Researching Resiliency

Presented by the AIA Residential Knowledge Community

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THE AMERICAN INSTITUTE OF ARCHITECTS

Future Programs

September 12 - Research in Practice

September 26 - Greening Housing Research

October 10 - Researching Resiliency

October 24 - Affordable Housing Research

November 7 - Healthy Homes Research

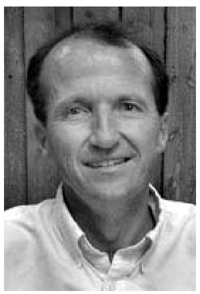
All AIA webinars: http://network.aia.org/events/webinars/

Researching Resiliency

Submit a question to the moderator via the "chat" box. They will be answered as time allows.

Moderator

Kathleen Dorgan, AIA, LEED-AP
Principal, Dorgan Architecture & Planning
dorgan@kdorgan.net



Speaker

Stephen Schreiber, FAIA
Professor and Program Director in Architecture + Design
University of Massachusetts at Amherst
schreiber@art.umass.edu

Speaker

David Perkes, AIA
Associate Professor for Mississippi State University
dperkes@gccds.msstate.edu

Copyright Materials

Course Description

This is the third in a series of FREE web seminars sponsored by the AIA Residential Knowledge Community that will explore the ways that architects use research to enhance the health, safety, social, economic and environmental performance of buildings as well as the experiences of housing residents.

Experts in research on resilient building practices will explore their research on design and strategies that mitigate the impact of natural disasters. Stephen Schreiber, FAIA will discuss, "Mitigating the effects of hurricanes on marginal housing in Florida", which will focus on the effects of wind and flooding on mobile home parks in south Florida, with a particular emphasis on the design of manufactured housing and communities. David Perkes, AIA will discuss his research on the response of various building systems to infiltration during flood events.

Learning Objectives

1. Participants will learn to identify various types and methods of research applicable to resilient building design.
2. Participants will learn about current trends in evidence-based design for natural disaster mitigation.
3. Participants will gain an understanding of various strategies for applying research on resilient design to their own practices.
4. Participants will gain an understanding of the limits of and gaps in research that's being conducted in the field and in the academy.

Speaker: Stephen Schreiber, FAIA

Professor and Program Director
in Architecture + Design

University of Massachusetts at Amherst

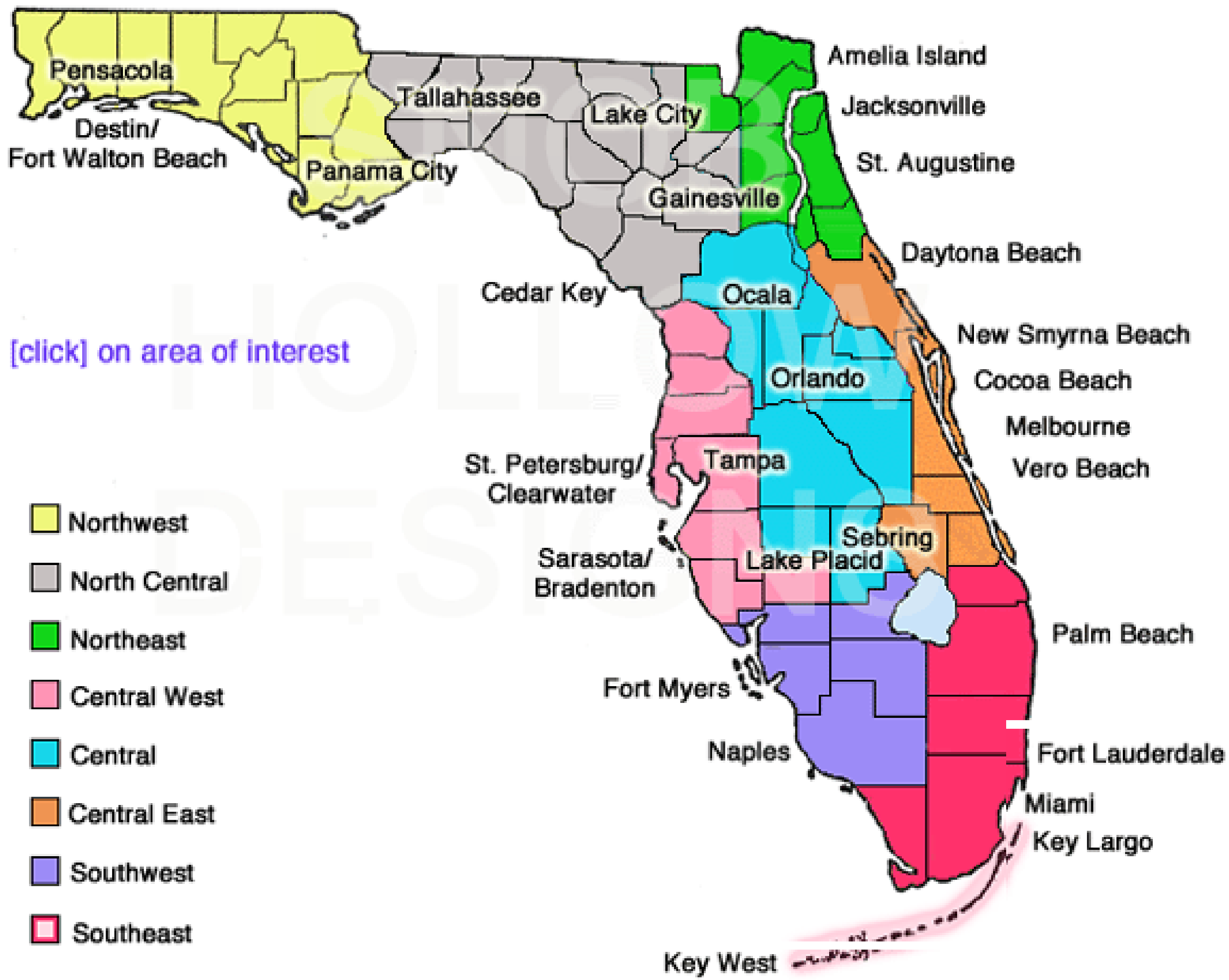
schreiber@art.umass.edu

Stephen Schreiber, FAIA
Professor, UMass Amherst

Hurricane Loss Mitigation Project--Florida

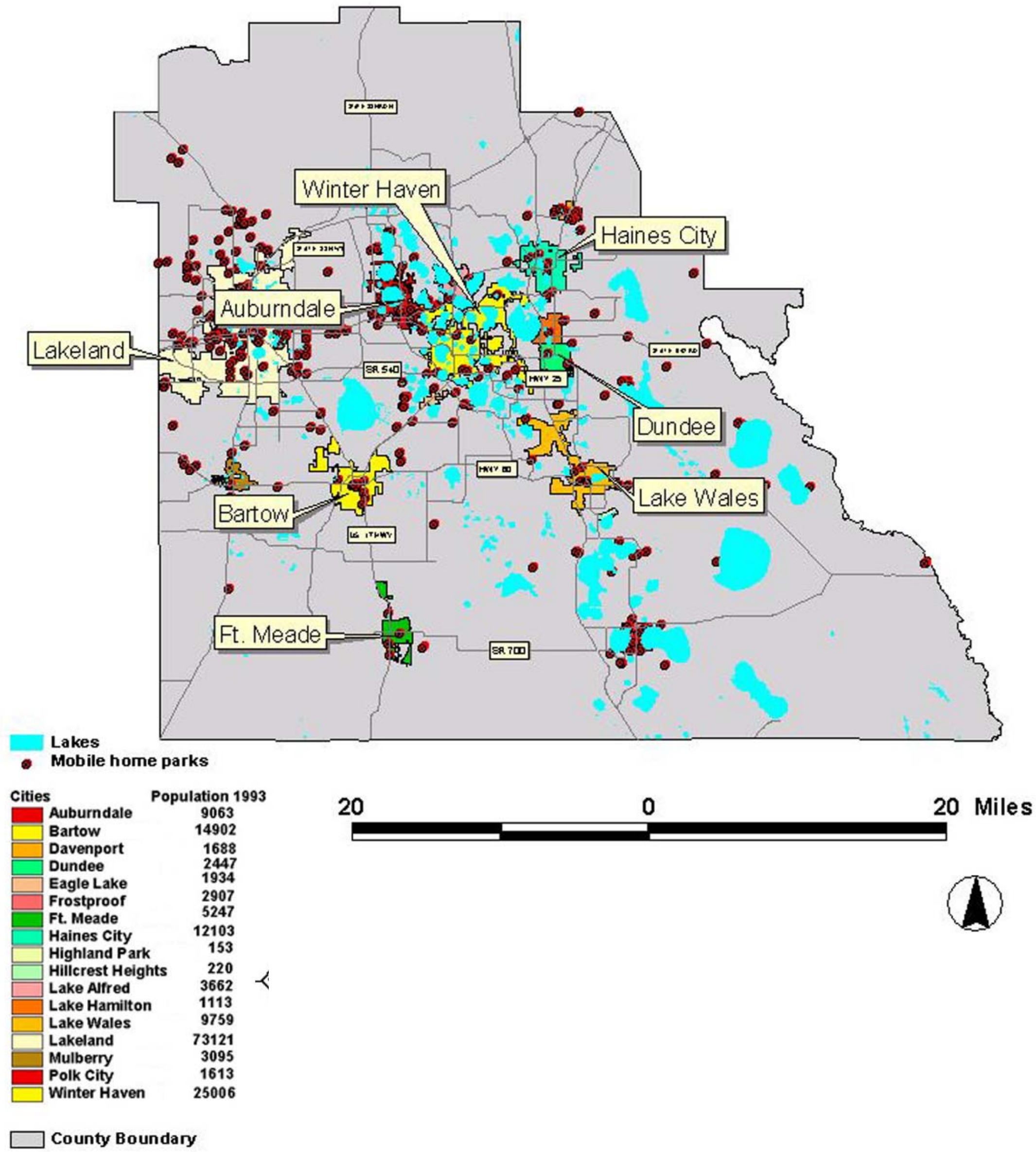
<u>Major Research Areas:</u>

1. **Obstacles to upgrading mobile home and communities**
2. **Case-studies of mobile home parks that are closing**
3. **Best practices in hurricane resistant construction**


Pensacola
Destin/
Fort Walton Beach
Tallahassee
Panama City
Lake City
Gainesville
Amelia Island
Jacksonville
St. Augustine
Daytona Beach
Cedar Key
Ocala
New Smyrna Beach
Orlando
Cocoa Beach
Melbourne
Vero Beach
St. Petersburg/
Clearwater
Tampa
Sarasota/
Bradenton
Sebring
Lake Placid
Palm Beach
Fort Myers
Naples
Fort Lauderdale
Miami
Key Largo
Key West
[click] on area of interest
Northwest
North Central
Northeast
Central West
Central
Central East
Southwest
Southeast

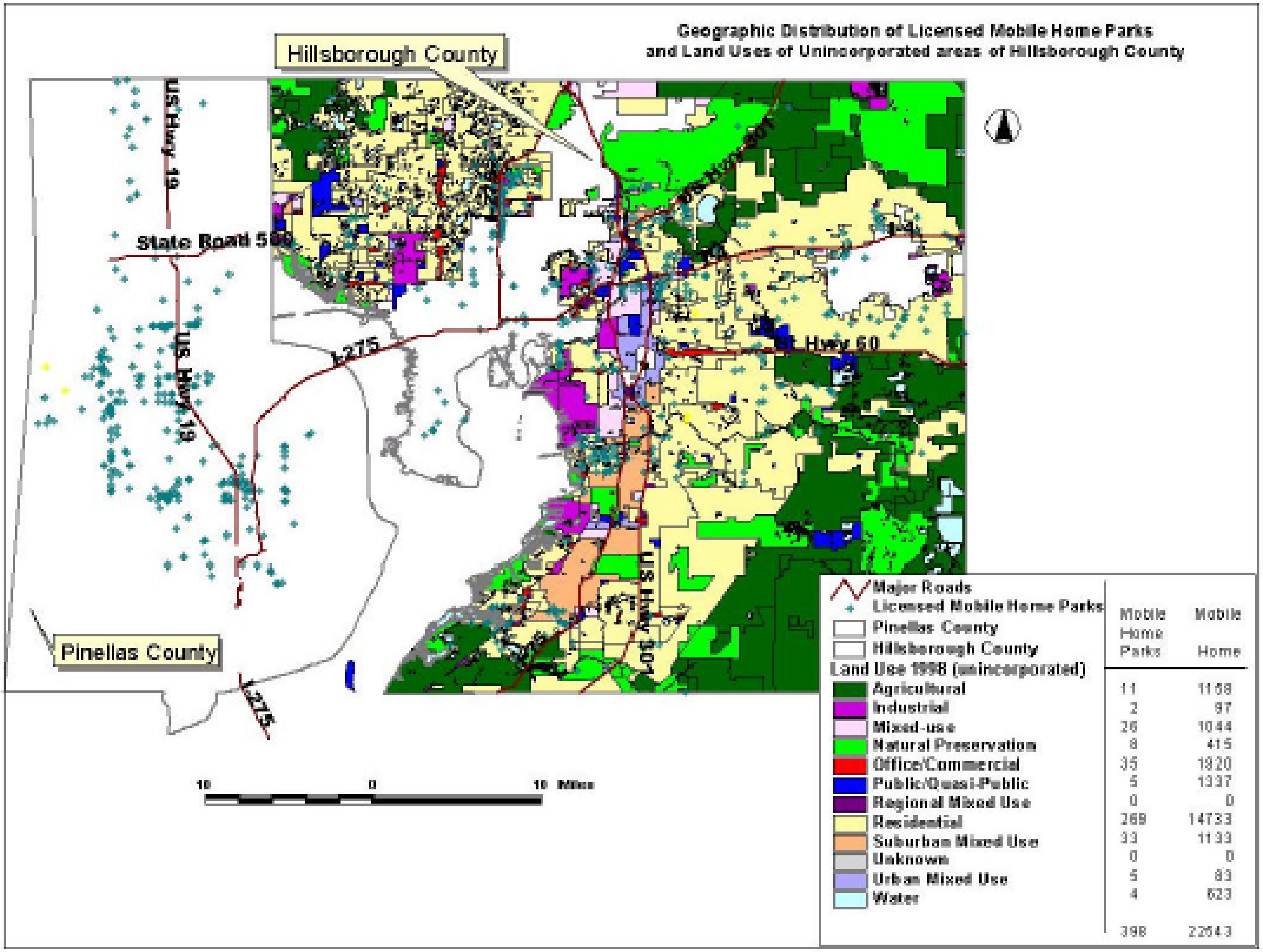
POLK COUNTY MOBILE HOME PARKS		
24 cities	MOBILE HOME PARKS	MOBILE HOME SPACES
TOTAL	502	45,810

Geographic distribution of Licensed Mobile Home Parks and Cities in Polk County

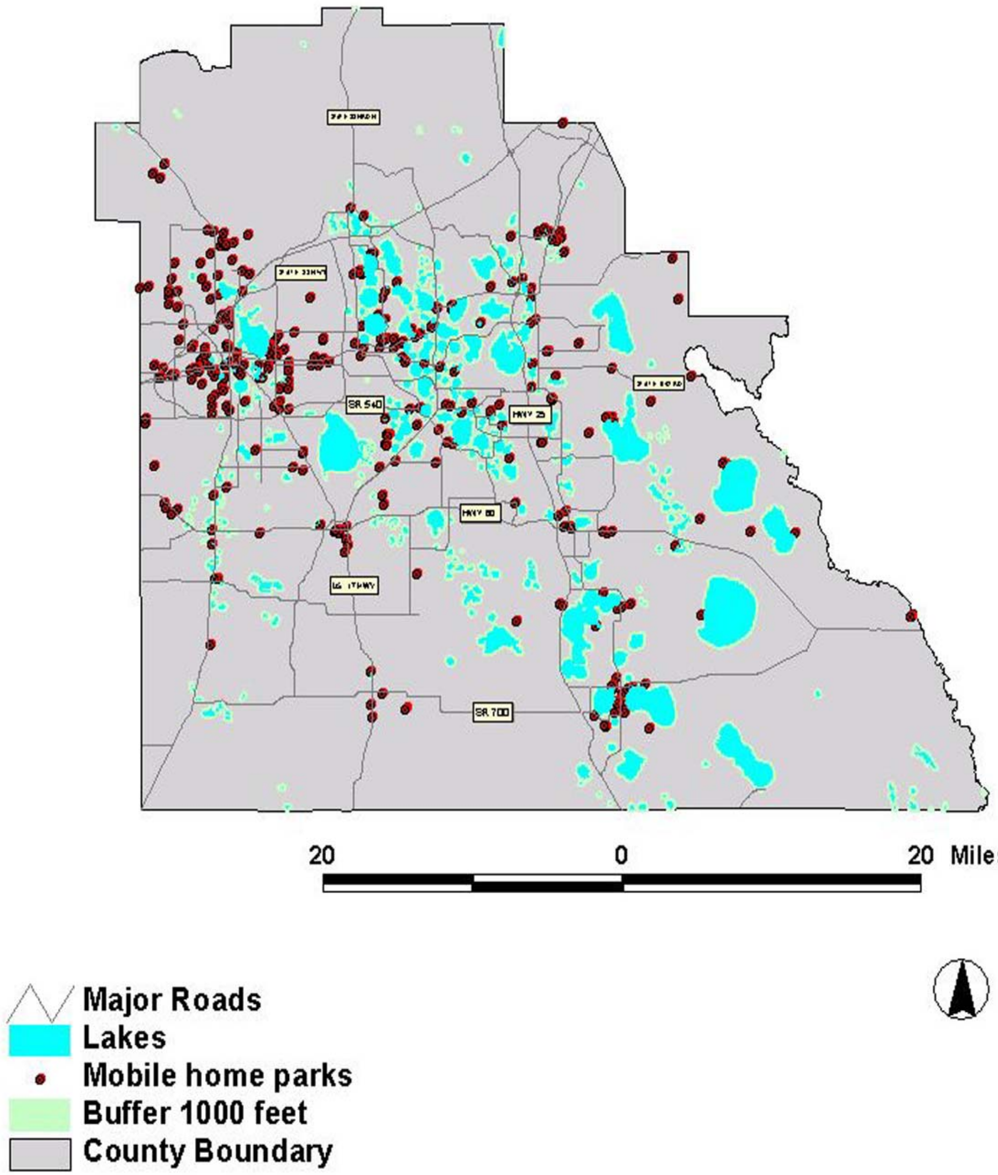


PINELLAS COUNTY MOBILE HOME PARKS		
18 cities	MOBILE HOME PARKS	MOBILE HOME SPACES
TOTALS	**342**	**43630**

HILLSBOROUGH COUNTY MOBILE HOME		
4 cities	MOBILE HOME PARKS	MOBILE HOME SPACES
TOTALS	**579**	**32,448**

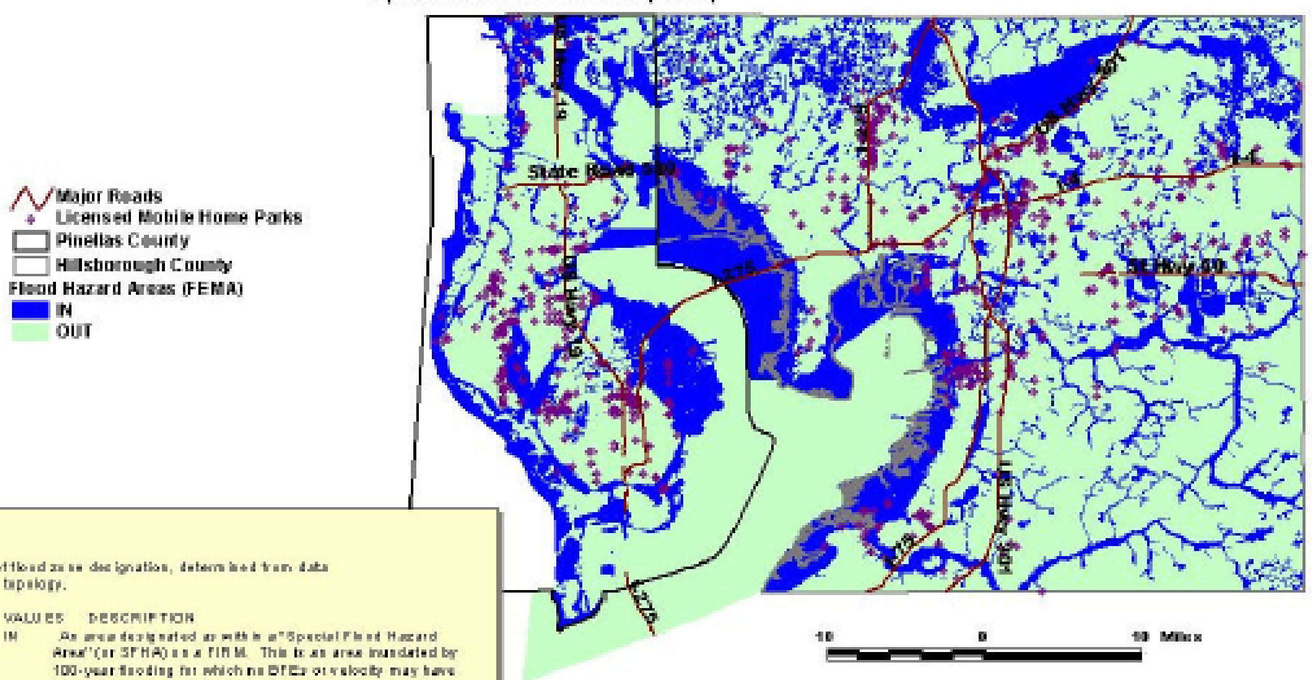

Geographic Distribution of Licensed Mobile Home Parks
and Land Uses of Unincorporated areas of Hillsborough County
Hillsborough County
Pinellas County
US Hwy 19
State Road 580
I-275
US Hwy 301
US Hwy 60
10 0 10 Miles
Major Roads
Licensed Mobile Home Parks
Pinellas County
Hillsborough County
Land Use 1998 (unincorporated)
Mobile Home Parks
Mobile Home
Agricultural 11 1168
Industrial 2 97
Mixed-use 26 1044
Natural Preservation 8 415
Office/Commercial 35 1920
Public/Quasi-Public 5 1337
Regional Mixed Use 0 0
Residential 269 14733
Suburban Mixed Use 33 1133
Unknown 0 0
Urban Mixed Use 5 83
Water 4 623
398 22643

Number of Licensed Mobile Home Parks within a 1000 feet of lakes 109 out of a total of 503 in Polk County



Zoom In Tool (Z)

Geographic Distribution of Licensed Mobile Home Parks
and
Special Flood Hazard Areas (FEMA)



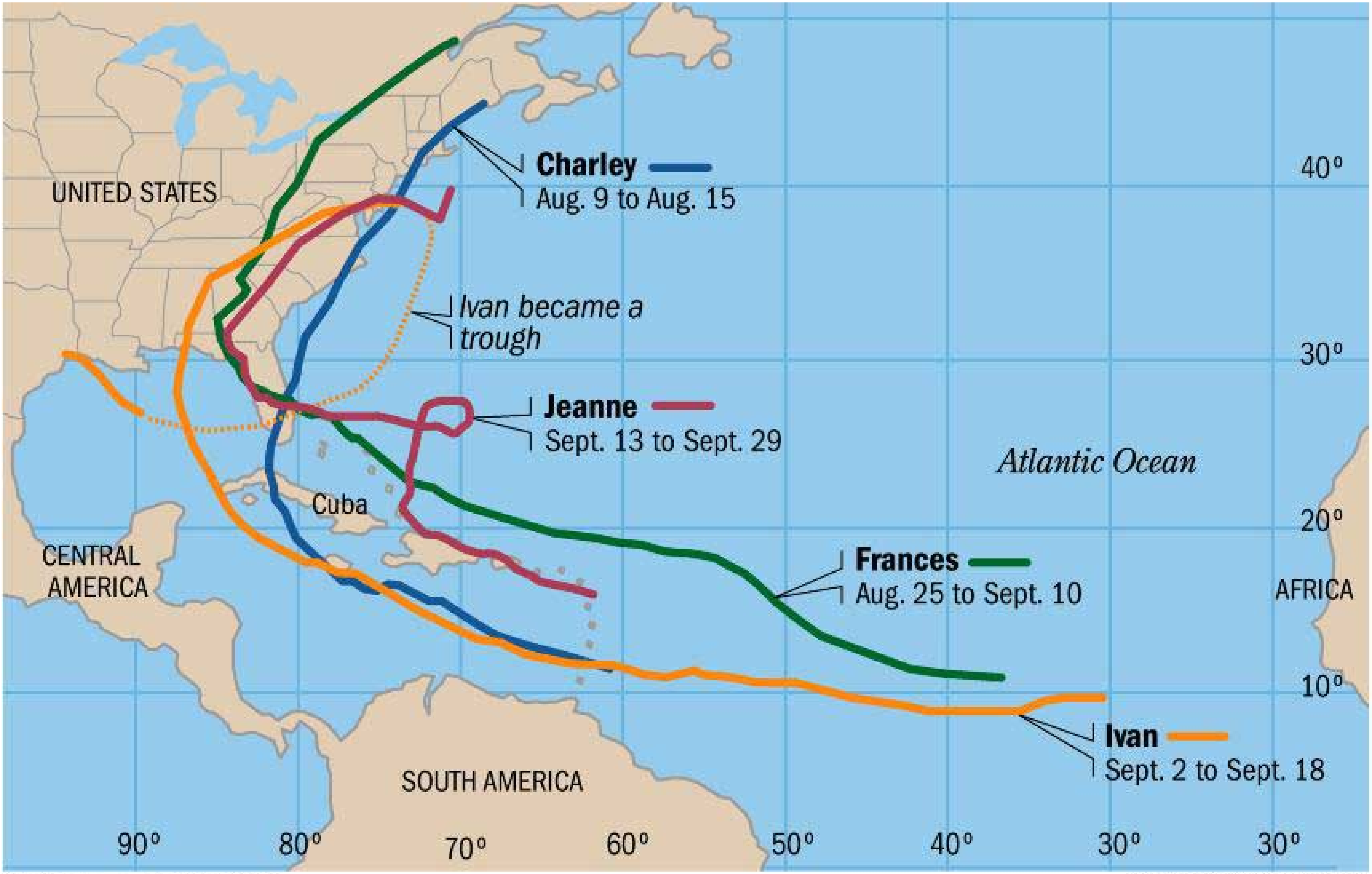
In/Out of flood zone designation, determined from data topology.

