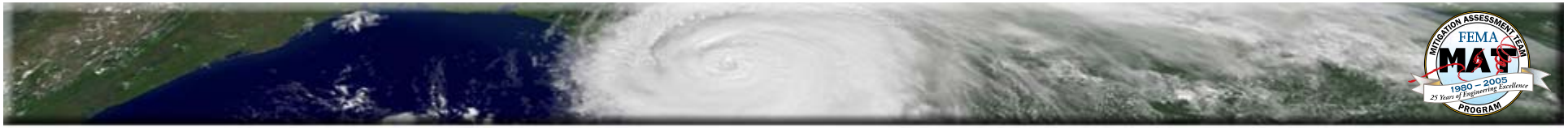
Mitigation Assessment Team Report on

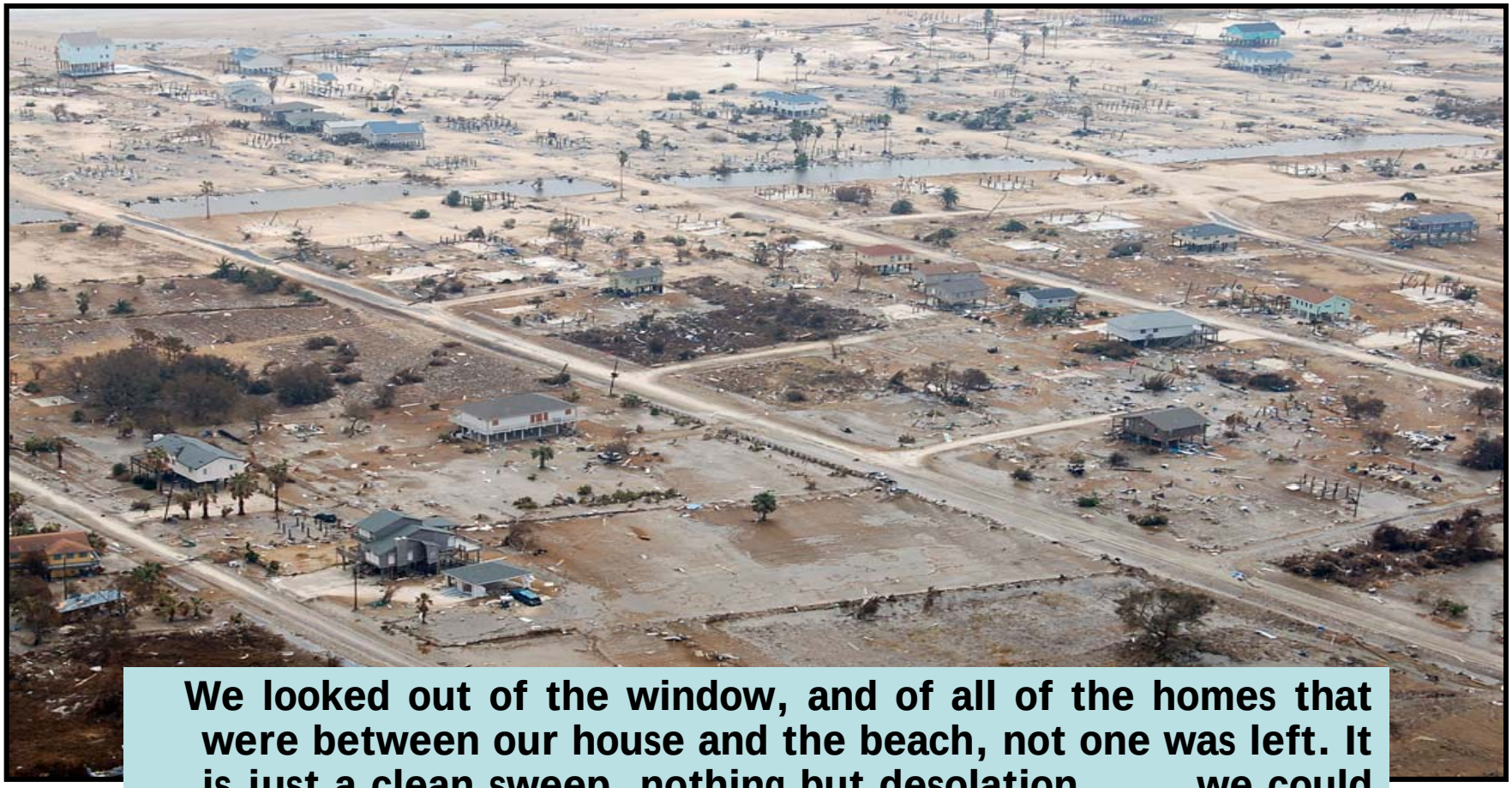
Hurricane Ike



MAT Mission

- Conduct *forensic engineering analyses*
- *Recommendations* to communities, states and organizations/agencies
- *Improve construction codes and standards, designs, methods, and materials*

