Flood Risk Reduction Technical Review

This job aid supplement covers the requirements associated with the technical reviews for flood risk reduction projects funded by Hazard Mitigation Assistance. FEMA will also conduct an Environmental Planning and Historic Preservation review of each project. Refer to the Flood Risk Reduction: Information Required for Environmental Review Job Aid.

This Technical Review Supplement provides additional information, examples, and potential sources of documentation for items listed in the job aid to help communities applying for Hazard Mitigation Assistance grants to comply with application requirements.

- All Hazard Mitigation Assistance (HMA) applications must comply with the requirements outlined in the HMA Guidance.
- According to the guidance, in addition to a general programmatic review, an EHP review and a technical review will be performed by FEMA for each proposed project.
- The technical review will verify that a project demonstrates feasibility, effectiveness, and cost-effectiveness. This document is intended for technical reviews of applications only.
- For assistance completing EHP compliance reviews, see the EHP Supplement Job Aids.

Introduction

The following provides a review of the information that should be provided with the grant application, including recommended documentation and a list of supplementary information, to assist FEMA when conducting technical reviews of the project application. Technical resources are identified throughout this supplement to provide clarifying information on specific project application components. The final section provides a comprehensive list of resources identified throughout this supplement.

In addition to these documents, local drainage and stormwater requirements will need to be followed when designing the project and all applicable codes and standards should be given in an accompanying engineering report.

It is recommended that the grant applicant consult a professional engineer to assist in preparing the application, as many of the documentation requirements are technical in nature. An engineer will be required for design and implementation. For complex flood risk reduction projects, applicants may want to consider Advanced Assistance or a phased project approach. Initial funds may be obtained to produce detailed designs of the project (Phase 1 or Advanced Assistance) for further FEMA review and approval prior to construction (Phase 2). Refer to HMA Guidance, Part VIII, A.12 and A.13 for additional guidance.

The project-specific guidance in this supplement does not provide all the information necessary to apply for funding through an HMA program and must be read in conjunction with all other relevant guidance documents.

Additional Resources

- Hazard Mitigation Assistance Guidance (HMA Guidance)
- Hazard Mitigation Assistance Guidance Addendum, Part F
- Benefit-Cost Analysis Reference Guide and Supplement to the Benefit-Cost Analysis Reference Guide
- Hazard Mitigation Assistance Application Development – Drainage/Stormwater Management
- Sample Engineering Case Study for Minor Structural Flood Control

A list of all resources referenced is provided on the last page of the supplement.

Summary of Steps

- ☐ STEP 1: Provide a Scope of Work
- ☐ STEP 2: Provide Available Technical Data
- ☐ STEP 3: Provide a Project Schedule
- ☐ STEP 4: Provide a Project Cost Estimate
- ☐ STEP 5: Provide a Project Site Map and Location Information
- ☐ STEP 6: Provide Site Photographs
- ☐ STEP 7: Document the Before-Mitigation Flood Risk
- ☐ STEP 8: Document the Post-Project Flood Risk
- ☐ STEP 9: Cost-Effectiveness Analysis
- ☐ STEP 10: Environmental and Historic Preservation Considerations

Important Terms

Base Flood Elevation (BFE): The elevation shown on the Flood Insurance Rate Map (FIRM) for Zones AE, AH, A1-A30, AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO, V1-V30 and VE that indicates the water surface elevation resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year.

Flood Insurance Rate Map (FIRM): The official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community.

Flood Insurance Study (FIS): A compilation and presentation of flood risk data for specific watercourses, lakes and coastal flood hazard areas within a community. When a flood study is completed for the National Flood Insurance Program (NFIP), the information and maps are assembled into an FIS. The FIS report contains detailed flood elevation data in flood profiles and data tables.

Floodway: A "Regulatory Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. Communities must regulate development in these floodways to ensure that there are no increases in upstream flood elevations. For streams and other watercourses where FEMA has provided BFEs, but no floodway has been designated, the community must review floodplain

development on a case-by-case basis to ensure that increases in water surface elevations do not occur or identify the need to adopt a floodway if adequate information is available.

Localized Flood Risk Reduction Projects: Projects to lessen the frequency or severity of flooding and decrease predicted flood damage within an isolated and confined drainage or catchment area that is not hydraulically linked or connected to a larger basin. These projects include, but are not limited to, installation or modification of culverts and other stormwater management facilities; construction or modification of retention and detention basins; and construction or modification of floodwalls, dams and weirs. Modifications must be for the purpose of increasing risk reduction capabilities of the existing structures and cannot constitute only repairs. Localized flood risk reduction projects must not duplicate the flood prevention activities of other federal agencies and may not constitute a section of a larger flood control system.

Lowest Floor: The lowest of the lowest enclosed area (including a basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access or storage in an area other than a basement area, is not considered a building's lowest floor provided that such an enclosure is not built to render the structure in violation of the applicable non-elevation design requirements of 44 Code of Federal Regulations (CFR) Part 60.3 (the NFIP).

Lowest Floor Elevation (LFE): The elevation of the top of the lowest finished floor in a building.

Lowest Horizontal Structural Member: In V Zones, new construction must have the elevation of the lowest horizontal structural member at or above the BFE. Horizontal structural members are obstructions and can transmit the force of wave impacts to the rest of the structure. This elevation is used as the reference level to determine insurance rates. This contrasts with construction and insurance rating in A Zones, which uses the elevation of the lowest floor including basement as the reference level. This requirement is to keep the entire building in a V Zone above the anticipated breaking wave height of a base flood storm surge.