VALUES	DESCRIPTION
IN	An area designated as within a "Special Flood Hazard Area" (or SFHA) on a FIRM. This is an area inundated by 100-year flooding for which no BFEs or velocity may have been determined. No distinctions are made between the different flood hazard zones that may be included within the SFHA. These may include Zones A, AE, AO, AH, A99, AR, V, or VE.
OUT	An area designated as outside a "Special Flood Hazard Area" (or SFHA) on a FIRM. This is an area inundated by 500-year flooding; an area inundated by 100-year flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; an area protected by levees from 100-year flooding; or an area that is determined to be outside the 100- and 500-year flood plains. No distinctions are made between these different conditions. These may include both shaded and unshaded areas of Zone X.

SFHA

	Mobile Home Parks	Mobile Homes
IN	123	12141
OUT	515	50170

MAJOR STORM EVENTS AFFECTING POLK COUNTY: 1994-2003		
Storm Type	**Number of Events**	**Reported Mobile Homes Damaged**
Flood	25	6
Hurricane/ Trop. Storm	13	4
Tornado	34	290
Thunderstorm High Winds	128	140
TOTALS	200 events	At least 440 mobile homes

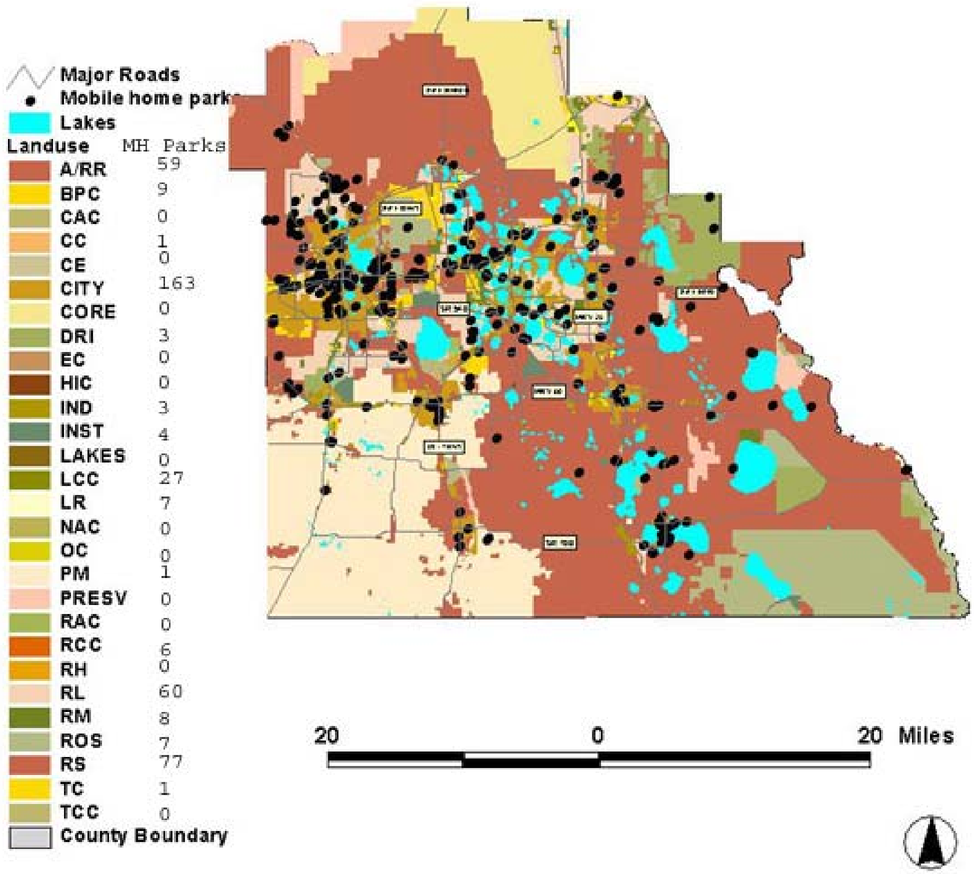


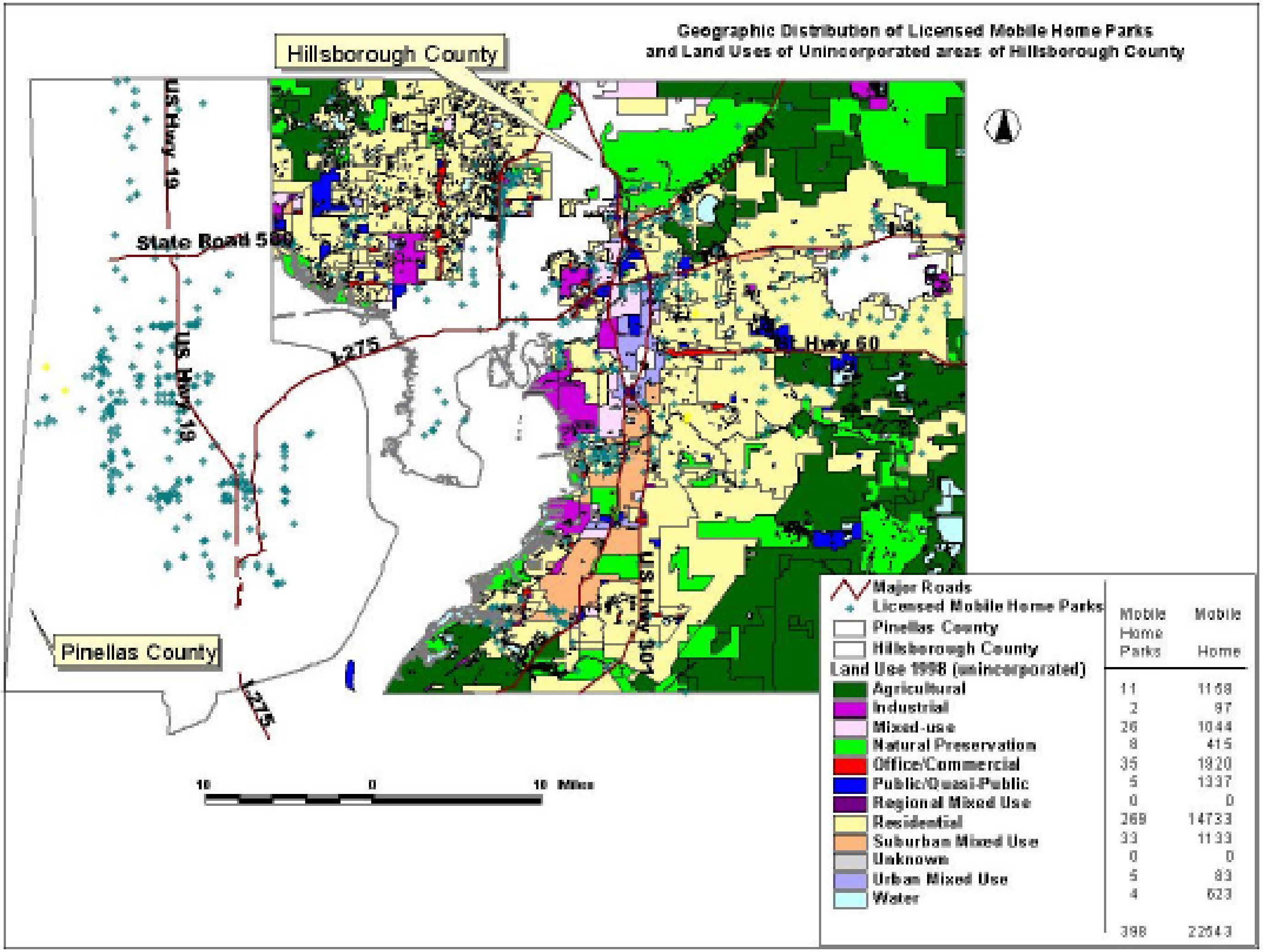
Source: www.wunderground.com

MARK HEMPHILL/Staff Artist

MAJOR STORM EVENTS AFFECTING POLK COUNTY: 2004		
Storm Type	**Number of Events**	**Reported Mobile Homes Damaged**
Hurricane/ Trop. Storm	4	3,110

Geographic distribution of Licensed Mobile Home Parks and Landuses in Polk County

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Licensed Mobile Home Parks
Pinellas County
Hillsborough County
Land Use 1998 (unincorporated)
Mobile Home Parks
Mobile Home
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Industrial 2 97
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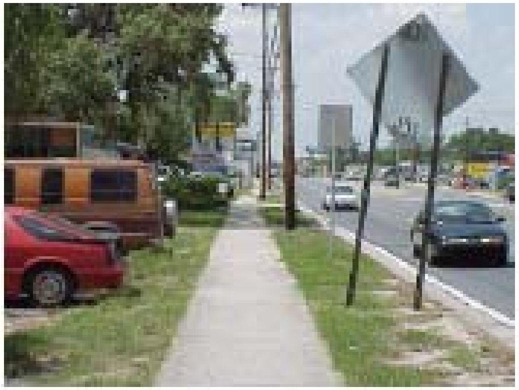
Public/Quasi-Public 5 1337
Regional Mixed Use 0 0
Residential 269 14733
Suburban Mixed Use 33 1133
Unknown 0 0
Urban Mixed Use 5 83
Water 4 623
398 22643

PROPOSED CLOSURES—Hillsborough				
Name	**MH spaces**	**Proposed Use**	**Currently Public or Private**	**Comments**
Bay Breeze	15	Residential	Private	Developing area—all RV spaces
Westshore	105	Residential	Private	Developing area
Affected spaces=120				
IN PROCESS OF CLOSING—PINELLAS, HILLSBOROUGH, LEE				
Name	**MH spaces**	**Proposed Use**	**Currently Public or Private**	**Comments**
Kapok	236	Retention pond	Public	Pinellas—Full report in this document
Oakwood	75		Private	Hillsborough
Bamboo	89	Residential/ Commercial	Public	Lee-- Community Redevelopment incentives
Palace	91	Commercial	Private	Pinellas

CLOSED—PINELLAS			
Name	**MH spaces**	**New Use**	**Public or Private**
Lake Seminole	50	Commercial	Private
Silvercrest	100	Commercial	Private
Largo Village	25	Retention pond	Public
Pine Grove	16	Park	Public
Snug Harbor	100	Residential	Private

CLOSED—HILLSBOROUGH			
Name	**MH spaces**	**New Use**	**Public or Private**
Sunnydale	200	Residential	Private
Drew Park/ Evans Park	200	Airport expansion	Public
TOTAL AFFECTED SPACES=2600 approx			

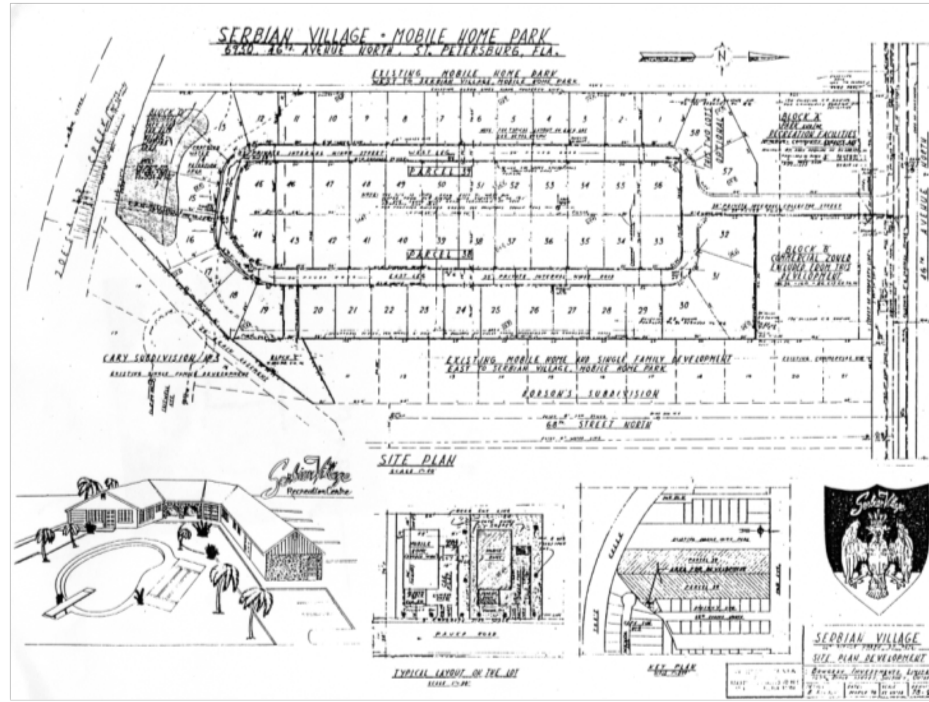
Wuizer MHP: Dilapidated deck and roof

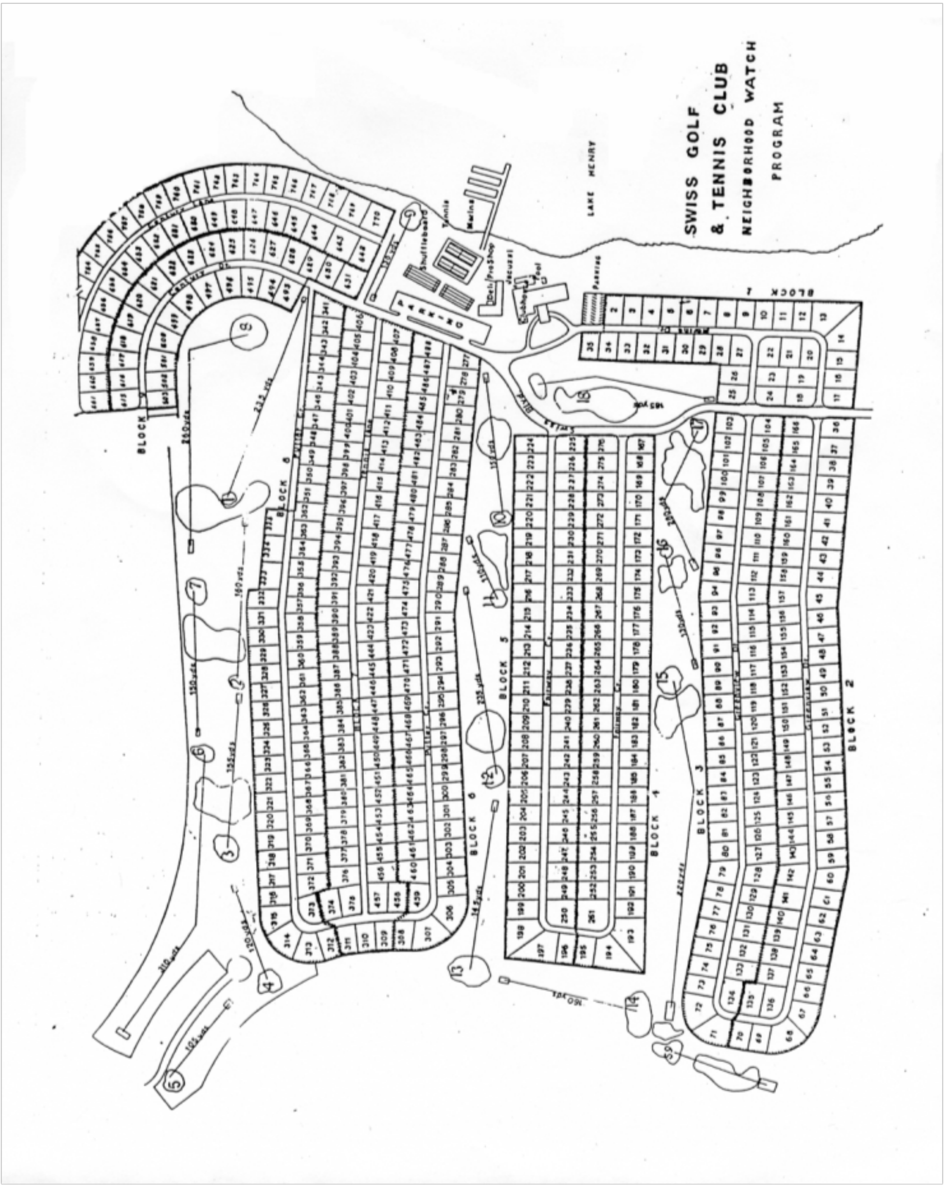


Wuizer MHP: Context – Nebraska Avenue


214

Plantation Oaks
Clubhouse site plan




SWISS GOLF
& TENNIS CLUB
NEIGHBORHOOD WATCH
PROGRAM
LAKE HENRY
Tennis
Marina
Shuffleboard
Pool
Parking
BLOCK 1
BLOCK 2
BLOCK 3
BLOCK 4
BLOCK 5
BLOCK 6

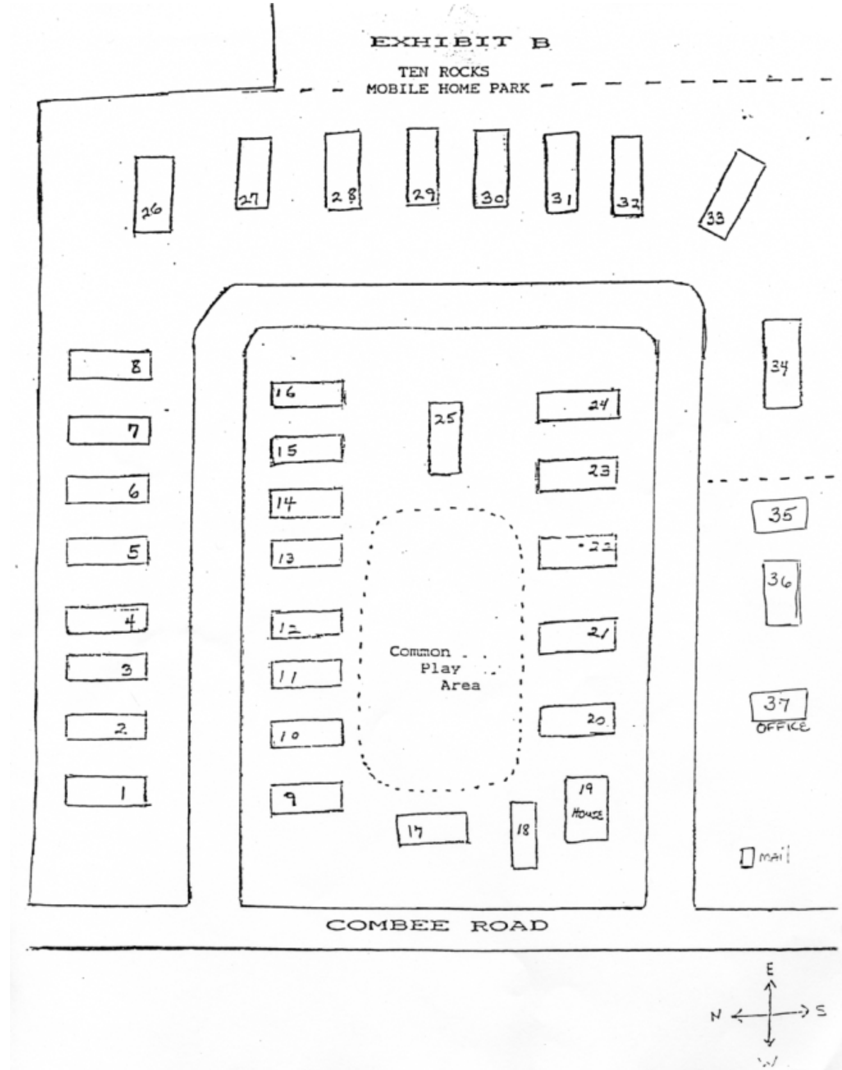
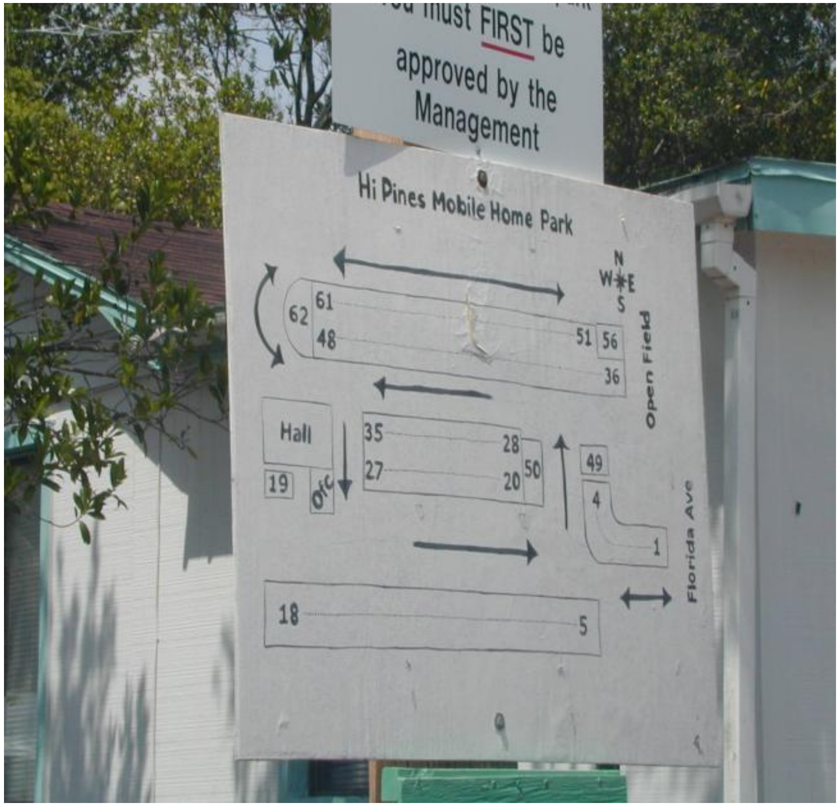
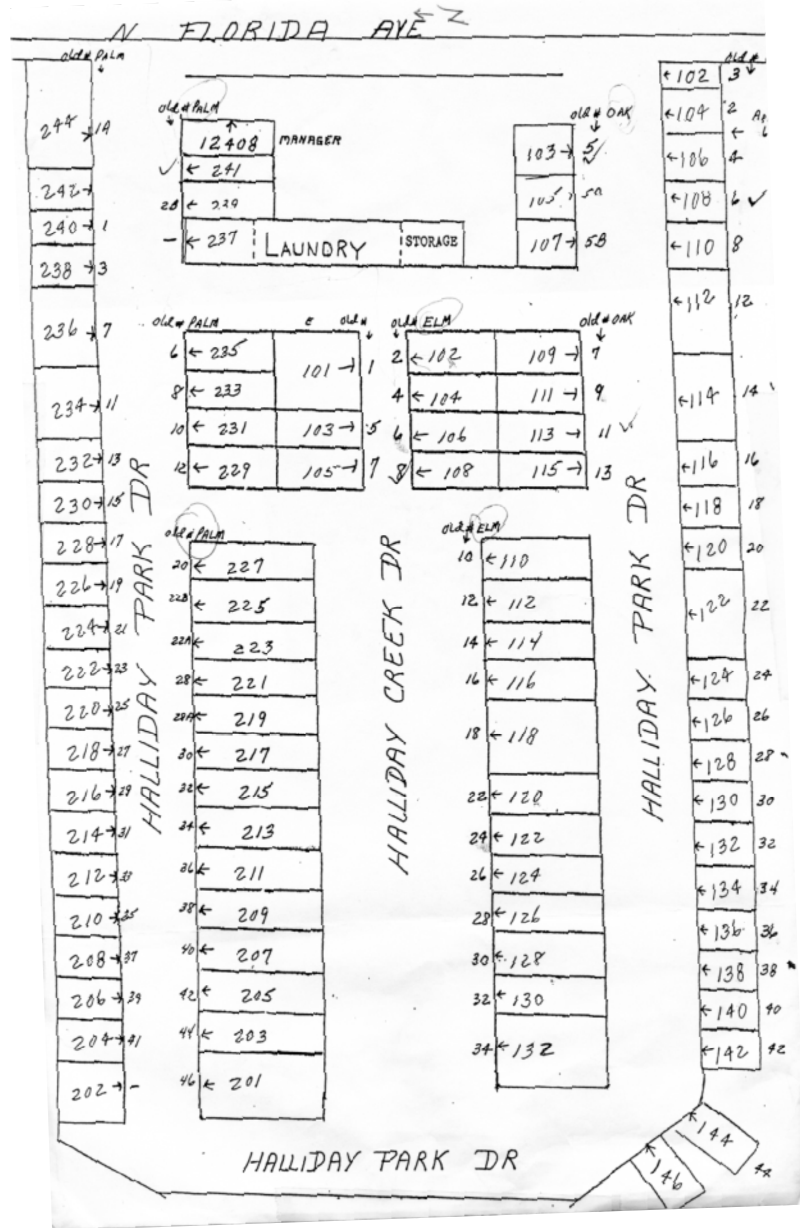
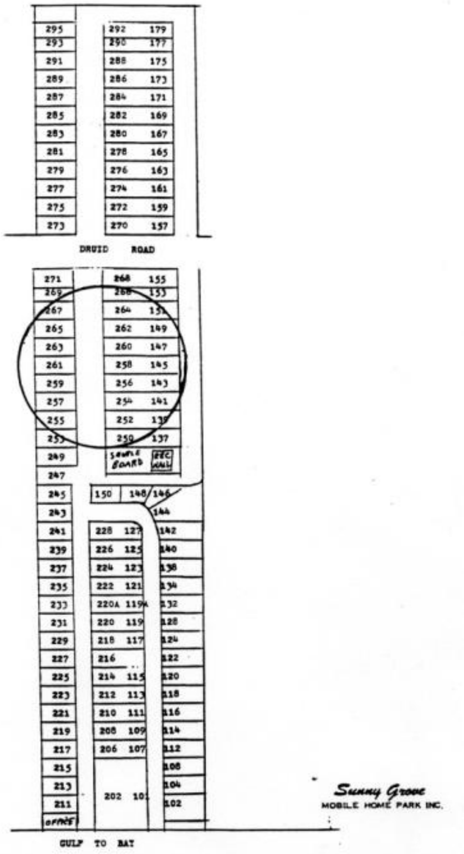
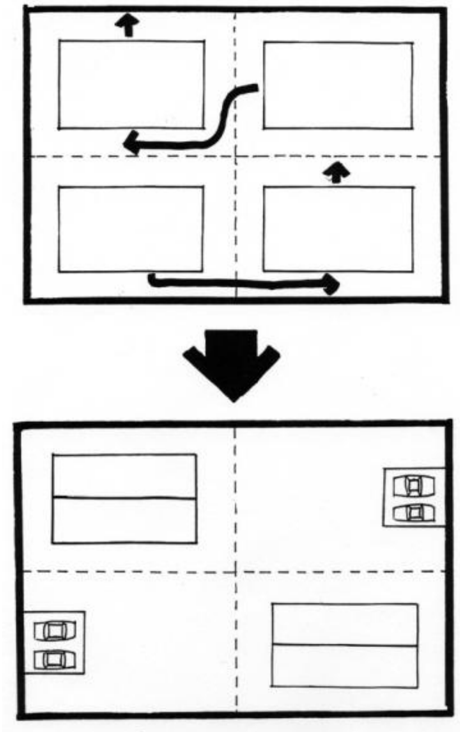