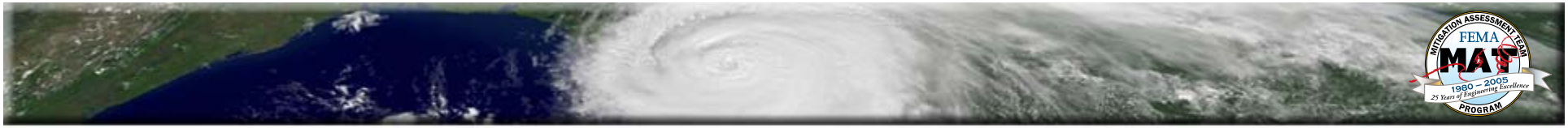
Hurricane Ike damage—Seen again and again



We looked out of the window, and of all of the homes that were between our house and the beach, not one was left. It is just a clean sweep, nothing but desolation. . . . we could not see the water from our house before this storm.

. . . Sarah Littlejohn, following the 1900 Hurricane

(Bixel and Turner. *Galveston and the 1900 Storm***. Univ. of Texas Press, 2000)**

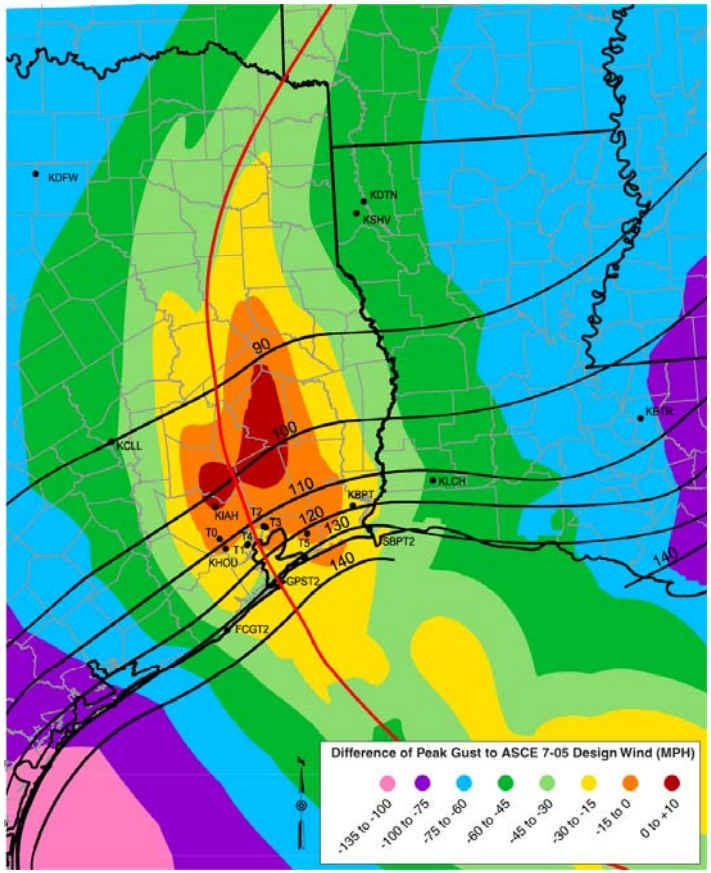


Recommendations

- 46 Specific Recommendations
  - 22 Residential
  - 11 Critical Facilities
  - 13 Further studies and standards
- Some recommendations
  - 3 feet of freeboard until new flood maps available
  - Vulnerability assessment of critical facilities
  - Remove aggregate from roofs in downtown Houston

