

# Strategies for Coastal Resilience

**MARIANNE EPPIG | STEFAN AL | EDGAR WESTERHOF | ISABEL DE CAIRES**

ULI URBAN RESILIENCE PROGRAM

FEBRUARY 6, 2024



## A Few Housekeeping Announcements

- Participants will remain muted through the duration of the webinar
- Submit your questions through the Zoom Q&A function
- This webinar is being recorded and will be sent to registrants and uploaded to ULI's Knowledge Finder platform
- Island Press has generously offered a 30% discount on the book *Adapting Cities to Sea Level Rise: Green and Gray Strategies* by Stefan Al to all webinar registrants!

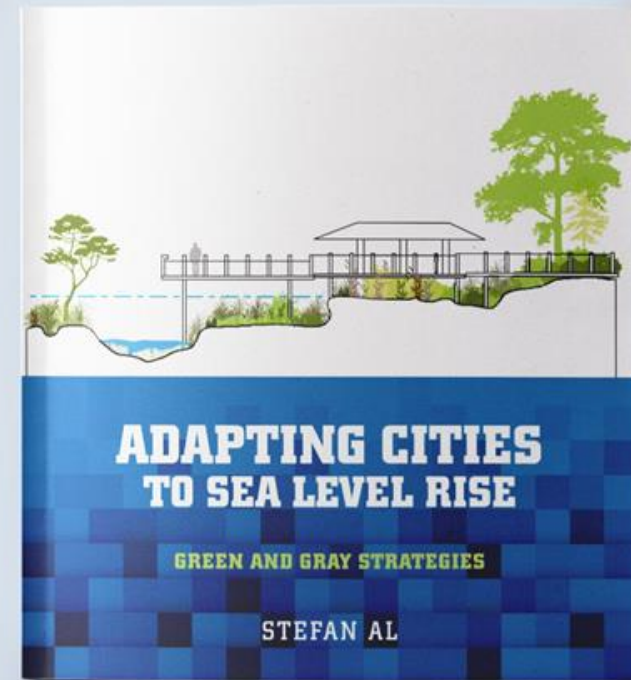
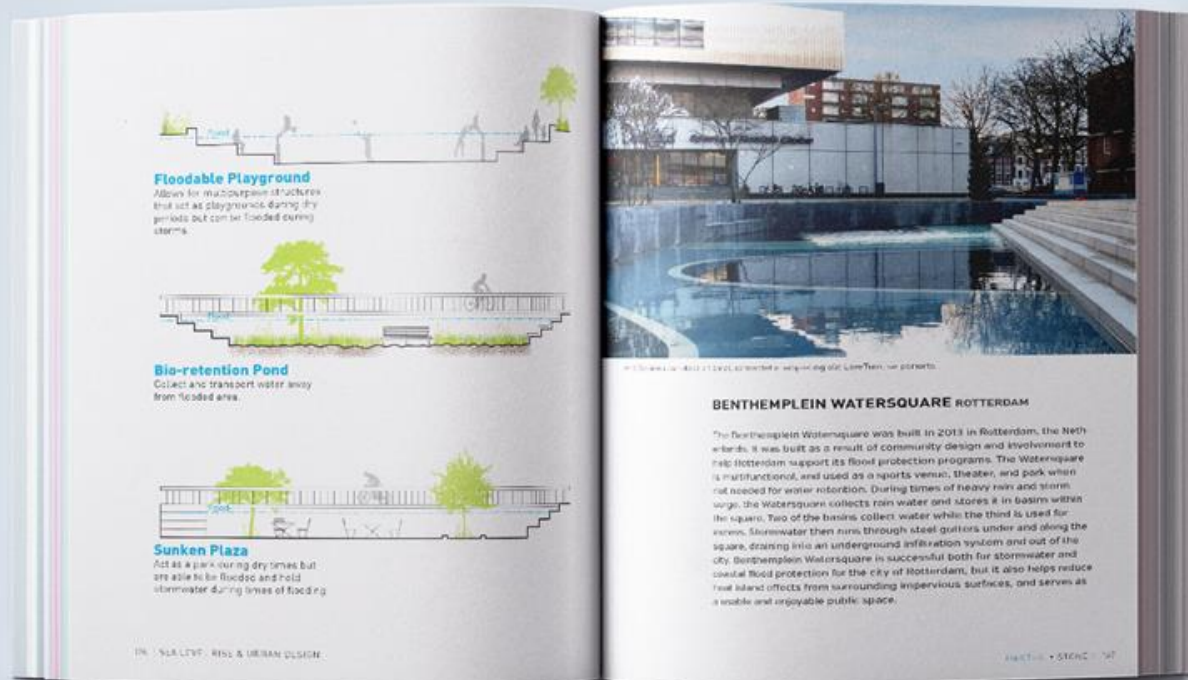


# Agenda

- Welcome and introductions – 5 min
- Presentation on coastal resilience strategies by **Stefan AI**, author of *Adapting Cities to Sea Level Rise: Green and Gray Strategies* – 15 min
- Presentation on engineering for coastal resilience by **Edgar Westerhof**, Vice President, North America Adaptation Solution Lead, Arcadis U.S., Inc. – 10 min
- Presentation on finance options for resilient real estate development by **Isabel de Caires**, Director, Investment Banking, CIBC FirstCaribbean International Bank – 10 min
- Q&A with audience – 20 min
- Optional networking – 30 min

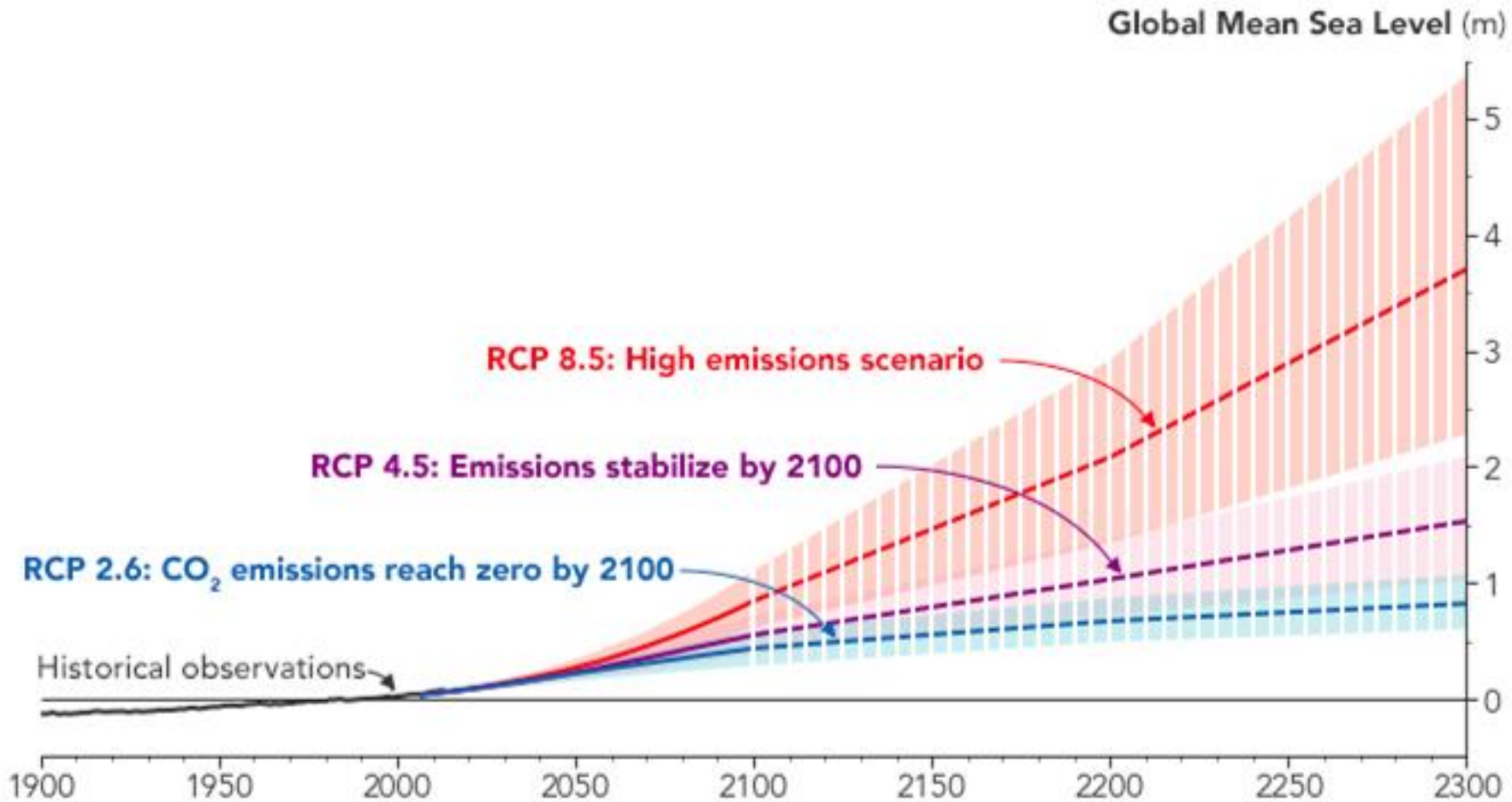


# Improving Coastal Resilience: Design-driven Adaptation Strategies



Stefan Al, PhD RA LEED  
Email: [stefan@stefanal.com](mailto:stefan@stefanal.com)





