The Floodway Encroachment Standard: Minimizing Cumulative Adverse Impacts

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Acknowledgements

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Cover Photographs
Top: Sept. 8, 2011. Rain associated with Tropical Storm Lee flooded a development that was allowed to encroach into the floodway of Lycoming Creek in Run, Pennsylvania. (AP Photo/Williamsport Sun-Gazette, Mark Nance)

Bottom Left: Nov. 6, 2006. A house swept away by flood waters being conveyed down the floodway of the Cowlitz River near Packwood, Washington in the aftermath of a *Pineapple Express* storm event. (The Seattle Times/Lewis County Sheriff's Office)

Bottom Right: Aug. 28, 2011. Emergency personnel search for anyone who may be occupying a building in the floodway of Ola Creek in Waitsfield, Vermont. Rain associated with Tropical Storm Irene caused floodwaters to rise and caused massive flooding across the region. (AP Photo/Sandy Macys)

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Introduction

Floods are the leading cause of natural disaster losses in the United States, having cost approximately $50 billion in property damage in the 1990s and accounting for more than two-thirds of federally declared natural disasters (National Research Council, 2009). Direct average annual flood damages have jumped from approximately $5.6 billion per year in the 1990s to nearly $10 billion per year in the 2000s, with some years much more that (GAO, 2007). One of the major contributors to this trend is encroachments into the floodplain (Galloway 2013).

Small encroachments into a floodplain in and of themselves may have a negligible impact on flood elevations. However, the combined, incremental effects of human activity, referred to as cumulative impacts, can cause significant increases in flooding. The National Flood Insurance Program attempts to address the cumulative impacts of encroachments into the floodplain through the use of a *regulatory floodway.* Federal minimum standards allow floodways to be developed based on the concept of allowing some encroachments but limiting the increase in flood elevations caused by these encroachments to one foot.

This report reviews the origin, use and establishment of regulatory floodways and provides an assessment of the impact of encroachments based upon allowing a one foot increase in flood elevations during the regulatory flood[1]. The assessment evaluated impacts on:

1. the physical characteristics of the floodway (floodway width, water velocity and area inundated),
2. damages to new and existing development in the floodplain and
3. floodplain natural resources.

The report also includes an appendix that highlights measures State and local governments have included in their floodplain management regulations to lessen the cumulative impact of encroachments into the floodplain.

Background

Everyone lives in a watershed, that is, the land area that collects and feeds water into a waterway. Within these watersheds are areas that become inundated following heavy rainstorms or snowmelt. These areas, called the floodplain, hold the excess water and allow it to be slowly released into the river system, to seep into groundwater aquifers, and be taken up by plants. Floodplains also offer a place for sediment to settle out of floodwaters, thereby keeping it out of waterways and creating fertile floodplain valleys.

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[1] The regulatory flood also known as the base flood adopted by the NFIP is the one-percent annual chance flood. The land area covered by the floodwaters of the base flood is called the base floodplain. On NFIP maps, the base floodplain is called the Special Flood Hazard Area (SFHA). The SFHA is the area where the NFIP's floodplain management regulations must be enforced by the community as a condition of participation in the NFIP and is where the mandatory flood insurance purchase requirement applies.

In the natural setting and in the absence of man, flooding occurs but there is no flood hazard. It is only with the introduction of human encroachment into the floodplain that a hazard is established and the problem of flood damage arises. As manmade development is introduced into the floodplain, it can become an obstruction in addition to being vulnerable to flood damage. It may so encroach upon the watercourse as to retard its capacity to pass flood flows. The impacts on neighboring residents in a community and on adjacent communities are an increase in flood crests and wider areas being flooded.

Historically disaster response was a State and local government responsibility. Following several major flood disasters in the early 1900s the U.S. Congress recognized the threat to lives and losses of property caused by unwise floodplain development and passed the Flood Control Act of 1936. The act directed federal efforts toward reduction of such losses by placing emphasis on control of floodwaters through the use of structural works.

However, major disasters from flooding continued. As a result, there came a realization that flood damage reduction programs needed to include not only levees, dams and other protective structures to correct existing problems, but also measures which would make people more aware of the risks. The use of floodplain maps and regulations to supplement flood control structures to reduce flood damage potential and encourage wise use of the floodplain was initiated in the 1950s by the Tennessee Valley Authority (TVA)[2]. The first floodplain maps in the U.S. were developed by the TVA in 1953. (Goddard, 1978) The floodplain regulations and associated maps were intended to make people more aware of the risk and encourage sound land use in the floodplain.

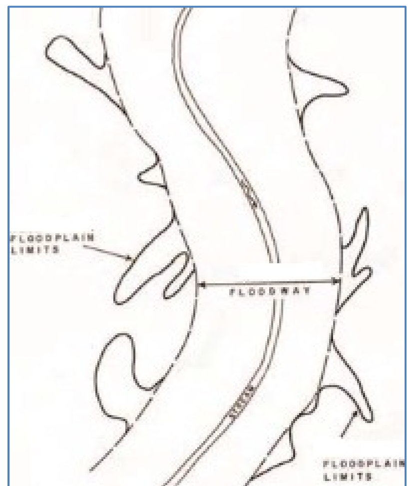

Figure 2 – Shallow areas that do not effectively convey flood waters not included in the floodway. (Source: modified from MN DNR – Technical Report 6 1972)

When developing floodplain maps, the Tennessee Valley Authority divided the floodplain into the floodway (the portion of the floodplain with flowing water) and the flood fringe (backwater areas). The TVA's first consideration in designating floodways was full conveyance floodways (see Figure 2). All of the area inundated by the selected flood (e.g. one-percent annual chance flood) was to be included, except those shallow areas and embayments into small drains or gullies where there was ponding but little if any flow. In other words, the mapped floodway would comprise those parts of the floodplain that have *moving* flood waters.

