

# (RE)DEFINING THE EDGE

FRAGILE: PLEASE BEND!

RE-THINKING THE URBAN FORM OF COASTAL RESILIENCE

ESTHER TRIANA

MASTER THESIS PROJECT - SPRING 2019

RE-THINKING THE URBAN FORM OF COASTAL RESILIENCE

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FLORIDA INTERNATIONAL UNIVERSITY

DATE: APRIL 19, 2019

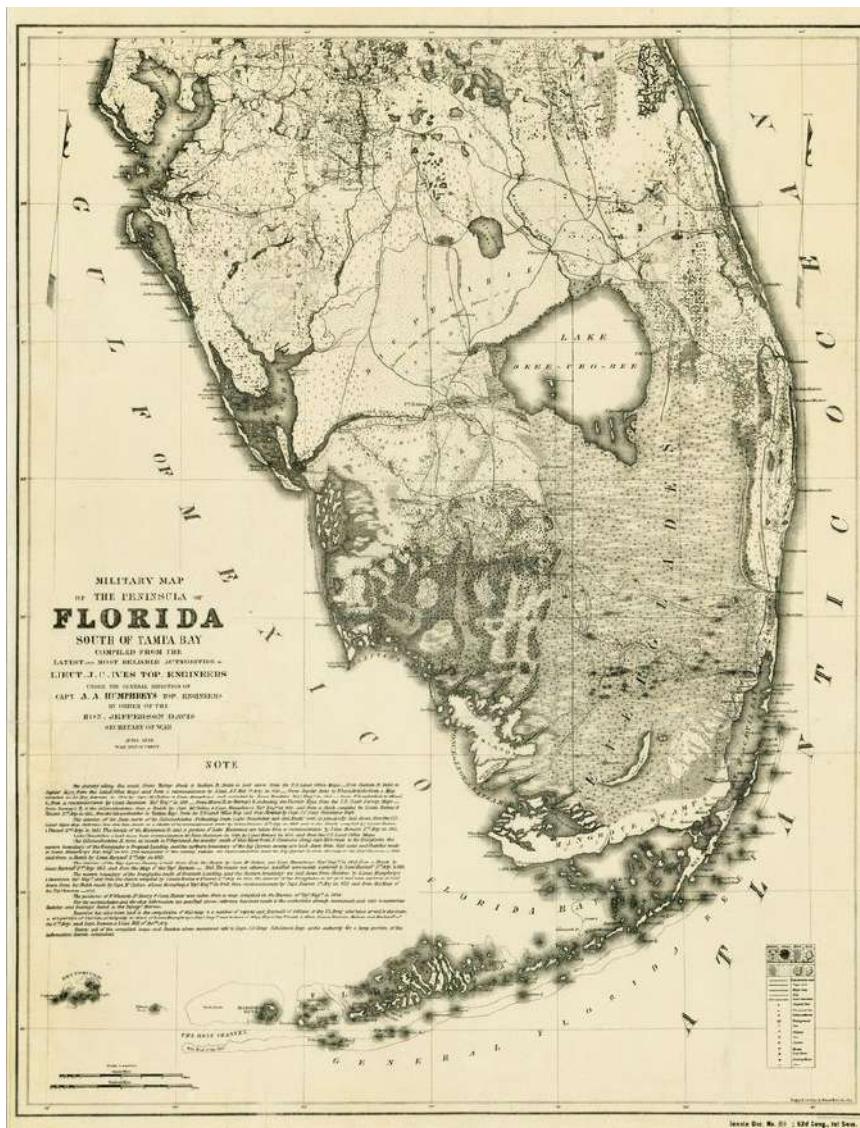
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## ACKNOWLEDGEMENTS

I WOULD LIKE TO THANK MY FAMILY AND FRIENDS FOR SUPPORTING AND ENCOURAGING ME THROUGHOUT THIS ACADEMIC CAREER. I WOULD ALSO LIKE TO EXPRESS MY SINCEREST GRATITUDE TO MY THESIS ADVISOR, MARILYS NEPOMECHIE FOR THE CONTINUOUS GUIDANCE AND SUPPORT THROUGH THE WHOLE PROCESS OF MY WORK. LASTLY, I WOULD LIKE TO THANK MY CLASSMATES, AND PROFESSORS AT FIU, FOR THEIR CRITIQUES AND HELPFUL FEEDBACK.

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**Barry Lawrence Ruderman** - The Peninsula of Florida South of Tampa Bay-1856  
Cred: Google

# 1. THESIS STATEMENT

GIVEN ITS POROUS GEOLOGY, MIAMI IS PARTICULARLY VULNERABLE TO THE EFFECTS OF SEA LEVEL RISE. WITH RISING WATERS ABLE TO INVADE FROM ALL SIDES, THE CITY'S CHALLENGES QUICKLY TEETER BETWEEN ADAPTIVE ARCHITECTURE AND INEVITABLE OCEAN RISE. SEA LEVEL RISE WILL EVENTUALLY LEAVE CERTAIN PARTS ON THE LAND INHABITABLE, IN TURN CAUSING WIDE SPREAD DISPLACEMENT.

IN ORDER TO RESPOND TO SEA LEVEL RISE, MIAMI'S ONLY OPTION WOULD BE TO REVAMP ITS ZONING AND LAND USE ON HIGHER ELEVATED GROUND TO BE ABLE TO ACCOMMODATE FOR THE NEW EDGE. IN THE PRIORITY AREAS, WHERE SEA LEVEL RISE IMPACT MOST, HIGH DENSITY BUILDINGS EXIST. MEANWHILE, LOW DENSITY BUILDINGS RESIDE IN AREAS THAT ARE LEAST IMPACTED BY SEA LEVEL RISE. IF AREAS IMPACTED THE LEAST WOULD BECOME REZONED FOR HIGH DENSITY BUILDINGS, THIS WOULD INCENTIVIZE BUILDING VERTICALLY TO ACCOMMODATE FOR A DENSER COMMUNITY.

HOW CAN THE CITY BE REORGANIZED, DENSIFIED, AND ARRANGED TO ACHIEVE A MUCH MORE SUSTAINABLE CITY?

HOW CAN INFRASTRUCTURES AND COMMUNITIES RESPOND TO THE NEW EDGE?



**Florida Sea Level Rise**

Cred: Climate Central

## 2. SEMINAR RESEARCH

SEMINAR CONSISTED OF A STUDY OF A SELECTED AREA THAT WOULD BE AFFECTED BY SEA LEVEL RISE. THE AREA I SELECTED WAS HOUSTON AND THE RESEARCH CONSISTED OF A SERIES OF THOROUGH MAPPING EXERCISES THAT EXPOSED THE PROBLEMS THROUGH ITS BUILDING TYPOLOGY, ZONING AND IF THE CITY HAS ANY FUTURE PLANS FOR RESILIENCE.

FROM WHAT WE ACQUIRED IN OUR RESEARCH WHEN THEY MOVED TO MIAMI AND SELECTED AN AREA WHICH WE COULD USE ANY OF THE FINDINGS WERE FOUND IN OUR SELECTED CITIES IN WHICH WE WOULD HAVE TO PROPOSE NEW ZONING AND A NEW BUILDING TYPOLOGY WHICH CAN RESPOND TO THE EFFECTS OF SEA LEVEL RISE.



**Houston Sea Level Rise**  
Cred: Texas Climate News

# Houston

## Mapping Liminality

Fall 2018 Ex 01

### 01 Houston

#### Metropolis Scale

Houston is a large metropolis with a population of 2.3 million. Located in Southeast Texas near Galveston Bay and the Gulf of Mexico, it is in Harris County and the principal city of the Greater Houston Metropolitan Area.

Houston's climate is classified as humid subtropical. The city endures very hot, long, and humid summers, and mild winters. Houston has an air pollution problem and is ranked among the most ozone-polluted cities in the United States.

### 02 Climate Change

#### Severe Problem

Flooding is Houston's biggest problem due to the flat wetlands and paved-over coastal prairie which drains slowly and easily floods. In the area, there are Bayous to help drain the area when it floods.



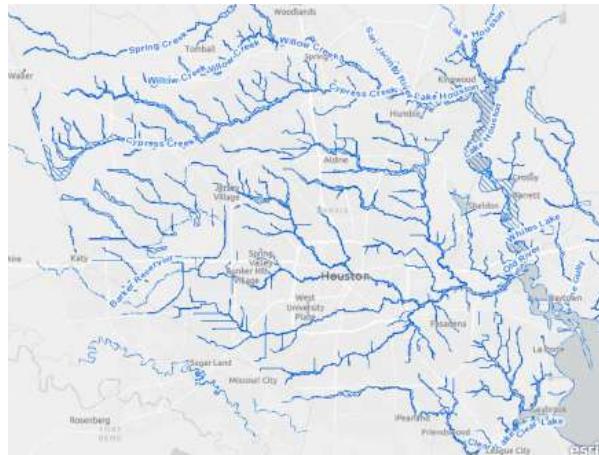
Left: The City of Houston, Right: Flooding caused by a hurricane in Houston.



Sea Level Rise Map at 6 FT



Houston Boundary



WaterwaysLine

Showing the boundaries of Houston and waterways

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**Studies show that Texas will experience the worst effects of climate change.**

### 03 La Porte



La Porte is a city in Harris County, within the Bay Area of the Houston Metropolitan area. The city falls on the Texas Coastline which is over 1,400 miles long. The climate in the area is hot, humid summers and mild winters.

# Houston

## Mapping Liminality

Fall 2018 Ex 01

**Average erosion rate of Texas coast is 4.1 feet per year.**



## 04 Sea Level

### Coast

During the last century, sea level has risen by 8 inches which cause the inundation of the Texas Coastline, as a result of sea level rise and subsidence. The current rate of erosion is now five times faster.



Top: Sea Level Rise in La Porte, Texas in 2100. Bottom: Sea Level Raise Section shown at a residential area and city

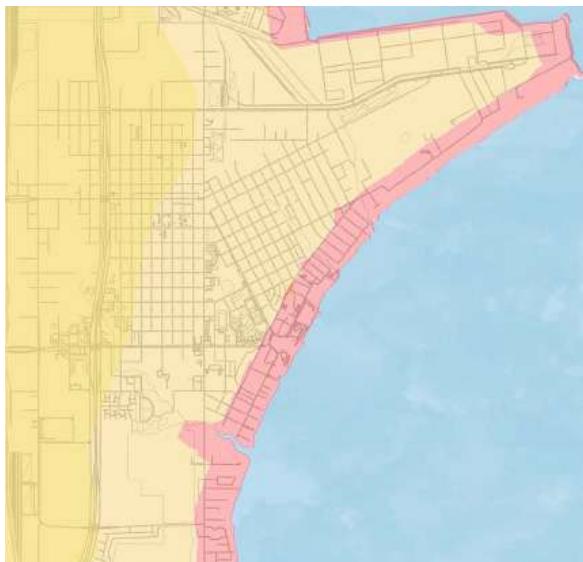


## 05 Current And Anticipated Climate



At Galveston Bay, Sea level is rising by 25 inches per century and will continue to rise by another 38 inches by 2100. There has been proposal responding to sea level, by building walls or raising the land but it would be too costly.

**Galveston is identified as having the most properties at risk of chronic inundation**



Strom Surge

- Category 1
- Category 2
- Category 3



La Porte Texas Flooded during Hurricane Harvey

Sea Level Rise



# Houston

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## Mapping Liminality 2

Fall 2018 Ex 02

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06

### Tropical Storm Allison & Hurricane Harvey

With Houston being located within Hurricane Alley, the city becomes much more vulnerable to the threat of rainfall that is brought by hurricanes.

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### Hurricane Allison

Tropical storm Allison devastated southeast Texas in June of 2001. It lasted long for a June storm which dumped torrential rainfall when over land. Houston received the worst flooding which caused tremendous damage, 30,000 became homeless after the storm flooded over 70,000 homes and destroyed 2,774 homes. Downtown was inundated with flooding that caused severe damages to hospitals and businesses.

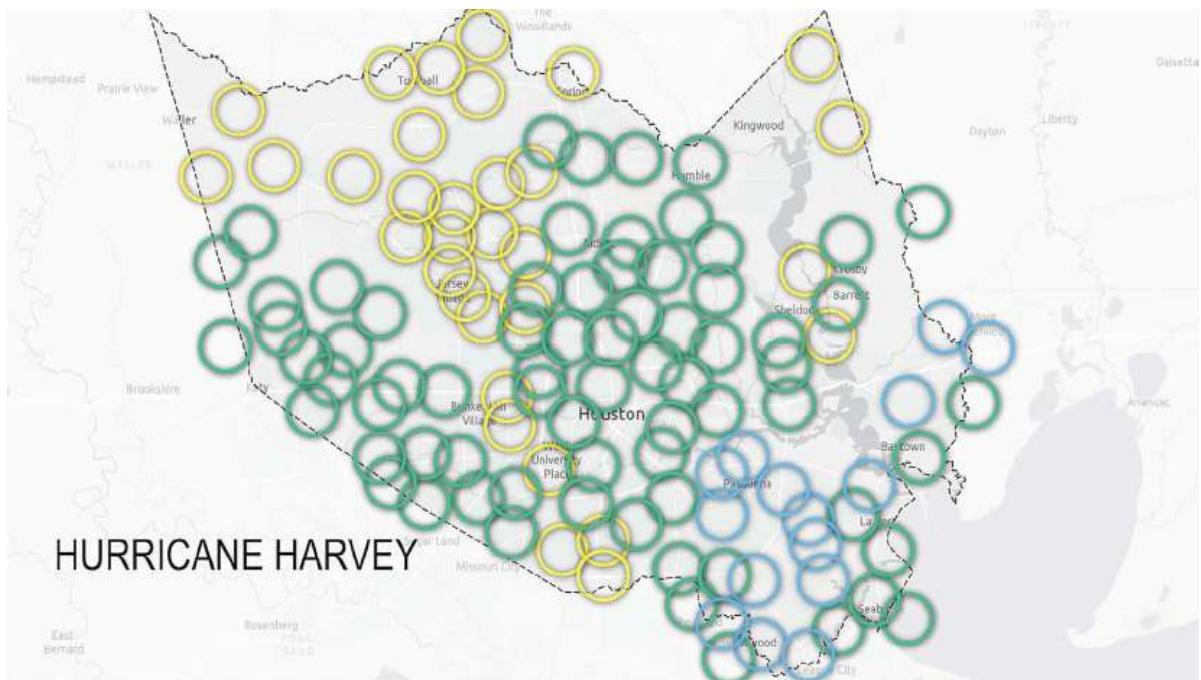
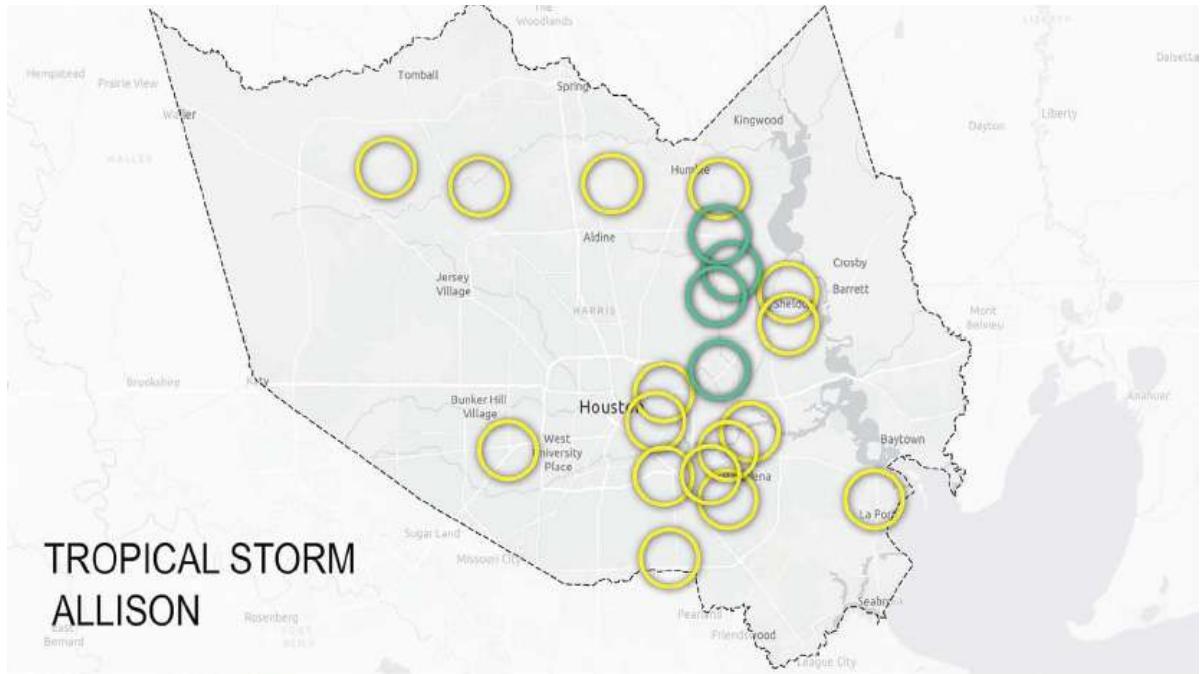
**Dropped heavy rainfall along its path, peaking 40 inches.**

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### Hurricane Allison

Hurricane Harvey made landfall in Houston Metropolitan area and Southeast Texas August 2017, which triggered catastrophic rainfall flooding. Thousands of homes were flooded which displaced more than 30,000 people.

**Dropped heavy rainfall along its path, peaking 60.58 inches.**



# Houston

## Mapping Liminality 2

Fall 2018 Ex 02

## 07 Critical Areas

These two areas were chosen because how they were affected throughout either Tropical Storm Allison or Hurricane Harvey:

1. West Houston/ Barker Reservoir
2. Downtown Houston



Barker Reservoir is a flood control structure which prevents downstream flooding of Buffalo Bayou. It operates in conjunction with the Addicks Reservoir to the northeast. During Hurricane Harvey, the maximum capacity for water storage was reached, Water then had to be released into the already flooded streets because it reached maximum capacity, this caused the residential areas behind the reservoir to flood heavily and a certain number of homes were damaged.

