

Guidance for Flood Risk Analysis and Mapping

Base Level Engineering (BLE) Analyses and Mapping

Submitted by ASFPM Mapping & Engineering Standards Committee
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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). 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.

Document History

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1.0 Introduction

Base Level Engineering (BLE) is riverine hydrologic and hydraulic modeling conducted at the minimum engineering standard necessary to support regulatory mapping of the 1-percent annual chance flood. BLE is as its name implies the base level that FEMA would provide as a flood study for a given area. Per standards #84 and #133, will include all recurrence intervals (0.2-percent, 1-percent, 1-percent plus, 2-percent, 4-percent, and 10-percent-annual-chance floods). As such a water surface elevation should be created for the 1-percent and 0.2-percent flood hazards. BLE can be conducted at any scale but is often conducted for larger areas (HUC-8 watershed or county level) and utilizes automated engineering processes to increase efficiencies and reduce the overall data development cost. The intent of BLE is to develop technically credible flood hazard information and models that reasonably establish floodplain boundaries (and when part of a Risk MAP study, water surface grids) at a low cost, which have supporting information that can be used for determining a BFE.

BLE is the preferred method of initial investigation and base level determination of flood hazard identification in watersheds and other study areas. It is intended to, and--as specified in this document can--be built upon to create enhanced (Zone AE) studies as warranted. This document will address the usability requirements, stakeholder communication and, technical issues, feasibility, and data deliverables for BLE.

BLE can replace current Zone A's or areas of no study and, when it is built upon to be Zone AE quality, can replace outdated Zone AE's on effective FIRMs. If it is being used to replace a Zone AE with floodway, a floodway will need to be produced as part of the process.

1.1 Background

BLE is building on and replacing the concept of First Order Approximation (FOA). FOA was first officially defined in November 2014 in the [First Order Approximation Guidance](#) document. FOA was intended to take advantage of technology improvements in hydrologic and hydraulic modeling of large areas. FOA was to be used to estimate floodplain boundaries in areas with no existing flood mapping and to estimate floodplain boundary changes in areas with outdated mapping. FOA was also widely used as the Coordinated Needs Management Strategy (CNMS) validation technique. FOA standards were noticeably less stringent than regulatory floodplain mapping standards, especially for topographic data, where 10-meter and 30-meter USGS Digital Elevation models (DEMs) were allowed.

FOA was widely procured by FEMA between 2014 and 2016. As the deliverables of FOA became more familiar to a larger group of people, some concerns arose. These included:

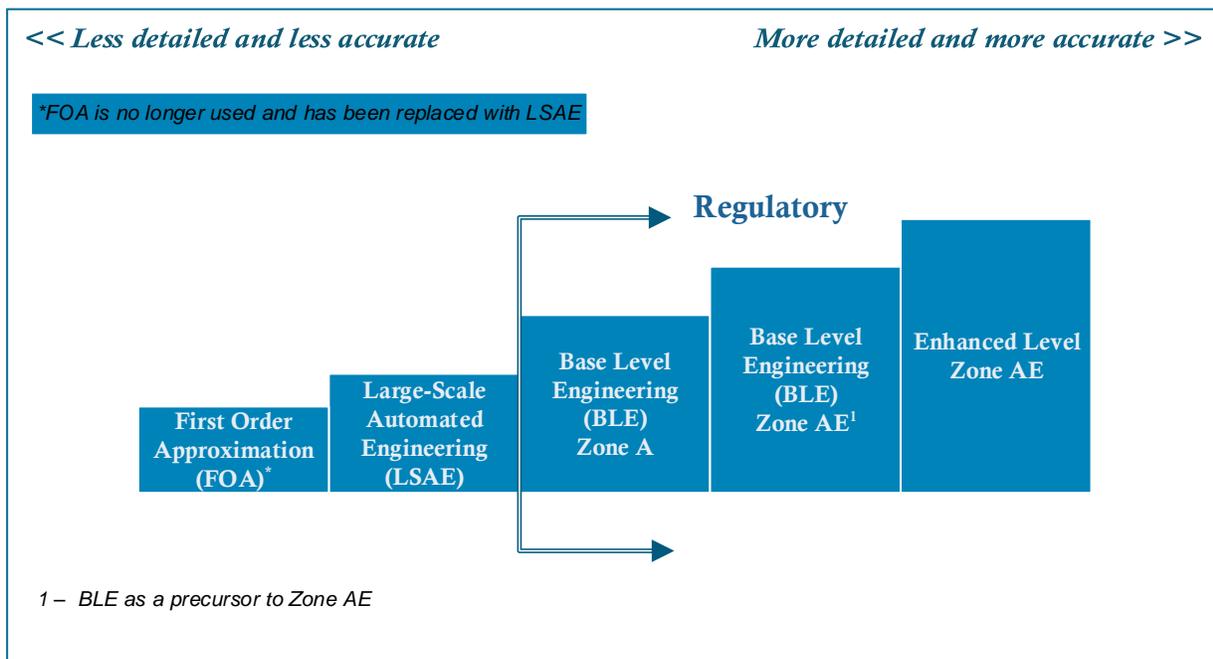
- FOA was too coarse to show critical changes in floodplain limits;
- It was difficult and not cost effective to scale up FOA to a regulatory flood map, especially where USGS DEM topography was used; and