In an elevated building, the lowest beam, joist or other horizontal member that supports the building is the lowest horizontal structural member. Grade beams installed to support vertical foundation members where they enter the ground are not considered lowest horizontal members.

Non-Localized Flood Risk Reduction Projects: Projects that lessen the frequency or severity of flooding and decrease predicted flood damage within an area that is hydraulically linked or connected to a drainage basin that is regional in scale. These projects reduce flood hazards in areas larger than that of localized flood reduction projects and may include the construction, demolition or rehabilitation of dams; construction or modification of dikes, levees, floodwalls, seawalls, groins, jetties, breakwaters and stabilized sand dunes; and large-scale channelization of a waterway. Modifications must be for the purpose of increasing risk reduction capabilities of the existing structures and cannot constitute only repairs. These projects cannot constitute a section of a larger flood control system or duplicate the flood prevention activities of other federal agencies on the same site. These project types are only eligible under the Hazard Mitigation Grant Program (HMGP) and Building Resilient Infrastructure and Communities (BRIC).

Special Flood Hazard Area (SFHA): A FEMA-identified high-risk flood area where flood insurance is mandatory for properties. An area having a special flood, mudflow, or flood-related erosion hazards and shown on a Flood Hazard Boundary Map or a FIRM as Zone A, AO, A1-A30, AE, A99, AH, AR, AR/A, AR/AE, AR/AH, AR/AO, AR/A1-A30, V1-V30, VE or V.

Technical Review Components

To complete a successful project application, a minimum amount of technical information is required for review. The following is a step-by-step approach to addressing the major components of a food risk reduction project. Data collected in these steps will provide reviewers with the necessary information to determine whether a project is feasible and effective.

The data requirements in the following steps should be compiled in an attachment to the project application. If the project impacts multiple structures, the structure-specific information must be provided for each.

STEP 1: Provide a Scope of Work

Description: Provide a project narrative clearly identifying the proposed mitigation action and structures to be mitigated, describing the proposed activities, and a clear explanation of how the project will mitigate risk. The SOW should include key milestones and coincide with the design information, project schedule and cost estimate.

References: When preparing a SOW, refer to the following:

- For guidance, see:
  - HMA Guidance Part IV, Section H: Scoping Narrative: Scope of Work, Schedule, and Cost Estimate
  - Addendum to the HMA Guidance, Part F: Supplemental Guidance
- For an example narrative for a flood risk reduction project, see the HMA Application Development - Mitigation Project Subapplication Scope of Work Examples and Sample Engineering Case Study for Minor Structural Flood Control Projects.
- For most flood risk reduction projects, a professional engineer should be consulted during the application phase and will be required for design and construction.

Approach: The following items should be included in the SOW; specific details and documentation required to support the narrative will be documented in subsequent steps:

- Provide a narrative of the flood risk being mitigated, including flood event history in the project area, if available.
- Describe how the project will reduce flooding depths and damages; specify the level of protection and how the level of protection will be achieved (e.g., the project will eliminate flooding to all homes during a 50-year event by increasing capacity to convey the 50-year event, whereas the current condition is only sized to convey the 25-year event).
- The narrative should clearly state how all parts of the project are necessary and contribute to lowering the risk of flood damages.
- Describe the structures and infrastructure that will benefit from the project (e.g., the project will reduce flood damages to 10 single-family homes and reduce road closures to two streets).
- Describe the existing conditions of the project area, including existing drainage structures, if any, and structures and infrastructure impacted by flooding.

- Mitigation project alternatives are required as part of application development. Document at least two alternatives that were considered as part of the planning or design phase. Clearly indicate which alternative is the preferred mitigation project and discuss why it is the most practical, effective and environmentally sound alternative. One alternative is often considered the "no-action alternative" and reflects conditions expected to exist if no mitigation project is completed. This is a key step to ensure an efficient EHP review process. For additional guidance, see the *Flood Risk Reduction EHP Review*.
- Clearly explain the proposed mitigation activity, specifying the deliverables, identifying the tasks required to complete the proposed activity and defining the tasks to be accomplished in clear, concise and meaningful terms. All cost elements must match tasks and provide sufficient detail for FEMA to determine whether the application is eligible. The scoping narrative will become part of the conditions of the award.
- Clearly identify that it is a stand-alone mitigation project that solves a problem independently or constitutes a **functional portion of a solution**. The identified level of protection described in the application and the BCA should be representative of the proposed project only. Projects that are dependent on a contingent action to be effective and/or feasible are ineligible.

  A project represents a **functional portion of a solution** if it produces quantifiable benefits shown through an approved BCA methodology.

- Describe project components:
  - For example, if the project is a floodwall, describe the alignment, materials, structural design, culvert penetration, pumps, pumping operations and maintenance, and how it will tie into the existing system.
  - This information will vary depending on the type of project, and a professional engineer may need to be consulted.
- Describe construction activities such as:
  - Site access, storage, staging and security
  - Site preparation
  - Temporary construction such as a coffer dam to allow dewatering of a streambed
  - Earthwork, including importation or disposal of fill
  - Installation of the conveyance features such as reinforced concrete pipe
  - Repairs to infrastructure that must be damaged during construction, such as streets that must be excavated, so that subsurface components can be installed
  - Installation of grade structures and scour protection
  - A description of the flood zone in which work is expected to be completed. If work within the floodplain or floodway is anticipated, including staging area, provide documentation that all local flood regulations are being met.
- Describe all permitting requirements:
  - A statement that the project will be designed to all applicable codes and standards and NFIP requirements is required.

