

# Guidance for Flood Risk Analysis and Mapping

## **Post-Flood Hazard Verification/ Recovery Tools**

February 2018



**FEMA**

Requirements for the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) Program are specified separately by statute, regulation, or FEMA policy (primarily the Standards for Flood Risk Analysis and Mapping). This document provides guidance to support the requirements and recommends approaches for effective and efficient implementation. Alternate approaches that comply with all requirements are acceptable.

For more information, please visit the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage ([www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping](http://www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping)). Copies of the Standards for Flood Risk Analysis and Mapping policy, related guidance, technical references, and other information about the guidelines and standards development process are all available here. You can also search directly by document title at [www.fema.gov/library](http://www.fema.gov/library).

## Table of Revisions

Affected Section or Subsection	Date	Description
First Publication	February 2018	Initial version of newly transformed guidance. The content was derived from the Guidelines and Specifications for Flood Hazard Mapping Partners, Procedure Memoranda, and/or Operating Guidance documents. It has been reorganized and is being published separately from the standards.

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## 1.0 Introduction

It is critical to establish a coordinated effort to collect and disseminate accurate flood data and risk information to aid response and recovery efforts after a flood disaster occurs. Furthermore, it is important to collect and share these data as quickly as possible following the event's occurrence to aid in these efforts. These data may assist in response and recovery activities that include planning (mitigation, capital improvement, operations), investigation of the event and infrastructure, and the completion of projects to mitigate residential and commercial structures and other infrastructure from future flood risk.

Possible applications for these data in response, recovery, and mitigation activities include the following:

- Facilitating safe rebuilding;
- Identifying heavily damaged areas;
- Identifying locations on which to focus response and recovery efforts;
- Identifying areas for which flood insurance claims have or possibly will be made;
- Estimating damages for residential and commercial structures, lifelines, and other infrastructure;
- Identifying areas in which buildings may be substantially damaged and which, therefore, would be the focus of flood mitigation activities;
- Determining the likelihood of future damages in floodplains;
- Identifying inaccuracies in existing flood hazard data;
- Quantifying the benefits of taking action to mitigate or of not taking any action at all; and
- Identifying mitigation success stories.

The purpose of this document is to provide the Mapping Partner with guidance and best practices pertaining to post-flood hazard verification and recovery tools. Outreach and interagency coordination are discussed as well as high-water mark data collection, wind/water line investigations, and assessment of post-disaster flood hazard data needs. This document also outlines recovery tools such as Advisory Base Flood Elevations (ABFEs) and non-regulatory mapping products.

The Mapping Partner may be a federal, state, local, tribal or territorial entity, or a contracted entity such as the Production and Technical Services contractor or a grantee such as a Cooperating Technical Partner (CTP).

## 2.0 Guidance for Post-Flood Hazard Verification Activities

The following activities are associated with post-flood hazard verification:

- Geographic Information System (GIS) support;
- Community outreach;
- FEMA and other federal agency coordination;
- Development of rough scope of recovery efforts;
- Riverine high-water mark data collection;
- Coastal high-water mark data collection;
- Wind/water line investigation;
- Flood frequency determination;
- Post-disaster flood hazard data needs assessment; and
- Flood hazard update needs.

### 2.1 Community Outreach

It is important to make contact with the community (officials, technical experts, response and recovery points of contact, and floodplain administrators) immediately after a flooding event has occurred. The FEMA Region and the Regional Support Center (RSC) should check to see if an active Risk MAP project or if the Risk MAP Discovery process has been performed in the affected areas prior to and/or immediately following the event. The Discovery report and community profiles completed as part of the Discovery process should contain outreach information, including community outreach efforts already conducted, and include a list of community officials and local points of contact. If the Risk MAP Discovery process has not been performed, the FEMA Region and the RSC will prepare a list of community officials and work to engage and coordinate with the local communities. In instances where a CTP exists, the FEMA Region and RSC can coordinate with the CTP to gather the above mentioned information.

To facilitate a streamlined communications and engagement process, consideration should be given to develop a strategic communications plan, which outlines communications goals and objectives, key stakeholders, messaging, and tools and tactics that would result in the most effective community engagement. Consideration should also be given to assessing the effectiveness of the engagement to ensure efficient use of community resources, which often are limited in a post-flood event situation. The FEMA Region and the RSC will use the local points of contact and knowledge to understand where the priority areas are located and identify areas of concern for the flood response and recovery efforts.

### 2.2 FEMA and other Federal Agency Coordination

Internal coordination among FEMA and other federal agencies is important to leverage data, information, and resources during the flood response and recovery efforts. One such way of leveraging the post-flood recovery effort is through interagency teams such as the Silver Jackets. The Silver Jackets Program ([silverjackets.nfrmp.us](http://silverjackets.nfrmp.us)) has established a network

between multiple state, federal, and local agencies through organizing Interagency Flood Risk Management Teams. The teams learn from one another in reducing flood risk and enhance response and recovery efforts when events do occur. Common State agency participants include departments dealing with hazard mitigation, emergency management, floodplain management, natural resources management or conservation, etc. Federal participation typically includes the U.S. Army Corps of Engineers (USACE), FEMA, National Weather Service (NWS), and the U.S. Geological Survey (USGS).

The Silver Jackets Program goals are to:

- Facilitate strategic life-cycle flood risk reduction;
- Create or supplement a continuous mechanism to collaboratively solve state-prioritized issues and implement or recommend those solutions;
- Improve processes, identifying and resolving gaps and counteractive programs;
- Leverage and optimize resources;
- Improve and increase flood risk communication and present a unified interagency message; and
- Establish close relationships to facilitate integrated post-disaster recovery solutions.

Consideration should also be given to engage with non-governmental disaster response organizations and faith-based organizations in a post-disaster setting. Often, these organizations have direct contact with impacted community members and can serve as liaisons with FEMA, and other federal and state organizations as communities respond to and begin to recover from the flooding event.

### 2.3 Development of Rough Scope of Flood Recovery Efforts

The FEMA Region should work closely with the local communities to develop a rough scope of flood recovery efforts. The FEMA Region should set priorities and coordinate with other recovery efforts in the area. The FEMA Region will assess available data sets through review of the Mapping Information Platform (MIP) for the Discovery database, existing high-water marks, survey, and engineering analyses developed for the effective flood maps.

The diagrams below present possible progressions for hazard identification efforts after a coastal flooding event and after a riverine flooding event.



Figure 1. Possible Progression of a Coastal Hazard Identification Effort



**Figure 2. Possible Progression of a Riverine Hazard Identification Effort**

### **3.0 Post-Flood Data Collection**

One valuable tool for post-flood data collection is the use of GIS which can be used to support emergency operations in response, recovery, and mitigation efforts before and after a disaster. The FEMA National Response Coordination Center (NRCC), Regional Response Coordination Center (RRCC), Joint Field Office (JFO) staff and Regional GIS Coordinators can use GIS to inform, analyze, and display information to expedite emergency management decisions

GIS support staff might include FEMA Regional staff, RSC staff, CTP staff, disaster assistance staff (such as the National Response Coordination Center (NRCC), Regional Response Coordination Center (RRCC), Joint Field Office (JFO), and/or state and local community staff.

