Guidelines and Stadards for Flood Risk Analysis and Mapping

Appendix N: Flood Risk Data Development

January 2012

FEMA

Summary of Changes

Appendix N - Flood Risk Data Development

The following Summary of Changes details the revisions of Appendix N, including and subsequent to its initial publication in October 2011. These changes represent new or updated guidance for Mapping Partners.

Date	Affected Section(s)	Summary of Change
January 2012	All	Initial Publication

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Acronyms and Abbreviations

AAL	Average Annualized Loss
BCA	Benefit-Cost Analysis
BFEs	Base Flood Elevations
CDMS	Comprehensive Data Management System
CFS	Cubic Feet per Second
CHAMP	Coastal Hazard Analysis Modeling Program
CNMS	Coordinated Needs Management Strategy
CRS	Community Rating System
CSLF	Changes Since Last FIRM
CTP	Cooperating Technical Partners
DEM	Digital Elevation Model
FIRM	Flood Insurance Rate Maps
FIS	Flood Insurance Study
FIT	Flood Information Tool
FRD	Flood Risk Database
FRR	Flood Risk Report
FY	Fiscal Year
G&S	Guidelines and Standards for Flood Risk Analysis and Mapping
GBS	General Building Stock
GIS	Geographic Information System
H&H	Hydrology and Hydraulics
HMA	Hazard Mitigation Assistance
HUC	Hydrologic Unit Codes
IA	Individual Assistance
IAA	Inter-Agency Agreement
LAS	Loss Avoided Study

LOMC	Letter of Map Change
MAP	Mapping, Assessment, and Planning
MAS	Mapping Activity Statement
MLI	Midterm Levee Inventory
MR	Major Release
NFIP	National Flood Insurance Program
NFHL	National Flood Hazard Layer
NLD	National Levee Database
NRCS	Natural Resources Conservation Service
OFAs	Other Federal Agencies
PA	Public Assistance
PMRs	Physical Map Revisions
PFD	Primary Frontal Dune
RL	Repetitive Loss
SFHA	Special Flood Hazard Area
SOW	Statement of Work
SRL	Severe Repetitive Loss
SWEL	Stillwater Elevation
TIN	Triangulated Irregular Network
TSDN	Technical Study Data Notebook
USACE	U.S. Army Corps of Engineers
WHAFIS	Wave Height Analysis for Flood Insurance Studies

Table of Standards

The Table of Standards is an overview of all mandatory elements within this document. For details regarding these standards, refer to the body of this document, where standards are shown in **bold** text and set off with a check mark (✓).

Table 1: Table of Standards

Section Number	Short Description
General Processing Issues	
N.3.1.1	When flood risk data extends outside the project area, it will not be clipped at the project area boundary (e.g. HUC-8 project area) before being added to the Flood Risk Database.
N.3.1.1	The Flood Risk Report will only report on the extent of the flood risk data that lies within the flood risk project area.
N.3.1.3	For any Flood Risk Datasets that rely on comparison of new data to effective data (e.g., CSLF, Water Surface Elevation Change grids, etc.), previously issued LOMRs or other revisions must be taken into account.
Changes Since Last FIRM	
N.4.3	The full extent of CSLF polygons must be included in the Flood Risk Database, even though the Flood Risk Report will only provide CSLF data results within the extent of the flood risk project.
N.4.3	The National Flood Hazard Layer is the source for the effective flood hazard area data. If this data is not available then there is no requirement to create the CSLF dataset.
N.4.3	The CSLF polygons are created by the unioning of four layers – the effective flood hazard areas, the new flood hazard areas, the political areas, and the flood risk project area boundary (e.g. HUC-8 project area).
N.4.3	Areas that were previously mapped as unshaded Zone X or Zone D in the effective flood hazard areas and that remain as unshaded Zone X or Zone D in the new flood hazard areas shall not be delivered as part of CSLF data.
N.4.3	CSLF polygons must be populated with standard attributes as well as an indication of the reason for the change (known as the Contributing Engineering Factor CSLF attributes). Table 3 and Table 4 provide a description of each CSLF attribute.
N.4.3	All CSLF polygons shall include both standard and Contributing Engineering Factors attribution according to the database specifications defined in Appendix O of the FEMA *G&S*.
N.4.3	The analysis to define each Contributing Engineering Factor does not have to be more granular than the extent of the study stream being modeled.

Table 1: Table of Standards

Section Number	Short Description
N.4.3	The "unknown" Contributing Engineering Factors CSLF attribute shall only be used as a reason for change in attributing contributing engineering factors after all reasonable engineering judgment has been applied to ascertain the possible reason for change.
N.4.3	When quantifying the numbers of structures and population affected by floodplain and/or floodway boundary changes, high quality local data shall be used. Pre-packaged Hazus population and general building stock information is not considered a sufficient data source for determining the number of affected structures and population.
N.4.3	Each structure should be compared to the CSLF polygon features that touch or 'intersect' the structure but only accounted for once. If the structure is touching more than one CSLF polygon, the structure shall be associated with the most restrictive new/revised flood zone polygon that it touches.
N.4.3	Watershed and community based tables shall be derived from the CSLF data within the project area and included in the Flood Risk Report.
	Flood Depth & Analysis Grids
N.5.3	Grid data should not be clipped at the project area boundary; the Flood Risk Database will contain grid data to the full extent of the underlying modeling.
N.5.3	Water surface elevations, used to create water surface and depth grids, for new or updated flood hazard studies must reflect the proposed regulatory elevations (i.e. reflecting backwater conditions even if the new model does not).
N.5.3	Water surface elevation grids used to calculate the water surface elevation change grids must reflect the effective and revised regulatory elevations shown on the FIRM.
N.5.3	The same ground elevation source used in new or revised study modeling should be used to create any grids that require calculations that include ground elevation.
N.5.3	Riverine depth grids for new studies will be created, at least, for the 10%, 4% 2%, 1%, and 0.2% annual chance flood events.
N.5.3	Depth grids for AO shallow flooding zones shall reflect the reported depth as shown on the FIRM or more detailed data from the model if the results (when rounded) would equal the whole foot rounded depths shown on the FIRM.
N.5.3	Depth grids for AH zones shall be based on the static whole foot regulatory elevation shown on the FIRM, or more detailed 1/10th foot elevations derived from models provided that the results round to the whole foot elevations shown on the FIRM.

Table 1: Table of Standards

Section Number	Short Description
N.5.3	Coastal depth grids for new studies will be created, at a minimum, for the 1% annual chance flood event.
N.5.3	Depth grids for areas of open water, except coastal areas, should be created based on the normal pool water surface elevation as opposed to using bathymetric data.
N.5.3	Coastal depth grids for open water areas will use the modeling bathymetry elevation source data (when available) to the full extent of the flood hazard zone shown on the FIRM.
N.5.3	Coastal velocity grids shall reflect the appropriate upper bound velocities from 2D storm surge modeling, equation #2 from the *Coastal Construction Manual (CCM),* or the extreme velocity from equation #3 for Tsunami prone areas.
N.5.3	The extent of water surface elevation change grids shall only reflect those areas that were both SFHA before and after the revision.
N.5.3	The percent-annual-chance flood event shall be computed by interpolating the log-linear relationship between the associated flood elevations at each point and the ground elevation. Calculations shall not exceed the 10% annual chance event.
N.5.3	The Percent 30-year Chance Grid shall use the following statistical equation: • Probability = $1 - (1\text{-}p)^n$
N.5.3	The 1% plus flood elevation grid shall be created by determining elevations that result from using discharges that include the average predictive error for the regression equation discharge calculation for the study.
Flood Risk Assessment Dataset	
N.6.3	The Flood Risk Assessment dataset will include the following tables: • S_CenBlk_Ar • L_RA_AAL • L_RA_Refined • L_RA_Composite • L_Exposure • L_RA_Summary
N.6.3	When a Hazus-based User Defined Facilities (UDF) analysis is conducted, the Flood Risk Assessment dataset will include the following additional tables: • S_UDF_Pt • L_RA_UDF_Refined
N.6.3	When the flood risk project updates the Hazus General Building Stock (GBS) data, the Flood Risk Assessment dataset will include the L_Local_GBS table.

Table 1: Table of Standards

Section Number	Short Description
N.6.3	The "S_CenBlk_Ar" census block polygon spatial table will be based on the modified version of the 2000 Census Block boundaries from Hazus Major Release (MR) 4 (boundaries used for the AAL Study).
N.6.3	The Flood Risk Assessment dataset will include all census blocks that are entirely or partially within the flood risk project area boundary. Census blocks will not be clipped.
N.6.3	The Annualized Average Loss L_RA_AAL lookup table will only include loss estimates from the 2010 Hazus Average Annualized Flood Loss (AAL) Study, with results on a census block basis only.
N.6.3	The Refined Risk Assessment L_RA_Refined lookup table will include any refined loss analysis results on a census block basis.
N.6.3	The L_RA_Composite lookup table will combine, on a census block basis, AAL Study and any Refined loss analysis into a Composite table.
N.6.3	The L_Exposure and L_RA_Summary lookup tables will include inventory and loss data summarized at a flood risk project area basis and at a community basis. • Data will be based on area-weighted calculations of S_CenBlk_Ar census blocks clipped to community and flood risk project area boundaries.
N.6.3	The 1% annual chance event (100-yr) total loss from the L_RA_Composite lookup table will be used on the Flood Risk Map.
N.6.3	When a Hazus-based UDF analysis is conducted, the S_UDF_Pt spatial table will include point locations from the analysis.
N.6.3	The L_RA_UDF_Refined lookup table will include loss analysis data associated with each UDF point from a Hazus-based UDF analysis. The L_RA_UDF_Refined table will need to be aggregated to a census block basis to assist development of the L_RA_Refined lookup table.

Table 1: Table of Standards

<table>
<tr><th>Section Number</th><th>Short Description</th></tr>
<tr><td>N.6.3</td><td>
The following summarizes inventory and loss estimates divided into different occupancy and loss requirements for the Risk Assessment tables in the Flood Risk Database:

<table>
<tr><th></th><th>Residential Occupancy</th><th>Commercial Occupancy</th><th>Other Occupancy</th></tr>
<tr><td>Building</td><td>Inventory, Loss</td><td>Inventory, Loss</td><td>Inventory, Loss</td></tr>
<tr><td>Contents</td><td>Inventory, Loss</td><td>Inventory, Loss</td><td>Inventory, Loss</td></tr>
<tr><td>Business Disruption</td><td>Loss</td><td>Loss</td><td>Loss</td></tr>
</table>
</td></tr>
<tr><td>N.6.3</td><td>
The following summarizes the minimum percent annual chance event requirements in the Flood Risk Database associated with the Flood Risk Assessment dataset:

<table>
<tr><th></th><th>L_RA_AAL</th><th>L_RA_Refined</th><th>L_RA_Composite</th><th>L_RA_Summary</th></tr>
<tr><td>10% annual chance (10-yr)</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>4% annual chance (25-yr)</td><td>No</td><td>Yes</td><td>No</td><td>No</td></tr>
<tr><td>2% annual chance (50-yr)</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>1% annual chance (100-yr)</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>0.5% annual chance (200-yr)</td><td>Yes</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td>0.2% annual chance (500-yr)</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Annualized</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
</table>
</td></tr>
<tr><td></td><td>Areas of Mitigation Interest Dataset</td></tr>
<tr><td>N.7.3</td><td>
AoMI elements are always represented by points and include the following features:

- Dams
- Levee and non-levee embankments
- Areas where stream flow is constricted
- Coastal structures
- Key emergency routes overtopped during frequent flood events
- At risk critical facilities
- Past flood insurance claims hot spots
- IA and PA claims
- Areas of significant land use change (recent past and proposed)
- Areas of significant coastal or riverine erosion
- Areas of mitigation success
- Other miscellaneous flood risk or hazard mitigation related areas
</td></tr>
</table>

Table 1: Table of Standards

Section Number	Short Description
N.7.3	An AoMI point feature class will be created per the guidelines in Appendix O of the FEMA *G&S*.
N.7.3	Sensitive AoMI data (e.g., data covered by the Privacy Act of 1974, Public Law No. 93-579 such as Individual Assistance claims) will be presented as a point (or clusters of points) at the centroid of the census block in which the data resides.
N.7.3	Each AoMI point will have associated attributes in tabular format in the Flood Risk Report and Flood Risk Database, per the requirements in Appendix O of the FEMA *G&S*.

N.1 Introduction

Appendix N includes data development guidance in the form of standards, and best practices that are intended to provide a consistent framework for the development of Flood Risk Datasets. These datasets will be used to develop the Flood Risk Database, Flood Risk Map, and Flood Risk Report (collectively known as Flood Risk Products). With these Flood Risk Datasets and Products, users will be able to more effectively to communicate flood risk to local stakeholders and to encourage actionable mitigation strategies to achieve at a measurable reduction to loss of life, property damage, and associated economic impacts.

This guidance applies to FEMA-funded flood risk projects conducted by FEMA's Mapping Partners, including contractors, other Federal agencies and Cooperating Technical Partners (CTPs). FEMA Regions are to apply the standards and guidance summarized in this appendix when preparing contract documents (SOWs, MASs, IAAs, etc.) for funding flood risk projects.

N.1.1 Scope

On a national basis, FEMA intends to assess, visualize and communicate flood risk using the non-regulatory Flood Risk Data and Flood Risk Products listed below and detailed in Section N.3. Although much of the Flood Risk Data leverages data also used to create FEMA's Flood Insurance Studies (FISs) and Flood Insurance Rate Maps (FIRMs), it is important to note that the Flood Risk Data is considered non-regulatory and not subject to the due-process or related protocols associated with the FIS and FIRM. It is also important to note that these non-regulatory products and datasets are intended to be complimentary to the regulatory products and do not necessarily represent "new or improved scientific or technical data."

- Changes Since Last FIRM (CSLF): This dataset enables a visualization of horizontal changes to the mapped floodplain and floodway extent since the last FIRM was published, and includes attribute data that provides insight into the reason for the changes.
- Flood Depth and Analysis Grids: These grids allow for visualization of the spatial variability of a predicted flood risk value (i.e. flood depth, percent chance of flooding, velocity, etc.) within the mapped floodplain. Water surface grids associated are included in this grouping due to the direct dependencies they share with Flood Depth and Analysis grids.
- Flood Risk Assessment Dataset: This dataset presents potential flood economic losses associated with exposure of general building stock, essential facilities and critical infrastructure to flood depths.
- Areas of Mitigation Interest (AoMI): This dataset provides insight into a variety of flood risk mitigation issues, ranging from potential flood risk mitigation project opportunities (such as fixing an undersized culvert that is exacerbating flood hazards) to success stories of effective flood risk mitigation activities that have already taken place.

These four Flood Risk Datasets are used to create the following non-regulatory Flood Risk Products that are discussed in more detail in Appendix O of the FEMA *Guidelines and Standards for Flood Risk Analysis and Mapping* (referred to hereafter as the FEMA *G&S*):

- Flood Risk Database (FRD): This is a relational database that stores all flood risk data for a given project area and that enables end users to produce the Flood Risk Map and Flood Risk Report as well as conduct and visualize a wide variety of ad-hoc flood risk analyses.
- Flood Risk Report (FRR): This is a report that provides flood risk data within the project area (normally watershed based) and also summarizes the flood risk on a community-by-community basis for those portions of the community within the project area.
- Flood Risk Map (FRM): This map is an element of the Flood Risk Report that depicts a high level understanding of particular flood risk data for the project area such as potential flood losses associated with the 1% annual chance flood event.

These non-regulatory Flood Risk Datasets and Products will be created as companion elements to the hydrologic and hydraulic study (or restudy) of flooding sources for a given project area that are normally conducted for the purpose of creating or revising the regulatory FIRM. Figure 1 provides a graphic depiction of the relationship between the Flood Risk Datasets and Products.

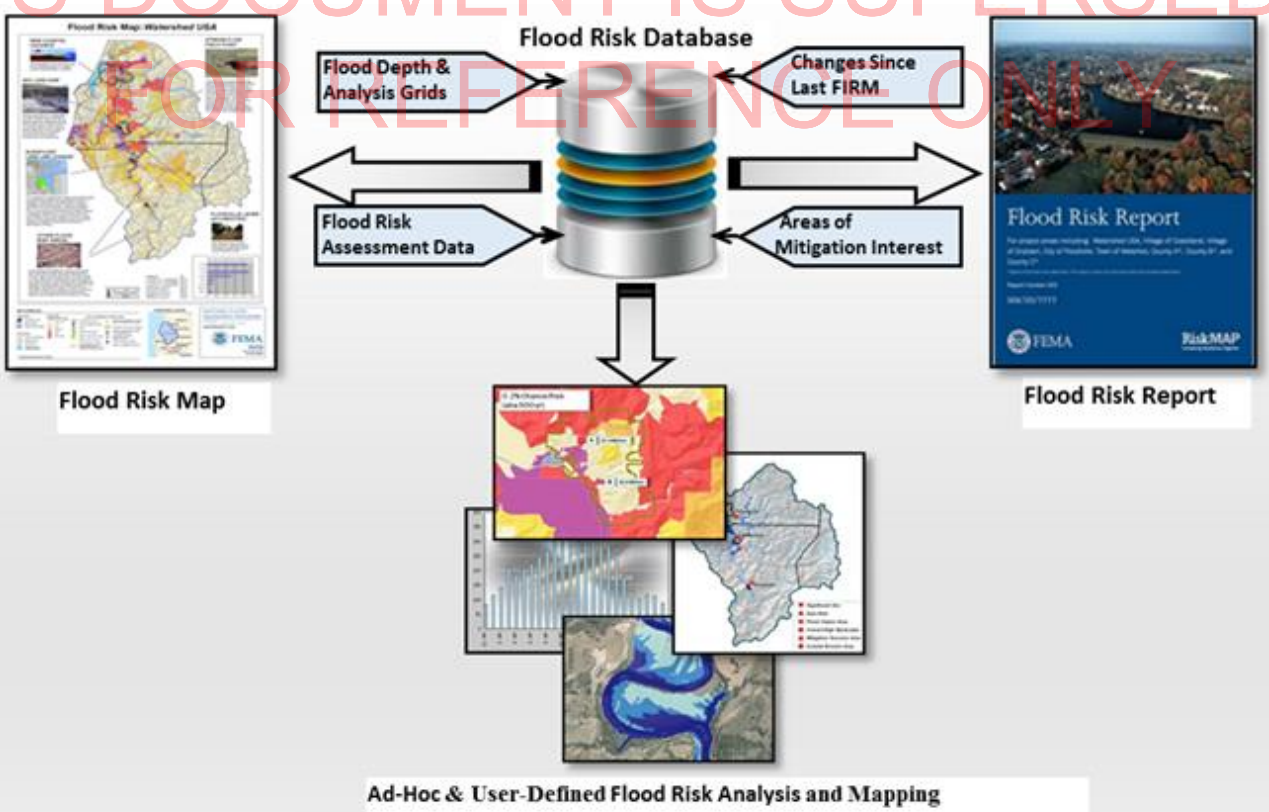


Figure 1: Flood Risk Data and Products Model

N.2 Flood Risk Assessment Process

Flood risk assessment is defined as the process of quantifying the flood risk associated with known flood hazards. The outcome of the flood risk assessment process is an analysis of flood risk for critical infrastructure, general building stock and contents, business, and people. The analysis is presented in FEMA's Flood Risk Datasets and Products that are intended to communicate flood risk to local stakeholders as well as to encourage and enable the development of actionable flood risk mitigation strategies. The Flood Risk Datasets and Products described in this document are intended to be used by local stakeholders with roles in flood risk reduction, including community/land use planners and local emergency managers.

Flood Risk Datasets and Products will support States, local communities, and Tribal entities in the effective engagement of risk-based mitigation planning, resulting in sustainable actions with a measurable reduction in loss of life, infrastructure, property damage, and associated economic impacts. Applicants with FEMA-approved hazard mitigation plans have opportunities to fund their mitigation strategies through an array of Federal programs including FEMA's Unified Hazard Mitigation Assistance (HMA) programs.

N.2.1 Flood Risk Project Scalability

To improve engineering analyses and to enable an understanding of flood risks in a more comprehensive way, the development of Flood Risk Datasets and Products will be conducted for individual watersheds on a Hydrologic Unit Codes (HUC-8 unit) sub-basin basis, with specific exceptions on a case-by-case basis. Analyzing flood hazards and associated flood risks on watershed basis facilitates a broader view of those hazards and risks, which enables an evaluation of watershed activities that may have an impact beyond the site of the activities themselves. As such, providing flood risk information at a watershed level allows for the development of strategies to reduce flood losses that can then be developed and managed across community boundaries in a more comprehensive manner. Important to note is that the scope of a flood risk project will normally be an outcome of the Discovery Process codified in Appendix I of the FEMA G&S.

As shown in Figure 2, while the watershed strategy provides a framework for development of flood risk data within a watershed-based project area, the flood risk data creation protocols provided herein are scalable to enable a flood risk projects to be undertaken for projects that span multiple HUC-8 watersheds (as with coastal studies) and at a custom-defined level such as might occur with a focused FIRM revision for a local project. In situations where a flood risk project crosses multiple watersheds, the Project Team will make a decision on whether multiple FRDs, FRRs, and FRMs will be produced (one for each affected HUC-8 watershed) or whether one FRD, FRR and FRM will be produced for the whole flood risk project. For coastal studies, it may be most common for multiple FRDs, FRRs, and FRMs to be created due the inherently larger extent of such projects, whereas some smaller custom-defined projects may be best suited for a single FRD, FRR and FRM. Additional details regarding the protocols associated with creation of single custom-defined and/or multiple HUC-8 flood risk projects is available in Appendix O of the FEMA *G&S*.

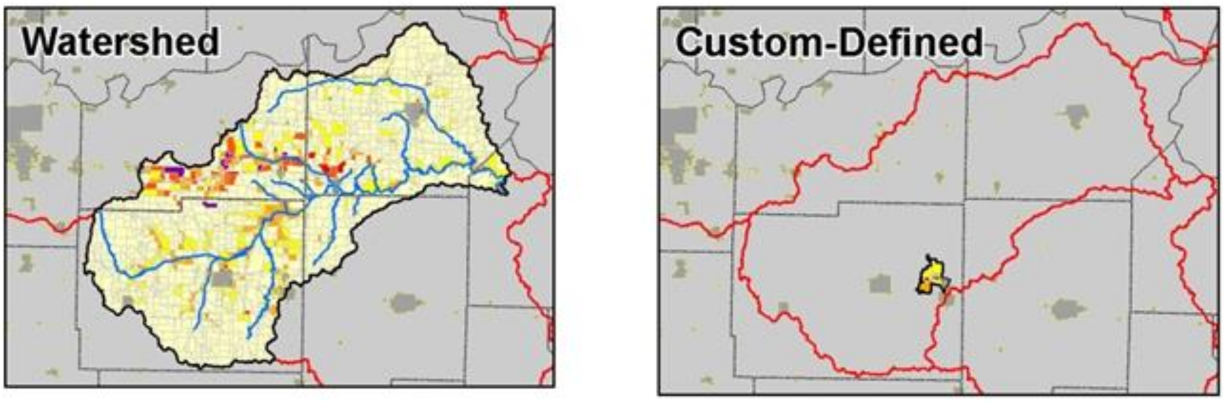


Figure 2: Flood Risk Study Scalability

N.2.2 Flood Risk Assessment Process Overview

The flood risk assessment process typically starts with an understanding of where flood hazards exist and ends with a detailed assessment of the associated risk to the built environment. Significant elements of the process include data mining, data development, and stakeholder coordination activities. Each step in the flood risk assessment process is intended to build on the previous step, while allowing for frequent validation of results and reassessment of needs. Best practice for the process includes multiple opportunities for collaboration with local stakeholders to ensure that the final risk assessment results are clearly understood, are based on the best available data, and enable actionable flood risk mitigation strategies.

Figure 3 provides a best-practice representation of a 10-step flood risk assessment process that provides a framework for the successful development of Flood Risk Datasets and Products described throughout this document. Critical to the success of this process is frequent outreach to, and collaboration with, local stakeholders. Effective collaboration through this process will not only enable local "ownership" of the risk assessment results, but will ensure that the results are based on the best available information. Anticipated collaboration opportunities are indicated in Figure 3 with a handshake icon. Following Figure 3 are descriptions of each flood risk assessment step. Important to note is Figure 3, and the descriptions of each flood risk assessment step that follow, are not intended to supersede any other FEMA guidance; rather this information is being provided in the context of best practices for the flood risk assessment process itself.

