BUILDING INNOVATION
Conference

Advancements in Flood Resilience

Chad Berginnis, CFM, Association of State Floodplain Managers

Dan Cox, Ph.D, Oregon State University

John Ingargiola, Lead Physical Scientist, FEMA

Our Floodprone Nation- Getting Worse!

3.5 million miles of streams rivers and coastlines in the United States (1.2 million miles mapped)

8.7 million properties at risk from flooding in SFHA (per FEMA)

Annual flood losses roughly doubling per decade - now $20+ billion/yr.

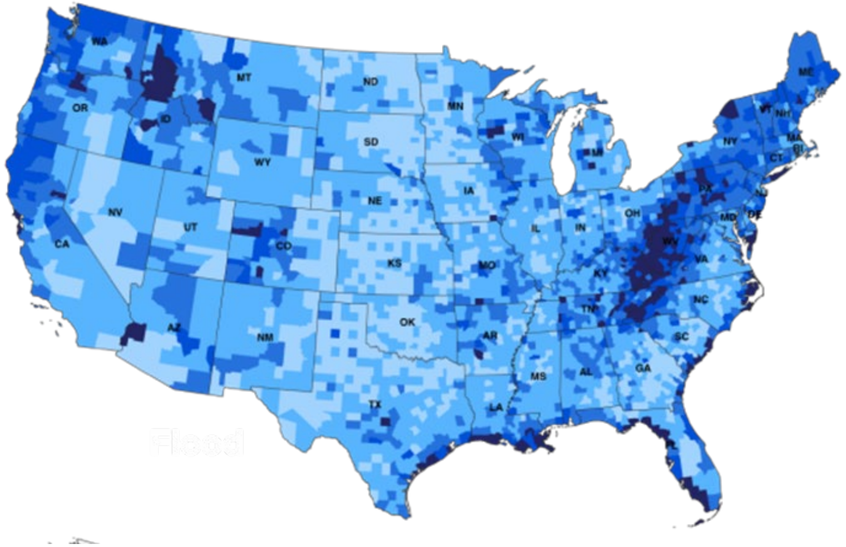
Photo Credit: Caltrans

Our Floodprone Nation – Getting Worse!

From First Street Foundation:

17.7 million properties similar risk from flooding in SFHA + non-mapped + pluvial areas (per First Street Foundation)

New precipitation model shows 1-in-100 year flooding can now be expected every 8 years in some areas



A Portfolio Approach to Flood Loss Reduction

Engineering & Technology Standards – **ANSI 2510**, ASCE 7, ASCE 24

Building Codes

Special Purpose Regulations – Minimum NFIP Standards, USACE Levee Design Manual and National Levee Safety Guidelines

Land Use Standards – Zoning and **Subdivision Regulations**

Infrastructure – Sedimentation and Erosion Control, Future Conditions Guidelines

ANSI 2510

Developed from FM Approvals 2510 for flood abatement technologies as they evolve

Standards for six types of products:

- Perimeter barriers
- Opening barriers
- Flood Mitigation Valves
- Flood Mitigation Pumps
- Penetration Sealing Devices
- Flood Glazing

ANSI 2510

ASFPM's Flood Mitigation Certification Program allows for testing and certification of these products connecting them to the practitioner community

Partnership

- ASFPM
- US Army Corps of Engineers
- FM Approvals

Requirement for ANSI 2510 certified products when using FEMA Public Assistance or Mitigation funds

Land Use: Subdivision Design and Flood Hazard Areas

1.43 million housing starts in the US last year. Most are in subdivisions

Over 60+ recommended standards for more effective flood risk management

Focuses more on the where to build as well as infrastructure layout and design

Partnership between ASFPM and the American Planning Association supported by FEMA

American Planning Association

SUBDIVISION DESIGN AND FLOOD HAZARD AREAS

Infrastructure: Planning for Resilience

As a nation we don't have consistent flood resilience design standards for infrastructure

Critical inputs – rainfall/frequency, future conditions

Another collaboration between APA and ASFPM, researched best practice and strategies from communities tackling this issue.

APA
American Planning Association
Creating Great Communities for All

PAS REPORT 596

PLANNING FOR INFRASTRUCTURE RESILIENCE

Joseph DeAngelis, AICP, Haley Briel, and Michael Lauer, AICP

Key Takeaways

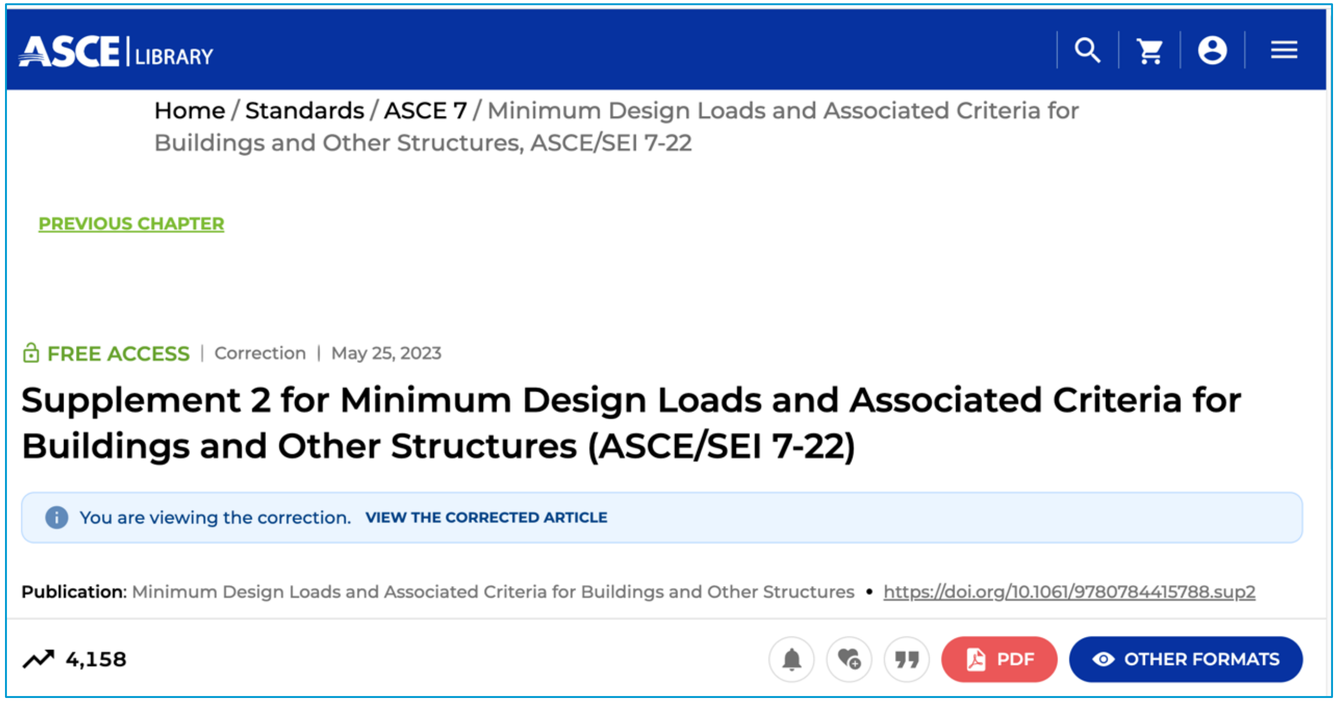
It is important that our standards and codes evolve when it comes to flooding

We pay far less attention to land use and its role in flood loss or hazards reduction than we should

Imperative that we identify all current and future flood prone areas in the nation and a national Atlas 15 – codes and standards depend on them

ASCE 7 Flood Supplement –Chapter 5

https://ascelibrary.org/doi/10.1061/9780784415788.sup2



Home / Standards / ASCE 7 / Minimum Design Loads and Associated Criteria for Buildings and Other Structures, ASCE/SEI 7-22

PREVIOUS CHAPTER

FREE ACCESS | Correction | May 25, 2023

Supplement 2 for Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-22)

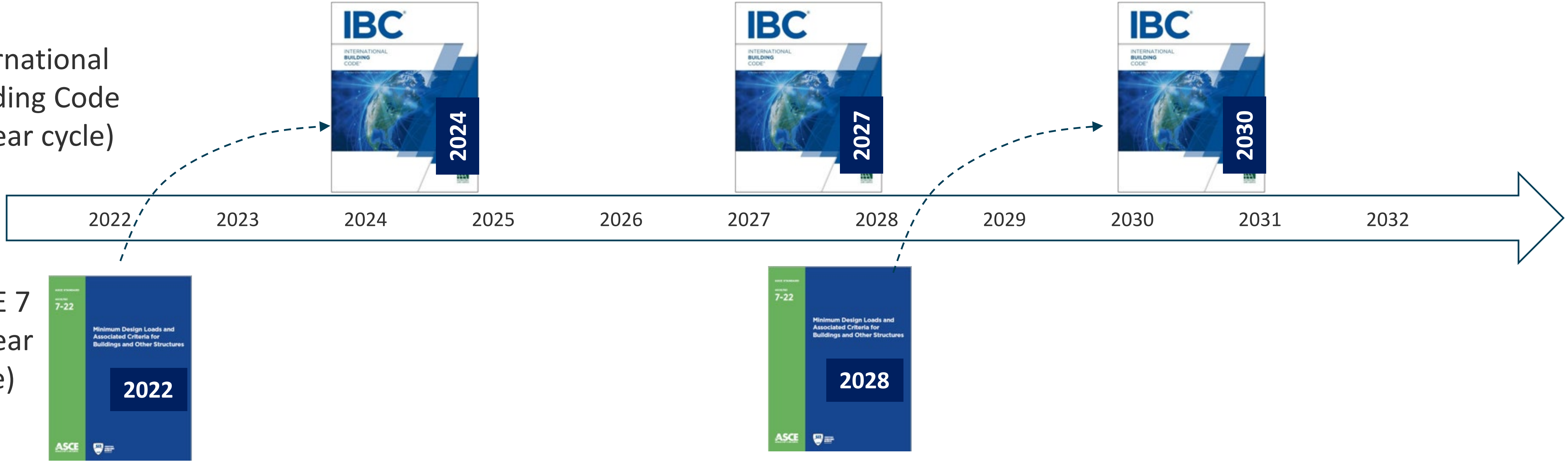
You are viewing the correction. VIEW THE CORRECTED ARTICLE

Publication: Minimum Design Loads and Associated Criteria for Buildings and Other Structures • https://doi.org/10.1061/9780784415788.sup2

4,158

- Supplement 2 approved by ASCE, published as part of ASCE 22 May 23, 2022
- Available for free online

From ASCE Standard to ICC Code Adoption



International Building Code (3-year cycle)

ASCE 7 (6-year cycle)

From ASCE Standard to ICC Code Adoption

International Building Code (3-year cycle)

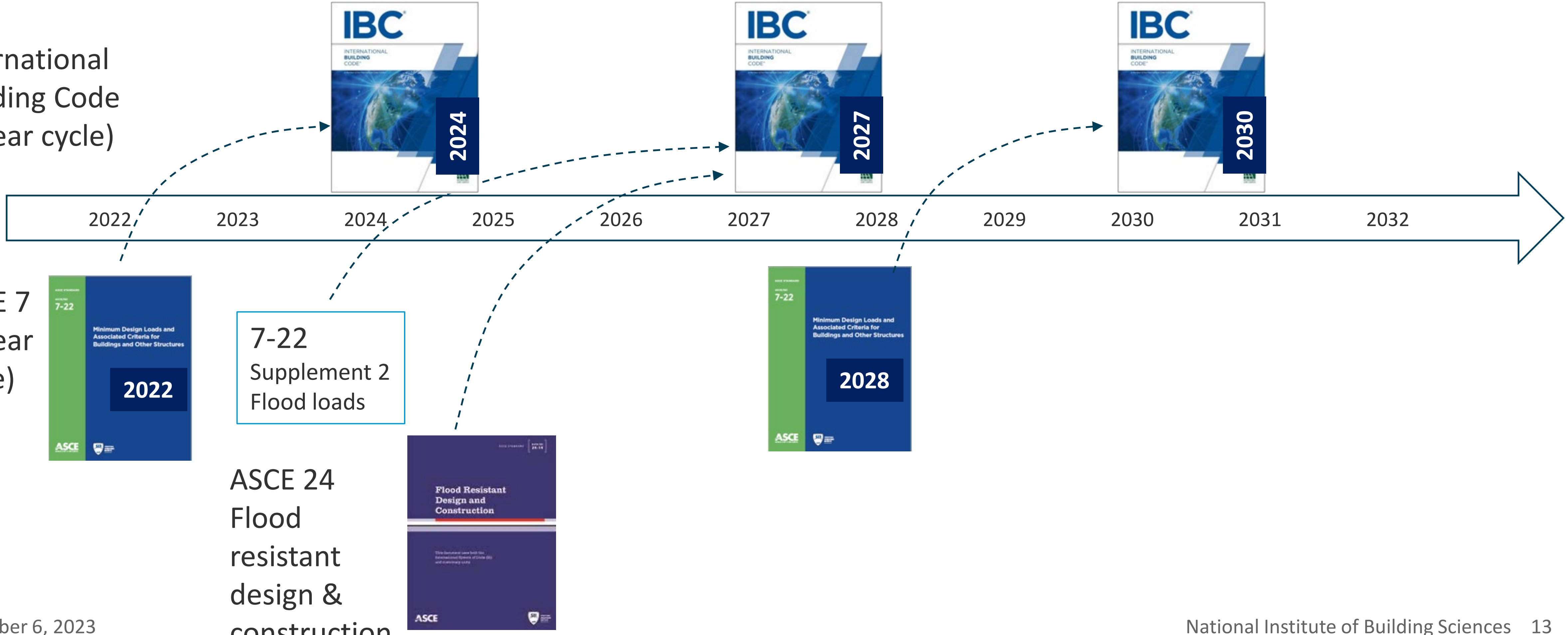
ASCE 7 (6-year cycle)

7-22
Supplement 2
Flood loads

From ASCE Standard to ICC Code Adoption

International Building Code (3-year cycle)

ASCE 7 (6-year cycle)



7-22
Supplement 2
Flood loads

ASCE 24 Flood resistant design & construction

Existing
(ASCE 7-22)