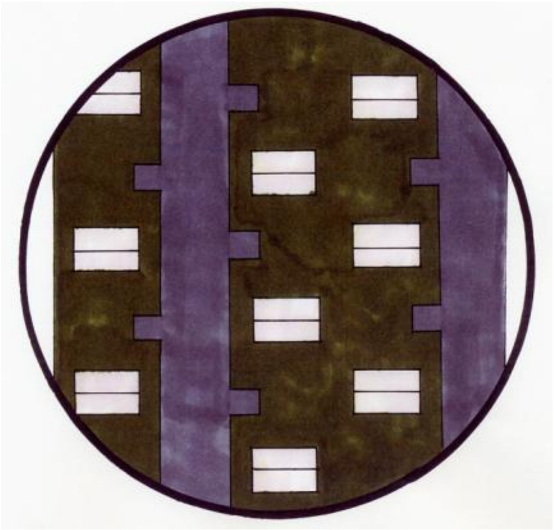
EXHIBIT B
TEN ROCKS
MOBILE HOME PARK
Common
Play
Area
19
House
37
OFFICE
mail
COMBEE ROAD
E
N
S
W


FIRST be
approved by the
Management
Hi Pines Mobile Home Park
Hall
Ofc
Open Field
Florida Ave

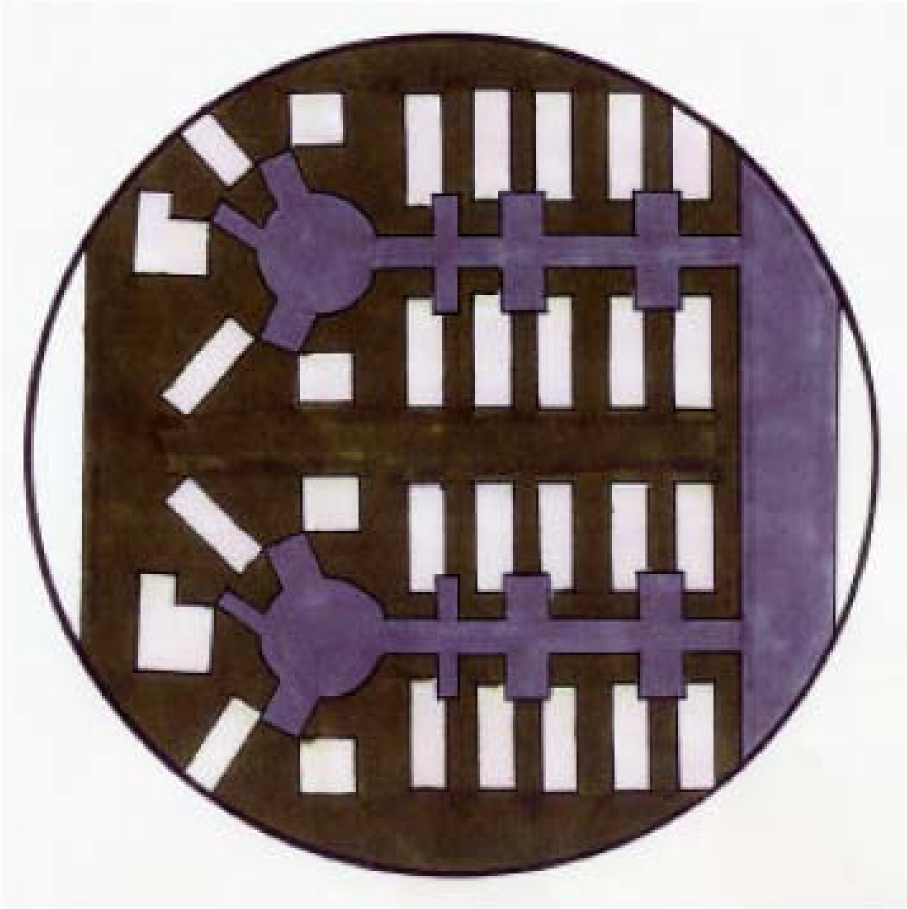

N FLORIDA AVE
MANAGER
LAUNDRY
STORAGE
HALLIDAY PARK DR
HALLIDAY CREEK DR
HALLIDAY PARK DR
HALLIDAY PARK DR







Option 1—Reconfigure with double wide duplexes



Option 1—Replace with permanent structures on same plats

Mobile Home Park layout

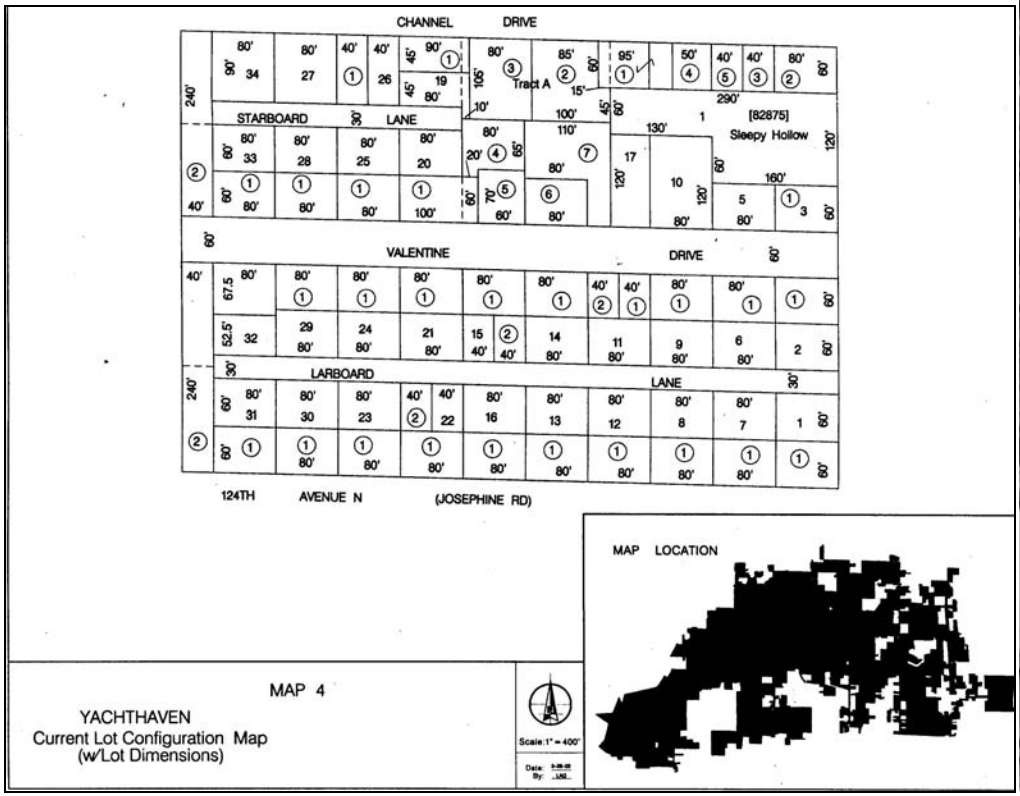
Does not have a direct physical impact on storm survivability, but layouts can affect the sense of community.

- The research team suggests that strong community pride is directly related to safer neighborhoods with greater potential for successfully surviving major traumas such as hurricane and other storm events.

- Additionally, alternate park layouts may allow for increasing densities that would promote the economic viability of the manufactured home parks as businesses and thereby continue to provide a stable housing alternative.

Yachthaven Estates community area was developed in unincorporated Pinellas County in the 1950s annexed into Largo in 1966 by referendum.

Total of **73 mobile home lots.**



PROBLEMS

[A home owner] discovered, at the worst possible time, that she and the other residents in the Yachthaven Estates mobile home community are stuck in a web of city, state and federal regulations, unable to replace their homes even if they are damaged or destroyed by hazards.

- They can't replace them with mobile homes because their community is in a flood zone and coastal high hazard area.
- So when their old,1950s-era, mobile homes deteriorate to the point of needing replacement the only option is to build houses on site.
- But other laws require site-built houses have to be on minimum lots of 5,808 square feet.
- Almost all the lots in Yachthaven are smaller than that. Some are half that size.
- Factor in required city setbacks of up to 20 feet, and that doesn't leave room for much of a house, even if a house were allowed.

SOLUTION

City Commission of Largo approved a neighborhood plan that made all the lots legal, creating an exception to city codes.

- Mobile homes are still not being allowed, but modular, wood, masonry or any other construction that meets Florida Building Codes is approved. The plan also would reduce the required front setback from 20 feet to 10 feet.

- The smaller lots (e.g., 40 ft. x 60 ft. and 45 ft. x 90 ft.) are allowed to redevelop in one of three ways:

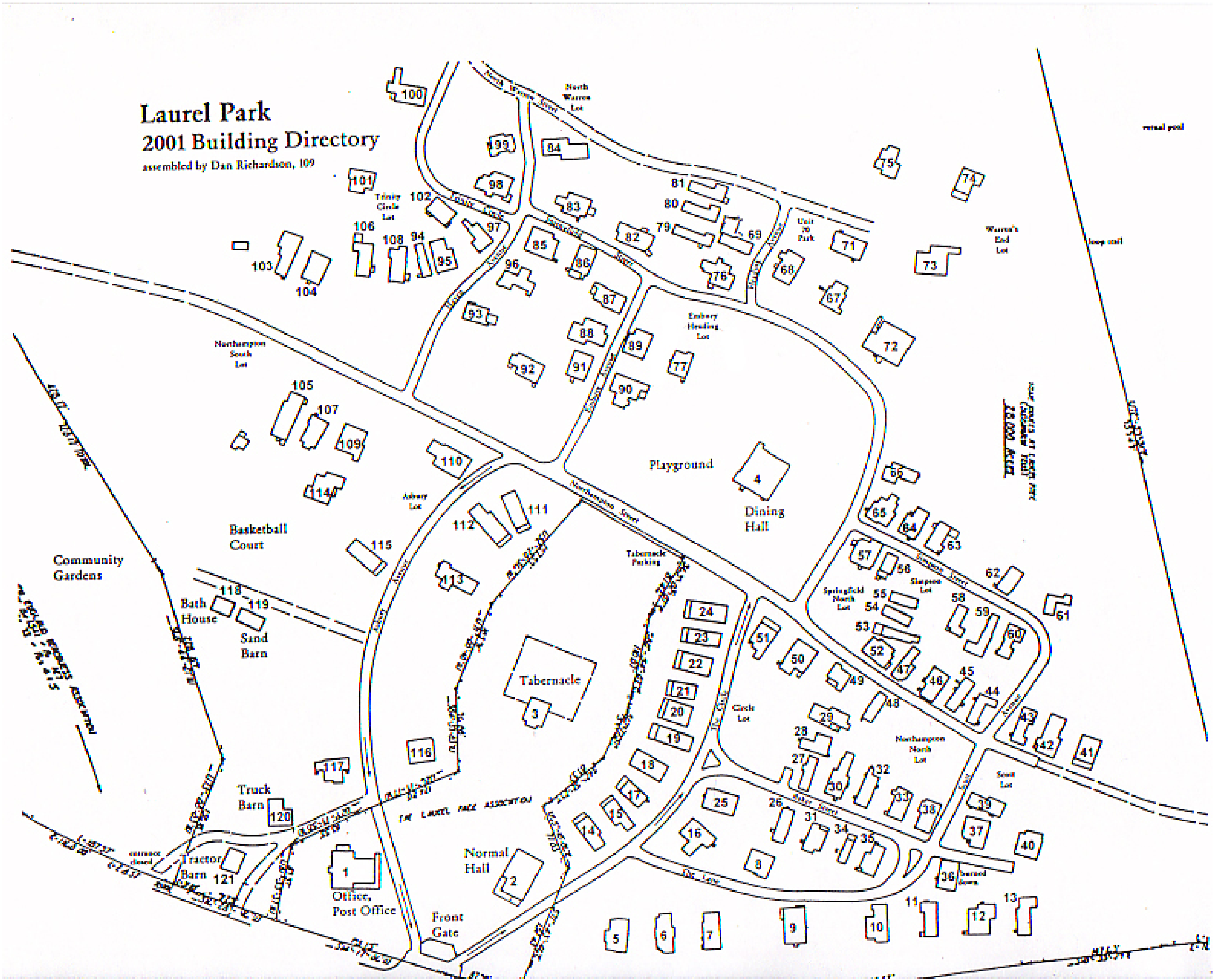
    - Individually as single-family residences following the same standards applied to the other lots;

    - "Together" as two single-family attached (zero lot line) residences with a single-family appearance. Each unit must be maintained on as a separately deeded parcel capable of being independently owned and sold;

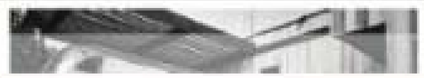
    - Be combined into one lot (without requiring replat), allowing them to be returned to the same size as the other surrounding lots.


Valentine Dr
Valentine Dr
Valentine Dr
143rd St
Larboard Ln
Larboard Ln
Larboard Ln
Larboard Ln

CASE STUDY—
Laurel Park, Northampton, Massachusetts
Former Methodist camp



COTTAGE HOUSING DEVELOPMENT--WASHINGTON



Without a Hitch—New Directions in Prefabricated Architecture

2008 Northeast Fall Conference of the
Association of Collegiate Schools of Architecture
September 25-27, 2008

University of Massachusetts, Amherst

Peggi Clouston, P.Eng., M.A.Sc., Ph.D.
Ray Kinoshita Mann, AIA
Stephen Schreiber, FAIA

Without a Hitch—New Directions in Prefabricated Architecture

Speaker: David Perkes, AIA

Associate Professor

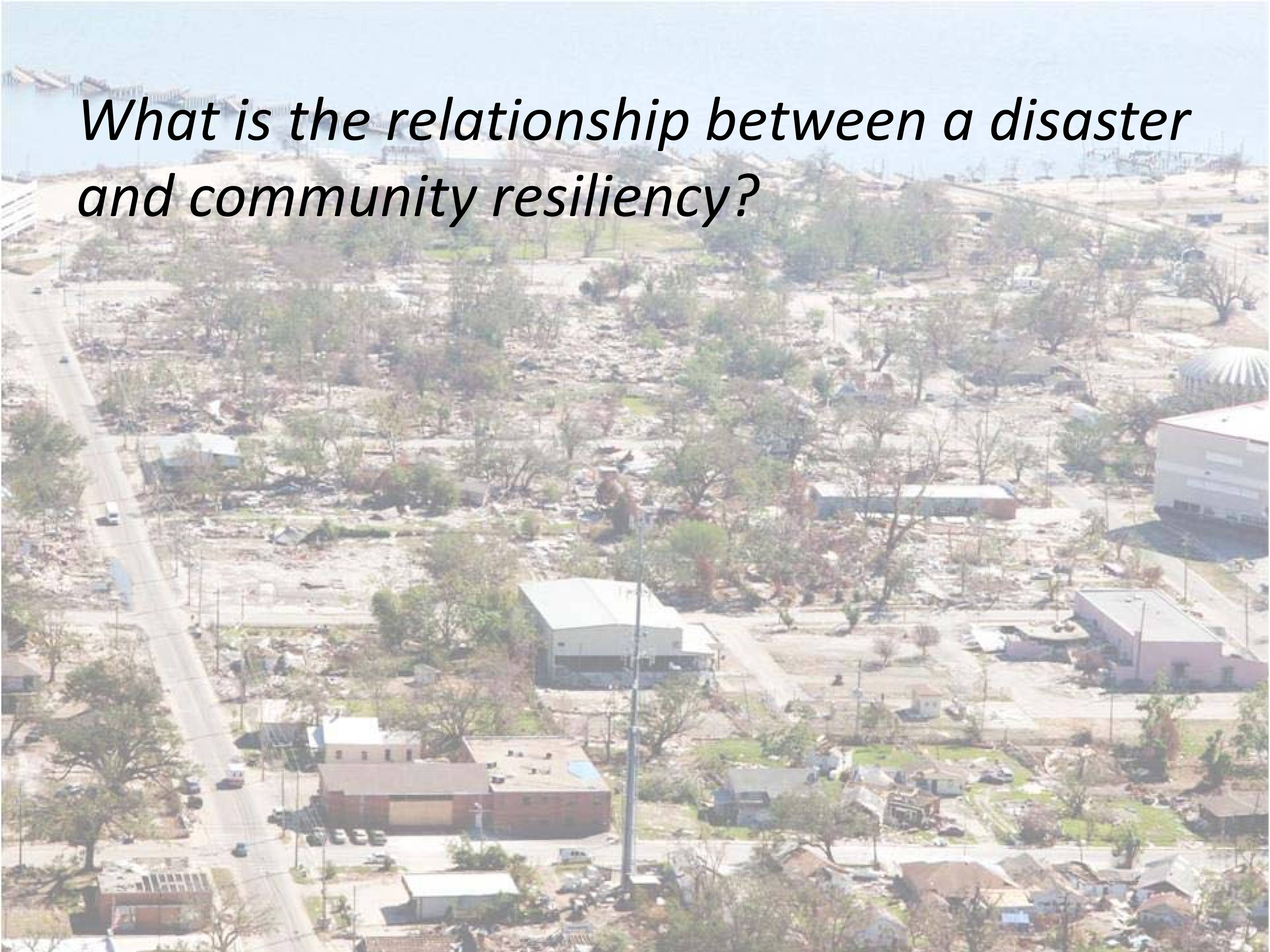
Mississippi State University

dperkes@gccds.msstate.edu

LEARNING FROM DISASTER: FLOOD-PROOF CONSTRUCTION RESEARCH

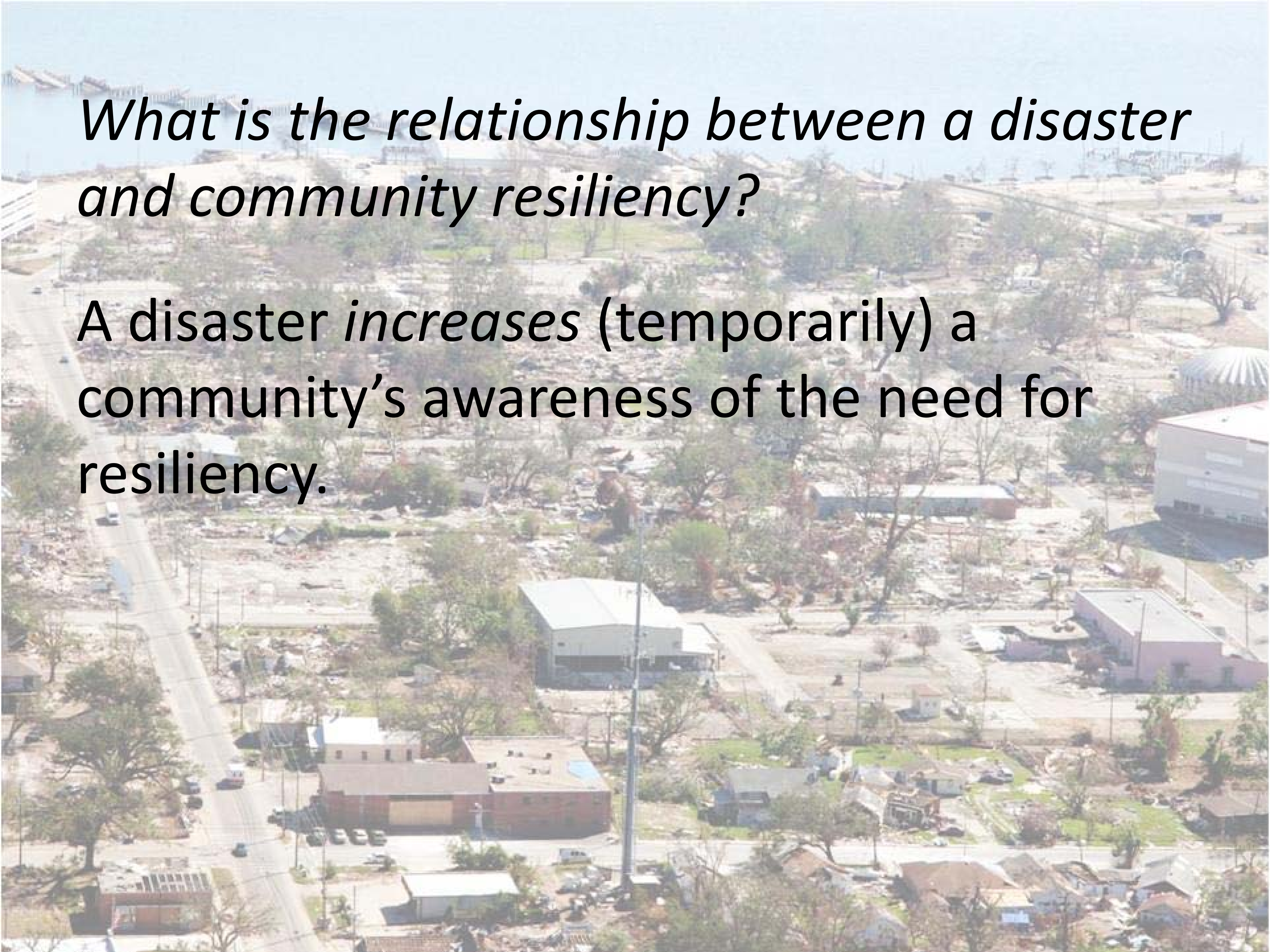
David Perkes, AIA
Gulf Coast Community Design Studio
Mississippi State University

What is the relationship between a disaster and community resiliency?



What is the relationship between a disaster and community resiliency?

A disaster *increases* (temporarily) a community’s awareness of the need for resiliency.



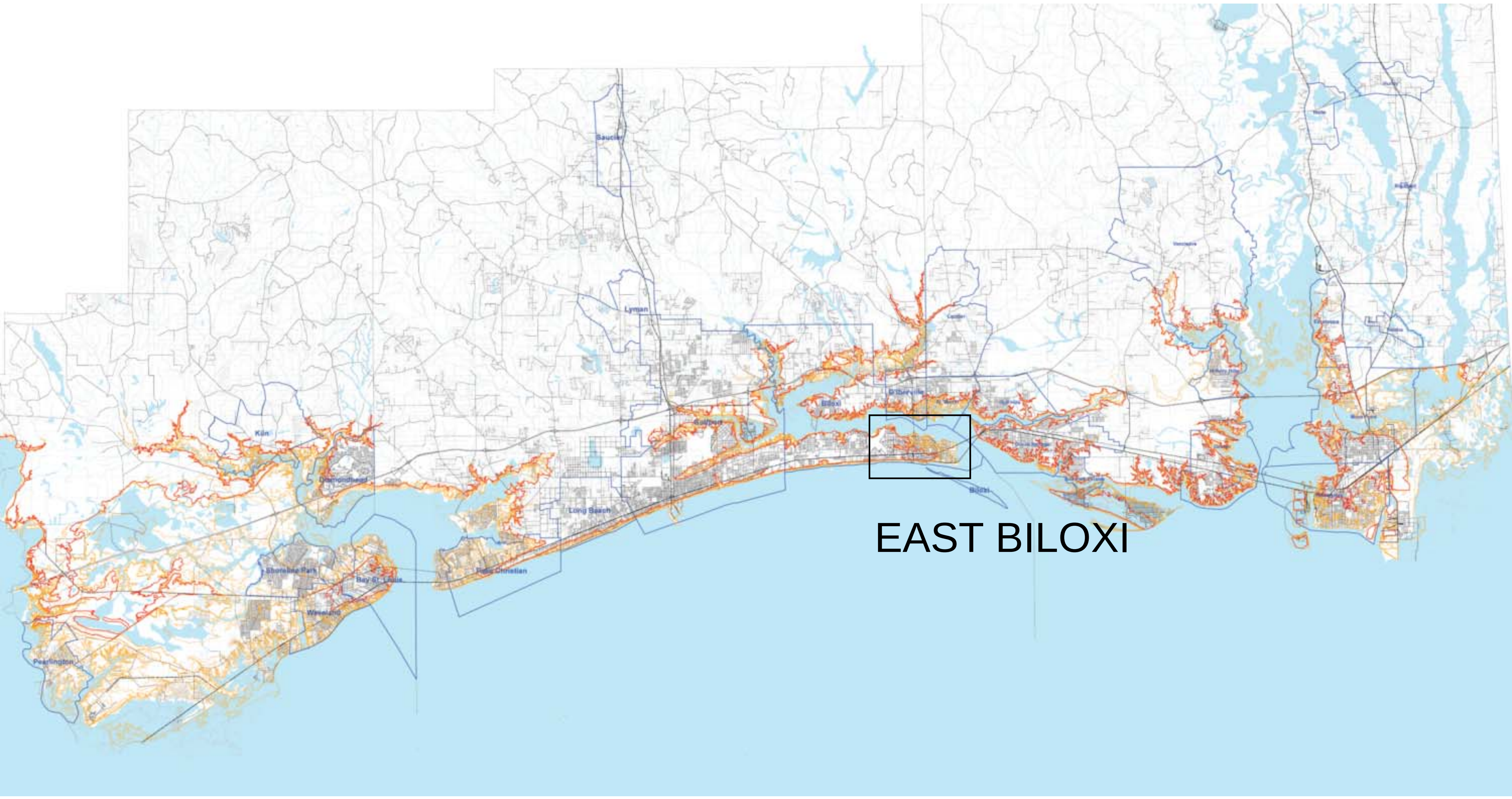
What is the relationship between a disaster and community resiliency?