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[2] The Tennessee Valley Authority is a federally owned corporation in the United States created by congressional charter in May 1933 to provide navigation, flood control, electricity generation, fertilizer manufacturing, and economic development in the Tennessee Valley.

However, the TVA received opposition on this concept. Issues associated with existing land use, development expectations, and the physical constraints presented by steep slopes outside the floodplain in the Tennessee River valley prompted the TVA to adopt a less conservative approach. According to Goddard:

"The floodway was to be the channel and that portion of adjacent floodplains necessary to carry the selected flood without increasing flood elevations significantly. By general acceptance among professionals 'significantly' had come to be considered no more than one (1) foot."

Instead of mapping full-conveyance[3] floodways TVA mapped narrower floodways in which one foot of increased flooding (also called surcharge) was allowed. It was to be a minimum criterion intended as a regional standard, recognizing that there were urbanizing areas where the existing development, physical conditions or other elements might demand a more-stringent evaluation and a much smaller rise might be considered more appropriate. (Goddard, 1978)

More restrictive State and local standards for mapping floodways

On this point, the Goddard report includes summaries of interviews with States that did not deem the one foot of increased flooding appropriate. The report lists a total of nine States that by the mid-1970s had developed or were considering State-specific minimum standards related to mapping floodways. In the interviews summarized in the report, State staff provided the rationale for the standard the State had adopted.

Illinois – interpreted *significantly* to mean *"anything greater than zero, but its practical interpretation is 0.1 foot for computer purposes"*[4]. Its rationale was that *"the overbank floodplain of most of the streams in the State is quite flat. A small increase in the flood profile can significantly expand the width of the floodplain. It seemed unreasonable economically to allow any significant increase in the flood stage that subjects previously 'safe' structures to flood waters."*

Indiana – also adopted 0.1 foot as the maximum surcharge allowed, and indicated *"there are few topographic restraints on development in Indiana, so there is no real need to view floodplains as the only developable area."*

The responses from Illinois and Indiana illustrate the opinion that allowing increases in flooding was unreasonable and unnecessary. The other States that had adopted or were

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[3] Full-conveyance floodways are also called zero-rise floodways due to the fact that when modeling floodways no increase in flood elevations due to encroachments is introduced into the modeling.

[4] The most common hydraulic engineering model being used at the time was the U.S. Army Corps of Engineers Hydraulic Engineering Center (HEC) HEC-2 water surface profile model. The output of the model provided calculated flood elevations to the nearest 0.1 foot. A number of States adopted a 0.1 foot standard with the intent of not allowing a measurable increase.

considering a more stringent criterion listed in the Goddard report were Wisconsin, Michigan, New Jersey, Montana, Minnesota, Montana, Maryland, Massachusetts and Ohio.

National Flood Insurance Act of 1968

NFIA promotes floodplain land use management

In an attempt to reduce flood damages to development in high risk flood areas, Congress passed the National Flood Insurance Act (NFIA) in 1968. The Act created the National Flood Insurance Program, presently administered by the Federal Emergency Management Agency (FEMA). The Act had three main goals: "to better indemnify individuals for flood losses through insurance; to reduce future flood damages through State and community floodplain management regulations; and to reduce federal expenditures for disaster assistance and flood control." A key provision of the 1968 Act prohibits FEMA from providing flood insurance in a community unless the community adopts the flood elevations and flood hazard maps developed by the federal government and enforces floodplain regulations that meet or exceed those stated in the Act.

NFIA addresses cumulative impacts

The National Flood Insurance Act also includes a provision intended to limit the cumulative impacts of encroachments into the floodplain. Communities are provided Flood Insurance Rate Maps (FIRMs) that can include a *regulatory floodway*. Section 59.1 of the NFIA defines the 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." The designated height is established in the Code of Federal Regulations (CFR) Title 44, Part 60, Section 60.3 (d)(2) as being no more than one (1) foot at any point.

When floodways are not mapped, communities must require landowners submitting proposals to analyze the impact of their proposed encroachment on conveyance to ensure the one-foot surcharge criterion is not exceeded. With a mapped floodway this analysis is conducted as part of the FEMA Flood Insurance Study, thus no additional analysis regarding loss of conveyance is needed when development in the flood fringe is proposed.

Base Flood Elevations not increased to reflect surcharge amount

The primary purpose of Flood Insurance Rate Maps (FIRMs) is to rate the flood insurance premiums for existing development at risk. FIRMs also identify where communities can allow new development not yet constructed. FEMA's position is that the maps must reflect conditions existing at the time the study was conducted, not projected future conditions that could be predicted. Consequently, base flood elevations (BFEs) reflected on the FIRMS do not reflect the impact of encroachments within the floodway fringe. This is due to concerns that it would be inappropriate to require owners of existing development to pay flood insurance premiums associated with a future risk that may never materialize. The BFEs that are established reflect existing development conditions within the Special Flood Hazard Area, not the flood elevations that will result when the new development in the SFHA occurs and the flood fringe is filled.

Thus FIRMs are dual-purpose maps, used both for:

1. establishing flood insurance rates for existing development at risk, and
2. guiding new development so that it is reasonably safe from flooding.

FEMA does not generate a separate map for insurance and one for managing future flood risk.

SFHAs include wider floodways in States with higher standards

The FEMA one-foot rise floodway is a minimal standard, and can be exceeded by States or communities with stronger standards, i.e., lower thresholds.

