revision under 44 CFR 65.7 just because a developer wants one. It is your floodway that you have adopted in accordance with your due process requirements and you as a community must approve the proposal and submit it to FEMA. Remember you are required to evaluate alternatives to the development that would meet the requirements of your floodplain management ordinance and demonstrate that these alternatives are not feasible before a LOMR will be issued by FEMA. In most situations there will be alternatives that do not require encroachments into your floodway or floodplain that would not require a floodway revision.

You will be required to submit evidence that all affected property owners and communities have been notified of your intent to revise the floodway to assure that they are aware of potential adverse impacts of the revision. Your community will also have to find that the revision and the proposed project meet or are designed to meet all community floodplain management requirements and that all necessary federal, state, and local permits have been or will be obtained. The most commonly required federal permits are wetlands permits under Section 404 of the Clean Water Act of 1972 and incidental take permits under Section 10 of the Endangered Species Act of 1972. If the floodway revision is approved by FEMA, you will be required to adopt the revised floodway as part of your floodplain management ordinance and use the revised floodway to regulate future development.

The procedure for applying for a floodway revision requires a hydraulic analysis similar to that required to demonstrate that a development would cause no-rise in the elevation of the base flood. The main difference is that instead of evaluating the impacts of a development in the floodway on the base flood elevation, the hydraulic analysis is instead demonstrating that the proposed revised floodway including any modifications that have been made to the channel and overbank areas within the revised floodway will carry the base flood without increasing the water surface elevation of that flood more than one foot at any point in the community. This is the same standard used to designate the floodway that is being revised.

13.2. Development Proposals that Exceed the One Foot Standard

There are limited situations where it may be necessary to allow development in the floodway or the floodplain that would result in increases in the base flood elevation greater than that generally allowed by NFIP minimum criteria. This could include:

- A proposal for development in the floodway that would cause an increase in the base flood elevation.
- A request for a revision to floodway boundaries that would result in a floodway that would result in greater than the allowable one foot surcharge.
- A proposal for development in a floodplain where no floodway has been designated that would cause greater than a one foot increase in flood stage.

Generally, this type of development is discouraged. Designation of the floodway can already cause up to a one foot increase in flood stage as determined by the engineering analysis completed and even this one foot increase can substantially increase upstream flood damages.

There are situations where it may be in the public interest to allow this development if no existing buildings are impacted and future buildings are elevated or floodproofed to the new base flood elevations. The procedure for obtaining a FIRM and floodway revision to allow this type of development has been established at 44 CFR 65.12 of NFIP regulations. Section 65.12 was developed to provide a mechanism to address several situations where it was thought to be in the public interest to allow development in the floodplain that would otherwise violate the provisions of the community's floodplain management ordinance. These situations include:

- Construction or increase in height of a dam or other water control structure particularly when it would reduce overall flood damages. Without the procedure at Section 65.12 this type of development would not be permitted under the community's floodplain management ordinance.
- Construction or replacement of roads or bridges that cross the floodplain. In situations where no existing development is impacted by the increase in flood stage there may be considerable cost savings in building a bridge with a smaller waterway opening.
- Other developments that have a net public benefit where there are no practicable alternative actions that would comply with the community's floodplain management requirements.

The procedure can only be used in situations where no existing structures will be impacted by the increase in the base flood elevation and only if all affected property owners are notified of the proposed revision. If FEMA approves the revised floodway, the community must adopt the revised floodway and higher base flood elevations and use them to regulate all future development. Often agencies proposing to construct such facilities are willing to purchase and relocate impacted buildings and purchase flowage easements to mitigate the impacts of the increased base flood elevations.

44 CFR 60.3(c)(13): *Notwithstanding any other provisions of Sec. 60.3, a community may approve certain development in Zones A1-30, AE, and AH, on the community's FIRM which increase the water surface elevation of the base flood by more than one foot, provided that the community applies for a conditional FIRM revision, fulfills the requirements for such a revision as established under the provisions of Sec. 65.12, and receives the approval of the Administrator.*

44 CFR 60.3(d)(4): *Notwithstanding any other provisions of Sec. 60.3, a community may permit encroachments within the adopted regulatory floodway that would increase in base flood elevations, provided that the community applies for a conditional FIRM and floodway revision, fulfills the requirements for such a revision as established under the provisions of Sec. 65.12, and receives the approval of the Administrator.*

Guidance for meeting the requirements of Section 65.12 can be found in the MT-2 Forms and Instructions and in Appendix C. A community may allow this type of development only if applies for and obtains a conditional FIRM and floodway revision and meets specific requirements in Section 65.12. A FIRM revision will be required to reflect any increase in base flood elevations due to the development. A floodway revision is required if there is a change in floodway boundaries. Once the community obtains approval of the FIRM and floodway revision, it must adopt the higher base flood elevations and revised floodway prior to permitting the development.