  - Verify that the project will be constructed to the appropriate codes and standards.
- Describe how the project will reduce flooding depths and damages; specify the level of protection (e.g., the project will eliminate flooding to all homes during a 50-year event).

STEP 2: Provide Available Technical Data

Description: Provide existing engineering analysis and design plans for the proposed project. Depending on the scope of the project, the plans may be conceptual in nature at the time of project application, and it may be possible to further develop following award. This should be accounted for in the scoping narrative, schedule and cost estimate if not available during application development.

Reference: For complex flood risk reduction projects, applicants may need to consider a phased approach, allowable for HMGP projects only. Using this approach, initial funds can be obtained to be used to produce detailed design (Phase 1) of the project for further FEMA review and approval (Phase 2). Refer to HMA Guidance, Part VIII, A.13 for additional requirements and guidance.

Approach: In addition to verifying that the project will meet the required codes and standards in the SOW narrative (**Step 1**), provide any available information to support the following:

- Demonstrate that it is feasible to meet the aforementioned standards (i.e., engineering design plans, results of feasibility studies, preliminary design plans).
- Provide design plans, specifications and engineering analysis (i.e., design calculations as available to, at a minimum, demonstrate the level of protection to be provided by the project).
- Provide documentation demonstrating that the project will not have negative impacts upstream or downstream of the project. Flood risk reduction projects are unique in that there is the potential to reduce the risk of flooding in one area while increasing flood risk in another location. An example of this is a project to line an earthen channel with concrete to increase its capacity and reduce flood elevations. Conveyance improvement projects, such as a concrete-lined channel, increase velocities associated with floods to accomplish reductions in water surface elevations. The increase in velocity can cause erosion issues along the channel and can also increase flood elevations downstream. The proposed project cannot cause an increase in flood risk or create potential for other damages (such as bank erosion) to any areas outside of the project limits.

It is necessary to show that there will be no adverse impacts due to the project using methods such as the following:

- A sealed statement by the professional engineer that there will be no adverse upstream or downstream impact
- An engineering analysis, such as a hydrology and hydraulics (H&H) report, that provides the data to support the professional engineer's statement
- Pre- and post-project inundation maps. See **Step 5**, Figure 1 as an example.

STEP 3: Provide a Project Schedule

Description: Include a detailed project schedule for all tasks identified in the project cost estimate and SOW. The schedule identifies major milestones, with start and end dates for each activity. Project schedules must show completion of all activities (including the construction period) within the period of performance (POP) allowed by the relevant HMA program. Sufficient details must be provided so FEMA can determine whether the proposed activities can be accomplished within the POP.

References: HMA Guidance Part VI, Section D.4: Program Period of Performance and Part IV, Section H: Scoping Narrative: Scope of Work, Schedule, and Cost Estimate

Approach: Ensure that the information in the schedule supports the SOW and aligns with the project cost estimate.

STEP 4: Provide a Project Cost Estimate

Description: Include a detailed line-item cost estimate for all tasks identified in the project schedule and SOW. Allowable costs are costs that are necessary and reasonable for the proper and efficient performance and administration of the federal award. All costs included in the subapplication should be reviewed to ensure they are necessary, reasonable and allocable consistent with the provisions of 2 Code of Federal Regulations Part 200. Include sufficient detail so that FEMA can determine whether costs are reasonable based on proposed activities and level of effort. Costs incurred prior to award may be considered pre-award costs and may be eligible for reimbursement. Eligibility may depend on the date they occurred and the grant program. Refer to HMA Guidance and the Notice of Funding Opportunity for specifics.

References: For more detailed information on eligible and ineligible costs for flood reduction projects, refer to the Addendum to the HMA Guidance Parts F.4.2 and F.4.3.

Approach: Ensure that the information in the cost estimate supports the SOW and aligns with the schedule.

Typical costs for a flood risk reduction project may include, but are not limited to:

- Engineering services for design and cost estimate preparation
- Data analyses/investigations directly related to the mitigation project, including geotechnical investigations, engineering reports and H&H analyses
- Project administration and construction management
- Surveying
- Permitting and/or legal fees
- Project planning and design activities, including construction verification
- All construction activities required for project completion
- Costs related to complying with local utility requirements
- The cost to obtain a Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR), if the project intends to reduce the area of inundation as delineated by the SFHA

STEP 5: Provide a Project Site Map and Location Information (Including Areas Impacted by Project)

Description: Provide a map showing project extents. To document project extents, the entire area impacted by the project must be considered. This should include at least the following:

- A clear delineation of areas disturbed to construct the project, including potential off-site areas such as spoils disposal locations
- A full description of the geographical location(s) of the project boundaries
- Topographic data with vertical data clearly shown
- Latitude and longitude for the project location. If the project involves multiple, discontinuous locations, provide enough coordinates to delineate the entire project boundary (e.g., four corners). Include coordinates for any properties that are affected by the mitigation project. It may be helpful to show the latitude and longitude coordinates on a map. The latitude and longitude should be taken at the center of the property. The latitude and longitude can be provided in either decimal degree (e.g., 27.9807, -82.5340) or degrees, minutes and seconds (27° 58' 50.5'' N, 82° 32' 2.4'' W).
- *Note: Additional figures may help support the scoping narrative; provide as appropriate and available. Pre- and post-mitigation inundation maps are especially valuable for demonstrating project effectiveness.*

Potential Sources: Maps from previously developed reports, official site survey, assessor maps, FIRM map or topographic maps with mark-ups, obtained from the project engineer or planner, or maps created using a web-based service such as Google Maps; ensure that a scale bar and north arrow are shown, and the map is clearly labeled to identify the project boundaries.