- FOA was not perceived as credible data by stakeholders.

In 2016, the term FOA was phased out and replaced with “Large Scale Automated Engineering (LSAE).” Notably, LSAE only to be developed in areas that have Light Detection and Ranging (LiDAR) topography or with topography with a resolution greater than 5 meters. While stakeholders were pleased with the requirement to use LiDAR higher resolution topography in LSAE, there continued to be concern about the overall quality and technical credibility of the work, the lack of guidelines and standards and the ease of conversion to a full regulatory floodplain mapping product.

In 2016 and early 2017, the concept of BLE as an improvement to LSAE gained traction. BLE is still intended to be highly automated, but with several key features that make it more accurate, technically credible and suitable to be used for easily scaled up a regulatory floodplain mapping product. On the continuum, FOA has been replaced by LSAE and now BLE is a new way to complete both the first investigatory flood mapping of an area as well as traditional Zone A regulatory mapping. Figure 1 below shows engineering techniques as they relate to regulatory riverine floodplain mapping and where each of these products fits within that spectrum.

Figure 1: Span of Riverine Flood Mapping



1.2 Need for BLE Scope Standardization

There are several factors driving the need for BLE scope standardization. These include:

- The importance of having a BLE product that can reliably be said to meet minimum regulatory floodplain mapping standards

- A way to identify for communities what they would receive as a base level of study for any projected FIRM update
- If products are to be built from BLE data and distributed to the public, it is important that there is a minimum level of quality and coverage, as well as a consistent look to the information.

2.0 Usability of BLE Data

This section guides all stakeholders on the potential uses of the data generated by BLE analysis. The driving guidance affecting the use of the BLE data prior to FIRM release are as follows:

- Floodplain Management Bulletin 1-98, Use Of Flood Insurance Study (FIS) Data As Available Data Floodplain Management Bulletin 1, Use of Flood Insurance Study (FIS) Data As Available Data (FMB-1) - provides guidance on the use of either FEMA draft or preliminary Flood Insurance Study data as "available data" for regulating floodplain development.
- FEMA 265: Managing Floodplain Development in Approximate Zone A Areas (April 1995).
- FEMA Policy: Guidance on the Use of Available Flood Hazard Information, FEMA Policy #104-008-2

Some of the potential uses are explained below in sections 2.1 – 2.6

2.1 Discussion data for Discovery

If BLE data is available during the Discovery phase of the Flood Risk Project, it can provide information necessary to engage the community stakeholders effectively. This data can help support engagement and productive communication

- to address community stakeholder interests, including, where flood hazard information might exist that hadn't previously been mapped,
- what exposure to risk looks like when compared with the flood hazard information, where potential mitigation projects could exist,
- how BLE can be used as Best Available Information (BAI) for floodplain management and the post disaster environment where a need for updated and/or enhanced flood hazard information is warranted, and
- understanding where the 1% annual chance floodplain boundaries and/or Base Flood Elevations (BFE) may change (e.g., an increase or decrease in depth or spatial extent of the 1% annual chance floodplain boundary) and what areas of the community will be impacted by those changes.

For additional details about this, refer to the [Discovery Guidance](#).

