# Strategies for Improving Accuracy and Efficiency in Emergency Flood Inundation Modeling

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## Extended Abstract

During a declared emergency, such as a dam or levee safety incident, hurricane, a flood, or a potential flood event, inundation modeling is conducted by USACE district offices in collaboration with NWS or by the MMC through the national flood inundation mapping (FIM) cadre to support real-time flood fighting effort. This includes the production of dynamic GIS data to provide real-time flood inundation mapping to the public in support of flood fighting activities as well as making the public aware of potential consequences. The two dimensional capabilities of HEC-RAS, which allow the inclusion of localized flooding due to rainfall in addition to riverine flooding, have allowed for the production of detailed flood inundations in as few as 24 - 48 hours. These detailed inundation maps, which show conditions throughout the watershed, are quickly becoming one of the preferred products of leadership and those coordinating flood fighting and emergency response. However, there are a few major issues that challenge the FIM cadre.

One of the major challenges for hydraulic modelers is being to produce and share inundation maps before the peak flooding occurs and with enough time to allow warnings to be released and preparations to be made. Under normal circumstances, it may take weeks or months to build, calibrate, and run a hydraulic model. During a flood event, this timeline is compressed significantly and results must be obtained in days. Under these circumstances, it can take up to as many as four days to obtain and process data, construct a hydraulic model, run model simulations, and prepare and upload inundation maps. Therefore, it is key that flood inundation modeling be initiated as soon as a major threat, such as a hurricane or potential dam or levee breach, is identified. This timeline can be reduced by about two to three days if there is an existing hydraulic model that can be used with minimal or no modifications.

Decision making capability is another key factor that affects the time it takes to produce a flood inundation map. Key deliverables and the level of detail required for each deadline need to be established at the time modeling is initiated and communicated to the modeler by leadership.

For example, a map that provides a statewide overview of flood extents and identifies areas at high risk for localized flooding may be required for a briefing twenty four hours before a hurricane landfall and more detailed maps for individual cities and counties may be required twenty four hours post landfall to aid in emergency response efforts. Each of these situations requires a different level of detail and the modeling effort should be adjusted accordingly to meet each deadline. Hydraulic modelers need to be able to anticipate the time required for each step of the flood inundation map production process and be able to make decisions on when each step needs to be completed in order to meet the established deadlines. Being able to decide what should be included to produce the best quality inundation map in such a short time takes experience or the guidance of an experienced modeler. For this reason, it is imperative that modelers document processes used and lessons learned during the flood event or immediately after so that the knowledge and experience gained can be shared. With each flood event, the cadre build their level of experience, make improvements to the FIM cadre's standard operating procedures, and share lessons learned through after action reports, webinars, and conferences. This has resulted in increased efficiency and a reduction in map delivery time.

The availability and ability to process and transfer data is another major issue that often hinders the production of flood inundation maps. The two-dimensional HEC-RAS models that are commonly used for flood inundation modeling rely upon large terrain datasets. These large datasets often require a significant amount of time to download and process before they can be used. For example, during Hurricane Florence in 2018, terrain download and processing accounted for 36 of the 46 hours required to produce an initial map for a major watershed in North Carolina. Large data transfers are facilitated by the use of network folders with organization-wide access and file exchanges. Model and data libraries are also being continually updated in order to reduce the amount of time needed to obtain data and build models.

There are key pieces of data that are critical for the development hydraulic models. These key data include flow and stage data, observed and forecast precipitation, antecedent conditions, and the dimensions and locations of dams and levees. These data are not always readily available and if they are, it often takes days to acquire. Modelers should organize, label, and store the data that was gathered during the event so that it can be used for future modeling efforts. This investment of time and resources can significantly reduce the time it takes for data collection for the next flood event.

Social media is one source of data that can be used when time is limited. A search of recent social media posts for the area of interest can provide insight on the current conditions in the watershed. During Hurricane Harvey, social media posts were used to verify model outputs of coastal flooding that seemed unreasonable at first glance. User posted photos of major highways and coastal towns were comparable to the model outputs. During another dam breach modeling effort, social media was also use as a data gathering tool. At the time the dam breach modeling was initiated, the dam was still under construction. As a result, the height of the embankment dam, one of the most important dam breach parameters, was unknown. Official requests for data did not initially yield any information. Through a social media search, a Facebook group related to the dam was found. In this group, regular updates were being posted by the construction workers at the dam detailing their progress. These posts revealed information about the dam height and gate operability which was then used for the dam breach model. This information was then verified later by on-site personnel. While caution should always be used when using social media as a data source, it is still preferable to a blind estimate or assumption. The ability to visually examine the project is invaluable to modelers. This creative method of gathering data when no other data sources are immediately available has allowed modelers to produce preliminary results under emergency conditions in as few as 24 hours.

Valuable lessons are learned from every flood event and that information is used to improve the efficiency of the team and the quality of the flood inundation products. As data processing and transfer capabilities are improved and modelers gain more experience, the time required to provide these products will decrease, and hopefully, a delivery time of 24-48 hours or less will become the new standard.