FACT SHEET
Agriculture and Natural Resources

AEX-445-02

Floodplains and Streamway Setbacks

Andy Ward, Jessica L. D'Ambrosio, and Jonathan D. Witter
The Ohio State University Department of Food, Agricultural, and Biological Engineering
and the Ohio NEMO Program

Anand D. Jayakaran
Agricultural and Biological Engineering, Clemson University

Dan Mecklenburg
Ohio Department of Natural Resources Division of Soil and Water Conservation

Note: Information in this fact sheet is based in part on information in Chapter 6 in Ward, A. D., & Trimble, S. T. (2004). *Environmental hydrology* (2nd ed.). Boca Raton: CRC Press., and is presented with permission of Taylor and Francis CRC Press. Reference also has been made to *USDA-NRCS National Engineering Handbook Part 654 Stream Restoration Design.* (2007).

Introduction—Terminology

This fact sheet addresses the role and importance of *floodplains*, *riparian zones*, and *streamway* or *riparian setbacks* for sustaining or establishing stability in stream systems. The goal of this fact sheet is to aid the reader in understanding these systems so that he or she may then use this knowledge to protect and create floodplains for a healthier channel system. The terms *flood zone*, *floodplain*, *active floodplain*, *floodprone area*, *riparian zone*, and *streamway* or *riparian setbacks* are often used to describe land near the stream that is flooded. Often, these terms are used interchangeably when describing a stream system, but they have different meanings and can describe different locations on the landscape.

In the United States, *flood zones* are geographic areas that the Federal Emergency Management Agency (FEMA) has defined according to varying levels of flood risk[1]. The United States is divided into High, Moderate, and Low Risk flood zones. High Risk areas are mapped based on a 100-year flood event and have a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage (Figure 1). In communities that participate in the National Flood Insurance Program, the purchase of flood insurance is mandatory for all high-risk areas.

A *floodplain* is the area next to a river that experiences flooding when water comes out of the banks of the main channel (Figure 2). Rarely are these areas totally flat as the name might suggest. The size and shape of floodplains can vary widely. They can be very wide with very shallow water covering the land, or they can be very narrow with very deep water covering the land. Having an adequate amount of floodplain on each side of the stream channel is important to maintain stream integrity and stability.

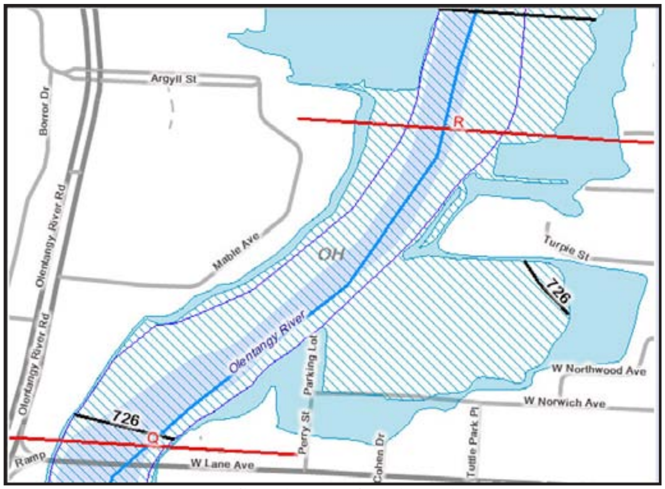

Figure 1. A 100-year flood zone for the Olentangy River near The Ohio State University campus in Columbus, Ohio.

Figure 2. Flow onto the active floodplain of a central Ohio river (shown in background).

From a stream's perspective, minimum floodplain sizes should be determined based on watershed drainage area or the width of the bankfull channel. The term *active floodplain* is used if the area receives periodic flooding (usually more than once annually) and aids in sustaining dynamic equilibrium. An *abandoned floodplain* or *terrace* describes an area that once served as the active floodplain but rarely experiences flooding because the main channel has downcut and is incised. A problem with the term *active floodplain* is that there is no upper limit to the size of the area described by this term.