2.2 Base for future creation of model backed Zone A or Zone AE

The level of effort expended in developing a floodplain analysis is generally related to the complexity of the flood hazard type (e.g. riverine split flows, levees, and alluvial fans), the study methodology, the cost and time of acquiring necessary input data (e.g. LiDAR, bathymetry and survey), and the type of study that that may or may not exist. Typically, at a minimum, the existing effective study, where applicable will be the baseline for any future study.

The cost for developing the data resulting from the BLE process should be lower than traditional Zone A flood production costs due to the degree of automation. The BLE models should be developed for the eventual production of regulatory and flood risk products and scalable to create enhanced level studies as requested and verified.

Within the base and enhanced level analysis study types, there are various options or assumptions that can be made to control the effort and cost to identify flood hazards. The following table presents a set of approaches and assumptions for various levels of base level analysis and the typical flood zone designation that may be mapped on a FIRM. Table 1 describes common methods of developing hydraulic modeling input data, but should be considered guidance, not a required approach. The final approach should be selected considering the needs and risk of the community, availability of input data and project funding.

Table 1: Base and Enhanced Level Analysis Approach Options

Option	Cross Sections	Flow Paths (Left, Right and Channel)	Manning's "n" Values	Structures	Flood Zone
A	Auto-placed; may be unnaturally straight with computerized look to them adjusted or auto-placed by "intelligent" methods.	Reach lengths are assumed equal.	Single value for each cross section.	Not included; cross sections placed as if structures don't exist or cross sections placed appropriately for structure modeling.	A
B	Auto-placed and hand adjusted or auto-placed by	Reach lengths computed by offsetting	Overbanks from Land Use Land Cover (LULC) data, channel	Not included; but cross sections placed appropriately for structure modeling.	A

Option	Cross Sections	Flow Paths (Left, Right and Channel)	Manning's "n" Values	Structures	Flood Zone
	"intelligent" methods.	stream centerline.	value estimated separately.		
C	Each section reviewed by engineers.	Reach lengths adjusted based on draft floodplain.	Overbanks LULC data, channel value estimated separately.	Included; structure data from national, state or other data source. Estimated base on topography and aerial photos for those not available.	A
D	Each section reviewed by engineers.	Reach lengths adjusted based on draft floodplain.	Overbanks from LULC data, channel value estimated separately and calibrated where possible.	Included; structure data from as-builts, design plans, "measured" in the field, or other community datasets with opening information.	A or AE
E	Each section reviewed by engineers, Channel bathymetry included in sections.	Reach lengths adjusted based on draft floodplain.	Overbanks from LULC data and field data, channel value estimated separately from field data and calibrated where possible.	Included; structure data from field survey, as-builts, design plans, "measured" in the field.	AE

For additional details about this, refer to [Guidance for Flood Risk Analysis and Mapping - General Hydraulics Considerations Guidance document](#).

2.3 BLE data on Elevation Certificates

An Elevation Certificate (EC) is an administrative tool of the National Flood Insurance Program (NFIP) which is to be used to provide elevation information necessary to ensure compliance with community floodplain management ordinances, to determine the proper insurance premium rate, or support a request for a Letter of Map Amendment (LOMA) or a Letter of Map Revision based on fill (LOMR-F).

During the elevation certificate process, stakeholders in certain cases (see BAI guidance document) can use the BFE data and WSEL produced as part of the BLE. BFEs certified on elevation certificates have been required to meet the standards of FEMA 265: Managing Floodplain Development in Approximate Zone A Areas (April 1995).

It is recommended to use the BLE data based on the current effective flood zone determination per Floodplain Management Bulletin 1-98.

BLE data prepared in accordance with this guidance document will meet the FEMA 265 requirements for elevation certificate BFE development.

2.4 BLE Data on Floodproofing Certificates

Floodproofing Certification is documentation by a registered professional engineer or architect that the design and methods of construction of a non-residential building are in accordance with accepted practices for meeting the floodproofing requirements in the community's floodplain management ordinance. For insurance rating purposes, a building's floodproofed design elevation must be at least one foot above the BFE to receive full rating credit for the floodproofing. If the building is floodproofed only to the BFE, the flood insurance rates will be considerably higher. BLE data in certain cases (see BAI guidance document) can provide BFE information needed for the floodproofing certificate.

BFEs certified on floodproofing certificates have been required to meet the standards of Technical Bulletin 3-93: Non-Residential Floodproofing — Requirements and Certification for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program (April 1993).

