

Health Care Planning for Future Flooding Storms, Tides, and Sea Level Rise



7th (2020) Edition of the
Florida Building Code

Introduction

This course was developed by:

AHCA

DBPR Provider #0001599

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Course Overview

This advanced course is an in-depth review of damage caused to health care facilities by flooding, tides, and sea level rise. It will better prepare architects, engineers, contractors, and providers to protect the critical assets of health care facilities. This course will discuss the meaning of specific terms and acronyms used in the FBC, explore the differences between the different types of flooding and inundation threats to a health care facility, and debunk the many myths surrounding sea level rise. It will provide detailed information regarding coastal storms, storm surge, rainfall and runoff, extreme tides, and other important catastrophic events involving water intrusion.

Information from the 7th edition of the Florida Building Code will be reviewed in detail with a concentration on Chapter 4, Special Occupancies, Sections 449.4 for hospitals and 450.4 for skilled nursing facilities, as well as other sections of the 7th edition of the FBC regarding flooding, especially Chapter 16. It will also provide detailed means and methods to increase the resiliency of health care structures against future flooding events.

Overview of the Issues



**Storms, extreme tides
and sea level rise all
increase flooding – yet
they are very different**

FEMA photo

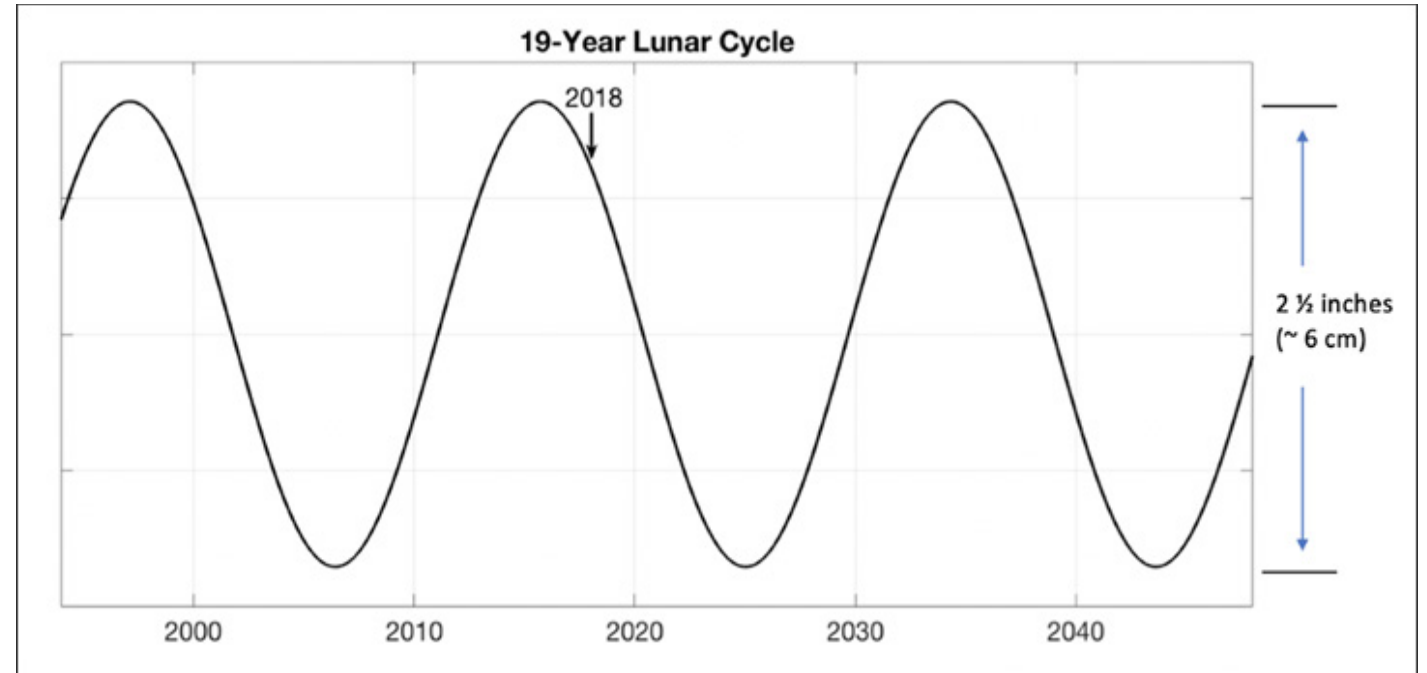
Five Flood Types Plus Erosion

1. Storms and Storm Surge

- Recede in days

2. Tides

- Recede in hours
- King Tides
- Sunny-Day Flooding
- 19-Year Lunar Cycle
 - Changing in 2024



