

Supplemental Guidance

For Conducting a Benefit-Cost Analysis (BCA) for a Floodwater Diversion and Storage Project

1. Purpose

According to the FY2016 Pre-Disaster Mitigation (PDM) program Notice of Funding Opportunity (NOFO), Climate Resilient Mitigation Activities are eligible for PDM funding. The NOFO lists the Floodwater Diversion and Storage (FDS) project type as one of these eligible project types. Because the benefits that could be applicable to an FDS project have not yet been incorporated into the BCA Tool, this document was developed to assist users of FEMA's BCA Tool in performing a benefit cost analysis for an FDS project. The process for conducting a BCA may involve inputting data in existing data fields in the BCA Tool, using a FEMA-created spreadsheet, and/or calculating losses manually and then entering them into new loss category fields in the BCA Tool.

2. Floodwater Diversion and Storage Project Type

Every year, communities face significant damages from flooding. A mitigation project that diverts floodwaters from a stream, river, or other body of water into a wetland, floodplain, canal/ditch, pipe, or other conduit (e.g., tunnels, wells) and stores them in reservoirs, floodplains, wetlands, or other storage facilities allows for a controlled release to reduce the peak flows and velocities to mitigate flooding. Managing floodwaters through diversion, storage, and infiltration also can replenish water supply aquifers through groundwater recharge, which can increase the baseflow and enhance usable water supply to mitigate the effects of drought. A floodwater diversion project also can help maintain healthy ecosystems.

3. BCA Tool Modules Used to Conduct a BCA

The first step in completing a cost effectiveness analysis for an FDS project is to determine the type of damages and losses that would be mitigated by the proposed project. Then determine which module of the BCA Tool should be used to conduct the BCA.

- Use the **Flood Module** if all of the following conditions are met:
 - The proposed project will lower flood levels to existing, floodprone structures.
 - Structure-specific data are available, such as the square footage and first floor elevation for each structure.
 - A detailed study of the effectiveness of the proposed project has been completed, such as a hydrology and hydraulics (“H&H”) study. Such a study will identify how much the proposed project would reduce the flood depths for each structure.

- Use the **Damage Frequency Assessment (DFA) Module** if the proposed project would result in mitigating any of the following categories of losses:

- Loss of function of public infrastructure (i.e., roads and bridges)
- Loss of function of utilities
- Loss of function of critical facilities, i.e., police stations, hospitals, or fire stations
- Agricultural and crop losses

It is possible to use **both** modules to analyze one project. The Flood Module would be used to assess the avoided damages to structures, and the DFA Module would be used to assess the avoided losses to public infrastructure, utilities, critical facilities, or crops.

Section 4 describes common data that will need to be inputted no matter which BCA Tool Module is used. Section 5 provides guidance on entering data used in the Flood Module, and Section 6 provides guidance on entering data used in the DFA Module.

4. Common Data Inputs

The following BCA Tool data are required to be entered no matter whether the Flood Module, DFA Module, or both modules are used to conduct an analysis:

- **Project Useful Life:** The FEMA standard value for the project useful life of an FDS project is 30 years. If a user enters a different value, supporting documentation from an expert should be provided.
- **Mitigation Project Cost:** The project cost estimate must be developed by a licensed professional and must meet the same programmatic requirements as for any hazard mitigation project. For more information about the requirements developing a cost estimate, refer to Section H.4.3 (p. 64) of FEMA's FY15 *Hazard Mitigation Assistance Guidance*.
- **Annual Project Maintenance Cost:** Annual operation and maintenance costs generally range from 0.5% to 1% of the construction costs and can include labor costs (for system operation and maintenance, regulatory requirements, and administration) and material and equipment costs (e.g., fencing, trails, equipment, parts replacement, inlet/outlet controls, and scour protection). Like the project costs, these estimates must be developed and documented by a licensed professional.