BLE data prepared in accordance with this guidance document will meet the Technical Bulletin 3-93 requirements for floodproofing certificate BFE development.

2.5 BLE Data for LOMC (Amendment or Revision) BFE determination

BLE data can provide BFE and modeling information which is required for various types of LOMC requests (LOMA, LOMR-F, and LOMR) where such data is not already published on a Flood Insurance Rate Map (FIRM). In instances where no BFE exists for an A Zone, the BFE and/or WSEL

generated by BLE can be used for LOMC applications (for additional details and uses of BAI please see the BAI guidance document).

BFEs certified on elevation certificates for requesting a LOMC, have been required to meet the standards of FEMA 265: Managing Floodplain Development in Approximate Zone A Areas (April 1995). BLE data prepared in accordance with this guidance document will meet the FEMA 265 requirements for elevation certificate BFE development.

2.6 FEMA Floodplain Inventory (NVUE) validation for Zone A

During CNMS assessments of existing effective Zone A studies, BLE data should support directly Refined Zone A Engineering study (A5) validation. For additional details about the A5 validation process, refer to Appendix C in the Coordinated Needs Management Strategy (CNMS) Technical Reference. BLE data prepared in accordance with this guidance document will meet the standards for comparison against effective floodplains as described in the CNMS technical reference.

3.0 Stakeholder Engagement

Stakeholder engagement is vital to the acceptance of the BLE analysis, which in turn is essential to the development of successful Flood Risk Projects. If BLE data is available and will be used, it is critical for the stakeholders to understand the future path to be followed will meet their expectations for the Flood Risk Project. Section 4 of this guidance provides additional details about the scenarios based on the current effective floodplain analysis inventory.

BLE data supports FEMA standard #29 that requires flood risk data to be provided in the early stages of a Flood Risk Project.

SID # 620 requires that, if the model or models that will be used to update the flood hazard information shown on the FIRM are known at this stage, then each community affected by the update must be notified of the planned model(s) to be used and provided with: (1), an explanation of the appropriateness of using the model(s) and (2), a 30-day period beginning upon notification to consult with FEMA regarding the appropriateness of the mapping model(s) to be used.

BLE data prepared in accordance with this guidance document will meet SID #29 and SID #620 requirements.

For additional details about this, refer to the Stakeholder Engagement – Discovery Phase Guidance document.

If BLE data development is planned during the “Data and Product Development” phase of the Risk MAP Project lifecycle, rather than during Planning or Discovery phases, additional stakeholder engagement may be necessary if the study types have changed since notification. The Mapping Partner should evaluate the need to have additional outreach to establish clear expectations and build stakeholder understanding and ownership of the BLE data.

For additional details about this, refer to the [Stakeholder Engagement - Data and Product Development Phase Guidance](#) document

4.0 Decision Tree

This section provides guidance for four common scenarios as to how to use BLE data from the early stages of the project to final data delivery. As referred to in the introductory section of this guidance, BLE analysis is typically conducted for larger areas (HUC-8 watershed or county level) to take advantage of economies of scale, irrespective of communities current NFIP participation status. Below are the main scenarios based on the current effective floodplain inventory (*Drafts are provided as a separate PDF*).

- Scenario 1 – No current mapping for county (subset NFIP participating versus not)
- Scenario 2 – County has multiple SFHA Zones (subset digital maps versus paper)

If a community and FEMA determine to attempt to streamline the process, there must be close coordination with the local governments prior to this decision. A decision may be made based on low risk or minimal community impacts to utilize more automated techniques when it comes to the graphical specifications to ensure a quicker and less expensive path to final FIRM products. Additionally, a county and the communities within it, may provide in writing a request to streamline the outreach in order to more quickly get to their final product. Region should coordinate with their FEMA HQ POC if these streamlined processes are to be requested.

++When advancing to the “Determine Need for Additional stream/panel updates” shown in Scenario 2, the Region should look at the cost for updating the area and whether providing the information as Best Available Information will be sufficient to ensure risk awareness and mitigation opportunities are available. The situation should be evaluated relative to the following criteria:

1. Is the unmapped stream/panel in a populated area?
2. Is the unmapped stream/panel in an area of current or near term growth?
3. Could you streamline the graphic specs to allow for a more automated mapping to allow for additional updated FIRM panels but maintaining lower costs to produce?
4. Is the community capable of accessing the Best Available Information if not located on the FIRM?