Five Flood Types Plus Erosion

3. Rain

- The myth of the 100-year flood

4. Runoff

- Downhill and downstream

5. Erosion

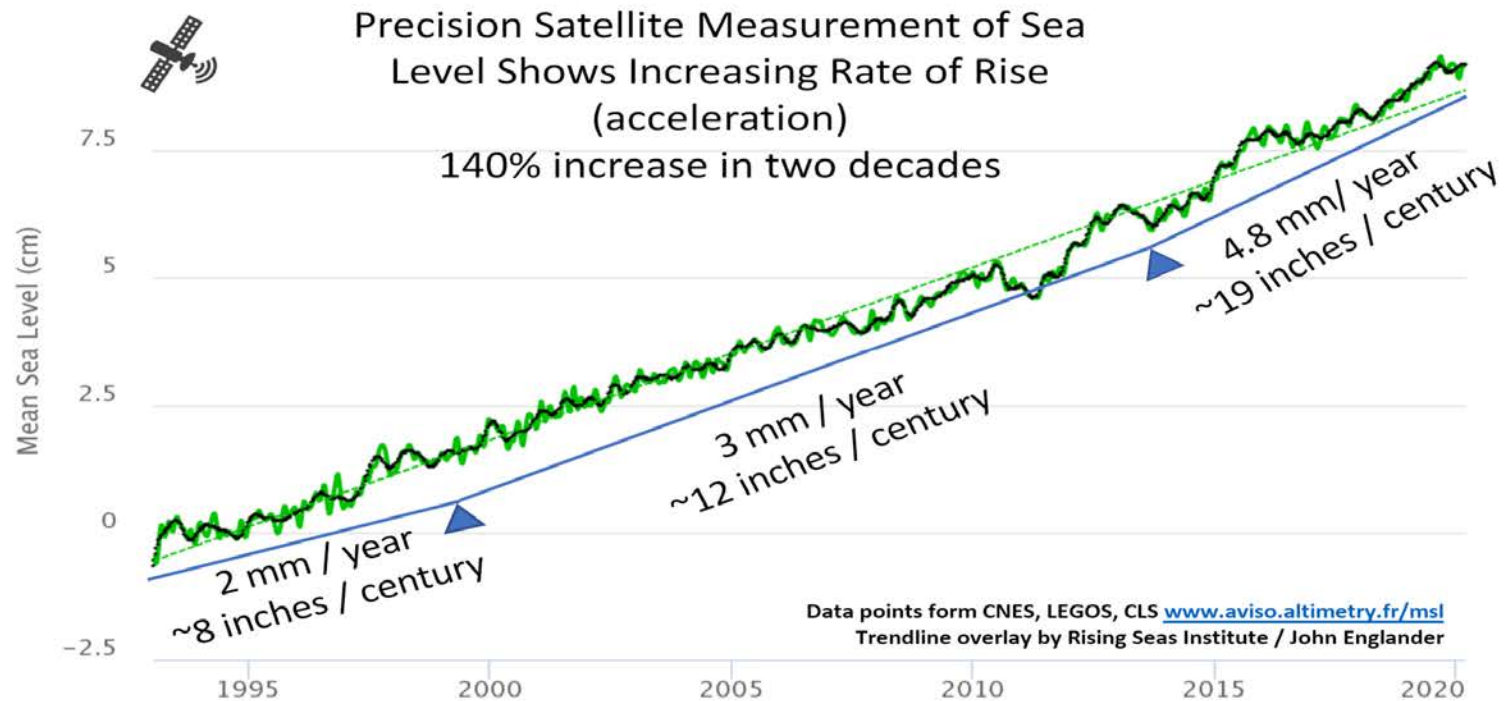
- Sudden, storm-related
- Incremental process

6. Sea Level Rise

- Essentially Permanent

Sea Level Rise

- Combines with storms and tides for amplified effects.
- Currently rising at approximately 0.2 inches per year (5 mm).
- The rate of rise is accelerating, potentially exponentially.



Section 1612

FBC Definitions

- **Base Flood**
- **Base Flood Elevation**
- Basement
- Coastal A Zone
- Coastal High Hazard Area
- Design Flood
- Design Flood Elevation
- Dry Floodproofing
- Essential Facilities
- Existing Structure
- Flood or Flooding
- **Finish Floor Elevation** (Not an FBC Definition)
- Flood Damage-Resistant Materials
- **Flood Hazard Area**
- **Flood Insurance Rate Map (Firm)**
- Flood Insurance Study
- **Floodway**
- Lowest Floor
- Risk Category
- **Special Flood Hazard Area**
- Start of Construction
- Substantial Damage
- **Substantial Improvement**

The Most Important Definitions from the FBC You Must Know... Explained

- **BASE FLOOD.** The flood having a 1-percent chance of being equaled or exceeded in any given year.
- **BASE FLOOD ELEVATION.** The elevation of the base flood, including wave height, relative to the National Geodetic Vertical Datum (NGVD), North American Vertical Datum (NAVD) or other datum specified on the Flood Insurance.
- **FLOOD HAZARD AREA.** The greater of the following two areas:
 1. The area within a flood plain subject to a 1-percent or greater chance of flooding in any year.
 2. The area designated as a flood hazard area on a community's flood hazard map, or otherwise legally designated.

The Most Important Definitions from the FBC You Must Know... Explained

FLOOD INSURANCE RATE MAP (FIRM). An official map of a community on which the Federal Emergency Management Agency (FEMA) has delineated both the special flood hazard areas and the risk premium zones applicable to the community.

FINISHED FLOOR ELEVATION The height of the finish material on the floor of a building in relation to the surrounding elevation (Not a definition of the FBC).

FLOODWAY The channel of the river, creek or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

The Most Important Definitions from the FBC You Must Know... Explained

SPECIAL FLOOD HAZARD AREA. The land area subject to flood hazards and shown on a Flood Insurance Rate Map or other flood hazard map as Zone A, AE, A1-30, A99, AR, AO, AH, V, VO, VE or V1-30.

SUBSTANTIAL IMPROVEMENT. Any repair, reconstruction, rehabilitation, alteration, addition or other improvement of a building or structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the improvement or repair is started. If the structure has sustained substantial damage, any repairs are considered substantial improvement regardless of the actual repair work performed. The term does not, however, include either:

1. Any project for improvement of a building required to correct existing health, sanitary or safety code violations identified by the building official and that is the minimum necessary to assure safe living conditions.
2. Any alteration of a historic structure provided that the alteration will not preclude the structure's continued designation as a historic structure.