Section 60.1(d) of the NFIP regulations states that any *"regulations adopted by a State or a community which are more restrictive . . . are encouraged and shall take precedence (over national minimum standards)."*

There are eight States that have adopted more stringent standards by legally enforceable statutes or regulations. For these States FEMA computes the regulatory floodways using those standards. Four of the eight States have established thresholds intended to represent a "measurable amount" while the remaining four are compromise positions. The eight States with their associated lower threshold are:

- Wisconsin - 0.01 foot
- Illinois - 0.1 foot
- Indiana - 0.1 foot
- Michigan - 0.1 foot
- New Jersey - 0.2 foot
- Colorado - 0.5 foot
- Minnesota - 0.5 foot
- Montana - 0.5 foot

Communities are treated differently than States because it is more likely that a new community administration could change the more restrictive floodway adopted by a previous administration (FIA Policy Notice 79-3). Recently, FEMA has shown greater flexibility in terms of actually publishing more restrictive floodways for communities that are Cooperating Technical Partners (CTP)[5]. Such communities "now have considerable latitude on how their floodways are designated and could map zero-rise floodways." (FEMA Call for Issues, June 2000, page II-3-6.) (FEMA, 2004)

[5] In 1999, FEMA initiated this program to enable capable communities to receive mapping funding and produce flood elevations and mapping that is incorporated into FEMA's Flood Insurance Rate Maps.

Impact Assessment

The assessment presented in this report focuses on the impacts of establishing regulatory floodways based on the one-foot surcharge criterion. The assessment evaluated impact on: 1) the physical characteristics of the floodway (floodway width, water velocity and area inundated), 2) damages to development in the floodplain and 3) floodplain natural resources.

Impact on the physical characteristics of the floodway

Methodology

For this assessment, the engineering modeling and floodway mapping for eight river segments in six states were analyzed to determine the cumulative impacts of establishing regulatory floodways based on the one-foot surcharge criterion. The streams were chosen based on the availability of updated HEC-RAS[6] models, with the goal of including streams of different sizes and gradients from various U.S. regions.

The characteristics of these eight streams are included in Table 1 below.

Streams selected for case studies

River System	Drainage Area (Sq Mi)	Discharge (CFS)	Stream Gradient (Ft/Mi)	Reach Length (Mi)	Number of Cross-Sections
Pine Creek (WI)	15.1	2,284	6.9	1.98	46
Patterson Creek (WA)	21.6	820	4.2	9.18	74
Stevens Branch (VT)	66.8	14,790	23.6	15.6	199
Sugar River (WI)	46.6	2,335	1.4	3.85	29
Four Mile Creek (NC)	18.8	4,750	8.3	4.55	60
Cypress Creek 100 (TX)	110.2	27,258	2.7	7.06	35
Cypress Creek 172 (TX)	7.9	2,585	9.3	4.48	25
Plum Creek (CO)	319	38,720	37.6	6.79	65

Table 1 – Study Reach Characteristics.

The hydraulic models associated with these streams were analyzed to quantify the cumulative impact of allowing encroachments that cause one (1) foot of increased flooding. The regulatory model for each stream was modified to create two hydraulic engineering

[6] HEC-RAS is an engineering modeling package developed by the U.S. Army Corps of Engineers. The letters stand for Hydrologic Engineering Center – River Analysis System.

models for each study area. One model reflects a full-conveyance floodway. The other model has encroachment stations inserted that reduce the width of the floodway based upon the one-foot surcharge threshold.

Results

Amount of floodway width reduction and mean velocity increase

River System	Avg. Decrease in floodway width (%)	Velocity w/o encroachments (ft/sec)	Velocity w/ encroachments (ft/sec)	Average velocity increase (%)
Pine Creek (WI)	**59**	2.28	3.69	**62**
Patterson Cr (WA)	**68**	1.11	1.61	**45**
Stevens Branch (VT)	**39**	4.98	5.82	**18**
Sugar River (WI)	**50**	1.57	2.07	**32**
Four Mile Creek (NC)	**43**	2.58	3.25	**26**
Cypress Cr 100 (TX)	**48**	1.92	2.46	**22**
Cypress Cr 172 (TX)	**64**	1.18	1.71	**45**
Plum Creek (CO)	**32**	7.15	8.31	**16**
Average	**50**	**2.85**	**3.62**	**33**

Table 2 – Comparison of Full-Conveyance and One-Foot Surcharge Floodways.

Encroachments essentially pinch in the sides of the floodplain and force more water toward the center of the stream. This makes the area available to convey floodwaters narrower. Since the volume of floodwater passing through this area remains unchanged, constricting floodwaters through a smaller area raises flood elevations and increases the velocity of the floodwaters passing downstream.

Table 2 shows how much the full conveyance floodway is narrowed and how much the velocity is increased for each case study.

On average, in evaluating the stream conveyance, encroachments that caused one foot of increased flooding:

- reduce the width of the cross-section available for the conveyance of floodwaters on average by one-half (50%) and
- increase the flood water velocities on average by (33%).

Floodway Constricted

The floodway widths determined were consistent with the summary of an analysis of floodway studies included in the Goddard report. Those results showed the average width of one-foot rise floodways was about 55 percent of the non-encroached floodway. Development in the flood fringe in some instances does not completely block flood flows. The analysis presented in the Goddard report indicates that flow blockage based on an evaluation by experienced engineers varied from zero to 100 percent and averaged 25 percent. The report notes that the analysis includes areas away from urban areas and that the average blockage through denser urban areas will be higher.

Flood debris can increase the amount of flow blockage and damage adjacent properties. Some States (e.g. Wisconsin) require development in the floodplain to be constructed on fill thereby creating a complete obstruction to flood flows. Finally, floodways determine how far levees can encroach into the floodplain and with levees flow blockage is 100 percent.

Velocity Increased

Increasing the flow velocity can be problematic in that it increases turbulence and therefore increases the stream's ability to erode. As water velocity increases so does the size of the largest piece of sediment that flood waters can carry. By increasing the velocity of water moving in the channel, the flowing water can scour the stream bed and deepen the channel. This means the banks are higher and often more unstable resulting in increased streambank erosion and more sediment entering the stream. Increased sedimentation makes it difficult for some fish to feed and spawn, and the increased velocity of the stream drives out fish that cannot tolerate fast-moving water (NMFS, 2008). These erosive waters cause streams to meander laterally, and fill or degrade vertically as they adjust to their water levels, sediments, and slope. Stream channels may change suddenly and catastrophically.