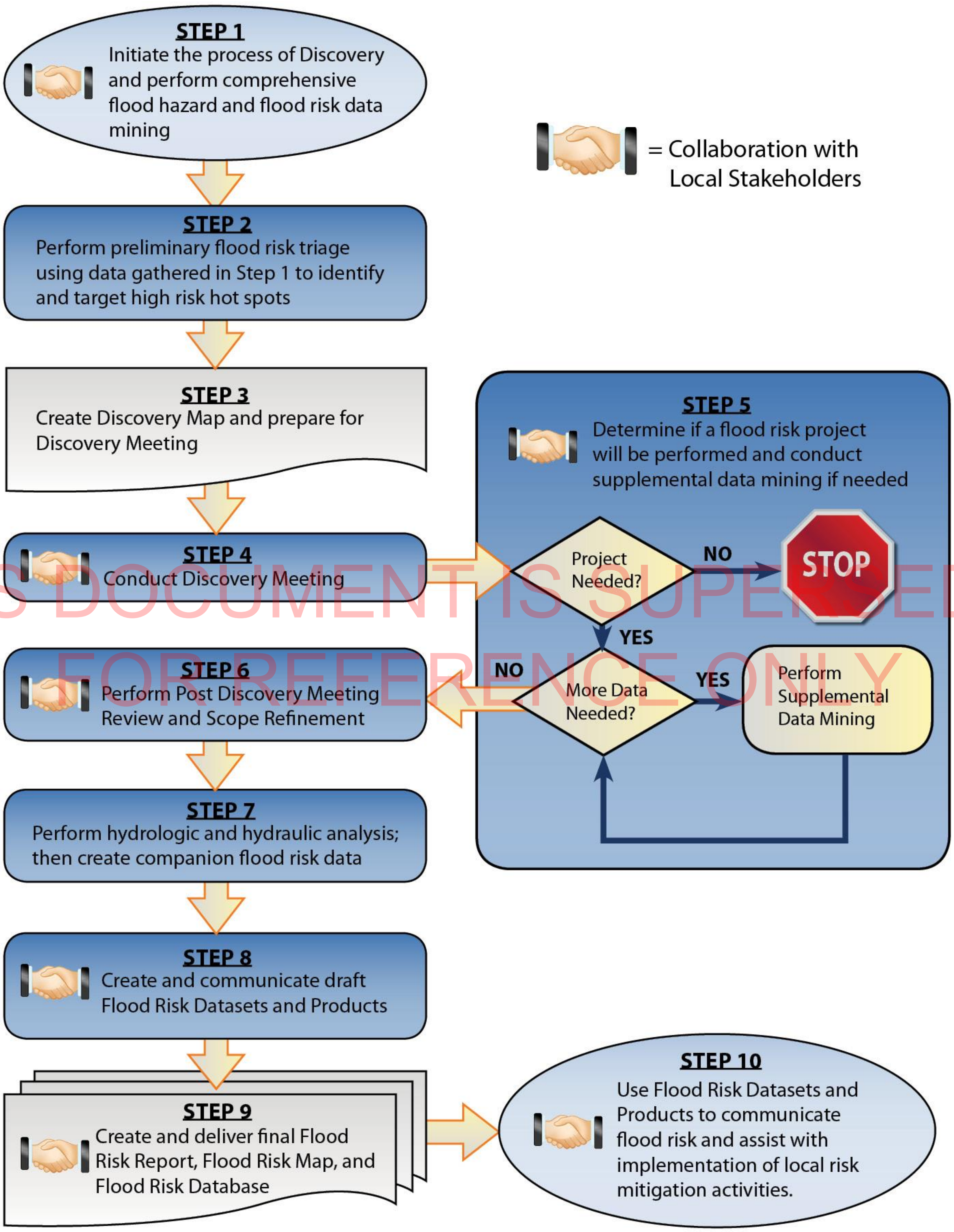
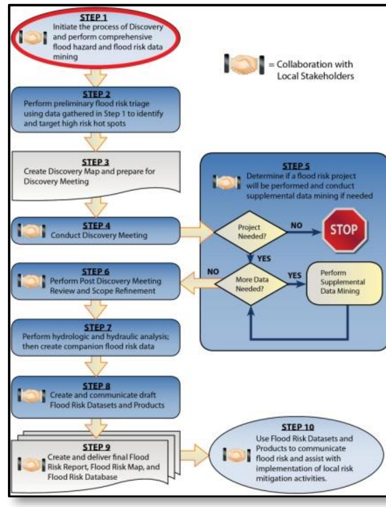


Figure 3: Best Practice for Flood Risk Assessment Process

Step 1: Initiate the Process of Discovery and Perform Comprehensive Flood Hazard and Flood Risk Data Mining

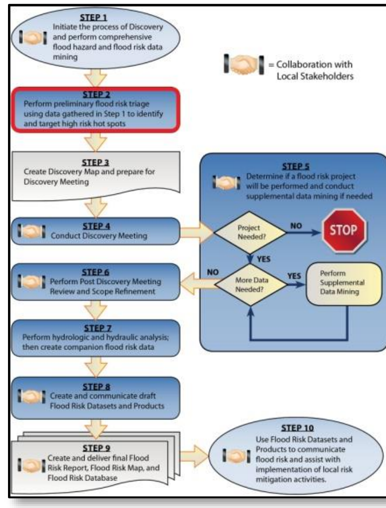


The flood risk assessment process begins with what is known as "Discovery". This involves the examination of a watershed or other project area that has been considered for study (or restudy) for the purpose of creating or revising a FIS and FIRM. In order to effectively conduct Discovery, a significant amount of data is required, that will normally require significant coordination with local stakeholders in order to develop a full understanding of the local flood hazards and risks and in order to gain an understanding of available data to support the associated flood study. Data gathered during Discovery will not only facilitate the study or restudy of flood hazards (such as stream gage data); it will also be used to facilitate an analysis of the flood risks associated with the identified flood hazards. This data will also be used to enable the creation of a suite of Flood Risk Datasets and Products described in Section N.1.1 and shown in Table 2. Once developed, these Flood Risk Datasets and Products will enable an understanding of local flood risks and will enable actionable mitigation strategies at the local level.

A full description of this data mining activity is provided in Appendix I of the FEMA *Guidelines and Standard for Flood Risk Analysis and Mapping (G&S)*. Although much of the information collected during Step 1 of this process will be used to create the Discovery Map and Discovery Report outlined in Appendix I of the FEMA *G&S*, much of the data will also be used to perform a preliminary flood risk "triage" for the project area. In order to effectively conduct the triage described in Step 2, the best available data for the project area will be procured through the Discovery process. As outlined in Appendix I of the FEMA *G&S*, it is expected that the process of procuring this data will include significant local stakeholder outreach and engagement to ensure the greatest chance of obtaining the most current and relevant information. A complete listing of data that will be gathered in advance of the Discovery meeting and that will be used to perform the preliminary Flood Risk Assessment is found in Appendix I of the FEMA *G&S*. Data that will enable this process includes, but is not limited to, the following:

- Repetitive Loss and Severe Repetitive Loss data
- Individual Assistance (IA) and Public Assistance (IA) claims data
- Data reflecting the built environment (i.e., general building stock and essential facilities)
- Hazard mitigation plans for the subject area
- Items that may qualify for the Areas of Mitigation Interest dataset (see Section N.7)

Step 2: Perform preliminary flood risk triage using data gathered in Step 1 to identify and target high risk hot spots

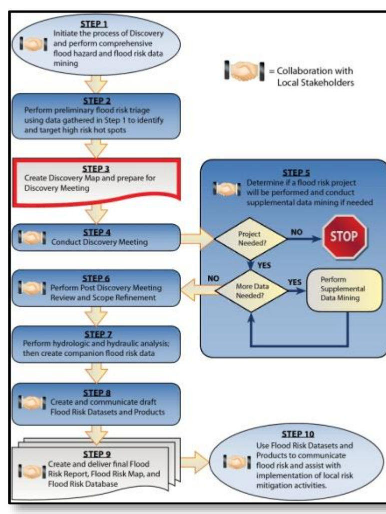


In preparation for the creation of the Discovery Map, a preliminary flood risk triage for the project area is conducted. This triage will reveal areas within the project area where flood risks are elevated, warranting possible focused flood hazard and flood risk analysis. This triage considers such factors as:

- Exposure of the built environment (structures and infrastructure) to flood depths.
- Areas of repetitive flood loss.
- Areas of significant Individual Assistance and Public Assistance (IA/PA) claims.
- Areas where the 2010 Hazus Average Annualized Loss (AAL) analysis show significant potential flood losses.
- Areas where the Coordinated Needs Management Strategy (CNMS) indicate the greatest study or restudy needs on a flooding source by flooding source basis.

The primary goal of Step 2 is to gain an understanding of the flood risks within the project area to faciliate the creation of the Discovery Map that will be used at the Discovery Meeting, and in order to facilitate focused flood hazard and flood risk study activity within the project area.

Step 3: Create Discovery Map and Prepare for Discovery Meeting

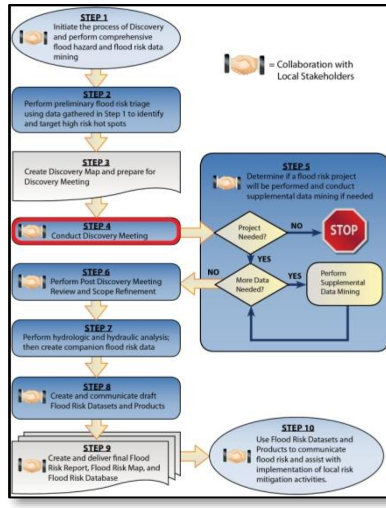


This step involves the creation of the Discovery Map that will be used at the Discovery meeting. The Discovery map is intended to facilitate discussions about the flood hazards and flood risks with watershed communities

- Communicate flood risk at the Discovery Meeting
- Understand the flood hazard identification and risk within a project area (e.g. HUC-8 project area) for consideration of a potential Flood Risk project.

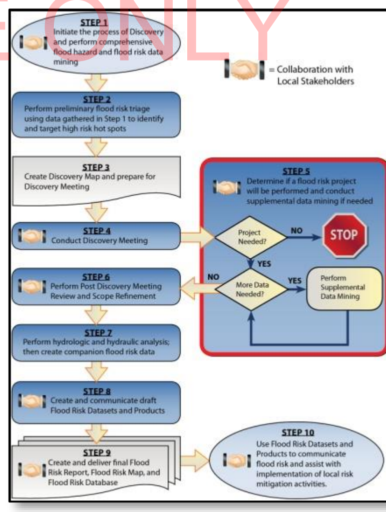
Data and thematic information that could be shown on the Discovery Map are itemized in Appendix I of the FEMA *G&S* and include CNMS data; identification of proposed new study areas; locations of flood control structures; AAL and other relevant data.

Step 4: Conduct Discovery Meeting



This step involves meeting with local stakeholders to present the results of the data mining and analysis conducted in Steps 1 through 3 to understand the extent of the flood hazard and flood risk in the project area. At the Discovery Meeting preliminary flood risk assessment results (and the Discovery Map) generated in Steps 1 – 3 will be presented. The Discovery Meeting provides an opportunity to procure additional local flood risk data or supporting resources as well as to gain additional insight into local flood risk. Local data procured at this stage (that may have been difficult to obtain during the pre-meeting data mining process) could include elements such as high-quality terrain data, building footprint data, parcel-based tax assessment data, and critical facility data (police stations, fire stations, hospitals, schools, etc). If not already done in Step 1 of the flood risk assessment process, a review of existing risk assessments and/or hazard mitigation plans in the project area may be performed.

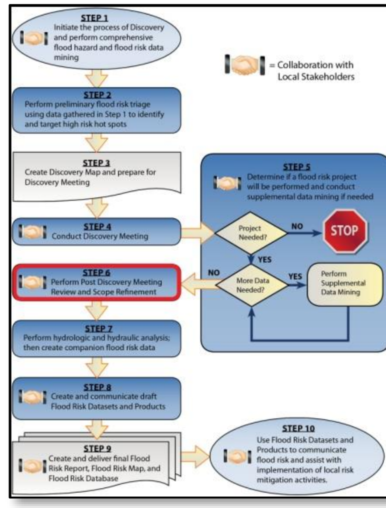
Step 5: Determine if a Flood Risk Project will be Performed and Conduct Supplemental Data Mining if needed



A result of the Discovery meeting should be a preliminary "go" or "no go" decision on a flood risk project that would create/update FISs and FIRMs in the project area, as well as create Flood Risk Datasets and Products described in Sections N.1.1 and N.3. If the decision is a "go", decisions need to be made regarding the adequacy of data procured through the Discovery process up to that point.

After the Discovery Meeting, it may be determined that additional targeted data mining at the local level will be needed to support certain elements of the flood hazard and risk analysis, as well as to support certain flood risk and flood loss analysis refinements (such as a refined Hazus loss analysis – see Section N.6.4.2). Additional data mining may also be needed in order to support the creation of Flood Risk Dataset enhancements such as the quantification of structures or population affected by changes to floodplain boundary revisions. As indicated in Section N.2.2, it is expected that the process of local data mining to support flood risk assessments will be collaborative with local stakeholders and will yield all or most required data to conduct the flood risk project. However, if additional data is needed, this step provides a contingency for additional data mining as needed.

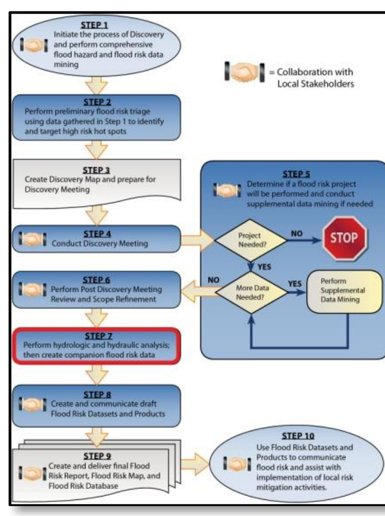
Step 6: Perform Post Discovery Meeting Review & Scope Refinement



After the Discovery Meeting is held, and a preliminary decision is made to proceed with a flood risk project, the Post Discovery Meeting Review will be conducted. This meeting (which could be in person, by Web conference, by e-mail and/or by conference call) is envisioned to occur between the FEMA Region and the local community officials (engineers, community development representatives, elected officials etc) to discuss potential impacts to the existing FIS and FIRM. These discussions will focus on things such as areas where Base Flood Elevations, Regulatory Floodways, and Special Flood Hazard Areas will increase and/or decrease if a Flood Risk Study were to be performed, which will be based on what was learned before, during and after the Discovery Meeting. Examples include (but are not limited to) things such as knowledge of significant floodplain development that reduces soil infiltration, thereby increasing flood discharges and flood elevations, or knowledge of a levee that does not meet FEMA requirements for being certified and recognized as providing 1% annual chance flood protection.

Discussions held during the Post Discovery Meeting Review are intended to ensure that the flood risk project is aligned with local need and priorities. As such, it is anticipated that decisions arising from these discussions will impact the final scope of the flood risk project.

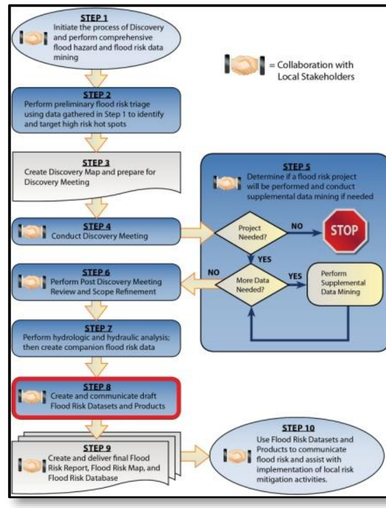
Step 7: Perform hydrologic and hydraulic analysis; then create companion flood risk data


STEP 1
Initiate the process of Discovery and perform comprehensive flood hazard and flood risk data mining
= Collaboration with Local Stakeholders
STEP 2
Perform preliminary flood risk triage using data gathered in Step 1 to identify and target high risk hot spots
STEP 3
Create Discovery Map and prepare for Discovery Meeting
STEP 5
Determine if a flood risk project will be performed and conduct supplemental data mining if needed
STEP 4
Conduct Discovery Meeting
Project Needed?
NO
STOP
YES
STEP 6
Perform Post Discovery Meeting Review and Scope Refinement
NO
More Data Needed?
YES
Perform Supplemental Data Mining
STEP 7
Perform hydrologic and hydraulic analysis; then create companion flood risk data
STEP 8
Create and communicate draft Flood Risk Datasets and Products
STEP 10
Use Flood Risk Datasets and Products to communicate flood risk and assist with implementation of local risk mitigation activities.
STEP 9
Create and deliver final Flood Risk Report, Flood Risk Map, and Flood Risk Database

This step involves performing the flood hazard analysis for selected flooding sources for the purpose of creating or revising FISs and FIRMs for the project area, and then developing companion flood risk datasets that enable visualization and quantification of flood risk. During this step, draft non-regulatory flood risk datasets detailed in Sections N.4 through N.7 (which leverage data from the flood hazard analysis) are created.

<u>Note:</u> If existing high quality flood risk assessment data contained in mitigation plans exceeds the quality or detail of risk assessment datasets normally created during the course of a flood risk study, consideration for its use will be made in Step 1 through Step 5.

Step 8: Create and communicate Draft Flood Risk Datasets and Products

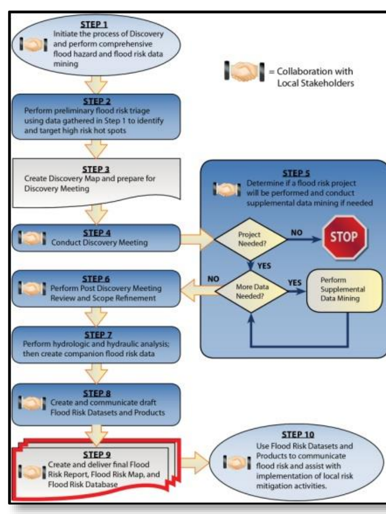


This step involves the creation of the following draft Flood Risk Datasets:

- Changes Since Last FIRM (Section N.4)
- Flood Depth and Analysis Grids (Section N.5).
- Flood Risk Assessment Data (Section N.6)
- Areas of Mitigation Interest (Section N.7)

These Flood Risk Datasets will then be used to create the FRR, FRM, and FRD. These Flood Risk Datasets and Products will then be presented to local stakeholders at the Flood Risk Review Meeting in advance of the Resilience Meeting. If, after meeting with local stakeholders to present draft Flood Risk Datasets and Products, the community understands the results and determines that the data and products meet their needs, such as, for mitigation planning purposes, then the Mapping Partner may proceed to Step 9. If, however, there appears to be a lack of understanding or there are concerns voiced over the draft Flood Risk Datasets and Products, the FEMA Regional office may opt to further refine the flood risk project scope and make associated changes to the Flood Risk Datasets and Products. It is important to note that changes in the study scope at this point in the study lifecycle will have significant impacts on the study schedule. Any issues to be addressed should therefore (whenever possible) be limited to flood risk data presentation issues and not changes in scope.

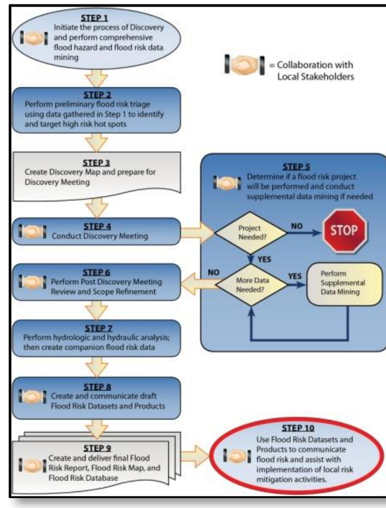
Step 9: Create and deliver final Flood Risk Report, Flood Risk Map, and Flood Risk Database



This step involves the creation of a final FRR, FRM, and FRD. These products will be utilized to store and deliver the flood risk data that will form the basis for the identification and prioritization of flood risk mitigation planning and implementation activities.

The Consultation Coordination Officer (CCO) / Open House meeting will be the venue for presentation and review of the final Flood Risk Datasets and Products. This meeting will focus on setting the stage for Step 10, where the Flood Risk Datasets and Products will become integral components of a community's flood risk mitigation strategy and planning activities.

Step 10: Use Flood Risk datasets and products to communicate flood risk and assist with implementation of local risk mitigation activities



This step involves stakeholders using the data and products developed in Steps 7 through 9 to inform local mitigation plan updates. The stakeholders will use flood risk data to assist with the development and implementation of flood risk mitigation actions. This step may also involve measuring and monitoring (to the extent is possible) the costs versus potential benefits associated with local flood risk mitigation actions.

More information on the potential uses of Flood Risk Datasets and Products is available in the FEMA Operating Guidance Document titled *User Guidance for Flood Risk Datasets and Products* that may be found here:

- http://www.fema.gov/plan/prevent/fhm/og_main.shtm

N.3 Overview of Flood Risk Datasets

The following sections provide a framework for the creation of the flood risk datasets. Developing these datasets requires the use of multiple data development tools and processes in order to successfully develop flood risk data that may be used to communicate an area's flood risk.

Flood risk data will be stored in the FRD and used to create the FRM (which shows generalized flood risk data) and the FRR (which provides flood risk data summaries). Equally important to what is shown on the FRM and FRR is the ability for local stakeholders to render ad-hoc visualizations for a variety of flood risk scenarios. These ad-hoc analyses may be based on the following flood risk datasets that will be created as companion elements to a flood hazard study (or restudy) and that will be stored in the FRD. Note that Water Surface Grids are included in this document due to the direct dependencies that they have with other flood risk data such as depth grids.

Guidance, standards and best practices for the following flood risk data is included in Sections N.4 through N.7 of this document as follows:

- Changes Since Last FIRM (Section N.4)
  - CSLF polygons and associated attributes
- Water Surface Grids (Section N.5.4.1)
  - Riverine and Coastal Flooding
- Flood Depth Grids (Section N.5.4.2)
  - Riverine, Coastal, Shallow Flooding, and Areas of Open Water
- Flood Risk Analysis Grids (Section N.5.4.4 through N.5.4.8)
  - Water Surface Elevation Change Grids (Section N.5.4.3)
  - Velocity Grids (Sections N.5.4.4 & N.5.4.5)
  - Percent Annual Chance Grids (Section N.5.4.6)
  - Percent 30-year Chance Grids (Section N.5.4.7)
  - 1% Plus Flood Elevation Grids (Section N.5.4.8)
- Flood Risk Assessment Results (Section N.6)
  - Average Annualized Loss (Section N.6.4.1)
  - Refined Risk Assessment (Section N.6.4.2)
  - Composite Risk Assessment (Section N.6.4.3)
- Areas of Mitigation Interest (Section N.7)

N.3.1 General Processing Issues

The following are general issues that Mapping Partners should be aware of during the creation of Flood Risk Datasets for use in flood risk projects.

N.3.1.1 Extent of Flood Risk Data Creation

Creation of flood risk data may require that data (such as a water surface grid) extend outside the project area, as demonstrated in Watershed A shown in Figure 4 below. This additional data may be needed to ensure a complete picture of flood risks within the project area. Flood risk data may also extend outside the project area when census blocks bisect the project area.

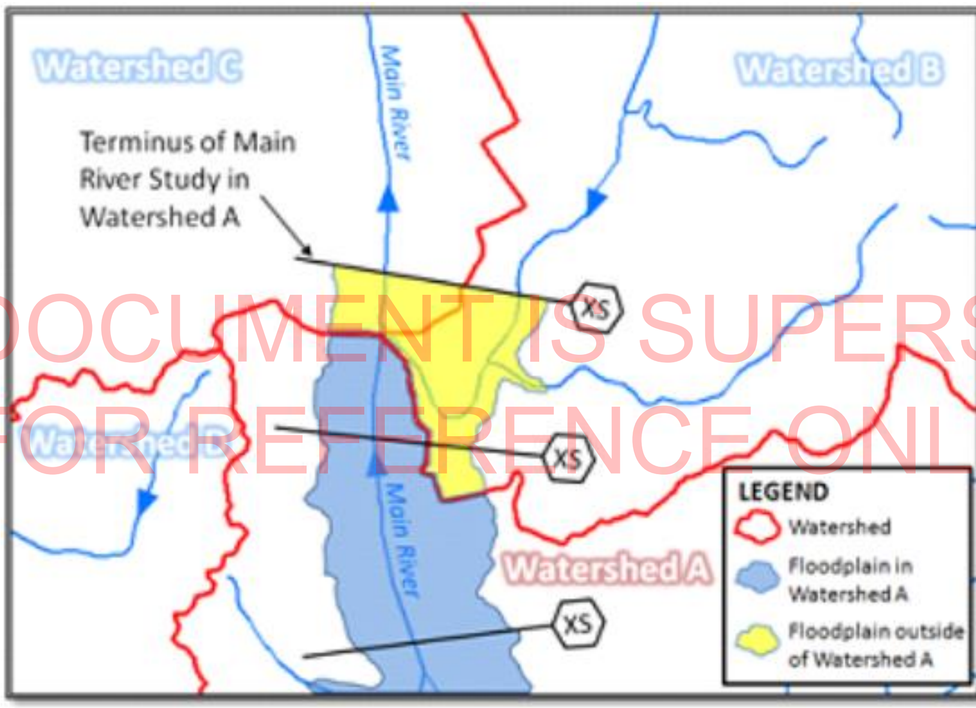


Figure 4: Flood Risk Data Outside of Project Area

- ✓ **When flood risk data extends outside the project area, it will not be clipped at the project area boundary before being added to the Flood Risk Database. However, the Flood Risk Report will only report on the extent of the flood risk data that lies within the flood risk project area.**

N.3.1.2 Flood Risk Datasets within Flood Risk Products

As indicated in this document, there are multiple Flood Risk Datasets that feed into three Flood Risk products. Table 2 provides an at-a-glance overview of which elements of each Flood Risk dataset will be included in each Flood Risk Product. A "Yes" is shown in the Flood Risk Report column indicates that there is a tabular listing of the data element. For example, in the Flood Risk Report, the CSLF is reported as a tabular summary of SFHA square mile changes.

Dataset	Sub-Element	Flood Risk Database	Flood Risk Report	Flood Risk Map
Changes Since Last FIRM (CSLF)	Horizontal Extent CSLF Polygons	Yes	Yes	No
	CSLF Polygon Attributes	Yes	No	No
	Affected Structures	Yes	Yes	No
	Affected Population	Yes	Yes	No
Water Surface Grids	Water Surface Elevation	Yes [1]	No	No
Depth Grids	Depth	Yes	No	No
Flood Risk Analysis Grids	Water Surface Change	Yes	No	No
	Velocity	Yes	No	No
	Percent Annual Chance	Yes	No	No
	Percent 30-year Chance	Yes	No	No
	1% Plus (Elevation)	Yes	No	No
	1% Plus (Depth)	Yes	No	No
Flood Risk Assessment	AAL Study Data	Yes	No	No
	Refined Hazus Data	Yes	No	No
	Composite Loss Data	Yes	Yes	Yes
Areas of Mitigation Interest (AoMI)	Dams	Yes	Yes	Yes
	Non-Accredited Levees	Yes	Yes	Yes
	Accredited Levees	Yes	Yes	Yes
	Coastal Structures	Yes	Yes	Yes
	Stream Flow Constrictions	Yes	Yes	Yes
	Key Emergency Routes Overtopped During Frequent Flood Events	Yes	Yes	Yes
	Past Claims Hot Spot	Yes	Yes	Yes
	Individual & Public Assistance (IA) and Public Assistance (PA) data	Yes	Yes	Yes
	Significant Land Use Changes	Yes	Yes	Yes
	Areas of Significant Coastal or Riverine Erosion	Yes	Yes	Yes
	Non Levee Embankments	Yes	Yes	Yes
	Other Flood Risk Areas	Yes	Yes	Yes
	Areas of Mitigation Success	Yes	Yes	Yes
	Other	Yes	Yes	Yes

Table 2: Flood Risk Datasets within Flood Risk Products

[1] Will be included in the FRD at the discretion of the FEMA Region. See Section N.5.4.1.1 for more information.

