APPENDIX C

Using the Hurricane Wind Module for Determining Cost Effectiveness of Retrofit Projects

C.1 Introduction

The FEMA BCA Tool (Version 4.5.5) is used to determine the cost-effectiveness of proposed mitigation projects submitted for funding under FEMA mitigation grant programs. The software estimates the economic consequences that may occur during a natural disaster (flood, hurricane, tornado, earthquake, or wildfire) based on two scenarios, with and without the proposed mitigation measure. For hurricane wind, losses are estimated using wind-damage functions developed to predict wind impacts to the building, its contents, and loss of use of the building following a storm. The wind-damage functions relate peak gust wind speeds to predicted percentages of damage that would be expected for a building exposed to storms at a given recurrence interval. The recurrence intervals of hurricane wind speeds are based on the building's location (using either the building zip code or latitude/longitude and wind speed data derived from HAZUS-MH). The anticipated damages vary based on the type of building and its construction attributes. Wind-damage functions are a critical factor in the economic analysis for determining the cost-effectiveness of proposed mitigation measures aimed at reducing losses during high-wind events.

The purpose of this appendix is to provide guidance on using the FEMA BCA Tool to complete a BCA for the retrofit solutions and best practices for single-family homes outlined in FEMA P-804, *Wind Retrofit Guide for Residential Buildings*. This appendix identifies the wind-damage functions in the FEMA BCA Tool that best represent the Mitigation Packages outlined in this Guide (see Figure 4-1); it provides a brief background and introduction to the software and step-by-step instructions on how to complete a BCA to evaluate cost effectiveness.

C.2 Background

As part of the process for developing this *Wind Retrofit Guide for Residential Buildings,* FEMA convened an expert panel to identify and develop the wind-damage functions to estimate the cost effectiveness of the mitigation projects outlined in this Guide. The panel reviewed the various characteristics and construction attributes that affect the wind-damage functions for a residential single-family building in the FEMA BCA Tool (see Table C-1 below).

TABLE C-1: FEMA BCA Tool Characteristics

Characteristic	Value	Comments
Building Type	Wood or Masonry	Indicates if the single-family residence is wood or masonry.
Number of Stories	One Story, or Two or More Stories	Indicates if the single-family residence is one or more stories.
Roof Shape	Hip or Gable	Indicates if the single-family residence has a hip or gable roof.
Secondary Water Resistance	Yes or No	Identifies whether there is a secondary water resistance barrier to prevent water penetration through the roof decking after the loss of the roof covering.
Roof Deck Attachment	6d Nails at 6/12, 8d Nails at 6/12, 6d/8d Mix at 6/6, or 8d Nails at 6/6	Refers to the size (e.g., 6d nails) and spacing of the nails (6/12 is 12 inches o.c., 6/6 is 6 inches o.c.) that attach the roof decking.
Roof-Wall Connection	Toe-Nail or Strap	Indicates if the load path of the single-family residence can transfer loads from the roof to the foundation. In general, a strap provides a better connection from the roof framing to the walls than solely nails. The roof-wall connection has been a primary point of failure in past hurricanes.
Shutters	Yes or No	This characteristic indicates if the single-family residence has shutters, thereby reducing windborne debris damage to the building and contents.
Garage	None, Weak Door, Standard Door, or South Florida Building Code (SFBC) 94 (if shuttered)	Indicates whether the residence has a garage, and, if present, the strength of the garage door. Reinforced garage doors are considered standard and unreinforced doors are considered weak.
Masonry Reinforcing	Yes or No	This characteristic indicates if a masonry single-family residence has reinforced or unreinforced masonry walls.

Based on the expected building performance accomplished by the retrofits associated with the Mitigation Packages outlined in this Guide, the scenarios presented in Table C-2 represent before- and after-mitigation conditions in the FEMA BCA Tool. Building properties in yellow highlighted cells are those that normally change as a result of implementing the retrofit project and therefore differ before versus after the mitigation, depending on existing building properties.

After a user selects the characteristics outlined in Table C-2, the FEMA BCA Tool automatically applies wind-damage functions to reflect before- and after-mitigation conditions. If necessary, the user can override the wind-damage functions with proper justification and documentation. Figure C-1 shows an example of a wind-damage function. It illustrates the expected ratio of building damages to building value before and after implementing each of the mitigation retrofit packages described in the Guide.

TABLE C-2: Scenarios Representing Before-Mitigation and After-Mitigation Conditions

Mitigation Package	Roof Replacement	Exposure	Garage	Construction Type	Building Type	Shutters	Garage: Without Shutters[1]	Garage: With Shutters[2]	Roof Shape	Masonry Reinforcing[3]	Secondary Water Resistance	Roof Wall Connection	Roof Deck Attachment
User Chooses		B/C	Yes/No	Wood or Masonry	Single-Family/ One/Two or More Stories	Yes/No	None/ Weak/ Strong/ SFBC 1994		Hip/ Gable	N/A, Yes (RM), No (URM)	Yes/No	Toe-Nail/ Strap	
Before Mitigation													
Existing Building[4]	No		Yes			No	Weak	N/A			No	Toe-Nail	6d at 6/12
	Yes		No			No	None	N/A			No	Toe-Nail	6d at 6/12
After Mitigation													
Basic	No		Yes			No	Weak	N/A			Yes	Toe-Nail	8d at 6/12
			No			No	None	N/A			Yes	Toe-Nail	8d at 6/12
	Yes		Yes			No	Weak	N/A			Yes	Toe-Nail	8d at 6/6
			No			No	None	N/A			Yes	Toe-Nail	8d at 6/6
Intermediate	No		Yes			Yes	N/A	SFBC 1994			Yes	Toe-Nail	8d at 6/12
			No			Yes	N/A	None			Yes	Toe-Nail	8d at 6/12
	Yes		Yes			Yes	N/A	SFBC 1994			Yes	Toe-Nail	8d at 6/6
			No			Yes	N/A	None			Yes	Toe-Nail	8d at 6/6
Advanced	No		Yes			Yes	N/A	SFBC 1994			Yes	Strap	8d at 6/12
			No			Yes	N/A	None			Yes	Strap	8d at 6/12
	Yes		Yes			Yes	N/A	SFBC 1994			Yes	Strap	8d at 6/6
			No			Yes	N/A	None			Yes	Strap	8d at 6/6

1) This characteristic will be N/A when the building has shutters.

2) This characteristic will be N/A when the building does not have a garage or shutters.

3) This characteristic will be N/A when the building construction type is wood.

4) This is representative of the worst case scenario.

NOTE: Yellow highlight indicates building properties that commonly change after implementing the retrofit project.

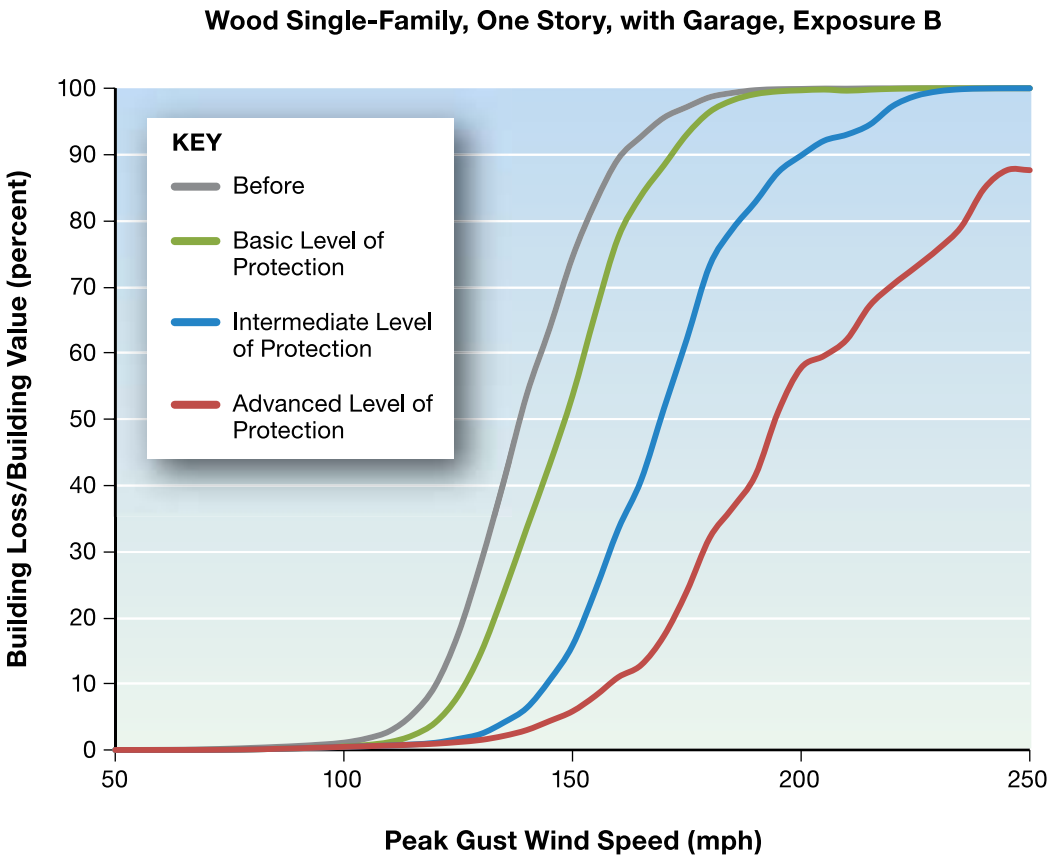


FIGURE C-1: Example wind-damage function for a wood single-family (one-story) building

In addition to identifying appropriate wind-damage functions, the expert panel applied some general assumptions to evaluate the cost effectiveness of hypothetical wind retrofit mitigation projects similar to those described in this Guide. The panel assumed:

Building Exposure	= B (urban and dense suburban)
Building Size	= 1,600 square feet
Building Replacement Value (BRV)	= $111.07/square foot
Building Contents Value	= FEMA standard value of 50 percent of the BRV (in this case, $88,856)
Displacement Cost	= FEMA standard value of $1.44/square foot/month (in this case, $2,304/month)
Estimated Mitigation Project Cost	= Calculated for each retrofit package using each of the characteristics described in Table C-1. The assumed project costs are shown in Table C-3.

More than 600 BCAs for hypothetical mitigation projects were completed using various locations throughout the United States, including San Juan, PR; Miami, FL; Pascagoula, MS; Bay Saint Louis, MS; New Orleans, LA; Houston, TX; and Boston, MA. These locations vary widely in their risk of experiencing hurricane winds, thereby allowing the expert panel to evaluate the sensitivity of the model and the likelihood of each retrofit package being cost effective. Individual retrofit projects are considered cost effective if the project is determined to have a BCR of 1.0 or greater. Aggregation of benefit and cost values is allowed for multiple structures if they are vulnerable to damage as a result of similar hazard conditions. Users of this document should check for the latest HMA guidance at www.FEMA.gov for the application of aggregation within a grant application .

The results are shown in Table C-3. In applying the assumptions outlined above, the results varied most based on whether the building had a hip or gable roof shape, as well as the building's height (number of stories). The same living area was applied for one- and two-story residences, giving the one-story residence a larger building footprint and roof than the two-story residence. Table C-3 illustrates the results and likelihood of the analysis being cost effective for the range of locations outlined above. Note that likelihood of cost effectiveness is highly dependent on location of the home (e.g., residences in the windborne debris region or areas susceptible to high winds are much more likely to be cost effective).