Example: The map below shows the project limits for a proposed storm sewer line and the pre- and post-project inundation extents. The project will eliminate flooding to homes in the 2-year and 25-year event; however, some minor road flooding will still occur during the 25-year event (see **Figure 1**).

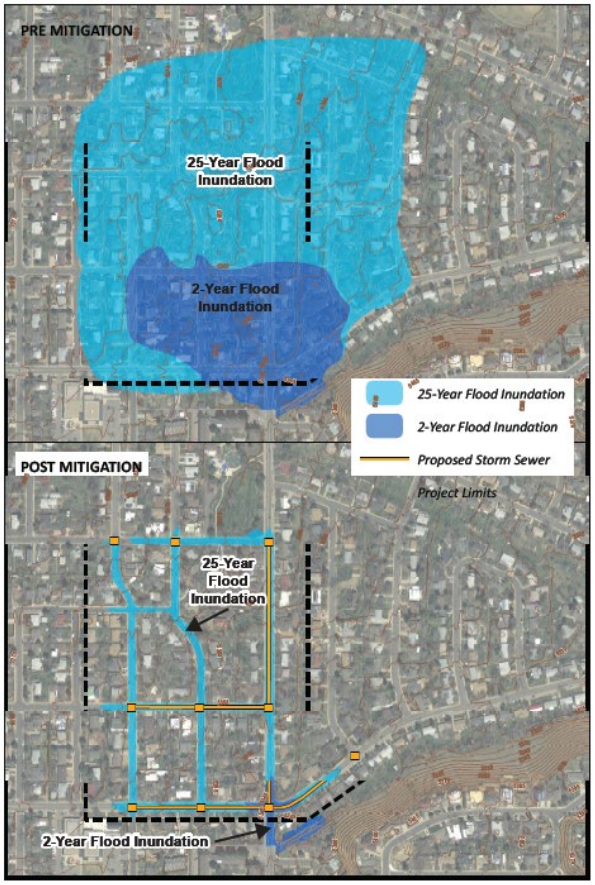


Figure 1. Example of before- and after-mitigation inundation map.

STEP 6: Provide Site Photographs

Description: Provide photographs of the proposed project area and the impacted properties. For example, if a floodwall is to be placed around a wastewater treatment plant, take photographs of the proposed wall location, as well as the building and facilities it will protect. Show all directions to the surrounding area. Provide photographs with as much detail as possible to support the description of the proposed project

Potential Sources: Use a cellular telephone, tablet, or camera to take clear, good quality photos for inclusion in the application.

STEP 7: Document the Before-Mitigation Flood Risk

Description: There are two ways to demonstrate the existing risk of flooding: using engineering analysis to estimate the risk or using historical information to demonstrate the risk. In many flood-prone areas, FEMA has performed an engineering analysis of the risk, which can be found in an FIS and accompanying FIRM. For flood risk reduction projects, you may need an independent study of the flood risk and an engineering report documenting the results to understand the risk pre- and post-project. If the area has not been studied in detail, flood risk can be demonstrated through documentation of a flood event history; however, it is possible

the project will need to be phased (eligible for HMGP projects only) allowing for development of an H&H study to ensure feasibility and effectiveness.

References: FEMA's How to Find Your FIRM and Make a FIRMette and FEMA's Map Service Center

Approach: The following steps should be taken to document existing flood risk:

1. If an FIS and FIRM are available for the project area, provide a copy of the map with the project location(s) outlined and a copy of the associated information in the FIS. Ensure that the flood zones for the project area are clearly defined. Note whether the project is in the SFHA (the 100-year floodplain) and if it located in a regulatory floodway.

   Note that if an FIS and FIRM exist for the project area, documentation should be provided whether or not an independent flood analysis or historical flood information was used to assess the project.

2. If an independent engineering study exists and is being used to assess the flood risk for the project, provide a copy of the professionally certified report. The report should include H&H calculations used to determine water surface elevations for multiple size events (flood recurrence interval such as the 10-year, 50-year, 100-year or other interval) for existing conditions. If these calculations were completed using modeling software, the engineering report should document all model inputs and outputs. Inundation maps are also recommended to support the analysis and document the structures or infrastructure at risk.
3. If detailed flood analysis is not available, provide a list of historical flood events along with the following information:
   - Specific date of each flood event
   - Measured or estimated high water marks from the event in the vicinity of the project area, if available
   - Length of loss of function to structures, public services, utilities, roads or bridges
   - Size of the event (flood recurrence interval such as the 10-year, 50-year or other), if known. See Supplement to the Benefit-Cost Analysis Reference Guide.
   - Damage description, further defined in **Step 9**

STEP 8: Document the Post-Project Flood Risk and Define Level of Protection

Description: Documenting the after-project flood risk (also referred to as the residual risk) is critical to understanding the project's effectiveness. It is important to clearly state the level of protection in the scoping narrative (e.g., the level of protection provided by the proposed storm sewer upgrades is the 25-year event. Flooding of homes and streets during the 25-year event will be eliminated, and minimal street flooding will still occur during the 50-year event).