A disaster *increases* (temporarily) a community’s awareness of the need for resiliency.

A disaster *decreases* (at least temporarily) the community’s resiliency.

What effects of a disaster decrease a community's resiliency?

- Loss of buildings.
- Decrease in demand from decrease in population.
- Increase in development costs from increased insurance and building costs.
- Increase in flood requirements.



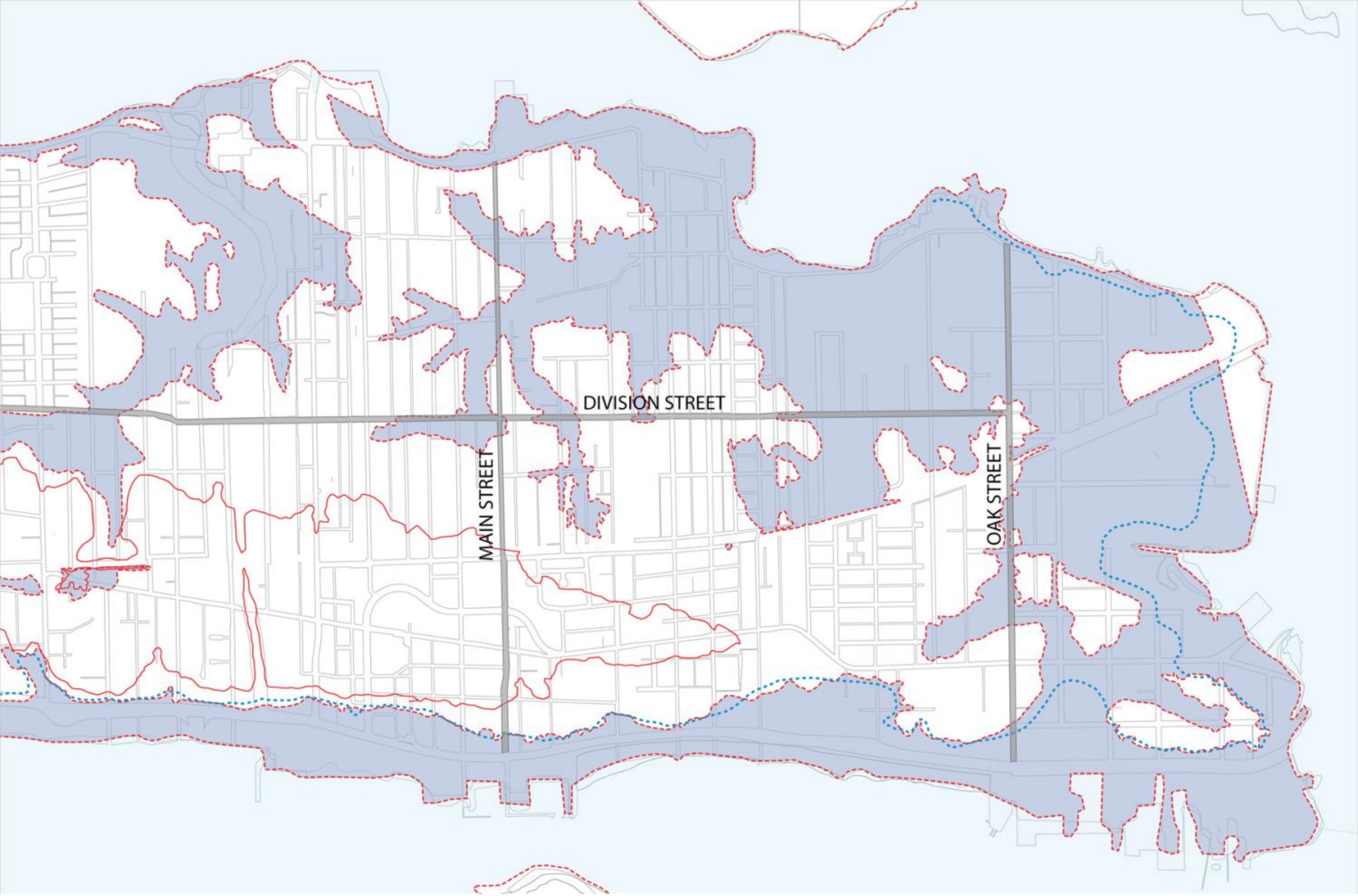
Hurricane Katrina’s 20 foot storm surge inundated the East Biloxi peninsula.


4000 HOUSES

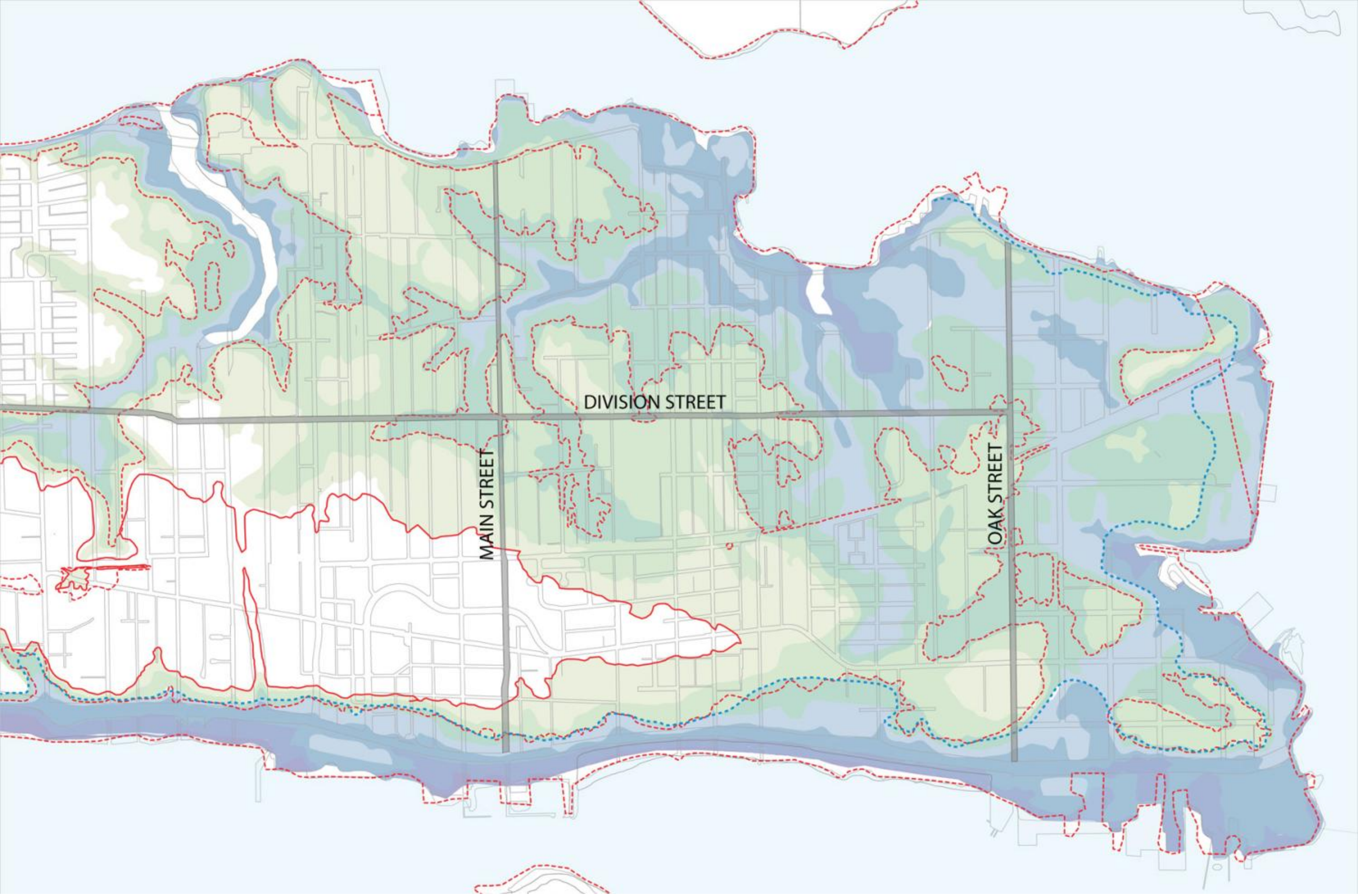

2000 HOUSES

Half of the buildings in East Biloxi were destroyed.

The other half of the buildings were flooded.



Flood map before Hurricane Katrina.

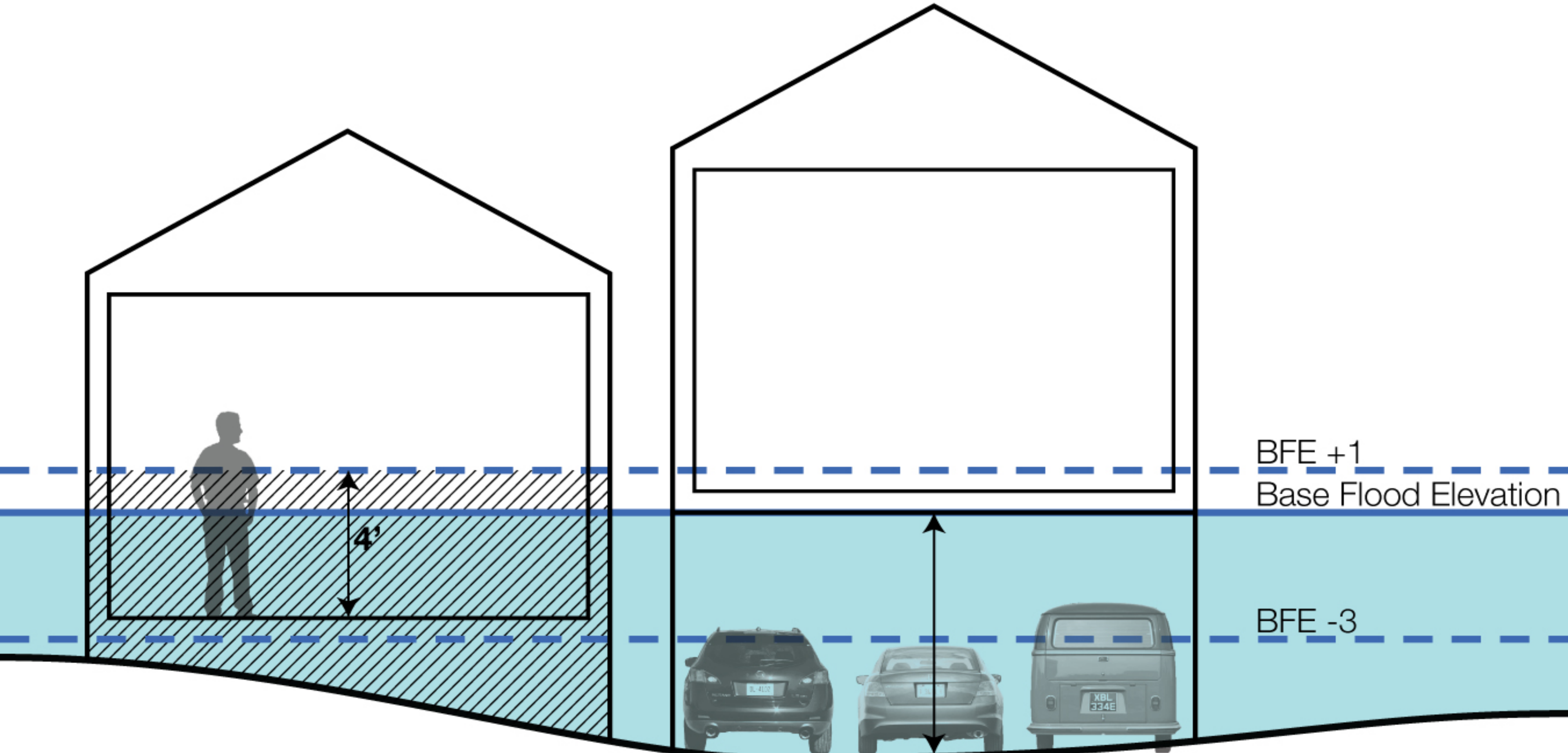


Flood map after Hurricane Katrina.

Typical commercial street now in a flood zone.

How can communities continue to develop in existing commercial districts that are now in flood zones?

DRY VS. WET FLOODPROOFING



Dry Floodproofing
Not recommended more than 3' below the BFE. Must extend 1' above the BFE to meet flood insurance requirements.

Wet Floodproofing
For parking, building access, and limited storage only. Other interior spaces must be elevated or dry floodproofed.

Flood-proof construction research

Task 1: UNDERSTAND THE HAZARDS

Task 2: PLAN NEIGHBORHOOD LAND USE

Task 3: INVESTIGATE MATERIALS AND ASSEMBLIES

Task 4: DESIGN A MIXED-USE BUILDING

Task 5: INFORM THE DEVELOPMENT COMMUNITY

Research Method

Task 1: UNDERSTAND THE HAZARDS

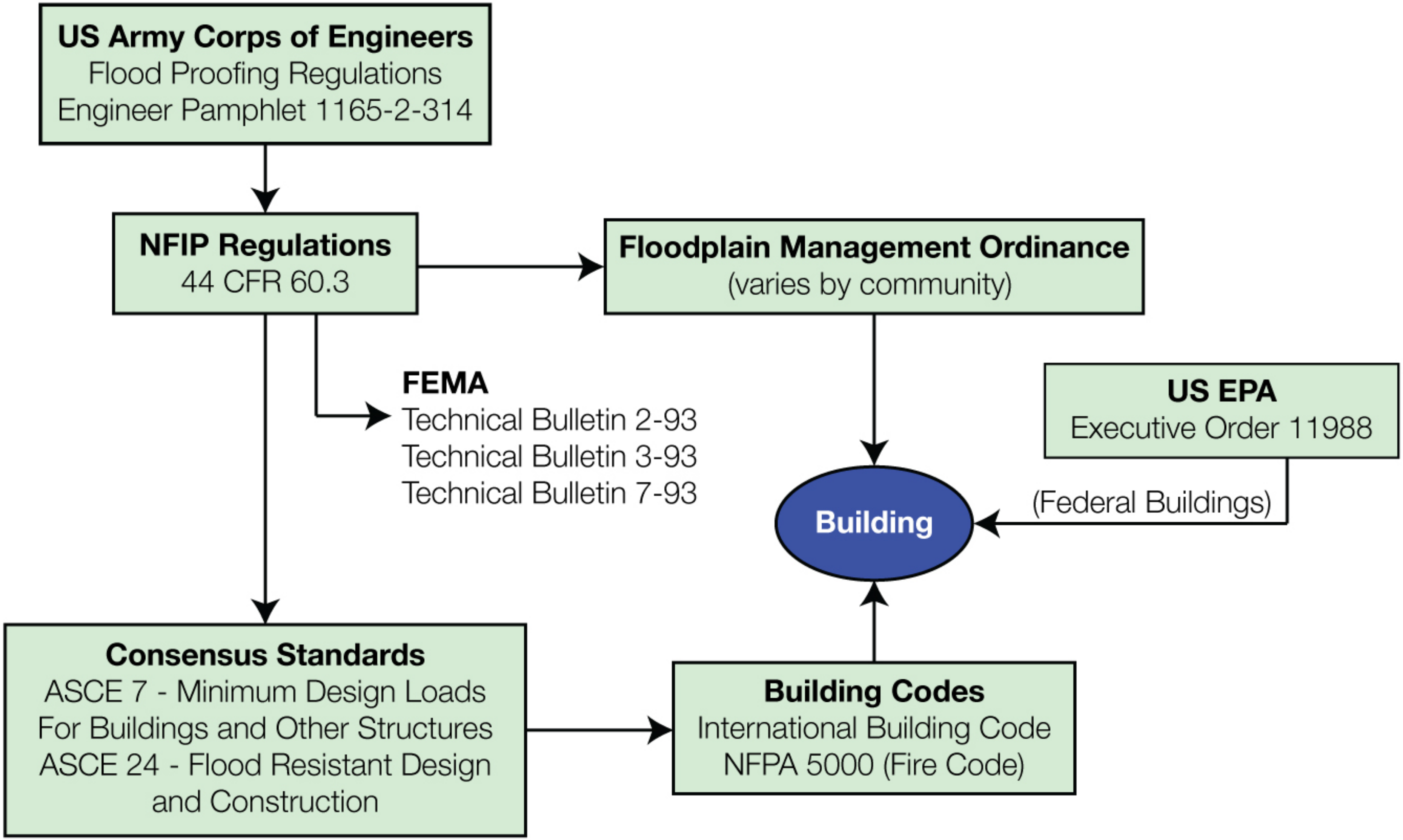
Task 2: PLAN NEIGHBORHOOD LAND USE

Task 3: INVESTIGATE MATERIALS AND ASSEMBLIES

Task 4: DESIGN A MIXED-USE BUILDING

Task 5: INFORM THE DEVELOPMENT COMMUNITY

OUTLINE OF FLOODPROOFING REGULATIONS



Source: Whole Building Design Guide.
http://www.wbdg.org/resources/env_flood.php

HYDROSTATIC LOAD

Hydrostatic loads are vertical and lateral forces that act on a building as a result of standing or slowly moving water. These loads are decreased significantly when the depth of the water acting on either side of an enclosed building is of similar depth. Hydrostatic loads are applied to a building face at a point 2/3 the depth of the stillwater elevation below the flood level. The design stillwater depth is determined by the local Flood Insurance Study provided by the National Flood Insurance Program.

$$F_{STA} = [(1/2)\,\gamma\, d_s^{\,2}]\,(w)$$

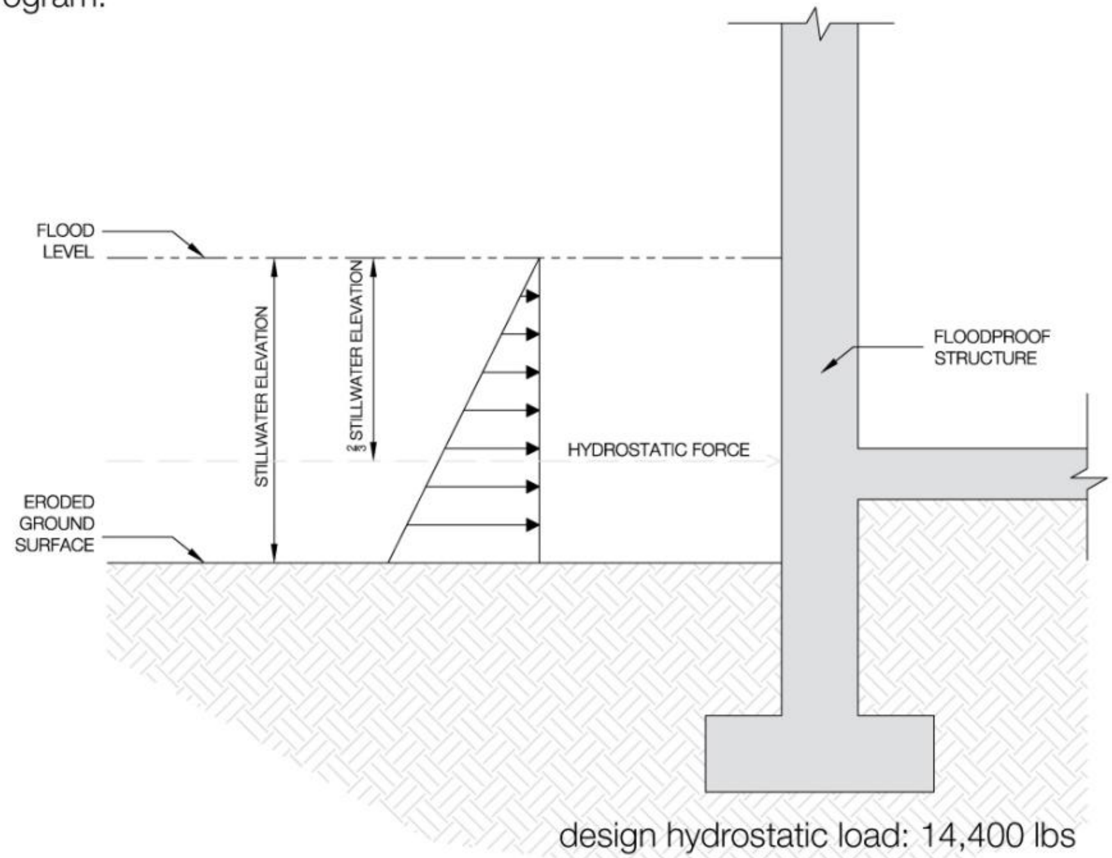
where:

F_{STA} = lateral hydrostatic force on a structure (in lb)

γ = specific weight of water = 64.0 lb/ft³ for saltwater

d_s = design stillwater flood depth

w = width of building (in ft)



design hydrostatic load: 14,400 lbs

HYDRODYNAMIC LOAD

Hydrodynamic loads are forces acting on a building due to moving water around the exterior walls. These loads impact all sides of the building: the seaward face, drag along the sides, and negative pressure (suction) on the downstream face. Hydrodynamic loads are a function of expected flood velocities, which are subject to high uncertainty. For flow velocities less than 10ft/sec, the hydrodynamic load can be converted to a hydrostatic load. For buildings within an A zone, flood velocities are expected to be less than 10ft/sec.

$$F_{dyn} = \{\gamma d_s[(1/2)C_d V^2/g]\}w$$

where:

F_{dyn} = lateral hydrostatic force in lb acting at the point 2/3 below the stillwater elevation

γ = specific weight of saltwater (64.0lb/ft^3)

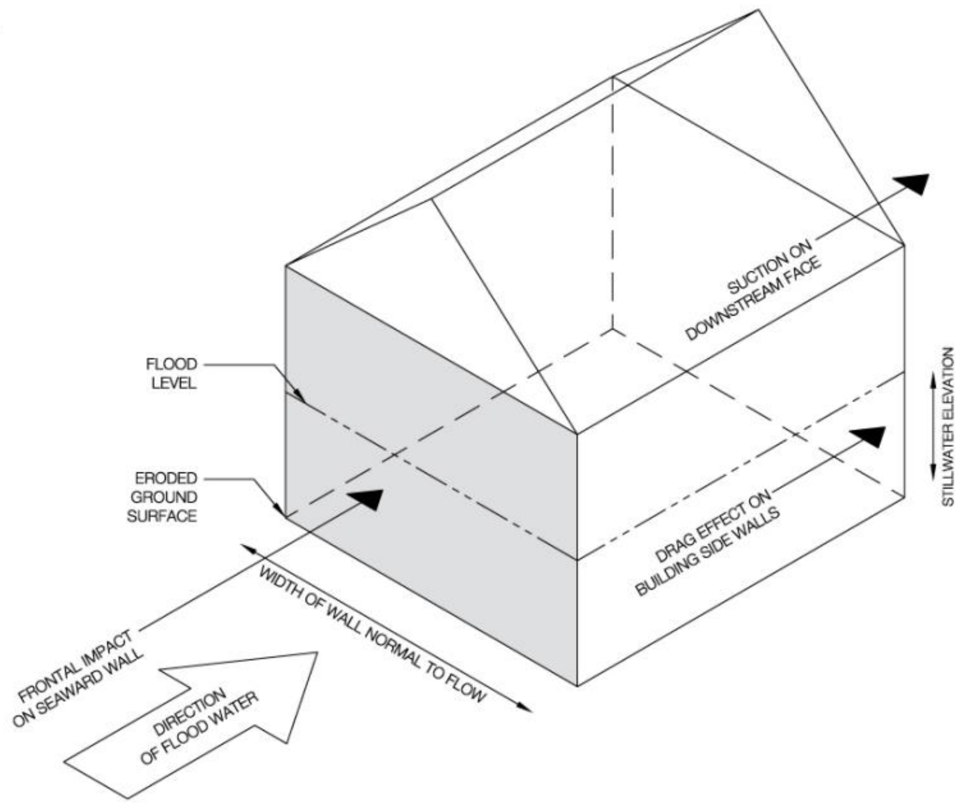
d_s = design stillwater flood depth

C_d = drag coefficient for width to depth ratio

V = velocity of water in ft/sec

g = acceleration due to gravity (32.2ft/sec^2)

w = width of structure in feet



design hydrodynamic load: 1,744 lbs

WAVE LOADS

Wave loads are forces acting on the walls of the building, at the stillwater elevation, as a result of four types of wave forces: non-breaking waves, breaking waves, broken waves, and uplift (as a result of wave runup or waves peaking under protruding horizontal surfaces). Because breaking waves produce the highest load, they are used to calculate the design wave load.

$$F_{brkw} = [1.1 C_p \gamma d_s^2 + 2.41 \gamma d_s^2](w)$$

where:

