Soil Stabilization Technical Review

This job aid supplement covers the requirements associated with the technical reviews for soil stabilization projects funded by Hazard Mitigation Assistance. FEMA will also conduct an Environmental Planning and Historic Preservation review for each project. Refer to the Soil Stabilization: Information Required for Environmental Review Job Aid.

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

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. For complex projects, applicants may want to consider Advance Assistance or a phased project approach (phasing is allowable for Hazard Mitigation Grant Program [HMGP] and Building Resilient Infrastructure and Communities (BRIC) projects only). Initial funds can be obtained (Advance Assistance or Phase 1) to perform geotechnical evaluations or produce a detailed design of the project for further FEMA review and approval (Application Development or Phase 2). Refer to 2015 HMA Guidance, Part VIII, A.12 and A.13 for additional Advance Assistance and phased project requirements and 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
- Benefit-Cost Analysis Reference Guide and Supplement to the Benefit-Cost Analysis Reference Guide
- Hazard Mitigation Grant Program – Post Fire

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 and Narrative
- ☐ STEP 5: Provide a Project Site Map
- ☐ STEP 6: Provide Property Location Information
- ☐ STEP 7: Provide Project Photographs
- ☐ STEP 8: Document the Before-Mitigation Risk
- ☐ STEP 9: Cost-Effectiveness Analysis
- ☐ STEP 10: Environmental and Historic Preservation Considerations

Important Terms

Coastal Erosion: Coastal erosion is the wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents or by deflation. Coastal erosion does not refer to the natural seasonal migration of beach sediments along a beach slope, where the sediment budget remains at equilibrium.

Imminent Risk of Failure: When an engineer, geologist or geomorphologist determines that structures and/or infrastructure will fail within a defined period due to coastal or streambank erosion or landslides.

Landslide: A landslide is rocks, earth or other materials moving down a slope. A mudflow is a landslide that is combined with up to 60% water.

Soil Stabilization: Methods to reduce the risk to structures or infrastructure from erosion and landslides include installing geotextiles, stabilizing sod, installing vegetative buffer strips, preserving mature vegetation, decreasing slope angles and stabilizing with riprap and other means of slope anchoring.

Streambank Erosion: Streambank erosion is a natural process that occurs when the forces exerted by flowing water exceed the resisting forces of bank materials and vegetation. Erosion occurs in many natural streams that have vegetated banks. However, land use changes or natural disturbances can cause the frequency and magnitude of water forces to increase, causing excessive streambank erosion.

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 addressing the major components of a soil stabilization 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.

STEP 1: Provide a Scope of Work

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

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

- 2015 HMA Guidance Part IV, Section H: Scoping Narrative: Scope of Work, Schedule, and Cost Estimate
- Streambank Bioengineering Job Aid
- Bioengineered Wildfire Mitigation Job Aid
- Engineering with Nature. Alternative Techniques to Riprap Bank Stabilization

Approach: An engineer, geologist or contractor may be required to assist in collecting the necessary information for the mitigation project. The following items are recommended for inclusion in the SOW, and specific details and documentation required to support the narrative will be documented in the remaining steps to this job aid:

- Provide a detailed narrative of the erosion or landslide risk being mitigated, including landslide hazard information in the project area, if available.
- Describe the existing conditions of the project area. Define the problem and extent of the erosion/instability.
- Define the level of protection the mitigation will provide (i.e., this project shall be designed to withstand erosion/landslide forces associated with a flood event with a recurrence interval (RI) of 50 years, or a seismic event with a recurrence interval of 100 years). If the protection is not designed to a specific flow rate in a channel or a specific ground acceleration from a seismic event, provide information on the design life and a narrative or analysis on the frequency or magnitude of the event that the mitigation will withstand.
- Describe the structure(s) and infrastructure that will benefit from the project (e.g., the project will reduce landslide damages to 10 single-family homes).
- Describe the existing conditions of the structure(s) (if any) to be acquired. Specific details and documentation to support the narrative are described in **Step 2**.
- Explain the proposed mitigation activity in a scoping narrative, including the mechanism for the mitigation (e.g., installing geotextiles, stabilizing sod, installing vegetative buffer strips, preserving mature vegetation, decreasing slope angles, stabilizing with riprap), 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 the SOW and schedule 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.