Health Care Facility Flood-Related Vulnerabilities

- Essential Electrical system
 - switchgear, emergency generator, fuel storage
- Access
 - roads, driveway, parking areas, emergency access
- Water supply (potable and non-potable)
 - local and source utility
- Wastewater
 - local and community plant
- Structural
 - roof and roofing
 - foundation
 - concrete issues such as spalling
- Geo-technical issues
 - sinkholes
 - subsidence
 - porous limestone

The Florida Building Code Before and After 1992

- Florida Building Codes Prior to 1992
 - No State-Wide Building Code
 - Standard Building Code, Broward Building Code, and Dade Building Code
 - Protections against high wind and flooding events varied between the codes
- Post Hurricane Andrew:
 - Lewis Report: *Hurricane Andrew was a relatively dry hurricane, bringing with it an average of three to six inches of rainfall. Therefore, the potential impact of serious flooding was not discussed in detail during the series of 6 meetings conducted by the Committee. **The potential implications of flooding must also be considered in future planning efforts.***
- Commentary Note: Hurricane Andrew was a warning but did not teach the lesson of preparing for the effects of flooding. However, the building codes slowly began to change.

The Goal of the Florida Building Code Requirements

- 449/450.4.2 Disaster preparedness construction standards.
 - *These minimum standards are intended to increase the ability of the facility to be structurally capable of serving as a shelter for patients, staff and the family of patients and staff and equipped to be **self-supporting** during and immediately following a disaster.*
- **Commentary Note:** This is the language from the original legislative statute and provides the legislative “intent”. The Florida legislature was very intent on protecting the most vulnerable citizens of the state and ensuring the health care system of the state would survive any natural disaster. They directed the Agency for Health Care Administration (AHCA) to bring together all of the stakeholders to develop standards that would actually make this goal happen.

The Meaning of “Self-Supporting”

The Implementation of Legislation:

- Legislation: broad stroke and must be implemented with detailed rules to make *Self-Supporting* a reality.
 - AHCA formed a committee of stake holders and technical experts.
 - The committee reviewed engineering reports, damage assessments, photographs, individual accounts, and other available material pertaining to high wind and flooding events.
 - The committee met for many months as consensus was sought and obtained.
-
- **Commentary Note:** Administrative Rules are easy to block, so the process becomes a political process, too... not just a best practice process.

Chapter 4 Special Occupancies

“Hardening Requirements”

Sections 449.4/450.4

- Only for Hospitals and Skilled Nursing Homes as a result of State Legislative mandate.
- Statute as originally written was directed at all hospitals and nursing homes, both new and existing. The estimated cost created huge concerns.
- The revised statute limited any new construction standards to new facilities and additions to existing facilities.
- After the statute sunset and after Hurricane Charlie in 2004, the FBC was revised to require all renovations made at a facility to meet current codes and standards,.

Understanding Special Definitions in Chapter 4

449/450.4.1.1 New Facility

- *A hospital or nursing home which has not received a Stage II Preliminary Plan approval from the Agency for Health Care Administration pursuant to this section.*

449/450.4.1.3 During and Immediately Following

- *A period of 72 hours following the loss of normal support utilities to the facility.*

449/450.4.1.4

Occupied patient/resident Area(s)

- *The location of patients/residents inside of the new facility or in the addition of a wing or floor to an existing facility during and immediately following a disaster. If these patients/residents are to be relocated into an area of the existing facility during and immediately following a disaster, then for purposes of this code, that location will be defined as the “occupied patient area.”*

Defining Improvement Areas

Building Enhancements to Obtain the Goal of “Self-Supporting”

- **Exterior Envelope** includes the roof, roof top equipment, exterior openings, and all appurtenances
- **Building Structure** to withstand wind, surge, and flooding
- **Building Utilities:** Mechanical, Medical Gas, Plumbing, Electrical
- **Safe zones** inside the structure or “Enhanced Hurricane Protection Areas” EHPA for occupants located inside the building
- **Emergency Communication Standards**
- **Site Standards** could prevent or slow access to the health care structure

Site Standards

Chapter 4 Special Occupancies, FBC

- Access to the Facility
 - 449/450.4.2.2.4 *Where an off-site public access route is available to the new facility at or above the base flood elevation, a minimum of one on-site emergency access route shall be provided that is located at the same elevation as the public access route.*
 - Commentary Note: Addresses the condition of a facility built above the surrounding land area where at least one access route must also be raised to the level of the facility for continued access during flooding.

Site Standards

Chapter 4 Special Occupancies, FBC

Landscaping

- 449.4.2.2.5 *New landscaping elements shall be located so if damaged they will not block the on-site emergency access route to the facility. Outdoor signs and their foundations shall be designed to meet the wind load criteria of the Florida Building Code, Building.*
- Commentary Note: As a result of high wind events, landscape elements were damaged and blocked egress to the emergency departments of hospitals.

Landscaping Elements

- Trees and tall planting can cause damage and block egress to the site



Photo by Skip Gregory

Site Standards

Chapter 4 Special Occupancies, FBC

Site Improvements

- 449/450.4.2.2.6 *New light standards and their foundations used for lighting the on-site emergency access route shall be designed to meet the wind load criteria of ASCE 7 with wind speeds determined from Figure 26.5-1B with appropriate exposure category dependent on site location.*
- **Commentary Note:** As a result of high wind events, landscape elements were damaged and blocked egress. It is important to keep light standards in place for emergency evacuations and to prevent collateral damage.

Light Standard and Ventilator Site Damage



Photos by Skip Gregory

Site Standards

Chapter 4 Special Occupancies, FBC

Location of the building:

- The location of the building and its proximity to possible flooding events including surge and extreme high tides caused by sea level rise.
- **Commentary Note:** The site standards that are the most important to the continued function of the health care building are its vertical location to bodies of water, including the ocean.