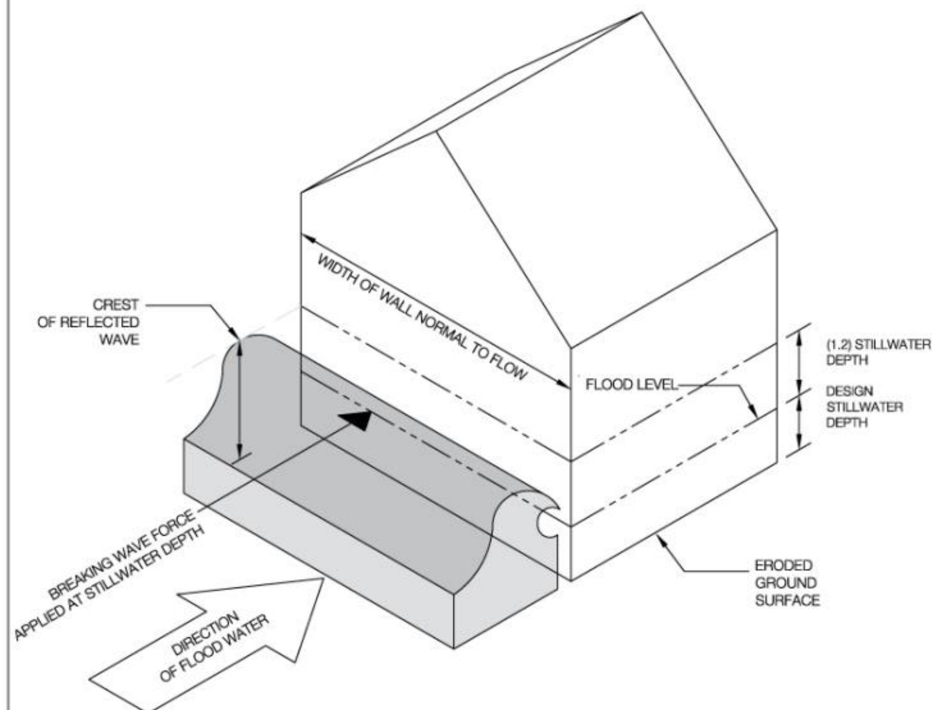
F_{brkw} = wave load per unit length of wall acting at the stillwater level

C_p = dynamic pressure coefficient (as a Function of Probability of Exceedance, Walton et al. 1989) = 3.2

γ = specific weight of water = 64.0 lb/ft^3 for saltwater

d_s = design stillwater flood depth in feet

w = width of wall normal to flow of flood water



design breaking wave load: 3,516 lb

DEBRIS IMPACT LOAD

Debris impact loads are lateral forces that act on a building as a result of debris floating in floodwaters and colliding with the facade of a building. The magnitude of this load is extremely difficult to predict, as it is a function of the weight of teh debris and the velocity for which it is traveling. Additionally, the type of debris cannot be accurately predicted for a flood event. Here, we asume that the object weighs 1,000lbs and is moving at the design floodwater velocity. Additionally, the duration of impact of the debris is influenced by the "rigidity" of a building. The city of Honolulu building code has determined this by the type of construction used, and FEMA has adopted this method for determining the duration of impact of debris.

$$F_i = wV/gt$$

where:

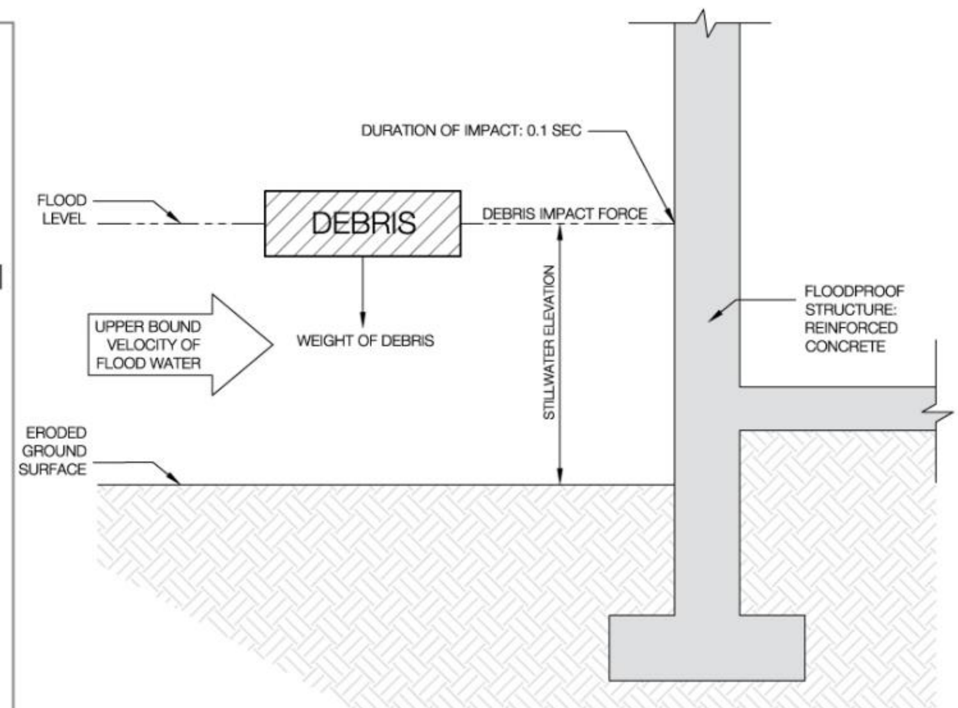
F_i = impact force, in lbs, acting at the stillwater level

w = weight of the debris object
= 1,000lbs

V = velocity of floodwater in ft/sec = $(gd_s)^{0.5}$;

g = gravitational constantat 32.2 ft/sec^2

t = duration of impact (in seconds)
= 0.1 for reinforced concrete



design debris impact load: 932 lbs

Research Method

Task 1: UNDERSTAND THE HAZARDS

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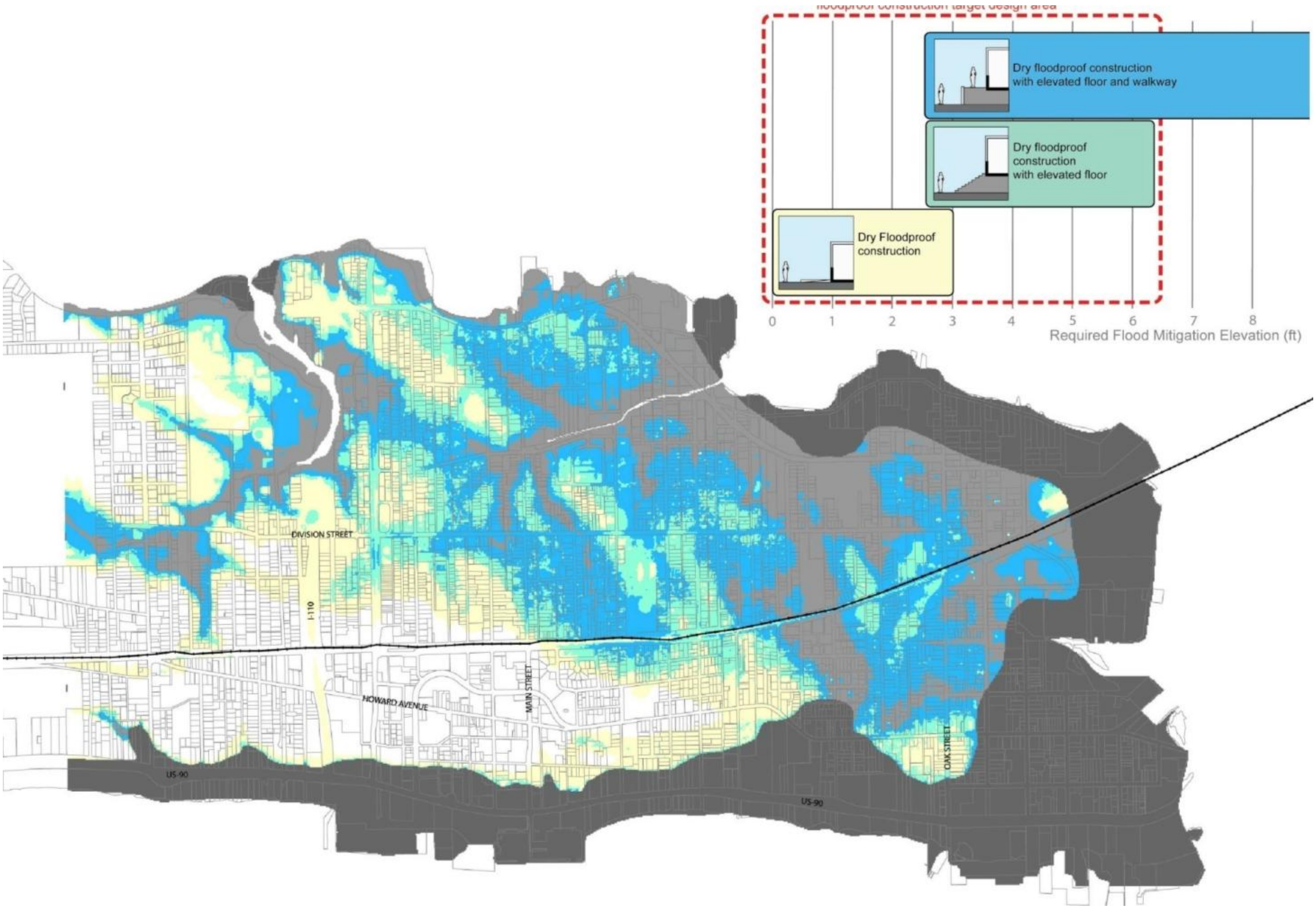
Task 3: INVESTIGATE MATERIALS AND ASSEMBLIES

Task 4: DESIGN A MIXED-USE BUILDING

Task 5: INFORM THE DEVELOPMENT COMMUNITY



East Biloxi neighborhood flood-proof building plan

East Biloxi commercial streets

Division Street redevelopment/infill sites

Research Method

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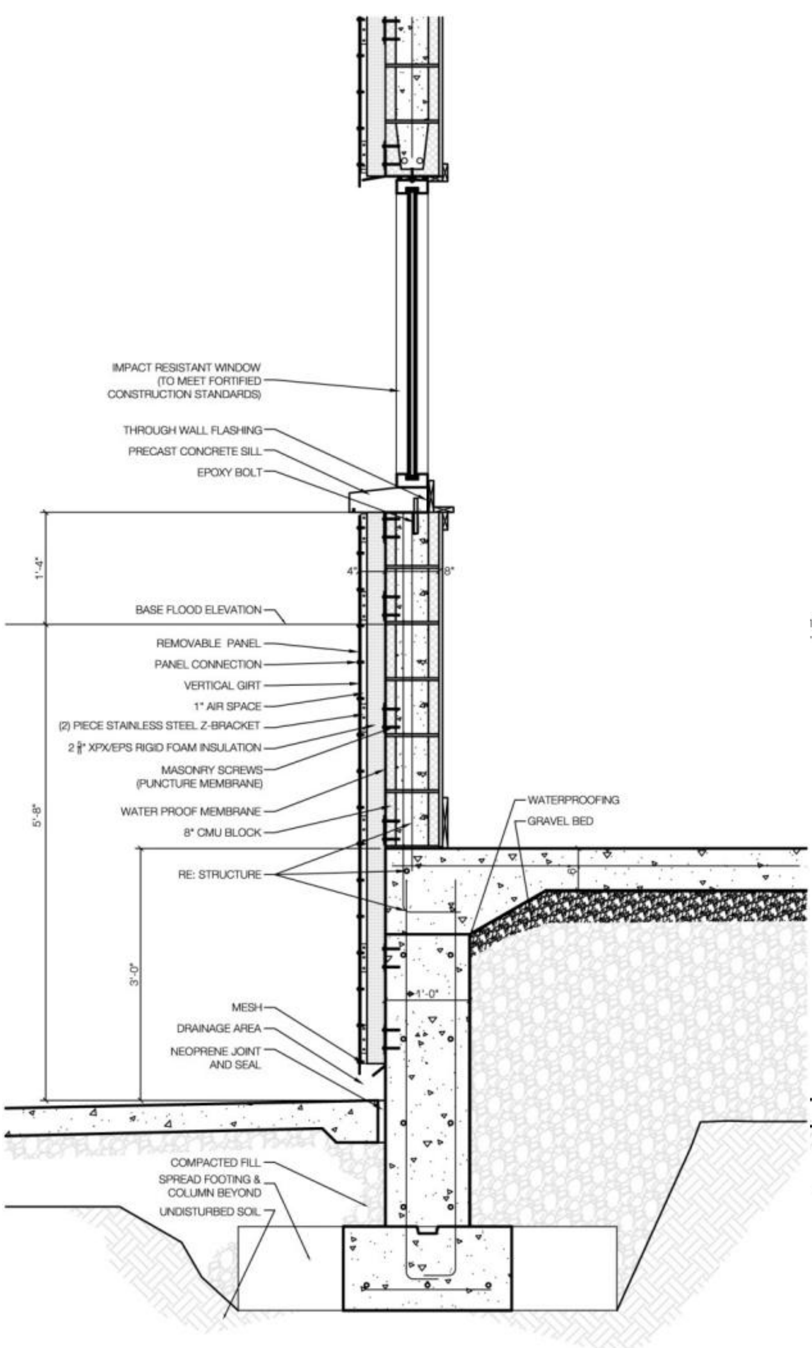
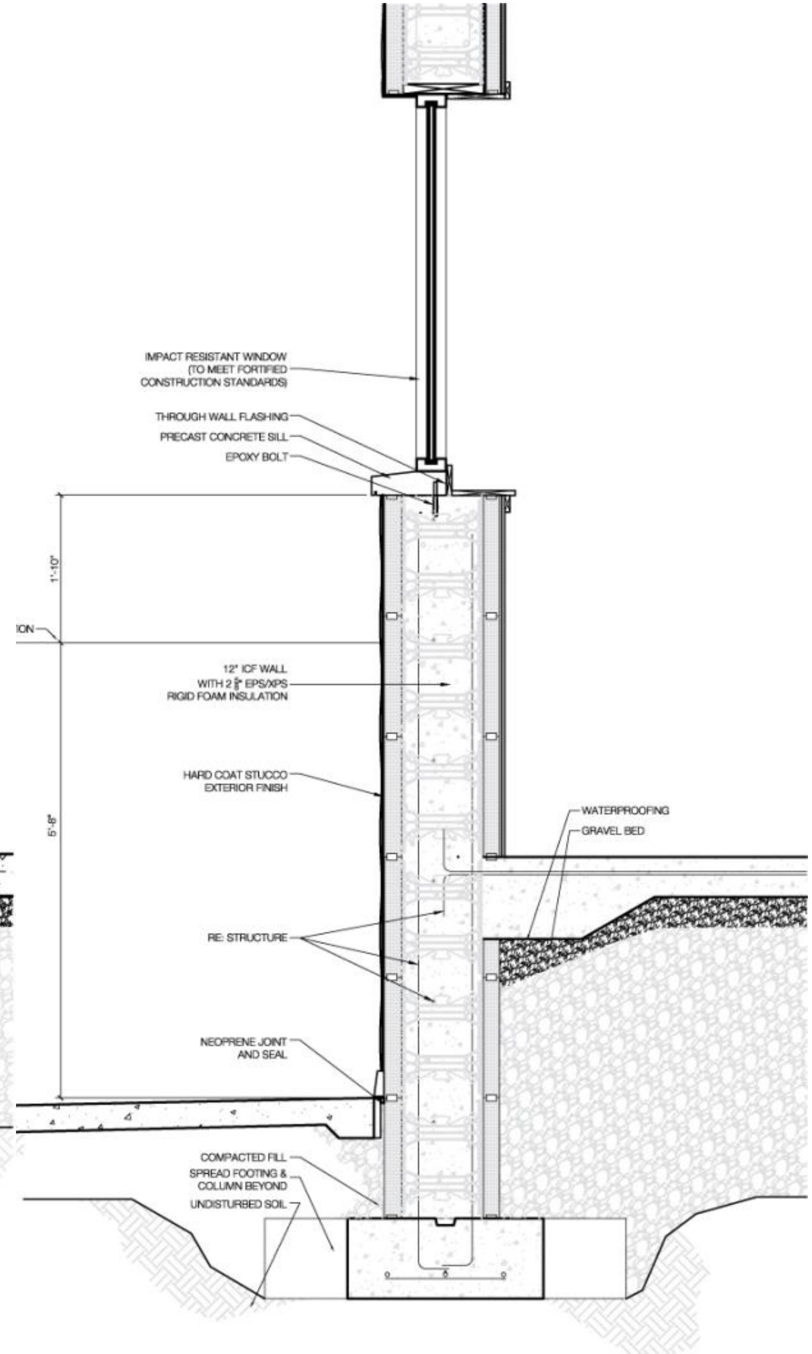
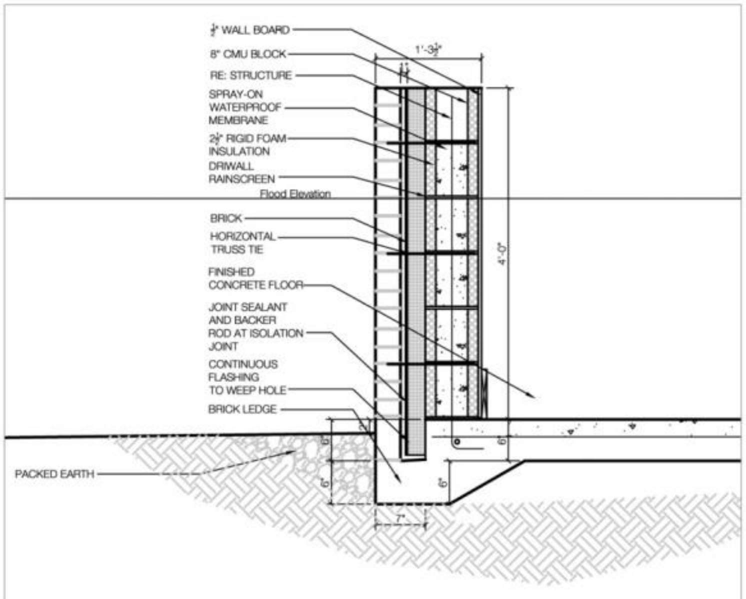
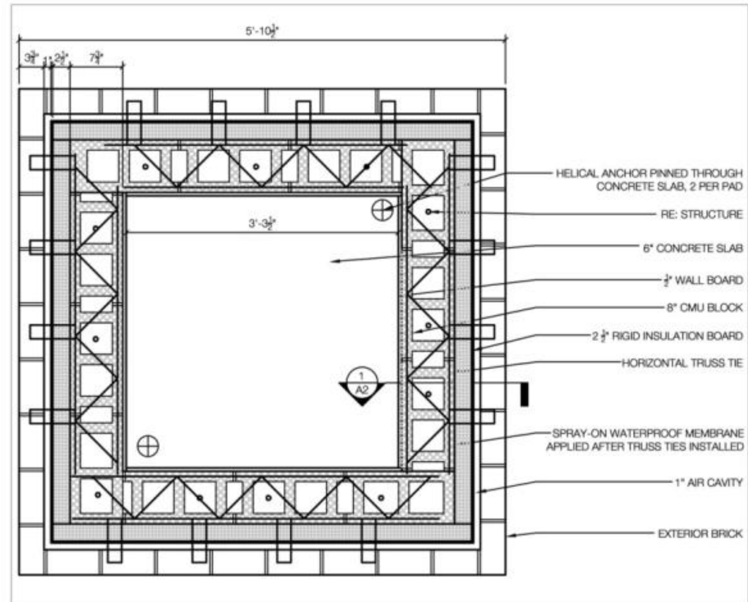
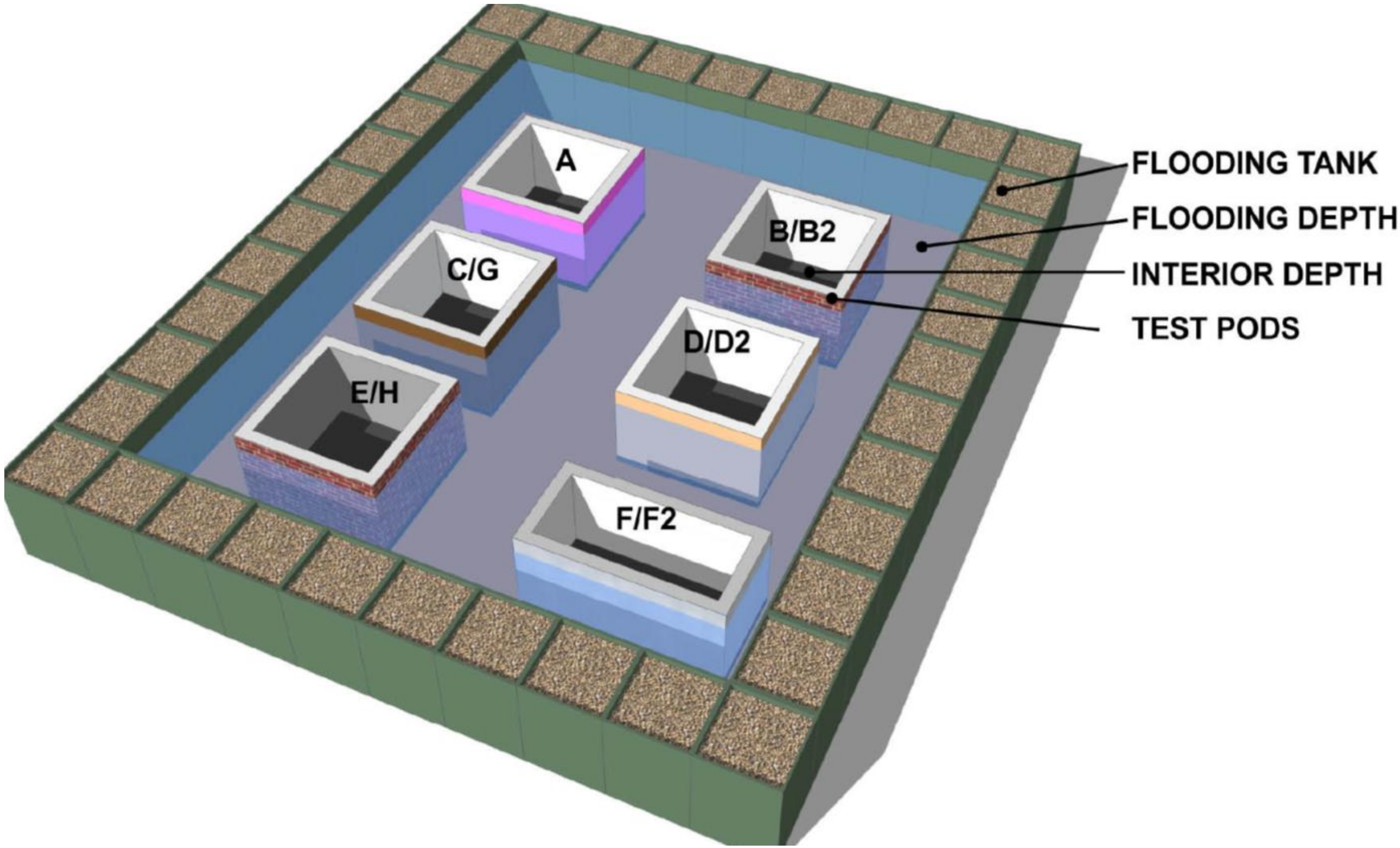

IMPACT RESISTANT WINDOW (TO MEET FORTIFIED CONSTRUCTION STANDARDS)
THROUGH WALL FLASHING
PRECAST CONCRETE SILL
EPOXY BOLT
1'-4"
4"
8"
BASE FLOOD ELEVATION
REMOVABLE PANEL
PANEL CONNECTION
VERTICAL GIRT
1" AIR SPACE
(2) PIECE STAINLESS STEEL Z-BRACKET
2 5/8" XPX/EPS RIGID FOAM INSULATION
MASONRY SCREWS (PUNCTURE MEMBRANE)
WATER PROOF MEMBRANE
8" CMU BLOCK
5'-8"
WATERPROOFING
GRAVEL BED
RE: STRUCTURE
3'-0"
1'-0"
MESH
DRAINAGE AREA
NEOPRENE JOINT AND SEAL
COMPACTED FILL
SPREAD FOOTING & COLUMN BEYOND
UNDISTURBED SOIL

