LIVING WITH IMPOUNDMENT

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MLA CANDIDATE 2018
Rhode Island School of Design

A thesis submitted in partial fulfillment of the requirements for the Master of Landscape Architecture Degree in the Department of Landscape Architecture of the Rhode Island School of Design, Providence, Rhode Island.

By
Date

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Overview

This research-based thesis uses Miami as a site to investigate how landscape intervention can contribute to adaptation to sea level rise (SLR) and shifts it will bring to this region in the future. The whole thesis is divided into three phases and each phase has specific objectives and builds foundations for research and experiments in the next phase.

Phase One: Possible Future of Freshwater Wetlands in Miami
Depict a full picture of the impact that sea level rise has had and will have on the city of Miami with particular emphasis on wetlands. The investigations include overlaying sea level rise projections from the National Oceanic and Atmospheric Administration (NOAA) with other information in order to hypothesize future SLR scenarios, and identifying a potential test area for the next phase.

Phase Two: Alternatives under SLR: Living with Water
Explore SLR footprints based on the selected site in terms of plant communities, surrounding neighborhoods, traffic and potential benefits it may have for people. Study possible approaches that can equip typical fragile region with capacity to live with SLR issue.

Phase Three: Spatial Strategies: Protect and Adapt
Unveil more details of the site with spatial and dimensional explorations conducted by digital modeling, sketches and models. Develop comprehensive strategies for the site to survive and evolve under future treats. Utilize typological or sectional studies to suggest a future alternative.

Site

The Lake Belt Area, which consists of an approximately 89 square-mile area, is adjacent to the Everglades and located in northwest Miami-Dade County. This is an active limestone mining area, which has five large aggregate mines that are ranked in the top 20 in terms of limestone production in the United States.[1] At the same time, it also functions as infrastructure for freshwater storage and stormwater treatment.

With unique ground texture, industrial and ecological functions, the Lake Belt Area lies in an intersection between multiple systems. It is not only a threshold between freshwater wetlands and urban fabrication but also a tipping point near Miami where salt marshes and mangroves may replace most freshwater wetlands in the future. In addition, there are currently very limited recreational or educational programs to inform people about this fragile area.

The Lake Belt Area is a perfect site to test the idea of living with water, especially a great amount of freshwater impoundment, and being adaptive to future SLR threats while also exploring how landscape interventions can transform this unique area with vast and grand spatial characteristics into ecological, infrastructural or even recreational agents.

The Lake Belt Storage Area, Miami-Dade County[2]

1. Miami-Dade Services - https://www.miamidade.gov/planning/
2. Eye On Miami - http://eyeonmiami.blogspot.com/2015_08_30_archive.html

Phase 1 Investigation

Possible Future of Freshwater Wetlands in Miami

Abstract

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.[3]

In Phase One, the research will focus on figuring out why wetlands are important in Miami as well as the impact on wetland ecosystems driven by ongoing SLR and human intervention. The preliminary research is mainly carried out using literature review and mapping. The main reference for sea water table change is the Int-High SLR Scenario 2017 produced by the NOAA. At the end of Phase One, those findings indicate that South Florida's ecosystem will continuously suffer from destabilization, potentially following massive migration of saltwater wetlands and replacement of freshwater wetlands in the Everglades.

Pine Trees are Dying from Salt Water Flooding, Maryland[4]

3. What Is a Wetland? - https://www.epa.gov/wetlands/what-wetland
4. NOAA - https://www.climate.gov/news-features/features/future-marylands-blackwater-marsh

Introduction

The investigation can be divided into three parts. The first part aims to explore the geographical and vertical distribution of the regional ecosystem and why it evolved the way it did. As a response to topography, water salinity, soil type, fire frequency and other factors, ecosystems vary from the coastal dunes, salt marshes and mangroves to the upland forests and continuous freshwater wetlands which are primarily distributed in the Everglades.[6] It not only occupies nearly 30% of Florida, which has a higher percentage of wetland than any other state but also stands on the frontier of sea level rise.

The second part of the investigation examines the vulnerability of freshwater wetlands and what has impacted them negatively in the past. In addition, projections and simulations are used to see what may happen in the future. Generally, the low-lying, interior portion of the Everglades is particularly vulnerable when saltwater moves inland and upstream, along with saltwater intrusion contributed by limestone base. Over the past 20 years, human development has generated a great decline of the freshwater wetlands near the Lake Belt Area. In the foreseeable future, the Everglades may be progressively replaced by saltwater marshes or mangroves and will finally be lost to open water.

The third part focuses on the value of Florida's freshwater and saltwater wetlands. Wetlands are a vital part of natural systems and provide countless benefits for other communities. Their functions include but are not limited to: erosion protection, water purification, oxygen generation and wildlife habitat.

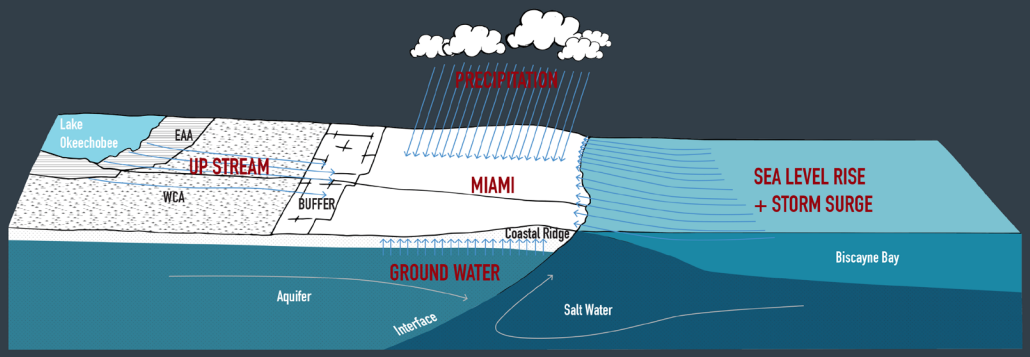
Methods

1. Literature Review regarding SLR and its Impact
2. Literature Review regarding Marsh Migration
3. Mapping of Miami's Elevation
4. Mapping of Future SLR Scenario
5. Data Visualization of Change in the Freshwater Wetland in terms of Quantity and Quality

6. Stys Beth and Tammy Foster. *Climate Change Impacts on Florida's Biodiversity and Ecology* . Report. Florida Fish and Wildlife Conservation Commission. 340-47.

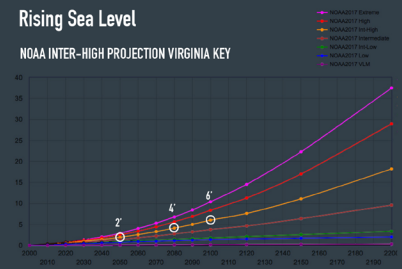
Water: The Threat to Miami

"The Water Comes From Six Sides In Miami"



Rising Sea Level

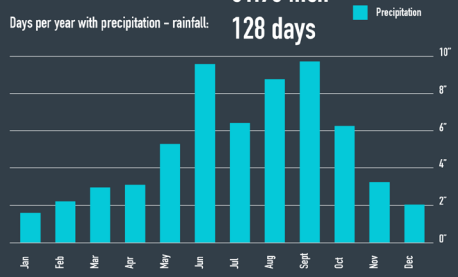
NOAA INTER-HIGH PROJECTION VIRGINIA KEY



Heavy Precipitation

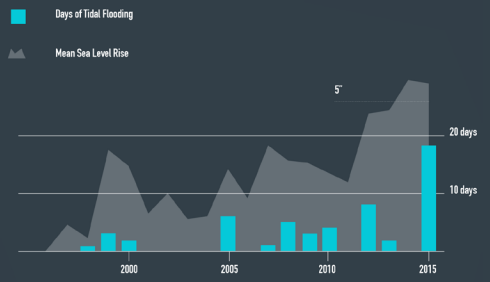
Average annual precipitation - rainfall: 61.93 inch

Days per year with precipitation - rainfall: 128 days

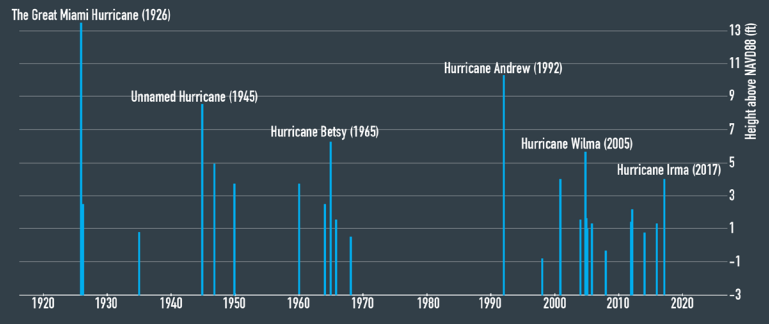


Increasing Tidal Flooding Frequency

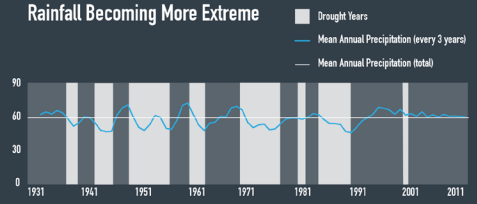
Data at Miami Beach



Severe Storm Surge Caused By Hurricane



Rainfall Becoming More Extreme

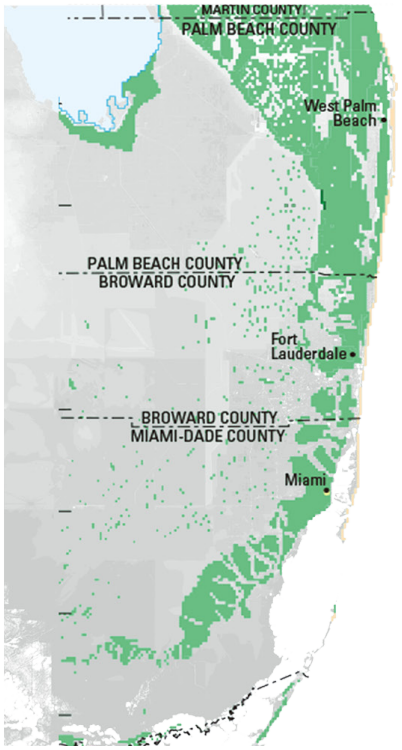


Shangyuan Li and Jing Zeng. "Factors Contributing to Miami's Flooding."

The water that causes current flooding problem comes from: (1) Increasingly serious tidal flooding (2) Storm surge (3) Rainfall extremes (4) Runoff from upstream (5) Rising groundwater level. Climate change and SLR are also important contributors to potential water disasters.

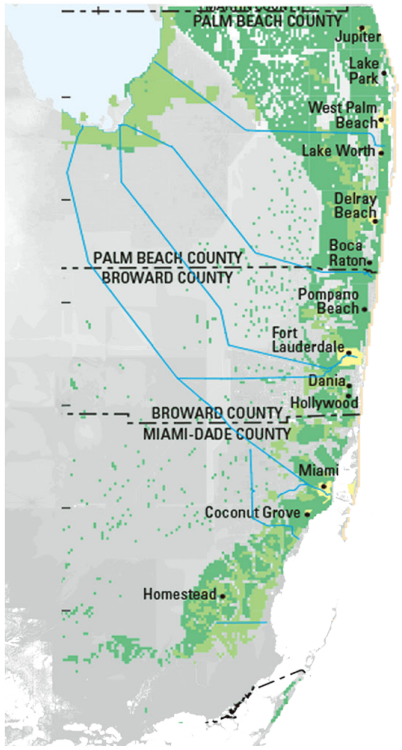
Miami: A City Built on Wet Terrain

1900



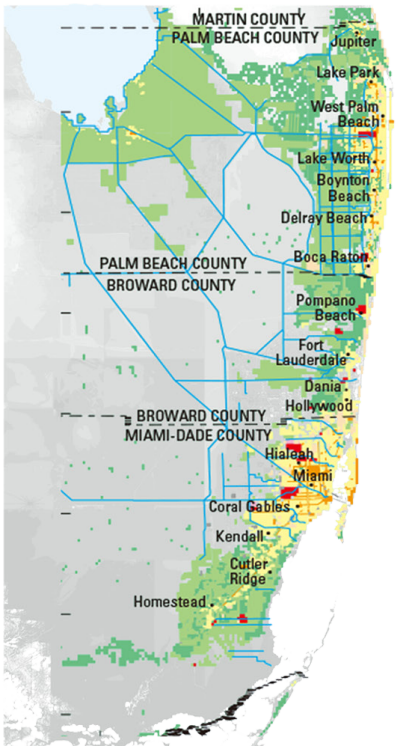
The historic Everglades formed an approximate 3,860 mi2 freshwater wetland marsh, extending from Lake Okeechobee to mangrove estuaries that border Florida Bay.

1920



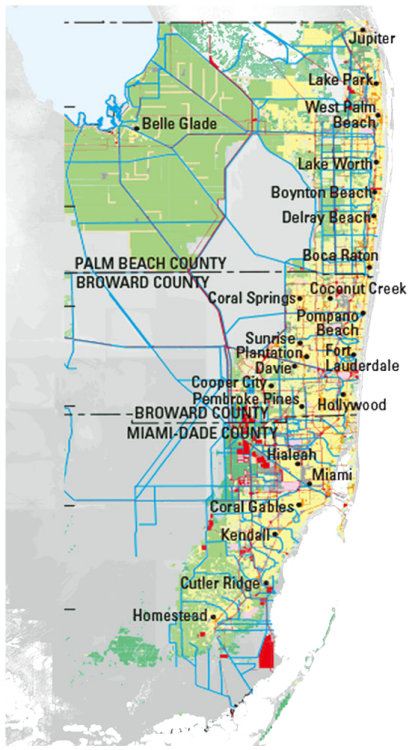
The "land boom" era 1903 to 1926 is signaled by the construction and completion of the primary drainage canals. The conversion of drained wetlands for tropical farm products.

1960



Miami grew quickly into modern cities.
During that time, growth was not limited to the larger cities. Outlying municipalities expanded and new municipalities were established.

2000



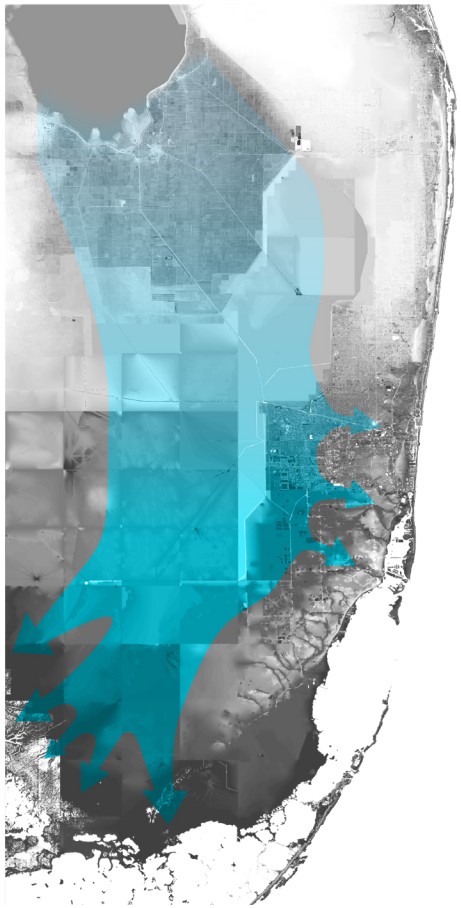
1980s is the beginning of large-scale influx of immigrants from Latin and South America which continued unabated into the 21st century.

Miami was originally built on wet terrain, which refers to the continuous and vast freshwater wetland. The land development was driven by agriculture and then by urbanization. By the end of 20th century, nearly 65 percent of the historic Everglades area was permanently demolished.

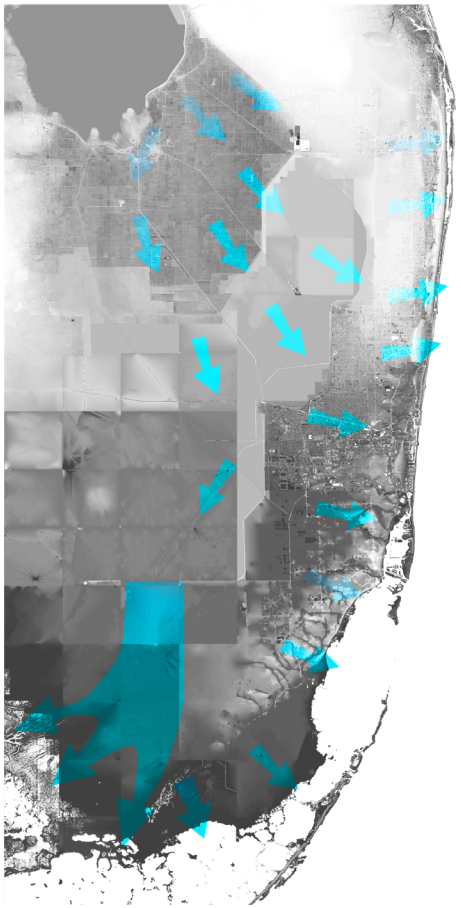
Shangyuan Li and Jing Zeng. "City Developed on Wet Terrain."

The Everglades: Changed Water Flow

– 1900 Water Flow



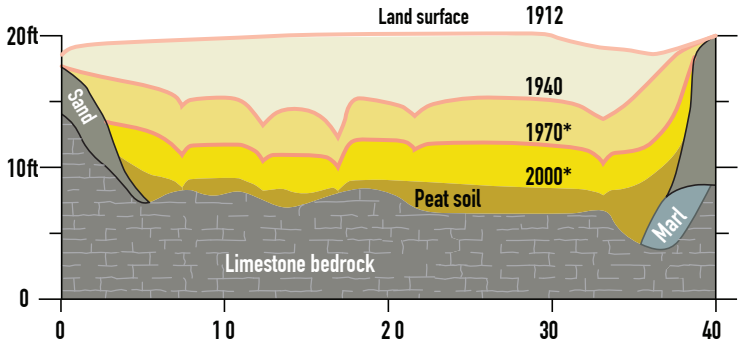
1900 – 1970 Water Flow



Shangyuan Li and Jing Zeng. "Water Flow and Saltwater Intrusion."

Peat Subsidence

Altitude of land surface in feet above NGVD1929

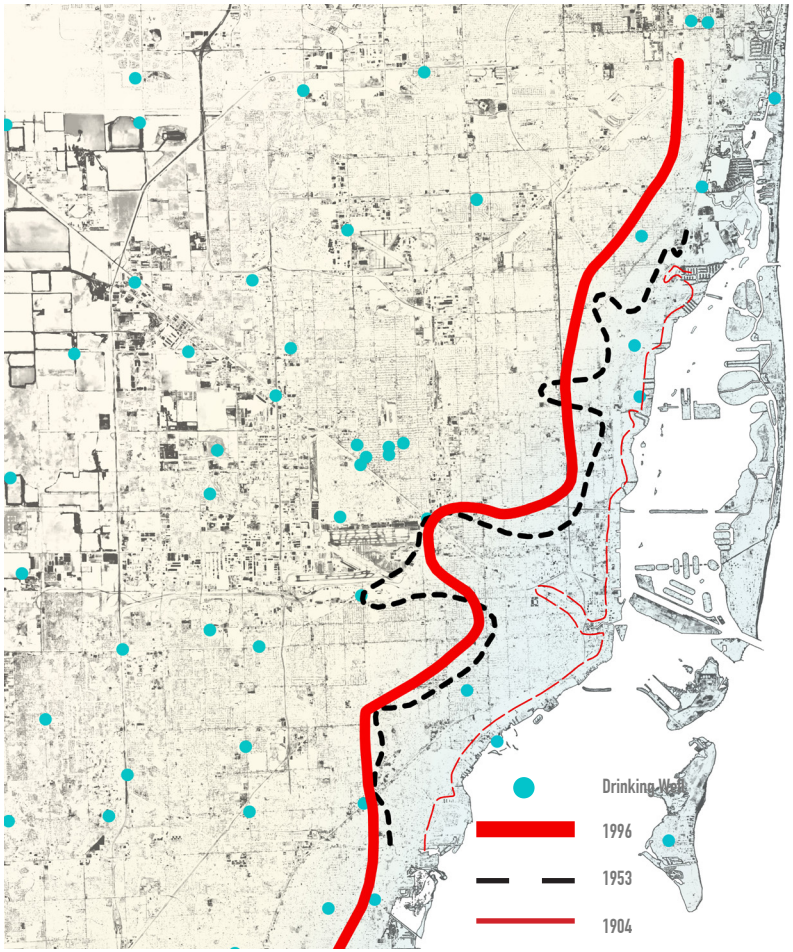


* Estimated

The alteration of water flow contributed greatly to a gradual loss of muck and peat soils through subsidence, compaction, and oxidation. With less freshwater flowing into and being stored in the Everglades, the water in the southern margin of Everglades National Park has already becoming salty. The reason is saltwater intrusion.