The GIS support staff should contact the following, at a minimum, to obtain data:

- State emergency management office;
- Other State offices, such as environmental protection, transportation, and GIS offices;
- Local communities (i.e., counties/parishes, townships, boroughs, towns, cities);
- USGS;
- U.S. Department of Agriculture;
- Local colleges and universities; and
- FEMA, its contractors, and other Mapping Partners.

The functions that the GIS support staff may have to perform include analysis and mapping support for the following:

- Best available information which may include the Flood Insurance Rate Map (FIRM), Base Level Engineering (BLE), Q3 Flood Data products, and local hazard information;
- Repetitive loss locations;
- Damage assessments;
- High-water mark surveys;
- Various progress reports;
- Teleregistration activities;



- Hazard Mitigation Assistance (HMA) program activities;
- Critical facilities and infrastructure;
- Demographics; and
- Control structure locations and failures.

These analyses and mapping support function may be altered to address changes in FEMA requirements.

Data may be presented on the FEMA GeoPlatform, with access options including internal-only FEMA access or public data access, on an as needed basis. Individual spatial features and attributes related to post-flood and recovery data availability can be stored on a record ID basis (e.g., county Federal Information Processing Standards (FIPS) code, Community Identification Number, or other unique record ID), linked to a “study footprint” or other polygon feature. To support a wide range of future applications, best practice is to make a dataset compatible with companion products, such as Flood Risk Data, Coordinated Needs Management Strategy (CNMS), FIRM Databases, or other local and State emergency management or mitigation datasets, so that FEMA, state, local, tribal or territorial partners can leverage flood risk and flood hazard data when responding to a disaster, and for future Discovery efforts, or when preparing other risk assessment data to fulfill the Risk MAP vision and integrate directly with the Risk MAP project lifecycle.

Companion datasets or services that may be leveraged from the FEMA GeoPlatform or other web service environments include:

- CNMS;
- Regional tracking data;
- Building footprints;
- Parcel footprints;
- Weather data;
- High-water marks;
- Geocoded property addresses; and
- Emergency Facilities.

The FEMA Region and the RSC should inventory and catalog all digital data related to the flood event. This documentation must be designed to allow access to this digital data for any future data processing needs. The documentation should contain descriptions of digital data, file format type, creation dates, and source documentation.

At the conclusion of the assignment, the assigned Mapping Partner will provide a copy of the data in digital format. A best practice would include providing the digital data to the FEMA GeoPlatform for distribution to other agencies. The assigned Mapping Partner also should

develop recommendations for standard products, applications, and procedures that could be developed for future events.

Post-flood hazard verification efforts should be coordinated, if possible, with FEMA Building Science Branch, and with NFIP Insurance. Both of these groups may obtain or know of relevant post-flood water surface elevation and building damage data that could be useful.

### **3.1 Riverine High-Water Mark Data Collection**

#### **3.1.1 Identification of Areas for Survey**

The FEMA Region in coordination with the Planning Section staff and the Geospatial Information Unit (GIU) staff at the JFO or in the NRCC and/or RRCC will determine stream reach areas for high-water mark data collection through coordination with FEMA, USGS, state officials, and local community officials; review any available or in process remote-sensing data; and review existing media reports. The FEMA Region will coordinate and/or obtain event specific information, remote-sensing data and media reports from the Planning Section staff and GIU staff at the FEMA JFO and/or NRCC and RRCC.

The FEMA Region will complete an initial overview and assessment of flooding within the subject area and identify flooding sources/stream reaches that experienced flooding for which high-water mark data and/or remote sensing data may be needed. In general, the FEMA Region should collect high-water mark data for major rivers and their tributaries and in other areas where severe flooding has occurred.

The Mapping Partner should place particular emphasis on areas where flood-related damage to buildings, infrastructure, or agricultural lands occurred as well as areas that experienced record or near-record flooding. The FEMA Region should base identification of areas for high-water mark surveys on available information regarding the recent event, such as satellite imagery, aerial photography, drone footage, media reports, and knowledge of local and State emergency managers and other Federal agencies.

The FEMA Region should contact and coordinate with other federal, state and local agencies to determine the existence of any similar data collection activities by their respective offices. A summary report (in digital format) to document the coordination between FEMA, and other federal, state and local agencies and officials as well as any additional data used in determining post flood data collection efforts (high-water mark collection, remote sensing collection) areas should be created and distributed amongst stakeholders.

As a way of leveraging expertise and resources, FEMA may use mission assignments to task the USGS with the collection and surveying of riverine high-water marks. The mission assignments allow for a coordinated federal emergency response between FEMA and USGS.

The use of social media and other online resources should be considered as best practices during the identification of riverine areas for survey. Social media, such as Twitter and Facebook, can be a source of information to keep up with real-time updates from local news media outlets, police and fire departments, and other response and recovery operations.

Crowdsourced mapping projects can also provide a source of data as community members monitor and report on flooded streets in local areas.

Other online resources include the U.S. Flooding Public Information Map ([www.esri.com/services/disaster-response/flooding](http://www.esri.com/services/disaster-response/flooding)). This resource has continuously updated flooding information from the NWS and shows observed flooding locations, current and forecast rainfall, and flood warning areas. The map shows the locations of stream gauges and provides flooding height data. The map is also linked to geotagged social media data and webcams.

The FEMA Region should check the USGS Flood Event Viewer (FEV) ([water.usgs.gov/floods/FEV](http://water.usgs.gov/floods/FEV)) for existing high-water mark data. The FEV provides a national database of high-water mark information for flood events and flood response data. The FEV also provides location of and flood height data collected by temporary deployed USGS stream gages. The USGS Water Watch for flooding ([waterwatch.usgs.gov/index.php?id=flood&sid=w\\_table](http://waterwatch.usgs.gov/index.php?id=flood&sid=w_table)) also provides tabular or map-based listings of stream gages that are currently above flood stage.

### **3.1.2 Riverine High-Water Mark Data Collection**

To locate and survey high-water marks for riverine areas identified and approved by FEMA, the FEMA Region, RSC and/or assigned Mapping Partner will establish high-water mark data collection teams based on the size of the project and deploy these teams in the field. Members of the data collection teams should identify and flag the high-water marks. The team members should then locate the high-water marks using differential Global Positioning Systems (GPS) units and conventional survey equipment. The teams will then identify GPS beacons, which are to be used as the base stations. If possible, the teams should record all measurements in real-time.

The assigned Mapping Partner should use traditional survey techniques in the event that GPS signals are blocked by buildings, trees, or other obstructions. An engineer from the assigned Mapping Partner will assist the surveyor in measuring the high-water marks and take all field notes required for the metadata documentation. High-water mark points should be collected to a vertical accuracy of 0.25 feet and horizontal accuracy of 10 feet. The vertical and horizontal datums should also be noted.

The Mapping Partner should consult the USGS publication Identifying and Preserving High-Water Mark Data at [pubs.usgs.gov/tm/03/a24/tm3a24.pdf](http://pubs.usgs.gov/tm/03/a24/tm3a24.pdf) for guidance on high-water mark identification (Koenig et al., 2016).

### **3.1.3 Spacing of High-Water Data Points**

The assigned Mapping Partner will subdivide each stream or river identified for survey into reaches based on the level of development within each reach. The assigned Mapping Partner will use Table 1 as a guide for classifying the reaches based on the general land use and level of development within the flooded area of the reach.

