CHAPTER 3 – SELECTING MITIGATION MEASURES

3.1 Introduction

The remainder of this document focuses on the process of selecting appropriate mitigation measures. This process includes the following steps:

1. **Initial screening using NT.** Conduct an initial screening using NT and determine appropriate mitigation measures by answering questions regarding flooding and structure characteristics (use **Worksheet A, Technical Considerations Scorecard**).
2. **Evaluate appropriate mitigation measures.** Based on information provided in Chapters 4 through 10, record rankings of each mitigation measure (use **Worksheet B, Appropriate Mitigation Measures**).

This process is designed to assist State and local officials in discussing which mitigation measures are the most appropriate to pursue with the individual property owners and other community officials who may need to make or support decisions. The initial results of the selection process may not always identify a single best option for any particular situation. However, it will narrow the options and document the selection process for all participants. It is assumed that structures and/or areas of interest within the community have been identified based on past flooding and a comprehensive mitigation planning process.

Hazard Mitigation Planning - For information on the mitigation planning process refer to the FEMA Mitigation Planning "How-To" Guides which are based on 44 CFR, Part 201 – Mitigation Planning (see Section 1.3). FEMA publication 511 provides an overview of how to conduct an area analysis to determine whether a neighborhood-level approach, such as drainage improvements, relocation, or acquisition, would resolve the flood problem (see Chapter 7, Area Analysis in FEMA 511, *Reducing Damage from Localized Flooding*).

This chapter includes the following:

- **Section 3.2, Mitigation Measures Overview,** provides a brief overview of seven categories of mitigation measures. Additional information on each mitigation measure is located in Chapters 4 through 10 with appropriate references for detailed information.
- **Section 3.3, Initial Screening Using the NT,** describes the initial screening process for identifying appropriate mitigation measures using data that are collected in the NT. Completed examples of worksheets are included in Appendix A.
- **Section 3.4, Hazard and Structure Characteristics,** includes information on the questions used in the initial screening process. This subsection describes how to obtain the data needed to answer the question and provides references for additional information. A screenshot from the NT illustrates where this information is located.
- **Section 3.5, Evaluating the Mitigation Measures,** describes how to further evaluate the identified mitigation measures following the initial screening process.

3.2 Mitigation Measures Overview

This subsection introduces seven categories of flood mitigation measures designed to protect properties from flooding. These mitigation measures are further discussed in Chapters 4 through 10.

3.2.1 Drainage Improvements (see also Chapter 4)

The drainage system moves surface water through channels to a receiving body of water. The system itself contains several conveyance systems that carry water away and may contain storage facilities to store excess water until it can be removed. Examples of improvements to regional or local drainage systems include modifying a culvert, stream, or river channel to provide a greater carrying capacity to move floodwaters off areas where damage occurs.

3.2.2 Barriers (see also Chapter 5)

Examples of barriers include building a floodwall or levee around a structure or a group of structures to hold back floodwaters. Levees are usually embankments of compacted soil, and floodwalls are usually built of concrete or masonry or a combination of both. Levees require more space than a floodwall since the sides of a levee are sloped to provide stability and resist erosion. An alternative to a permanent barrier is a temporary one, such as large water-filled tubes or bladders, metal walls lined with impermeable materials that act as floodwalls**,** and expandable gates that block floodwaters from entering structures through openings such as doors and windows.

3.2.3 Wet Floodproofing (see also Chapter 6)

Wet floodproofing a structure involves making uninhabited portions of the structure resistant to flood damage and allowing water to enter during flooding. Damage to a structure is reduced since water is allowed to enter and balances the hydrostatic pressure on both sides of the walls and floors.

3.2.4 Dry Floodproofing (see also Chapter 7)

Dry floodproofing involves sealing structures to prevent floodwaters from entering. A structure can be dry floodproofed using waterproof coatings or impermeable membranes to prevent seepage of floodwater through the walls, installing watertight shields over doors or windows, and installing sewer backup prevention measures.

3.2.5 Elevation (see also Chapter 8)

Elevating a structure consists of raising the lowest floor to or above the flood level. This can be done by elevating the entire structure, including the floor, or by leaving the structure in its existing position and constructing a new, elevated floor within the structure. The method used depends on the construction type, foundation type, and flooding conditions.

3.2.6 Relocation (see also Chapter 9)

Relocating a structure includes moving the structure out of the floodplain to higher ground where it will not be exposed to flooding. The process involved in relocating a structure includes raising the structure and placing it on a wheeled vehicle to be moved to a new location.

3.2.7 Acquisition (see also Chapter 10)

Acquisition involves buying and tearing down a structure. The property owners would then move to another property that is located outside of the floodplain. A new building meeting all building and flood protection code requirements can be built on the lot or the lot can remain as open space.

3.3 Initial Screening Using the NT

The steps listed below describe how to fill out **Worksheet A, Technical Considerations Scorecard.** Appendix A includes a completed sample packet. For blank versions of this worksheet, see Appendix B.

1. Use **Worksheet A, Technical Considerations Scorecard,** to record responses to the nine questions under the first column (titled "Question").

   For background information on each question, see Section 3.4, Hazard and Structure Characteristics. This subsection also discusses how to obtain the data needed to answer these questions as well as where this information, once collected, is located in the NT.

2. Based on the responses selected in the Response column of Worksheet A, for each row with a check mark in the "Response" column, check all boxes that are <u>not</u> blacked out.

   Repeat this step for each question. Include any notes or comments in the far right-hand column of Worksheet A.

3. Place an "X" in the row (titled "Appropriate Mitigation Measures") of Worksheet A under the column of any mitigation measure that does not include a black box in any selected response row.

   For example, a response of manufactured home to Question #1 will exclude the selection of wet floodproofing and dry floodproofing in the Appropriate Mitigation Measures row. In the sample packet in Appendix A, the response of "Deep" to Question #6 eliminates the mitigation measures of drainage improvements, wet floodproofing, and dry floodproofing from consideration as appropriate.

Worksheet A: Technical Considerations Scorecard

Date Prepared: _____ Date Property Visited: _____
Property Owner Name: _____
Property Address: _____
Repetitive Loss Property Locator Number: _____
Prepared by: _____

Legend
- Mitigation measure is not appropriate.
- Mitigation measure may be appropriate and requires additional consideration.
- Mitigation measure is appropriate.

NT Reference indicates where the information may be found in the National Tool.

Instructions to complete Worksheet A: Technical Considerations Scorecard

1. For each of the questions, based on the property information, put a check mark in the appropriate box in the "Response" column.
2. For the row with a check mark in the "Response" column, check all boxes that are not blacked out.
3. After completing the questions, review each of the mitigation measures columns. Select the "Appropriate Mitigation Measures" box only for those columns that do not have any blacked out boxes in the selected response row.

Question	Response	Drainage Improvements	Barriers	Wet Floodproofing	Dry Floodproofing	Elevation	Relocation	Acquisition	Comments
1. What is the structure type? *NT Reference - Limited Data View, Site Observations* tab	☐ Wood Frame/ Metal/ Other	☐	☐	☐	☐	☐	☐	☐	
	☐ Concrete/ Masonry/ Brick Faced	☐	☐	☐	☐	☐	☐	☐	
	☐ Manufactured Home	☐	☐			☐	☐	☐	
2. What is the condition of the structure? *NT Reference - Limited Data View, Site Observations* tab	☐ Good	☐	☐	☐	☐	☐	☐	☐	
	☐ Fair	☐	☐	☐	☐	☐	☐	☐	
	☐ Poor	☐	☐					☐	
3. What is the foundation type? *NT Reference - Limited Data View, Site Observations* tab Diagram numbers refer to Elevation Certificate found in the NT.	☐ Slab-on-grade (Diagram 1, 3, 6, or 7)	☐	☐	☐	☐	☐	☐	☐	
	☐ Basement/ Split level (Diagram 2 or 4)	☐	☐	☐	☐	☐	☐	☐	
	☐ Piers, Posts, Columns, or Crawlspace (Diagram 5 or 8)	☐	☐	☐		☐	☐	☐	