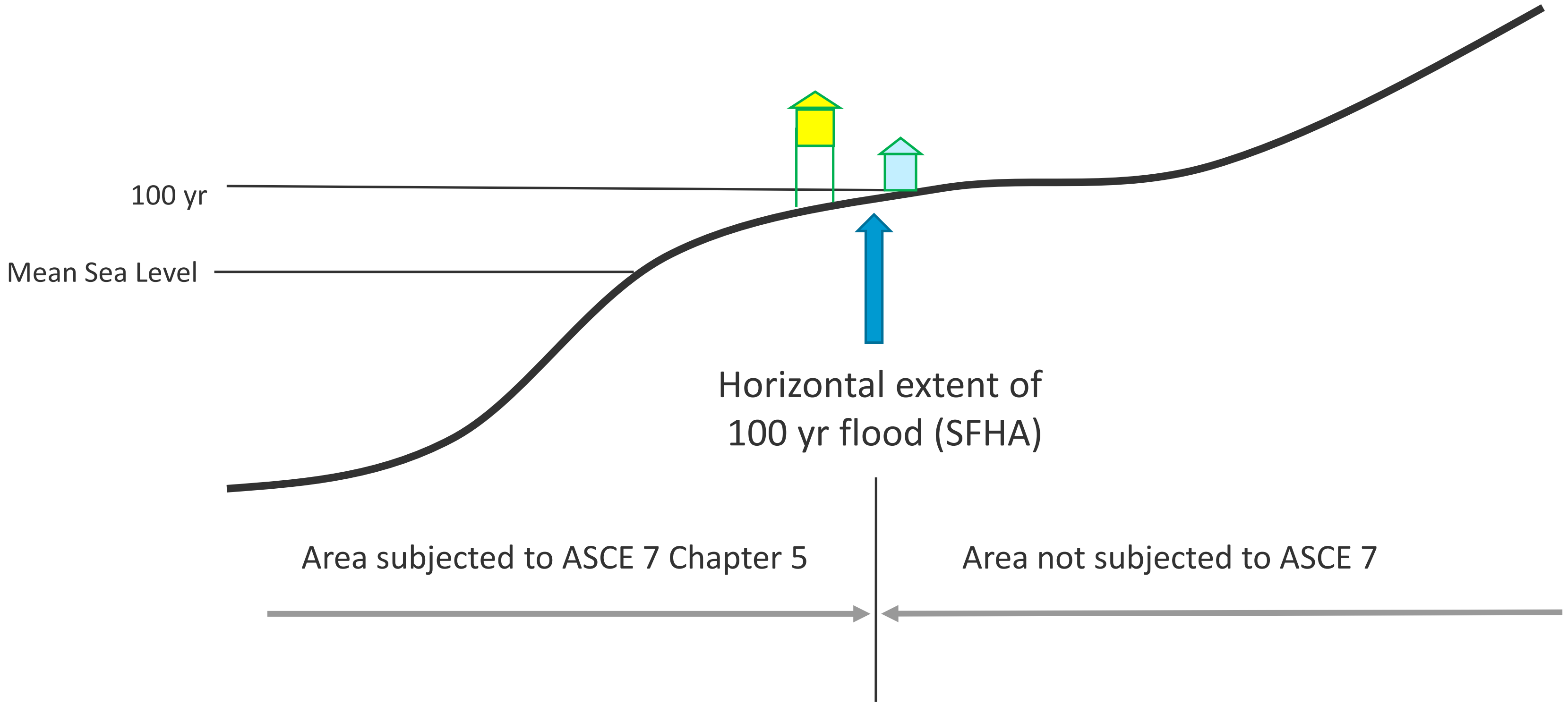
- **5.1 General**
- **5.2 Definitions**
- **5.3 Design Requirements**
  - 5.3.1 Design Loads
  - 5.3.2 Erosion and Scour
  - 5.3.3 Loads on Breakaway Walls
- **5.4 Loads During Flooding**
  - 5.4.1 Load Basis
  - 5.4.2 Hydrostatic Loads
  - 5.4.3 Hydrodynamic Loads
  - 5.4.4 Wave Loads
    - 5.4.4.1 Breaking Wave Loads on Vertical Piles or Columns
    - 5.4.4.2 Breaking Wave Loads on Vertical Walls
    - 5.4.4.3 Breaking Wave Loads on Non-Vertical Walls
    - 5.4.4.4 Breaking Wave Loads from Obliquely Incident Waves
    - 5.4.4.5 Impact Loads
- **5.5 Consensus Standards and Other Affiliated Criteria**

Changes
(ASCE 7-22 Supplement 2)

- 5.1 **General**
- 5.2 **Definitions** and Symbols
  - 5.2.1 Definitions
  - 5.2.2 Symbols
- **5.3 Design Requirements**
  - 5.3.1 Flood Hazard Area
  - 5.3.2 Design Loads
  - 5.3.3 Design Stillwater Flood Depth
    - 5.3.3.1 Stillwater Elevation Determination When Data Not Available Beyond the 100-year Flood
  - 5.3.4 Effects of Relative Sea Level Change
  - 5.3.5 Erosion
  - 5.3.6 Flood Velocity
    - 5.3.6.1 Flood Velocity in Coastal Areas
    - 5.3.6.2 Flood Velocity in Riverine Areas
  - 5.3.7 Wave Effects
    - 5.3.7.1 Wave Height
    - 5.3.7.2 Wave Period and Wavelength
  - 5.3.8 Scour
    - 5.3.8.1 Scour at Walls
      - 5.3.8.1.1. Scour at Walls Due to Nonbreaking Waves
      - 5.3.8.1.2. Scour at Walls Due to Breaking Waves
    - 5.3.8.2 Scour at Vertical Piles and Columns
  - 5.3.9 Debris
    - 5.3.9.1 Debris Impact
      - 5.3.9.1.1. Debris Impact Objects
      - 5.3.9.1.2. Site Hazard Assessment for Localized Marine Debris. Shipping Containers, Ships, Small Vessels, and Barges
      - 5.3.9.1.3. Extraordinary Debris Impact Loading
    - 5.3.9.2 Debris Damming
  - 5.3.10 Loads on Breakaway Walls
  - 5.3.11 Site-Specific Studies
  - 5.3.12 Performance Based Design
- **5.4 Loads During Flooding**
  - 5.4.1 Load Basis
  - 5.4.2 Hydrostatic Loads
    - 5.4.2.1 Vertical Hydrostatic Force
    - 5.4.2.2 Lateral Hydrostatic Force
    - 5.4.2.3 Seepage
  - 5.4.3 Hydrodynamic Loads
  - 5.4.4 Wave Loads
    - 5.4.4.1 Wave Loads on Vertical Piles or Columns
      - 5.4.4.1.1. Non-breaking Wave Loads on Vertical Piles or Columns
      - 5.4.4.1.2. Breaking Wave Loads on Vertical Piles or Columns
    - 5.4.4.2 Lateral Wave Loads on Walls
      - 5.4.4.2.1. Lateral Non-Breaking Wave Loads on Non-elevated Vertical Walls
      - 5.4.4.2.2. Lateral Breaking Wave Loads on Non-elevated Vertical Walls
      - 5.4.4.2.3. Lateral Breaking Wave Loads on Non-Vertical Walls
      - 5.4.4.2.4. Lateral Breaking Wave Loads from Obliquely Incident Waves
      - 5.4.4.2.5. Lateral Wave Loads on Walls of Elevated Walls
    - 5.4.4.3 Wave Uplift Forces on Elevated Structures and Non-Elevated Structures with Overhangs
  - 5.4.5 Debris Impact Loads
    - 5.4.5.1 Debris Impact Load Determination
      - 5.4.5.1.1. Simplified Debris Impact Load for Passenger Vehicles or Small Vessels
      - 5.4.5.1.2. Elastic Debris Impact Loads
      - 5.4.5.1.3. Alternate Methods of Debris Impact Analysis
    - 5.4.5.2 Debris Types and Properties
    - 5.4.5.3 Extraordinary Debris Impact
    - 5.4.5.4 Debris Impact Load Redistribution
- 5.5 Flood Load Cases
  - 5.5.1 Stability for Global Uplift
  - 5.5.2 Stability for Global Sliding
- 5.6 **Consensus Standards and Other Affiliated Criteria**

Chapter 5 Revisions (Supplement 2)

Increase the flood hazard **area** from 100-year to 500-year for all RC II, III, and IV structures



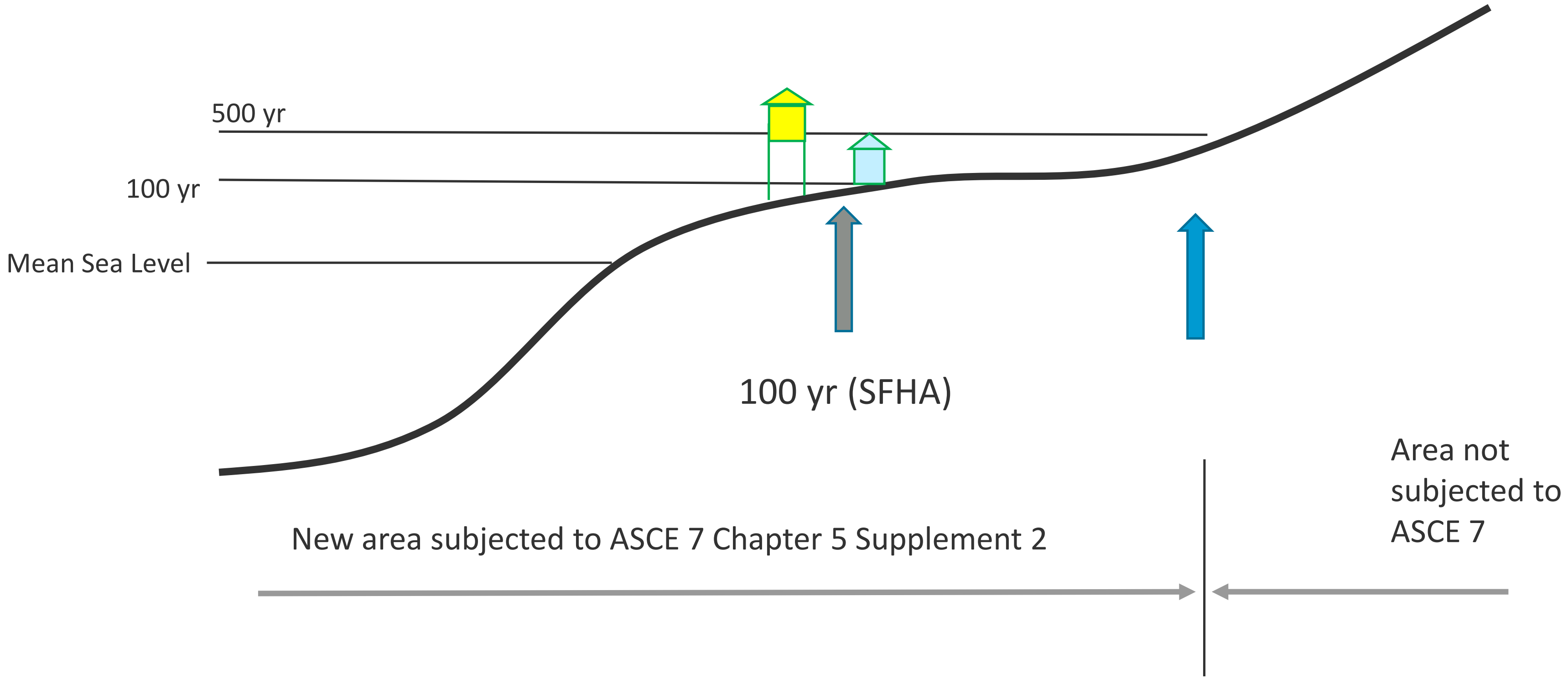
Horizontal extent of 100 yr flood (SFHA)

Area subjected to ASCE 7 Chapter 5

Area not subjected to ASCE 7

Chapter 5 Revisions (Supplement 2)

Increase the flood hazard **area** from 100-year to 500-year for all RC II, III, and IV structures



Who is impacted by Flood Hazards?

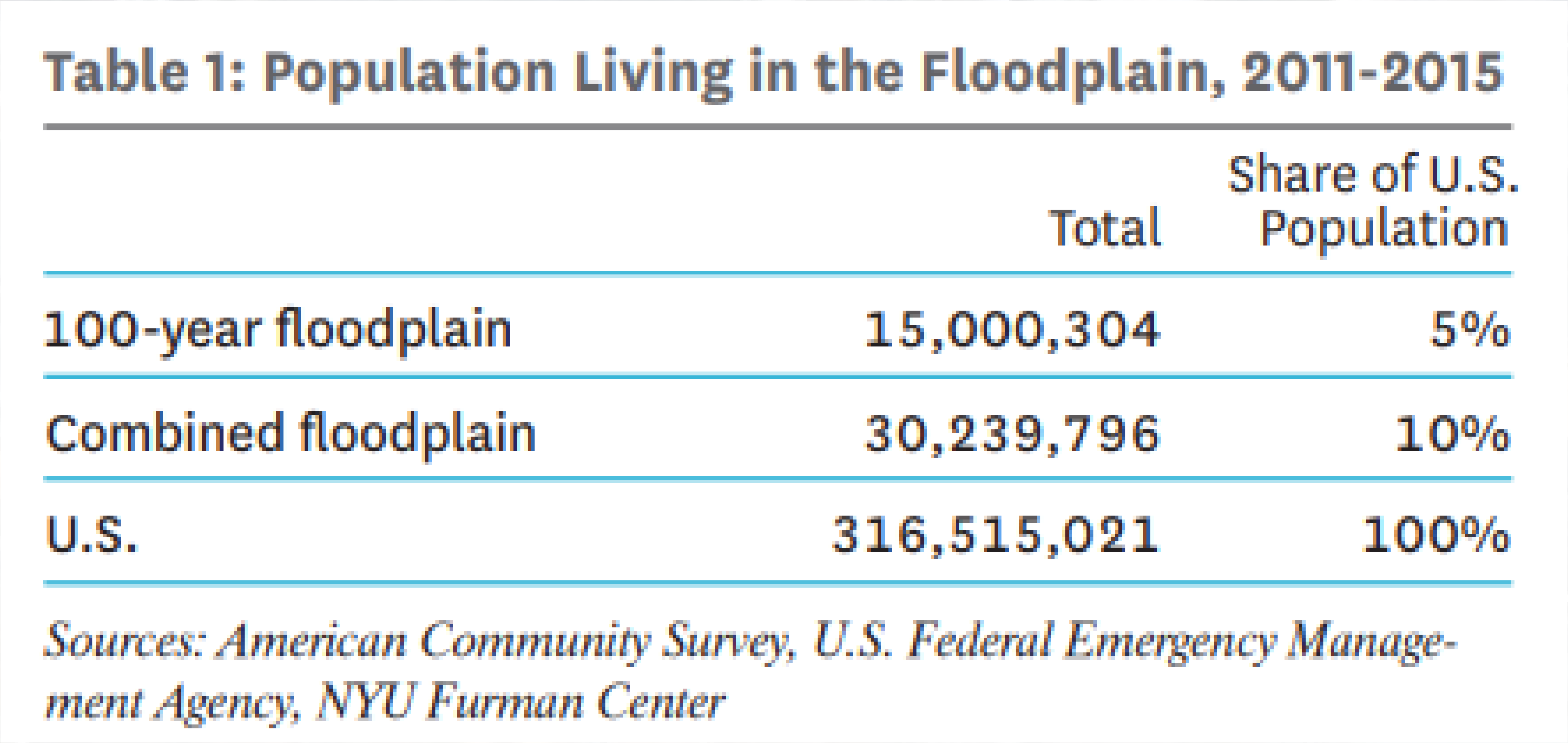


Table 1: Population Living in the Floodplain, 2011-2015

	Total	Share of U.S. Population
100-year floodplain	15,000,304	5%
Combined floodplain	30,239,796	10%
U.S.	316,515,021	100%