- Verify that the project will be designed and constructed to meet current industry standards and minimum requirements of the selected soil stabilization method to be implemented.
- Mitigation project alternatives are required as part of the application development. Document at least three alternatives, including the preferred alternative, that were considered during the planning or design phase. Indicate which alternative is the preferred mitigation alternative and discuss why it is the most practical, effective and environmentally sound alternative. One alternative often considered is the “no-action alternative” and reflects conditions expected to exist if a mitigation project is not completed. This is a key step to verify an efficient EHP review process.
- Describe the mitigation method and the steps required to implement the soil stabilization mitigation activities, including the mechanism for the mitigation. A professional engineer may need to be consulted.
- Describe the construction activities such as:
  - Site access, storage, staging, and security
  - Site preparation
  - Temporary construction, such as a coffer dam or other diversion structure
  - Earthwork, including importation or disposal of fill
  - Installation of the conveyance features such as reinforced concrete pipe
  - Repairs to infrastructure that may be damaged or require temporary or permanent removal, relocation or realignment during construction such as temporary or permanent relocation of utilities
  - Installation of grade structures or other slope/surface improvements
- Describe all permitting requirements.

STEP 2: Provide Available Technical Data

Description: It is necessary to demonstrate that a project is feasible and effective at reducing risk. Provide existing engineering or design plans; these may be conceptual (e.g., sketches or schematics) at the time of project application. This information can be developed following award and should be accounted for in the scoping narrative, schedule and cost estimate if not available during application development.

For complex projects, applicants may need to consider a phased project approach, allowable for HMGP and BRIC projects. Using this approach, initial funds can be obtained to be used to produce a detailed design (Phase 1) of the project for further FEMA review and approval (Phase 2). Refer to 2015 HMA Guidance, Part VIII, A.13 for additional requirements and guidance.

It is possible that a registered professional engineer, registered geotechnical engineer, geologist or contractor will be required to assist with collecting or developing the necessary information for the mitigation project.

Approach: Project plans should comply with the applicable codes, standards and minimum construction requirements. Providing project plans and specifications will allow reviewers to determine the technical feasibility for the proposed mitigation project and check the validity of the cost estimate against the drawings and specifications. Document how the SOW solves the identified hazard risk or is **a functional portion of a solution**. Documentation should indicate that the final design drawings and specifications will be signed and sealed by a professional engineer licensed in the state or jurisdiction where the project is located prior to beginning construction.

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

- In addition to verifying that the project will meet the required codes and standards in the SOW narrative (**Step 1**), provide available design plans, specifications and engineering analysis (i.e., design calculations to, at a minimum, demonstrate the level of protection to be provided by the project) to demonstrate that the project will meet applicable codes and standards.
- For streambank stabilization projects, provide documentation demonstrating the project will not cause adverse effects upstream or downstream of the project site. Acceptable documentation includes a sealed statement from a professional engineer, an engineering analysis or analyses or reports that provide data to support the statement.

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 construction period, within the period of performance (POP) allowed by the relevant HMA program. Sufficient detail must be provided so FEMA can determine whether the proposed activities can be accomplished within the POP.

References: 2015 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: Verify 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 application should be reviewed to verify they are necessary, reasonable and allocable consistent with the provisions of 2 Code of Federal Regulations (CFR) 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: 2015 HMA Guidance Part IV, Section H: Scoping Narrative: Scope of Work, Schedule, and Cost Estimate

Approach: Verify that the information in the cost estimate supports the SOW and aligns with the schedule. Well-documented project cost estimates contain quantities, unit costs and a source for each unit cost. Lump sum cost estimates are not acceptable. Source material used to support the cost estimate should be referenced.

Allowable costs are costs that are necessary and reasonable for the proper and efficient performance and administration of the federal award. They may include but are not limited to:

- Engineering services for design, geotechnical assessments and cost estimate preparation
- Project administration and construction management
- Surveying and inspection
- Soil sampling
- Completion of a title search and deed recording fees
- Permitting and/or legal fees
- All construction activities required for soil stabilization
- Disconnecting and reconnecting utilities and extending lines and pipes, as necessary
- Debris disposal and erosion control
- Costs for repair of lawns, landscaping, sidewalks or driveways if damaged by the project

It is necessary to verify that an annual maintenance cost has been determined using appropriate methods. The annual maintenance cost is necessary to address those costs associated with maintaining the effectiveness of the mitigation measures. Although the costs will not be funded by FEMA, they are required to be included in the benefit-cost analysis (BCA).

STEP 5: Provide a Project Site Map

Description: Provide a map showing the project location. If the project includes multiple structures, show the project boundaries, including the staging area. **Figure 1** provides an example of a project site map.

Reference: Supplement to the Benefit-Cost Analysis Reference Guide, Section 5: Available Technology Aids

Potential Sources: Official site survey, assessor maps, topographic maps obtained from the project engineer or planner, maps created using a web-based service such as Google Maps

Approach: Provide a map showing the project location, including structures, map scale and location information. For any maps provided, verify that a scale bar is shown and the map is clearly labeled to identify the project boundaries.