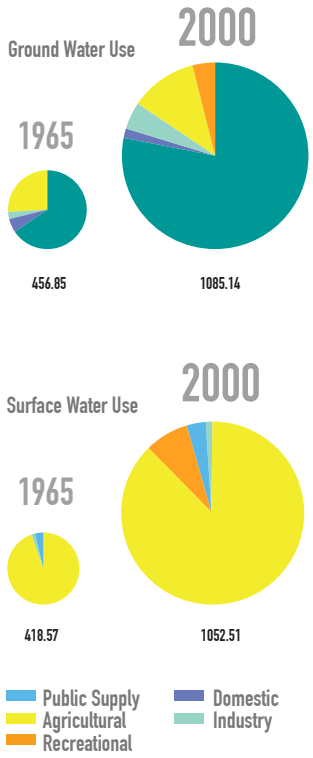
Saltwater Intrusion: Threated Drinking Water Supply

Area Affected by Saltwater Intrusion

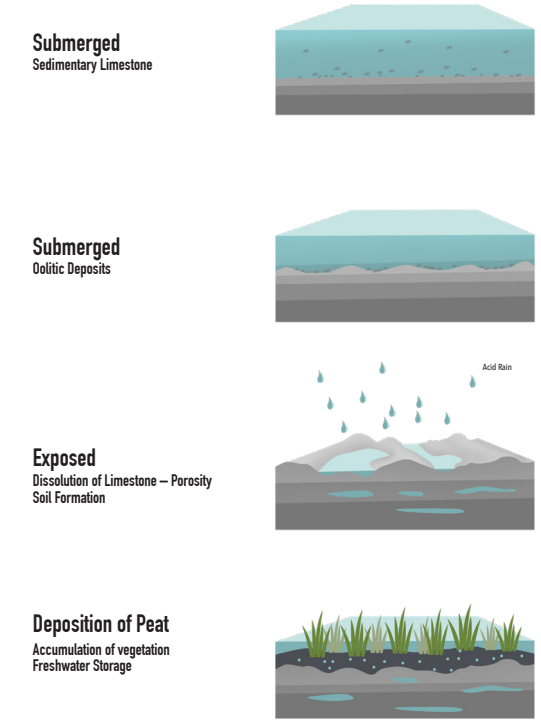


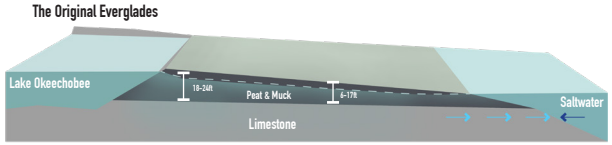
Shangyuan Li and Jing Zeng.
"Saltwater Intrusion Map"

Water Usage in Miami-Dade, Broward, Palm Beach Counties

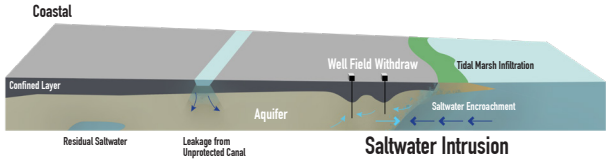


Aquifer Forming & Saltwater Intrusion





Freshwater Stored in Peat and Limestone



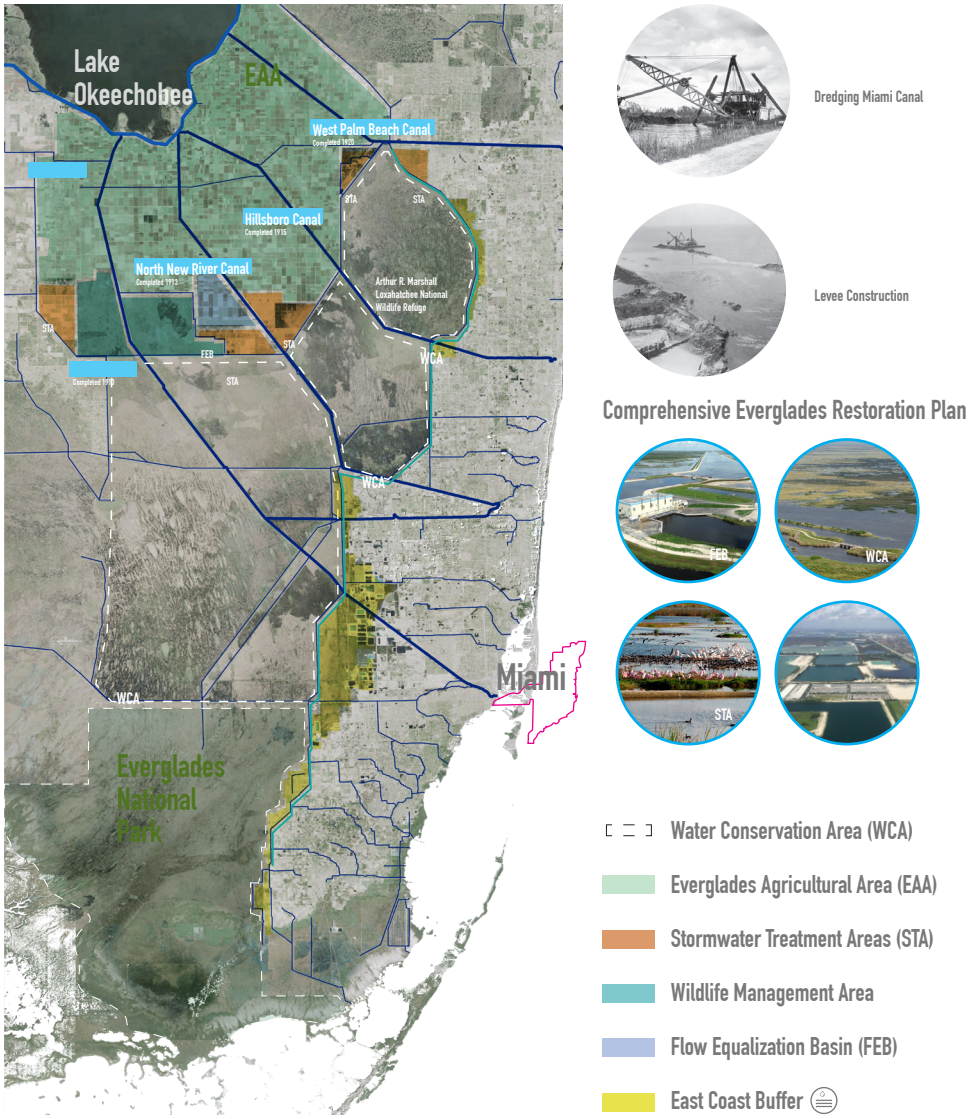
Saltwater Intrusion

Saltwater intrusion is one of major concerns in urban areas, which is mainly caused by increasing uses of groundwater.

Miami gets its most freshwater supply from Biscayne Aquifer, which is a shallow layer of highly permeable limestone under a portion of South Florida. It is a result of sedimentary limestone casing by changing sea level of the past millions of years, which ranges from 400ft higher or 100ft lower than current sea level. The aquifer is basically like a sponge.When less freshwater is recharged to aquifer, saltwater begins encroaching. Since 1904, the front-line of saltwater has invaded almost 5 miles inland in Miami.

Restoration: Ongoing Efforts

From Draining to Restoration



Dredging Miami Canal

Levee Construction

Comprehensive Everglades Restoration Plan

- Water Conservation Area (WCA)
- Everglades Agricultural Area (EAA)
- Stormwater Treatment Areas (STA)
- Wildlife Management Area
- Flow Equalization Basin (FEB)
- East Coast Buffer

Shangyuan Li and Jing Zeng. "From Draining to Restoration"

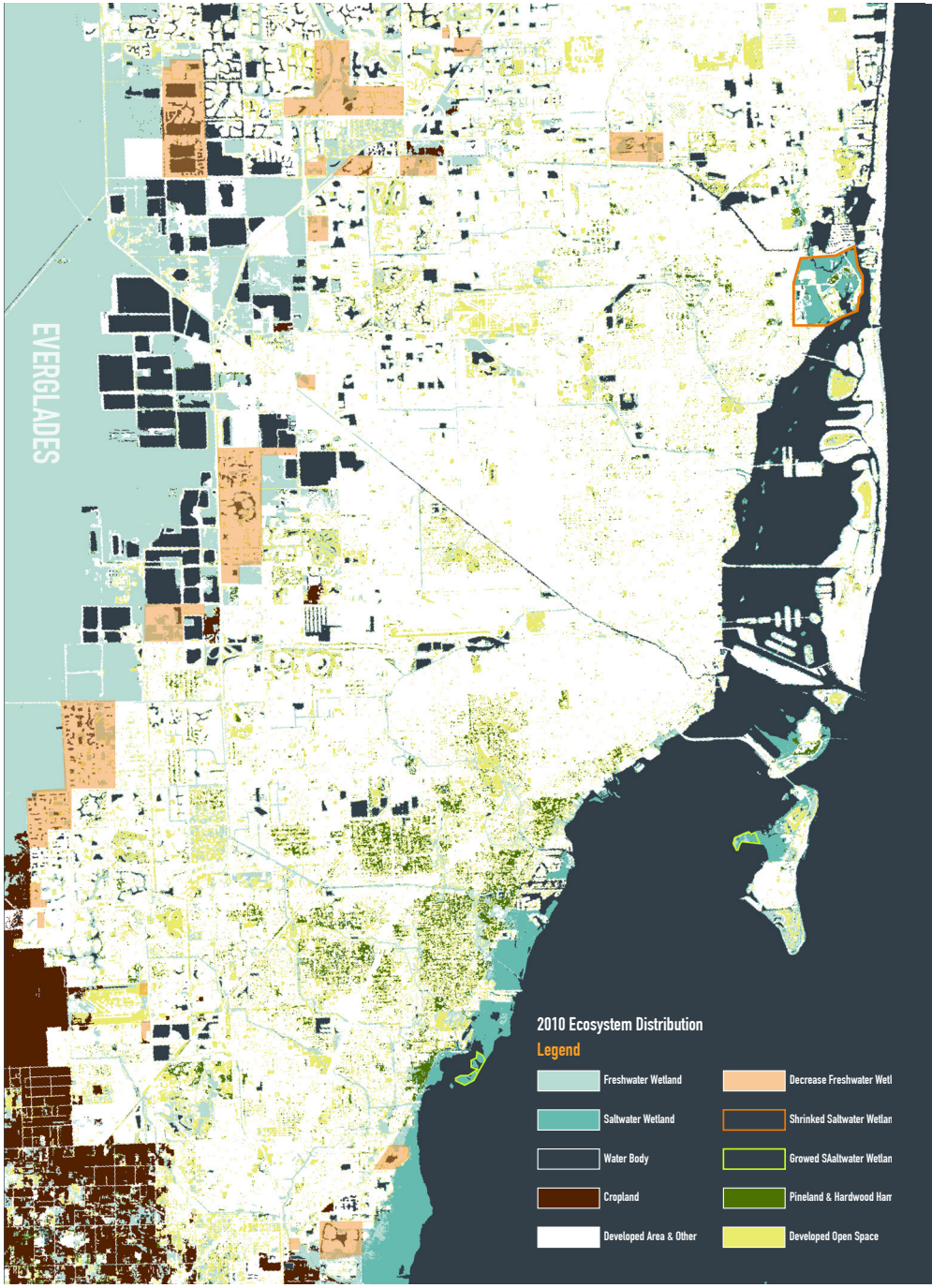
To deal with these problems. The Comprehensive Everglades Restoration Plan (CERP) was authorized in 2000 as a plan to "restore, preserve, and protect the south Florida ecosystem while providing water supply and flood protection.

The Stormwater Treatment Areas (red) are man-made wetlands designed to clean up nutrients from surrounding agricultural areas before the runoff reaches the Everglades.

East Coast Buffer zone is a string of impoundments and restored wetlands that act as a buffer between the Everglades and east coast urban centers,

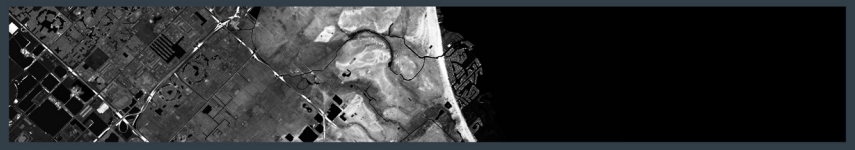
Three large areas are Water Conservation Area (WCA) Which aims to serve multiple environmental purposes including flood control, water supply and habitat for regional plant and animal communities. Also provide recreational activities such as fishing, hunting and bird watching.

Unique Distribution of Ecosystem

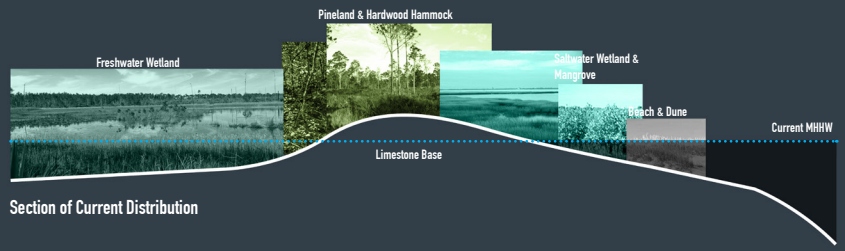


South Florida is home to a variety of ecosystems. As this Land Cover Mapping of 2010 provided by NOAA shows, different ecosystems vary horizontally from coastal sand dune, salt marsh and mangrove to upland forest and continuous freshwater wetland, which is in response to synthesis of topography, water salinity, soil type, fire frequency and other factors.

Freshwater wetland, which is composed of wet prairie, sawgrass marsh and freshwater swamp, plays an unique role in South Florida's ecosystem. It not only occupies nearly 30% of Florida, which has a higher percentage than any other states, but also stands on the frontier of sea level rise. The low-lying portion of everglades are the most vulnerable area when saltwater move inland and upstream, along with saltwater intrusion contributed by limestone base.



Inland Ocean

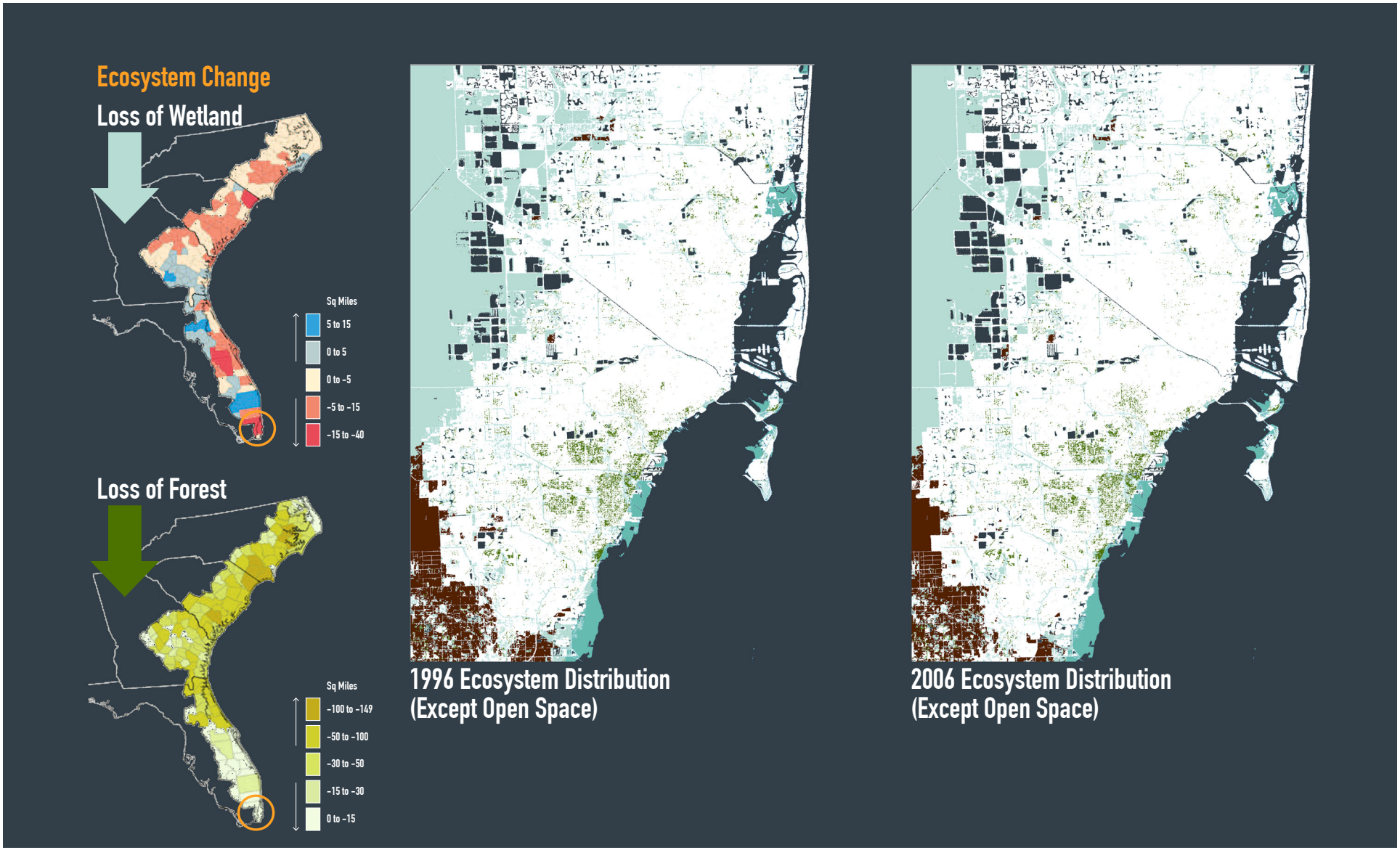


Section of Current Distribution

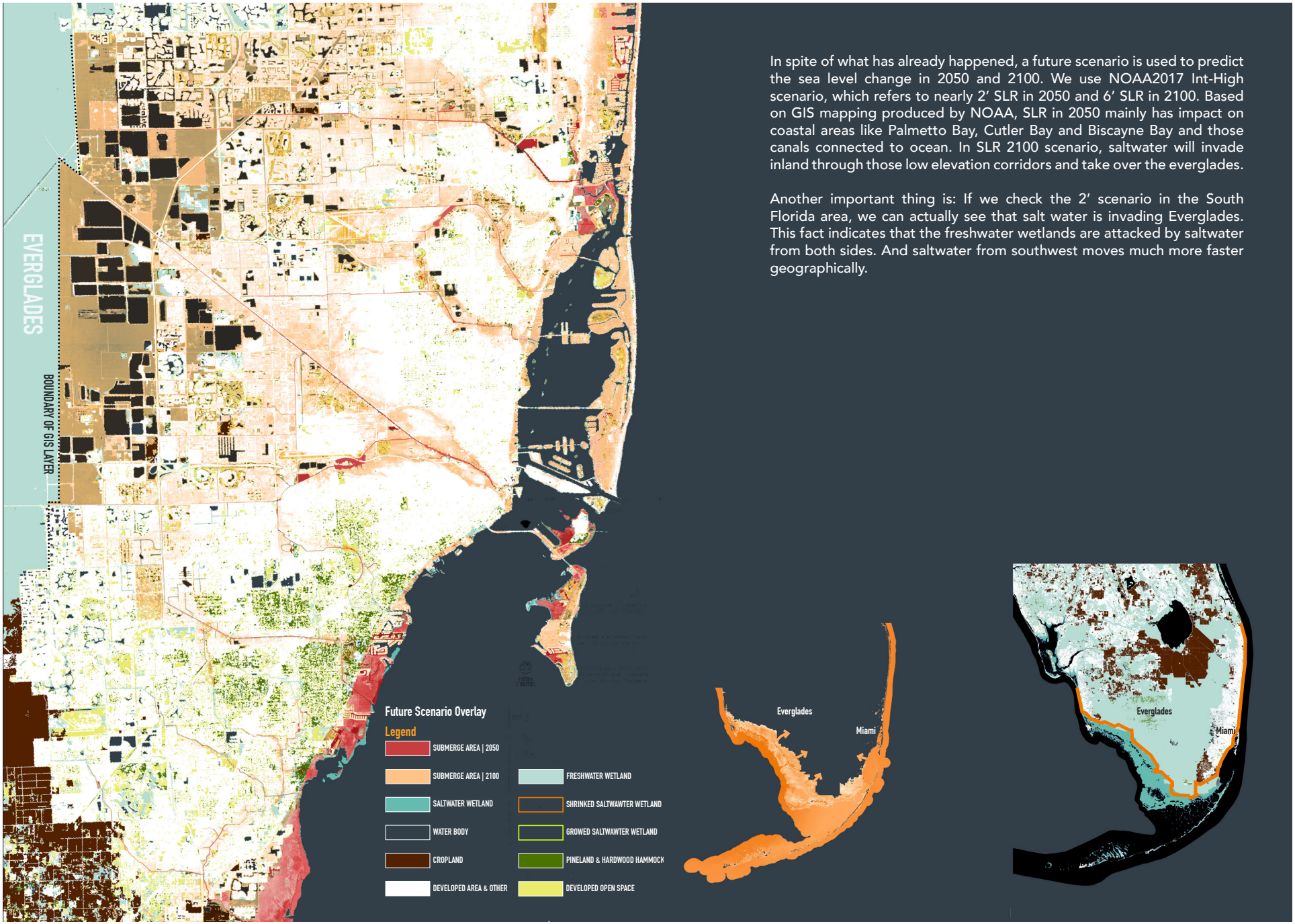
The Freshwater Wetland in Decrease

According to NOAA's Southeast Regional Land Cover Change Report from 1996 to 2010, this region's wetland has been suffering from great decrease while the decrease of forest is not as great as wetland. The conclusion that the decrease of wetland in past 20 years was mainly generated by human development can be drawn by comparing Land Cover Change at the same period.

The disappeared wetland area from 1996 to 2006 are all mapped out as orange patches and most of them are located in the threshold between everglades and urban developed area, which is also known as a part of East Coast Buffer Zone. Other visible changes include expansion or constriction of saltwater wetland in specific area but their changes are not massive.



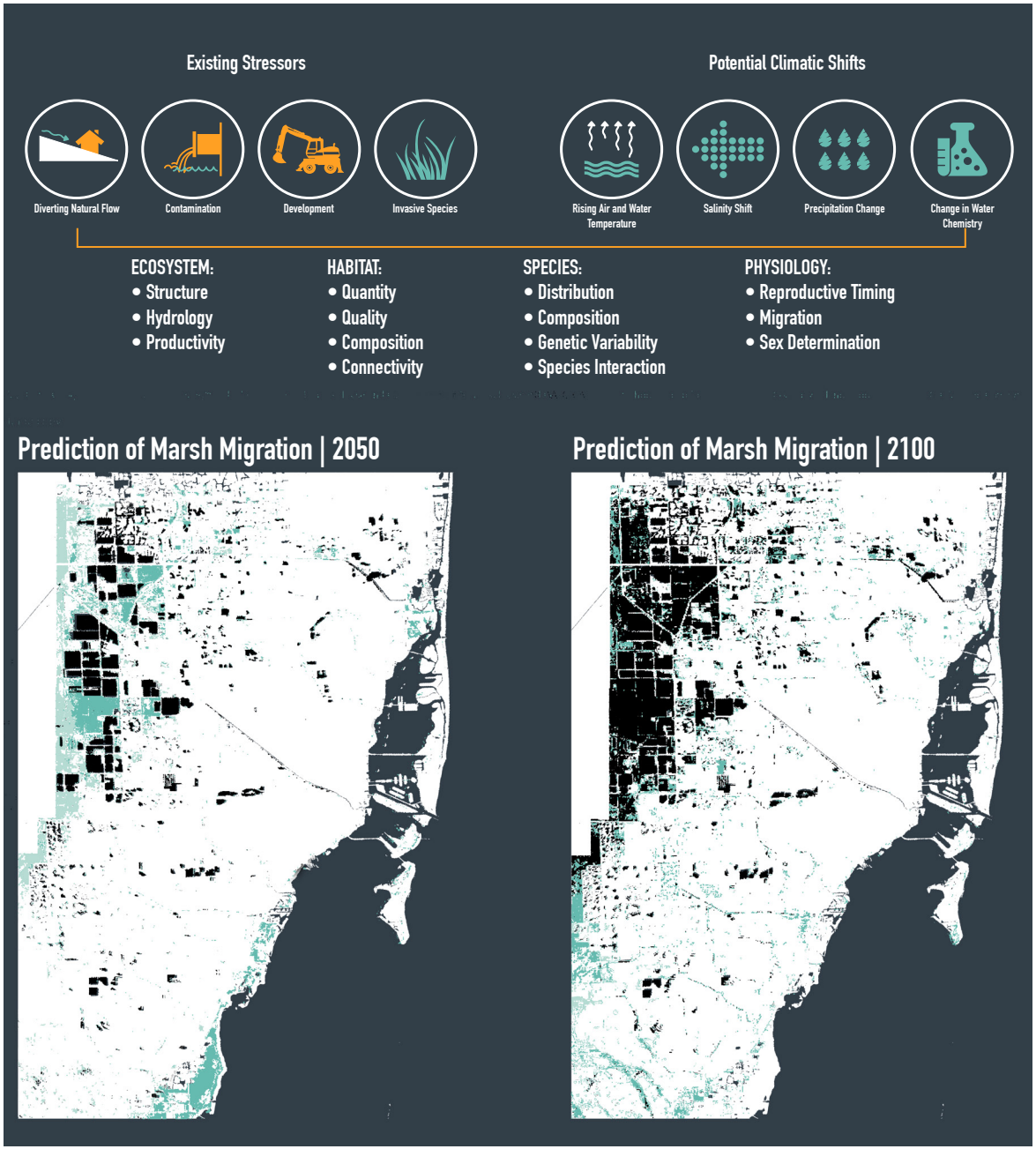
Future Scenario: The Disappearing Everglades



In spite of what has already happened, a future scenario is used to predict the sea level change in 2050 and 2100. We use NOAA2017 Int-High scenario, which refers to nearly 2' SLR in 2050 and 6' SLR in 2100. Based on GIS mapping produced by NOAA, SLR in 2050 mainly has impact on coastal areas like Palmetto Bay, Cutler Bay and Biscayne Bay and those canals connected to ocean. In SLR 2100 scenario, saltwater will invade inland through those low elevation corridors and take over the everglades.