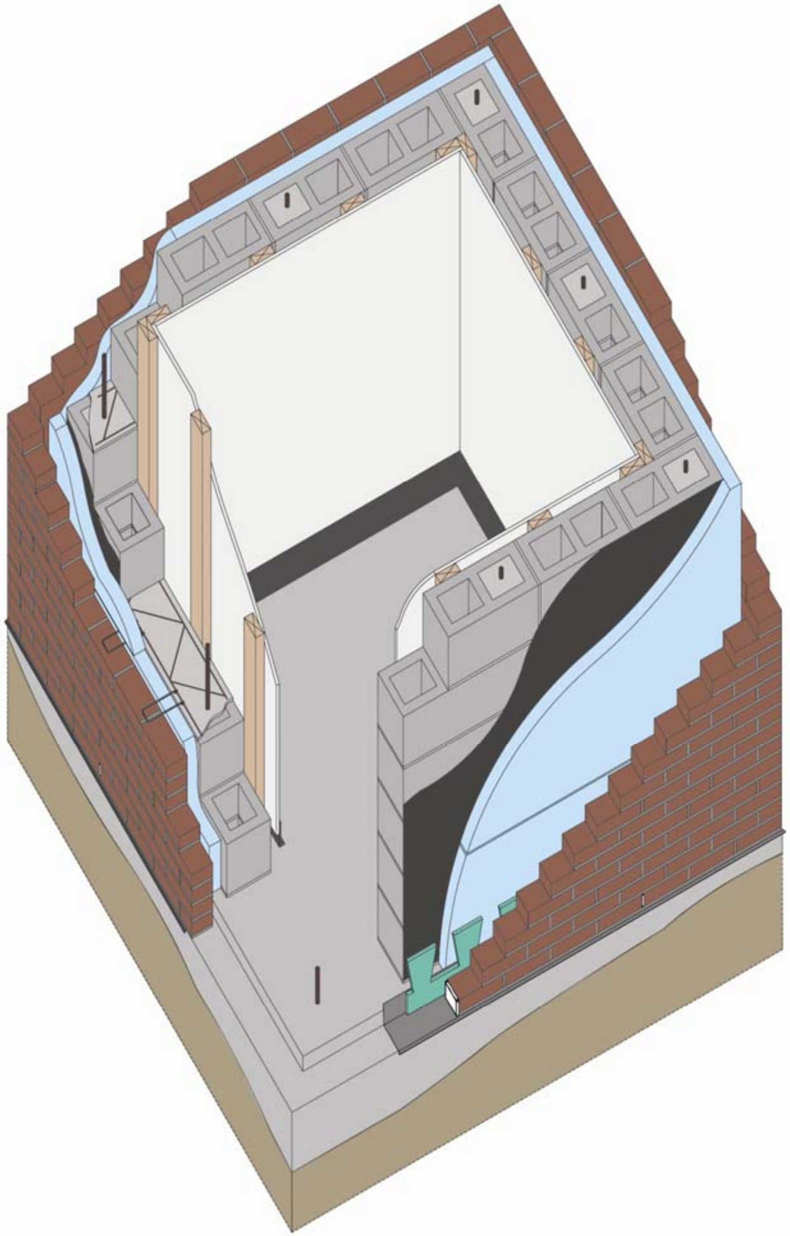

IMPACT RESISTANT WINDOW (TO MEET FORTIFIED CONSTRUCTION STANDARDS)
THROUGH WALL FLASHING
PRECAST CONCRETE SILL
EPOXY BOLT
1'-10"
12" ICF WALL WITH 2 5/8" EPS/XPS RIGID FOAM INSULATION
HARD COAT STUCCO EXTERIOR FINISH
5'-8"
WATERPROOFING
GRAVEL BED
RE: STRUCTURE
NEOPRENE JOINT AND SEAL
COMPACTED FILL
SPREAD FOOTING & COLUMN BEYOND
UNDISTURBED SOIL



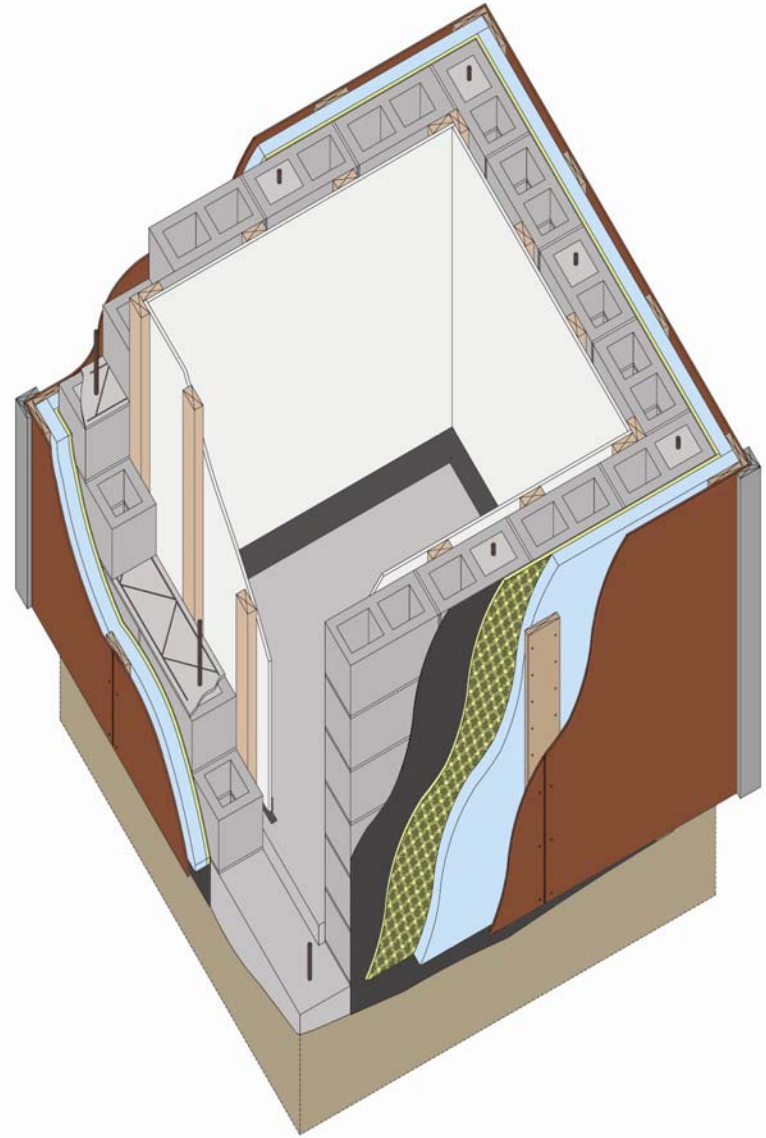


TEST POD #2: CMU W/ WASHABLE BRICK CAVITY

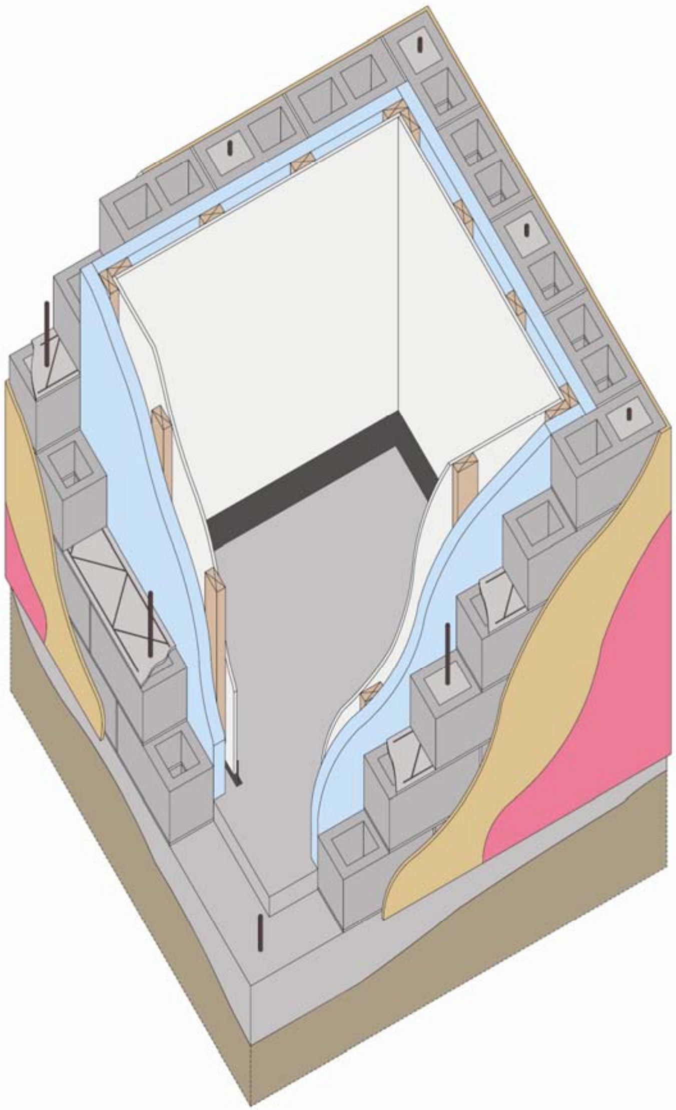

A
B/B2
C/G
D/D2
E/H
F/F2
FLOODING TANK
FLOODING DEPTH
INTERIOR DEPTH
TEST PODS



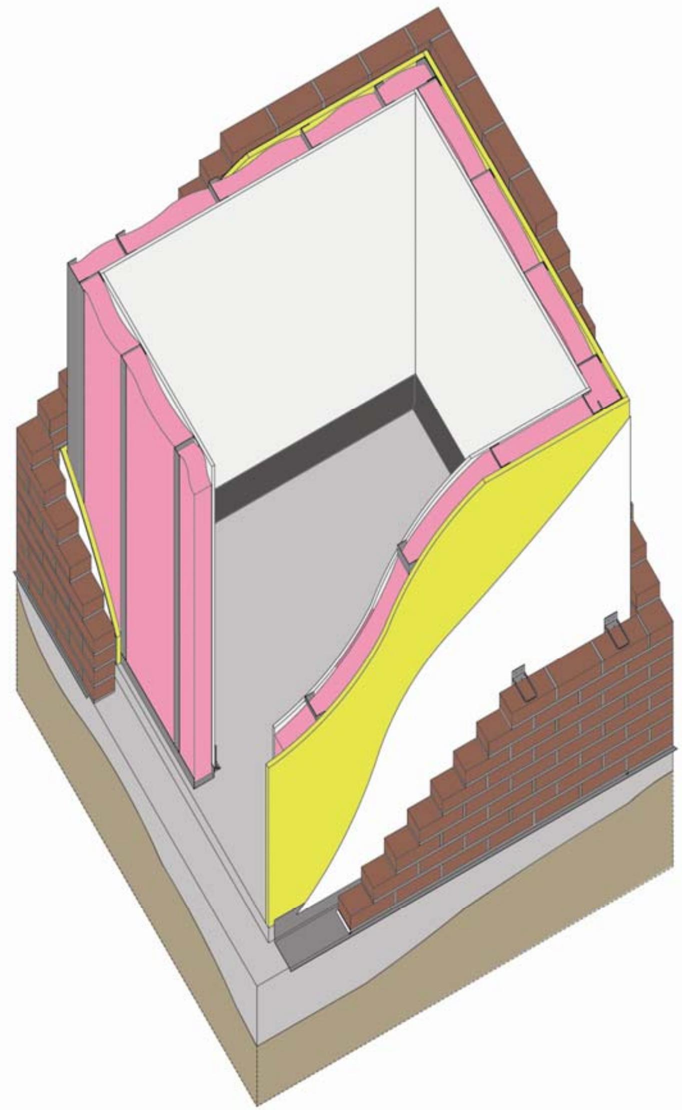
Brick/cmu cavity wall



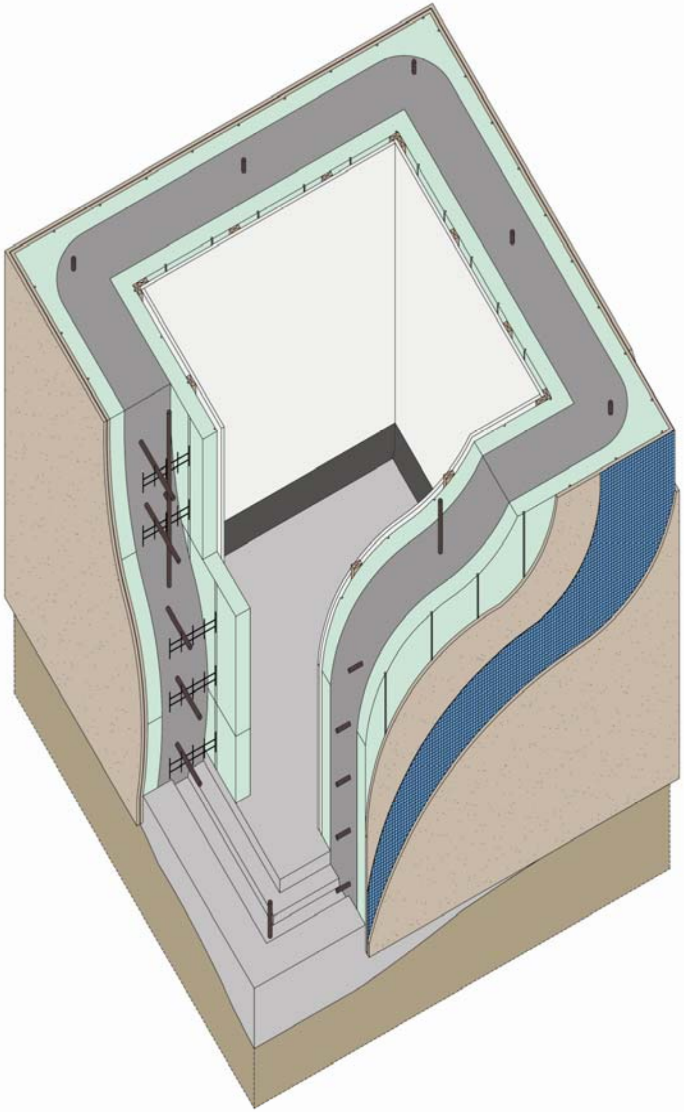
Panel/cmu rain screen

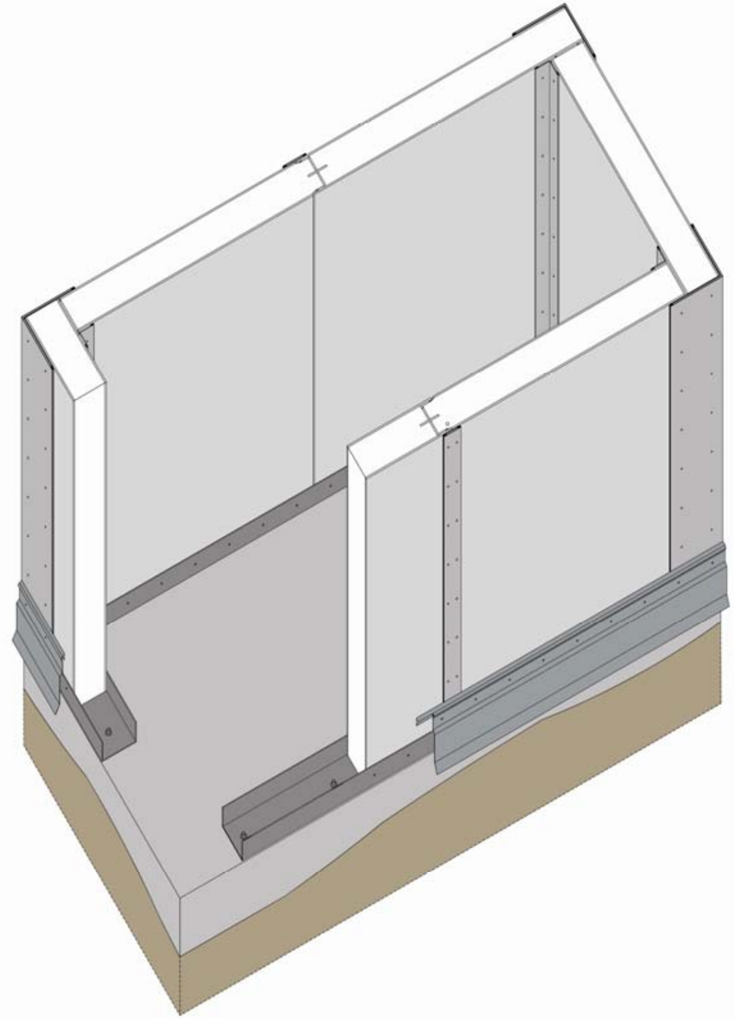


Sealed cmu

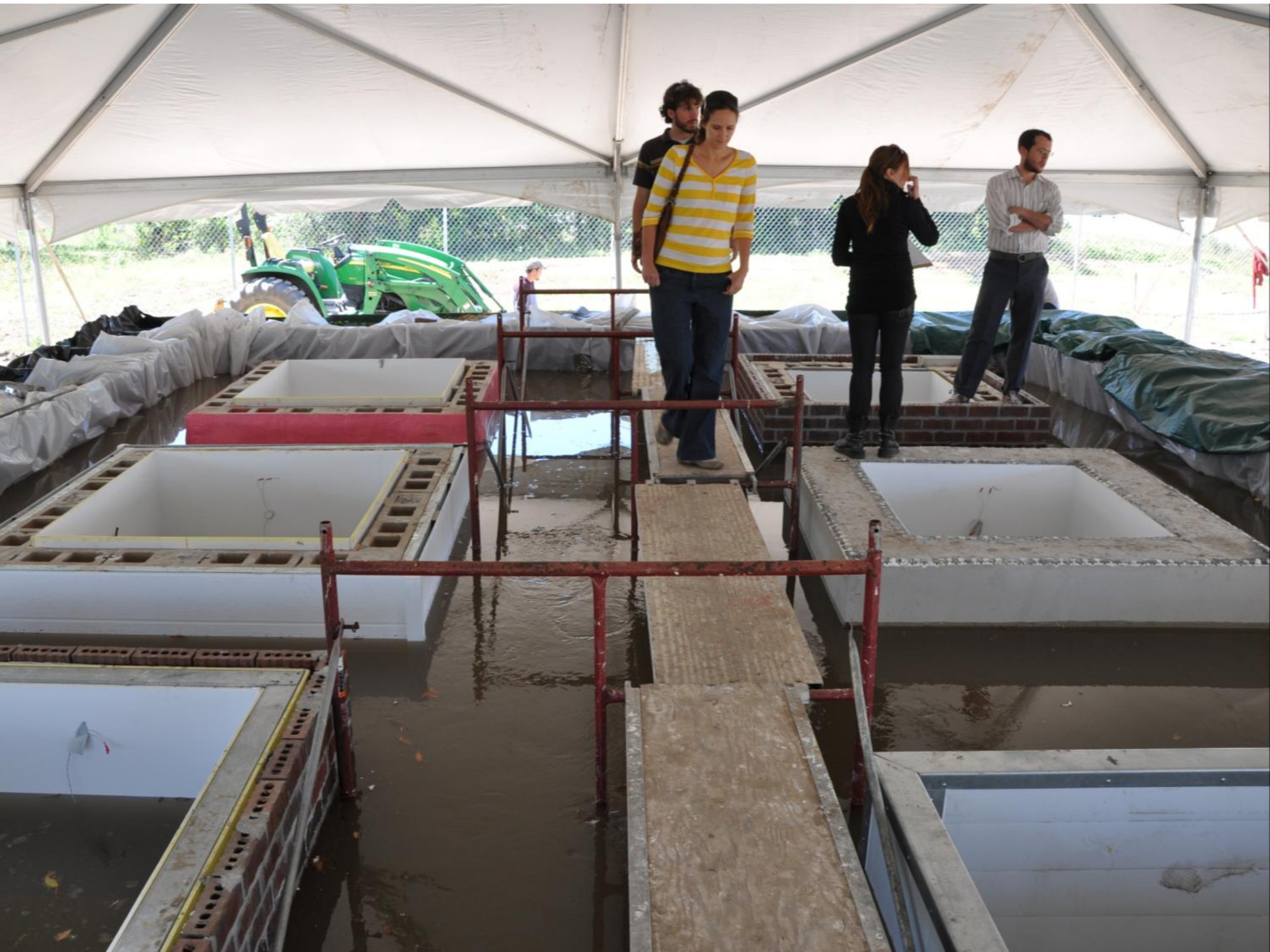


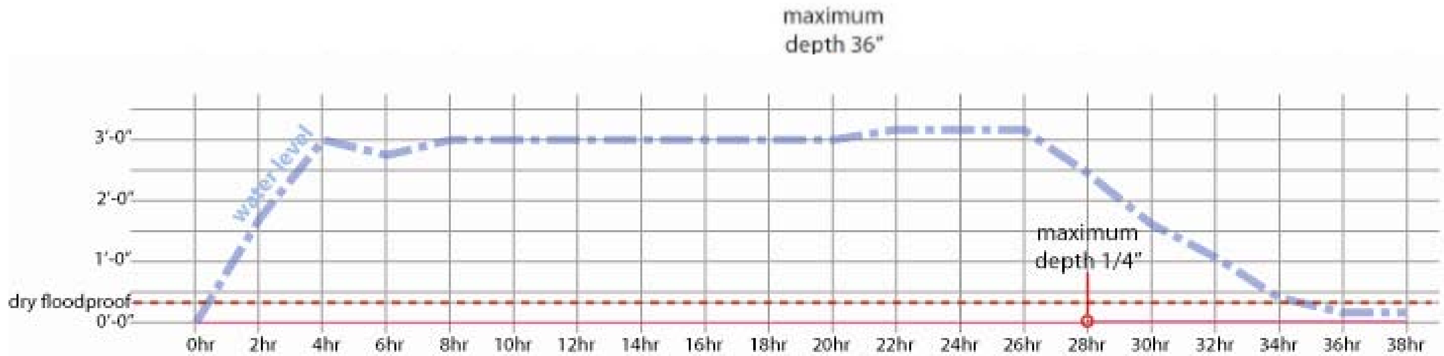
Brick veneer/metal stud



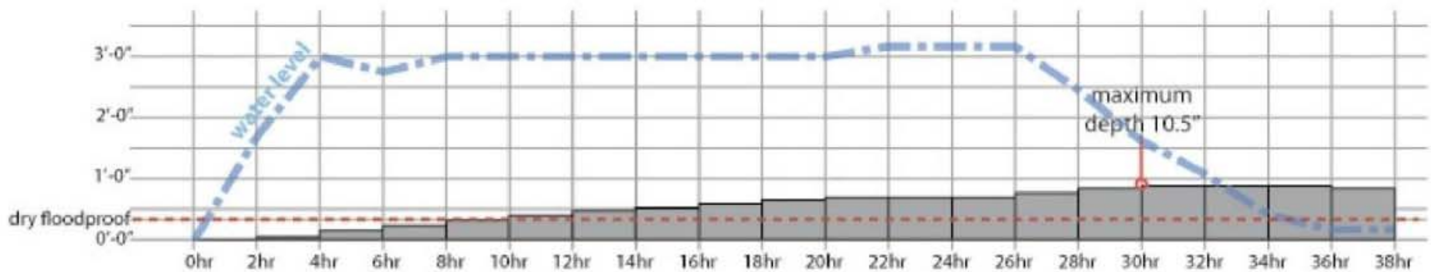


Insulated concrete form (ICF)   Metal clad SIP

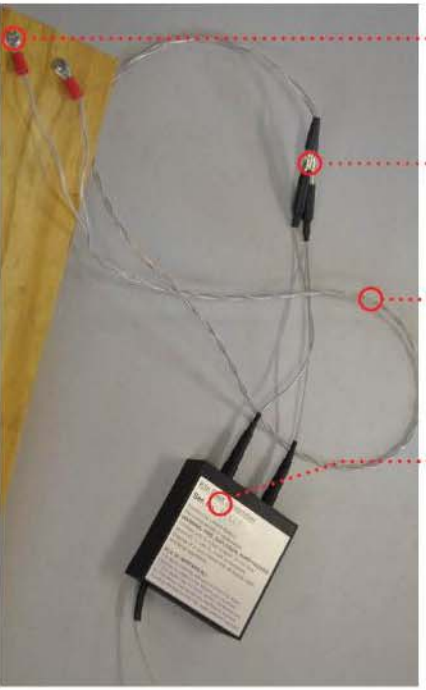




interior water depths during flood simulation 2 : sealed block test pod GCCDS April 6th 2011
a CMU wall coated w/ polymer resin layered exterior.



interior water depths during flood simulation 2 : ICF test pod GCCDS April 6th 2011
an insulated concrete formwork wall w/ a stucco finish.



