Section 9
Benefit-Cost Analysis

9.1 Introduction

Due to the magnitude of the recommended CIP program (Section 8), specifically projects 1 through 6, which include the stormwater conveyance and detention basin projects, a benefit-cost analysis (BCA) was conducted to evaluate the economic feasibility of implementing these projects. The economic evaluation was conducted using a benefit-cost ratio (BCR) approach based on FEMA procedures.

The FEMA BCR procedure consists of determining whether the cost of the mitigation project today will result in sufficient flood damage reduction in the future to justify the capital investment of the project. If the benefit is determined to be greater than the estimated project cost, then the project is considered justified. However, if the benefit is less than the project cost, then the project is not considered cost-effective. Thus, the BCR, which is calculated by dividing the benefits by the costs, should have a value of 1.0 or greater. The following section describes the process used to perform the FEMA BCR analysis.

9.2 Benefit-Cost Analysis Approach

The methods outlined in the FEMA BCA toolkit can be used for flood hazards by using frequency-damage relationships that are established from the hydraulic modeling, floodplain mapping, and application of GIS toolsets. The benefits for any project can be estimated by determining the amount of reduced damages as a result of constructing the project. The flood damage types are categorized into four main categories, as summarized in Table 9-1.

Table 9-1
Categories of Avoided Damages

Category	*Damage Types*	
Physical Damages	▪ Buildings ▪ Contents ▪ Infrastructure ▪ Landscaping	▪ Site Contamination ▪ Vehicles ▪ Equipment ▪ Streambank/bed erosion
Loss-of-Function Costs	▪ Displacement costs for temporary quarters ▪ Loss of rental income ▪ Loss of business income ▪ Lost wages	▪ Disruption time for residents ▪ Loss of public services ▪ Economic impact of loss of utility services ▪ Economic impact of road/bridge closures
Emergency Management Costs	▪ Flood insurance premiums ▪ Emergency operations center costs ▪ Evacuation or rescue costs ▪ Security costs	▪ Temporary protective measure costs ▪ Debris removal and cleanup costs ▪ Other management costs
Casualties	▪ Deaths ▪ Injuries	▪ Illnesses

The majority of losses suffered during a severe flood are physical damages to building structures and their associated interior contents. The process of estimating physical damages is fairly straightforward using automated GIS tools to estimate the severity of flooding associated with the various flood return intervals (i.e., 10-, 50-, and 100-year design storms). Conversely, the process of estimating loss of function, emergency costs, and casualties requires significant economic research, analysis, and assumptions. For this study, the goal was to develop a preliminary BCR based solely on physical damages since the data for this category was readily available, and because the projects are still at conceptual level where detailed economic and emergency management information is not available. In general, for projects with a BCR above 0.75 when assuming only physical damages, it is likely that the final BCR will be above 1.0 after the damages from the other remaining categories (loss of function, emergency costs, and casualties) are estimated. For example, the reduction in flood insurance premiums (emergency management costs), which would occur if the buildings were removed from the floodplain, could be a substantial benefit to the property owners and contribute to an increase in the BCR.

The BCR was based on the total project cost and associated benefits from the watershed solution (Section 8.5), which combines projects 1 through 6. This was done because the benefits from these projects cannot be realized unless all of these projects are constructed. In addition, these projects cannot be constructed independently of each other to avoid downstream adverse impacts.

9.3 Benefit-Cost Ratio Calculation Process

In general, a five-step process is used to calculate the BCR, which is summarized in Table 9-2.

Table 9-2
Benefit-Cost Ratio Procedures

Step	*Description*
1	The total CIP cost at present value is estimated.
2	Damages under existing conditions are estimated. The total annualized cost at present value is calculated based on the different design storm event frequencies.
3	Damages after implementation of the recommended projects are estimated. The total annualized cost at present value is calculated based on different design storm event frequencies.
4	Benefits are defined as the damage before projects (Step 2) subtracted by the damages after projects (Step 3).
5	BCR is equal to the benefits divided by the project cost (Step 4/Step 5).

The BCR calculation process for the Deadmans Run watershed solution (projects 1, 2, 3, 4, 5, and 6) using the steps outlined above is discussed on the following pages.

Step 1: Total Capital Improvement Project Cost

The total conceptual cost for the recommended watershed solution, including projects 1 through 6, is approximately $49.0 million (Section 8.6).

Steps 2 and 3: Calculation of Flood Damages

The process of estimating flood damages before the project (existing conditions) and after the project is calculated using the same procedures. As discussed above, only physical damages were estimated for this analysis.

Physical damages to buildings, their contents, and streets were calculated as follows:

- The depth of flooding for each individual building structure and street segment was determined separately for the 10-, 50-, and 100-year storm events. The depths were calculated using ArcGIS by applying individual storm frequency depth grids to digitized building structures and street segments.

- A monetary value for the building was obtained based on Lancaster County assessor information, supplied by the City of Lincoln. The monetary value of contents was assumed to be 30 percent of the total building value. The street replacement monetary value was estimated using $60 per square yard.

