# **ECONOMIC MODELING OF FLOODS**

### Calculating a B/C Ratio for Hazard Mitigation Grants

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# **PRESENTATION OVERVIEW**

- Purpose of a B/C Ratio
- Damage Calculations
  - Damages Models
  - Average Annual Damages
  - Present Value
- Cost Calculations
- Benefit Cost (B/C) Ratio



# **PURPOSE OF A B/C RATIO**

- An economic analysis is performed to assess the value of a hazard mitigation project
  - The B/C ratio quantifies the benefits of a project to its costs
- Benefits = Existing damages With Project damages
  - Reduction in damages between Existing and With-Project Conditions
- Costs
  - Costs to implement a project
- Ratio of benefits to costs
  - B/C = Benefits / Costs
  - When B/C > 1, project benefits exceed project cost



### Damages Models

- IDNR-OWR: Damages 4.22
- DuPage County: DEC-2
- Cook County: Watershed Planning Online Database Tool (MWRD Database)
- FEMA: Benefit Cost Analysis, Version 4.5.5.0



### **DAMAGES MODELS – IDNR-OWR**



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| DAMAGES MODELS – FEMA   |  |  |   |   |  |  |
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| Benefit Cost Analysis 4.5.  Home (CtrI+H) Projects (CtrI+P) Struct  My Projects  My Projects  Serens-Monaldi Pump Station  Cluster 635N · 12  Cluster 637N · 10  Cluster 637N · 1 story  Cluster 635N · 2 sto | 5.0         wres(Ctrl+S)       Import/Export(Ctrl+I)       Backup/Restore(         Save and Go Back       PROJECT NAME: Berens-Monaldi Pump Station         -12hr critical       PROJECT STRUCTURES SUMMARY         Name       Struct       Bene       Costs       Bf/x       A         Cluster 635       Building       \$870,       \$779,554       1.12       6 S         Cluster 635       Building       \$127,       \$0       0.00       7 T         Cluster 636       Building       \$127,       \$0       0.00       4 H         Cluster 636       Building       \$127,       \$0       0.00       19         Cluster 637       Building       \$10,1       \$0       0.00       10         Cluster 637       Building       \$10,1       \$0       0.00       39 | Project: Cluster 636N<br>Cluster | Finduced: bereat-Monade - Jum context, STRUCTURE: Cluster 636N       STRUCTURE BCR. 0         Save and Go Back       Save and Go Back         RivERINE ELEVATION AND DISCHARGE DATA       637.00         FEMA Elevation certificate dagram description       Dagram 2         Streambed Elevation (H)*       624.00         Find Your Control of Policy       Differ elevation control of the servation cource         Streambed Elevation (H)*       624.00         Flood Policy Number       Chour dates Ministright         Note that the vertical datum for the Flood Elevation must match the vertical datum used for the Fast Floor Elevation       Mitigation (t) *         Note that the vertical datum for the Flood Elevation must match the vertical datum used for the Fast Floor Elevation       Image: Cource Mitigation (t) *         10       100       635.87       0.1         25       100       635.67       0.1         100       100       636.70       0.4 |   |  |  |
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• Damages output in variety of ways:

- DuPage County DEC-2: per storm basis
- IDNR-OWR Damages 4.22: Average Annual Damages
- MWRD Database: 50-year Present Value
- FEMA Benefit Cost Analysis: Average Annual Damages and Present Value
- However, the basic calculation is the same to get damages for a storm event





## **STRUCTURE DATA**

### **1 Story with Basement**



### **1 Story with Crawlspace**



• Low water entry elevation:

- Water starts entering structure
- "Minimum water elevation"
- Zero damage elevation:
  - DuPage
- First floor elevation:FEMA, IDNR, and MWRD



\*Graphics taken from the DEC-2 User Manual

## **STAGE DATA** 1 Story with Basement

100-year (+1.1 feet) 50-year (+0.1 feet) **First Floor** 

/ 25-year (-0.4 feet)

Low Entry (-1.5 feet from FF) 10-year (-1.4 feet) 5-year (below Low Entry)

# DAMAGE CURVES

|          | 1st Floor<br>Depth<br>(feet) |
|----------|------------------------------|
| 100-year | 1.1                          |
| 50-year  | 0.1                          |
| 25-year  | -0.4                         |
| 10-year  | -1.4                         |
| 5-year   | N/A                          |





- First Floor: FEMA, MWRD, and IDNR
- "Zero damages depth": DuPage County
- Contents value/curves
  - Contents cost less to replace than the Structure
  - FEMA and MWRD: lower contents value automatically built into the contents curve

# DAMAGE CURVES

IDNR Damages 4.22 Manual, May 2003

Built-in codes, or can manually input

DuPage DEC-2 Manual, May 1999

Examples provide, or can manually input

MWRD, October 2003

Built-in, cannot manually input

FEMA, October 2003

Built-in, or can manually modify



#### **One Story with Basement**



#### **Two Stories or Greater with Basement**



#### **One Story without Basement**



- Other damages to consider:
  - Transportation damages
    - May assume 15%, or more specific analysis for a major road closure
  - Erosion damages
    - Structures in danger of eroding due to flood damages
  - Displacement damages
    - Relocation of residents
  - Site specific damages



### • Need a way to compare with the project costs:

- Average Annual Damages
- 50-year Present Value





### Present Value

- Current worth of a future sum of money or stream of cash flows given a specific rate of return
- 50-year Present Value
  - PV = \$100,225

Average Annual Damages (e.g. mortgage payment)

Present Value (e.g. buy a house)



# **COST CALCULATIONS**

- Costs
  - Calculated over the life of the project
  - Typically project life spans are 50-year or 30-year
- Engineer's Estimate of Probable Cost
  - Include annual O&M
  - Engineer's Fees
  - Administrative Costs



# **BENEFIT COST (B/C) RATIO OVERVIEW**

- A \$100,000 house has the following damages:
  - Current AAD = \$5,275
  - 50-year PV = \$100,225
- A berm is built above the 100-yr el. (meeting Corps. Levee requirements) to protect the house:
  - Proposed AAD = \$0
  - 50-year PV = \$0
- The benefits are:
  - AAB = \$5,275 \$0 = **\$5,275**
  - 50-year PV = \$100,225 \$0 = **\$100,225**



# **BENEFIT COST (B/C) RATIO OVERVIEW**

### • To get those benefits, a berm and pump are installed that cost:

- Berm + Pump = \$75,000
- Permit = \$5,000
- Annual O&M = \$1,000
- Average Annual Costs (AAC):
  - Total construction costs = \$80,000 PV ----> AAC = \$4,211

  - Total AAC = \$4,211 + \$1,000
    Total = \$5,211
- 50-year Present Value (PV):
  - Construction Costs = \$80,000 PV
  - O&M = \$1,000 AAC
  - Total 50-year PV = \$80,000 + \$19,000 -----> Total = \$99,000

→ PV = \$80,000

→ PV = \$19,000



# **BENEFIT COST (B/C) RATIO OVERVIEW**

- Average Annual Benefits and Costs:
  - AAB = **\$5,275**
  - AAC = **\$5,211**
- 50-year Present Value Benefits and Costs:
  - 50-year PV Benefits = **\$100,225**
  - 50-year PV Costs = **\$99,000**
- B/C Ratio
  - AAB/AAC = \$5,275/\$5,211 = **1.01**
  - 50-year PV Benefits/Costs = \$100,225/\$99,000 = 1.01



# **DISCUSSION AND QUESTIONS**

MOTOR REPAIR

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