Surge Damage in Mississippi Hurricane Katrina



Photos by Skip Gregory

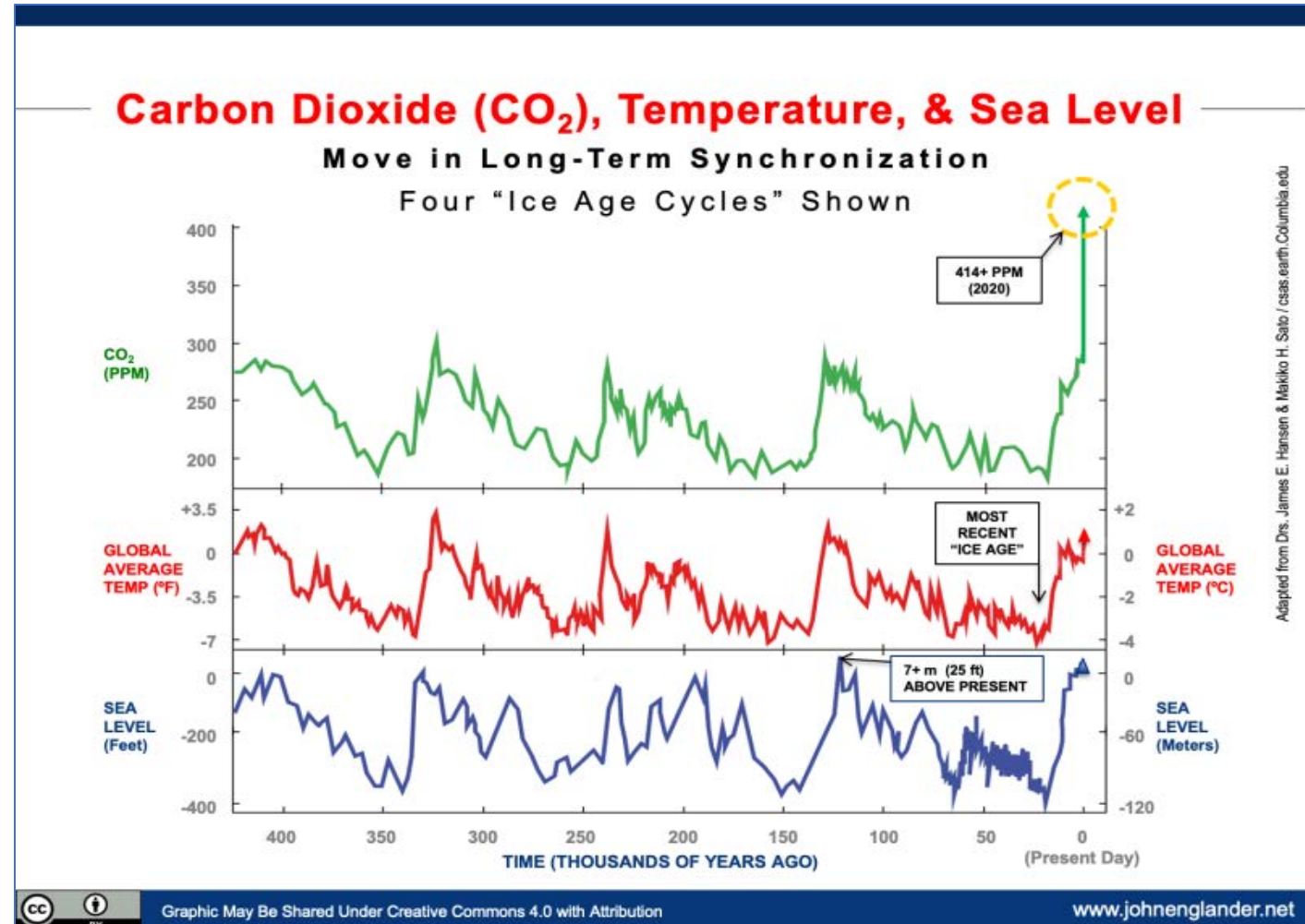
Surge Damage in Mississippi Hurricane Katrina