5. Flood Module Data Inputs

The data required to be entered when using the Flood Module to conduct a BCA are associated with elevations and discharges before and after mitigation and data needed to calculate environmental/ecosystem benefits.

5.1 Elevations and Discharges After Mitigation

On the Riverine Elevation and Discharge Data screen, first select the "Show After Mitigation" button to change the data entry table. In the table associated with each structure (see screen capture below), enter the flood elevations after mitigation and the discharges after mitigation for each recurrence interval.

Riverine Elevation And Discharge Data

Enter the First Floor Elevation *

FEMA Elevation certificate diagram description Other elevation source

Streambed Elevation (ft) *

Flood Source Name

Flood Profile Number

(Note that the vertical datum for the Flood Elevation must match the vertical datum used for the First Floor Elevation)

Recurrence Interval (yr) *	Percent Annual Chance (%)	Elevation Before Mitigation (ft) *	Elevation After Mitigation (ft)	Discharge Before Mitigation (cfs) *	Discharge After Mitigation (cfs)
10	10.00%	762.10	762.10	4530.0	4530.0
50	2.00%	763.80	763.80	6100.0	6100.0
100	1.00%	764.80	764.80	6780.0	6780.0
500	0.20%	767.00	767.00	8420.0	8420.0

5.2 Benefit-Cost Ratio from Mitigation of Structures

Environmental benefits are applicable to any project that would create or restore wetlands, estuaries, riparian areas, or green open space. Current BCA policy (Section I.6, p. 66, of FEMA's FY15 *Hazard Mitigation Assistance Guidance*) states that a project must have a benefit cost ratio (BCR) ≥ 0.75 calculated from avoided damages/losses to structures before environmental benefits can be included. Therefore, after all structures have been analyzed, check to see if the project BCR is ≥ 0.75 on the Project Inventory screen. If the BCR is < 0.75 , environmental benefits will not be added. (Note that even if the analysis below is conducted and submitted, FEMA will not approve the added benefits.) If the BCR ≥ 0.75 , complete the analysis below to calculate the environmental benefits, add them to the existing benefits, and calculate a new BCR.

5.3 Environmental/Ecosystem Benefits

Because the new and updated environmental benefits have not yet been programmed into the BCA Tool, the Ecosystem Service Benefits Calculator spreadsheet was created to use as a workaround. Along with the exported Flood Module BCA, the completed spreadsheet is required to be submitted with the subapplication as cost effectiveness documentation.

The Ecosystem Service Benefits Calculator spreadsheet is available by contacting your FEMA Region or by calling the BC Helpline at 1-855-540-6744. The format of the spreadsheet is shown in the graphic below. There are thirteen data fields in the spreadsheet. An asterisk (*) is used to denote whether the user must input the data. The rest of the data fields are either pre-populated or calculated fields. For each numbered data field, an explanation is provided to aid in completing the spreadsheet.

- #1. **Enter Project Type.** *Input required. Enter "Floodwater Diversion and Storage."
- #2. **Ecosystem Service Type.** *Input required. By clicking in the shaded cell, a drop-down menu appears and offers the selections of Forest, Green Open Space, Marine, Estuary and Marine, Riparian, or Wetland. Select the ecosystem service type that matches the anticipated land use after the project is completed.

Including Additional Ecosystem Service Benefits for FEMA's Benefit Cost Analysis			Input Required
Enter Project Type	Floodwater Diversion and Storage		* 1
Ecosystem Service Type	Green Open Space		* 2
Benefits Per Acre	\$	8,308	3
Number of Acres of the Project		5	* 4
Total Benefits per Year	\$	41,540	5
Enter Project Useful Life		30	* 6
Discount Rate		0.07	7
Total Additional Benefits (Discounted)	\$	526,153.08	8
Benefits Calculated by BCA Tool (Project Benefits)	\$	377,730.00	* 9
Project Costs utilized in BCA Tool	\$	189,610.00	* 10
Benefit Cost Ratio Before Additional Benefits		1.99	11
*Note: Ecosystem Service Benefits cannot be included if the project ratio is less than 0.75			
Total Project Benefits with Ecosystem Service Benefits (if meeting the >0.75 requirement)	\$	903,883.08	12
Adjusted Benefit Cost Ratio		4.77	13

