SALTY URBANISM

Sea Level Rise Adaptation Framework for Urban Areas

Fort Lauderdale, Florida

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Symposium on Flooding Adaptation

October 31, 2024

Cities Most Vulnerable to Coastal Flooding Today

Top 25 cities and their populations at risk (thousands) within FEMA's 100-year coastal floodplain

1.	New York	245
2.	Miami	126
3.	Pembroke Pines, Fla.	116
4.	Coral Springs, Fla.	115
5.	Miramar, Fla.	93
6.	St. Petersburg, Fla.	88
7.	Davie, Fla.	87
8.	Fort Lauderdale, Fla.	85
9.	Miami Beach, Fla.	85
10.	Hialeah, Fla.	76
11.	Sunrise, Fla.	74
12.	Pompano Beach, Fla.	73
13.	Hollywood, Fla.	69
14.	Lauderhill, Fla.	66
15.	Charleston, S.C.	64
16.	Cape Coral, Fla.	59
17.	Tamarac, Fla.	58
18.	Margate, Fla.	50
19.	Tampa, Fla.	50
20.	Fountainebleau, Fla.	48
21.	Miami Gardens, Fla.	44
22.	Country Club, Fla.	43
23.	Atlantic City, N.J.	37
24.	North Lauderdale, Fla.	37
25.	Kendale Lakes, Fla.	37

CLIMATE CENTRAL

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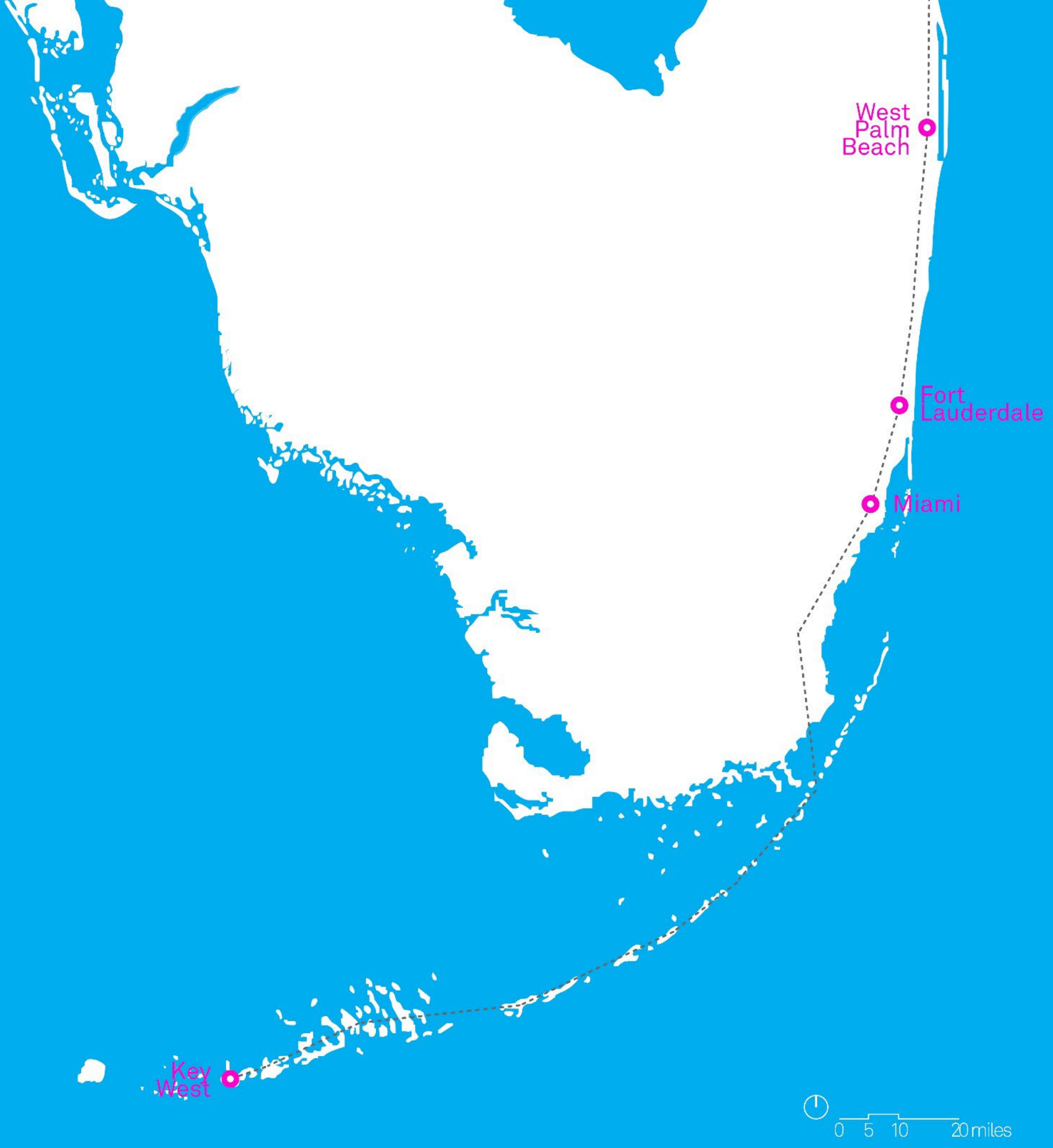
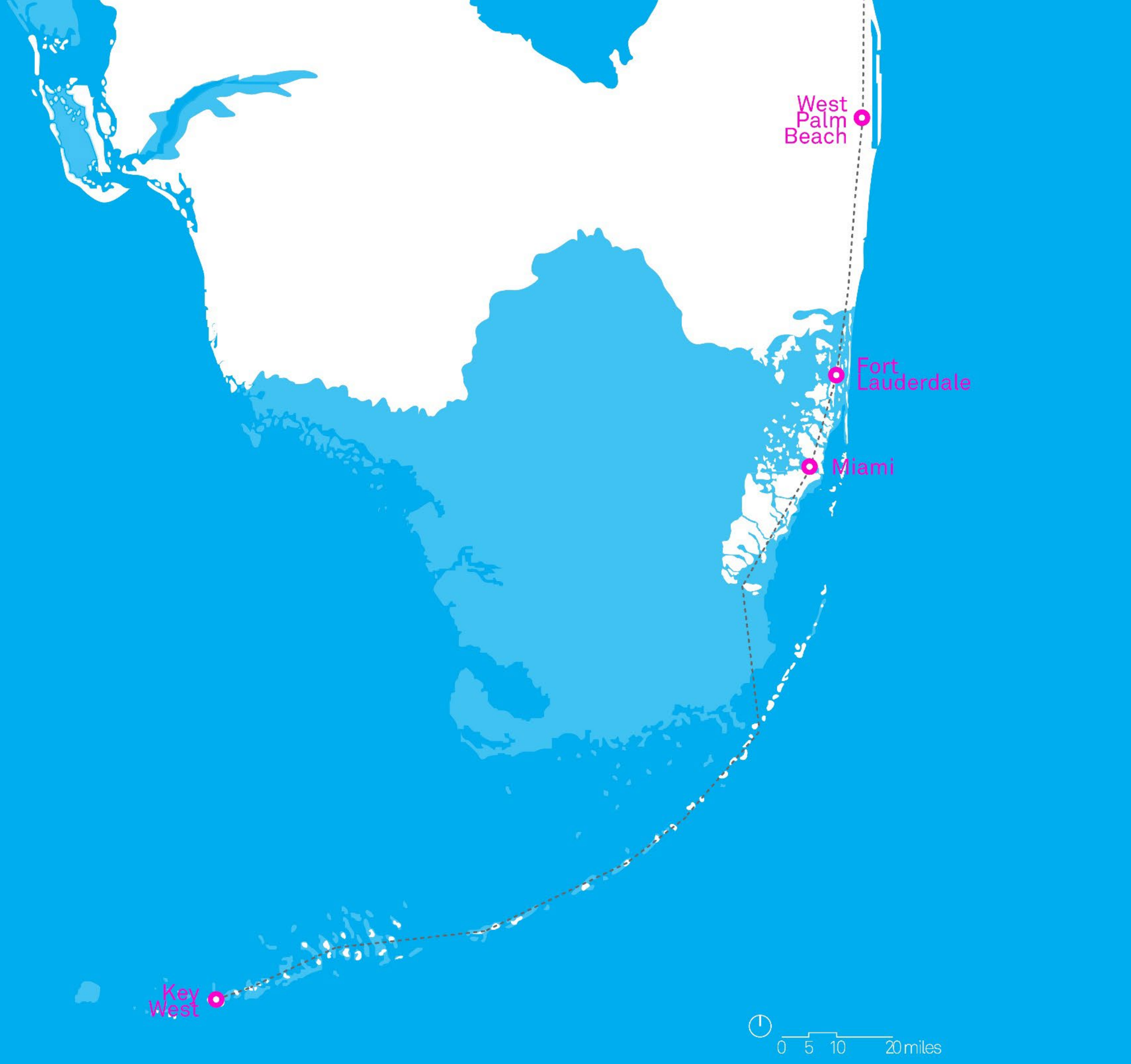
CLIMATE CENTRAL

“The most important line on this planet is the coastline, and we mistake it as something static, but understandably so because throughout recorded human history it has relatively remained the same, but it’s now shifting and we need to adapt.”

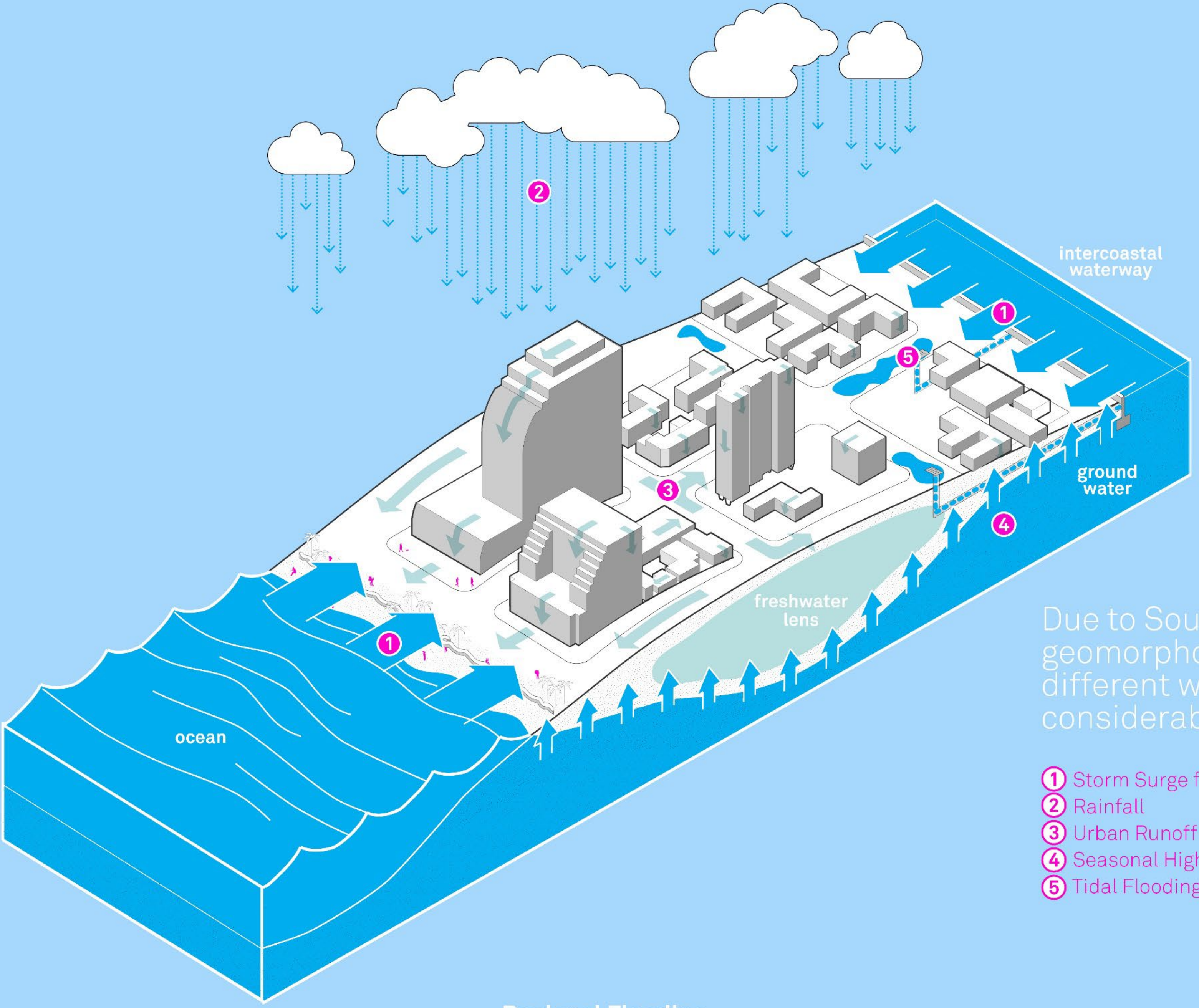
-John Englander, Oceanographer-



Just **six feet of sea level rise** will inundate the region, drastically changing the environment. Essentially South Florida will become the Upper Keys.



Seasonal high tide flooding, commonly referred to as "King Tides."



Regional Flooding

Due to South Florida's unique geomorphology it floods five different ways and poses considerable challenges.

1 Storm Surge from Coastal Storms
2 Rainfall
3 Urban Runoff
4 Seasonal High Ground Water
5 Tidal Flooding/ Future Sea level Rise

“the infrastructure we have is built for a world that doesn’t exist anymore”

Nicole Hernandez Hammer, 2015
Environmental Studies Researcher,
Union of Concerned Scientists

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Florida Atlantic University

KU SCHOOL OF ARCHITECTURE, DESIGN & PLANNING
The University of Kansas

USC School of Architecture

BROOKS + SCARPA

CITY OF FORT LAUDERDALE

FAU
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FAU
COLLEGE OF ENGINEERING & COMPUTER SCIENCE
Florida Atlantic University

FAU FLORIDA CENTER FOR ENVIRONMENTAL STUDIES
Charles E. Schmidt College of Science
Florida Atlantic University

2022
Upjohn Research Initiative
AIA

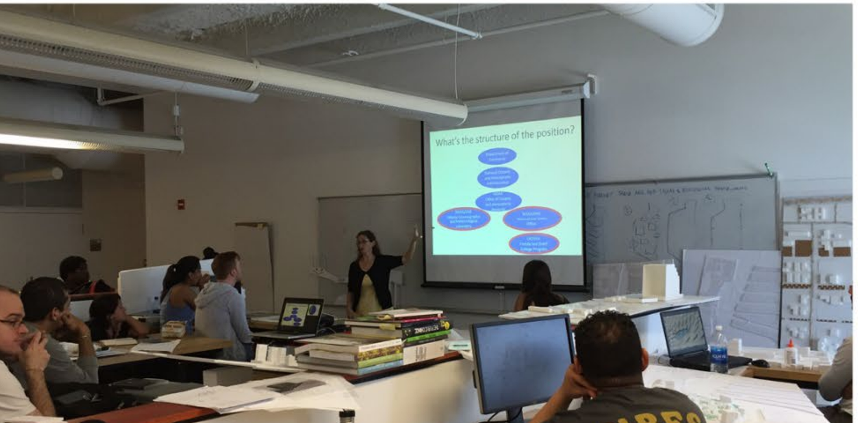
Sea Grant
Florida

NATIONAL ENDOWMENT FOR THE ARTS
A great nation deserves great art.



