Coastal Flood Studies

The State of North Carolina, through the Federal Emergency Management Agency's (FEMA's) Cooperating Technical Partnership initiative, has assumed primary ownership of and responsibility for the Flood Insurance Rate Maps (FIRMs) for all North Carolina Communities as part of the National Flood Insurance Program (NFIP). These maps show the extent of the 1% annual chance floodplain, also known as the Special Flood Hazard Area (SFHA). Floodplain management regulations apply within the SFHA, and flood insurance is required for all property in the SFHA used to secure federally backed loans.

Along rivers, streams, and lakes, flood elevations are computed and used to delineate the extent of SFHAs. These elevations are a function of the amount of water expected to drain into particular water body as a result of precipitation and runoff. In coastal areas, however, the primary contributor to flood elevations is the phenomenon known as "storm surge". Furthermore, wave action contributes significantly to coastal flood elevations. The purpose of this fact sheet is to provide information on the different components of coastal flood elevations and explain how coastal SFHAs and flood zones are mapped on the FIRM. For information on flood insurance for property located in coastal SFHAs, please refer to the "Flood Insurance Facts for Coastal Homeowners" fact sheet.

How are coastal flood elevations determined?

Along a coastline, major floods are caused by coastal storms, usually hurricanes and northeasters. These types of storms bring very strong winds and waves that combine to "pile" water up against the shore and cause damage to both manmade and natural coastal features. An engineering study, often referred to as a **coastal flood study**, analyzes the effects of a direct or near-direct hit on a coastal community by a hurricane to determine flood elevations and delineate SFHAs. The study also identifies **coastal high hazard areas** within the SFHAs that are at the highest risk of damage caused by the combined effects of flooding and high wave action.

How is a coastal flood study performed?

A coastal flood study considers four separate effects of a coastal storm which, when added together, determine the coastal flood elevations for a particular location along the shoreline and further inland.

<u>Stillwater Elevation</u>

Long before a hurricane or northeaster makes landfall, the combined effect of circulating winds and large drop in air pressure causes a rise in sea level that creates a dome of water a few feet high in the vicinity of the storm. When it reaches the shoreline, the shallower seafloor forces the dome of water to rise dramatically, reaching heights of 10 to 20 feet above sea level. As it moves onshore, this **storm surge** is the largest component of coastal flooding. When considered separately from wave effects, its elevation is referred to as the **stillwater elevation**.

<u>Wave Setup</u>

As waves from a coastal storm batter a coastline for several hours, they tend to "pump" up the water surface higher than the stillwater elevation. This effect is referred to as **wave setup**.

<u>Wave Crest Elevation</u>

Waves driven by hurricane-force winds ride atop the storm surge plus wave setup and alternately increase and decrease the water surface elevation. The **wave crest elevation** is the additional height that water reaches above the combined stillwater elevation plus wave setup height as a coastal storm moves onshore.

<u>Wave Runup</u>

When waves hit the shoreline, the water is moving with such momentum that it is forced upward as it moves inland, particularly where there are steep bluffs, dunes, or man-made structures. The additional height beyond the stillwater elevation reached by waves is called **wave runup**.

How are these effects analyzed to determine coastal flood elevations?