Source: Intergovernmental Panel on Climate Change, 2019



NEW YORK CITY, USA +0



+5ft



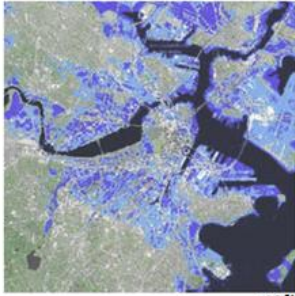
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BOSTON, USA +0



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MIAMI, USA +0



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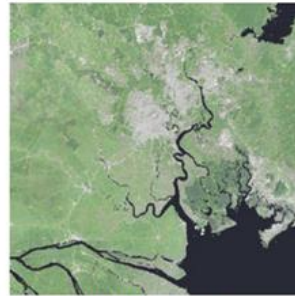
NEW ORLEANS, USA +0



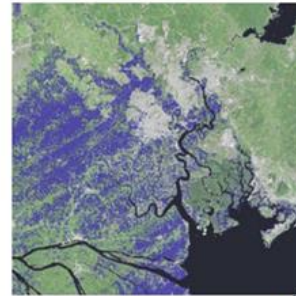
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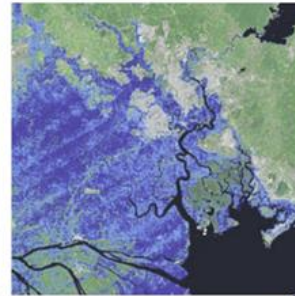
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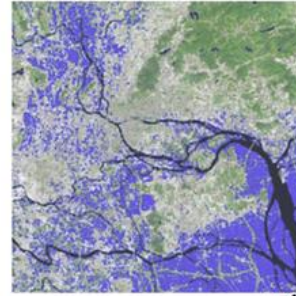
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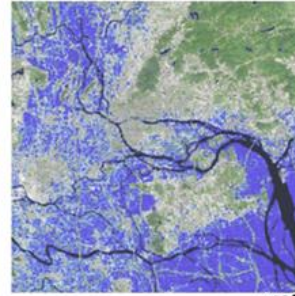
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GUANGZHOU, CHINA +0



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ROTTERDAM, THE NETHERLANDS +0



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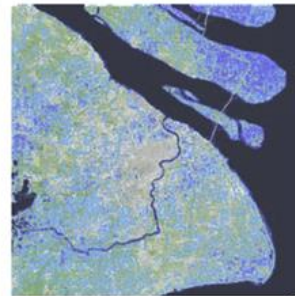
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SHANGHAI, CHINA +0



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+10ft

Med-Risk Scenario (+5ft)

High-Risk Scenario (+10ft)





“The City and the Storm”  
Iwan Baan, November 1, 2012

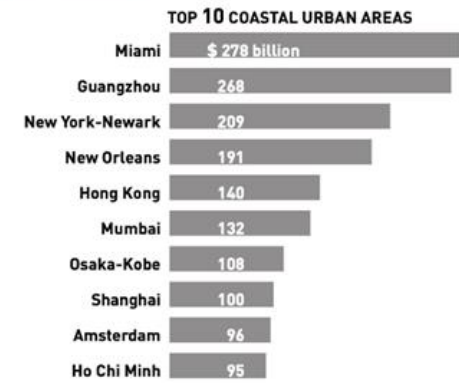








Adapted from: Stephane Hallegatte et al., 2013. Natural Climate Change  
<http://ngm.nationalgeographic.com/2015/02/climate-change-economics/coastal-cities-map>



## WORLD CITIES SEA LEVEL RISE THREAT



New Orleans floodwall





China's new "Great Wall"





Elevated homes, New Jersey Shore





**Floodable Playground**  
Allows for multipurpose structures that act as playgrounds during dry periods but can be flooded during storms.



**Bio-retention Pond**  
Collect and transport water away from flooded areas.



**Sunken Plaza**  
Act as a park during dry times but are able to be flooded and hold stormwater during times of flooding.



PHOTO: NATURE, RISE & URBAN DESIGN

#### BENTHEPLEIN WATERSQUARE ROTTERDAM

The Bentheplein Watersquare was built in 2013 in Rotterdam, the Netherlands. It was built as a result of community design and involvement to help Rotterdam support its flood protection programs. The Watersquare is multifunctional, and used as a sports venue, theater, and park when not needed for water retention. During times of heavy rain and storm surge, the Watersquare collects rain water and stores it in basins within the square. Two of the basins collect water while the third is used for events. Stormwater then runs through steel gutters under and along the square, draining into an underground infiltration system and out of the city. Bentheplein Watersquare is successful both for stormwater and coastal flood protection for the city of Rotterdam, but it also helps reduce heat island effects from surrounding impervious surfaces, and serves as a viable and enjoyable public space.



## ADAPTING CITIES TO SEA LEVEL RISE

GREEN AND GRAY STRATEGIES

STEFAN AL



# **Design with Risk**

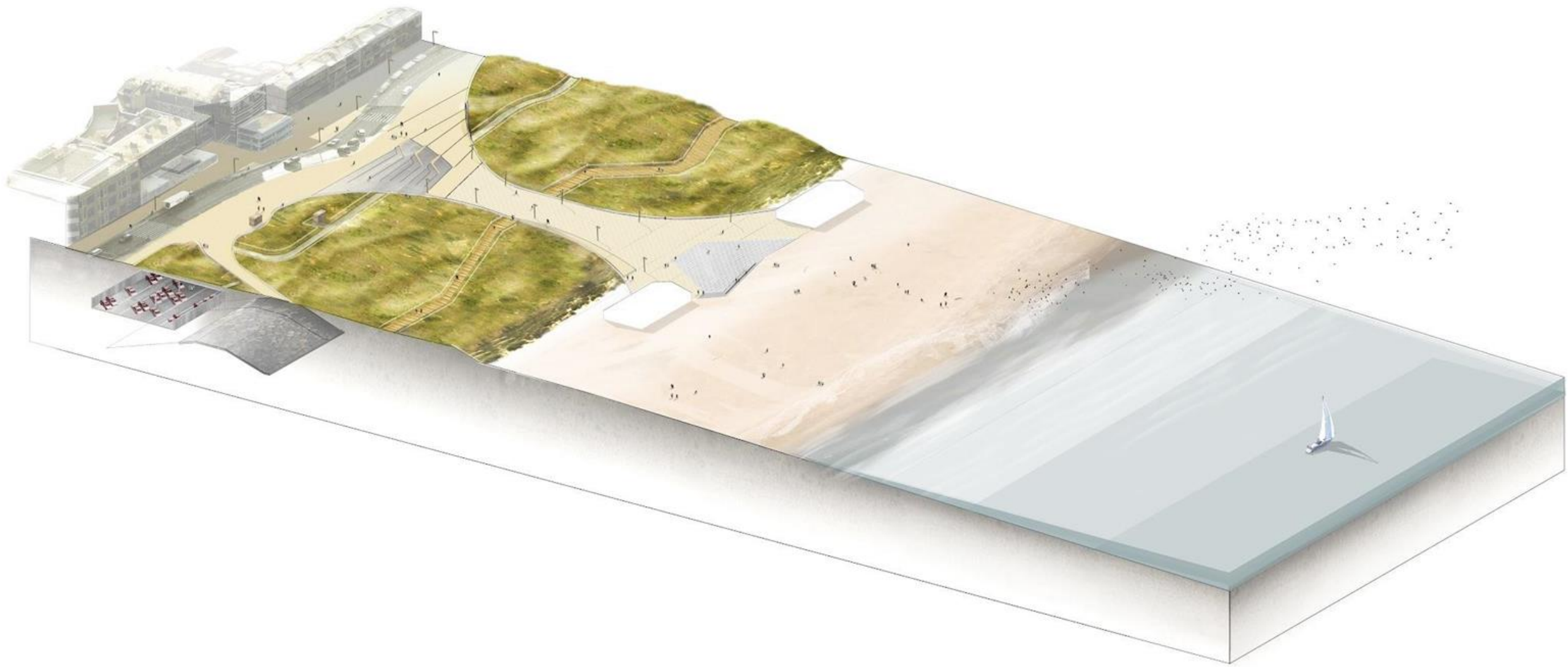
- 1. Multi-Disciplinary**
- 2. Multi-Stakeholder**
- 3. Multi-Scenario**
- 4. Multi-Functional**