Photos by Skip Gregory

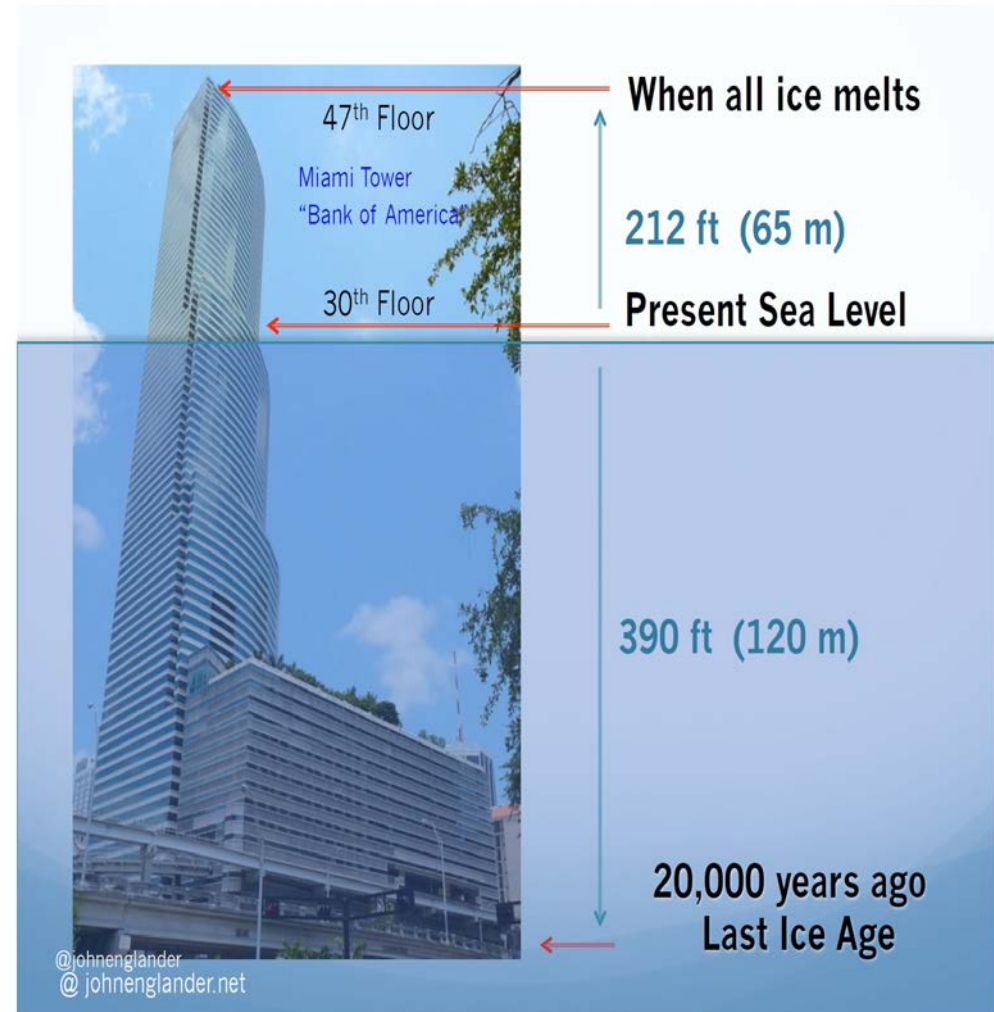
CO₂, Temperature, and SLR

- Sea level varies hundreds of feet
- Ice Ages (Milankovitch Cycle)
- Greenhouse Effect



What to Expect

- More high heat days and droughts
- Increased frequency of storms
- Record rainfall and runoff
- Accelerating sea level rise (SLR)
 - 1-2 ft. (50 cm) possible by mid-century;
 - 5-10 ft (1.5-3 m) possible this century



Sources of Global Sea Level Rise

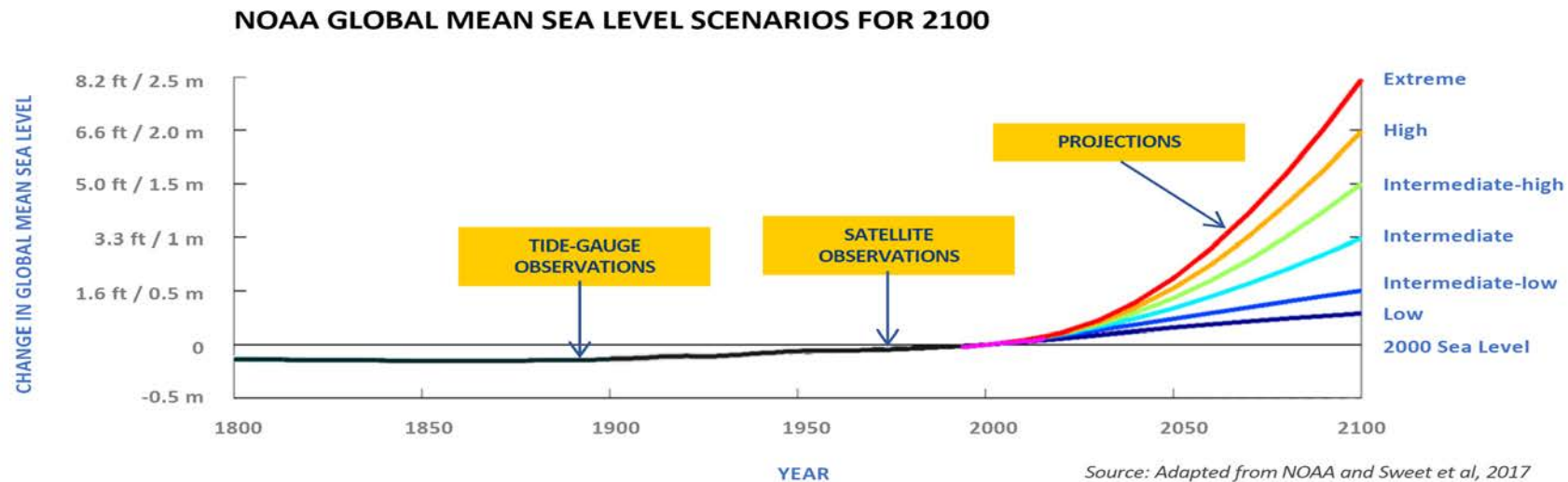
- Contributions of Greenland and Antarctica
- East vs West Antarctica
- Ice shelves
- Icebergs – NOT
- Thermal Expansion

Location of Potential Sea Level Rise	Feet	Meters	Percent
East Antarctic Ice Sheet	169	51.6	80
West Antarctic Ice Sheet	15	4.5	7
Antarctic Peninsula	2	0.5	1
Greenland Ice Sheet	24	7.3	11
All Other Glaciers	2	0.6	1
Total Potential Sea Level Rise	212	64.5	100