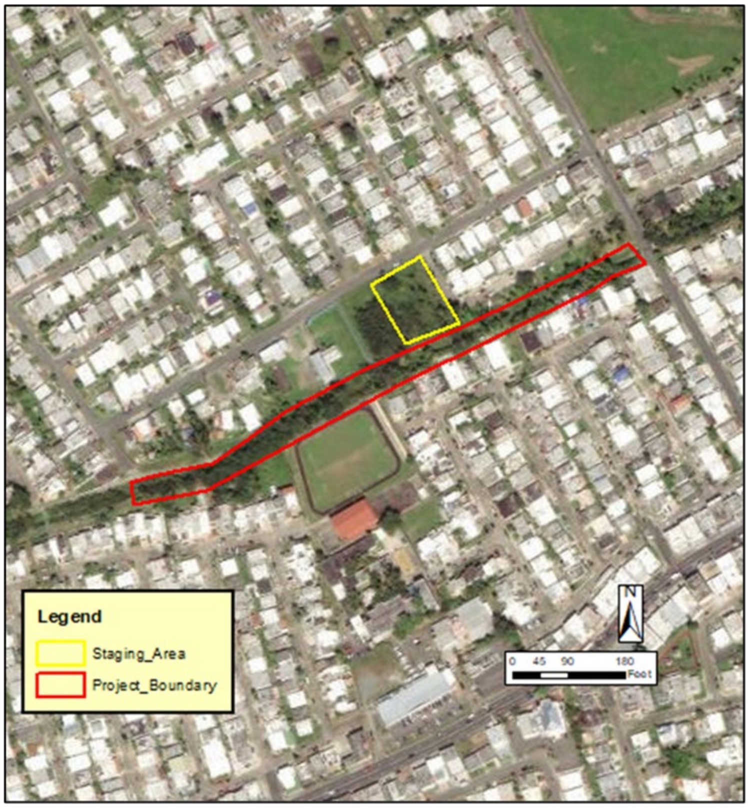


Figure 1. Example of a project site map for a streambank stabilization project. The map identifies the project boundaries and staging area and includes a north arrow and a scale.

STEP 6: Provide Property Location Information: Address and Latitude and Longitude

Description: Provide the physical address(es) and/or the latitude and longitude of all mitigation activities. For projects that include multiple properties, tables containing all relevant information by property can be helpful.

PROPERTY ADDRESS

Approach: Provide property address(es) of each structure involved in the mitigation project, if applicable. This includes street name and number; city, county or parish; state; and zip code. A post office box number is not an acceptable address. If the address provided does not clearly match up with the structure(s) to be mitigated, provide photos or a site map with the structure(s) footprint(s) clearly identified.

Potential Sources: Property owner, local building inspector, tax assessor records, deed to the property, engineering plans

Example: 456 Terremoto Road, San Francisco, San Francisco County, CA 94102

LATITUDE AND LONGITUDE

Approach: Provide the latitude and longitude of the project site and each structure involved in the mitigation, if applicable. The latitude and longitude should be taken at the center of the property or project area. The latitude and longitude can be provided in either decimal degrees (e.g., 27.9807, -82.5340) or degrees, minutes and seconds (e.g., 27° 58' 50.5'' N, 82° 32' 2.4'' W).

Potential Sources:

- GPS device
- Free online map tools or search engines that generate latitude and longitude when an address is supplied

Example: 27.9807, -82.5340 or 27° 58' 50.5'' N, 82° 32' 2.4'' W

STEP 7: Provide Project Photographs

Description: Provide multiple representative photographs of the project area and any structure(s) impacted by the mitigation, if applicable. Pictures should indicate the relative direction the photograph was taken (e.g., eastside looking west, upstream from culvert) (see **Figure 2**).

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

Example:

Figure 2. Example of project site photos of a streambank stabilization project along Fountain Creek, Woodland Park, Colorado. The photo to the left shows the eroded downstream reach while the photo to the right shows the already stabilized upstream reach.

STEP 8: Document the Before-Mitigation Risk

Description: Provide information on the risk of an erosion or landslide event and the effects of that event in physical damages and, when appropriate, loss of function. The recurrence interval (RI) of the event can be used to identify the risk. Recurrence intervals of the failure of structures or infrastructure are determined differently if they are caused by **coastal or streambank erosion** or **landslide.** For instance, **coastal or streambank erosion** is a gradual process; thus, the failure of structures does not occur until the coastal or streambank erosion encroaches on them. **Landslides** are usually associated with a triggering event such as flooding, seismic or volcanic activity. Therefore, the recurrence of a landslide could be tied to the recurrence of a triggering event. In some cases, **coastal or streambank erosion** could lead to a landslide if there is a slope on the coastline or next to a stream.