Approach: One of the following steps should be taken to document existing post-project flood risk:

1. Provide detailed documentation in the form of an engineering report that has been sealed by a professional engineer. The engineering report should clearly identify the proposed project conditions and include hydrologic and hydraulic calculations used to determine post-project water surface elevations. If these calculations were

completed using modeling software, the engineering report documenting all model inputs and outputs should be provided.

Post-project flood elevations should be calculated for similar flood scenarios (e.g., 10-year, 50-year, 100-year or other) as was performed for the before-mitigation scenario. Inundation maps are also recommended to support the analysis and document the structures and infrastructure at risk.

2. If detailed flood analysis is not available, clearly define the level of protection the project provides and any engineering calculations supporting the design. If this is the best available data, it is possible the project will need to be phased (eligible for HMGP projects only) allowing for development of an H&H study to ensure post-project flood risk is accurate and that the project will not have negative upstream or downstream impacts.

STEP 9: Cost-Effectiveness Analysis

Description: Cost-effectiveness of an elevation project must be demonstrated to obtain FEMA funding. A benefit-cost analysis (BCA) is required to assess the cost-effectiveness of the project. **Figure 2** and **Table 1** help illustrate this concept.

This section provides guidance on the following:

- **Step 9A:** Benefit-Cost Analysis – Modeled Damages
- **Step 9B:** Benefit-Cost Analysis – Historical or Professional Expected Damages
- **Step 9C:** Additional Benefits for a Benefit-Cost Analysis

All BCA inputs must be **justified and documented**. When appropriate FEMA standard values are used, it should be clearly stated.

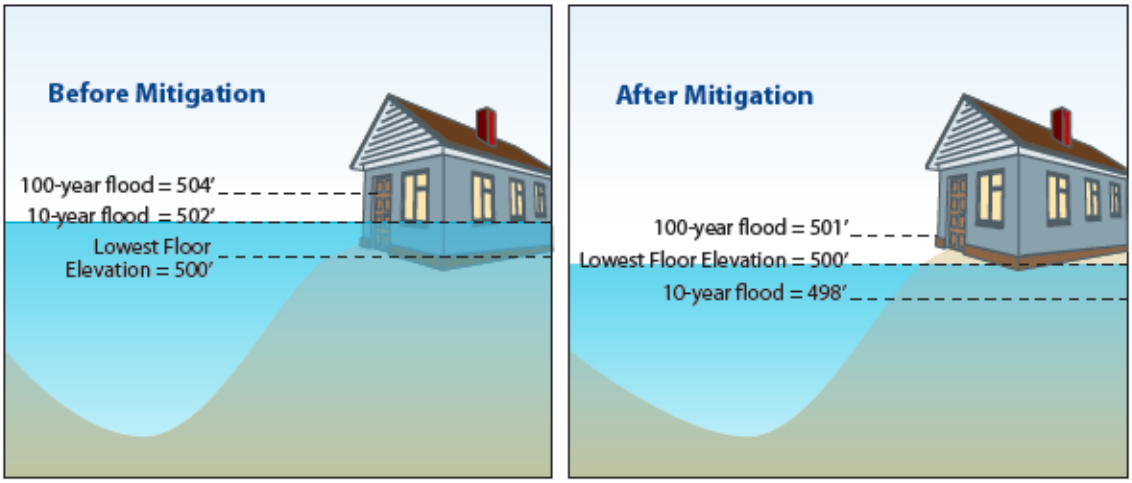


Figure 2. Before and after mitigation flood risk.

Table 1. Comparison of mitigation benefits.

Flood Depth above LFE (feet) Before Mitigation	Recurrence Interval	Expected Damages Before Mitigation	Flood Depth above LFE (feet) After Mitigation	Expected Damages After Mitigation	Damages Avoided (Benefits)
2	10-year flood	$2,124	0	$0	$2,124
4	100-year flood	$3,150	1	$1,112	$2,038

LFE = lowest floor elevation

Before Mitigation, the impacted structure's Lowest Floor Elevation is at 500 feet. At this location, the 10-year flood event has impacted the structure up to 502 feet, causing $2,124 in damages to the structure, and the 100-year flood event is estimated to be at 504 feet, causing an estimated $3,150 in damages to the structure. After Mitigation, the project has reduced the flood risk to the structure so that the 10-year flood event is estimated to be at 498 feet, and the 100-year flood event is at 501 feet. In the After Mitigation scenario, there is a residual risk of 1 foot of flooding in the structure during the 100-year event that causes an estimated $1,112 in expected damages to the structure.

FEMA will only consider applications that use a FEMA-approved methodology to demonstrate cost-effectiveness. FEMA provides a BCA tool that allows applicants to calculate a project benefit-cost ratio (BCR). The BCR is a calculation of the project benefits divided by the project costs. Projects for which benefits exceed costs (a BCR of 1.0 or greater) are generally considered cost-effective. Benefits may include avoided damage, loss of function and displacement. In the case of flood risk reduction projects, these may include:

- Avoided physical damage to the building and contents
- Avoided displacement costs: the costs required to move and stay in a temporary location while repairs are performed on the building
- Residential properties: avoided mental stress and lost productivity
- Commercial properties: avoided loss of net revenue
- Public properties: avoided loss of public services
- Utilities: loss of service
- Roads: loss of function
- Avoided volunteer labor time that typically supports cleanup and repair work

It is important to note that there are several benefits that could be counted for a project, and any or all the benefits can be included in a BCA when analyzing cost-effectiveness. It is recommended that the applicant start a BCA using the benefits most likely applicable to the project.