Area Inundated Increased

As the floodway is constricted and flood elevations rise, the area inundated by the same flood event increases. For two of the streams analyzed topographic data was available which allowed the generation of two sets of flood inundation maps.

The percent of increase in the area inundated is shown in Table 3 below.

River System	Increase in area inundated (%)
Pine Creek	6
Sugar River	14
Average	**10**

Table 3 - Comparison of area inundated for two scenarios

Two streams do not provide enough data to extrapolate the numbers but they do highlight that with one-foot surcharge floodways people that build structures just outside the floodplain will likely find those structures impacted as the allowable encroachments into the floodplain occur.

Impact on flood damages

The U.S. Army Corps of Engineers[7] has developed flood depth-damage relationships based on reviews of damages associated with historic flood events for the most common types of building construction. Figure 3 below is the flood depth to damage relationship for a single-family residential structure with no basement (a common type of residential construction).

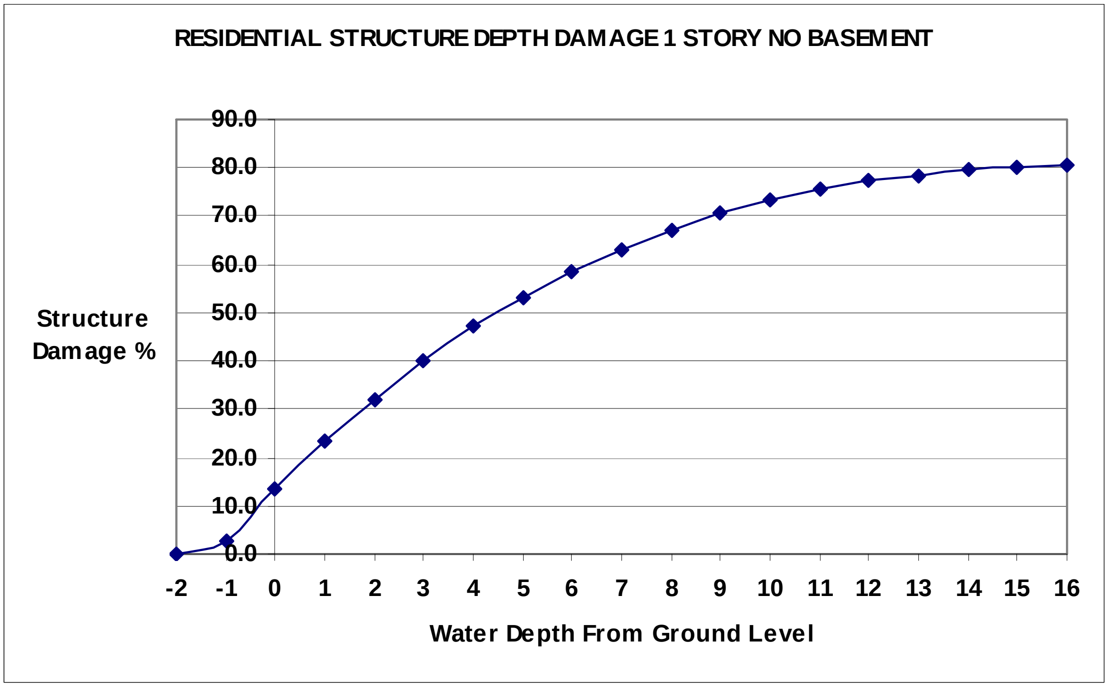

Figure 3 – Flood Depth-Damage Curve for a Single-Story Residential Structure with No Basement at Ground Level. (Source: U.S. Army Corps of Engineers Floodplain Inventory Tool (CEFIT)

Impact on existing and new development built at or above the BFE

As indicated previously, while NFIP regulatory floodway limits the cumulative impacts of encroachments to one foot, the associated base flood elevations (BFEs) are not raised to reflect that increase. Structures constructed at the BFE could expect to experience increased flooding as new development is constructed in the floodway fringe. Table 4 (on the next page) is derived from Figure 3 to provide the incremental and cumulative increases in flood damage associated with each additional foot of flooding.

According to Table 4, in the case of a single-family structure with no basement (slab on grade) built to the BFE the structure would begin to incur damages when flooding is about a foot below the BFE. When there is one foot of flooding above the first floor of the structure

[7] The U.S. Army Corps of Engineers has collected and analyzed actual flood damages to various types of properties and developed flood depth to damage curves as part of their HEC-FDA (Hydrologic Engineering Center – Flood Damage Analysis) program.

the one foot of additional flooding caused by narrowing the floodway would increase the flood damages incrementally by ~10% to over 20% of the total value of the structure.

Flood Damages Associated with Flood Depth One Story Residence With No Basement		
Depth	Incremental Increase in Flood Damages	Cumulative Increase in Flood Damages
-2	0.0%	0%
-1	2.5%	2.5%
0	10.9%	13.4%
1	9.9%	23.3%
2	8.8%	32.1%
3	8.0%	40.1%
4	7.0%	47.1%
5	5.9%	53.2%
6	5.4%	58.6%
7	4.8%	63.2%
8	4.0%	67.2%
9	3.3%	70.5%
10	2.8%	73.2%

Table 4 - Amt of damages per one-foot increment of increased flooding

Impact on existing development constructed below the BFE

Existing development constructed below the BFE is by definition more vulnerable to flood damages. An additional foot of flooding will increase the damages incurred. As an example for a one story structure with no basement where the amount of flooding increases from 4 to 5 feet during a base flood event the damages would increase from 47% to 53%. There is also the potential for other impacts, which include:

- Limitation of access to flooded properties. The maximum depth through which most vehicles can safely drive is two feet. Increasing flood depths from 1.5 feet to 2.5 feet could mean a homeowner may not be able to safely reach high ground during a flood event. In addition, emergency vehicles could be prevented from responding to a house fire or medical emergency.
- Possible compromise of flood-proofing measures. Homeowners can at times prevent their structures from being inundated if threatened by one to two feet of flooding by using sandbags. An additional foot or more of flooding could overwhelm a sandbag effort or dry floodproofing.