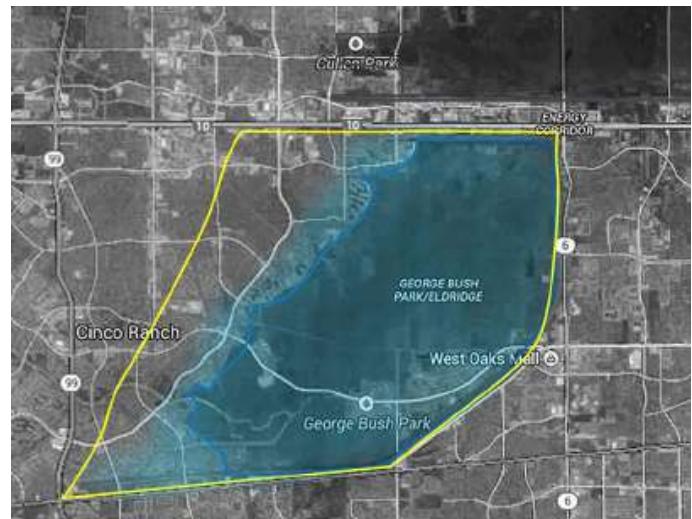


Existing Condition: Barker Reservoir

Existing Boundary



Predicted flooding for Barkers Reservoir



Flooding during Hurricane Harvey

# Houston

## Mapping Liminality

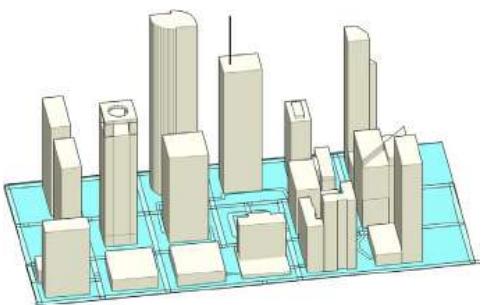
Fall 2018 Ex 01

### 09 Downtown

Downtown Houston is the largest business district in Houston. It contains Houston's civic center and is also a major public transportation hub.

The Houston tunnel system connects 95 city blocks below Houston's Streets. During Tropical Storm Allison, it sustained a large amount of flooding due to the fact that its prone to flooding.

After Allison, some of the buildings installed floodgates to prevent another occurrence from happening.



1-



2-



3-



Top & Middle Images: Flooding of the tunnel system during hurricane Allison. Bottom: Floodgates installed after Allison. Bottom: Shows Before and after Buffalo Bayou during a flood.



Existing Condition: Downtown  
Houston

Existing Water Edge



Land Use Diagram

# Houston

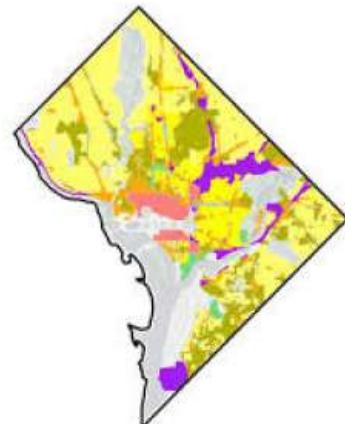
## Mapping Codes + Regulations

Fall 2018 Ex 04

Codes+Regulations

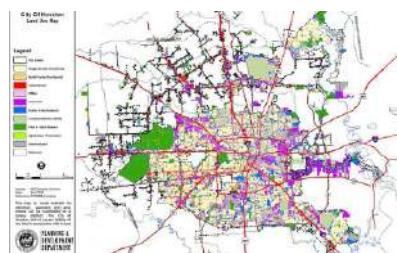
What Houston doesn't do:

Houston doesn't mandate single-use zoning



"Washington DC Zoning Map", dcoz.dc.gov/page/zoning-maps-district-columbia. Web. 14 Oct 2018.

The City of Houston doesn't mandate the separation of residential, commercial, and industrial developments



Houston Land use Map



— Zoning Diagram  
- - - Neighborhood



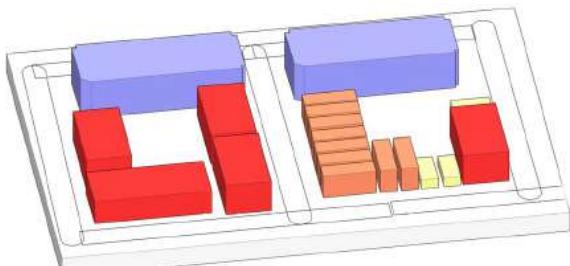
Land Use Diagram

Houston doesn't segregate residential developments



Midtown Neighborhood, DigitalGlobe 2012. <http://www.earth.google.com> [October, 14, 2018]

Houston doesn't mandate the separation of different building types.



- Multi-Family Residential
- Two-story Single Family
- Single Family Residential
- Mixed-use Housing

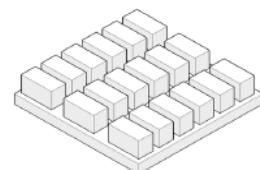
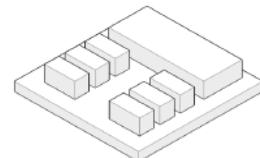
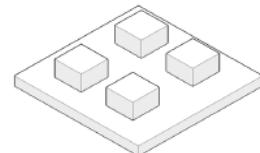
Residential Development Axon

Houston doesn't regulate density



Midtown Neighborhood, DigitalGlobe 2012. <http://www.earth.google.com>.

Houston doesn't restrict the number of units that can be built per acre.



Density Axons

# Houston

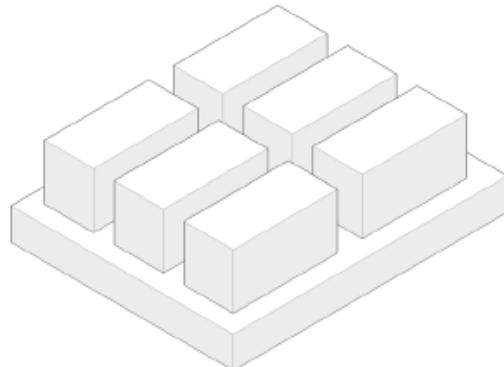
## Mapping Codes + Regulations

Fall 2018 Ex 04

Codes+Regulations

What Houston does do:

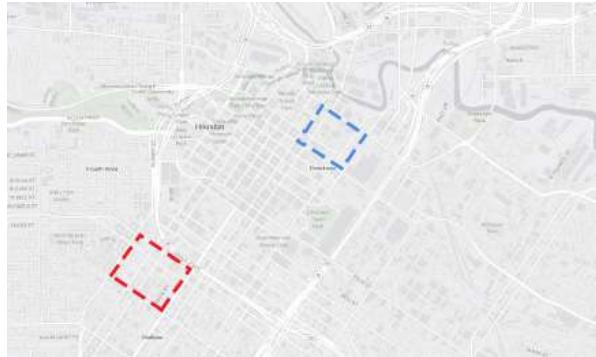
Houston does mandate minimum lot sizes



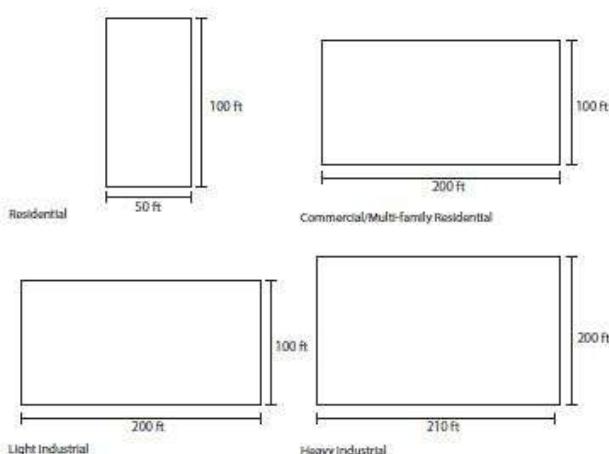
### 11 Zoning/Land use

The type of regulations Houston uses to regulate the development of the city.

The City of Houston does mandate lot sizing to be 50 ft wide and 100 ft in deep residential. This restriction does not apply to multi-family housing, commercial, industrial.

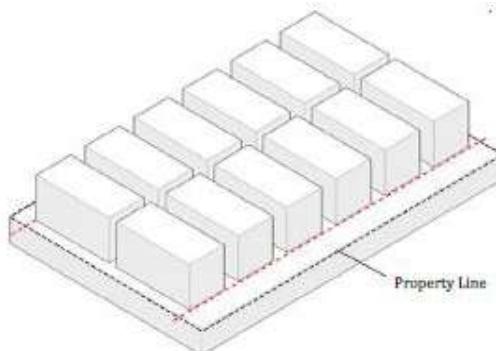


— Zoning Diagram  
- Neighborhood



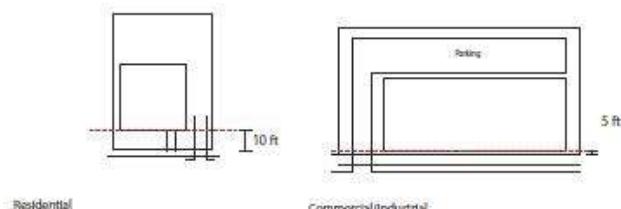
Lot Size Diagrams

Houston does mandate front setbacks



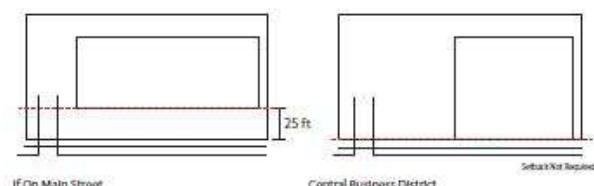
Axon Diagram Showing Front

For single family homes, the maximum setback is 25 ft. Commercial and industrial is 5 ft and any building within the central business district has no setbacks.



Residential

Commercial/Industrial



If On Main Street

Central Business District

Setback Diagrams Setback

Houston does mandate off street parking



Downtown Houston, , DigitalGlobe 2012. <http://www.earth.google.com> [October, 14, 2018]

Houston mandates off-street parking for every development.



Parking lots/Garage Diagrams

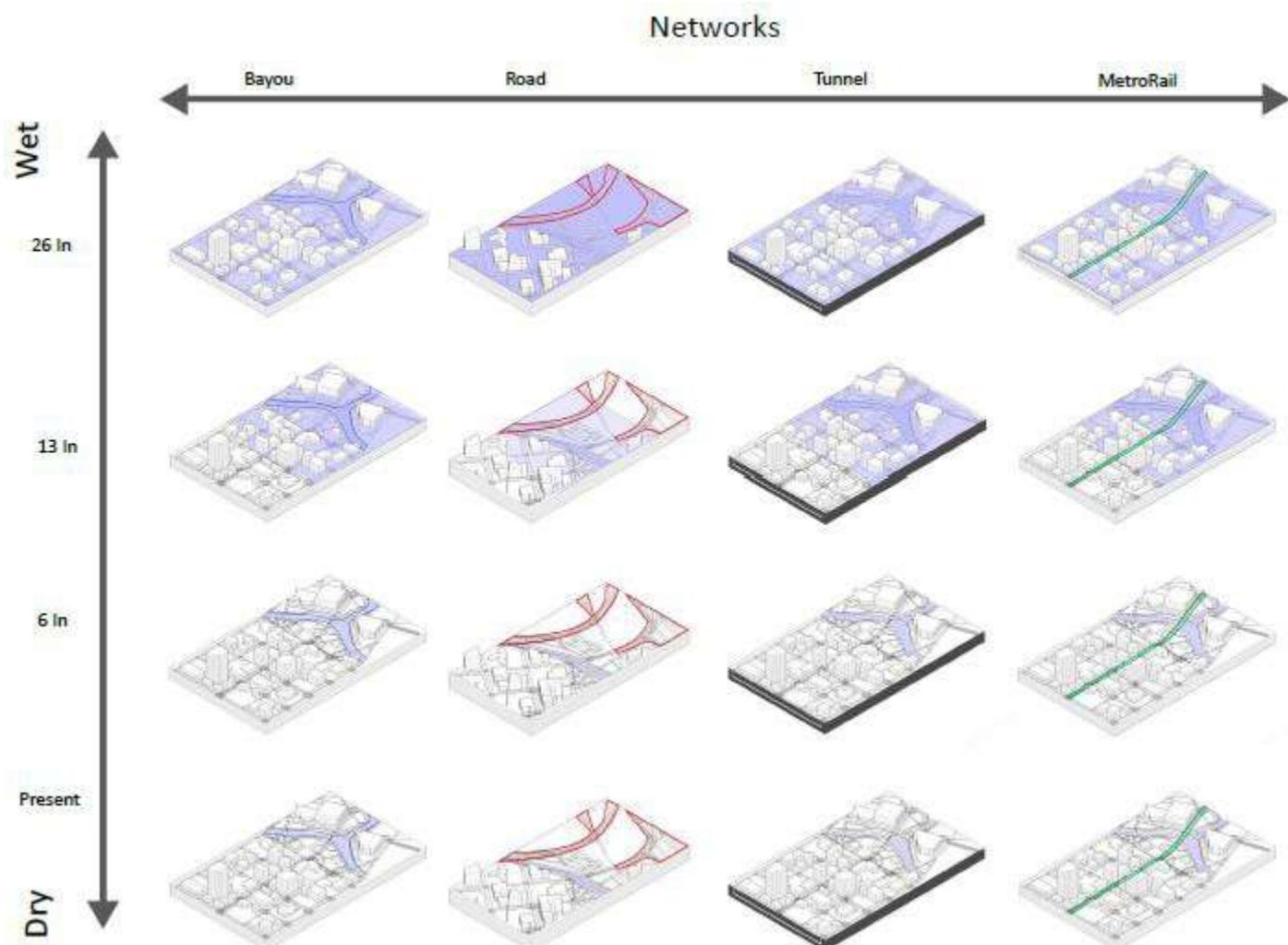
# Houston

## MAPPING LIMINALITY 3

Fall 2018 Ex 03

## 12 Matrices

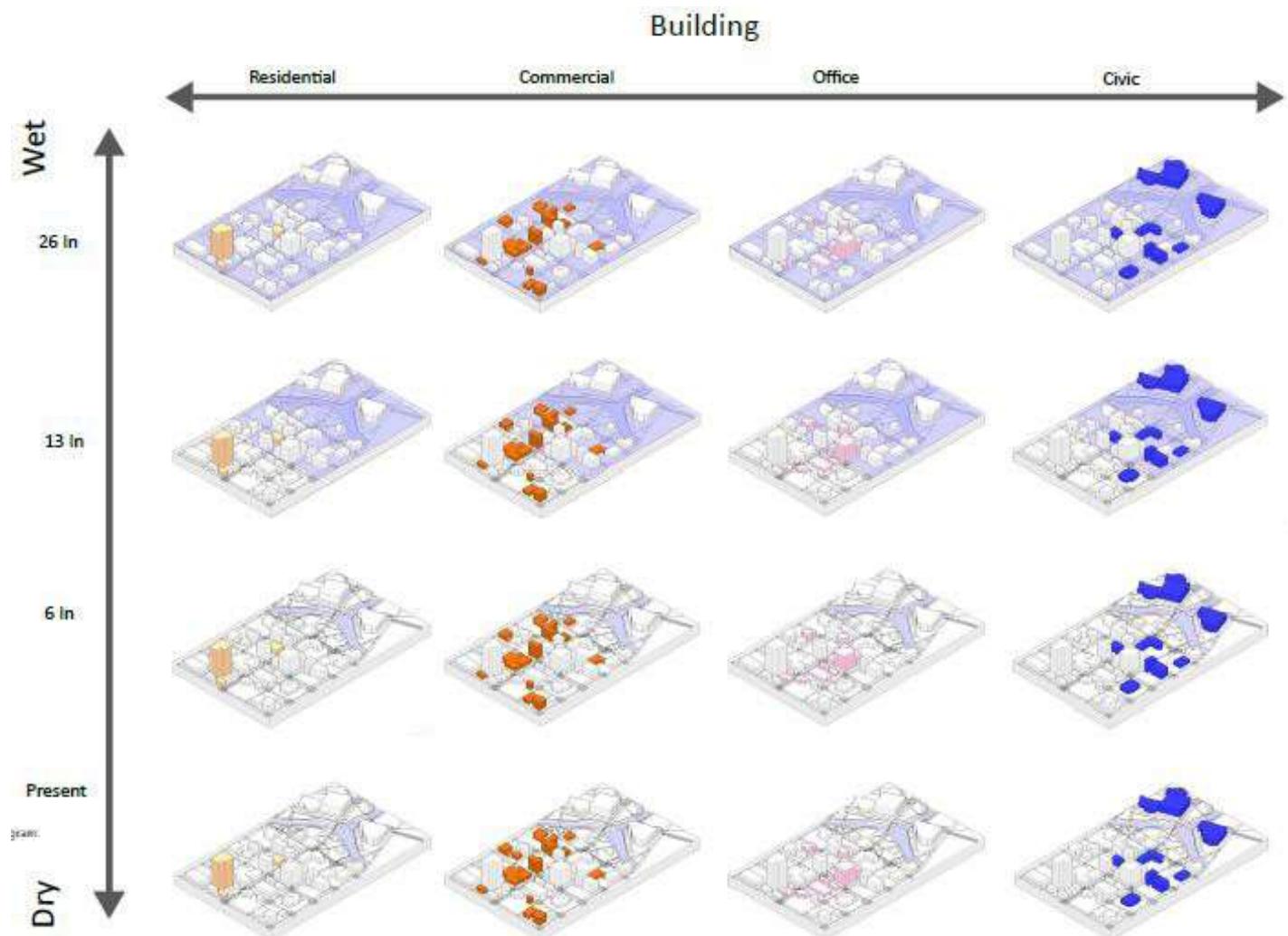
Houston contains different types of networks that run along and throughout downtown.



## 13 Matrices

Due to the variety of program found in downtown, you can find high-rises, mid-rises, and low rises coexisting with each other.

Land Use/Program:  
Yellow Residential  
Orange Commercial  
Pink Office  
Dark Blue Civic



# Houston

## Mapping Codes + Regulations

Fall 2018 Ex 04

### Resilience Projects

Houston Downtown Master Plan



"Downtown Masterplan", "<https://www.downtownhouston.org/news/article/downtown-future-almost-here/>". Web. 14 Oct 2018.

## 14 Resilience Projects

The future of Houston relies on it becoming a more resilient city against the impacts of climate change. Houston has already taken a proactive approach to the problem. These are some proposed.



"Downtown Masterplan", "<https://www.downtownhouston.org/news/article/downtown-future-almost-here/>". Web. 14 Oct 2018.

The project's important features are its five-mile long Green Loop, a band of parks and bike lanes that would wrap the downtown area and connect it with further-flung neighborhoods. North corner of downtown opens a large parcel of land that can be used as stormwater retention.

This downtown master plan was released after Hurricane Harvey and it focuses on disaster mitigation. Apart from increasing the number of green spaces, the proposal has set land for retention areas and shifting away from car-dominated urban planning.

## Resilience Projects



100 Resilient Cities



Adopt A Drain

Houston joined the 100 Resilient Cities organization as well as creating the Adopt A Drain Program. The program encourages residents, schools, and businesses to assume the responsibility of a nearby storm drain, committing to keeping it free from debris throughout the year.

