

Flood Plain Delineation and Preparation of Enhanced DFIRM Maps

Author:

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Abstract:

Henrico County, Virginia has been working with FEMA to accomplish a comprehensive update to the locality's Flood Plain Management Program. This included complete re-delineation of the locality's Special Flood Hazard Areas and creation of Enhanced Digital Flood Insurance Rate Maps (E-DFIRMs). This locality is one of the first localities in that nation to develop E-DFIRMs. This GIS-based effort allows the determination of flood plain extent on a site-by-site basis including all related flood study documentation in the form of a GIS-enabled Relational Database Management System (RDBMS). The new flood plain delineation provides the basis for updating the locality's Code of Ordinances in regards to the management of flood plain areas in the locality. This comprehensive approach gives detailed and accurate planimetric and topographic data as well as provide the legislative framework to protect life and property in the locality.

Paper Body:

Henrico County, Virginia covers an area of about 242 square miles and is part of the Richmond Metropolitan Area that is home to over 1 million people. The County's real estate base is made up of just over 105,000 parcels while there are over 75,000 water customers and over 80,000 sewer customers. Henrico County is a locality adjoining the city of Richmond, it has a wide variety of land uses from high density residential to wide-open agricultural fields. The wide variation in land uses in the County cause a considerable challenge to public service agencies. This is compounded by the location within the County of the Richmond International Airport and the Richmond International

Raceway. These two facilities cause a considerable volume of visitors to traverse the County on a regular basis.

The County has been implementing a detailed and highly accurate Geographic Information System (GIS) program. The focus of this is to enhance the level of service delivery and increase the efficiency of County agencies. The GIS program started in 1998 and it includes accurate planimetric base map layers that are controlled by an extensive geodetic control network. The functionality of the GIS has been successfully deployed in many County agencies, including Planning, Real Estate Assessments, Public Works, and Recreation and Parks. It has been a desire of the County to extend the functionality of the GIS to field personnel.

In 1974, the County carried out a project known as the Comprehensive Drainage Study. In this project, the County compiled planimetric and topographic features based on aerial stereo-photography. This provided for the manual photogrammetric compilation of photo-identifiable features and the topography of the County. This was the basis to determine drainage areas and delineate streams and bodies of water. The base data developed through this process was used to manually model areas of the County that were susceptible to flooding. At the time, the County decided to extend the delineation of flood studies to the limits of 100 acre drainage basins. After the studies were completed, a set of ink-on-mylar maps at the relative scale of 1 inch to 200 feet (absolute scale of 1:2,400) were produced. Flood plain management ordinances were crafted and were based on the reference to the Comprehensive Drainage Study.

For the next ten years, the County managed development and land uses in the flood plain based on the effort described above. In 1981, FEMA carried out its Flood Insurance Rating Map (FIRM) effort in Henrico County. This effort provided a set of standard FIRM panels which were the basis for the National Flood Insurance Program (NFIP). The County's ordinance, however, was never amended to make reference to the 1984 FIRM panels and the local administration of the flood plain continued to be based on the 1974 study. Consequently, FEMA never approved or accepted the County's earlier study leaving the curious scenario where there are two unrelated flood plain delineations: the County's own and FEMA's. The County used its own flood plain delineation to manage land use and construction design requirements while FEMA used its own delineation to administer the NFIP.

With the development of the County's GIS Program in 1998, it became clear that there was an opportunity to update, upgrade, and unify the County's flood plain delineation with that of FEMA. The County approached FEMA to become a Cooperating Technical Partner (CTP). The CTP designation initiated a formal cooperative relationship between the County and FEMA that outlines responsibilities and benefits. The CTP designation provides the basis for a Mapping Activity Statement (MAS) that sets forth activities to accomplish the re-mapping of what is now known as Special Flood Hazard Areas (SFHA).

The County's GIS Program developed complete planimetric and topographic features from 6 inch resolution true-color aerial photography acquired in 1998. The County's

base map features that were compiled through Fully Automated Analytical Triangulation (FAAT) meet or exceed the National Map Accuracy Standards (NMAS) for maps at the relative scale of 1 inch to 100 feet (absolute scale of 1:1,200). The accuracy states that at least 90% of photo-identifiable features are to be horizontally located within 3.33 feet of the actual location on the ground and vertically within 1 foot. The County's base map features have since been updated from 6 inch resolution true-color aerial photography acquired in 2003. The accuracy of these features continue to meet or exceed the NMAS.