Question	Response	Drainage Improvements	Barriers	Wet Floodproofing	Dry Floodproofing	Elevation	Relocation	Acquisition	Comments
4. What is the number of stories? *NT Reference - Limited Data View, Site Observations* tab	☐ 1-2	☐	☐	☐	☐	☐	☐	☐	
	☐ 3 or more	☐	☐	☐	☐	☐	☐	☐	
5. What is the building footprint? *NT Reference - Detailed Data View, Additional Site Information* tab	☐ < 2,500 sq ft	☐	☐	☐	☐	☐	☐	☐	
	☐ > 2,500 sq ft	☐	☐	☐	☐	☐	☐	☐	
6. What is the flood protection depth? *NT Reference - Detailed Data View, Elevation and Hazard* tab	☐ Deep (> 6ft)		☐			☐	☐	☐	
	☐ Moderate (3 to 6 ft)	☐	☐	☐		☐	☐	☐	
	☐ Shallow (<3 ft)	☐	☐	☐	☐	☐	☐	☐	
7. Does flash flooding occur at the project site? *NT Reference - Detailed Data View, Elevation and Hazard* tab	☐ Yes	☐	☐	☐	☐	☐	☐	☐	
	☐ No	☐	☐	☐	☐	☐	☐	☐	
8. What is the flood velocity? *NT Reference - Detailed Data View, Elevation and Hazard* tab	☐ Fast (>5 fps)	☐	☐	☐	☐	☐	☐	☐	
	☐ Slow/Moderate (<5 fps)	☐	☐	☐	☐	☐	☐	☐	
9. Is the structure located in the floodway? *NT Reference - Detailed Data View, Elevation and Hazard* tab	☐ Yes	☐	☐	☐	☐	☐	☐	☐	
	☐ No	☐	☐	☐	☐	☐	☐	☐	
Appropriate Mitigation Measures		☐	☐	☐	☐	☐	☐	☐	

fps = feet per second
ft = feet
sq ft = square feet

3.4 Hazard and Structure Characteristics

3.4.1 Question #1. What is the structure type?

What are the most common structure types? The most often used structure types include wood frame, metal, concrete, masonry, manufactured home, or a combination of two or more of these types. Definitions of these terms are included in the Glossary in Appendix I.

What is the significance of the structure type? The structure type influences the considerations that will need to be addressed.

- Dry floodproofing may not be an appropriate mitigation measure for a wood-frame or metal structure since they are difficult to make watertight.
- Solid masonry, stone walls, or wood-frame construction with a brick veneer may not be appropriate for elevation or relocation projects since these structures will need significant support during the lifting process, which may be expensive.
- If the construction type is a manufactured home, wet and dry floodproofing are not appropriate mitigation measures because virtually any depth of flooding causes significant and irreparable damage.

Where is structure type information located in NT? The structure type can be found under Limited Data View on the *Site Observations* tab (Figure 3-1).

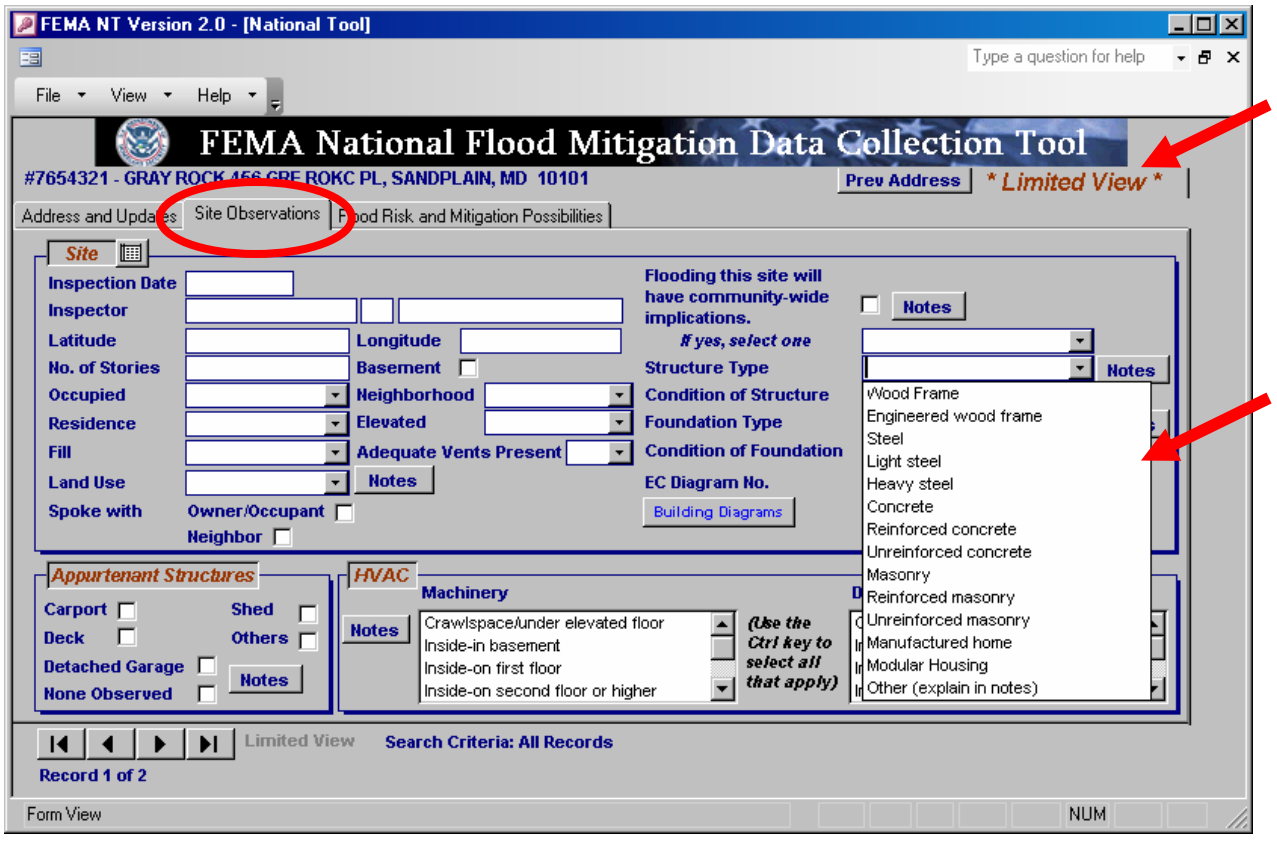

Figure 3-1. *Site Observations* tab - Structure Type menu

Where to find additional information:

FEMA 259. *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures***.** See Chapter III, Parameters of Retrofitting (page III-31).

FEMA 497. *National Flood Mitigation Data Collection Tool Guide*. See Chapter 6, Data Collection with the NT 6.2.2.1 – Site for additional information on structure types (page 6-13).

3.4.2 Question #2. What is the condition of the structure?

How is the condition of the structure determined? This information is based on the level of repair needed and may be obtained by a site visit. It is recommended that the local building official be consulted for the condition of the structure. An explanation of the terms (Good, Fair, and Poor) can be found in FEMA 497, *National Flood Mitigation Data Collection Tool Guide***.**

The condition of the structure will have implications for selecting an appropriate mitigation measure:

- For a structure in fair condition, wet and dry floodproofing, elevation, and relocation may not be appropriate mitigation measures unless it is determined that the structure is sound enough to undergo the mitigation measure.
- Wet and dry floodproofing, elevation, and relocation are not appropriate mitigation measures for structures in poor condition since these projects may not be technically feasible or cost-effective.

Where is structure condition information located in NT? An assessment of the structure condition can be found on the *Site Observations* tab in Limited Data View (Figure 3-2).