Approach: Provide documentation of the calculations, studies or data used to determine the recurrence intervals of the hazard events.

COASTAL AND STREAMBANK EROSION

For coastal and streambank erosion, the RIs of the failure of structures or infrastructure should be defined as the period at which the coastal or streambank erosion encroaches on them, such as they become unsafe for use. This period can be estimated based on annual erosion rate (in feet/year). The RI (in years) can be calculated by dividing the distance (in feet) from the coastline or streambank to the structure (**Figure 3**) by the annual coastal or streambank erosion rate (in feet/year).

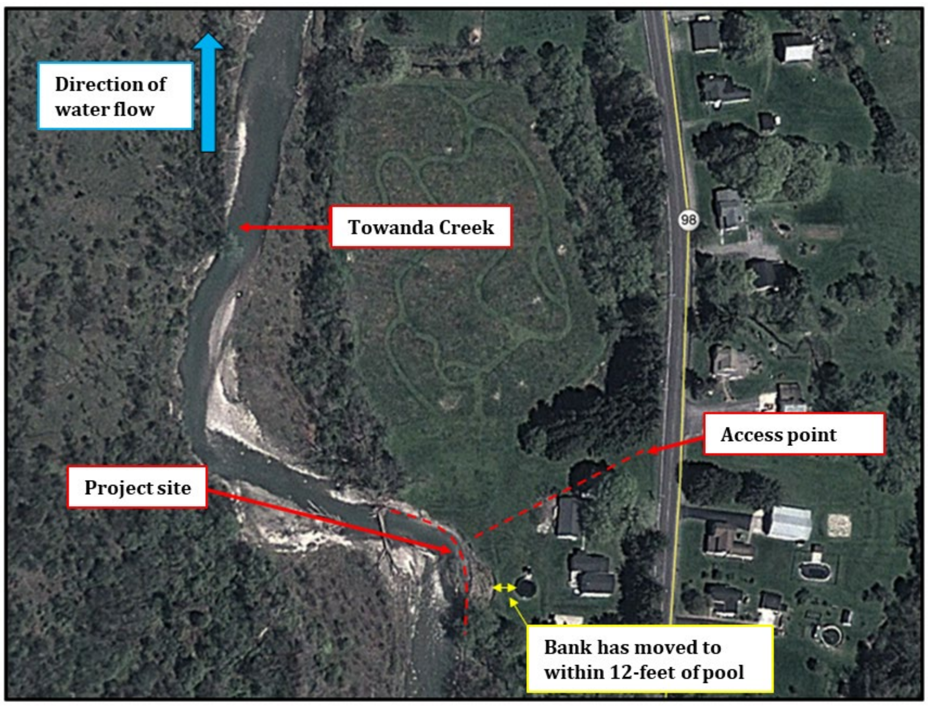


Figure 3. Distance from streambank to threatened structure (yellow line).

LANDSLIDES

The failure mechanism of structures or infrastructure **from landslides** is different from that **of coastal and streambank erosion**. The term "landslide" describes a variety of processes that result in the downward and outward movement of slope-forming materials, such as, but not limited to, rock, soil or artificial fill. **Figure 4** presents major types of landslide movement. Although there are multiple causes of landslides, the three major causes of landslides are (1) water, (2) seismic activity and (3) volcanic activity.

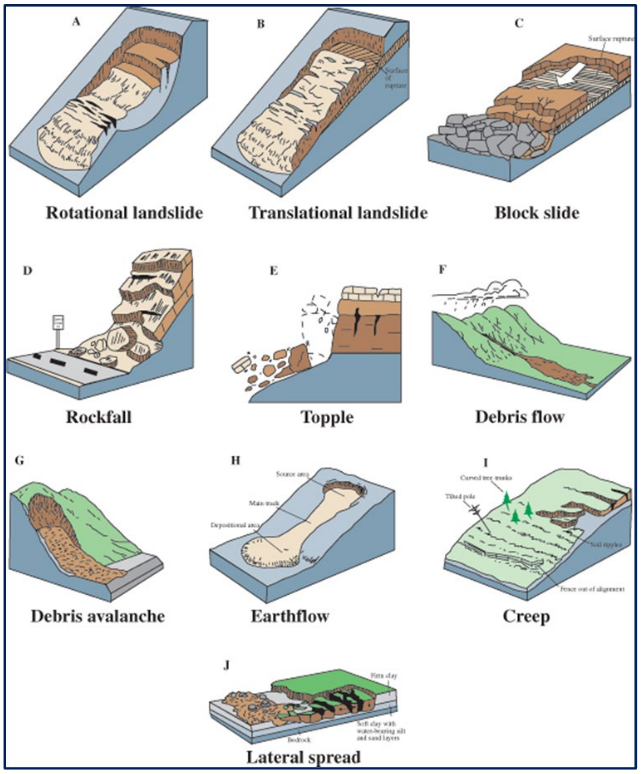


Figure 4. The 10 prominent types of landslides comprise rotational landslide, translational landslide, block slide, rockfall, topple, debris flow, debris avalanche, earthflow, creep and lateral spread.