The *floodprone area* is an area bordering a stream that will be covered by water at a height of twice the maximum bankfull depth (Figure 3). The width of the *floodprone area* is the stream width at which the discharge level is defined as twice the maximum bankfull depth. The width of the *floodprone area* is one of several factors used in the Rosgen stream classification system[2] and is not related to a specific storm event such as the 100-year event. However, in stable systems, *active floodplains* can also be considered the *floodprone area*.

The *streamway* is the zone within an *active floodplain* that is large enough to sustain dynamic equilibrium and provides enough space for the main channel to adjust its pattern. A *streamway setback* (often called a *riparian setback*) is a human-defined zone in which a "stream rules," and it should not be of concern if the main channel encroaches on or floods activities within this zone. If the setback is wide enough, it will have the same minimum size as the *streamway*.

Figure 4 illustrates the *streamway setback* concept by showing natural changes in the meander pattern and dimensions of Salt Creek, Ohio, from 1951–1997. It can be seen that a *streamway setback* based on a relationship to drainage area indicates that 518 feet of floodplain (indicated by the red solid lines in the upper figure) would be needed to encompass all the movement in the channel position over time. In 1951, the main channel was close to the right side of the floodplain, and in 1997 it was close to the left side of the floodplain. Figure 4 (lower figure) also illustrates that although much adjustment had taken place, the cross-section of Salt Creek was fairly similar in 1966, 1989, and 1997.

The word *riparian* means riverbank. A *riparian zone* is the land located immediately adjacent to a channel, and it provides the buffer between a channel and upland areas. Parts of *active floodplains* and *riparian zones* are often times the same areas of land. The term

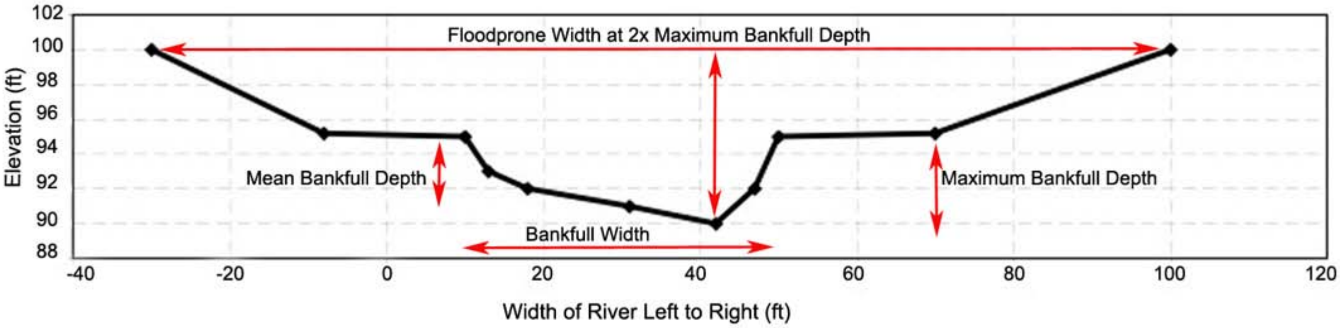

Figure 3. Floodprone area as defined by the Rosgen Stream Classification System.