- FEMA depth damage curves were applied for buildings (Figure 9-1), contents (Figure 9-2), and streets (Figure 9-3) to obtain a percentage of total value damaged for each respective storm event. The total monetary value was then multiplied by the percentage of damage to obtain a total damage for each individual building, contents, and street segment. The total physical damage for each storm event was calculated as the sum of all individual damages.

- The total annualized cost at present value for the 10-, 50-, and 100-year monetary damages for buildings, contents, and street repairs were calculated.

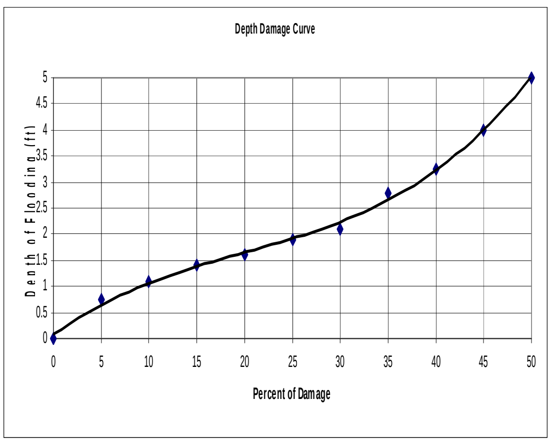

Figure 9-1
FEMA Building Depth-Damage Curve

Figure 9-2
FEMA Contents Depth-Damage Curve

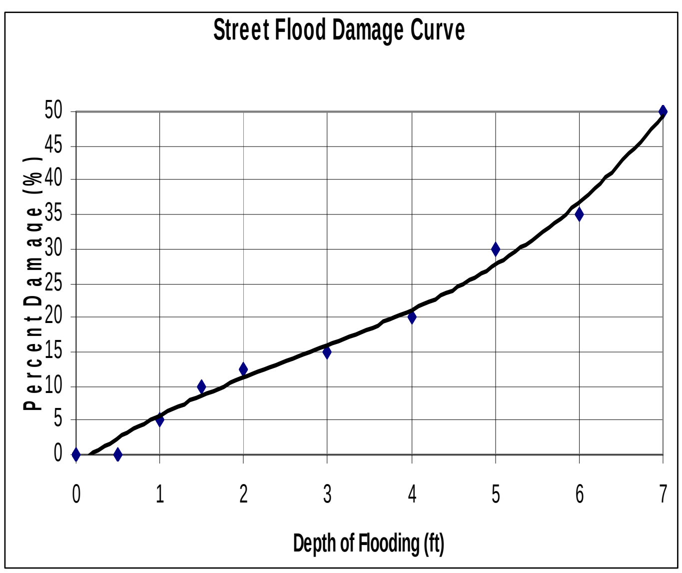

Figure 9-3
Street Flooding Depth-Damage Curve
(Based on previous Lincoln, NE flood damage replacements)

The estimated flood damages before the projects (existing conditions) and after the projects are summarized in Tables 9-3 and 9-4, respectively.

Table 9-3
Total Physical Damages *Before* Projects

Flood Frequency Events (Years)	*Buildings*	*Contents*	*Streets*	*Total Damages and Losses*
10	$4,490,280	$713,713	$944,600	$6,148,593
50	$31,233,266	$2,384,824	$5,097,344	$38,715,434
100	$50,019,320	$3,363,949	$6,538,511	$59,921,780
			Total Annualized Damages	$2,219,193

Table 9-4
Total Physical Damages *After* Projects

Flood Frequency Events (Years)	*Buildings*	*Contents*	*Streets*	*Total Damages and Losses*
10	$157,963	$152,477	$58,296	$368,736
50	$1,514,629	$365,909	$399,233	$2,279,770
100	$2,285,128	$404,588	$547,819	$3,237,535
			Total Annualized Damages	$127,043

Step 4: Calculation of Benefits

The benefit is defined as the avoided physical damages after project compared to that of existing conditions. Subtracting the total annualized damages of existing conditions from the total annualized damages after implementing projects 1 through 6, the total benefit equals approximately $2.09 million. Before calculating BCR, the benefit must be converted to present value dollars. Using the current Water Resources Institute discount rate of 4 $^{7/8}$% and a project life of 50 years, the present value of $2.09 million equals $38.9 million.

Step 5: Calculation of Benefit-Cost Ratio

BCR is calculated by dividing the present value benefit ($38.9 million) with the present value cost ($49.0 million), which equals 0.79.

9.4 Conclusions

In summary, a BCR value of 1.0 or above is desirable to justify the economic feasibility of constructing large-scale improvement projects. For the Deadmans Run watershed solution (projects 1 through 6) a preliminary BCR value of 0.79 was estimated based solely on physical damages. Typically, if the BCR ratio is above 0.75 when only assuming physical damages, then the BCR will exceed 1.0 when the other three categories (loss of function, emergency management, and casualties) are factored into the calculations. Therefore, at this conceptual stage of the project formulation process, projects 1 through 6 appear to be economically viable.

The next step in the planning process is to move from a conceptual level (DMR Master Plan) to preliminary design. During the preliminary design stage, the engineering details and construction phasing issues will become better defined for projects 1 through 6, which will be the appropriate time to update the BCR using more refined data.