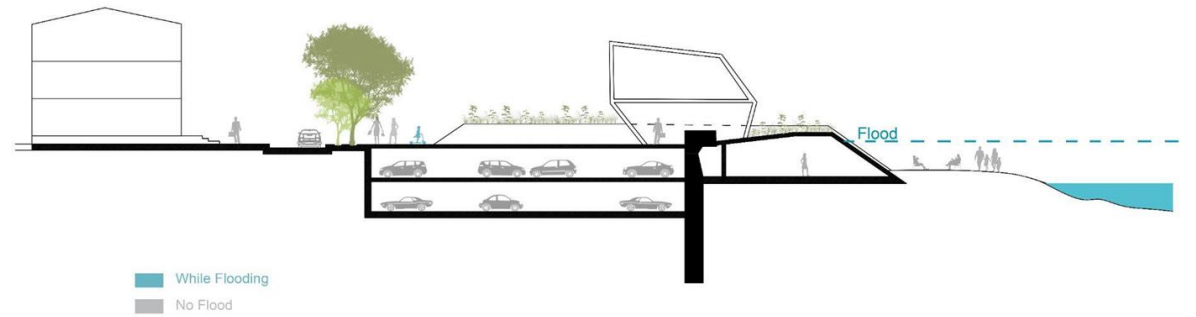


Best Building of the Year 2016 by the Royal Institute of Dutch Architects (BNA)

Royal Haskoning DHV, OKRA Landscape Architects, Municipality of Katwijk



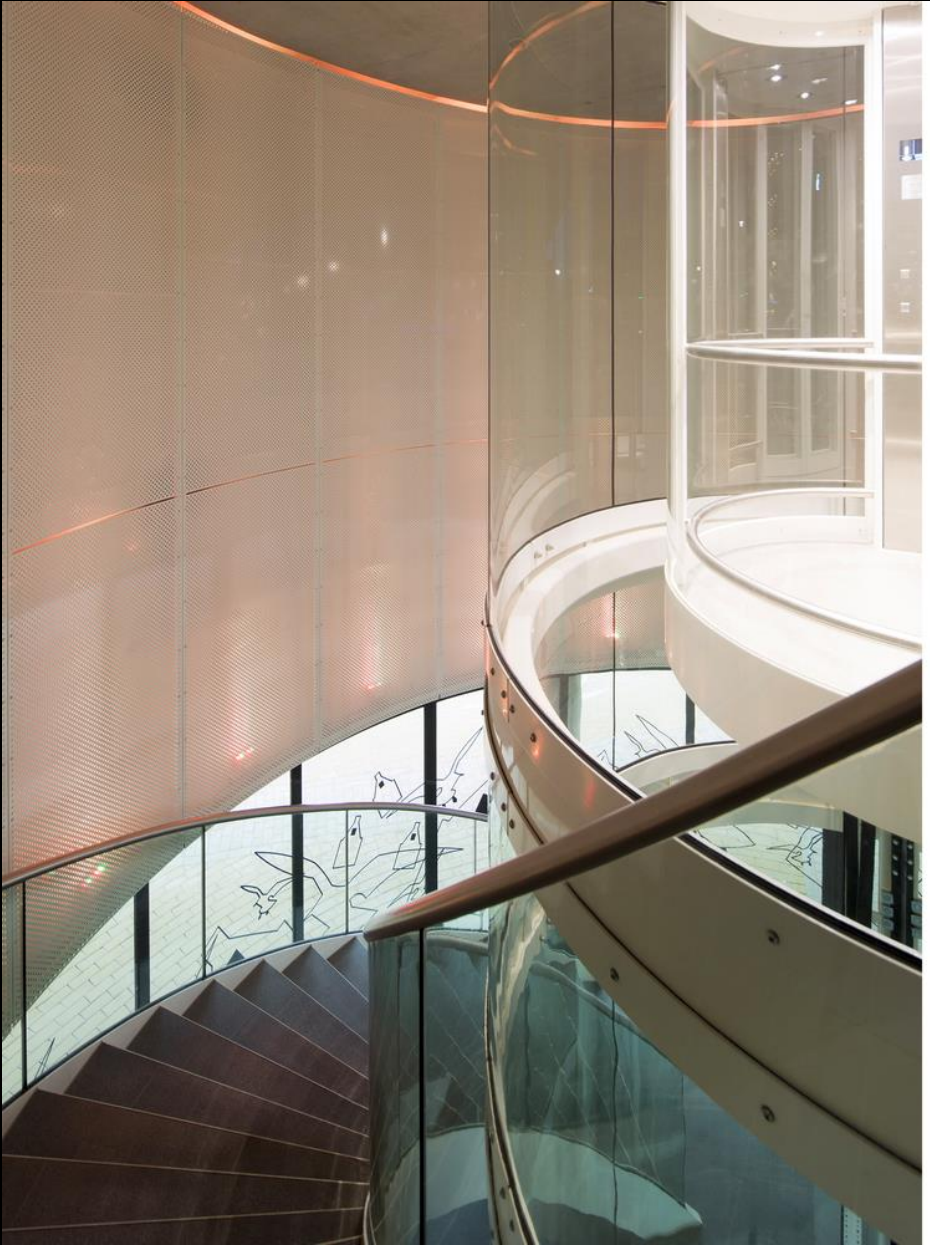




Parking Garage, Katwijk aan Zee











BOULEVARD  
ZEEZHDE

21

Informational panel with text and graphics, including a map and descriptive text.









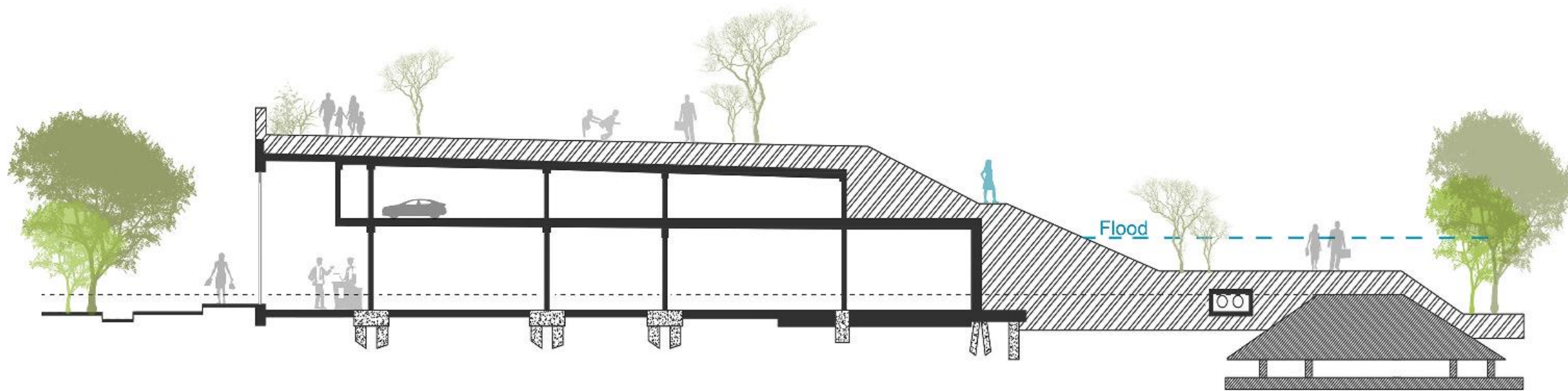






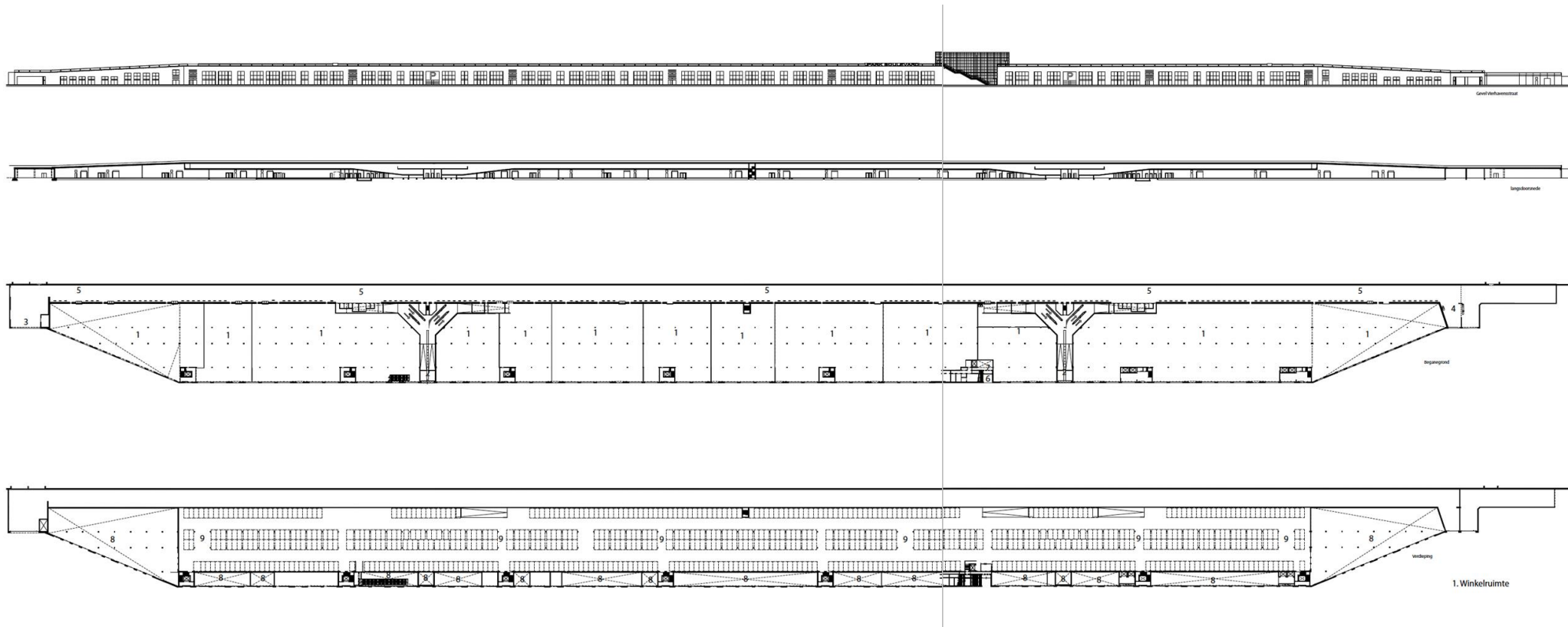
Butzelaar Van Son Architecten (building), Buro Sant and Co (Landscape), Playground (Vitibuck Architects)  
Municipality of Rotterdam, EDGE Technologies and VolkerWessels Vastgoed