13.3. Meeting the Requirements of 44 CFR 65.12

Prior to permitting a proposed development in the floodway that would cause an increase in the base flood elevation, a request for a revision to floodway boundaries that would result in greater than the allowable one foot surcharge, or proposed development in a floodplain where no floodway has been designated that would cause greater than a one foot increase in flood stage the community must apply for and obtain approval from FEMA of a conditional FIRM and floodway revision.

44 CFR 65.12 Revision of flood insurance rate maps to reflect base flood elevations caused by proposed encroachments.

(a) When a community proposes to permit encroachments on the floodplain when a regulatory floodway has not been adopted or to permit encroachments upon an adopted regulatory floodway which will cause base flood elevations increases in excess of that permitted under paragraphs (c)(10) or (d)(3) of s.60.3 of this subchapter, the community shall apply to the Administrator for conditional approval of such action prior to permitting the encroachments to occur and shall submit the following as part of the application:

The requirements for obtaining conditional approval are found in 44 CFR 65.12. The community must:

- Evaluate alternatives to the development that would meet the requirements of 60.3(c)(10) or (d)(3) and demonstrate that these alternatives are not feasible.
- Provide individual notice to each property owner explaining the impact of the proposed action on their property.
- Obtain concurrence of the Chief Executive Officer of any other community impacted by the proposed action.
- Certify that no structures would be impacted by the increased base flood elevations.

Once the conditional map change has been approved by FEMA the community must adopt the increased base flood elevations and revised floodway prior to permitting the proposed action. The increased base flood elevations and revised floodway become part of the ordinance and apply to all future development in the community.

You are under no obligation to request a floodway revision under 44 CFR 65.12 just because a developer wants one. It is your floodway that you have adopted in accordance with your due process requirements and you as a community must approve the proposal and submit it to FEMA. Remember you will be required to evaluate alternatives to the development that would meet the requirements of your floodplain management and demonstrate that these alternatives are not feasible before a CLOMR will be issued by FEMA. In most situations there will be alternatives that do not require encroachments into your floodway or floodplain that would exceed those permitted in your floodplain management ordinance.

14. Alterations and Relocations of Watercourses

Communities that participate in the NFIP are also required to assure that flood carrying capacity of an altered or relocated watercourse in a floodplain is maintained. This requirement applies in Zone A where FEMA has not provided base flood elevations as well as in Zones AE, A1-30, AO and AH which have been studied in detail. In order to meet this requirement, communities must assure that:

- Any altered or relocated watercourse has the same or greater flood carrying capacity as it did before the alteration occurred, and
- Once the watercourse has been altered or relocated, the community has an affirmative responsibility to assure that it is properly maintained.

The community is also responsible for notifying adjacent communities and the state coordinating office prior to altering or relocating a watercourse and providing FEMA with a copy of this notification.

> 44 CFR 60.3(b):
>
> *(6) Notify, in riverine situations, adjacent communities and the State Coordinating Office prior to any alteration or relocation of a watercourse, and submit copies of such notifications to the Administrator;*
>
> *(7) Assure that the flood carrying capacity within the altered or relocated portion of any watercourse is maintained;*

14.1. Definition of Watercourse

Watercourse is not defined in NFIP regulations, but generally means the channel of a river, stream or drainage way and not the adjacent overbank areas. Placement of fill in the overbank areas only and outside of the channel is not an alteration or relocation of a watercourse. The overbank areas are addressed under the NFIP floodway requirements. Watercourses include not only rivers or streams that are the source of flooding used to determine the base flood and the floodplain boundaries, but also smaller streams, drainage ways and ditches within the floodplain that could flood during smaller more frequent events.

14.2. Application

The requirement to maintain the carrying capacity of altered or relocated watercourses applies to watercourses in all mapped floodplains. In a Zone A where no base flood elevations have been provided by FEMA, the requirements are particularly important because there are no floodways designated and no other requirements that would preserve the capacity of the floodplain to convey floodwaters. Preserving the capacity of the watercourse to convey floodwaters will help prevent flooding from becoming worse as the area develops. Historically, the failure to maintain the carrying

capacity of altered relocated channels has created numerous flood problems. For example, it was common practice to force a natural stream into a pipe or culvert when developing an industrial area or a subdivision. Frequently these pipes or culverts did not have the capacity to pass the 1% annual-chance flood or even much more frequent floods. The result was chronic flooding, repetitive flood losses, and eventually costly corrective measures.

Once FEMA provides a community with base flood elevations and a floodway is designated the requirements continue to apply to the channel of the river or stream. The floodway designation will prevent encroachments in the floodplain that cause more than a one foot increase in flood stage while the (b)(6) and (b)(7) requirements will protect the capacity of the channel of river or stream to convey floodwaters. The (b)(6) and (b)(7) requirements also will continue to apply to watercourses such as smaller tributary streams and drainage ways within the floodplain even though they are not the flooding source that produces the base flood elevation.