**Table 1: Guide for Classifying Riverine Reaches Based on Land Use and Development**

Land-Use/Development Category	Description
Low	Rural, agricultural, and/or areas of no or minimal development
Medium	Areas of moderate development
High	Areas of dense development, such as large residential, urban, commercial, or industrial areas

The spacing of the high-water mark data points should be a function of the development category for each reach. The assigned Mapping Partner will use Table 2 as guidance for determining the maximum spacing between survey locations for the various development categories. The assigned Mapping Partner will apply these spacing guidelines such that high-water mark data points are collected at locations where reliable high-water marks can be readily obtained, such as downtown areas in which buildings are flooded. The density of spacing may be irregular as more high-water marks may be flagged in areas that were more significantly impacted by flooding. Fewer high-water marks may be flagged in areas that received less flooding or where there were fewer buildings.

**Table 2: Guide for Determining Maximum Spacing Between Riverine Survey Locations**

Land-Use/Development Category	Description
Low	At upstream and downstream end of reach <b>and</b> no more than 10 miles apart
Medium	Upstream of the most upstream bridge or culvert within the reach <b>and</b> downstream of the most downstream bridge or culvert and no more than 1 mile apart
High	Upstream and downstream of each bridge or culvert within the reach <b>and</b> no more than 0.5 miles apart

### 3.1.4 Selection of Physical Features for High-Water Mark Survey

At each survey location, the assigned Mapping Partner will survey at least one high-water mark data point at fixed physical features. If practicable, the assigned Mapping Partner will survey two or more points. One point should be on a bridge or culvert or on a building located adjacent to or near the channel that was inundated during the flood event. The second point should be on a building that was inundated located away from the channel, in the fringe area of the flooding event.

In the absence of bridge, culvert, or buildings for collecting a high-water mark data point, the assigned Mapping Partner may use other fixed physical features, such as trees or utility poles. If a fixed physical feature is not available to survey the high-water mark data point, the assigned Mapping Partner may use the downed vegetation line as a last resort.

### **3.1.5 High-Water Mark Type**

The assigned Mapping Partner will note the type of high-water mark for each data point such as mud line, wrack line, debris line, debris snag, water line, seed line, and other. In general, the mud or residue line on buildings or bridges is considered the most reliable. In a clear-water event, the assigned Mapping Partner should exercise great care in using the water line on buildings as the high-water mark, because of the “wicking” effect of some building construction materials. This wicking effect can cause the water to penetrate the building materials and then seep upward. This effect would tend to overstate the actual flooding event. The assigned Mapping Partner may use the debris line on the ground or suspended in vegetation as a last resort. The assigned Mapping Partner should take digital photographs of each high-water mark data point surveyed.

### **3.1.6 Other Flooding Factors**

For each location surveyed, the assigned Mapping Partner should note and photograph other information regarding the flooding event, including the following, and include these data in the GIS metadata:

- Blockage of a bridge or culvert by debris;
- Damage to or structural failure of bridge or culvert;
- Channel scouring;
- Sediment deposition in the channel; and
- Channel bank erosion, meandering, or avulsion.

For each high-water mark data point, the assigned Mapping Partner will provide the following GIS metadata:

- Identification number (for cross referencing purposes);
- River or stream name;
- Reach identification;
- Location (city/town/borough/village, county/parish, state);
- Address of high-water mark structure, if applicable;
- Description of physical feature surveyed (e.g., bridge, culvert, building, utility pole, tree), including name of the structure or road for bridge or culvert and street address for buildings;
- Location relative to channel (i.e., in channel, immediately adjacent to channel, in fringe area);
- Zone designation on effective FIRM (e.g., Zone A, AE, X);
- Type of high-water mark, such as mud line, wrack line, debris line, debris snag, water line, seed line, or downed vegetation line;
- Date and time high-water mark was located;

- Date and time high-water mark was surveyed (if different from above);
- Digital photograph of high-water mark;
- Name and seal of surveyor;
- Vertical datum;
- Latitude, longitude, and elevation (x, y, z) coordinates; and
- Accuracy or uncertainty (i.e., excellent, good, fair, poor).

### 3.1.7 Reporting

The assigned Mapping Partner will provide a summary report to FEMA that documents the high-water mark survey. At a minimum, this report should document the dates of survey, survey methods used, benchmarks used, High-Water Mark Certificates, and interviews with local officials and/or residents regarding the event.

The assigned Mapping Partner will submit the report in digital format. The assigned Mapping Partner will supply copies to the FEMA Project Officer (PO), FEMA Regional Risk Analysis Branch Chief, USGS, USACE, CTPs, and State National Flood Insurance Program (NFIP) Coordinator and coordinate making the report available through the FEMA Flood Hazard Mapping website ([www.fema.gov/national-flood-insurance-program-flood-hazard-mapping](http://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping)) for other interested parties.

The assigned Mapping Partner will ensure the data for each high-water mark metadata file are submitted in a GIS map coverage file format that complies with FEMA's FIRM Database Technical Reference (FEMA, 2017). The assigned Mapping Partner will provide the high-water mark survey points in a GIS point coverage. Final selection of file formats will be coordinated with the FEMA PO or his/her designee.

The assigned Mapping Partner will cross-reference all supporting documentation to the tabular data using the identification number, and include the following other items:

- Digital photographs of each high-water mark;
- Digital photographs of bridge, culverts, or channel, if other flooding factors are noted; and
- USGS (Digital Raster Graphic as minimum) quadrangle maps (or comparable base map source) showing the location, designation, and elevation of all high-water marks as a GIS spatial data coverage.

The assigned Mapping Partner will create GIS maps through coordination with the FEMA PO, his/her designee, and other FEMA staff and submit the maps in digital format. The assigned Mapping Partner will provide digital copies to the FEMA JFO and Regional Office (RO).

## 3.2 Coastal High-Water Mark Data Collection

### 3.2.1 Identification of Areas for Survey

The FEMA Region in coordination with the Planning Section staff and the GIU staff at the JFO or in the NRCC and/or RRCC will determine the coastal shoreline and embayment reach areas for coastal high-water mark data collection through coordination with FEMA, USGS, state and local community officials; review any available or in process remote sensing data; and review existing media reports. The FEMA Region will coordinate and/or obtain event specific information, remote-sensing data and media reports from the Planning Section staff and GIU staff at the FEMA JFO and/or NRCC and RRCC.

The FEMA Region will complete an initial overview and assessment of flooding within the subject area by identifying flooding sources and reaches of shoreline that experienced flooding for which high-water mark data and/or remote sensing data may be needed. In general, high-water mark data are needed for open coast shorelines (Atlantic Ocean, Gulf of Mexico, Pacific Ocean and Great Lakes) and major embayments (e.g., Chesapeake Bay, Delaware Bay, Long Island Sound). The FEMA Region may also collect high-water mark data for smaller bodies of water. The FEMA Region should place particular emphasis on water bodies that caused flooding damage to buildings, infrastructure (including, but not limited to, evacuation routes, wastewater treatment facilities, and schools), agricultural lands, and areas that are estimated to have experienced near-record or record flooding.

