DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OPEN FILE REPORT 78-767
MOHLER AND NOVAK—100-YEAR FLOOD MAP,
FAIRFAX CO., VA.

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FAIRFAX COUNTY 100-YEAR FLOOD MAP

This map shows approximately the land area that will be covered by a 100-year flood for all major streams in Fairfax County. The map is based largely on information from highly detailed reports. At any site within the delineated flood plains there is at least a 1 in 100 or 1 percent chance of being flooded each year. The elevation of the 100-year flood in feet above mean sea level (msl), and the flood discharge in cubic feet per second (ft^3/s), under conditions of ultimate development, are shown at selected sites on the map. Ultimate development is the condition of land use where imperviousness will be increased to a maximum expected value in accordance with zoning plans adopted for a given area. Also, as development proceeds and changes are made to the natural drainage system, time for storm runoff to move downstream generally decreases, resulting in increased flood peak discharges and elevations. Flood boundaries determined by the U. S. Geological Survey are shown as solid lines on the map. Dashed lines show flood boundaries defined by other government agencies or by private engineering firms. They include flood plains within the city of Fairfax, as well as those for Tripps Run and Holmes Run upstream from Lake Barcroft, Little Hunting Creek, Dogue Creek, and several small headwater streams.

This map is one of a series describing geologic and hydrologic conditions in Fairfax County, and is intended to provide a broad overview of flood information. For planning purposes, this map can be used in combination with related maps published at the same scale that depict landforms, geology, and ground-water hydrology. For detailed design or specific site evaluation, users should consult the larger scale flood maps cited in the references.

FACTORS AFFECTING FLOODING

Climate, geology, topography and man-made features affect flood potentials. The natural features remain relatively constant in time but vary areally and alter flood characteristics of different streams through control of rainfall, soil infiltration, storage, land slopes, and so forth. Man-made features can vary significantly in both time and space and may either increase or decrease the flood potentials.

Three types of storms cause flooding in Fairfax County: thunderstorms, hurricane or tropical storms, and frontal storms. Summer thunderstorms with high intensity-short duration rainfall are the major cause of local flooding. Tropical storms, producing excessive amounts of rain, cause widespread severe flooding. Frontal storms generally have less rainfall, but may cause significant flooding depending upon antecedent soil-moisture conditions. An example of severe flooding resulting from a tropical storm is the flood of June 22, 1972 on Horsepen at Sully Road. Torrential rains caused by tropical storm "Agnes" produced a peak flow of 8,250 ft^3/s, 234 cubic meters per second (m^3/s) at this site. This discharge was about 20 percent greater than the 100-year flood of 7,000 ft^3/s (198 m^3/s) shown on the map.

The extent of flooding is strongly influenced by topographic features which in turn are controlled by the local geology. Fairfax County includes parts of two physiographic provinces; the Coastal Plain in the east and the Piedmont in the west. The Fall Line, which separates the two provinces, is a northeast trending line that generally is followed by the route of Shirley Highway (I-95). The Piedmont province consists of two distinct geologic terranes: the deeply weathered crystalline rocks (granite, schist, and similar rocks) in the central part of the county, and the sandstone, shale, and diabase in the western part of the county. (See bedrock map by Drake and Froelich, 1977, for occurrence and description of these rocks). Flood plains are generally narrow in the relatively steep stream valleys draining the crystalline rock terrane, such as, in the Difficult Run basin. In contrast, wider flood plains typify the flatter terrane formed on sandstone and shale on the western Piedmont, as in the Cub Run basin. Similarly, flood plains in the Coastal Plain are broader as the streams approach the Potomac estuary and stream velocities are greatly reduced.

Man-made features may either increase or decrease flood run-off. Urbanization usually increases run-off by reducing infiltration and magnifies flood peaks through improved drainage systems. The construction of streets, parking lots, buildings, etc., increases the amount of impervious surface thereby reducing infiltration and increasing run-off. Also, when natural drainage channels are improved or replaced by storm sewer systems the travel time of storm run-off is shortened resulting in higher peak discharges and flood elevations.

