CHAPTER 1
THE ROLE OF BENEFIT-COST ANALYSIS IN HAZARD MITIGATION PROJECTS

Introduction

Acknowledgements

This manual and accompanying software were prepared by Goettel & Horner Inc. for the use of the Federal Emergency Management Agency (FEMA) in conducting benefit-cost analyses of hazard mitigation projects. This module is applicable to **Riverine Flood** hazard mitigation projects; other modules are applicable to Coastal A-Zone Flood, Coastal V-Zone Flood, Hurricane Wind, and Seismic hazard mitigation projects.

Hazard Mitigation Projects

Hazard mitigation projects are specifically aimed at reducing or eliminating **future** damages. Although hazard mitigation projects may sometimes be implemented in conjunction with the repair of damages from a declared disaster, the focus of hazard mitigation projects is on strengthening, elevating, relocating or otherwise improving buildings, infrastructure or other facilities to enhance their ability to withstand the damaging impacts of **future** disasters. In some cases, hazard mitigation projects may also include training or public-education programs if such programs can be demonstrated to reduce **future** expected damages.

The Benefit-Cost Program

Benefit-cost analysis provides estimates of the "benefits" and "costs" of a proposed flood hazard mitigation project. The **benefits** considered are **avoided** future damages and losses which are expected to accrue as a result of the mitigation project. In other words, benefits are the reduction in expected future damages and losses (i.e., the difference in expected future damages before and after the mitigation project). The **costs** considered are those necessary to implement the specific mitigation project under evaluation.

Costs are generally well determined for specific projects for which engineering design studies have been completed. Benefits, however, must be estimated probabilistically because they depend on the improved performance of the building or facility in future floods, the timing and severity of which must be estimated probabilistically.

The benefits considered in the **Benefit-Cost Program** include: avoided damages to the building and contents, avoided displacement costs, avoided rental and business income losses, and avoided loss of public/nonprofit services

The "benefits" calculated by the program are expected future benefits which are estimated over the useful lifetime of the mitigation project. To account for the time value of money, a net present value calculation must be performed. This calculation is done automatically in the program, using the discount rate and project useful lifetime entered by the user. Results of benefit-cost calculations are presented two ways: first, the benefit-cost ratio (benefits divided by costs) and second, the present value criterion (benefits minus costs).

LEVEL ONE vs. LEVEL TWO B-C Analyses

The **Benefit-Cost Program** is designed to facilitate two different levels of analysis. A **LEVEL ONE (Minimum Data)** analysis relies heavily on default values built into the model and requires the minimum data input from users. A **LEVEL TWO (Detailed)** analysis allows the user to override default values with user-entered, building-specific estimates.

The validity of any benefit-cost calculation and the robustness of conclusions drawn therefrom depend entirely on the validity of the data used in the calculations. Calculations based on detailed, building-specific engineering analysis will be much more accurate (and correspondingly more useful) than calculations based largely on typical or default values of input parameters.

What Data are Needed for B-C Analysis?

For any benefit-cost analysis of a hazard mitigation project, basic information about the building/facility under evaluation is required, including: building type, size, replacement value, contents value, and various economic data about the use and function of the building. Estimates of the vulnerability of the building and contents to flood damage both before and after mitigation are particularly important.

In most cases, few of the data inputs will be exact numbers. Rather, approximate data or informed, reasonable estimates will be used. See **Chapter 5, Benefit-Cost Program: Guidance** for helpful hints regarding exact data vs. reasonable estimates.

In addition to data about the building under evaluation, benefit-cost analysis of flood hazard mitigation projects requires a quantitative assessment of the degree of flood risk at the site. This assessment is performed automatically by the **Benefit-Cost Program** using flood data input from a Flood Insurance Study and a Flood Insurance Rate Map, along with data on the **Zero Flood Depth Elevation** of the building. The degree of flood risk at a given site profoundly affects the benefit-cost results.