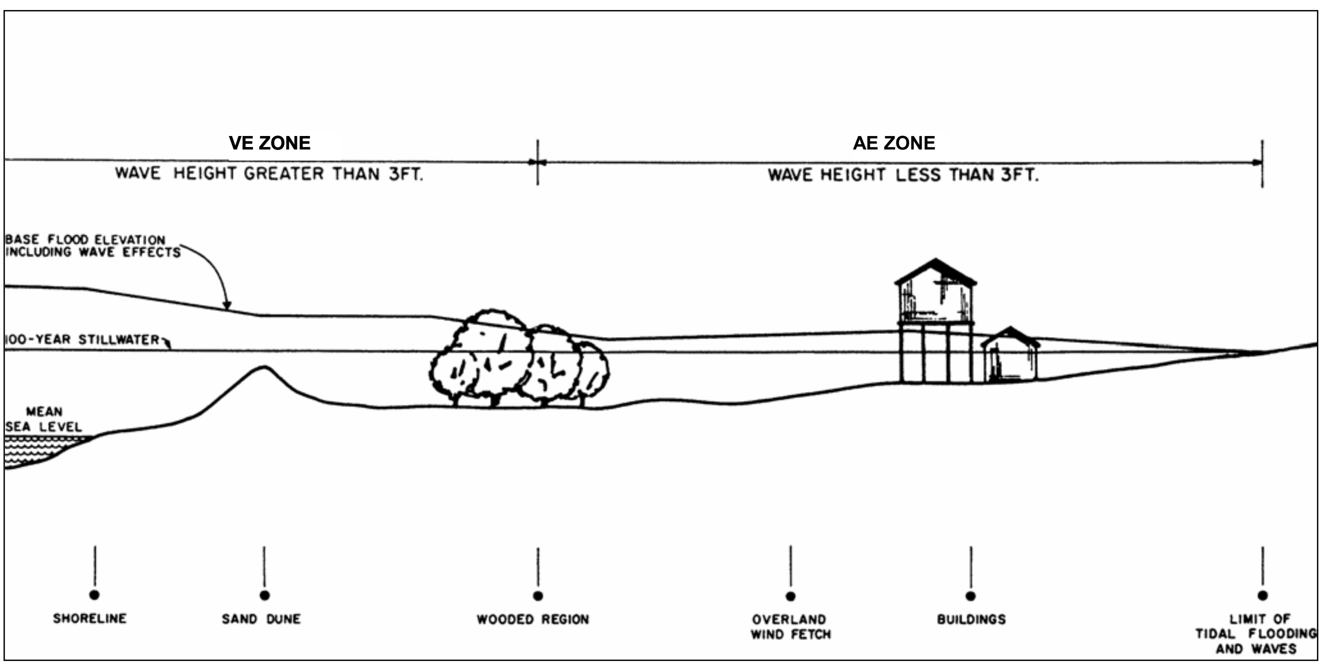
The methods used to analyze coastal storm effects are established by FEMA. Three computer programs are used to simulate the impact of a coastal storm on a section of coastline. The FEMA Coastal Storm Surge Model is used to determine the elevations for the 10% (10-year), 2% (50-year), 1% (100-year), and 0.2% (500-year) annual chance stillwater elevations. The second FEMA computer program, Wave Height Analysis for Flood Insurance Studies (WHAFIS), accounts for erosion and provides the maximum expected wave crest elevation that must be added to the stillwater elevation plus wave setup. Wave setup is determined using engineering equations derived by the U.S Army Corps of Engineers. These equations take into account the offshore wave conditions and the slope of the beach and seafloor. On coastlines where wave runup must be considered, it is computed using the FEMA Runup Model computer program.

Using these methods, coastal engineers calculate storm surge and wave heights along a series of **transects** that represent the path of a coastal storm as it moves onshore.

How is the information from the computer simulations used to draw the Flood Insurance Rate Map?

From the stillwater elevation and wave height data computed along the transects, coastal engineers can use topographic map data to interpolate flood elevations between the transects. The engineers transfer this information to a base map that shows features of the community: shorelines, roads, municipal boundaries, etc. New flood maps use an aerial photograph as a base map.

The figure below is a schematic view showing the stillwater elevation and the increased water surface elevation caused by wave effects along a transect. The combination of the 1% annual chance stillwater and wave effect (crest, setup, and runup) water elevation above the vertical datum is the Base Flood Elevation, or **BFE**, that will be shown on the Flood Insurance Rate Map. For more information about the vertical datum, please refer to the "Vertical Datum Changes" fact sheet which explains the difference between the National Geodetic Vertical Datum of 1929 (NGVD 29) historically used on FIRMs, and the North American Vertical Datum of 1988 (NAVD 88) used on recently updated FIRMs.



Engineers depict flood hazard data on the map by drawing outlines of the flood risk zones. The SFHAs (areas where the there is a 1% or greater annual chance of flooding) are identified as AE Zones or VE Zones. Areas where there is a lower (between 0.2% and 1% annual chance) risk of flooding are identified as Shaded X Zones. Areas where there is a minimal risk of flooding (less than 0.2% annual chance) are identified as Unshaded X Zones.

The coastal AE and VE zones are further subdivided by lines that separate areas with different BFEs. Within each of these areas, the risk zone (AE or VE) and the BFE are identified. For instance, **ZONE VE (EL 14)** on the FIRM indicates that the area is in the VE risk zone and the BFE is 14 feet above mean seal level. A coastal AE Zone with a BFE of 12 feet is designated on the FIRM as **ZONE AE (EL 12)**.

What is the difference between an AE Zone and a VE Zone?

One output of the aforementioned WHAFIS computer model is the distance inland from the shoreline where wave heights are greater than three feet during the 1% annual chance storm. This distance defines the boundary of the coastal high hazard area where the combined risk of flood and wave damage is highest. These areas are designated as VE Zones. The "V" stands for "velocity wave action", indicating that waves in these areas will be powerful enough to break the wall panel of a residential structure away from the floor to which it has been nailed. The VE designation is also assigned to areas seaward of a continuous, substantial dune feature. Coastal flood areas with wave heights <u>less</u> than three feet are mapped as AE Zones.

Are construction standards different for structures in VE Zones versus AE Zones?

Yes. Because of the risk of damage by wave action, VE Zones are subject to more stringent regulatory requirements than AE Zones. At a minimum, the bottom of the lowest horizontal structural members supporting the lowest floor of a residential or commercial building must be elevated to or above the BFE in a VE Zone. No enclosed area is allowed below the lowest floor unless it is constructed of breakaway walls that will not damage the rest of the building if they are detached by storm waves. And, there is no option to floodproof a VE Zone non-residential building instead of elevating it, as there for non-residential structures in AE Zones.