TABLE C-3:
Likelihood of Cost Effectiveness

		One-Story		Two-Story	
	Roof Type	Assumed Cost[1]	Cost Effective[2]	Assumed Cost[1]	Cost Effective[2]
Basic without replacing roof cover	Hip	$3,150	Less likely	$1,950	Less likely
Basic without replacing roof cover	Gable	$4,350	Less likely	$3,150	Less likely
Basic with replacing roof cover	Hip	$7,110	Less likely	$4,150	Less likely
Basic with replacing roof cover	Gable	$9,310	Less likely	$6,350	Less likely
Basic with opening protection without replacing roof cover	Hip	$7,150	Less likely	$5,950	Less likely
Basic with opening protection without replacing roof cover	Gable	$8,350	Less likely	$7,150	Less likely
Basic with opening protection with replacing roof cover	Hip	$11,110	Less likely	$8,150	Less likely
Basic with opening protection with replacing roof cover	Gable	$13,310	Less likely	$10,350	Less likely
Intermediate without replacing roof cover	Hip	$8,850	Likely	$8,650	Likely
Intermediate without replacing roof cover	Gable	$10,350	Highly likely	$10,150	Highly likely
Intermediate with replacing roof cover	Hip	$13,810	Likely	$11,850	Likely
Intermediate with replacing roof cover	Gable	$15,310	Highly likely	$13,350	Highly likely
Advanced without replacing roof cover	Hip	$20,000	Less likely	$23,800	Less likely
Advanced without replacing roof cover	Gable	$21,500	Likely	$25,300	Likely
Advanced with replacing roof cover	Hip	$24,960	Less likely	$27,000	Less likely
Advanced with replacing roof cover	Gable	$26,460	Likely	$28,500	Likely

1. Maintenance costs are not included in the total project cost estimate.

2. Cost effectiveness ratings:
   Highly likely = Cost effective more than 66 percent of the time
   Likely = Cost effective more between 33 and 66 percent of the time
   Less likely = Cost effective less than 33 percent of the time
   (Likelihood varies based on project location)

Table C-3 shows the general likelihood of a retrofit being cost effective and is intended to provide users of this appendix with a preliminary probability before investing time in collecting the data necessary to complete a BCA. Structures in high-risk regions, such as Exposure C (Open), will have different results than those summarized in Table C-3. As a result, it is important to complete a BCA, especially if the characteristics or costs differ from the assumptions outlined above. Instructions for completing a BCA are provided in Section C.3.

C.3 Instructions

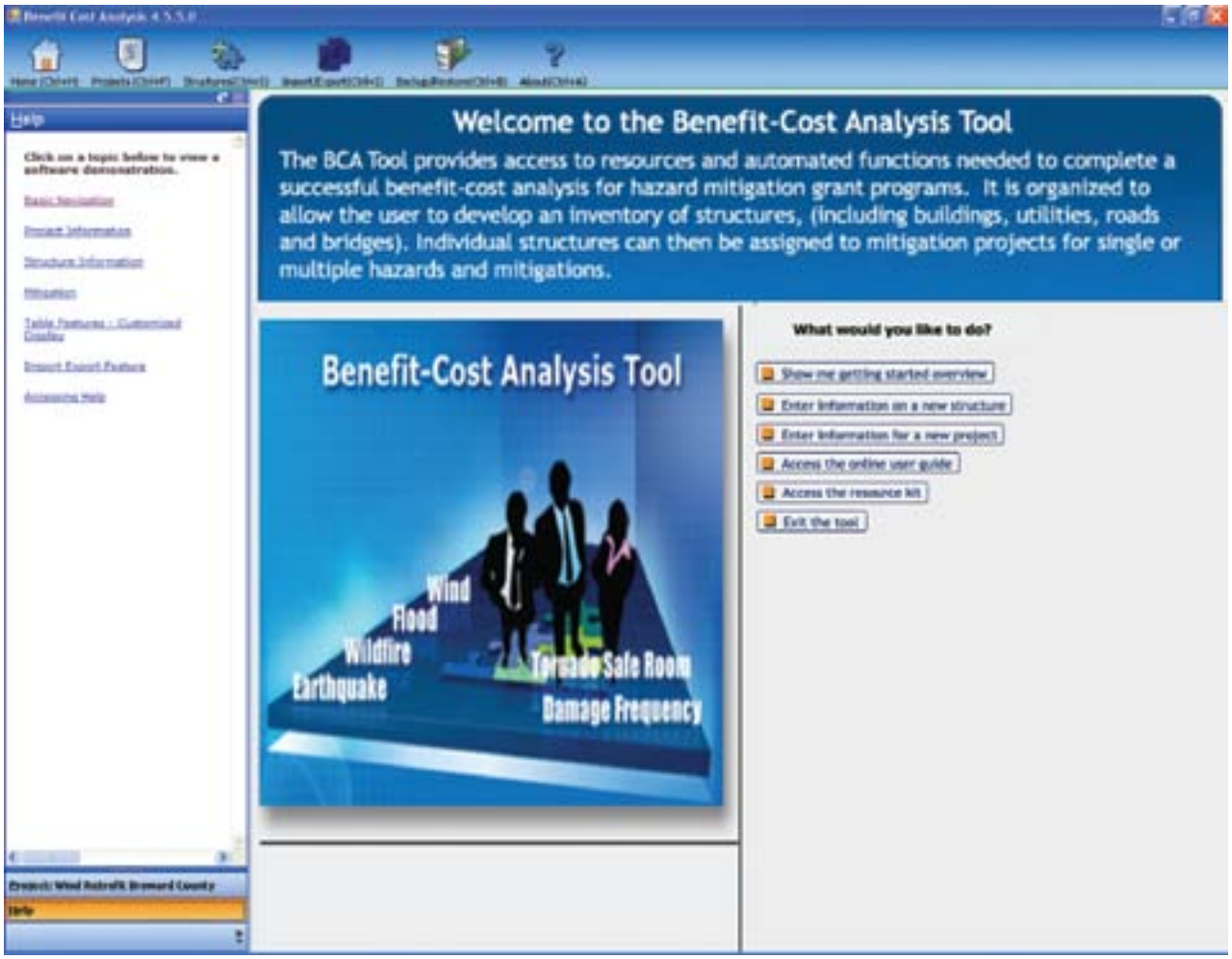
Table C-4 provides parameters for a hypothetical mitigation project in Fort Lauderdale, FL developed for the purpose of illustrating the steps required for a user to complete a BCA utilizing the FEMA BCA Tool. Note that the software has a built-in help feature that addresses frequently asked questions while the user navigates the BCA. Alternatively, users can visit the FEMA BCA Web site at www.fema.gov/government/grant/bca.shtm#1 for additional resources and guidance.

TABLE C-4: Hypothetical Mitigation Project Parameters

Mitigation Project	Intermediate Package without replacing roof cover
Address	123 1st Street, Fort Lauderdale, FL 33155
Project Useful Life	20 years
Cost	$10,350
Annual Maintenance Cost	$150
Exposure	B (urban and dense suburban)
Building Size	1,600 square feet
Building Replacement Value	$111.07/square foot
Building Description	Unreinforced masonry, single-family, one-story residence with a gable roof, without shutters, without reinforced garage, without secondary water resistance, without a load path, and minimal roof sheathing nailing (6d at 6/12)

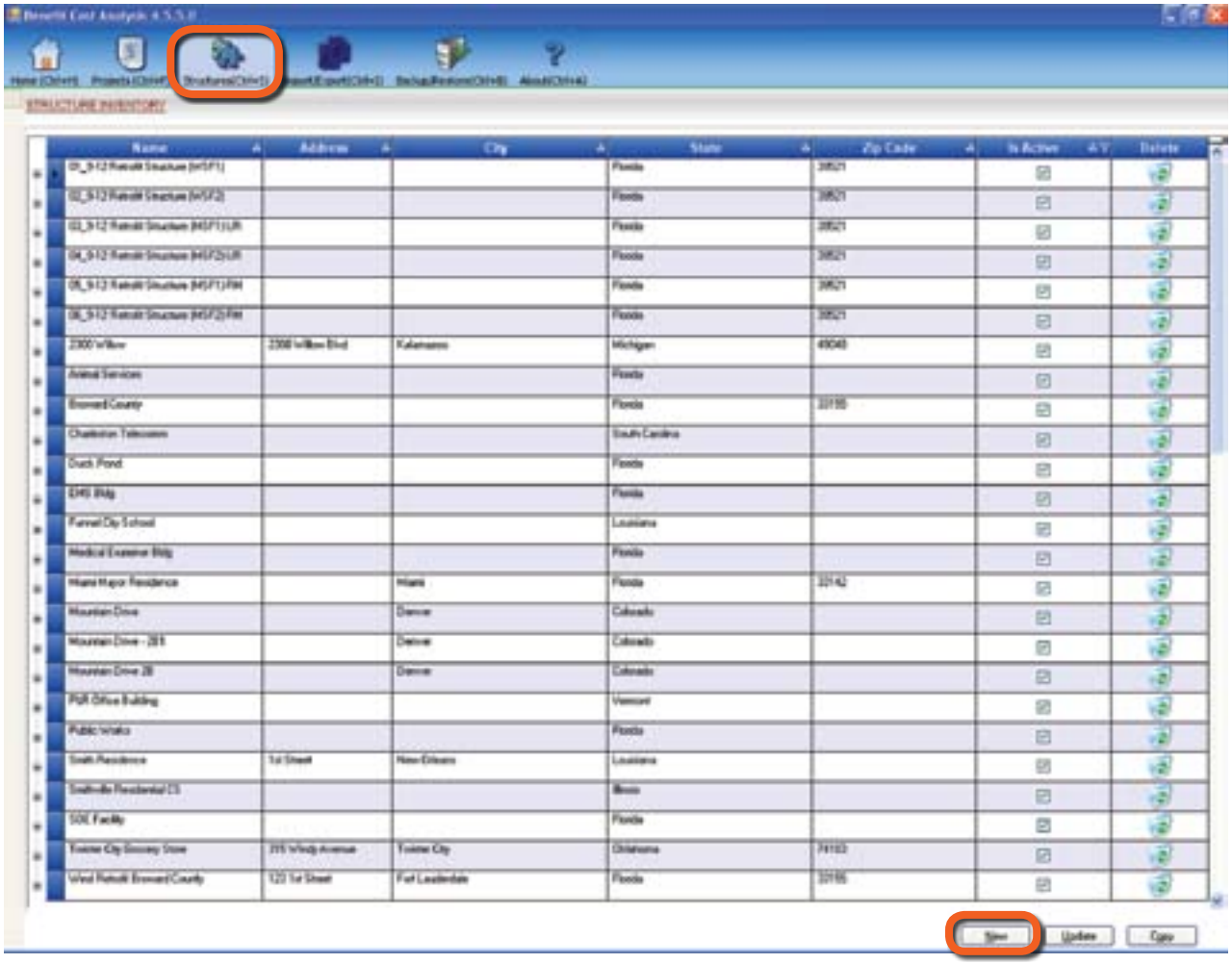
Step 1: Getting Started

- Press the **BCA 4.5.5 Tool** button to get started.
- Press the **Help** button at any time for on-line support.



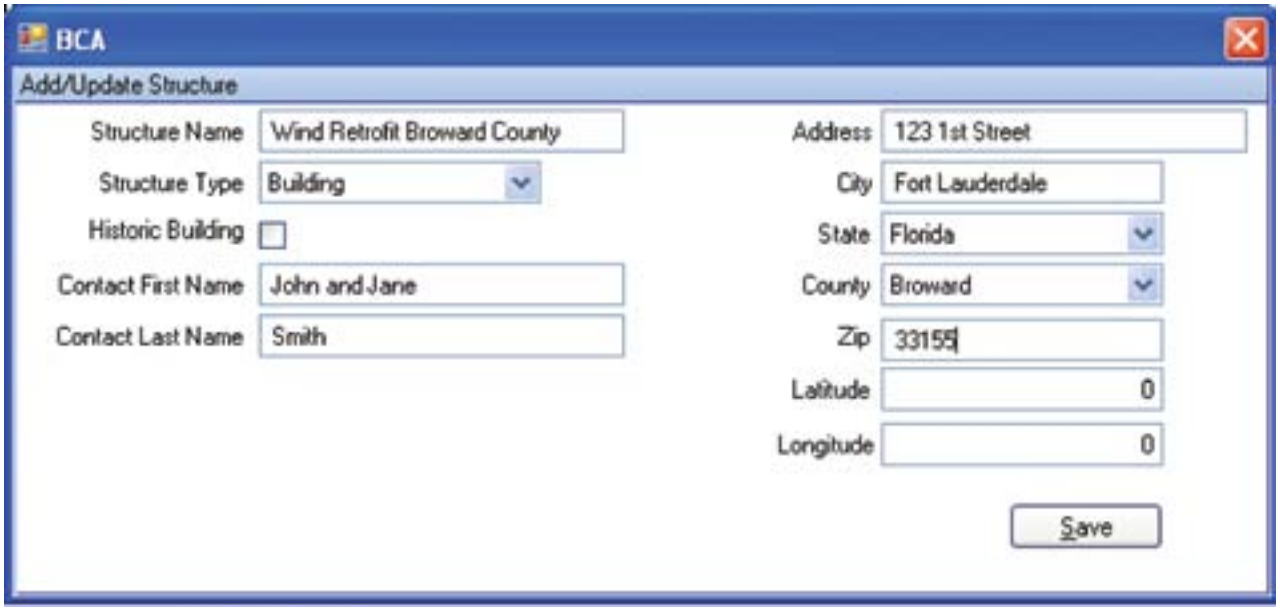
Step 2: Create Structure

- Select the **Structures** button.
- Press the **New** button.