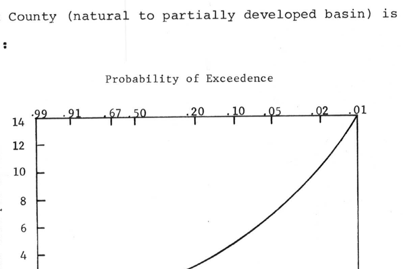
Structures such as detention ponds artificial lakes, and reservoirs retard the movement of flood waters and reduce downstream flood potential until design capacities are exceeded. An example of the effect of reservoir storage on flood discharges and stages can be seen on Snakeden Branch at Lake Elsa (Difficult Run drainage basin). Flood runoff is controlled by the dam and the discharge outlet structure. This detention of the flood waters results in greatly reduced flood heights in the channel downstream. As the 100-year flood peak of 2,600 ft^3/s (73.6 m^3/s) passes through the lake, the water surface rises to an elevation of 297 feet (above msl). However, as the water rises in the lake, the flow through the outlet structure increases slowly and stabilizes at a maximum rate of only 400 ft^3/s (11.3 m^3/s) during the passage of the flood. Although detention structures reduce flood potential immediately downstream, the location of such structures in an urbanizing basin may be critical. For example, the detention of flood waters in the downstream part of a drainage basin combined with increased flood-runoff from upstream developing areas may result in increased flood potential downstream from the "controlled" tributaries. In any case downstream flood plains will have to carry flows in excess of the design capacity of storage structures and floods resulting from structural failure.

FLOOD MAGNITUDE AND FREQUENCY

Knowledge of the magnitude and frequency of floods is necessary for effective planning and optimal design of highways, parks, lakes, dams, water-supply plants, sewage-treatment plants, and industrial and residential buildings. Knowledge of flood frequency also is required for flood insurance and flood-plain management programs designed to manage economic losses associated with floods.

In order to establish the frequency with which floods of various sizes occur, flood discharges are measured at specific sites for many years. The largest flood discharge that occurs during each year is called the annual flood. A statistical analysis of annual floods provides a flood frequency curve relating flood size to the probability of occurrence of a larger size flood during any one-year period. Probability, as related to flooding, is the chance that a flood larger than a particular size will happen during any year and is expressed as a decimal fraction (i.e. zero to one) or as a percentage. Thus, a flood discharge with a probability of 0.50 means that there is a 50 percent chance that a larger flood can occur in any year.

Frequency of flood events also is often expressed by the terms "recurrence interval" or "return period." The recurrence interval is the average interval of time within which a flood of a given size will be exceeded once. For example, a 100-year flood will be exceeded, on the average, 5 times in a 500-year period. However, one or more of the 5 rare floods may occur in consecutive years within the period. The reciprocal of the recurrence interval is the probability of the flood occurring in any one year. Thus, a 100-year flood has a 1-percent chance of occurring in any one year. The frequency of flooding, expressed as the relation of recurrence interval (and probability) to peak discharge for a stream in Fairfax County (natural to partially developed basin) is as follows:



Flood-frequency curve for Difficult Run at Great Falls, Va.

A frequency analysis of flood records at gaging stations provides information at a specific site. Since it is neither possible nor desirable to gage all streams where information is needed, techniques have been developed to transfer data from gaged sites to ungaged sites. Using multiple regression methods, streamflow data, such as flood peak discharges have been related to measurable climatic and topographic basin characteristics.. For a detailed explanation of these techniques as they apply to the Potomac River basin see Thomas and Benson (1970).

Flood peak discharges in urbanizing areas of Northern Virginia are related to five physical characteristics of a drainage basin as shown by Anderson (1970). These are basin size, length and slope of the main channel, the percentage of impervious surface, and the type of drainage system installed as the basin is developed. Anderson's study showed that man-made changes to stream channels can drastically reduce lag time (the time interval between rainfall and runoff); to as little as one-eighth that of natural channels. A reduction in lag-time, combined with increased storm runoff from impervious areas can increase flood peak discharges by a factor of about two to eight times. For example, the flood-frequency curve for Difficult Run at Great Falls, Virginia shows the 100-year flood to be 14,000 ft^3/s (396 m^3/s) for natural to partly developed conditions. However, under conditions of ultimate development the expected 100-year discharge would be 27,000 ft^3/s (765 m^3/s) as shown on the map.