- #3. **Benefits Per Acre:** This is the default economic value associated with the benefits per acre of land for the Ecosystem Service Type selected in #2. This value cannot be modified.
- #4. **Number of Acres of the Project:** *Input required. From the design or other documentation included in the subapplication, enter the number of acres that are being set aside for use as flood storage.
- #5. **Total Benefits per Year:** This economic value is automatically calculated as Benefits Per Acre (#3) multiplied by Number of Acres of the Project (#4).
- #6. **Enter Project Useful Life:** *Input required. The FEMA standard value for the useful life of an FDS project is 30 years. If a user enters a different value, supporting documentation from an expert should be provided. The value entered here in the spreadsheet should be the same value as entered in the BCA Tool as stated in Section 1.
- #7. **Discount Rate:** A discount rate of 7%, or 0.07, is currently required by the Office of Management and Budget. This value cannot be modified.

- #8. **Total Additional Benefits (Discounted):** This economic value is automatically calculated using the Total Benefits per Year (#5), the Project Useful Life (#6), and applying the annual Discount Rate (#7).
- #9. **Benefits Calculated by BCA Tool (Project Benefits):** *Input required. This economic value is calculated by the Flood Module in the BCA Tool and must be transferred to the spreadsheet. On the Summary of Benefits screen (see screen capture below), the economic value for Mitigation Benefits are the Project Benefits for your project. Enter this value for #9.

Summary of Benefits	
Expected Annual Damages Before Mitigation	
Annual	\$ 26,472
Present Value	\$ 377,730
Expected Annual Damages After Mitigation	
Annual	\$ 0
Present Value	\$ 0
Expected Avoided Damages After Mitigation (BENEFITS)	
Annual	\$ 26,472
Present Value	\$ 377,730
MITIGATION BENEFITS	\$ 377,730
MITIGATION COSTS	\$ 189,610
BENEFITS MINUS COSTS	\$ 188,120
BENEFIT-COST RATIO	1.99

- #10. **Project Costs utilized in BCA Tool:** *Input required. This value of Project Costs is the same as the value for Final Mitigation Project Cost found at the bottom of the Cost Estimation Info screen of the BCA Tool as shown in the screen capture below. Note that this value includes annual project maintenance costs.
- #11. **Benefit Cost Ratio Before Additional Benefits:** This value for BCR is automatically calculated by dividing Benefits Calculated by BCA Tool (Project Benefits) (#9) by Project Costs utilized in BCA Tool (#10). This calculated value for BCR should be the same as the Benefit-Cost Ratio value calculated in the Flood Module and shown on the Summary of Benefits screen.
- #12. **Total Project Benefits with Ecosystem Service Benefits:** If the BCR in #11 is ≥ 0.75 , then this economic value is automatically calculated by adding the Total Additional Benefits (#8) and Benefits Calculated by BCA Tool (#9). This value becomes the new value for total project benefits. If the BCR in #11 is ≥ 0.75 , then this value is equal to the value of Benefits Calculated by BCA Tool (Project Benefits) in #9, and the additional environmental benefits calculate in #8 are not included in the total.
- #13. **Adjusted Benefit Cost Ratio:** This value is automatically calculated as the new project BCR. It is calculated by dividing the Total Project Benefits with Ecosystem Service Benefits (#12) by the Project Costs utilized in BCA Tool (#10).

If the Adjusted Benefit Cost Ratio (#13) is > 1 , then export the Flood Module BCA, and submit both that BCA and the spreadsheet with the subapplication.