N.3.1.3 Letters of Map Revision

Letters of Map Revision (LOMRs) are incorporated into the National Flood Hazard Layer (NFHL) as they are issued, but may not have been incorporated into other FEMA products as of the start of a new flood risk project.

- ✓ **For any Flood Risk Datasets that rely on comparison of new data to effective data (e.g., CSLF, Water Surface Elevation Change grids, etc.), previously issued LOMRs or other revisions must be taken into account.**

If effective models obtained from the FEMA library, FIRM Databases obtained from the Map Service Center, or FIS documents are used as the starting point for creation of Flood Risk Products, the Mapping Partner will need to verify that all revisions have been taken into account.

N.4 Changes Since Last FIRM (CSLF)

The CSLF geographic data resides within the FRD and reflects an analysis of floodplain changes from the previous to the new FIRM.

N.4.1 Dataset Definition

This polygon feature class resides in the FRD and contains all polygons that result from a union between the effective NFHL digital FIRM polygons, the new revised FIRM polygons, the political areas, and the project area boundary. This dataset reflects changes that have occurred in the horizontal extent of the regulatory floodway boundary, 1% annual chance floodplain boundary, and 0.2% annual chance floodplain boundary. This dataset also contains a set of unique attributes that provide insight into the historical and current flood hazard data (including zone designation), and an indication into the reason for the change.

Important to note is that this dataset does not include any vertical change elements. That information is provided in the Water Surface Elevation Change Grid (see Section N.5.4.3).

N.4.2 General Guidance

See Section N.4.4 for best practices in the creation of the CSLF dataset. Each CSLF polygon will be attributed to describe the changes to the SFHA extent and indicate potential reasons why the area changed. The CSLF dataset will contain two groups of attribute data for each CSLF polygon as follows and as shown in Table 3 and Table 4:

- Standard attributes such as the watershed ID, the Community Identification Number that each CSLF polygon falls in, and the old and new flood zone designation.
- Contributing Engineering Factor attributes that provide insight into what may have influenced the floodplain change, such as the introduction of a new hydrologic model, new terrain data, or new hydraulic structures in the floodplain.

Political area summary calculations for structure counts, population, and areas should only be determined for areas within the project area boundary. As defined in Appendix O of the FEMA *G&S*, the political areas delivered within the FRD political area feature class should only include the political areas within the project area boundary. When flood risk data extends outside the project area, the political areas outside the project area can be delivered within the cartographic feature class to preserve the data for visualization purposes (e.g. Project Locator diagram).

N.4.3 Requirements and Standards for the CSLF Dataset

All items in this sub-section represent minimum standards for the creation of the CSLF dataset, and are therefore mandatory elements that Mapping Partners shall follow.

- ✓ **As discussed in Section N.3.1.1, when flood risk data extends outside the project area, the full extent of CSLF polygons must be included in the Flood Risk Database, even though the Flood Risk Report will only provide CSLF data results within the extent of the flood risk project as defined within the Project Charter.**

- ✓ **The NFHL is the source for effective flood hazard area data. If this data is not available then there is no requirement to create the CSLF dataset.**

- ✓ **The CSLF polygons are created by the unioning of four layers – the effective flood hazard areas, the new flood hazard areas, the political areas, and the project area boundary (e.g. HUC-8 project area).**

- ✓ **CSLF polygon areas that were previously mapped as unshaded Zone X or Zone D in the effective flood hazard areas and that remain as unshaded Zone X or Zone D in the new flood hazard areas shall not be delivered as part of CSLF data.**

- ✓ **All CSLF polygons shall include both standard and Contributing Engineering Factors attribution according to the database specifications defined in Appendix O of the FEMA *G&S*.**

  - **Table 3 provides the CSLF attribute fields mapping partners must populate.**

  - **Table 4 provides a list of the Contributing Engineering CSLF attribute fields that mapping partners must populate to indicate the reason for various mapping changes.**

- ✓ **The analysis to define each Contributing Engineering Factor does not have to be more granular than the extent of the study stream being modeled (e.g. It is adequate to indicate that there were changes in discharge for the entire study stream area. A mapping partner does not have to identify each location along the studied stream where significant discharge changes occurred).**

- ✓ **When attributing Contributing Engineering Factor fields, "Unknown" shall only be used as a reason for change after all reasonable engineering judgment has been applied to ascertain the possible reason for change.**

- ✓ **When quantifying the numbers of structures and population affected by floodplain and/or floodway boundary changes, high quality local data shall be used. Pre-packaged Hazus population and general building stock information is not considered a sufficient data source for determining the number of affected structures and population. See Section N.4.4.3 for more details.**

- ✓ **When quantifying the number of structures affected by floodplain and/or floodway boundary changes, each structure should be compared to the CSLF polygons that touch or 'intersect' the structure but only accounted for once. If the structure touches only one CSLF polygon, it will be associated with that polygon. If the structure is touching more than one CSLF polygon, the structure shall be associated with the most restrictive new/revised flood zone polygon that it touches. Attribution hierarchy is provided within the best practices section.**

- ✓ **The Flood Risk Report watershed and community based tables shall be derived from the CSLF data within the project area boundary (e.g. HUC-8 project area). Flood risk data that extends beyond the project area boundary shall not be included.**

N.4.4 Best Practices for CSLF Dataset Creation

This section includes best practices for creation of the CSLF dataset; alternate approaches that comply with program standards that effectively and efficiently support program objectives are also acceptable. The CSLF dataset is created through two separate processes; geographic unioning and attribution of the resulting polygons as follows:

- Geographic "unioning" of the effective floodplain and floodway boundary layers from the National Flood Hazard Layer (NFHL), the political areas, the new/revised floodplain, and the project area boundary. This process will yield change polygons representing changes in extent to the 1% and 0.2% annual chance floodplains and the regulatory floodway, and representing the political areas and project area boundary intersections. A basic example of unioning is shown in Figure 5.

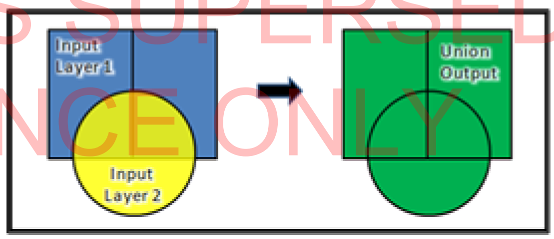


Figure 5: Unioning Geographic Datasets

- CSLF attribution will be conducted for all change polygons created in the unioning process. This will normally require assigning CSLF attributes, including Contributing Engineering Factors attributes (see Section N.4.4.2.2).

This two-step process will result in a dataset that shows changes to the horizontal floodplain and floodway extent, and changes to the flood zone designations. Through polygon attribution described in Section N.4.4.2, this dataset also provides insight into why the changes occurred.

N.4.4.1 Geographic Unioning

Geographic unioning includes minimal preprocessing of both the previous and updated flood hazard area layers to ensure that appropriate data fields have been added and attributed as specified by Appendix O of the FEMA *G&S*. For this process, Mapping Partners may consider applying the following intermediate steps:

1. Perform a geospatial union of both pre- and post-input flood hazard data layers to produce a new composite CSLF polygon layer for the project area that possesses all combinations of previous and new flood zone types. When the political areas and project area boundary layers are also included in the union process, the resulting CSLF polygons can be attributed with those IDs as well.
2. Remove any polygons that possess an attribute of 'unshaded Zone X' or 'Zone D' for both previous and new flood zone types. Areas that were mapped as unshaded Zone X or Zone D on the previous FIRMs and that remain as unshaded Zone X or Zone D on the new FIRMs are not to be delivered within the CSLF dataset.

The result of applying the above steps should produce a data layer containing all combinations of floodplain change as shown in Figure 6.

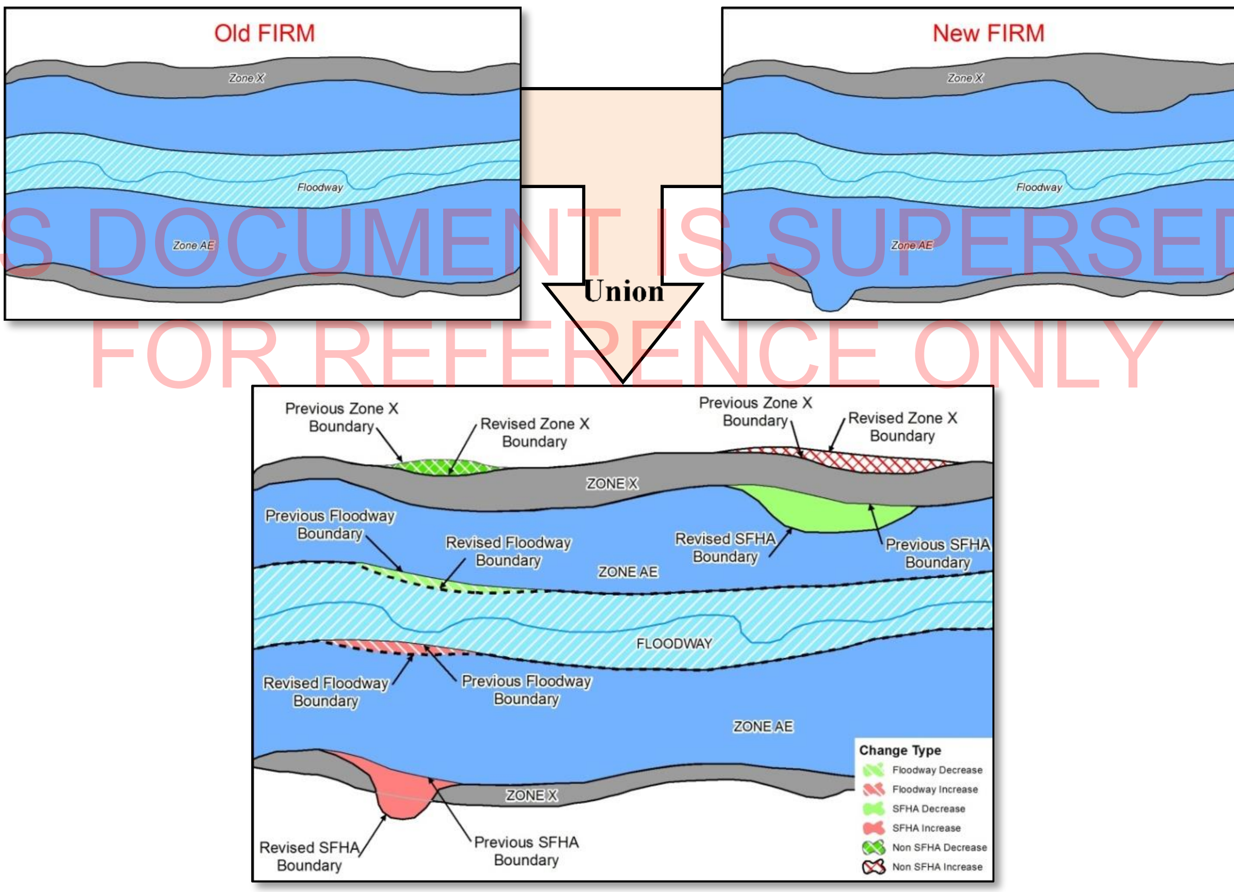


Figure 6: Geographic Unioning of Previous and New/Revised Floodplain Polygons

N.4.4.2 CSLF Attribution

The CSLF attributes will provide dataset users with insight into the previous and new condition of the subject area as well as providing insight into the cause of the floodplain change. CSLF attributes are generally divided between "Standard" attributes and Contributing Engineering Factors attributes as described in Sections N.4.4.2.1 and N.4.4.2.2.

N.4.4.2.1 Description of Standard CSLF Attributes

Standard CSLF attributes reflect the "before" and "after" condition of the subject area such as the previous and new flood hazard zone. Refer to Appendix O for a complete list of the CSLF attributes and field names. For attribution of standard attributes (such as the zone designation on the previous FIRM) it is recommended that the attribution be performed before the unioning process so those attributes will be inherited to the unioned CSLF dataset.

✓ **Table** 3 **provides standard CSLF attribute fields that mapping partners must populate.**

Table 3: Standard CSLF Attributes

CSLF Attribute *	Purpose or Use
CSLF ID	The unique identifier for each CSLF polygon
CNMS Identifier	The 5-digit county FIPS code, '02' indicating the S_Studies_Ar feature class, and a 5-digit unique sequential number
Area of Change	The area of each CSLF polygon, expressed in square feet
Previous Zone	The previous flood hazard zone designation for the change polygon
Previous Zone Subtype	The previous zone subtype (e.g. Floodway for Zone AE or 0.2% for Zone X)
Previous Model Info	The linkage identifier for previous FIRM model information
Previous Topo Info	The quality and type of topographic information used for the previous FIRM
Source Citation	The source citation for the previous FIS/FIRM data
New Zone	The new or updated flood hazard zone designation for the change polygon
New Zone Subtype	The new or updated zone subtype (Floodway for AE or 0.2% Chance for X)
New Model Info	The linkage identifier for the updated or new FIRM model information
New Topographic Info	The quality and type of topographic information used for the new/revised FIRM
New Source Citation	The source citation for the new FIS/FIRM data
SFHA Change	Type of SFHA change for each CSLF polygon based on previous and new flood zones

Table 3: Standard CSLF Attributes

CSLF Attribute *	Purpose or Use
Non SFHA Change	Type of non-SFHA change for each CSLF polygon based on previous and new flood zones. Normally only shaded X changing in size or being re-designated to an SFHA zone.
Floodway Change	Type of floodway change for each CSLF polygon based on previous and new flood zones
Affected Structures **	The estimated count of affected structures within the area of change
Affected Population **	The estimated affected population within the area of change
CID	The FEMA Community Identification number in which each CSLF polygon falls
HUC8 Code	The 8 digit Hydrologic Unit Code for the watershed in which the CSLF polygon falls
Case Number	Case number used for national roll-up of data
Version ID	The version of guidance and data standards in effect at time of project

* Refer to Appendix O of the FEMA *G&S* for a current list of all CSLF attributes and field names
** This only applies if high quality community-supplied data is available (see Section N.4.4.3for details)

N.4.4.2.2 Description of Contributing Engineering Factor Attributes

Contributing Engineering Factors are those attributes that provide insight into the reason for a change to the floodplain or floodway boundary and/or the flood zone change. Items that fall into this category include factors that are considered to have actively influenced the floodplain change such as the use of a new hydrologic model, the addition of a hydraulic structure, or the introduction of new terrain data.

- ✓ **Table 4 provides a list of the Contributing Engineering Factor CSLF attribute fields that mapping partners must populate to indicate the reason for various mapping changes.**

Table 4: Contributing Engineering Factors

CSLF Attribute	Description
Peak Discharge Changes	This field is used to indicate a change to the study's peak discharges that may have impacted the analysis
Change in Model Methodology	This field is used to indicate changes to primary assumptions associated with the updated model methodology
Flood Control Structure Change	This field is used to indicate a change to the study's major flood control structure(s) that may have impacted the analysis
Hydraulic Structure Change	This field is used to indicate a change to the study's number of hydraulic structures that may have impacted the analysis

CSLF Attribute	Description
New Topographic Data	This field is used to indicate a change in the topographic information used in the modeling or used to re-delineate the floodplain boundaries
Sedimentation Change	This field is used to indicate significant changes to channel sedimentation
Erosion Change	This field is used to indicate significant changes to channel erosion or scour
Channel Configuration Change	This field is used to indicate significant changes to channel geometry
Levee Accreditation Change	This field is used to indicate a change to the accreditation status of a levee
Stream Runoff Change	This field is used to indicate changes in stream runoff caused by land use, vegetation or imperviousness changes that impacted the analysis
Dune Change	This field is used to indicate changes to primary frontal dunes since last the last study
Other Change	This field is used to indicate other changes the Mapping Partner believes to have contributed to the results of the analysis

N.4.4.2.3 Establishing Spatial Extent for Contributing Engineering Factors

Associating Contributing Engineering Factors will depend upon the spatial extent that each factor influences. For example, a change in topographic data or hydrologic discharge might apply to an entire project area (e.g. HUC-8 project area) extent whereas a change to the number of hydraulic structure(s) added or removed since the previous study may be more localized.

Mapping Partners shall apply best judgment to define the area of impact and appropriately associate each relevant Contributing Engineering Factor. At a minimum, Mapping Partners shall associate Contributing Engineering Factors to the model limits for a given stream or coastline. However, Mapping Partners should further refine these extents where practical and directed by FEMA.

Figure 7 depicts a layered approach for assigning Contributing Engineering Factors to appropriate CSLF polygons. Mapping Partners may elect to use this or other methods for attribution of CSLF polygons.

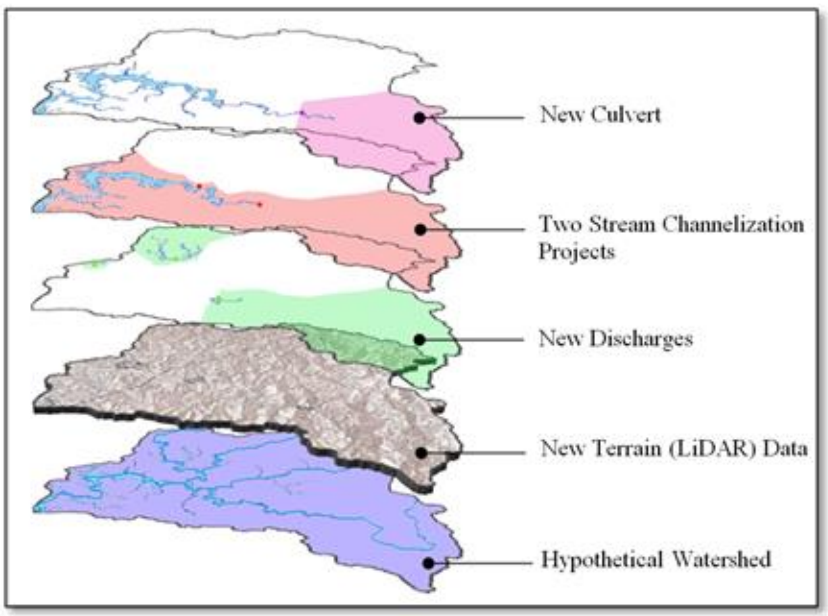


Figure 7: Assigning Contributing Engineering Factors

N.4.4.2.4 *Describing the Contributing Engineering Factors*

As a best practice, engineering judgment should be the primary rationale used to determine which of the following categories best describes the amount of change to a particular contributing factor:

- Increase: Was there a significant increase to the factor being measured which may have impacted the result?
- Decrease: Was there a significant decrease to the factor being measured which may have impacted the result?
- Negligible: Was there an increase and/or decrease in the factor being measured, but no measurable impact to the results, or the impact was insignificant?
- None (Zero): There were absolutely no increases or decreases in the factor being measured which impacted the result.
- True/False: The engineering factor either applied or did not apply. An example is for the New Terrain Data attribute. If new terrain data was introduced and that new data caused the floodplain boundaries to change, the attribute would be "True".
- Unknown: The engineering factor was not analyzed, so no determination can be made as to the impact on the result. This attribute may also be used if it cannot reasonably be determined if the engineering factor being analyzed impacted the results. This 'Unknown' option is not meant to be a 'catch-all' and the Mapping Partner should use professional judgment and an appropriate standard of care in making these determinations.

N.4.4.2.5 *Leveraging the Coordinated Needs Management Strategy (CNMS) Data*

CNMS is one source that could be used to inform the CSLF Contributing Engineering Factors attribution. CNMS may be consulted to help determine potential changes within the project area that were identified during Discovery or that were noted during the Hydrologic and Hydraulic flood hazard analysis. Table 5 summarizes how each of the CSLF Contributing Engineering Factors might relate to an associated CNMS element:

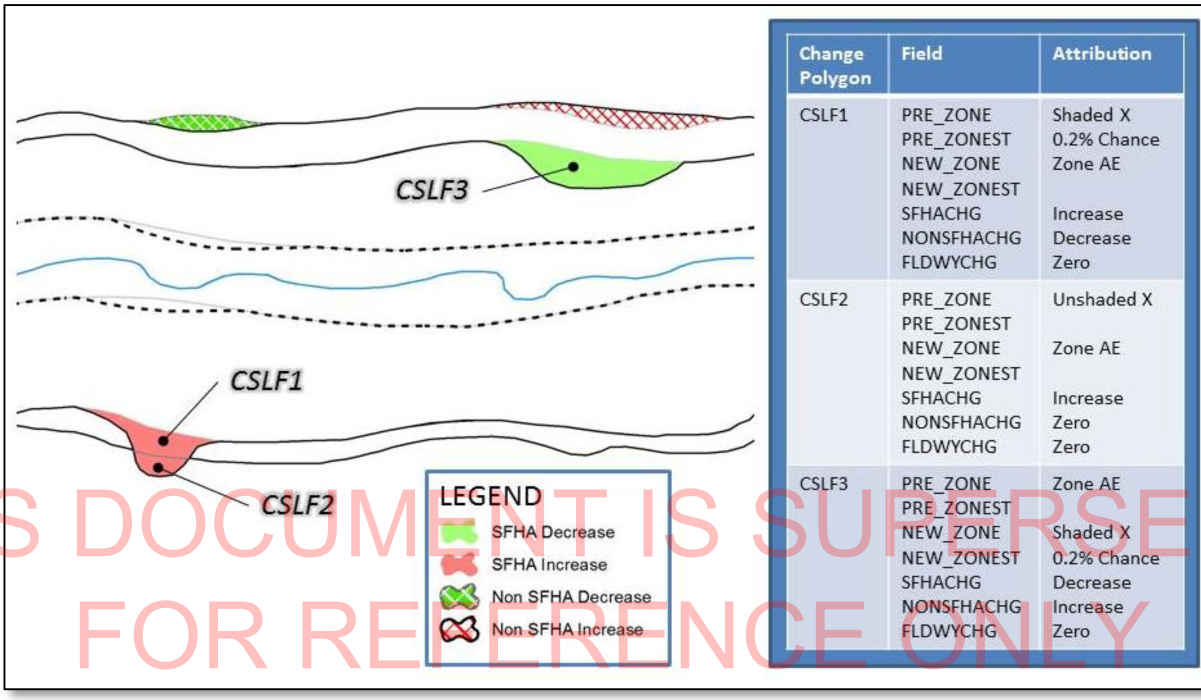
Table 5: Contributing Engineering Factors and CNMS

Contributing Engineering Factor	Potential CNMS Linkage
Peak Discharge	• CNMS elements C1 and C2 indicate issues with discharges used for effective analysis. • Element C1 attempts to determine if there was a major change in gage record, rainfall record, or other climatological data • Element C2 assesses whether or not the effective discharges were outside the tolerance level based on the confidence limit criteria listed in Bulletin 17B
Model Methods	• Element C3 indicates if the model methods used in the effective study are no longer appropriate (not just an older version of a currently accepted model)

Contributing Engineering Factor	Potential CNMS Linkage
Levee Accreditation Change	• N/A: Elements within CNMS which address changes in levee accreditation status cannot be used to inform this attribute in CSLF since those elements also capture other flood control changes without differentiation
Flood Control Structure Change	• Element C4 indicates if there has been a removal or addition of a major flood control structure on a stream reach. A flood control structure can be a dam, weir, levee, etc.
Hydraulic Structure Change	• Element S4 indicates if there are one to four new/removed structures • Element C6 indicates if there are five or more new/removed structures
New Topographic Data	• Element S6 captures information to indicate if better (not necessarily newer) topographic information that meets FEMA minimum standards is available
Sedimentation Change	• Element C7 captures information about the presence of significant changes to channel sedimentation due to bridge scour since the last study • Evaluation of this element during CNMS Phase 3 analysis relied upon a certain level of community outreach. In instances where this element indicates significant channel fill this can be used as evidence of sedimentation change. However in instances where this element does not indicate fill, further investigation will be necessary to confirm.
Erosion Change	• Element C7 indicates if there is significant bridge scour on a stream reach • Evaluation of this element during CNMS Phase 3 analysis relied upon a certain level of community outreach. In instances where this element indicates significant channel scour this can be used as evidence of erosion change. However in instances where this element does not indicate scour, further investigation will be necessary to confirm.
Channel Configuration Change	• Element S5 indicates if there have been hydraulically significant channel modifications since the effective study on a given reach • Element C5 indicates if the channel is outside of the SFHA now; this could be due to poor topographic data used in the effective study or could be due to channel changes. Imagery would need to be checked to determine this • The addition or removal of structures is represented by CNMS C6 and S4
Stream Runoff Change	• Elements S3 and/or S7 indicate if there have been significant changes to land use and/or impervious area that would affect runoff
Dune Change	• Element S8 indicates whether or not a primary frontal dune has been identified for a coastal study. • FEMA is reviewing the process for Coastal Study inclusion in CNMS as most of the Nation's coastline is being currently revised. As of the data of issuance of this guidance, no coastal or coastally influenced studies are represented within the CNMS Inventory.
Other Change	Other Changes may be indicated by the following CNMS elements: • Use of rural regression equations in urbanized areas (S1) • Repetitive losses near but outside of the SFHA (S2) • Significant storms occurred with High Water Marks collected (S9) • Newer regression equations are available since the data of the effective study (S10)

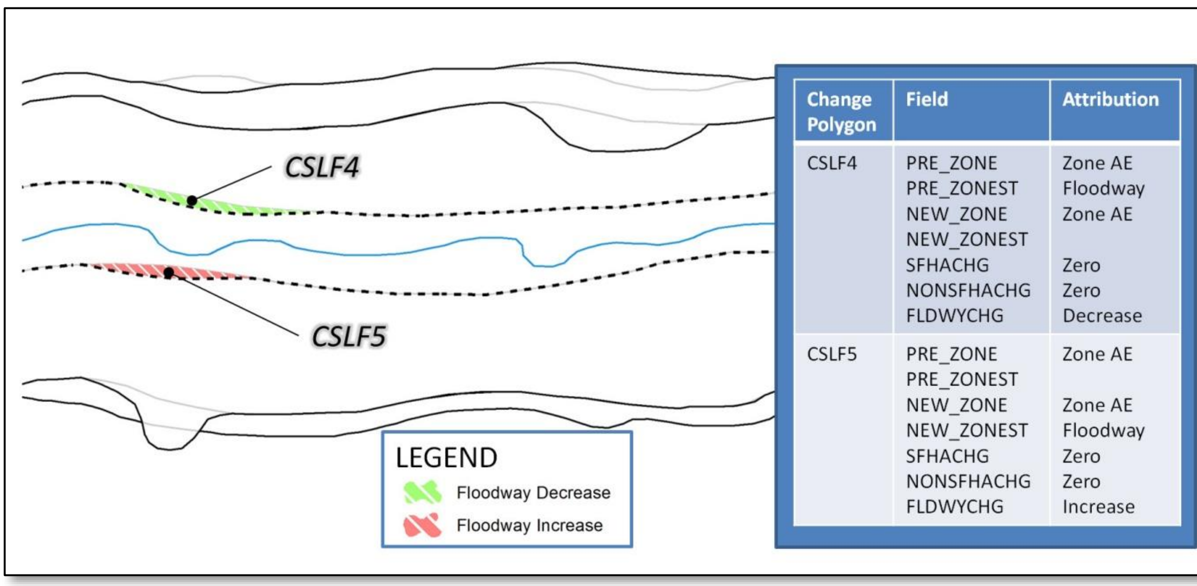
N.4.4.2.6 *Results of Proper CSLF Attribution*

Figure 8 and Figure 9 below provide examples of proper CSLF attribution using the same graphic example from Figure 6. For a detailed listing of all attributes and their specific applicability (i.e., which attributes are required, optional, etc.) refer to Appendix O of the FEMA G&S.