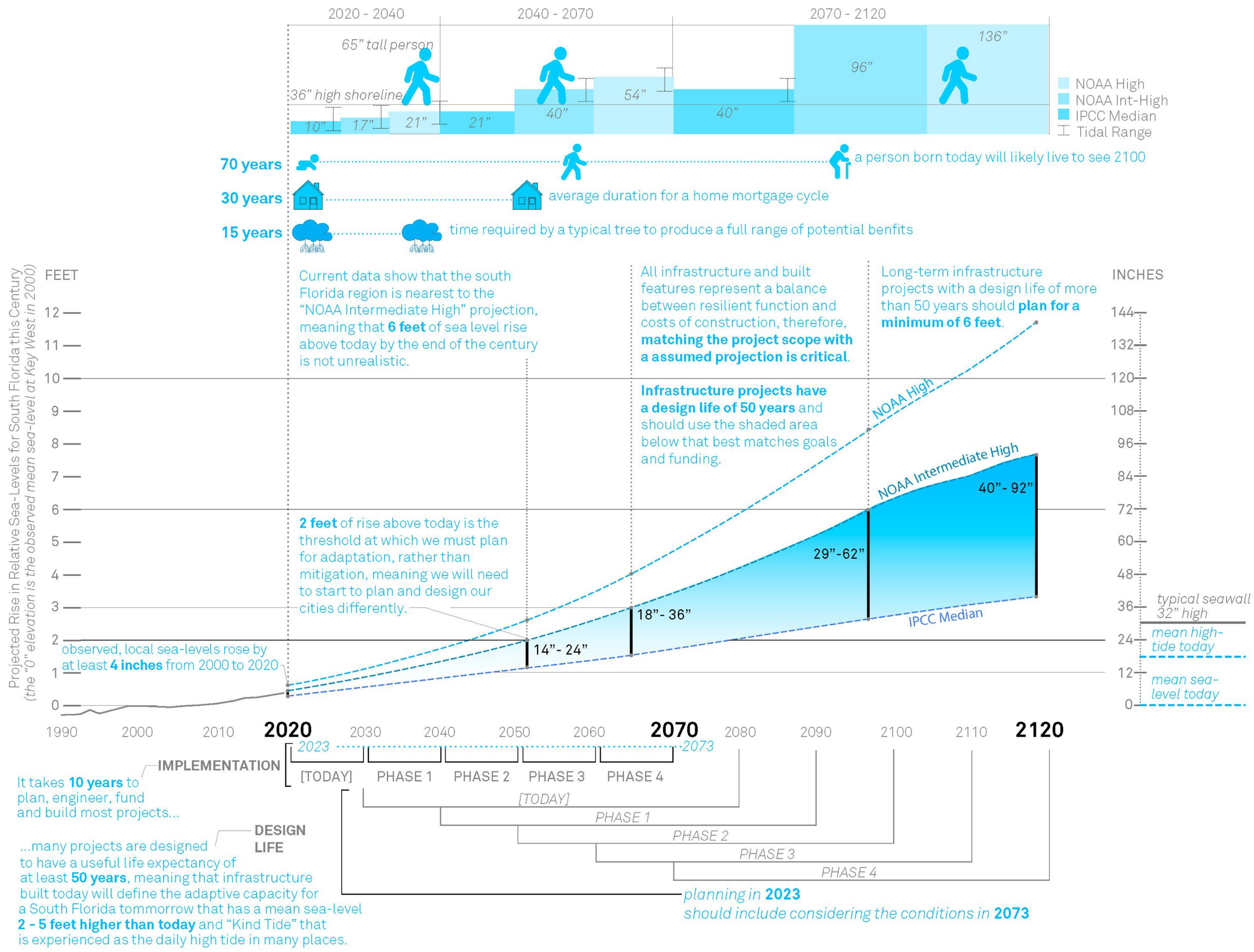





What's the structure of the position?


HOW CAN WE MERGE
NATURE + ARCHITECTURE
TO MAKE A WETTER FLORIDA
A BETTER FLORIDA?

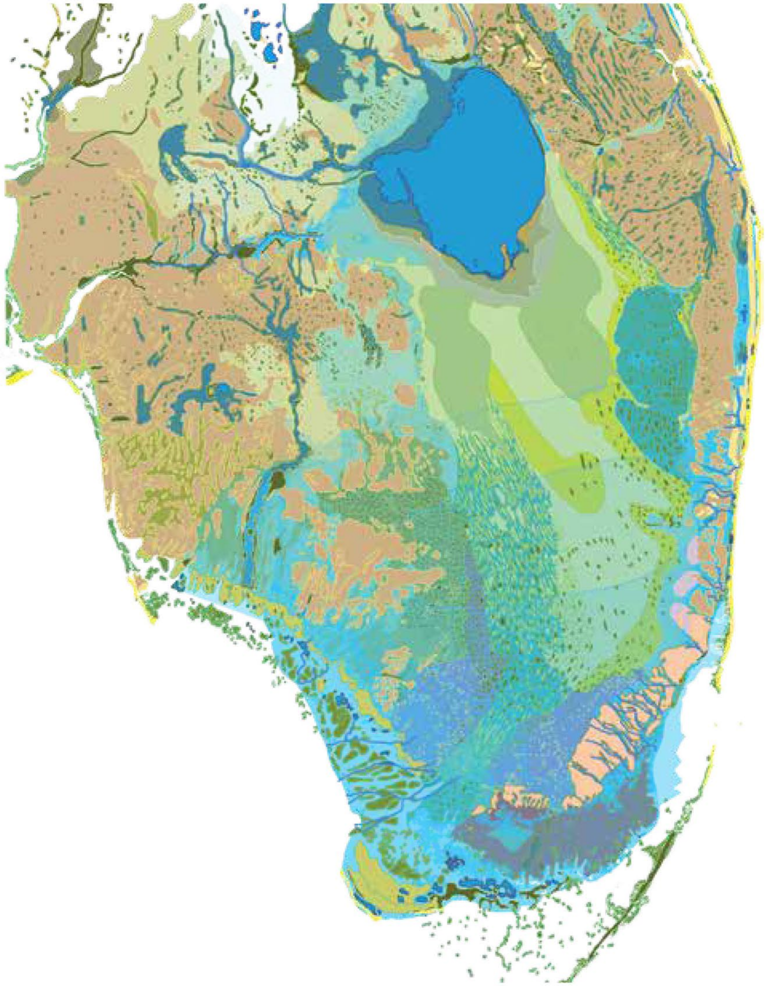
What if future development in the region served as a **flood adaptive asset**, rather than an environmental liability in the face of rising seas and climate change?

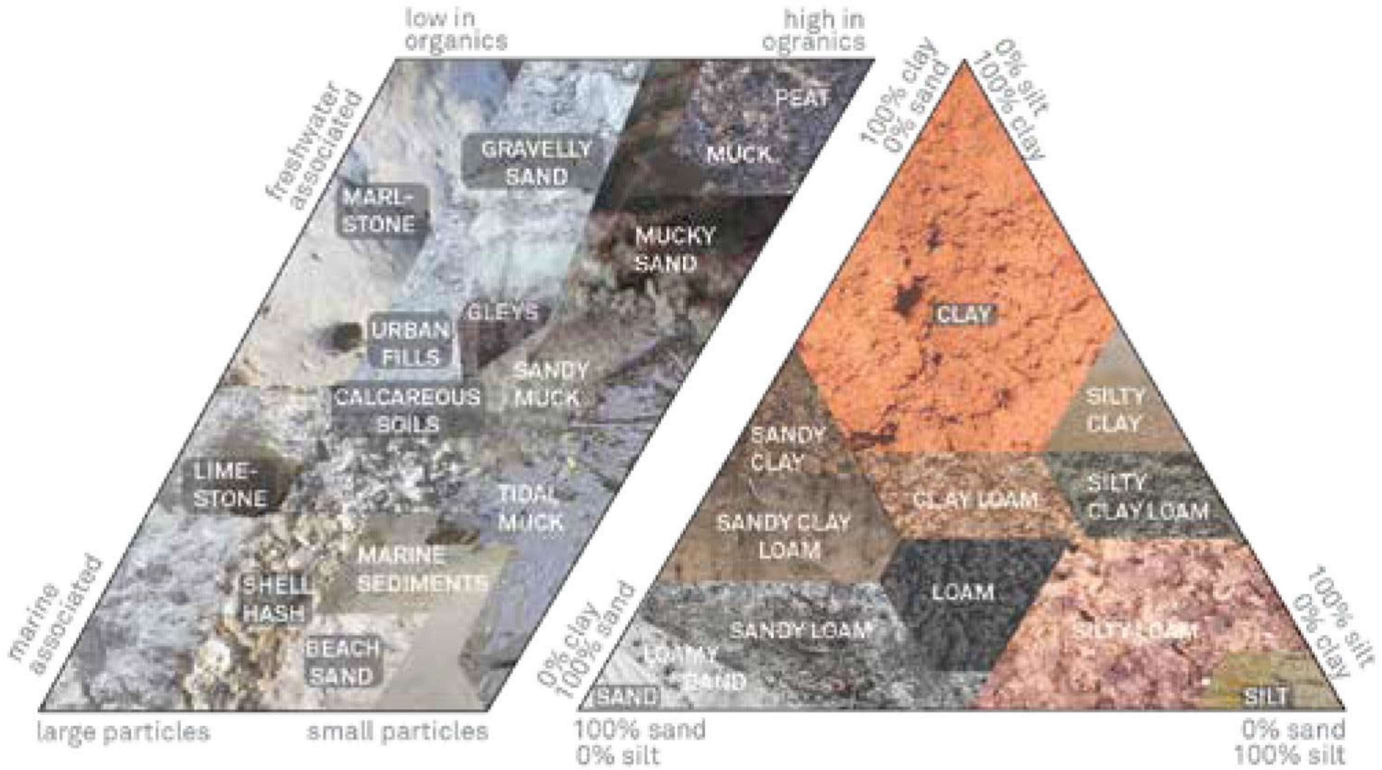


2020 - 2040
2040 - 2070
2070 - 2120
65" tall person
36" high shoreline
10"
17"
21"
21"
40"
54"
40"
96"
136"
NOAA High
NOAA Int-High
IPCC Median
Tidal Range
70 years
a person born today will likely live to see 2100
30 years
average duration for a home mortgage cycle
15 years
time required by a typical tree to produce a full range of potential benfits
FEET
Projected Rise in Relative Sea-Levels for South Florida this Century
(the "0" elevation is the observed mean sea-level at Key West in 2000)
Current data show that the south Florida region is nearest to the "NOAA Intermediate High" projection, meaning that **6 feet** of sea level rise above today by the end of the century is not unrealistic.
All infrastructure and built features represent a balance between resilient function and costs of construction, therefore, **matching the project scope with a assumed projection is critical**.
Long-term infrastructure projects with a design life of more than 50 years should **plan for a minimum of 6 feet**.
INCHES
Infrastructure projects have a design life of 50 years and should use the shaded area below that best matches goals and funding.
NOAA High
NOAA Intermediate High
IPCC Median
2 feet of rise above today is the threshold at which we must plan for adaptation, rather than mitigation, meaning we will need to start to plan and design our cities differently.
observed, local sea-levels rose by at least **4 inches** from 2000 to 2020
14"- 24"
18"- 36"
29"-62"
40"- 92"
typical seawall 32" high
mean high-tide today
mean sea-level today
12
11
10
9
8
7
6
5
4
3
2
1
0
144
132
120
108
96
84
72
60
48
36
24
12
0
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
2110
2120
2023
2073
IMPLEMENTATION
[TODAY]
PHASE 1
PHASE 2
PHASE 3
PHASE 4
It takes **10 years** to plan, engineer, fund and build most projects...
DESIGN LIFE
[TODAY]
PHASE 1
PHASE 2
PHASE 3
PHASE 4
...many projects are designed to have a useful life expectancy of at least **50 years**, meaning that infrastructure built today will define the adaptive capacity for a South Florida tommorrow that has a mean sea-level **2 - 5 feet higher than today** and "Kind Tide" that is experienced as the daily high tide in many places.
planning in **2023**
should include considering the conditions in **2073**

historic plant communities

As south Florida experienced one of the first of its many major development booms in the 1940s, ecologist John Henry Davis set out to produce the first comprehensive map of vegetation communities in the region. Thanks to this and similar efforts at that time, today we have an invaluable snapshot of the natural greater Everglades from a period in history when systematic drainage of the basin was well underway but before the landscape had been completely cleared, leveled, and paved. While understanding climate patterns and soils is critical to developing resilient green infrastructure, nothing is quite as instructive to nature-based solutions as native plant communities.





Maritime Hammock Guild
gumbo limbo (*Bursera simaruba*)
cocoplum (*Chrysobalanus icaco*)
seagrape (*Coccoloba uvifera*)
silver palm (*Coccothrinax argentata*)
sevenyear apple (*Genipa clusiifolia*)
firebush (*Hamelia patens*)
erect pricklypear (*Opuntia stricta*)
cabbage palm (*Sabal palmetto*)
thatch palm (*Thrinax radiata*)

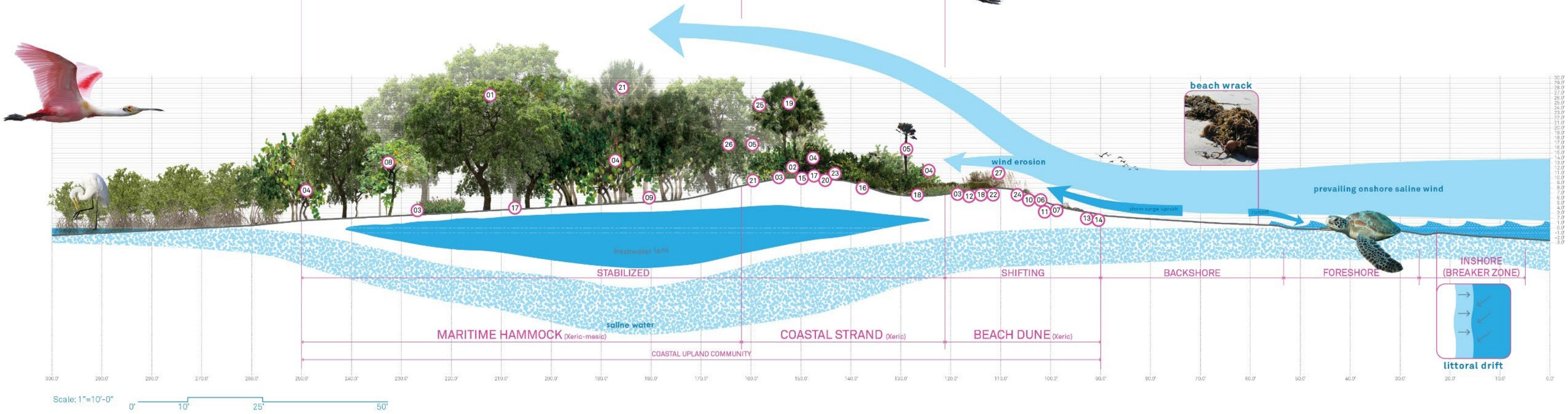
Tropical maritime hammocks serve as crucial resting and foraging areas for songbirds during fall and spring migration to and from the tropics.

Coastal Strand Guild
beach bean (*Canavalia maritima*)
cocoplum (*Chrysobalanus icaco*)
seagrape (*Coccoloba uvifera*)
silver palm (*Coccothrinax argentata*)
sea lavender (*Heliotropium gnaphalodes*)
wild sage (*Lantana involucrata*)
beach peanut (*Okenia hypogaea*)
erect pricklypear (*Opuntia stricta*)
bitter panicgrass (*Panicum amarum*)
cabbage palm (*Sabal palmetto*)
inkberry (*Scaevola plumieri*)
saw palmetto (*Serenoa repens*)
necklace pod (*Sophora tomentosa*)
bay cedar (*Suriana maritima*)
aloe yucca (*Yucca aloifolia*)

Provides critical habitat for gopher tortoises.