Impact on floodplain natural resources

Rivers and floodplains are complex ecosystems capable of supporting many life-forms and natural processes. Floodplains moderate water systems by absorbing stream overflow, thus lessening flood events and providing storage for groundwater. Riparian vegetation contributes nutrients, refuges, and dissolved oxygen, shades streams (lowering water temperatures) and retains water. In their natural state, streams meander across a floodplain, forming intricate networks of waterways with a wide array of habitats. (NMFS 2008)

Despite representing an average of less than two percent of the surface area of watersheds, floodplains provide 25 percent of all the services and benefits to terrestrial ecosystems. (Opperman, Luster et. al. 2010)

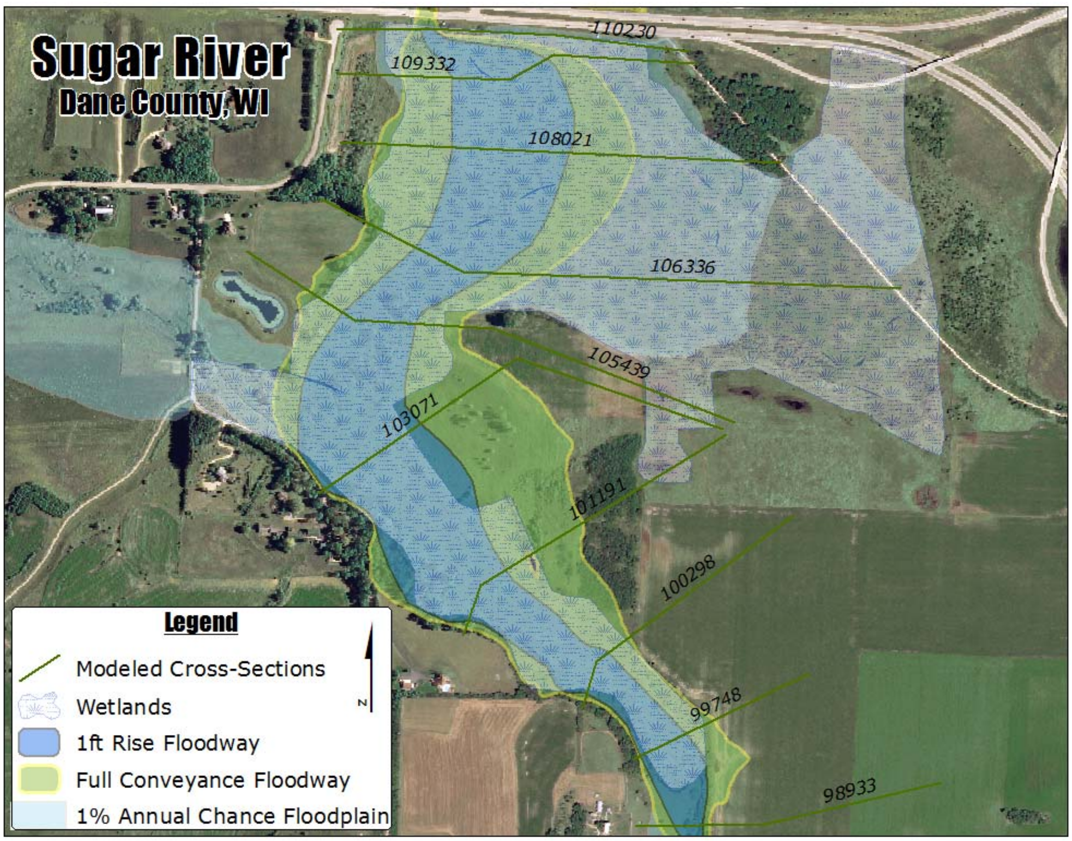

Figure 4 - Sugar River, Dane County, WI floodplains and wetlands

One of the streams analyzed for this assessment was the Sugar River in southern Wisconsin. For this case study, two floodways were mapped. One floodway map was based on the federal minimum standard of one (1) foot of allowable increase in flooding due to loss of conveyance. The other was the non-encroached floodway.

In order to assess the impact of cumulative allowable encroachments on ecosystem services based on the federal one-foot surcharge standard, the wetlands component of ecosystem services was evaluated for this stream segment. Wetlands mapping was compared with the two different floodway maps developed for the Sugar River case study (see Figure 4).

Results: The total acres of wetlands lying within the two Special Flood Hazard Areas for this two-mile segment of the Sugar River were:

- Floodway without encroachments (95 acres), and
- One-foot surcharge floodway (58 acres).

Based on this analysis, 37 acres of wetlands (18.5 acres/stream mile) would potentially be impacted if encroachments were allowed into the full-conveyance floodway to the limit of a one-foot flooding increase due to loss of conveyance. When using a one-foot surcharge for mapping the floodway, these 37 acres would be identified as flood fringe, where development is generally allowed. Note: This does not necessarily apply to all stream segments in a watershed or all watersheds in the country. Wetlands more often occur along stream segments in the lower portion of a watershed. In the arid west there are fewer wetlands than in the east and Midwest. In these areas, other types of habitat (e.g. floodplain forests) may instead be the resource impacted.