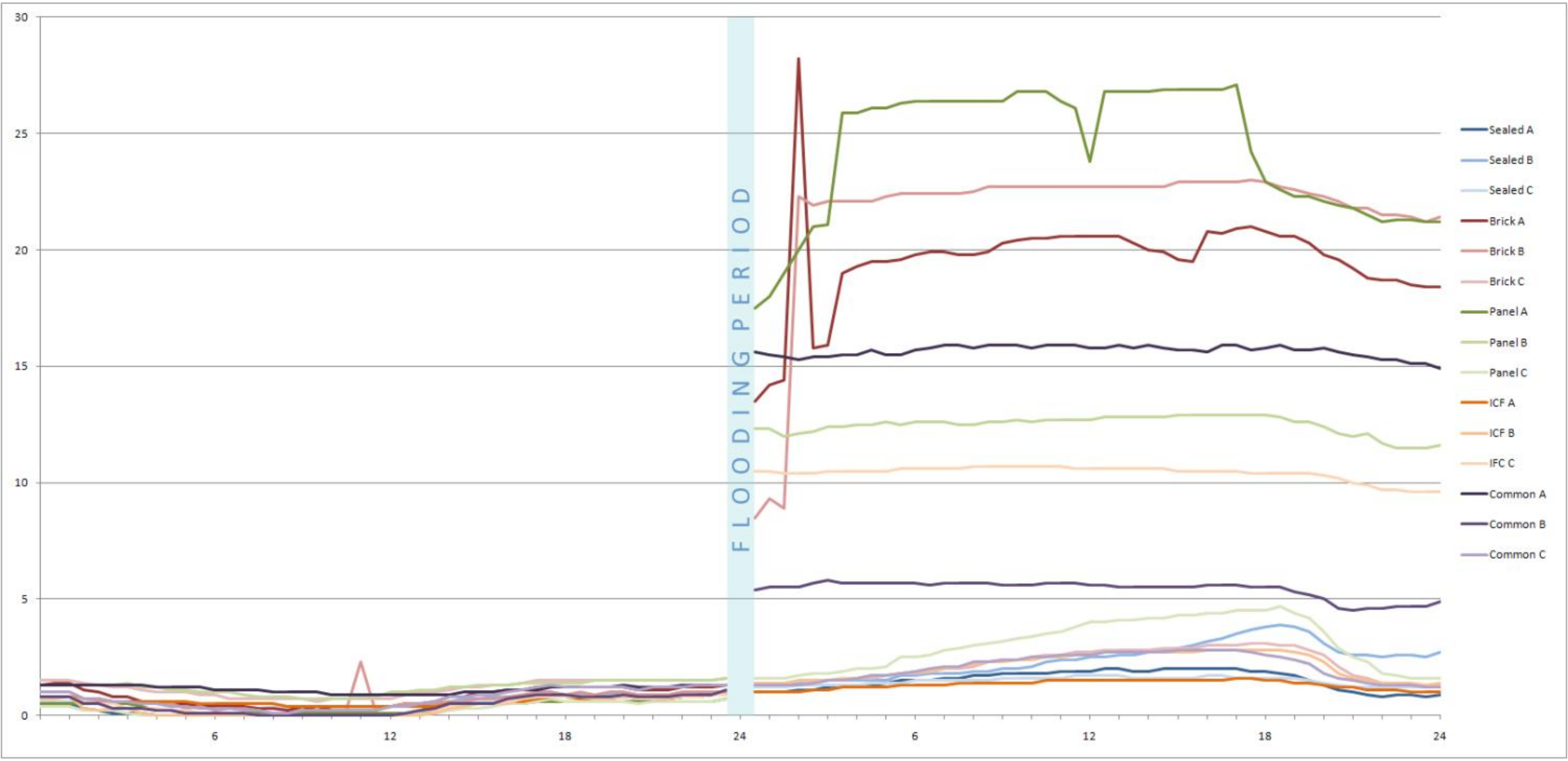
sensors
dry-wall screws pictured. Longer probes are usefull for measuring wood. Proper placement is key to accurate readings.

banana clips
attach to probes or extension wires as shown here

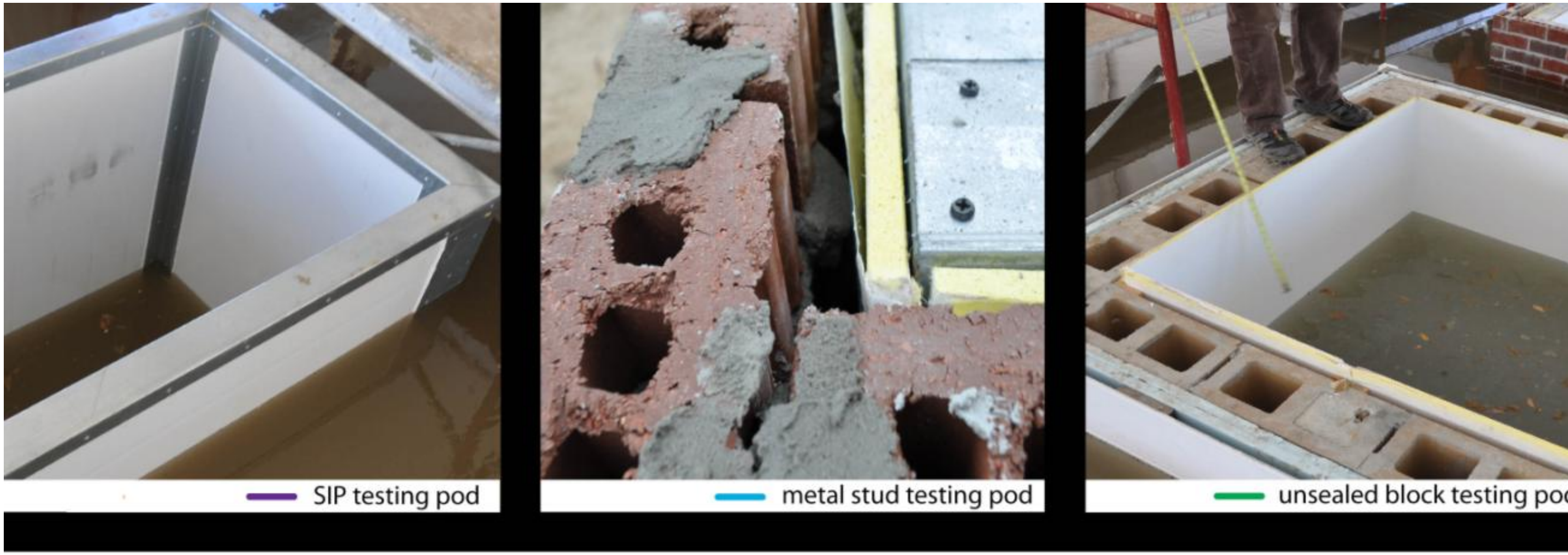
extension wire
length does not effect or measurement

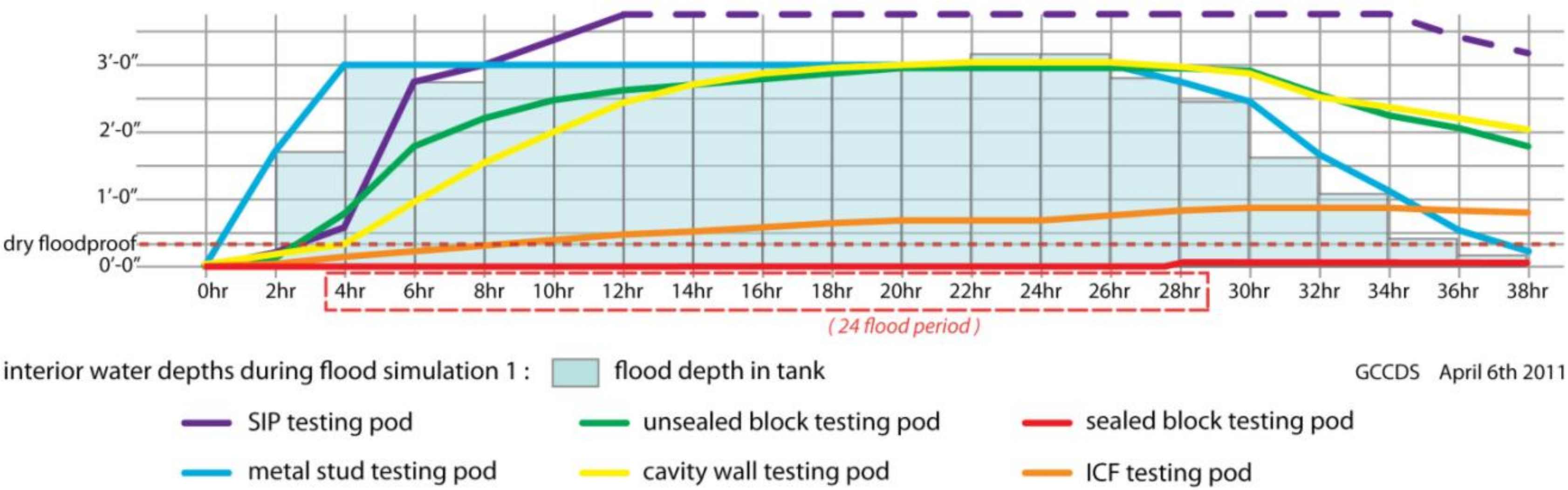
wireless transmitter
collects and transmits data. This sensor collects moisture content information by measuring resistance. Other sensor can measure moisture, temperature, and humidity.

Sensor Equipment
Measuring and Transmitting
all equipment from Lignomat U.S.A.