There are also specific foundation requirements for structures in VE Zones. Buildings must be supported on pile, post, or column foundations. Fill material cannot be used for structural support because of the severe potential for erosion in VE Zone locations. The foundation and the attached structure must be designed to resist the combined forces imposed by winds and water during the 1% annual chance storm. A registered professional engineer or architect must certify that the design and methods of constructions for VE Zone structures are in accordance with accepted standards of practice for meeting the above provisions.

If the FIRM shows that my property is located in a VE Zone, will I need a CAMA permit to build a new house or modify my existing house?

Yes. The North Carolina Coastal Area Management Act (CAMA) requires permits for development in Areas of Environmental Concern (AEC). According to the Act, a VE Zone is considered to be a "High Hazard Flood" AEC which is one of three AECs that make up the CAMA "Ocean Hazard System". The other two AECs in this category are the "Ocean Erodible" AEC and the "Inlet Hazard" AEC. Contact one of the CAMA offices in Raleigh, Elizabeth City, Morehead City, Washington, or Wilmington for help with determining whether your coastal property is subject to CAMA permitting requirements.

Do NFIP insurance rates differ in AE Zones and VE Zones?

Yes. The higher level of risk in VE Zones is also reflected in the higher insurance rates that are charged for a similar amount of insurance coverage in VE Zones, as compared to AE Zones. Please refer to the "Flood Insurance Facts for Coastal Homeowners" fact sheet for more information, including a comparison of insurance premiums for different flood risk zones and coverage amounts.

The FIRM for my community shows my property in an AO Zone. How does an AO Zone differ from AE and VE Zones?

In coastal areas, wave runup can send water flowing inland over flat areas and dunes. Coastal engineers can perform a shallow flood study to determine the depth of flooding resulting from the 1% annual chance flood event. If the flood depth is between one and three feet above the ground surface, the area will be designated as an AO Zone. For instance, **ZONE AO (DEPTH 2')** on the FIRM indicates that flowing water in this area reaches a depth of 2 feet.

Often, wave-driven water will flow behind an obstruction such as a dune which keeps it from draining back into the ocean. If a shallow flood study indicates that this water will collect or "pond" behind an obstruction to a depth of one to three feet, the area will be designated as Zone AH and the BFE will be indicated on the FIRM.

NFIP flood insurance rates for houses in AO and AH Zones are lower than rates for houses in AE and VE Zones.

My community recently undertook a beach renourishment project. Does the new coastal flood study take this into account?

No. Under FEMA's required methodology for coastal flood studies, beach renourishment projects are not considered in the engineering analyses. This is because a renourishment project represents a temporary alteration of the beach profile which is likely to erode away over a relatively short period of time. Since no permanent funding source exists for local renourishment projects, there is no assurance that the beach will continue to be renourished in the future. Flood Insurance Rate Maps typically remain in effect for several years, so FEMA requires that coastal flood studies be based on the natural (unaltered) beach profile.

My community is protected from coastal storms by a large dune. Does the new coastal flood study take this into account?

If there is a continuous dune along the shoreline (referred to as a **primary frontal dune**), the coastal flood study includes an analysis of how the dune will be affected by the 1% annual chance storm. The analysis considers the height of the dune relative to the predicted height of the combined storm surge and wave effects to determine whether the dune will be overtopped. Since the dune will be subject to severe erosion during a coastal storm, the analysis also considers whether the dune is large enough to survive the storm or not. FEMA has established the following criterion based on historical data: primary frontal dunes with a cross sectional area of more that 540 square feet are considered to provide adequate protection from a 1% annual chance coastal storm; dunes with less that 540 square feet are considered to fail and provide no protection from the 1% annual chance coastal storm.

If the analysis shows that the primary frontal dune is not overtopped and has a large enough cross section to survive the effects of the model storm, then the inland limit of the VE zone is mapped at the inland "toe" of the primary frontal dune. If the dune is overtopped but still survives the storm, then the VE zone will extend inland beyond the dune, but the wave energy absorbed by the dune will limit the extent of the VE zone. However if the analysis indicates that the dune will fail during the model storm, the analysis does not consider the dune and the VE zone typically extends much further inland.

Where can I find specific information about the coastal flood study for my community?

FEMA and the State of North Carolina issue a "Flood Insurance Study" (FIS) report for each county in North Carolina. Section 5 of the FIS report describes the engineering methods used to analyze both coastal and riverine flooding in a particular county. Tables in the FIS report show the storm characteristics used in the storm surge computer model and the 10%, 2%, 1%, and 0.2% annual chance stillwater elevations, wave runup, and wave height analysis results for each transect.