### 3. URBAN ANALYSIS

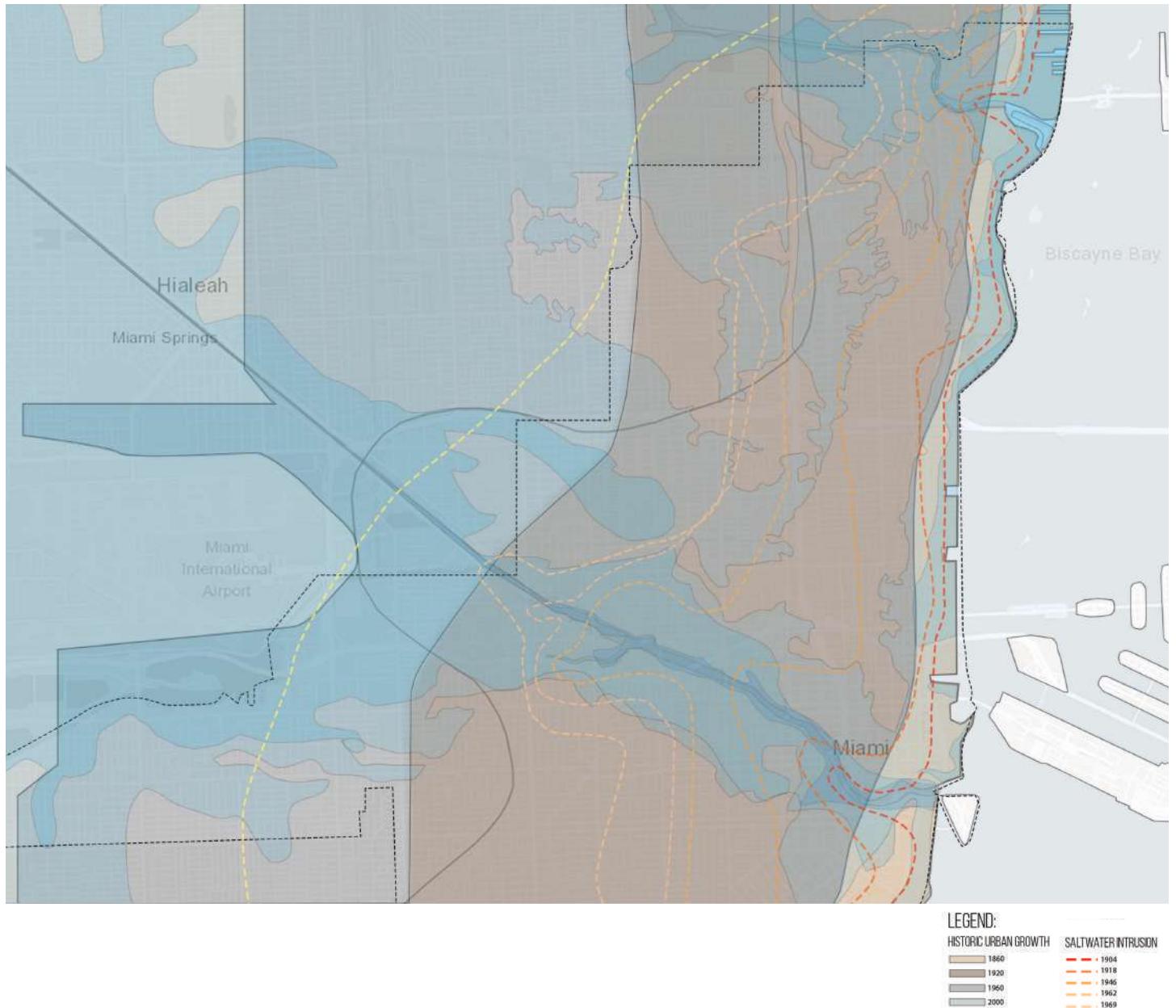
FROM WHAT WE ACQUIRED IN OUR RESEARCH DURING SEMINAR WE THEN MOVED TO MIAMI TO ANALYZED AND SELECT AN AREA WHICH WE COULD USE ANY OF THE FINDINGS WE FOUND IN OUR SELECTED CITIES. FROM THIS I CREATED A SERIES OF MAPPING AT AN URBAN SCALE SHOWING WHAT AREAS ARE AT HIGH RISK.