Myths and Misconceptions About Benefit-Cost Analysis

1. The benefits of hazard mitigation projects are avoided **future** damages. Benefits are **not** the damages experienced in the declared event, even if such damages would be 100% avoided by the mitigation project. Rather, benefits are the present value of the sum of expected avoided future damages for all levels of intensity of future disasters (e.g., floods).

2. To estimate future damages (and the benefits of avoiding them), the probabilities of future events **must** be considered. The probabilities of future events profoundly affect whether or not a proposed hazard mitigation project is cost effective. The benefits of avoiding flood damage for a building in the 10-year flood plain will be enormously greater than the benefits for an identical building situated at the 1000-year flood elevation.

3. Mitigation **may not** be cost-effective even though a particular facility experienced great damage in the declared event, if the event were a low probability (i.e., a 500- or 1000-year) event. Conversely, mitigation **may** be cost effective even though the particular facility experienced little or no damage in the declared event, **if** the probability of future damage is high.

4. The benefits of hazard mitigation projects for critical facilities such as hospitals, emergency operations centers, and fire stations, and for high occupancy facilities such as schools tend to be higher than the benefits of projects for non-critical or low occupancy facilities. The higher benefits arise because future damages and losses may be high if the hazards are not mitigated. However, just because a proposed hazard mitigation project is for a critical facility does **not** guarantee that the project is cost-effective. On the contrary, **even for critical facilities,** hazard mitigation projects may **not** be cost-effective if the project is too expensive or the risk of future damage is not high enough.

5. Each proposed hazard mitigation project **must** be evaluated on its own merits to compare the benefits and costs of a specific project. There are no "rules of thumb" which determine eligible and ineligible projects because the costs and benefits of each project are different. The benefits of a particular project may vary markedly depending on the vulnerability of the existing facility to damages and losses, the probabilities of future damages, and the effectiveness of the mitigation measure in avoiding future damages.

Overview of User's Manual

The User's Manual provides a comprehensive guide to conducting Benefit-Cost Analysis of Riverine Flood Hazard Mitigation Projects.

Chapter 2, Getting Started, provides elementary guidance for novice users about loading and starting the Benefit-Cost Program.

Chapter 3, Program Basics, provides basic information about how to move around within the program, how to make data entries, etc.

Chapter 4, Tutorial, provides a worked example illustrating the process of entering data and obtaining benefit-cost results.

Chapter 5, Benefit-Cost Program: Guidance, provides helpful hints for conducting benefit-cost analysis, including data requirements, **LEVEL ONE** and **LEVEL TWO** analyses, and expediting benefit-cost analysis.

Chapter 6, Benefit-Cost Program: Level One Analysis, provides a detailed discussion of all the data inputs necessary for a **LEVEL ONE (Minimum Data)** Benefit-Cost Analysis.

Chapter 7, Benefit-Cost Program: Flood Hazard Risk, provides detailed information about modeling flood hazards and determining expected annual numbers of floods.

Chapter 8, Benefit-Cost Program: Level Two Analysis, provides a detailed discussion of the data inputs necessary for a **LEVEL TWO (Detailed)** Benefit-Cost Analysis, including guidance on overriding default values with user-entered, building-specific data.

Chapter 9, Benefit-Cost Program: Results, provides a detailed discussion of the results of benefit-cost analysis, including guidance on interpretation of results.

Chapter 10, Benefit-Cost Program: Print-Out, is a full print-out of a sample benefit-cost analysis, including all of the data entry screens, results screens, and the graphical presentation of data and results.

Chapter 11, Glossary, defines technical terms used in the program and in the user's manual.

Appendix 1, Equations, summarizes all of the underlying equations in the Benefit-Cost Program and defines all technical terms used in the equations.

CHAPTER 2
GETTING STARTED

This chapter describes the computer hardware and software required to run the **Benefit-Cost Program** and how to install it on your computer. **Chapter 3, Program Basics**, describes the basics of using Quattro Pro for Windows (QPW), how to get around in the **Benefit-Cost Program**, and how to enter the data requested. **Chapter 4, Tutorial**, provides a an example benefit-cost analysis with guidance for the novice user.