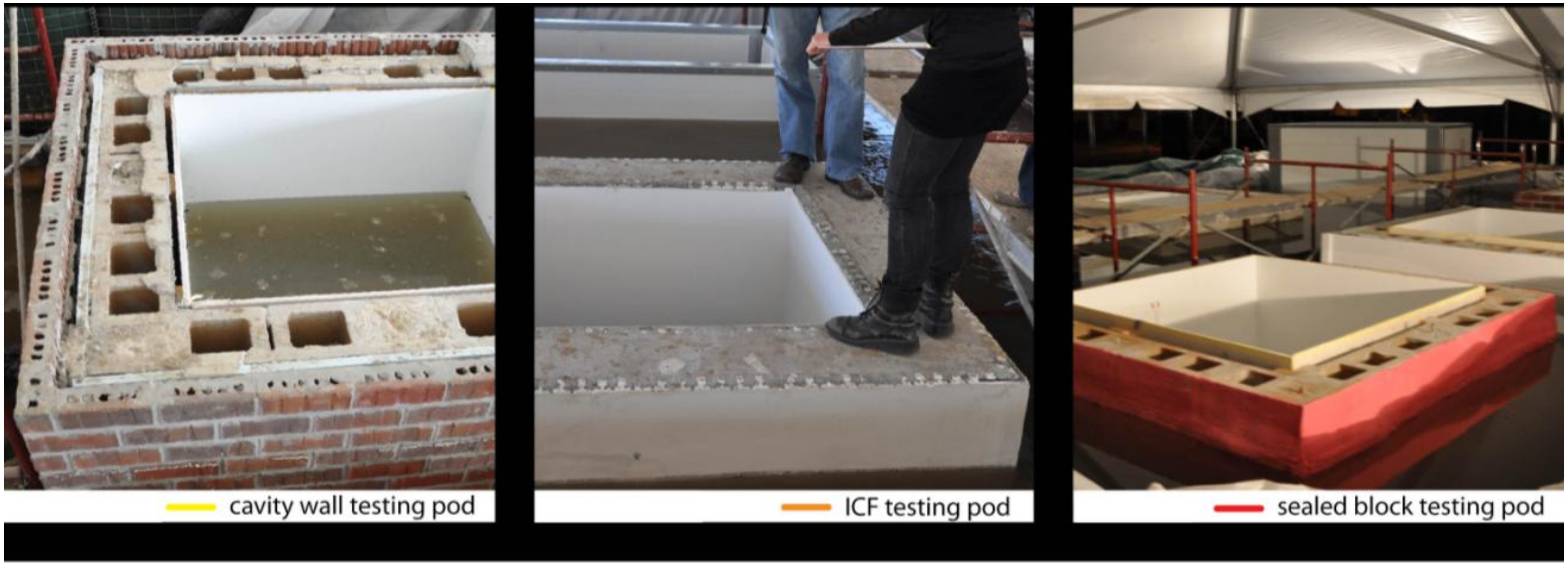


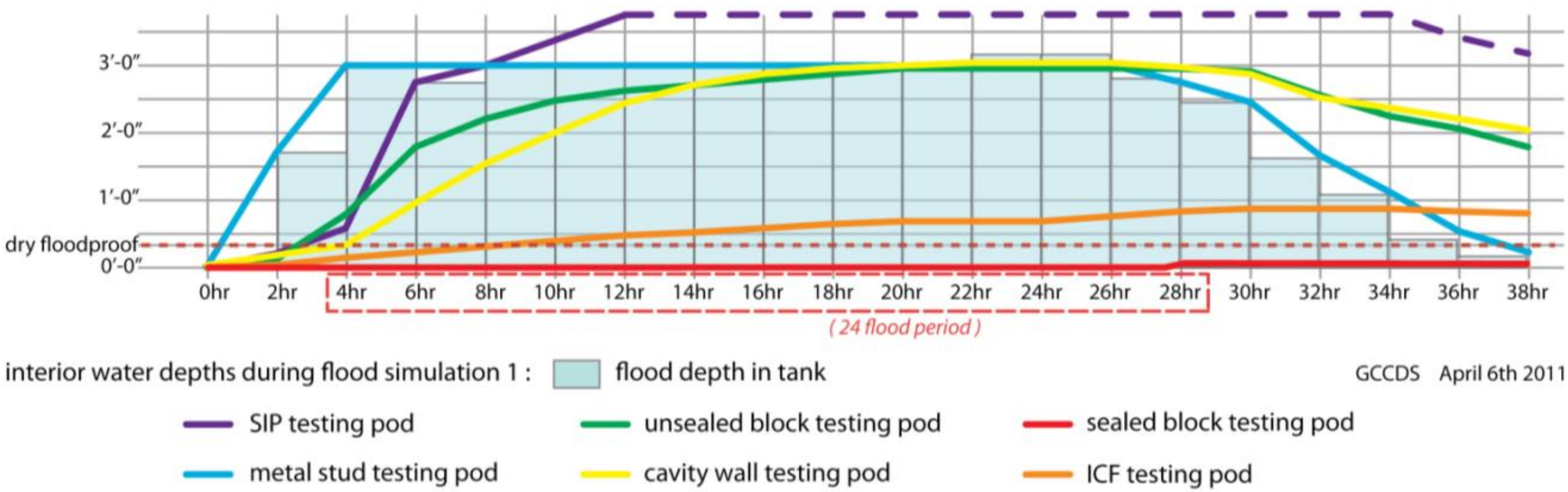
Gypsum board moisture content



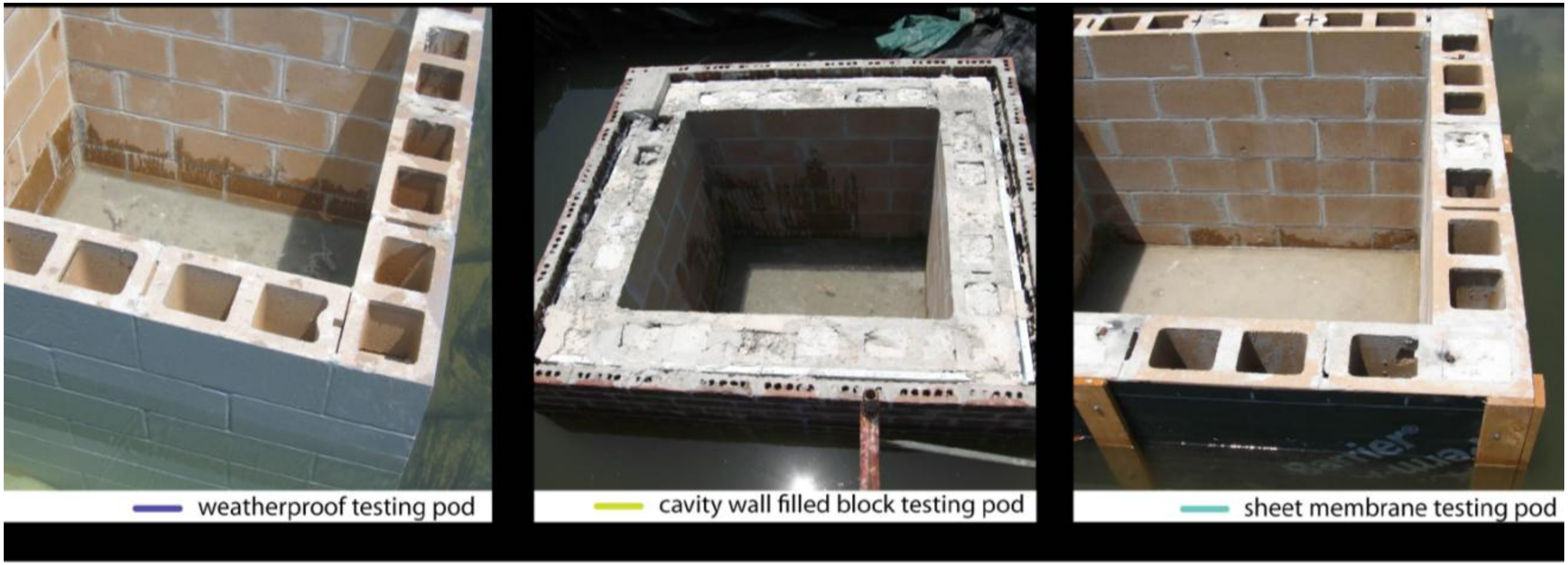


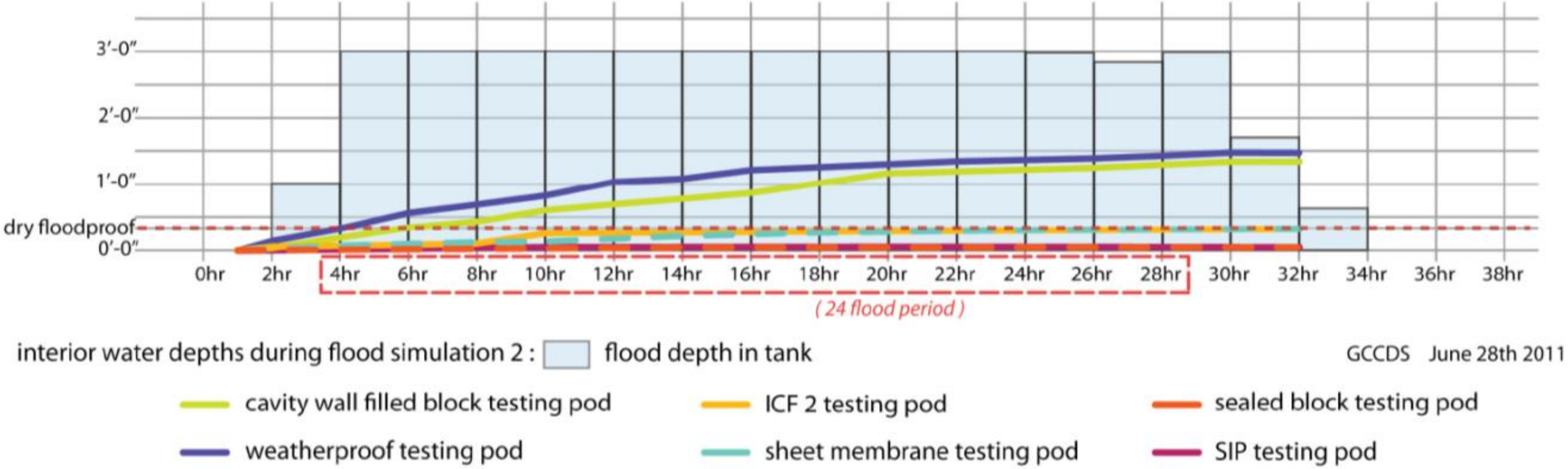
Flood test one



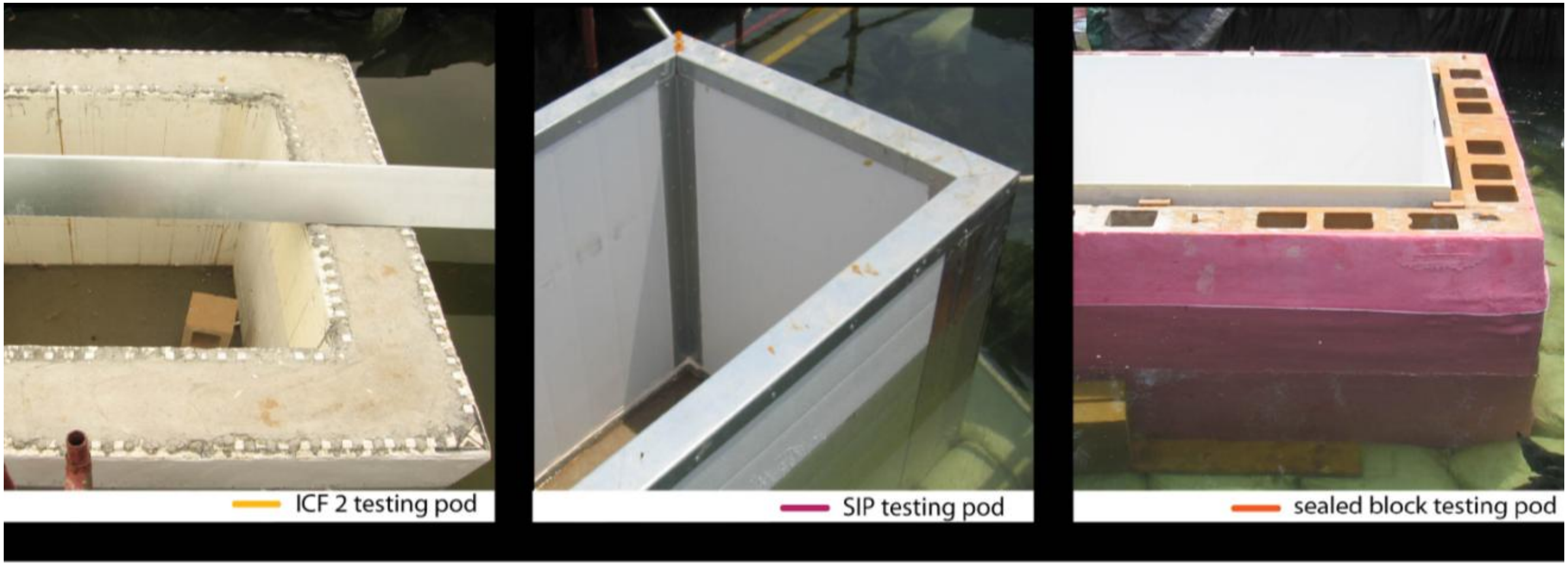


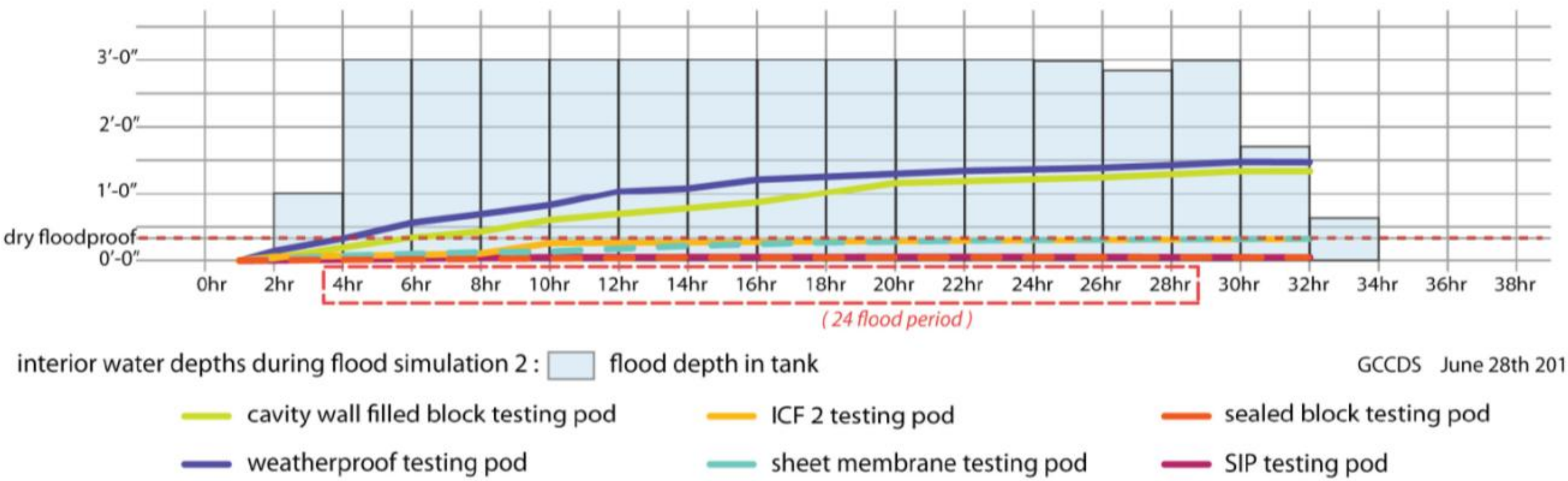
Flood test one





Flood test two





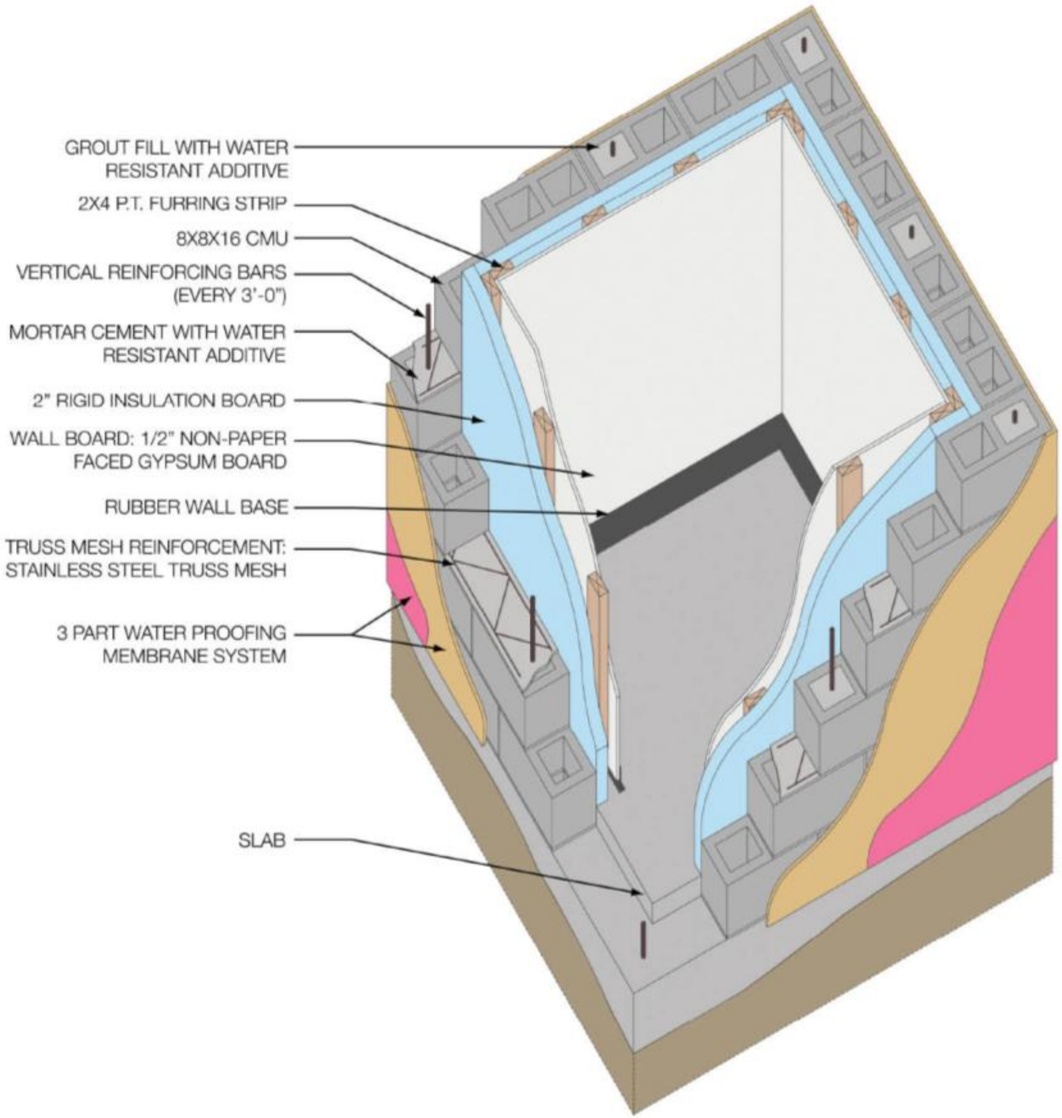
Flood test two

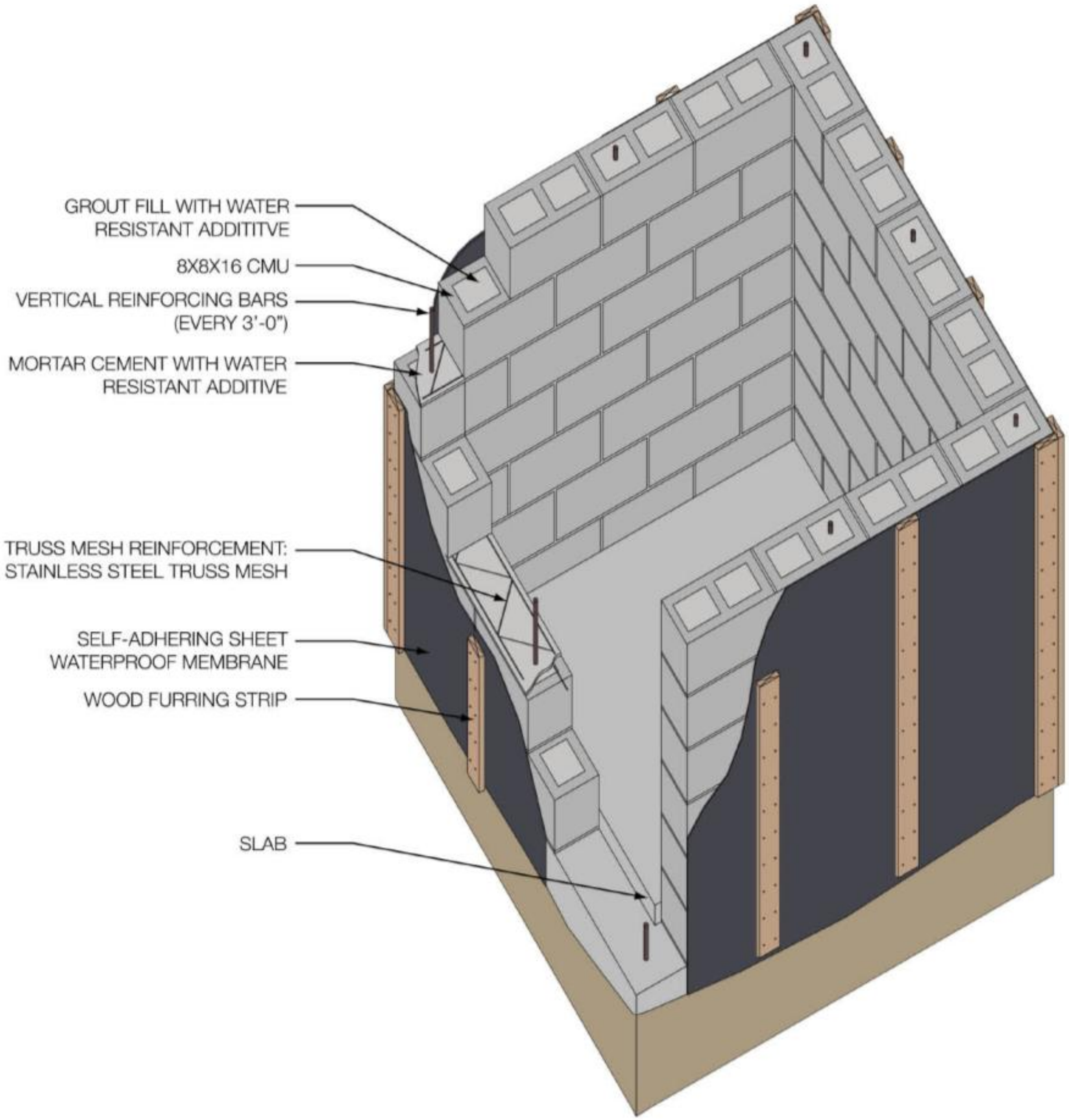
Sealed cmu

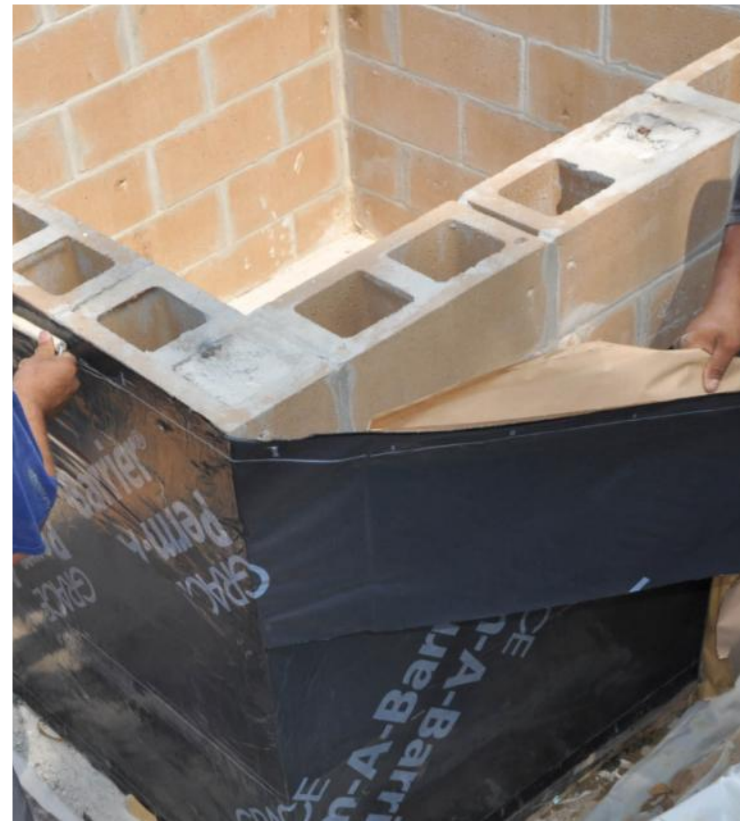
Sheet membrane

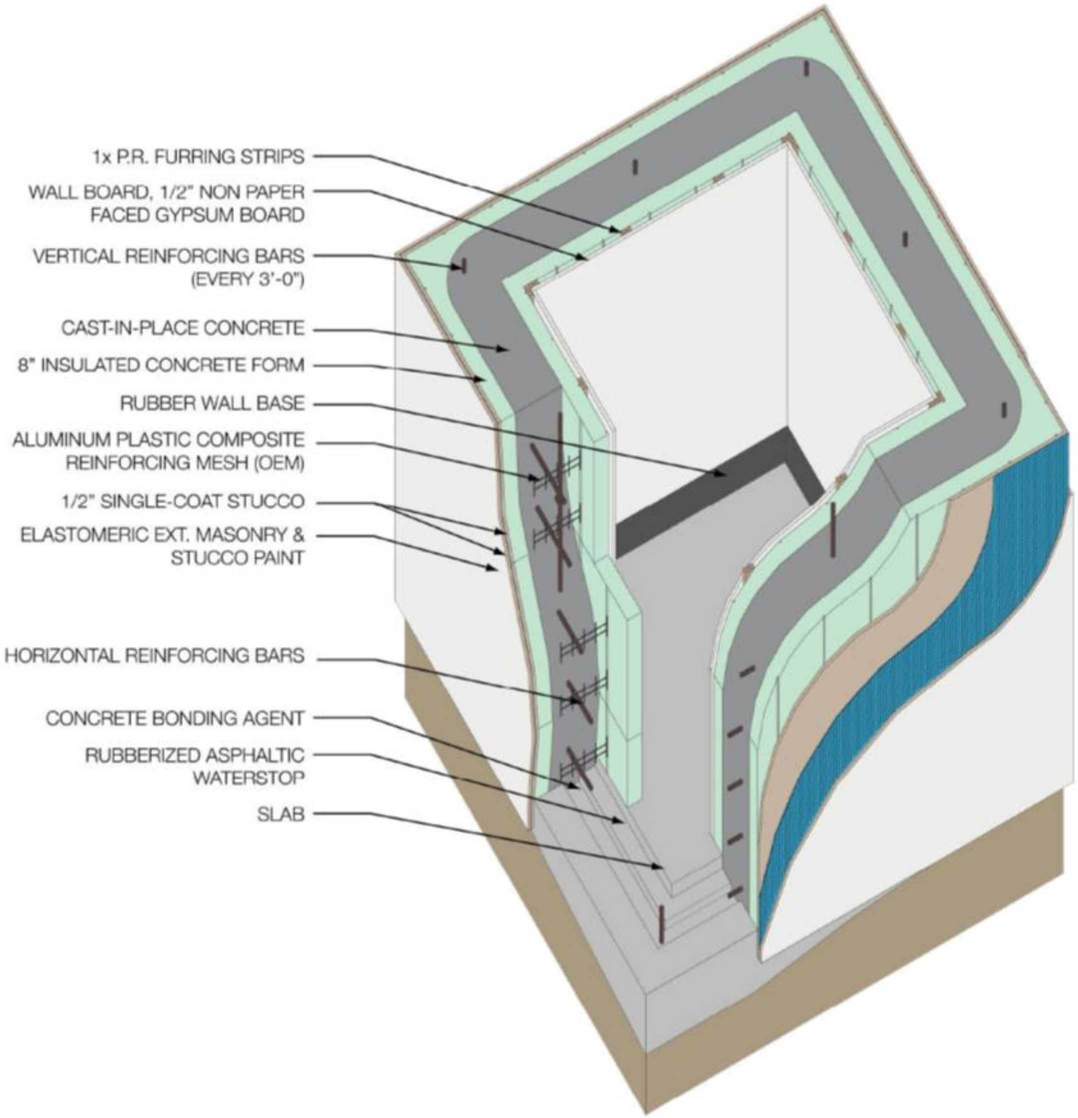
ICF

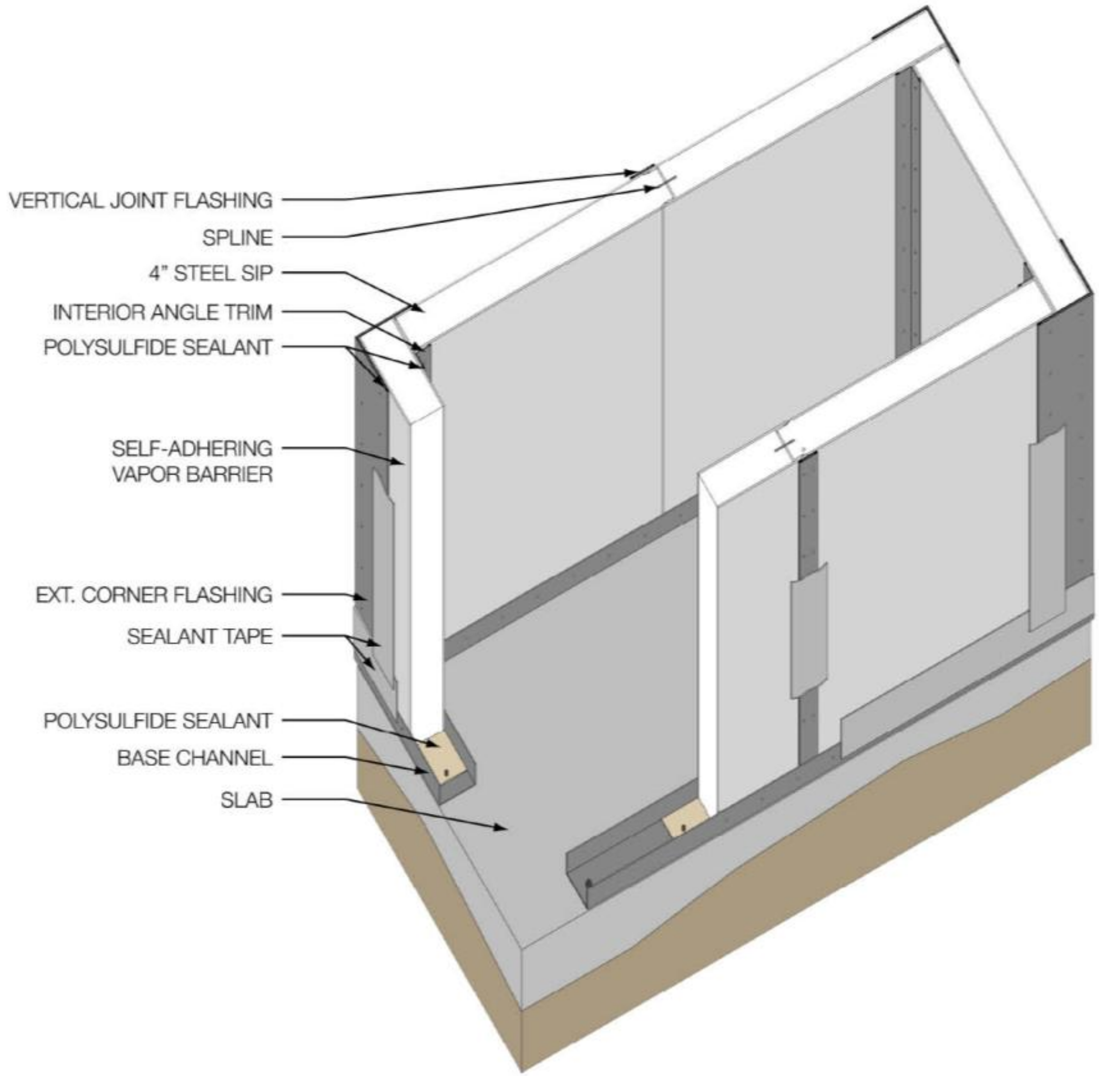
SIP


GROUT FILL WITH WATER
RESISTANT ADDITIVE
2X4 P.T. FURRING STRIP
8X8X16 CMU
VERTICAL REINFORCING BARS
(EVERY 3'-0")
MORTAR CEMENT WITH WATER
RESISTANT ADDITIVE
2" RIGID INSULATION BOARD
WALL BOARD: 1/2" NON-PAPER
FACED GYPSUM BOARD
RUBBER WALL BASE
TRUSS MESH REINFORCEMENT:
STAINLESS STEEL TRUSS MESH
3 PART WATER PROOFING
MEMBRANE SYSTEM
SLAB


GROUT FILL WITH WATER
RESISTANT ADDITITVE
8X8X16 CMU
VERTICAL REINFORCING BARS
(EVERY 3'-0")
MORTAR CEMENT WITH WATER
RESISTANT ADDITIVE
TRUSS MESH REINFORCEMENT:
STAINLESS STEEL TRUSS MESH
SELF-ADHERING SHEET
WATERPROOF MEMBRANE
WOOD FURRING STRIP
SLAB




1x P.R. FURRING STRIPS
WALL BOARD, 1/2" NON PAPER FACED GYPSUM BOARD
VERTICAL REINFORCING BARS (EVERY 3'-0")
CAST-IN-PLACE CONCRETE
8" INSULATED CONCRETE FORM
RUBBER WALL BASE
ALUMINUM PLASTIC COMPOSITE REINFORCING MESH (OEM)
1/2" SINGLE-COAT STUCCO
ELASTOMERIC EXT. MASONRY & STUCCO PAINT
HORIZONTAL REINFORCING BARS
CONCRETE BONDING AGENT
RUBBERIZED ASPHALTIC WATERSTOP
SLAB


VERTICAL JOINT FLASHING
SPLINE
4" STEEL SIP
INTERIOR ANGLE TRIM
POLYSULFIDE SEALANT
SELF-ADHERING VAPOR BARRIER
EXT. CORNER FLASHING
SEALANT TAPE
POLYSULFIDE SEALANT
BASE CHANNEL
SLAB

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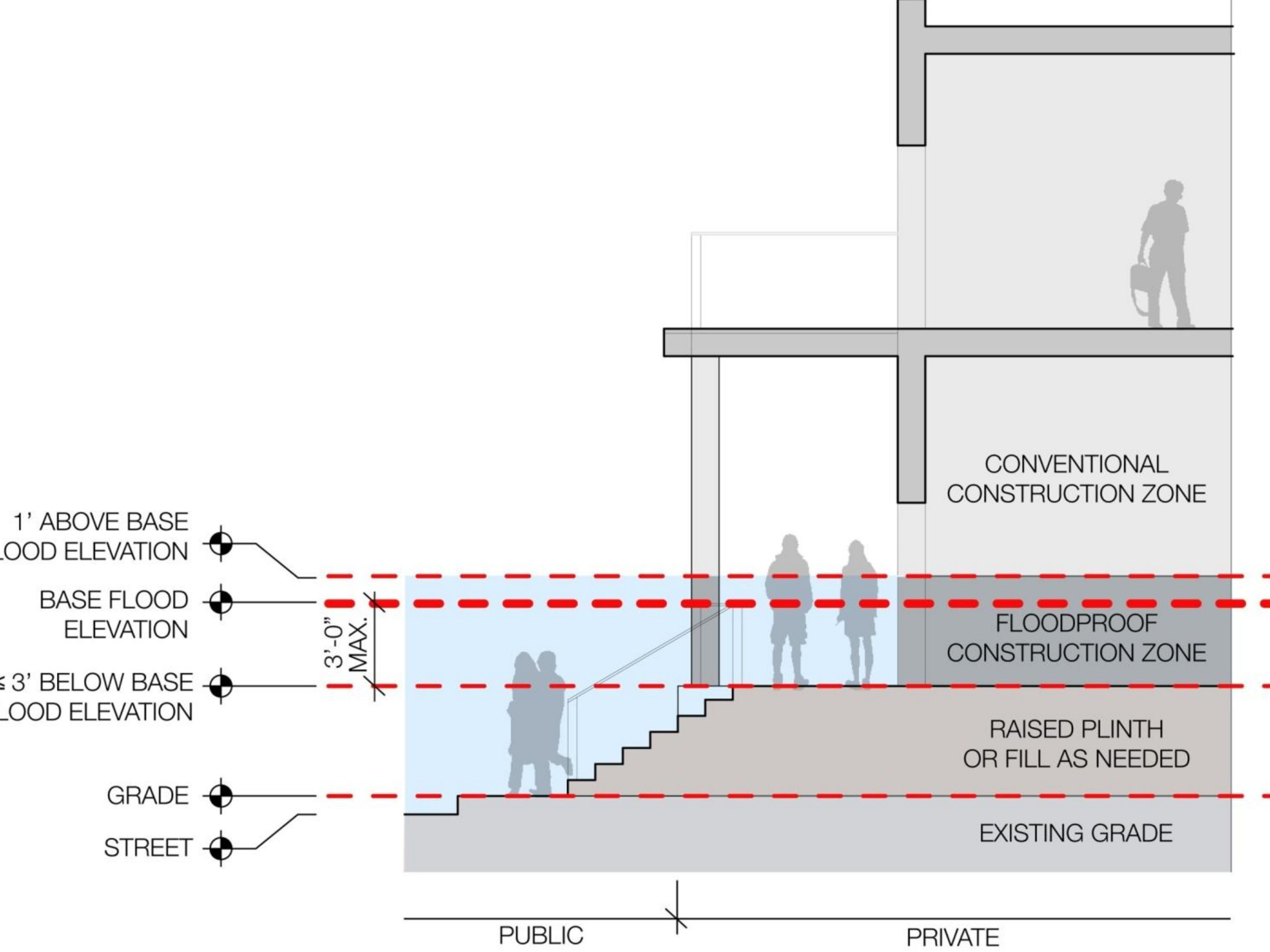
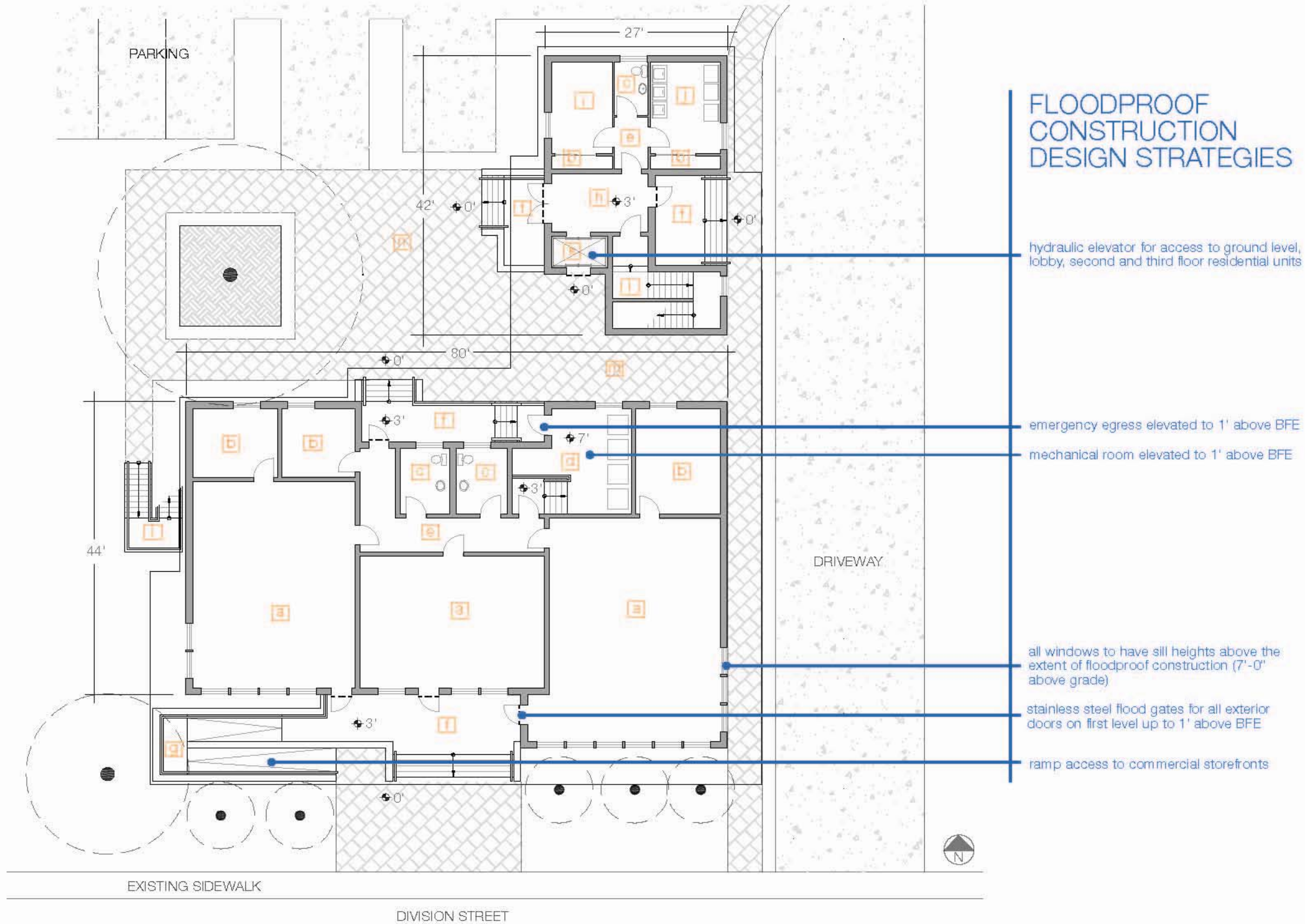

1' ABOVE BASE
LOOD ELEVATION
BASE FLOOD
ELEVATION
≤ 3' BELOW BASE
LOOD ELEVATION
GRADE
STREET
3'-0" MAX.
CONVENTIONAL
CONSTRUCTION ZONE
FLOODPROOF
CONSTRUCTION ZONE
RAISED PLINTH
OR FILL AS NEEDED
EXISTING GRADE
PUBLIC
PRIVATE

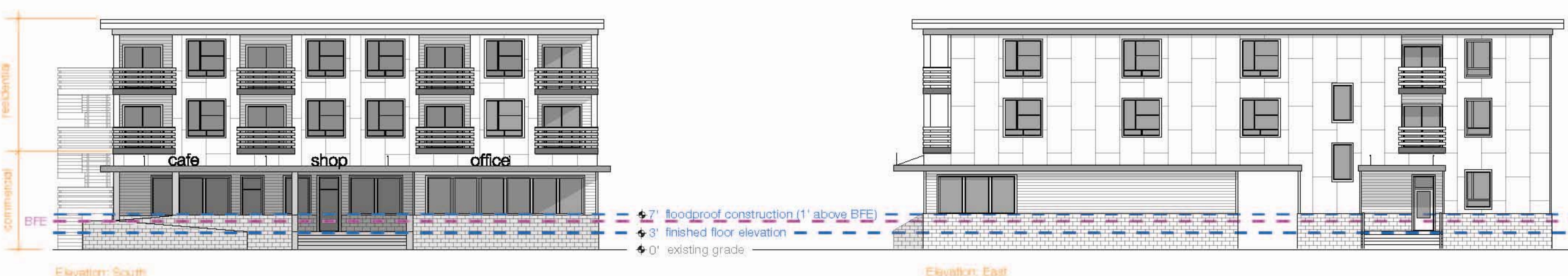
MIXED-USE BUILDING

Plan: Level 1

- a commercial space
- b storage
- c restroom
- d mechanical room
- e hallway
- f covered entry
- g ramp
- h lobby
- i leasing office
- j laundry room
- k elevator
- l stairwell
- m breezeway
- n courtyard

FLOODPROOF CONSTRUCTION DESIGN STRATEGIES





Research Conclusions

Because flood-proof construction is only feasible for up to three feet its application may require site and building designs that elevate the floor level.

Flood-proof construction is possible with a variety of wall systems, but requires more than ordinary supervision because the failures typically occur at joints, such as the joint between the slab and the bottom of the wall.

Flood-proof construction website and blog

www.gccds.org