Landslides due to water: Water saturation of a slope is a primary cause of landslides. This effect can occur in the form of intense rainfall, changes in groundwater levels and flooding along coastlines and rivers. Landslide and flooding are closely related to each other because both are related to precipitation, runoff and the saturation of ground by water. Therefore, the RIs for the failure of structures or infrastructure from landslides caused by water could be related to the RIs from flooding. If the failure from a landslide has already occurred, the frequency of the storm event at the time of the failure can be selected as the RI. In addition, an estimate for the percent-annual-chance of a landslide occurring can be provided by geotechnical engineers based on a field investigation and analysis. In that case, the estimated percent-annual-chance of the failure needs to be converted into the RI per the definition of the RI. The RI is the inverse of the percent-annual-chance (e.g., a 50-percent-annual-chance of the failure can be converted into the RI of 2 years).

Landslides due to seismic activity: Earthquakes could lead to landslides in the form of soil avalanche, rock avalanche, lateral spreading of soil and soil flow. Soil and rock avalanches are also known as debris avalanches (see Figure 4). Earthquakes could induce landslides through: (A) applying horizontal and vertical forces to slopes, (B) weakening slope soils or a combination of (A) and (B). The strength of the slope, before any earthquake occurs, slope geometry and the magnitude of future earthquakes affect the chance (probability) of future slope failure. Because of the interaction between these factors, a detailed analysis should be made by a registered geotechnical engineer who is an expert in earthquake engineering. The goal of such detailed analysis is to estimate the recurrence interval of each potential form of landslide based on detailed geological and geotechnical studies and performing probabilistic analyses. Earthquake-induced ground accelerations can be assessed using the Unified Hazard Tool (on the website of the U.S. Geologic Survey). The U.S. Geologic Survey Earthquake Hazards Program has the return period of earthquake as one of its inputs and includes lists, maps, and statistics of earthquakes.

Landslides due to volcanic activity: Volcanic landslides could be **debris avalanches** or **lahars.** A debris avalanche is a rapid downhill movement of rocky material, snow and/or ice. Debris avalanches are triggered typically when eruptions occur, although they could occur because of heavy rainfall or earthquakes. Lahars are mudflows, or debris flows, composed mostly of volcanic materials on the flanks of a volcano. Close to their source, these lahars are powerful enough to rip up and carry trees, houses, and large boulders downstream. Because volcanic slides are closely related to volcanic eruptions, a detailed analysis by a registered geotechnical engineer or geologist who has the prerequisite expertise should be performed. The RI of volcanic eruptions could be estimated from historical records. However, the geotechnical analysis of a given volcano should provide the probability of debris avalanches and/or lahars occurring and the extent of damage that such landslides could inflict. The USGS Volcano Hazards Program has useful references and records of volcanic eruptions. Additionally, the Volcano Hazards Program includes the Lahar Modeling Tool that can assist in developing lahar hazard maps.

Imminent failure: Due to either streambank erosion or landslides, structures and infrastructure may be deemed to be at risk of **imminent risk of failure**. An engineer, geologist or geomorphologist must certify in a geotechnical report, provided with the grant application, that structures or infrastructure is at imminent risk of failure and how long until the slope is anticipated to fail. For example, an engineer may determine that a slope will fail within a defined period if no mitigation action occurs. If this is the case, the imminent failure BCA methodology can be used for either an acquisition or a mitigation project. This will be discussed in the next steps.

STEP 9: Cost-Effectiveness Analysis

Description: Cost-effectiveness must be demonstrated to obtain FEMA funding. A BCA is a quantitative procedure that assesses the cost-effectiveness of a hazard mitigation measure over the useful life of the project by comparing the potential avoided damages (benefits) associated with the mitigation measure to the cost of a project in current dollars. This section provides guidance on the following:

- **Step 9A:** Benefit-Cost Analysis Tool – Historical Damages and Professional Expected Damages
- **Step 9B:** Imminent Failure Benefit-Cost Analysis Methodology
- **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.