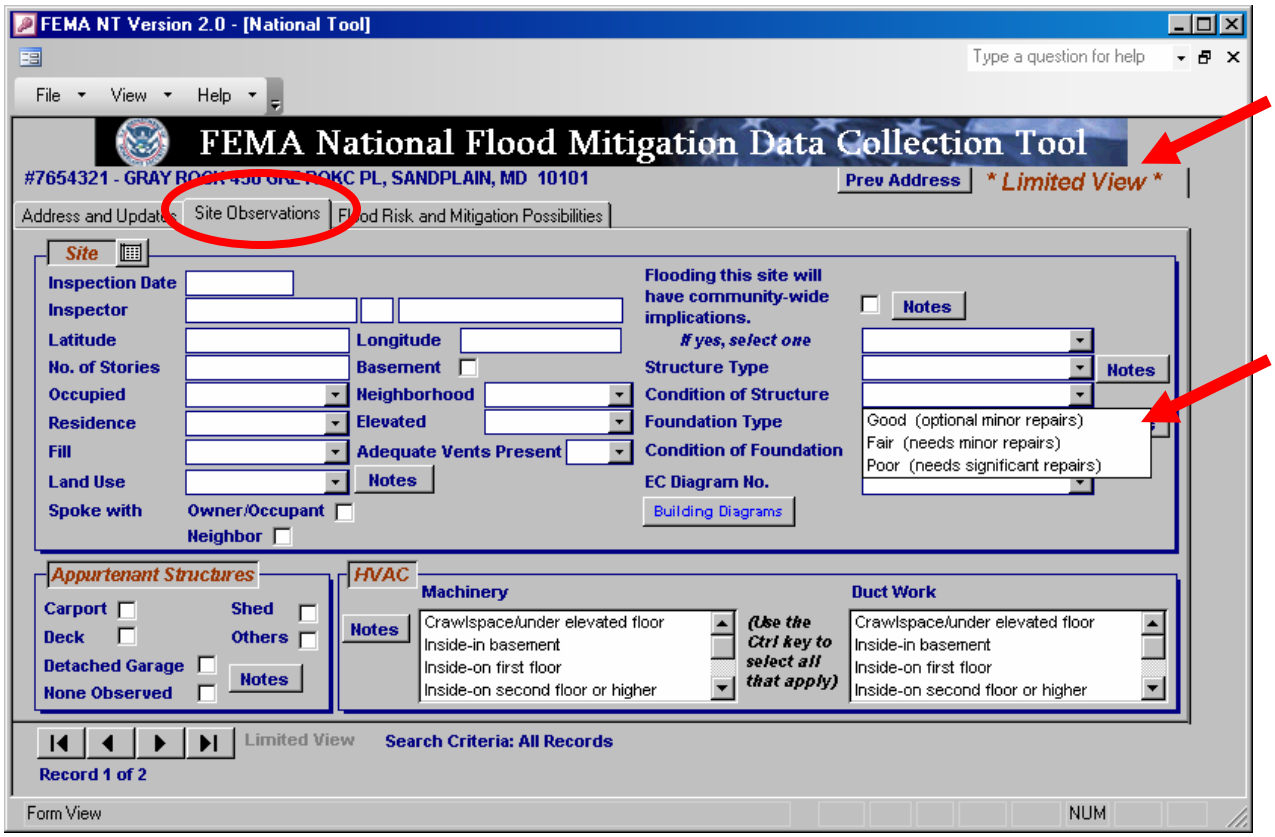

Figure 3-2. *Site Observations* tab - Condition of Structure drop down menu

Where to find additional information

FEMA 259. *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*. See Chapter III, Parameters of Retrofitting (pages III-32 to III-34).

FEMA 497. *National Flood Mitigation Data Collection Tool Guide***.** See Chapter 6, Data Collection with the NT 6.2.2.1 – Site for additional information on the condition of the structure (pages 6-13 to 6-14).

3.4.3 Question #3. What is the foundation type?

What types of foundations are most common? The main types of foundations are slab-on-grade; basement; elevated on piers, posts, piles, columns, or shear walls; and crawlspaces. Each type has specific considerations that can affect a mitigation project:

- Slab-on-grade structures are more difficult to elevate or relocate than structures on basement or crawlspace foundations, if the slab is attached.
- Elevating structures on basement foundations involves elevating or relocating utility system components usually found in basements, such as furnaces and hot water heaters. In addition, if the structure is substantially damaged or is being substantially improved, the basement may need to be filled in to meet local floodplain regulations. Basement

walls are subject to hydrostatic pressure and buoyancy forces, which may make barriers and dry floodproofing inappropriate mitigation measures.

- Structures with piers, posts, piles, columns, shear walls, or crawlspaces should not be dry floodproofed since the floors are not watertight and flotation will cause damage to the foundation.

Where is foundation information located in the NT? The type and condition of the foundation can be found on the *Site Observations* tab in the Limited Data View (Figure 3-3).

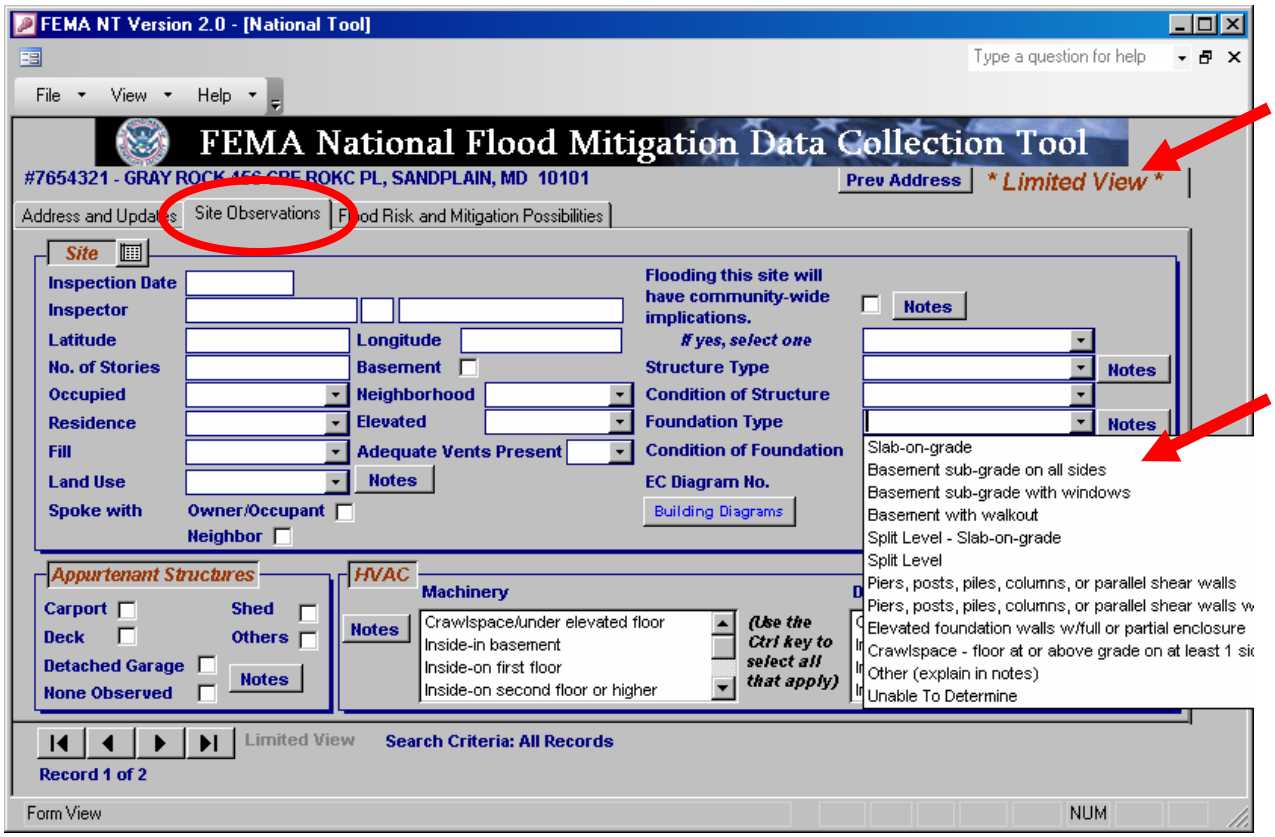

Figure 3-3. *Site Observations* tab - Foundation Type menu

Where to find additional information:

FEMA 85. *Manufactured Homes in Flood Hazard Areas: A Multi-Hazard Foundation and Installation Guide*. See Chapter 9, Foundation Systems.

FEMA 259. *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*. See Chapter III, Parameters of Retrofitting (pages III-28 to III-29).

FEMA 497. *National Flood Mitigation Data Collection Tool Guide*. See Chapter 6, Data Collection with the NT 6.2.2.1 – Site for additional information on foundation types (page 6-14).

3.4.4 Question #4. What is the number of stories?

Why is the number of stories in a structure important? Multi-story structures are difficult to elevate and relocate. One consideration is that moving overhead power lines along the route may cause the cost of the mitigation measure to increase and thereby reduce the cost-effectiveness. It is also technically more difficult to elevate or relocate a larger structure than a smaller more compact structure.

Where is number of stories information located in NT? The number of stories for the structure may be identified on the *Site Observations* tab in the Limited Data View (Figure 3-4).