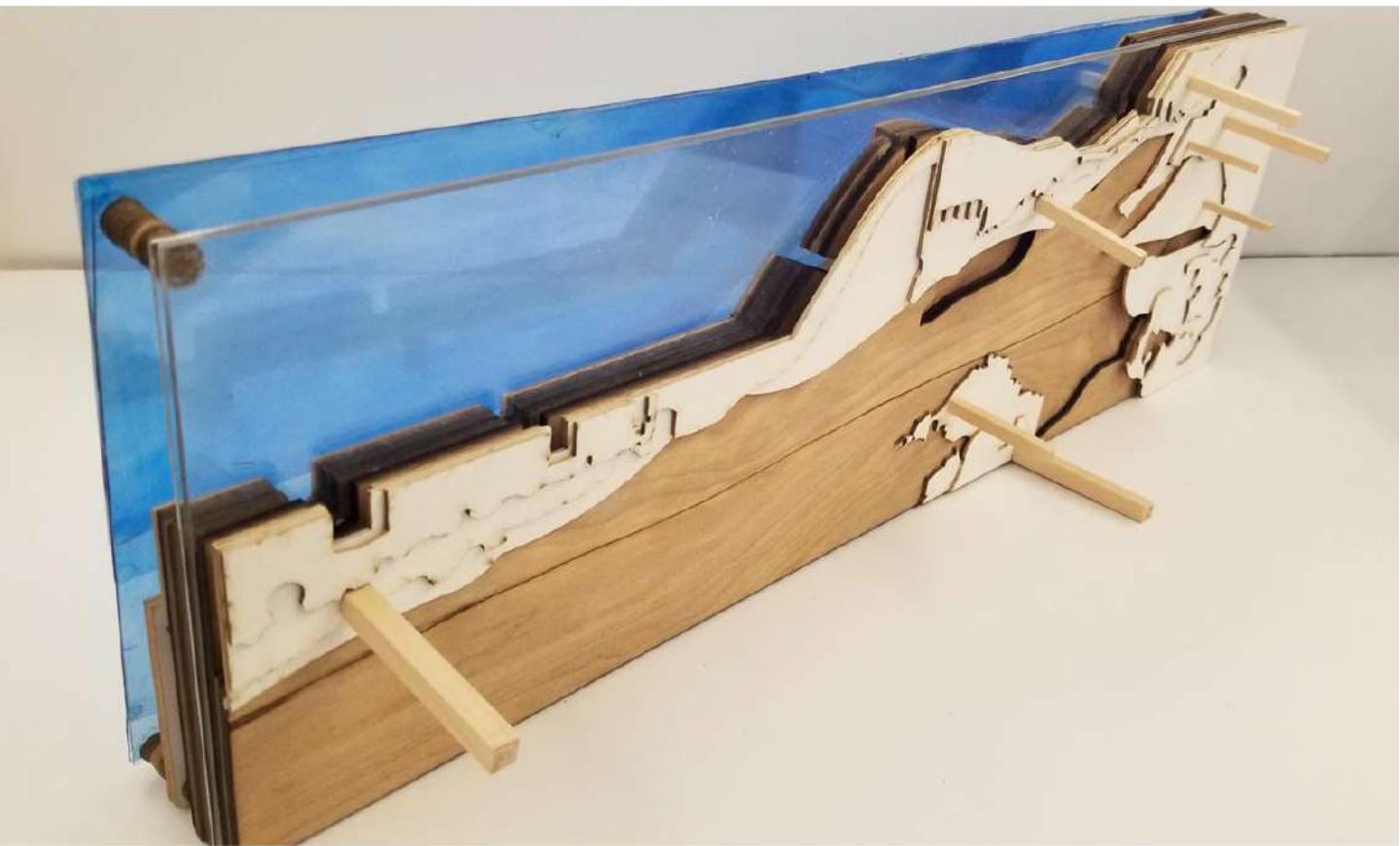


**City of Miami**

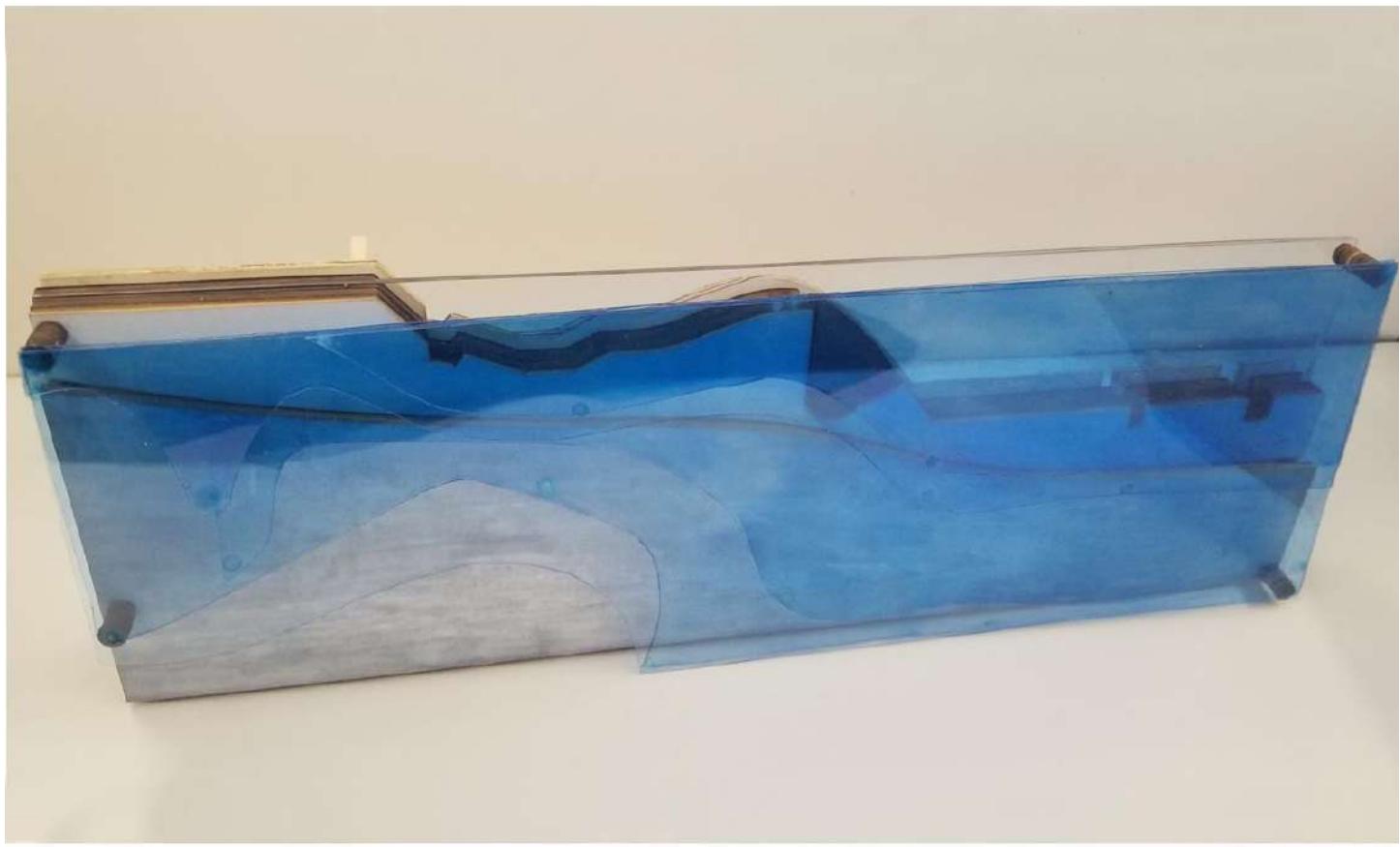
Cred: Miami Herald

# HISTORICAL EDGE



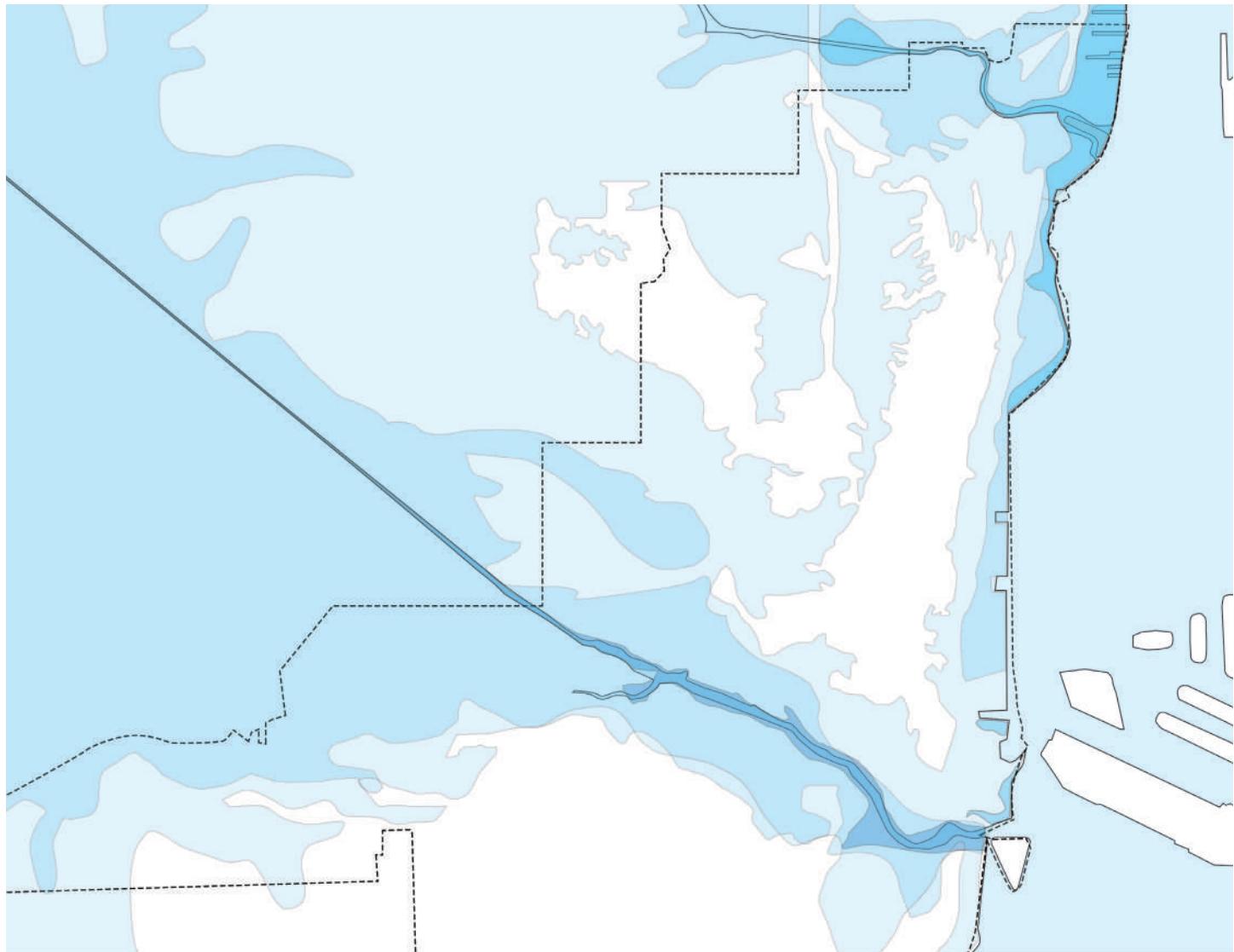


**Historical Analysis**  
Concept Model



**Historical Analysis**  
Concept Model

# SEA LEVEL RISE



## LEGEND:

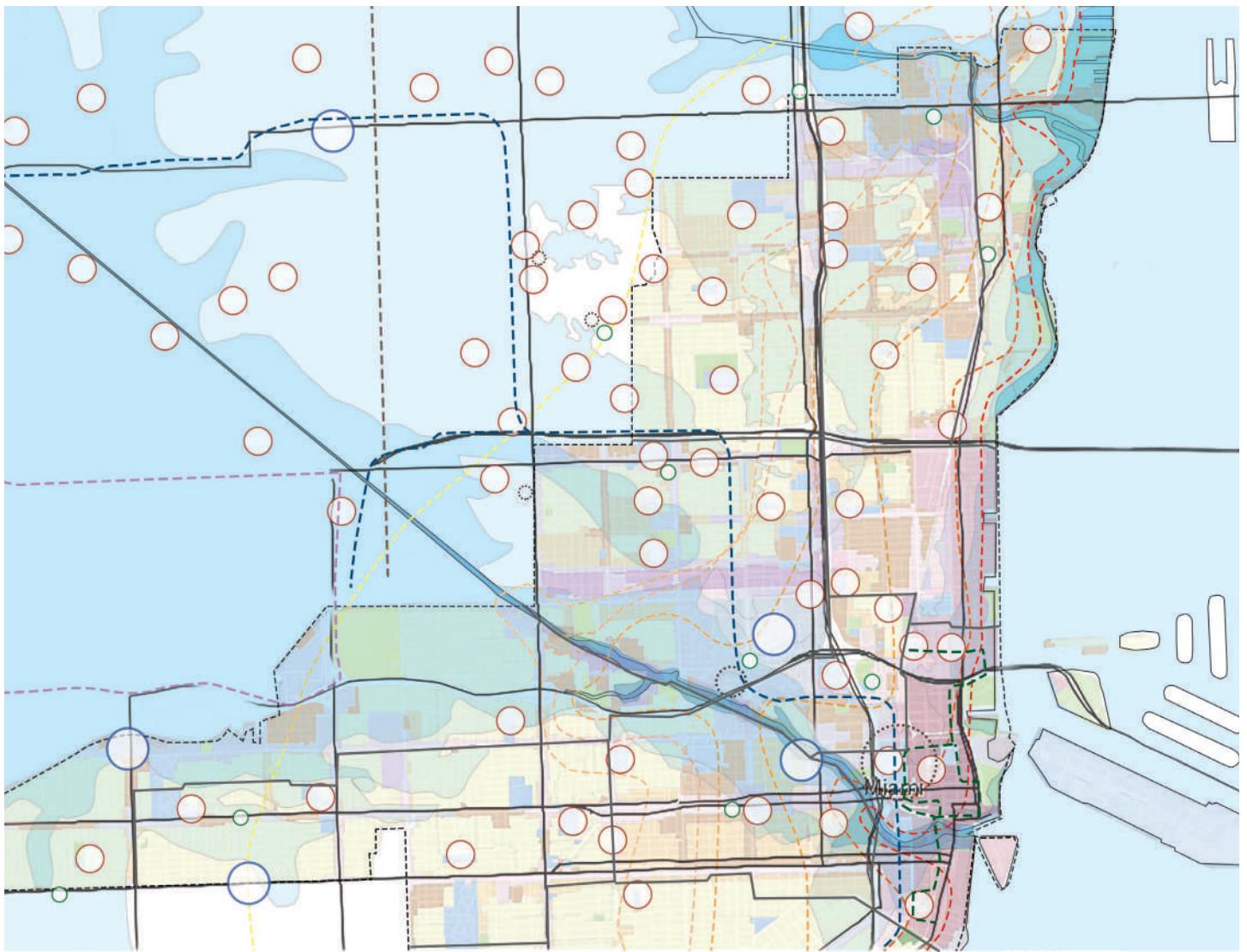
### ZONING

----- Miami 21

### SEA LEVEL RISE

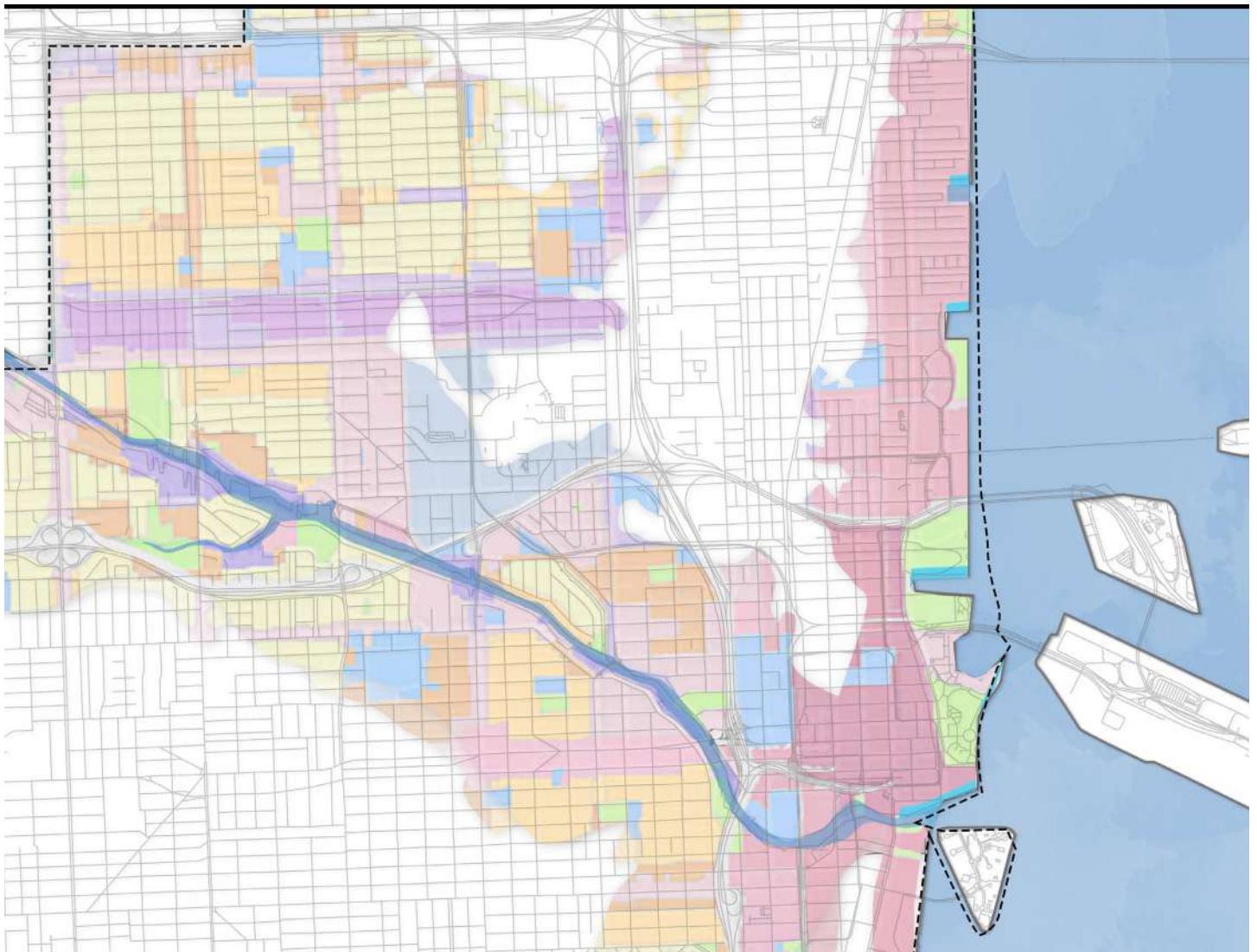
3 FT
6 FT
9 FT

# EXPOSED AREAS



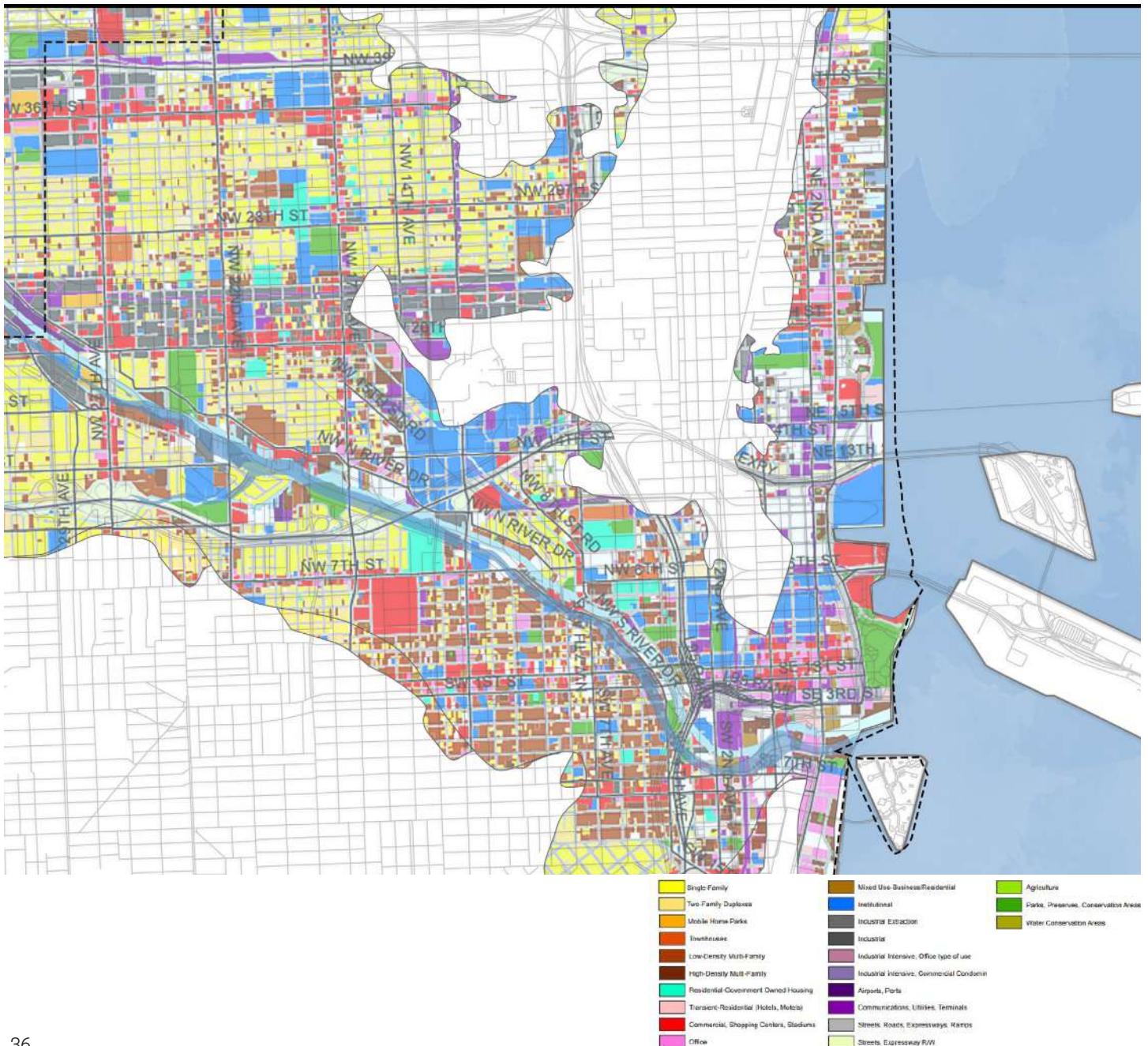
HARD INFRASTRUCTURE	
Major Roads	Miami 21
SEA LEVEL RISE	
3 FT	
6 FT	
9 FT	
SALTWATER INTRUSION	
1904	
1918	
1946	
1962	
1969	
1972	
1995	
SOFT INFRASTRUCTURE	
Public Schools	
Hospitals	
Libraries	
Civic	

# EXPOSED AREAS

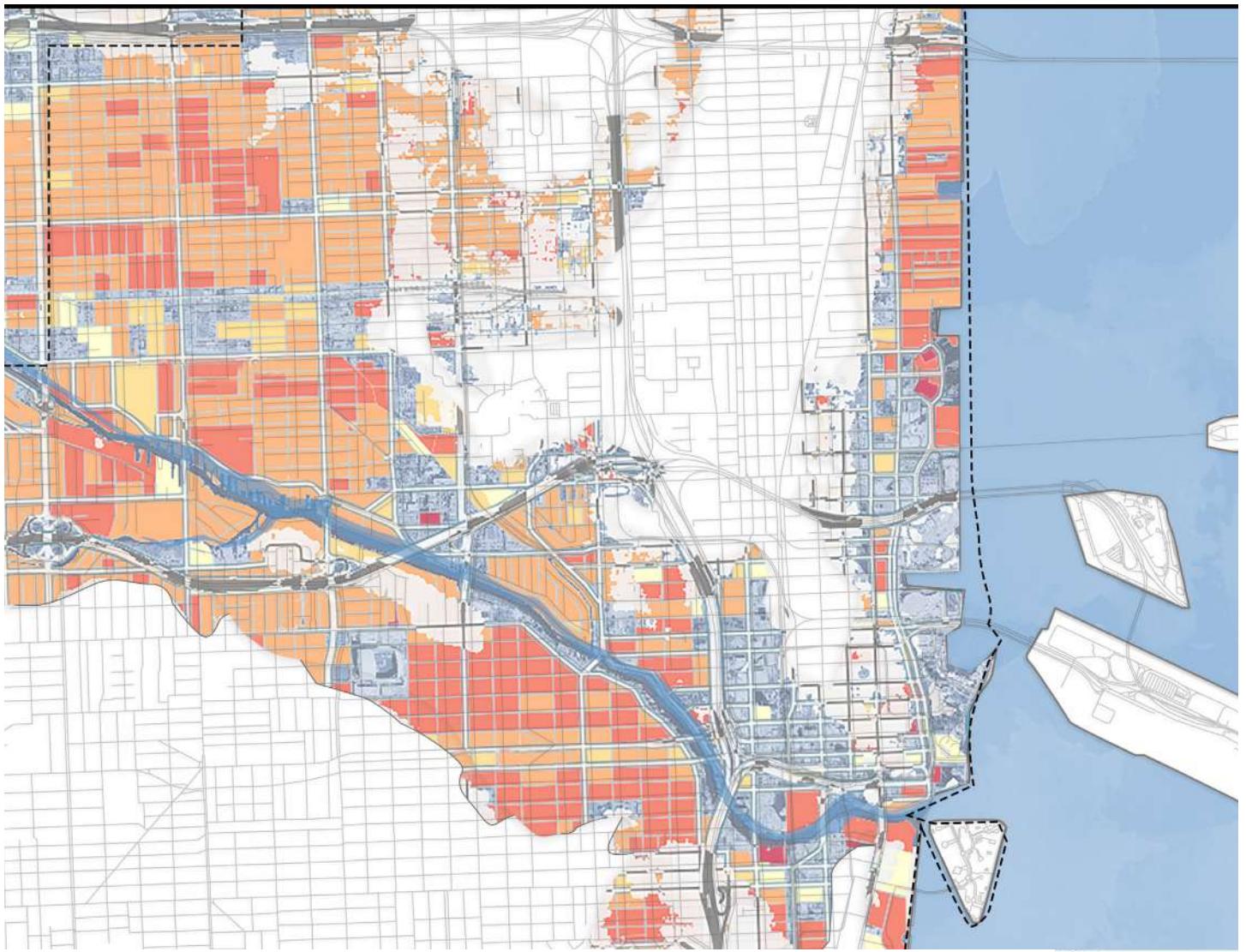


T1	NATURAL	T6-24° URBAN CORE	D1	WORK PLACE
T3	SUB-URBAN	T6-36° URBAN CORE	D2	INDUSTRIAL
T4	GENERAL URBAN	T6-48° URBAN CORE	D3	MARINE
T5	URBAN CENTER	T6-60° URBAN CORE	CS	CIVIC SPACE/PARKS
T6-8° URBAN CORE	T6-60° URBAN CORE	CI	CIVIC INSTITUTION	
T6-12° URBAN CORE	D1	WORK PLACE	CI-HD	CIVIC INSTITUTION - HEALTH DISTRICT
T6-24° URBAN CORE	D2	INDUSTRIAL		

# EXPOSED AREAS



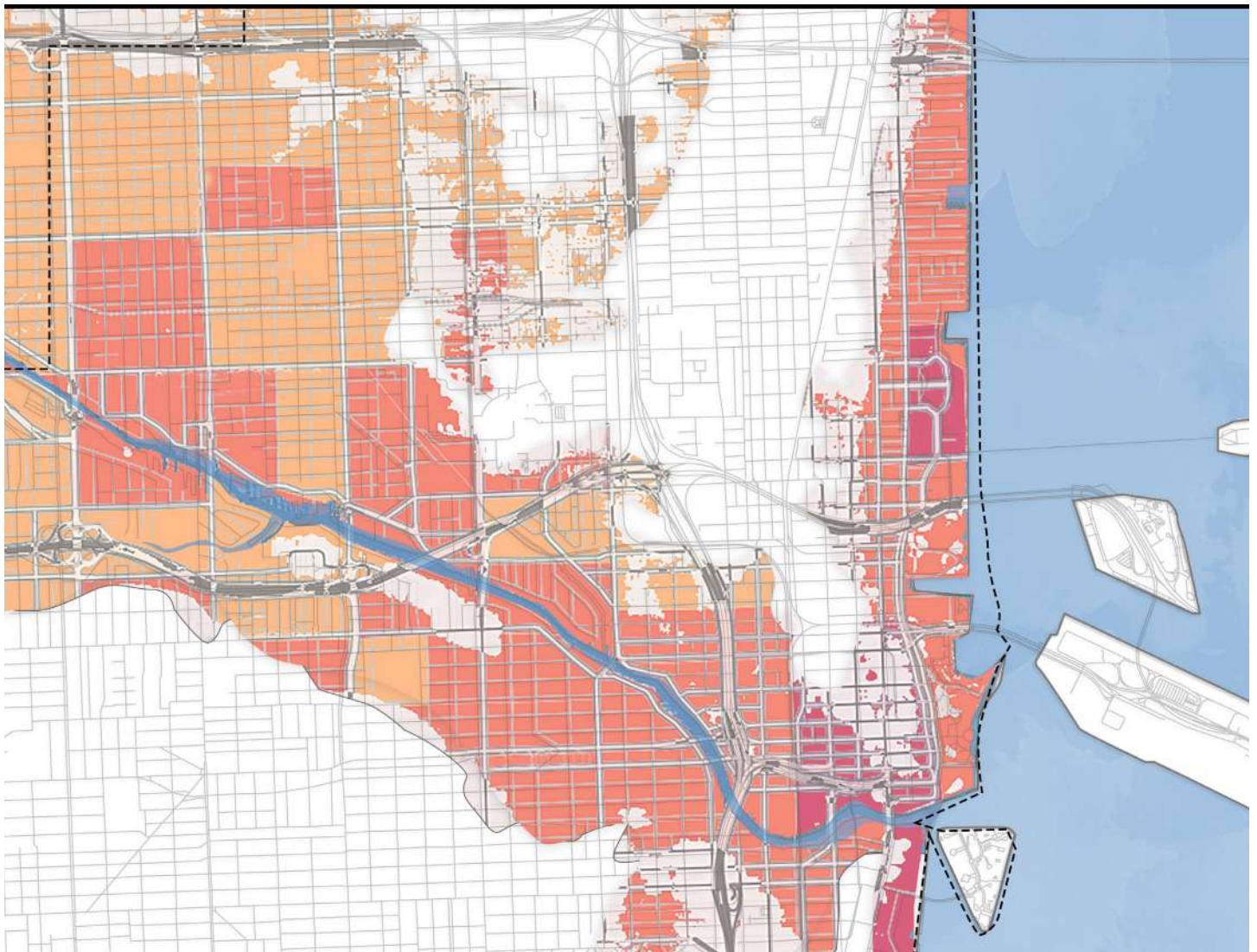
# EXPOSED AREAS



Cost

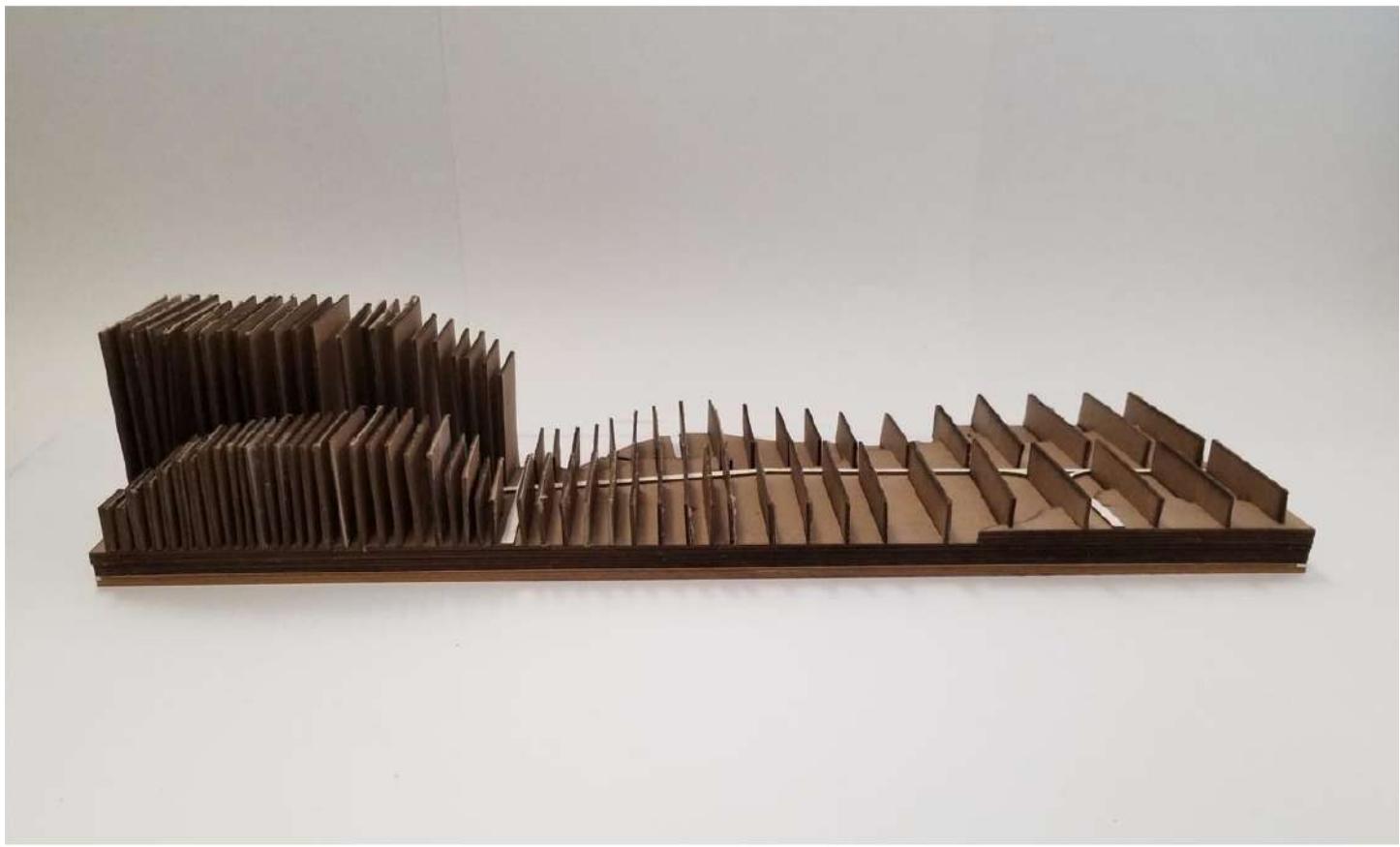
- >\$100 K
- \$100K-\$999K
- \$1M-\$10M
- \$10M-\$100M
- <100M