The FEMA Region should base the identification of flooding sources and their representative shoreline reaches for follow-up high-water mark data collection on available information regarding the recent event, such as the following:

- Wave and tide gage data from the USGS (available at [www.usgs.gov](http://www.usgs.gov)) and NOAA (available at [www.noaa.gov](http://www.noaa.gov));
- Satellite imagery or drone footage;
- Inundation mapping prepared by the FEMA Mapping and Analysis Center;
- SLOSH simulation runs from the NWS and/or National Hurricane Center;
- Information from the NWS, Tides and Coastal Flooding page (<https://www.weather.gov/akq/CoastalFlooding>);
- Aerial photography and “on-ground” reports from NOAA and/or the media;
- Media reports (online, newspaper, television); and
- Information provided by local and State emergency managers and other Federal Agencies (i.e., USACE Preliminary Damage Assessments for hurricane events, FEMA situation reports, FEMA Preliminary Damage Assessments, telephone logs, discussions).

The FEMA Region should contact and coordinate with other federal, state and local agencies to determine the existence of any similar data collection activities by their respective offices. A summary report (in digital format) to document the coordination between FEMA, and other



federal, state and local agencies and officials as well as any additional data used in determining post flood data collection efforts (high-water mark collection, remote sensing collection) areas should be created and distributed amongst stakeholders.

As a way of leveraging expertise and resources, FEMA may use mission assignments to task the USGS with the collection and surveying of coastal high-water marks and the deployment and recovery of storm-surge sensors. The mission assignments allow for a coordinated federal emergency response between FEMA and USGS.

The use of social media and other online resources should be considered as best practices during the identification of coastal areas for survey. Social media, such as Twitter and Facebook, can be a source of information to keep up with real-time updates from local news media outlets, police and fire departments, and other response and recovery operations. Crowdsourced mapping projects can also provide a source of data as community members monitor and report on flooded streets in local areas.

Other online resources include the U.S. Flooding Public Information Map ([www.esri.com/services/disaster-response/flooding](http://www.esri.com/services/disaster-response/flooding)). This resource has continuously updated flooding information from the NWS and shows observed flooding locations, current and forecast rainfall, and flood warning areas. The map shows the locations of stream gauges and provides flooding height data. The map is also linked to geotagged social media data and webcams.

The FEMA Region should check the USGS FEV ([water.usgs.gov/floods/FEV](http://water.usgs.gov/floods/FEV)) for existing high-water mark data. The FEV provides a national database of high-water mark information for flood events and flood response data. The FEV also provides a link to the USGS Surge, Wave, and Tide Hydrodynamics (SWaTH) network ([water.usgs.gov/floods/swath/](http://water.usgs.gov/floods/swath/)). The SWaTH network comprises long-term USGS and National Ocean Service tide gages as well as mobile, rapidly deployable, but temporary, real-time gages, and mobile storm-tide sensors.

### **3.2.2 Coastal High-Water Mark Data Collection**

To locate and survey high-water marks for coastal areas, the FEMA Region, RSC and/or assigned Mapping Partner will establish and deploy high-water mark data collection teams based on the size of the project. These data collection teams should locate high-water marks using differential GPS units and conventional survey equipment. The teams will identify GPS beacons and use these beacons as the base station. If possible, the teams should record measurements in real-time. The teams should use conventional survey equipment in the event that GPS signals are blocked by buildings, trees, or other obstructions. An engineer from the assigned Mapping Partner will assist the surveyor in measuring the high-water marks and take all field notes required for the metadata documentation. High-water mark points should be collected to a vertical accuracy 0.25 feet and horizontal accuracy of 10 feet. The vertical and horizontal datums should also be noted.

The Mapping Partner should consult the USGS publication Identifying and Preserving High-Water Mark Data at [pubs.usgs.gov/tm/03/a24/tm3a24.pdf](http://pubs.usgs.gov/tm/03/a24/tm3a24.pdf) for guidance on high-water mark identification (Koenig et al., 2016).



### 3.2.3 Spacing of High-Water Mark Data Points

The assigned Mapping Partner will subdivide each coastal flood source identified for survey into reaches based on the level of development within each reach. In coastal floodplains, the Mapping Partner will determine the density of high-water marks based on a range of points per square mile of coverage, with higher density of points per linear mile of coastline for barrier islands at or near the hurricane or northeaster impact zone. The geographic reach of the high-water mark data collection for a coastal flood event should be the limits of the measurable storm surge flooding.

The assigned Mapping Partner will use the guidance in Table 3 to classify the reaches based on the general land-use or development category within the flooded area of the reach.

**Table 3: Guide for Classifying Coastal Reaches Based on Land Use and Development**

Land-Use/Development Category	Description
Low	Rural, agricultural, and/or areas of no or minimal development
Medium	Areas of moderate development
High	Areas of dense development, such as large residential, urban, commercial, or industrial areas

The spacing of the high-water mark data points should be a function of the development category for each reach. The assigned Mapping Partner should use Table 4 as guidance for determining the maximum spacing between survey locations for the various development categories. The assigned Mapping Partner will apply these spacing guidelines such that high-water mark data points are collected at locations where reliable high-water marks can be readily obtained, such as downtown areas that experience flooded buildings.

**Table 4: Guide for Determining Maximum Spacing Between Coastal Survey Locations**

Land-Use/Development Category	Description
Low	At upstream and downstream end of reach <b>and</b> no more than 10 miles apart
Medium	Upstream of the most upstream bridge or culvert within the reach and downstream of the most downstream bridge or culvert <b>and</b> no more than 1 mile apart
High	Upstream and downstream of each bridge or culvert within the reach <b>and</b> no more than 0.5 miles apart

### 3.2.4 Selection of Physical Features for High-Water Mark Survey

At each survey location, the assigned Mapping Partner will survey at least one high-water mark data point at fixed physical features, such as residential or commercial buildings. When practicable, the Mapping Partner will survey two or more points at fixed physical features.

In the absence of available structures for collecting a high-water mark data point, the assigned Mapping Partner may use other fixed physical features, such as trees or utility poles. If a fixed physical feature is not available to survey the high-water mark data point, the Mapping Partner may use the debris line on the ground within a roadway or property area as a survey point.

### **3.2.5 High-Water Mark Type**

The assigned Mapping Partner will note the type of high-water mark for each data point. In general, the mud, residue, or debris line within the interior of structures is considered the most reliable. In other areas, the exterior mud, residue or debris line on the exterior of structures can be used, with the understanding that the wave effects may be a factor in the actual measured elevation at the high-water mark. This effect would tend to overstate the actual flooding event. The Mapping Partner may also use the debris line on the ground or suspended in vegetation as a last resort; however, this may result in the Mapping Partner overstating the actual flooding event because of the influence of wave effects. The Mapping Partner should take digital photographs of each high-water mark data point surveyed.