Discussion

Goddard's 1978 report states that the floodway *"was to be the channel and that portion of adjacent floodplains necessary to carry the selected flood without increasing flood elevations significantly".* Further, *"By general acceptance among professionals [in the Tennessee Valley at that time] 'significantly' had come to be considered no more than one foot."*

According to Goddard, the number *one* (1) did not suggest an accuracy or degree of guidance that a fraction or fractions of a foot might connote. It related, practically, to the engineering judgment applied in hydrologic and hydraulic computations.

Unfortunately, what Goddard failed to recognize is the difference between *absolute* and *relative* accuracy. It is indeed correct that floodplain studies have a degree of uncertainty, especially in early studies. However, what is being addressed when assessing proposed encroachments is not the absolute accuracy of the study but the relative increase in flood elevations that an encroachment into the floodplain will cause. This increase can be measured with a good deal of precision and is related more to the surveying methods used to determine the amount of the encroachment than to the engineering judgment associated with the study methodology. Survey standards are such that measurements to within a few centimeters' (about one inch) are common.

The rationale provided for selecting the one-foot rise criterion was that was a compromise between prohibiting encroachments into the floodplain while permitting economical land use and protecting against unreasonable invasion of property rights. However, a basic property legal principle that dates back to ancient Justinian (Roman) law is: "Sic utere tuo ut alienum non laedas", or "so use your own property that you do not injure others". Allowing new development that increases flood elevations and velocities on existing development injures others and therefore violates their property rights. (Kusler and Thomas, 2007; Thomas and Medlock, 2008)

As indicated earlier, the State of Illinois interpreted *significantly* to mean *"anything greater than zero, but its practical interpretation is 0.1 foot for computer purposes"*. The most common hydraulic engineering model being used at the time was the U.S. Army Corps of Engineers Hydraulic Engineering Center HEC-2 water surface profile model. The output of the model provided calculated flood elevations to the nearest tenth of a foot. A number of States (Illinois, Indiana, Michigan and Wisconsin) adopted a 0.1 foot standard with the intent of not allowing a measurable increase. In the 1980s the U.S. Army Corps of Engineers modified the engineering modeling program so that the output provided calculated flood elevation to the nearest hundredth of a foot (0.01 foot). Consequently, Wisconsin modified its standard to allow less than 0.01 foot to maintain its restriction on any encroachment that would cause a measurable increase in flooding.

The Merriam-Webster definition of the word *significant* is "having or likely to have an influence or effect; also: of a noticeably or measurably large amount." This assessment demonstrates that the one (1) foot surcharge standard does indeed have a significant impact. It decreases the cross-sectional area available for the conveyance of floodwaters on average by one-half. It increases flow velocities by one-third. When evaluating the impact on flood damages to structures, the Corps of Engineers flood depth-damage curves demonstrate that structures built to the BFE can sustain significant damages that amount to over 20% of the value of the structure. When people receive an approval to build in or near the floodplain they trust they will not be impacted by the flood event to which the regulations apply – the base flood. In actuality as allowed encroachments into the floodplain occurs those encroachments could cause one foot of flooding on the first floor of the structure.

Conclusions

The combined, incremental effects of human activity in the floodplain, known as cumulative impacts, can significantly increase flood risk and flood damages and pose a serious threat to the environment. While most encroachments are seemingly insignificant in and of themselves, numerous encroachments from one or more sources can have significant cumulative impacts over time. It is important that the cumulative impacts of encroachments into the floodplain be addressed when permitting new development in the floodplain.
FEMA defines the 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* <u>*cumulatively*</u> [emphasis added] *increasing the water surface elevation more than a designated height."* Reserving a portion of the floodplain for the discharge of floodwaters is in and of itself a good thing. Doing so not only ensures that encroachments into the floodplain do not cause increased flooding, but it helps keep human development out of areas where stream velocity, flood depths and currents can be a threat to life and safety.

While the federal standard does establish an upper limit, setting the designated height at one (1) foot perpetuates an upward trend of increased flood damages. Allowing the designated height to be anything greater than zero is problematic.

This typical method of establishing a floodway implicitly allows levees to be constructed along an entire reach of a river at the outer limits of the regulatory floodway; allows parts of the natural conveyance and storage to be filled; and allows any type of residential or nonresidential development as long as first floor elevations are at or above the BFE. (AIR, 2007)

Impacts associated with the federal minimum standard for mapping floodways based upon the one-foot rise criterion include:

- new development is allowed within the Special Flood Hazard Area that will increase flooding on existing development,
- BFEs are not increased to avoid new development also being placed at risk, and
- encroachments are allowed that can be detrimental to the natural and beneficial functions of the floodplain.

Not all streams in the U.S. currently have mapped Special Flood Hazard Areas. Presently there are a little over a million miles of streams with mapped SFHAs and another 2 million miles in the National Hydrography Dataset (NHD)[8] with no mapped SFHA. Of the million plus miles of streams with mapped SFHAs about 20% include mapped floodways. (ASFPM 2013)

However, automated modeling and mapping tools are making floodplain studies less expensive. Opportunities exist to greatly increase the amount of mapped floodways over the next decade. Adopting a standard that reduces the allowable cumulative impacts of encroachments into the floodplain could help reverse the upward trend in flood damages and disaster costs and improve the economic resiliency of communities throughout the nation.

Appendix A is a summary of practices that have been implemented by States and communities demonstrating measures that can be taken to reduce the cumulative impact of encroachments into the floodplain.

[8] The NHD is a digital vector geospatial dataset that represents the streams, rivers, canals, lakes and ponds in the U.S.

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Appendix A - Mitigating the Impact

The following is a summary of the impacts associated with some current practices in the mapping of floodways with some best practices highlighted that have been implemented by States and communities to help mitigate those impacts.