If the BCR does not exceed 1.0, or is only slightly over 1.0, after analyzing the primary benefits, refer to **Step 9C** to find additional methods of calculating potential benefits for the project.

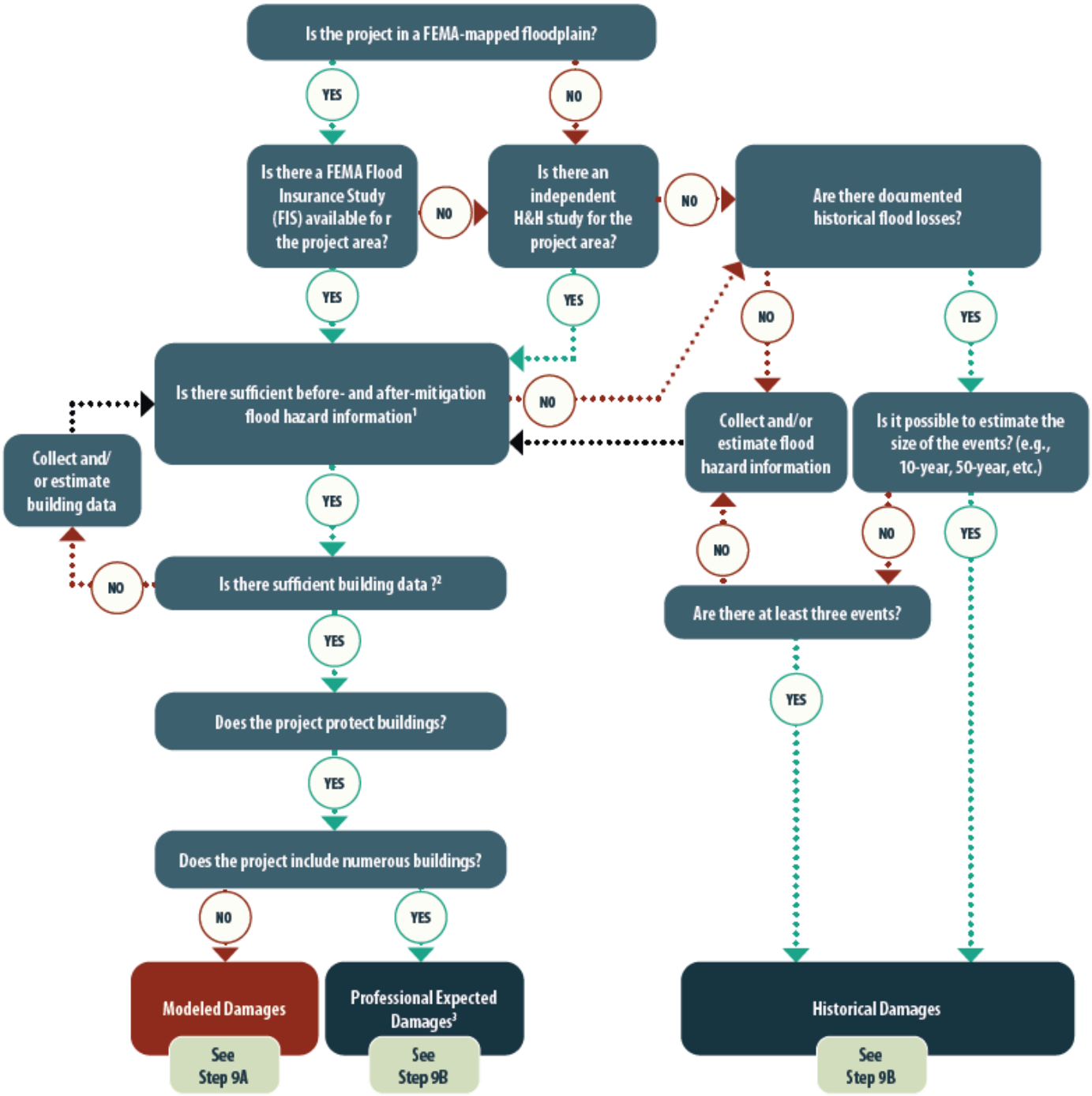
A flood risk reduction project can reduce risk to several facilities, including buildings, roads and utilities. The approach to the BCA depends on the facilities being protected and the data available.

- Modeled damages can only be used to evaluate avoided losses to buildings. To use modeled damages, detailed flood information must be available for pre- and post-project conditions for four scenario events (**Step 9A**).
- If data for historic damages, or professional expected damages is available, the BCA tool will use a Damage Frequency Assessment (DFA) module (**Step 9B**) to evaluate any type of facility (including buildings).
- A combination of modeled, historical and estimated damages can be used when evaluating buildings and other infrastructure.

This supplement only provides a recommended approach to documenting cost-effectiveness. For detailed guidance on using the FEMA BCA Tool, refer to FEMA BCA Reference Guide and FEMA Supplement to the BCA Reference Guide. For additional questions, please contact the BC Helpline at ***bchelpline@dhs.gov*** or at ***1-855-540-6744***. Provide a .pdf of the BCA report and an export of the BCA as a .zip file.