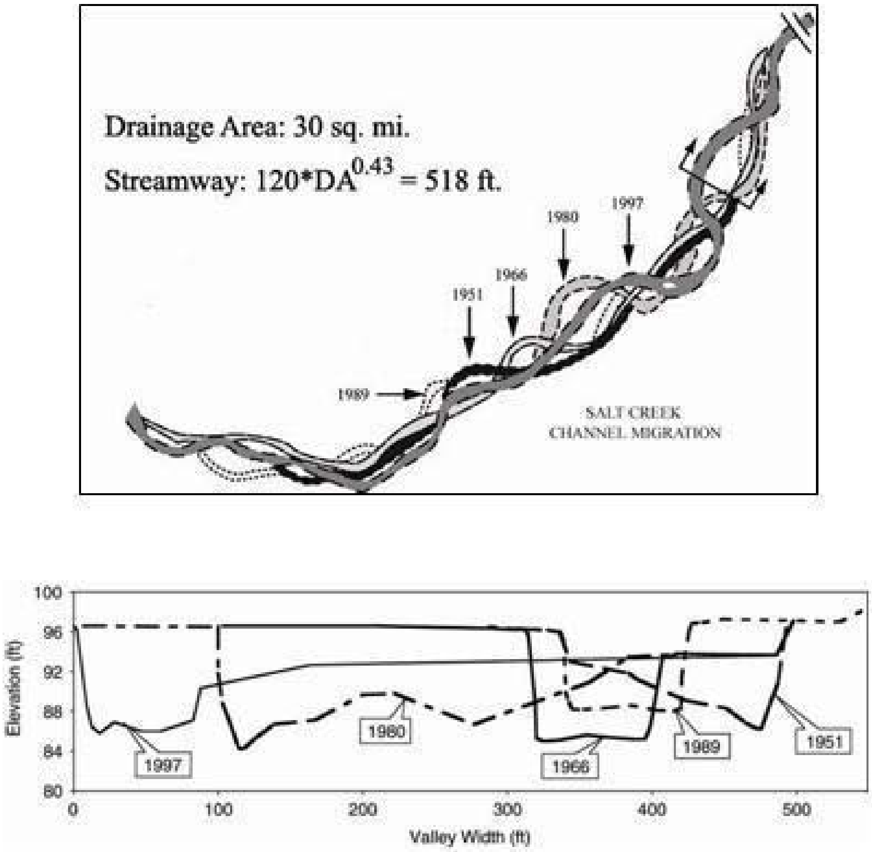

Figure 4. Plan view of meander patterns for Salt Creek, Ohio, from 1951 to 1997 (top). Cross-section view showing the changes in position and geometry during this time period (bottom).

riparian zone, however, is generally used to describe more natural areas (such as forests, grasslands, and wetlands) that have a lot of vegetation and provide a benefit to the local ecosystem (Figure 5).

Figure 5. Aerial view of an agricultural ditch with a grass riparian zone in the foreground and trees in the upper reaches.

The Importance of Floodplains

Floodplains serve many functions in a stream system. In streams that have not been affected by human modifications, the floodplain often contains well-established, rooted vegetation to help absorb the force as well as volume of rising floodwaters (Figure 6). The floodplain also serves to protect and stabilize stream banks from erosion. Vegetated floodplains offer other benefits to a stream system such as filtering pollutants; shading and cooling the stream; reducing floods by slowing down the speed of flood waters and increasing water seepage into the soil; and providing habitat for wildlife and recreation areas for humans.

Figure 6. Stable stream system with a vegetated active floodplain.

Structural attempts at flood control, such as making a channel deeper, straighter, or harder (i.e., rip-rap or concrete to line the channel), can cause a stream to go out of equilibrium, sometimes resulting in unexpected damage. In other words, the impact of altering channels and floodplains for the purpose of increasing the rate at which floodwaters move downstream will often worsen the severity, duration, and frequency of flooding events downstream. The flooding problem is not controlled; it is relocated from one spot to another.

Placing impervious surfaces such as buildings, roads, and parking lots within floodplains impairs their capacity to slow and absorb floodwaters and runoff from adjacent uplands, and increases the volume and speed of runoff into stream channels. This often results in downcutting and widening of the channel (Figure 7). The channel becomes incised and detached from the original floodplain. Bigger discharges remain within the channel rather than spilling on to the floodplain, and further widening and downcutting occurs until there is sufficient space for the channel to start recovering equilibrium by building a new floodplain at a lower elevation.

Figure 7. Incised urban stream in central Ohio that has downcut and widened.

Like other physical systems, streams always try to be in a state of equilibrium. Many factors influence the system, but the movement of water and sediment are the two primary influences on system equilibrium. Lane's classic description of channel stability states that dynamic equilibrium exists between stream power and the discharge of bed-material sediment[3]:

$$Q_s d_{50} \infty QS$$

where Q_s is the sediment discharge, d_{50} is the mean or median sediment size, Q is the discharge and S is the bed slope. This equation generally states that the force that flowing water exerts on the bed and banks of a stream channel, called the *shear stress*, is proportional to the product of the depth of flow of the water and the slope of the bed of the channel. The deeper the depth of flow, or the steeper the bed slope, the greater the force.