1. **Current practice:** The default process in States that do not have higher standards for floodways is to map floodways based on the one-foot rise criterion. Outside the States with higher standards for mapping floodways, FEMA does not routinely recognize community higher standards when mapping floodways.

   Issue: Section 60.1(d) of the NFIP regulations indicates that any *"regulations adopted by a State or a community which are more restrictive. . . are encouraged and shall take precedence (over national minimum standards)."*

   Further, according to Section 60.3(d)(2), communities must *"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."*

   Risk Mitigation Practices:

   a. Minnesota has a State floodway mapping standard that limits the surcharge to 0.5 feet. It also has a Regulatory Flood Elevation (RFE) that adds one foot of freeboard to the BFE. The RFE is used for siting new development in the floodplain. The State encourages communities to adopt a more restrictive floodway standard. If they adopt a floodway with no surcharge allowed, the RFE for new development is the BFE plus one foot of freeboard. If the community adopts the State minimum standard that allows 0.5 feet of surcharge, the State requires the surcharge be added to the RFEs established. Therefore, in this instance the RFE would be the BFE plus 1.5 feet.

   Note: To be consistent with NFIP requirements associated with requests for increasing BFEs after floodways have been established, Minnesota limits surcharges to areas where no existing residential structures are impacted.

   b. The State of Wisconsin requires communities that allow development to increase flooding on neighboring property to obtain easements from all impacted property owners.

   Discussion: A process in which a community selects the surcharge used (one foot or less) to map the floodway, in conjunction with a correlated increase in the height to which new development is constructed, helps to mitigate the impact. It also enables the community to be compliant with the requirement that new development be reasonably safe from flooding. It helps ensure new development would not be damaged by the allowable increase in flood elevations when development in the floodway fringe occurs. Furthermore, requiring easements from the impacted properties in communities that opt for a mapped floodway that includes a surcharge helps to ensure that impacted property owners are aware of the impacts and are properly compensated to offset the associated damages.

2. **Current practice:** Once floodways are established, encroachments into the floodway often are not analyzed based on the concept of *equal degree of encroachment*.

   Example from FEMA's Floodway Guidance for Community Officials: According to this 1978 document, in order to address the cumulative impacts of any proposed development in the floodway, the development needs to also be analyzed based on an equal degree of encroachment engineering analysis. For example, if one structure is proposed 100 feet into the floodway, the engineer will assume that future structures in the area will also be allowed to encroach into the floodway to this degree. The engineer will then block out this area in making the analysis. Figure 5 shows that the engineer assumes more obstruction than is created by the single proposed structure. This assumption is based on the legal difficulty a community would have in denying similar proposals. The equal degree of encroachment rule provides a uniform legal basis for granting or denying a proposed development and all future developments. Therefore, any proposed encroachment into the floodway should include a revised floodway analysis based on the equal degree of encroachment concept. (FEMA, 1978)

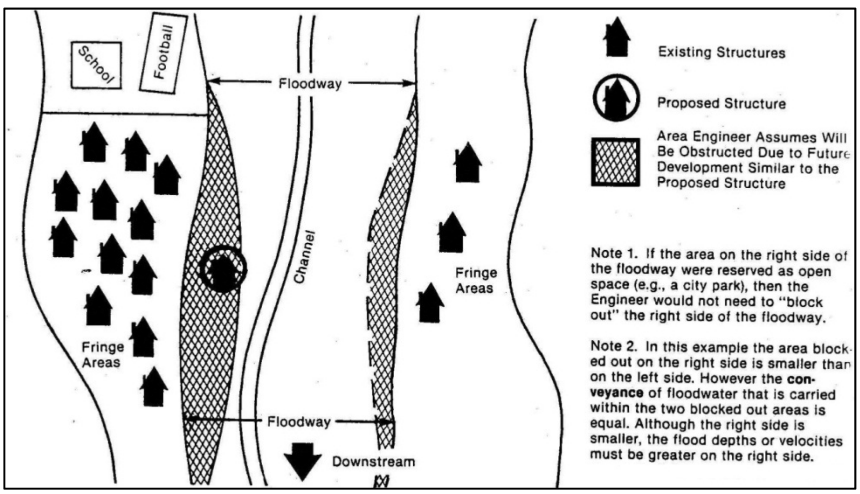

Figure 5 – Using Equal Degree of Encroachment principles in evaluating development proposals. (Source: *The Floodway: A Guide for Community Permit Officials* (FEMA, 1978))

   Issues: The intent in mapping regulatory floodways is to address cumulative impacts of encroachments into the floodplain. Once established, if the cumulative impacts associated with encroachments are not analyzed, the basic tenet associated with mapping floodways is undermined.

   Risk Mitigation Practices: Minnesota and Wisconsin conduct State engineering reviews of proposed encroachments into the floodway. Both States require that an equal degree of encroachment analysis be conducted to assess cumulative impacts of proposed encroachments.

3. **Current practice:** Where a floodplain engineering study has been completed and flood elevations have been established but floodways have not been mapped, development proposals often are not required to conduct a cumulative impacts analysis.

   Issues: According to CFR Title 44, Part 60, Section 60.3 (c)(10), communities must require 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 until a regulatory floodway is designated, 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 by more than one foot at any point within the community.

