Chapter 4 – Fundamentals of Flooding

4.0 Evaluating Floods

Flooding is a natural process. It occurs on every river, large and small, in urbanized streams and mountainous creeks. Flooding can result from a shift in the weather patterns, basin topography, channel changes, land use, flow restrictions (dams), or flood control structures (dikes, levees).

This chapter describes how floods occur. Some of the factors that are used to evaluate impacts caused by flooding include the magnitude of the flood (its peak flow rate); the duration of the flood; potential for migration of the river channel; the deposition of sediments; the presence of and failure of levees; land development status (such as the presence of structures that can be damaged); land or crops lost; and the combination of tide and wind.

4.1 Flood Terminology

When describing flood events, engineers, scientists, and others generally refer to a flood's magnitude, duration, and timing. Once these parameters are quantified, the flood's size is designated. The following subsections describe these terms.

4.1.1 Flood Magnitude

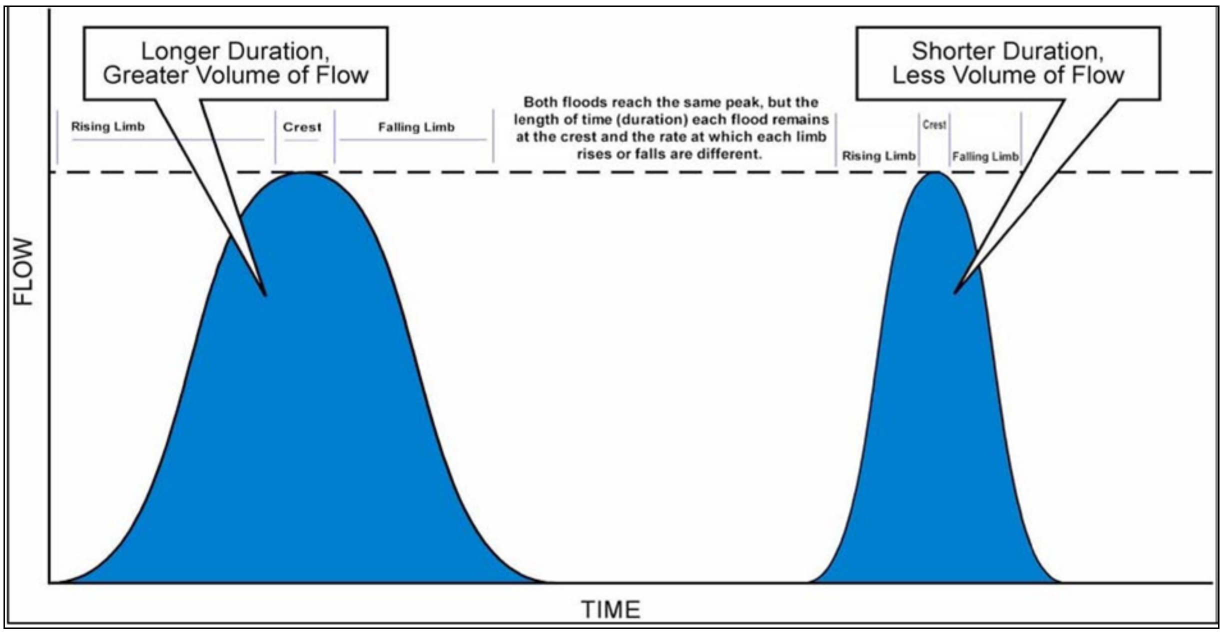
Floods are a regular, natural occurrence. Large floods have occurred on the Skagit River throughout its recorded history. As a general rule, floods with greater flow rates, or magnitudes, usually caused more damage. Today, however, smaller flood events cause more damage than in past decades. This increased damage is not necessarily because the floods themselves have grown, but because development that is susceptible to flood damage has increased in areas where flooding naturally occurs, including the *floodplain*. As the river aggrades and the floodplain becomes more developed, the smaller magnitude events can cause significant damage. U.S. Geological Survey (USGS) gages are used to record Skagit River flows. The gages record parameters that allow river flow in *cubic feet per second* or *discharge* to be determined.

The records from the USGS gages over the years are used to determine the likelihood of floods of a certain magnitude on the Skagit River (measured as a *recurrence interval*). Most rivers have a natural capacity to contain only the 2- or 5-year flood before floodwaters overtop the banks. The statistics on which flood-frequency definitions are based are the records of actual flooding that has taken place in the past. As records continue to be collected over time, flood-frequency estimates are modified to reflect the newest data. In the United States, the 100-year flood is used as a base flood to rate the effectiveness of flood hazard management measures.

4.1.2 Flood Duration

Floods may have similar peak flows, but floods that remain at that peak for a longer period of time or duration can cause significantly more property damage. Floods of longer duration can be more devastating for several reasons. Soils lose their absorption capacity and more water runs off on the ground surface. Levees can become saturated, which increases their potential to fail. In addition, rapid drops in water levels after the river has crested can make levees more susceptible to failure. If the flood occurs during planting, crops can be destroyed if soils remain inundated for long periods of time. Landslides and the subsequent sediment loads to the river become more likely as well.

Figure 4.1 – Flood Duration Hydrographs



(Snohomish, 2003)

4.1.3 Flood Timing

Over the course of a flood, the flow in a river rises to a peak and then subsides. This peak can be measured in either flow (cfs) or in terms of *stage* (in feet). Generally when flood warning information is provided to the public, it is provided in terms of *stage* or *elevation* that corresponds to the peak that water levels rise at a particular location along the river.