### **3.2.6 Other Flooding Factors**

For each location surveyed, the assigned Mapping Partner should note and photograph other information regarding the flooding event, including the following, and include these data in the GIS metadata:

- Waterway or inlet bridge crossing blockage by debris;
- Damage to or structural failure of waterway bridges, inlet jetties, coastal structures (seawalls and revetments), and inland bulkheads;
- Channel scouring or breaching of barrier islands;
- Sediment deposition in the channel or overland due to beach and dune washover effects; and
- Beach and dune erosion, meandering, or avulsion

For each high-water mark data point, the assigned Mapping Partner will provide the following GIS metadata:

- Identification number;
- Name of flooding source;
- Reach identification number;
- Location (city/town/borough/village, county/parish, state);
- Address of high-water mark structure, if applicable;
- Description of high-water mark (e.g., mud line, debris line);
- Description of the physical feature being surveyed, such as bridge, culvert, residential structure, or utility pole (for buildings, street address is included);
- Zone designation on effective FIRM (e.g., Zone V, VE, X);

- Type of high-water mark, such as mud line, debris line, clear water line, or downed vegetation;
- Orientation of high-water mark on structure (e.g., interior or exterior);
- Digital photograph of high-water mark and site condition;
- Approximate location of high-water mark relative to the shoreline in feet (include time of day for this observation);
- Date and time high-water mark was located;
- Date and time high-water mark was surveyed in (if different from above);
- Determination as to whether high-water mark is indicative of surge only, wave height, or wave runup;
- Latitude, longitude, and elevation (x, y, z) coordinates;
- Vertical datum;
- Name and seal of surveyor;
- Other notes to include brief assessment of erosion; and
- Accuracy or uncertainty (i.e., excellent, good, fair, poor).

### 3.2.7 Reporting

The assigned Mapping Partner will provide a summary report to FEMA that documents the high-water mark survey and inundation limits of the flood event. At a minimum, this report must document the following:

- Dates of survey;
- Survey methods;
- Benchmarks used;
- Location and elevation of high-water marks;
- Digital photographs of high-water marks;
- Completed High-Water Mark Certificates;
- Interviews with local residents and officials regarding the event; and
- Pertinent information on other flooding factors.

The assigned Mapping Partner will submit the report in digital format to the FEMA PO, FEMA Regional Risk Analysis Branch Chief, USGS, USACE, CTPs, and state NFIP Coordinator. The Mapping Partner should also coordinate making this report available on the FEMA Flood Hazard Mapping website ([www.fema.gov/national-flood-insurance-program-flood-hazard-mapping](http://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping)) for any other interested parties.

The assigned Mapping Partner will submit the data outlined for each high-water mark metadata file in a GIS map coverage file format that complies with FEMA's FIRM Database Technical

Reference (FEMA, 2017). The Mapping Partner will provide the high-water mark survey points in a GIS point coverage. Final selection of file formats should be coordinated with the FEMA PO or his/her designee.

Using the high-water mark data, the assigned Mapping Partner will map a projection of the flood inundation limits and elevations on USGS topographic quadrangles or another base map approved by FEMA. The Mapping Partner will ensure that supporting documentation is clearly cross-referenced to the tabular data using the identification number.

The Mapping Partner is to submit include the following:

- Digital photographs of each high-water mark;
- Digital photographs of waterway and inlet bridges, coastal structures, and bulkhead retaining walls, if other flooding factors are noted; and
- USGS (Digital Raster Graphic as minimum) quadrangle maps (or comparable base map source) showing the location, designation, and elevation of all high-water marks as a GIS spatial data coverage.

The assigned Mapping Partner will create the GIS-based maps through coordination with the FEMA PO or his/her designee, and submit these maps to the FEMA JFO and RO in digital format. .

### **3.3 Wind/Water Line Investigation**

The purpose of the wind/water line (WWL) investigation is to establish the geographic region of impact, distinguish between areas suffering wind and water damage from those suffering wind damage only, identify storm surge level variations, and assess the impacts on open coasts, inland bays, and sounds.

#### **3.3.1 Identification of Areas for Survey**

The FEMA Region, RSC and/or assigned Mapping Partner should perform an initial overview and assessment of the storm-surge levels and impacts for locating a WWL and identifying physical/cultural feature changes. (This task may be performed in conjunction with a detailed coastal high-water mark data collection activity.) The Mapping Partner should base the identification of areas for high-water mark surveys on available information regarding the recent event, such as satellite imagery, aerial photography, drone footage, media reports, and information provided by local and State emergency managers and other Federal agencies.

The assigned Mapping Partner should limit the lateral extent (perimeter) of WWL investigations to regions where the storm-surge levels caused damage to structures or property and WWLs exceed elevations of approximately 5 feet referenced to the North American Vertical Datum of 1988. (Note: The assigned Mapping Partner must modify this elevation for any work along the Great Lakes.) The Mapping Partner should obtain WWL points along the ocean shorelines (both barrier island and mainland), in rivers, bays, estuaries, and lagoons where significant storm surge occurred.

The assigned Mapping Partner will submit a summary of the above findings to the FEMA PO or his/her designee. The Mapping Partner should submit the findings in the form of a brief report, supported by USGS quadrangle maps (or comparable mapping source, such as aerial photographs) identifying the areas proposed for WWL data collection. The Mapping Partner should also submit any supporting documentation used to complete this assessment, such as satellite imagery or aerial photography.

### **3.3.2 Data Collection for Wind/Water Line Identification**

The assigned Mapping Partner should locate and survey WWL high-water marks for areas identified and approved by the FEMA PO or his/her designee. The guidelines for spacing of WWL high-water mark survey locations, selection of physical features for collecting the WWL high-water mark data points, types of WWL high-water marks to survey, and other factors to be noted are discussed in the following subsections.

For WWL investigations of mainland shorelines along inland bays and sounds, generally landward of the barrier island, the assigned Mapping Partner should investigate and document at least one WWL high-water mark per five-mile reach in developed regions. The preferred WWLs for mainland shoreline areas would be those inside of structures; however, any outside debris lines (i.e., on a roadway perpendicular to the shoreline or tree mudlines) are acceptable for delineating the inundation limits and elevation of surge levels. The elevation of surge levels outside of the open coast region helps to document the inland surge reduction.

The assigned Mapping Partner should obtain WWL high-water marks from locations inside structures to replicate stilling wells as well as outside structures to include wave effects. When conducting WWL high-water mark surveys, the Mapping Partner should also perform preliminary site investigations of primary frontal dune impacts and new storm-induced washovers/inlets for open coast barrier islands. These site investigations should include brief narrative description and photographic evidence of site. For primary frontal dune erosion areas, the Mapping Partner will record spot elevations of dune toe (landward and seaward) and crest. For new storm-induced washover/inlets, the Mapping Partner should record geographic location and dimensions (approximate width and length) of the area. Along shorelines of mainland bays and sounds, only WWLs are needed.

For WWL investigations of developed barrier islands of approximately 2 to 3 miles in length, the assigned Mapping Partner should document at least four WWLs, one near each inlet along the open coast and back bay shoreline flooded areas, preferably inside marks outside of wave influence (i.e., splash zone). An inside mark would be a mud line or debris line located within a structure (with no wave influence). An outside WWL would be a mud line or debris line on the outside of a building (these marks would have added wave effects).

The assigned Mapping Partner should investigate and document intermediate points between inlets (at approximately 2-mile intervals) along barrier islands greater than 4 miles in length, especially where new storm-induced washovers/inlets are located. For each WWL data point, the Mapping Partner will provide the following metadata:

- Identification number (for cross referencing purposes);
- General Location (street address, city/town, county/parish, State);
- Digital Photograph;
- Latitude, longitude, and elevation coordinate;
- Type of WWL (debris line, mud line);
- WWL location (outside or inside of structure);
- Date collected; and
- Any additional notes necessary.

The assigned Mapping Partner will provide the documentation of primary frontal dune changes and new washover/inlet in narrative and photographic format.

### **3.3.3 Reporting**

The assigned Mapping Partner will submit a summary report in digital format that documents, at a minimum, the dates of survey, survey methods used, benchmarks used (including horizontal and vertical reference datums), interviews with local officials and/or residents regarding the event, and information on dune impacts and washovers/inlets.