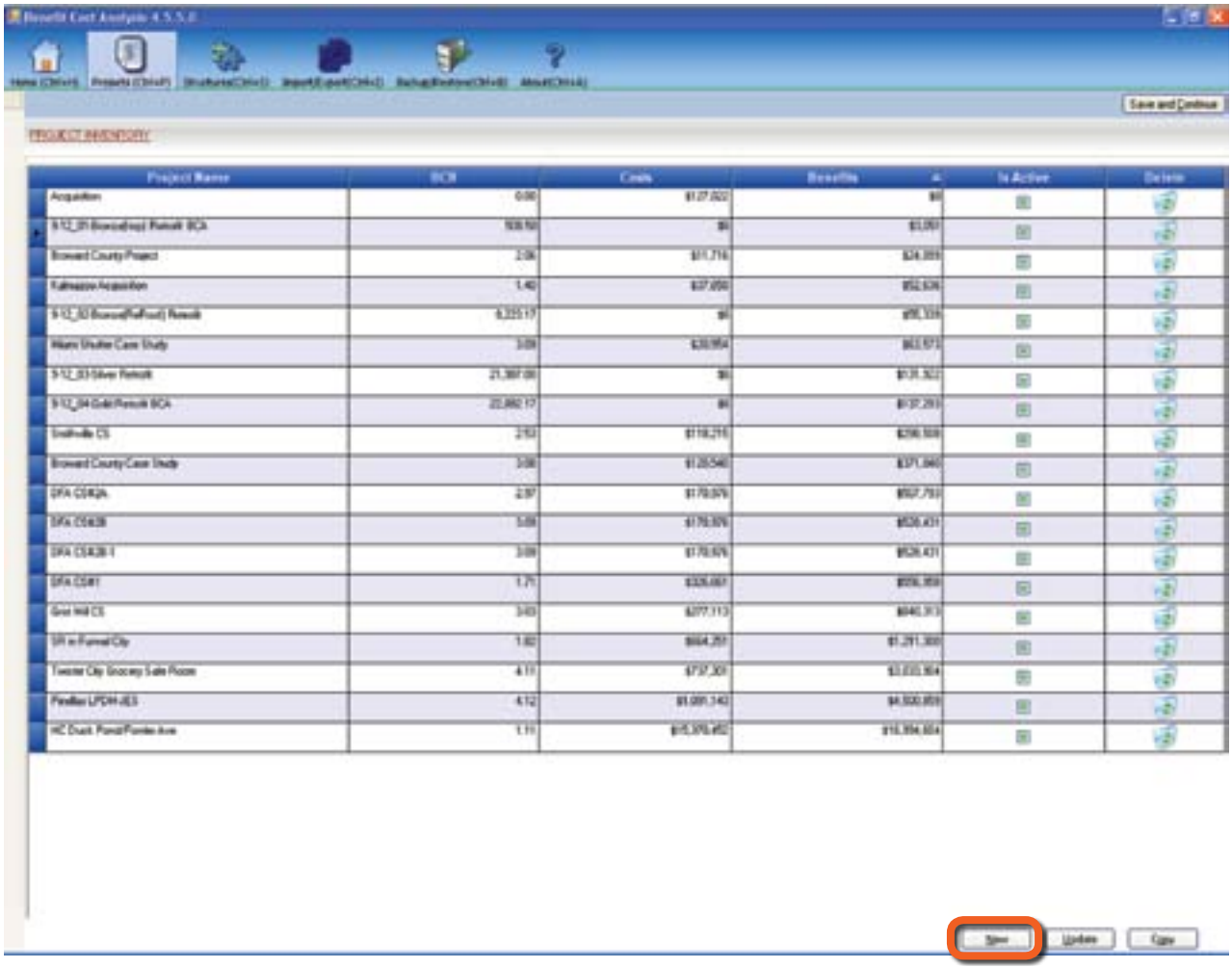
Step 2 (continued):

- Select the State and county.
- Enter a zip code or latitude and longitude to allow the software to auto-populate default wind speed data for the structure location.



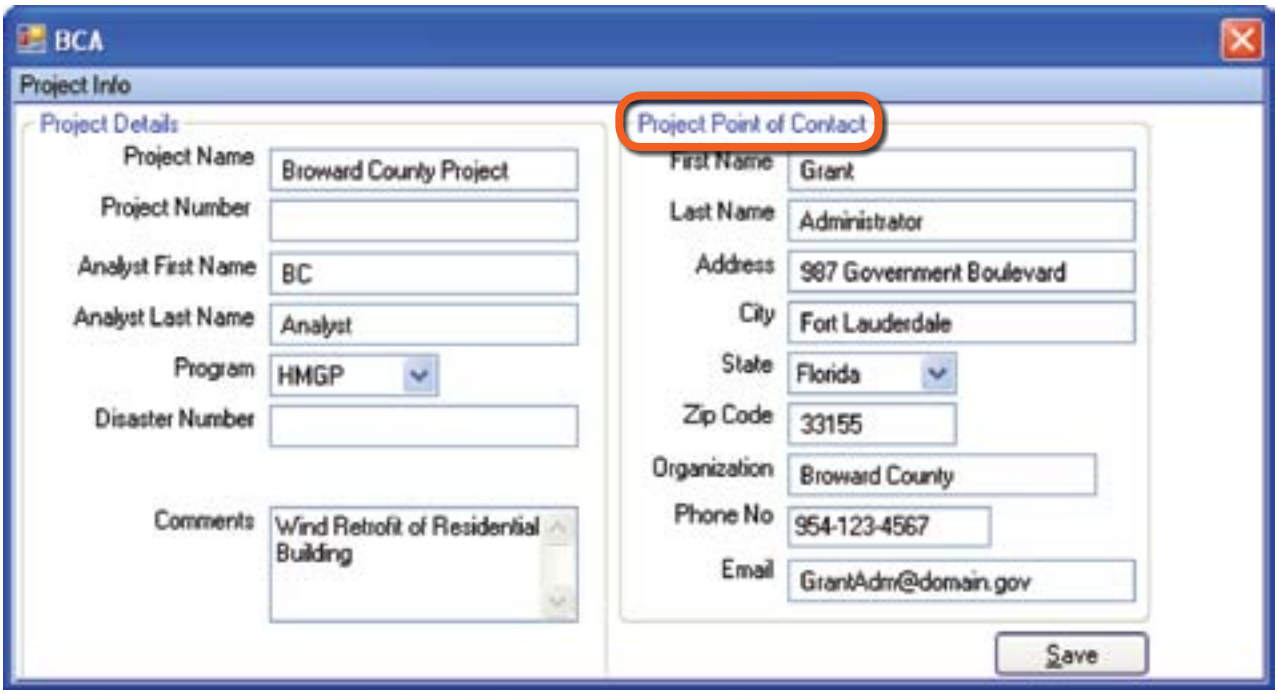
Step 3: Create Project

- Select the **Projects** button.
- Press the **New** button.



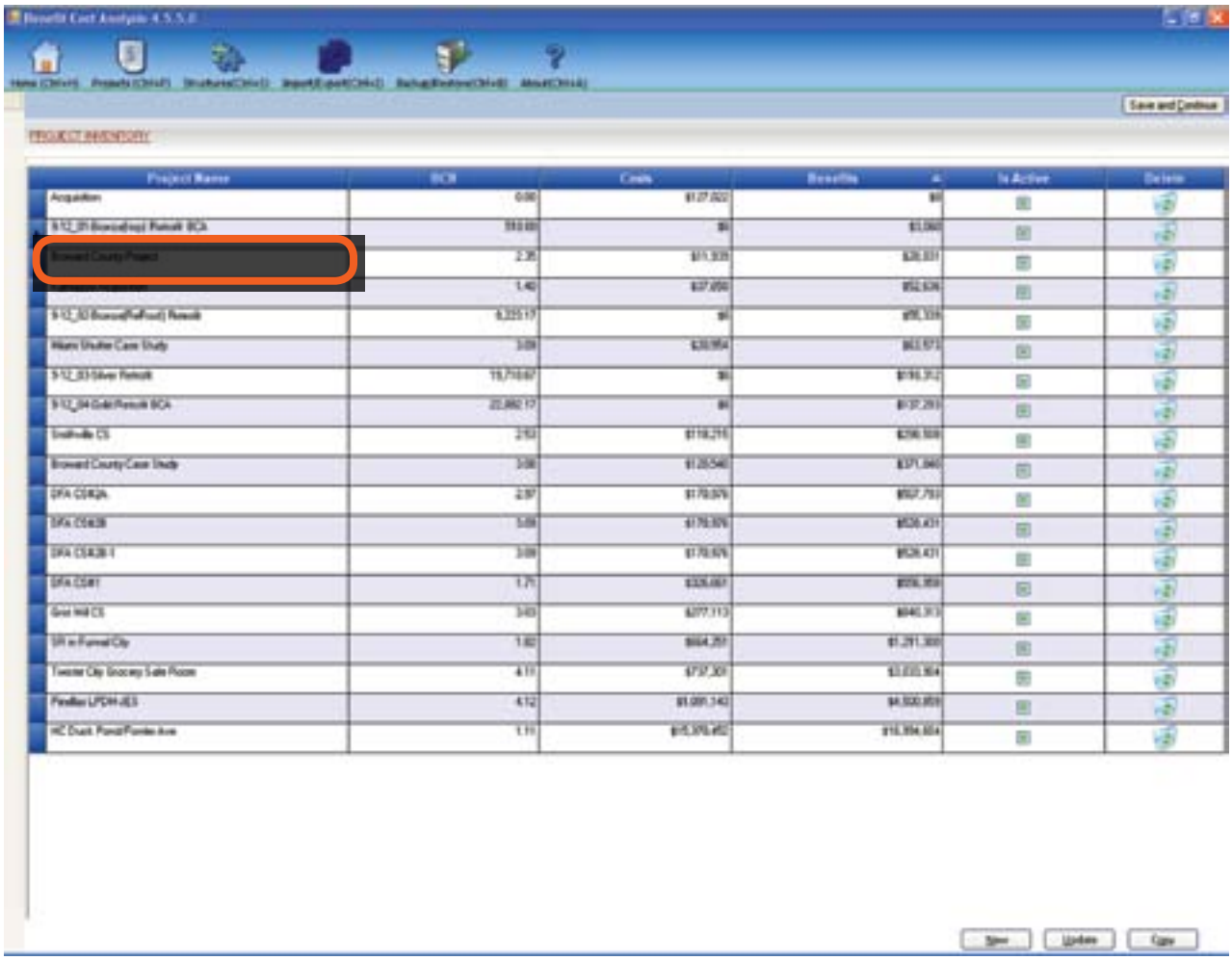
Step 3: (continued)

The point of contact is the person who can answer questions about the project (not the point of contact for the structure). For example, this might be the local grant administrator.