FEMA will only consider applications that use a FEMA-approved methodology to demonstrate cost-effectiveness. FEMA provides BCA software 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 considered cost-effective. FEMA requires the use of the BCA Tool to verify calculations are consistent with Office of Management and Budget Circular A-94 *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.* The BCA must be performed using the most current version of the BCA Tool. Benefits may include avoided damage, loss of function, and displacement. In the case of landslide projects, these include:

- Avoided physical damage to structure(s) and contents

- Avoided displacement costs – the costs required to move and reside in a temporary location while repairs are performed on the structure
- Avoided life safety damages (injuries or casualties)
- Avoided loss of public services (for public properties)
- Avoided loss of life or delay in essential services (critical services)
- Avoided loss of service (for utilities)
- Avoided loss of function (for roads and bridges)
- Avoided loss of rental income
- Avoided volunteer labor time that typically supports cleanup and repair work
- Avoided loss of business income or net revenue (for commercial properties)

There are several benefits that could be counted for a project, and any or all benefits can be included in a BCA when analyzing cost-effectiveness. The approach outlined in Step 9A of this supplement is focused primarily on avoided physical damage, loss of service/function and displacement costs associated with a soil stabilization project. It is recommended that the applicant start on a BCA using these types of benefits as they are typically the largest benefits.

The approach outlined in Step 9B of this supplement is focused on the BCA methodology if the soil stabilization project will protect structures and/or infrastructure determined to be at imminent risk or failure. Damages that were discussed in Step 9A will also be used in this step.

If the BCR does not exceed 1.0 or is slightly over 1.0 after following Step 9A or Step 9B, move to Step 9C to find additional methods for calculating potential benefits for the project.

While setting up your BCA for a soil stabilization project, be sure to select the Property Structure Type that most represents the structures and/or infrastructure the project will be protecting. For the Hazard Type, select "Landslide" and for Mitigation Action Type, select "Soil Stabilization."

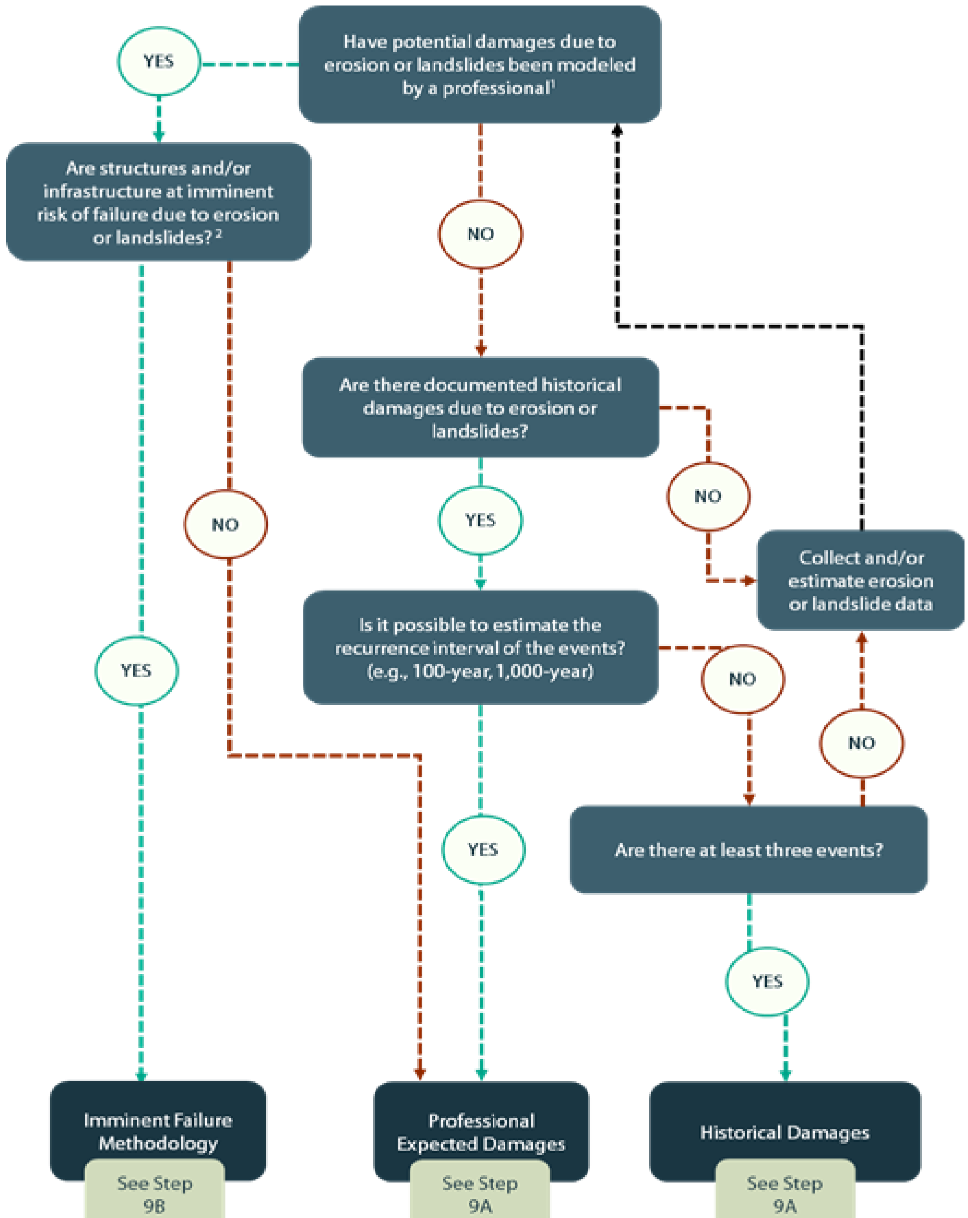
A soil stabilization project can reduce risk to several facilities, including roads, bridges and utilities. The approach to the BCA depends on the facilities being protected and the data available.