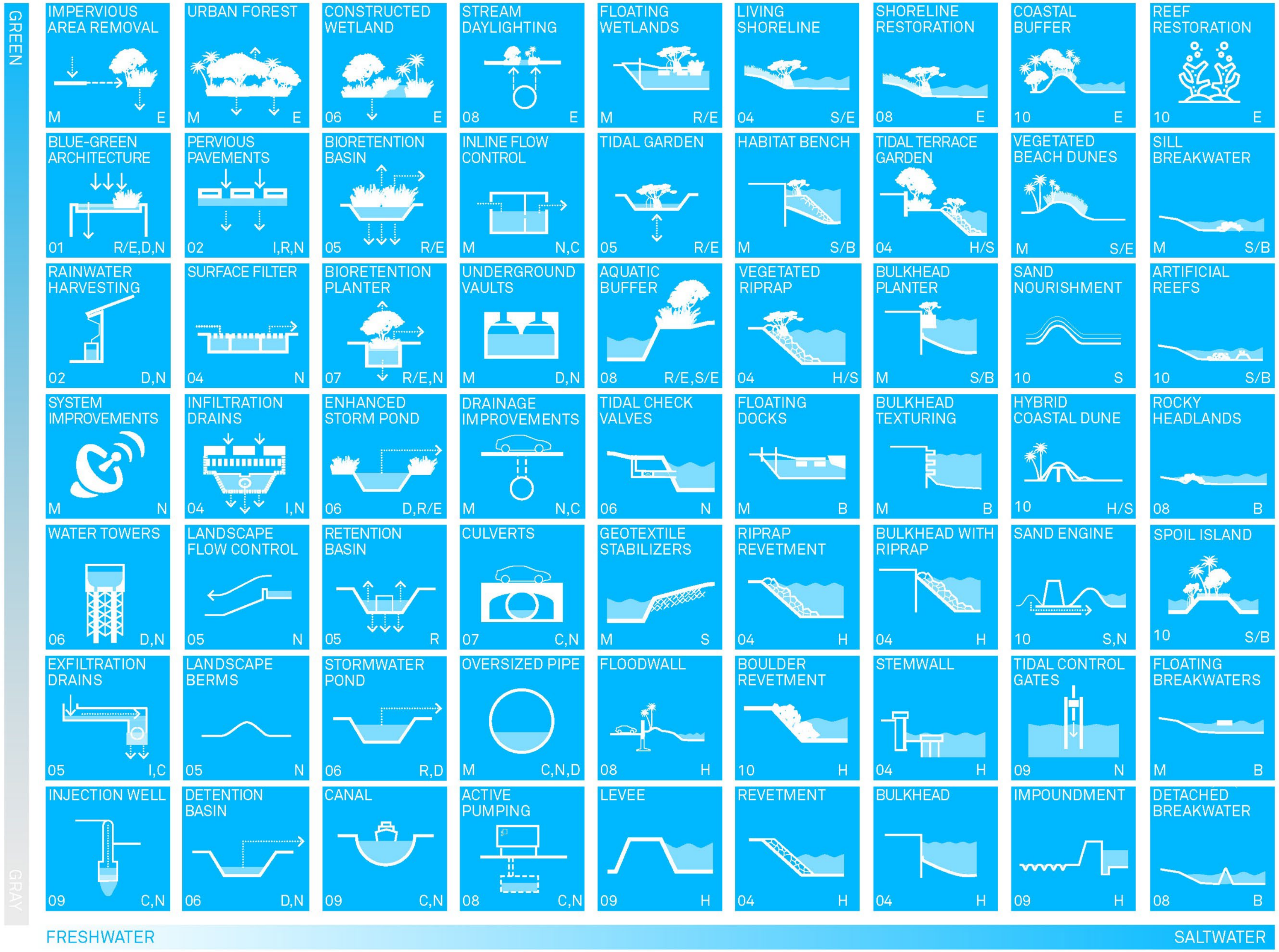
Beach Dune Guild
cocoplum (*Chrysobalanus icaco*)
seagrape (*Coccoloba uvifera*)
beach croton (*Croton punctatus*)
blanketflower (*Gaillardia pulchella*)
beach sunflower (*Helianthus debilis subsp. debilis*)
sea lavender (*Heliotropium gnaphalodes*)
spiderlily (*Hymenocallis latifolia*)
railroad vine (*Ipomoea pes-caprae*)
beachelder (*Iva imbricata*)
bitter panicgrass (*Panicum amarum*)
shoreline purslane (*Sesuvium portulacastrum*)
saltmeadow cordgrass (*Spartina patens*)
sea oats (*Uniola paniculata*)

Beach and beach dunes are used for foraging and nesting by beach mice, shorebirds, and sea turtles, especially Loggerhead (Caretta caretta).



infra-
structure

infrastructural menu



00 X

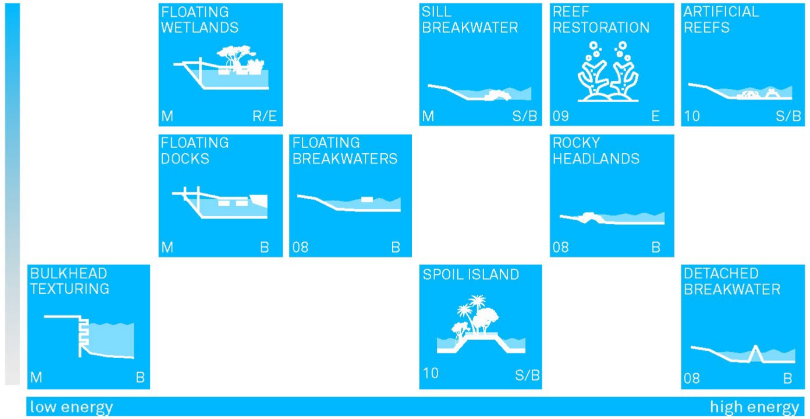
legend

00. relevant scale(s)
01 - buildings only
02 - buildings to blocks
03 - parcels only
04 - parcels/shorelines
05 - parcels to neighborhoods
06 - blocks to neighborhoods
07 - street/shore to blocks
08 - street/shore to neighborhoods
09 - sub-regional to regional
10 - coast region only
M - modular

X. infrastructural focus
E - ecological
D - detention
R - retention
C - conveyance
I - infiltration/exfiltration
R/E - bioretention
S - soft stabilization
H - hard stabilization
H/S - hybrid stabilization
S/E - nature-based stabilization
B - breakwater
S/B - hybrid breakwater
N - network enhancement

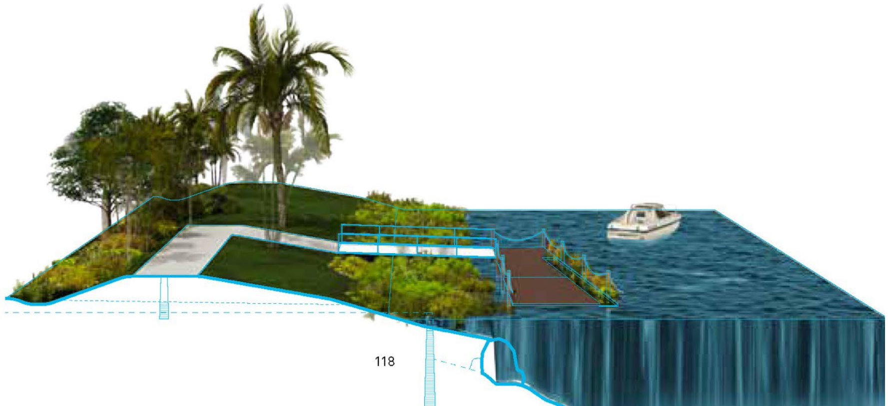
breakwaters

In highly-exposed settings, whether from fetch or boat activity, one effective option for mitigating erosion can be to site strategic structural elements offshore that redirect waves from vulnerable areas and/or foster sediment deposition landward. Since these features are sited underwater, their design and implementation is inherently more complex than other shoreline strategies and so are only recommended where their benefits are deemed necessary or can be easily achieved using existing site elements.



floating docks

Floating docks can be designed and sited to provide very small-scale breakwater benefits to some estuarine shorelines and may be especially useful for designs that wish to incorporate shoreline vegetation but also experience a lot of boat wake. Floating docks can be designed to adapt to some amount of sea level rise but also require careful consideration of storm conditions.



Example of seawall texturing showing contributor Dr. Keith Van de Riet's Mangrove Reef Wall System.

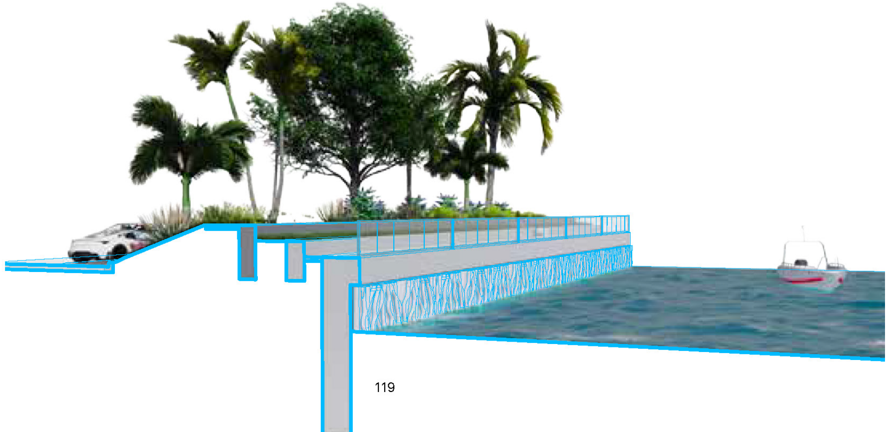
All breakwaters diffuse wave energy through a similar combination of methods, but designs tend to be either above or below water, with considerations differing dramatically between these. Currently, only a few south Florida settings utilize breakwaters, these being fairly exposed sites. The southeast Florida reef tract naturally provides breakwater benefits to much of the coast, as can oyster reefs, seagrass meadows, and even sand eroded from beach nourishments. While breakwaters are more difficult to permit and complex to design, they can also provide a variety of shoreline enhancement benefits not possible by any other means. Below are two uniquely small-scale designs accessible to property-owners.

seawall texturing

Covering the seaward walls of existing seawall with textured "habitat panels," designed to look and function like mangrove roots, can help to reduce the impact of wave energy on the seawall, improving it's longevity, while also providing enhanced wildlife habitat. Cheaper and easier to install than other breakwaters but provides fewer protection benefits.

summary

problem areas addressed	erosion, (storm surge)
applicable scales - facilities	varies - onshore, offshore
infrastructural goals/outcomes	wave-energy diffusion, wave/surge protection, sediment deposition, facility enhancement
ecological pairings	–
architectural setbacks	–
landward	tidal flow control, soft, hard, or hybrid stabilization
waterward	–



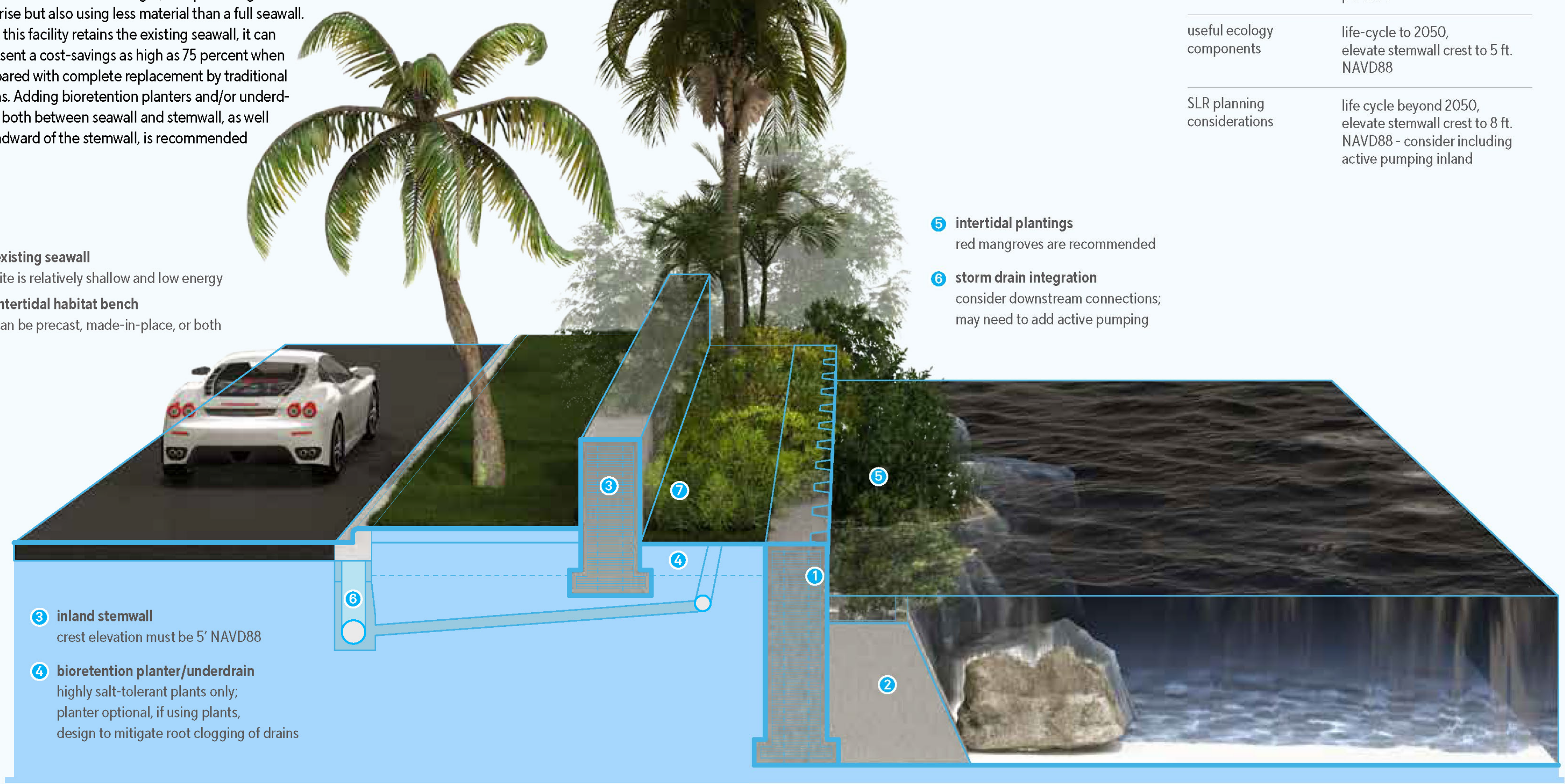
stemwall stair planter

enhancing estuarine seawalls

Space and funds-limited hybrid designs that wish to maximize more engineering-oriented outcomes should focus on improving the longevity and performance of any existing armor. For urban shorelines with an aging seawall, likely the most cost-effective hybrid improvement is to combine an intertidal planter, habitat bench, or riprap feature seaward of the existing wall, and a "stemwall" inland of it. The seaward planter/bench/riprap provides long-term support and protects the toe area from erosion, while the stemwall adds elevation to the shoreline's overall height, compensating for sea level rise but also using less material than a full seawall. Since this facility retains the existing seawall, it can represent a cost-savings as high as 75 percent when compared with complete replacement by traditional means. Adding bioretention planters and/or underdrains, both between seawall and stemwall, as well as landward of the stemwall, is recommended to improve drainage and reduce the potential for inland erosion/pressure while adding co-benefits, such as cooling through shade (where shade trees are used).

summary

problem areas addressed	tidal flooding, erosion, storm surge, (heat)
recommended scales - sites	lots, streets - space constrained sites
infrastructural goals/outcomes	mitigate erosion, elevate shoreline, reduce adaptive costs, reduce impact guides - 2a,2b,2c, palettes -
useful ecology components	life-cycle to 2050, elevate stemwall crest to 5 ft. NAVD88
SLR planning considerations	life cycle beyond 2050, elevate stemwall crest to 8 ft. NAVD88 - consider including active pumping inland



1 **existing seawall**
site is relatively shallow and low energy

2 **intertidal habitat bench**
can be precast, made-in-place, or both

3 **inland stemwall**
crest elevation must be 5' NAVD88

4 **bioretention planter/underdrain**
highly salt-tolerant plants only;
planter optional, if using plants,
design to mitigate root clogging of drains