The assigned Mapping Partner will submit the data outlined for each WWL outlined above in a GIS map coverage file format that meets the requirements of FEMA's FIRM Database Technical Reference (FEMA, 2017). The Mapping Partner should provide the WWL survey points in a GIS point coverage. The Mapping Partner will coordinate final selection of file formats with the FEMA PO or his/her designee. The Mapping Partner should ensure that the supporting documentation is clearly cross-referenced to the tabular data using the identification number.

The assigned Mapping Partner should also submit digital photographs of primary frontal dune impacts and new storm-induced washovers/inlets for open-coast barrier islands if these were noted. The assigned Mapping Partner should submit USGS (Digital Raster Graphic as minimum) quadrangle maps (or comparable base map source) showing the location, designation, and elevation of all WWLs as a GIS spatial data coverage. The assigned Mapping Partner should provide map products to the PO or his/her designee that may be posted on the FEMA website.

## **3.4 Post-Disaster Flood Hazard Data Needs Assessment**

An important function within the JFO is to assess the available flood hazard data and determine if the accuracy and level of detail are sufficient to support benefit/cost analysis, reconstruction guidance, insurance determinations, GIU, and other activities. The steps outlined below describe a process that will result in the collection and identification of flood hazard data needs for the area affected by the disaster. This activity will allow priorities to be set for the development of additional flood hazard information determined for recovery activities.

### 3.4.1 Preliminary Investigation

The assigned Mapping Partner should obtain maps (hardcopy or digital format) that show major waterways, communities; roads and railroads; locations of Individual Assistance (IA) applications and/or flood insurance claims data; and flood insurance risk zone designations from the FIRMs for all affected counties/parishes. The assigned Mapping Partner may obtain these maps from the FEMA GeoPlatform or Map Service Center ([msc.fema.gov](https://msc.fema.gov)). As additional applications for FEMA Individual Assistance (IA) are received, it may be necessary to obtain updated versions of these maps.

The Mapping Partner should review the maps to determine areas for further investigation and/or field reconnaissance. The following preliminary reviews may help to identify areas for further examination:

- Identification of areas with large concentrations of IA applications and/or flood insurance claims data;
- Comparison of remotely sensed flood inundation limits to the FIRM boundaries;
- Comparison of any flagged locations of any field-collected high-water marks (x,y locations), with all data collected flagged with lat/long in decimal degrees and referenced to the North American Datum of 1983; and
- Any geocoded locations for potential or recently completed HMA program projects.

The assigned Mapping Partner may need to perform field reconnaissance to clarify issues identified through this process.

The assigned Mapping Partner should determine if the state or any other entities (local communities, USGS, USACE districts, water management districts, regional development districts, others) are collecting data that may provide additional information.

### 3.4.2 Detailed Data Collection

The FEMA Region, RSC and/or Mapping Partner should gather pre-flood event data available such as topographic data, stream gage information (flow/stage), hydrologic and hydraulic modeling, and updated or in process mapping data. The Mapping Partner may review the MIP for existing data sets and check to see if the Risk MAP Discovery process or if BLE has been performed in the affected areas. Geospatial data collected during the Discovery process or during BLE analyses could provide pre-flood event data such as:

- Topographic and bathymetry data status and availability, locations of future topographic and/or bathymetric data acquisition;
- Flood risk assessment data;
- Flood-control structure location data from national or regional inventories (e.g., National Inventory of Dams, levee inventories) and accreditation status information including information from Dam Emergency Action Plans (if available);
- Locations of stream gages;



- Known flooding issues not represented on effective FIRMs or listed in the CNMS database;
- Areas of ongoing or planned development;
- In coastal areas, the locations of wave and tide gages; wind stations; the proposed inland limit of the Primary Frontal Dune, if present; the location of any beach nourishment or dune restoration projects; a comparison of preliminary stillwater elevations (SWELs) with effective SWELs;
- Available effective study data;
- Available orthophotography; and
- History of other major hazards.

Other data may include:

- Hydraulic structures such as bridges or culverts, with inspection status, if available;
- Coastal structures, including flood protection structures (e.g., levees), shoreline structures (e.g., jetties, groins, seawalls), manmade embankments (e.g., elevated roads, railroads), surge conveyance pathways, and shoreline change data; and
- Inundation areas of historic major flood events and declared disasters and high-water marks lusters or locations of Individual Assistance/Public Assistance grants and locations of grant projects completed, planned, or underway; locations of projects and structures completed or planned for FEMA Hazard Mitigation Assistance grant programs or mitigation funds from other agencies or entities, such as the Small Business Administration.

The FEMA Region, RSC and/or Mapping Partner may access the effective hydrologic and hydraulic modeling analyses data from the MIP or the FEMA Engineering Library. The FEMA Region, RSC and/or Mapping Partner may also access the CNMS database for an inventory of flood hazard studies and flood hazard mapping needs.

The Mapping Partner should review the CNMS database for reporting mapping needs to FEMA and determine if any mapping needs specific to the disaster event must be added. The Mapping Partner should distribute the completed form to FEMA planners for their “to go” kits, and brief them on the form.

FEMA planners should provide the Disaster Data Needs Assessment Form to the communities when mapping issues are raised to document them for input into the flood hazard data needs database.

The assigned Mapping Partner will do the following to attribute the CNMS database:

- Review hydrology from Flood Insurance Study (FIS) text to determine date and method of hydrologic analyses;
- Review hydraulics from FIS text to determine date of hydraulic analyses;



- Compare remotely sensed flood inundation limits to the FIRM boundaries;
- Compare any flagged locations of any field-collected high-water marks (x,y locations);
- Identify locations for potential Hazard Mitigation Grant Program (HMGP) projects;
- Identify geocoded substantially damaged structures;
- Identify information on severely damaged critical infrastructure;
- Identify Approximate Zone A areas/unmapped areas with damages that need base flood elevations (BFEs) for reconstruction efforts; and
- Review CNMS data for affected communities.

The assigned Mapping Partner will input data gathered into the CNMS database, which is located at [msc.fema.gov/cnms](https://msc.fema.gov/cnms). The Mapping Partner should prioritize flood hazard data collection and analyses needs for possible contract Task Orders.

The assigned Mapping Partner should obtain or develop maps that show major waterways, communities, roads and railroads, IA, insurance claims information, and FIRMs for all affected counties/parishes. Additionally, other useful map products may be developed using GIS support at the federal, state, local, tribal or territorial level. From a review of the maps and other resources, the Mapping Partner should identify and conduct reconnaissance of the areas that need further investigation. The assigned Mapping Partner should also review the FIS Reports for the affected communities to determine the methods used to perform the hydrologic and hydraulic analyses. The Mapping Partner should use a myriad of resources to perform this detailed data collection including, but not limited to, CNMS, high-water mark inspections, and previous flood hazard studies in the area. Data related to hazard mitigation projects should also be collected and compared against areas with substantially damaged structures and flood insurance claims.

### **3.5 Flood Hazard Data Update Needs**

Based on the data collected from the post-disaster flood hazard data needs assessment discussed previously, the assigned Mapping Partner should develop a priority list of flood hazard data update needs in coordination with the CTP, State NFIP Coordinator, local communities, and the FEMA Region. This list should include communities, flooding sources, reach lengths, and FIRM panels. The Mapping Partner should also assemble data from the FIS Reports, FIRMs, CNMS, USGS, CTP, State NFIP Coordinator, and local communities.