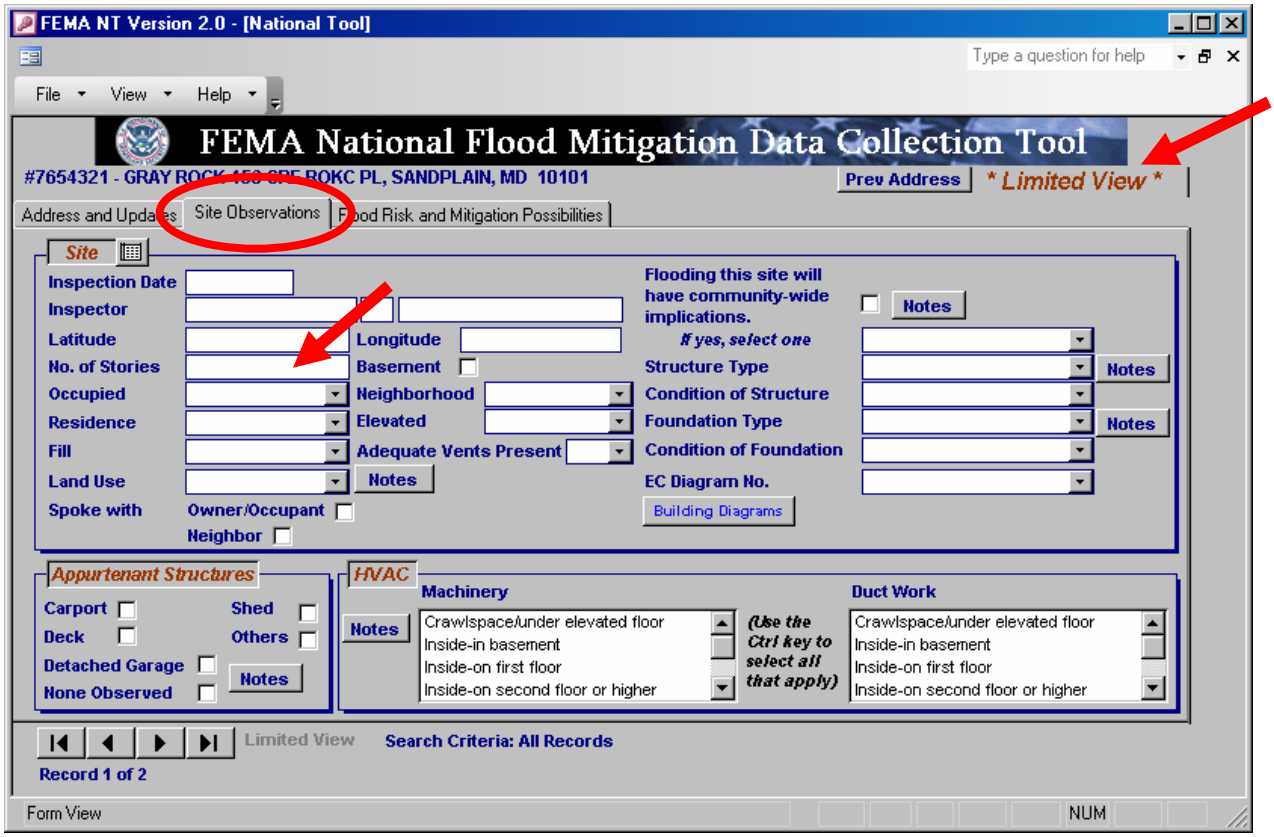

Figure 3-4. *Site Observations* tab - Number of Stories

Where to find additional information:

FEMA 497. *National Flood Mitigation Data Collection Tool Guide*. See Chapter 6, Data Collection with the NT 6.2.2.1 – Site (page 6-11).

3.4.5 Question #5. What is the building footprint?

Why is footprint an important issue? Larger, heavier, more complex shaped buildings are more difficult and expensive to elevate or relocate. While large buildings are not necessarily a different type of construction, they do present a significant challenge to the elevation or relocation contractor, primarily because of their weight or configuration. They may include a rambling, ranch-style house; a multi-storied house or commercial building; or a very large and heavy masonry, concrete, or stone building. Rambling construction can be handled by cutting the building into two or more pieces and elevating each piece individually. Once elevated, the individual sections are rejoined and cosmetically corrected to disguise the fact the building was cut.

Where is structure size information located in NT? The building footprint area or square feet of the structure can be found on the *Additional Site Information* tab in the Detailed Data View (Figure 3-5).

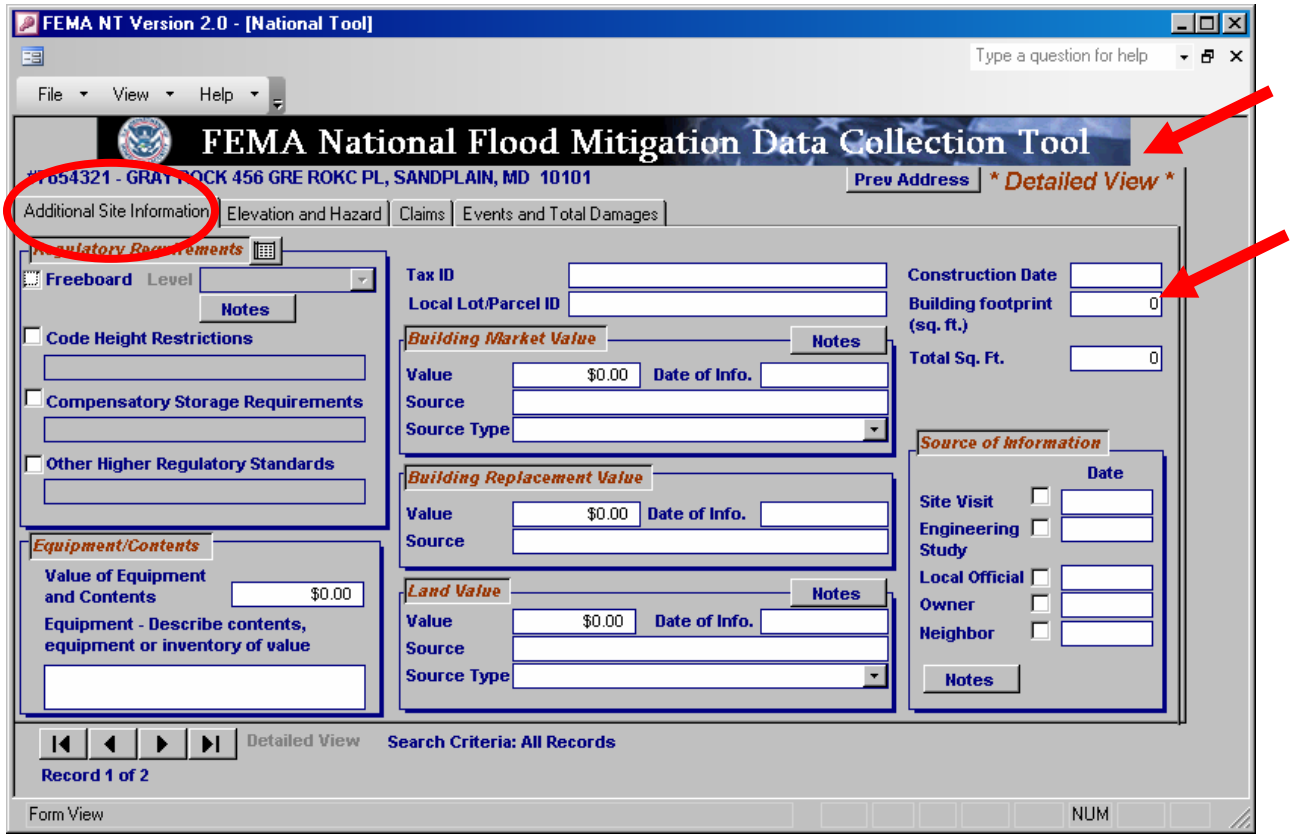

Figure 3-5. *Additional Site Information* tab - Building footprint

Where to find additional information:

FEMA 497. *National Flood Mitigation Data Collection Tool Guide*. See Chapter 6, Data Collection with the NT 6.3.1 - *Additional Site Information* tab (page 6-18).

3.4.6 Question #6. What is the flood protection depth?

What is flood protection depth? Flood protection depth is the depth above the lowest adjacent grade to which a mitigation measure is designed. It is the flood protection elevation (or flood protection level) minus the elevation of the lowest adjacent grade. "Flood protection elevation" is used in other FEMA mitigation publications, including FEMA 259. It is usually the BFE plus 1 or more feet of freeboard. Floodwaters, even when they are not moving, exert pressure on structural components such as walls and concrete floor slabs. This hydrostatic pressure is caused by the weight of the water and increases as the depth of the water rises.

Flood Protection Depth Example. If the base flood elevation is 480 feet above sea level and the lowest adjacent grade is 475 feet above sea level and the community wants to have the margin of protection of a 1-foot freeboard, the flood protection depth is (480 + 1) -475 = 6 feet.

Flood protection depth may be a higher level, especially if a recent flood was higher than the base flood. If protecting to the BFE proves infeasible, the designer may want to use a lower flood protection level, such as the depth of the repetitive flooding. For example, if the building is a large masonry industrial building on a slab foundation, elevation may be infeasible. Dry floodproofing to 3 feet may be the only feasible approach, so the flood protection depth would be 3 feet, even though the base flood depth may be 4 or more feet above lowest adjacent grade.

How does flood depth affect a structure? Floodwater, including water-saturated soil, pushes in on walls and up on floors, posing a special hazard for basement walls. Because pressure increases with the depth of the water, the pressure on basement walls is greater than the pressure on the walls of the upper floor. This pressure is made even greater by the weight of the saturated soil that surrounds the basement. Drainage improvements will not be technically feasible for structures that experience deep flooding. Dry floodproofing is not an appropriate mitigation measure for flooding that exceeds 3 feet due to the hydrostatic pressure on the structure.