5 **intertidal plantings**
red mangroves are recommended

6 **storm drain integration**
consider downstream connections;
may need to add active pumping

coastal corridor design

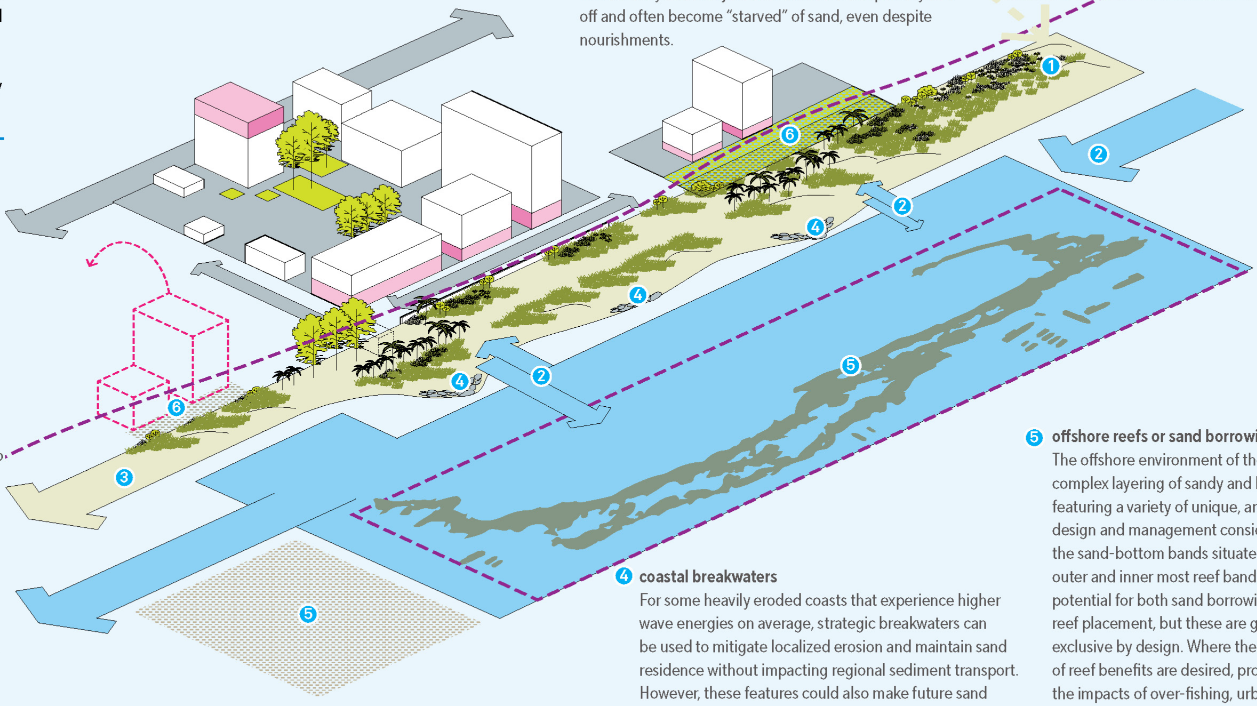
Nearly all of the sandy coastline separating urban south Florida from the Atlantic is considered "critically eroded" today. While sand "nourishments" have successfully mitigated local erosion rates in Florida for many decades, the practice is not without contention. Some experts claim it will continue to be an effective adaptation strategy against rising seas, while others point to the extreme costs associated with the apparent need to source ever increasing amounts of sand. "Sand borrowing" for nourishments from limited offshore reserves comes with many negative environmental costs, especially concerning sedimentation of reefs. Sand sourced from inland mines must be trucked to the beach overland at great expense, and these sources are not infinite. While an integrated system of sand nourishment and borrowing could theoretically result in a "closed loop" - with any eroded sand carried south by prevailing longshore currents relocated north again through future nourishments - in reality, this practice is not so simple. However, this kind of system may explain why observed rates of erosion in south Florida have not reflected observed rates in sea level rise. Reefs provide far more value than simply breakwaters, but continued nourishments are likely required to maintain the existing coast. Managers must consider the socio-ecological trade-off related to these choices carefully. Armoring of the coast is not a good solution either. While taller floodwalls may be effective at protecting areas from surge, such features could also worsen rates of beach erosion. Many of the Coastal Construction Control Line (CCCL) program's mandates are expressly concerned with mitigating this potential, limiting the amount of armoring that can occur on the coast, including that from building foundations. Ultimately, management of the coastline will require the holistic design coordination of a regional corridor, one that integrates management offshore, onshore, and inland, across stakeholders, design scales, and political boundaries.

1 sand nourishment & vegetated beach dunes
Sand inputs are encouraged to integrate closely with dune restorations, as covering beach sands with densely planted, native vegetation can enhance outcomes of nourishment.

2 the regional "sand budget"
Waves and currents shape and reshape sandy coastlines, with lower energy waves tending to build up beaches and higher energy waves tending to relocate sand offshore and/or move it south – this ideally results in a balanced "sand budget," with eroded sand on any given beach being replaced by new sand seasonally.

3 man-made erosion
The main cause attributed to the presently eroded condition of south Florida's coast is urbanization, not sea level rise, as the dredging/armoring of inlets combined with the covering of dunes by impervious surfaces has collectively hindered the region's sand budget – beaches immediately south of jetties and inlets are especially bad off and often become "starved" of sand, even despite nourishments.

6 the CCCL, buildings, & coastal realignment
The main regulating component of the CCCL is the Coastal Construction Control Line itself, a semi-political geographic boundary running roughly parrallel to the coast. The Line's exact distance from the ocean varies from location to location, determined by a variety of site-specific and political criteria and enforced by the FDEP. Generally, the CCCL seeks to reduce the impacts of construction activities and built features on coastal erosion and vulnerable coastal organisms, such as sea turtles. A newer but related state effort managed by the FDEP, the Sea Level Impact Projection Study Tool, or "SLIP Study," mandates that new construction in the coastal zone consider low-impact alternatives. While mitigating some of the most harmful types of development, both of these regulations still allow new construction in highly vulnerable areas. Climate change is expected to increase hurricane intensities by as much as 50 percent over the next century, and by the year 2100, a single category 5 hurricane could erode up to 47 percent of the beach area. Future managers should look to considering stronger setback regulations.

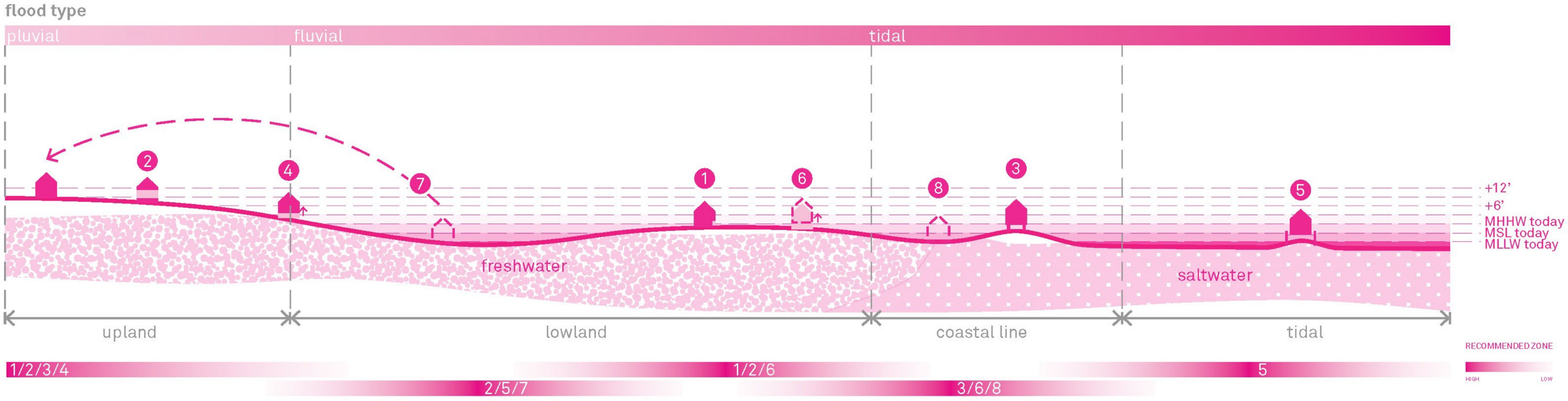


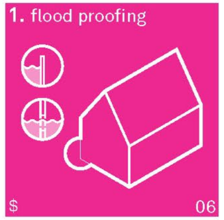
4 coastal breakwaters
For some heavily eroded coasts that experience higher wave energies on average, strategic breakwaters can be used to mitigate localized erosion and maintain sand residence without impacting regional sediment transport. However, these features could also make future sand nourishments more challenging.

5 offshore reefs or sand borrowing
The offshore environment of the southeast coast is a complex layering of sandy and hard-bottom "bands," featuring a variety of unique, and often conflicting, design and management considerations. Generally, the sand-bottom bands situated between the outer and inner most reef bands have the greatest potential for both sand borrowing and artificial reef placement, but these are generally mutually exclusive by design. Where the enhancement of reef benefits are desired, protecting reefs from the impacts of over-fishing, urban runoff pollution, and sand borrowing/dredging is paramount.

archi-
tecture

flood-adaptive architecture menu





1. Dry flood-proofing: utilizes water-resistant materials and panel systems at openings to prevent water intrusion.

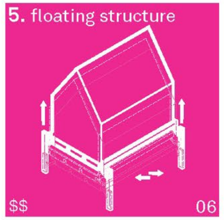
2. Wet flood-proofing: utilizes flood vents or breakaway walls to allow flooding to pass through.

3. Or increase the floor to ceiling dimension at ground level and raise floor.

Structure is built to accomdate retreat over time by abandoning lower-floor levels.

Building is raised above bfe on stilts. Keep in mind that nfip criteria does not account for future land development, coastal erosion and subsidence, or sea level rise. These would have to be factored in to ensure lifespan considerations. Consideration of what happens under the building should be addressed.

Structure is bulit on the raised platform. The raised platform can increase in elevation over time as adaptation demands.

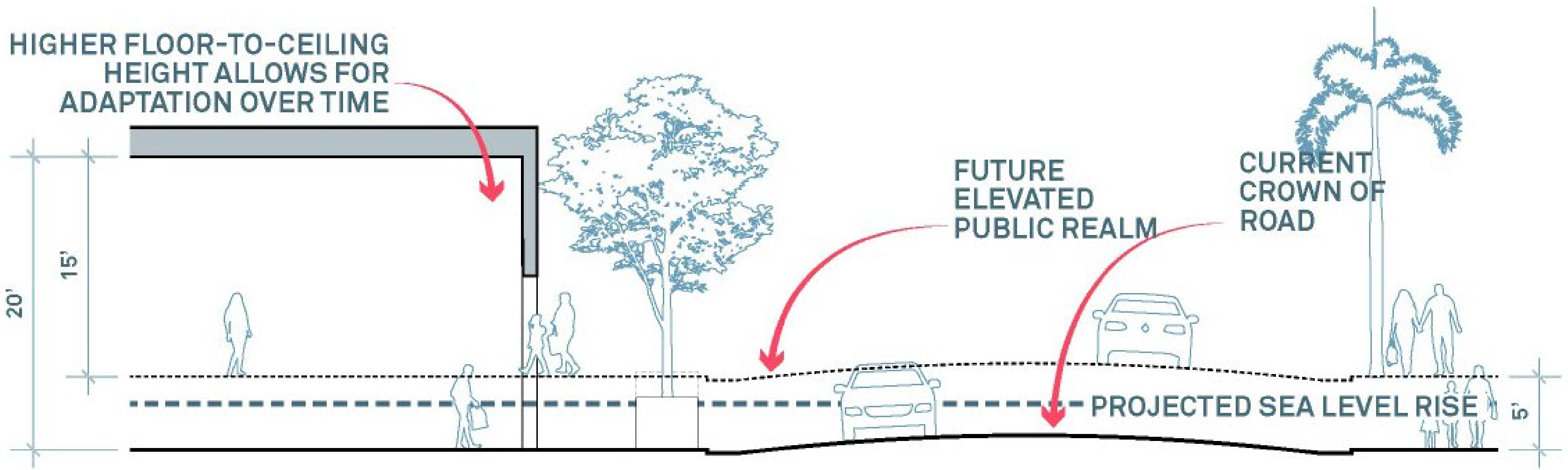


Structure is built to float on water and tethered to a mooring or anchoring device while allowing the building to move freely in multiple directions

Structure is built to float on elevated flood water. The piles anchor the structure in place while the buoyant base floats up and down. The building rests atop the ground during non-flood events.

Relocation of buildings to higher elevations where flooding is less likely to occur. This could be a few hundred feet or miles.

Abandoned structures can be reclaimed or re-purposed, for example, the building could become an artificial reef or breakwater once materials that can pollute waterways are removed.


HIGHER FLOOR-TO-CEILING HEIGHT ALLOWS FOR ADAPTATION OVER TIME
FUTURE ELEVATED PUBLIC REALM
CURRENT CROWN OF ROAD
PROJECTED SEA LEVEL RISE
20'
15'
5'

materials

Materials in flood prone areas will require careful consideration. Choosing water-resistant materials (materials that will be fully submerged or in the tidal/littoral zone, or may become part of those zones due to future sea rise), managing moisture effectively, and selecting corrosion-resistant options in a heavy salt-laden environment are essential. Farthermore, hotter temperatures and extreme heat will mean faster chemical reactions and thus faster degradation. Durability, ease of cleaning and maintenance, and sustainable choices are other important factors. By balancing these considerations, architects and builders can select materials that withstand flooding, promote resilience, and minimize environmental impact.

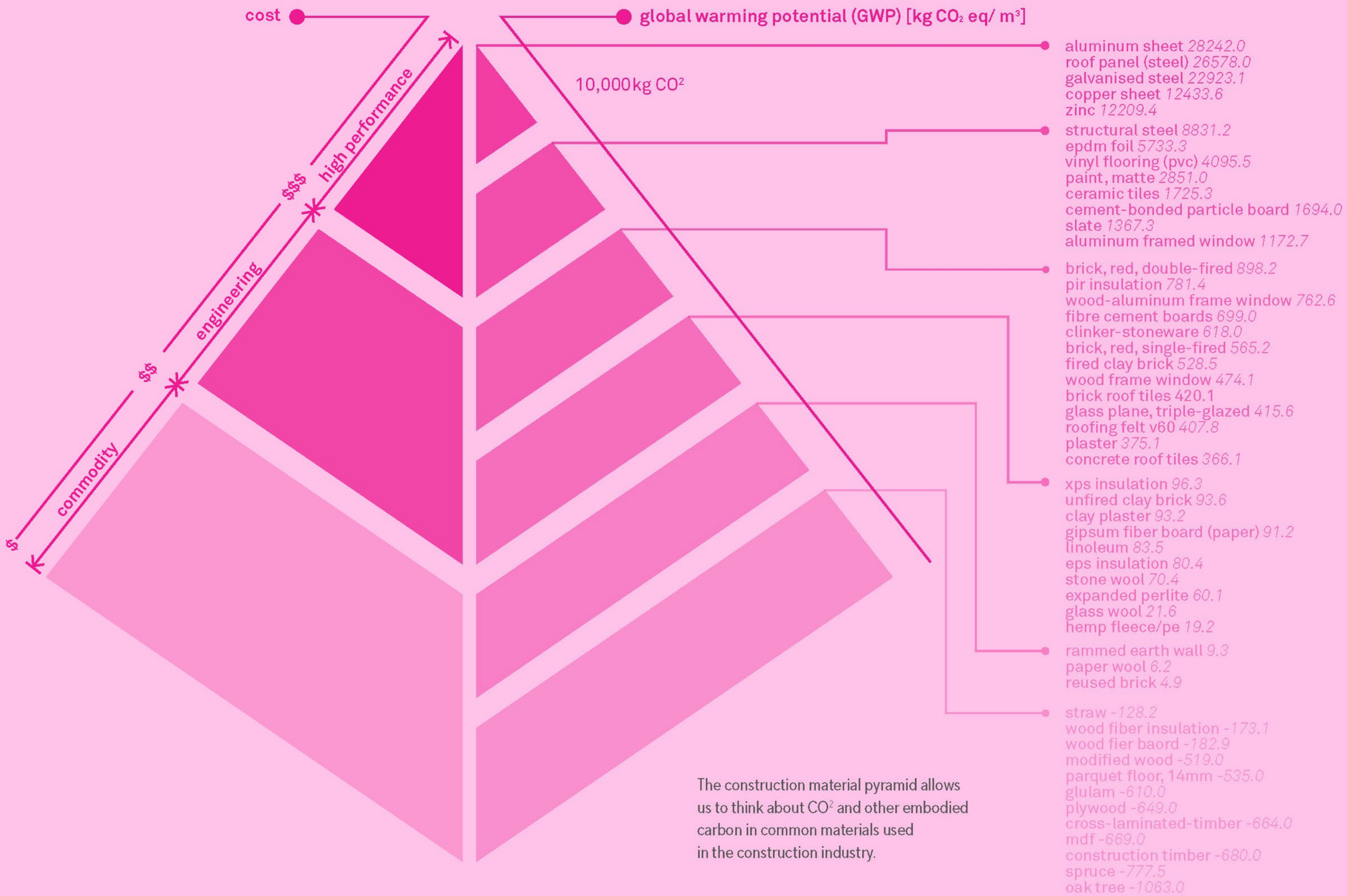
environmental impact and corrosion

Materials and their environmental impact and corrosion are important considerations. Regarding environmental impact, the choice of materials used in flood adaptation should aim to minimize ecological consequences. Sustainable and environmentally friendly materials, such as recycled or low-impact materials, can help reduce the overall carbon footprint and resource consumption associated with construction. Corrosion is a particular concern in flood-prone areas due to the prolonged exposure to moisture and, in some cases, saltwater. Corrosion-resistant materials, such as stainless steel or treated metals, can be utilized to ensure the longevity and structural integrity of flood-adaptive architecture. Proper coating, sealing, or galvanizing methods can also enhance the resistance of materials to corrosion.