Change Polygon	Field	Attribution
CSLF1	PRE_ZONE	Shaded X
	PRE_ZONEST	0.2% Chance
	NEW_ZONE	Zone AE
	NEW_ZONEST	
	SFHACHG	Increase
	NONSFHACHG	Decrease
	FLDWYCHG	Zero
CSLF2	PRE_ZONE	Unshaded X
	PRE_ZONEST	
	NEW_ZONE	Zone AE
	NEW_ZONEST	
	SFHACHG	Increase
	NONSFHACHG	Zero
	FLDWYCHG	Zero
CSLF3	PRE_ZONE	Zone AE
	PRE_ZONEST	
	NEW_ZONE	Shaded X
	NEW_ZONEST	0.2% Chance
	SFHACHG	Decrease
	NONSFHACHG	Increase
	FLDWYCHG	Zero

Figure 8: CSLF Example (focused on floodplain boundary changes and attribution)



Change Polygon	Field	Attribution
CSLF4	PRE_ZONE	Zone AE
	PRE_ZONEST	Floodway
	NEW_ZONE	Zone AE
	NEW_ZONEST	
	SFHACHG	Zero
	NONSFHACHG	Zero
	FLDWYCHG	Decrease
CSLF5	PRE_ZONE	Zone AE
	PRE_ZONEST	
	NEW_ZONE	Zone AE
	NEW_ZONEST	Floodway
	SFHACHG	Zero
	NONSFHACHG	Zero
	FLDWYCHG	Increase

Figure 9: CSLF Example (focused on floodway boundary changes and attribution)

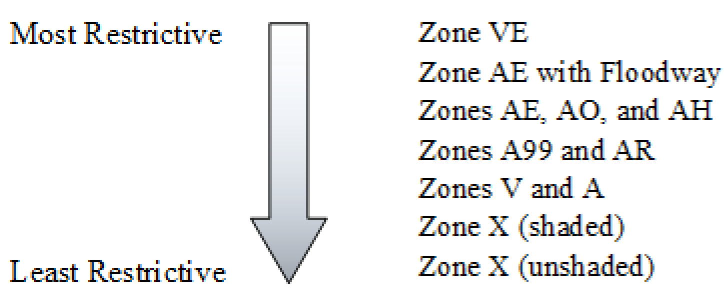
N.4.4.3 Quantification of Affected Structures and Population

A unique element of the CSLF dataset involves quantifying the structures and population affected by changes to the spatial extent of floodplains from the effective to the new/revised FIRM. This dataset element is dependent upon receiving high quality local data reflecting building location and associated population data. Building footprints, centroids, or parcel data are the minimum data requirement for performing this analysis. It is not considered acceptable to use census or general building stock data that comes pre-packaged with Hazus for this analysis due to the higher accuracy requirements/expectations necessary to perform this extremely localized analysis.

When performing this analysis, Mapping Partners should associate structure and population counts to the applicable CSLF polygon feature that best represents the location of the given structure. The intent is to document changes in zone designation for each structure from the prior FIRM to the new/revised FIRM. One potential use of this data will be an analysis of the change in insurance rating caused by changes to the floodplain extents. For this reason, it is important (whenever possible) to select a polygon touching the structure that represents both the most restrictive flood zone associated with the structure before the map revision and the most restrictive flood zone affecting the structure as a result of the map revision. See conditions a) through c) below for a suggested approach to the development of the flood zone polygon structure change data.

a) If a structure touches only one CLSF polygon (regardless of whether there was a change or not), associate the structure with that CSLF polygon. Structure "A" in Figure 10 demonstrates this condition.

b) If condition a) is not met because the structure touches more than one CSLF polygon, do an assessment of the most restrictive old and most restrictive new flood zone polygon. If one of the CSLF polygons that touch the structure meets both criteria (most restrictive old and most restrictive new flood zone), associate the structure with that CSLF polygon. If more than one CSLF polygon meets both criteria, then select the largest qualifying polygon. Structures B through F in Figure 10 demonstrate this condition.



c) If condition b) is not met, select the most restrictive CSLF polygon as shown in structure G below where. In this condition, even though the structure went from shaded Zone X to AE, there isn't any polygon that meets both criteria, so the most restrictive new CSLF polygon is selected. This condition acknowledges that there is no way to always know the most restrictive old and the most restrictive new flood zone by selecting only one CSLF polygon; therefore the selection defaults to the most restrictive flood zone that now affects the structure. If more than one polygon meets this condition, then the largest should be selected.

Figure 10 and Table 6 below use the same graphic example from Figure 6 and provide examples of how the rules are applied relative to conditions a), b), and c) above.

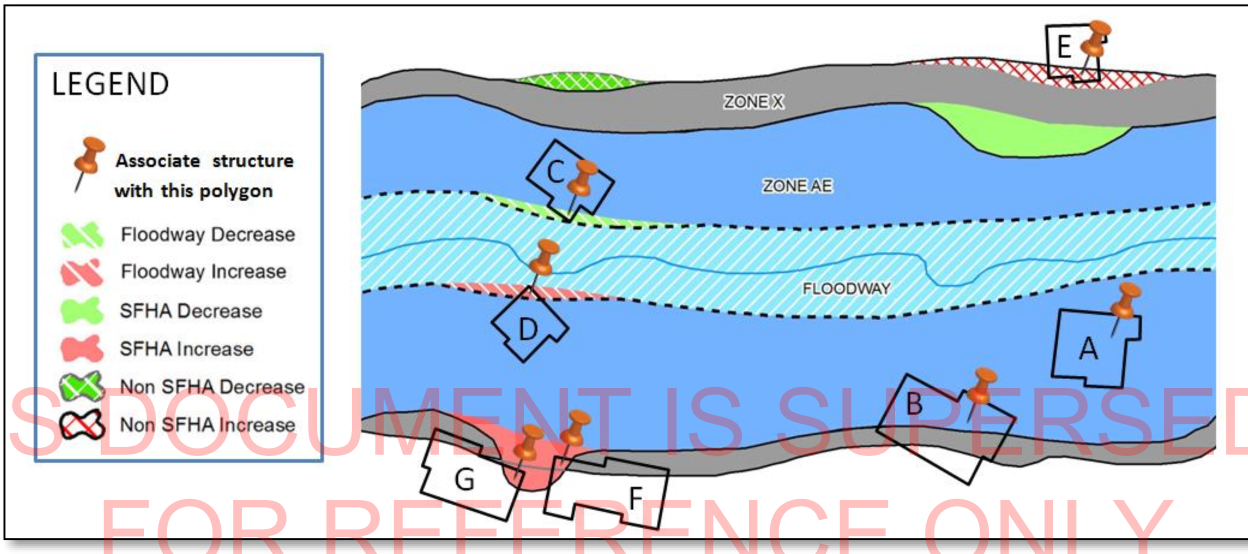


Figure 10: Associating Structures with CSLF Polygons

Table 6: Associating Structures with CSLF Polygons

Structure	Description	Previous Most Restrictive Zone	New Most Restrictive Zone	Condition
A	Structure was and is now entirely in Zone AE	AE	AE	a
B	Structure was and is now partially in Zone AE	AE	AE	b
C	Structure was partially in the floodway but is now out of the floodway and entirely within Zone AE	AE Floodway	AE	b
D	Structure was totally in Zone AE but is now also partially in the floodway	AE	AE Floodway	b
E	Structure was entirely in unshaded Zone X before but is now also partially in shaded Zone X	X (unshaded)	X (shaded)	b
F	Structure was partially in shaded Zone X before but is now also partially in Zone AE	X (shaded)	AE	b
G	Structure was partially in shaded Zone X before but is now also partially in Zone AE	X (shaded)	AE	c

In addition to procuring geo-coded structure footprint data during the Discovery data mining process, a Mapping Partner may also be required to procure data reflecting the population associated with each structure affected by a floodplain or floodway boundary change. In the absence of actual population data associated with each structure, the affected population count attribute may be determined by calculating the average population per structure and using that data to associate population to CSLF change polygons. In order to determine the average population per structure, the census population data for each census block should be divided by the number of residential structures located in that census block and then attributed to the CSLF structure data record accordingly.

Proper attribution of the CSLF polygons will enable local stakeholders to apply basic GIS selection queries to isolate and quantify zone changes and associated impacts to structures or population. The CSLF dataset is intended to provide end-users maximum flexibility for evaluating these changes and the factors responsible for influencing them.

N.4.4.4 Processing CSLF Data for Inclusion in Flood Risk Report

There are project-based and community-based tables in the Flood Risk Report that provide a quantification of additions and removals from the SFHA and Floodway (see sample shown as Table 7 below). Since the CSLF polygons included both political areas and the project area boundary during the unioning and attribution processes, the dataset includes all the information necessary to query and prepare the various Flood Risk Report tables.

Table 7: Flood Risk Report Table for CSLF (for affected area data)

Area of Study	Total Area (mi^2)	Increase (mi^2)	Decrease (mi^2)	Net Change (mi^2)
Within SFHA	21.1	1.0	2.5	-1.5
Within Floodway	3.2	0.7	0.1	3.0

There are also options for assessing the structures and population affected by changes to the floodplain extents. That information will be presented as shown in Table 8 below. Full details regarding the location of the data fields in the Flood Risk Database that are used to populate these tables may be found in Appendix O of the FEMA *G&S*.

Table 8: Flood Risk Report Table for CSLF (for affected structure and population data)

Area of Study	Buildings			Population		
	Increase	Decrease	Net Change	Increase	Decrease	Net Change
Within SFHA	4	23	-19	12	69	-57
Within Floodway	0	3	-3	0	9	-9

N.5 Flood Depth and Analysis Grids

Raster grids are included as part of the FRD deliverable and reflect the results of riverine and coastal engineering and analysis.

N.5.1 Data Definition

Table 9 provides a summary of Flood Depth and Analysis Grids that will be stored in the FRD for the individual flood frequencies analyzed:

Table 9: Flood Depth and Analysis Grids

Product	Description
Water surface elevation grids	Representations of the modeled water surface elevation for various flood frequencies, primarily the 10%, 4%, 2%, 1% and 0.2% annual chance flood events.
Flood depth grids	Representations of the flood water depths for various flood frequencies.
Water surface elevation change grids	Representations of the difference between the effective and revised 1% annual chance floodplain water surface elevations for areas that were both SFHA before the revision and after the revision.
Velocity grids	Representations of the flood velocity distribution created by mapping the velocity output data using FEMA accepted hydraulic models
Percent annual chance grids	Representations of the percent-annual-chance of flooding for discrete locations within the extent of the mapped flooding source.
Percent 30-year chance grids	Representation of the percent chance of a discrete location experiencing flooding at least one time during a 30-year period. This dataset is developed for all locations within the mapped floodplain.
1% plus flood elevation grids	Representations of the upper statistical confidence limit flood elevations for the 1% annual chance flood event.

N.5.2 General Guidance

A digital raster grid defines geographic space as an array of equally sized square cells arranged in rows and columns. Each grid cell stores a numeric value that represents a geographic attribute. The Flood Risk Database deliverable includes grids with flood engineering attributes. Refer to Appendix O of the FEMA *G&S* for details about the grid specifications required for delivery.

Flood Depth and Analysis Grids provide valuable information for local stakeholder to understand flood risk by enabling visualization of flood risk elements for each grid cell such as the change in water surface elevations between the old and new flood study; areas of high floodwater velocity, probability grids that communicate the chance of being flooded in any given year or in a 30-year period, and grids that communicate increased flood risks associated with statistical confidence limits of hydraulic models.

Grid creation across streams within a watershed that were modeled at different times or using different methods often reveals flood elevation tie-in issues. The grids creation process is not intended to resolve all existing study or modeling issues. Additionally, grids do not have to be clipped or altered to match floodplain or project area boundaries nor to resolve negative depths that may occur due to using high precision elevation data.

N.5.3 Requirements and Standards for Depth and Analysis Grids

All items in this sub-section represent minimum standards for the creation of Flood Depth and Analysis Grids, and are therefore mandatory elements that Mapping Partners shall follow.

- ✓ **As discussed in Section N.3.1.1, when flood risk data extends outside the project area, grid data should not be clipped at the project area boundary; the Flood Risk Database will contain grid data to the full extent of the underlying modeling.**
- ✓ **Water surface elevations, used to create water surface and depth grids, for new or updated flood hazard studies must reflect the proposed regulatory elevations (i.e. reflect backwater conditions even if the new model does not).**
- ✓ **Water surface elevation grids created from effective data and used to calculate the water surface elevation change grids must reflect the effective regulatory elevations as shown on the FIRM.**

- ✓ **The same ground elevation source used in new or revised study modeling should be used to create any grids that require calculations that include ground elevation.**
- ✓ **Riverine depth grids for new studies will be created, at least, for the 10%, 4% 2%, 1%, and 0.2% annual chance flood events.**
- ✓ **Depth grids for AH zones shall be based on the static whole foot regulatory elevation shown on the FIRM, or more detailed 1/10th foot elevations derived from models provided that the results round to the whole foot elevations shown on the FIRM.**
- ✓ **Depth grids for AO shallow flooding zones shall reflect the reported depth as shown on the FIRM or more detailed data from the model if the results (when rounded) would equal the whole foot rounded depths shown on the FIRM.**
- ✓ **Coastal depth grids for new studies will created at least for the 1% annual chance flood event. Additional frequencies for inclusion will be determined on a case by case basis.**
- ✓ **Depth grids for areas of open water, except coastal, should reflect the difference of water surface elevation above the normal pool elevation. Elevations below the normal pool, or bathymetric data, should not be considered.**

- ✓ **Coastal depth grids for open water areas will use the modeling bathymetry elevation source data (when available) to the full extent of the flood hazard zone shown on the FIRM.**
- ✓ **Coastal velocity grids shall reflect the appropriate upper bound velocities from 2D storm surge modeling, equation #2 from FEMA's *Coastal Construction Manual : Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas* (CCM), or the extreme velocity from equation #3 for Tsunami prone areas.**
- ✓ **The extent of water surface elevation change grids shall only reflect those areas that were both SFHA before and after the revision.**
- ✓ **The percent-annual-chance flood event associated with inundating the ground elevation at each given location shall be computed by interpolating the log-linear relationship between the associated flood elevations at each point and the ground elevation (linear interpolation of the Water Surface Elevations, log interpolation of the percent annual chance flood event). Calculations shall not exceed the 10% annual chance event.**
- ✓ **The Percent 30-year Chance Grid shall use the following statistical equation:**
  - **Probability = 1 – (1-p)^n where p = the percent annual chance and n = the time horizon (30 years)**
- ✓ **The 1% plus flood elevation grid shall be created by determining elevations that result from using discharges that include the average predictive error for the regression equation discharge calculation for the study. This error will then be added to the 1% annual chance discharge to calculate the new 1% plus discharge. The upper 84-percent confidence limit will be calculated for Gage and rainfall-runoff models for the 1% annual chance event.**

N.5.4 Best Practices for Grid Creation

This section includes best practices for all of the raster grid products; alternate approaches that comply with program standards that effectively and efficiently support program objectives are also acceptable.

N.5.4.1 Water Surface Elevation Grid

Water surface grids have been included in Appendix N due to the direct dependency that exists between them and the flood depth and analysis grids. In conjunction with flood depth and flood risk analysis grids, these grids enable quantification of potential flood losses as well as visualization and communication of flood risks for mitigation planning and emergency management.

Creation of water surface grids for new or updated flood hazard studies will use the same hydraulic models and ground source information used to calculate water surface elevations. While new or updated models will be used for new or revised studies, the creation of water surface grids for older or effective studies should reflect the regulatory flood elevations shown on the effective FIRM.

N.5.4.1.1 Riverine Water Surface Elevation Grids

Riverine water surface elevation grids are used for the creation of depth grids and water surface elevation change grids. Water surface grids may be delivered in the FRD, but only by specific FEMA regional request and only if provided with appropriate caveats that the data is not to be considered regulatory in lieu of information shown on the FIRM.

While Mapping Partners may utilize differing hydraulic models, geospatial software and platforms, creation of the Water Surface Grids involve the following common elements:

- Use of the water surface elevations from the hydraulic model to create a Triangulated Irregular Network (TIN). In the case of 1-D step backwater analysis, the water surface elevations will be extracted from modeled cross sections. In the case of 2-D modeling, either the water surface grid is included in the output or can be developed using the model's output.
- Converting the TIN into GRID format (see Figure 11).

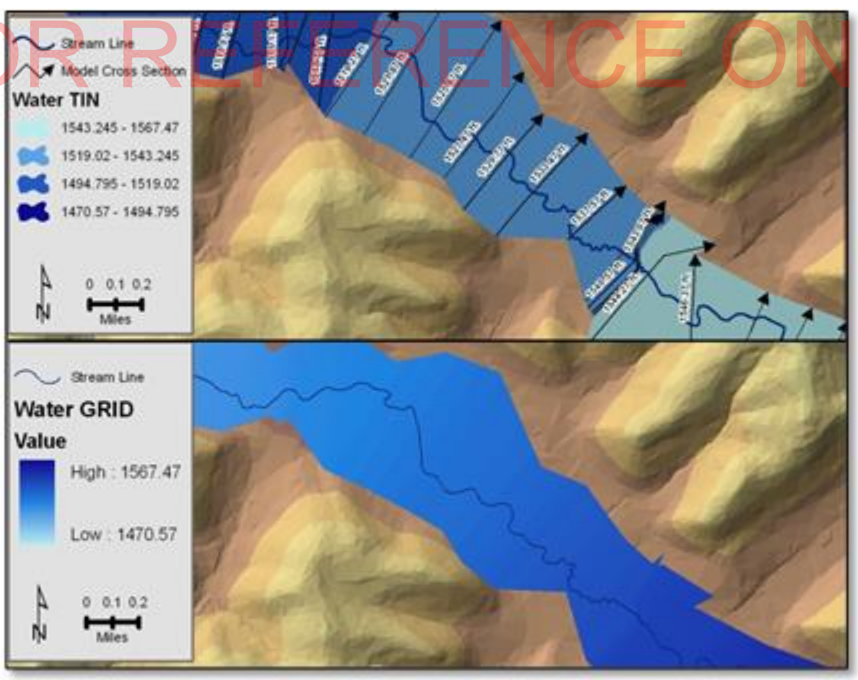


Figure 11: Water Surface TIN and GRID

Note: When creating a riverine water surface elevation grid for use as the effective elevations in the Water Surface Elevation Change Grid (see Section N.5.4.3) the resulting grid should reflect, to the greatest degree possible, the regulatory elevations shown on the effective FIRM.

N.5.4.1.2 *Shallow Flooding Water Surface Elevation Grids (Zones AH and AO)*

Shallow flooding zones (Zone AH and Zone AO) will include either a reported a static elevation as shown in Figure 12, or a depth as shown in Figure 13. The respective values for either will be found in the FIRM Database as an attribute of the S_FLD_HAZ_AR feature class.

- Floodplain areas that have static flood elevations (Zone AH and select AE zones) will have a reported static BFE in the FIRM Database as an attribute of the S_FLD_HAZ_AR feature class.

  In these cases, the mapping partner will convert the polygon area to a GRID format appropriately attributed with the elevation shown on the FIRM. See Section N.5.4.2.3 for more information.

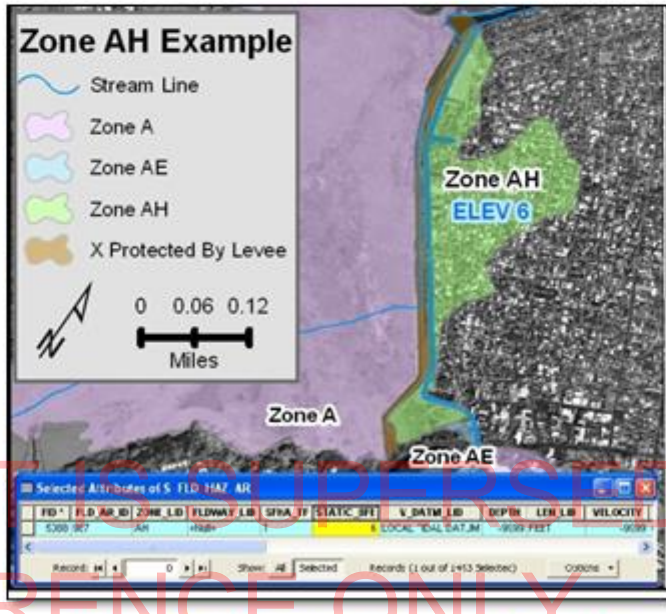


Figure 12: Water Surface Grid for Zone AH

- In the case where a depth is reported on the FIRM (Zone AO – See Figure 13), a water surface grid is not required. In these situations, the Mapping Partner will convert the Zone AO polygons directly to GRID format using the reported DEPTH as shown on the FIRM to create a depth grid.

  If depth data that is accurate to the tenth of a foot is available, the Mapping Partner may use that in lieu of deriving the information on the FIRM provided that the depths would round to the whole foot depth shown on the FIRM. See Section N.5.4.2.3 for more information.

Figure 13: Depth Grid for Zone AO

N.5.4.1.3 *Coastal Water Surface Elevation Grids*

Water surface grids for coastal flooding sources are created by using the NFIP mapped coastal floodplain zones and their associated base flood elevations directly.

N.5.4.1.3.1. Use of FIRM Coastal Zone Mapping

Coastal modeling culminates in static water surface elevations assigned to the mapped coastal floodplain zones. It is important to note that final mapped flood hazard areas often represent engineering judgment and/or intentional generalization of the specific coastal model outputs. Therefore while users may be tempted to use coastal modeling GIS layers such as Coastal Transects, use of the final mapped floodplains to generate coastal water surface grids is considered best practice, as it is intended to yield results that most closely match the FIRM. Therefore, coastal floodplain mapping with associated static BFE's (as shown on Figure 14) will normally be used to generate coastal 1% annual chance water surface grids.

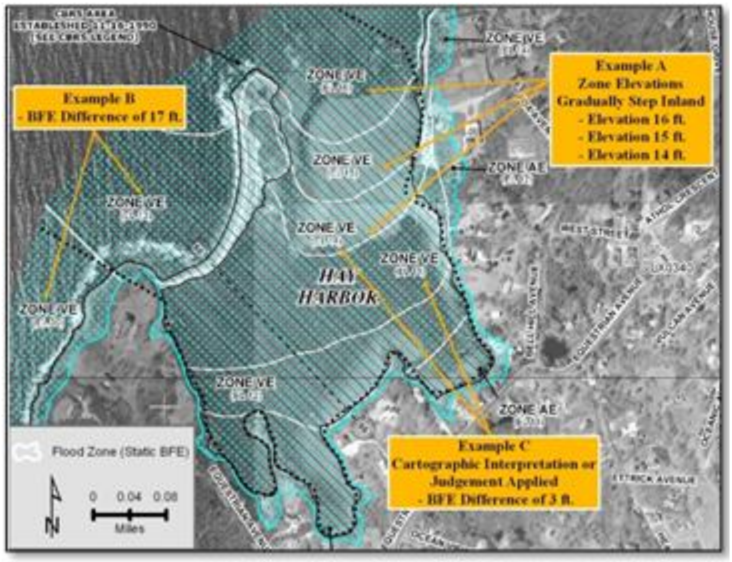


Figure 14: Coastal Floodplain Mapping Examples

While coastal water surface mapping may produce outputs that appear unnatural; (noted in Example A – Figure 14 & Figure 15) the stair-step effect between coastal zones is considered normal and acceptable. The same applies even if the stair-stepping effect is like Example B (where the transition is gradual) or Example C, which may also appear unnatural but is a function of the mapping process where cartographic interpretation and/or engineering judgement has been applied.