While Flooding

No Flood



1. Winkelruimte
2. In/uitrit parkeergarage
3. Ingang expeditiestraat
4. Uitgang expeditiestraat
5. Expeditiestraat
6. Hoofdingang naar dakpark en oranjerie
7. Entreehal paviljoen
8. Vide
9. Parkeergarage





BRUYNZEEL KEUKENS



BRUYNZEEL KEUKENS







Dakpark, Rotterdam ("Roof Park")  
Photos: Sant en Co Landschapsarchitectuur

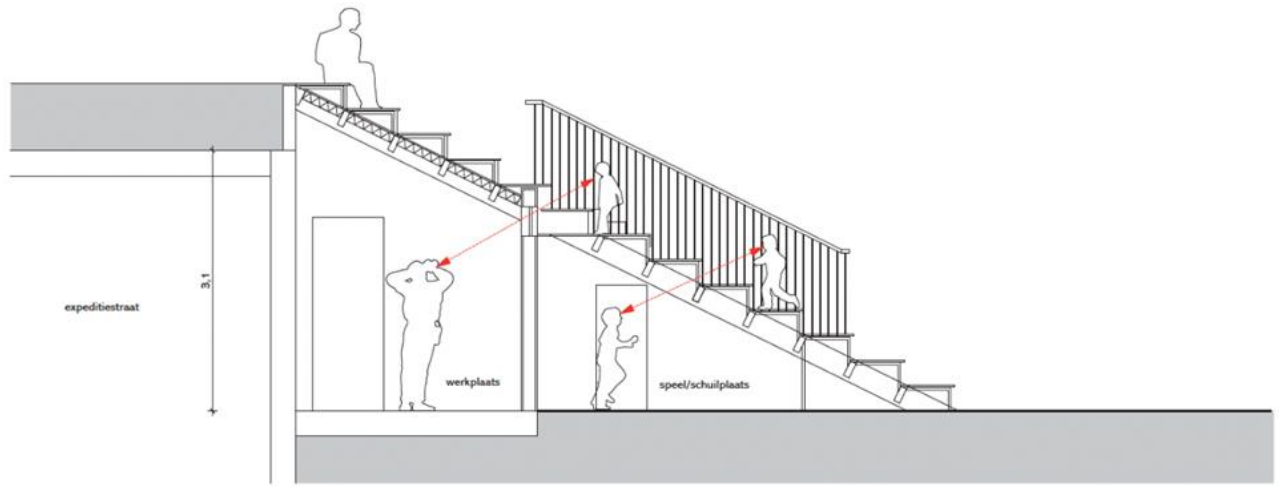




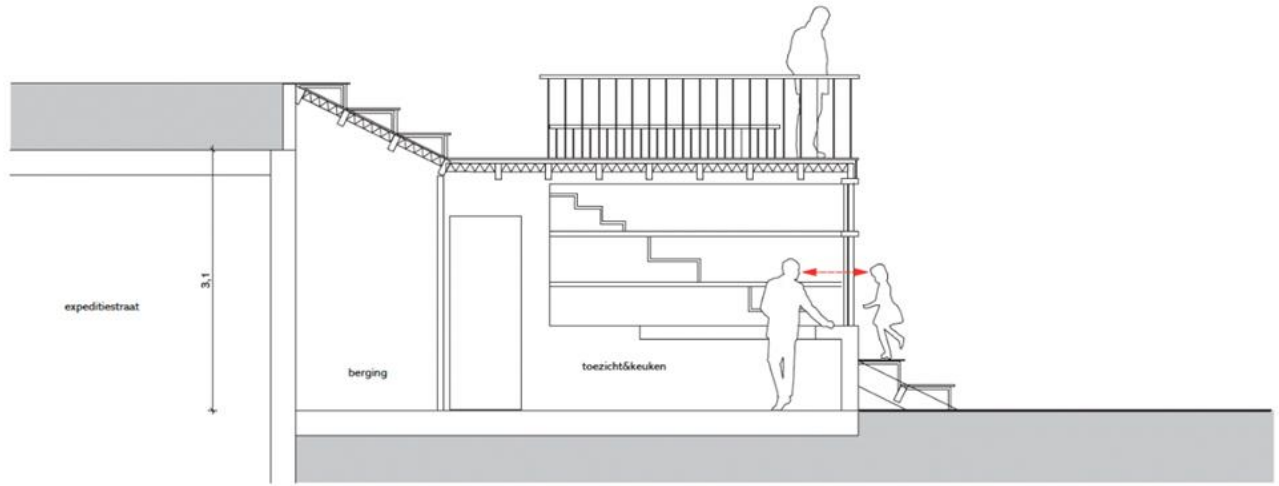




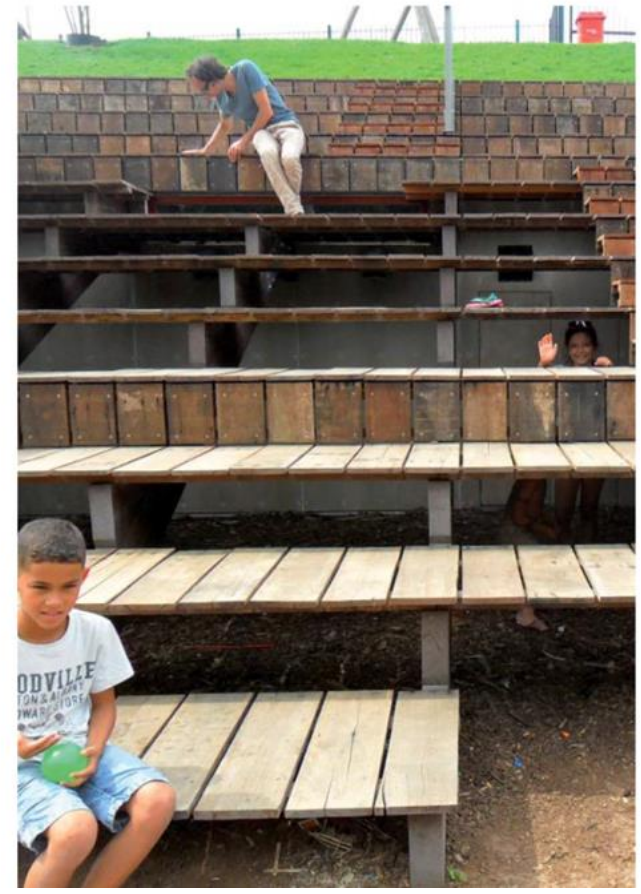




Doorsnede A



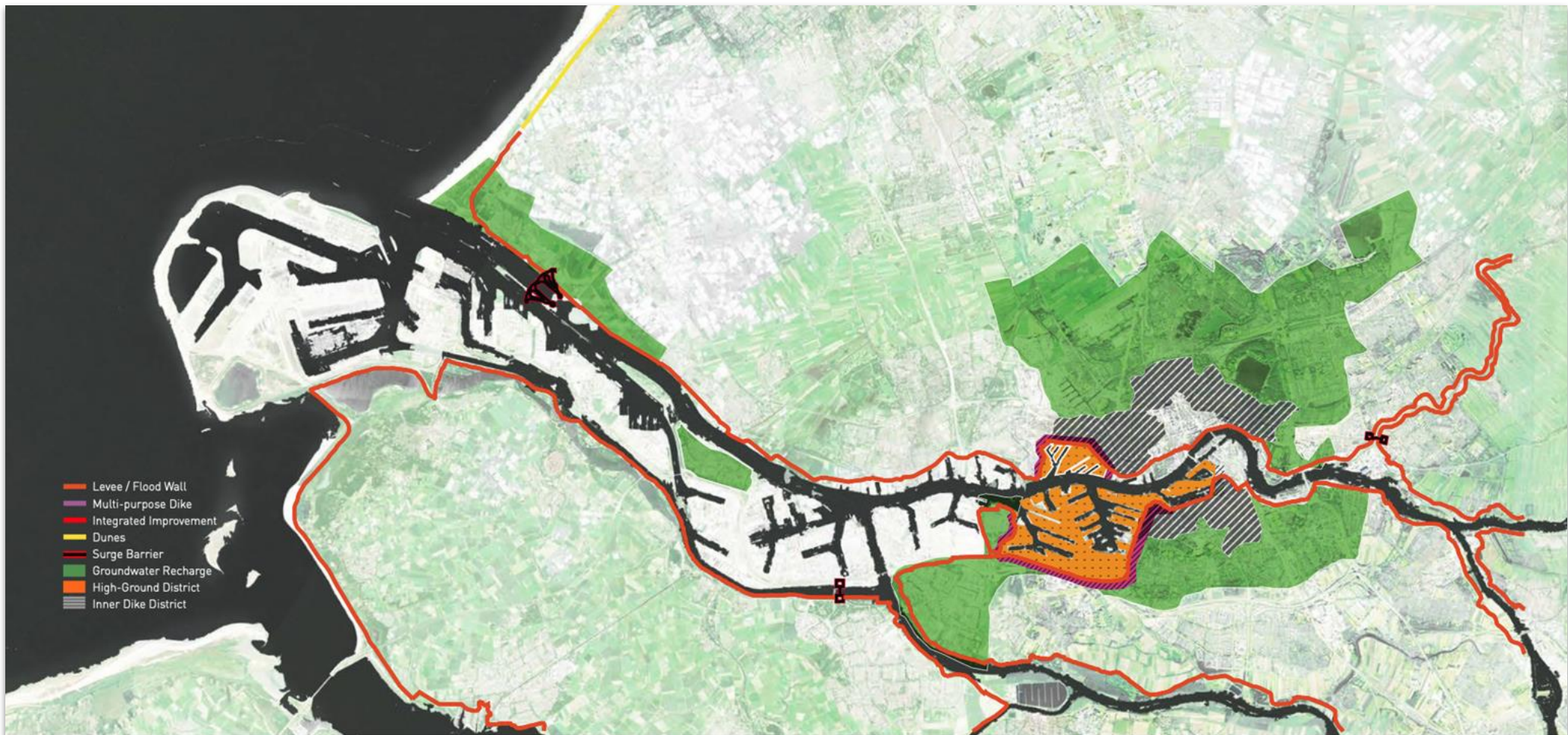
Doorsnede B





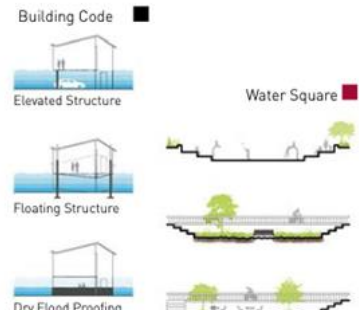
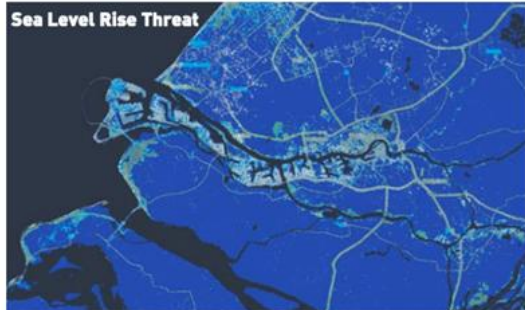




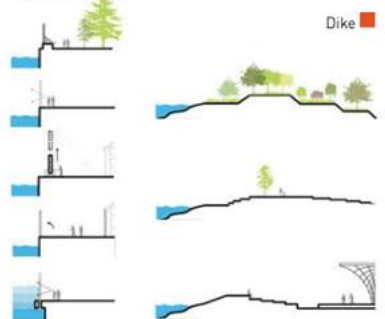