Cost Estimation Info	
Project Useful Life (years) *	30
Do you have a detailed Scope of work ? *	<input checked="" type="radio"/> Yes <input type="radio"/> No
Do you have a detailed estimate for the entire project ? *	<input checked="" type="radio"/> Yes <input type="radio"/> No
<small>(If not complete the summary of cost estimation data entries below)</small>	
Mitigation Project Cost *	\$151,142
Annual Project Maintenance Cost	\$3,100
Summary Of Cost Estimation	
<input type="checkbox"/> Construction Markups	
<input type="checkbox"/> Annual Project Maintenance Costs	
Number of Years of Maintenance	30
Present Worth of Annual Maintenance Costs	\$38,468
Does estimate reflect current prices?	<input type="radio"/> Yes <input type="radio"/> No
Cost Basis Year:	YYYY
Construction Start Year:	YYYY
Construction End Year:	YYYY
Project Escalation	\$
Final Mitigation Project Cost *	\$189,610

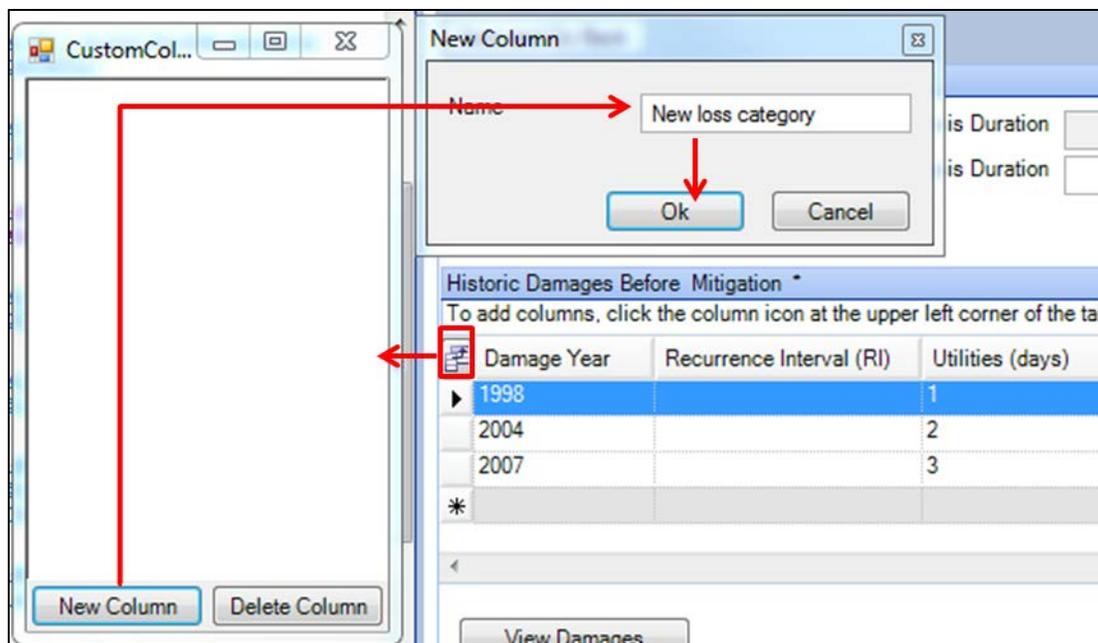
6. DFA Module

One of the following methods is used in the DFA Module as a basis for calculating cost effectiveness:

- **Historic Damages**, which requires information about the frequency (i.e., dates) and severity (i.e., the amount of damage and losses caused) of actual, past flood events.
- **Expected Damages**, which requires an analysis of how much damage and losses would be experienced in the future if flood events of a known frequency (i.e., recurrence interval) were to occur.

The applicable categories of losses/damages should be reflected on the Damages Before Mitigation screen table. The partial screen capture below shows how to add a loss/damage category to the Historic Damages Before Mitigation table. First, click the column icon in the top, left corner of the table. This will open a new window to the left of the table. Select the “New Column” button to create a new column titled “New loss category.” Type the name of the loss category, click “OK,” and the new column will be added to the Historic Damages Before Mitigation table. Repeat this process to add all applicable loss categories.