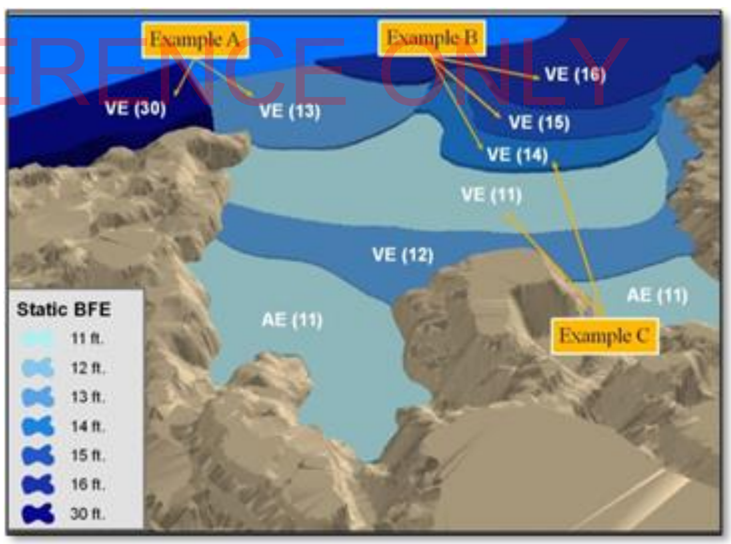


Figure 15: Stair-Stepped Coastal Elevations

N.5.4.2 Flood Depth Grids

Flood depth grids communicate flood water depth for computed flood frequency events by subtracting the terrain being used for the hydraulic analysis from the water surface grid as shown in Figure 16. As stated in Section N.5.3, the same terrain data used for the hydraulic analysis should be used for the creation of the depth grid, and the water surface elevation matching the FIRM should be used for the creation of the depth grid. For information on creation of water surface grids, refer to Section N.5.4.1.

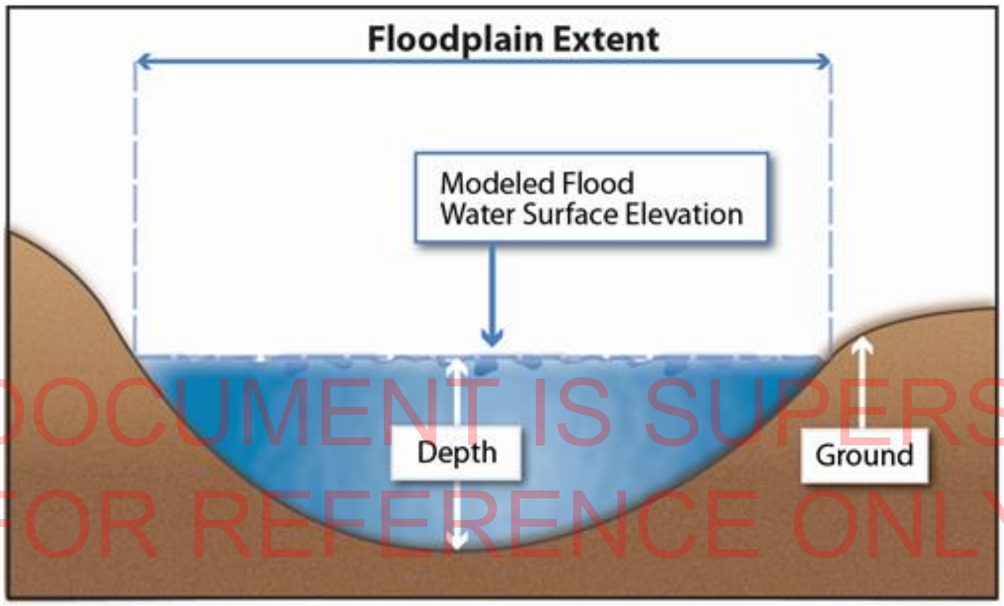


Figure 16: Depth Grid in Cross Section View

N.5.4.2.1 Riverine Depth Grids

The Riverine Depth Grid datasets reside in the Flood Risk Database and will be created using the water surface elevation data from effective, new, and updated models along with the ground surface data.

Riverine Depth Grids contain values in each grid cell (within the mapped floodplain) representing flood depths for all calculated return intervals (e.g. the 10%, 4%, 2%, 1% and 0.2% annual chance flood events.

The depth values for each depth grid cell are computed by subtracting the ground elevation value from the water surface elevation value for each return period computed. Ideally, the topographic data used for the development of any depth grid should be the same source as used to generate the effective floodplain boundaries to ensure consistent and accurate results. New or revised studies shall only use the same source ground data used to generate the new floodplain boundaries.

N.5.4.2.1.1. Creation of Riverine Depth Grids

While Mapping Partners may utilize differing hydraulic models and/or geospatial software or platforms and core data storage models or methods, creation of Riverine Depth Grids involves the following generic steps that may be performed universally across all GIS platforms.

1. Development of the water surface grid as described in Section N.5.4.1.
2. Development of a ground source grid using the same topographic information that was used in the hydraulic analysis for the development of the flood water surface elevations used to create the FIRM.
3. Computation of the depth values for each Depth Grid cell by subtracting the ground elevation value from the water surface elevation value for each return period computed.
4. Removal of any negative values from the resulting depth grid.
5. Combining depth grids for various river reaches into a single depth grid for the study area (e.g. HUC-8 watershed).

Figure 17 shows a floodplain map translated to a depth grid. Note that depth grids may be rendered or visualized many ways. The most common method is to express the depth grid using a color ramp to represent different depths as shown below.

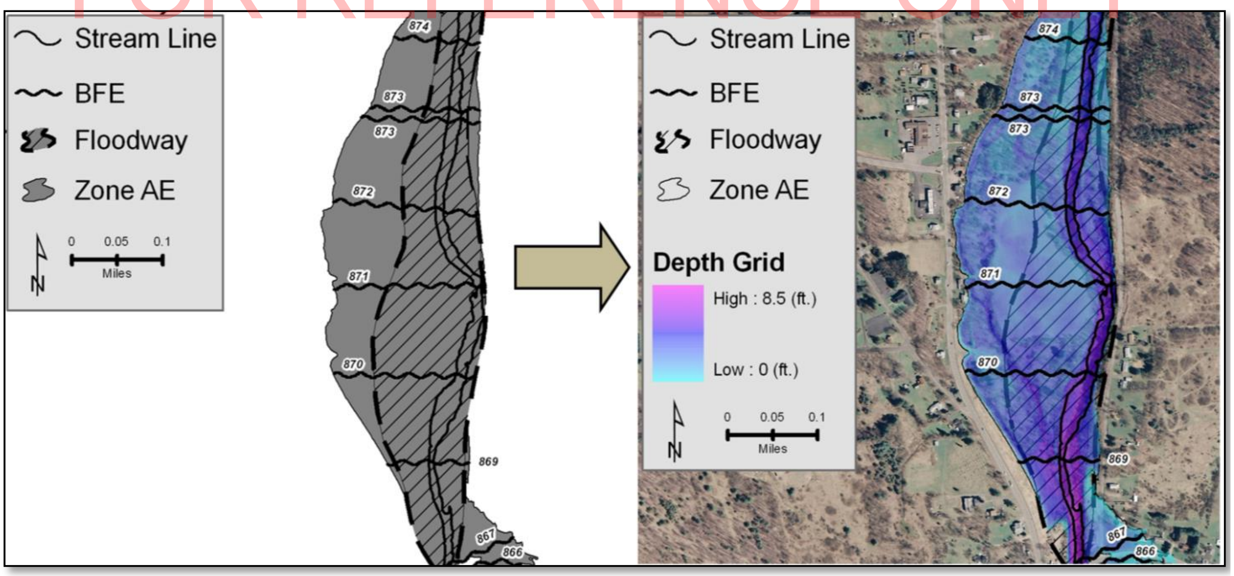


Figure 17: Flood Insurance Rate Map and Associated Depth Grid

N.5.4.2.2 Coastal Depth Grids

The Coastal Depth Grid datasets reside in the Flood Risk Database and will be created using the water surface elevation data from effective, new, and updated coastal models along with the ground source data. Coastal Flood Depth Grids contain values in each grid cell (within the mapped floodplain) representing flood depths for the 1% annual chance flood event only. Unlike riverine depth grids, coastal depth grids are normally limited to the 1% annual chance flood event. Similar to riverine depth grids, the topographic data used for the development of any depth grid should be the same source as used to generate the effective floodplain boundaries to ensure consistent and accurate results. New or revised studies shall only use the same source ground data used to generate the new floodplain boundaries.

N.5.4.2.2.1. Creation of Coastal Depth Grids

Flood depth grids for coastal flood hazards (See Figure 18) are normally created for only the 1% annual chance event using a combination of wave height, wave surge, wave runup, and stillwater elevations (whichever is higher) to create the water surface grid that is needed to create the depth grid. Once the coastal water surface grid has been created (refer to Section N.5.4.1.3), the depth values for each grid cell are calculated by subtracting the ground elevation from the water surface grid. It is important to note that the ground surface for the subtraction of ground surface from water surface in open water areas will not follow the protocol used for depth grids in open water specified in Section N.5.4.2.4, but rather, will use bathymetric data (when available) to the full extent of the flood hazard zone shown on the FIRM.

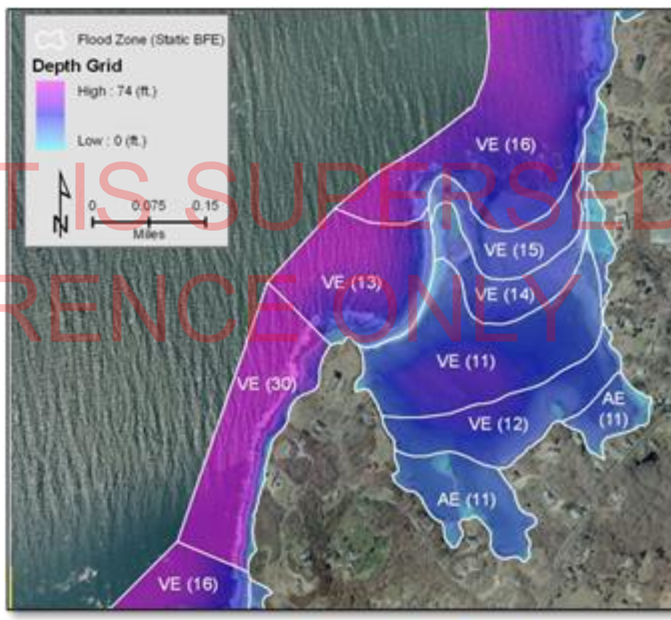


Figure 18: Coastal Depth Grid

N.5.4.2.3 Shallow Flooding and Static Elevation Zone Depth Grids

Due to the nature of shallow flooding and static elevation flood zones, the process for creation of the depth grids differs somewhat from riverine and coastal depth grids based on variable flood elevation data. In addition, for shallow flooding zones, because the depth has already been determined, it may be converted to a grid format as follows:

- Zone AO (sheet flow over sloping terrain): Zone AO is normally calculated to the tenth of a foot, but only reported as a whole foot rounded elevation on the FIRM. The Mapping partner may either use the reported depth on the FIRM, or may determine the tenth foot value that the Zone AO and then develop a depth grid that equals the spatial extent of the Zone AO floodplain shown on the FIRM. Each grid cell with either reflect the whole-foot rounded depth value reported on the FIRM, or the modeled depth to the tenth of a foot, provided that the values, when rounded, would equal the whole foot depth reported on the FIRM.

- Zone AH (ponding) and Static Flood Elevation Zones: Although Zone AH is considered a shallow flooding depth zone with depth ranging between 1 and 3 feet, it is shown on the FIRM as a whole-foot rounded Base Flood Elevation, the same as a static AE flood zone. The following protocol may be followed to create depth grids for these flood zones:
  - Convert the AH zone or static AE zone polygon area to a water surface grid using the reported static 1% annual chance water surface elevation shown on the FIRM, or the actual water surface elevation derived from the model provided that it results (when rounded to the whole foot) in the same flood elevation shown on the FIRM.
  - Create a ground source grid using the same topographic information used to develop the Zone AH water surface elevations.
  - Compute the depth values for each Depth Grid cell by subtracting the ground elevation value from the 1% annual chance water surface elevation value.

N.5.4.2.4 Open Water Depth Grids

The creation of a seamless depth grid across flooding sources will frequently result in the need for depth grid cells comprised entirely of open water. When this occurs, the ground surface within those cells will not be computed from bathymetric data due to the fact that flood depths are intended to represent an increase in water surface elevation from a non-flooding condition.

N.5.4.2.4.1. Creation of Open Water Depth Grids

To create depth grids in areas of open water, a false terrain surface should be created based on the normal pool water surface elevation as opposed to using bathymetric data. This process involves two basic steps as follows:

1. Obtain the normal pool elevation for the open water body. If the normal pool elevation is unavailable, the shoreline elevation may used to determine a "pseudo" normal pool elevation.
2. Calculate the depth values for each Depth Grid cell by subtracting the normal pool (or "pseudo" normal pool) value from the water surface elevation value for the open water body for each return period computed.
   - Note: This protocol does not apply to offshore coastal depth grids. See Section N.5.4.2.2 for more details.

N.5.4.3 Water Surface Elevation Change Grids

Water Surface Elevation Change Grids are the vertical equivalent of the horizontal CSLF dataset, whereby changes to the 1% annual chance recurrence interval water surface elevations from the previous to the new FIRM are created with this dataset. As such, Water Surface Elevation Change Grids are developed to visualize and communicate the water surface elevation changes associated with FIRM revisions.

The Water Surface Elevation Change Grid is a floating point grid in which each cell describes the difference between the effective and revised floodplain water surface elevations where there are coincident effective and revised water surface elevations raster cells. It is important to understand that, unlike the extent of the CSLF dataset, the extent of the water surface elevation change grid should reflect only those areas that were both SFHA before the revision and after the revision as illustrated in Figure 19. Areas that reflect an SFHA increase and those that reflect an SFHA decrease are not included in this dataset.

Because the Water Surface Elevation Change Grid requires two water surface elevation grids for

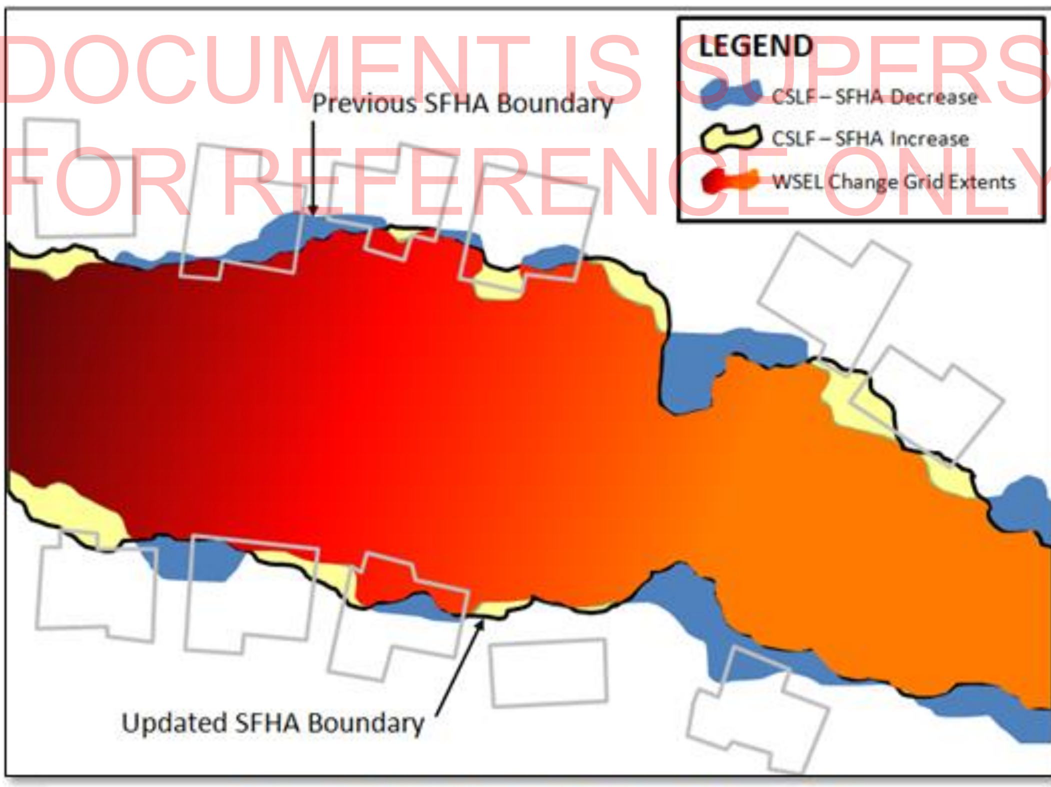


Figure 19: Water Surface Elevation Change Grid

comparison, mapping partners should refer to the guidance in Section N.5.4.1 and its subsections for protocols associated with the creation of the source grids for this dataset.

Figure 20 shows one possible example of how the 1% annual chance Water Surface Elevation Change Grid could be displayed. This grid can be used in conjunction with the CSLF dataset to provide a more integrated picture of both the horizontal and vertical changes that have occurred to the floodplains within the project area since the previous study was completed.

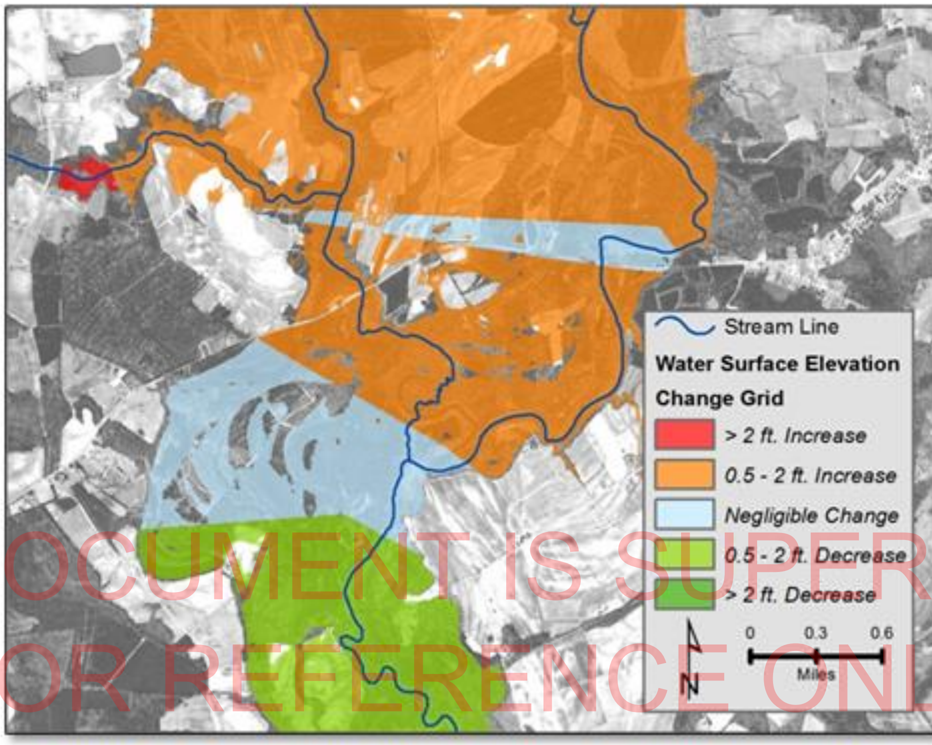


Figure 20: Visualization of Water Surface Elevation Change Grid

N.5.4.3.1 *Creation of the Water Surface Elevation Change Grid*

The creation of a Water Surface Elevation Change Grid is the result of subtracting the water surface grid associated with the effective hydraulic study from the water surface grid created from the revised study. The following are basic steps for creation of this dataset:

1. Using the water surface derived from the existing hydraulic modeling and the water surface derived from the revised hydraulic modeling, perform a subtraction of the two surfaces using the following formula:

   WSEL Change = *Revised WSEL - Effective WSEL*

2. Produce a final grid for inclusion in the delivery of products, making sure that the data extents are limited to the extents of only those areas that are wetted in both the existing and revised studies. Ensuring that such areas are included in the output may include other geospatial operations to limit the results to the wetted areas. For example, when working with grids it is typically possible to supply a separate polygon data layer as a mask to limit the area of analysis.

N.5.4.4 Riverine Velocity Grids

Because high velocity floodwaters may be associated with increased flood risk, riverine velocity grids may provide valuable insight into possible flood risk mitigation opportunities such as avoiding development in these areas or reinforcing channel walls where high velocities are anticipated. Velocity Grids may also be used as a visualization and communication tool to increase public awareness of flood hazard risks in areas identified as subject to high floodwater velocities.

Figure 21: Velocity Grid (1% Annual Chance Event)

The Velocity Grid dataset is comprised of a digital representation of flood velocity distribution created by mapping the velocity output data using FEMA accepted riverine hydraulic models. Any point on the grid describes the average flood velocity for that floodplain location for a given flood frequency. Figure 21 shows an example visualization of a Velocity Grid.

The following general guidance is provided for the creation of Velocity Grids for studies where digital models are available.

- Floodplain conveyance should be subdivided and included in the model output of each cross section. For a 1-D hydraulic model such as HEC-RAS, this can be done by using the flow distribution option.
- There is currently no standard for the capture of flood velocity distribution data, but the scale or number of velocity points or subdivisions to be specified per cross section should be representative of the variation of velocity across the channel and overbank areas.
- It may be necessary to augment user defined cross sections with interpolated cross sections in order to obtain sufficient flood depth velocity data at areas of interest such as known flooding "hot spots," existing flood prone structures, critical facilities, populated areas, etc.
- For older or un-modernized studies where the flow distribution option may not be readily available, the flood velocity at specific locations along a cross section can be approximated using average flow velocities provided in the Floodway Data Tables of FIS reports in conjunction with generalized patterns of velocity distribution for different channel shapes.

N.5.4.4.1 *Creation of Riverine Velocity Grids*

While Mapping Partners may utilize differing hydraulic models, geospatial software or platforms, velocity grids can be developed directly via HEC-GeoRAS (see Figure 22) or 2-D hydraulic modeling software (e.g., FLO-2D).

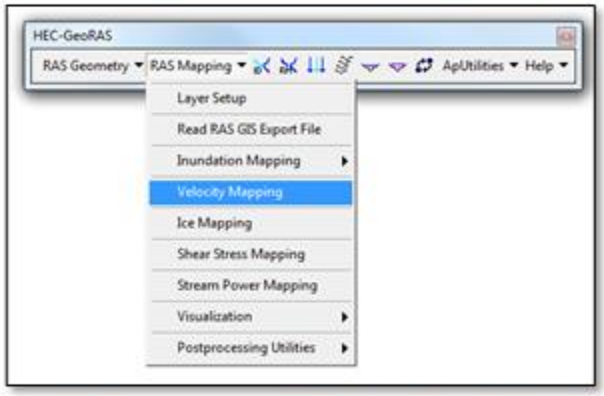


Figure 22: Development of Velocity Grids Using HEC-GeoRAS

N.5.4.5 Coastal Velocity Grids

Coastal velocity grids may be used to identify the portion of coastal floodplains subject to high-velocity wave action from storms or seismic sources (tsunami). These grids may provide valuable insight into possible flood risk mitigation opportunities such as avoiding development in these areas or the need to elevate structures or reinforce existing foundations.

The Coastal Velocity Grid dataset is comprised of a digital representation of flood velocity distribution created by mapping the velocity output data using FEMA accepted coastal hydraulic models.

N.5.4.5.1 *Creation of Coastal Velocity Grids*

Methods to develop the Coastal Velocity Grid include the following:

- Calculation of the water velocity grids from the stillwater depth grid using equations presented in FEMA's *Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas* (CCM). Note that estimation of design flood velocities in coastal flood hazard areas by this methodology is subject to considerable uncertainty as discussed in the CCM. Given this uncertainty, it is recommended that equation #2 from the CCM be used for the upper bound velocities. Similarly, for areas subject to tsunami hazards, Mapping Partners should apply the extreme form of the equation (equation #3) for approximation of water velocity.
    - Equation #2: *Velocity (ft/s) = (32.2× stillwater depth) ^ 0.5*
    - Equation #3: *Extreme Velocity (ft/s)=2[(32.2× stillwater depth) ^ 0.5]*

If a 2-D storm surge modeling is being undertaken for the study area, the water velocity will be included in the output and can be used to develop the velocity grid. This effort would require defining scenarios that produce peak water velocities and would best match with the CCM-based upper bound velocities and tsunami velocities. Figure presents examples of a coastal velocity grid.

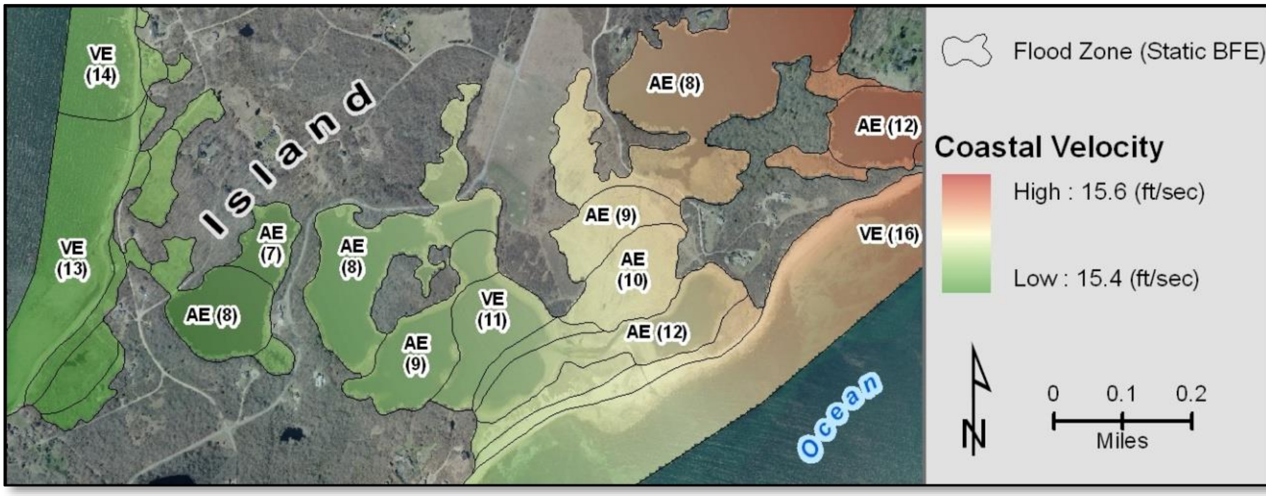


Figure 23: Coastal Velocity Grids

N.5.4.6 Percent Annual Chance Grid

The Percent Annual Chance Grid is an effective communication tool for helping officials and residents understand the varying probabilities associated with flood hazards are discrete locations throughout the special flood hazard area. In lieu of the traditional "in or out" philosophy of floodplain management, this flood risk dataset may provide local stakeholders with a better understanding of the relative probability of being flooded for any given location within the mapped floodplain.