This peak is also commonly referred to as the river crest. The river crests in the upstream reaches of a river first, and then moves downstream. Faster moving crests tend to have higher velocities causing accelerated bank erosion. The speed that the crest moves downstream depends on a number of factors. The crest on smaller systems tends to translate downstream to the main system more quickly. The greater the difference in elevation at the uppermost point of the river (beginning of the crest) and the outlet point, generally the faster the crest travels downstream. Increasing the availability of flood storage areas, providing additional conveyance channels, or retaining forest or vegetative cover in the headwater regions can slow the rate a crest travels downstream.

To prepare for floods, it is important to understand how quickly the peak travels from one point to another along the river. Gages on the Skagit River allow emergency management officials to more accurately predict when the flood crest will reach critical areas downstream. This knowledge aids in providing necessary warning to residents on the mainstem.

4.1.4 Flood Designation

Generally, changes in flood events over time are analyzed using the highest flow or peak flow for each year. Gages are placed at select points on rivers to measure the stage at that point. To more accurately assess changes in peak flows, gages should be continuously operated for 30 years or more.

4.2 ~~100-Year Flood~~ Extreme Floods and the 100-Year Flood

Across the Pacific Northwest, rivers rose to record flood levels during November 1990 and 1995, February 1996, and March 1997. The 100-year flood has a 1 in 100 probability of occurring or 1 percent chance of being equaled or exceeded in any given year. The actual number of years between floods of any given size varies. Big floods can happen more than once in a given year or not at all for several years in a row. Climatic conditions, such as El Niño, can change weather patterns, making it possible to have several wet years in a row, which increases the chances of getting significant flooding regularly.

The problem lies in the terminology. Although the 25-year flood sounds like it should occur only once every 25 years, it actually has a 4 percent chance that it will occur in any year. Similarly, the 100-year flood has a 1 in 100 probability of occurring or 1 percent chance of being equaled or exceeded in any given year.

The actual number of years between floods of any given size varies. Big floods can happen more than once in a given year or not at all for several years in a row. Climatic conditions, such as El Niño, can change weather patterns, making it possible to have several wet years in a row, which increases the chances of getting significant flooding regularly.

4.3 What Causes Flooding?

Flooding is a natural process. It occurs on every river, large and small, in urbanized streams and mountainous creeks. Flooding can result from a shift in the weather patterns, basin topography, channel changes, land use, flow restrictions (dams), or flood control structures (dikes, levees).

Samish Island (2009)
(Courtesy of Skagit County Public Works)

4.3.1 The Hydrologic Cycle

The hydrologic cycle begins with evaporation of water from the oceans. Moving air masses transport the resulting vapor. Precipitation is produced when the air masses are lifted, cooling the air, condensing the moisture and forming clouds. Air masses can be lifted through local heating or as air passes over a mountain range. The latter is called *orographic uplift* and it results in zones of high annual precipitation on the windward side of mountains.

The precipitation that falls on land as rain and snow is dispersed in several ways. A large part is temporarily retained in the soil near where it falls. Heavily forested areas intercept a significant amount of precipitation, which is released back to the atmosphere through *evapotranspiration*.

Evapotranspiration reduces the volume of flows in rivers and streams (Booth and Jackson, 1997) because less water reaches the river system to begin with. A portion of the precipitation finds it way over and through the surface soil to stream channels, while other water infiltrates into the soil to become part of the groundwater. Both groundwater and surface water flow, through gravity, back toward the ocean.

4.3.2 Land Management and Flooding

The impacts of flooding can also be exacerbated by how land is managed in the basin. Human activities such as forest and agricultural practices, and urbanization can effectively increase the volume of flow and speed up the arrival of the peak flow. Clearcutting large tracts of land, constructing housing developments or industrial areas, constructing roads and highways, establishing infrastructure, eliminating floodwater storage areas (e.g., wetlands) or removing obstacles that slow the flow down (e.g., trees) can all contribute to increasing flood damages.

These practices can add significant volumes of sediment to the river system. Large landslides can cause aggradation, destroy critical spawning grounds and fill in the channel forcing the water to create new flow paths. Managing land use can assist in reducing potential impacts of flooding.

4.3.3 "Controlling" Floods

Flood control structures in any form can temporarily prevent floodplain buildings from being flooded, but dikes, levees, channelization, and other manmade structures designed to restrict or alter flow paths cannot withstand every flood. Overtopping of the structure will eventually occur. Some may even increase flood damages if floodwaters pond behind the structure, increasing the length of time homes are inundated or saturating the flood control structure itself causing it to fail. Channelization or straightening the river increases channel velocities, bank erosion, and may aid in increasing debris loading (trees).

Constructing dikes can give a false sense of security in that homeowners feel protected from floodwaters. This feeling leads to more development, which places more buildings on the floodplain leading to higher flood damages when the flood control structure is eventually overtopped. Effective use of flood storage or conveyance areas aids in reducing flood damages, but it will not eliminate the potential of flooding from occurring. For these reasons, actions that encourage natural floodplain processes were incorporated in this plan to reduce public exposure to risk and prevent continued property damage. (Snohomish, 2003)

4.4 References

Booth, D.B. and C. R. Jackson. 1997. *Urbanization of Aquatic Systems: Degradation Thresholds, Stormwater Detention and the Limits of Mitigation*. Journal of the American Water Resources Association. USA.

Snohomish County. 2003. *Draft Public Review Stillaguamish River Comprehensive Flood Hazard Management Plan*. Snohomish County, WA. Snohomish County Public Works.