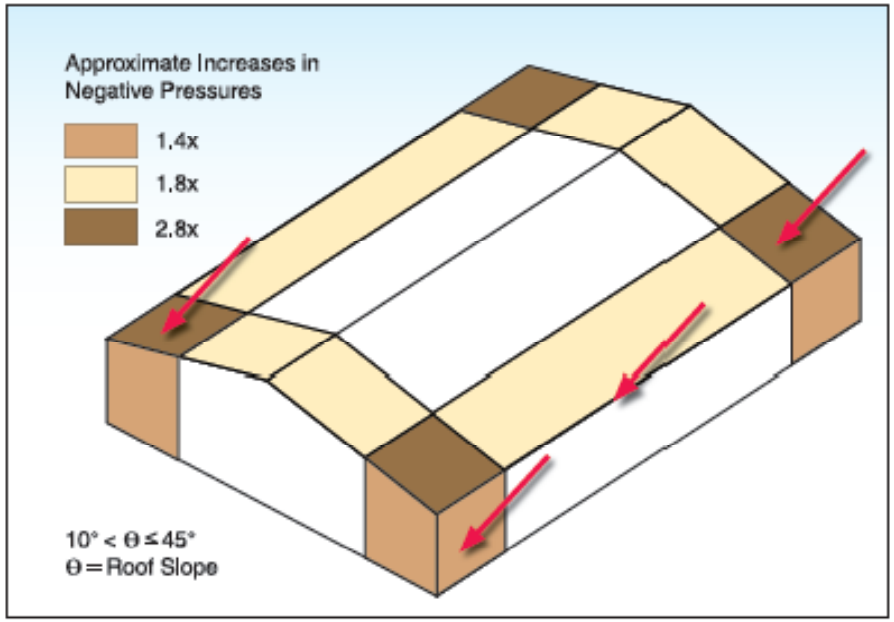
MAT Observations of Residential Building Performance vs. Ike's Winds

- Ike's winds were less than IRC/ASCE 7 design levels.
- Expectations were that minimal damage to both structural elements and components would be seen.
- MAT observed good structural performance, but poor cladding performance.



Keeping the Building Connected

Keeping the Building Components Connected – C&C



Asphalt Shingle Recommendations

- TDI should only allow ASTM D 7158 rated shingles:
  - Class D – 90 mph rating
  - Class G –120 mph rating
  - Class H – 150 mph rating
- Manufacturers should provide Class labeling on the backside of shingles

Building Sheathing Failures

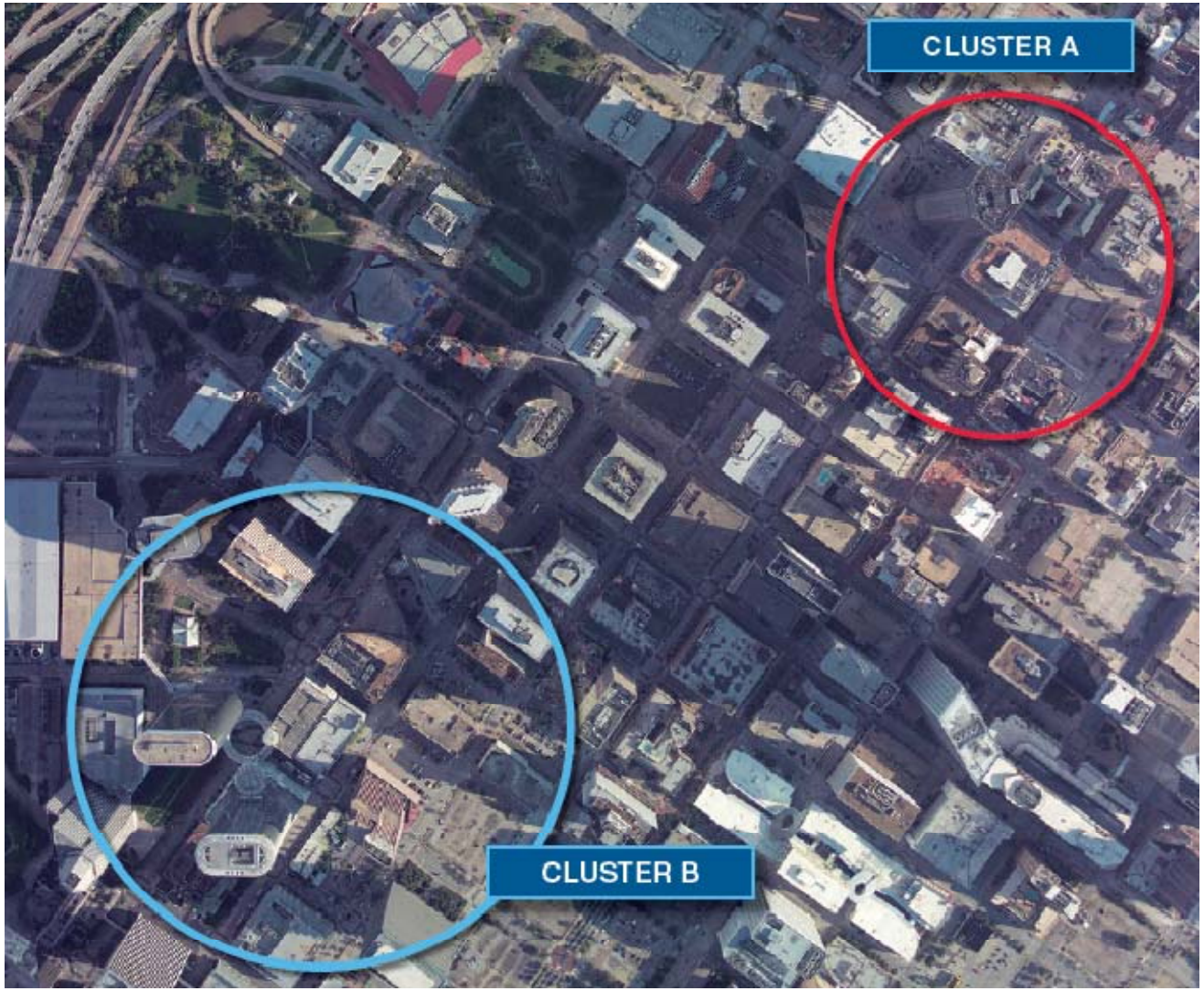
- It is recommended that TDI require that exterior wall substrates be fully sheathed with plywood or OSB.