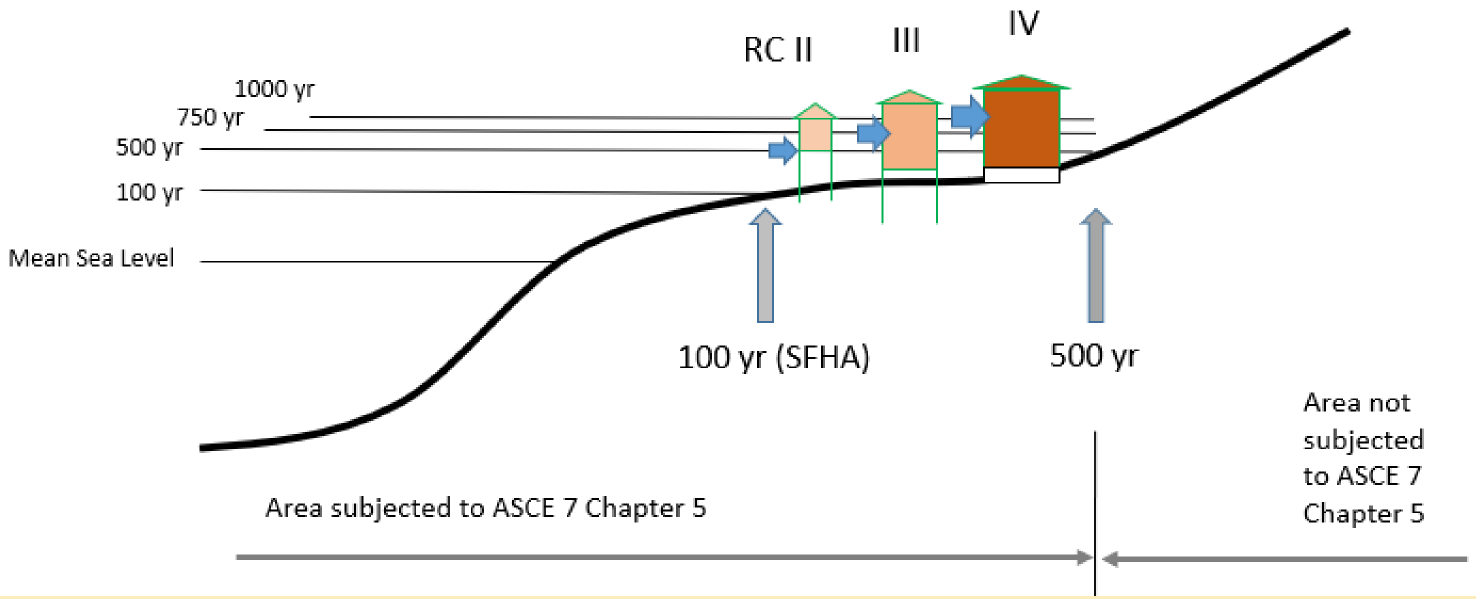
Sources: American Community Survey, U.S. Federal Emergency Management Agency, NYU Furman Center

- ❖ Approximately 10% of the US population lives within 500-year floodplain

Chapter 5 Revisions (Supplement 2)

- Incorporate a risk-based approach where flood hazard is tied to structure risk category

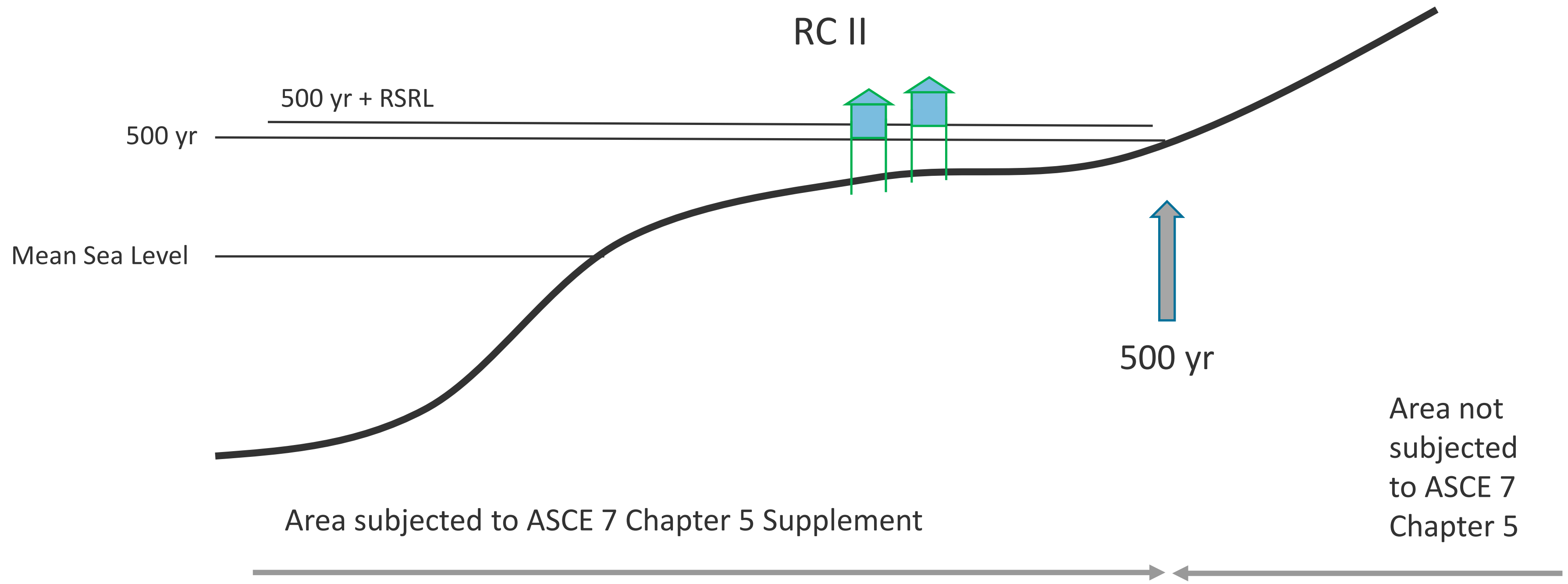
RC I 100-year RC II 500-year RC III 750-year RC IV 1000-year



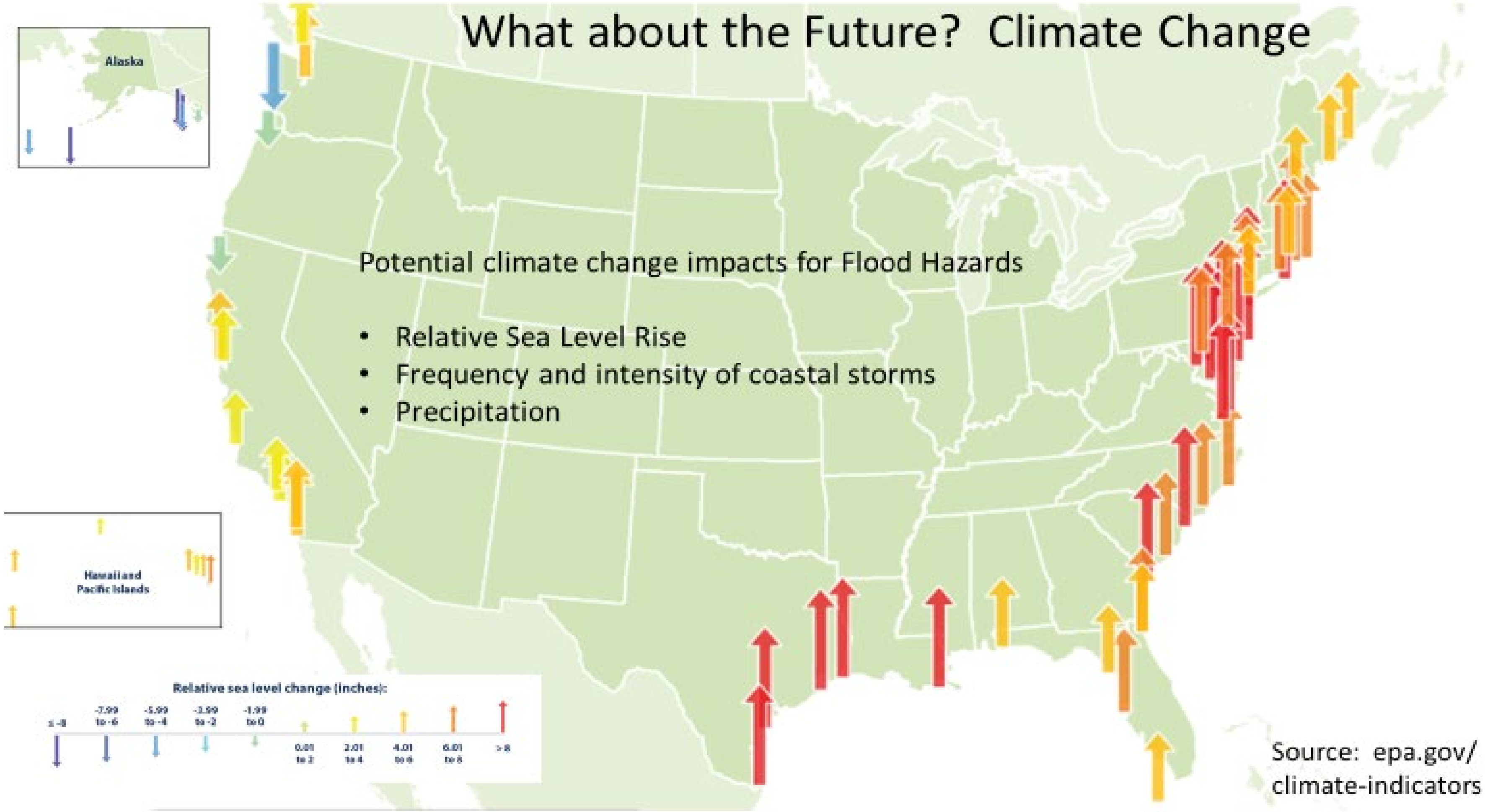
Note: ASCE 7 Chapter 5 does not prescribe elevation requirements for structures. ASCE 24 does that.

Chapter 5 Revisions (Supplement 2)

Add the effects of Relative Sea Level Rise



Future- Climate Change



What about the Future? Climate Change

Potential climate change impacts for Flood Hazards

- Relative Sea Level Rise
- Frequency and intensity of coastal storms
- Precipitation

Source: epa.gov/ climate-indicators

Chapter 5 Revisions (Supplement 2)

Revisions provide requirements and guidance for Hazards, Loads, Load Cases, Reliability Analysis

- Hazard
  - Flood depth,
  - Flood velocity,
  - Wave conditions,
  - Scour depth,
  - Debris hazards

- Load
  - Hydrostatic,
  - Hydrodynamic,
  - Wave forces,
  - Debris impact

- Load Cases
  - Combinations of loads
  - Stability check

- Reliability Analysis
  - Consistency with Chapter 2

Flood Hazard Area

Hazard

- Flood depth,
- Flood velocity,
- Wave conditions,
- Scour depth,
- Debris hazards

Load

- Hydrostatic,
- Hydrodynamic,
- Wave forces,
- Debris impact

Load Cases

- Combinations of loads
- Stability check

Reliability Analysis

- Consistency with Chapter 2

5.3 DESIGN REQUIREMENTS

5.3.1 Flood Hazard Area.

For Risk Category II, III, and IV structures, the Flood Hazard Area shall be the 500-year floodplain designated as the Special Flood Hazard Area and the Shaded X-Zone. For Risk Category I structures, the Flood Hazard Area shall be the 100-year floodplain designated as the Special Flood Hazard Area.

Intention to extend the design requirements out to the 500-year floodplain for RC II, III, and IV structures

Flood Hazard Area

Hazard

- Flood depth,
- Flood velocity,
- Wave conditions,
- Scour depth,
- Debris hazards

Load

- Hydrostatic,
- Hydrodynamic,
- Wave forces,
- Debris impact

Load Cases

- Combinations of loads
- Stability check

Reliability Analysis

- Consistency with Chapter 2

5.3.3 Design Stillwater Flood Depth.

The design stillwater flood depth, d_f, in ft (m) shall be determined in accordance with Equation 5.3-1:

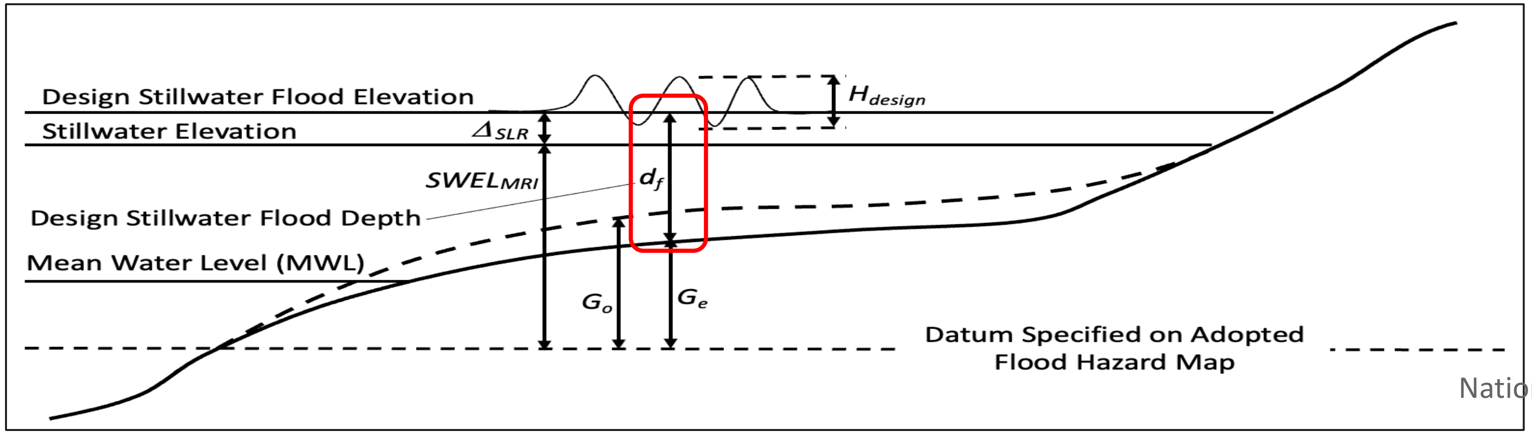
$$d_f = (SWEL_{MRI} - G_e) + \Delta_{SLR} \qquad (5.3\text{-}1)$$

where

$SWEL_{MRI}$ = stillwater elevation corresponding to the risk category and MRI defined in Table 5.3-1 provided by a flood hazard study adopted by the Authority Having Jurisdiction in ft (m). Where the stillwater elevation for a given MRI is not provided in the flood hazard study, the 100-year stillwater elevation shall be scaled to the required MRI per Section 5.3.3.1.

G_e = elevation of grade at the building or other structure inclusive of effects of erosion in ft (m), per Section 5.3.5.

Δ_{SLR} = relative sea level change for coastal sites in ft (m), see Section 5.3.4. D_{SLR} shall not be taken as less than 0.



Flood Hazard Area

Hazard

- ○ Flood depth,
- ○ Flood velocity,
- ○ Wave conditions,
- ○ Scour depth,
- ○ Debris hazards

Load

- ○ Hydrostatic,
- ○ Hydrodynamic,
- ○ Wave forces,
- ○ Debris impact

Load Cases

- ○ Combinations of loads
- ○ Stability check

Reliability Analysis

- ○ Consistency with Chapter 2

5.3.3.1 Stillwater Elevation Determination When MRI Data Not Available.

Where MRI data is not available, $SWEL_{MRI}$ shall be determined according to Equation 5.3-2

$$SWEL_{MRI} = C_{MRI}\,(SWEL_{100} - Z_{datum}) + Z_{datum} \qquad (5.3\text{-}2)$$

where

$SWEL_{100}$ = stillwater elevation for the 100-year MRI provided by a flood hazard study adopted by the Authority Having Jurisdiction in ft (m).