**VISION FOR 2050**

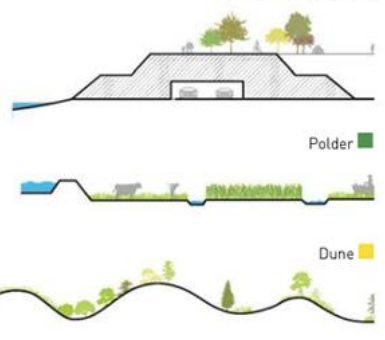
Adapted from: City of Rotterdam Rotterdam Climate Change Adaptation Strategy, 2016  
[http://www.rotterdamclimateinitiative.nl/documents/2015-en-ouder/Documenten/20121210\\_RAS\\_EN\\_lr\\_versie\\_4.pdf](http://www.rotterdamclimateinitiative.nl/documents/2015-en-ouder/Documenten/20121210_RAS_EN_lr_versie_4.pdf)



**Integrated Improvement**



**Multipurpose Dike**





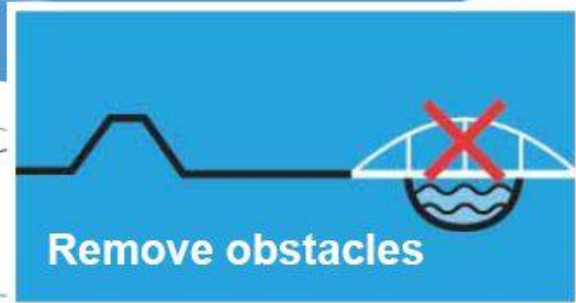
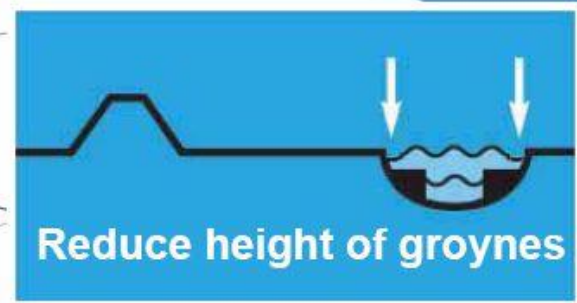
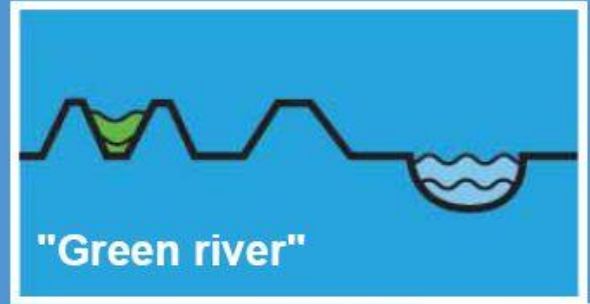
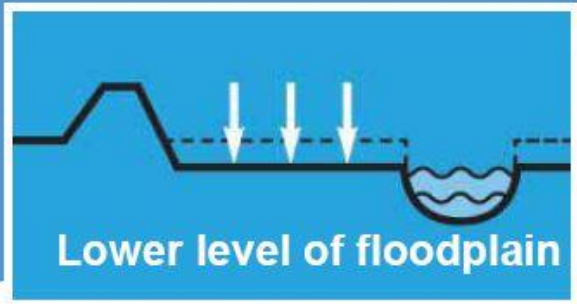
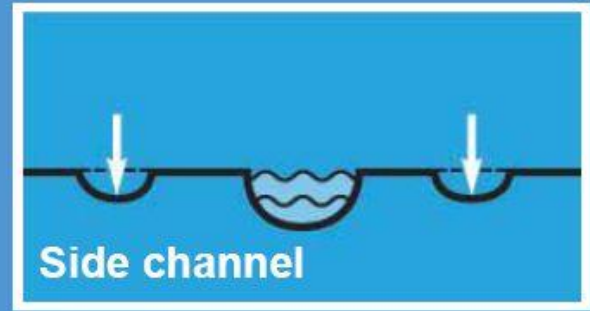
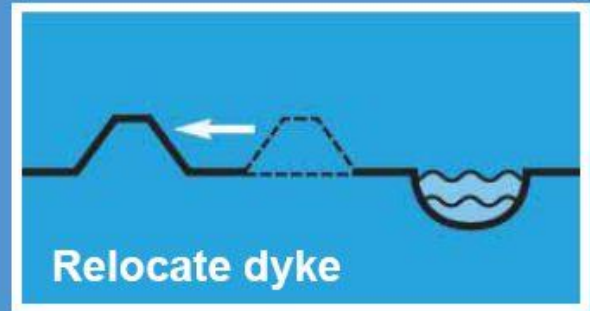