Approach: There are several methods to evaluate cost-effectiveness. The method used will depend on the data collected in the previous steps of this supplement. Use the flow chart in **Figure 3** to analyze the data available for the project site and determine the recommended approach.

The FEMA BCA Tool includes embedded Help Content. Click on the information button within the tool to access the Help Content.



[1] Building information must include LFE.

[2] Described in Step 8, the project must have information on 4 events (e.g., 10-year, 50-year, 100-year or other) for per- and post project.

[3] Modeled damages may be used for multiple structures; however, each structure must be included in the BCA project as its own mitigation action.

Figure 3. Flowchart for Determining the Appropriate BCA Frequency and Damage Relationship in the FEMA BCA Tool.

STEP 9A: Benefit-Cost Analysis Tool – Modeled Damages

Description: Using modeled damages is suitable when the project is primarily protecting buildings as it only calculates avoided damages to buildings. The tool analyzes proposed mitigation projects by comparing estimated flood elevations for various scenario events to the LFE. The BCA Tool then uses the depth of each scenario flood event above (or below in some instances) the structure's LFE and establishes depth-damage curves to estimate damages to the building based on a percentage of the Building Replacement Value (BRV). Additionally, it uses the same depth-damage curves to estimate damage to building contents, displacement from the building, and loss of use of the building. Using modeled damages is recommended for BCAs when users have detailed pre- and post-project flood hazard information and structural data.

References: FEMA's Benefit-Cost Analysis Reference Guide, Supplement to the Benefit-Cost Analysis Reference Guide, FEMA BCA Tool (including Help Content within the tool)

Approach: The following describes the essential flood hazard and structural data required to estimate avoided physical damages using modeled damages in the BCA Tool. The data collected in **Step 1** through **Step 8** of this supplement will be utilized in the BCA; some additional data will need to be gathered and are described below:

1. Provide building information for each structure impacted by the project.
   - Total size of building(s):
     - Number of stories
     - Square footage of first floor (non-residential buildings only)
     - Potential sources: tax card, estimated from maps/site plans
   - Building type (i.e., residential, hotel, police station)
   - Building Replacement Value (BRV)
   - Lowest floor elevation (BFE)

   Note: Cost-effectiveness is achieved when the BCR is greater than 1.0; it may be efficient to collect data first on properties showing the greatest reduction in flood depths and only collect additional information if needed.
2. The FEMA BCA Tool will utilize the following flood risk data collected in **Step 7** and **Step 8** to estimate pre- and post-project flood depths at each structure.
   - Streambed elevation (riverine flood hazard analysis only)
   - Stillwater elevations (coastal flood hazard analysis only)
   - Flood elevations for the 10-year, 50-year, 100-year and 500-year recurrence intervals (alternative recurrence intervals are acceptable when using non-FEMA H&H studies for pre- and post-project conditions)
   - Flood discharge rates for the 10-year, 50-year, 100-year and 500-year recurrence intervals (riverine flood hazard analysis only; alternative recurrence intervals are acceptable when using a non-FEMA H&H study for pre- and post-project conditions)
   - Project useful life

- Annual maintenance cost associated with maintaining the effectiveness of the components installed as part of the drainage project

Note that while the information listed above is required to calculate avoided building damages, the Modeled Damages approach will use FEMA standard values to automatically count avoided loss to contents and avoided displacement costs (the costs required to move and stay in a temporary location while repairs are performed on the structure). If additional benefits are to be calculated, go to **Step 9C**.

STEP 9B: Benefit-Cost Analysis Tool – Historical or Professional Expected Damages

Description: The BCA Tool Damage Frequency Assessment (DFA) module calculates project benefits and costs for proposed mitigation projects for any hazard. The DFA module compares user-entered damages/losses and the frequency that they occur in the before-mitigation scenario versus the after-mitigation scenario to calculate benefits based on avoided damages. The DFA module is used when the user has hazard data for historical damages or professional expected damages.

References: FEMA's Benefit-Cost Analysis Reference Guide, Supplement to the Benefit-Cost Analysis Reference Guide, FEMA BCA Tool (including Help Content within the tool)

Approach: The DFA module calculates project benefits for proposed hazard mitigation projects based on either documented historic damages (such as loss of function or physical damage) or professional expected damages from at least one known-frequency event. If recurrence intervals are not known and there are historical damage data from at least three events, the DFA module can estimate a recurrence interval. Otherwise, additional data collection or analysis will be needed. The calculation compares before- and after-mitigation conditions and an example calculation is shown in **Table 2**.

- **Before-mitigation:** Based on existing conditions at the site. To demonstrate the current risk, actual historical damages, or professional expected damages for certain severity events (e.g., the 10-year flood, the 50-year flood) can be entered in the DFA module to perform a BCA.
- **After-mitigation:** The same scenario flood events should result in reduced damages due to the mitigation project. The after-mitigation damages should be estimated based on the level of protection provided by the project. For example, for a flood wall that protects 10 structures during the 100-year flood event, it could be assumed that there would no longer be damages to the structures below the 100-year level of protection but there may be some minor damages due to overtopping in a 500-year event.

Table 2: Before- and after-mitigation estimated damages.