Another important thing is: If we check the 2' scenario in the South Florida area, we can actually see that salt water is invading Everglades. This fact indicates that the freshwater wetlands are attacked by saltwater from both sides. And saltwater from southwest moves much more faster geographically.

Destablization of Ecosystem + Marsh Migration



The existing stressors, including contamination, development, diverting of natural flow and invasive species, are constantly adding ecosystems' vulnerability and contributing to loss and degradation of habitats. Increasing climatic shifts, which refer to rising air and water temperature, salinity shift, precipitation change and change in water chemistry will deteriorate current situation and finally push for local ecosystems' disruption or restructuring.

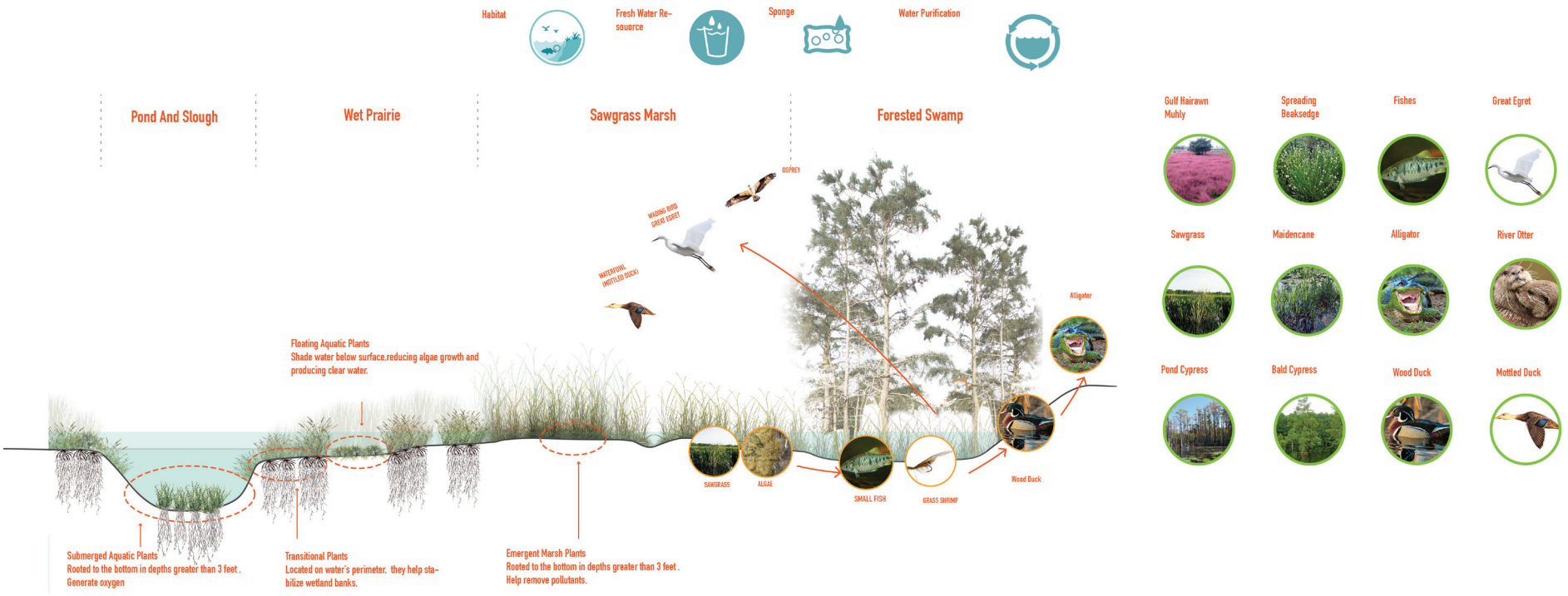
This is a complex synergy. Climate change has differential impacts on coastal ecosystems, freshwater wetlands and upland ecosystems. The Everglades is particularly vulnerable to sea level rise over the next 50 to 100 years.

Based on this information, we specifically focus on wetlands in this region. A marsh migration prediction simulated by NOAA is used for checking the future of wetlands.

The Importance of The Freshwater Wetland

Generally, wetlands can provide these important functions:

(1) Erosion protection - Transitional Plants: Located on water's perimeter, the high density and high depths of root help to stabilize wetland banks.
(2) Purification - Floating Aquatic Plants: Shade water below the surface, reducing algae growth and producing clear water.
(3) Habitat - These wetland communities offer habitat that allows for the survival of wildlife during even times of flooding and drought.

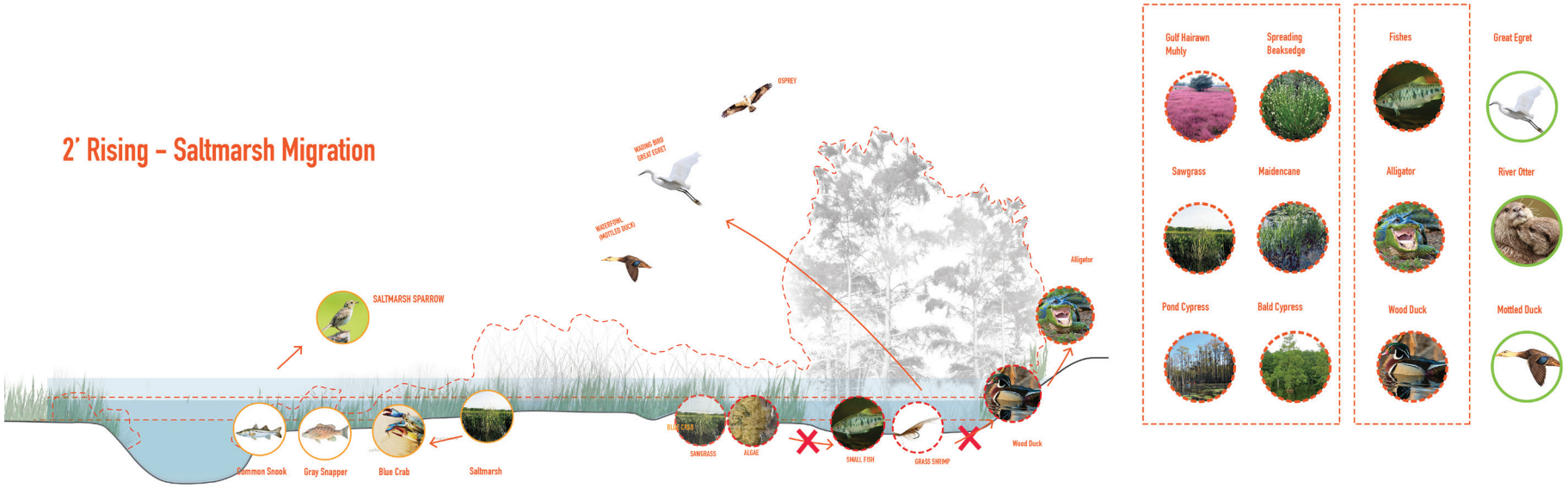


Siyu Zheng. "Succession of Freshwater Wetland."

How Will Marsh Migration Happen?

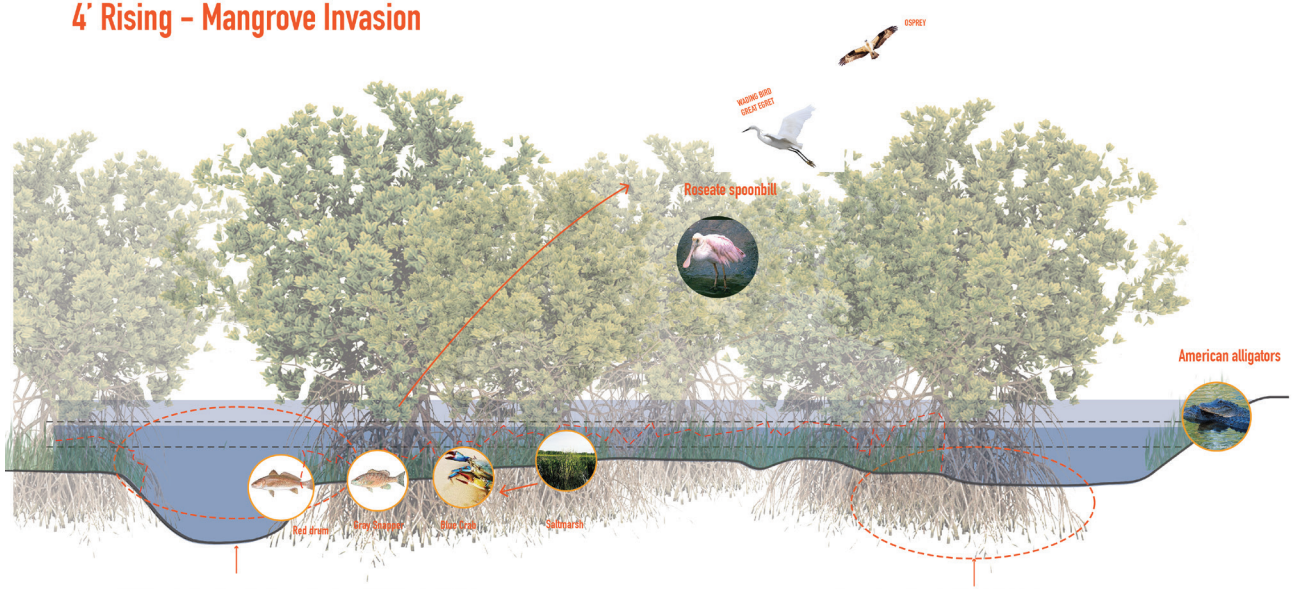
Marsh migration is known as the process that marshes shift gradually inland with sea level rise onto the formerly dry land. Under this unique circumstance, the Everglades may be gradually replaced by saltwater marshes or mangroves and finally lose themselves in open water. The tipping point near Miami is in East Coast Buffer Zone. The massive replacement will start here.

However, not every ecosystem in Florida has the strong ability to relocate itself like salt marsh or mangrove. Florida's species have migrated and adapted to climate change in the past, but that ability is severely compromised now largely due to human modification of the landscape. Up to 76% of 236 surveyed species were deemed unlikely to be able to relocate inland in response to rising sea level.



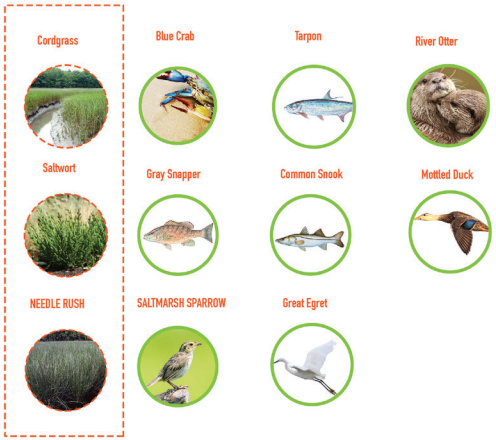
Siyu Zheng. "Succession of Freshwater Wetland."

4' Rising – Mangrove Invasion

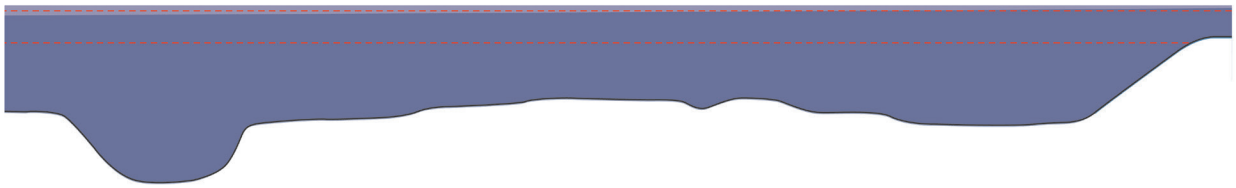


220 fish species, 24 reptile species, 18 mammal species, and 181 bird species that all utilize mangroves as habitat during some period of life. Additionally many species, though not permanent mangrove inhabitants, make use of mangrove areas for foraging, roosting, breeding, and other activities.

Dense and aggresive root contribute to limitation to the number of species able to thrive in their habitat.



6' Rising – Open Water In The End



Siyu Zheng. "Succession of Freshwater Wetland."

Findings + Conclusions

Sea level rise is an inevitable part of Miami's future. During Phase One, the future SLR footprints and their impact on the ecosystem are visualized by mapping and information overlay, which distinguishes freshwater wetlands from other ecosystems. Freshwater wetlands are vulnerable in terms of SLR and saltwater intrusion, and will be gradually replaced by mangroves and salt marshes, which will cause the loss of valuable benefits such as wildlife habitat, freshwater storage and flood control.

Miami's freshwater wetland has been suffering from notable decline, while the decrease of the woodland is not as significant. By comparing changes in the Land Cover Map provided by NOAA it is evident that human development over the past 20 years has mainly generated the decline of the wetland.[5]

Despite what has already happened, a future scenario is used to predict the sea level change in 2050 and 2100, which predicts a nearly two foot SLR in 2050 and six foot SLR in 2100. SLR in 2050 mainly has an impact on coastal areas like Palmetto Bay, Cutler Bay and Biscayne Bay and those canals connected to the ocean. In the 2100 SLR scenario, saltwater will invade inland through those low-elevation corridors and take over the Everglades. Moreover, the Everglades will be inundated by saltwater from both sides, and saltwater from the southwest moves much faster geographically.[6]

The existing environmental stressors, including pollutants and contamination, human development, diversion of natural water flow, and invasive species, are continually adding vulnerability and contributing to loss and degradation of habitats. Aggravated climatic shifts, which refer to rising air and water temperature, salinity shift, precipitation change and change in water chemistry will deteriorate the current situation and finally disrupt or restructure local ecosystems.[7]

This is a complex synergy. Climate change has differential impacts on coastal ecosystems, freshwater wetlands, and upland ecosystems. The Everglades is particularly vulnerable to sea level rise over the next 50 to 100 years.

Marsh migration is known as the process by which marshes shift gradually inland as sea level rises until they take over formerly dry land. Under this unique circumstance, the Everglades may be progressively replaced by saltwater marsh or mangrove and finally be lost to open water. The tipping point near Miami is in the East Coast Buffer Zone, specifically in the Lake Belt Area.

However, not every ecosystem in Florida has the keen ability to relocate itself like mangrove can. Florida's species have migrated and adapted to climate change in the past, but that ability is severely compromised now, primarily due to human modification of the landscape. Up to 76% of 236 surveyed species were deemed unlikely to be able to relocate inland in response to rising sea level.[8]

5. Digitalcoast - https://coast.noaa.gov/digitalcoast/tools/slr
6. Digitalcoast - https://coast.noaa.gov/digitalcoast/tools/slr
7. Stys Beth and Tammy Foster. *Climate Change Impacts on Florida's Biodiversity and Ecology* . Report. Florida Fish and Wildlife Conservation Commission. 340-47.
8. Stys Beth and Tammy Foster. *Climate Change Impacts on Florida's Biodiversity and Ecology* . Report. Florida Fish and Wildlife Conservation Commission. 340-47.

Assessment

The findings in Phase One describe the importance of wetlands and visualize the future threats to them in terms of SLR and human intervention. These findings lay the foundation for the zoom-in test.

However, there are still many things that have not been articulated yet, which makes the whole argument less compelling. For example, why does the visualization of future threats matter? How does this visualization benefit people? How does this transformation of infrastructure contribute to Miami and the Everglades? How does the Lake Belt Area perform currently and work within the East Coast Buffer Zone? More systematic information needs to be added to the argument to explain the importance of design intention.

In Phase Two, more emphasis will be put on positive impacts that potential scheme may have on this region. It will include the study of precedents, which refers to landscape projects and art works. Based on that, a series of visualization strategies will be tested.

Phase 2 Investigation

Alternatives under SLR: Living with Water

Abstract

In Phase Two, the research explores possible solutions to Miami's future living with water. First, the Lake Belt is examined as a possible destination for relocating the residents of Miami. Also, the research explores possible coastal adaptations for the Lake Belt as the sea level continues to rise to form a new sea frontier along its edge. In order to craft real solutions and avoid being lost in many variables of SLR issues, the assumption is made that the population in Miami will inevitably have retreat and relocation as the sea level rises. The scenario is set from 2050 to 2100. The findings confirm that the Lake Belt has the potential to adapt to coastal changes in the future and develop a new living typology, based on its current human occupancy, topography, freshwater resources, and anticipated chorological changes in the future. The whole research process is conducted by reviewing relevant literature, data visualization and information overlay.

Housing on pile foundations in infrastructure pond, Rotterdam[9]

9. Hill, Kristina. "Hybrid Edges: A Typology of Coastal Adaptation Strategies." Lecture.

Introduction

The investigation in Phase Two aims to explore the implementation and innovation of adaptive coastal protection together with developing a new living typology in the Lake Belt. The first step closely examines the potential of the Lake Belt to be a strong choice for Miami residents displaced by rising sea level to relocate in the future. The purpose of this research and the accompanying diagrams is to articulate the importance, specificity and feasibility of the Lake Belt in terms of relocation and adaptive protection. The research also collects baseline data for a more detailed and spatial exploration in the next phase.

The second step is reviewing relevant literature to understand the current technologies, experiences, and precedents of adaptive coastal protection and how they contribute to local socio-economic conditions. The Netherlands and Germany have made important contributions to this topic. In addition, efforts in coastal areas of the Unites States, including the San Francisco Bay Area, to build a new living environment more resilient against SLR can provide valuable guidance.

Three main reasons that the Lake Belt area has great potential for this project include: (1) The Lake Belt will suffer from chronological change and stand on the approaching frontier of SLR by the 2070's, which indicates that it will gradually shift towards being a coastal area with shallow seawater; (2) A socio-economic decline is estimated to occur in the Lake Belt and its surrounding industrial land, which are optimal bases for new human occupancy; (3) Large quarry pits, which currently also function as freshwater reservoirs, have great potential to contribute to a better living environment and new living typology.

Methods

1. Literature review regarding plan of the Lake Belt area
2. Literature review regarding Limestone production of the Lake Belt area
3. Data Visualization of the importance of the Lake Belt in terms of economy and ecology
4. Mapping of surrounding land use and industrial infrastructures
5. Diagrams of chronological change in the Lake Belt
6. Diagrams of site-specific analyses of the Lake Belt
7. Sketches of exploratory schemes

Two Approaches of Protecting the Coastal Line

Elevated building to live with flooding, Hamburg[10]

Floating settlements along the waterfront, Maasbbommel[11]

Coastal protection is now facing a paradigm shift. The adaptive pathways design approach introduces an array of different concepts and measures, including the selective opening of dikes and the creation of emergency flood plains, or "polders". Specialists distinguish between conventional protection and adaptive protection by considering the following: ability to work with water, flexibility, and additional functions.[12]

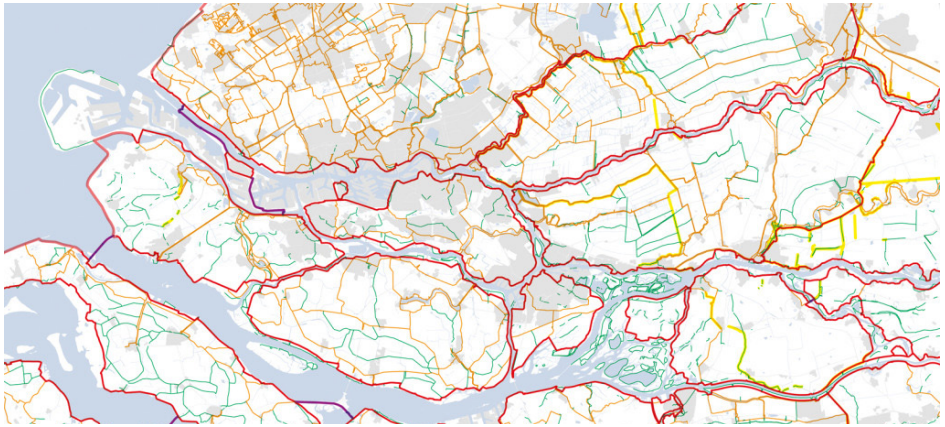
World Ocean Review discusses the approaches of coastal line defense:

Conventional coastal protection
•Resistance: Planning and construction of coastal protection measures at a large economic cost, which are designed for today's extreme events such as 100-year floods. This approach represents the classical method for designing coastal protection systems.