The size of bed material moving through the system is a measure of resistance of the flow of materials through the system. Larger material will have greater resistance to flow than smaller material. In other words, more stream power is necessary to move larger particles than smaller particles. If stream power is higher than the ability of the materials to resist being swept downstream, scour of the bed and banks, or *degradation*, will occur. If stream power is lower than the ability of the materials to resist being swept downstream, deposition of sediments on the bed and bank, or *aggradation*, will occur.

For every place in a section of stream there will be some combination of water depth and bed slope that will cause the movement of sediment to occur. The maximum stream power and shear stress on the bed and banks can not be greatly exceeded over a long period of time if the geometry (i.e., the pattern, dimension, and profile) of the main channel is to achieve equilibrium. In order to accomplish equilibrium, flows larger than the bankfull, or channel-forming, discharges need to get out of the channel and spread across an active floodplain. Therefore, the maximum flow depths, discharges, and sediment loads in the main channel stay within the equilibrium threshold, and the bed and bank materials do not scour.

A simple but approximate way of estimating when scour will occur is to use Andy's Rule, which states, "if the depth of flow is 1 foot and the bed slope is 1% then the average size bed material that will start to move will have a size of 1 inch."[3]. For many streams that are in equilibrium, we find that by using Andy's Rule, the mean bed material size is related to the mean bankfull depth and the bed slope.

How Much Floodplain Is Really Needed?

Many local communities, watershed groups, counties, and states are developing rules to help protect stream systems and alleviate flooding concerns. Floodplain regulations have ranged from mandating no development in the 100-year floodplain to having a fixed setback width, such as 100 feet. Unfortunately, existing guidelines are highly variable, having been developed on the basis of different objectives. Federally recommended buffer widths vary from 30–300 feet, which encompass the range of buffers expected for water quality control, wildlife habitat protection, and stream buffer programs[4]. A variety of scientific studies on the minimum and optimum width of a vegetated floodplain along a stream indicate that a width of 10 feet is not enough to provide adequate filtration or habitat[5]. A study by the U.S. Environmental Protection Agency indicates that in order to effectively remove nutrients and sediments, a buffer of 100 feet is needed[4]. These approaches are only loosely related to the size and shape of a stream, if at all, and will provide highly variable levels of effectiveness.

The authors developed two empirical-based approaches to sizing floodplains. Based on regional curves for the eastern United States that relate channel width to drainage area, DA (mi^2), the following relationship was developed:

$$S_w = 120^* DA^{0.43}$$

where, S_w is the streamway width in feet. The empirical approach presented here is appropriate in valleys that are broad enough for the meander pattern to be a function of the bankfull width or drainage area. For incised agricultural channels in the Midwest region of the United States, the authors recommend a streamway width that is at least three times the bankfull width[3]. Systems with these magnitude streamways likely have the potential to self-adjust to low levels of development, human alteration, and floodplain modification. Where streamway widths are less than 3 times the bankfull width, equilibrium is very dependent on the bank, floodplain vegetation, and/or human measures to maintain stability.

A more process-based approach to sizing floodplains is to consider sediment transport, the shear stresses on the bottom and sides of the channel, and mean velocities within the stream system[6]. This process is illustrated with an example comparing an incised trapezoidal channel, which is typical of many large agricultural ditches in the Midwest region of the United States, and a channel that has a well-connected active floodplain[6] (Figure 8). A floodplain ratio (FPR) was used to evaluate different active floodplain widths. The FPR was defined as the floodplain width, at the bottom of the second stage, to the bankfull width, which is the channel width at the top of the first stage (see figure 8).

Where small benches have developed (Figure 8B), there is a 20% increase in the shear stresses in the main channel and an 80% increase in bedload transport when compared with the single-stage channel (Figure 8A). Even with high roughness on the floodplain (i.e., lots of vegetation), the mean bank shear stresses in the second stage are lower than they were for the single-stage trapezoidal channel[6].

