Flood Risk Management
Nonstructural Flood Proofing

CAFM Annual Conference

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Outline

• Project History & Background
• Existing Conditions:
  Hydrologic & Hydraulic Analysis
  Structure Inventory
• Alternatives
• Nonstructural Plan
• Recommendations
Project Background

Byram River Flood Risk Management Study
- Town of Greenwich
- Army Corps of Engineers

Feasibility Study
- Hydrologic & Hydraulic Analysis
- Structure Inventory
- Geotechnical Evaluation
- Environmental Inventory Report
- Nonstructural Analysis
- Alternatives Analysis
- Impact Assessment
Hydrologic & Hydraulic Analysis

- **Existing Conditions**
- **Modeling**
  - Hydrologic Model: **HEC-HMS**
  - Hydraulic Model: **HEC-RAS**
  - 10-, 50-, 100-, and 500-year Storms
- **Development of Alternatives**
  - Initial screening of mitigation measures
  - Modifications to existing model to provide comparative analysis of mitigation measures

Figure 8.11
Design Flood Inundation
Existing Conditions
Byars River 2 of 4
Structure Inventory

- Structure Type
- Condition
- Land Use
- Construction Type
- Garage
- Foundation
- Ground Elevation
- Low Opening
- Main Floor Elevation
- Assessed Value
Development of Alternatives

- Four Alternatives
  - No Action
  - Nonstructural
  - Structural
  - Combination of Measures
Development of Alternatives – Structural Alternative

• Reduces the frequency of flooding
• Alternatives Considered:
  – Diversion/Channel Modifications
  – Storage
  – Levees
  – Floodwalls
  – Pumps
  – Bridge Modifications
• Structural Alternatives:
  – Floodwall, Levee & Channel Modifications (1977 Recommendations)
  – Combination – Bridge Replacement, Modifications to 1977 Recommendations & Nonstructural
Development of Alternatives

- **Impact Assessment**
  - Hydrology & Hydraulics
  - Traffic & Transportation
  - Geotechnical
  - Structural
  - Environmental
  - Utilities
Nonstructural Plan

- Evaluated all 493 structures for the 10 year, 100 year and 500 year storm events
- Recommendation for flood proofing

Elevation  | Relocation  | Localized Levees and ringwalls  | Dry Floodproofing  | Wet Floodproofing
Elevation

• Raising a home to prevent floodwaters from reaching living areas
• Foundation or elevate on fill, piles, or columns

Things to consider:
  – House must be structurally sound
  – Homes with basement will require it to be filled as part of elevation
  – Space below a house on an open elevation can be utilized for parking
Ringwalls

- Small floodwall or levee, around your home to hold back floodwaters
- Surround a home or protect isolated openings such as doors, windows, and walkout on-grade basements

Things to consider:
- Home and surrounding area will be protected from inundation
- No significant changes to the home will be required
- Designed for an elevation equal to the base flood elevation
Dry Flood Proofing

- Sealing your home to prevent floodwater from entering
- Not recommended for flood depths greater than 3-feet

Things to consider:
- Requires human intervention
- Seal walls with waterproof coatings, impermeable membranes, or supplemental layers of masonry or concrete
- Shield all openings, such as doors and windows, below the design flood elevation
Wet Flood Proofing

- Modifying uninhabited portions of the home so floodwaters will enter but not cause significant damage
- Reduces risk of structural collapse as hydrostatic pressures equalizes

Things to consider:
- Requires space above the design flood elevation where items can be stored temporarily or permanently
- Service equipment should be protected by relocating above flood elevation or protecting it in place
- Requires removal of water after the event
Nonstructural Plan

- Recommendations for Each Storm Event
  - 10 Year
  - 100 Year
  - 500 Year
- Based on Structure Type & Use
- Determine Flood Proof Measure Based on Algorithm Results
  - Slab-on-grade
  - Subgrade Basement
  - Elevated
  - Bi-levels/Raised Ranches
  - Raised Foundations/Split Levels
  - Large Residential
Nonstructural Plan

- **Algorithms**
  - Structure Type
  - Use
  - Flood Elevation (FE)
  - Ground Elevation (GE)
  - Flood Depth (FD)
  - Main Floor Elevation (ME)
  - Low Opening Elevation (LE)

- **Determine Details for Recommended Flood Proof Measure**

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### Structure Type

**Slab-on-Grade Foundation**

**Description**

Structures that are constructed on a slab foundation at grade.

**Assumptions**

Structures will not be dry flood proofed for main floor flood depths greater than 2-feet.