The Percent Annual Chance grid is a dataset that represents the percent annual chance of flooding for locations within the extent of the mapped flooding source. The grid is computed by using the standard (0.2%, 1%, 2%, 4%, and 10%) water surface elevations and their associated percent-annual-chance of exceedance as inputs, and interpolating the percent annual chance at each grid cell based on those inputs coupled with the ground elevation at each specified point.

N.5.4.6.1 Creation of the Percent Annual Chance Grid

The percent-annual-chance flood event associated with inundating the ground elevation at each given location shall be computed by interpolating the log-linear relationship between the associated flood elevations at each point and the ground elevation (linear interpolation of the Water Surface Elevations, log interpolation of the percent annual chance), as shown in Figure 24.

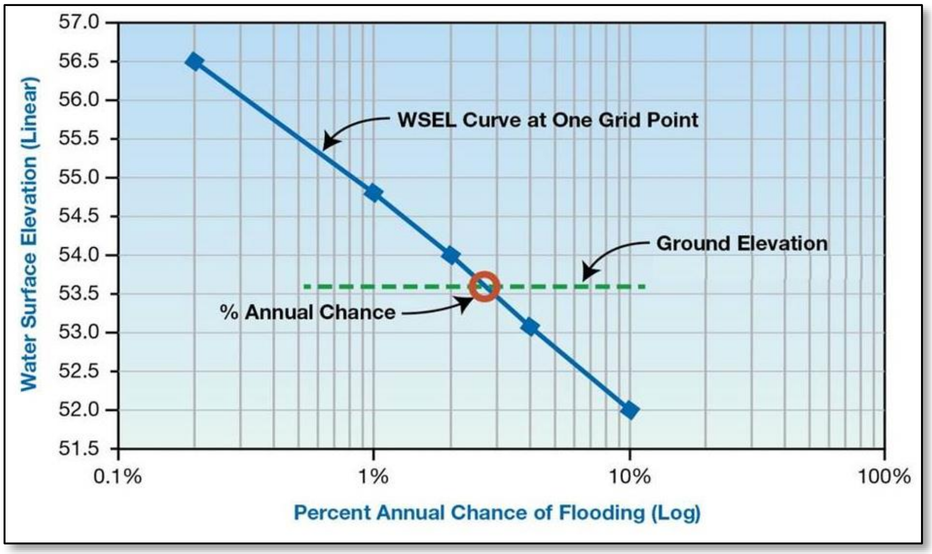


Figure 24: Log-Linear Relationship for Determining Percent Annual Chance Flood Event

As part of this analysis, there will be locations where the above calculations are performed within the 10% annual chance floodplain. These values will mathematically yield a percent annual chance in excess of 10%. Rather than extrapolate values beyond the 10% annual chance, estimates should be capped at 10% and considered as locations with at least a 10% annual chance of flooding.

This raster dataset can be used to show the approximate flooding extents for multiple return period flood events using a single GIS layer. The layer can be rendered using GIS software to show each return period as a banded, transparent color. See Figure 25 for a sample visualization of the Percent Annual Chance Grid.

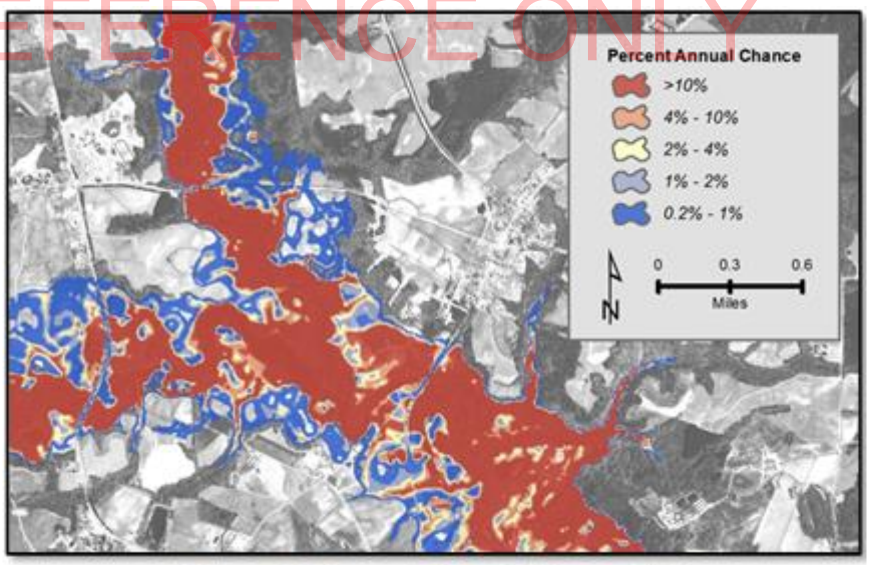


Figure 25: Percent Annual Chance Grid

N.5.4.7 Percent 30-Year Chance Grid

Similar to the Percent Annual Chance Grid, the Percent 30-Year Chance Grid provides a valuable risk communication dataset showing the potential for being flooded in any given location within the mapped floodplain within a specific period of time (30-years) equivalent to the standard home mortgage timeframe. This grid is very useful in dispelling misconceptions that there is little chance of being flooded by the 1% flood event during the life of a mortgage.

The Percent 30-Year Chance Grid represents the percent chance of flooding at least one time during a 30-year period for all locations within the mapped floodplain. Although a 30-year interval was chosen for this dataset, other time periods may also be selected and the likelihood can be computed for other floodplain management and risk assessment/communication applications.

N.5.4.7.1 Creation of the Percent 30-Year Chance Grid

The process for developing the Percent 30-Year Chance Grid is not complex, assuming that the Percent-Annual-Chance Grid has been developed (see Section N.5.4.6). Once the Mapping Partner has the Percent-Annual-Chance Grid developed, the process for developing the Percent 30-year Chance Grid uses the following statistical equation:

- *Probability* $= 1 - (1-p)^n$
  - p = percent annual chance of flooding at each location sampled within the 0.2% annual chance floodplain (values can be derived from the Percent Annual Chance raster layer).
  - n = time period in years (for this example 30 years will be the default).

The grid can be symbolized with user-defined color ramps to communicate areas of higher risk throughout the entire floodplain as shown in Figure 26.

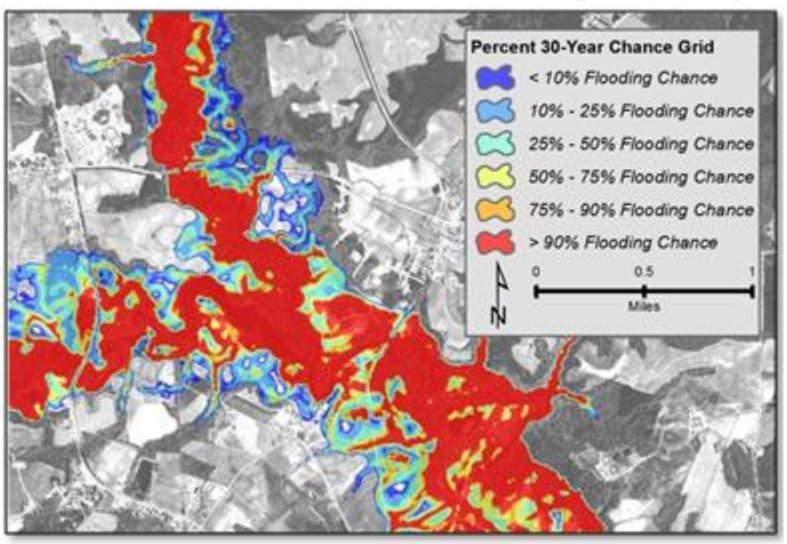


Figure 26: Percent 30-Year Chance Grid

N.5.4.8 1% Plus Flood Elevation Grid

The 1% Plus Flood Elevation Grid dataset is intended to highlight uncertainty within the hydrologic model and the potential underestimations in the resulting mapped floodplain.

The 1% Plus Flood Elevation Grid provides insight into the uncertainties associated with the hydrologic modeling by using the upper confidence limits discharges to compute a higher flood elevation. All flood risk dataset development options associated with water surface grids also apply to the 1% Plus Elevation Grid dataset.

Examples include (but are not limited to):

- Creation of a 1% Plus Water Surface Elevation Grid.
- Creation of a depth grid based on the 1% Plus water surface elevation.
- Creation of a horizontal change dataset (similar to CSLF) to reflect the increase in floodplain extent.
- Creation of a vertical difference dataset to show the difference between the 1% plus and 1% flood elevation.

Figure 27 shows a generic river valley cross section showing the riverine 1% annual flood event with the 1% plus frequency superimposed to demonstrate the vertical and horizontal increases associated with the confidence limits of the hydrologic modeling methods.

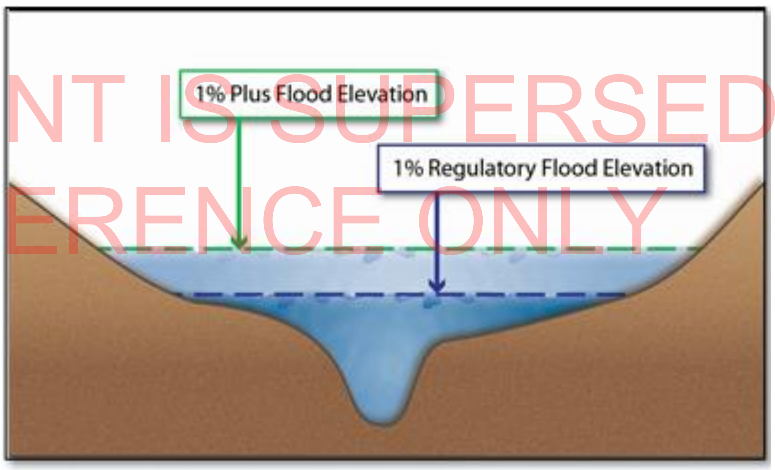


Figure 27: 1% Plus Flood Elevation

N.5.4.8.1 Creation of the 1% Plus Flood Elevation Grid

This dataset will be created by modeling an additional flood profile/event based on the hydrologic methodology scoped for the study area, as defined below.

- Regression Equation: The discharge applied will be calculated by the applicable regression equation for the 1% annual-chance event, plus the standard error of prediction (preferred) or estimate as reported in the regional flood frequency report. For example, if a State or Region's regional regression equations were used to develop the hydrology for a riverine flooding source and the documented average predictive error for the results of the equations is +/- 47% for the 1% annual-chance flood, then the Mapping Partner would develop modeling based on the 1%

annual-chance computed flows + 47%. In other words, if the computed 1% annual-chance discharge based on the above regression equations is 4,800 cubic feet per second (cfs), the "1% Plus" model would include 7,056 cfs (4,800 cfs x 1.47 = 7,056 cfs).

- Gage Estimate: The discharge applied will be based on the upper 84 percent confidence limit calculated for the 1% annual-chance event. This upper limit is equivalent to plus one standard error and is consistent with the upper limit used for regression estimates.
- Rainfall-Runoff Models: The discharge applied will be based on the upper 84-percent confidence limit calculated for the 1% annual-chance event which is consistent with the recommendations for the regression and gage estimates. Since there are multiple parameters in a rainfall-runoff model that, if adjusted within reasonable limits, can affect the calculated discharge, the following approach is recommended:
    - Estimate the 10-, 2-, 1- and 0.2-percent chance discharges (or at least three of these events) using the most reasonable model parameters.
    - Estimate the 50-percent chance discharge using the rainfall-runoff model or probability analysis.
    - Estimate the skew, standard deviation, and mean of the frequency curve using the equations in Appendix 5 of Bulletin 17B ("Guidelines for Determining Flood Flow Frequency").
    - Estimate the upper 84 percent confidence limit for the calculated 1-percent chance discharge using procedures in Appendix 9 of Bulletin 17B. Estimate the equivalent record length for the rainfall-runoff model estimates using guidance given in Table 4-5 of USACE EM 1110-2-1619 on "Risk-Based Analysis for Flood Damage Reduction Studies," dated August 1, 1996.

N.6 Flood Risk Assessment Dataset

The Flood Risk Assessment dataset reflects potential flood loss estimates resulting from an analysis of flood depth within the built environment.

N.6.1 Dataset Definition

The Flood Risk Assessment dataset consists of spatial and lookup tables which represent the geographic extent of flood losses within the Flood Risk Project Area. Many loss estimates may make use of the FEMA Hazus software, which can provide losses aggregated to US Census block areas. Loss estimates include damages to a building (foundation, walls, floors, roof, etc.), contents of the building, and losses associated with disruption to a building's function, such as temporary business relocation during repairs or loss of sales. Because losses are estimated from different flood events, this dataset includes database entries for several percent annual chance events (return period), as well as an average annualized loss estimate for each census block.

N.6.2 General Guidance

Census block spatial data are stored in the FRD in a polygon spatial table. The Flood Risk Assessment dataset provides tables associated with the following:

- Loss estimates from the 2010 Hazus Average Annualized Flood Loss (AAL) Study.
- "Refined" loss analysis for new or updated flood study reaches. Typically these will be based on Hazus analysis using depth grids from the Flood Depth and Analysis Grids dataset.
- A "Composite" table of the AAL and Refined data, which represents the best available flood risk results. This composite data is used on the FRM.

Additional tables that summarize inventory and loss data for communities and the entire flood risk project area, which are used in the FRR.

When the flood risk project includes Hazus results based on User Defined Facilities (UDF), the Flood Risk Assessment dataset will also include a point spatial table and an associated lookup table with individual loss data itemized.

The Flood Risk Assessment dataset will include all census blocks that are entirely or partially within the flood risk project area boundary as defined in the Project Charter. Census blocks will be kept in their entirety for most of the lookup tables. However, tables used to populate the FRR should not include data outside of the project area boundary. See Section N.6.4.4.1 for more information.

To provide an idea of how severe the loss estimates are when compared to existing inventory values, the Flood Risk Assessment dataset will include estimates of total inventory values for building and contents replacement values. These replacement values typically are used by loss estimation models, including Hazus, to derive loss values.

Losses will be estimated for three general categories as follows:

- Building losses are those losses associated with damage to the fixed elements of a structure, such as the foundation, walls, or floors.
- Contents losses are those losses associated with damage to structural elements not permanently fixed within a structure such as furniture, appliances, and personal possessions.
- Business Disruption losses are additional losses not included in the building and contents losses, most commonly associated with businesses. These losses can include the costs of temporary displacement or disruption while flood repairs are being performed. It can also include business losses during the disruption. From Hazus, business disruption costs should include the sum of Inventory Loss, Relocation Cost, Income Loss, Rental Income Loss, Wage Loss, and Direct Output Loss.

In addition to these three categories of loss, the Flood Risk Assessment dataset will also need to provide loss estimates divided into three categories of building use or general occupancy. The three categories of general occupancy to be used for the Flood Risk Assessment dataset are as follows:

- Residential occupancy as defined by Hazus, including single family dwellings, mobile homes, apartment buildings, and dormitories.
- Commercial occupancy as defined by Hazus, including retail and wholesale trade, repair services, banks and hospitals.
- Other occupancy not included in Residential or Commercial occupancy as defined by Hazus. These include Hazus occupancy categories of industrial, agricultural, education, religious, and government structures.

See the latest version of the Hazus *Flood Model Technical Manual* for a complete list of all Hazus occupancy types and which Standard Industrial Codes (SIC) are included in each occupancy category.

N.6.3 Requirements and Standards for Flood Risk Assessment Dataset

All items in this sub-section represent minimum standards for the creation of the Flood Risk Assessment dataset, and are therefore mandatory elements that Mapping Partners shall follow.

- ✓ **The Flood Risk Assessment dataset will include the following tables:**
  - **S_CenBlk_Ar**
  - **L_RA_AAL**
  - **L_RA_Refined**
  - **L_RA_Composite**
  - **L_Exposure**
  - **L_RA_Summary**

- ✓ **When a Hazus-based User Defined Facilities analysis is conducted, the Flood Risk Assessment dataset will include the following additional tables:**
  - **S_UDF_Pt**
  - **L_RA_UDF_Refined**

- ✓ **When the flood risk project updates the Hazus General Building Stock (GBS) data, the Flood Risk Assessment dataset will include the L_Local_GBS table.**

- ✓ **To be consistent with the boundary data that was used to establish the 2010 Hazus Average Annualized Flood Loss (AAL) Study, the "S_CenBlk_Ar" polygon spatial table will be based on the modified version of the 2000 Census Block boundaries from Hazus Major Release (MR) 4.**
  - **Note: All references in this Appendix to "census blocks" and "census block data" refer to this Hazus MR4 version of the 2000 census block data unless otherwise noted.**

- ✓ **The Flood Risk Assessment dataset will include all census blocks that are entirely or partially within the flood risk project area.**
  - **Census blocks will be kept in their entirety (not clipped) in the S_CenBlk_Ar spatial table.**

- ✓ **The L_RA_AAL lookup table will only include loss estimates from the 2010 Hazus Average Annualized Flood Loss (AAL) Study, with results reported at the census block level. Data will be kept in their entirety (not area weighted) for each census block.**

- **The L_RA_Refined lookup table will include any refined loss analysis conducted as part of a flood risk project, with results reported at the census block level. Data will be kept in their entirety (not area weighted) from the source analysis model for each census block.**
  - **Note: "Refined loss analysis" is defined in this Appendix as any flood loss analysis, including Hazus-based and non-Hazus based analysis that are supplemental to the AAL Study.**
- **The L_RA_Composite lookup table will combine, at the census block level, AAL Study and any Refined loss analysis into a Composite table representing the best available flood risk results. Data will be kept in their entirety (not area weighted) for each census block.**
- **The L_Exposure and L_RA_Summary lookup tables will include inventory and loss data summarized at a flood risk project area basis and at a community basis.**
  - **Data in the L_Exposure and L_RA_Summary lookup tables will be based on area-weighted calculations, where the S_CenBlk_Ar census blocks are clipped to community and flood risk project area boundaries with inventory and loss results area-weighted to the resulting partial census blocks.**
  - **The summarized data will be used in the Flood Risk Report for tables related to the Flood Risk Assessment dataset.**
- **The 1% annual chance event (100-yr) total loss from the L_RA_Composite lookup table will be used on the Flood Risk Map.**
- **When a Hazus-based UDF analysis is conducted, the S_UDF_Pt spatial table will include point locations from the analysis.**
- **The L_RA_UDF_Refined lookup table will include loss analysis data associated with each UDF point from a Hazus-based UDF analysis. The L_RA_UDF_Refined table will need to be summarized to a census block basis to assist development of the L_RA_Refined lookup table.**
- **The following table summarizes the inventory and loss estimates divided into different occupancy and loss requirements for the L_RA_AAL, L_RA_Refined, L_RA_Composite, L_Exposure, and L_RA_Summary tables:**

	Residential Occupancy	Commercial Occupancy	Other Occupancy
Building	Inventory, Loss	Inventory, Loss	Inventory, Loss
Contents	Inventory, Loss	Inventory, Loss	Inventory, Loss
Business Disruption	Loss	Loss	Loss

✓ **The following table summarizes the minimum percent annual chance event requirements for the L_RA_AAL, L_RA_Refined, L_RA_Composite, L_RA_Summary tables:**

	L_RA_AAL	L_RA_Refined	L_RA_Composite	L_RA_Summary
10% annual chance (10-yr)	Yes	Yes	Yes	Yes
4% annual chance (25-yr)	No	Yes	No	No
2% annual chance (50-yr)	Yes	Yes	Yes	Yes
1% annual chance (100-yr)	Yes	Yes	Yes	Yes
0.5% annual chance (200-yr)	Yes	No	No	No
0.2% annual chance (500-yr)	Yes	Yes	Yes	Yes
Annualized	Yes	Yes	Yes	Yes

N.6.4 Best Practices for Flood Risk Assessment Dataset Creation

This section includes best practices for creation of the Flood Risk Assessment dataset; alternate approaches that comply with program standards that effectively and efficiently support program objectives are also acceptable.

N.6.4.1 Hazus AAL Study Results

In 2010, FEMA conducted a Level 1 Hazus MR4 flood analysis to estimate average annualized losses (AAL). This AAL study examined riverine and coastal flood hazards in the 48 contiguous states (including the District of Columbia) by county. Hawaii, Alaska, and Puerto Rico, and US territories were not analyzed as part of this study. Alaska was not analyzed because of the lack of adequate topographic data required by Hazus. Puerto Rico and Hawaii were not analyzed because the regression equations needed for analysis were not available. The AAL study estimated flood losses for the following storm events:

- 10% annual chance (10-year)
- 2% annual chance (50-year)

- 1% annual chance (100-year)
- 0.5% annual chance (200-year)
- 0.2% annual chance (500-year)

These multiple storm loss values were used to develop the annualized loss estimate. More details on this study can be obtained from the Hazus Program in FEMA; refer to the FEMA website for the current Hazus Program contact information.

The data from the AAL Study to be used for the Flood Risk Assessment dataset can also be obtained from the FEMA Hazus Program. The AAL data will be provided in a tabular format at the census block level, following the Flood Risk Database standards as defined in Appendix O of the FEMA *G&S*. Table 10 provides a listing of AAL data available by census block for Building Value (inventory) Data (one set of values per census block) and Building Loss Data (six sets of values corresponding to the 10%, 2%, 1%, 0.5%, and 0.2% frequency flood events, as well as annualized losses).

Table 10: Generic AAL Hazus Data

Building Value Data	Building Loss Data **
• Census block ID • Total building value for all structure types • Total contents value for all structure types • Total building value for residential structure types • Total contents value for residential structure types • Total building value for commercial structure types • Total contents value for commercial structure types • Total building value for other structure types * • Total contents value for other structure types *	• Total losses • Total building losses • Total contents losses • Total building losses for residential structures • Total contents losses for residential structures • Total building losses for commercial structures • Total contents losses for commercial structures • Total building losses for other structure types * • Total contents losses for other structure types * • Business Disruption Costs ***

* Other structure types include Hazus general occupancy categories industrial, agricultural, education, religious, and government structures.

** Building Loss Data is provided for the 10%, 2%, 1%, 0.5% and 0.2% frequency flood events, as well as annualized losses

*** Business Disruption Costs are the sum of Inventory Loss, Relocation Cost, Income Loss, Rental Income Loss, Wage Loss, and Direct Output Loss.

N.6.4.2 Refined Loss Analysis

A refined loss analysis includes any flood loss analysis, including Hazus-based and non-Hazus based analysis, which are supplemental to the AAL Study. The purpose of the refined loss analysis is to supplement the AAL results to deliver a refined analysis based on updated hydrologic, hydraulic, and/or coastal data for flooding sources. Typically, a flood risk project that produces new depth grids will use those depth grids to conduct a refined loss analysis using a loss analysis tool like Hazus. The outputs are data that are used to populate the FRD fields in the L_RA_Refined table.

In additional to conducting analysis with new or updated depth grids, a refined Hazus analysis may also include the following:

- Direct use of the FIRM floodplain boundaries and flood elevations.
- Use of locally-supplied general building stock and/or population data (to update the default census data that comes pre-packaged with Hazus).
- Terrain data with a higher resolution than 30 meter USGS Digital Elevation Model (DEM) data.
- Performing site-specific and structure-specific flood loss assessments rather than calculating losses at a census-block level.

N.6.4.2.1 Hazus-based Refined Loss Analysis Using Depth Grids

The most common type of refined flood loss analysis assumes that depth grids have been developed for new and updated reaches (which includes riverine, levee, and coastal analysis). The 4-step refined Hazus flood loss analysis process is as follows:

N.6.4.2.1.1. Step 1 - Import of User-defined Depth grids

Hazus allows the user to import User-Defined flood depth grids. These User-Defined depth grids replace the depth grids that Hazus derives from Hazus-based hydrology and hydraulics (H&H) methods. A detailed description of how to import User-Defined depth grids is provided in the latest version of the Hazus *Flood Model User Manual*.

Refined Flood Risk Assessment dataset creation will require the following depth grids:

- 10% annual chance (10-year)
- 4% annual chance (25-year)
- 2% annual chance (50-year)
- 1% annual chance (100-year)
- 0.2% annual chance (500-year)

Note that this list differs from the AAL Study list by including the 4% annual chance (25-year) event, but not including the 0.5% annual chance (200-yr) event. Refined Flood Risk Assessment datasets may also include additional flood frequency events as established in the scope of study during the Discovery process.

N.6.4.2.1.2. Step 2 - Loss Calculation

Once each of the depth grids have been imported, the user will need to conduct single event Hazus runs for each of the percent annual chance events. The annualized loss option within some Hazus versions, such as MR4, will not be used, because it includes the 0.5% annual chance event, but not the 4% annual chance event. Other versions, such as MR5, do not include annualized loss calculations. Refer to Section N.6.4.2.2 for how to calculate annualized losses outside of Hazus. A detailed description of how to run the Hazus loss calculation for individual depth grids is provided in the latest version of the Hazus *Flood Model User Manual*.

Hazus Analysis Options (see Figure 28) should only include "General Building Stock Damage and Loss", specifically "Building and Content Damage" and "Direct Economic Loss". Enhanced analysis may also include other Hazus loss options, as also shown in Figure 28, which shows a screenshot from Hazus release MR4.