Balancing environmental impact and corrosion resistance is crucial in selecting appropriate materials for flood adaptation. Considering life cycle assessments, embodied energy, recyclability, and durability can help make informed choices that promote sustainability and mitigate the negative environmental impacts associated with flood-resistant materials.

environmental impact and corrosion

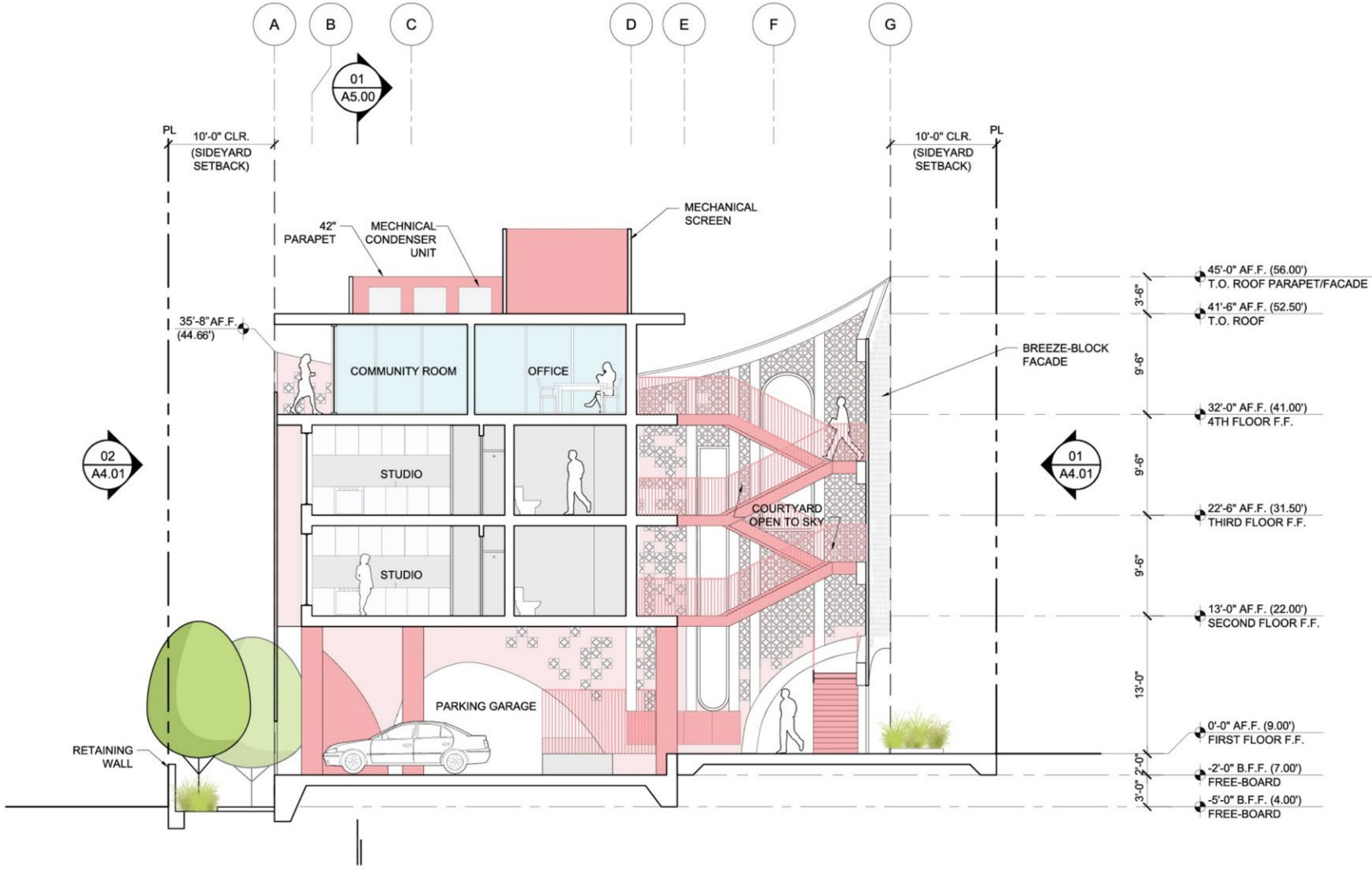
Structural considerations involve designing buildings to withstand flood forces and impacts. This includes ensuring load-bearing capacity to support floodwaters and debris, designing robust and elevated foundations, implementing efficient water flow systems, using resilient materials, and incorporating structural reinforcements. FEMA and NFIP regulate building design in floodplains, but does not account for future sea level rise. It is also important to consider alternative and innovation materials. Materials like conventional steel reinforcement steel or concrete mixes have alternatives. Fiberglass or basalt have entered the market and provide non-corrosive alternatives to rebar, however, building codes and regulations have not kept up with the pace and are not currently accepted. Professional expertise is essential to meet building codes and standards, ensuring the safety and longevity of flood-adaptive structures.



The construction material pyramid allows us to think about CO^2 and other embodied carbon in common materials used in the construction industry.


MIAMI-DADE FIRE RESCUE
STATE LAW ENFORCEMENT
FWC


the Heron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B
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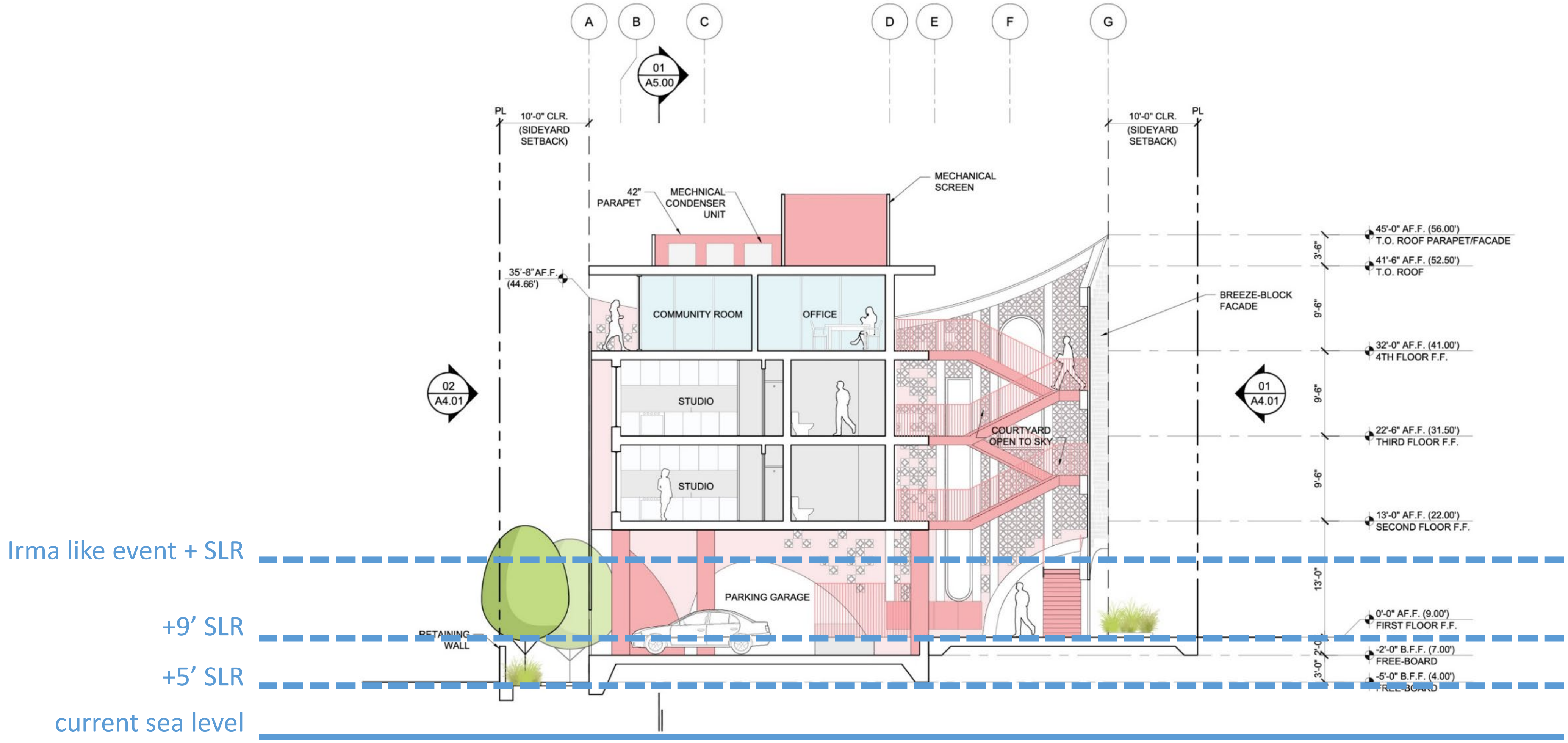
01
A5.00
PL
10'-0" CLR.
(SIDEYARD
SETBACK)
10'-0" CLR.
(SIDEYARD
SETBACK)
PL
42"
PARAPET
MECHNICAL
CONDENSER
UNIT
MECHANICAL
SCREEN
35'-8" AF.F.
(44.66')
COMMUNITY ROOM
OFFICE
BREEZE-BLOCK
FACADE
02
A4.01
01
A4.01
STUDIO
STUDIO
COURTYARD
OPEN TO SKY
PARKING GARAGE
RETAINING
WALL
45'-0" AF.F. (56.00')
T.O. ROOF PARAPET/FACADE
41'-6" AF.F. (52.50')
T.O. ROOF
32'-0" AF.F. (41.00')
4TH FLOOR F.F.
22'-6" AF.F. (31.50')
THIRD FLOOR F.F.
13'-0" AF.F. (22.00')
SECOND FLOOR F.F.
0'-0" AF.F. (9.00')
FIRST FLOOR F.F.
-2'-0" B.F.F. (7.00')
FREE-BOARD
-5'-0" B.F.F. (4.00')
FREE-BOARD
3'-6"
9'-6"
9'-6"
9'-6"
13'-0"
2'-0"
3'-0"



Irma like event + SLR
+9’ SLR
+5’ SLR
current sea level
A
B
C
D
E
F
G
01
A5.00
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2'-0"
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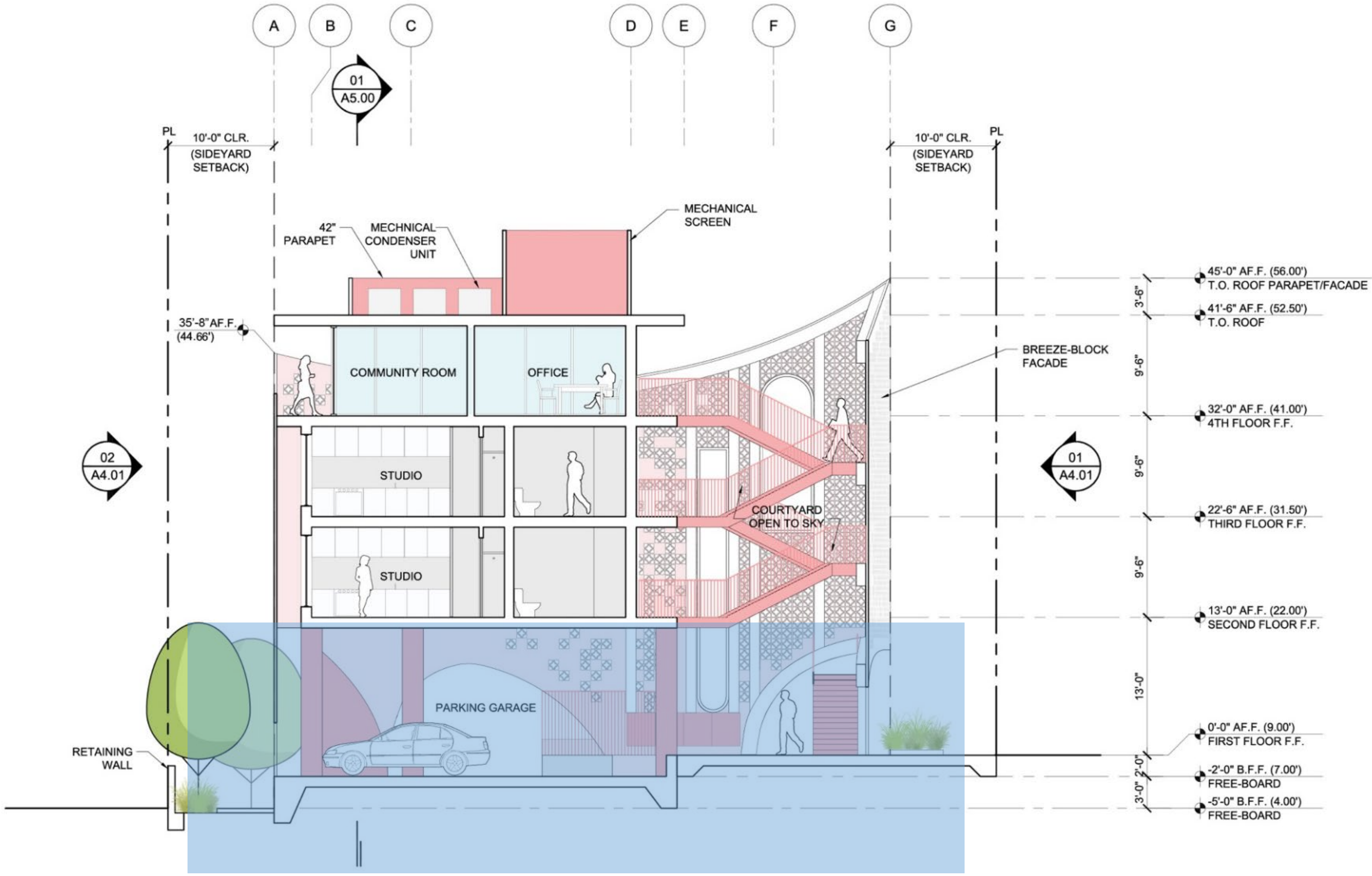
XYPEX
ADMIX C-1000
Concrete Waterproofing
By Crystallization
NET 60 lb./27.2 kg
C-2000
C-500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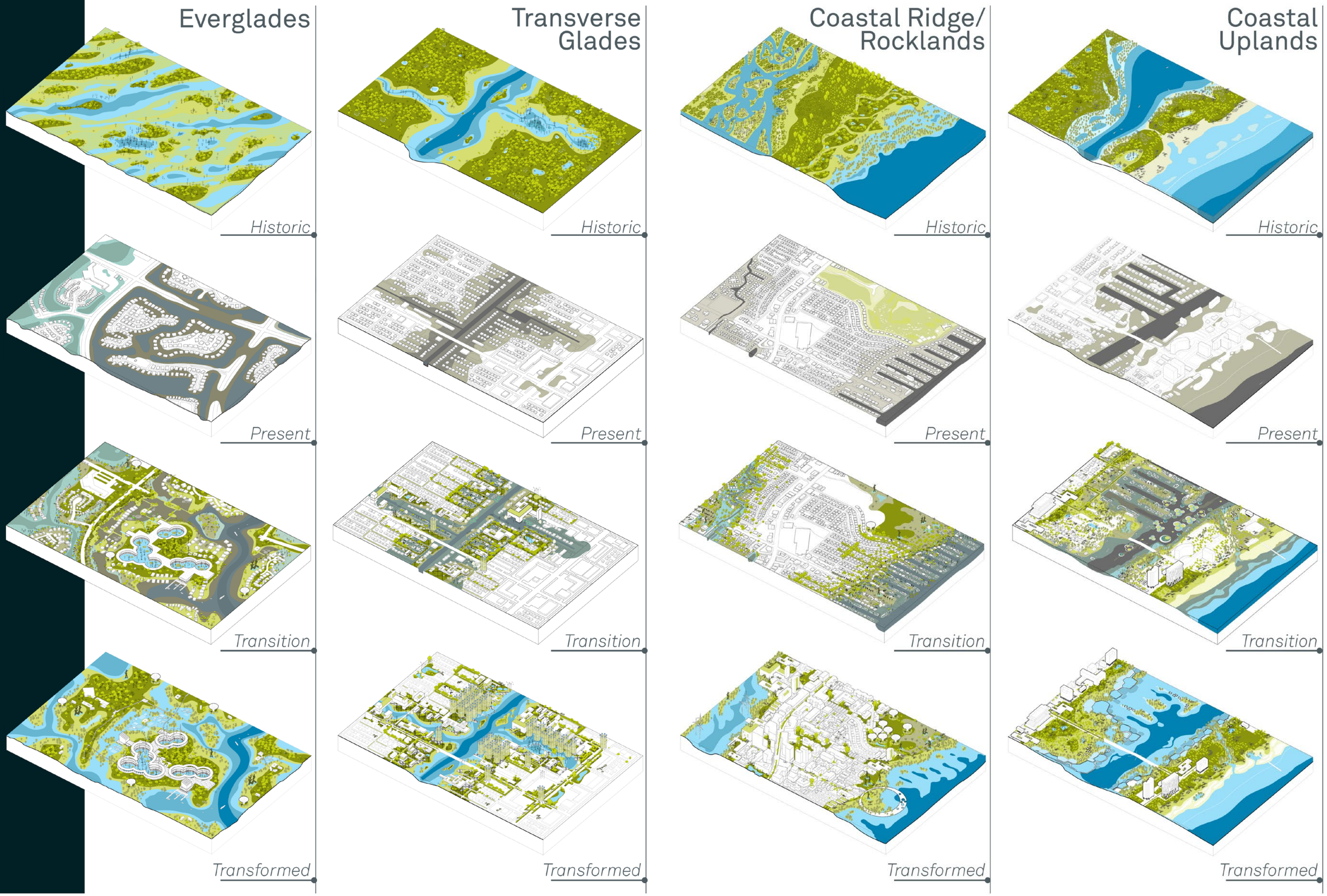
urban
design