“Room for the River” project



ruimte voor de rivier

# Measures





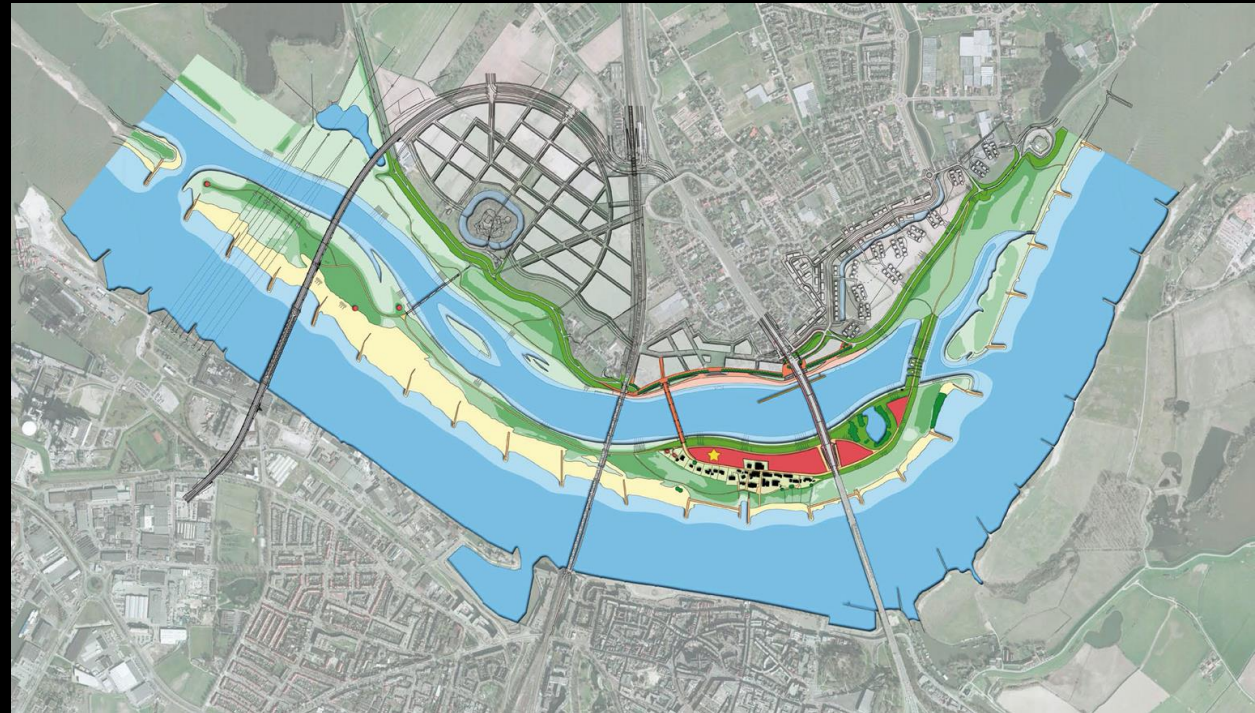
## Present situation



## Future situation



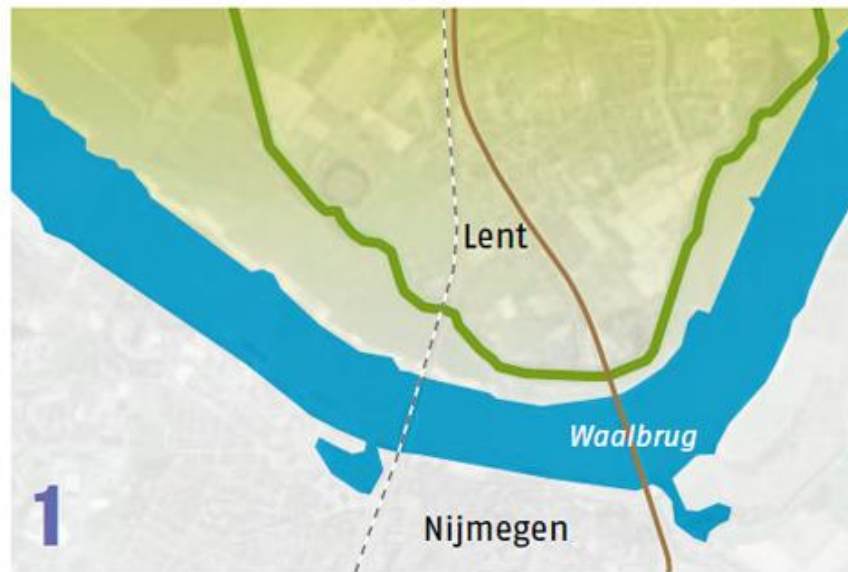




Before (Room for the River, Nijmegen)

After

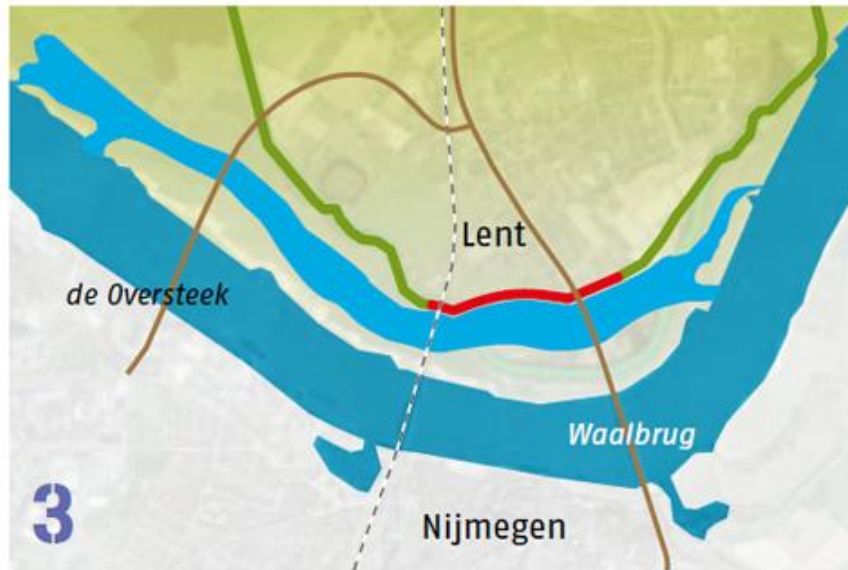




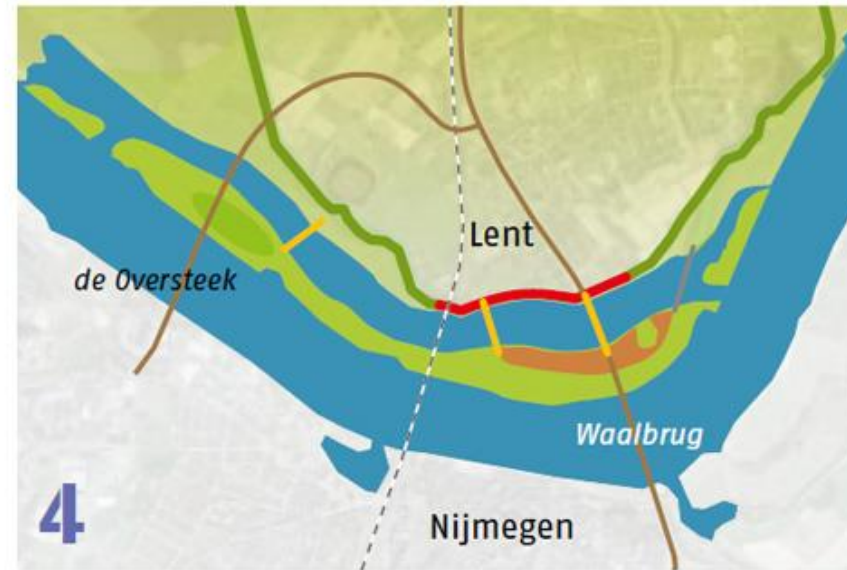
The initial situation with the existing dike.



The dike was moved 350 metres inland.



An ancillary channel is to be dug in order to give the river more room. This will create an elongated island.