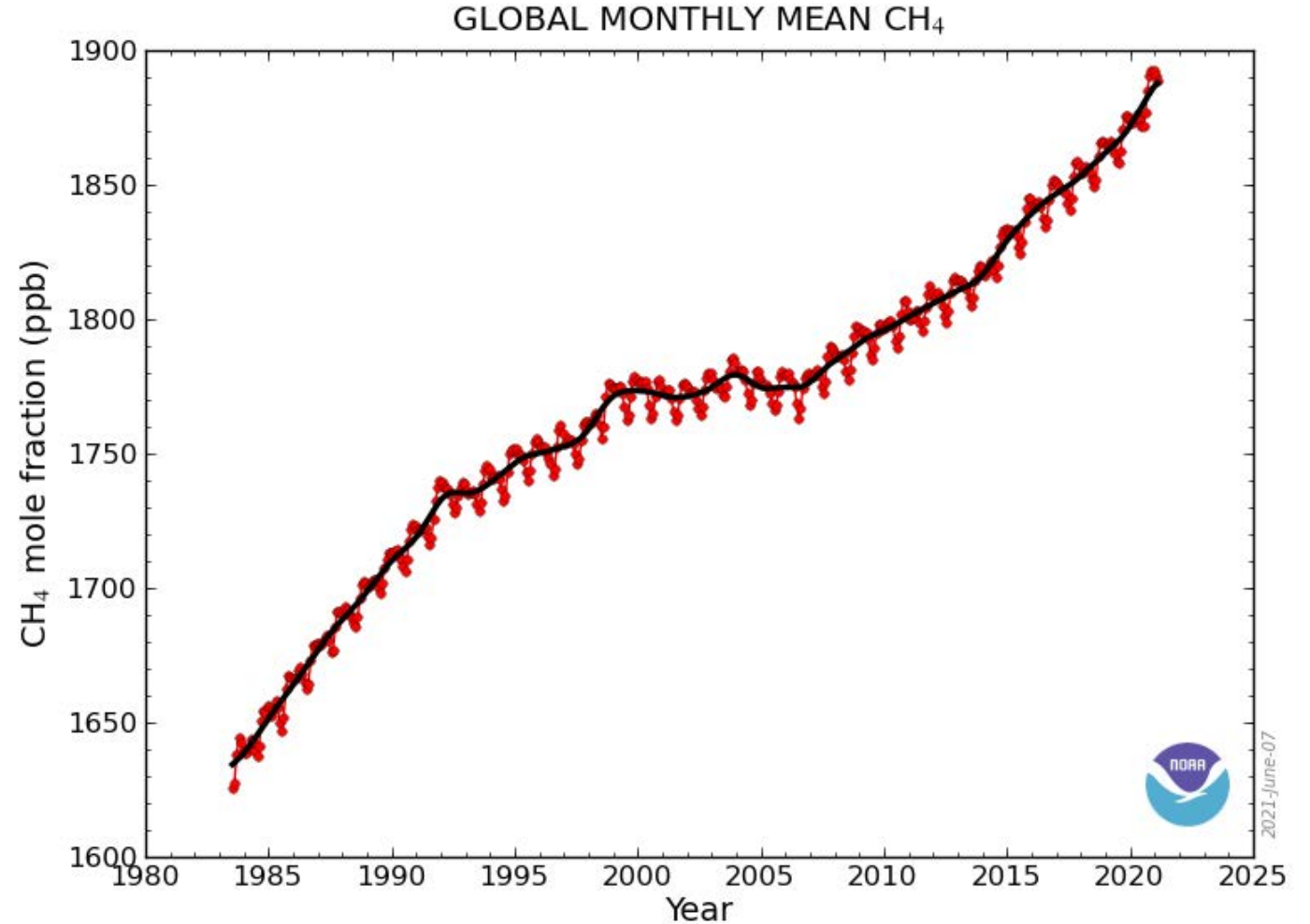
Why Projections Underestimate

- Uncertainty of future emissions
- Uncertainty of how hot it will get
- Uncertainty of how quickly the ice will melt
 - Potential for abrupt change



Tipping Points

- Arctic Ocean
- Antarctica
- Methane (CH_4): 86 times more potent than carbon dioxide (CO_2)



Local Factors to Consider

- Land subsidence / uplift
- Geologic structure, e.g.
 - porous limestone; limitations of seawalls;
 - sinkholes
- Saltwater intrusion into the water table
- Hazardous waste
- Affect of rising saltwater levels on *spalling*, etc. (e.g., possible effect condominium collapse Surfside June 2021)

Why Insurance Rates are Misleading

- Short-term vs Long-term risk
- Flood insurance premiums are not a good proxy for future flood risk
- Limitations of National Flood Insurance Program

Site Standards

Facility Location

- New Facilities:
 - Should meet the new requirements
 - Should not be constructed in vulnerable areas of the state
- Existing Facilities:
 - How to Accommodate and permit expansions
 - Is this the best thing to do?
- **Commentary Note:** There are requirements that must be met for new facilities and additions to existing facilities.

The Meaning of Important Terms and Acronyms Used in the FBC

- Hurricane Categories 1-5
- (SLOSH) Sea, Lake, and Overland Surge
- (FEMA) Federal Emergency Management Agency
- USACE United States Army Corps of Engineers
- ASCE American Society of Civil Engineers

Site Standards FBC

New Construction:

- 449/450.4.2.2.1 *Except as permitted by Section 1612 of this code, the lowest floor of all new facilities shall be elevated to the base flood elevation as defined in Section 1612 of this code, **plus 2 feet**, or to the height of hurricane Category 3 (Saffir-Simpson scale) surge inundation elevation, as described by the Sea, Lake, and Overland Surge (SLOSH) from Hurricanes model developed by the Federal Emergency Management Agency (FEMA), United States Army Corps of Engineers (USACE), and the National Weather Service (NWS), whichever is higher.*

Site Standards FBC

Existing Facilities:

- 449/450.4.2.2.2 *For all existing facilities, the lowest floor elevations of all additions, and all patient support areas including food service, and all patient support utilities, including mechanical, and electrical (except fuel storage as noted in Section 449/450.4.2.9.3 of this code) for the additions shall be at or above the elevation of the existing building, if the existing building was designed and constructed to comply with either the site standards of Section 449/450.4 of this code or local flood-resistant requirements, in effect at the time of construction, whichever requires the higher elevation, unless otherwise permitted by Section 1612 of this code.*