It should be noted that the intention is for all data produced to be scheduled to completion as a FIRM update, with the understanding that it may not all happen in the given fiscal year it was produced. Some data may need to go on hold if priorities for the community are low and risk is low in the given area, to be evaluated in a future fiscal year when funding is available.

**When a project reaches the “Regulatory Path”, it can advance as a full Risk MAP project with the identified flood risk products or it can continue as a Paper Inventory Reduction as discussed and approved during Regional allocation process.

5.0 Data Deliverables

The Flood Risk Database (FRD) provides a standard, systematic method for FEMA to collect, store, and distribute comprehensive flood risk data to the public and others in a digital format. The FRD contains geospatial data layers, attribute lookup tables, supporting files, and other information necessary to create all the flood risk datasets. Using the existing standards for FRD will alleviate the need to have a separate data deliverable standard for BLE.

The current version of the FRD standard does not have all the necessary geospatial data layers to differentiate BLE-generated flood risk products. However, minimum revisions to the existing FRD data structure should support consistent data deliverables. BLE Data delivery through the existing FRD database is currently under review. The [FRD Technical Reference](#) will be updated in the future to reflect this addition.

BLE-generated stream centerlines, cross-sections, and floodplain mapping can be stored and maintained in FRD. An example database scheme is shown below, and this should support future FIRM production with a minimum of effort.

- BLE_Datasets
 - BLE_S_XS
 - BLE_S_Str_LN
 - BLE_S_FLD_Mapping (0.1 % and 0.2 % chance events)

For additional details about this, refer to [Guidance for Flood Risk Analysis and Mapping – Flood Risk Database](#), and [Flood Risk Database \(FRD\) Technical Reference Guidance](#) document.

6.0 Data Sharing

One of the major objectives of the BLE process is to make the data accessible to stakeholders for use. Below are some possible solutions to sharing the data.

- Community meetings and training
- GIS databases
- Workmap format with minimal graphic standards
- Geo-platform
- ArcGIS Storybook

7.0 Data Maintenance

To take full advantage of the BLE data generated, it is appropriate to maintain BLE inventory so that all stakeholders are aware of the data availability. Maintaining BLE inventory through the existing CNMS database is currently under review. The CNMS Technical Reference will be updated in the future to reflect this addition.

Additionally consideration should be made to the ability for communities and other land owners or lessees in a community to appeal or request Letters of Map Change. When developing grids for the BLE, ensuring that there is a way to break out smaller subsets of the modeling to deliver to communities for map maintenance should be considered.

Once data is available for communities, there are several ways that the data will progress through the regulatory process. As stated in SID218, once data has been released as a preliminary FIRM product, LOMC's can't be issued until the FIRM is effective. BLE data in the stages prior to Preliminary FIRM issuance may be used to make changes as follows:

- If a community wishes to make changes to FEMA data to submit newer or changed data as a LOMR, that is acceptable
- If a community wishes to utilize the "pay for PMR" option to speed up portions of FIRM delivery that is acceptable
- All other FEMA generated data will follow the standard mapping timelines. Communities may provide concurrence on data and request an expedited outreach process to get through the regulatory process sooner; this will be coordinated with the Regional POC

Based on the decision tree, FEMA can attempt to expedite portions of the process such as graphical, outreach depending on community specifics. The Community should be using the preliminary data in accordance with the criteria set out in the BAI memo and other floodplain management guidance as with any "newer data" until it becomes Effective data on the FIRM.

8.0 Related Topics Covered by Other/Future Guidance

The following is a list of related topics that have been developed or are planned to be developed to provide additional guidance related to hydrologic and hydraulic modeling riverine flooding analyses and mapping.

- Cross Sections - Planned
- Hydrology: Regression Equation Analyses - November 2017
- Hydraulics: One-Dimensional Analyses – November 2016
- Hydraulics: Two-Dimensional Modeling Analyses - November 2016
- Floodway Analysis and Mapping - November 2016

- Riverine Mapping & Floodplain Boundaries - November 2016
- Base Flood Elevations - Planned
- Water-Surface Profiles – Planned

9.0 Minimum BLE Criteria

Using the requirements and preferences stated above in Table 2 and the “Options” from Table 1, the following minimum criteria for BLE are recommended nationwide. In addition, common “buy up” or additional data options have been listed, so users can choose to upgrade the BLE beyond minimum criteria if desired.