How is flood depth calculated? Flood depth is the difference between the water surface elevation and the grade elevation of the flooded area. Ground elevations are established by topographic surveys and BFEs are included on FIRM panels where a detailed study has been performed and should be estimated using the flood profile in the corresponding FIS.

Guidance provided in FEMA 265, *Managing Floodplain Development in Approximate Zone A Areas*, suggests other methods to determine the BFE and appropriate Design Flood Elevation (DFE). One method involves extrapolating existing BFE data by using the flood profile from a FIS for a site that is within 500 feet upstream of a detailed studied portion of a stream and the floodplain and channel bottom slope characteristics are fairly similar. FEMA 265 also provides information on QUICK-2, which is a computer program developed by FEMA that may be used to compute BFEs. This software program is available on the FEMA website at http://www.fema.gov/plan/prevent/fhm/frm_soft.shtm.

Where is depth of flooding information located in NT? The depth of flooding may be identified in the NT on the *Elevation and Hazard* tab in the Detailed Data View in the "Depth of 100 yr flood at site" box (Figure 3-6, number 3). When the BFE (Figure 3-6, number 1) and Lowest Adjacent Grade (Figure 3-6, number 2) are entered in the *EC or Elevation Data* section,

the flood depth of 100-year flood (Figure 3-6, number 3) at the project site is calculated automatically by the NT. The Lowest Adjacent Grade is subtracted from the BFE to determine flood depth. Both the BFE and Lowest Adjacent Grade information can be found on a FEMA Elevation Certificate. Freeboard requirements are included in the Additional Site Information Tab (Figure 3-7, number 1). The drop down box includes options for the amount of freeboard required.

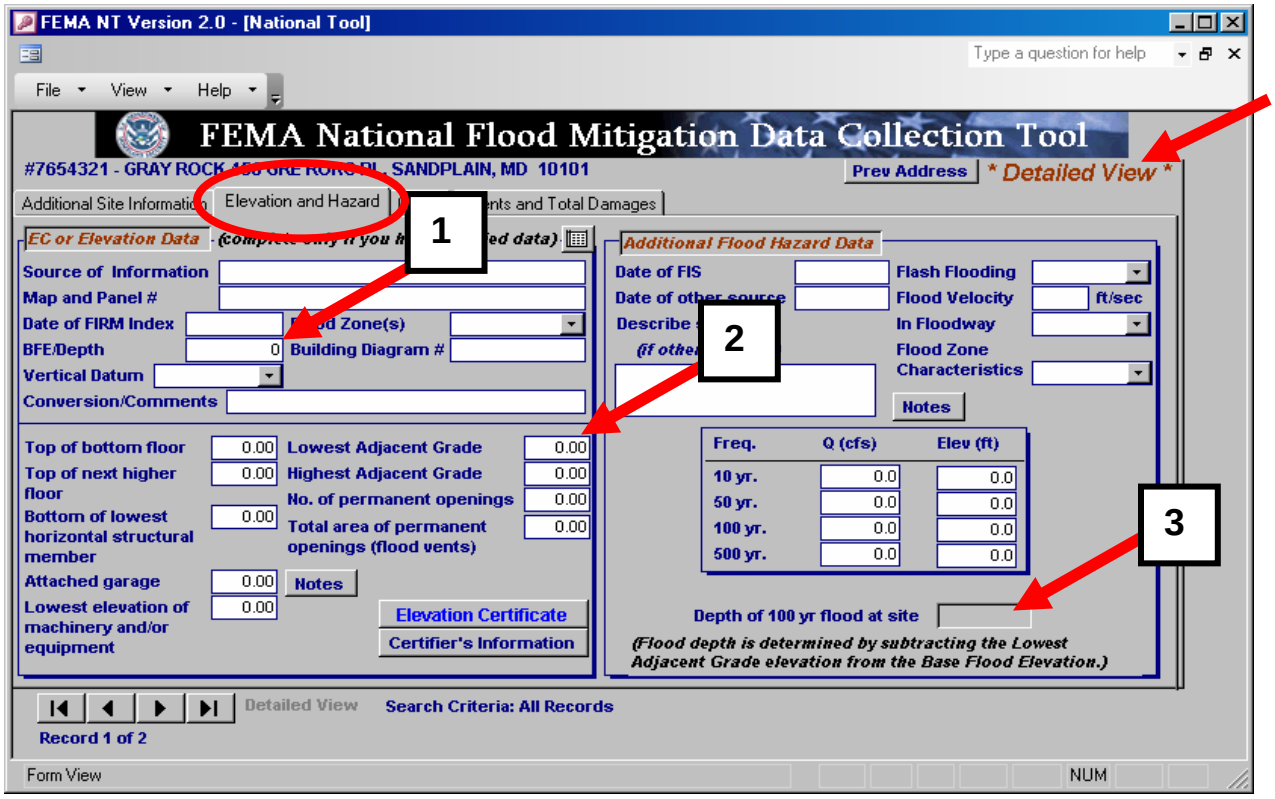

Figure 3-6. *Elevation and Hazard* tab - Flood Depth

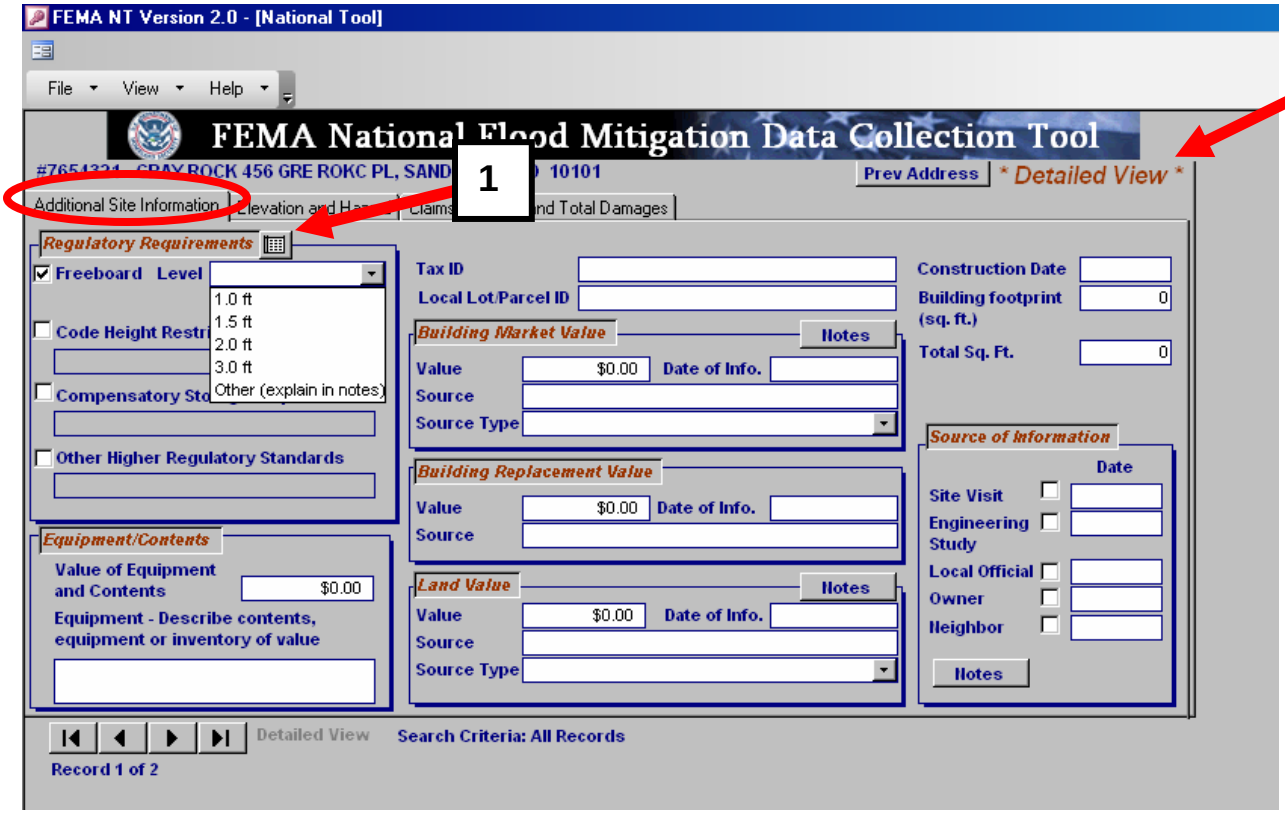

Figure 3-7. *Additional Site Information* tab - Regulatory Requirements

Where to find additional information:

FEMA 85. *Manufactured Homes in Flood Hazard Areas: A Multi-Hazard Foundation and Installation Guide.* See Chapter 5, Natural Hazards – Design Considerations 5.2.2 Flood Elevation and Depth (pages 5-18 to 5-20).