All categories that are entered into the Damages Before Mitigation table will be automatically displayed in the Damages After Mitigation table on the next screen, Damages After Mitigation. This enables the Tool to calculate the impact of the project on reducing losses.



6.1 Reduced Agricultural/Crop Losses

An FDS project may mitigate losses from crops. To estimate Historic Damages of crops, a farmer may be able to provide documented damage from past flood events, possibly from insurance payments. In the absence of documentation, an estimate of how much damage occurred due to past events could be completed by determining the number of acres impacted by an event and then documenting assumptions for the yield per acre and the market price for the crop grown. To estimate Expected Damages to crops, the same procedure could be followed, making sure that the documentation is included so a reviewer can determine whether the calculations are accurate and the assumptions are reasonable.

To enter the estimated damages in the BCA Tool, the user would add a new loss/damage category named “Crop Damage” (or similar descriptor) to the Historic Damages Before Mitigation table. Then the user would enter the documented value of crop damage for each historic event. In the Damages After Mitigation table, the user would enter the values of expected damages for each expected event.

6.2 Reduced Loss of Function of Roadways

An FDS project may mitigate the loss of function of roadways that are located within the project area through reduced water surface elevations. The loss of function parameters are entered on the Type of Services (left) portion of the screen (see screen capture below). For each roadway, select “Roads/Bridges” as the Facility Type for Loss of Function, and then enter the roadway description on the Roads/Bridges (right) portion of the screen. Enter the required parameters for the loss of function of that roadway: traffic count (one-way trips per day), the additional time of the detour, number of additional miles, and the current Federal mileage Rate (for 2016, the Internal Revenue Service has set this at \$0.54 per mile).

Type of Services	Roads/Bridges
Facility Type For Loss of Function * <input type="checkbox"/> Utilities <input checked="" type="checkbox"/> Roads/Bridges <input type="checkbox"/> Non Residential Buildings <input type="checkbox"/> Not Applicable	Roads/Bridges Facility Description CR180 bridge detour to closest river crossing at CR86 Estimated Number of One-Way Traffic Trips Per Day * 1800 Additional Time per One-Way Trip (hh:mm) * HH: 0 MM: 20 Number of Additional Miles * 15.0 Federal Rate * \$ 0.540 Economic Loss Per Day of Loss of Function * \$ 32,358

The BCA Tool calculates the Economic Loss Per Day of Loss of Function and automatically carries that value over to the Damages Before Mitigation table. The user would enter the loss of function for a roadway in number of days that function is lost. In this example, the Tool would calculate the value of damages as \$32,358 lost per day of loss of function multiplied by the number of days of loss of function. Similarly, to estimate expected Damages After Mitigation, the user would enter the number of days of loss of function for the roadway after mitigation. The same process should be followed for each Historic Damages event and each Expected Damages event.

6.3 Avoided Costs of Stormwater Conveyance and Treatment Infrastructure

If an FDS project would result in increased groundwater infiltration and, therefore, increased water supply, including drought resiliency, then the benefit category of Avoided Costs of Stormwater Conveyance and Treatment Infrastructure is eligible. Reducing stormwater runoff may help avoid investment in expensive stormwater systems. A standard economic value for avoided costs of stormwater conveyance and treatment infrastructure is \$101 per one million gallons of stormwater.

To enter avoided damages from stormwater conveyance and treatment infrastructure into the BCA Tool, the user must manually calculate the total economic value based on the project's design documentation and/or a relevant professional. For example, if the documentation demonstrates that a project would result in storing an additional three million gallons of stormwater, the benefit, or value of avoided damages, would be calculated as:

$$\begin{aligned} \text{Avoided Damages} &= \frac{\$101}{1 \text{ million gallons stormwater}} \times 3 \text{ million gallons stormwater} \\ &= \$303 \end{aligned}$$

This value would be entered in the Damages Before Mitigation table, either for every event in a Historic Damages assessment or for every recurrence interval in an Expected Damages assessment. A value of \$0 should be entered for every recurrence interval in the Damages After Mitigation table.