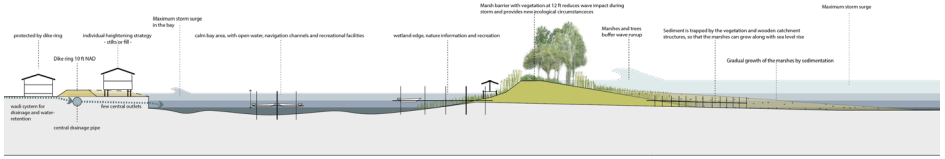
•Static robustness: Planning and carrying out coastal defenses measures that are already designed for the worst-case climate scenario for today. This entails the danger that the protection measures will not be adequate if climate change becomes more intense than expected.[13]"

10. Voorendt, Mark. "Hambburg." Accessed April 16, 2018. https://www.flooddefences.org/hamburg.html.
11. "The Battle for the Coast." World Ocean Review. Accessed April 16, 2018. https://worldoceanreview.com/en/wor-1/coasts/living-in-coastal-areas/.
12. World Ocean Review. https://worldoceanreview.com/en/wor-5/improving-coastal-protection/coping-with-rising-sea-levels/
13. World Ocean Review. https://worldoceanreview.com/en/wor-5/improving-coastal-protection/coping-with-rising-sea-levels/

Storm protection barrier around port of Rotterdam, Rotterdam[14]



Map of dikes in Nertherlands[15]



Living with the bay, Nassau County, New York[16]

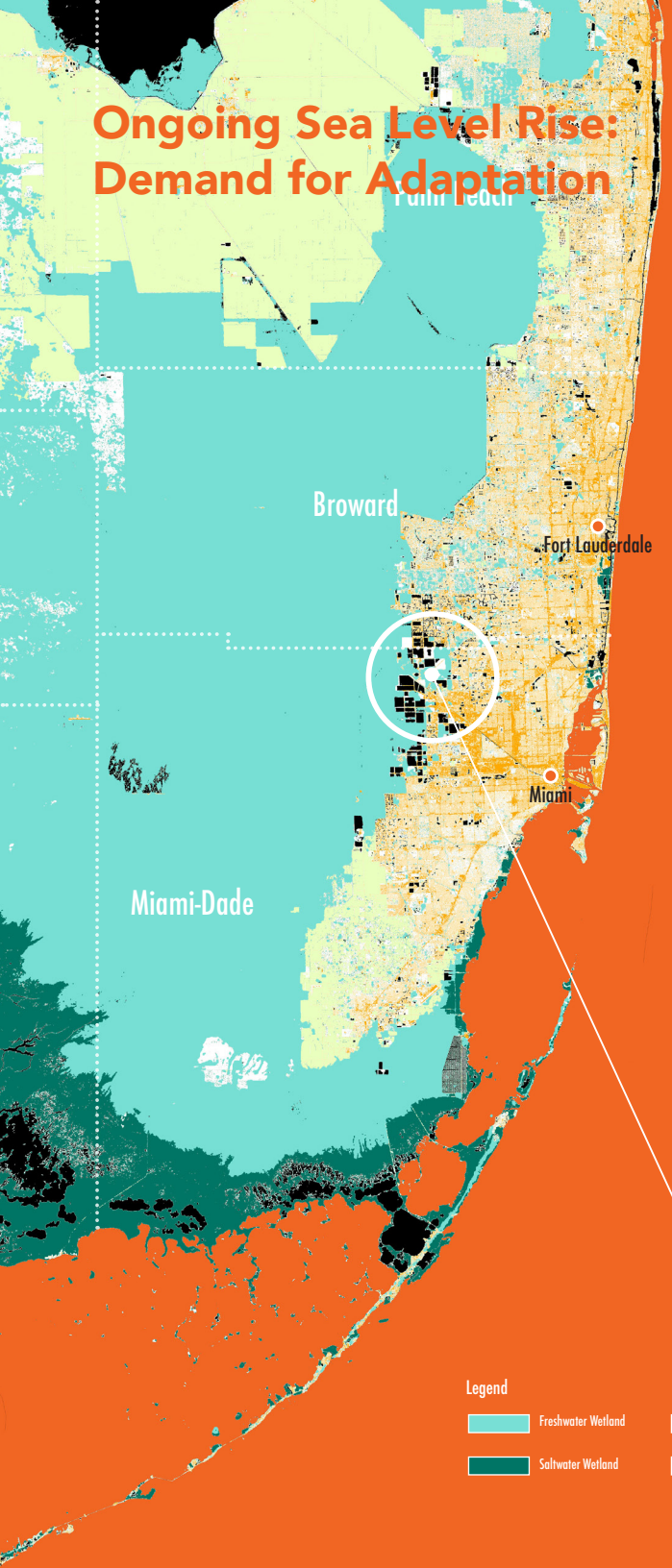
Adaptive coastal protection

•Resilience: Planning and construction of coastal protection structures that are designed so that their failure does not result in losses and severe damage to infrastructures, buildings or ecosystems, and allows rapid recovery or restoration. This could be achieved, for example, by building floating houses. Another possibility would be to build elevated streets and railways on the tops of dams. This would limit the extent of dam¬age. Ideally, damage would be completely avoided.

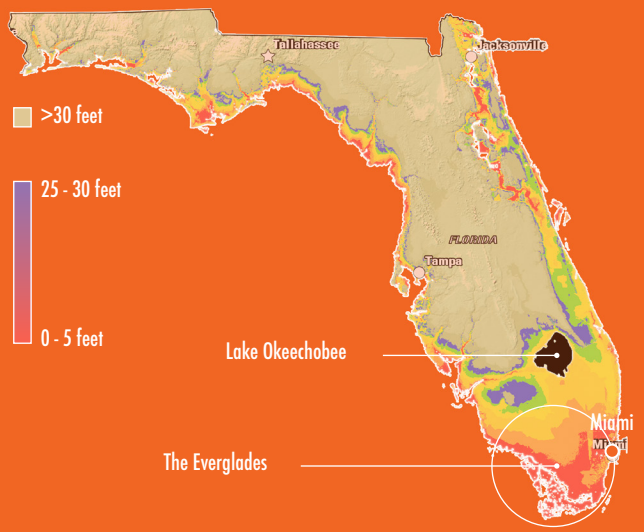
•Dynamic robustness: Coastal protection structures are implemented in succession, to a degree that is based on the latest available knowledge about the development of climate change. This refers to measures that would have societal benefits even when the extent of climate change turns out to be greater or less than what was expected, and that do not entail irreparable damage if false assumptions were made in the scenarios. One example of this measure is the creation of a "polder" that serves not only for coastal protection, but at the same time can function as a local recreation area or nature conservation area – and thus has an additional societal or ecological value. [17]

14. Bentley, Chris. "As Sea Levels Rise, Rotterdam Floats to the Top as an Example of How to Live with Water." Living with Rising Seas. Accessed April 16, 2018. https://www.pri.org/stories/2016-06-20/sea-levels-rise-rotterdam-floats-top-example-how-live-water.
15. Dutch Dikes - http://dutchdikes.net/map/
16. Living with the Bay - http://www.hnsland.nl/en/projects/living-bay
17. World Ocean Review. https://worldoceanreview.com/en/wor-5/improving-coastal-protection/coping-with-rising-sea-levels/

Ongoing Sea Level Rise: Demand for Adaptation



Low Elevation Portion



Located next to the Everglades and sharing the portion of land at the lowest elevation in South Florida, the Lake Belt area will be directly affected by saltwater around 2065. By that time, the Lake Belt will have become a new borderline between the marine system and the terrestrial system, along with the gradient composed of salt marshes and mangroves. The newly formed coastal line and the shallow bay will create a need for specific protection to mitigate the damage on the wellfield and urban fabric, while also providing many-faceted resources with diverse potential.

Urban Edge

The Everglades + Urban Fabric

Infrastructure

Eco-Infrastructure + Industrial Infrastructure

Ecotone

Freshwater Ecosystem + Deep Pond Ecosystem + Urban Forest Ecosystem

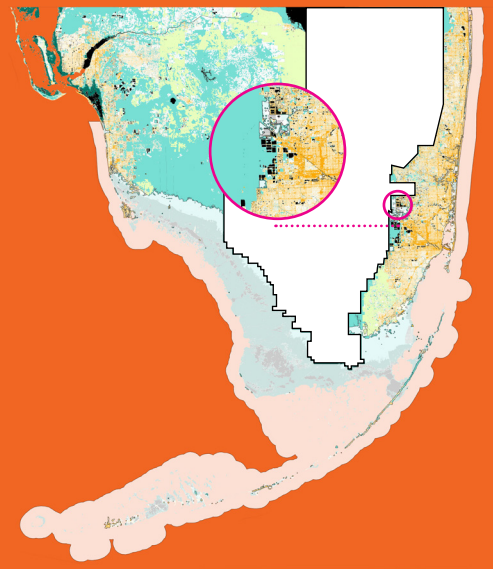
Lake Belt Area

Legend

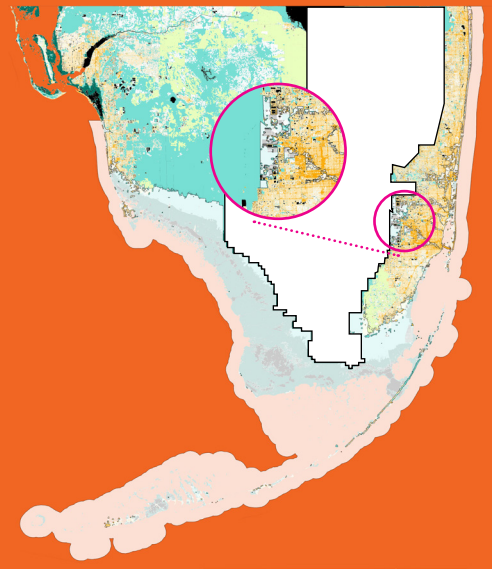
- Freshwater Wetland
- Saltwater Wetland
- Productive Cropland
- Low-density Development
- Medium-density Development
- High-density Development
- Open Water
- Unmapped Area
- Sea Level Rise

Sea Level Rise

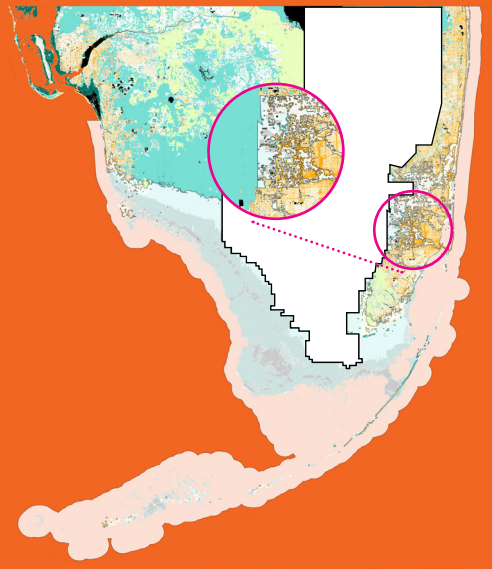
4′ Sea Level Rise



5′ Sea Level Rise

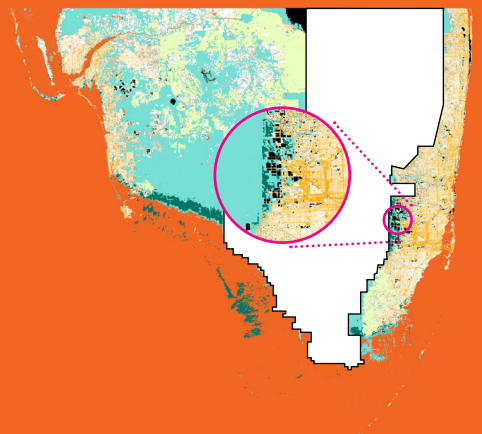


6′ Sea Level Rise

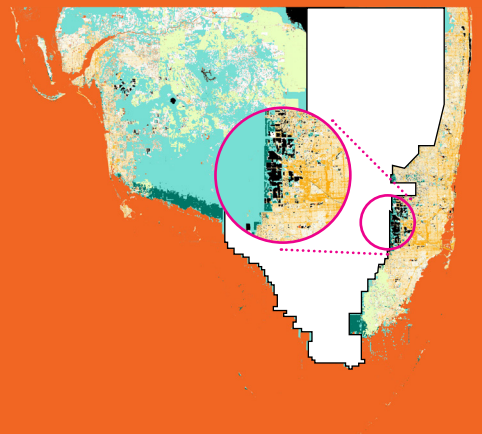


Marsh Migration

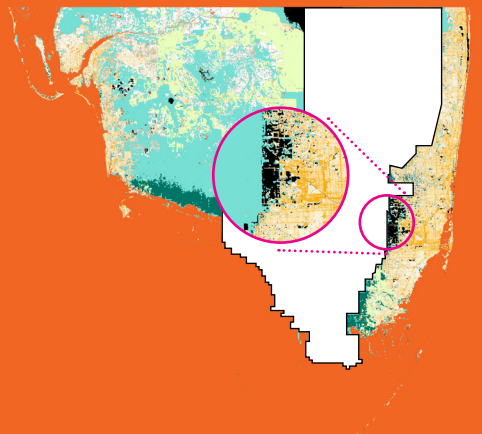
4′ Sea Level Rise



5′ Sea Level Rise



6′ Sea Level Rise



The rising saltwater from Southwest Florida will quickly take over the floodplain of the Everglades in the foreseeable future. Located in the margin between the Everglades and Miami, the Lake Belt Area will be touched by salt water when SLR is 3′. The migration of saltwater marsh will possibly happen at the same time.

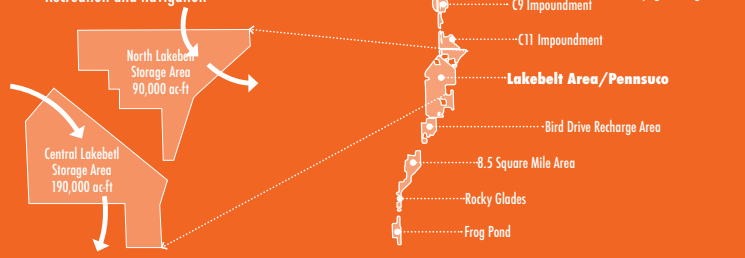
Freshwater Resorvoir: Base for Future Living

Miami Canal

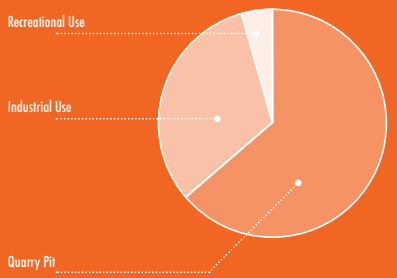
East Cosst Buffer Zone

The purposes of this project include:

- Flood control
- Regional water supply for agricultural & urban areas
- Prevention of salt water intrusion
- Water supply to Everglades National Park
- Preservation of fish and wildlife
- Recreation and navigation



Siginificant Water Storage Area



Percentage of Inland Water Area

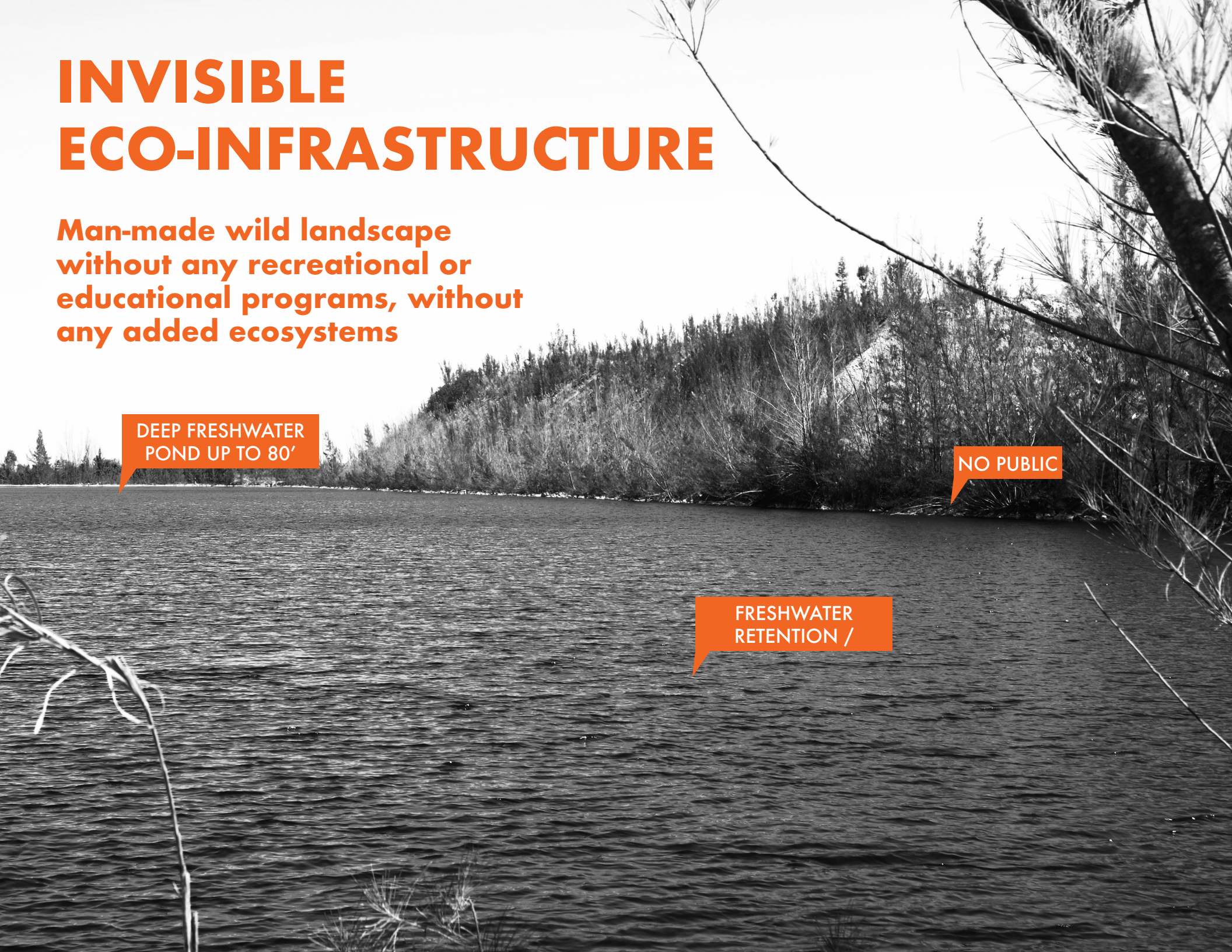
Quarry pits in the Lake Belt occupy nearly 60% of areas of open water inland and play an important role in the East Coast Buffer. They are natural water tanks that manage stormwater flow and replenish downstream area. These water tanks are uniquely useful in terms of the volume of water they can hold, both freshwater and saltwater, in the future. Currently, the volume and depth of freshwater in quarry pits is not actively used to support the development of an ecosystem or human occupancy. Great potential lies in these deep freshwater tanks to provide a foundation and benefits for the future living environment.

Legend

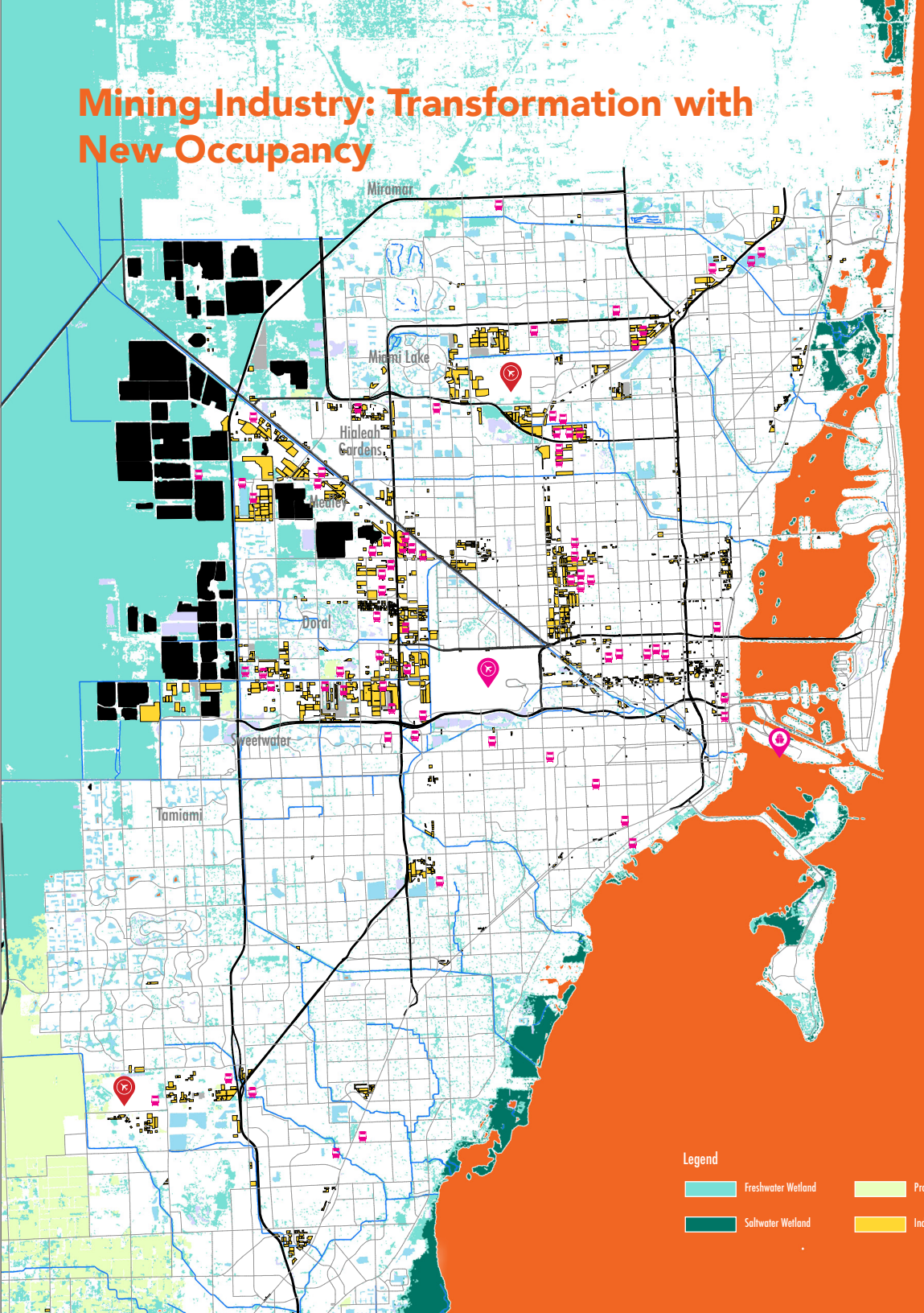
- Freshwater Wetland
- Saltwater Wetland
- Productive Cropland
- Lakebelt Storage Area
- Mining-associated Inland Water
- Industrail-associated Inland Water
- Recreational-associated Inland Water

INVISIBLE ECO-INFRASTRUCTURE

Man-made wild landscape without any recreational or educational programs, without any added ecosystems



Mining Industry: Transformation with New Occupancy



3nd Florida's rank of the production and use of aggregate products in nation

153,000,000 Tons of consume per year

40% - 60,000,000 Tons of limestone comes from Lake Belt

14,000 Jobs Related to Limestome Industry Provide to Miami-Dade County

$ 550,000,000 Payroll and pays $22 million in local sales taxes and $10 million in rpoperty taxes each year

Limestone and its refinary products are Miami-Dade's second largest outboutd freight. The mining industry here not only leave those large, deep quarry ponds, but also greatly affect the distribution of other industrial infrastructures.