FEMA 259. *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*. See Chapter III, Parameters of Retrofitting (pages III-21 to III-23).

FEMA 265. *Managing Floodplain Development in Approximate Zone A Areas*.

FEMA 480. *National Flood Insurance Program (NFIP) Floodplain Management Requirements: A Study Guide and Desk Reference for Local Officials*. See Unit 4 – Using NFIP Studies and Maps for instruction on how to use the FIRM and FIS to determine the BFE.

FEMA 497. *National Flood Mitigation Data Collection Tool Guide*. See Chapter 6, Data Collection with the NT 6.3.2.2-Additional Flood Hazard Data (page 6-24).

FEMA 499. *Home Builder's Guide to Coastal Construction.* Technical Fact Sheet No. 4 Lowest Floor Elevation.

3.4.7 Question #7. Does flash flooding occur at the project site?

Why is flash flooding important? Flash flooding determines the amount of warning time prior to an impending flood. With adequate warning, property owners can be better prepared to protect themselves and their property. For example, property owners in the floodplains of large rivers such as the Mississippi and Missouri may know days in advance that flooding is occurring upstream and will eventually reach their property. Conversely, the warning time may be very short on small streams or drainageways where flooding from an intense thunderstorm may begin only minutes after the rainfall begins. With adequate warning, property owners can be better prepared to implement actions designed to protect themselves and their property. Mitigation measures that require human intervention to operate such as barriers, and wet and dry floodproofing may not be appropriate mitigation measures without adequate warning time.

How is flash flooding determined? Information on whether the structure is subject to flash flooding may be obtained from the FIS. In addition, surrounding and upstream terrain is a good indicator of the likelihood of flash flooding.

Where is flash flooding information located in NT? To identify whether the structure is in an area that experiences flash flooding and thereby has a short warning time, the Additional Flood Hazard Data section of the *Elevation and Hazard* tab in Detailed Data View would be reviewed (Figure 3-8).

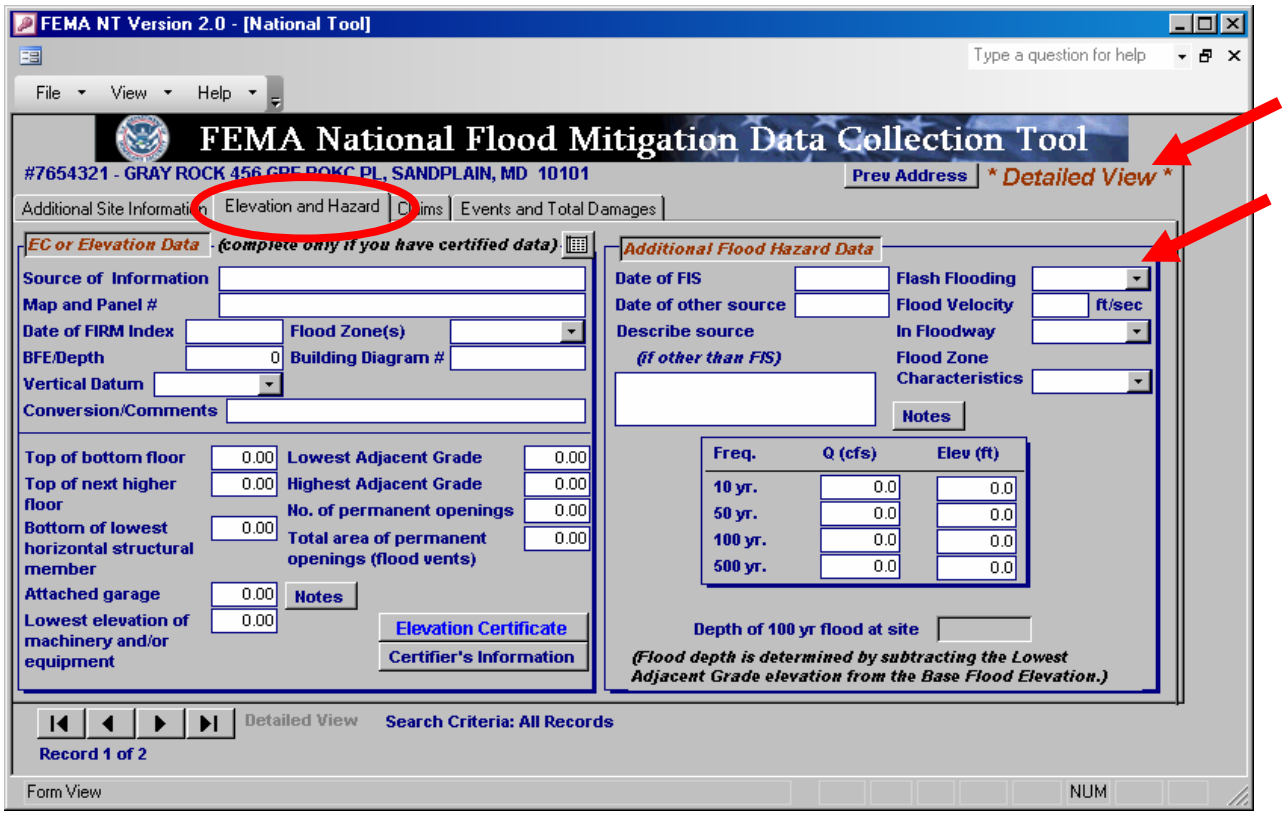

Figure 3-8. *Elevation and Hazard* tab - Flash Flooding

Where to find additional information:

FEMA 85. *Manufactured Homes in Flood Hazard Areas: A Multi-Hazard Foundation and Installation Guide.* See Chapter 5, Natural Hazards – Flood Characteristics 5.2.1 Frequency, Duration and Rate of Rise (pages 5-16 to 5-18).

FEMA 259. *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures.* See Chapter III, Parameters of Retrofitting (page III-25).

FEMA 497. *National Flood Mitigation Data Collection Tool Guide*. See Chapter 6, Data Collection with the NT 6.3.2.2 – Additional Flood Hazard Data (page 6-23).

FEMA 511. *Reducing Damage from Localized Flooding.* See Chapter 6, Warning and Emergency Services.

3.4.8 Question #8. What is the flood velocity?

What is flood velocity? Flood velocity is the speed at which floodwaters move. It is usually measured in feet per second (fps). Flow velocities during riverine floods can easily reach 5 to 10 fps, and in some situations may even be greater; 10 fps is roughly equivalent to 7 miles per hour.

What affects flood velocity? The velocity of floodwaters depends on factors such as the slope of the stream channel and floodplain and surface roughness. Floodwaters generally move faster along streams in steep mountainous areas than streams in flatter areas. Flood velocity also depends on surface roughness. For example, water will flow more swiftly over impervious surfaces, such as parking lots, roads, and other paved surfaces, than over ground covered with large rocks, trees, dense vegetation, or other obstacles.

Flood velocities in the floodplain are usually higher nearer the stream channel than at the outermost fringes of the floodplain where water may flow very slowly or not at all. Even with only a few feet of flooding depth, floodwaters with velocities as low as 1 or 2 fps can exert tremendous forces on a building.

There are several reasons why flow velocity is important. The pressure on the structure caused by flowing water, known as “hydrodynamic pressure,” pushes harder on walls than still water. Hydrodynamic forces are caused by water moving around an object and consist of frontal pressure against the structure, drag forces along the sides, and negative forces on the downstream side. In addition, flowing water can cause erosion and scour. Erosion removes soil that lowers the ground surface across an area. Scour is the removal of soil around objects that obstruct flow, such as foundation walls. Both erosion and scour can weaken a structure by removing supporting soil and undermining the foundation. In general, the greater the flow velocity and the larger the structure, the greater the extent and depth of the erosion and scour will be. The impact, drag, and suction from fast-moving water may move a building from its foundation or otherwise cause structural damage or failure. Any mitigation measure that is implemented in an area that experiences high flood velocity (5 fps or greater) will need to factor this technical consideration into its design.

How is flood velocity calculated? The mean flood velocity in the floodway can be obtained from the community's Flood Insurance Study. Mean floodway velocities can be obtained from the FIS by matching the cross-section on the FIRM with the cross-section in the FIS Floodway Data Table. The floodway's mean velocity usually overestimates the flood velocity within the flood fringe, which is the portion of the floodplain lying outside of the floodway. In general, floodwaters move slower as they extend outward from the floodway. However, the floodway velocities can be used as a general measure to determine cross-section locations within the floodplain where floodwaters will move relatively faster or slower, and provide an upper limit for velocities in the flood fringe.