QPW works very much like other spreadsheet programs such as Lotus 1-2-3, or Excel, so that experience with any of them is almost 100% transferable to QPW. However, even if you have little or no experience with spreadsheet programs, the **Benefit-Cost Program** is self-contained and easy to use.

Hardware and Software Required

COMPUTER HARDWARE

This **Benefit-Cost Program** requires an IBM-compatible computer (PC). The central processing unit (CPU) must be a 386 or higher; the program will run faster with a 486 or Pentium CPU. In addition, the computer **MUST** have:

1. at least 4 (more is better) megabytes of memory (RAM),
2. a hard drive with at least 15 (more is better) megabytes of free disk space, and
3. a high density (HD) 3.5" floppy disk drive.

The **Benefit-Cost Program** files require a large amount of disk space, about 3 megabytes per file saved (i.e., for each worked benefit-cost analysis for a mitigation project). Therefore, it is desirable to have a large hard disk if you anticipate saving a substantial number of files. Alternatively, files can be saved on high density (HD) floppy disks. However, because of the file size (HD floppy disks hold only about 1.4 megabytes), the files **MUST** be compressed using utility programs available on recent versions of DOS or a separate utility program (such as PKZIP). When compressed, each file is less than 1 megabyte. Files can also be saved on tape or Bernoulli drive back-up systems.

COMPUTER SOFTWARE

This **Benefit-Cost Program** is a **WINDOWS** program; therefore, your computer must have **Windows** (Version 3.1 or higher) installed before you load or run the **Benefit-Cost Program**. **Windows** Version 3.11 is recommended because of additional features and somewhat less propensity to "crash" than Version 3.1.

All **Windows** programs require the use of a mouse; thus your computer system must have a mouse properly installed and operational.

Windows

To install Windows:

1. Turn on your computer.

2. Insert the **Windows** Disk 1 in the drive (**A:** or **B:**) that you want to use for the installation and close the drive door. **Windows Setup** lets you use any active floppy disk drive.

3. At the DOS prompt, **C:\>**, to make the installation drive active, type the drive letter desired followed by a colon (**A:** or **B:**) and press **Enter**. Your DOS prompt will change to **A:>** or **B:>** depending on which drive you made active.

4. Type **SETUP** and press **Enter**. This command initiates the self-installing **Windows Setup** program.

   NOTE: DOS commands are not case-sensitive and may be entered either in upper or lower case. For clarity, all DOS commands in this manual are shown in upper case.

5. Follow the instructions on the screen.

The Setup program's instructions should be self-explanatory. But, if you do have questions about any of the procedures or options, you can request on-line Windows Help by pressing the **F1** key. For more information, see the Microsoft Windows User's Guide.

HINT: The installation routine will ask if you want to choose a "custom" installation or allow Windows to perform a "standard" installation. Most computers will operate well if you allow Windows to self-install (i.e., select the "standard," not the "custom" installation).

Quattro Pro for Windows (QPW)

The **Benefit-Cost Program** runs in **QUATTRO PRO FOR WINDOWS (QPW)**. You must have **QPW** (**Version 5.0** or **6.0**) installed on your computer before loading or running the **Benefit-Cost Program**.

To install QPW:

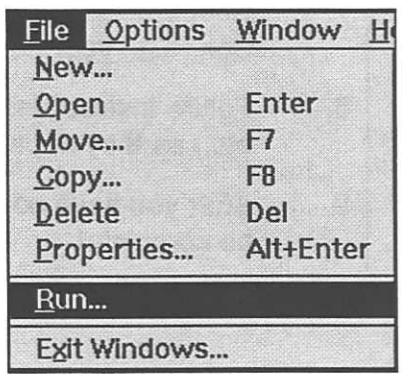
1. Be sure you are in **Windows** (i.e., install Windows first): open Windows if it does not automatically come up when you turn on your computer. At the DOS prompt, **C:\>**, to open Windows, type **WIN**