The criteria below have also considered that there are some tasks in hydraulic modeling that are more difficult to complete or revise later in the modeling process. Thus, the BLE criteria listed below are designed to minimize the following:

- Revising the network, model structure, or layout of the underlying hydraulic model
- Adding additional cross-sections to model areas more precisely to add structures in future.
- Modifying Manning’s n values at the cross-section level.
- Modifying the hydraulic model to accept additional flows (where the flows are substantially smaller or bigger than the modeled values).

The minimum criteria stated below either those that are necessary to produce a credible BLE product or are more cost-effectively done at an earlier stage. The optional additional data products are those that require more manual work during the analysis process and may be specific to certain geographies. These optional components provide Regions with flexibility to meet the stakeholder expectations and usability of the BLE datasets.

The minimum BLE criteria as defined below will meet the requirements to be used “as-is” for regulatory flood mapping per current FEMA standards, as well as the standards for Tier A mapping in Table 1. Be sure to review all standards as they are updated based on the biannual Policy Memo update to ensure you are addressing all of the required standards for flood hazard mapping.

Minimum criteria to ensure cost effective BLE data development

- Derived directly from Regulatory Mapping Standards
 - Use topography meeting SID #43 (LiDAR) with NAVD88 vertical datum.
 - Flow profile baseline created from topography, visually compared against aerial imagery, falling within all mapped floodplains, and meeting SID #132.
 - Use USGS regression equations for flow rates (with urban adjustments, where available).
 - Use HEC-RAS as the 1-D base hydraulic model, meeting SID #62

- Model 0.2-, 1-, 1+-, 2-, 4-, and 10-percent annual chance flows, exceeding SID #84. The 1- and 1+ flow is added to aid in future comparisons and CNMS validation.
- Produce floodplains for the 0.2-, and 1-percent annual chance floodplains, meeting #133.
- Based on common user preferences
 - Place cross-sections upstream and downstream of flow structures¹.
 - Develop Manning's n values for each cross-section from a pre-determined table linking land cover types in the National Land Cover Database (NLCD) to Manning's n values in the model.
 - Use multiple or composite Manning's n values per cross-section.
 - Identify areas that do not meet 1-D modeling assumptions (split flows, sheet flow, etc.), but do not attempt to resolve.
- Based on efficient modeling practice
 - Create XS perpendicular to flow and with some degree of bend or curve to simulate manually-drawn XS.
 - Starting water surface elevation of tributary streams based on normal or critical flow depth.
 - For areas beyond the applicability ranges of the USGS regression equations, use gage-derived flows interpolated by drainage area.
- Based on usability needs for the data
 - Produce a report documenting the project, including the necessary parts of the Technical Support Data Notebook (TSDN).
 - Upload all data to the relevant Mapping Information Portal (MIP) areas.
 - Develop Water surface elevation grids to allow for easier access by communities to the data.
 - Upload digital floodplain data to an appropriate publicly-accessible location for use by floodplain managers and other stakeholders

Additional BLE preparation options

- Supplement modeling with additional structure data, either upgrading from structures "as-weirs" or inserting actual structure data where only bracketed XS exist
- Adjust regression equation values (within the range of applicability) to match gage flows better, or to modify flows to account for local meteorological effects.

- Generate Flood Risk Datasets
- Flood Risk Assessment
- Identification of AoMI targets based on the BLE analysis results.

¹ A FEMA research paper published in February 2016 (*Impact of Flood Hazard Modeling Parameters on Base Flood Elevation (BFE) and Floodplain Top Width, Including Calculation of Return on Investment (ROI) for Selected Input Variables*), found that the following hydraulic model improvements have the highest return on investment, in terms of improving the accuracy of losses modeled.

Related Templates associated with this Guidance

Note:

The following templates will be a tool to help practitioners comply with the guidance contained in this document and will help with overall program consistency. Once they have been reviewed and comments have been addressed, the templates will be stored individually on the *fema.gov* G&S web page under the "Templates and Other Resources" link (<http://www.fema.gov/media-library/assets/documents/32786?id=7577>). However, they are provided here to aid in the consolidation of review comments to one document.