Risk of exceeding a selected flood level increases with time. Risk may be defined as the probability that one or more floods will exceed a given flood discharge within a period of years. For a 1-year period (annual flood period) the probability of exceedence expresses the risk. Thus, there is a .01 probability, or 1 percent chance that the 100-year flood will be exceeded in any year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, there is a 26 percent chance that the flood with annual exceedence probability of 1 percent (100-year flood) will be exceeded one or more times in a 30 year future period at a specific site. In other words, the chances are at least 1 in 4 that a house built in the 100-year flood plain will be flooded one or more times during the term of a 30-year mortgage.

FLOOD MAPPING IN FAIRFAX COUNTY

In 1959 the U. S. Geological Survey began an investigation of the effects of urban development on floods in the Cameron Run drainage basin. In addition to assessing the flood discharge potential of streams under conditions of future development, the boundaries for the 25-, 50-, and 100-year floods were delineated. The initial work was done in cooperation with the city of Alexandria and Fairfax County. Eventually the study included all drainage basins larger than about 1 square mile (2.59 square kilometers) in the unincorporated areas of Fairfax County. The Dogue Creek and Little Hunting Creek drainage basins, and Tripps Run and Holmes Run above Lake Barcroft in the Cameron Run basin were not included in the study because flood plain information for these areas had been previously developed.

Using the graphical and mathematical relations developed in Anderson's study, the 25-, 50-, and 100-year flood peak discharges that might be expected to occur at ultimate development were calculated for Fairfax County streams. Flood elevations corresponding to these discharges were then computed for each stream using standard hydraulic engineering methods. The computed flood elevations defined the flood profiles along the stream channels, and the profiles were used to define the flood boundaries on topographic maps. The elevation to which a flood will rise in a natural stream valley is dependent on the cross-sectional dimensions and the frictional characteristics of the channel system. The effects of man-made structures on the flow of the water must also be considered. Examples of such structures are channel improvements, bridges, culverts, dams, highway and railroad embankments, and buildings. New construction within a stream channel may modify hydraulic properties of the channel, thus changing flood profiles and boundaries in the future.

AVAILABILITY OF FLOOD MAPS AND RELATED INFORMATION

More than 500 large scale maps showing the 25-, 50-, and 100-year flood boundaries for areas greater than about 1 square mile are available from the Fairfax County Department of Environmental Management. These maps are at a scale of 1 inch (2.54 cm) equals 100 feet (30.5 meters) with a 2 foot (0.61 meter) contour interval. They include 27 drainage basins listed in 9 reports by Soule (see selected references). Survey, hydrologic, hydraulic, and other pertinent data used in the preparation of these maps are on file at the local field office of the U. S. Geological Survey. Similar maps for flood plains on Tripps Run and Holmes Run upstream from Lake Barcroft, Little Hunting Creek, and Dogue Creek prepared by private engineering firms are also available from the Fairfax County Department of Environmental Management. Flood-plain maps at a scale of 1 inch equals 200 feet (2 foot contour interval) for streams in the City of Fairfax are available from the City of Fairfax Department of Public Works.

Flood boundaries are not shown on this map for streams draining areas less than about 1 square mile. However, flood plains for many of these streams have been mapped by the Fairfax County Department of Public Works and the County Soil Scientist. Also, consulting engineers have defined 100-year flood plains within developing areas as part of required storm-water management plans. Other sources of flood plain information are; Fairfax County tax maps (including certain areas draining less than 1 square mile) and Flood Hazard Boundary Maps prepared by the Federal Insurance Administration. Users should consult the references listed for detailed flood information in specific areas. In addition streamflow data including flood peak stages and discharges are published annually by the U. S. Geological Survey in cooperation with the Virginia State Water Control Board as noted in the references.

EXPLANATION

100-YEAR FLOOD BOUNDARY:

From U.S. Geological Survey-Fairfax County flood plain studies

From flood plain studies by other governmental agencies and private consultants

ELEVATION AND DISCHARGE OF 100-YEAR FLOOD:

287 / 7,000 — Elevation in feet above mean sea level; Discharge in cubic feet per second for ultimate development

DRAINAGE BASIN BOUNDARY

SCALE 1:48 000

1 0 1 2 3 MILES

1 0 1 2 3 4 5 KILOMETERS

100-YEAR FLOOD MAP, FAIRFAX COUNTY, VIRGINIA

By
E. H. Mohler and C. E. Novak

1978