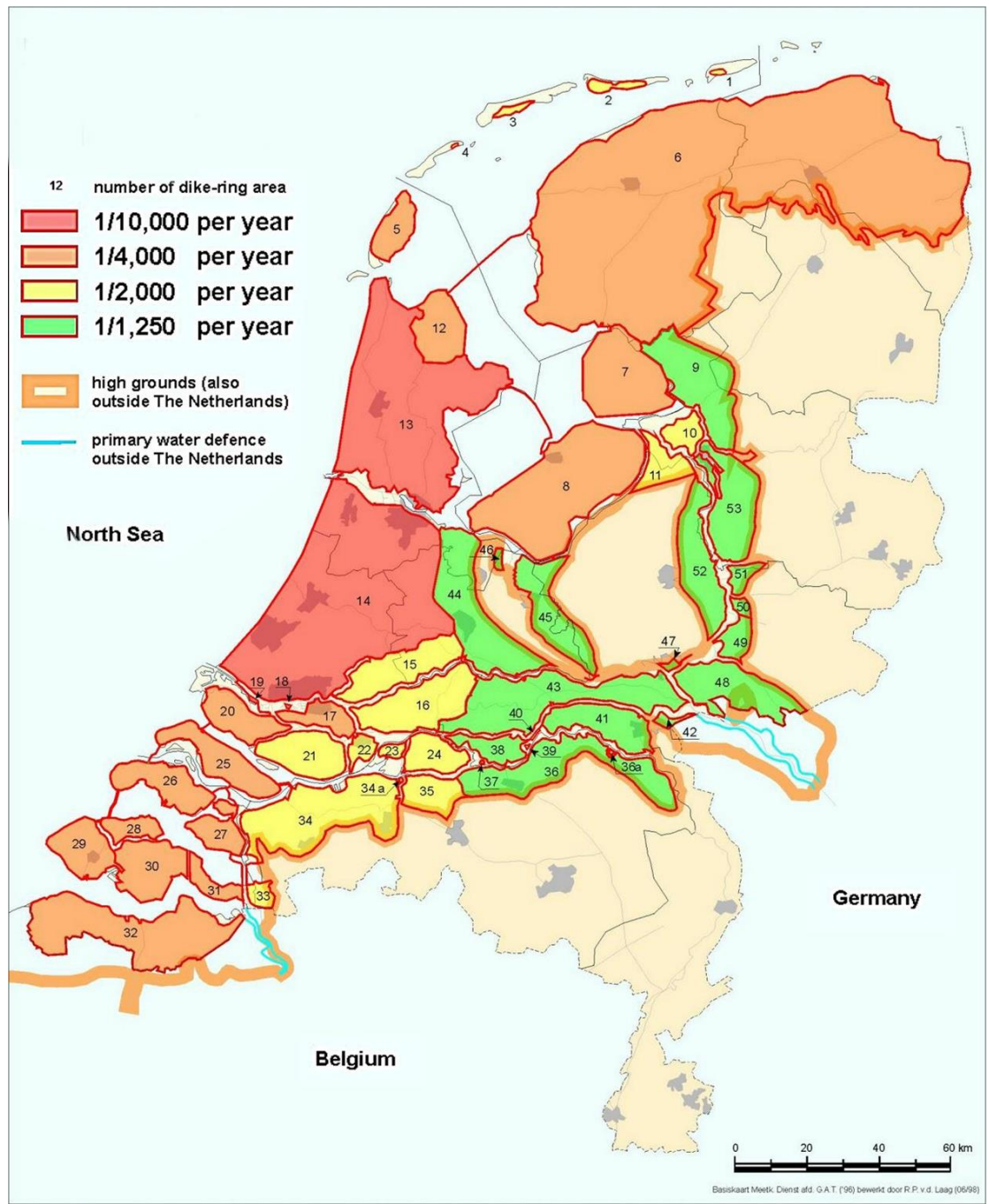


Bridges across the ancillary channel.









- 12 number of dike-ring area
- 1/10,000 per year
- 1/4,000 per year
- 1/2,000 per year
- 1/1,250 per year
- high grounds (also outside The Netherlands)
- primary water defence outside The Netherlands

North Sea

Belgium

Germany



Basiskaart Meetb. Dienst afd. G.A.T. (196) bewerkt door R.P. v.d. Laag (06/98)



## Key features

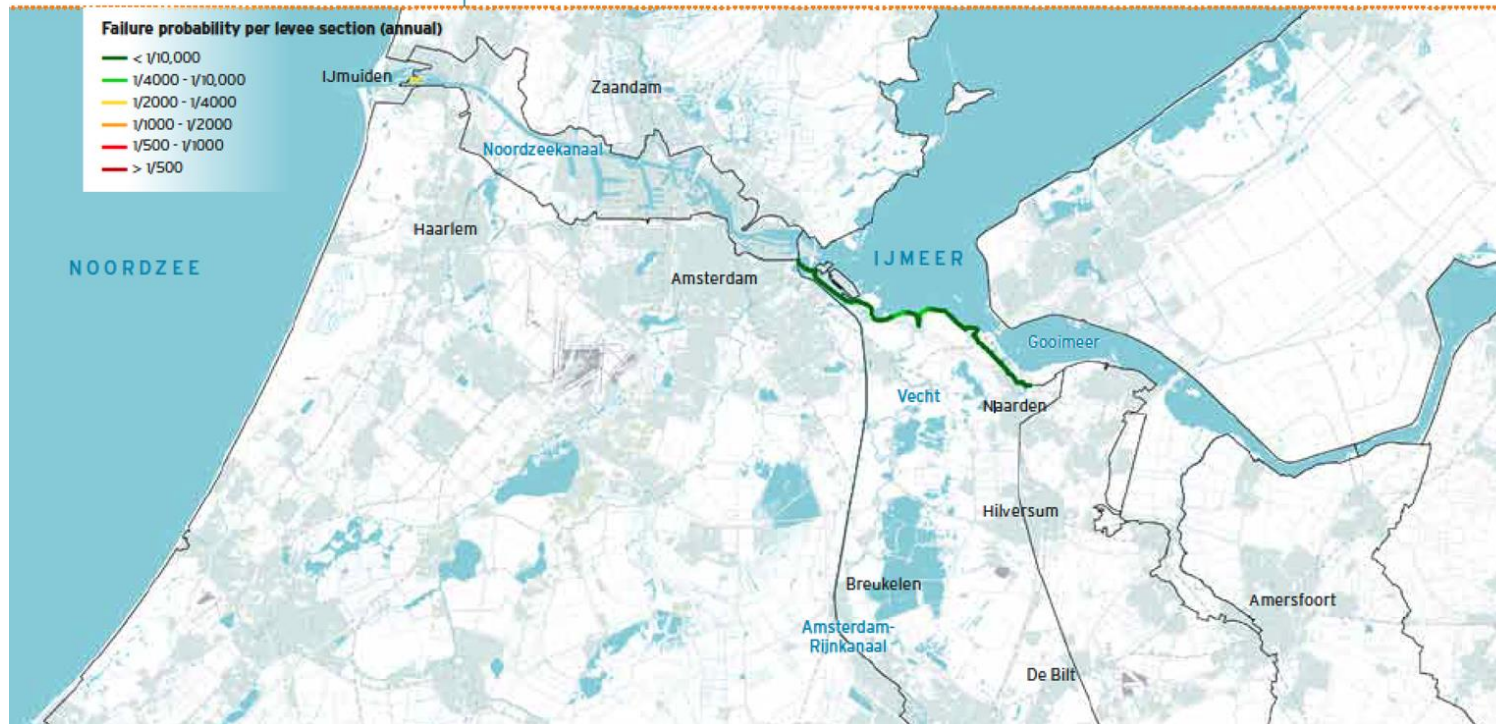
Management authority/ies	Waternet, De Stichtse Rijnlanden water authority
Length of category-A defences	56.4 km
No. of hydraulic structures	27
Surface area	63,800 ha
Population	656,300



## Flood risks

Annual probability of flooding	1/200
Annual economic risk	€ 31.0 million
Ave. losses per flood event	€ 6.3 billion
Annual loss-of-life risk	0.6
Ave. no. of fatalities per flood event	130

## Societal risk



# The Dutch Have Solutions to Rising Seas. The World Is Watching.



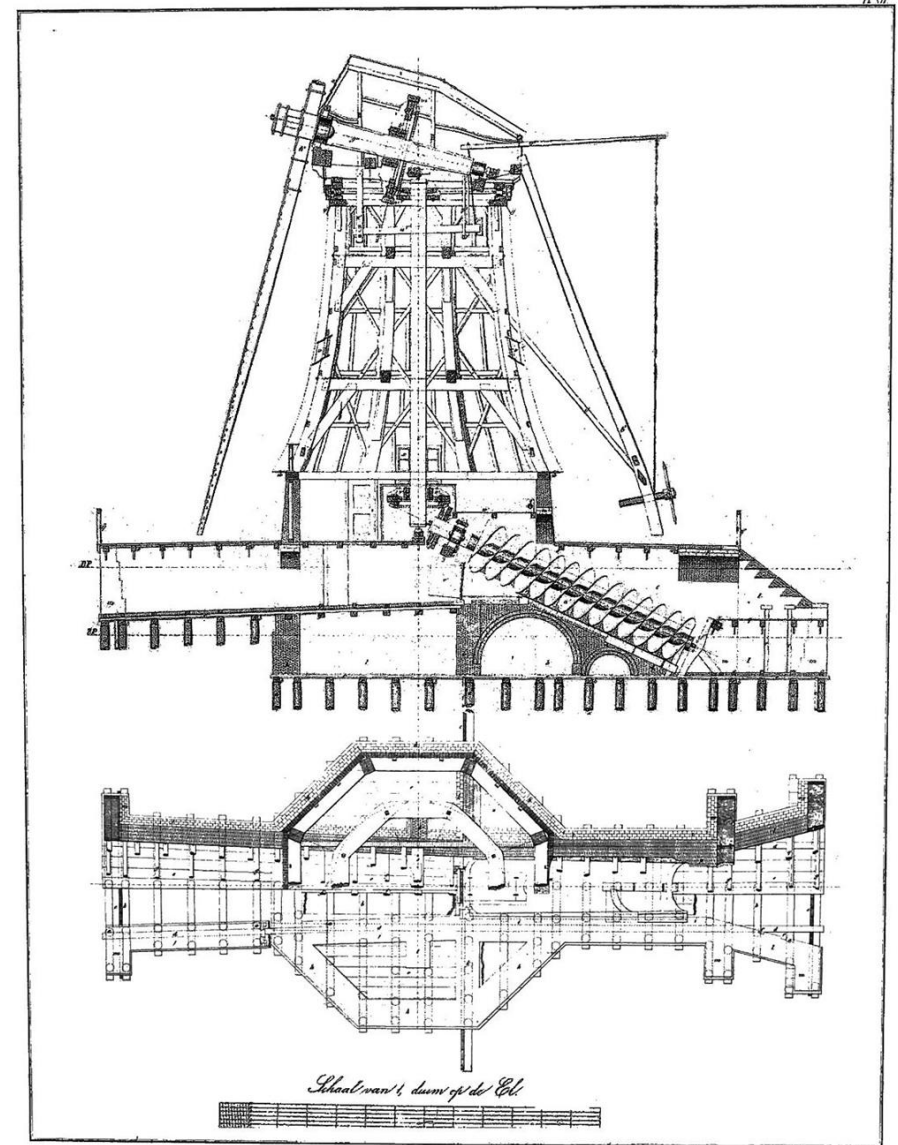
**In the waterlogged Netherlands, climate change is considered neither a hypothetical nor a drag on the economy. Instead, it's an opportunity.**