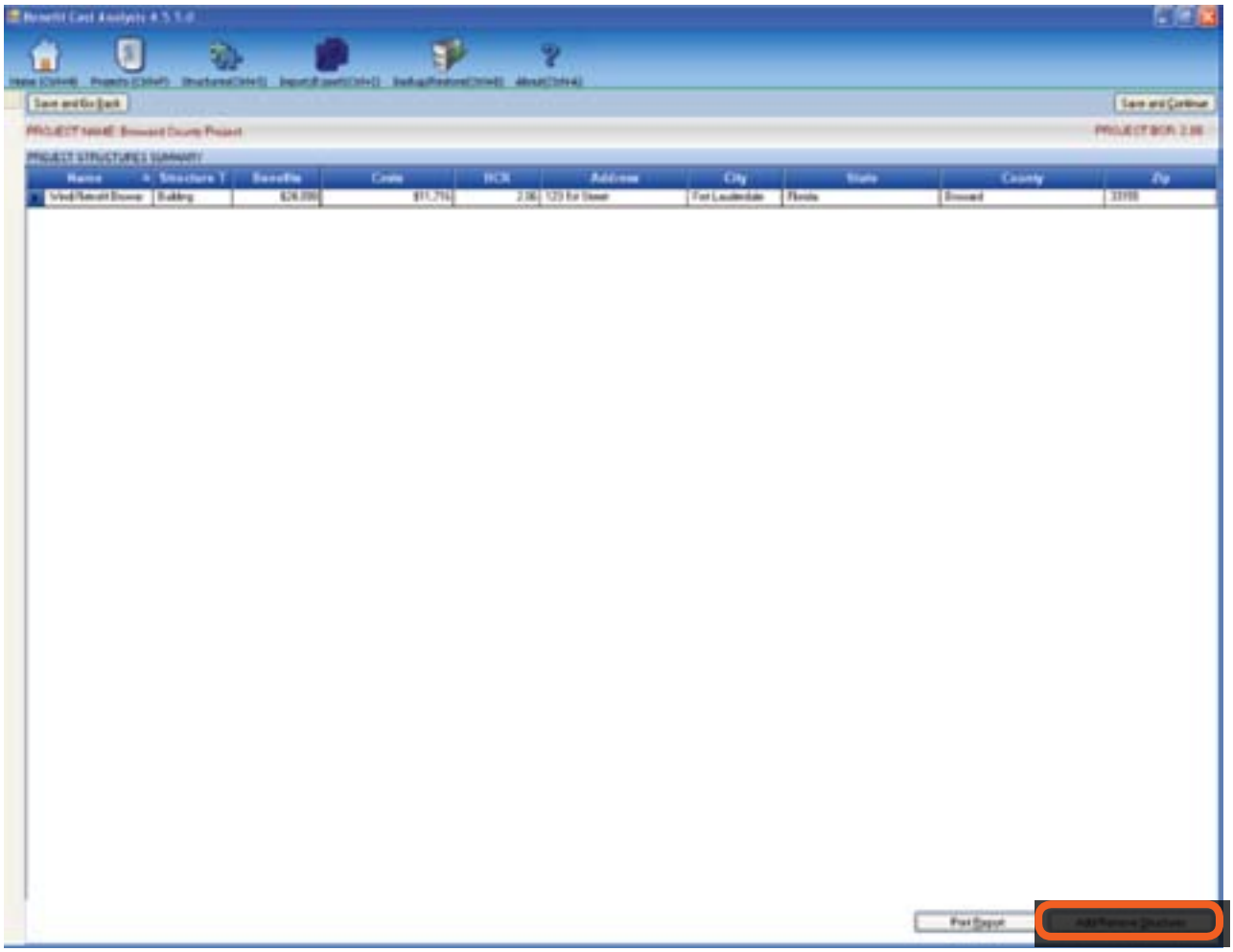
Step 3 (continued):

To associate the structure with the project, double click on the project name in the **Project Inventory**.



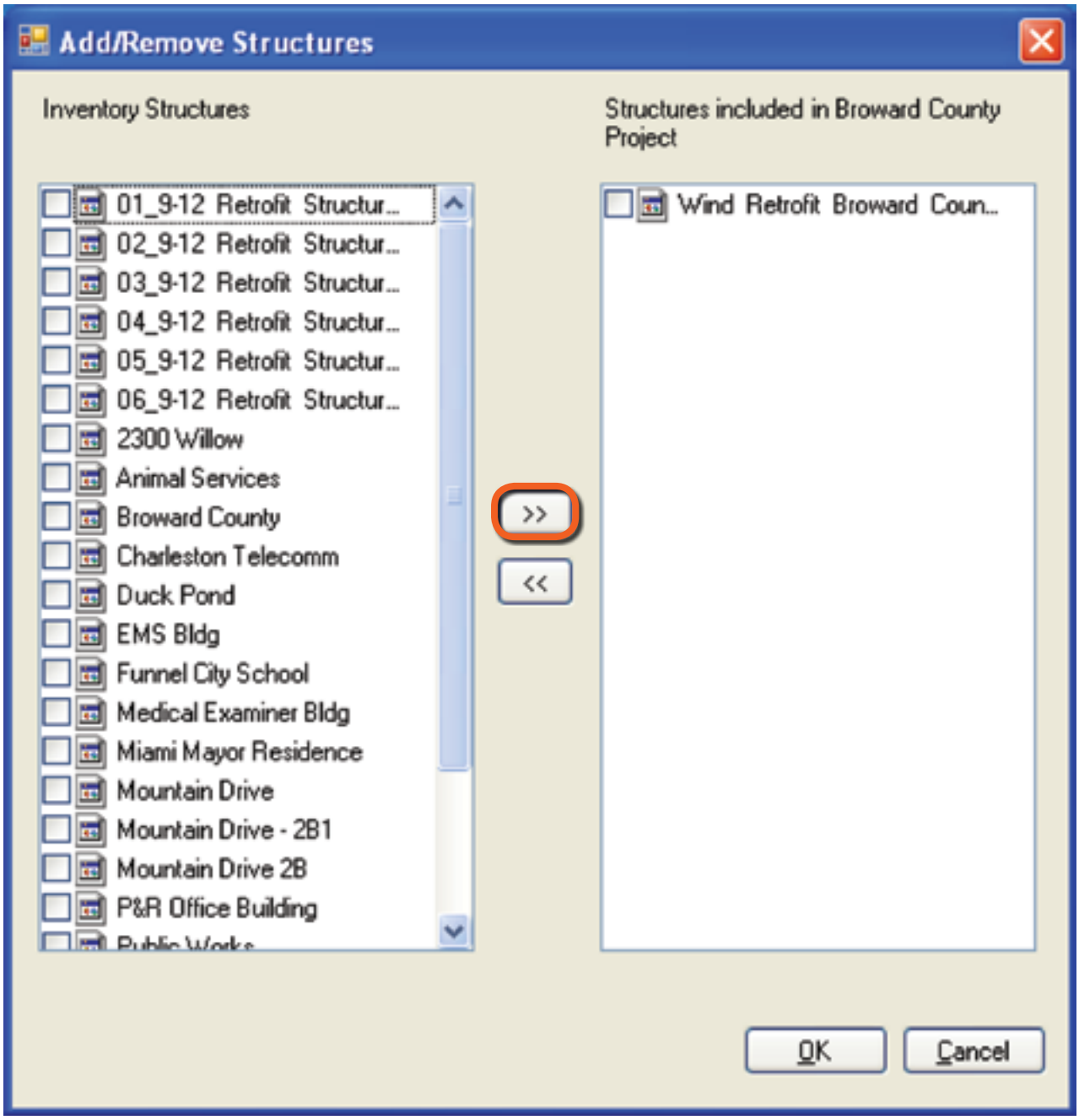
Step 3 (continued):

Select the **Add/Remove Structures** button and associate the structure with the project.



Step 3 (continued):

Associate the structure with the project by selecting the structure in the left-hand column and clicking the double right arrow.

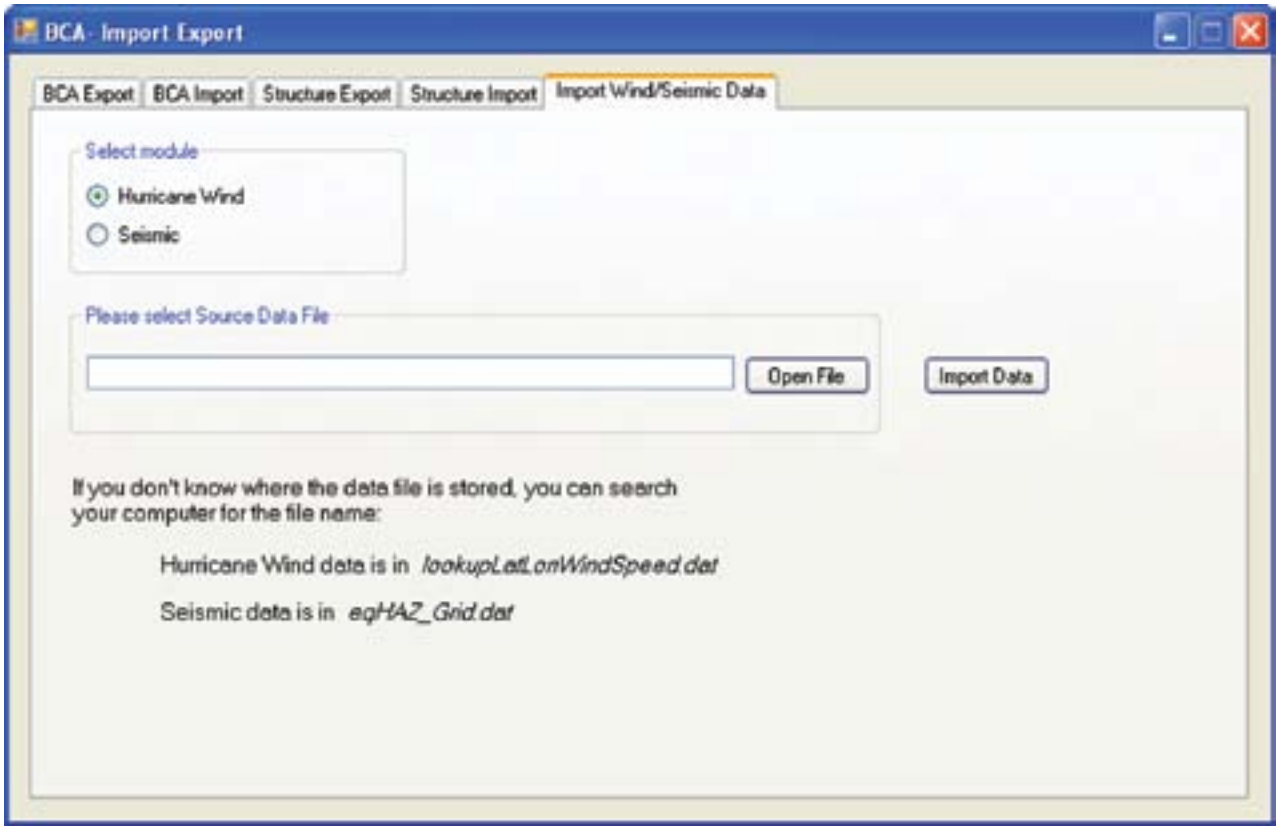


Step 4: Import Wind Speed Data

- To complete a Hurricane Wind BCA using the software's zip code and latitude and longitude function, users must first import the wind speed data.
- Select the **Import/Export** button.

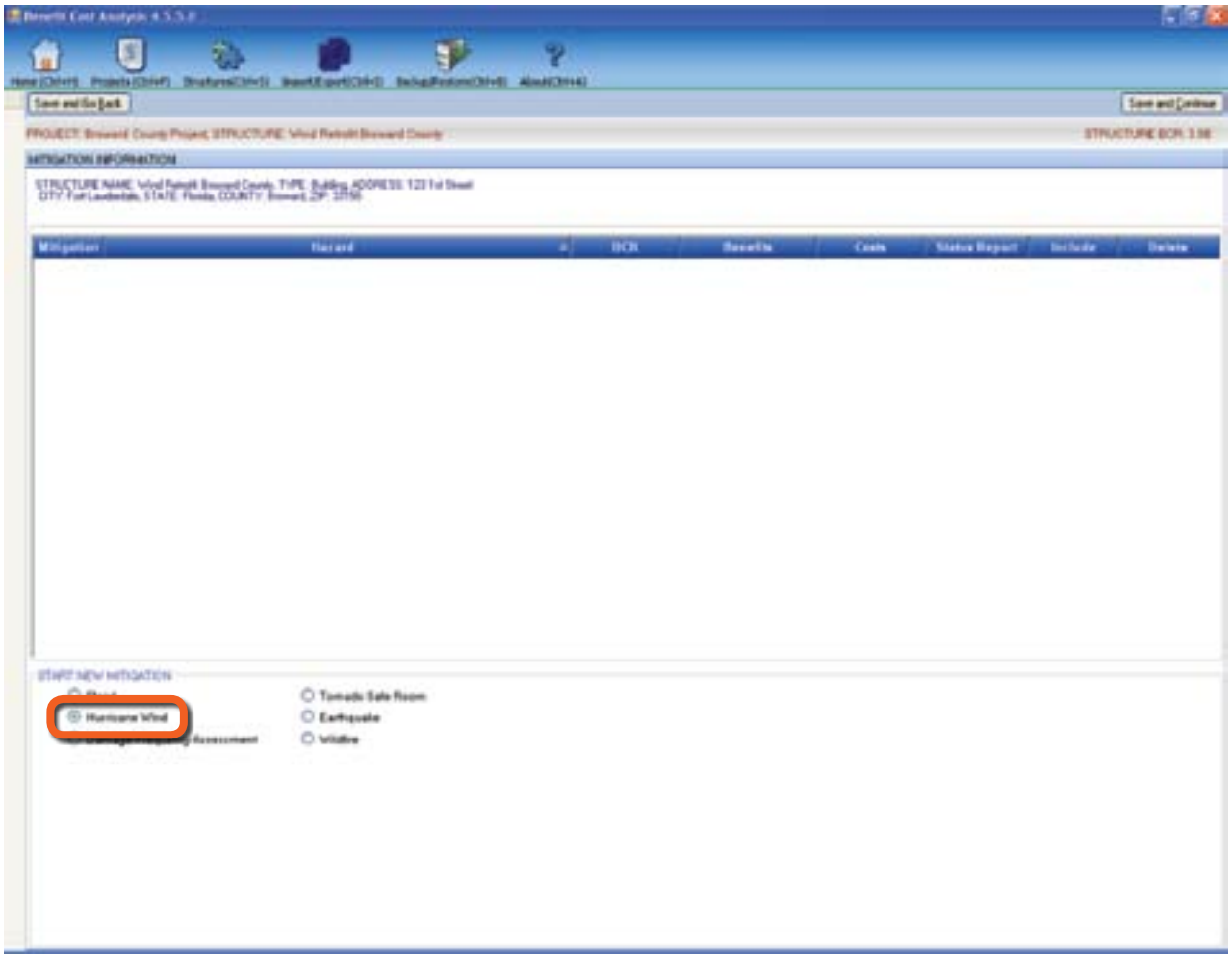
Step 4 (continued):

- The data is typically stored at C:\Documents and Settings\All Users\Application Data\FEMA upon installation of the software.
- You may have to search the hard drive.
- Search for: LatLonWindSpeed.dat file or download it from www.bchelpline.com/Download.aspx.
- This data only needs to be uploaded once on each computer.