# EXPOSED AREAS



People Per Square Mile

- >100
- 100-999
- 1000-9,999
- 10,000-99,999
- <100,000



**Building Density Along The Coast**

Concept Model



**Building Density Along The Coast**

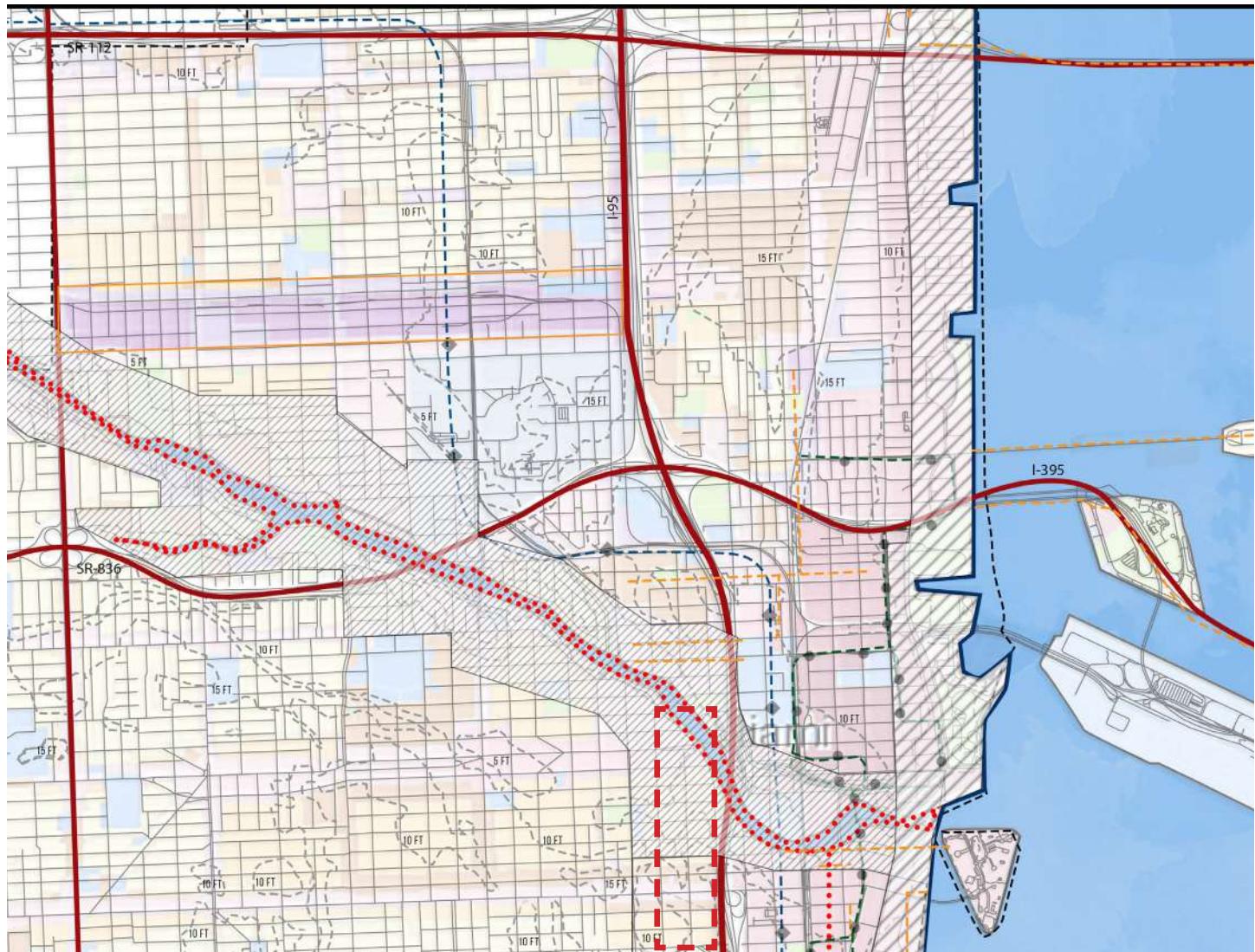
Concept Model

## 4. RETHINKING THE URBAN SCALE

A SERIES OF URBAN PLANS WERE CREATED TO SHOW CHANGE OVER TIME ON HOW TO CREATE A STRATEGIC RETREAT FOR THE CITY. THIS PROCESS I WENT THROUGH WAS TO UNDERSTAND THE TYPES OF INFRASTRUCTURE, LAND USE, ZONING THAT WOULD WIDELY BE AFFECTED CLOSE TO THE WATER EDGE. I THEN DECIDED IT WAS BEST TO CEASE DEVELOPMENT ON LOW- LYING AREAS AND MOVE IT TO HIGHER ELEVATED AREAS TO CREATE DENSER COMMUNITIES.

REDEFINING THE EDGE WOULD CREATE A STRATEGIC RETREAT IN AREAS OF THE CITY THAT ARE MOST Affected BY THE SEA LEVEL RISE. THOSE BUILDINGS THAT ARE COSTLIEST TO MAINTAIN WITHIN THE PLAN WOULD RECEIVE INCENTIVES PROVIDED BY THE CITY.

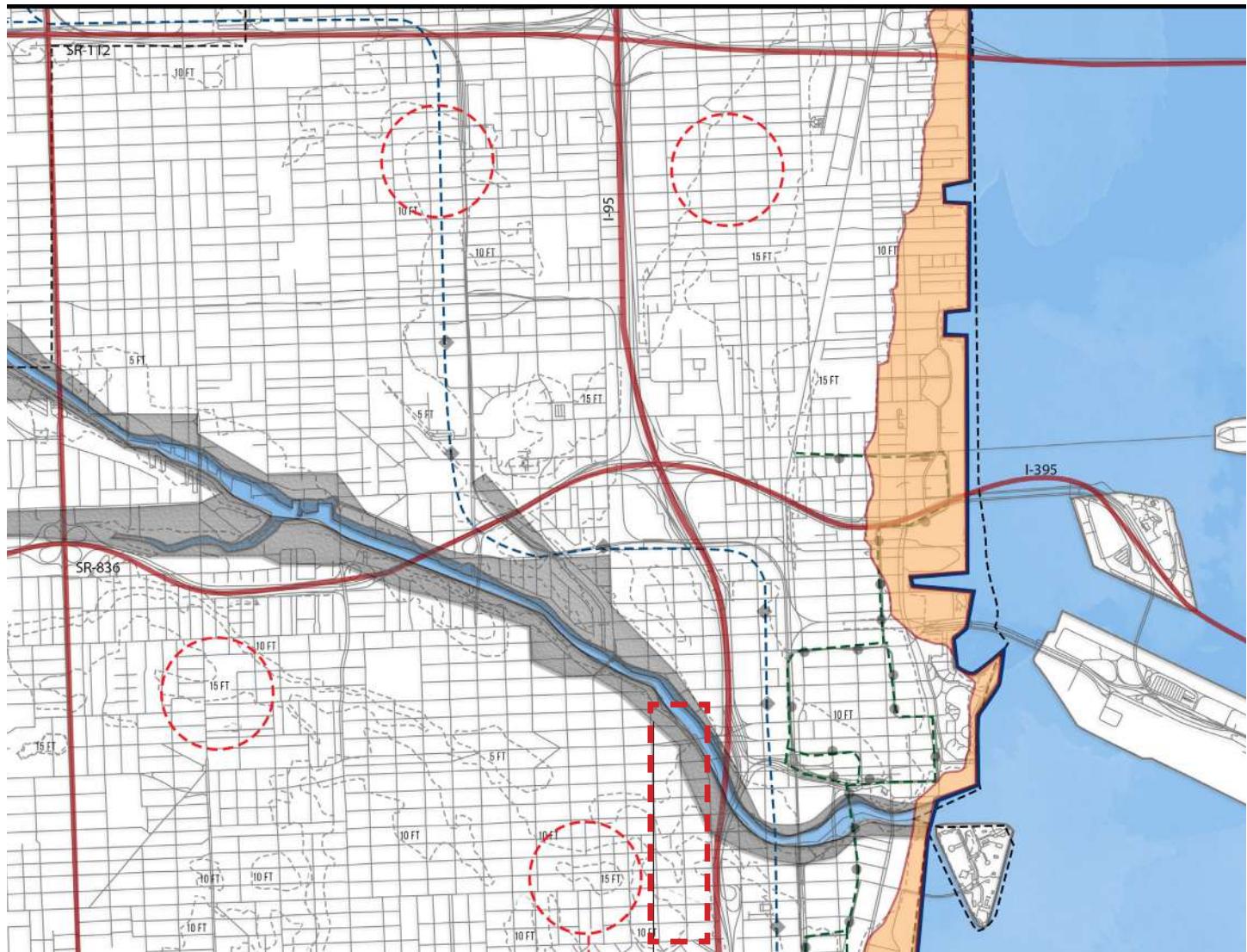
# MASTERPLAN - PHASE I - 0' RESPONSE



## LEGEND:

FOCUS AREA	CONTOUR
East Little Havana	Contour Lines
Greater Miami Limit	
Dezone Area	
HARD INFRASTRUCTURE	
Major Roads	
Metromover	
Metrorail	
TriMet	
Bike Lane	
Coast Edge	