Recurrence Interval	Before Mitigation Damages			After Mitigation Damages		
	Building	Contents	Roads	Building	Contents	Roads
10-year	$16,000	$5,000	$5,000	$0	$0	$0
100-year	$25,000	$17,500	$10,000	$5,000	$2,500	$2,500
500-year	$50,000	$25,000	$20,000	$10,000	$5,000	$5,000

- If an H&H study is available for the post-project scenario (**Step 8**), damages to impacted facilities can be estimated based on the flood depths for each scenario event studied.
- If no H&H study was performed for the post-project scenario, it may be possible to use historic flood events to estimate damages from **Step 8**. For example, if the post-project flood elevations for the 25-year event would be like those experienced in a 5-year event under existing conditions, historic losses for the 5-year event can be used to estimate losses for the post-project, 25-year event. If recurrence intervals are not available, the BCA Tool will calculate a recurrence interval when historical damage data from at least three events are provided.

Potential Sources:

- Insurance claims, receipts from repair of flood damages, FEMA Public Assistance Worksheets, BureauNet data, documentation of lost service from a utility provider, Public Works Department
- Property owner affidavit, estimated from damage functions

STEP 9C: Additional Benefits for a Benefit-Cost Analysis

Description: As previously noted, there are several benefits that could be counted for a project. Any or all the benefits can be used to demonstrate that a project is cost-effective or, in other words, has a BCR greater than 1.0. Once the initial BCA information is collected and a preliminary analysis is performed, additional benefits may be analyzed, if needed.

Approach: Answer the following questions:

1. Is the impacted building residential? If yes, how many residents reside in each building? If not readily available, use averages from Census data related to the municipality or county.
2. Does the building include any rental property for which the owner receives rental income?
3. Is there a business run out of the building or home?
4. Are there any non-critical governmental services provided from the building such as a permit office or library?
5. Are there any critical services provided by the building such as police, fire or medical services?

6. Does the project eliminate or reduce the need for volunteer labor?
7. Does the project protect against loss of service to a utility?
8. Does the project protect loss of service to a road?
9. Does the project change or enhance the land use of the project area to create beneficial environmental space? For example, if a property is acquired, then a new green space is created.
    - Ecosystem services benefits accrue when a parcel's land use is changed or enhanced by a mitigation activity to one that provides a higher level of natural benefits. For example, the change from an urban land use to green space because of mitigating a structure within an acquisition/demolition project will mean improved ecosystem services benefits for infiltration, habitat, nutrient cycling, climate regulation and other natural floodplain functions.

STEP 10: Environmental and Historic Preservation Considerations

Environmental and historical preservation compliance will need to be considered as part of the application process. Please refer to Flood Risk Reduction EHP Review.

Resources

Below is a list of resources identified throughout this supplement. Not all these resources are necessary for every flood risk reduction project but are provided to ease in identification of source material.

PROGRAM AUTHORITIES

- The National Flood Insurance Act of 1968, as amended, 42 U.S.C. 4001 et seq.
- The Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended, 42 U.S.C. 4001 et seq.
- 44 Code of Federal Regulation Part 206, Subpart N
- 44 Code of Federal Regulations Part 60.3
- 2 Code of Federal Regulations Part 200

PROGRAM GUIDANCE

- FEMA Hazard Mitigation Assistance Guidance and Hazard Mitigation Assistance Guidance Addendum, Part F
- Benefit-Cost Analysis Reference Guide
- Supplement to the Benefit-Cost Analysis Reference Guide

TECHNICAL GUIDANCE AND STANDARDS

- American Society of Civil Engineers (ASCE) Structural Engineering Institute's ASCE/SEI 24-14 Flood-Resistant Design and Construction (or latest version)
    - Using ASCE 24 for Hazard Mitigation Assistance

- U.S. Army Corps of Engineers (USACE). 1989. Retaining and Flood Walls
- U.S. Army Corps of Engineers (USACE). 1991. Tidal Hydraulics
- U.S. Army Corps of Engineers (USACE). 1993. Hydrologic Frequency Analysis
- U.S. Army Corps of Engineers (USACE). 1994. Flood-Runoff Analysis
- U.S. Army Corps of Engineers (USACE). 1994. River Hydraulics
- U.S. Army Corps of Engineers (USACE). 1994. Hydraulic Design of Flood Control Channels
- U.S. Army Corps of Engineers (USACE). 1995. Gravity Dam Design
- U.S. Army Corps of Engineers (USACE). 1995. Design of Costal Revetments, Seawalls, and Bulkheads
- U.S. Army Corps of Engineers (USACE). 1998. Conduits, Culverts, and Pipes
- U.S. Army Corps of Engineers (USACE). 2000. Design and Construction of Levees
- U.S. Army Corps of Engineers (USACE). 2002. Environmental Engineering for Flood Control Channels
- U.S. Army Corps of Engineers (USACE). 2002. Coastal Engineering Manuals, Parts 1 through VI
- U.S. Army Corps of Engineers (USACE). 2002. Environmental Engineering for Coastal Shore Protection

ADDITIONAL TOOLS AND RESOURCES

- FEMA's How to Find Your FIRM and Make a FIRMette
- FEMA's Map Service Center
- Benefit-Cost Analysis (BCA) Tool
- Cost Estimating Principles for Hazard Mitigation Assistance Applications
- FEMA's National Flood Hazard Layer
- Hazard Mitigation Assistance Application Development Scope of Work Examples
- Hazard Mitigation Assistance Application Development Engineering Case Studies
- Flood Risk Reduction EHP Review
- FEMA Hazard Mitigation Assistance Job Aids