   If this command opens Windows, proceed to Step 2. If not, then an error message, "bad command or file name," will appear. If this error message appears, it means that Windows is not in the path list and you must change directories before opening Windows. At the DOS prompt, **C:\>**, to change directories, type **CD\WINDOWS**

   This command changes the DOS prompt to **C:\WINDOWS>**. At the DOS prompt, **C:\WINDOWS>**, to open Windows, type **WIN**

2. Insert the QPW Disk 1 in the drive (**A:** or **B:**) you want to use for the installation and close the drive door.

3. With your mouse, point the cursor on **File** on the menu bar (at the top of your screen), press and hold the left button of your mouse. While holding down the left mouse button, move the mouse until **Run...** is highlighted and release the mouse button. Or, click on **File**, then click on **Run...**

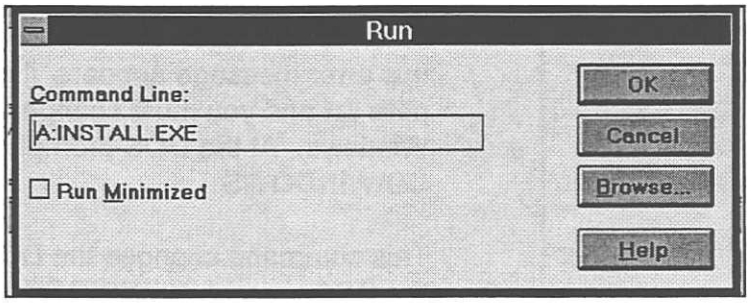


4. On the **Command Line** (i.e., inside the box which will appear next on your screen, as shown below), type

   A:INSTALL.EXE

   or **B:INSTALL.EXE**

   depending on which drive the QPW disk is in. **Be sure to type the command exactly as written: do not add spaces or change punctuation.** Then left-click the mouse on **OK**.



5. Enter the requested information in the Installation Dialog Box which will appear on your screen. Accept the default choice of QPW for the Quattro Pro directory.

6. Quattro Pro will ask you for various information during the installation. Simply type the response and press **Enter** or click the mouse on **OK**. The default (standard) settings are usually suitable for your first installation of Quattro Pro.

7. After entering the information requested in the Installation Dialog Box (e.g., your name), click on **Install** to continue.

8. Follow instructions (e.g., change from Disk 1 to Disk 2 to Disk 3 etc.) as they appear.

9. After you have completed these steps, your QPW installation will be complete!

Installing the Benefit-Cost Program

Network Systems

Computer networks may be set up and managed in many different ways. Therefore, this manual cannot give detailed instructions for installing the **Benefit-Cost Program** on a specific network system. To install the program on a computer which is connected to a network system, give the program disk and the User's Manual to your computer system operator or network administrator. After installation is completed, go to the **Start QPW** section on page 3-1.

Stand-Alone Computers

1. Turn on your computer.

2. If you are not at a DOS prompt (such as **C:\>**) either exit from Windows to DOS, or select a DOS prompt from within Windows. To exit from Windows, click on **File** on the menu, then click on **Exit Windows**. The program will display: "This will end your Windows Session." Click on **OK**. Your screen will show: **C:\>**

   If your hard disk drive is designated **D**, or some other letter, that letter will appear in place of **C**.

3. Insert the first **Benefit-Cost Program** disk (3.5") in either the **A** or **B** drive of your computer (whichever floppy drive is the high density 3.5" drive).

4. At a DOS prompt (**C:\>**),

   If the Program diskette is in the A drive, type:
   A:INSTALL A: C:

   If the Program diskette is in the B drive, type:
   B:INSTALL B: C:

   Be sure to type the command exactly as written: do not add spaces or change punctuation. The install routine will automatically ask for the second Program disk at the proper time.

5. The install routine will automatically create a new subdirectory on your **C** drive: **C:\BC_FLOOD**

6. Two files will be loaded into the **C:\BC_FLOOD** directory:

   A. An example file with all data entries filled in:
   BC_EXAMP.WB1

   B. A blank file, for user data input:
   BC_BLANK.WB1

7. **PROGRAM INSTALLATION IS COMPLETE!**