Step 5: Begin Mitigation Project Analysis

Select **Hurricane Wind** to begin the mitigation project analysis.



Step 6: Select Applicable Mitigation Types

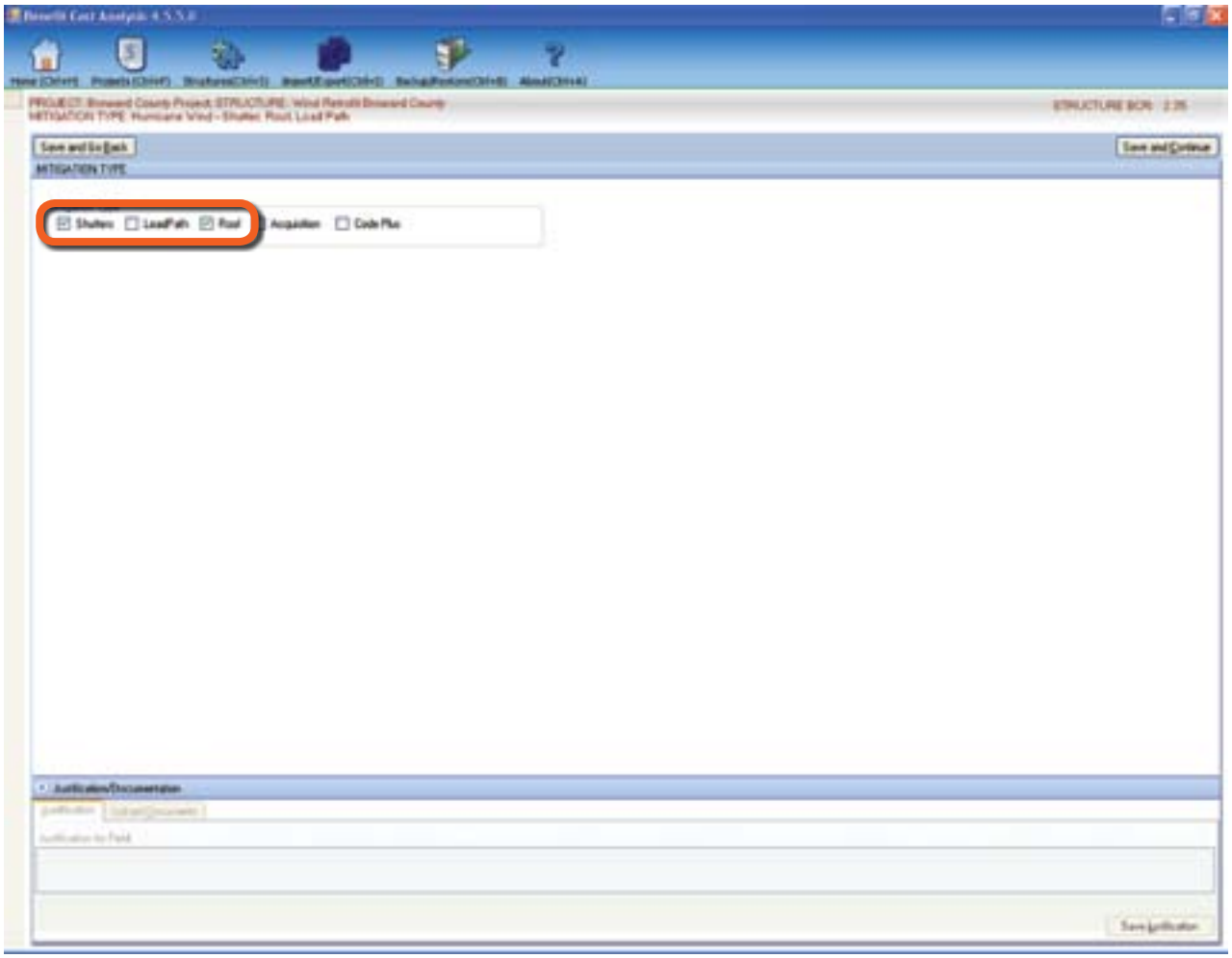
- Select the hazard mitigation measure(s)/project type(s) that apply to the scope of work (shutter, load path, and/or roof retrofit)
- Retrofit projects by Mitigation Package are:

  Basic – Roof

  Intermediate – Roof and Shutters

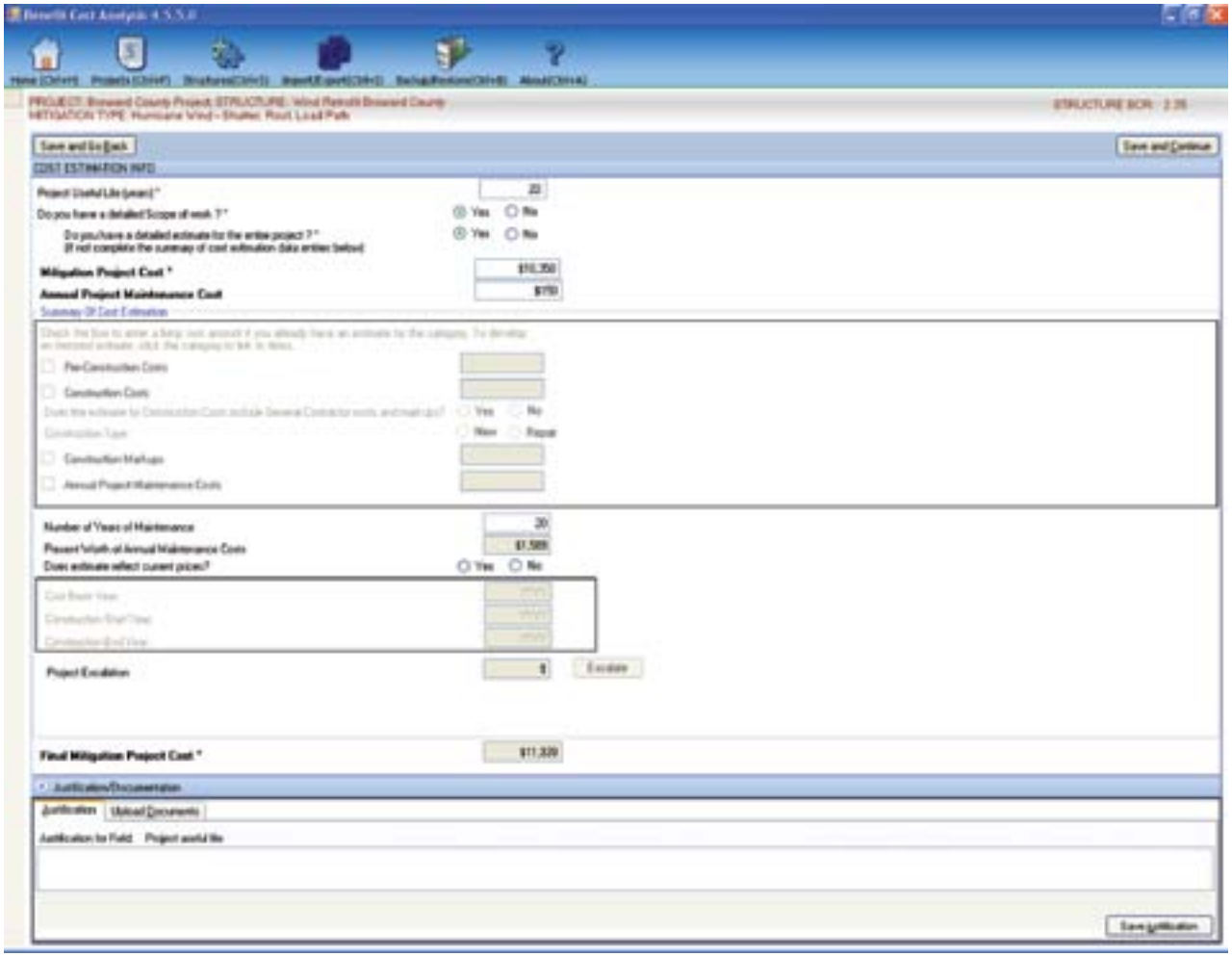
  Advanced – Roof, Shutters, and Load Path

NOTE: Since this project will implement the Intermediate Package, there are no load path retrofits involved.



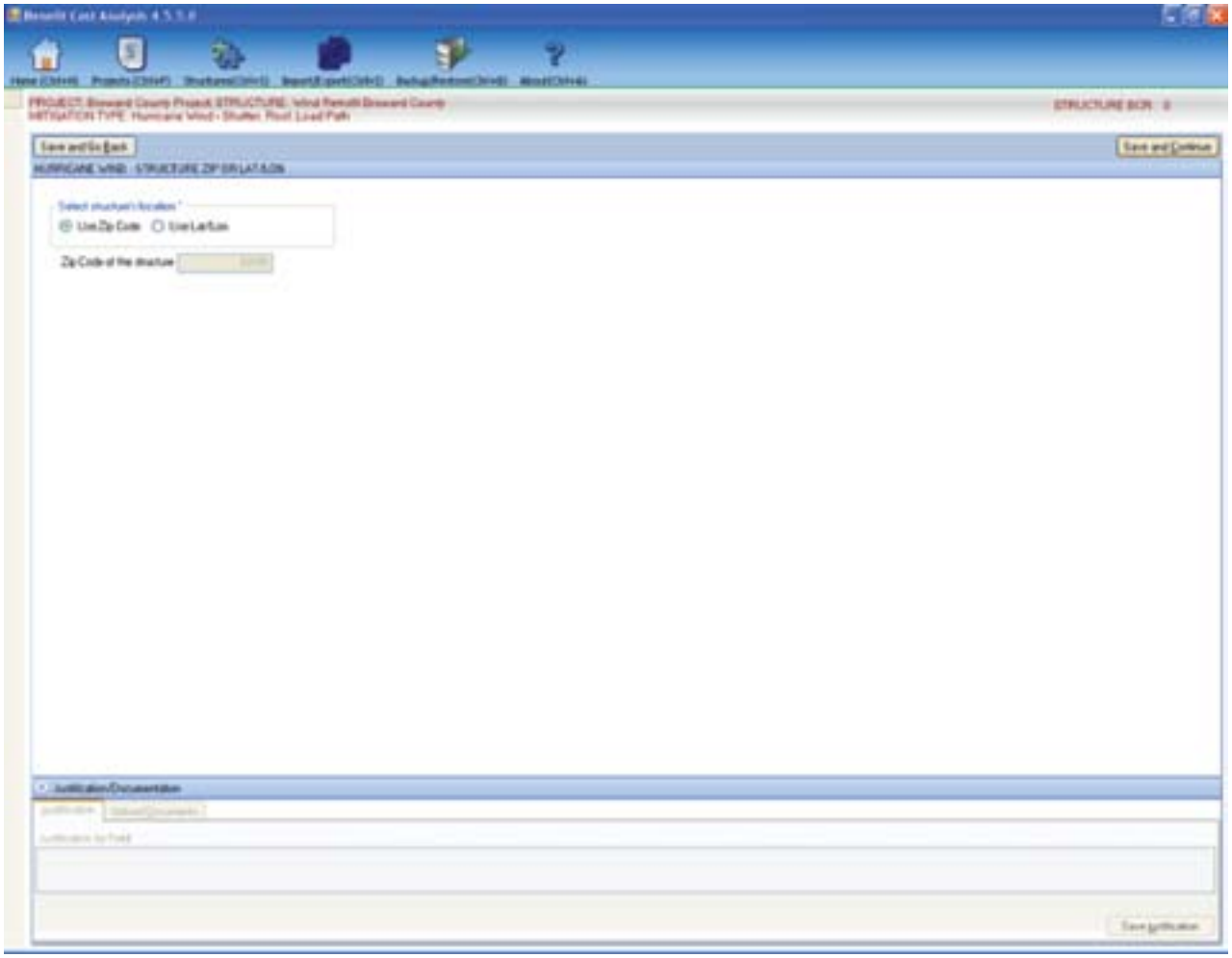
Step 7: Enter Project Useful Life and Cost

- A FEMA standard project useful life for wind retrofit projects is 15 years (without documentation required).
- Projects meeting the requirements of this Guide can estimate a project useful life of 20 years without documentation required.
- The project useful life can be more than 20 years as long as it is justified and documented by the benefit-cost analyst.