**Algorithm**

#### Residential

1. If FE < GE then No Flood Proofing Required
2. If FE+1 < ME then No Flood Proofing Required
3. If FE+1 > ME then
   - a. If FE+1 > ME+3 then
      - i. If Poor Condition then Buyout
      - ii. Otherwise Elevation
   - b. If FE+1 < ME+3 then
      - i. If FE+1 < GE+6 then Dry Flood Proofing or Ringwall
      - ii. If FE+1 > GE+6 then Dry Flood Proofing

#### Nonresidential

1. If FE<GE then No Flood Proofing Required
2. If Wood or Metal Construction Type then
   - a. If FE+1 < ME then No Flood Proofing Required
   - b. If FE+1 > ME then
      - i. If FE+1 > ME+3 then
         - 1. If Poor Condition then Buyout
         - 2. Otherwise Elevation
      - ii. If FE+1 < ME+3 then Dry Flood Proofing or Ringwall
3. If Masonry Construction Type then
   - a. If FE+1 < ME then No Flood Proofing Required
   - b. If FE+1 > ME then
      - i. If FE+1 > GE+3 then Ringwall
      - ii. If FE+1 < GE+3 then Dry Flood Proofing or Ringwall
Nonstructural Plan

10 Year Water Surface Elevations

47 Flood Proofing Measures
- Dry Flood Proofing
- Wet Flood Proofing
- Floodwall
- Elevation
- Acquisition

Design to 100 Year Elevation
## Nonstructural Plan – 10 Year

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Flood Proofing Measure</th>
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<tbody>
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<td>Wet</td>
<td>Ringwall</td>
<td>Elevation</td>
<td>Acquisition</td>
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<tr>
<td>Bi-Levels</td>
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<tr>
<td>Raised Ranch</td>
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<td>Raised Foundation</td>
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<td>Split Level</td>
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<tr>
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<td><strong>Total</strong></td>
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<td>29</td>
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Nonstructural Plan

100 Year Water Surface Elevations

202 Flood Proofing Measures
  – Dry Flood Proofing
  – Wet Flood Proofing
  – Floodwall
  – Elevation
  – Acquisition
## Nonstructural Plan – 100 Year

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<thead>
<tr>
<th>Structure Type</th>
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<td>Subgrade Basement</td>
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<td>Raised Ranch</td>
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<td>Split Level</td>
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<td>Large Residential</td>
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<tr>
<td><strong>Total</strong></td>
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</table>
Nonstructural Plan

Detailed quantities for each alternative
- Storm event
- Structure type
- Flood proofing measure

<table>
<thead>
<tr>
<th>STREET ADDRESS</th>
<th>PARCEL PERIMETER (RINGWALL LENGTH, FT)</th>
<th>HEIGHT OF 10-YEAR RINGWALL</th>
<th>HEIGHT OF 100-YEAR RINGWALL</th>
<th>HEIGHT OF 500-YEAR RINGWALL</th>
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<tbody>
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<td>Hillside Avenue</td>
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Cost Benefit Analysis

- **Benefit Cost Ratio > 1**
- **No Action**
  - $5M - $8M Estimated Annual Damages
- **Nonstructural**
  - $17M - $50M Based on Protection Level
- **Structural (1977 Modified Plan)**
  - $50M - $56M
- **Combination Plan**
  - >$56M

IF BCR > 1

Tentatively Selected Plan (TSP)
### Proposed Nonstructural Plan

<table>
<thead>
<tr>
<th>Non-Structural Measure</th>
<th>Number of Properties</th>
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<tbody>
<tr>
<td></td>
<td>10-YR</td>
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<tr>
<td>Wet or Dry Floodproofing</td>
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</tr>
<tr>
<td>Localized Ringwalls / Levees</td>
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<tr>
<td>Elevation (or raising) on Piers</td>
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<tr>
<td>Buyout / Acquisition / Relocation</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>47</strong></td>
</tr>
</tbody>
</table>

**Estimated Cost Range**

- $17M to $21M
- $24M to $30M
- $45M to $50M
Recommendations

• Selected Alternative Needs to Meet BCR >1
• Cost < 4 x Damages
• Damages $5M - $8M
• Recommended Project $20M - $32M
• Structural Plans BCR <1 (i.e. too costly to support damages)
• 10 Year or 100 Year Nonstructural Plan BCR close to 1
Next Steps

- More Detailed Structure Inventory - Survey
- Refine Flood Proofing Measures for 10 year and 100 year storm events
- More Detailed Cost Estimate for each Structure/Recommended Flood Measure
- Determine BCR for each alternative
- Select the Tentatively Selected Plan

- Nonstructural Plan is the Cost Beneficial Alternative
Questions?

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