Vinyl Siding

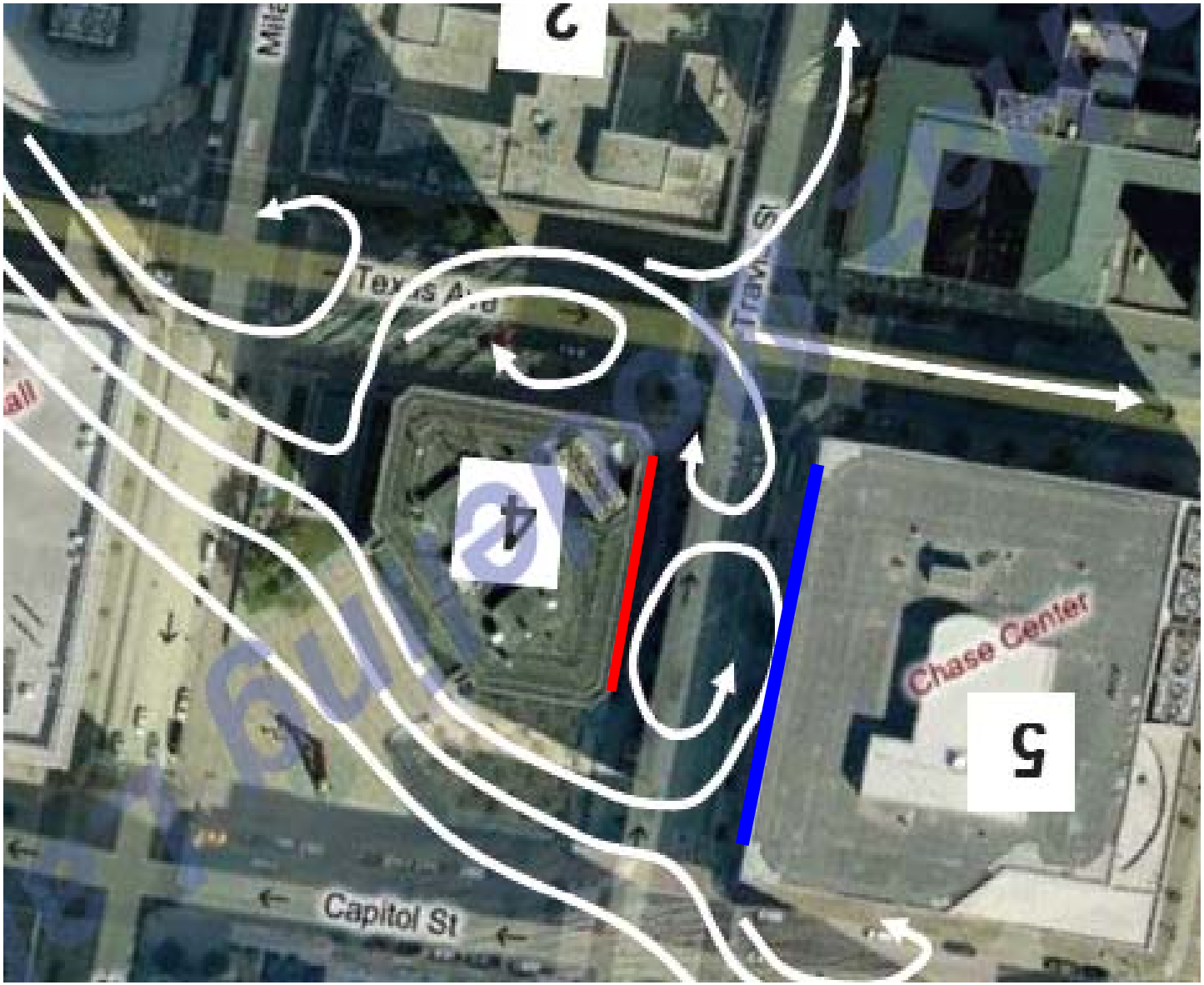
Fiber Cement Siding

Windborne Debris Protection

Wind -- Downtown Houston



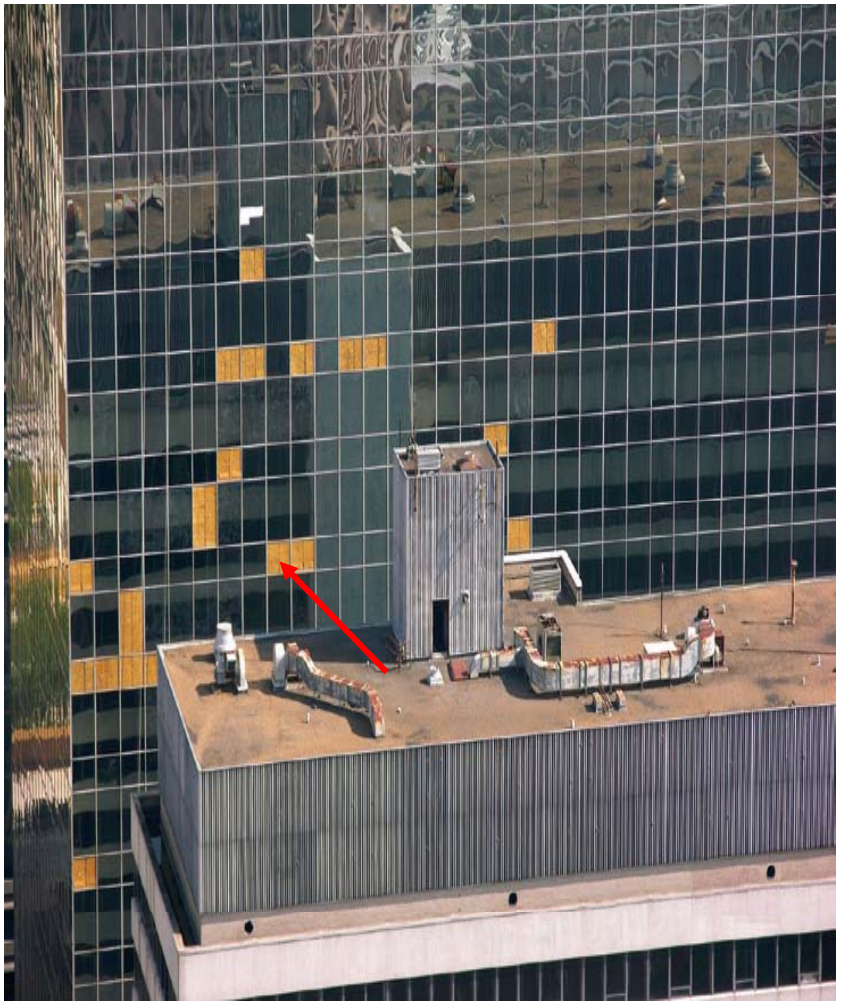

2008.09.19


Capitol St
Chase Center
4
5
6

Wind Recommendations -- Central Business Districts

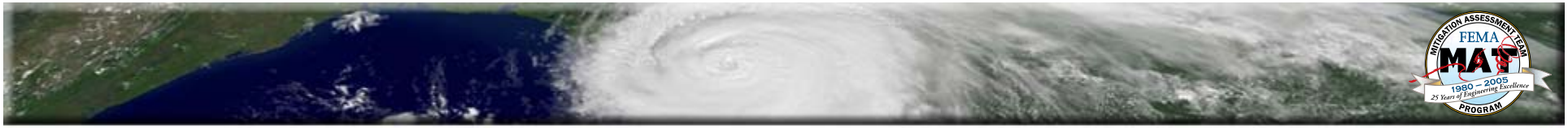
- In urban areas in hurricane-prone regions, existing aggregate surface roofs should be removed to avoid damage to other buildings