What is happening now?

Blasting | Noise | Dust | Water Quality | Surface Water | Ground Water

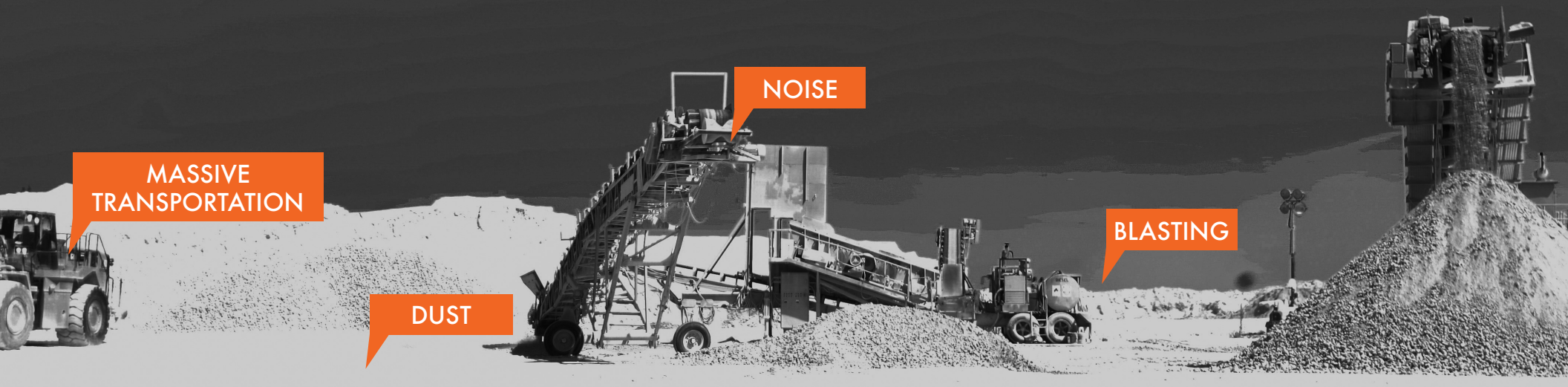
The mining industry is the main socio-economic source for the Lake Belt, as well as surrounding communities such as Medley and Doral. Imagine what will happen to these areas when those quarries are mined out? The decline of the Lake Belt will cause chain reactions estimated to occur in the 2050's. This area will need to be used in a new way, which creates opportunities for the relocation of Miami's population.

Legend

- Freshwater Wetland
- Saltwater Wetland
- Productive Cropland
- Industrial Development
- Mining-associated Inland Water
- Industrail-associated Inland Water
- Recreational-associated Inland Water
- Major Roads
- SIS Airport
- Airport
- Sea Airport
- Strategic Intermodal System Highways

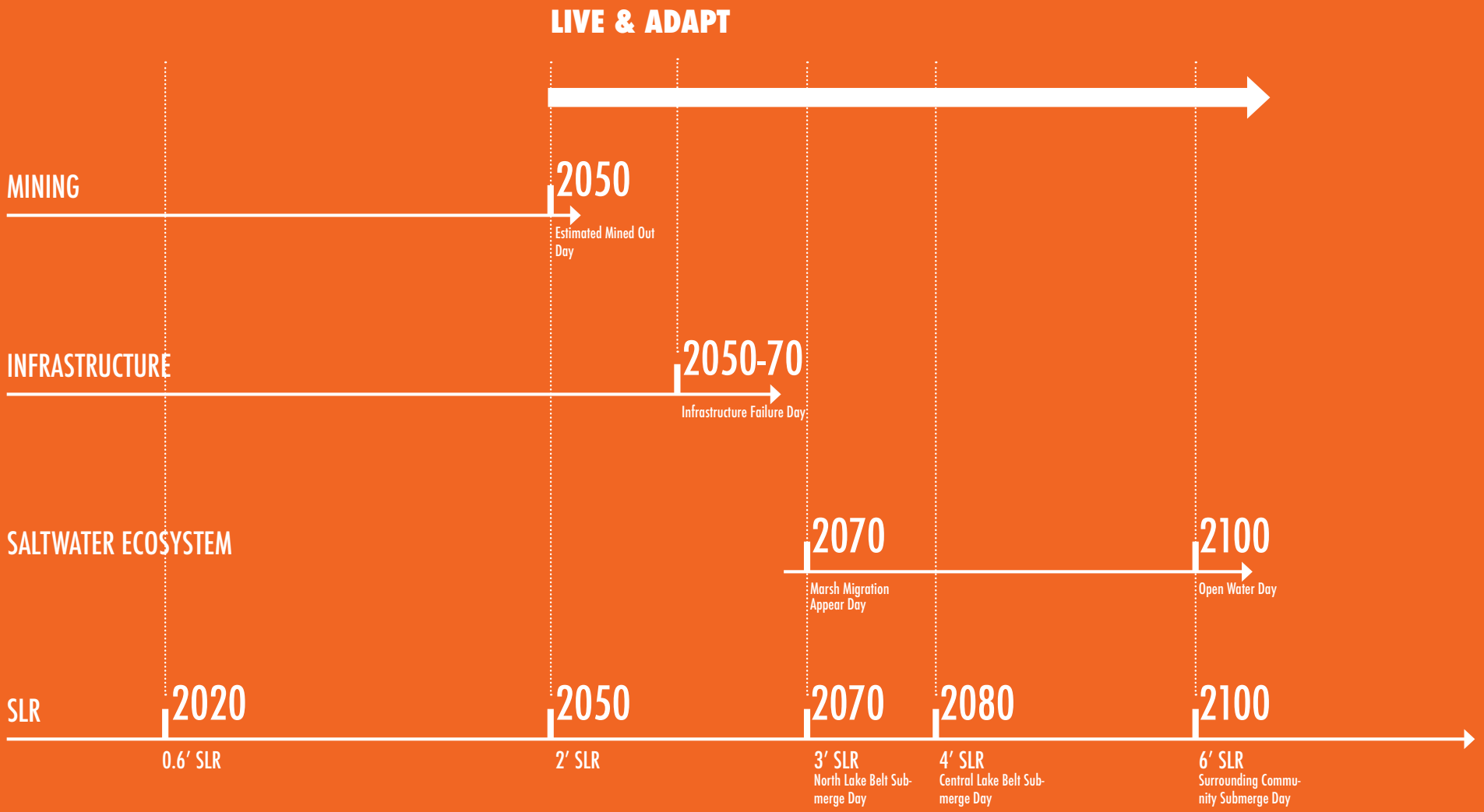
VISIBLE INDUSTRIAL LANDSCAPE

Dangerous, disturbing, dusty, and annoying landscape with atrracting features



Respond to Chronological Change

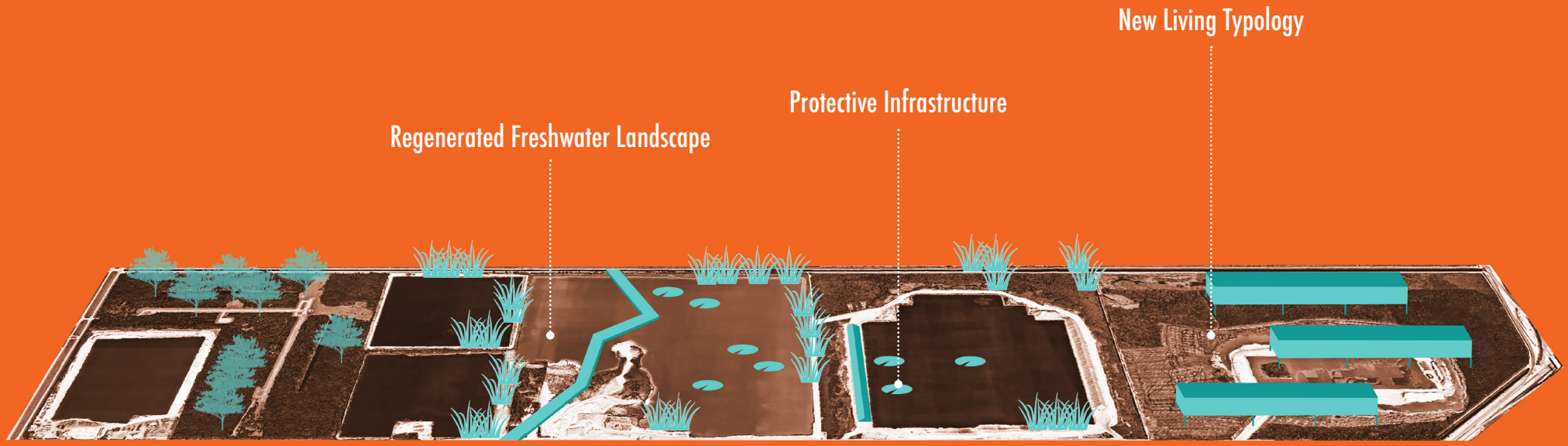
The design aims to create an adaptive living environment that explores the co-existence of urban lives, ecosystems, and coastal protections. Those changes that will mark the critical shift of the Lake Belt are used as references for designing under future scenario.s



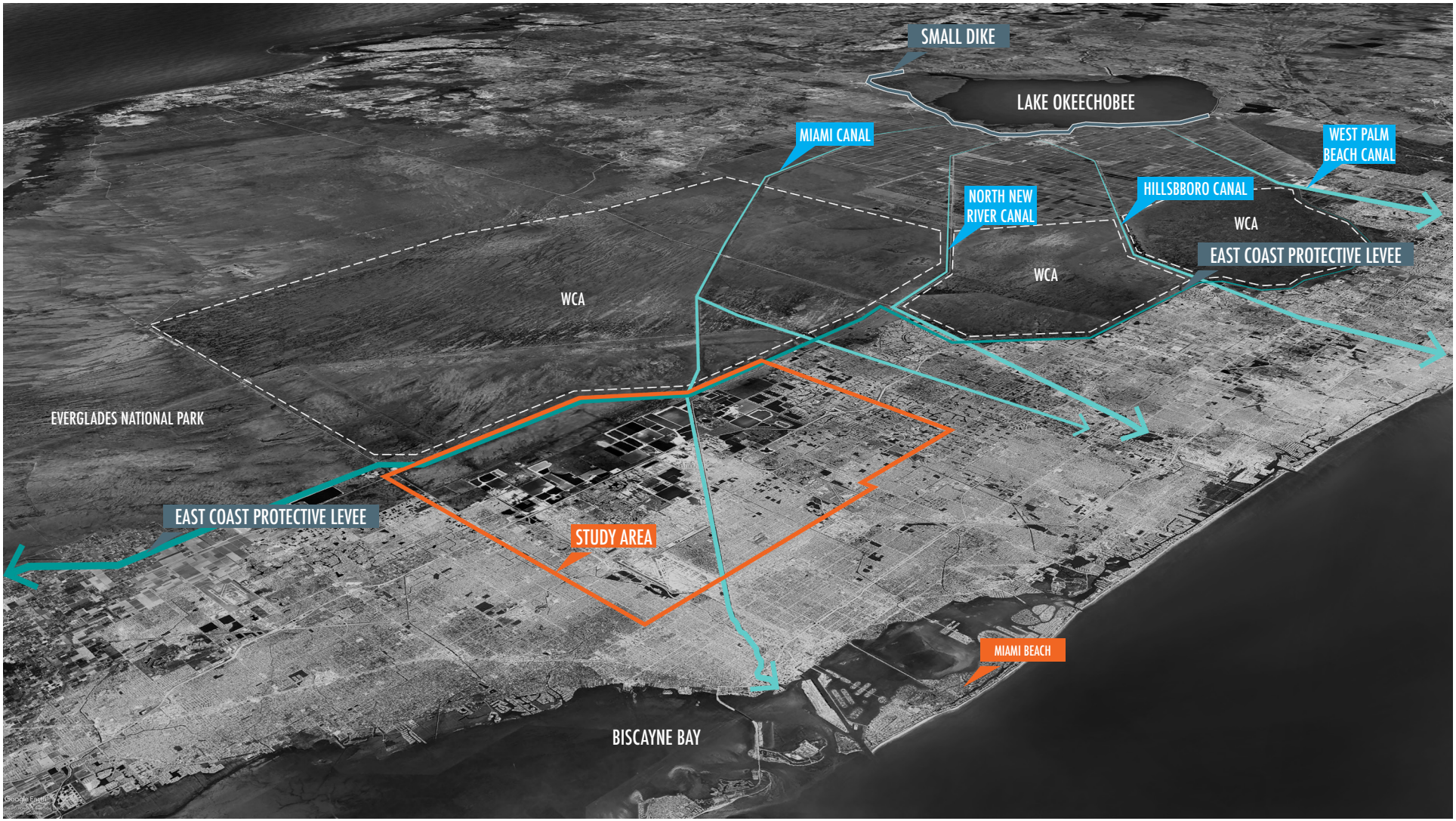
Proposal for Future Occupancy

In consideration of all factors, this proposal will focus on the scenario from 2050 to 2100. The assumption of this proposal is that the population of Miami will move inland because of SLR. By developing adaptive coastal protection together with new living typology, the Lake Belt can become a qualified and suitable site for relocating Miami's displaced population.

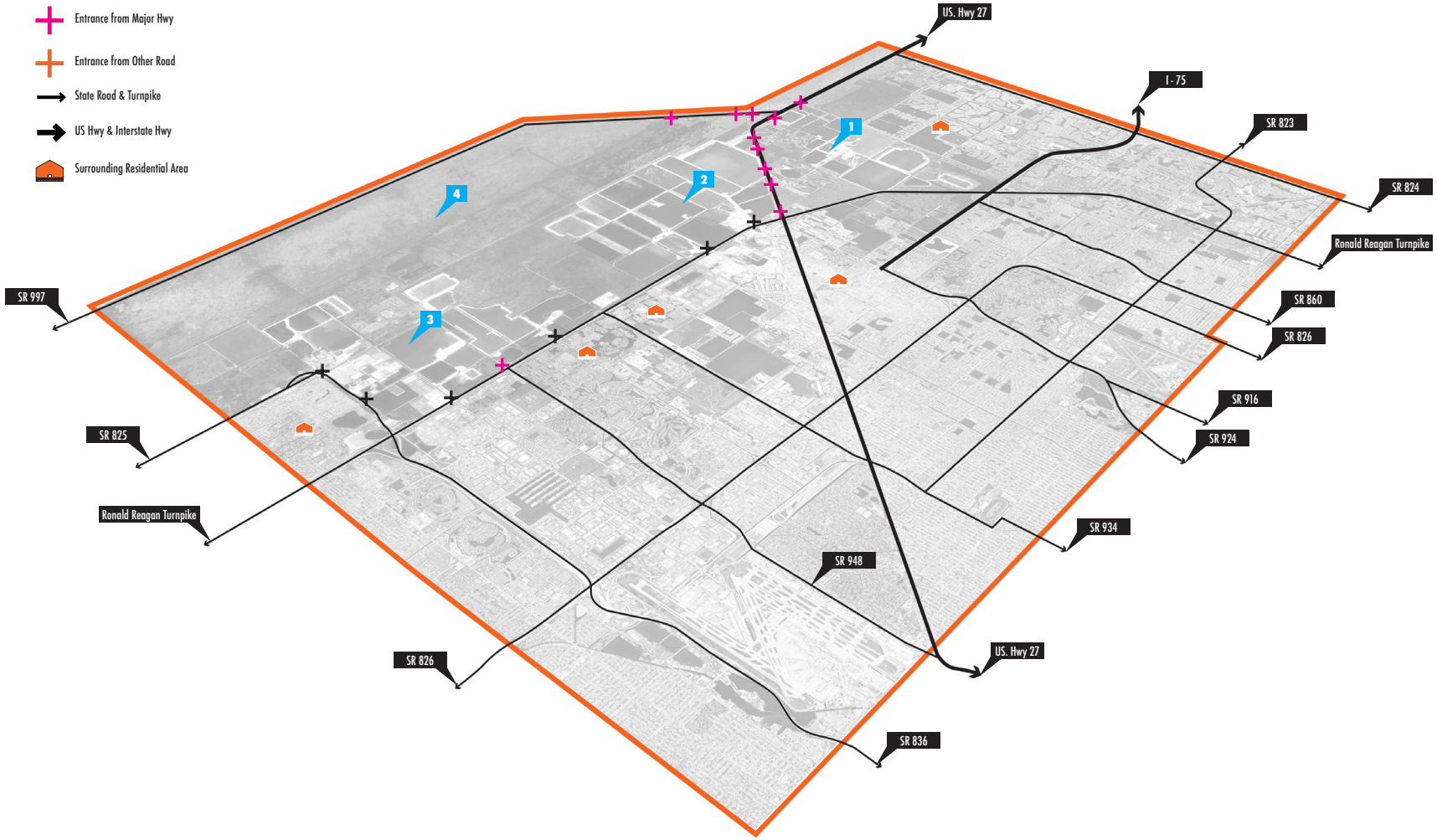
The missions of this proposal include:
(1) Add coastal protection structures to the Lake Belt, including ecosystem strategies, infrastructure strategies and building strategies;
(2) Attach additional social, economic or ecological values to protective infrastructures in order to benefit the future population;
(3) Develop a successional, flexible relationship with sea level rise.



Zoom-in Study Area

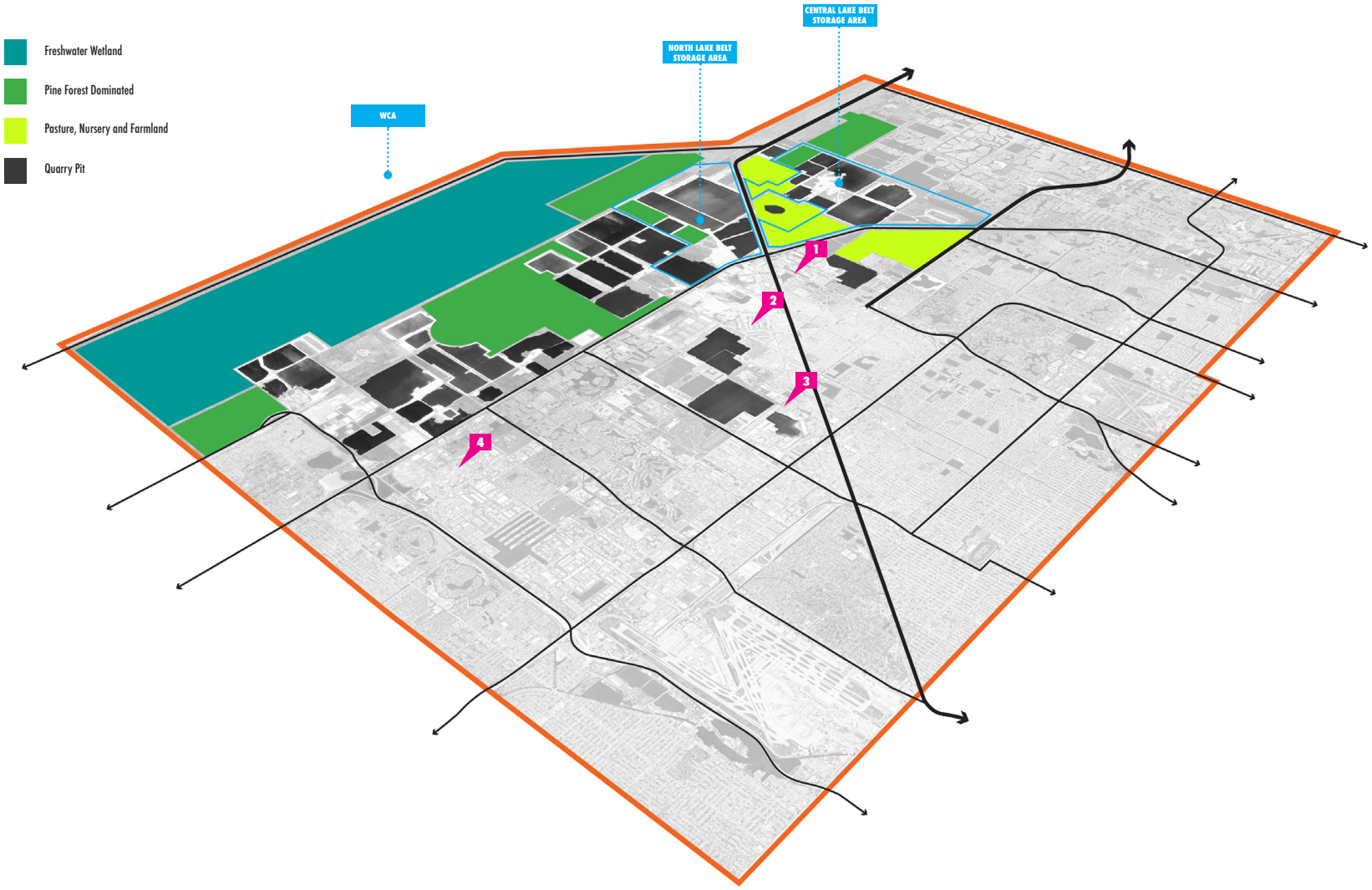


Site Analyses: Accessibility



- The Lake Belt is mainly devided by RR Turnpike, US Hwy 27 and SR 97.
- Generally, the Lake Belt has poor accessability from outside for its industry.
- All entraces to Area 1 are located on US Hwy 27. Even nearby neighbour cannot access to Area 1 directly.
- Area 2 connects directly with nearby indusrial area through roads under elevated turnpike.
- Area 3 has both on ground and elevated access to surrounding area.
- Area 4 is a restored wetland, which is currently no access to outside.

Site Analyses: Land's Potential



- In addition to quarry pit, the upper Lake Belt has much agriculture land.
- The central and lower part of Lake Belt is dominated by pine land and freshwater wetland landscape.
- Area 1, 2, 3, 4 are all contain great amounts of surface parking and assemblage area.