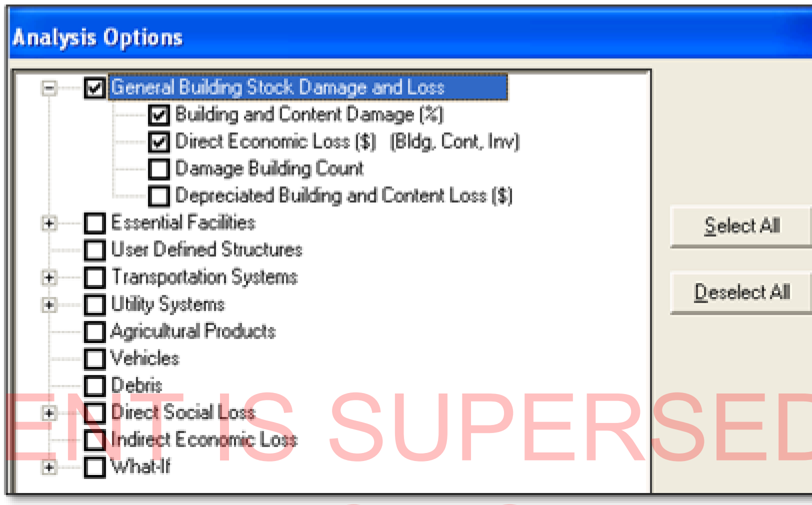


Figure 28: Hazus Analysis Options

N.6.4.2.1.3. Step 3 - Export of Loss Results

After all the loss calculations have been completed, certain Hazus tables will need to be exported to be used to populate the refined Hazus data fields in the L_RA_Refined table in the Flood Risk Database. Table 11 summarizes the tables that need to be exported for the refined Hazus data fields.

Table 11: Hazus Tables to be Exported for Refined Analysis

Menu	Item	Sub-item	Tab	Table Type Selections	Basis
Inventory	General Building Stock	Dollar Exposure (Replacement Value)	By Occupancy	Table Type: General Occupancy Exposure Type: Building	By Hazus Study Area
Inventory	General Building Stock	Dollar Exposure (Replacement Value)	By Occupancy	Table Type: General Occupancy Exposure Type: Contents	By Hazus Study Area
Results	General Building Stock	By Full Replacement	Total	Pre/Post FIRM: Total	By Percent Chance Event (typically 5

Table 11: Hazus Tables to be Exported for Refined Analysis

Menu	Item	Sub-item	Tab	Table Type Selections	Basis
	Economic Loss				percent-annual chance events)
Results	General Building Stock Economic Loss	By Full Replacement	By General Occupancy	Occupancy: Residential Pre/Post FIRM: Total	By Percent Chance Event (typically 5 percent-annual chance events)
Results	General Building Stock Economic Loss	By Full Replacement	By General Occupancy	Occupancy: Commercial Pre/Post FIRM: Total	By Percent Chance Event (typically 5 percent-annual chance events)

N.6.4.2.1.4. Step 4 - Derivation of Flood Risk Database Fields

Table 12 provides a generic list of the data related to a refined Hazus analysis. For the Building Loss Data column, these data are to be calculated for the 10%, 4%, 2%, 1%, 0.2% and for annualized losses. Appendix O of the FEMA *G&S* provides the complete list of fields.

Table 12: Generic Refined Hazus Data

Building Value Data	Building Loss Data **
• Total building value for all structure types • Total contents value for all structure types • Total building value for residential structure types • Total contents value for residential structure types • Total building value for commercial structure types • Total contents value for commercial structure types • Total building value for other structure types * • Total contents value for other structure types *	• Total losses • Total building losses • Total contents losses • Total building losses for residential structures • Total contents losses for residential structures • Total building losses for commercial structures • Total contents losses for commercial structures • Total building losses for other structure types * • Total contents losses for other structure types * • Business disruption costs ***

* Other structure types include Hazus general occupancy categories industrial, agricultural, education, religious, and government structures.

** Building Loss Data is provided for the 10%, 4% 2%, 1%, and 0.2% frequency flood events, as well as annualized losses

*** Business Disruption Costs are the sum of Inventory Loss, Relocation Cost, Income Loss, Rental Income Loss, Wage Loss, and Direct Output Loss.

Table 13 provides more detail on derivation of certain Refined Hazus data fields.

Table 13: Calculation of Certain Refined Hazus Data Fields

Data Field	Derivations
Total building value for all structure types	Hazus Inventory: GBS Dollar Exposure (Building Exposure Type, Total Exposure Field)
Total contents value for all structure types	Hazus Inventory: GBS Dollar Exposure (Contents Exposure Type, Total Exposure Field)
Total building value for residential structure types	Hazus Inventory: GBS Dollar Exposure (Building Exposure Type, Residential Field)
Total contents value for residential structure types	Hazus Inventory: GBS Dollar Exposure (Contents Exposure Type, Residential Field)
Total building value for commercial structure types	Hazus Inventory: GBS Dollar Exposure (Building Exposure Type, Commercial Field)
Total contents value for commercial structure types	Hazus Inventory: GBS Dollar Exposure (Contents Exposure Type, Commercial Field)
Total building value for other structure types	Hazus Inventory: GBS Dollar Exposure (Building Exposure Type, Total Exposure minus Residential and Commercial Fields)
Total contents value for other structure types	Hazus Inventory: GBS Dollar Exposure (Contents Exposure Type, Total Exposure minus Residential and Commercial Fields)
Total losses	Hazus Results: GBS Economic Loss Full Replacement: Total (Total Loss Field)
Total building losses	Hazus Results: GBS Economic Loss Full Replacement: Total (Building Loss Field)
Total contents losses	Hazus Results: GBS Economic Loss Full Replacement: Total (Contents Loss Field)
Total building losses for residential structures	Hazus Results: GBS Economic Loss Full Replacement: Residential (Building Loss Field)
Total contents losses for residential structures	Hazus Results: GBS Economic Loss Full Replacement: Residential (Content Loss Field)
Total building losses for commercial structures	Hazus Results: GBS Economic Loss Full Replacement: Commercial (Building Loss Field)
Total contents losses for commercial structures	Hazus Results: GBS Economic Loss Full Replacement: Commercial (Contents Loss Field)
Total building losses for other structures	Total building losses minus building losses for residential structures and building losses for commercial structures
Total contents losses for other structures	Total contents losses minus contents losses for residential structures and contents losses for commercial structures
Business disruption costs	Total losses minus Total buildings losses and Total contents losses

N.6.4.2.2 *Annualized Loss Calculations*

Until Hazus is modified to allow annualized calculations from scenarios based on user-defined depth grids, users will need to calculate annualized losses outside of the Hazus software. An annualized loss formula that can be used (based on the standard 5 annual chance events is as follows), where Loss X% = the loss value for that specific percent annual chance event (e.g., "Loss 10%" equals the loss value associated with the 10% annual chance flood event):

<u>Annualized Loss</u> = (10% – 4%) *(Loss 10% + Loss 4%) / 2 +
(4% – 2%) * (Loss 4% + Loss 2%) / 2 +
(2% – 1%) * (Loss 2% + Loss 1%) / 2 +
(1% – 0.2%) * (Loss 1% +Loss 0.2%) / 2 +
0.2% * Loss 0.2%

This formula would be used individually for every loss calculation, such as residential structure losses or commercial contents losses.

For example, assume a census block has the following loss values:

- 10% annual chance event = $0
- 4% annual chance event = $0
- 2% annual chance event = $2,000
- 1% annual chance event = $30,000
- 0.2% annual chance event = $80,000

The formula for this would therefore be as follows:

<u>Annualized Loss</u> = (10% – 4%) * (0 +0) / 2 +
(4% – 2%) * (0 + 2000) / 2 +
(2% – 1%) * (2000 + 30000) / 2 +
(1% – 0.2%) * (30000 + 80000) / 2 +
0.2% * 80000

This, therefore, results in the following calculation:

<u>Annualized Loss</u> = 0 + 20 + 160 + 440 + 160 = $780/yr

If more than the standard 5 annual chance events are modeled, the equation can be expanded where the first line includes the two most frequent events and the last two lines use the two least frequent events.

N.6.4.2.3 Other Hazus-Based Refined Loss Analysis Options

For some studies, an enhanced loss analyses may be conducted. These enhancements relate to the use of more detailed data than is available within Hazus to conduct the loss analysis and associated options such as the use of supplemental elevation and depth grid data; performing a building-specific “User Defined Facility” analysis; and updates to the General Building Stock data that comes pre-packaged with Hazus as described in Sections N.6.4.2.3.1 through N.6.4.2.3.3. More details on the specifics for each type of enhanced analysis can be found in latest version of the Hazus *Flood Model User Manual*.

N.6.4.2.3.1. Supplemental Elevation and Depth Grid Data

If elevation data or depth grids already exists that could improve the quality of Hazus analysis and loss estimation, it may be leveraged for the refined loss analysis. This can include grids developed from previous flood modeling, past local Hazus analyses, and use of new or enhanced terrain data. Actual use of this data for Refined Hazus will need to be decided on a study-by-study basis. In general, depth grids based on riverine and/or coastal modeling superior to that performed as a Hazus level 1 analysis with 30-meter DEMs should be used when available. Details describing the process of using supplemental depth grids in Hazus may be found in the latest version of the Hazus *Flood Model User Manual*. If supplemental depth grids are not available, then using more detailed terrain data (over the 30 meter DEM data used for AAL Study) may be appropriate.

N.6.4.2.3.2. User-Defined Facilities (UDFs)

Hazus does not include any default UDF data, but includes capability for a user to import data to analyze specific structures. When the flood risk project includes Hazus results based on UDF, the Flood Risk Assessment dataset will need to include the following:

- “S_UDF_Pt”: Point locations for UDF stored as a point spatial table.
- “L_RA_UDF_Refined”: Loss analysis data associated with each UDF point store as a lookup table.

While the Flood Risk Database has this separate table for the refined UDF loss results, these UDF results will still need to be summarized to a census block basis to be used to produce the L_RA_Refined lookup table. More details on the UDF analysis can be found in latest version of the Hazus *Flood Model User Manual*.

N.6.4.2.3.3. Supplemental Local Inventory Data

When the flood risk project updates the Hazus General Building Stock (GBS) data, the Flood Risk Assessment dataset will include the L_Local_GBS table. Hazus allows the update of GBS data using the Comprehensive Data Management System (CDMS) tool. With the CDMS tool, users can update and manage datasets by streamlining and automating raw data processing, converting external data sources into Hazus-compliant data, and transferring data into and out of the statewide datasets. Additional information about updating the GBS data and for updating facilities and infrastructure data can also be found in the latest version of the Hazus *Flood Model User Manual*.

N.6.4.2.4 Non-Hazus Refined Risk Assessment

Communities may have risk assessments conducted outside of Hazus for hazard mitigation plans such as site-specific exposure analysis or loss calculation. The results of these assessments would be considered enhanced data and would need to be addressed on a case-by-case basis for inclusion in the Flood Risk Products. If a community proposes to use a non-Hazus assessment in place of Hazus, then the assessment will need to produce defendable results to populate all required refined risk assessment fields in the Flood Risk Database.

N.6.4.3 Composite Flood Risk Assessment Analysis

The composite flood risk assessment is developed by combining the AAL data and the refined analysis data into a joint dataset. In most cases, the refined results will take precedence over the AAL results, but there may be circumstances where the AAL results will be used. For a given census block, the composite dataset should represent either the refined or AAL results for all data fields and percent annual chance events. Important to note is that the standard composite dataset will not include either the 4% annual chance (25-yr) or the 0.5% annual chance (200-yr) events. The standard composite dataset will include the 10%, 2%, 1%, and 0.2% annual chance events.

N.6.4.3.1 When refined analysis takes precedence over AAL

- *Refined results where no previous AAL results exist*

  This includes the circumstances where the AAL Study did not model losses, which could include stream reaches of less than 10 square mile and problem or failed reaches (where hydrology or hydraulics failed during the AAL study). This also includes where the refined losses for a census block for any event had a non-zero loss value, but the AAL results were zero, for events that were modeled by both AAL and refined analysis.

- *Refined depth grids based on higher quality modeling than AAL Study*

  Where both refined and AAL results have loss values for certain return periods for a census block, the refined results should be used when the depth grids and background flood studies used models superior to the simplified methods used in the AAL Study. For most cases, any new or revised studies that can develop depth grids will likely be based on higher quality methods. Also, if a census block includes multiple reaches in AAL, but the refined results only included a portion of reaches, then the AAL results may be appropriate (see Section N.6.4.3.2 for more detail).

N.6.4.3.2 *When AAL takes precedence over refined analysis*

Because AAL results will usually be more geographically extensive than refined analysis results, the AAL results will be used for census blocks that are not covered by any of the depth grids created as companion data for a new or revised flood study. AAL results will also take precedence when the AAL analysis represents more stream reaches than the refined results. Because this may vary based on the percent annual chance event, a worst-case scenario may be used where the total 0.2% annual chance (500-year) losses are compared. Whichever loss value is greater (AAL or refined) should be used as the composite value for that census block. This choice of results (AAL or refined) would also be applied to all the other percent annual chance losses for that census block.

N.6.4.3.3 *Special Considerations*

For most census blocks, the composite dataset will be based on comparing the AAL results and refined analysis results from within the project area (watershed, coastal, etc.). However, for census blocks along the boundary of the flood risk project area, there may be circumstances where loss results from a neighboring flood risk project area may be more appropriate. This will especially be the case for the census blocks at the outlet of a watershed or when the outlet is along a coastal hazard. The guidelines listed in the previous paragraphs should be applied to these situations, where one compares all total 0.2% annual chance (500-year) loss values in the census block and uses the greatest of all values for the composite dataset.

Also, special consideration may be needed when census blocks contain depth grids representing multiple scenarios, such as levees or coastal depth grids derived from a variety of models (wave runup, wave height, surge, and stillwater). In these cases, the composite should use the refined Hazus results that represent the scenario used for the regulatory products.

In addition, if the refined analysis did not include all standard percent annual chance events, then the composite should only represent those percent annual chances where development of the composite is possible. This will usually pertain to coastal studies, but may be applicable to riverine and levee studies with data limitations.

N.6.4.3.4 *Composite Data Fields*

The composite data fields represent the combination of the AAL and refined analysis results into one common set of fields. Based on census block by census block decisions, either the AAL data or the refined analysis data will be copied into the composite data table for each census block / return period / hazard type combination as shown in Table 14 below. This list is nearly identical to the refined analysis fields except that this will include only the four common percent annual chance events (10%, 2%, 1%, and 0.2%) and annualized losses. Appendix O of the FEMA *G&S* provides a complete list of fields that are in the FRD related to the composite data.

Table 14: Generic Composite Data

Building Value Data	Building Loss Data **
• Total building value for all structure types • Total contents value for all structure types • Total building value for residential structures • Total contents value for residential structures • Total building value for commercial structures • Total contents value for commercial structures • Total building value for other structure types * • Total contents value for other structure types *	• Source of the results (AAL study, Refined, etc.) • Total losses • Total building losses • Total contents losses • Total building losses for residential structures • Total contents losses for residential structures • Total building losses for commercial structures • Total contents losses for commercial structures • Total building losses for other structures types * • Total contents losses for other structures types * • Business disruption costs ***

* Other structure types include Hazus general occupancy categories industrial, agricultural, education, religious, and government structures.

** Building Loss Data is provided for the 10%, 2%, 1%, and 0.2% frequency flood events, as well as annualized losses

*** Business Disruption Costs are the sum of Inventory Loss, Relocation Cost, Income Loss, Rental Income Loss, Wage Loss, and Direct Output Loss.

N.6.4.4 Flood Risk Assessment Data for the Flood Risk Report

Additional analysis is required to take the composite data to develop the L_Exposure and L_RA_Summary tables with community-based and the study-based (typically watershed-based) summary tables for the FRR (see Table 15 below). Appendix O of the FEMA *G&S* provides the complete list of FRD fields related to the FRR.

Table 15: Generic Flood Risk Assessment Data Fields for the FRR

Building Value Data	Building Loss Data **
• Total building and contents value for all structure types • Total building and contents value for residential structures • Percent of total residential building and contents value • Total building and contents value for commercial structures • Percent of total commercial building and contents value • Total building and contents value for other structures * • Percent of total other building and contents value *	• Total losses for all structure types • Total building and contents losses for all structure types • Percent Damage for total building and contents losses • Total building and contents losses for residential structures • Percent Damage for building and contents losses for residential structures • Total building and contents losses for commercial structures • Percent Damage for building and contents losses for commercial structures • Total building and contents losses for other structures types ** • Percent Damage for building and contents losses for other structures types ** • Business disruption costs ***

* Other structure types include Hazus general occupancy categories industrial, agricultural, education, religious, and government structures.

** Building Loss Data is provided for the 10%, 2%, 1%, and 0.2% frequency flood events, as well as annualized losses

*** Business Disruption Costs are the sum of Inventory Loss, Relocation Cost, Income Loss, Rental Income Loss, Wage Loss, and Direct Output Loss.

Table 16 provides more detail on derivation of certain flood risk assessment fields for the Flood Risk Report.

Table 16: Calculation of Certain Flood Risk Assessment Data Fields for the FRR

Data Field	Derivations
Total losses	Area weighted sum of total losses for census blocks within area of analysis (community or study)
Total building and contents losses	Area weighted sum of total building losses plus total contents losses for census blocks within area of analysis (community or study)
Percent Damage for total building and contents losses	Area weighted sum of total building losses plus contents losses for census blocks within area of analysis (community or study) divided by Area weighted sum of total building losses plus contents values for census blocks within area of analysis (community or study)
Building and contents losses for residential structures	Area weighted sum of building losses plus contents losses for residential structures for census blocks within area of analysis (community or study)

Table 16: Calculation of Certain Flood Risk Assessment Data Fields for the FRR

Data Field	Derivations
Percent Damage for building and contents losses for residential structures	Area weighted sum of residential building losses plus contents losses for census blocks within area of analysis (community or study) divided by Area weighted sum of residential building losses plus contents values for census blocks within area of analysis (community or study)
Building and contents losses for commercial structures	Area weighted sum of building losses plus contents losses for commercial structures for census blocks within area of analysis (community or study)
Percent Damage for building and contents losses for commercial structures	Area weighted sum of commercial building losses plus contents losses for census blocks within area of analysis (community or study) divided by Area weighted sum of commercial building losses plus contents values for census blocks within area of analysis (community or study)
Building and contents losses for other structures	Area weighted sum of building losses plus contents losses for other structures for census blocks within area of analysis (community or study)
Percent Damage for building and contents losses for other structures	Area weighted sum of other building losses plus contents losses for census blocks within area of analysis (community or study) divided by Area weighted sum of other building losses plus contents values for census blocks within area of analysis (community or study)
Business disruption costs	Area weighted sum of Business disruption costs for census blocks within area of analysis (community or study)

N.6.4.4.1 Area Weighting Loss Values

In order to derive appropriate certain loss values within a community or within the project area as a whole, the loss values for a census block will need to be area weighted when they bisect a community and/or the project area. This is accomplished by intersecting census block boundaries with community and/or project area boundaries to derive the percent of the census block that is associated with the subject community and/or project area. This percent area is then multiplied by the values represented by the census block (such as total asset loss) to derive the values that apply to the subject community and/or project area.

N.7 Areas of Mitigation Interest

The Areas of Mitigation Interest (AoMI) dataset is intended to communicate areas and issues associated with flood risk reduction opportunities and/or success stories. This dataset allows local stakeholders to provide information about local mitigation successes and gain a more holistic picture of flood risk related issues that may impact them, as well as allowing them to take a more systematic approach to addressing their community's overall flood risk.

N.7.1 Dataset Definition

The AoMI dataset is comprised of attributed point features stored in the FRD to represent items that warrant flood risk mitigation attention. Similar to the Contributing Engineering Factors associated with the CSLF dataset, the AoMI dataset identifies factors that may be contributing (positively or negatively) to flood risks within a project area.

N.7.2 General Guidance

Unlike the other flood risk datasets, information for the AoMI dataset is largely procured through the Discovery data mining process (through interactions with multiple stakeholders up until, during, and after the Discovery Meeting) and then validated, processed and enhanced in post-Discovery activities. Refer to Sections N.7.4.1 through N.7.4.3 for more details on the process of developing the AoMI dataset and refer to Appendix I of the FEMA _G&S_ for more details on the data that should be procured for its use.

While most of the AoMI data will be included in the Flood Risk Database and symbolized on the Flood Risk Map, there will also be (space permitting), call-outs shown on the Flood Risk Map with photographs and descriptions of the most significant AoMIs (shown in the red dashed circles superimposed on an image of a Flood Risk Map in Figure 29).

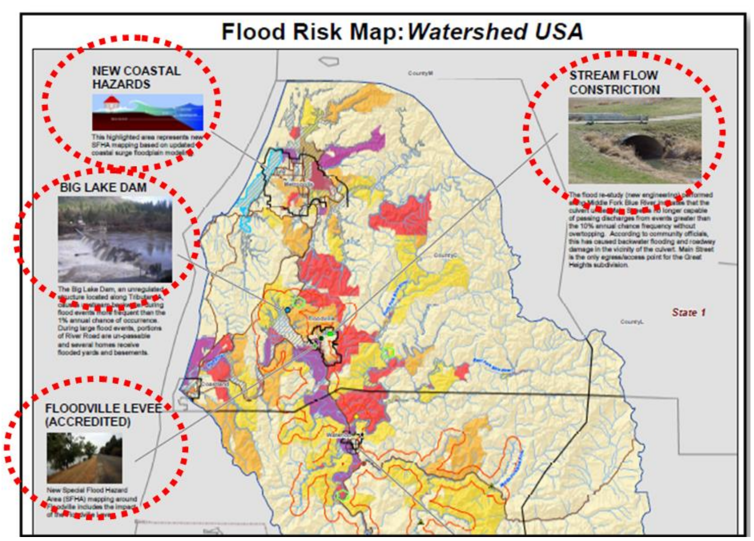


Figure 29: FRM Showing AoMI Callouts

N.7.3 Requirements and Standards for the AoMI Dataset

All items in this sub-section represent minimum standards for the creation of the AoMI dataset, and are therefore mandatory elements that Mapping Partners shall follow.

- ✓ **AoMI elements are always represented by points and include the following features:**
  - **Dams**
  - **Levee and non-levee embankments**
  - **Areas where stream flow is constricted**
  - **Coastal structures**
  - **Key emergency routes overtopped during frequent flood events**
  - **At risk critical facilities**
  - **Past flood insurance claims hot spots**
  - **IA and PA claims**
  - **Areas of significant land use change (recent past and proposed)**
  - **Areas of significant coastal or riverine erosion**
  - **Areas of mitigation success**
  - **Other miscellaneous flood risk or hazard mitigation related items**

- ✓ **An AoMI point feature class will be created per the guidelines in Appendix O of the FEMA *G&S*.**

- ✓ **Sensitive data (e.g., data covered by the Privacy Act of 1974, Public Law No. 93-579 such as Individual Assistance claims) will be presented as a point (or clusters of points) at the centroid of the census block in which the data resides.**

- ✓ **Each point will have associated attributes in tabular format in the Flood Risk Report and Flood Risk Database, per the requirements in Appendix O of the FEMA *G&S*.**

N.7.4 Best Practices for AoMI Data Mining and Dataset Creation

This section includes best practices for creation of the CSLF dataset; alternate approaches that comply with program standards that effectively and efficiently support program objectives are also acceptable. Table 17 provides an overview of the AoMI dataset elements including potential data sources, collection points in the project lifecycle, data evaluation and qualifying criteria, and data processing and enhancements. It is important to note that there may be other data included in the AoMI dataset on a case by case basis provided they meet appropriate qualifying criteria for inclusion.

Table 17: Areas of Mitigation Interest

Item	Description	Potential Data Source(s)
Dams	An impoundment structure demonstrated to increase flood elevations upstream.	• Discovery Data Mining and Discovery Meeting • National Inventory of Dams (USACE)
✓ Collection Points in the Project Lifecycle: Before the Discovery Meeting for verification at Discovery meeting. Data may continue to be collected through the lifecycle, but it is anticipated that most Dam data will have been procured shortly after the Discovery meeting.	✓ Data Evaluation and Qualifying Criteria: All dams identified during Discovery will be included; field validation will normally not be required.	✓ Data Processing and Enhancement: Data will be captured as points for inclusion in the FRD and for display on the FRM. The AOMI_INFO field should indicate if an Emergency Action Plan (EAP) exists or not and when it was created (e.g., "EAP created 02/13/2008" or "No known EAP").
Non-Accredited Levees	A levee that does not meet 44CFR Part 65.10 criteria and/or has recently had its provisionally accredited status expire without evidence that it meets the 65.10 accreditation criteria.	• Discovery Data Mining and Discovery Meeting • National levee database (USACE) • FEMA Levee Inventories • Other agency inventories
✓ Collection Points in the Project Lifecycle: Before the Discovery Meeting for verification at Discovery meeting	✓ Data Evaluation and Qualifying Criteria: All levees will be included	✓ Data Processing and Enhancement: Existing inventory data will be captured as point features in S_AOMI_Pt in the FRD and displayed on the FRM. The AOMI_INFO field should indicate if an EAP exists or not and when it was created (e.g., "EAP created 02/13/2008" or "No known EAP"). If displaying the accredited levee on the FRM as a linear feature better communicates the location of the levee, a feature will be added to S_Carto_Ln representing the levee location.