Ecotypic Response Matrix

Basic services and economies organized around a decentralized network tooled for salty and desert-like conditions creates novel approaches to tourism (ruin porn), agriculture, and scientific research. Water would be produced through harvesting and cleaning rainwater, as well as desalination. Waste would be collected and metabolized through phytoremediation networks. Power would be generated with wave, wind, waste, and solar as a distributed and redundant system. Food would be grown within localized networks to service and provide sustenance farming for residents and visitors. Automated and autonomous vehicles would be placed into service to aide in clean up and detoxifying previously developed areas and waters. Abandoned structures become scaffolding for transitional and transformed ecologies.



glades adaptation

glade problems

The Everglades and developed glades areas experience natural flooding due to its unique hydrological characteristics and the interaction between rainfall, surface water, and underground aquifers.

Flooding in the glades areas occurs due to its flat topography, heavy rainfall, natural water storage areas, and human alterations to the hydrological system. The Everglades' low-lying wetland terrain and slow water movement make it susceptible to prolonged inundation during intense rainfall events. Additionally, the ecosystem's natural storage areas become saturated, causing water to spread out and contribute to flooding. Human modifications, such as canals and levees, farther impact water flow and exacerbate flooding. While natural flooding is essential for the Everglades' ecological balance, managing and balancing the hydrological processes with human needs is crucial to mitigate adverse impacts on the ecosystem and surrounding areas.

glade solutions

Adapting glades areas to flooding involves implementing strategies that aim to manage and allow for the impacts of excessive water and preserve the ecological integrity of the wetland. Some key approaches for adapting the glades to flooding include:

Hydrological Restoration: Restoring the natural water flow patterns is essential. This can involve removing or modifying levees and canals to reestablish historic water flows and allow for more natural distribution and drainage of water during flood events.

Water Storage and Retention: As seas rise salt water and brackish conditions will emerge; implementing water storage and retention areas for freshwater can help retain native ecosystems, but more as islands.

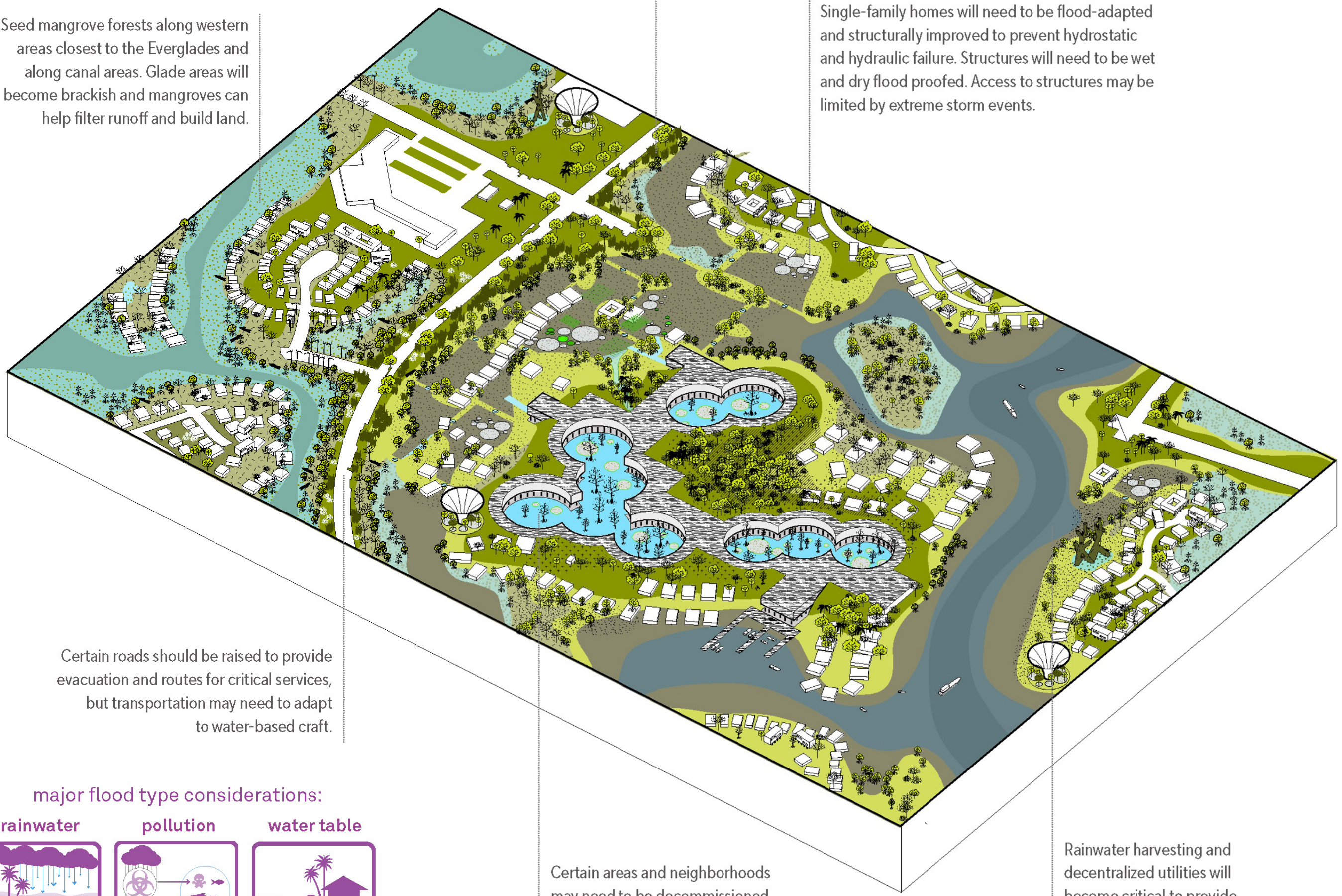
Land Use Planning: Land use planning is crucial to adapt to flooding. Zoning regulations and development guidelines should be implemented to restrict construction and seek to develop a "Department of Unplanning" to decommission these urban areas into small hamlets of development.

By combining these approaches, the glades can be better prepared to handle flooding events.

Biomounds and bioswales can be installed to help with evapotranspiration rates. Vegetation will need to be installed that is salt tolerant or halophytic.

Seed mangrove forests along western areas closest to the Everglades and along canal areas. Glade areas will become brackish and mangroves can help filter runoff and build land.

Single-family homes will need to be flood-adapted and structurally improved to prevent hydrostatic and hydraulic failure. Structures will need to be wet and dry flood proofed. Access to structures may be limited by extreme storm events.



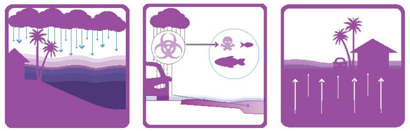
Certain roads should be raised to provide evacuation and routes for critical services, but transportation may need to adapt to water-based craft.

Certain areas and neighborhoods may need to be decommissioned to allow for more room for water, especially to ensure freshwater recharge is maintained.

Rainwater harvesting and decentralized utilities will become critical to provide services to residents in these areas as infrastructure becomes too costly to serve entire areas.

major flood type considerations:

rainwater | pollution | water table



transverse glades adaptation

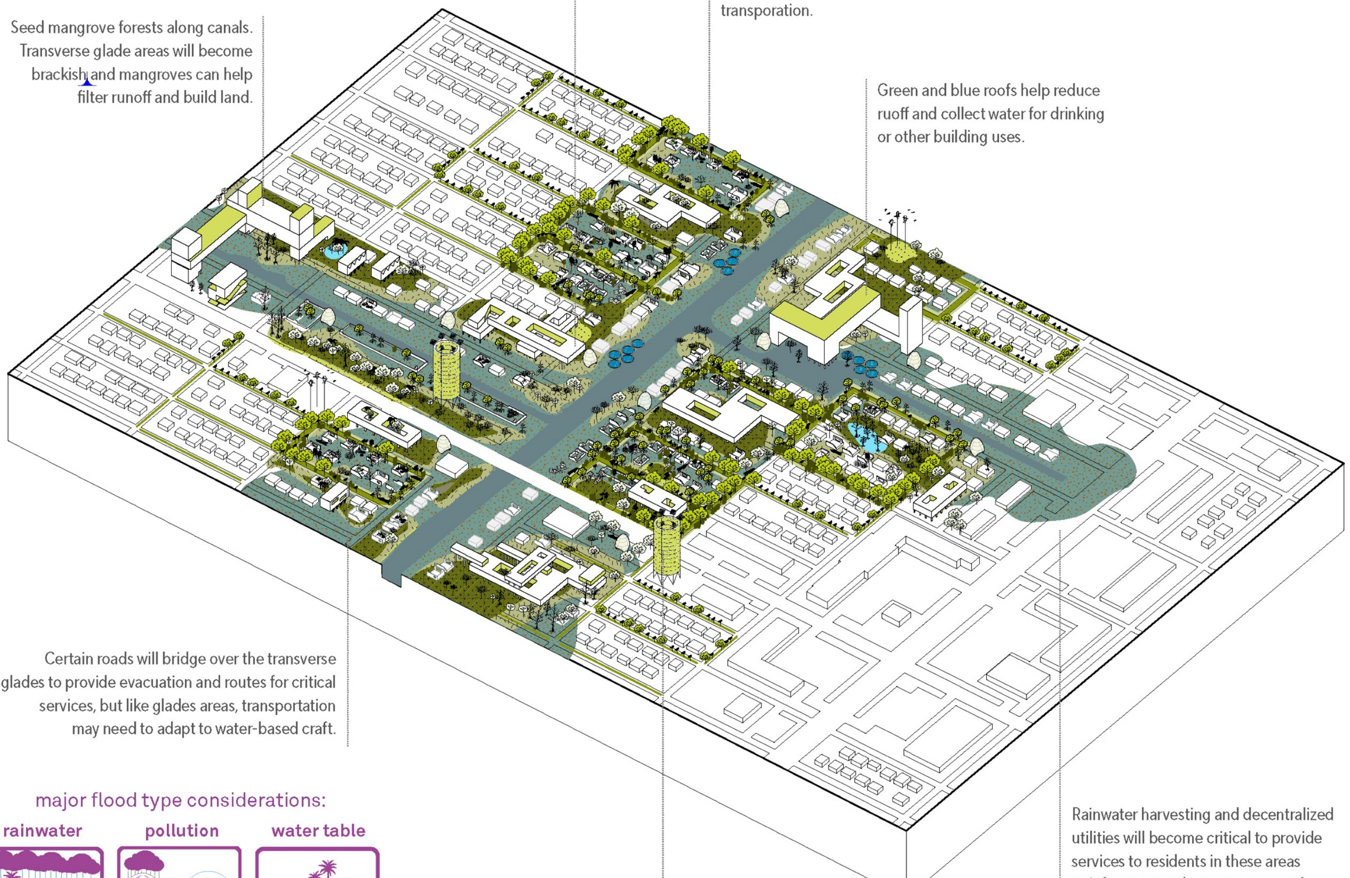
transverse glades problems

The Transverse Glades are unique due to their distinct geological and hydrological characteristics. These include a series of limestone ridges and depressions, known as the Atlantic Coastal Ridge, which separate the Everglades from the Atlantic Ocean. The Transverse Glades play a vital role in south Florida's hydrological system, supporting diverse ecosystems, acting as wildlife corridors, and facing environmental challenges. Preserving and managing these areas are essential for maintaining the region's ecological balance and biodiversity. With both marl and peat, as well as some cypress strands these drainage ways are critical and low areas ~~are~~ where dredged canals can be seen throughout the region. Though urban development has continued since the original dredging of canals in the turn of the ~~20th~~ century, the canals have never been widened or altered in any significant way.

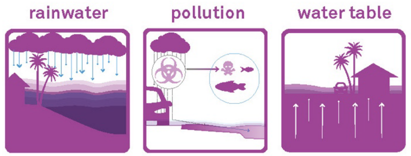
transverse glade solutions

Adapting the Transverse Glades to flooding involves implementing strategies to manage and allow the impacts of excessive water in this specific region. Some key approaches include:

Understanding Geology, Hydrology and Biodiversity: The Transverse Glades are characterized by a series of limestone ridges and depressions that run east-west across the southern part of the Florida Peninsula. These corridors should remove urban development and rewild the corridor. They act as natural barriers that control the flow of water from the north to the south, influencing the movement of surface and groundwater. The interaction between the shallow aquifer, wetlands, and canals in the Transverse Glades contributes to the unique water flow patterns and the delicate balance of freshwater and saltwater in the region. A diverse range of ecosystems and habitats, that include freshwater marshes, cypress swamps, hardwood hammocks, and pinelands. These habitats provide important refuge and nesting grounds for numerous plant and animal species, including rare and endangered species such as the Florida panther and the Cape Sable seaside sparrow, thus these areas serve as important wildlife corridors, allowing for the movement and migration of various species across the region, but more importantly, will regulate freshwater supply and flooding in the future and should be designed appropriately. A clear development edge that makes room for water must be implemented.



major flood type considerations:



coastal ridge and uplands adaptation

uplands problems

The Atlantic Coastal Ridge possesses some unique characteristics. The interaction between the ridge's geological features and the surrounding hydrological system is of particular note and when viewed with all the other ecotypes that interface it. The Atlantic Coastal Ridge acts as a natural barrier, influencing the movement and flow of water across the region. The flat topography and underlying limestone formations of the ridge play a crucial role in water storage, retention, and flow patterns during flood events. The interplay between urban development, land use patterns, and the natural hydrological system poses unique challenges in managing and adapting to flood events.

uplands solutions

Adapting the Atlantic Coastal Ridge with flood resilient urban design features requires a combination of strategies. Effective drainage and stormwater management systems in these upland areas should be implemented to control water flow and prevent flooding downstream or in adjacent low-lying areas. Preserving and restoring natural water storage areas, such as wetlands and floodplains, is essential. These areas act as buffers, absorbing and retaining water during flood events, thereby reducing the risk of flooding along the Atlantic Coastal Ridge. Additionally, implementing land use planning and zoning regulations to restrict construction in flood-prone areas and intensifying development on higher ground that is less vulnerable. Monitoring systems and early warning systems provide crucial information for timely response and evacuation, while community education and preparedness play a vital role in building resilience.