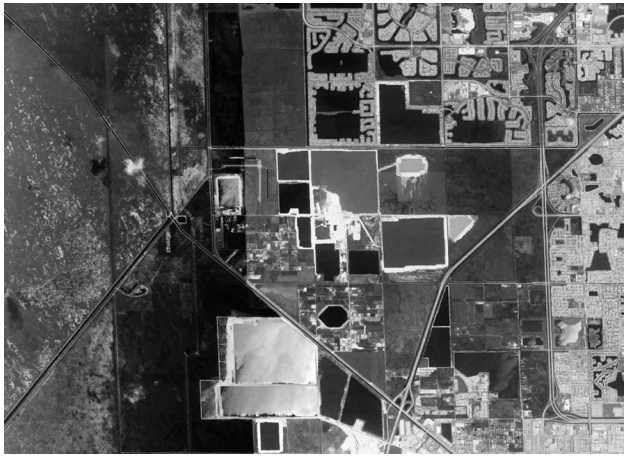
Site Analyses: Development through the time

1984

1994

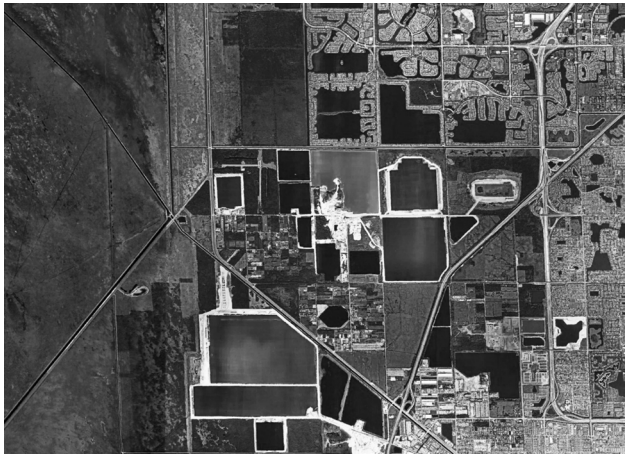
2002

2007



2014

2017



Findings + Conclusions

Although the coastal line is approaching Miami from the back side, there are still alternatives to explore and develop in order to identify the best strategies for adaptation to changing forms of water. Once we assume that the population in Miami is inevitably going to have moved inland in the future, the Lake Belt emerges as a place that could accommodate urban living and develop important adaptations to SLR. Under this circumstance, the Lake Belt can be turned into a dynamic and multifunctional landscape infrastructure.

Located next to the Everglades and sharing the portion of land at the lowest elevation in South Florida, the Lake Belt area will be directly affected by saltwater around 2065. By that time, the Lake Belt will have become a new borderline between the marine system and the terrestrial system, along with the gradient composed of salt marshes and mangroves. The newly formed coastal line and shallow bay will call for specific protection to mitigate sthe damage to the wellfield and urban fabric, while those same protections also provide great resources and potential.

The quarry pits in the Lake Belt comprise nearly 60% of the open water inland and play an important role in the East Coast Buffer. They are natural water tanks that can store water and manage stormwater flow. These water tanks are uniquely useful in terms of the volume of water they can hold, both freshwater and saltwater, in the future. Currently, the volume and depth of freshwater in the pits is not actively used to support the development of the surrounding ecosystem or to support human occupancy. Great potential lies in these deep freshwater tanks to provide foundations and benefits for the future living environment for the whole ecosystem.

The mining industry is the main socio-economic source for the Lake Belt, as well as those surrounding communities like Medley and Doral. Imagining what will happen to these areas when those quarries are mined out? The decline of those communities and associated chain reactions will possibly occur in the 2050's. This area will need to be used in a new way, which creates opportunities for the relocation of Miami's population.

Most importantly, the beginning of Phase Three will analyze the possible technologies that may be implemented in the Lake Belt and how they can be combined with local conditions to generate a new eco-urban fabric in Miami. The criteria for selection of the site to carry out the spatial tests will also be determined.

Assessment

The findings in Phase Two indicate the importance, specificity, and feasibility of transforming the Lake Belt area into a common ground for SLR protection and relocation of Miami's population. These findings lay the foundation, but there is a need for more detailed and spatial tests of adaptive strategies in Phase Three.

During this phase, the main goal and stance of the design has gradually shifted from visualization to adaptive living. Questions explored in Phase Two are different from those raised at the end of Phase One. However, the purpose of the whole design is developed more clearly and specifically, which will benefit the following exploration.

In Phase Three, more research about the implementation of landscape intervention will be tested through dimensional and spatial design.

Phase 3 Investigation

Spatial Strategies: Protect and Adapt

Abstract

In Phase Three, the emphasis of the work gradually shifts from research to design that aims to explore physical and spatial alternatives for the Lake Belt to protect, utilize and create more possibilities for people to benefit from this great volume of freshwater it holds. With more focus on the freshwater itself instead of the shape and geometry of this unique industrial area, the driving question becomes how can the freshwater resources be used actively for people and ecosystem, both before and after seawater gets into the Lake Belt. During this final phase, the assumption raised in Phase two remains unchanged while a more aggressive stance is taken, which refers to the potential retirement of industrial area near the Lake Belt. The outcomes from this phase provide a perspective for people to look at possible applications of saline-based successional landscape interventions. The whole research and design process is conducted through a combination of literature review, case study, digital and hand modeling, sketches and information overlay and study of alternatives.

Great impoundment for water storage, Lake Belt

Introduction

The exploration in Phase Three builds upon knowledge regarding functions of region-specific intertidal and freshwater ecosystems and possible living strategies acquired in previous phases. Through a series of spatial analysis, this phase aims to understand the quality and potential of the Lake Belt to provide foundations for zoom-in design. During this process, the acknowledgments of the value of design are shifted a little bit to form a better narrative and make the whole argument more believable.

The first step of Phase Three is identifying goals for the whole design and generating strategies in territorial scale to respond to these goals. By doing this, more detailed criteria can be provided to set the guidelines for spatial manipulation. Through the comparison between Lake Okeechobee and the Lake Belt area in terms of restored volume of water, two principles are set for the next operation: (1) Protect Lake Belt as much as possible before sea water comes in; (2) Equip this land with adaptability to let ecosystem and people benefit from its situation after sea water comes in.

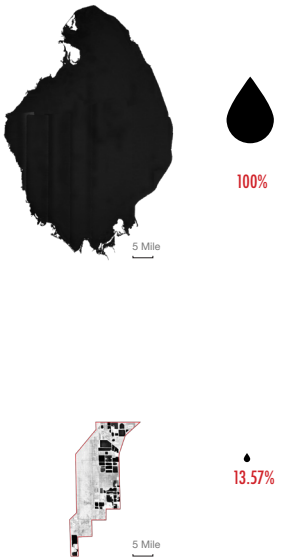
A key method to achieving goals raised above is reclaiming freshwater wetland by retiring part of surrounding industrial lands. More spatial explorations are carried out to test how this land can potentially accommodate this shift of ecosystems and salinity. Representative models and topographic study are produced by using different materials, including clay, sponge, and wood. After zooming in step by step by using sketch plans and digital section drawings, a transition composed of different toolkits are designed to be applicable for the Lake Belt.

Methods

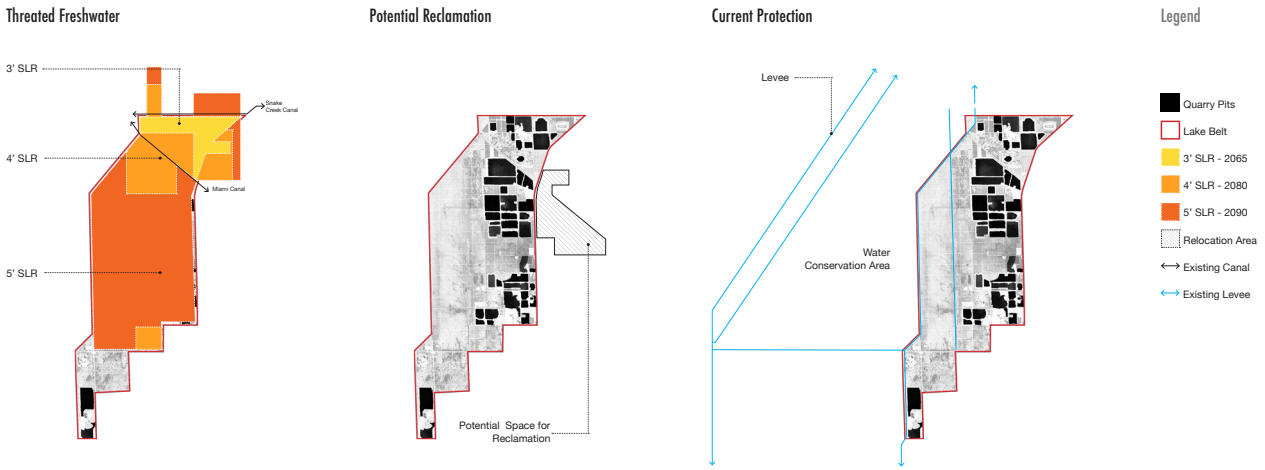
1. Literature review regarding reclamation of wetland
2. Literature review regarding theory of saltwater intrusion
3. Data visualization of the volume of freshwater the Lake Belt holds
4. GIS mapping of existing site condition, including contours, hydrological infrastructures and major roads
5. Spatial studies regarding topographic manipulation
6. Sectional studies vary from territorial scale to site scale

Challenges and Principles

IMPORTANT FRESHWATER STORAGE



PROTECT IT, THEN ADAPT TO IT



The design builds on the assumption that the population of Miami may have retreated and the city will shrink its size in the future. By then, its surrounding industrial area can be partly retired to form a more important ecological infrastructure to embrace this great impoundment.

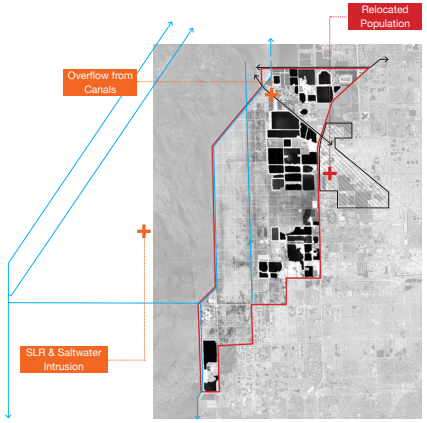
In time scope between 2050 to 2100, three challenges are identified for the Lake Belt. (1) Expanding sea frontier from the Everglades – this drawing shows how the area will be submerged. (Above ground); (2) Saltwater intrusion from the seawater (underground); (3) Overflow from the canals. These challenges threaten the Lake Belt, the area with the great amount of freshwater and drinking water well-fields. If Lake Belt loses to salinity, the loss is huge. And it's just a matter of time.

Under this circumstance, two general principles are raised: (1) Protect Lake Belt as much as possible before sea water comes in; (2) Equip this land with adaptability to let ecosystem and people benefit from its situation after sea water comes in.

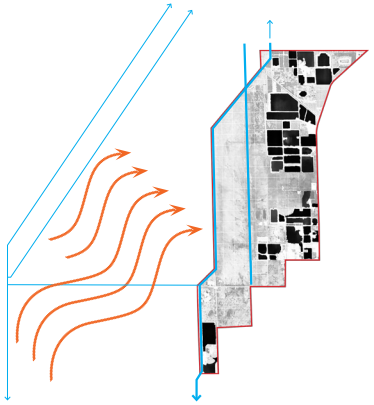
To Protect Impoundment before SLR Comes in

3 STRATEGIES TO PROTECT & UTILIZE IMPOUNDMENTS BEFORE SEAWATER COMES IN

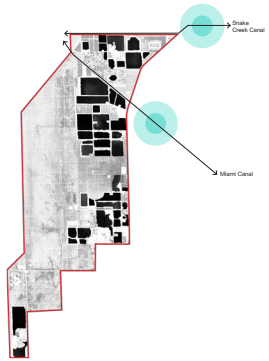
Identify 3 Challenges & 1 Opportunity



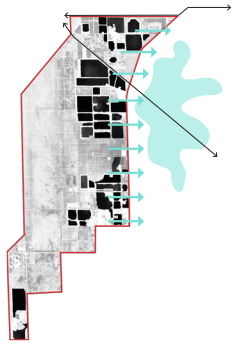
Strategy 01: Reinforce Existing Protection



Strategy 02: Create Flood Plain



Strategy 03: Supply New Freshwater Wetland



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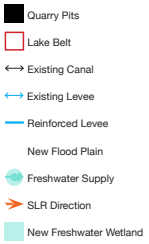


(1) Utilize the latest technology to update levees at the margin of Lake Belt to postpone the invasion of salinity and maintain them as freshwater reservoirs. The whole Everglades is out of the discussion.

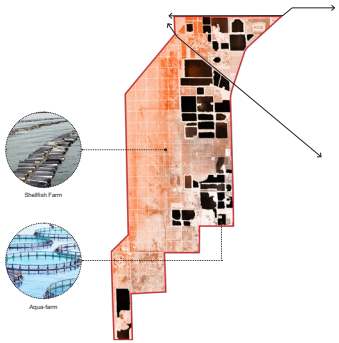
(2) Retire available land along those canals, especially Miami canal, to form a new floodplain to reduce the impact of overflow from canals.

(3) Partly and carefully retire industrial areas and utilize the freshwater from existing impoundments to reclaim freshwater wetlands in these areas. Create sponges to hold extensive freshwater and charge the aquifer in order to slow ongoing saltwater intrusion and protect important drinking water well-fields.

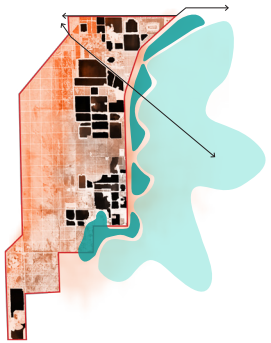
To Adapt to Salinity after SLR Comes in

3 STRATEGIES TO ADAPT TO SALINITY AFTER SEAWATER COMES IN

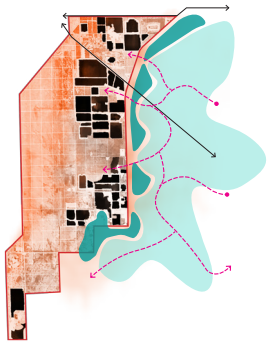
Strategy 01: Supply New Freshwater Wetland



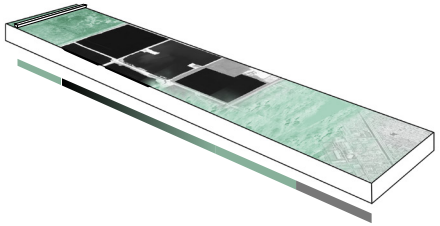
Strategy 02: Supply New Freshwater Wetland



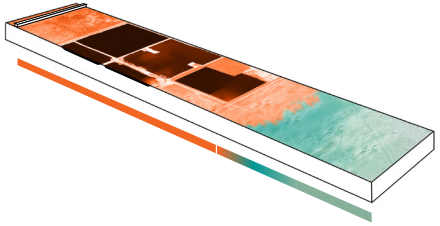
Strategy 03: Supply New Freshwater Wetland



Before SLR Take Lake Belt



After SLR Take Lake Belt



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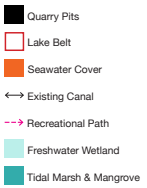


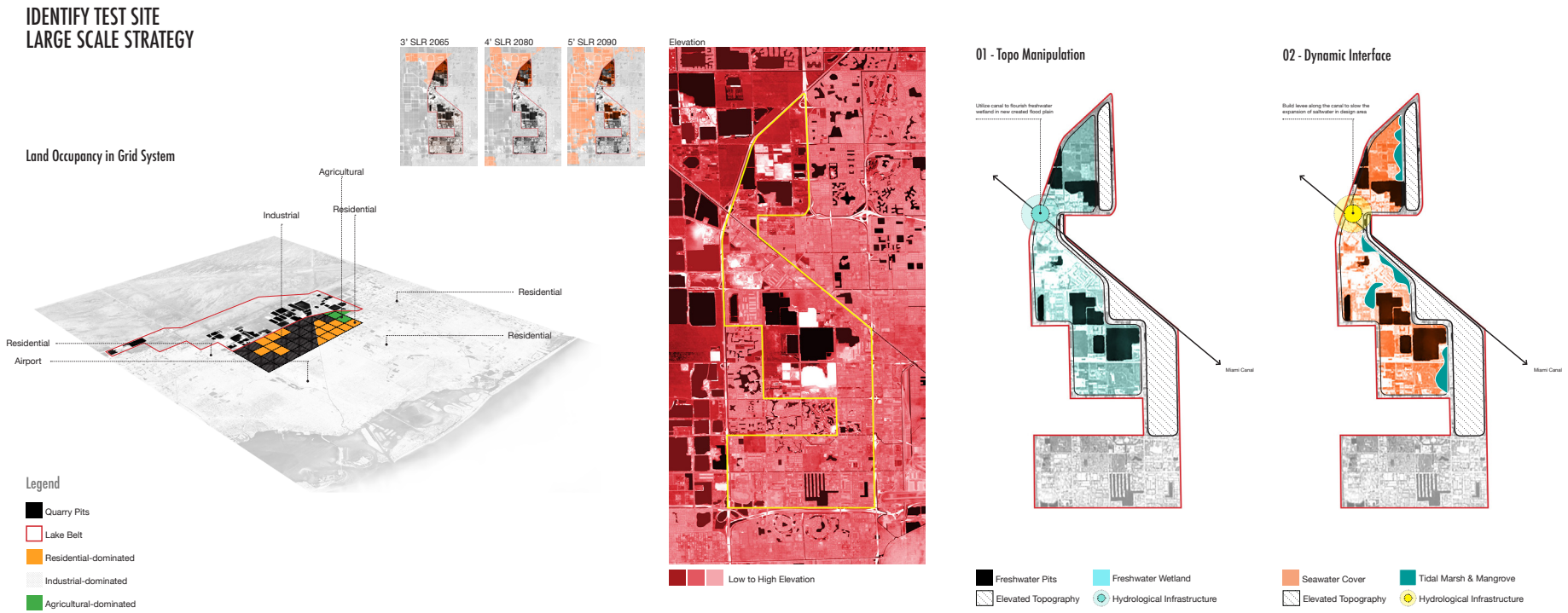
Although some efforts can be put into protections and mitigate the expansion of seawater, the failure of those infrastructures is just a matter of time. After seawater comes into the Lake Belt and the salinity shift starts, new ecosystem-based strategies need to be implemented to form a new defense line while providing opportunities for humans to benefit from this status. Those strategies include:

(1) Change the identity of existing water containers and utilize the volume of water they have to generate new economic production like shellfish and aqua farms.

(2) Create landforms to be supportive to a new intertidal zone with dynamic coastal protection. This new threshold between freshwater and saltwater will continuously shift with SLR footprints and creates a changing landscape;

(3) Add accessibility and recreational opportunities to the successional landscape to make sure the city of Miami can still benefit from this land.

Identify Test Ground

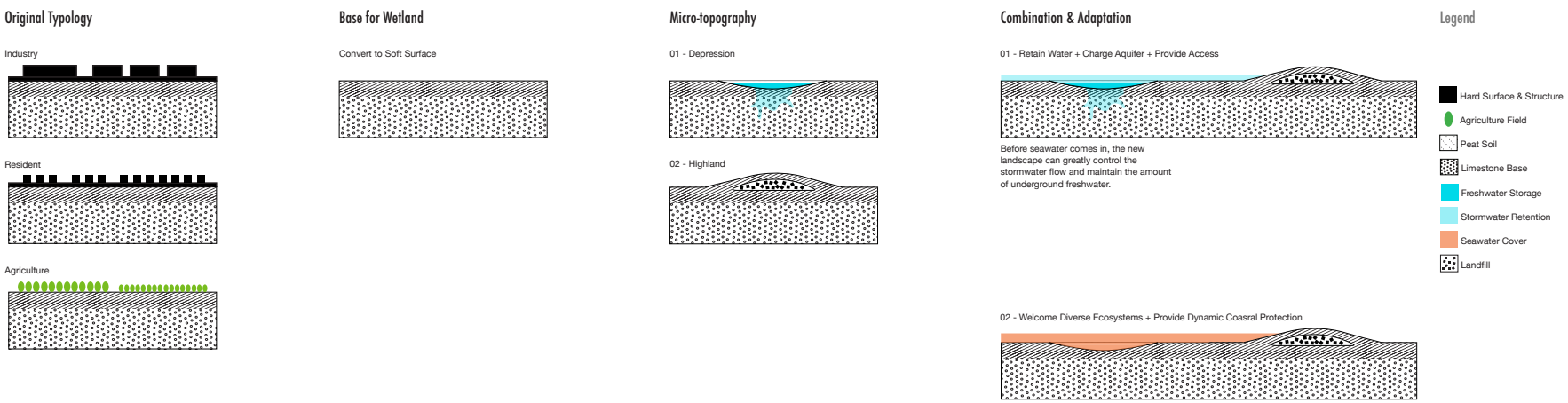


A zoom-in area is identified through study of land use. The whole site has relatively flat terrain. The average difference between elevation is only 2'. The first thing to do is reclaiming a floodplain by retiring existing land. By doing this, the water from upper stream can be easily used to support freshwater wetland and the overflow problem can be solved by adding control infrastructures.

And then a ridge will be created between this land and large amount of residential area on the other side to provide protection for inland. After seawater comes in, the existing wetland and landforms can help to shape a shifting interface so people can benefit from the variation of salinity.