Site Standards FBC

Existing Facilities:

- 449/450.4.2.2.2 (Cont.) *If the existing building was constructed prior to the adoption of either the site standards of Section 449.4 of this code or local flood-resistant requirements, then the addition and all patient support areas and utilities for the addition as described in this section shall either be designed and constructed to meet the requirements of Section 449/450.4.2.2.1 of this code or be designed and constructed to meet the dry flood proofing requirements of Section 1612 of this code.*

Site Standards FBC

- Existing Facilities in Flood Areas
 - 449/450.4.2.2.3 *Substantial improvement, as defined by Section 1612 of this code, to all existing facilities located within flood areas as defined in Section 1612 of this code or within a Category 3 surge inundation zone as described in Section 449/450.4.2.2.1 of this code, shall be designed and constructed in compliance with Section 1612 of this code.*
- Commentary Note: Meeting these sections of the FBC for additions to existing health care facilities that are not sited in accordance with these requirements is complicated, difficult, expensive, and sometimes impossible.

Chapter 16

Structural Design

- Scope: Section 1601
 - GENERAL
 - *1601.1 Scope. The provisions of this chapter shall govern the structural design of buildings, structures and portions thereof regulated by this code.*
 - *Exception: Buildings and structures located within the high-velocity hurricane zone shall comply with the provisions of Sections 1605, 1607, 1611, 1616 through 1626, **and, as applicable in flood hazard areas, Section 1612.***

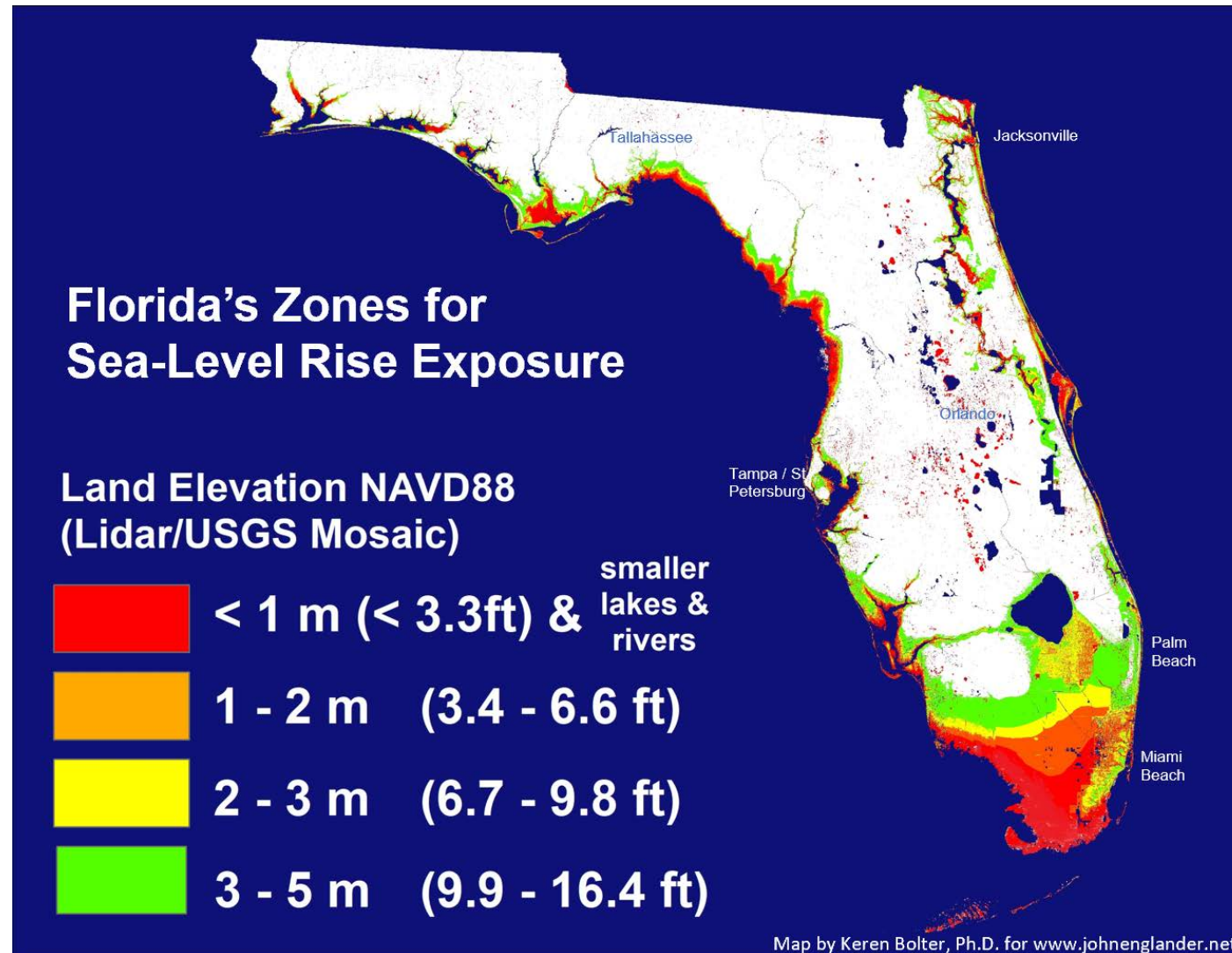
Section 1612 Flood Loads

- Section 1612.1 General.
 - *Within flood hazard areas as established in Section 1612.3, all new construction of buildings, structures and portions of buildings and structures, including substantial improvement and restoration of substantial damage to buildings and structures, shall be designed and constructed to resist the effects of flood hazards and flood loads. For buildings that are located in more than one flood hazard area, the provisions associated with the most restrictive flood hazard area shall apply.*

How to Plan for the Future

- “Tipping Points”
- Why reducing greenhouse gas emissions (“GHG”) will not stop SLR
- Elevation of property and infrastructure is as important as location.