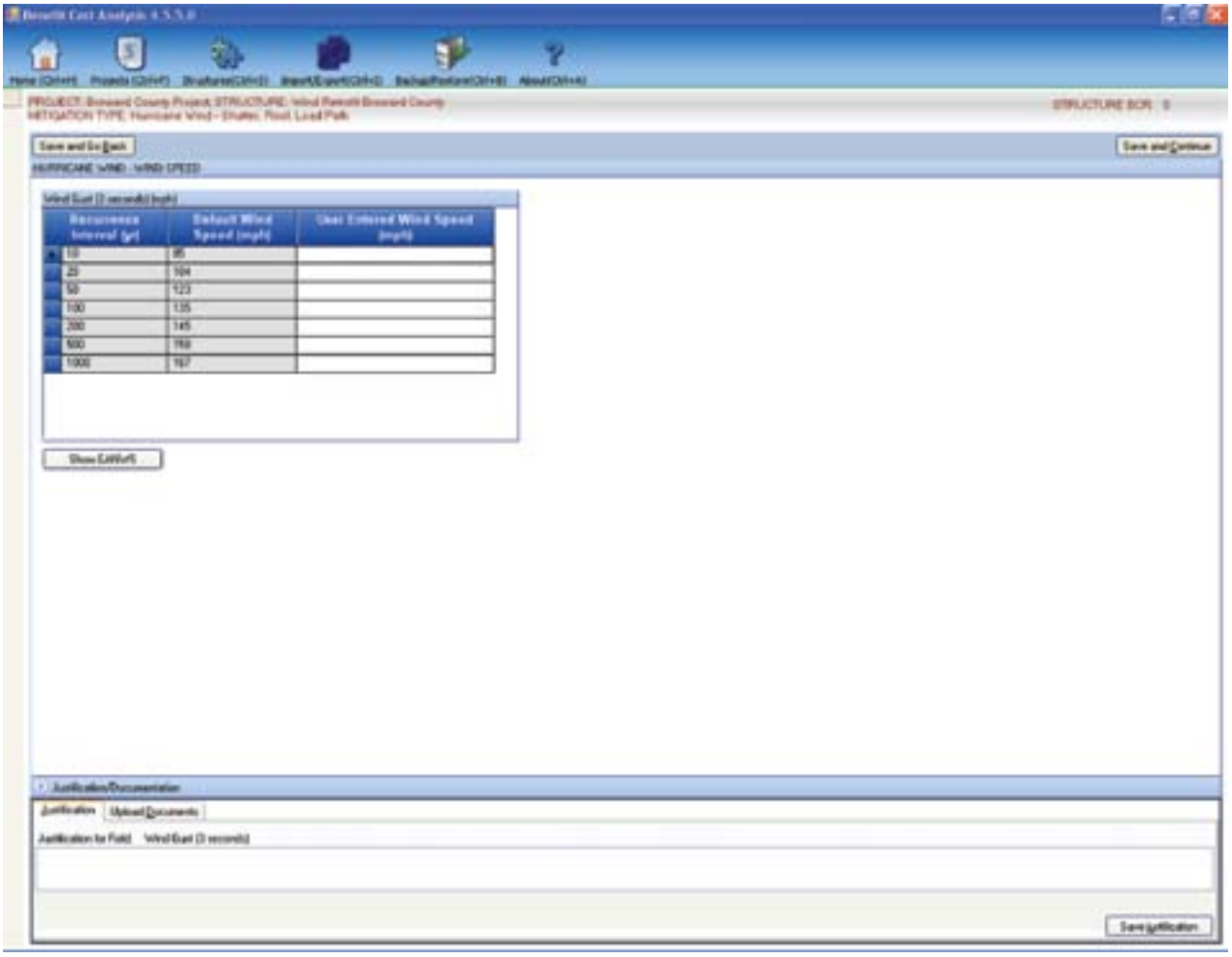
Step 8: Populate Wind Speed

- Select zip code or latitude and longitude for structure location to populate the wind speed default values.
- Note: if the zip code or latitude and longitude were not saved when creating the new structure, the user must go back and update the structure data and save it.
- To update the structure data, select **Structures** from the toolbar, select the structure name from the **Structure Inventory**, select the **Update** button at the bottom of the screen, enter the zip code and/or latitude/longitude, and select the **Save** button.



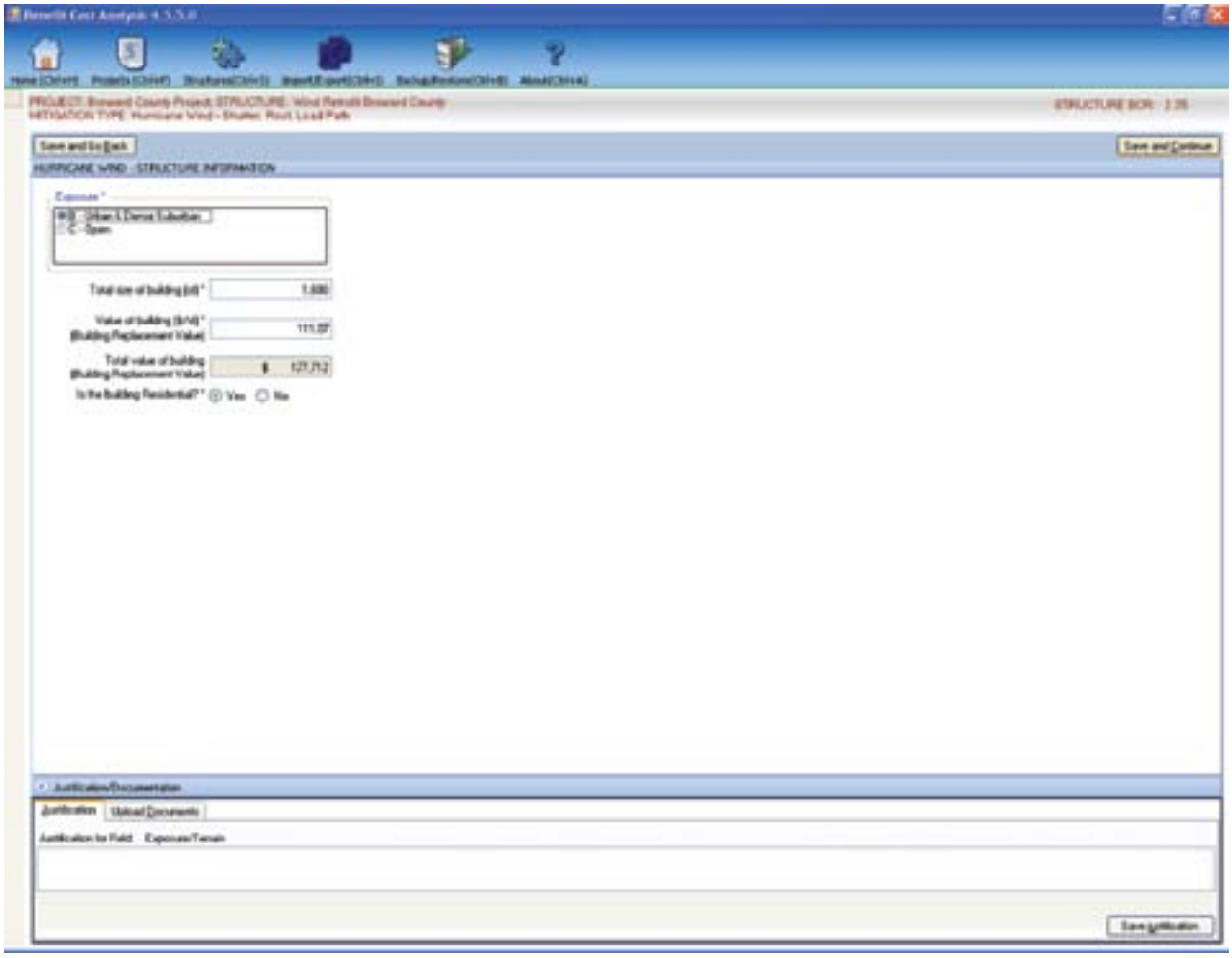
Step 8 (continued):

- Default wind speed data in 3-second gusts for multiple return periods are auto-populated based on zip code or latitude and longitude values.
- If necessary, the user can override the wind speed data with proper justification and documentation.



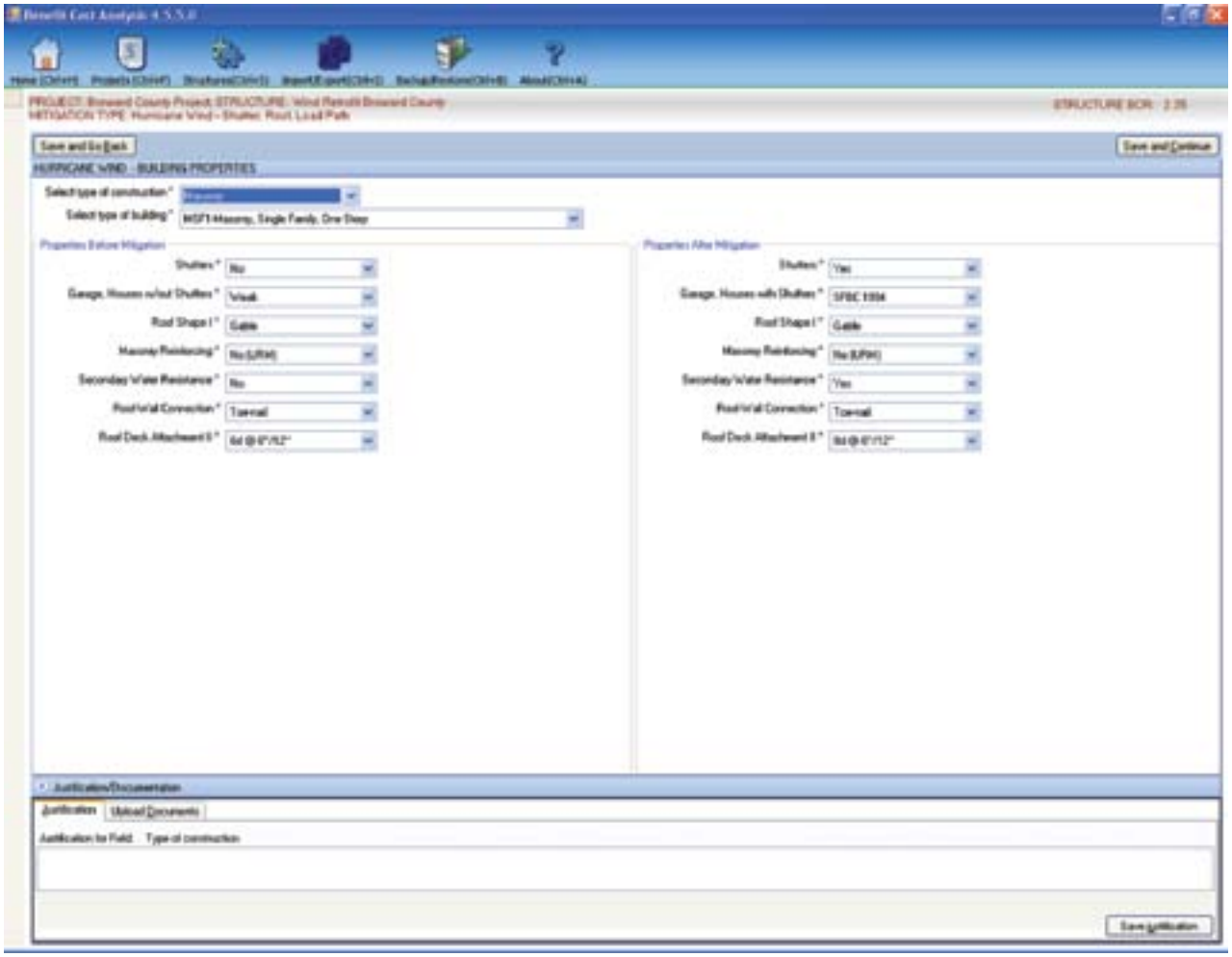
Step 9: Enter Structure Information

- Select exposure category (typically B or C).
- Enter building size (square feet).
- Enter value of building (BRV in dollars per square foot).
- Select **Yes** to indicate the building is residential.