At an FPR of 3, the depth of flow for the 25-year recurrence interval discharge is at twice the maximum bankfull depth and corresponds to the *floodprone area* described by the Rosgen classification system[2]. An FPR of 5 reduces the shear stresses and velocities of flow in the main channel to values that are similar or less than those in the single-stage trapezoidal channel (FPR of 1). An FPR of 9, along with high floodplain roughness, provides lower values than the single-stage channel for all attributes except bedload transport. Based on this example and other studies by the authors, it appears that an FPR between 5 and 10 is needed to obtain a self-flushing, self-sustaining system[7, 8, 9].

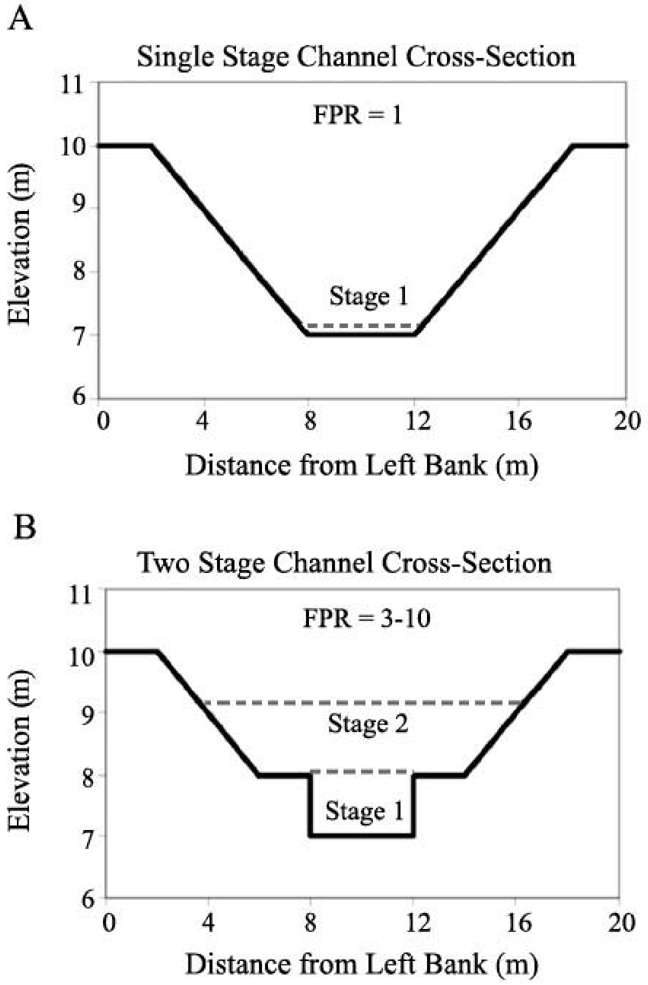

Figure 8. Cross-section of a A. typical 1-stage trapezoidal channel with a Floodplain Ratio = 1; and a B. a 2-stage channel with a Floodplain Ratio of 3–10 (from Jayakaran et al., 2007).

This fact sheet is not intended as a guide to restoration. Procedures that are helpful in stream channel design are present in a new handbook released by the USDA-NRCS[9]. Application of these approaches reduces the amount of initial engineering of the system and focuses on assisting nature in developing a more self-sustaining system. Regardless of the method used, a floodplain protection plan should have the main goal of providing enough space for the stream to adjust and maintain itself in a state of equilibrium. We conclude that an important consideration in most stream projects is the availability of an active floodplain. Ideally, active floodplains should have FPRs greater than 5; however, smaller floodplains will have some beneficial influences on the sustainability of channel systems.

Acknowledgments

This publication was produced in cooperation with the Ohio Department of Natural Resources Division of Soil and Water Conservation, The Ohio State University Department of Food, Agricultural, and Biological Engineering, and the Ohio NEMO Program with funding from the Ohio Environmental Protection Agency as part of a larger Section 319 Nonpoint Source Program grant. The authors express their appreciation to the reviewers of this project and to Heather Murphy Gates, Associate Editor (Communications and Technology, The Ohio State University), for editorial and graphic production.

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Keith L. Smith, Ph.D., Associate Vice President for Agricultural Administration and Director, Ohio State University Extension

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