Florida Elevation Map



How to Plan for the Future

- Need to design with a margin of safety
- Flood Factor .com and other tools
- Keeping your assets above water checklist (See Handout)
- 9 Box Matrix

9 Box Matrix sanctioned by British IMechE

“9-Box Matrix” – Planning height guidance for sea level rise, plus a margin of safety

Risk Sensitivity	30 Years*	50 Years	100 Years
Low	30 cm (1 ft)	60 cm (2 ft)	2 m (7 ft)
Medium	60 cm (2 ft)	1.3 m (4 ft)	4 m (13 ft)
High	1 m (3 ft)	2 m (7 ft)	6 m (20 ft)

* Reference year for projection = 2020, i.e., first column is approximately the year 2050

Adaptation

- Three options for resilience:
 1. Elevate
 - Facilities
 - Utilities
 - Access roads
 2. Isolate
 - Fixed and deployable barriers
 3. Relocate
- Adaptive engineering

Mitigation Strategies to Meet the FBC

Examples of Mitigations:

- Water Filled Cofferdams
- Dry Flood Proofing
- Elevation of the addition
- Elevation of new hospital
- Elevation of non-essential elements of healthcare facility
- Dynamic flood protection

Water Filled Barriers – an example

Hydrological Solutions, Inc.

EZ Roller System

800/245-0199

www.hydrologicalsolutions.com

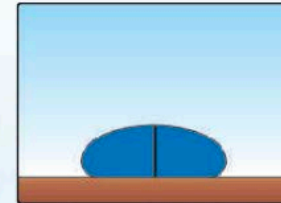


EASY TO STORE

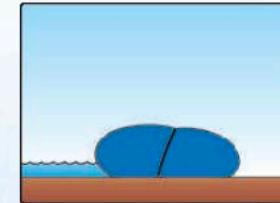


QUICK TO USE

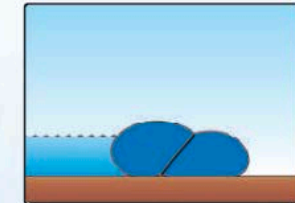
The Patented Baffle Makes the Difference



System prior to flooding.

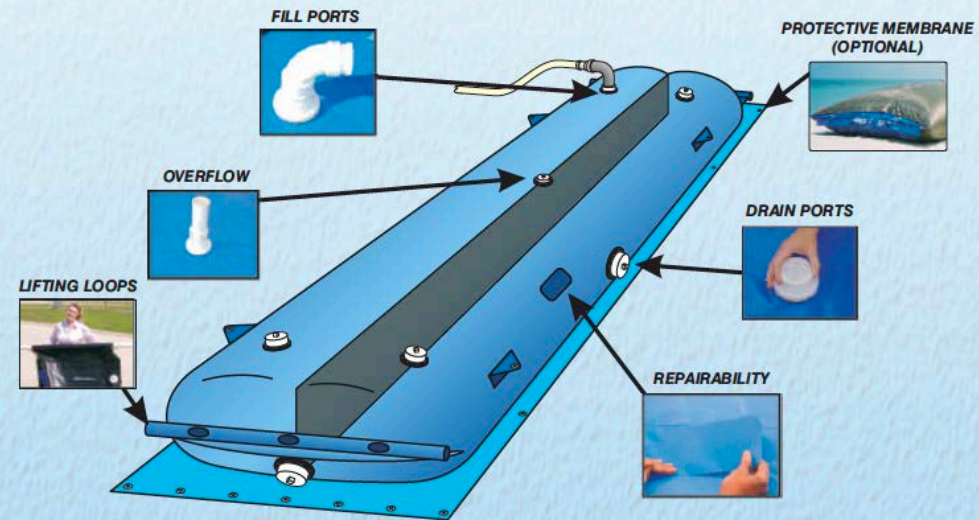


Baffle shifts to stabilize the unit.



Protected site. Baffle has stabilized.

Unique Accessories Make Installation A Snap



Fill port with adapter: Each unit will contain the appropriate number of female threaded fill ports and

Lifting loop: End loops are available and act as an aid in the installation and removal process.

Emergency Department Addition



Tampa General Hospital
Davis Island
Tampa, Florida



Hospital Located in Naples Florida



All Patient Care and Support
Areas are Elevated

ICU 1 – ICU 10	3
301 - 340	3
PRE-ADMIT TEST	3
ADMINISTRATION	2
SURGICAL SERVICES	2
CAFETERIA	2
RESTROOMS	←

Examples of elevated utilities and masonry flood barrier



Photos from FEMA publication 557

Future Florida Building Code Revisions

- Possible Revisions to the 8th edition of the FBC
 - Raising the surge inundation levels to meet hurricane Category 5 levels instead of Category 3 levels
 - Revising the length of being self sufficient from 72 hours to 96 hours
 - Including more facility types like Assisted Living Facilities, SRTs, ICF/DDs, CSUs, and other such health care facilities that are occupied 24/7
 - Further limiting types of roofing
 - Planning for future sea level rise for all new health care facilities

Roof Damage of Mechanically Fastened Roofing



Photos by Skip Gregory

The Challenge for Architects and Engineers

- Risks
- Responsibility
- Opportunity
 - Better designs
 - Mitigation
 - Better Return on Investment (ROI)

Closing Thoughts and Questions

- The “new normal”
- Why health care facilities should set the example for communities
- Separating normal weather, extreme events, and rising sea level
- Value of short, medium, and long-range planning
- “Adaptation” is different than sustainable, resilient, and “green”