Unfortunately, there is usually no definitive source of information to determine potential flood velocities in the vicinity of specific buildings. Hydraulic computer models or hand computations based on existing floodplain studies may provide flood velocities in the channel and overbank areas. Where current analysis data are not available, historical information from past flood events is probably the most reliable source. The property owner should consider special precautions if velocities exceed 5 fps or if there is a history of higher velocities during previous local floods.

The estimation of design flood velocities in coastal flood hazard areas is subject to considerable uncertainty. There is little reliable historical information concerning the velocity of floodwaters during coastal flood events. Floodwaters can approach a site from many different directions and the flow velocities can vary from close to zero to high velocities during a flood event. FEMA 55 provides a formula to calculate the design flood velocity in coastal areas (see FEMA 55, *Coastal Construction Manual,* page 11-10).

Where is velocity of flooding information located in the NT? The velocity of flooding may be identified in the NT on the *Elevation and Hazard* tab in the Detailed Data View (Figure 3-9).

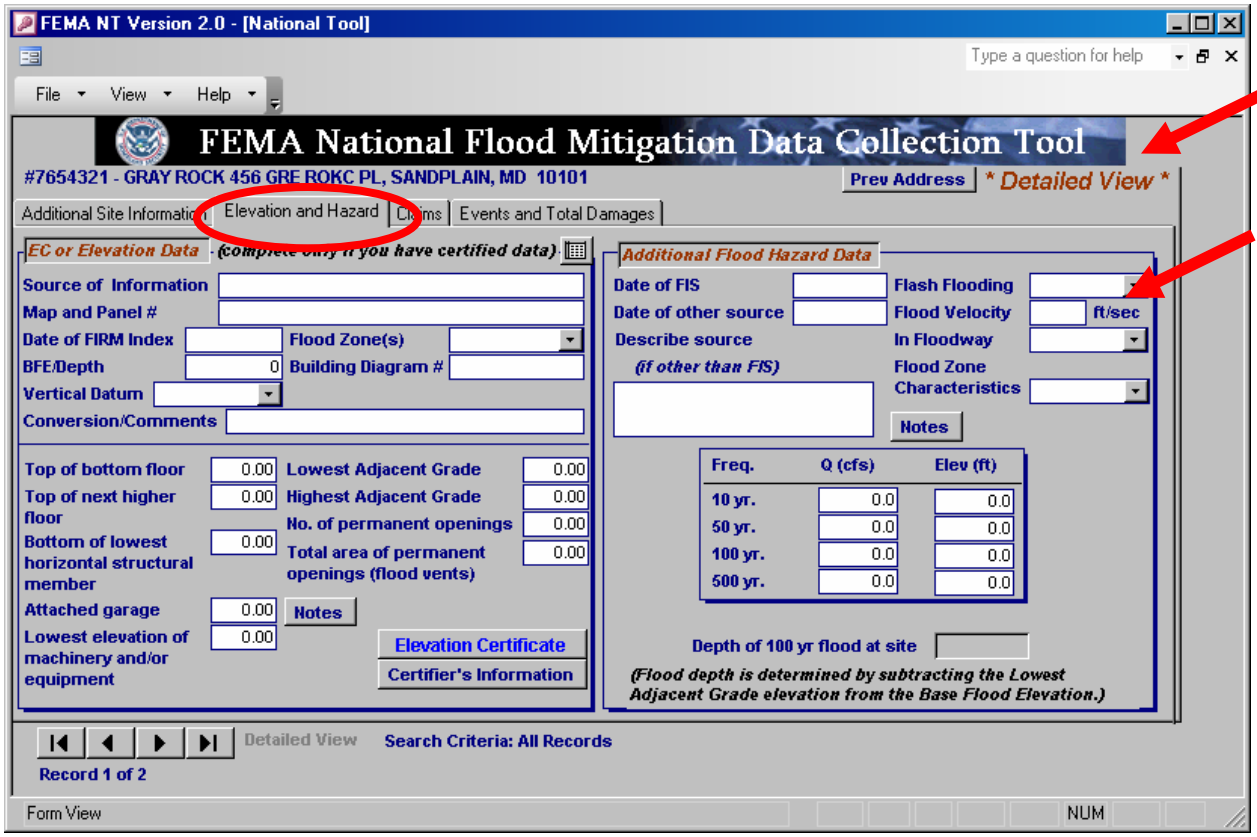

Figure 3-9. *Elevation and Hazard* tab - Flood Velocity

Where to find additional information:

FEMA 55. *Coastal Construction Manual.* See Chapter 11, Determining Site-Specific Loads, Subsection 11.6.6 Design Flood Velocity (V) for a description of how to estimate the velocity of floodwaters during coastal flood events (pages 11-9 to 11-11).

FEMA 85. *Manufactured Homes in Flood Hazard Areas: A Multi-Hazard Foundation and Installation Guide.* See Chapter 5, Natural Hazards – Design Considerations 5.2.4 Hydrodynamic Forces (pages 5-22 to 5-24). Section 10.3.1 Velocity Data in Chapter 10, Pre-engineered Foundations, includes tools and sources of information that are available to provide an estimate of the floodwater velocity. They include hydraulic modeling, documented historic information, alternate methodologies for estimating velocities, knowledge of past flooding, and site indicators.

FEMA 259. *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*. See Chapter III, Parameters of Retrofitting (page III-24).

FEMA 312. *Homeowner's Guide to Retrofitting: Six Ways to Protect Your House from Flooding.* See Chapter 2, Introduction to Retrofitting – Flow Velocity (pages 13 to 15).

FEMA 497. *National Flood Mitigation Data Collection Tool Guide*. See Chapter 6, Data Collection with the NT 6.3.2.2-Additional Flood Hazard Data (page 6-23).

FEMA 511. *Reducing Damage from Localized Flooding.* See Chapter 10, Retrofitting – Design Parameters (page 10-17).

3.4.9 Question #9. Is the structure located in the floodway?

What is a floodway? The floodplain associated with the base flood (or the 100-year flood) is known as the Special Flood Hazard Area (SFHA). Within the SFHA of a riverine system is the floodway, which is where water is likely to be deepest and fastest. It is the area of the floodplain that should be reserved and kept free of obstructions to allow floodwaters to move downstream. Requirements are included in 44CFR 60.3 (d)(3) for proposed development in regulatory floodways. This requirement applies to all types of development where a floodway has been delineated. Delineated floodways are most often found in A1-30, AH, and AE-Zones; however, there may be information available for approximate A Zones as well.

In floodway areas, encroachments, which include fill, new construction, substantial improvements, and other development, are not permitted if they result in any increase in the BFE. In general, very little development is permitted in the floodway since even minor encroachments lead to an increase in the BFE. Therefore, any mitigation measure, except demolition where the property is removed from the floodway, must meet NFIP, State, and local floodplain requirements regarding encroachment of the floodway conveyance area.

How is a floodway identified? Whether the structure is located in the floodway will be determined based on the Flood Insurance Rate Map. The floodway delineation, as depicted on the legend of the FIRM, will indicate whether the property is within or outside the floodway. A FIRM may be requested through the FEMA Map Service Center via the web at http://store.msc.fema.gov.

Where is floodway information located in NT? Structures located in the floodway can be identified in the NT by viewing the *Elevation and Hazard* tab in the Detailed Data View (Figure 3-10).