Collaboration among various stakeholders is key to the successful adaptation of the Atlantic Coastal Ridge. Government agencies, local communities, and conservation organizations need to work together to implement and maintain these adaptation measures. By combining scientific knowledge, community engagement, and sustainable management practices, the Atlantic Coastal Ridge can be better equipped to handle and mitigate the effects of flooding, ensuring the long-term resilience of the region. One of the unique challenges will be to design and develop in a way that does not alienate, nor push out those populations that have occupied the land for generations—climate gentrification is an issue that will need to be solved at the neighborhood and community scale.

Transfer of development rights can be a powerful tool to incentivize development to the coastal ridge.

Transfer of development rights or TDR allow for intensification of development at the higher elevations. New development should still plan for flooding and design to integrate green and blue roofs, living walls, and green infrastructure.

Neighborhoods should implement green and blue streets and redevelop with flood-adpative architecture.

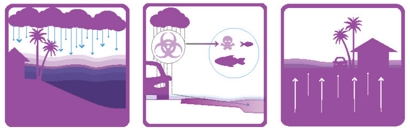
Allow for transportation to adapt to water-based craft and have new development provide access to public waterways.

Certain areas and neighborhoods may need to be decommissioned to allow for more room for water, especially to ensure freshwater recharge is maintained.

Vulnerable properties along the intracoastal waterways should be decommissioned or redeveloped. Access should be converted to water-based transportation only.

major flood type considerations:

rainwater | pollution | water table



coastal uplands-esturaine adaptation

coastal upland problems

Flooding of the coastal uplands and barrier islands presents several unique challenges. One significant aspect is the proximity to the ocean and the susceptibility to storm surge during hurricanes and other severe weather events. Barrier islands, in particular, serve as a protective barrier between the mainland and the open ocean, making them prone to coastal flooding and erosion. Storm surge, combined with high tides and heavy rainfall, can result in significant inundation.

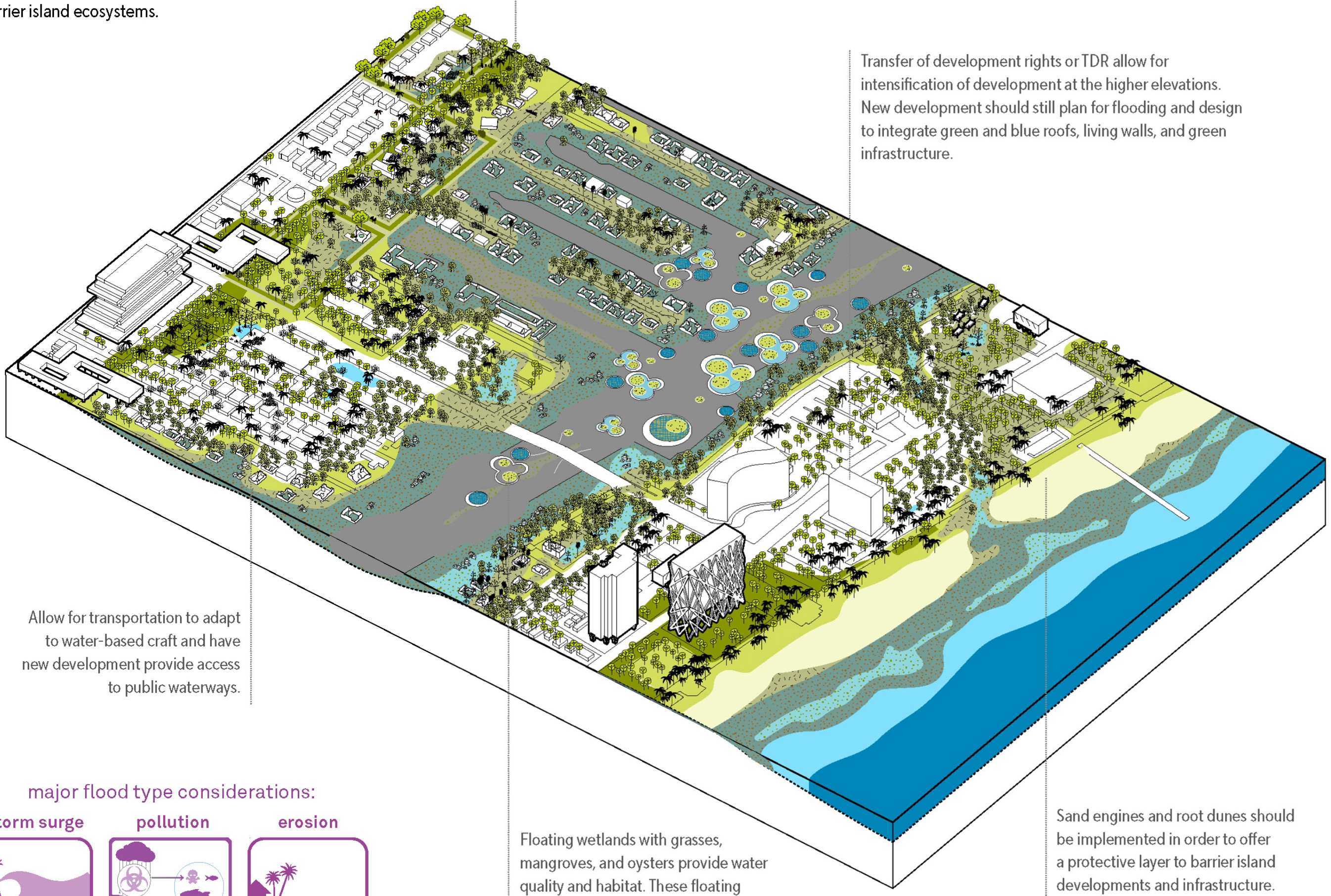
The flat topography of the coastal uplands and barrier islands also plays a role in flooding dynamics. With minimal elevation changes, even relatively small increases in water levels can lead to widespread flooding. The permeability of the soils in these areas is another factor that affects flooding, as it can impact the rate of water infiltration and drainage.

Farthermore, the delicate balance between saltwater and freshwater in these coastal ecosystems makes them particularly vulnerable to flooding. Excessive flooding can cause saltwater intrusion into freshwater superficial aquifers, threatening drinking water supplies and impacting the delicate balance of coastal ecosystems.

coastal upland problems

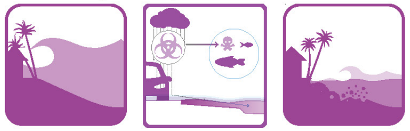
Adapting to flooding in the coastal uplands and barrier islands of south Florida requires specific strategies that address the unique challenges posed by their coastal location, storm surge vulnerability, flat topography, and the delicate balance of saltwater and freshwater ecosystems. Coastal protection measures, such as dune restoration and beach nourishment, as well as the development of resilient infrastructure and land use planning, are vital for mitigating the impacts of flooding in these areas.

Adapting barrier islands to flooding involves a range of strategies. These include beach nourishment to restore eroded beaches, dune restoration to strengthen natural barriers, living shorelines to dissipate wave energy, elevated structures and flood-resistant infrastructure, strategic land use planning, monitoring systems and early warning systems, and public education. By combining these approaches, barrier islands can enhance their resilience to flooding, protecting coastal communities and infrastructure from the impacts of storm surge and wave action. Collaboration among stakeholders is vital to implementing these measures effectively and ensuring the long-term sustainability of barrier island ecosystems.

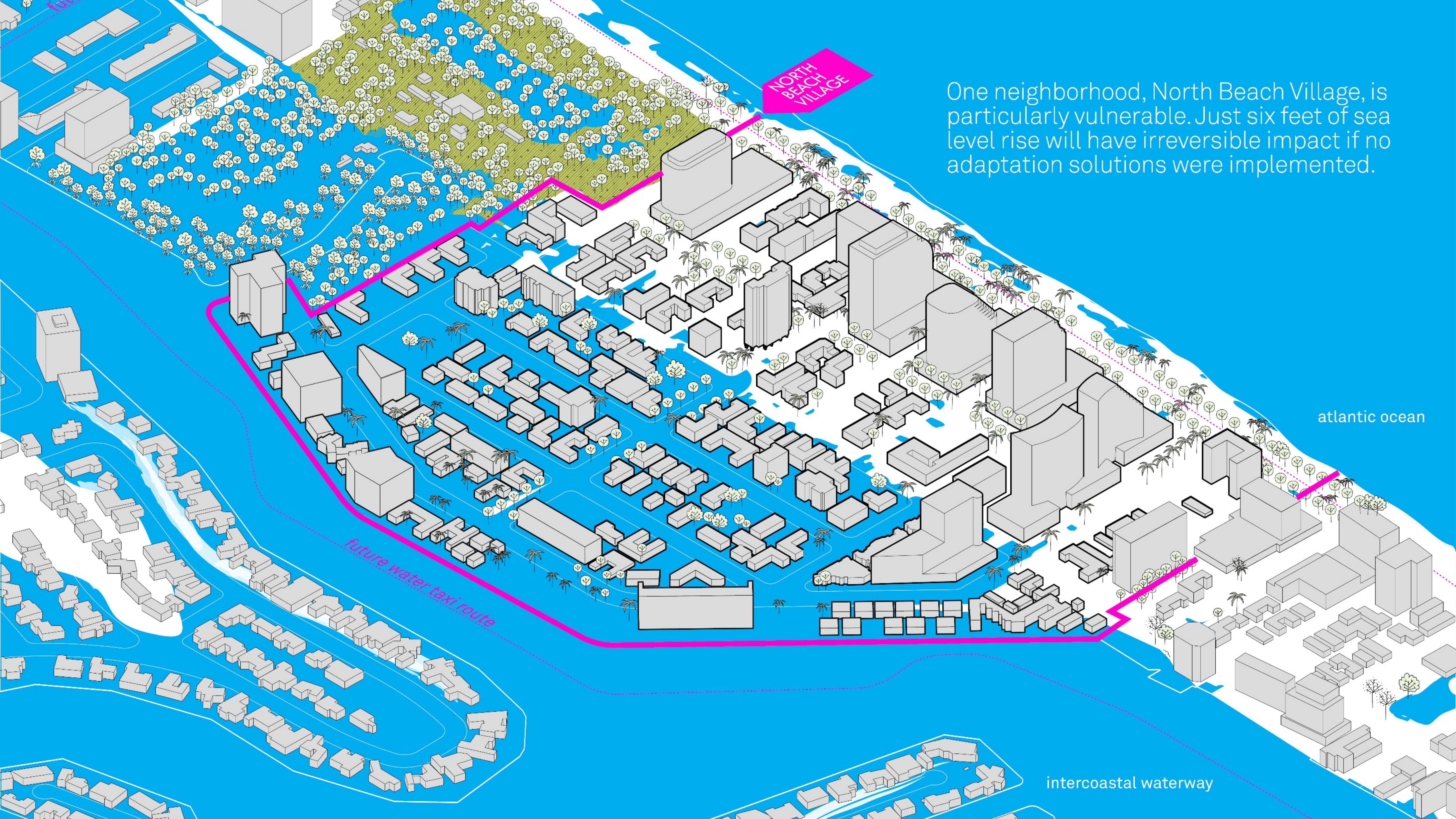


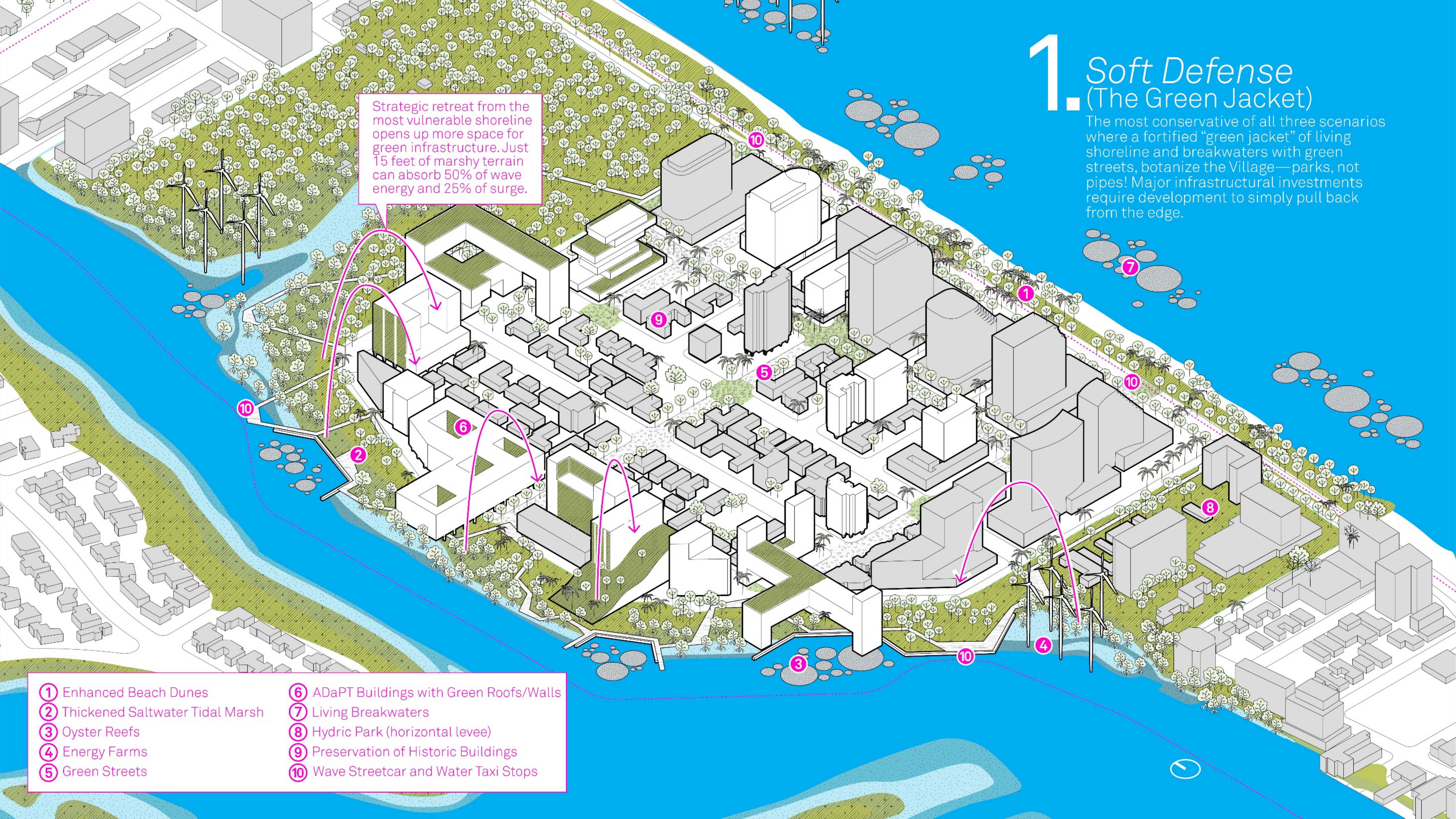
major flood type considerations:

storm surge | pollution | erosion



One neighborhood, North Beach Village, is particularly vulnerable. Just six feet of sea level rise will have irreversible impact if no adaptation solutions were implemented.