- If data for historical damages or professional expected damages is available, the BCA Tool uses a damage frequency assessment (Step 9A and Step 9B) to evaluate any type of facility, including structures.
- A combination of modeled, historical and estimated damages can be used when evaluating structures and other infrastructure together.

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

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

Approach: There are several methods to evaluate cost-effectiveness. The method used will depend on the project type and the data collected in the previous steps of this supplement. Use the flowchart in **Figure 5** to analyze the data available for the project site and determine the recommended approach.



NOTES

[1] If professional expected damages are used, the application must include the recurrence interval in the models and the model results must be included as documentation.

[2] If the imminent failure BCA methodology is used an engineer, geologist, or geomorphologist must certify in a geotechnical report, provided with the grant application, that structures or infrastructure is at imminent risk of failure and how long until the slope is anticipated to fail.

Figure 5. Flowchart for determining the appropriate BCA frequency and damage relationship in the FEMA BCA Tool.

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

Description: The FEMA BCA Tool Damage Frequency Assessment (DFA) modules calculate project benefits and costs for proposed mitigation actions to mitigate any hazard. These modules compare user-entered damages/losses and the frequency of occurrence in the before-mitigation scenario versus the after-mitigation scenario to calculate benefits based on avoided damages. They are used when the user has damages data for historical hazard events or based on professional expected damages, such as model results.

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: Historical and Professional Expected Damages calculate project benefits for proposed hazard mitigation projects based on either documented historical damages (such as physical damages or loss of function) or professional expected damages (estimated damages that have not yet occurred or that occurred but not to the extent possible) from at least one known frequency event. If RIs are not known and there are historical damage data from at least three events, the FEMA BCA Tool can estimate the RIs for each event. Otherwise, additional data collection or analysis will be needed. The calculation compares before- and after-mitigation conditions for events with the indicated recurrence intervals. An example calculation is shown in **Table 1**.

- **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., 10-year event, 50-year event) can be entered in the historical and professional expected damages modules to perform a BCA. For example, if a road has been closed because of a landside, historical and/or professional expected damages will estimate the loss of function damages based on information provided by the applicant on estimated number of traffic trips, additional travel time and number of additional miles during the road closure. Other damages, such as emergency road repair costs, also could be included.
- **After-mitigation:** Damages for the same scenario 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.

Table 1: Before- and after-mitigation estimated damages for a landslide event causing a road closure.

Recurrence Interval	Historical or Expected Damages Before Mitigation		Expected Damages After Mitigation	
	Emergency Cleaning/Repair	Loss of Function (Road)	Emergency Cleaning/Repair	Loss of Function (Road)
10-year	$5,000	$47,070	$0	$0
100-year	$15,000	$94,140	$3,000	$9,414

To verify the information entered in the BCA software, the following supporting information needs to be provided.

1. Project useful life – FEMA-approved values can be found in the BCA Reference Guide or within the BCA Help Content

2. Project cost – Refer to **Step 4**
3. Provide the annual maintenance cost associated with maintaining the effectiveness of the mitigation project.
4. Provide technical calculations detailing the event's frequency analysis and explaining how recurrence intervals were determined.
5. Provide engineering calculations, studies or designs to document the project's level of protection.
6. For loss of function, provide the basis for determining the BCA Toolkit properties for the infrastructure benefitting from the project (i.e., roads and bridges, utilities, critical facilities). For example, for a road closure, provide a traffic study to document the number of traffic trips and maps or other documents to support additional miles and time per trip.