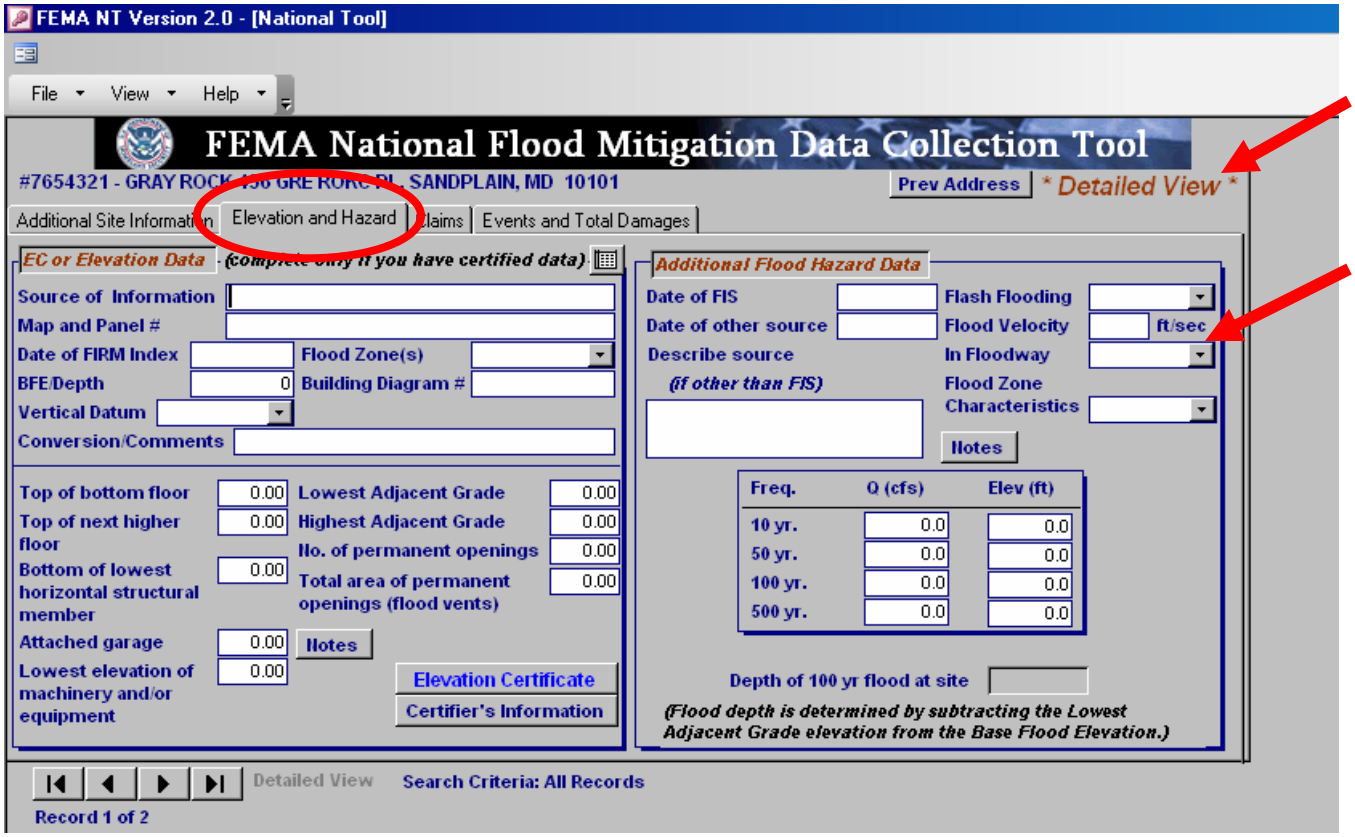

Figure 3-10. *Elevation and Hazard* tab - Floodway

Where to find additional information:

FEMA 85. *Manufactured Homes in Flood Hazard Areas: A Multi-Hazard Foundation and Installation Guide.* See Chapter 3, Regulatory Requirements for information on the regulatory requirements for development in the floodway (page 3-9). See Chapter 5, Natural Hazards – Design Considerations for a step by step description of how to use the FEMA Map Center website to access both the FIRM and FIS for a particular property (pages 5-1 to 5-16).

FEMA 259. *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*. See Chapter III, Parameters of Retrofitting (page III-26).

FEMA 480. *National Flood Insurance Program (NFIP) Floodplain Management Requirements: A Study Guide and Desk Reference for Local Officials.* See Unit 4 – Using NFIP Studies and Maps.

FEMA 497. *National Flood Mitigation Data Collection Tool Guide*. See Chapter 6, Data Collection with the NT 6.3.2.2 – Additional Flood Hazard Data (page 6-23).

FEMA 499. *Home Builder's Guide to Coastal Construction.* Technical Fact Sheet No. 3 Using a Flood Insurance Rate Map (FIRM).

3.5 Evaluating the Mitigation Measures

After completing **Worksheet A, the Technical Considerations Scorecard**, the next step is to evaluate the remaining appropriate mitigation measures to confirm applicability and to develop a recommendation for the property owners to consider. This information is recorded on **Worksheet B, Appropriate Mitigation Measures**. A sample of a completed Worksheet B is included in Appendix A.

The steps in evaluating the remaining mitigation measures include the following:

1. From Worksheet A, list each of the remaining mitigation measures with an "X" in the Appropriate Mitigation Measures row into the far left column (titled "Mitigation Measures") of **Worksheet B, Appropriate Mitigation Measures**.
2. Assign a relative ranking of High, Moderate, or Low for each consideration column based on the mitigation measures listed.
3. Check the appropriate box (High, Moderate, or Low) under each of the decision factors.
4. Add up the scores for each row of mitigation measures and record it in the Total Score column of Worksheet B. The mitigation measure with the LOWEST score is the measure that is most appropriate.
5. Record additional information regarding the decision factors for the mitigation measures in the Notes column.

The scores for the Technical Considerations and Relative Costs column are weighted higher (twice the value) than the other two columns. This means the result of these considerations have a greater influence on the outcome since these considerations are more significant in selecting an appropriate mitigation measure.

The information contained in Chapters 4 through 10 is structured in the following manner to assist in the comparative evaluation process:

- **Technical Considerations** provide other factors to determine whether the mitigation measure addresses the project objectives.
- **Relative Costs** identify the associated costs of the mitigation measures and include a determination of cost-effectiveness.
- **Additional Considerations** include Human Intervention, Annual Maintenance, and other factors in the decision-making process.

Worksheet B: Appropriate Mitigation Measures

Date Prepared:___________________ Date Property Visited:_____________
Property Owner Name: ____
Property Address:____
Repetitive Loss Property Locator Number:__________________________________
Prepared by: ____

Instructions to complete Worksheet B: Appropriate Mitigation Measures

1. List the mitigation measures from the “Appropriate Mitigation Measures” row from Worksheet A, Technical Considerations Scorecard (all checked boxes in last row of Worksheet A).
2. Using information from Chapters 4 through 10 of FEMA 551, *Selecting Appropriate Mitigation Measures for Floodprone Structures*, rank each measure as High, Moderate, or Low. See “Tips to Rank Mitigation Measures” on next page for additional information.
3. Check the appropriate box (High, Moderate, or Low) under each of the decision factors.
4. Total the points for each mitigation measure. **The LOWEST total points indicates the most appropriate mitigation measure(s).**
5. Include notes describing how the determination was made for a particular ranking.

*NOTE: Since Technical Considerations and Relative Costs are more significant in selecting appropriate mitigation measure(s), they are weighted higher than Human Intervention and Annual Maintenance.

Decision Factors – LOWEST score is most appropriate – See Reverse for Notes					
Mitigation Measures	**Technical Considerations***	**Relative Costs***	**Human Intervention**	**Annual Maintenance**	**Total Score**
__________	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	__ pts
__________	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	__ pts
__________	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	__ pts
__________	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	__ pts
__________	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	__ pts
__________	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	__ pts
__________	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (6 pts) M ☐ (4 pts) L ☐ (2 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	H ☐ (3 pts) M ☐ (2 pts) L ☐ (1 pts)	__ pts

Tips to Rank Mitigation Measures (Worksheet B Cont.)

Technical Considerations

Use the responses in Worksheet A, Technical Considerations Scorecard, to determine a ranking of High, Moderate, or Low for each mitigation measure.

- If there are no grayed out boxes checked for a mitigation measure, the technical consideration ranking is Low.
- If there are 1 or 2 grayed out boxes checked for a mitigation measure, the technical consideration score is Moderate.
- If there are 3 or more grayed out boxes checked for a mitigation measure, the technical consideration score is High.

List any considerations in the implementation process that could be a limiting factor or clear constraint in the Notes section.

Relative Costs

Rank each of the mitigation measures based on the estimated cost to address the flood risk and the likelihood of cost-effectiveness. Chapters 4 through 10 include information to rank each mitigation measure based on FEMA 312, *Homeowner's Guide to Retrofitting: Six Ways to Protect Your House From Flooding*, and FEMA 259, *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*. Low cost indicates Low ranking and high cost indicates High ranking.

Need for Human Intervention

This reflects the need for human intervention to operate the mitigation measure and the warning time to conduct the required activity. Generally, the more "passive" the system (i.e., requiring the least human interaction), the more reliable the system will be over time, thereby resulting in a Low ranking. Mitigation measures that require human intervention, such as barriers and dry floodproofing, receive a High ranking..

Need for Annual Maintenance

This reflects the level of effort of annual maintenance required by each mitigation measure. Similar to human intevention, less annual maintenance results in a Low ranking.

NOTE: If two or more mitigation measures tie with the lowest score, other decision factors should be considered in determining the most appropriate mitigation measure(s). These considerations include, but are not limited to aesthetics; access to site; housing of occupants during the project; compliance with all applicable codes, ordinances, and regulations; historic preservation concerns; and availability of contractors.

The other decision factors should be listed in the Comments section of Worksheet C.

NOTES:

Mitigation Measures	Technical Considerations

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