Strategies in Topographic Manipulation

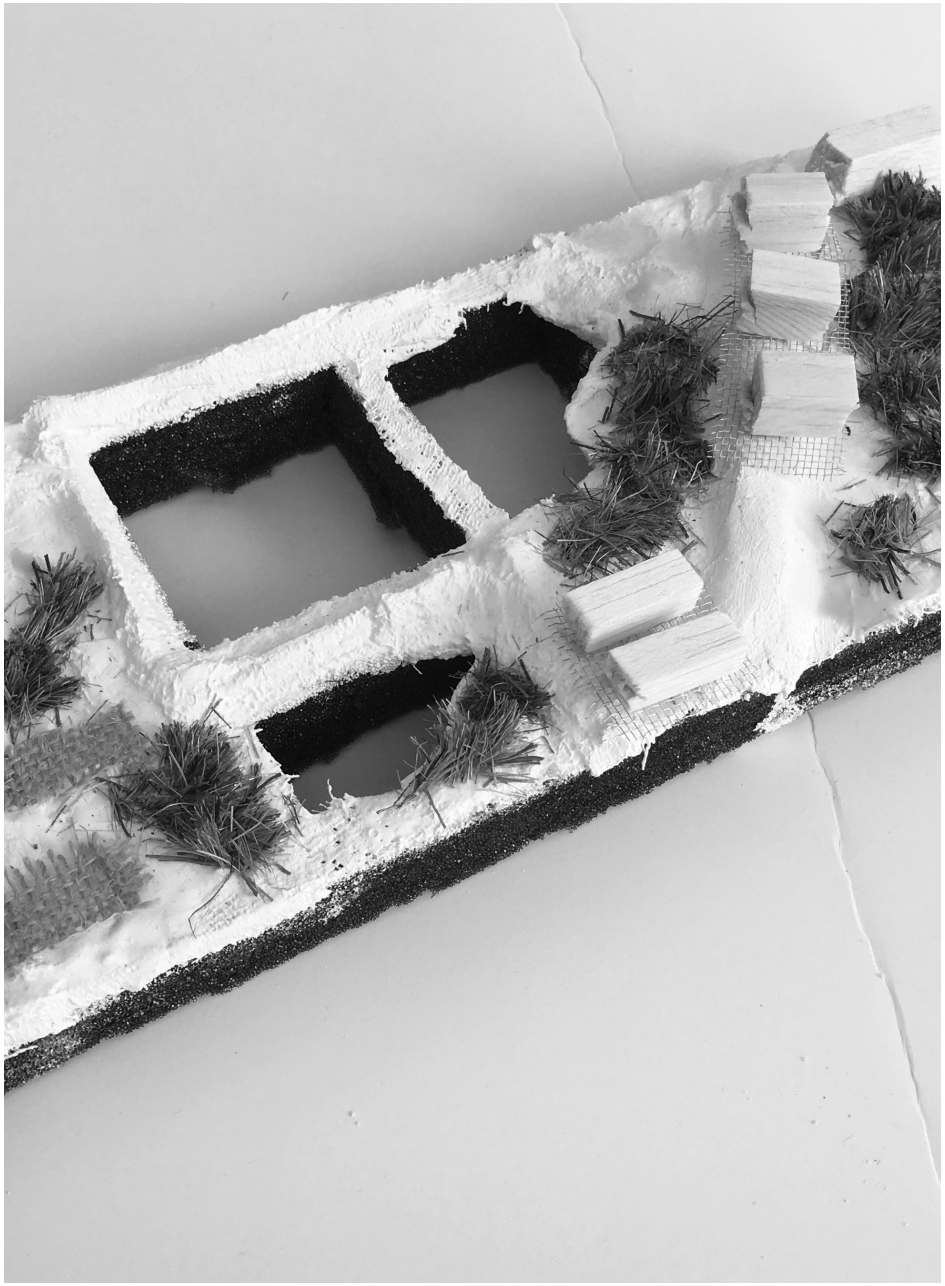
SPATIAL STRATEGY
SOFTEN THE SURFACE, CREATE SPONAGE



Generally, the zoom-in site can be divided into three main categories - residential area, agriculture field and industrial area.

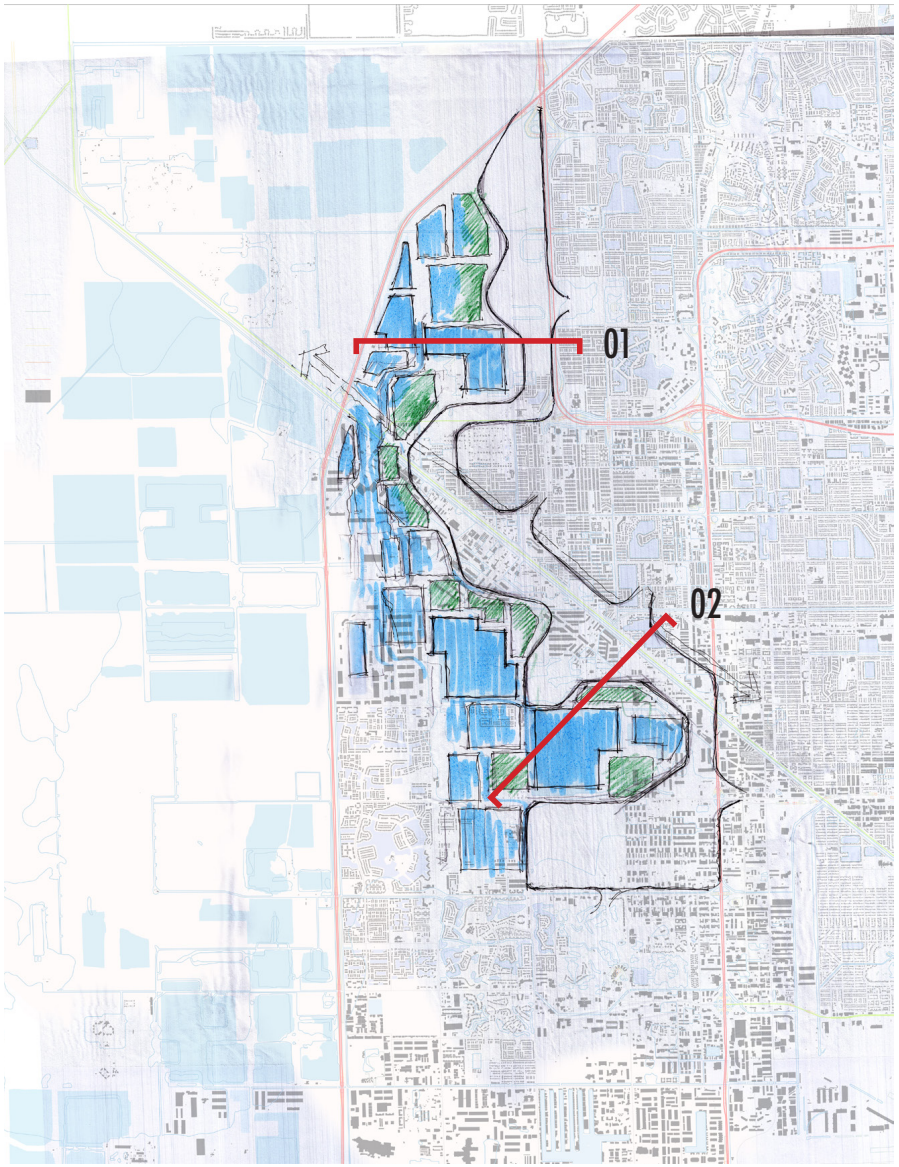
Main spatial strategy is creating depressions and highlands. Depression can retain more freshwater for wetlands and function as sediment catchment. Highlands provide human access and place for diverse vegetations.

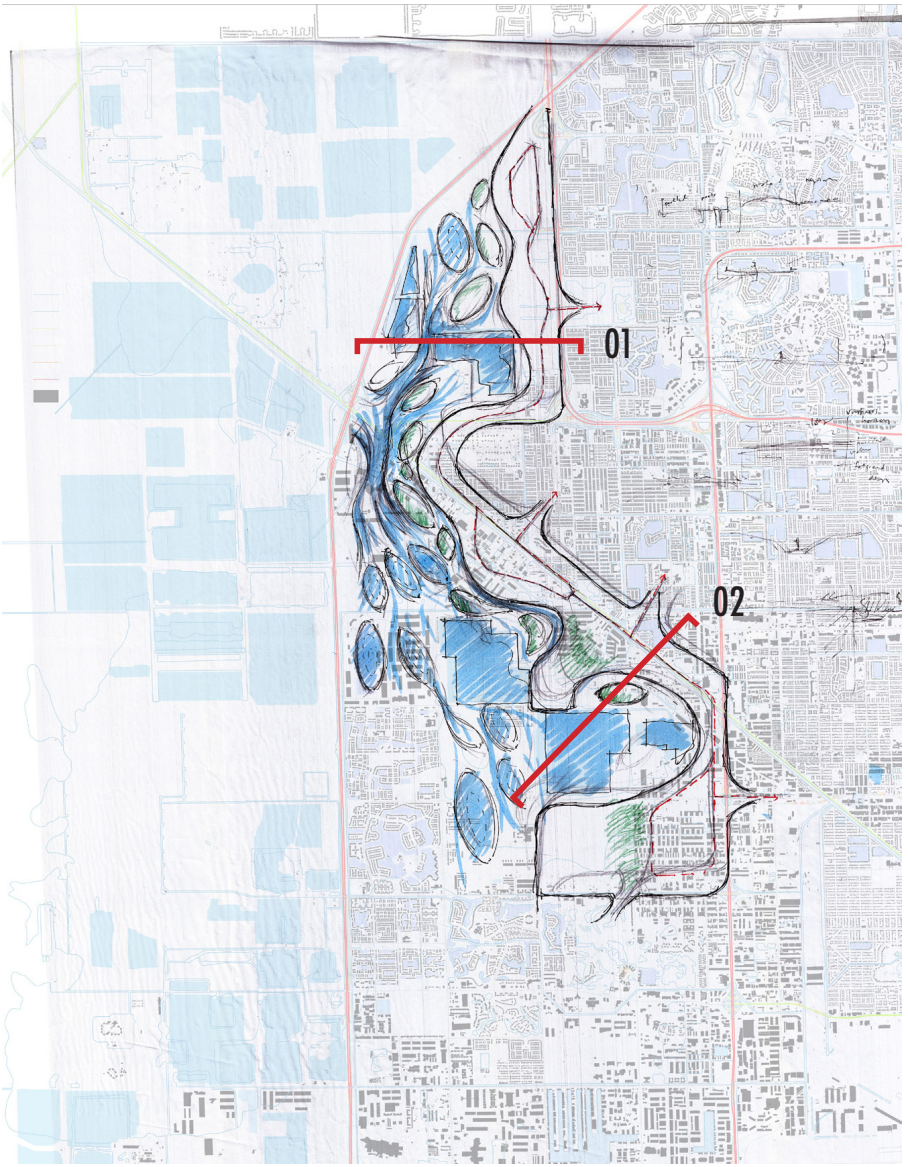
Before seawater comes in, the new landscape can greatly control the stormwater flow and maintain the amount of underground freshwater. After seawater comes in, the new landscape can provide places for different ecosystems to form new, dynamic coastal protection.



Sketch models to test the idea of creating topography as a base for new relationship between humans and water.

Concept Plan and Sectional Studies for Understanding Space





Sketches on the plan are used to develop a series of different ideas and as a tool to understand more in spatial aspect. In these drawings, my intention is to create a unified ground texture to accommodate landforms and existing patterns. After zooming in two times, a more detailed scale comes out to examine how to apply strategies to a series of thresholds.

THRESHOLD STUDY 01: BERM
1" = 60'

STAIRS

Advantages:

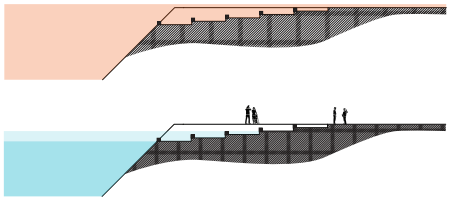
1. Easy to combine with waterfront activities; 2. Be visually attractive; 3. Able to provide habitats for diverse ecosystems; 4. Easy to retain water from upstream; 5. Form certain grid that can be used after SLR comes in

Support:

1. Diverse freshwater wetland;
2. Seagrass bed & Shellfish with enough sediment supply (After SLR)
3. Saltmarsh with enough sediment supply (After SLR)

Disadvantages:

1. Less vegetated area; 2. Require extra construction; 3. Need channels or ditches to connect with other freshwater pits; 4. More energy will be transported to waterfront after SLR



GENTLE SLOPE

Advantages:

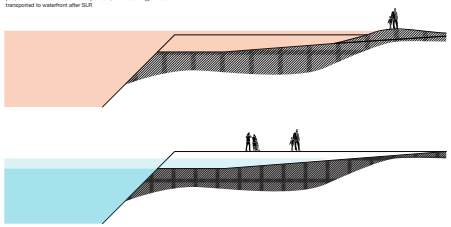
1. Less construction; 2. Able to provide habitats for diverse ecosystems; 3. Create a "natural" status; 4. Remain flexibility after SLR comes in

Support:

1. Diverse freshwater wetland;
2. Seagrass bed & Shellfish with enough sediment supply (After SLR)
3. Saltmarsh with enough sediment supply (After SLR)

Disadvantages:

1. Less visually attractive; 2. Require extra construction for waterfront activities; 3. Need channels or ditches to connect with other freshwater pits; 4. Hard to retain water from upstream; 5. More energy will be transported to waterfront after SLR



DITCH & CHANNEL

Advantages:

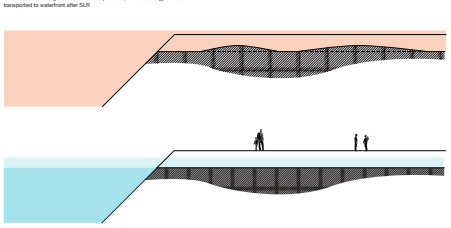
1. Easy to connect with other freshwater pits; 2. Relatively less construction; 3. Remain flexibility after SLR comes in; 4. Fast to implement as pioneer test

Support:

1. Limited freshwater wetland;
2. Seagrass bed & Shellfish with enough sediment supply and volume expansion
3. Saltmarsh with enough sediment supply and volume expansion (After SLR)

Disadvantages:

1. Less visually attractive; 2. Require extra construction for waterfront activities; 3. Less vegetated area will be provided; 4. More energy will be transported to waterfront after SLR



MOUND & DEPRESSION

Advantages:

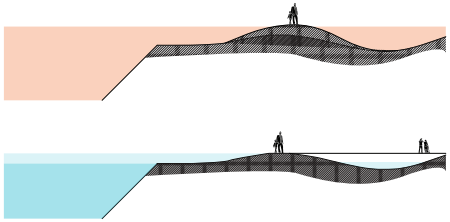
1. Easy to combine with waterfront activities; 2. Be visually attractive; 3. Able to provide habitats for diverse ecosystems; 4. Easy to retain water from upstream; 5. Remain flexibility after SLR comes in; 6. Reduce energy to the waterfront after SLR

Support:

1. Diverse freshwater wetland;
2. Limited upland vegetations
3. Seagrass bed & Shellfish with enough sediment supply (After SLR)
4. Saltmarsh with enough sediment supply (After SLR)

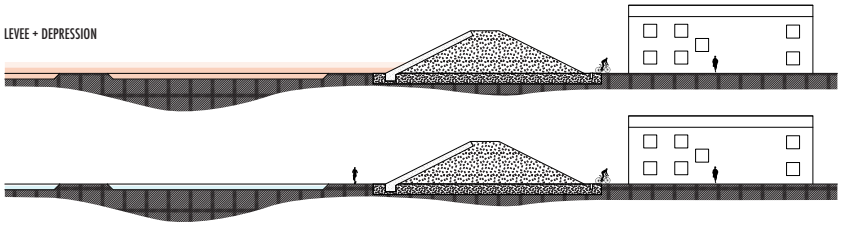
Disadvantages:

1. Require extra construction; 2. Need channels or ditches to connect with other freshwater pits

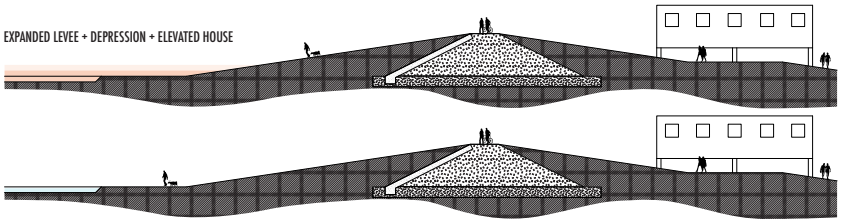


THRESHOLD 02: RESIDENTIAL AREA
1" = 120'

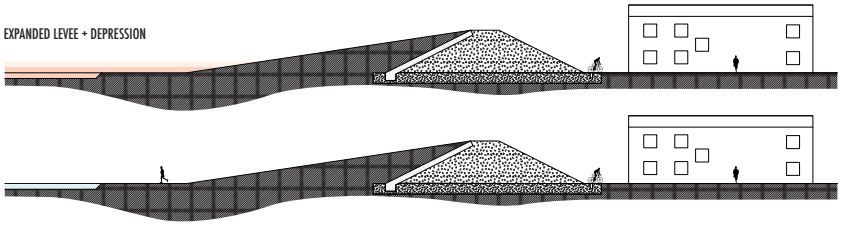
LEVEE + DEPRESSION



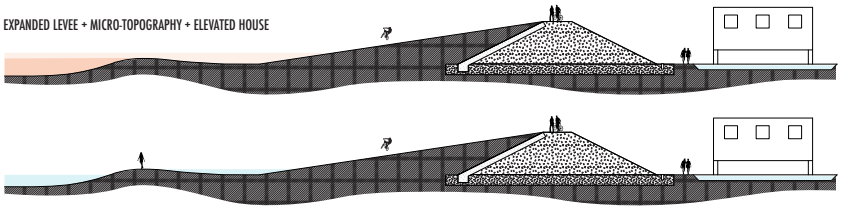
EXPANDED LEVEE + DEPRESSION + ELEVATED HOUSE



EXPANDED LEVEE + DEPRESSION



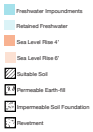
EXPANDED LEVEE + MICRO-TOPOGRAPHY + ELEVATED HOUSE



CONCLUSIONS:

1. Levee can function as "ridge" to provide protection and leave enough space for freshwater wetland;
2. Expanded slope can largely accommodate recreational opportunities, living and other possible activities;
3. Erosion and sediment from the inland side are important to the whole system;
4. A series of mound and depression in the water side of the levee can be beneficial for recreation, spatial experience and diversity.

LEGEND

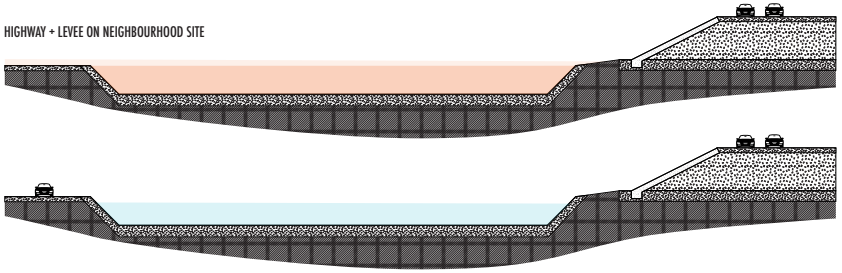


The first threshold is the berm space between two quarry pits. It averages 300' width and the depth quarry pits vary from 50' to 80'. The second is the threshold between residential and ridge. The third is the belt area near the Miami canal. Questions how to place different hydrological infrastructures and how to give them abilities to accommodate more activities are asked for exploring space relationships.

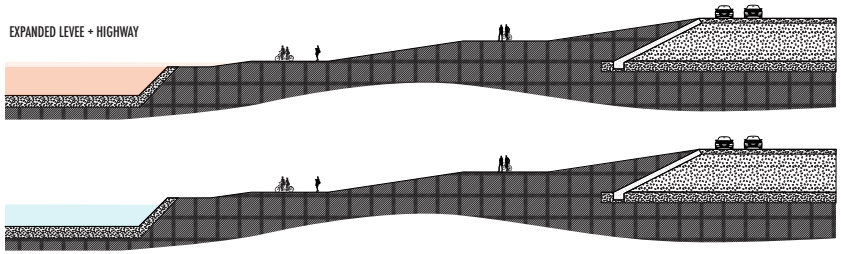
Concept Plan and Sectional Studies for Understanding Space

THRESHOLD STUDY 03: CANAL
1" = 120'

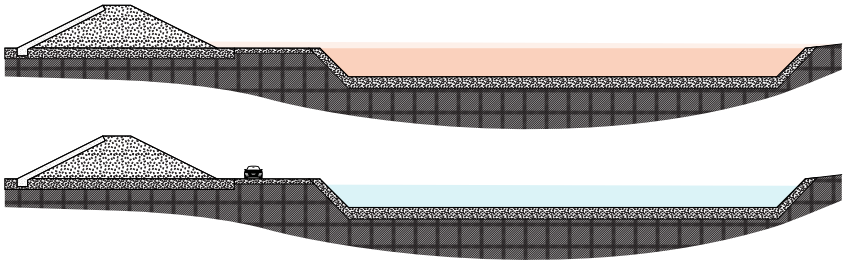
HIGHWAY + LEVEE ON NEIGHBOURHOOD SITE



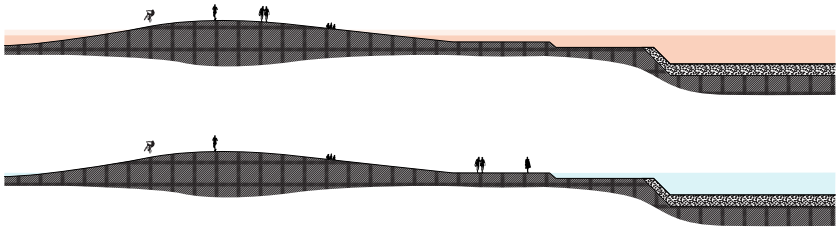
EXPANDED LEVEE + HIGHWAY



LEVEE ON INDUSTRY SIDE



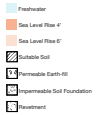
EXPANDED CANAL + MICRO-TOPOGRAPHY



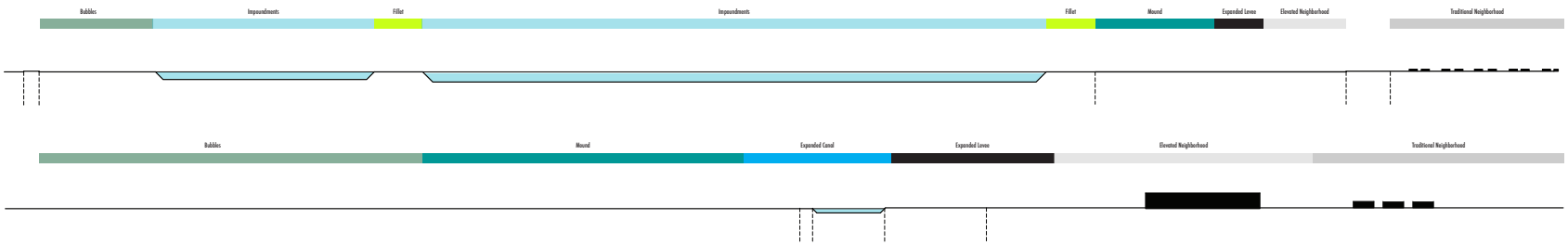
CONCLUSIONS:

1. Levee can function as "ridge" to provide protection and combined with highway, it should be placed on neighbourhood side;
2. Expanded slope can largely accommodate recreational opportunities, living and other possible activities;
3. Expanded canal can provide more capacity of water and work well with new freshwater wetland;
4. A series of mounds and depressions in the industrial side can be beneficial for recreation, spatial experience and diversity.