- Add aggregate abatement criteria to the ICC International Existing Building Code



Wind – Critical Facilities

- Observation: Most critical facilities had wind vulnerabilities -- some were significant



Critical Facilities Recommendations

- Existing facilities: perform comprehensive vulnerability assessment of wind-force resisting system and building envelope

- Mitigation: Consider Guidance in FEMA 543 and 577. If recommendations not implemented, base decision on deliberation and consideration of residual risks

- Mitigation projects: 2-stage peer review.

Flood Lesson: Elevate Residential Structures

- **Observation: Ike Flood Levels reached 2-5 ft above the BFE across much of the study area**
- **Homes elevated several ft above BFE survived**

BFE = 16 ft NGVD, Floor at 21.5 ft

Wave Crest Above Floor

Recovery Advisory on Designing for Flood Levels Above BFE

Designing for Flood Levels Above the BFE

FEMA
http://www.fema.gov

HURRICANE IKE RECOVERY ADVISORY

Purpose: To recommend design and construction practices that reduce the likelihood of flood damage in the event that flood levels exceed the Base Flood Elevation (BFE).

Key Issues

- BFEs are established at a flood level, including wave effects, that has a 1-percent chance of being equaled or exceeded in any given year, also known as the 100-year flood or base flood. Floods more severe and less frequent than the 1-percent flood can occur in any year.
- Flood levels during some recent storms have exceeded BFEs depicted on the Flood Insurance Rate Maps (FIRMs), sometimes by several feet. In many communities, flooding extended inland, well beyond the 100-year floodplain (Special Flood Hazard Area (SFHA)) shown on the FIRM (see Figure 1).
- Flood damage increases rapidly once the elevation of the flood extends above the lowest floor of a building, especially in areas subject to coastal waves. In a V zone, a coastal flood with a wave crest 3 to 4' above the bottom of the floor beam (approximately 1 to 2 feet above the walking surface of the floor) will be sufficient to substantially damage or destroy most light-framed residential and commercial construction (see Figure 2).
- There are design and construction practices that can eliminate or minimize damage to buildings when flood levels exceed the BFE. The most common approach is to add freeboard to the design (i.e., to elevate the building higher than required by the FIRM).
- There are other benefits of designing for flood levels above the BFE: reduced building damage and maintenance; longer building life; reduced flood insurance premiums; reduced displacement and dislocation of building occupants after floods (and need for temporary shelter and assistance); reduced job loss; and increased retention of tax base.
- The cost of adding freeboard at the time of home construction is modest, and reduced flood insurance premiums will recover the freeboard cost in a few years time.