Communities are not required to maintain natural streams or channels and watercourses that were altered or relocated before the community joined the NFIP. Natural streams and watercourses that were altered or relocated before the community joined the NFIP are treated as existing conditions that are taken into account when the floodplain is mapped by FEMA. FEMA recognizes that maintaining natural streams can be costly to the community and often raises environmental issues. Watercourses that were altered or relocated prior to the community's participation in the NFIP can also be costly to maintain and the community may not have the legal authority to undertake or require their maintenance. However, if these watercourses do silt in or become clogged with debris or other obstructions, FEMA will eventually have to re-map these areas to reflect the increased flood hazard. The floodplain will likely become larger and the base flood elevation will increase. It is usually in the best interests of communities to maintain these pre-existing altered or relocated channels even though it is not required by FEMA to ensure that flooding does not increase and to avoid the need for this remapping.

14.3. Maintaining the Carrying Capacity of the Watercourse

Communities must assure that the carrying capacity of the altered or relocate watercourse is maintained. This means that the carrying capacity of the altered or relocated channel must be the same or greater than the original watercourse. The community will have to undertake some kind of analysis to assure that this occurs.

In undeveloped areas designated as Zone A where FEMA has not conducted a detailed engineering study and not developed base flood elevations, this analysis can be as simple as the community engineer reviewing the proposal and determining that:

- The channel size and cross section are as big, and the channel is as straight as the original watercourse and that there are smooth hydraulic transitions into and out of the altered or relocated portion of the watercourse.
- The channel sides and bottom are of the same or similar materials to the original watercourse and that the roughness coefficient is roughly the same.

If there are substantial differences between the altered and relocated channel and the original watercourse it may be necessary to require that the permit applicant submit a hydraulic analysis by a registered professional engineer.

In developed areas a detailed hydraulic analysis will usually be necessary to assure that the carrying capacity of the watercourse is maintained because of the potential for increasing flood damages to existing buildings. If the area has a floodway designated, this can be done as part of the hydraulic analyses necessary to meet floodway requirements.

If you choose to enlarge a watercourse you may impact on downstream peak flood discharges. The larger channel will carry more floodwaters and depending on the watershed may increase or decrease these peak discharges. You should consider requiring the permit applicant to provide an analysis assessing these impacts before you approve the development.

14.4. Maintaining the Altered or Relocated Portion of the Watercourse

Once a watercourse is altered or relocated an artificial condition is created. If the watercourse is not maintained, erosion of the banks and sedimentation could occur decreasing the capacity of the channel to carry flood flows. Altered and relocated rivers or streams will often meander and try to return to their old location. In addition, vegetation can grow choking the altered or relocated channel. Any benefits in reducing flood hazards from the altered or relocated channel will be lost and flood hazards could increase. Figure 13 shows a constructed channel that is overgrown with vegetation and for which the conveyance is significantly reduced.

Figure 13. Picture of a constructed channel in Arizona that is overgrown with vegetation (from U.S. Geological Survey Scientific Investigations Report 2006-5108)

As a result, it is critical that any altered or relocated channel be maintained. There are two ways that this can be done. First, the community can formally assume ownership or responsibility for the maintenance of the channel and obtain from the permit applicant any necessary easements or other permissions necessary to conduct the maintenance. Second, the community can negotiate an enforceable maintenance agreement with the owner of the watercourse to assure that the watercourse is maintained. Whichever alternative is chosen the community will have to periodically inspect the watercourse. When maintenance is required, the community will either have to conduct the maintenance or require the owner of the watercourse to conduct the maintenance.

If a community requests that FEMA revise its FIRM based on an altered or relocated watercourse, FEMA will require you to submit a maintenance agreement prior to issuing a Letter of Map Revision (LOMR) or physical map revision. If the channel is not maintained, FEMA can rescind the LOMR, revise the FIRM to show the increased flood hazard, or initiate an enforcement action against the community.

14.5. NFIP Community Rating System (CRS) Credits for Drainage System Maintenance

The NFIP provides credit under its Community Rating System (CRS) for communities that have Drainage System Maintenance programs that meet CRS requirements. The CRS provides discounts on flood insurance premiums in communities that undertake floodplain management activities that go beyond the minimum requirements for community participation in the NFIP.

For the purposes of CRS, a community's drainage system includes those natural and man-made drainage ways and channels, storm sewers and ditches, and detention and retention basins that must be maintained in order to prevent damages to buildings during smaller more frequent storms. Drainage System Maintenance credits are provided for communities that establish and implement programs to systematically inspect their drainage systems, including all channels and debris basins, and remove debris and correct any drainage problems they encounter. This credit applies to all natural and man-made watercourses that are part of the community's drainage system, not just those that have been altered or relocate since the community joined the NFIP.