# MASTERPLAN - PHASE II - 3' RESPONSE



## LEGEND:

### FOCUS AREA

----- East Little Havana

### CITY LIMIT

----- Greater Miami Lim

### CUT

----- Cut Area

### FILL

----- Fill Area

### UPZONE

----- Highest Elevated Area

### CONTOUR

----- Contour Lines

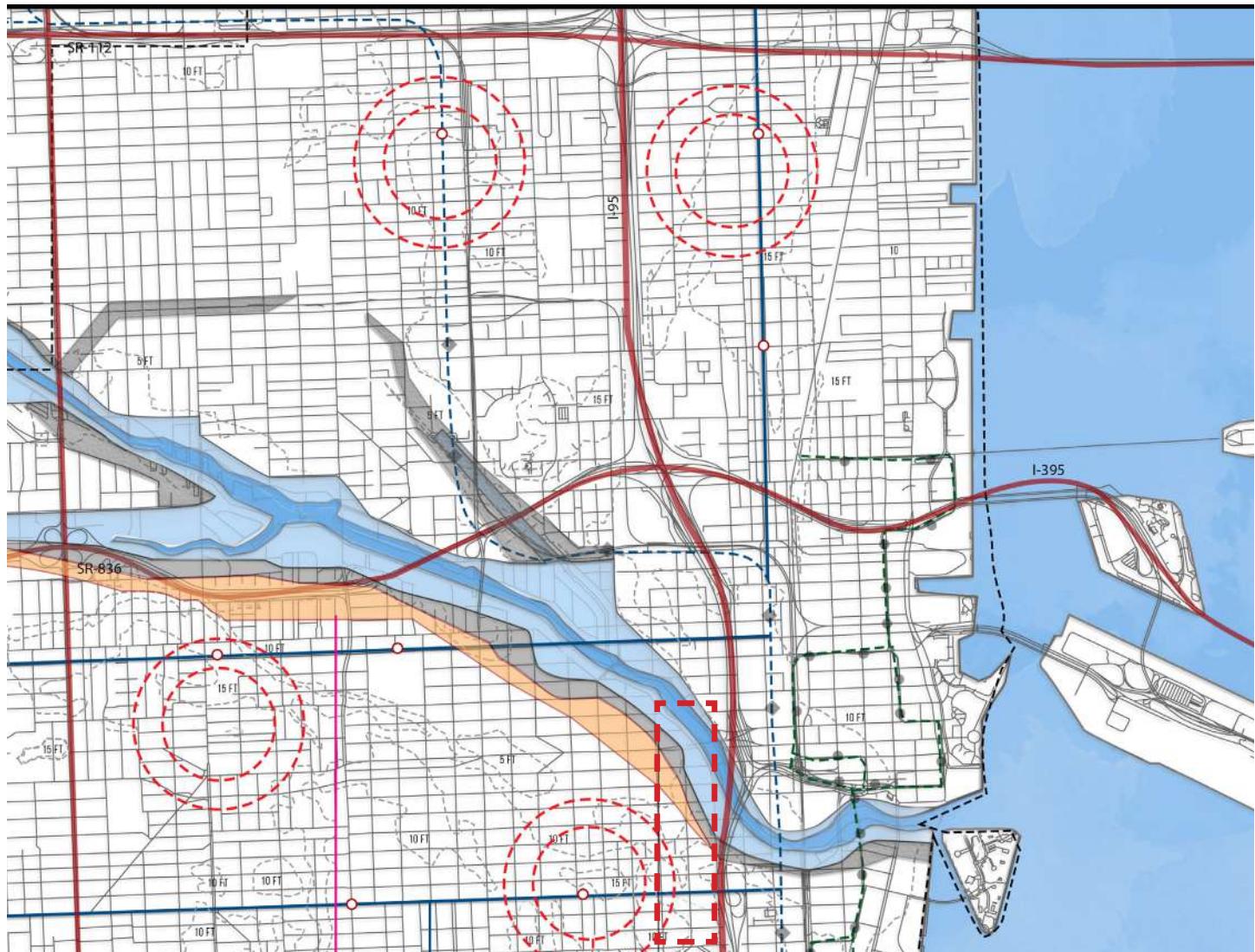
### HARD INFRASTRUCTURE

----- Major Roads

----- Metromover

----- Metrotail

# MASTERPLAN - PHASE III - 4' RESPONSE



## LEGEND:

### FOCUS AREA

- - - East Little Havana

### CITY LIMIT

- - - Greater Miami Lim

### CUT

■ Cut Area

### FILL

■ Fill Area

### UPZONE

○ Highest Elevated Area

### CONTOUR

- - - Contour Lines

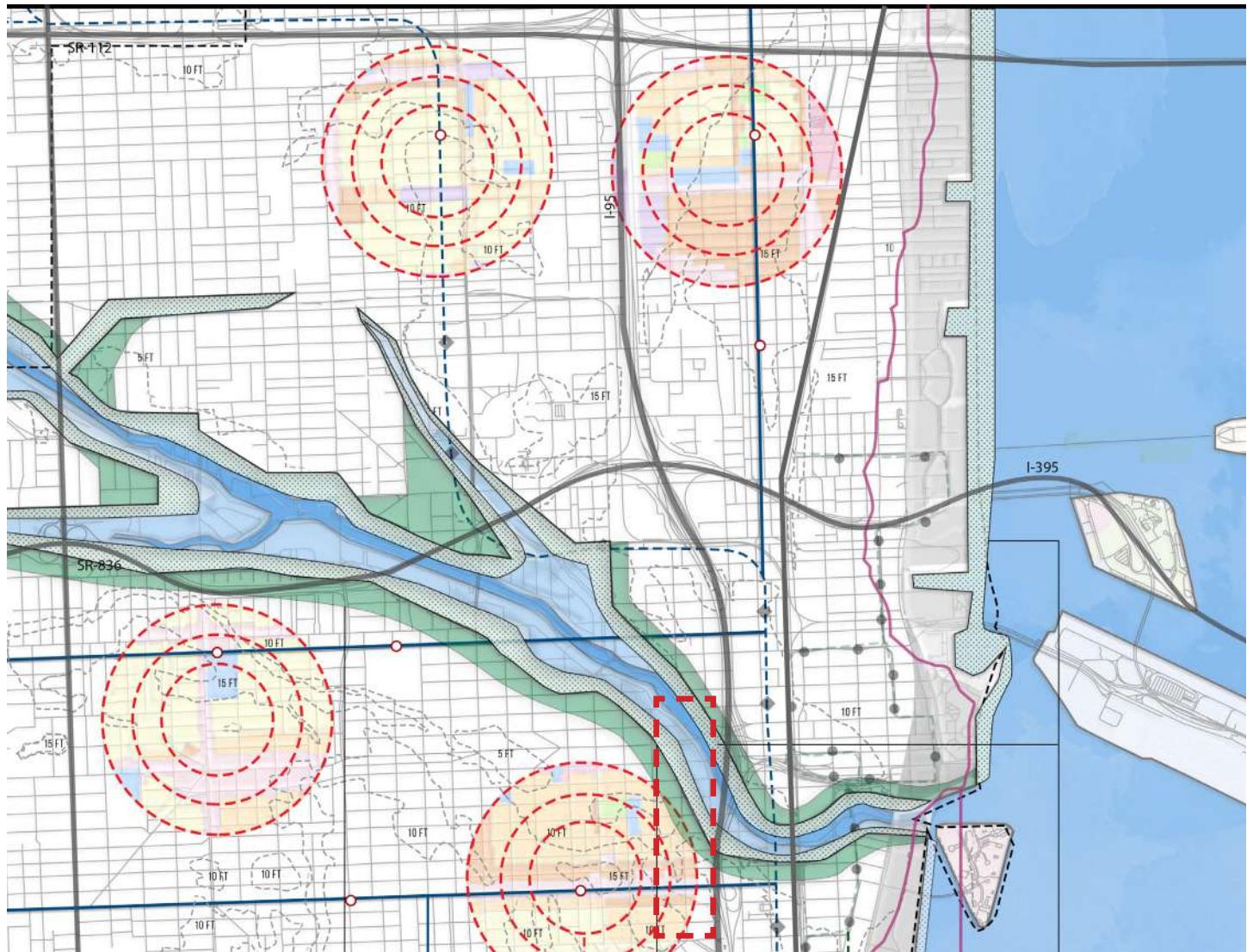
### HARD INFRASTRUCTURE

— Major Roads

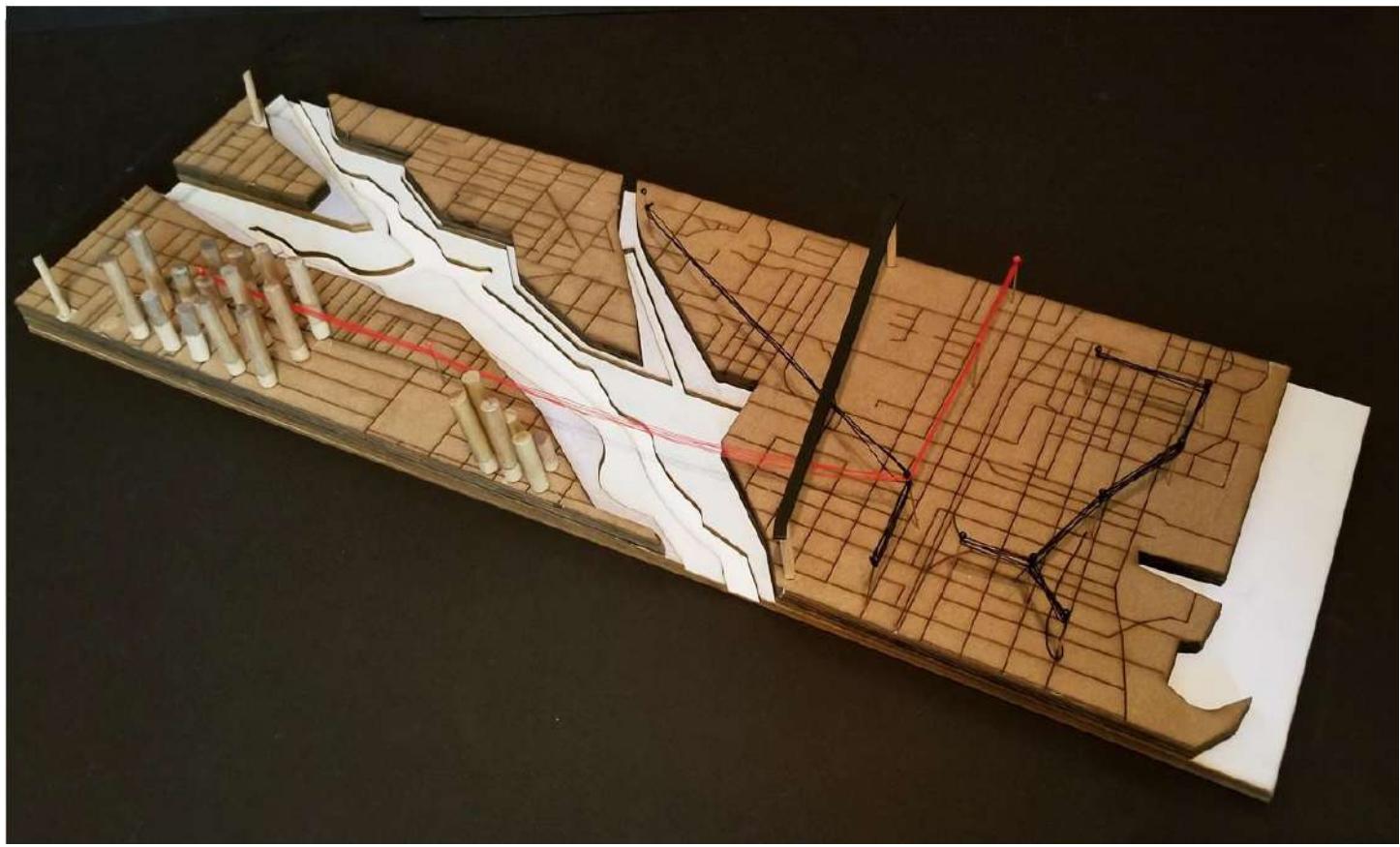
— Metromover

— Metrorail

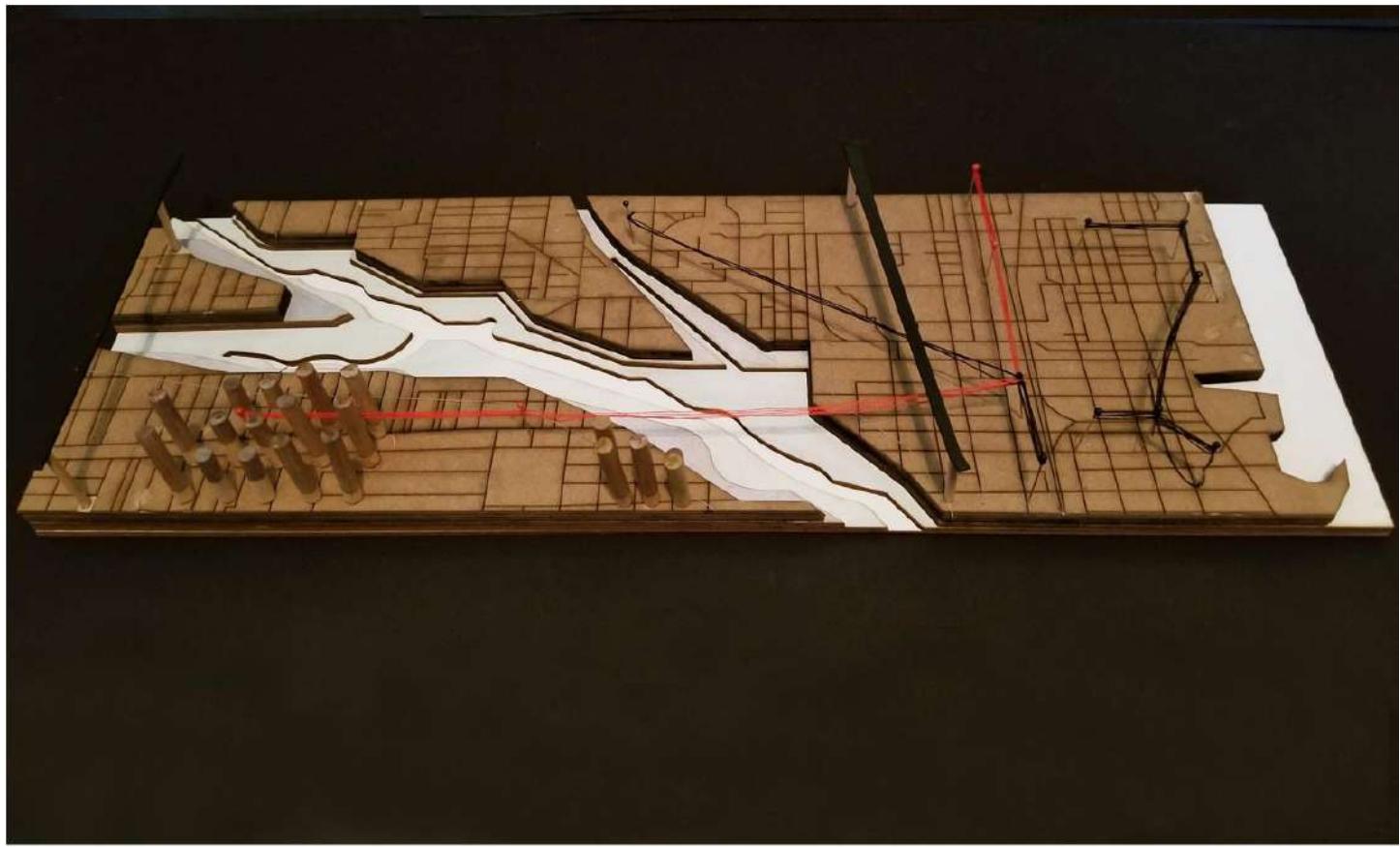
# MASTERPLAN - PHASE IV - 6' RESPONSE



LEGEND:	
FOCUS AREA	CONSTRUCTED WETLAND
----- East Little Havana	Fill Area
CITY LIMIT	UPZONE
----- Greater Miami Limit	Red Circle: Highest Elevated Area
PROPOSED INFRASTRUCTURE	
Metro Extension	HARD INFRASTRUCTURE
-----	Major Roads
-----	MetroMover
-----	MetroRail



**Urban Scale**  
Concept Model

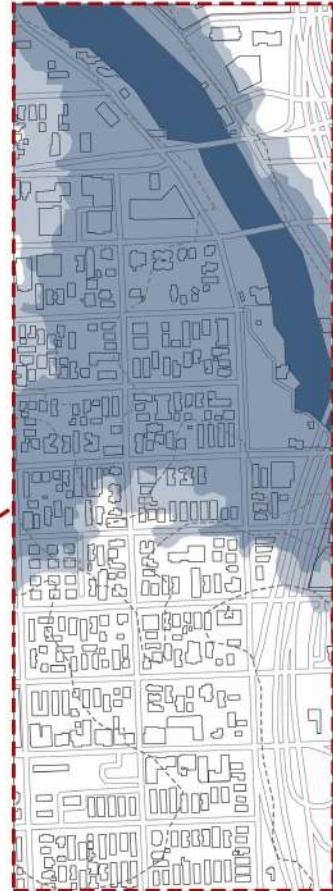
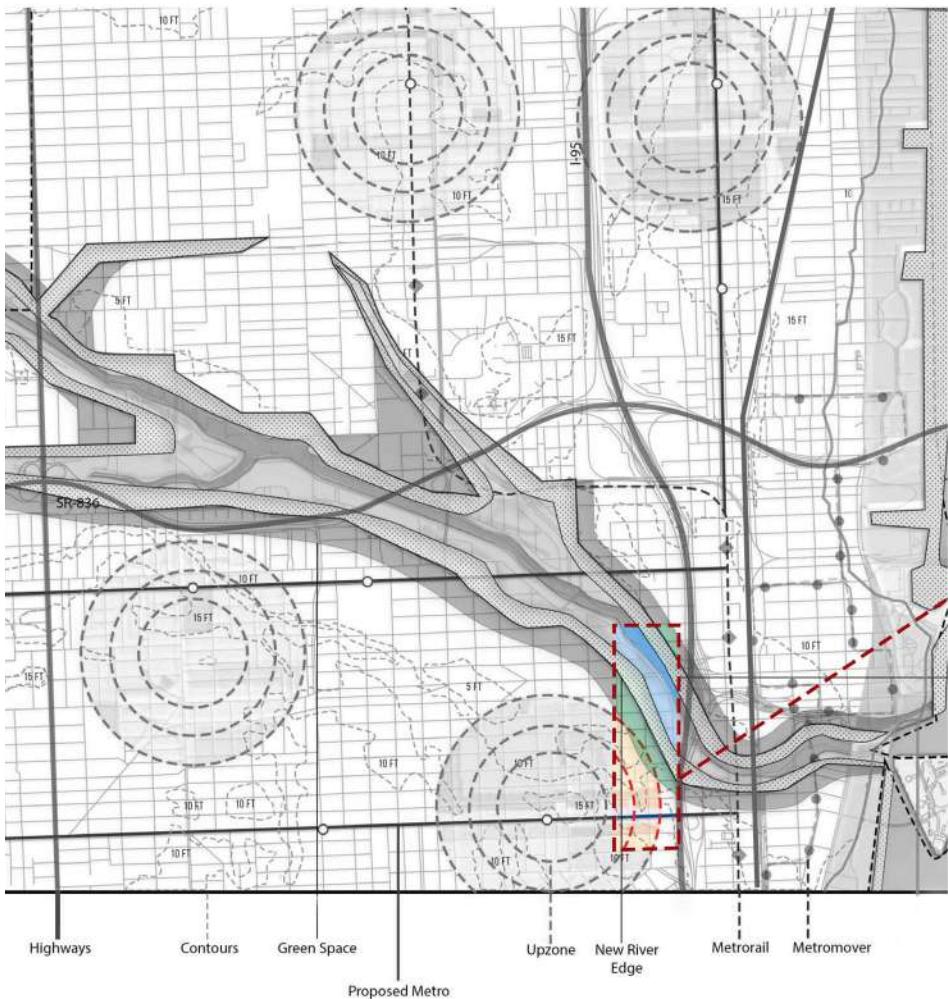


**Urban Scale**  
Concept Model

## 5. RETHINKING THE NEIGHBORHOOD SCALE

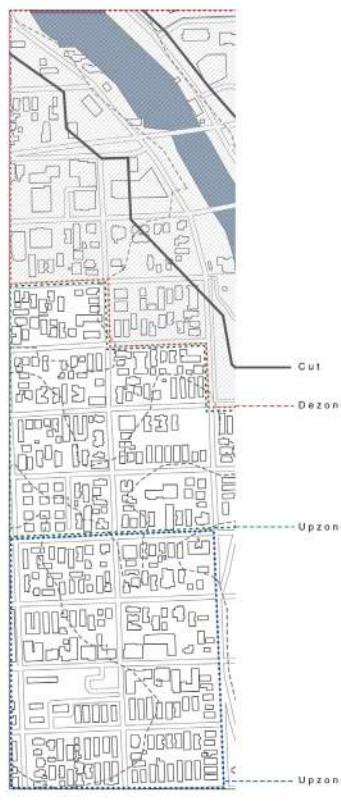
EAST LITTLE HAVANA WAS AN AREA OF INTEREST BECAUSE IT IS LOCATED ON HIGHER ELEVATION AND THROUGH RESEARCH OF THE ZONING AND LAND USE, IT SHOWED THAT IN THAT AREAS MOST OF THE BUILDINGS WERE LOW DENSITY. THIS AREA WOULD BE THE PERFECT OPPORTUNITY TO SHOW HOW AREAS LIKE THIS CAN BE PROPERLY UP ZONE AND DENSIFIED TO CREATE A STRATEGIC RETREAT FOR SIMILAR AREAS IN THE CITY.

# FOCUS AREA

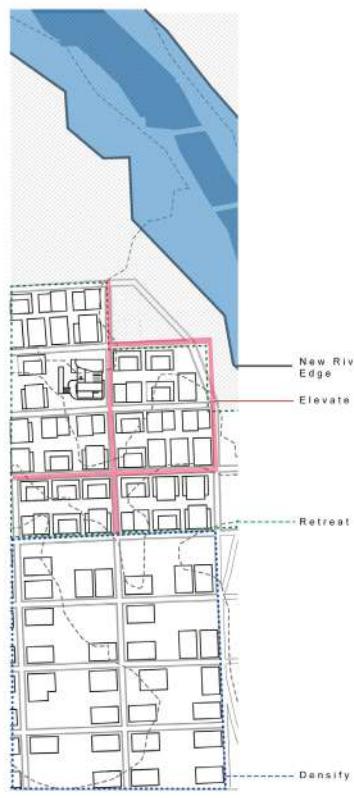


EAST LITTLE HAVANA

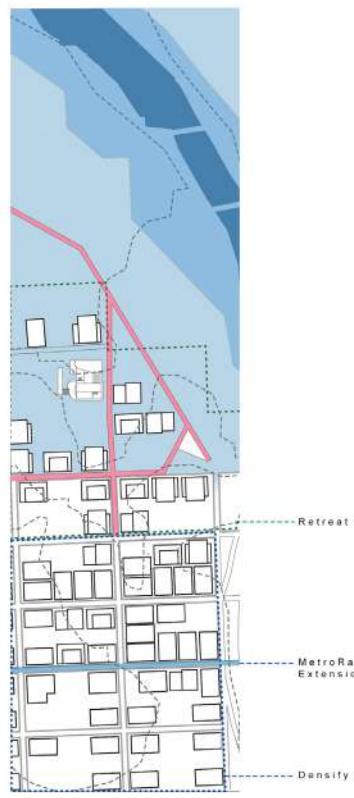
# SITE PLAN



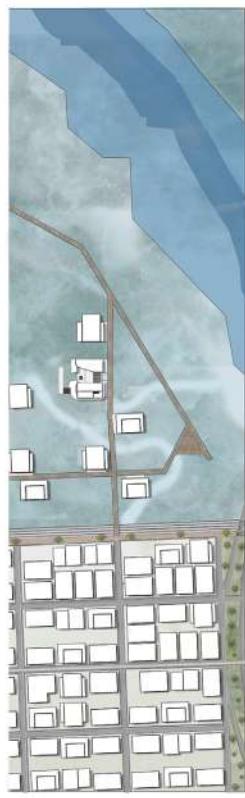
2025 - 0'



2050 - 2'



2075 - 4'



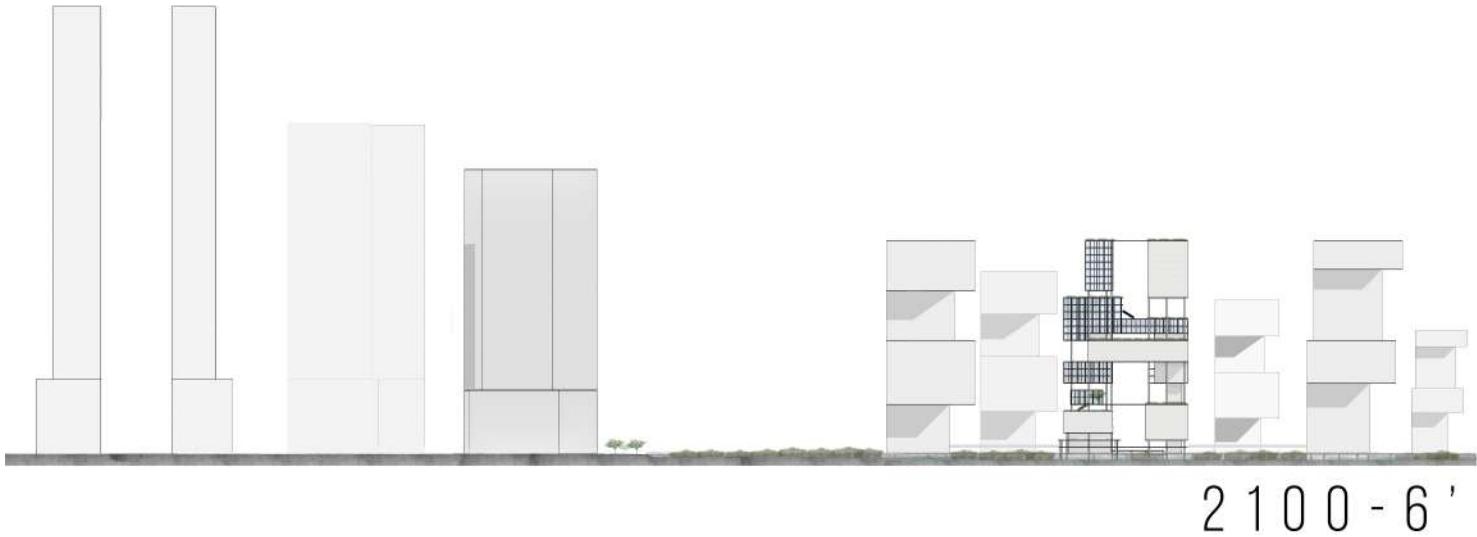
2100 - 6'

## 6. BUILDING TYPOLOGY

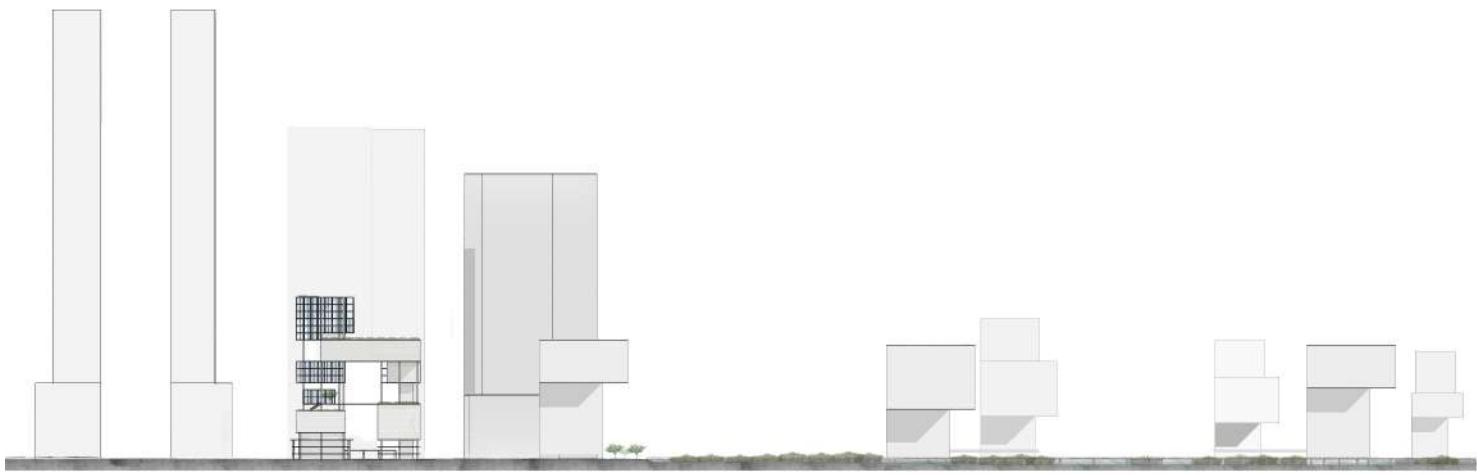
THE VISION OF THIS PROJECT IS TO CREATE A MODULAR BUILDING TYPOLOGY TO INHABIT LAND/WATER FOR AS LONG AS WE CAN, BUT ONCE THE EDGES START TO SHIFT AND THOSE AREAS BECOME INHABITABLE, WE'D DISMANTLE THIS NEW BUILDING TYPOLOGY AND RETREAT TO HIGHER LAND FOR THE LONG TERM.