C_{MRI} = flood scale factor associated with the MRI from Table 5.3-1 for different locations.

Z_{datum} = elevation of mean water level based on local datum, in ft (m). For riverine sites, Z_{datum} shall be taken as the annual high-water level. Z_{datum} shall be permitted to be taken as zero for coastal sites. Values for SWEL_{100}, SWEL_{MRI}, and G_e shall all reference the same local datum.

V

Risk Category	MRI (year)	Annual Exceedance Probability (AEP)	C_{MRI} Gulf of Mexico Coastal Sites^1	C_{MRI} All Other Coastal Sites^1	C_{MRI} Great Lakes Sites^2	C_{MRI} Riverine Sites
I	100	1.00%	1.00	1.00	1.00	1.00
II	500	0.20%	1.35	1.25	1.15	1.35
III	750	0.13%	1.45	1.35	1.20	1.45
IV	1,000	0.10%	1.50	1.40	1.25	1.50

Intention is to use modern flood information as it becomes available.

Requirement to Consider Sea Level Rise Based on Historic Rates

Hazard
- ○ Flood depth,
- ○ Flood velocity,
- ○ Wave conditions,
- ○ Scour depth,
- ○ Debris hazards

Load
- ○ Hydrostatic,
- ○ Hydrodynamic,
- ○ Wave forces,
- ○ Debris impact

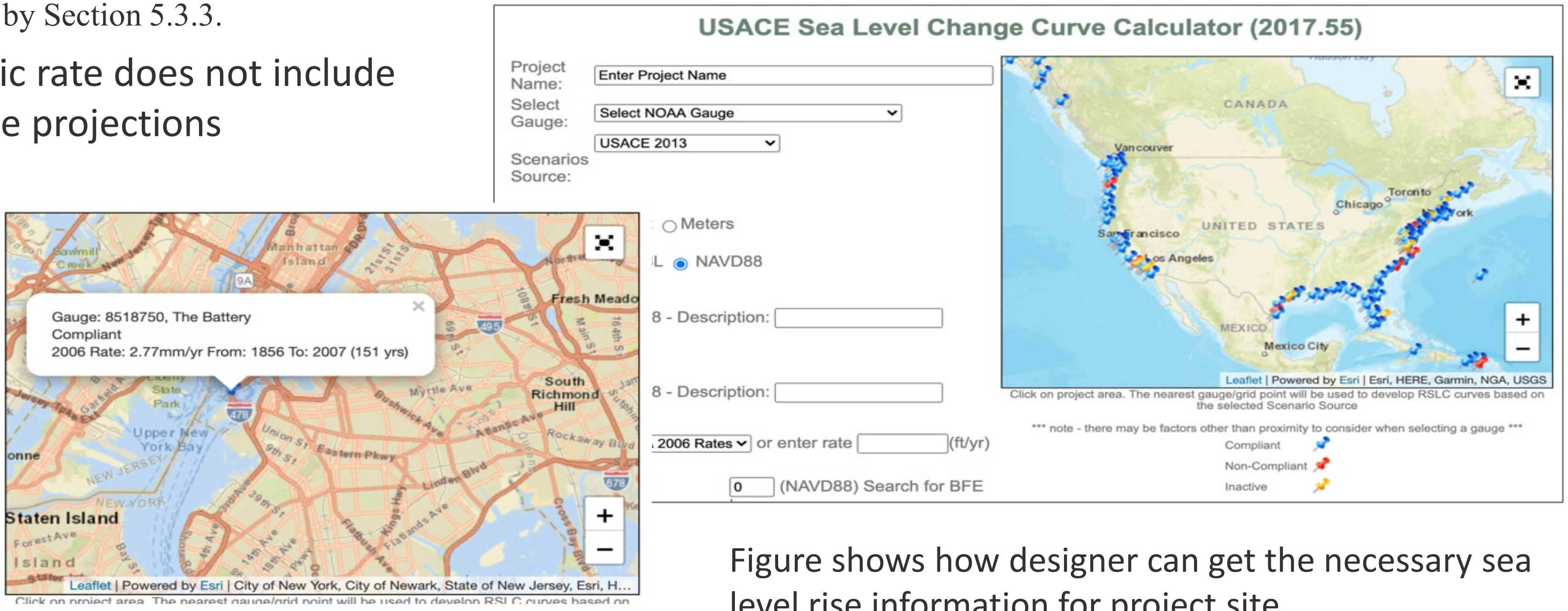
Load Cases
- ○ Combinations of loads
- ○ Stability check

Reliability Analysis
- ○ Consistency with Chapter 2

5.3.4 Effects of Relative Sea Level Change.

The effects of relative sea level change shall be included in the calculation of flood conditions and flood loads for sites whose flooding comes from coastal sources. A project lifecycle of not less than 50 years shall be used for this quantification. The minimum rate of relative sea level change shall be the historically recorded sea level change rate for the site over a 50-year period. The increase in relative sea level during the project lifecycle of the structure shall be added to the design stillwater flood elevation as required by Section 5.3.3.

Historic rate does not include climate projections


USACE Sea Level Change Curve Calculator (2017.55)

Project Name: Enter Project Name

Select Gauge: Select NOAA Gauge

Scenarios Source: USACE 2013

○ Meters

● NAVD88

8 - Description:

8 - Description:

2006 Rates or enter rate (ft/yr)

0 (NAVD88) Search for BFE

Gauge: 8518750, The Battery
Compliant
2006 Rate: 2.77mm/yr From: 1856 To: 2007 (151 yrs)

Click on project area. The nearest gauge/grid point will be used to develop RSLC curves based on the selected Scenario Source

*** note - there may be factors other than proximity to consider when selecting a gauge ***

Figure shows how designer can get the necessary sea level rise information for project site

Commentary Language to Bridge Between Existing Practice and Proposed Changes

Hazard

- Flood depth,
- Flood velocity,
- Wave conditions,
- Scour depth,
- Debris hazards

Load

- Hydrostatic,
- Hydrodynamic,
- Wave forces,
- Debris impact

Load Cases

- Combinations of loads
- Stability check

Reliability Analysis

- Consistency with Chapter 2

In ASCE 7-22 Supplement 3, loads in Chapter 5 are based on the stillwater elevation. In prior editions, flood loads also were based on stillwater elevation, but the Chapter referenced a DFE in some load calculations. ASCE 7-22 Supplement 3 drops the reference to the DFE.

If needed for comparison purposes, the ASCE 7-22 Supplement 3 coastal DFE can be determined in accordance with Equation C5.3-1:

$$DFE = d_f + G_e + 0.7H_{design} \qquad (C5.3\text{-}1)$$

where

H_{design} = design wave height in ft (m) as calculated in Section 5.3.7.1.

G_e = elevation of grade at the building or other structure inclusive of effects of erosion in ft (m), per Section 5.3.5.

d_f = design stillwater flood depth, in ft (m), per section 5.3.3

The ASCE 7-22 Supplement 3 riverine DFE is the same as the Design Stillwater Flood Elevation. The DFE calculated above is not the same DFE that is used for NFIP, ASCE 24, or other model building code purposes. Each DFE should be calculated separately per the applicable Standard for its intended purpose.

Revised Method to Estimate Velocity

Hazard
- Flood depth,
- Flood velocity,
- Wave conditions,
- Scour depth,
- Debris hazards

Load
- Hydrostatic,
- Hydrodynamic,
- Wave forces,
- Debris impact

Load Cases
- Combinations of loads
- Stability check

Reliability Analysis
- Consistency with Chapter 2

- Based on USACE Hurricane Simulations
- Reduction Factor, C = 0.5
- Cap on maximum velocity, Vmax depends on MRI

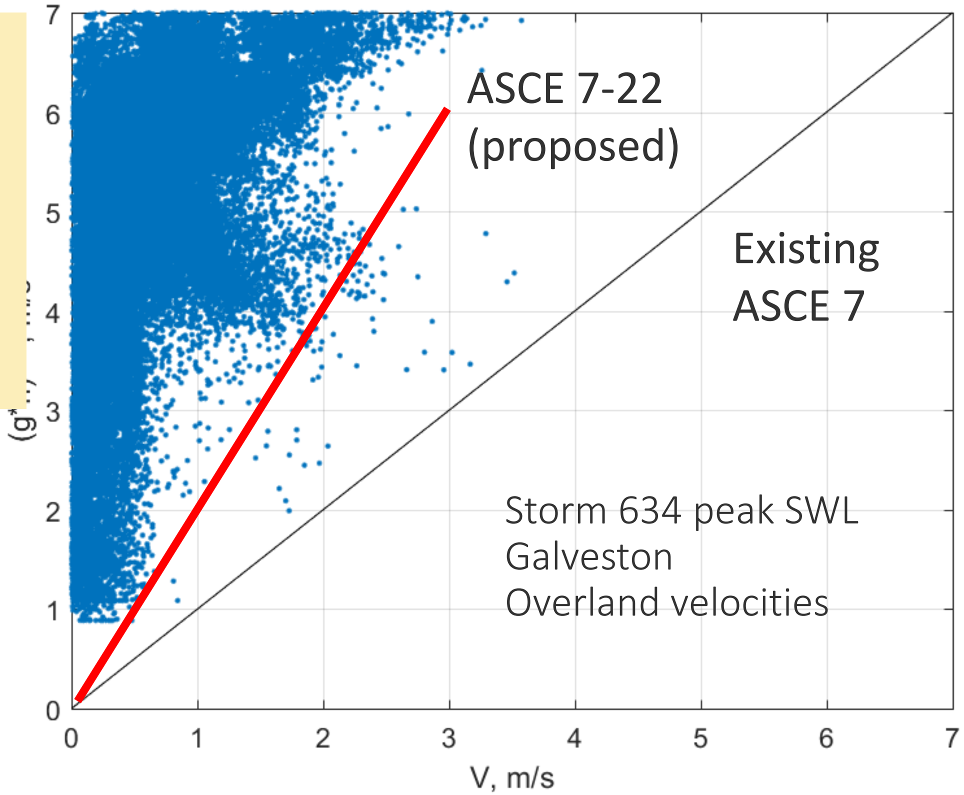


Figure compares existing ASCE 7 method to estimate velocity (black) with new method (red). Data points are computer simulation by USACE for scenario hurricane impacting Galveston, TX.

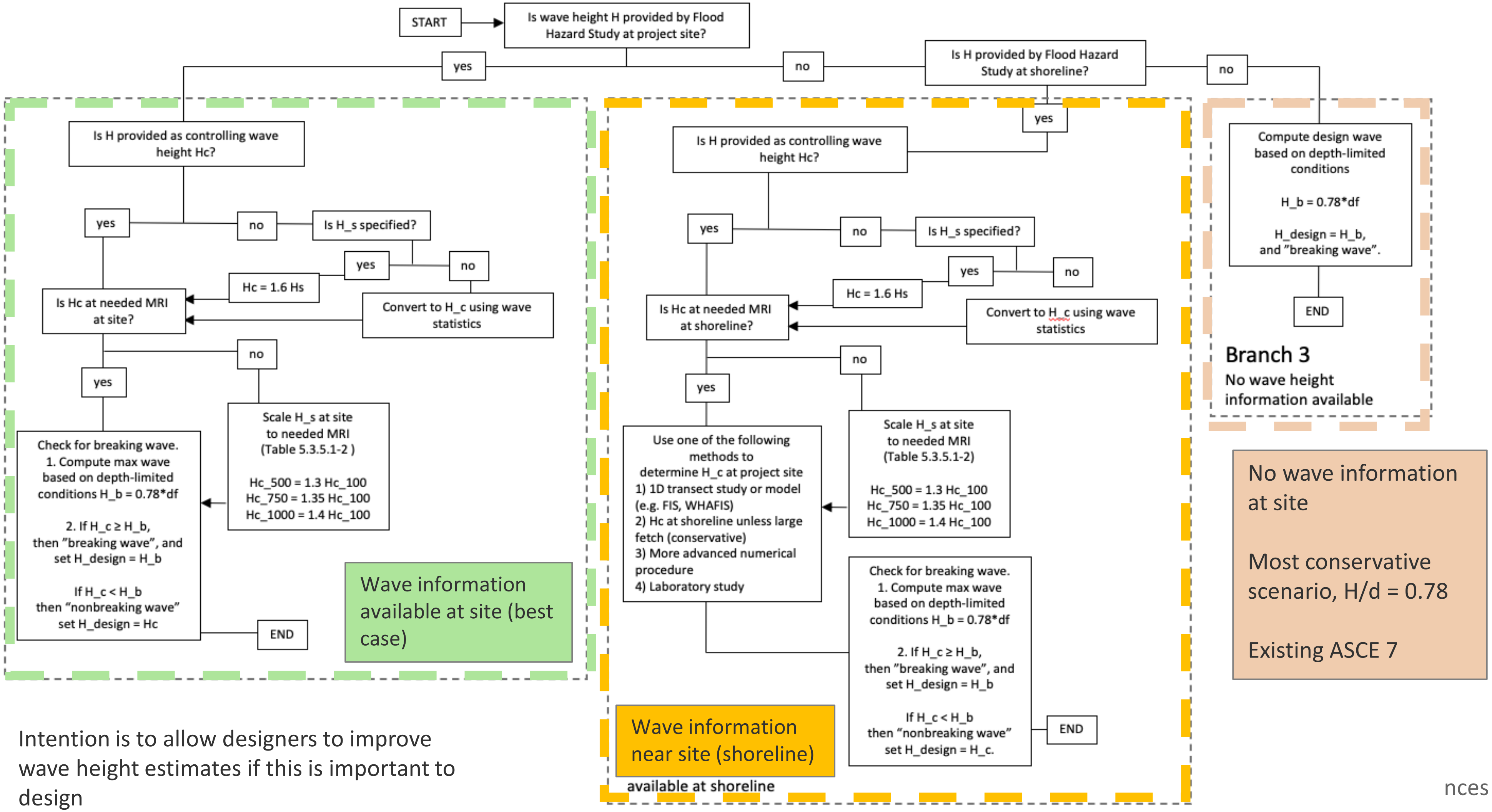
New Methods Gives Designers Ability to Refine Wave Height at Project Site

Hazard
- ○ Flood depth,
- ○ Flood velocity,
- ○ Wave conditions,
- ○ Scour depth,
- ○ Debris hazards

Load
- ○ Hydrostatic,
- ○ Hydrodynamic,
- ○ Wave forces,
- ○ Debris impact

Load Cases
- ○ Combinations of loads
- ○ Stability check

Reliability Analysis
- ○ Consistency with Chapter 2



START

Is wave height H provided by Flood Hazard Study at project site?

yes

no

Is H provided by Flood Hazard Study at shoreline?

yes

no

Is H provided as controlling wave height Hc?

yes

no

Is H_s specified?

yes

no

Hc = 1.6 Hs

Convert to H_c using wave statistics

Is Hc at needed MRI at site?

yes

no

Scale H_s at site to needed MRI (Table 5.3.5.1-2)

Hc_500 = 1.3 Hc_100
Hc_750 = 1.35 Hc_100
Hc_1000 = 1.4 Hc_100

Check for breaking wave.
1. Compute max wave based on depth-limited conditions H_b = 0.78*df

2. If H_c ≥ H_b, then "breaking wave", and set H_design = H_b

If H_c < H_b then "nonbreaking wave" set H_design = Hc

END

Wave information available at site (best case)

Is H provided as controlling wave height Hc?

yes

no

Is H_s specified?

yes

no

Hc = 1.6 Hs

Convert to H_c using wave statistics

Is Hc at needed MRI at shoreline?

yes

no

Scale H_s at site to needed MRI (Table 5.3.5.1-2)

Hc_500 = 1.3 Hc_100
Hc_750 = 1.35 Hc_100
Hc_1000 = 1.4 Hc_100

Use one of the following methods to determine H_c at project site
1) 1D transect study or model (e.g. FIS, WHAFIS)
2) Hc at shoreline unless large fetch (conservative)
3) More advanced numerical procedure
4) Laboratory study

Check for breaking wave.
1. Compute max wave based on depth-limited conditions H_b = 0.78*df

2. If H_c ≥ H_b, then "breaking wave", and set H_design = H_b

If H_c < H_b then "nonbreaking wave" set H_design = H_c.