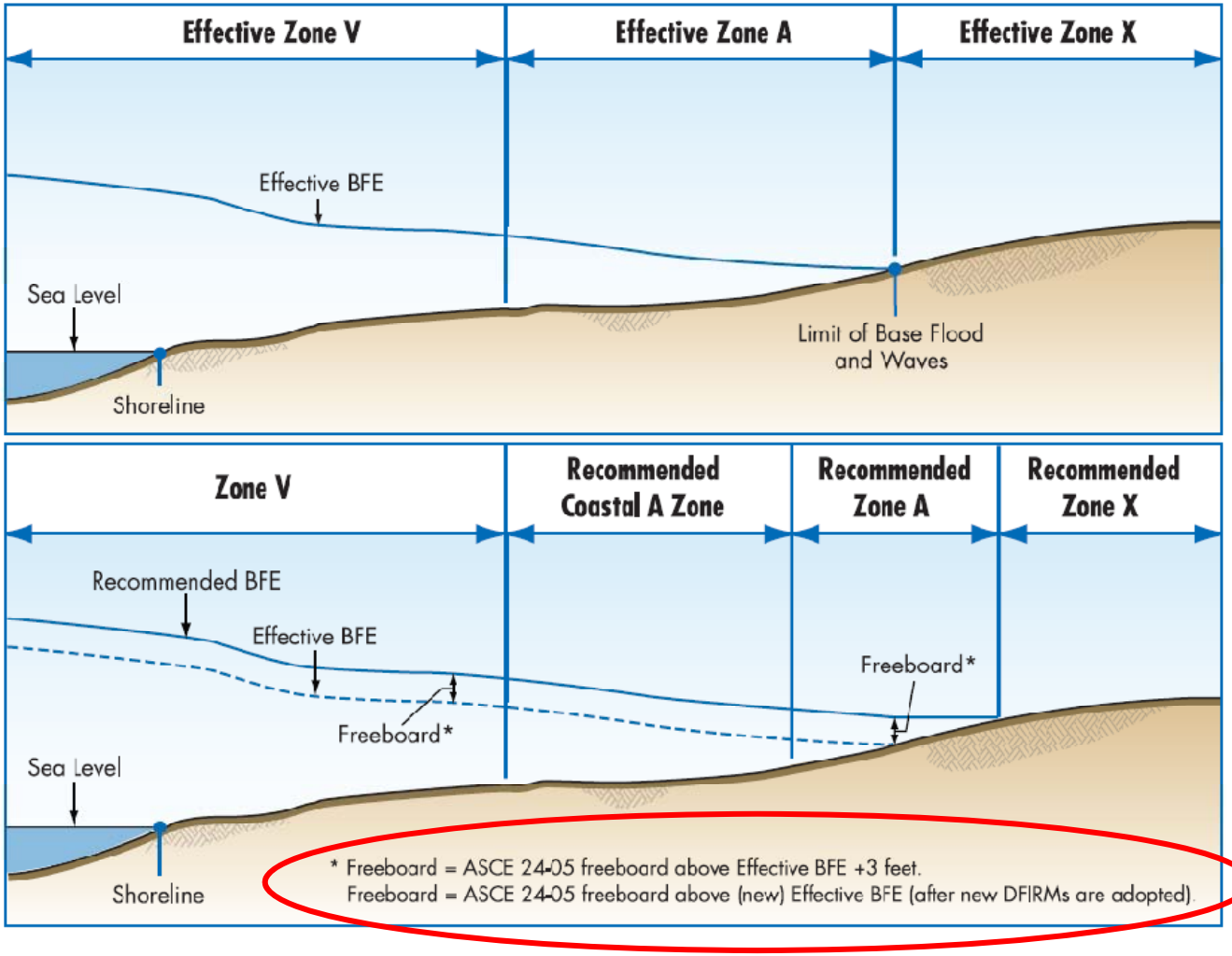
Figure 1. Bridge City, TX, homes were flooded during Ike, even though they were constructed outside the SFHA and in Zone B. The flood level was approximately 4' above the closest BFE.

Figure 2. Bolivar Peninsula, TX, V-zone house constructed with the lowest floor (bottom of floor beam) at the BFE (dashed line). The estimated wave crest level during Ike (solid line) was 3 to 4' above the BFE at this location.

How High Above the BFE Should a Building be Elevated?

Ultimately, the building elevation will depend on several factors, all of which must be considered before a final determination is made:

MAT Recommendation: 3-ft Freeboard



Flood Lesson: Use Strong & Deep Foundations

- **Observation: Many foundations failed due to lack of embedment and/or scour/erosion**

Recovery Advisory on Erosion, Scour and Foundation Design

Erosion, Scour, and Foundation Design

FEMA
http://www.fema.gov

HURRICANE IKE RECOVERY ADVISORY

Purpose: To discuss how any lowering of the ground surface can affect the ability of a building foundation to resist design loads, and to provide additional guidance for coastal foundation design.

Key Issues

- Coastal buildings are often subject to flood loads and conditions that do not affect inland buildings. These include waves, high velocity storm surge flow, floodborne debris, and **erosion** and **scour**. This Recovery Advisory will focus on erosion and scour. See FEMA 499, *Home Builder's Guide to Coastal Construction* (2005), Fact Sheets 11 through 15 at: http://www.fema.gov/library/viewRecord.do?id=1570, and FEMA 55, *Coastal Construction Manual* (2000) at: http://www.fema.gov/library/viewRecord.do?id=1671 for discussion of other foundation issues.

Erosion refers to a general lowering of the ground surface over a wide area.

Scour refers to a localized loss of soil, often around a foundation element.