# ELEVATION

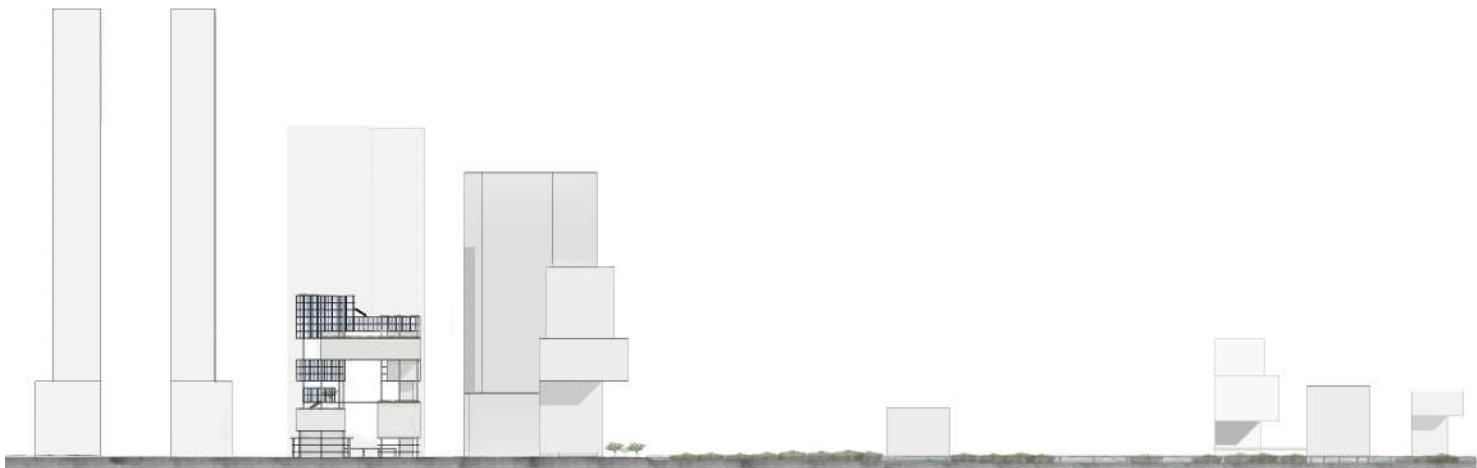




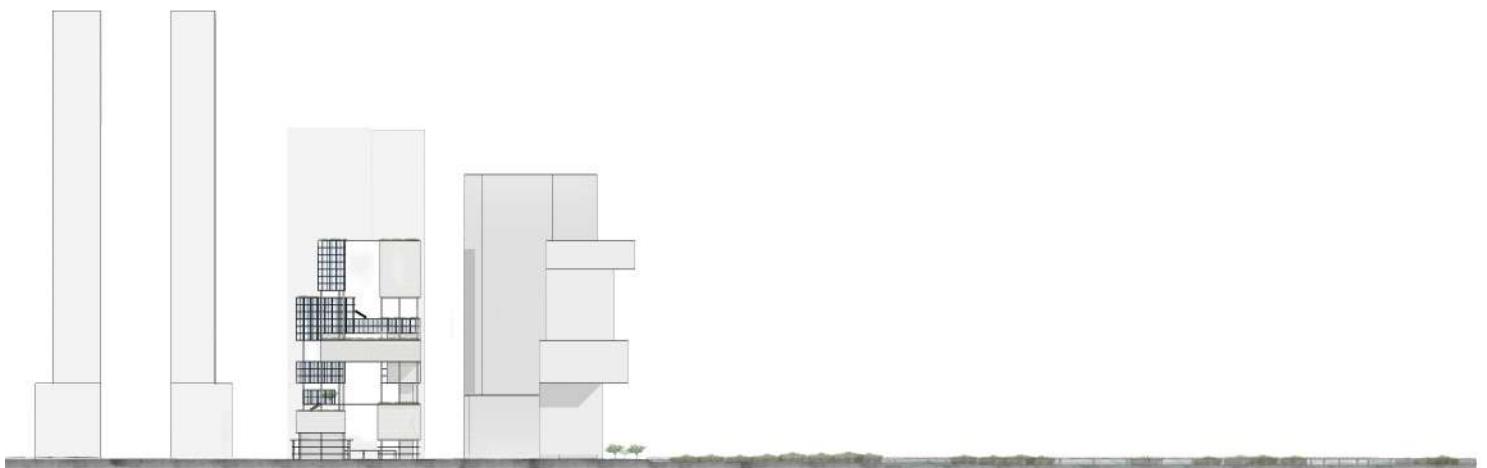
# ELEVATION



2120

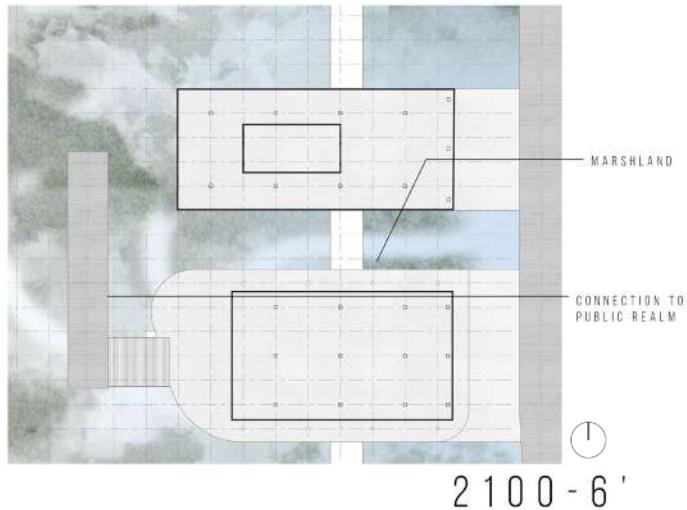
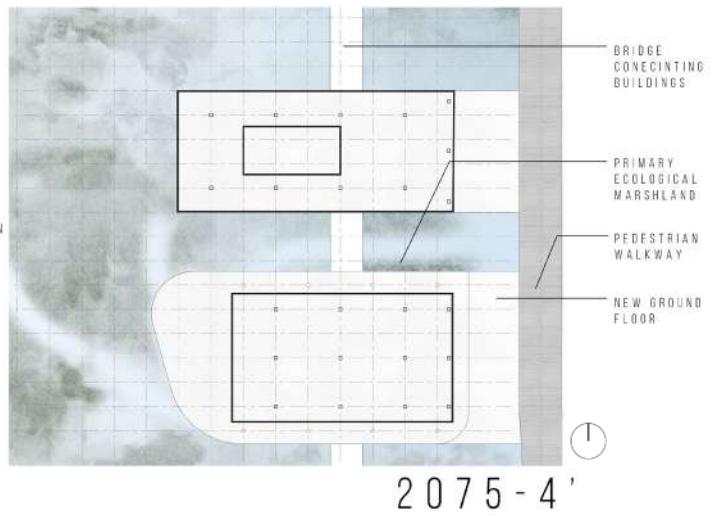
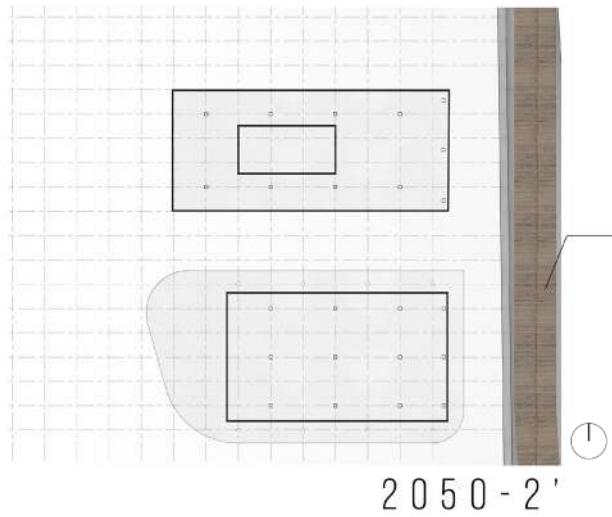


2130

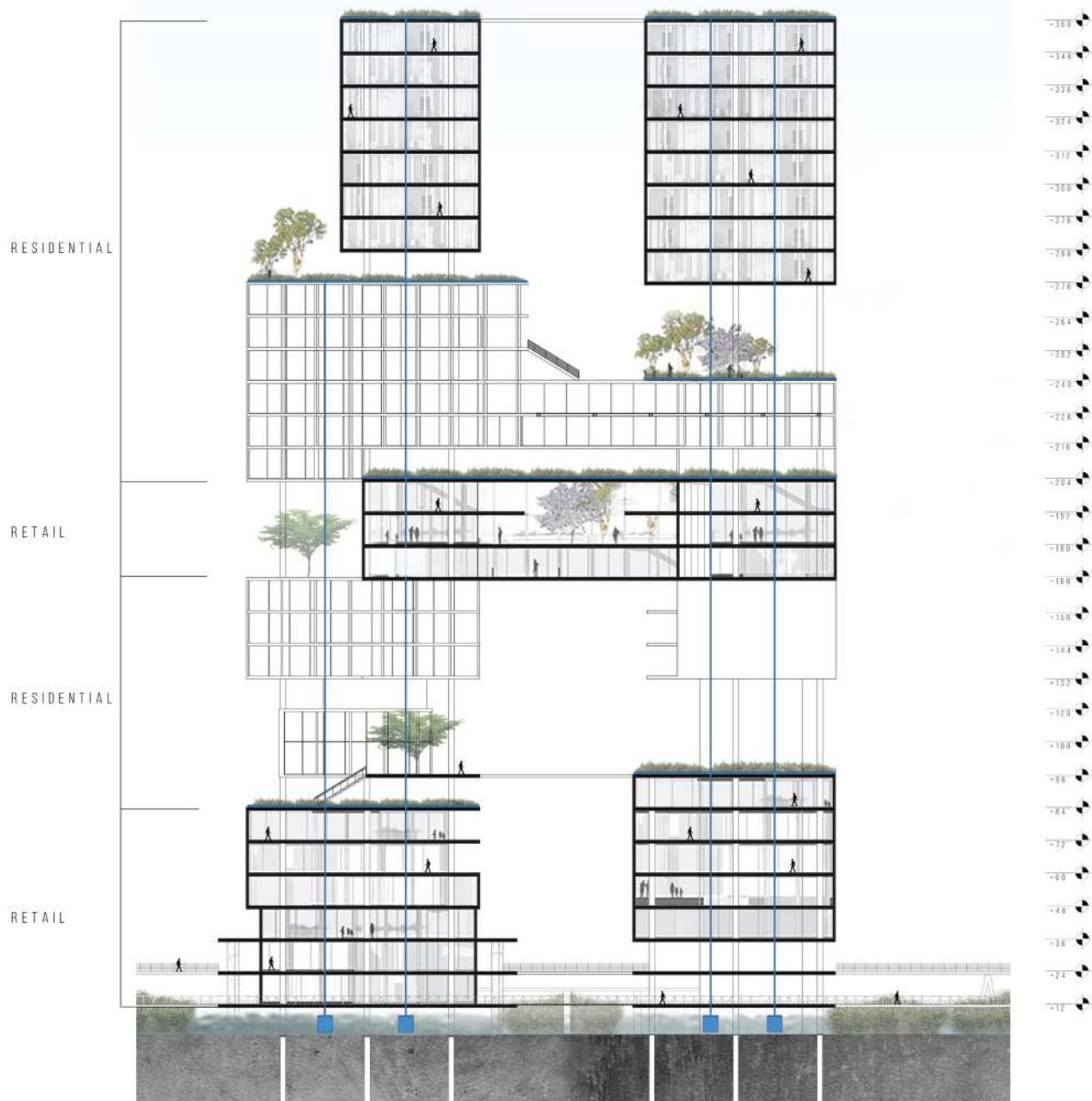


2140

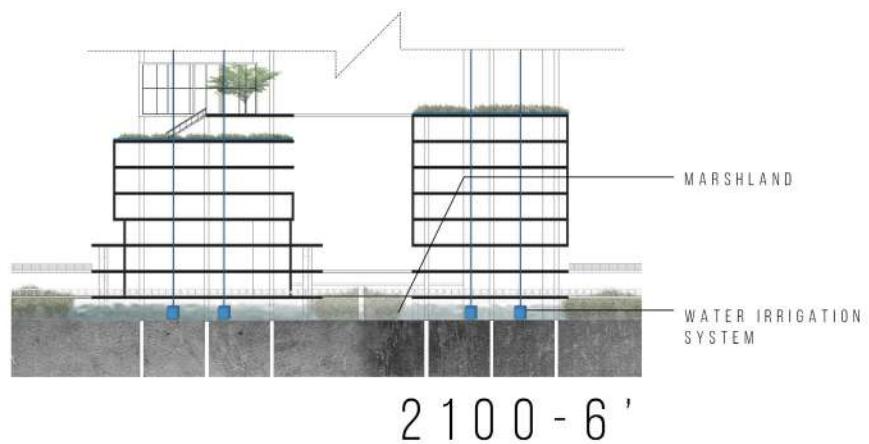
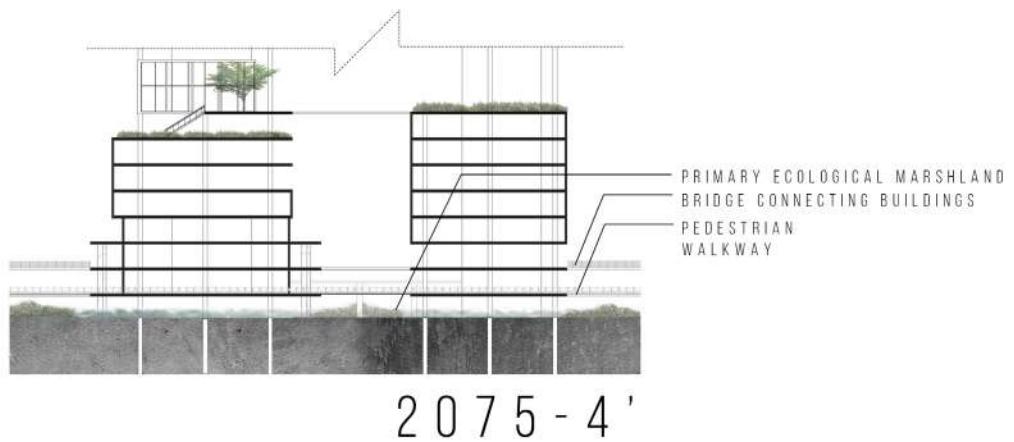
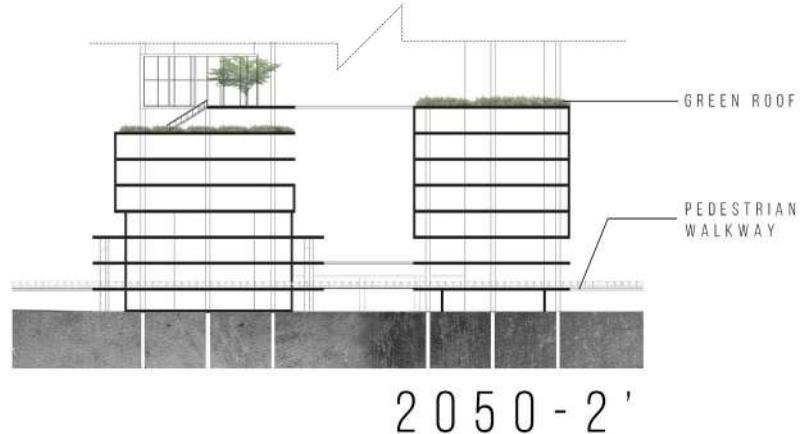
# FLOOR PLANS



# SECTION



# SECTION





**Modular Building Typology Perspective**

Rendering



**Modular Building Typology Perspective**

Rendering



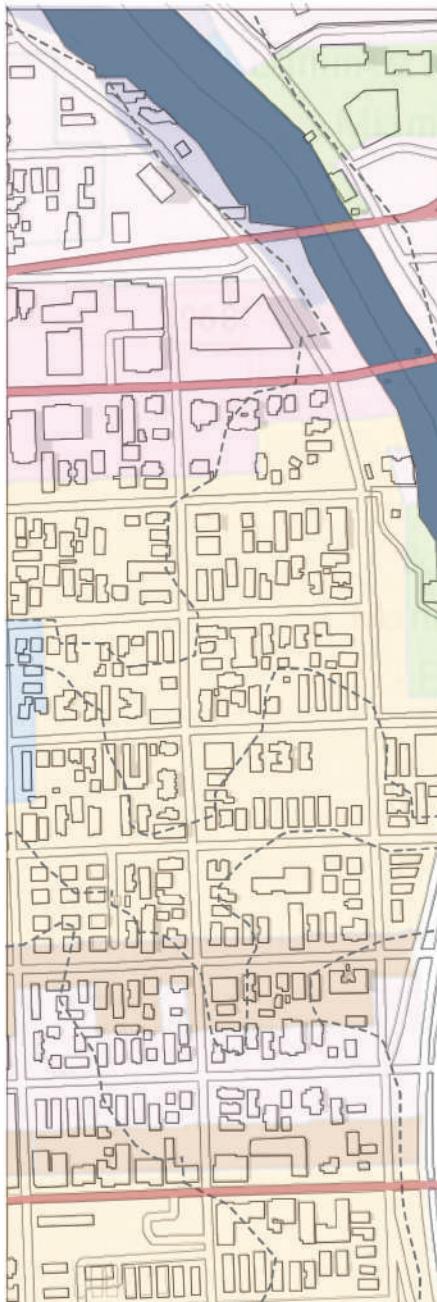
**Building Typology**  
Concept Model



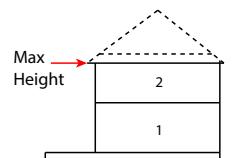
**Building Typology**  
Concept Model

## 7. ZONING

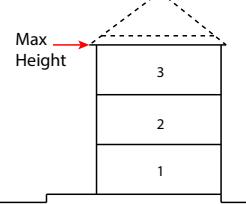
TO CREATE A STRATEGIC RETREAT, NEW ZONING REGULATIONS HAD TO BE PROPOSED TO MAKE THIS THESIS WORK. AREAS THAT WERE LOW DENSE WERE UPZONE TO BE ABLE TO CREATE THESE DIGNIFIED AREAS. NEW INFRASTRUCTURE WAS PROPOSED TO CREATE A MORE PEDESTRIAN FRIENDLY CITY THAT WOULD RELY LESS ON CARS AND MORE ON PUBLIC TRANSIT.