LEGEND



DESIGN STRATEGY - TRANSITIONAL TOOLKITS



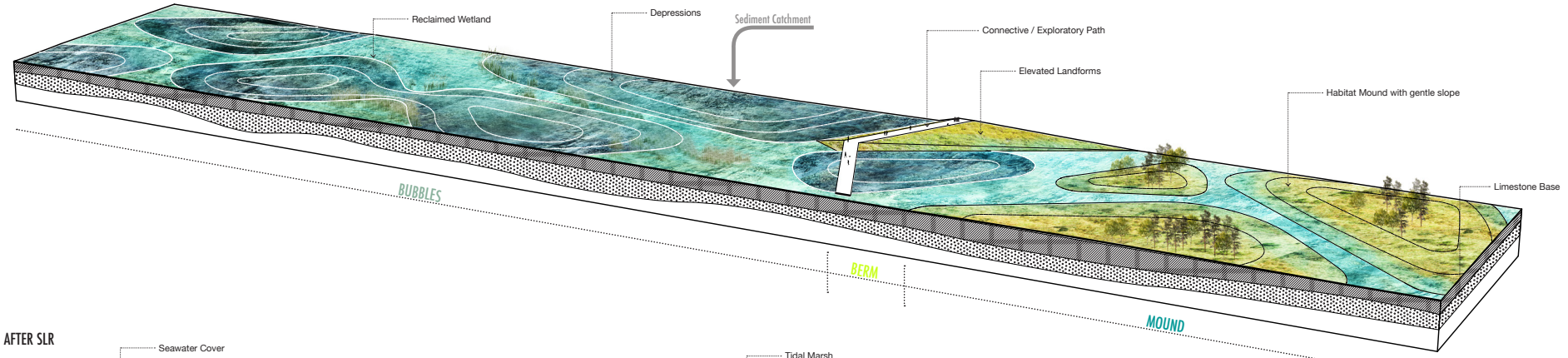
The feedback and assessments contribute to possible toolkits. Typological strategies are developed to form a transition from Lake Belt to the residential area. They are bubbles, mounds, berms, impoundments, expanded levees and elevated houses.

Developed Toolkits - Bubbles

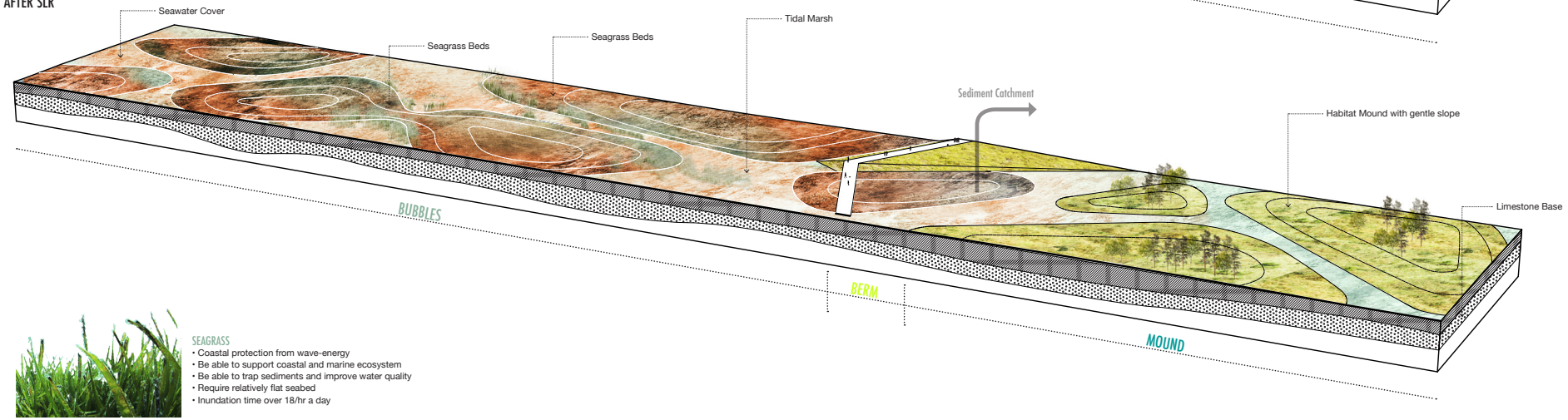
Bubbles are depressions with varied depth. They help to retain freshwater, supply diverse wetland species and catch the sediment. After seawater comes in and the site becomes a new coast line, the sediment and gentle elevation will help sea-grass to be planted here.

SUCCESSIONAL LANDSCAPE

BEFORE SLR



AFTER SLR



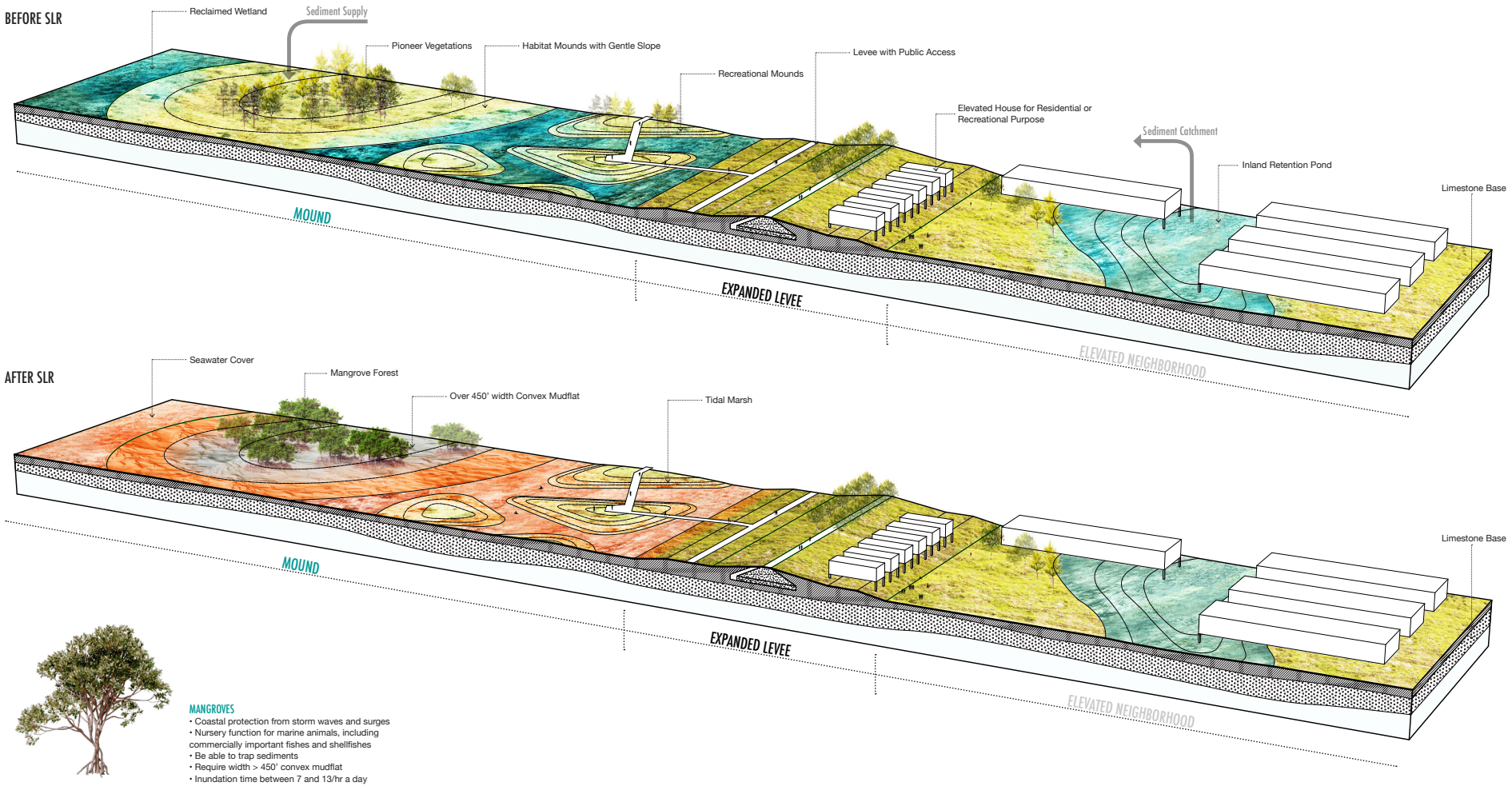
SEAGRASS
- Coastal protection from wave-energy
- Be able to support coastal and marine ecosystem
- Be able to trap sediments and improve water quality
- Require relatively flat seabed
- Inundation time over 18/hr a day

Developed Toolkits - Mounds and Expanded Levees

Mounds are in more inland areas to provide energy defense, ecosystem support and recreational opportunities. After seawater comes in, the sediment supply can help to form mudflats to support the growth of mangroves while some of them can still be used for people to walk on.

Expanded Levees are used to accommodate more activities. With gentle slope, they can work well with nearby communities.

SUCCESSIONAL LANDSCAPE + ADAPTIVE LIVING



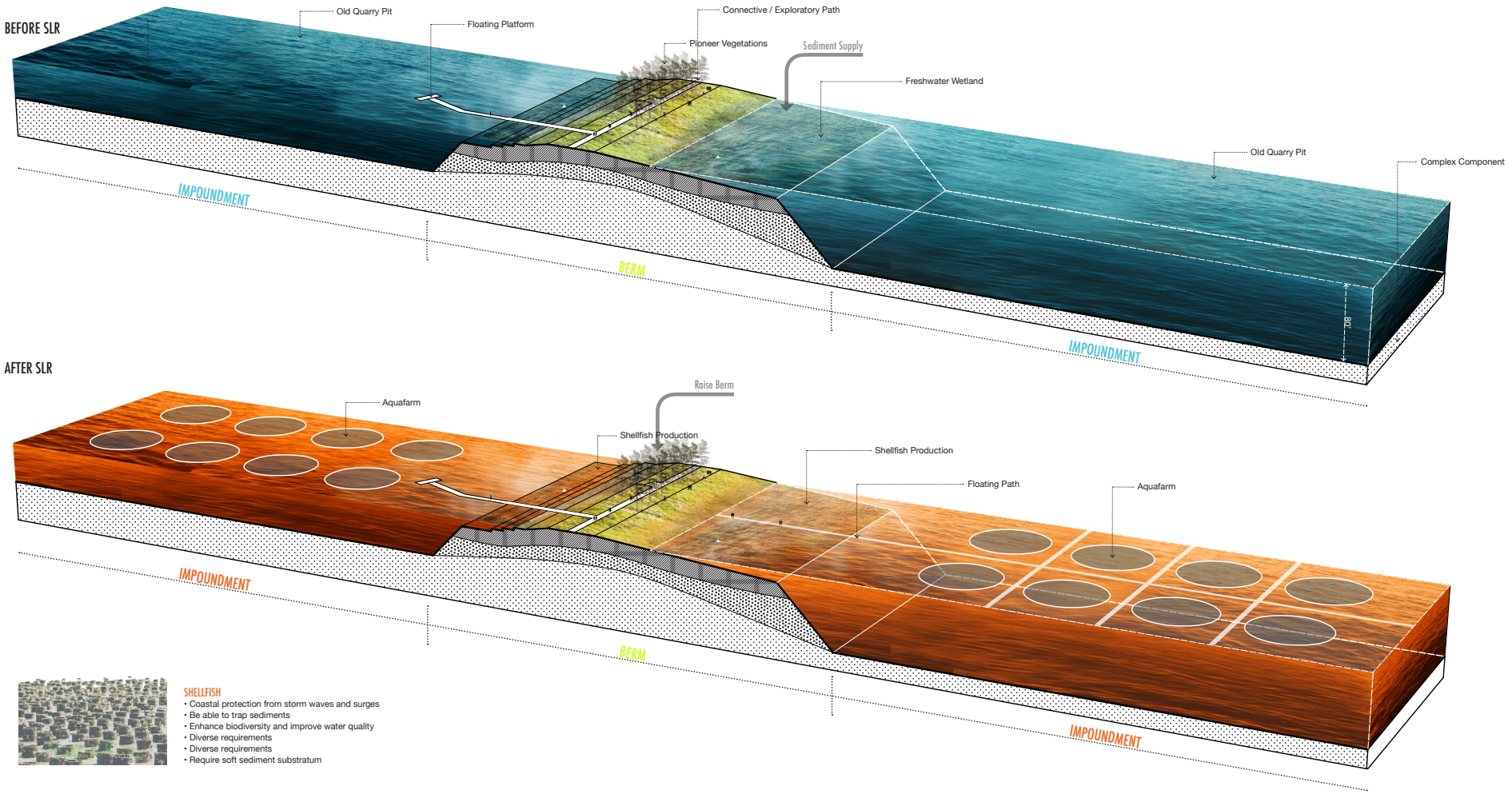
MANGROVES

- Coastal protection from storm waves and surges
- Nursery function for marine animals, including commercially important fishes and shellfishes
- Be able to trap sediments
- Require width > 450' convex mudflat
- Inundation time between 7 and 13/hr a day

Developed Toolkits - Berms

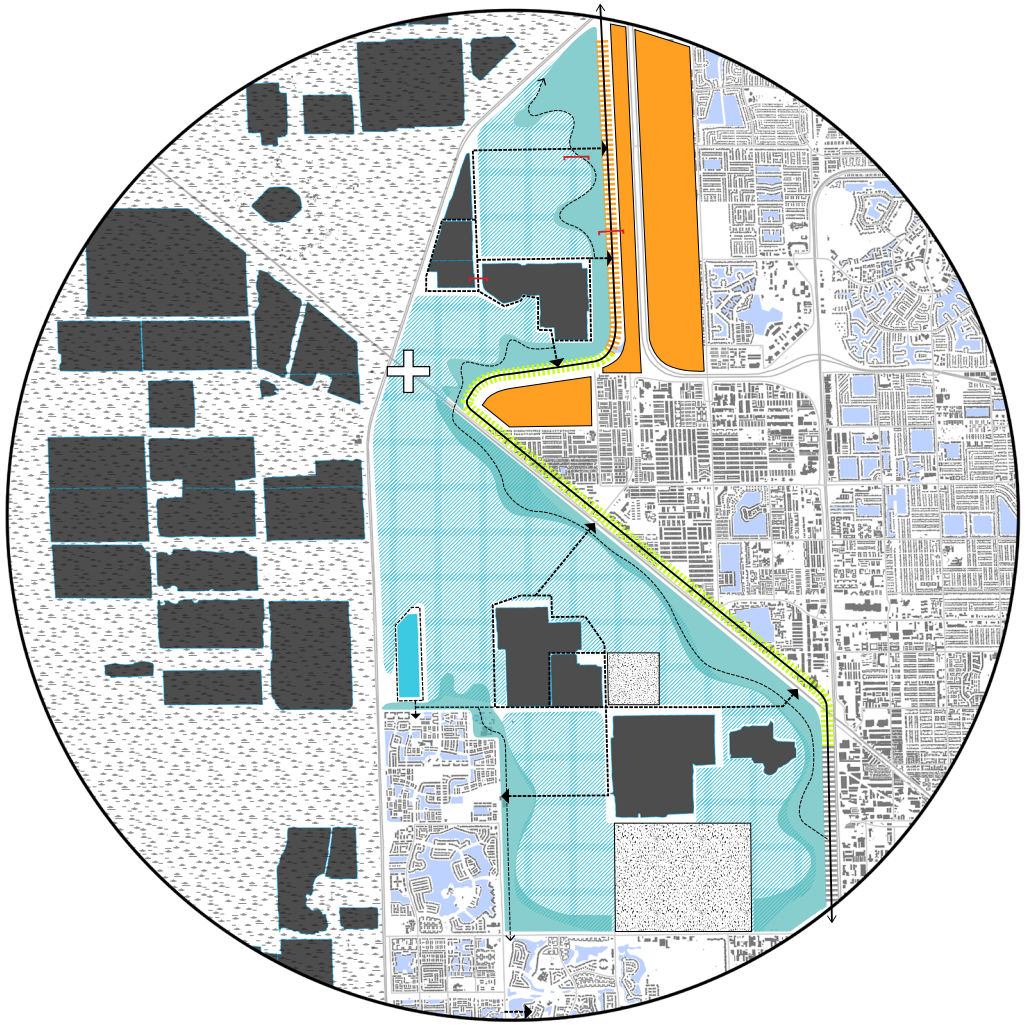
Berms are unique existing typology. Paths will take advantage of their higher ground to form a major circulation for people. Diverse depth along the edges will support diverse species and usage.

ALTERED FUNCTION + PROTECTED ACCESS



SHELLFISH
- Coastal protection from storm waves and surges
- Be able to trap sediments
- Enhance biodiversity and improve water quality
- Diverse requirements
- Diverse requirements
- Require soft sediment substratum

Application of Toolkits



DIAGRAMMATIC PLAN 1":25,000"

Findings + Conclusions

The investigation in Phase Three explores alternatives for humans to benefit from the great impoundment of the Lake Belt before and after SLR under a specific scenario. The impoundment of the Lake Belt is extremely important because it almost equals 10% of the freshwater volume of Lake Okeechobee. It can be valuable whether it is freshwater or not. However, it would be beneficial to use it to support surrounding neighborhoods and ecosystems before it is entirely transformed into saltwater.

Within the selected time scope and SLR projection, the Lake Belt area cannot avoid the fate of being submerged. Thus, it's essential that the interventions should be divided into two parts to discuss the roles of Lake Belt, both before and after being taken over by SLR. In addition to reinforcement of existing hydrological infrastructures, the regeneration of massive freshwater wetland becomes critical in order to mitigate the saltwater intrusion, which will continuously threaten the city of Miami's drinking resources.

Although lacking more scientific and accurate support, the test of spatial manipulation provides an alternative for the city of Miami to be adaptive to SLR. Moreover, great potential lies in the combination and application of these toolkits for a better integration with the unique features of landforms in Lake Belt area. A further study worth being carried out examines how to shape a self-evolving ecological infrastructure to mitigate the impact of SLR while providing memorable spatial feelings for people to engage with.

Assessment

The findings in Phase Three explore feasible, logistic and chronological ways for people to live with the great volume of water that the Lake Belt holds under the approaching SLR. Although the progress successfully gets into spatial research at the end of this phase, it would be better if more time can be used in the understanding of relationships between landforms, human activities and proposed shifts of different ecosystems. To be honest, too much time was used in raising strategies in territorial scale. However, it was a great learning experience.

The original question has shifted too much along the whole thesis investigation. The scope of the probing question keeps expanding because of the specificity of the site and topic. It's really challenging to manage and solve problems on such a large scale because sometimes it becomes easier to be disturbed by less important information.

It's constructive to get the criticism that final perspectives produced at the end of this thesis period, partly present intriguing spatial features of this site. If this phase were redone, I think I should target those spatial features that fascinate me a lot and use this as a base point for testing instead of keeping my eye on the territorial scale.

Overall Assessment

Final Conclusions

The understanding of the Lake Belt has got deeper and deeper through the process of research and design. Fortunately, the important individual interest and preference in spatial manipulation was unveiled in the final presentation and pointed out by critics.

The whole site-specific design and research starts from the Lake Belt area's impressive historical, spatial and hydrological characteristics. In Phase Two, too much effort was put into the investigation and understanding of Lake Belt as a base for active mining industry instead of carefully examining the dynamics and status of freshwater restored in those quarry pits. There are many fascinating things in this site, which include landfills, industrial buildings, quarries, and vast agriculture fields. These elements partly delineate the focus of design for a long time. Finally, the focus of the research turns back to the freshwater impoundment itself as well as the great shapes that hold this water. The most exciting part is to see how these two elements can work together under sea-level rise to form a new dynamic relationship and provide adaptability to this region. The berm, which is a typological space, lies in the threshold between two quarry pits and presents a highly geometric shape and can be a great typology for prototypical studies.

Back to investigations in Phase One, preliminary research and great resources regarding marsh migration were conducted and indicate a possible solution for this land to live with salinity shift in the future. After the three phased investigation, the conclusion is that a proposed ecosystem shift that aims to provide diverse intertidal habitats and wave-energy protection is a possible alternative for the city of Miami to adapt to impact of sea-level footprints. The relationship between topography and different intertidal or freshwater ecosystems can be manipulated to form experiential spaces for human utilization.

Final Assessment

This thesis process is definitely a valuable and memorable experience to mark a temporary stop in my life. Although everything doesn't go to perfection at the end of this semester and there are many painful moments in the investigation process, a reflection of all the mistakes can be beneficial for my future career. It's constructive to see my individual interest is becoming more and more clear during this long and tough journey.

During each phase, the probing question gets modified and shifted, more or less. The original question in Phase One wants to talk about possibilities of visualizing sea level rise by using resources in a specific area, which refers to the Lake Belt. The expectation of future design in this phase is a highly site-concentrated and detailed design. However, the scale of the design starts to expand in order to understand this site and sea-level rise issues comprehensively and the final design stays at planning strategies and typological designs, which departs from my initial thoughts. Fortunately, my final design partly goes back to my interest, which focuses on the vast wildness and geometry of this land.

By examining my thesis development, the most important emerging problem is that a way to tie large scale study with site scale design and exploration is extremely important. In addition, sometimes we need to avoid trying to make ourselves logistic in each step of deign. It's great to use research as a tool to develop a clear logic and make a strong and perfect argument, but sometimes it will hurt you and force you to concentrate your energy on data and information instead of finding and unearthing mystery of space, which is the most impressive part of the design. It's also important to get your initial interests exposed and try to find a way to work towards it, even though you are placed in a much broader context.

Combining with final outcomes, I think my plan for this thesis contains too much regional research while it has limited exploration that purely originates from certain spatial quality or dynamics. Sketches and models are really great tools to get inspirations from and I should utilize these tools more actively to acquire more dimensional and spatial knowledge of the Lake Belt. If this thesis could be redone, I would definitely focus more on the fascinating space of my site and use this as a start point to understand more about dynamic shifts between freshwater and saltwater in the Lake Belt, as well as the landscape interventions that can unify space, dynamics and future threats together.

At the end of this book, I want to thank those people who gave me help, instruction and inspiration. It's a great honor to work with your guys. I would also specifically thank to those criticisms from my presentation, which forces me to rethink my stance towards design. I do believe this is not an end of my design exploration while it should be a new start for me to take a better position in this discipline with strong confidence and bravery.

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