END

Wave information near site (shoreline)

available at shoreline

Compute design wave based on depth-limited conditions

H_b = 0.78*df

H_design = H_b, and "breaking wave".

END

Branch 3

No wave height information available

No wave information at site

Most conservative scenario, H/d = 0.78

Existing ASCE 7

Intention is to allow designers to improve wave height estimates if this is important to design

Debris Hazard Considerations

- Hazard
    - Flood depth,
    - Flood velocity,
    - Wave conditions,
    - Scour depth,
    - Debris hazards
- Load
    - Hydrostatic,
    - Hydrodynamic,
    - Wave forces,
    - Debris impact
- Load Cases
    - Combinations of loads
    - Stability check
- Reliability Analysis
    - Consistency with Chapter 2

- Bring forward items from Commentary
- Make consistent with Chapter 6 Tsunami
- Limit the ‘sphere of influence’ overland

Debris Type	Applicable Risk Categories	Threshold Depth (ft)[1]	Impact on Columns, piles, bearing walls and transfer beams	Impact on non-load bearing elements[2]
Wood Poles	RC III/IV	3 ft (0.91 m)	Yes	Yes
Passenger Vehicles	RC II/III/IV	3 ft (0.91 m)	Yes	Yes
Small Vessels	RC II/III/IV	3 ft (0.91 m)	Yes[3]	Yes[3]
Shipping Containers	RC III/IV	3 ft (0.91 m)	Yes[3]	n/a
Ships/barges	RC III/IV	6 ft (1.8 m)	Yes[3]	n/a
Extraordinary Debris	RC IV	12 ft (3.7 m)	Yes[3]	n/a

Table indicates what debris types must be considered based on structure RC

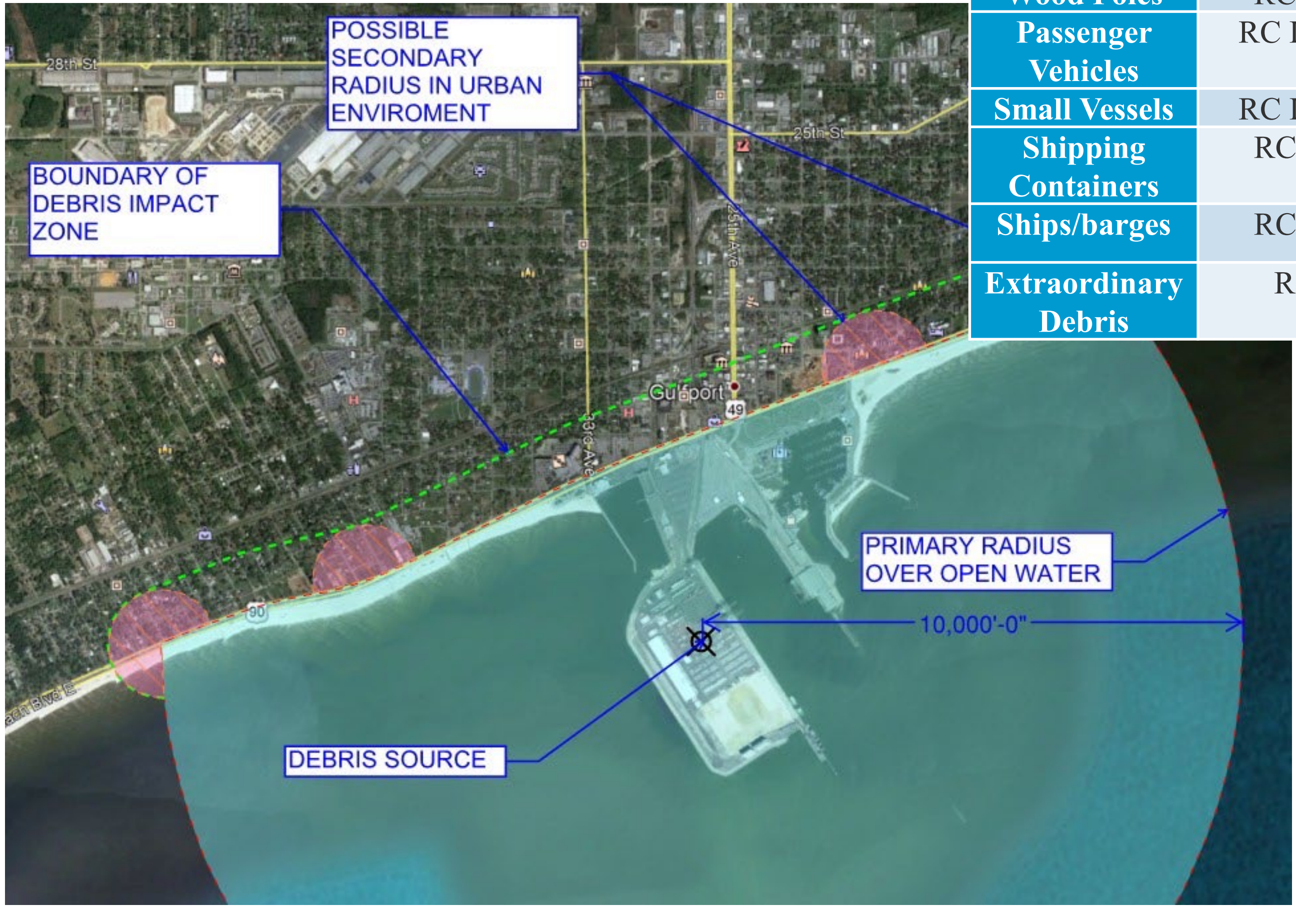


Figure shows how debris hazard is considered based on debris source, open water, and urban environments

Other Improvements in First Section

Hazard
- Flood depth,
- Flood velocity,
- Wave conditions,
- Scour depth,
- Debris hazards

Load
- Hydrostatic,
- Hydrodynamic,
- Wave forces,
- Debris impact

Load Cases
- Combinations of loads
- Stability check

Reliability Analysis
- Consistency with Chapter 2

- Loads on Breakaway Walls – in existing standard
  - ✓ Added requirement to resist the lateral earth pressure requirement of Chapter 3

- Site-specific studies
  - ✓ allowed for velocity and wave hazards but not depth
  - ✓ reductions comparable to other chapters

Table 5.3-6 Maximum Allowable Reductions for Site-specific Studies

Hazard	Allowable Reduction with Peer Review	Allowable Reduction without Peer Review
Velocity, V	30%	20%
Wave height, H	30%	20%

- PBD allowable per Section 1.3.1.3. PBD statement in Chapter 5 allows for flood-specific guidance in commentary

Table C5.3-4 Matrix of Expected Performance and Hazard Levels for Flood

Hazard Level vs Performance	Operational	Repairable	Significant Damage	Unsafe to Occupy
Routine	RC IV, RC III	RC II		
Design	RC IV	RC III, RC II		
Extreme		RC IV	RC III	RC II

Wave Forces

Hazard
- ○ Flood depth,
- ○ Flood velocity,
- ○ Wave conditions,
- ○ Scour depth,
- ○ Debris hazards

Load
- ○ Hydrostatic,
- ○ Hydrodynamic,
- ○ Wave forces,
- ○ Debris impact

Load Cases
- ○ Combinations of loads
- ○ Stability check

Reliability Analysis
- ○ Consistency with Chapter 2

- Added provisions for nonbreaking waves based on accepted engineering practice
- Include wave loads on elevated structures

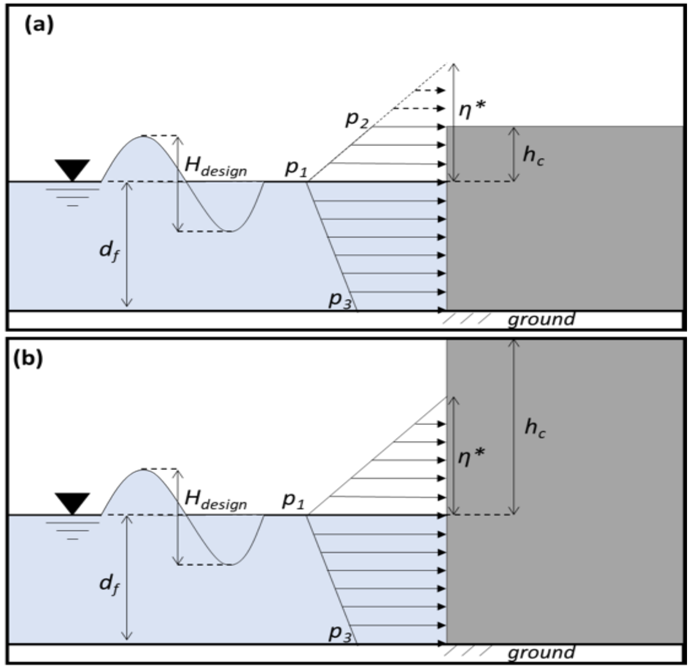


Figure shows definition sketch for non-elevated structures for use with Goda Equations

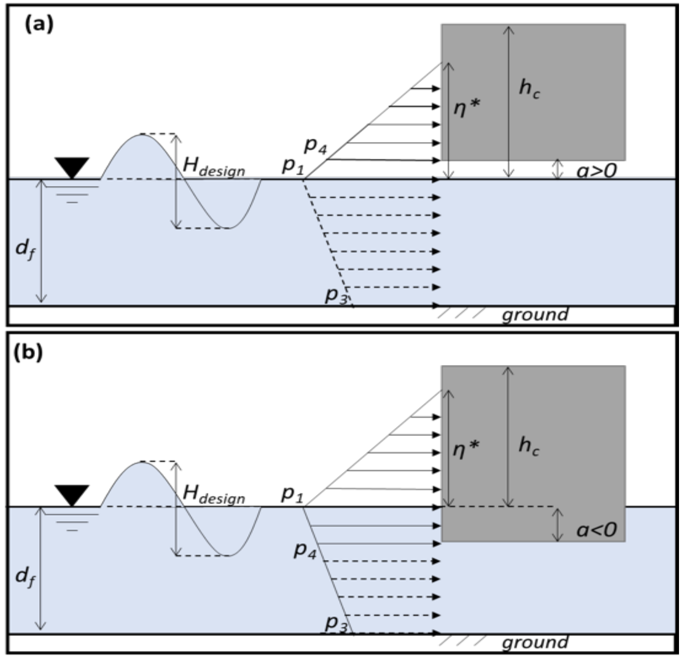


Figure shows definition sketch for elevated structures for use with Goda Equations

Intention is to provide designers with explicit equations commonly used in engineering practice not found in existing Chapter 5

Debris Impact

Hazard
- ○ Flood depth,
- ○ Flood velocity,
- ○ Wave conditions,
- ○ Scour depth,
- ○ Debris hazards

Load
- ○ Hydrostatic,
- ○ Hydrodynamic,
- ○ Wave forces,
- ○ Debris impact

Load Cases
- ○ Combinations of loads
- ○ Stability check

Reliability Analysis
- ○ Consistency with Chapter 2

- Debris impact loads required per 5.3.9 with several exceptions
- Some guidance from 7-22 commentary moved to provisions
- Three procedures to calculate debris impact
- Specification of debris types and properties

Table 5.4-4 Minimum Debris Properties

Debris Type	Minimum debris weight (W_{debris})	Minimum elastic debris stiffness (k_e)
Wood Log/Pole	1,000 lb (4.448 kN)	4,200,000 lb/ft (61,300 kN/m)
Passenger Vehicle	2,400 lb (12.455 kN)	72,000 lb/ft (1,051 kN/m)
Small Vessels	2,500 lb (11.121 kN)	360,000 lb/ft (5,254 kN/m)
20 ft Shipping Container	5,000 lb (22.241 kN)	2,940,000 lb/ft (42,900 kN/m)
40 ft Shipping Container	8,400 lb (37.365 kN)	2,040,000 lb/ft (29,800 kN/m)
Ships/Barges	Established based on local conditions	

Table lists minimum debris properties used for design

- Extraordinary Debris Impact for RC IV structures
- Debris impact load redistribution – related to progressive collapse
- Improved consistency of debris impact with Chapter 6 Tsunami

Combination of Loads

Hazard

○ Flood depth,

○ Flood velocity,

○ Wave conditions,

○ Scour depth,

○ Debris hazards

Load

○ Hydrostatic,

○ Hydrodynamic,

○ Wave forces,

○ Debris impact

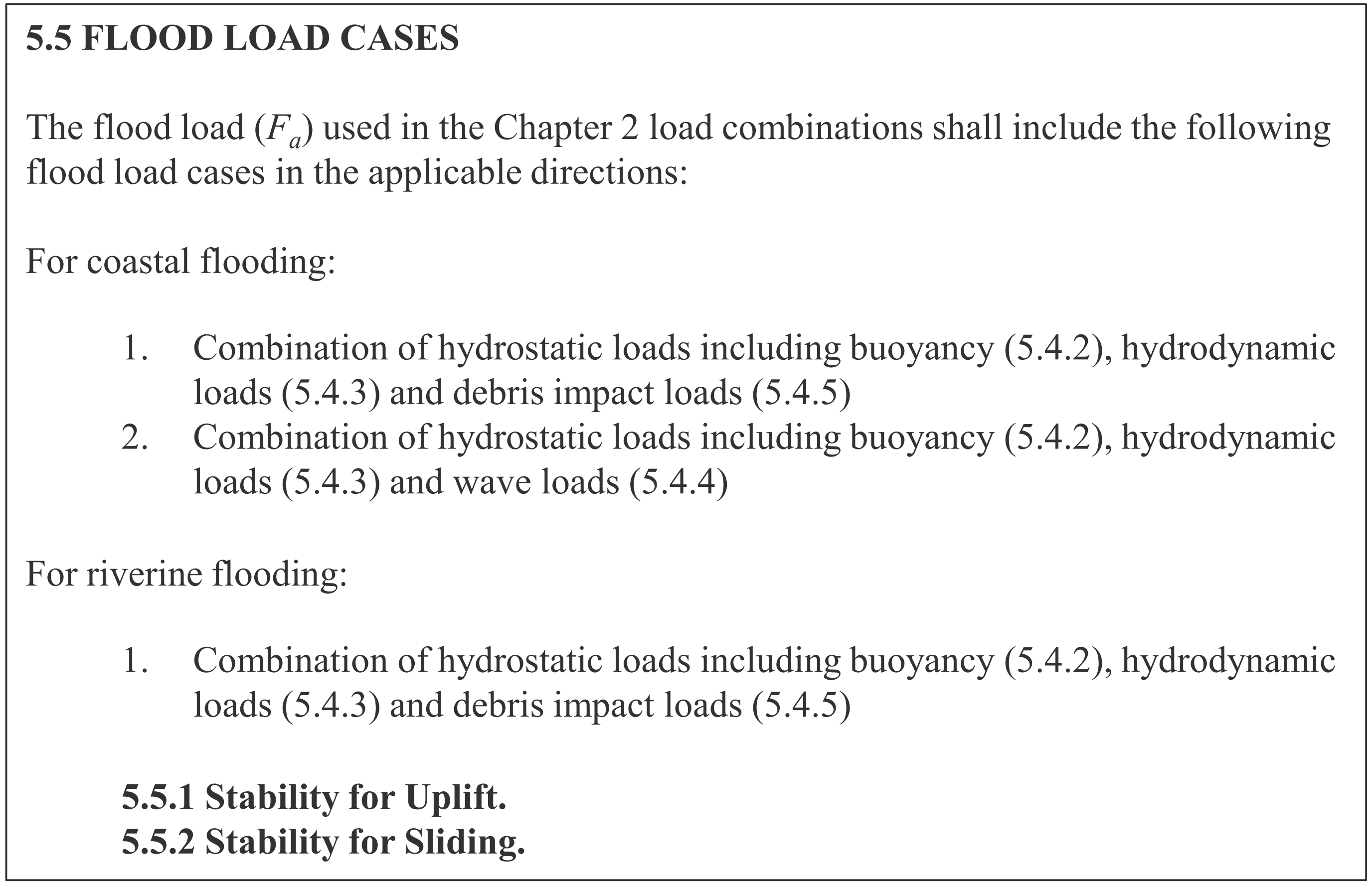
Load Cases

○ Combinations of loads

○ Stability check

Reliability Analysis

○ Consistency with Chapter 2



5.5 FLOOD LOAD CASES

The flood load (F_a) used in the Chapter 2 load combinations shall include the following flood load cases in the applicable directions:

For coastal flooding:

1. Combination of hydrostatic loads including buoyancy (5.4.2), hydrodynamic loads (5.4.3) and debris impact loads (5.4.5)
2. Combination of hydrostatic loads including buoyancy (5.4.2), hydrodynamic loads (5.4.3) and wave loads (5.4.4)

For riverine flooding:

1. Combination of hydrostatic loads including buoyancy (5.4.2), hydrodynamic loads (5.4.3) and debris impact loads (5.4.5)

5.5.1 Stability for Uplift.
5.5.2 Stability for Sliding.

Clear requirement on how individual loads must be combined

Overall flood load F_a is used in Chapter 2.

Stability checks are often done in practice, but existing standard does not include this.

Summary

Complete revision to Chapter 5

- Increase the flood hazard area from 100-year to 500-year for all RC II, III, and IV structures
- Incorporate a risk-based approach where flood hazard is tied to structure risk category
  RC I 100-year   RC II 500-year   RC III 750-year   RC IV 1000-year
- Hazards: Flood depth, velocity, wave, scour and debris hazards
- Loads: Provides hydrostatic, hydrodynamic, wave, and debris impact loads
- Load cases: Combination of flood loads and stability checks, consistency w/ Chapter 2

and as a subcommittee

- Understand how proposed changes would affect engineering design and impact related standards
- Document analytical work and case studies for future cycles and for engineering practice

FEMA's Role

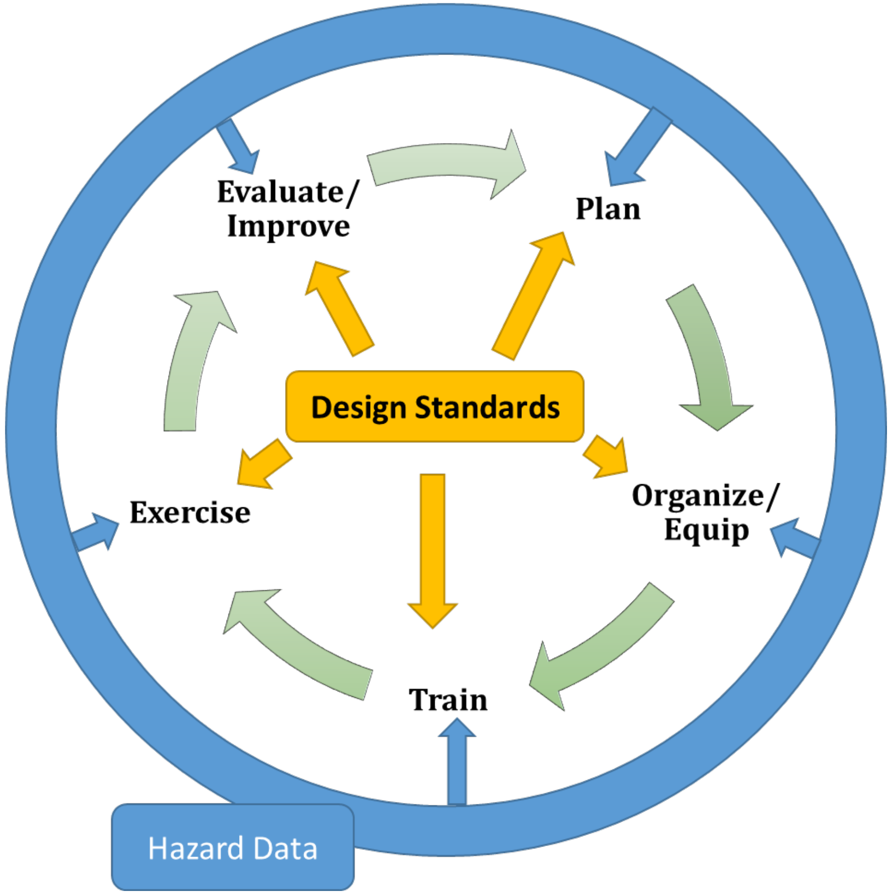
Provides Support to:

- Communities
- Design Community
- Other Agencies

Through:

- Funding/Flood Insurance
- Hazard Data Products
- Guidance Publications
- Technical Assistance

Hazard & Design Data Is Key!



FEMA Programs Over Time

National Flood Insurance Program

- Request for Information 2021

Maps and products have evolved and improved over time

Agency goals

- Climate Change
- Equity

Federal Contribution

- Data from the US Army Corps of Engineers contributed to the C_{MRI} factor in ASCE 7 Chapter 5 Flood Loads
- Integration of flood resistant design and construction requirements in consensus codes and standards
- Guidance on flood code provisions
- FEMA currently evolving flood hazard data from binary to graduated risk

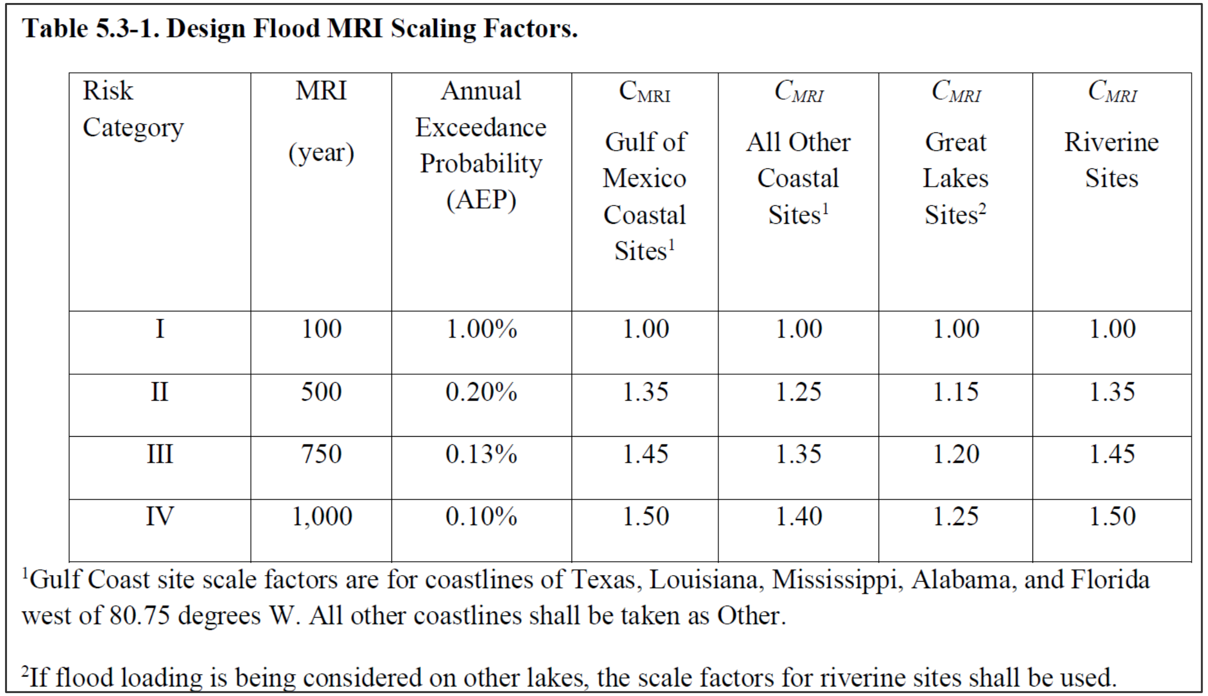


Table 5.3-1. Design Flood MRI Scaling Factors.

Risk Category	MRI (year)	Annual Exceedance Probability (AEP)	C_{MRI} Gulf of Mexico Coastal Sites[1]	C_{MRI} All Other Coastal Sites[1]	C_{MRI} Great Lakes Sites[2]	C_{MRI} Riverine Sites
I	100	1.00%	1.00	1.00	1.00	1.00
II	500	0.20%	1.35	1.25	1.15	1.35
III	750	0.13%	1.45	1.35	1.20	1.45
IV	1,000	0.10%	1.50	1.40	1.25	1.50

[1] Gulf Coast site scale factors are for coastlines of Texas, Louisiana, Mississippi, Alabama, and Florida west of 80.75 degrees W. All other coastlines shall be taken as Other.

[2] If flood loading is being considered on other lakes, the scale factors for riverine sites shall be used.

Source - ASCE Standard 7-22 Minimum Design Loads and Associated Criteria for Buildings and Other Structures SUPPLEMENT 2

Changing Market Conditions

Catastrophe & Flood · Private flood insurers seize market growth amid NFIP pricing challenges

Private flood insurers seize market growth amid NFIP pricing challenges

Market up 24% from 2016 to 2022, according to new report

The Washington Post + Follow

Home insurers cut natural disasters from policies as climate risks grow

Story by Jacob Bogage • 2d

MARKETS TODAY ···

DJI ▼ -0.33%

INX ▼ -0.16%

Rise of the Climate Rating Agencies

Government and the private sector rely increasingly on risk-m
that claim they can zero in on exposure to climate change.

BY LEE HARRIS APRIL 12, 2023

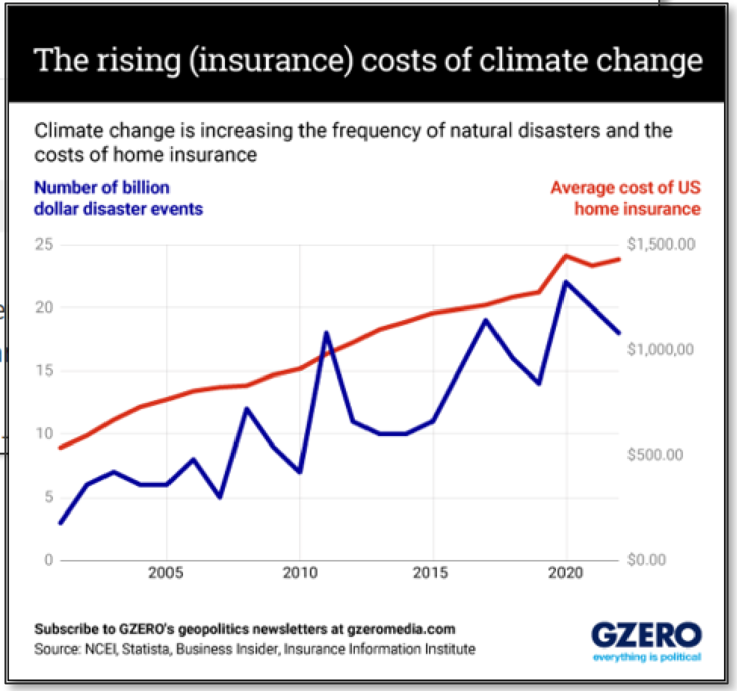
2.3k Shares

EXPERTS BLOG

Why Investors Can't Avoid Climate Risk by Divesting

Save

JEAN ROGERS: The topic of divestment often comes up in conversations about how to mitigate climate change. But these discussions often miss an important point: Climate risk is real and embedded across a portfolio, and as such, investors cannot diversify away from climate risk by divesting.



The rising (insurance) costs of climate change

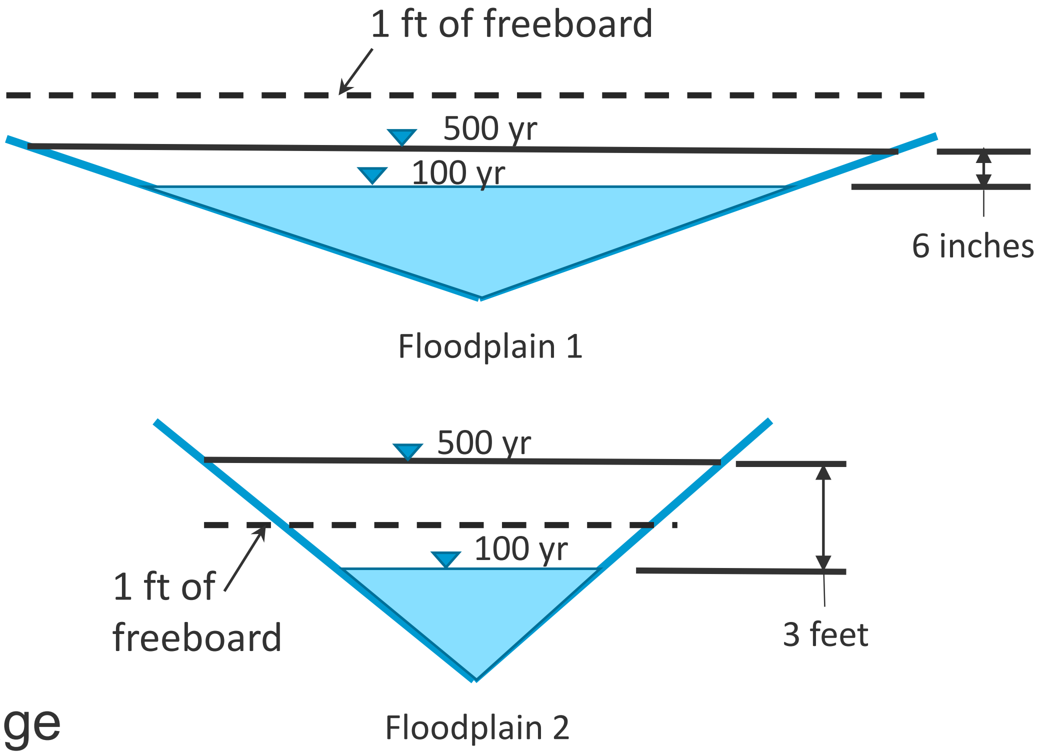
Climate change is increasing the frequency of natural disasters and the costs of home insurance