1. Soft Defense
(The Green Jacket)
The most conservative of all three scenarios where a fortified "green jacket" of living shoreline and breakwaters with green streets, botanize the Village—parks, not pipes! Major infrastructural investments require development to simply pull back from the edge.
Strategic retreat from the most vulnerable shoreline opens up more space for green infrastructure. Just 15 feet of marshy terrain can absorb 50% of wave energy and 25% of surge.
1 Enhanced Beach Dunes
2 Thickened Saltwater Tidal Marsh
3 Oyster Reefs
4 Energy Farms
5 Green Streets
6 ADaPT Buildings with Green Roofs/Walls
7 Living Breakwaters
8 Hydric Park (horizontal levee)
9 Preservation of Historic Buildings
10 Wave Streetcar and Water Taxi Stops
1
2
3
4
5
6
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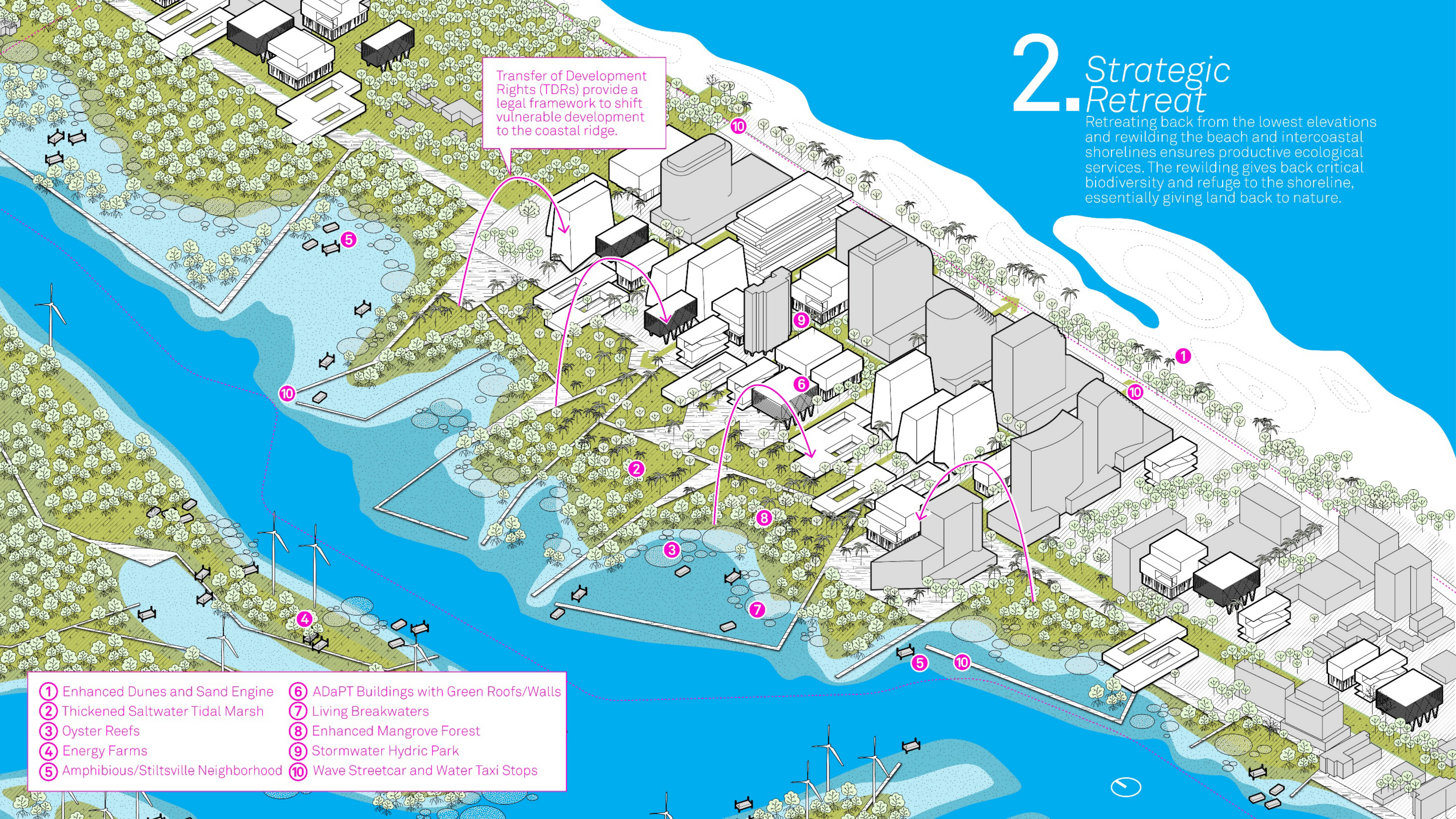
10
10
10

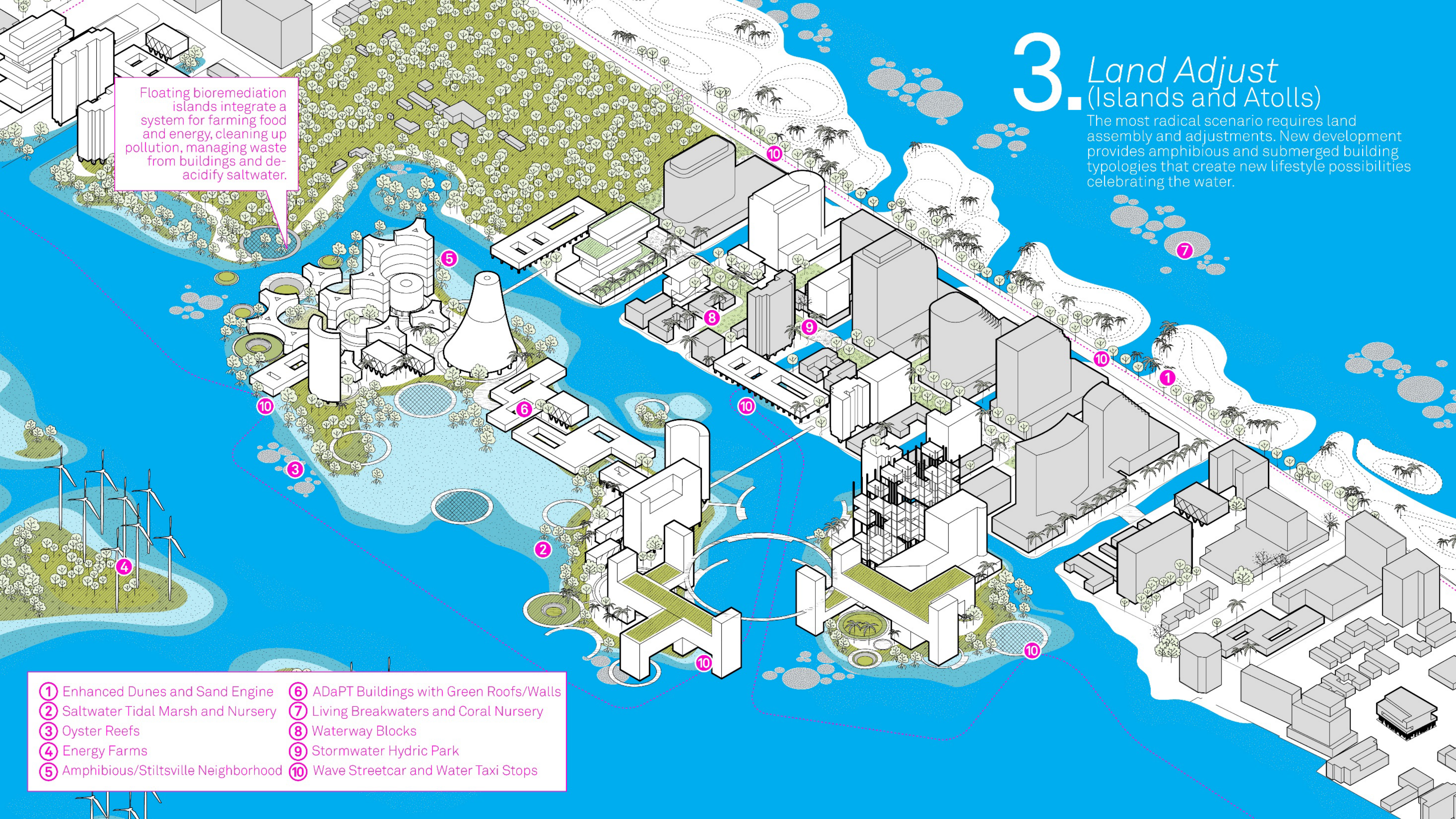
2. *Strategic Retreat*

Retreating back from the lowest elevations and rewilding the beach and intercoastal shorelines ensures productive ecological services. The rewilding gives back critical biodiversity and refuge to the shoreline, essentially giving land back to nature.

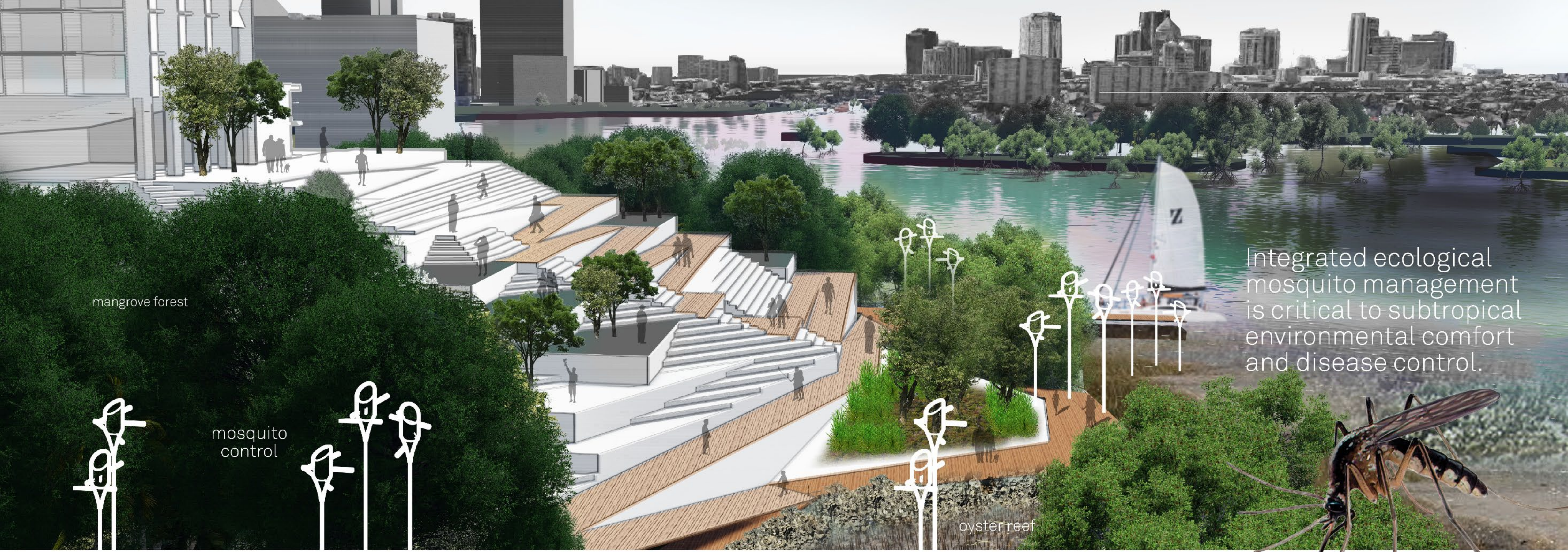


3. *Land Adjust* (Islands and Atolls)

The most radical scenario requires land assembly and adjustments. New development provides amphibious and submerged building typologies that create new lifestyle possibilities celebrating the water.

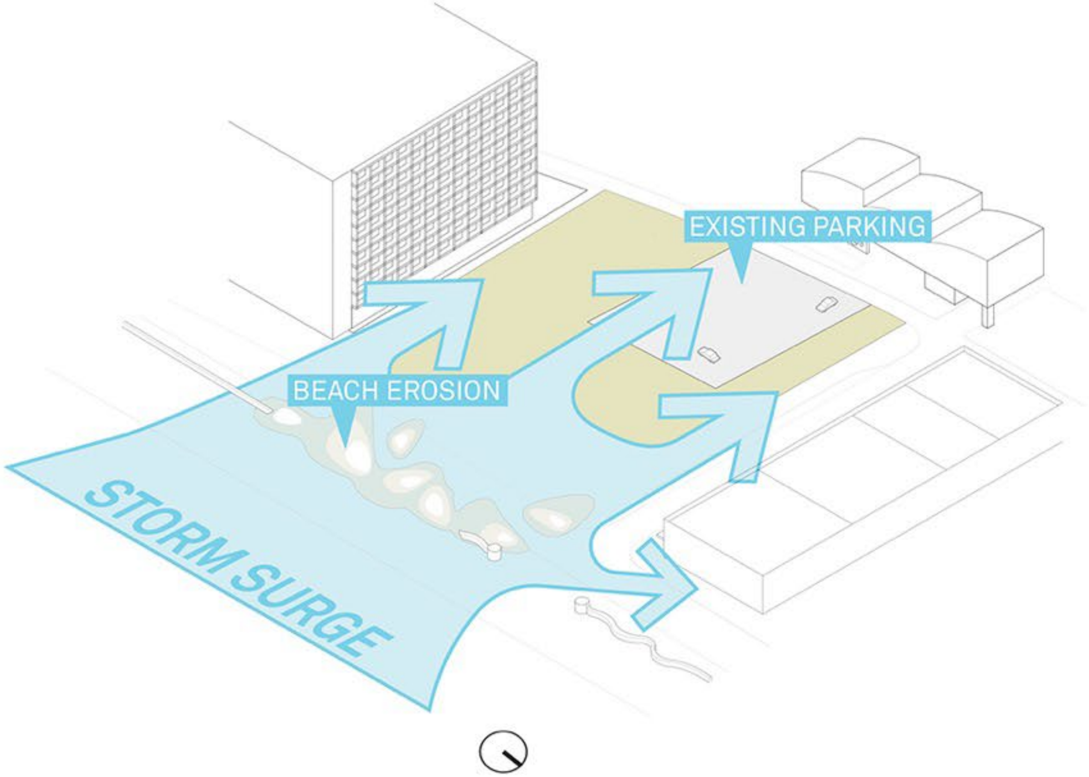


Birch Avenue becomes
Birch Eco-Boulevard.
New permeable median of bioswales and rain gardens create oases within the street corridor.

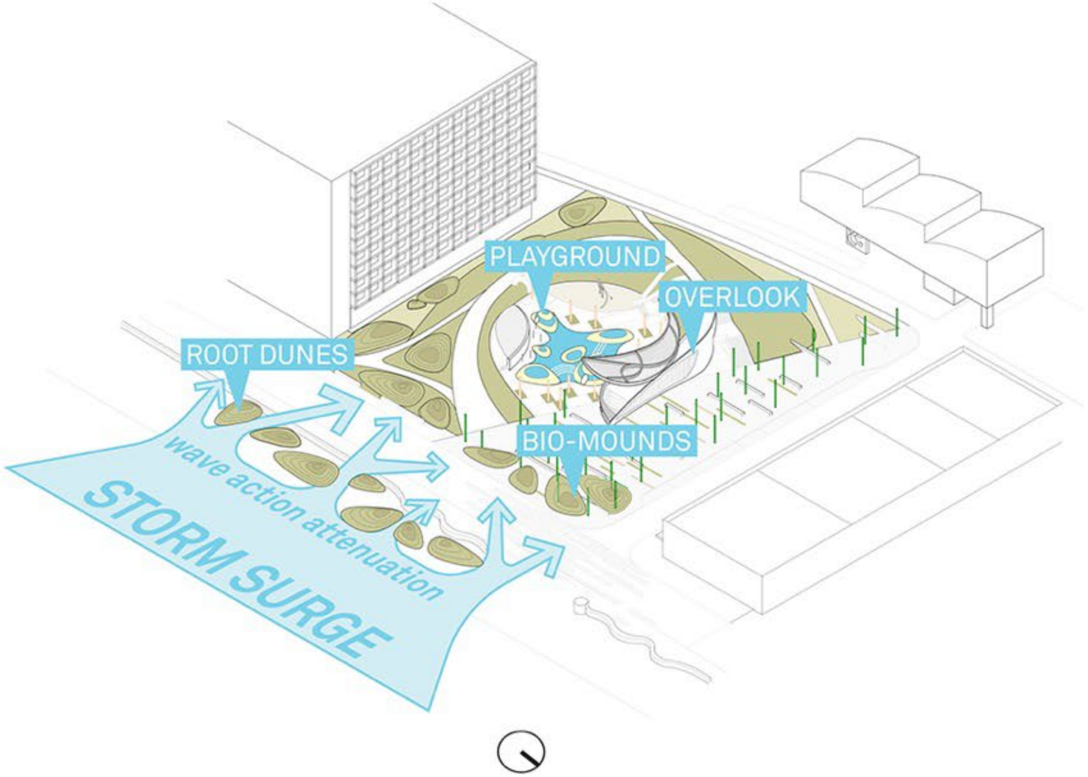

mangrove forest
mosquito control
oyster reef
Integrated ecological mosquito management is critical to subtropical environmental comfort and disease control.


The beach is enhanced with “root” dunes and sand engines.


SITE



EXISTING PARK



PROPOSED PARK


MAREN
ALEXANDER
PARK


MAREN

"Supply creates its own demand." Jean-Baptiste Say, French Economist

Jeffrey Huber, FAIA, ASLA, LEEDap, NCARB, WEDG
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