- Foundations must transfer all loads imposed on the building into the ground. If the foundation is not strong enough or deep enough to do this, the building will be destroyed. If the foundation embedment into the ground is not sufficient to account for erosion and scour that may occur over the life of the building, the building is vulnerable to collapse under design flood and wind conditions.
- Predicting the incidence, location, and magnitude of coastal erosion and scour is difficult, and present-day building codes and standards do not prescribe clear-cut solutions for designers. Therefore, designers should be conservative with their foundation designs. This means foundations may need to be stronger, deeper, and higher than what has historically been used. Lessons learned from Hurricane Ike and other recent coastal storm events should be incorporated into foundation designs.

Erosion and Scour Basics

Erosion is defined by the International Building Code® (ICC, 2006) as the "wearing away of the ground surface as a result of the movement of wind, water or ice." Section 7.5 of FEMA's *Coastal Construction Manual* describes erosion as "the wearing or washing away of coastal lands." Since the exact configuration of the soil loss is important for foundation design purposes, a more specific definition is used in this Recovery Advisory (see text box and Figure 1).

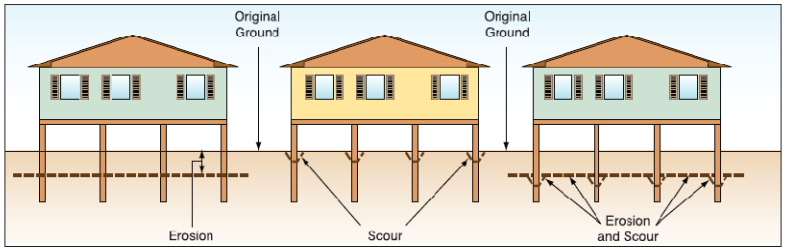


Figure 1. Distinguishing between coastal erosion and scour. A building may be subject to either or both, depending on the building location, soil characteristics, and flood conditions.

Flood Lesson: We Need to do a Better Job Mitigating Residential Structures

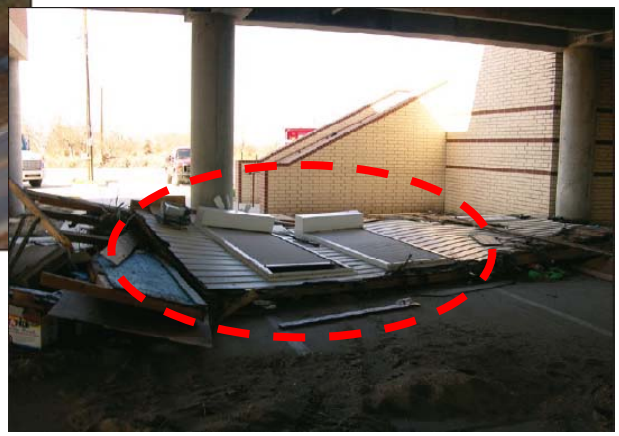
- **MAT viewed 31 homes that had been elevated**
- **Good News: none sustained flood damage during Ike**
- **Bad News: many of the homes lacked continuous load paths from elevated home to foundation to ground; other problems**

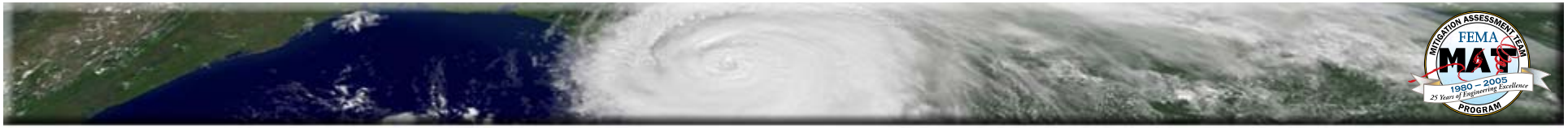
Flood Lesson: Elevate Critical Facilities

- **Observation: Critical Facilities elevated above Ike surge and waves on strong foundations survived**

Crenshaw Elementary and Middle School, Bolivar Peninsula

Elevated 10 ft above grade, Ike surge reached 5 ft above grade





Flood Lesson: Better Job with Siting *Some* New Critical Facilities

Case in Point: South Cameron Parish Hospital

- Constructed in 1963, 6 years after Audrey, with floor elevation ~ 8 ft NGVD (several feet below Audrey surge level)
- Destroyed by Rita in 2005 (storm surge at site ~ 12-13 ft NGVD)
- Rebuilt in 2008, with top of floor elevation at 10 ft NGVD
- Ike water level was just below floor, utilities were damaged

South Cameron Hospital