Subscribe to GZERO's geopolitics newsletters at gzeromedia.com
Source: NCEI, Statista, Business Insider, Insurance Information Institute

GZERO everything is political

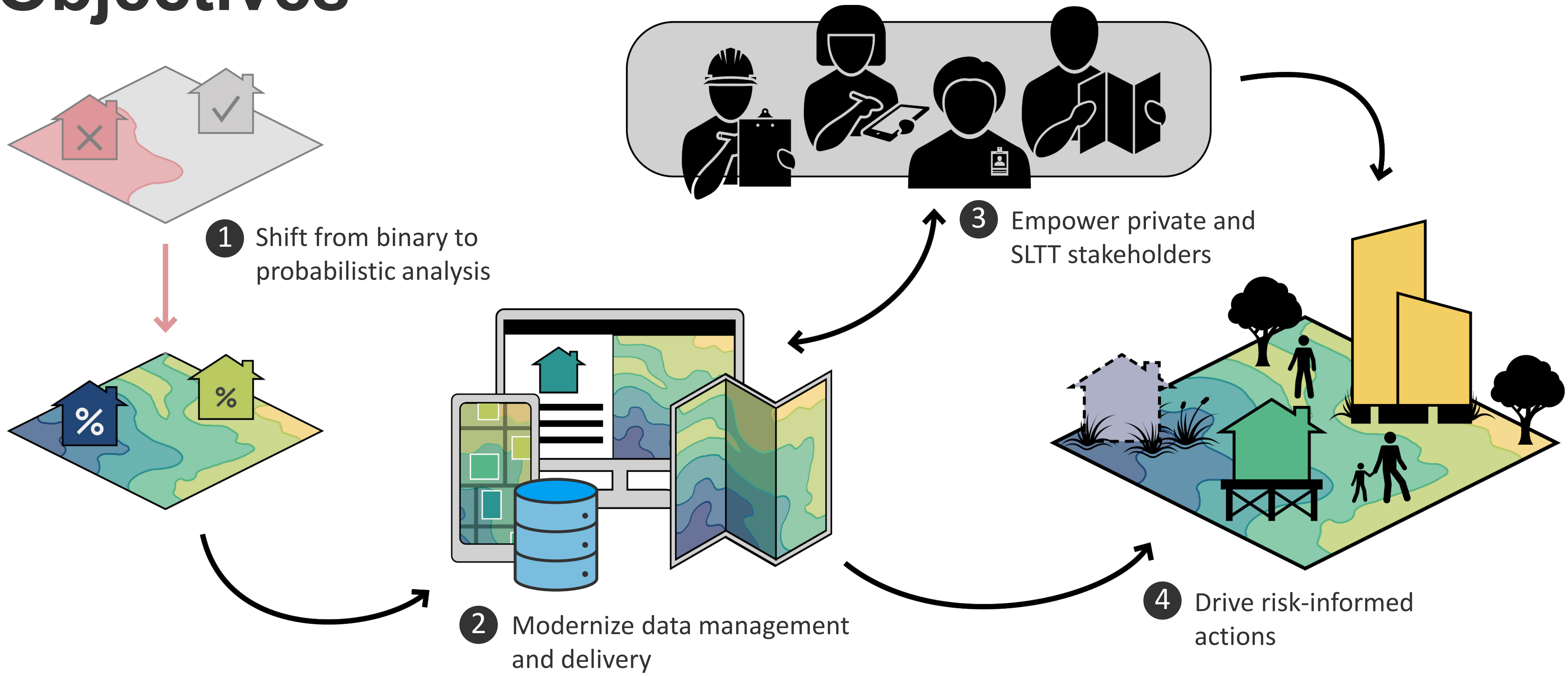
Moving towards higher minimum return periods or risk-based consensus standard

- Freeboard provides **varying levels of protection** within the floodplain
- Freeboard could provide protection to the **1,000-year flood or just over the 100-year flood** depending on the area
- A Return Period based approach is **more consistent protection**
- Calculations should **reflect flood heights** as well as **other changing factors** (e.g., velocity or wave heights)
- **Useful life of the building** – it's longer than the mortgage
  - Non-Residential Expected Service Life* 51.6 – 87.2 years
  - Residential Expected Service Life** 61 years



Riverine Example

Future of Flood Risk Data (FFRD) Initiative: Objectives



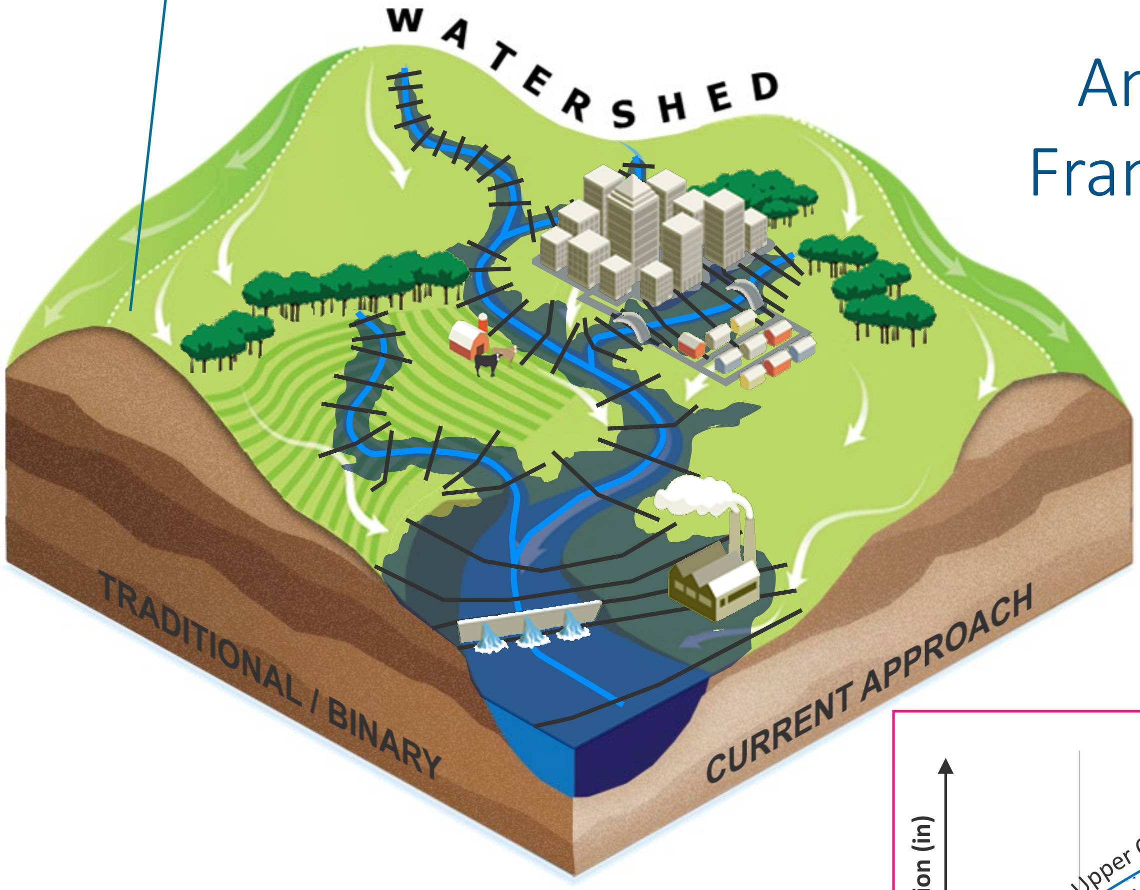
① Shift from binary to probabilistic analysis