6.4 Avoided Costs of Providing Alternative Drinking Water Sources

An FDS project would result in recharged water that becomes available for human consumption, and there would be a benefit, i.e., avoided costs, associated with not having to construct alternative water supplies because of compromised potable water supply. For drought mitigation, a standard economic value for the avoided cost of building infrastructure of alternative public drinking water supplies is \$3,455 per one million gallons of water.

To enter avoided damages from building infrastructure of alternative public drinking water supplies into the BCA Tool, the user must manually calculate the total economic value based on the project's design documentation and/or a relevant professional. For example, if the documentation demonstrates that a project would result in not having to construct infrastructure to store three million gallons of alternative water supply, the benefit, or value of avoided damages, would be calculated as:

$$\begin{aligned} \text{Avoided Damages} &= \frac{\$3,455}{1 \text{ million gallons water}} \times 3 \text{ million gallons water} \\ &= \$10,365 \end{aligned}$$

This value would be entered in the Damages Before Mitigation table, either for every event in a Historic Damages assessment or for every recurrence interval in an Expected Damages assessment. A value of \$0 should be entered for every recurrence interval in the Damages After Mitigation table.

6.5 Reduced Damages Associated with Subsidence

An FDS project may result in aquifer recharge and water table stabilization, which can help slow or lessen land subsidence, which, in turn, would potentially reduce structural damage to facilities in the vicinity of the project. There are currently no standard values in the BCA Tool for this type of benefit. If a subapplicant wishes to include this benefit, the subapplicant would need to quantify the benefits and provide proper documentation for inclusion in the BCA. The documentation must include information so a reviewer could determine whether the calculations are accurate and the assumptions are reasonable. For assistance with specific questions, users are encouraged to contact the BC Helpline.

As described for the other categories of avoided losses/damages, this loss category would be added to the Damages Before Mitigation table. Actual or calculated losses from past events would be entered in the Historic Damages Before Mitigation table, and the reduced values of losses reflecting the impact of the project would be entered in the Damages After Mitigation table.

6.6 Avoided Costs Associated with Loss of Business for Water-Dependent Sectors

An FDS project could result in a benefit of reducing the loss of business for businesses in water-dependent sectors. Examples of such benefits include reduced unemployment benefits or reduced losses of tax revenue from businesses. There are currently no standard values in the BCA Tool for this type of benefit. If a subapplicant wishes to include this benefit, the subapplicant would need to quantify the benefits and provide proper documentation for inclusion in the BCA. Per OMB Circular A-94, care should be taken to avoid the use of economic multipliers and to make

sure any damage values are directly tied to the project. The documentation must include information so a reviewer could determine whether the calculations are accurate and the assumptions are reasonable.

As described for the other categories of avoided losses/damages, this loss category would be added to the Damages Before Mitigation table. Actual or calculated losses from past events would be entered in the Historic Damages Before Mitigation table, and the reduced values of losses reflecting the impact of the project would be entered in the Damages After Mitigation table.

6.7 Environmental/Ecosystem Benefits

To calculate Environmental/Ecosystem Benefits using the DFA Module, follow the same process described in Section 5.1, Environmental/Ecosystem Benefits, for the Flood Module.

If project benefits are calculated using **both** the DFA Module and the Flood Module, then the benefits calculated by each module will need to be combined. The value of the Benefits Calculated by BCA Tool (Project Benefits) (#9 in spreadsheet) should be the sum of project benefits calculated by each module. An export of both the Flood Module analysis and the DFA Module analysis would be required as documentation for the reviewer to validate.