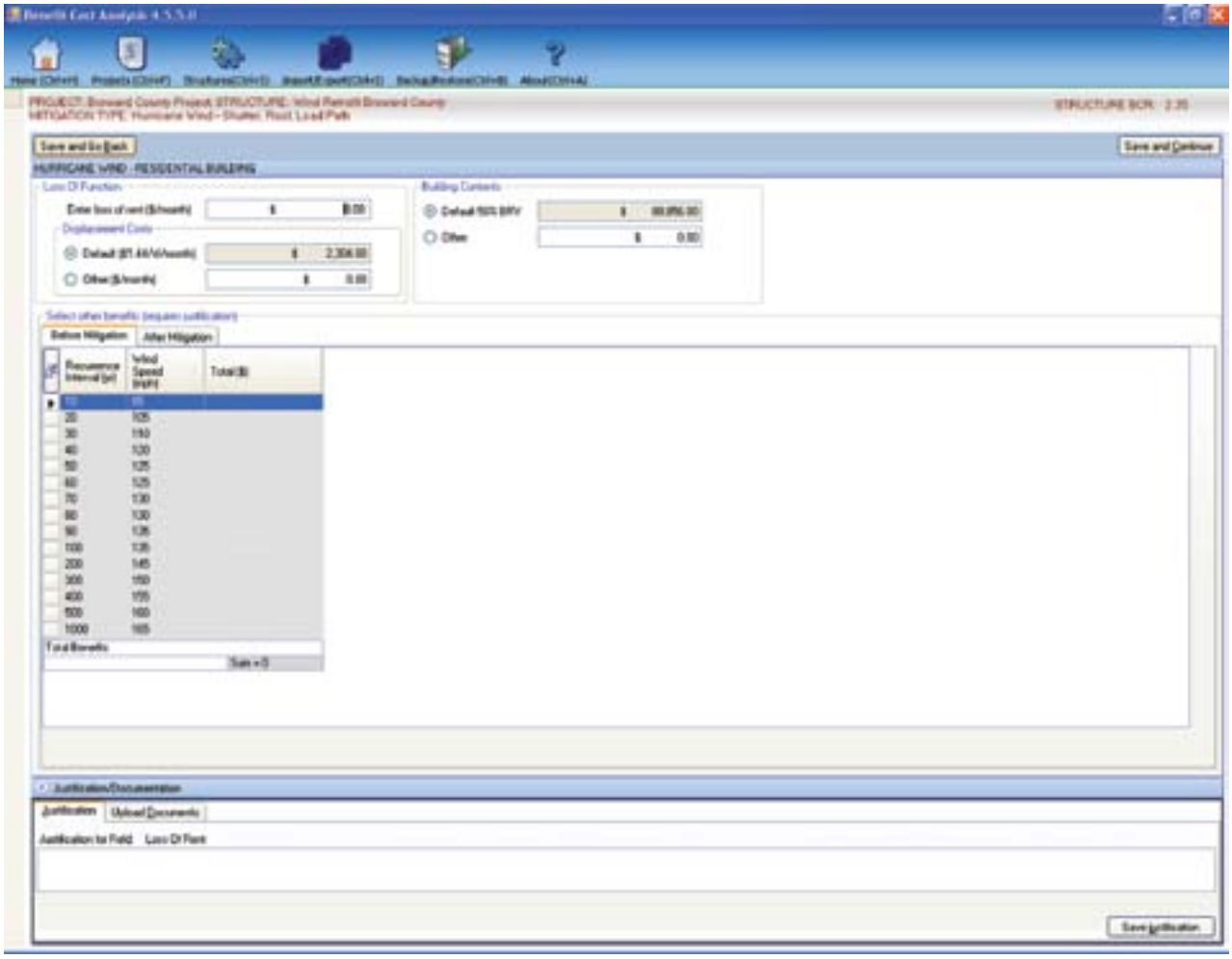
Step 10: Select Building Properties

- Select the building properties based on existing and proposed building characteristics.
- Refer to Table C-2, Scenarios Representing Before-Mitigation and After-Mitigation Conditions, for guidance on selecting building properties that best represent the three Mitigation Packages outlined in this Guide.
- For this hypothetical mitigation project, the selected Mitigation Package is 'Intermediate w/out replacing roof cover' and the after-mitigation building properties reflect those in Table C-2:
  Shutters – Yes
  Garage – SFBC 1994
  Roof Shape – Gable
  Masonry Reinforcing – No (URM)
  Secondary Water Resistance – Yes
  Roof Wall Connection – Toe-Nail
  Roof Deck Attachment – 8d at 6/12



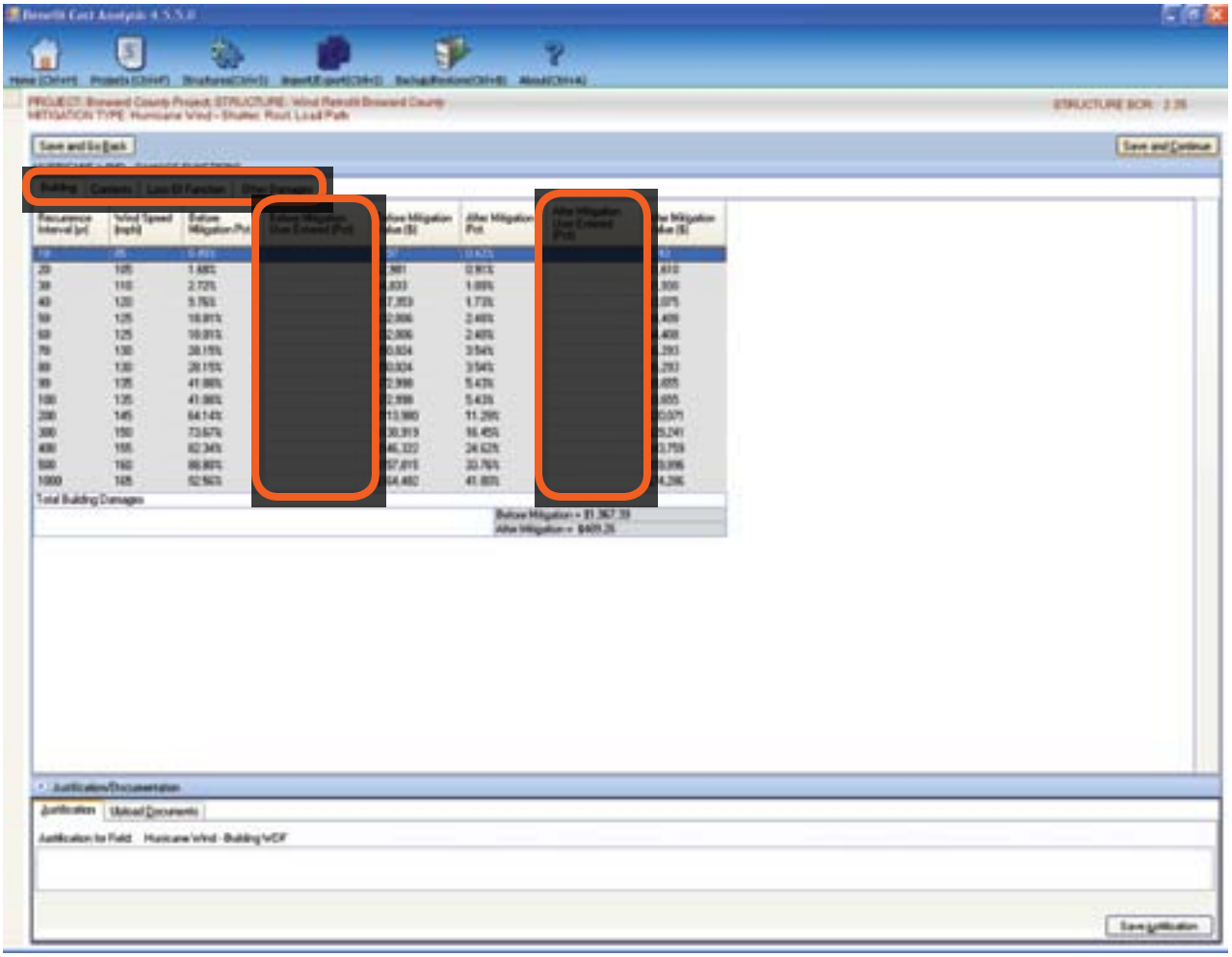
Step 11: Building Contents and Displacement

- Input data for value of building contents and displacement costs.
- Provide justification and documentation if needed.
- Justification and documentation is not required when using the FEMA default values in the software.



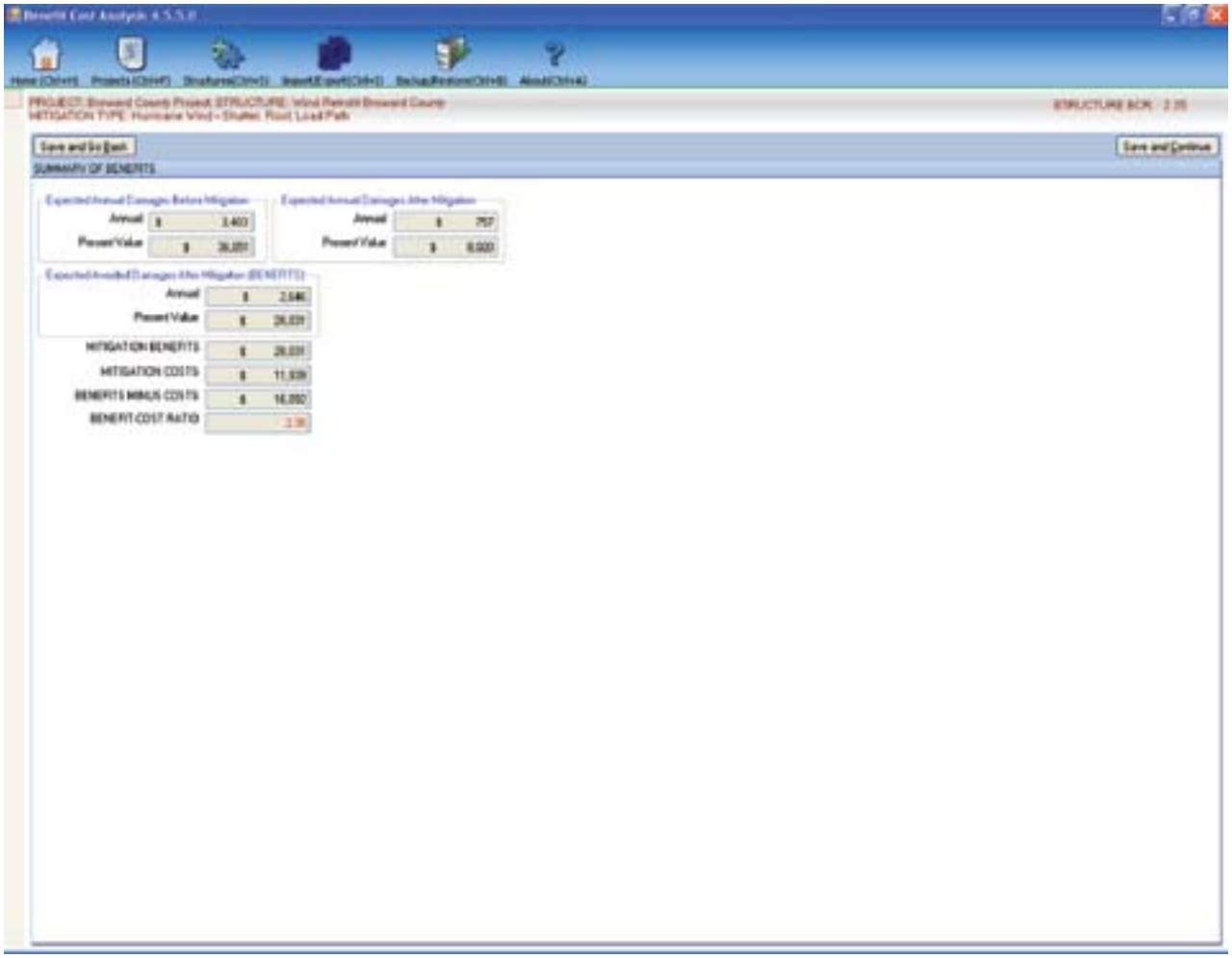
Step 12: Wind-Damage Functions

- The software will automatically populate this field.
- If necessary, the user can override the wind-damage functions with proper justification and documentation by entering user-entered percentages.