② Modernize data management and delivery

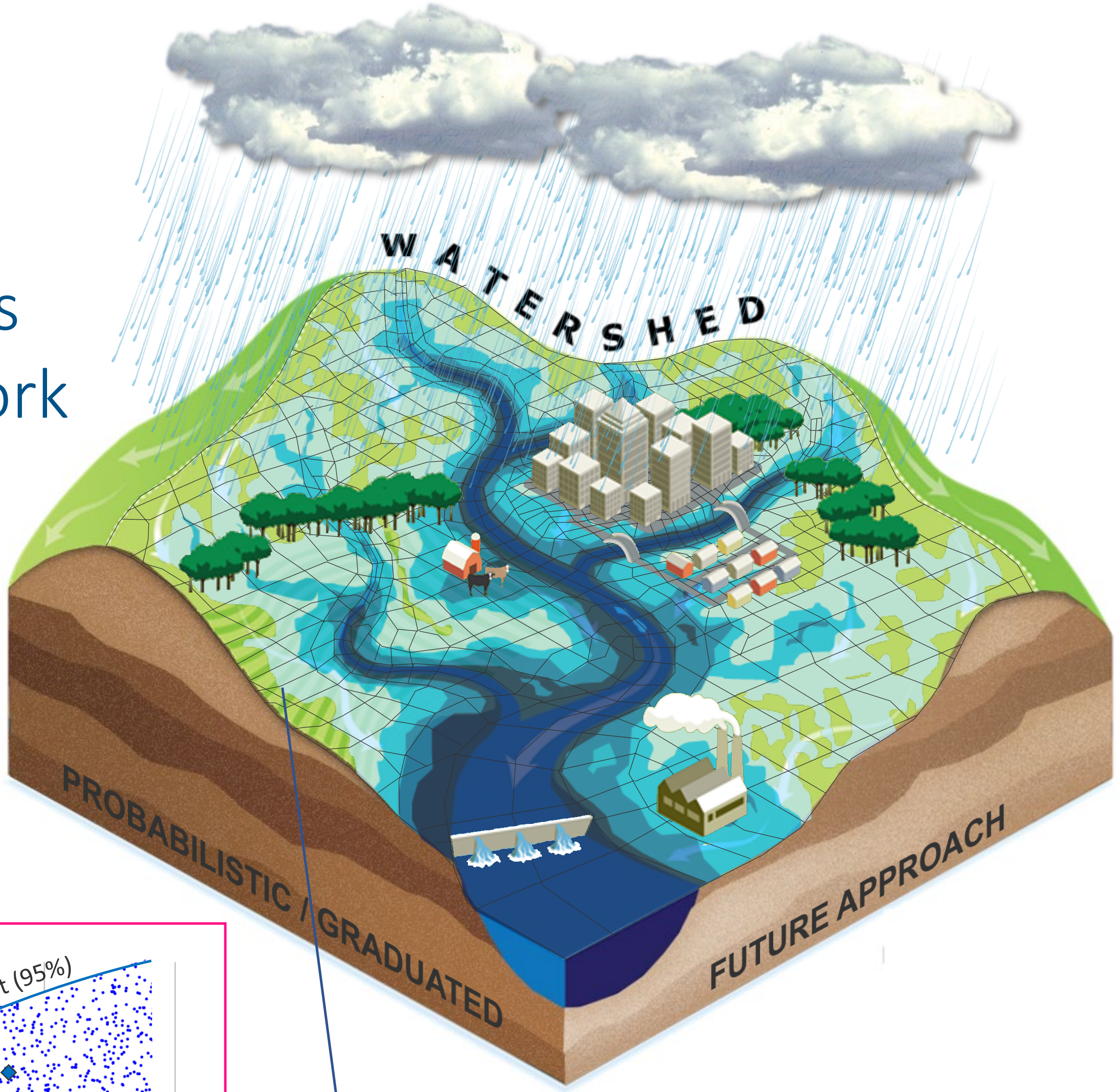
③ Empower private and SLTT stakeholders

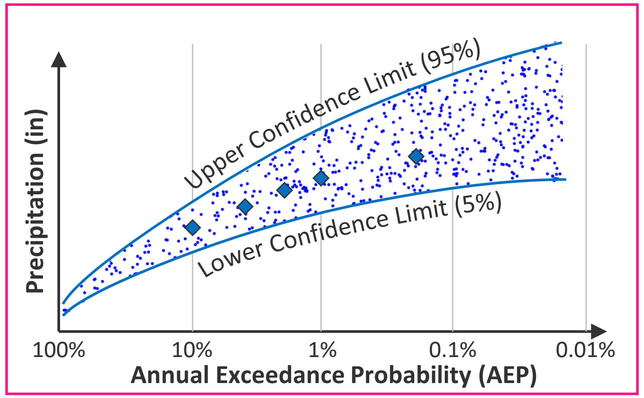
④ Drive risk-informed actions

- 1D Modeling
- Fluvial flooding only
- Event-based analyses



Analysis Framework

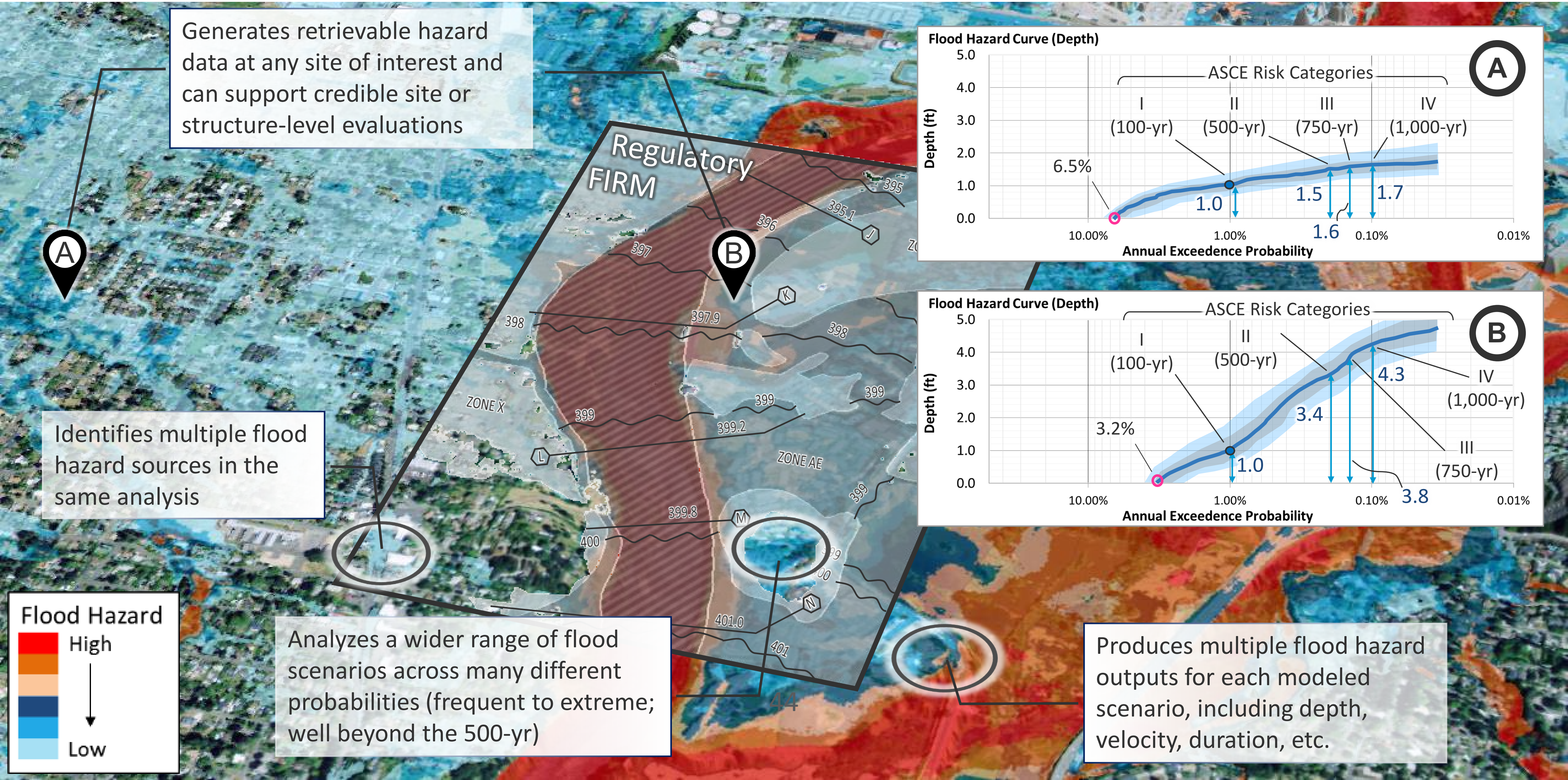




- 2D Modeling
- Fluvial and pluvial flooding
- Probabilistic analyses

Inland/Riverine Flooding Examples

Some of the Features, Benefits, and Uses of FFRD



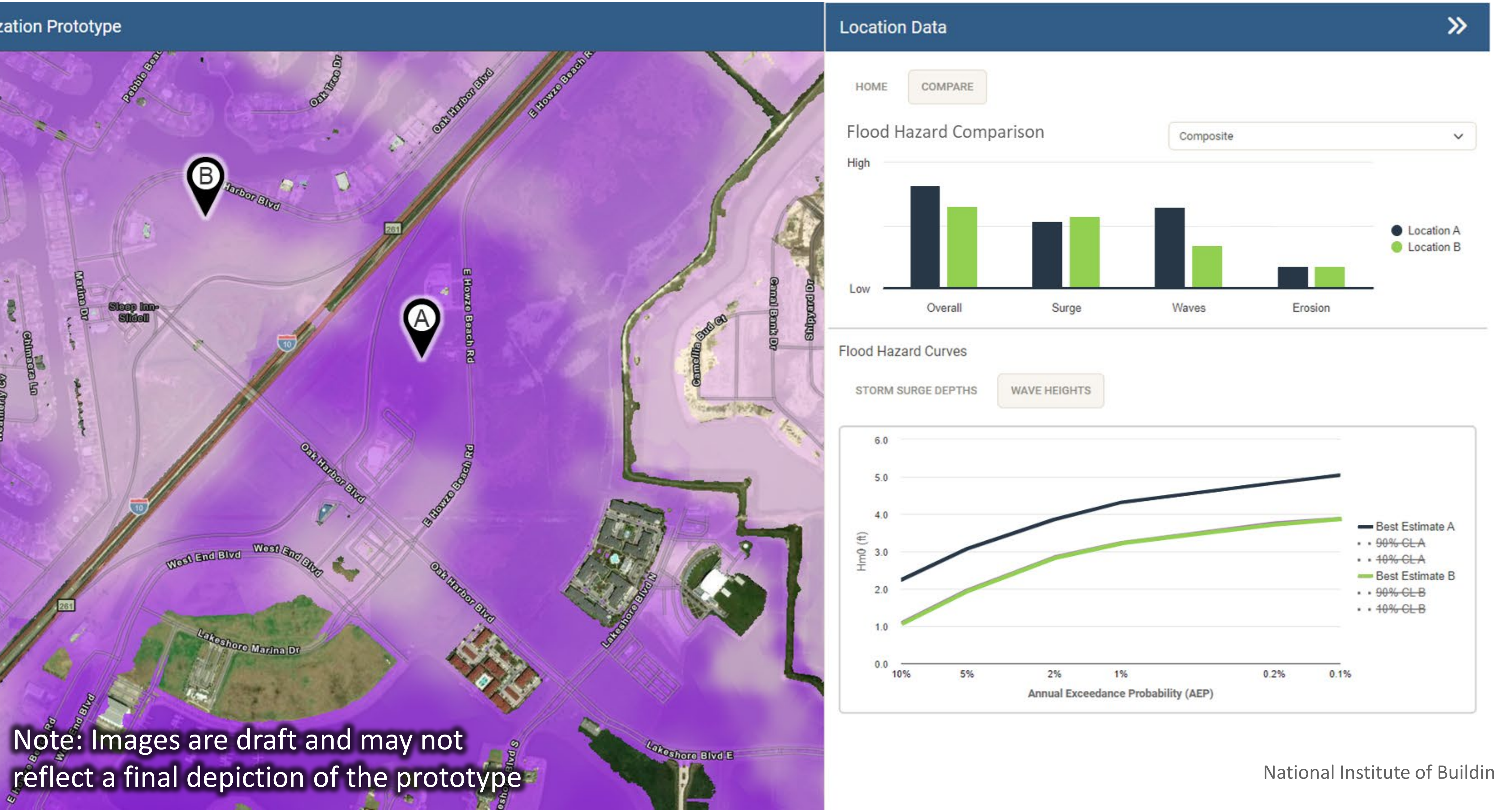
Generates retrievable hazard data at any site of interest and can support credible site or structure-level evaluations

Identifies multiple flood hazard sources in the same analysis

Analyzes a wider range of flood scenarios across many different probabilities (frequent to extreme; well beyond the 500-yr)

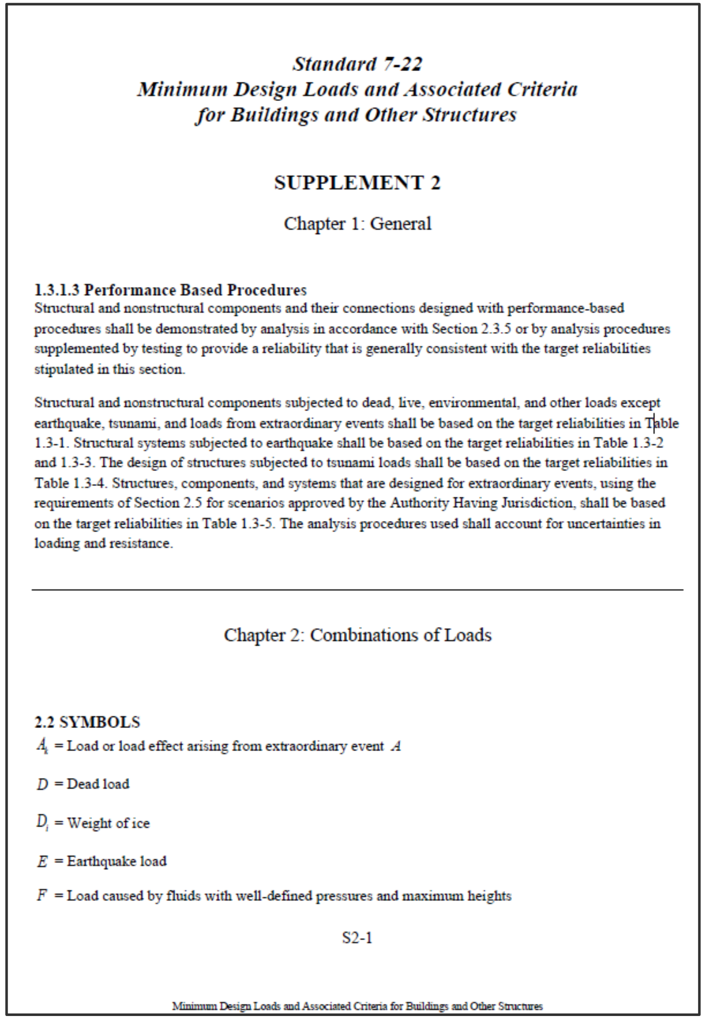
Produces multiple flood hazard outputs for each modeled scenario, including depth, velocity, duration, etc.

Prototype – Compare Conditions at Multiple Sites



Note: Images are draft and may not reflect a final depiction of the prototype

Developing Guidance on Supplement with Examples



Standard 7-22
Minimum Design Loads and Associated Criteria
for Buildings and Other Structures

SUPPLEMENT 2

Chapter 1: General

1.3.1.3 Performance Based Procedures

Structural and nonstructural components and their connections designed with performance-based procedures shall be demonstrated by analysis in accordance with Section 2.3.5 or by analysis procedures supplemented by testing to provide a reliability that is generally consistent with the target reliabilities stipulated in this section.

Structural and nonstructural components subjected to dead, live, environmental, and other loads except earthquake, tsunami, and loads from extraordinary events shall be based on the target reliabilities in Table 1.3-1. Structural systems subjected to earthquake shall be based on the target reliabilities in Table 1.3-2 and 1.3-3. The design of structures subjected to tsunami loads shall be based on the target reliabilities in Table 1.3-4. Structures, components, and systems that are designed for extraordinary events, using the requirements of Section 2.5 for scenarios approved by the Authority Having Jurisdiction, shall be based on the target reliabilities in Table 1.3-5. The analysis procedures used shall account for uncertainties in loading and resistance.

Chapter 2: Combinations of Loads

2.2 SYMBOLS

A_k = Load or load effect arising from extraordinary event A

D = Dead load

D_i = Weight of ice

E = Earthquake load

F = Load caused by fluids with well-defined pressures and maximum heights

S2-1

Minimum Design Loads and Associated Criteria for Buildings and Other Structures

CLARIFICATION **text boxes provide additional information on topics to elicit a deeper understanding which may include section introduction information.**

EXCEEDING MINIMUMS **text boxes provide methods and rationale to consider going above the minimums outlined in ASCE 7-22 Supplement 2 (ASCE 7-22-S2).**

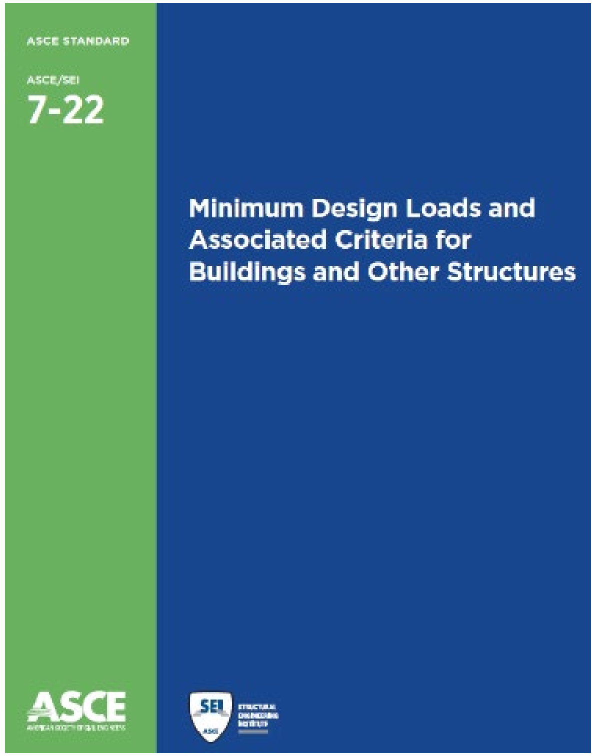
ADDITIONAL CONSIDERATIONS **text boxes provide additional guidance to practitioners to aid in the completion of load calculations or a compliant design.**

RESOURCES **text boxes provide resources for further details on a specific topic or for tools to perform specific tasks.**

EXAMPLE **text boxes provide example calculations of methods either defined by ASCE-22-S2, this guidance document, or a combination thereof.**

Remain engaged in advancing flood-resilient standards

Coming Attractions: ASCE 7-28



ASCE STANDARD

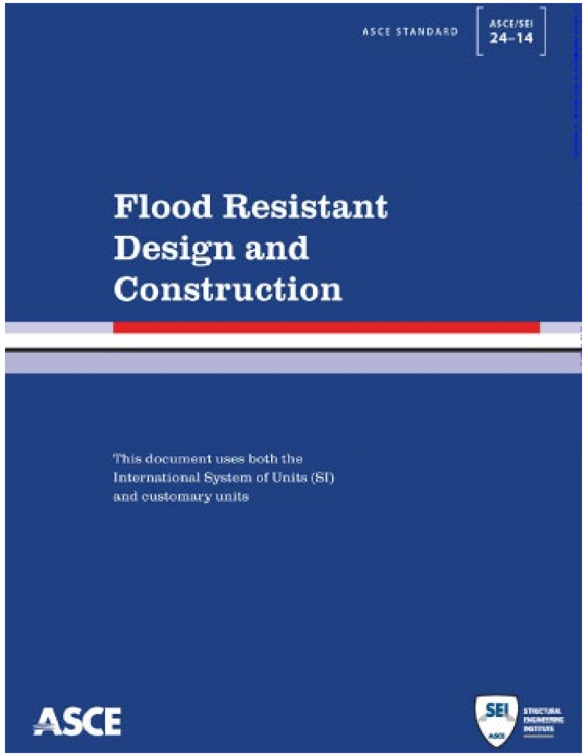
ASCE/SEI

7-22

Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASCE

SEI



ASCE STANDARD

ASCE/SEI 24–14

Flood Resistant Design and Construction

This document uses both the International System of Units (SI) and customary units

ASCE

SEI

Pathways to Resilient Communities (1).pdf (asce.org)

ASCE 7-28 **Future Conditions** Subcommittee goals;

- Current loads based on historical data, which may not represent future conditions well with respect to climate related loads in particular
- Propose a new chapter for ASCE 7-28 (chapter 36)
- Written in mandatory language for potential (voluntary) adoption by jurisdictions/projects
- Address **Flood, Snow, Rain, Ice, & Wind**
- Starting point for us: “preparing for a 3 deg C world” and its impacts on loads
- Use climate models rather than analysis of historical data
- Modifies environmental loads for those who wish/required to include them.
- Will be dependent on Design Life/Risk Category of the building

National Initiative to Advance Building Codes (NIABC) Priorities

Modernize Building Codes

- Incentivize state, local, tribal and territorial governments to adopt and enforce current building codes
- Improve resilience to hazards
- Incorporate science and technology

Improve Climate Resilience

- Increase smart design and construction
- Build resilience to extreme weather events
- Save lives and reduce property damage

Reduce Energy Costs

- Increase energy efficiency
- Establish federal building performance standards
- Achieve net-zero emissions across federal buildings by 2045

Prioritize Underserved Communities

- Invest in capacity building for communities
- Provide tools to reduce damage and accelerate recovery
- Identify needs for rural and underserved communities

Create Good Jobs

- Develop equitable workforce training partnerships
- Assist federal, state and local agencies in creating high-quality job opportunities
- Prioritize needs of disadvantaged communities

Mitigation Framework Leadership Group (MitFLG) Progress Report:

National Initiative to Advance Building Codes

December 2022

FEMA

USDA

SBA

GSA

NIST

US Army Corps of Engineers

https://www.fema.gov/sites/default/files/documents/fema_niabc-progress-report_122022.pdf

Advancements in Flood Resilience

- Rapidly changing technology
- Comprehensive approach (zoning, comprehensive planning, subdivision standards, floodplain management requirements, codes and standards, research, testing, etc.)
- Evolving
    - Expanding regulatory floodplain
    - Flood hazard data from binary to graduated risk
    - Risk Category/performance-based design

National Institute of
BUILDING SCIENCES

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Association of State Floodplain Managers
ASFPM

Questions?

Thank you

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John.Ingargiola@fema.dhs.gov