To determine if a new flood hazard analysis is warranted, the assigned Mapping Partner should use the 68-percent confidence interval (one standard error). Generally, if the new 1-percent-annual-chance (100-year) storm discharge from the preliminary frequency curve produces a new 1-percent-annual-chance (100-year) flood profile that is 1.0 foot or more above that developed for the effective FIS Report, then a new flood hazard analysis may be warranted based on changes in the flood discharges (FEMA, 2016a).

In addition, the assigned Mapping Partner will assign a priority category to the priority list and coordinate with the CTP, State NFIP Coordinator, local communities, and the FEMA Region. The priority categories are:

- **Emergency** — Immediately needed for Mitigation Recovery Activities;
- **Priority** — In support of Mitigation Recovery Activities; and
- **Routine** — Normal Restudy Needs List.

For those projects that have the same ranking on the priority list, the FEMA Region and the State NFIP Coordinator will coordinate to decide which community has the higher ranking. The assigned Mapping Partner may list the final priorities in a spreadsheet and deliver it to the FEMA Region, the State NFIP Coordinator, and local communities. The suggested procedures for streams and communities by priority category are outlined below. The assigned Mapping Partner will ensure any data collected on these communities are input to the CNMS database.

### **3.5.1 Emergency**

The assigned Mapping Partner should perform accelerated hydrologic and hydraulic analyses and present the results on a digital work map showing 1-percent-annual-chance (100-year) floodplains and regulatory floodway and the best available base map information available. These data would be used as best available information for assisting hazard mitigation recovery activities. As a best practice, the Mapping Partner may utilize the BLE process to perform the hydrologic and hydraulic analyses and floodplain mapping. The proposed timeframe for this action is one month.

### **3.5.2 Priority**

The assigned Mapping Partner should perform accelerated hydrologic and hydraulic analyses and present the results on a digital work map showing 1-percent-annual-chance (100-year) floodplains and regulatory floodway and the best available base map information available. These data would be used as best available data for assisting hazard mitigation recovery activities. As a best practice, the Mapping Partner may utilize the BLE process to perform the hydrologic and hydraulic analyses and floodplain mapping. The proposed time frame for this action is three months.

### **3.5.3 Routine**

These communities will be reprioritized, as appropriate, by the FEMA RO as part of its annual review of study/restudy requests from communities.

## **4.0 Development of Recovery Tools**

Collection and assessment of flood data and preparation of flood recovery maps, if needed, are activities outside of FEMA's normal flood hazard mapping operations. These activities must take place in the immediate aftermath of a disaster. When a flood occurs, valuable data become available that enable FEMA and its Mapping Partners to reassess the estimates of flood risk.

Also, rebuilding efforts begin within a short period after the disaster, and timely updated flood risk data are necessary to ensure that the rebuilding will protect properties from future flooding disasters. The new data need to be evaluated and, if necessary, incorporated into new engineering analyses. Appropriate hazard identification tools (such as flood recovery maps) must be produced quickly. In some cases, there may not be any detailed flood mapping at all,

and flood recovery maps may be the only detailed guidance to assist the State and community in planning and managing rebuilding efforts.

Subsections below provide guidance for preparing flood recovery tools.

#### **4.1 Purpose and Intended Use of Advisory Base Flood Elevations**

Following large storms, FEMA may perform an assessment to determine whether the effective 1-percent-annual-chance flood event adequately reflects the current flood hazard. In some cases, due to the age of the original analysis and the science used to develop the effective FIRMs, FEMA may determine that there is a need to produce ABFEs.

ABFEs can be developed in a relatively short time span and may be used “fill the gap” between a large storm event and the amount of time it would take to develop updated regulatory data. Although ABFEs can be used to provide elevation guidance for rebuilding and support reconstruction efforts, they are not intended to support regulatory floodplain designations or insurance ratings (FEMA, 2013). ABFEs can be created for riverine or coastal areas.

Developing riverine ABFEs is typically done in a manner similar to a FEMA regulatory FIS Report with the difference being that the updated hydrology is often based on provisional water level gage data. This methodology can be applied in areas with existing detailed studies or in areas with Zone A studies (without BFEs). Riverine ABFEs can be developed using gage analysis following the guidance available in Guidance for Flood Risk Analysis and Mapping: General Hydrologic Considerations (FEMA, 2016a).

For coastal areas, the ABFE will depend upon updated coastal SWEL data as well as updated wave height analysis. There may be an updated 1-percent-annual-chance SWEL data set available that can be used as the foundation of the coastal ABFE analysis; however, it is more likely that the best available SWEL data is from the most recent effective FIS Report. In this case, a flood frequency analysis should be undertaken based on tide gage data available in the study region. The tide gage analysis should include the data from the flood event. If the results of this analysis do not show an increased 1-percent-annual-chance SWELs over the effective data, then the FEMA PO should be consulted as this result would indicate that the effective maps are likely still valid. If the analysis indicates a general increase in the 1-percent-annual-chance SWELs over the effective data, then after consultation with the FEMA PO, the study should advance to evaluate the wave height effects.

#### **4.2 Flood Frequency Determination**

The assigned Mapping Partner will contact the USGS and NWS to gather preliminary data for stream gages and rain gages in or adjacent to the impacted areas. These analyses should be performed in conformance with the Bulletin 17B, published by the Interagency Advisory Committee on Water Data in 1982 (Interagency Advisory Committee on Water Data, 1982). A proposed update by the USGS in 2015, known as Bulletin 17C (USGS, 2015), may become final in the coming months. The Mapping Partner should check for the updated version and follow standards from the most recent flood frequency determination guidance. The assigned Mapping Partner should coordinate with the USGS and/or USACE to review the agencies’ post-flood summary reports.

For those gages with peak stages that exceeded stages in the historic record, the assigned Mapping Partner will perform a log-Pearson Type III analysis to extrapolate the frequency of the storm. These data are used to adjust the stage-discharge curves (rating curve) of the stream gage. In addition, the Mapping Partner should research existing data, including the effective FIS Reports, FIRMS, and other sources such as the USGS, USACE, state, and local communities to determine the documented 1-percent-annual-chance (100-year) flood stages at each gage site.

The assigned Mapping Partner should develop spreadsheets to compare the new peak 1-percent-annual-chance (100-year) flood stages and/or floodflows and the flood stages and/or floodflows that are reflected in the effective FIS Report and on the effective FIRM. Although these data are preliminary, the Mapping Partner should investigate areas where new peak stages exceed the mapped stage to determine the reason for the differences in water-surface elevations. The Mapping Partner should revisit the new stage-frequency analyses when high-water mark data and indirect measurements are available. In addition, the Mapping Partner may need to assess targeted flooding sources that did not have USGS gage data information based on future high-water mark data.

The assigned Mapping Partner will perform stage-frequency analyses where no finite flood discharge information is available. The Mapping Partner will perform direct and indirect discharge measurements to verify stage-frequency analyses. The Mapping Partner should perform the discharge measurements in accordance with standards set forth in the 1994 USGS Water Resources Investigation Report 94-4002 (USGS, 1994).