STEP 9B: Imminent Failure Benefit-Cost Analysis Methodology

Description: For structures and/or infrastructure determined to be at imminent risk of failure, this BCA methodology may be used. As in **Step 10A**, the FEMA BCA Tool Professional Expected Damages will be used to calculate project benefits and costs for proposed mitigation projects. For this methodology, professional expected damages will be used.

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: Professional Expected Damages will be used to calculate project benefits for a proposed hazard mitigation action that will mitigate the risk of imminent failure. Before-mitigation damages will be based on the time to failure as determined in a geotechnical report and potential damages associated with the failure. An example calculation is shown in **Table 2**.

- **Before-mitigation:** Based on existing conditions at the site. To demonstrate the current risk, enter the estimated time to failure as the recurrence interval. Then enter the estimated damages to the structure and/or infrastructure if the slope were to fail. For example, an engineer has determined that a bridge will be structurally compromised within 10 years due to streambank erosion. If this erosion occurs, traffic will not be allowed to use the bridge and significant repairs would be necessary. The BCA Tool will estimate the loss of function damages based on information provided by the applicant on estimated number of traffic trips, additional travel time and number of additional miles during the road closure.
- **After-mitigation:** The after-mitigation damages should be estimated based on the level of protection provided by the project.

Table 2: Before- and after-mitigation estimated damages for a landslide event causing a road closure.

Expected Damages Before-Mitigation			Expected Damages After-Mitigation		
Recurrence Interval	Repairs	Loss of Function (Road)	RI	Repairs	Loss of Function (Road)
10-year	$2,000,000	$167,000	100-year	$1,500,000	$58,000

To verify the information entered in the BCA software, the following supporting information needs to be provided.

1. Project useful life – The time to failure as determined by a professional should be used as the project useful life
2. Project cost – Refer to **Step 4**
3. Provide the annual maintenance cost associated with maintaining the effectiveness of the components installed as part of the mitigation project.
4. Provide technical calculations to support the time to imminent failure.
5. Provide engineering calculations, studies or designs to document the project's level of protection.
6. For loss of function, provide the basis for determining the BCA Toolkit properties for the infrastructure benefitting from the project (i.e., roads and bridges, utilities, critical facilities). For example, for a road closure, provide a traffic study to document the number of traffic trips and maps or other documents to support additional miles and time per trip.

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

Description: There are several benefits that could be counted for a project. Any or all 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. Are there any non-critical government services, such as a permit office or library, provided from impacted properties?
2. Are residential structures impacted? If so, how many residents live within the structure? If this information is not readily available, use averages from Census data related to the municipality or county. This information can be used to estimate displacement costs.
3. 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 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.
4. Are there any businesses impacted? How much income does that business bring in per month?

STEP 10: Environmental and Historic Preservation Considerations

Description: Environmental and historic preservation compliance will need to be considered as part of the application process for soil stabilization projects. The assistance of a licensed professional engineer, architect or contractor may be required to help obtain the necessary information about EHP compliance. Refer to the EHP Supplement Job Aids.

Resources

Below is a comprehensive list of resources identified throughout this supplement. Not all these resources are necessary for every soil stabilization project but are provided to ease identification of source material.

PROGRAM AUTHORITIES

- 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
- 2 Code of Federal Regulations, Part 200

PROGRAM GUIDANCE

- FEMA Hazard Mitigation Assistance Guidance (and Hazard Mitigation Assistance Guidance Addendum)
- Benefit-Cost Analysis Reference Guide and Supplement to the Benefit-Cost Analysis Reference Guide

TECHNICAL GUIDANCE AND STANDARDS

- Streambank Bioengineering Job Aid
- Engineering with Nature. Alternative Techniques to Riprap Bank Stabilization
- Streambank and Shoreline Protection Manual
- Summary Metadata – Landslide Inventories across the United States: U.S. Geological Survey data release
- Earthquake Hazards and Risk Assessment: U. S. Geological Survey
- Volcano Assessment: U.S. Geological Survey Webpage

ADDITIONAL TOOLS AND RESOURCES

- FEMA's How to Find Your FIRM and Make A FIRMette
- FEMA's Map Service Center
- FEMA Benefit-Cost Analysis (BCA) Tool
- Cost Estimating Principles for Hazard Mitigation Assistance Applications
- FEMA's National Flood Hazard Layer
- Hazard Mitigation Assistance Application Development
- Hazard Mitigation Assistance Application Development
- EHP Review Supplements
- FEMA Hazard Mitigation Assistance Job Aids
- USGS Landslide Hazard Program