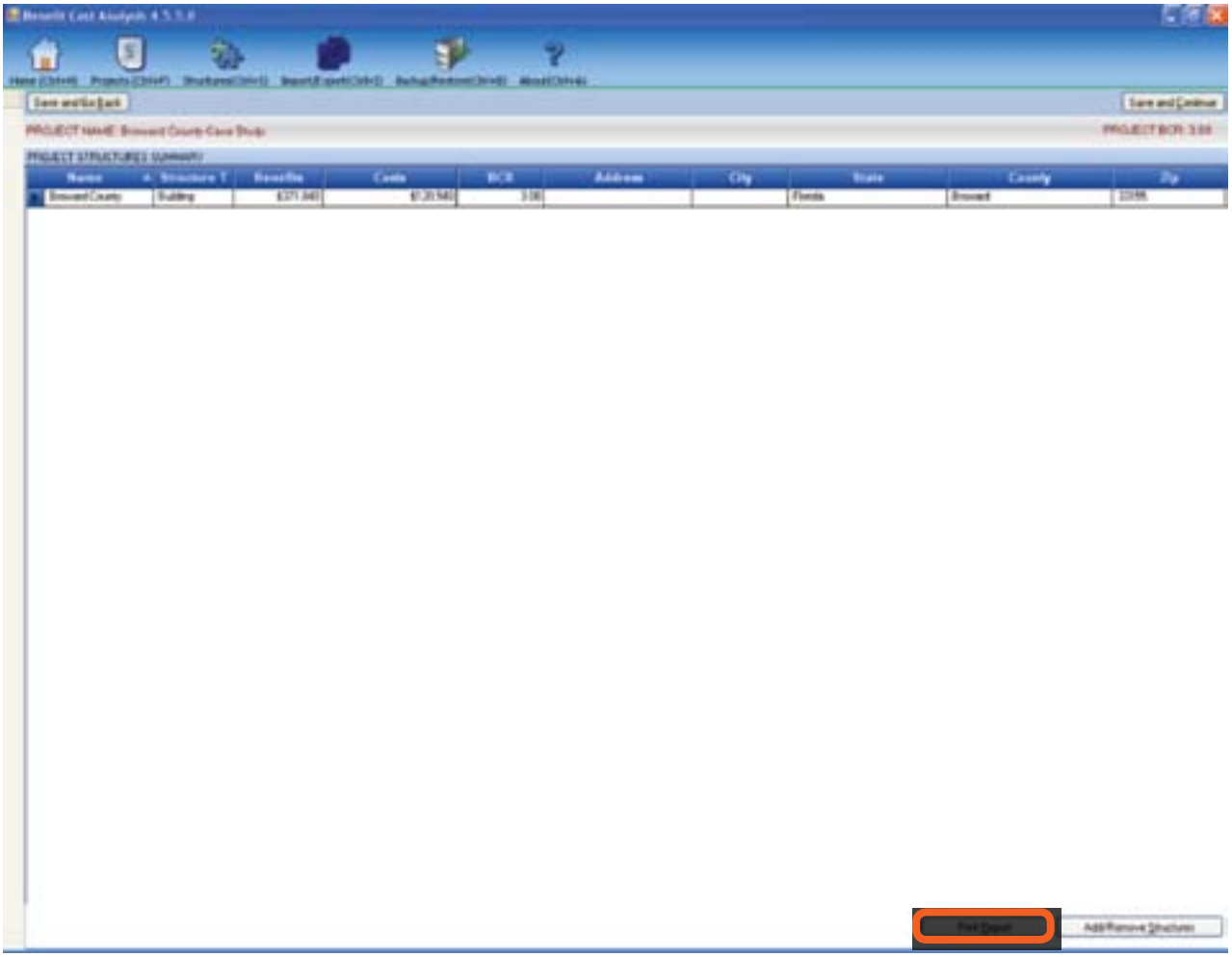
Step 13: Review

- Review results.
- The proposed mitigation project is considered cost effective if the BCR is greater or equal to 1.0.



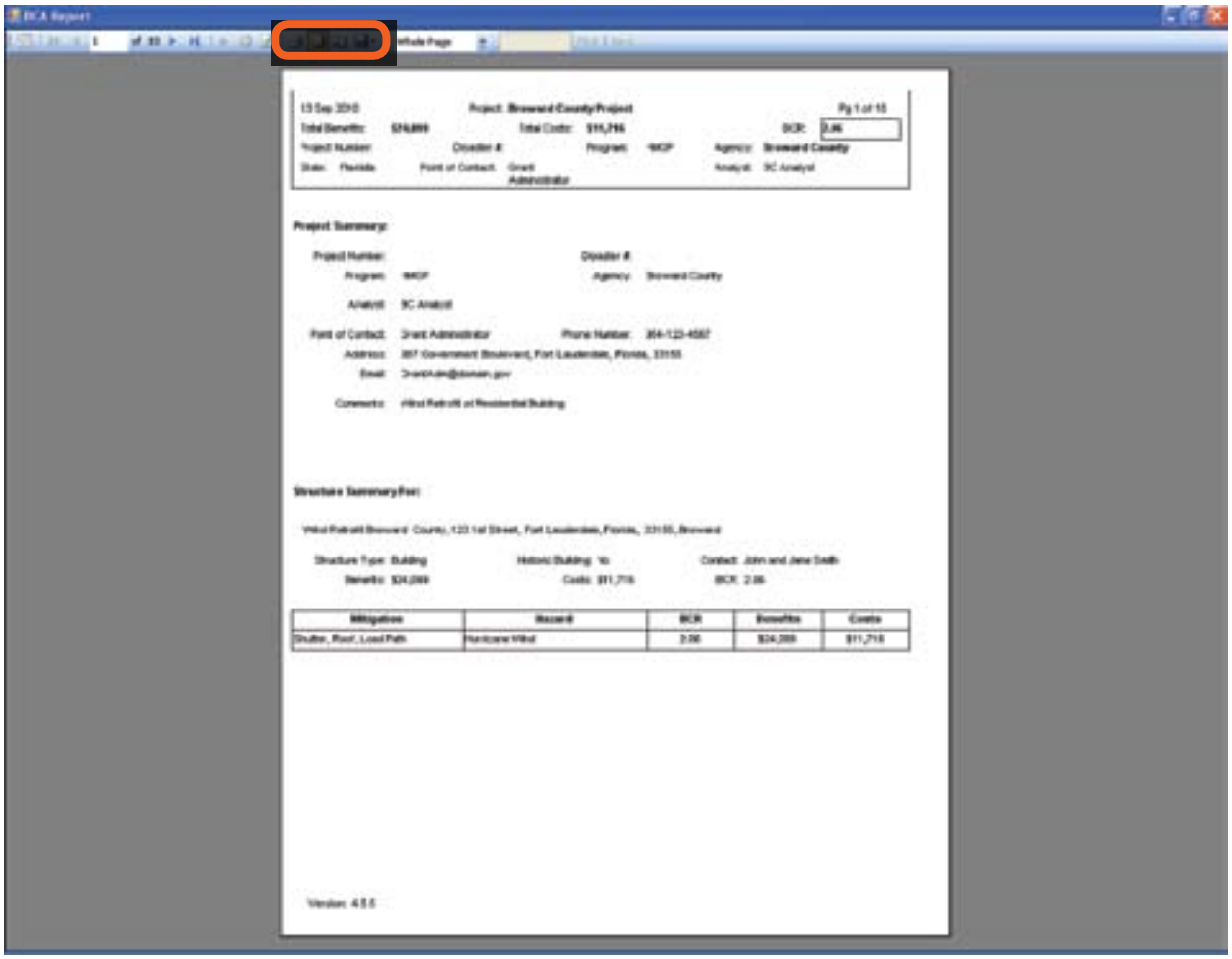
Step 14: Save, Print, and Export

- To save or print a report, return to the Project Structures Summary screen (by selecting **Projects** from the toolbar and then the Project Name from the **Project Inventory**).
- Select the **Print Report** button to print or export the BCA report.



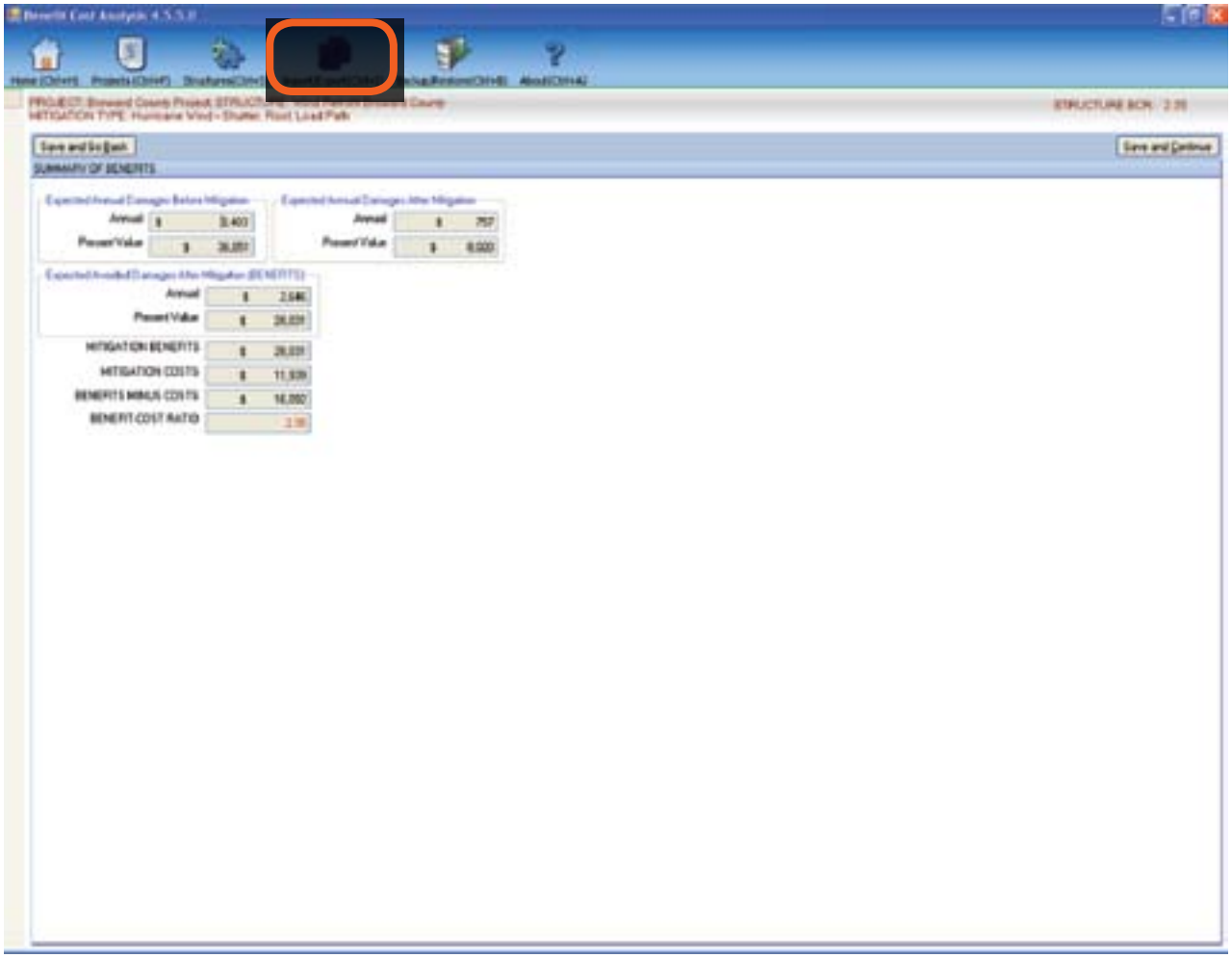
Step 14: (continued)

The report includes a summary of the overall project showing the total costs and benefits and the BCR.



Step 14 (continued):

To export the BCA.zip file to send to a reviewer and/or submit to FEMA, select **Import/Export** from the navigation tool bar.



Step 14 (continued):

Select the **BCA Export** tab, check the project to export, and click **BCA Export**.