In the event that no direct USGS data are available for a community, the assigned Mapping Partner may establish preliminary flood frequencies on a watershed basis or based on the storm's rainfall frequency. Although these are not the most accurate methods, they do provide a characteristic of the storm. In this case, the assigned Mapping Partner should not determine final flood frequencies until a new detailed flood hazard analysis is performed, if applicable.

### **4.3 Estimated BFEs for Zone A Areas**

When no detailed flood data exists for specific waterways, the assigned Mapping Partner may have to perform hydraulic studies to establish BFEs to assist in proper floodplain management and redevelopment. At FEMA's request, the Mapping Partner may be required to perform hydrologic and hydraulic analyses (the type of model will be assigned by the FEMA PO or his/her designee in the Scope of Work) and develop the 1-percent-annual-chance (100-year) Flood Profile for specific waterways. The Mapping Partner may use the BLE approach as a best practice to perform the hydrologic, hydraulic, and floodplain mapping to produce estimated BFEs for Zone A areas.

#### **4.3.1 Hydrologic Analysis**

The assigned Mapping Partner should develop the peak 1-percent-annual-chance (100-year) flood discharge using the appropriate USGS regression equations. As a best practice, the Mapping Partner may use the BLE to produce the hydrology information. The Mapping Partner will develop drainage from the best available topographic data sources. General guidance for performing the hydrologic modeling can be found in Guidance for Flood Risk Analysis and Mapping: General Hydrologic Considerations (FEMA, 2016a).

### **4.3.2 Hydraulic Analysis**

The assigned Mapping Partner will develop the cross sections to be used in the hydraulic model from the best available topographic data sources. Bathymetric or channel survey data may also be used. General guidance for performing the hydraulic modeling can be found in Guidance for Flood Risk Analysis and Mapping: General Hydraulics Considerations (FEMA, 2016b). As a best practice, the Mapping Partner may use the hydraulic approach for BLE analysis.

### **4.3.3 Mapping**

The assigned Mapping Partner will produce work maps that present 1-percent-annual-chance (100-year) and 0.2-percent-annual-chance (500-year) floodplains and regulatory floodway using the best topographic data available on a suitable base map. The Mapping Partner may use the BLE methodology as a best practice for developing the floodplain boundaries. The Mapping Partner will ensure all digital mapping files are produced in accordance with the requirements documented in the Guidance for Flood Risk Analysis and Mapping sections: Riverine Mapping and Floodplain Boundaries Guidance (FEMA, 2015a) and Coastal Floodplain Mapping (FEMA, 2015b).

## **4.4 Coastal Analyses**

The assigned Mapping Partner will perform all coastal analyses in accordance with the requirements documented in Guidance for Flood Risk Analysis and Mapping: Coastal General Study Considerations (FEMA, 2016c).

## **4.5 Riverine Analysis**

The assigned Mapping Partner will perform all riverine analyses in accordance with the requirements documented in Guidance for Flood Risk Analysis and Mapping: General Hydrologic Considerations (FEMA, 2016a) and General Hydraulics Considerations (FEMA, 2016b). The Mapping Partner may utilize the BLE methodology as a best practice for the riverine analysis.

## **4.6 Recovery Products**

### **4.6.1 Non-Regulatory Mapping Products/Map Books**

Non-regulatory flood risk datasets can be used to communicate more complete flood risk information so that actions may be taken to reduce the flood risk. These non-regulatory products are valuable outreach tools to help community officials identify high risk areas and determine priorities for mitigation efforts.

According to the Guidance for Flood Risk Analysis and Mapping: Flood Depth and Analysis Grids (FEMA, 2014a), the following non-regulatory flood risk datasets, in the form of grid datasets, may be developed and used as a tool to help communicate the levels of risk within the local communities:

- Water Surface Elevation (WSEL) grid;
- Flood depth grid;
- WSEL change grid;

- Percent Annual Chance of Flooding grid;
- Velocity grid; and
- Flood severity grid.

Another non-regulatory dataset, Change Since Last FIRM (CSLF), shows changes that have occurred in the horizontal extent of the regulatory floodway, 1-percent-annual-chance floodplain, and 0.2-percent-annual-chance floodplain. The CSLF dataset allows local community officials to visualize areas that have been added to or removed from the regulatory floodplain and help identify where significant numbers of households and/or businesses may be affected. This can help focus outreach and flood risk communication efforts to raise risk awareness (FEMA, 2014b).

Map books, or story maps may also be used to convey flood risk information to the community. A report can be transformed into an interactive map book to visually present graphics and results. The map books may be made available online.

Coastal areas may have other non-regulatory datasets that include:

- Increased Flooding Scenarios (dataset estimates hypothetical increases above the base flood levels associated with a particular annual-chance event);
- Dune Size and Location, and
- Simplified Coastal Zones (dataset shows the wave hazards determined from overland wave propagation or wave runup analyses.)

General guidance for preparing the database of non-regulatory flood risk data can be found in the [Flood Risk Database Technical Reference](#) (FEMA, 2016d).

#### **4.6.2 Advisory BFE Maps**

ABFE maps, sometimes called Recovery Maps, may be developed to help local communities begin rebuilding and recovery operations post-flood event. The ABFE maps provide an updated analysis of the 1-percent-annual-chance flood hazard elevations in a given area and can be an essential tool to help communities recover and rebuild in ways that will make them more resilient to future flood events. In the case of FEMA Region II Coastal ABFE work following Hurricane Sandy, the ABFE information was provided through an outreach website where the user could look up the ABFE and advisory flood zone information for a particular address.

#### **4.6.3 High Water Mark and Inundation Mapping**

Providing information on high water marks and mapping the approximate inundation locations after a flood may be a valuable tool to help communities and other stakeholders know where post-flood recovery efforts are most needed.

Information on high-water marks may be provided as reports with graphics, but this information can also be displayed on maps. Using GIS tools, HWMs can be used to create inundation maps that show the approximate boundary of flooding. Using seamless topographic datasets, the high-water marks can also be used to create depth grids showing the approximate depth of



water associated with a particular flood event. As an example, after Hurricane Sandy, the USGS-collected high-water mark data was used by FEMA's Modeling Task Force along with a Digital Elevation Model to create a storm surge inundation boundary and depth grids for Hurricane Sandy. This data was made available as downloadable GIS files or viewable through an online map viewer, which provided different levels of access for different stakeholders.

The USGS Flood Inundation Mapping (FIM) Program ([water.usgs.gov/osw/flood\\_inundation](http://water.usgs.gov/osw/flood_inundation)) provides tools and information to help communities understand their local flood risks and make cost-effective mitigation decisions. Under the FIM Program, the USGS partners with local communities to develop a flood inundation map library that can be used for preparedness, real-time streamflow data and flood forecast information, potential loss estimates, as well as mitigation and planning.

Another outreach and engagement tool includes the High-Water Mark Initiative ([www.fema.gov/high-water-mark-initiative](http://www.fema.gov/high-water-mark-initiative)). Through this campaign, high-water mark signs are posted in prominent locations within a community. The signs are unveiled during a launch event, help to educate community members, and build local awareness of flood risk.

#### **4.6.4 Reporting and Documentation**

The assigned Mapping Partner should prepare recovery products according to the Guidance for Flood Risk Analysis and Mapping. Advisory map products may be made available on FEMA's GeoPlatform.

## **5.0 References**

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