In 2001 the County issued a Request for Proposals to carry out re-delineations of existing detailed flood studies and to re-study all other areas. The result would be a complete re-mapping of the SFHA in the County. This would provide the basis for the production and publication of new FIRM maps. The County received four proposals and eventually selected Michael Baker, Jr., Inc. The project was kicked off in March of 2002. The total cost of the project was about \$700,000.00 with FEMA providing \$95,000.00. The balance of funding was provided by the County.

At the beginning of the project, the County identified 524.4 linear miles of streams that met the criteria for delineation of SFHA. The County's planimetric and topographic base map developed in 1998 was used as the basis for all re-delineation of existing detailed studies and all new flood plain studies.

The flood plain studies in the County were broken down as follow:

- 1) A total of 398.4 linear miles of streams were studied using limited-detail study methods. This method uses the County's GIS base map data (planimetrics and topography) as the basis of the study, so no new field surveys are carried out. Automatic cross section layouts and takeoffs were generated. HEC-RAS inundation models were applied to determine the 1.0% annual chance of flooding based on a 100 year storm event. The model output was calibrated to the County's base map data and the horizontal extent of the SFHA was delineated using automated mapping techniques.
- 2) A total of 100.6 linear miles of streams already had existing detailed flood studies and those were re-delineated on the County's planimetric and topographic base map. This method provides for digitization of existing effective profiles, cross sections, and floodway limits. The profile data is imported into the "Watershed Information SysEm" (WISE) and the vertical datum shift from NAVD27 to NAVD88 is applied. Results were controlled in regards to currently effective floodway data tables. Modeled flood elevations were applied to cross sections. Finally, automated re-mapping of existing detailed flood studies on the County's terrain data was completed.
- 3) A total of 25.4 linear miles of streams were studied using detail study methods. This included carrying out field surveys and automatic cross section layouts and takeoffs. The model output was calibrated to the field survey data, field surveys of bridges and stream channels were integrated, and the horizontal extent of the SFHA was delineated using automated mapping techniques.

As can be seen, three different methods were used: 1) limited-detail, 2) re-delineation of existing detailed studies, and 3) detailed. The only difference between the first and the last is that detailed studies are based on actual field survey data rather than on the County's planimetric and topographic base map. In all about 10,500 real estate properties were directly affected by this project.

Hydrology studies include gage data, USGS regression equations, and no rainfall runoff modeling. Hydraulics studies include WISE integrated with HEC-RAS, and Integrates the County's GIS with Hydraulics and flood plain mapping using the County's Digital Terrain Model (DTM).

All deliverables of this project were provided to the County and FEMA in ESRI format GIS databases for integration into the County's ArcSDE system. This allows direct analysis and correlation of flood plain data within the context of the County's GIS. Overlay capabilities allow the visualization of the extent of flood plains at the site-specific level. This capability provides considerable benefits over the previous hard copy FIRM panels.

One of the primary deliverables of this effort is the provision of Enhanced Digital FIRM (E-DFIRM) data. This makes available in a single GeoDatabase format file all the components of flood plain studies. The primary elements of E-DFIRM includes:

- Subbasins with links to discharges, storm data, and regression equations;
- Gages;

- Nodes with links to node discharge data and zipped hydrologic model(s);
- Profile base lines;
- Overbank flow paths;
- Additional cross section data including links to a frequency (rating) table and the zipped hydraulic model(s);
- An outline of the studied area(s) with links to FEMA case information;
- Photographs, sketches, etc. linked to spatial features;
- Documentation for variable data that may be developed for the flood study (e.g., topographic data, land use, soils, roughness);
- Zipped files containing general information on methodology (e.g., Technical Support Data Notebook); and
- Zipped Flood Insurance Study (FIS) documents (e.g., FIS text, flood profiles, Floodway Data Tables).

The availability of this system gives County staff considerable capabilities that they never before had. Henrico County Staff are very excited about continuing the use of this technology and being part of any upgrades in the future.

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