Building Heights



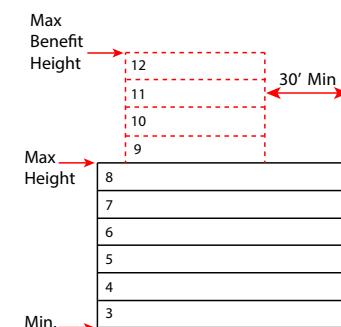
T3-R



T4-R



T5-O

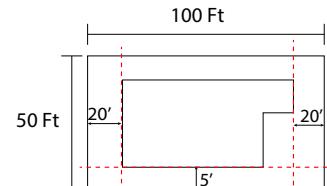


Max Benefit Height

Max Height

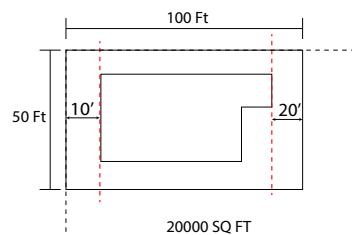
Min. Height

Building Lot



Lot Area: Min: 5000 sq ft

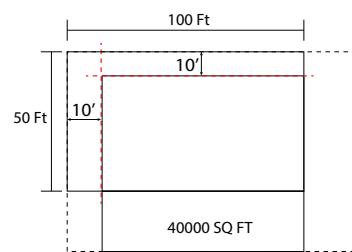
Green Space Requirement: 25%



20000 SQ FT

Lot Area: Min: 5000 sq ft  
Max: 20000 sq ft

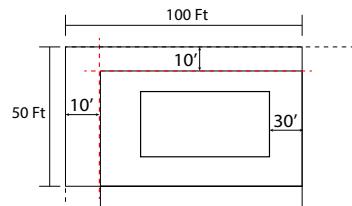
Green Space Requirement: 15%



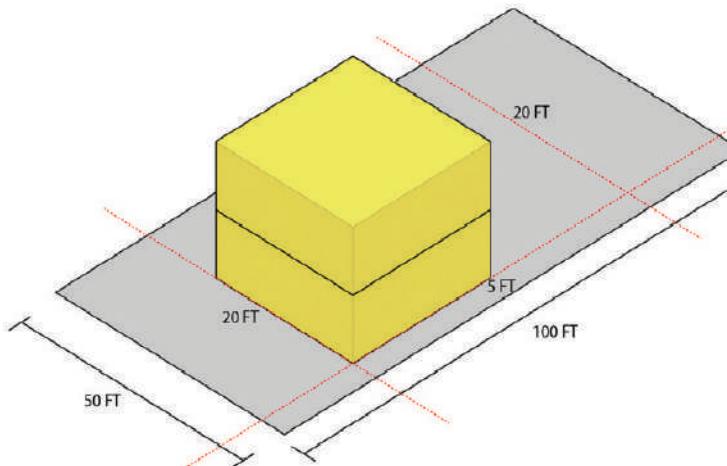
40000 SQ FT

Lot Area: Min: 5000 sq ft  
Max: 40000 sq ft

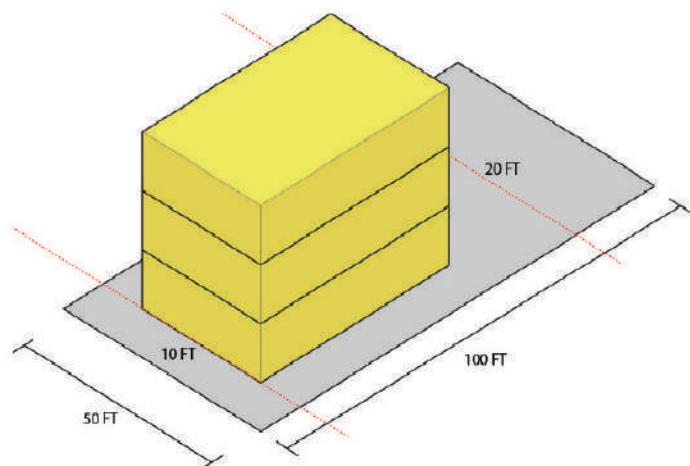
Green Space Requirement: 10%



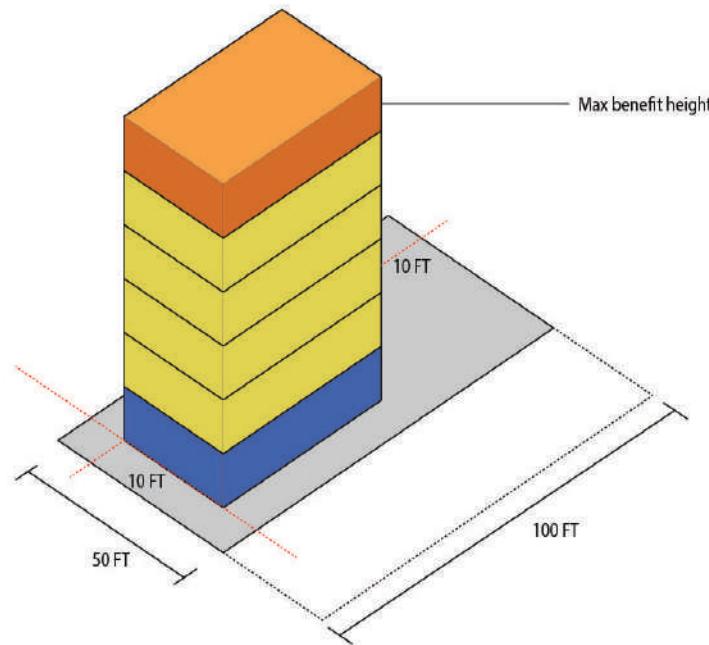
# CURRENT ZONING



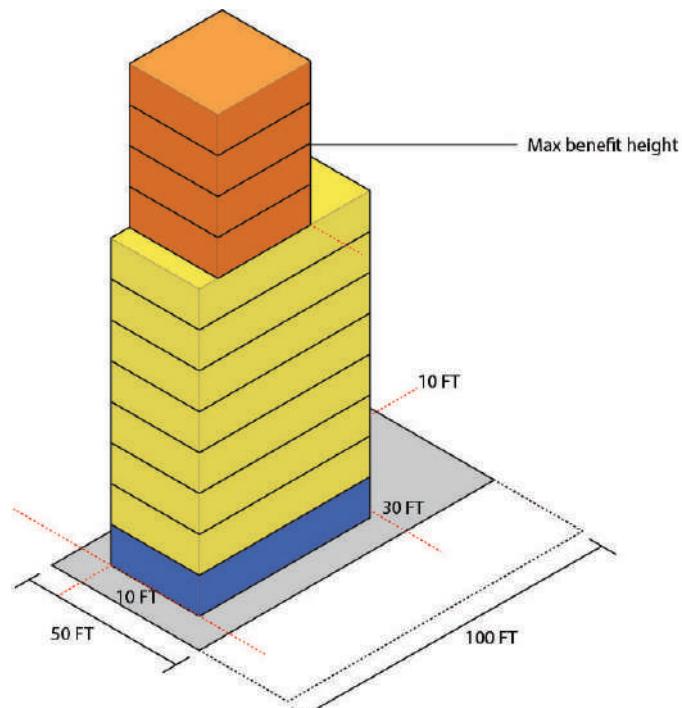
T-3-R



T4-R



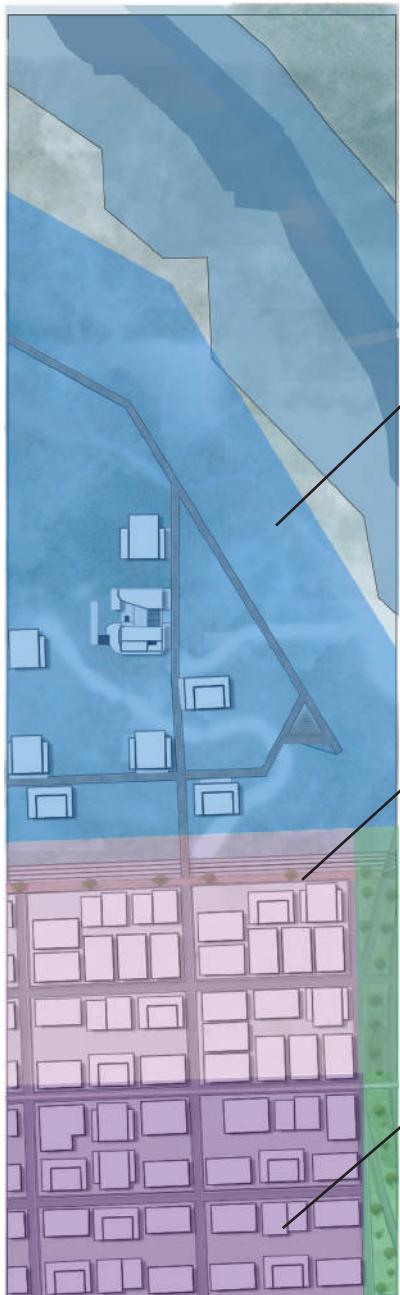
T5-0



T6-8-0

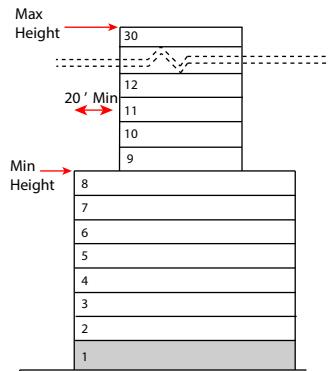
RESIDENTIAL

RETAIL

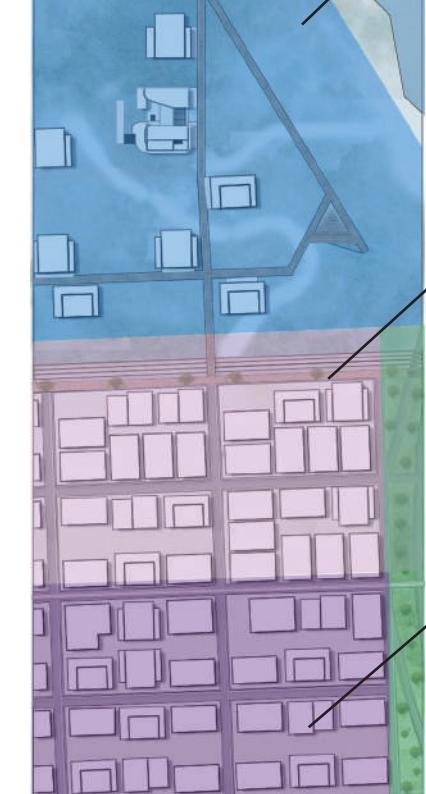


## PROPOSED ZONING

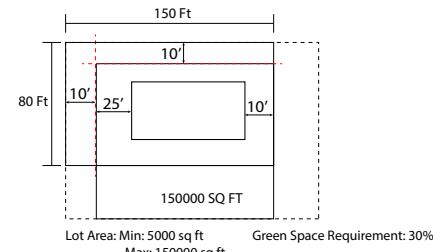
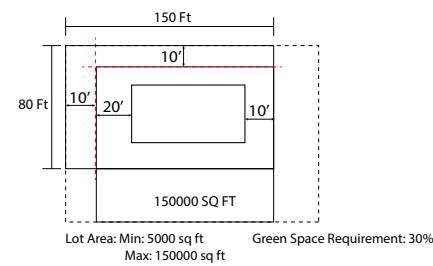
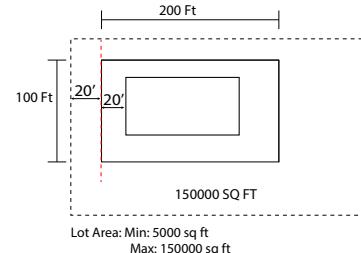
**Building Heights**

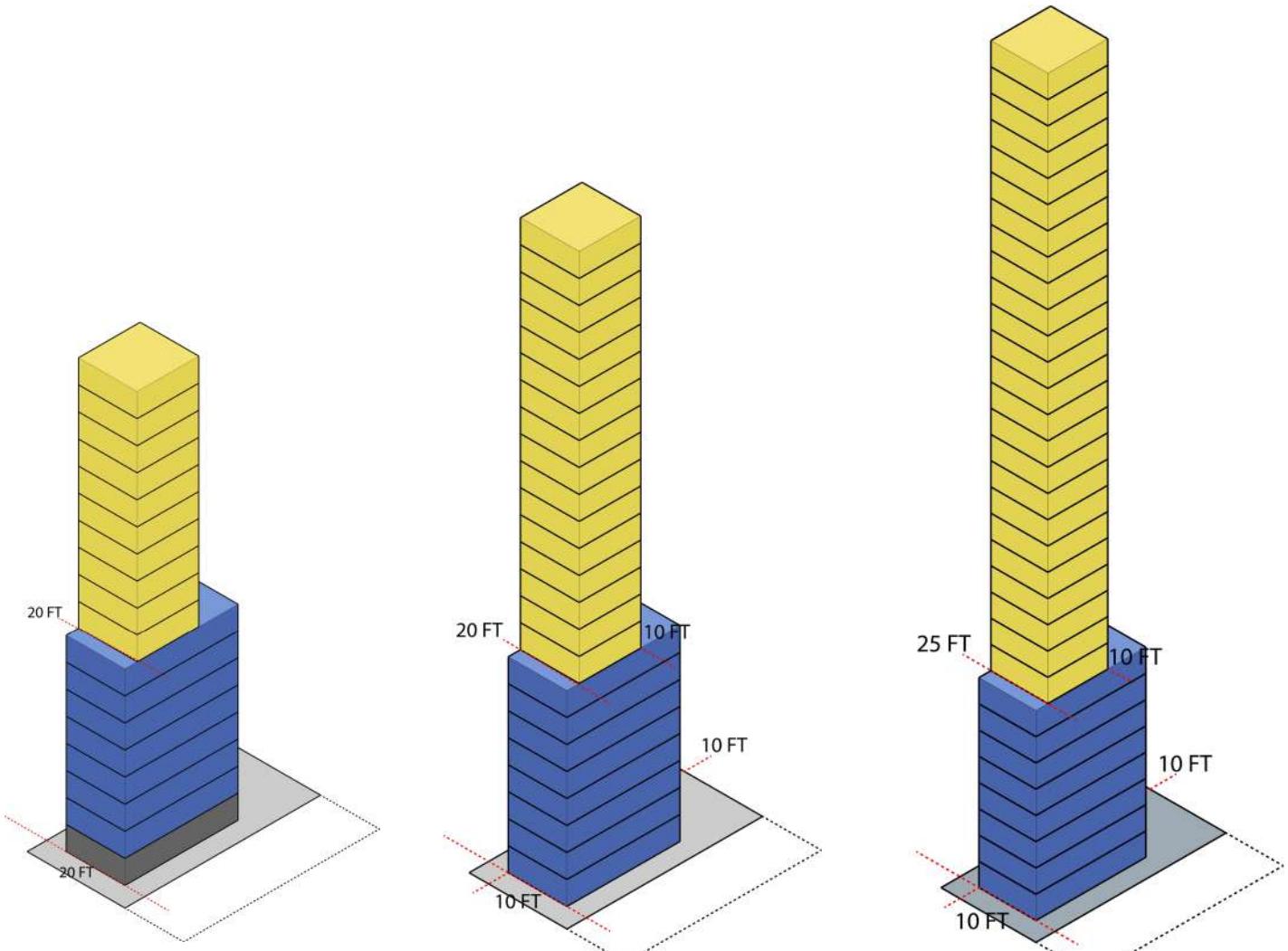


T6-30-W



**Building Lot**





REMOVABLE

RESIDENTIAL

RETAIL

# ZONING REGULATIONS

## LIMITED PARKING GARAGES

- BUILDINGS WILL NOT REQUIRE TO HAVE PARKING GARAGES TO PROMOTE THE USE OF PUBLIC TRANSPORTATION. THIS WILL ALLOW TO CREATE A PEDESTRIAN FRIENDLY CITY.

## ELEVATED PEDESTRIAN WALKWAYS

- ROADS THAT WILL EVENTUALLY BE AFFECTED BY THE RISE OF WATER WILL BE CONVERTED TO ELEVATED PEDESTRIAN WALKWAYS TO SERVE AS A CONNECTION TO BUILDINGS THAT ARE LOCATED IN THE WATER AND A CONNECTION TO THE PUBLIC REALM.

## POROUS BUILDING

- THE MODULAR BUILDING TYPOLOGY WILL BE REQUIRED TO HAVE POROUS AREAS THROUGHOUT THE BUILDING TO ALLOW FOR CROSS VENTILATION, AS WELL AS CREATING PUBLIC SPACES WITHIN.

## DISASSEMBLE FIRST FLOOR

- THE MODULAR BUILDING TYPOLOGY FIRST FLOOR WILL BE REMOVED ONCE THE WATER STARTS TO RISE IN THE AREAS THAT ARE AFFECTED AND MOVE TO A HIGHER FLOOR.