Table 17: Areas of Mitigation Interest

Item	Description	Potential Data Source(s)
Accredited Levees	A levee that does meet the criteria specified in 44CFR Part 65.10 and/or a levee that is provisionally accredited	• Discovery Data Mining and Discovery Meeting • National levee database (USACE) • FEMA Levee Inventories • Other agency inventories
✓ Collection Points in the Project Lifecycle: Before the Discovery Meeting for verification at Discovery meeting	✓ Data Evaluation and Qualifying Criteria: All levees will be included	✓ Data Processing and Enhancement: Existing inventory data will be captured as point features in S_AOMI_Pt and displayed on the FRM. The AOMI_INFO field should indicate if an EAP exists or not and when it was created (e.g., "EAP created 02/13/2008" or "No known EAP"). If displaying the accredited levee on the FRM as a linear feature better communicates the location of the levee, a feature will be added to S_Carto_Ln representing the levee location.
At Risk Essential Facilities	Essential facilities, sometimes called "critical facilities," are those whose impairment during a flood could cause significant problems to individuals or communities, such as a flooded community wastewater treatment facility or hospital.	• Discovery Data Mining and Discovery Meeting (community provided) • State Databases/Inventories • Hazus
✓ Collection Points in the Project Lifecycle: Before the Discovery Meeting, when available from local or state sources, for verification at the Discovery Meeting. In the absence of any inventory, at the Discovery Meeting.	✓ Data Evaluation and Qualifying Criteria: Work with community officials at the Discovery Meeting to ensure that the structures meet the definition and that the inventory used is complete and current.	✓ Data Processing and Enhancement: Existing locations will be captured as points in S_AOMI_Pt and displayed on the FRM. The AOMI_INFO field should be populated with pertinent information such as "St Joseph Hospital is subject to flooding during frequent flooding events. This hospital serves as a critical trauma unit."

Table 17: Areas of Mitigation Interest

Item	Description	Potential Data Source(s)
Coastal Structures • Jetties • Groins • Sea walls • Other coastal structures	Coastal structures that "harden" the shoreline, interrupt the natural dynamic shoreline processes, and accelerate coastal erosion.	• Discovery Data Mining and Discovery Meeting • Community input on structures known to cause erosion problems or those not providing intended protection. • NOAA National Shoreline Survey • State Coastal Zone Management Programs' Beach Management Plans
✓ Collection Points in the Project Lifecycle: Before the Discovery Meeting, when available from Coastal Zone Management Programs, for verification at Discovery Meeting.	✓ Data Evaluation and Qualifying Criteria: All structures will be included.	✓ Data Processing and Enhancement: Existing inventory data will be captured as points in S_AOMI_Pt and displayed on the FRM. The AOMI_INFO field should be populated with pertinent information such as "Sea wall under-sized based on updated analysis." If displaying the coastal structure on the FRM as a linear feature better communicates the location of the structure, a feature will be added to S_Carto_Ln representing the structure.
Stream Flow Constrictions • Undersized culverts or bridge openings	Hydraulic structures intended to carry flood discharges that are too small to function effectively and that cause increased flood elevations within the vicinity and in upstream areas.	• Discovery Data Mining, Discovery Meeting, and H&H Engineering Analysis • State/Local Hazard Mitigation Plans. • State Stormwater Management Programs (per EPA 310 Program). • Engineering models • Local drainage reports

Table 17: Areas of Mitigation Interest

Item	Description	Potential Data Source(s)
✓ Collection Points in the Project Lifecycle: Data can be collected prior to the Discovery phase from existing models and verified at Discovery with community officials. Further evaluation and technical validation will occur in cases where new modeling is conducted in areas where stream flow pinch points are identified.	✓ Data Evaluation and Qualifying Criteria: Work with community after engineering to determine what criteria are most appropriate to qualify the area for inclusion in the AoMI dataset.	✓ Data Processing and Enhancements: Data will be selectively collected as points in S_AOMI_Pt and displayed on the FRM (as room allows). The AOMI_INFO field in S_AOMI_Pt should indicate the most frequent event at which the structure is overtopped (e.g., “Road overtopped at 5% event”).
Key emergency routes overtopped during frequent flooding events.	Key emergency routes that the hydraulic analysis indicate are overtopped during the 4% flood frequency or more frequent event plus those that are noted by community officials as being frequently overtopped will be identified	• Discovery Data Mining and Discovery Meeting • Flood Profiles • Hydraulic models
✓ Collection Points in the Project Lifecycle: Data collected at Discovery meeting from community and during engineering.	✓ Data Evaluation and Qualifying Criteria: Limited to routes identified as key emergency routes at Discovery and verified by modeling or existing profiles as overtopped by the 4% flood frequency or more frequent event	✓ Data Processing and Enhancements: Data will be collected as points in S_AOMI_Pt and displayed on the FRM. The AOMI_INFO field should indicate the most frequent event at which the structure is overtopped (e.g., “Overtopped at 5% event” or “Local Public Works Dept indicates the road is frequently overtopped”).

Table 17: Areas of Mitigation Interest

Item	Description	Potential Data Source(s)
Past Claims Hot Spot	Indicators of repeated flood-related insurance claims within a focused geographic area. This shall be included as generalized point data (not claim-specific)	• FEMA NEXTGEN database • NFIP State Coordinator
✓ Collection Points in the Project Lifecycle: Data to be collected and presented during Discovery, both prior to and at the Discovery Meeting.	✓ Data Evaluation and Qualifying Criteria: Areas with 5 or more RL or SRL properties in close proximity, sufficient to indicate that the area has a higher frequency of damage than other areas in the community. Evidence of claims or damages should be apparent from more than one event.	✓ Data Processing and Enhancements: Data will be collected as a point location in S_AOMI_Pt at the centroid of the census block in which they reside and displayed on the FRM. The AOMI_INFO field should indicate the number of structures, number of claims, RL vs. SRL, when the claims occurred, aggregate claims amounts represented by that point (e.g. "From 2004~2010, 42 Claims affecting 44 structures, totaling $8.2 million, of which 6 were RL and 1 was SRL").
Individual Assistance (IA) & Public Assistance (PA) Data	Indicators of past flood flood-related damage where IA/PA funds were used. This shall be included as generalized point data.	• Existing FEMA data source (contact the FEMA Region or State to gain access to the data)
✓ Collection Points in the Project Lifecycle: Data to be collected and presented during Discovery, both prior to and at the Discovery Meeting.	✓ Data Evaluation and Qualifying Criteria: Areas with 5 or more PA or IA claims in close proximity, sufficient to indicate that the area has a higher frequency of damage than other areas in the community. Evidence of claims or damages should be apparent from more than one event. Note: data included will be limited to that available digitally.	✓ Data Processing and Enhancements: Data will be collected as a point location in S_AOMI_Pt at the centroid of the census block in which they reside and displayed on the FRM. The AOMI_INFO field should indicate number and types of claims, claims dates, and aggregate claims amount (e.g., "From 2000 -2009, 23 IA claims totaling $1.2 million and 2 PA claims totaling $15.2 million.").

Table 17: Areas of Mitigation Interest

Item	Description	Potential Data Source(s)
Significant Land Use Changes (within the past 5 years and looking forward 5 years) • Proposed and recent development (verified with the community)	Development normally decreases the ability of a watershed to absorb flood waters which results in potentially significant increases in flood water runoff (and velocity) and damages to the downstream built environment	• Discovery Data Mining and Discovery Meeting • Community Comprehensive Plans • State Growth Management Plans • Real Estate Trends • National Urban Change Indicator (NUCI) dataset
✓ Collection Points in the Project Lifecycle: Data collected prior to or at Discovery meeting from the sources noted above.	✓ Data Evaluation and Qualifying Criteria: Limited to areas where plans or community officials indicate growth in past 5 years or anticipated in the next 5 years. Data will not identify specific projects or developments.	✓ Data Processing and Enhancements: Data will be collected as a point location in S_AOMI_Pt and displayed on the FRM. The AOMI_INFO field shall give a brief description of the land use change (e.g., "400 homes constructed in the last 2 2008~2009, with 200 additional homes anticipated in the next 4 in 2010~2013" or "300 acres of agricultural land has been recently converted to a commercial park in 2009"). If displaying the areas of land use change on the FRM as a polygonal feature better communicates the location of the land use change area, a feature will be added to S_Carto_Ar representing the area of land use change.
Areas of significant riverine or coastal erosion	Self-explanatory	• Discovery Data Mining and Discovery Meeting • SHMO • County and Stormwater Engineer • Director of Planning

Table 17: Areas of Mitigation Interest

Item	Description	Potential Data Source(s)
✓ Collection Points in the Project Lifecycle: Data collected prior to or at Discovery meeting	✓ Data Evaluation and Qualifying Criteria: Limited to areas identified by the communities where erosion poses a threat to the built environment	✓ Data Processing and Enhancements: Data will be collected as a point location in S_AOMI_Pt and displayed on the FRM. Information about the erosion area should be listed in the AOMI_INFO field (e.g., "Long Term Erosion Hazard Area"). If displaying the areas of significant erosion on the FRM as a linear or polygonal feature better communicates the location of the area of significant riverine or coastal erosion, a feature will be added to S_Carto_Ln or S_Carto_Ar representing the erosion area.
Non-Levee Embankments	Structures not designed for flood control, but which have an impact on flooding, such as railroad embankments and roadways.	• Discovery Data Mining and Discovery Meeting • Hydraulic Models
✓ Collection Points in the Project v Lifecycle: Data collected at Discovery meeting and during engineering analysis	✓ Data Evaluation and Qualifying Criteria: Structure must be visible in terrain data or identified from modeling in re-study areas with engineering judgment applied to community claims of flooding or protection level	✓ Data Processing and Enhancements: Data will be collected as a point location in S_AOMI_Pt and displayed on the FRM. If displaying the non-levee embankment on the FRM as a linear feature better communicates the location of the non-levee embankment, a feature will be added to S_Carto_Ln representing the embankment.
Other Flood Risk Areas	Flooding areas not identified as SFHAs are likely not regulated or even considered in local land use planning decisions. These could include drainage or stormwater-based flood hazard areas, or areas known to be inundated during storm events.	• Discovery Data Mining and Discovery Meeting • Local Hazard Mitigation Plans • Local planning or public works departments • Floodplain managers

Table 17: Areas of Mitigation Interest

Item	Description	Potential Data Source(s)
✓ Collection Points in the Project Lifecycle: Data collected prior to and at Discovery meeting	✓ Data Evaluation and Qualifying Criteria: Community provided data	✓ Data Processing and Enhancements Data will be collected as a point location in S_AOMI_Pt and displayed on the FRM The AOMI_INFO field should indicate the nature of the flood risk (e.g., "Area experiences surcharging from Combined Sewer Overflows during the 10% and less frequent events"). If displaying the flood risk area on the FRM as a polygonal feature better communicates the risk associated with the area, a feature will be added to S_Carto_Ar representing the flood risk area.
Areas of Mitigation Success	Any flood mitigation strategies, tactics, and/or projects that have been demonstrated to reduce losses associated with flooding events	• Discovery Data Mining and Discovery Meeting • SHMOLocal Emergency Management • Public Works
✓ Data Collection Points in the Project Lifecycle: At any point during or after the Discovery meeting	✓ Data Evaluation and Qualifying Criteria: All successfully completed projects will be included	✓ Data Processing and Enhancements: Data will be compiled as point data in S_AOMI_Pt and attributed with a brief description of the project and the project owner in the AOMI_INFO field (e.g. "42 homes purchased by the City of Chicago with FEMA HMGP grant in 2003").
Other	Other types of mitigation actions or opportunities that are not captured under one of the previously defined categories.	• Discovery Data Mining and Discovery Meeting • SHMO • Local Emergency Management • Public Works

Table 17: Areas of Mitigation Interest

Item	Description	Potential Data Source(s)
✓ Data Collection Points in the Project Lifecycle: At any point during or after the Discovery meeting	✓ Data Evaluation and Qualifying Criteria: Community provided information	✓ Data Processing and Enhancements: Data will be compiled as point data in S_AOMI_Pt and attributed with a brief description of the action or opportunity. If losses were avoided in a post-project flooding event they should be described and quantified to the extent reliable data is available (e.g., "project constructed in 2008 for $800k; more than 2 million in damages avoided in 2010 flooding").

AoMI data will be stored and represented as point features (as opposed to line and area features). Sensitive data (e.g., data covered by the Privacy Act of 1974, Public Law No. 93-579) will be presented as a point at the centroid of the census block in which the data resides. Each point will have associated attributes in tabular format in the Flood Risk Report and Flood Risk Database.

Because the AoMI dataset is different from other flood risk data in terms of the lifecycle of development, a flow diagram showing the interrelationships of data development through the lifecycle is shown as Figure 30. Full details on the process are provided below in Sections N.7.4.1 through N.7.4.3.

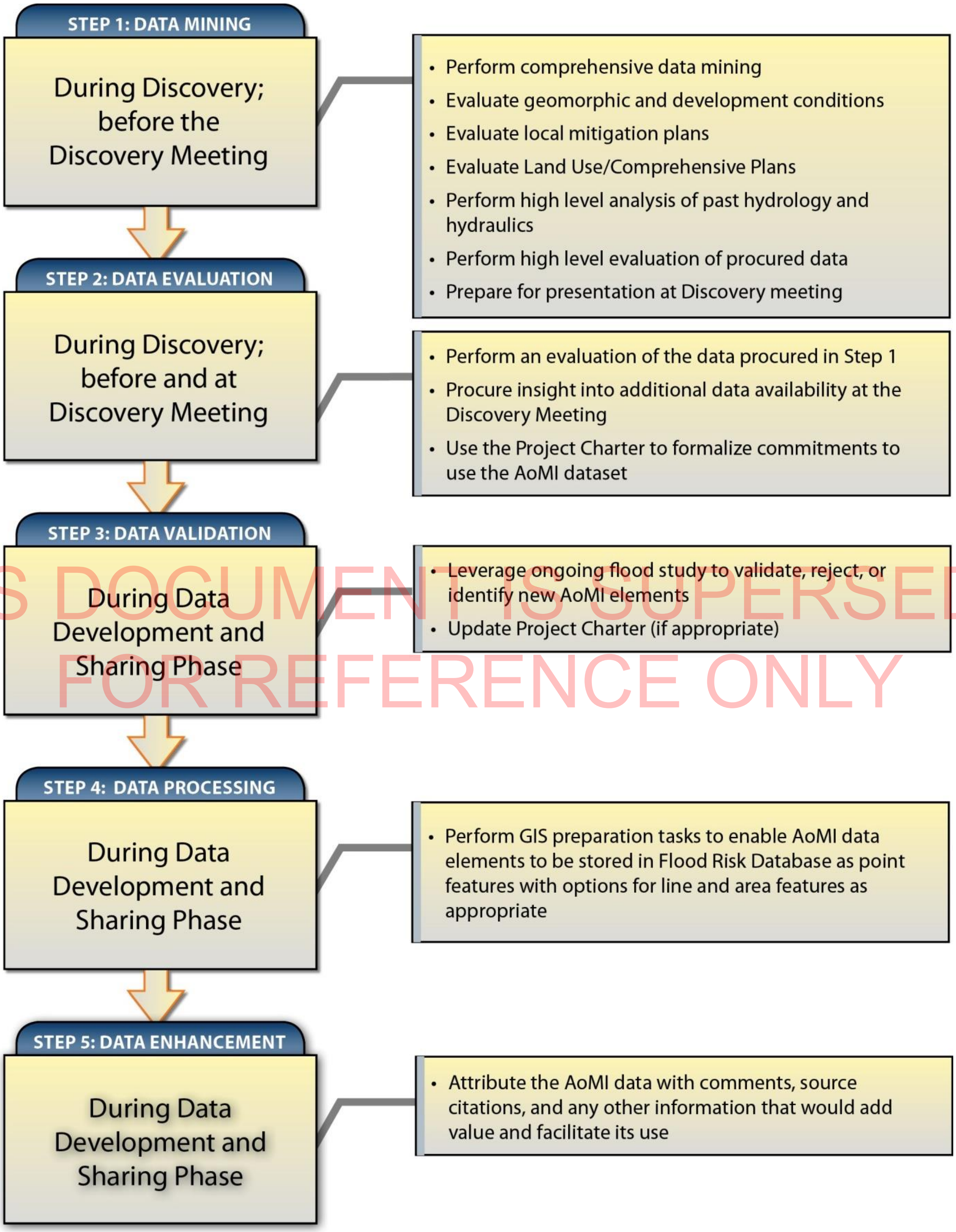


Figure 30: AoMI Data Creation Lifecycle

FEMA will apply minimum technical and validation criteria for data procured before it becomes integrated into the Flood Risk Database, shown on the Flood Risk Map, and provided in tabular format in the Flood Risk Report. The process of collecting, evaluating, validating, processing and enhancing the AoMI dataset are described below.

N.7.4.1 Data Collection

Before the AoMI dataset may be created, a significant amount of data collection must occur throughout the project lifecycle. The Areas of Mitigation Interest dataset originates from three primary sources as follows:

- Community or state supplied data from mitigation and floodplain management plans, discovery and other meetings, and surveys
- Federal government data (e.g., flood claims, disaster assistance claims, data from other federal agencies like USGS, USACE, NOAA, etc.)
- Engineering data from the revised H&H and/or coastal analyses, other studies or previous flood studies

Since the AoMI dataset requires a significant amount of data collection and coordination but relies on other local, State and Federal sources, FEMA and its Mapping Partners will implement an outreach process to familiarize the stakeholders with the type and format of data sought. For all flood risk projects, FEMA and its Mapping Partners should also contact other government agencies and stakeholders with specialty expertise (e.g., the NOAA Coastal Services Center, US Army Corp of Engineers, etc.) to include them in the outreach and to find out if they have data in the communities under study.

The following subsections provide more details on the types of data and process to obtain it for each one of the primary sources.

N.7.4.1.1 Community, State and other Local Data

State and local officials experienced at responding to, regulating, and addressing the impacts of flood hazards have the best knowledge of their jurisdiction’s flooding problems. Often this information is captured in Local Multi-Hazard Mitigation Plans, stand-alone Floodplain Management Plans or a community’s comprehensive plan. Prior to initiating contact with the communities in the project area, FEMA’s Mapping Partner will review the plans for potential Areas of Mitigation Interest to discuss with community officials and other stakeholders. As described above, FEMA will implement a process to introduce this new subject to local officials to build a productive working relationship to gain buy-in from the communities’ during the development of their Areas of Mitigation Interest section and to determine which areas of mitigation interest to mine data for, focusing on those areas that are of interest to the affected communities. The following information will be requested from each community using the AoMI questionnaire, and during the Web and Discovery meetings:

- Locations of successful mitigation projects
- Areas of significant erosion (both riverine and coastal)
- Coastal structures of interest
- Significant recent or proposed development (or land use changes)
- High risk essential facilities
- Community stormwater or drainage flooding “hot spots” – could be within the SFHA or outside the SFHA where drainage issues are contributing to flooding and could include any of the engineering factors listed in the previous section

The outreach and data collection process will be initiated once the study begins. Due to the wide range of detail, format, and quality of data that will be submitted to FEMA, a minimum test of relevance, or application of qualifying criteria will be applied when deciding to include the area of interest. In some cases, the data submitted, like constriction to flow, may be anecdotal or captured through mitigation plans or through collection of local agency reports, newspaper articles, and photographs. As stated above, the entry into the Flood Risk Database is flexible to account for the range of information that may be provided. The Flood Risk Report should indicate that ownership of the data is associated with the source and that scientific validation has not been conducted.

During Discovery, (both prior to and during the Discovery Meeting) it is anticipated that the following types of data will be collected, as outlined in Appendix I of the FEMA *G&S*:

- Base map: Boundaries, Hydrography, Transportation
- Flood study needs, risk, elevation data
- Flooding issues, historical flooding, disasters
- Mitigation activities, CRS, CAVs, grant projects, mitigation plans
- Local development, floodplain management plans
- Regional watershed plans
- Infrastructure: culverts, dams, bridges, levees
- Building footprints or parcel data

N.7.4.1.2 Federal Government Data

FEMA and other federal agencies responding to flood events have data that reflects damages to buildings and infrastructure, and other expenditures resulting from the floods. This data is useful in establishing a pattern of flooding based on actual events that sometimes may occur outside of SFHAs; it can help FEMA, flood management officials, and planners understand the frequency and magnitude of flood events in the areas where data is available. It can also help focus flood mitigation efforts. This data will primarily be obtained from the appropriate agency or FEMA Division. In addition, information on successful mitigation projects will be included as a way of showing the public, neighboring communities in the project area or study area, and other stakeholders examples that may work as solutions to some of their problems. Much of this information is Privacy Act protected and a process will be established to ensure that all Privacy Act criteria are consistently followed in the collection, storage, transfer, and display of this information. For example, a cluster of repetitively flooded properties may be on a city block level to protect the identity of individual property owners. The following are the types of information sought:

- Locations of successful mitigation projects
- Clusters of Repetitive Loss / Severe Repetitive Loss (RL/SRL) properties
- Clusters of Public Assistance (PA) Project Worksheets for past floods
- Clusters of Individual Assistance (IA) grants for past floods
- Clusters of Small Business Administration (SBA) Loans from Past Floods
- Other post-disaster data including High Water Marks, post-disaster debris lines, Advisory Base Flood Elevation data, and coastal inundation maps.
- Cluster of flood prone areas where damage and losses are significant but may not be enough within the whole community to warrant an IA or PA declaration.

A “cluster” will be defined as a number of claims, damage reports, or assistance locations sufficient to indicate that the area has a higher frequency of damage than other areas in the community. Evidence of claims or damages should be apparent from more than one event. For RL and SRL claims, five or more from at least two events is considered sufficient. For IA/PA sites, five or more from at least two different events is considered sufficient

Although FEMA is the primary data source for this type of information, internal outreach, and a set process will need to be established for increases in multiple users requesting access to the data. Standard and well-defined limitations on the use, presentation, distribution, and storage of the data will be provided for consistency among FEMA Regions and Mapping Partners. Overall, the purpose of repackaging and providing the Areas of Mitigation Interest dataset to communities on the Flood Risk Map and in the Flood Risk Report is not to verify that the factors are impacting flood conditions, but rather to help direct the attention of planners to areas warranting further investigation. Again, by providing the Areas of Mitigation Interest dataset on a project extent basis, needed attention should be drawn to the necessity of coordinating with upstream/downstream neighbors in planning to reduce losses.

N.7.4.1.3 *Engineering Data from H&H and Coastal Flood Studies*

This data will primarily be obtained during the FIRM production process (H&H modeling) and will include the following:

- Significant stream flow constriction locations (e.g., undersized bridges and culverts) that create backwater conditions impacting the built environment or major evacuation and response transportation routes
- Major roads overtopped by higher frequency flooding events
- Major embankments
- Dams, Levees, and coastal structures that contribute to flooding conditions.

The FIRM production team will be briefed at the beginning of the study on the types of information needed for the AoMI dataset, much of which will have already been collected during Discovery but will still require validation during the ongoing flood risk project.

N.7.4.2 AoMI Data Evaluation and Validation

Discretion shall be applied regarding which Areas of Mitigation Interest to include in the FRD and FRR for any given project based on dialogue with the communities before, during and after the discovery meeting. It is FEMA's intention to include data that is endorsed by the communities with some level of commitment to use the data, to be identified in the project charter, which will be developed at the discovery meeting. After initial data collection, which will occur primarily before and at the discovery meeting, and before data development or value added work commences, FEMA/Mapping Partner will need to evaluate the collected data.

N.7.4.2.1 *AoMI Data Evaluation*

All data procured will be evaluated for potential use in the AoMI dataset. This evaluation will include the condition, age, veracity and integrity of the data received to determine approximate level of effort for its preparation to be used as an AoMI element.

After the initial evaluation of the data, the Mapping Partner will communicate with the communities in the project area, FEMA Regional representatives and representatives from the State Hazard Mitigation Officer and State and Local Floodplain Managers offices to:

- Discuss findings of the evaluation of the data and include recommendations on items to include in the dataset
- Gain consensus from the community on data that will be useable to them for planning and project development

Concurrent with this evaluation stage will be a data selection process that must be satisfied before data elements are included in the AoMI dataset. The following evaluations will be made:

- Compatibility for use within the FRD
- Completeness
- Currency
- Source and integrity

If the AoMI data procured during Discovery meets these criteria, they will move into the AoMI data validation step.

N.7.4.2.2 AoMI Data Validation

Although some of the AoMI elements are subjective, many are based on objective engineering data that should be validated during the course of the flood risk project. An example would be where a culvert was anecdotally cited by local stakeholders as being of insufficient capacity to efficiently carry the 1% annual chance flood discharge. During the flood risk project, it is expected that assumptions of this nature will be validated with engineering data to validate anecdotal citations and thereby ensure integrity in the final dataset.

For those AoMI elements that are not impacted by the flood risk project (such as significant changes in land use), engineering judgment shall be applied in the decision process to add these features to the AoMI dataset. See Table 17 for additional guidance in terms of qualifying criteria for inclusion of AoMI elements in this dataset.

N.7.4.3 AoMI Data Processing and Enhancement

The major focus of AoMI is to take existing data compiled from a variety of sources (outlined above) and add value so that it is easily retrievable, easy to use and more widely available for outreach, awareness, planning and loss reduction activities. It is not the intention of this dataset to simply repackage existing data, unless value can be added. Processing of the data is significantly different than all of the other datasets, since raw data will be available from multiple sources with varying levels of completeness, formats, and quality.

N.7.4.3.1 AoMI Data Processing

The FRD will house the AoMI elements point data and attributes, which will subsequently be used to populate the tables in the FRR and for display on the FRM. For data that has privacy sensitivities (e.g. insurance claims data, PA and IA data) points will represent clusters (as defined in Section N.7.4.1.2) and will be placed at the centroid of the census block containing the element.

The format for the entry in the FRR and on the FRM will be primarily narrative to allow latitude in expressing the information available. At a minimum, the entry will indicate that there is a potential flood risk contributing factor that warrants additional attention by planners.

N.7.4.3.2 AoMI Data Enhancement

The AoMI features that will be displayed on the FRM and in the FRR will be accompanied by attribute tables, stored in the FRD and presented in the report. The attributes will add value to the items selected for inclusion in the dataset. For several of the AoMI the attributes fields (particularly AOMI_SRCE, AOMI_INFO and NOTES) are be free-form text, to allow for comments and contact information and to accommodate the varying level of detail that will be available for attributing the fields. Table 17 in Section N.7.4 provides examples of attributes that will be included. Appendix O of the FEMA *G&S* provides the complete list of fields that are in the FRD related to AoMI.