   Risk Mitigation Practices:

   a. Minnesota and Wisconsin require new development proposals in areas without mapped floodways to evaluate the cumulative impact of similar development by mapping a floodway as one of the first steps in the process. Minnesota has especially succinct guidance on evaluating for cumulative impacts:

   "Compute the floodway necessary to convey or store the regional flood without increasing flood stages more than 0.58 foot. A lesser stage increase than 0.5' shall be required if, as a result of the additional stage increase, increased flood damages would result. An equal degree of encroachment on both sides of the stream within the reach shall be assumed in computing floodway boundaries."

   b. North Carolina has established flood elevations for all mapped Special Flood Hazard Areas in the State. While all of these mapped SFHAs have flood elevations developed with an engineering model, many of them do not have mapped floodways. To make it easier for communities to implement floodplain zoning in these areas, North Carolina has established non-encroachment areas for all streams lacking mapped floodways. Non-encroachment stations have been determined at each modeled cross-section by a hydraulic modeling technique similar to the process used to determine regulatory floodway widths. However, the widths have not been optimized by repeated runs of the model. Therefore, the state requires that these surcharge values at individual cross-sections be less than the maximum value of 1.0 feet allowed by 44 CFR 60.3 (d)(2). North Carolina limits the surcharge to 0.7 feet unless the developer provides an engineering study that includes a mapped floodway. In this way, communities can allow development landward of these non-encroachment areas and also meet the requirements in 44 CFR 60.3 (c)(10) associated with SFHAs that have flood elevations but no floodways identified.

4. **Current practice:** FEMA's Guidelines and Specifications include guidance on how to develop a one-foot rise floodway based on loss of storage. However, when mapping regulatory floodways evaluating the loss of flood storage is not standard practice.

   Issues: The floodplain provides a valuable function by storing floodwaters. When fill or buildings are placed in the flood fringe, flood storage areas are lost and flood heights will increase because there is less room for the floodwaters. The cumulative impacts of encroachments in the floodplain can actually be more significant than identified in this assessment. As an example, Mecklenburg County, North Carolina analyzed several watersheds in their jurisdiction to determine the cumulative impact of fill in the floodplain fringe on downstream flood depths due to loss of floodplain storage. The results of the Mecklenburg County study indicated that based on the standard NFIP regulations (maximum surcharge of one (1) foot), continued in-filling of the floodplain fringe could result in flood elevation increases of up to 2.3 feet. (Mecklenburg County, 2008)

   Risk Mitigation Practice: The State of Illinois has enacted administrative rules for the northeast portion of the State in which the floodway is defined as: that portion of the channel and floodplain needed to store and convey the 100-year frequency flood event with no more than 0.1 foot increase in stage due to <u>loss of flood storage</u> (emphasis added) and conveyance, and no more than a 10% increase in velocity. DuPage County, Illinois (located in the northeastern portion of the State) has adopted floodplain regulations stating that any placement of fill, structures, or other materials above grade in the floodplain shall require compensatory storage equal to at least 1.5 times the volume of floodplain storage displaced, and shall be provided at the same incremental flood frequency elevation as the flood storage displaced.

5. **Current practice:** The NFIP regulatory floodway—and any floodway that is calculated using a hydraulic engineering model—is a hydraulic concept that is designed to prevent unacceptable increases in flood levels due to encroachments into the NFIP Special Flood Hazard Area. The concept does not address hydrologic changes that could increase flood levels such as the loss of floodplain storage, increase in impervious surface, or changes in precipitation patterns.

   Issues: One of the shortcomings of FEMA FIRMs is that the mapped flood zones are not based on future land use conditions.

   Risk Mitigation Practice: Charlotte-Mecklenburg, NC – To estimate the potential impacts of land use changes, Charlotte-Mecklenburg Storm Water Services assessed the hydrologic conditions of several watersheds using both existing land use and future land use. The general conclusion of the land use change pilot study is that flood depths would increase significantly for many of the watersheds. If the community continued to regulate floodplain development under hydrologic conditions based on the existing land use, a significant number of buildings would be expected to be constructed in areas that would become floodplain when the watersheds are re-studied in future years. As a result, Charlotte-Mecklenburg has developed Floodplain Land Use Maps (FLUMs) based on projected future land use conditions, which are used for new development.

6. **Current practice:** The Special Flood Hazard Area depicted on FIRMs identifies areas that will be inundated during the base flood (the one-percent annual chance flood event). FEMA has developed guidelines and administrative rules associated with flood-related hazards other than inundation but in most cases have not been authorized to include them on FIRMs.

   Issues: Inundation is not the only form of damage from flooding. Over time, streams meander laterally, and fill or degrade vertically as they adjust to their water levels, sediments, and slope. Stream channels may change suddenly and catastrophically.

   Risk Mitigation Practice: In Vermont, where erosion from flash flooding is the most expensive form of flood damage, the State has developed procedures for mapping Fluvial Erosion Hazard Zones and provides incentives to communities to adopt these maps to complement the FEMA flood inundation maps to address flood risks within their community. Vermont's designation of these zones as floodway has been affirmed by the Vermont State Supreme court.

7. **Current practice:** When evaluating the potential impact of encroachments into the floodway the analysis primarily focuses on lose of conveyance only. Again, the NFIP regulatory floodway is a hydraulic concept that is designed to prevent unacceptable increases in flood levels due to encroachments into the NFIP Special Flood Hazard Area. For encroachments that cause a surcharge that exceeds the acceptable threshold, modifications to the floodway hydraulics to mitigate the increase include increasing the flow conveyance by reducing the roughness of the stream channel and/or adjacent floodplain (U.S. Army Corps of Engineers, 1990).

   Issues: Removing native vegetation and paving the area reduces the roughness and allows the area to be constricted without increasing flood heights. However, this increases the flood flows velocities and increases the erosive properties of the flood flows. In addition, it removes valuable natural habitat in the floodplain.

   Risk Mitigation Practices:

   a. As stated previously, the State of Illinois has enacted administrative rules for the northeast portion of the State in which the floodway is defined as: that portion of the channel and floodplain needed to store and convey the 100-year frequency flood event with no more than 0.1 foot increase in stage due to loss of flood storage and conveyance, and <u>no more than a 10% increase in velocity</u> (emphasis added).

   b. Kenosha County, WI has adopted a floodplain overlay district in which the removal of trees, shrubs and foliage from the Floodplain Overlay District is prohibited.