By [MICHAEL KIMMELMAN](#), Photographs by [JOSH HANER](#)





King Willem II grants privileges to Dijkgraaf "Dike Count"



Drainage windmill





Pérez Art Museum Miami, Herzog and De Meuron









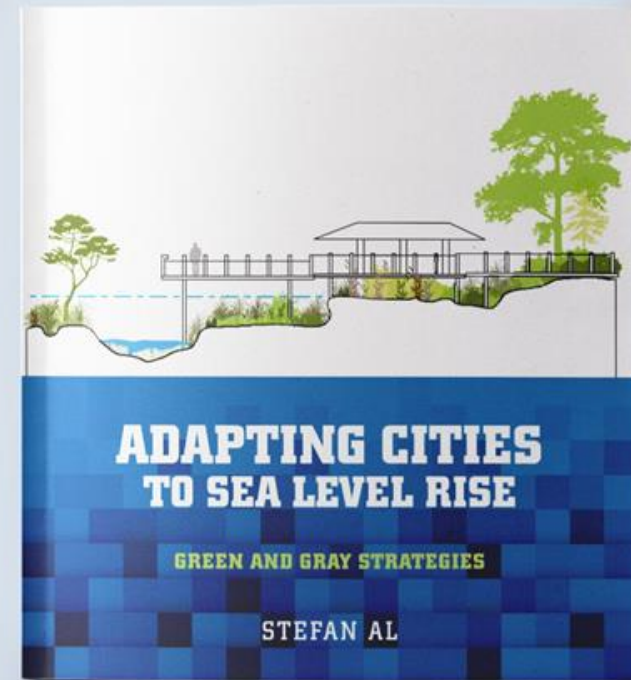
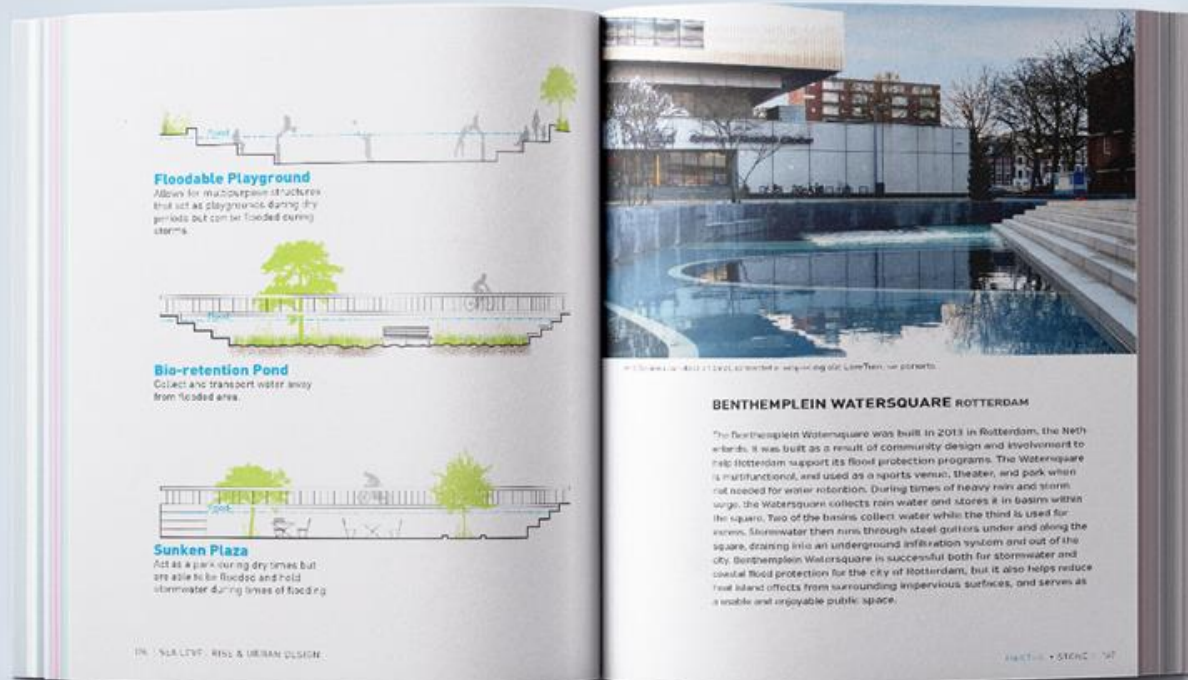




Elevated road in Sunset Harbor, Miami Beach



# Improving Coastal Resilience: Design-driven Adaptation Strategies



Stefan Al, PhD RA LEED  
Email: [stefan@stefanal.com](mailto:stefan@stefanal.com)



*Innovation in Coastal & Watershed Resilience for Urban Centers*

*Engineered and Nature Based Solutions at Scale*

*Edgar Westerhof, February 6, 2024*





# Agenda

1. Global Best Practices, Lessons Learned & Innovations in Flood Protection
  - a) A Systems Approach to Flood Control
  - b) Integrated, Multifunctional and Watershed Scale Strategies
2. US National Case Study: Houston, New York City
3. Conclusions



1



2



## CONNECTING THE PUBLIC & PRIVATE REALM

3

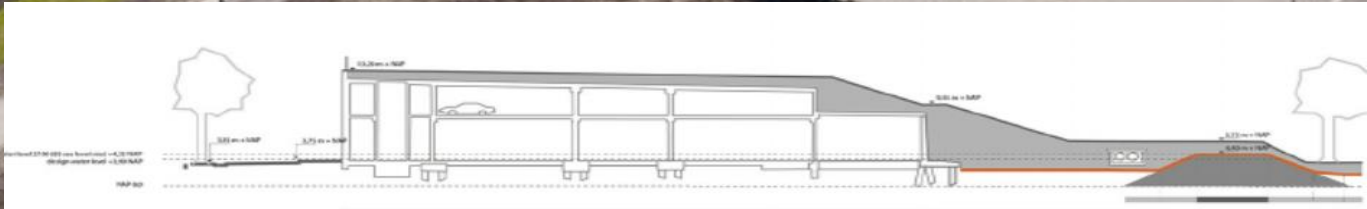


4





# Multi-functional urban flood protection, Rotterdam Roofpark Urban Dike





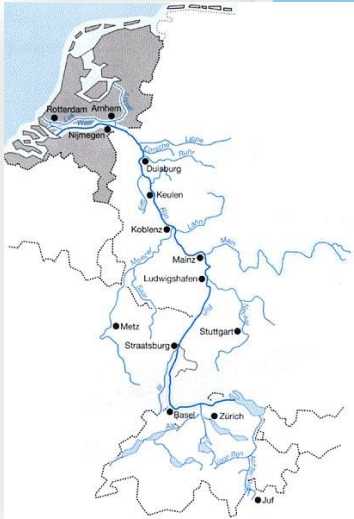
# Room for the River – Managed Overflow of River Floodplain



Source Rijkswaterstaat



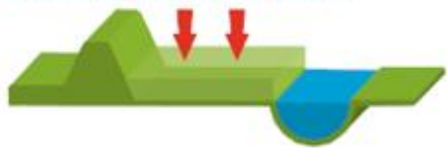
# Room for the River – Managed Overflow of River Floodplain



Source Rijkswaterstaat

- Launched in the Netherlands after 1993 and 1995 river floods, forcing evacuation of 250,000 people
- Extreme river discharges become more frequent, higher dikes alone not enough
- Multifunctional River widening as an opportunity to add spatial quality and allow for urban development and public / private funding
- RvR Project Office: combining National, Regional and Local authorities in 1 organisation

## Lowering of floodplains



Lowering (excavating) an area of the floodplain increases the room for the river at high water levels.

## Dike relocation



Relocating a dike land inwards increases the width of the floodplains and provides more room for the river.

## High-water channel



A high-water channel is a diked area that branches off from the main river to discharge some of the water via a separate route.

## Strengthening dikes



Dikes are strengthened in areas in which creating more room for the river is not an option.



# Room for the River Nijmegen - Lent



- National authority invested 350 million Euro's in a blue green bypass of the River Waal.
- Based upon reducing flood risk and to avoid future socio-economic losses.
- Nijmegen city used took this momentum to fulfill city's ambition; the river being in the center of its city.
- Investment: national taxes, based upon macroeconomics.





## **Water Storage and...**

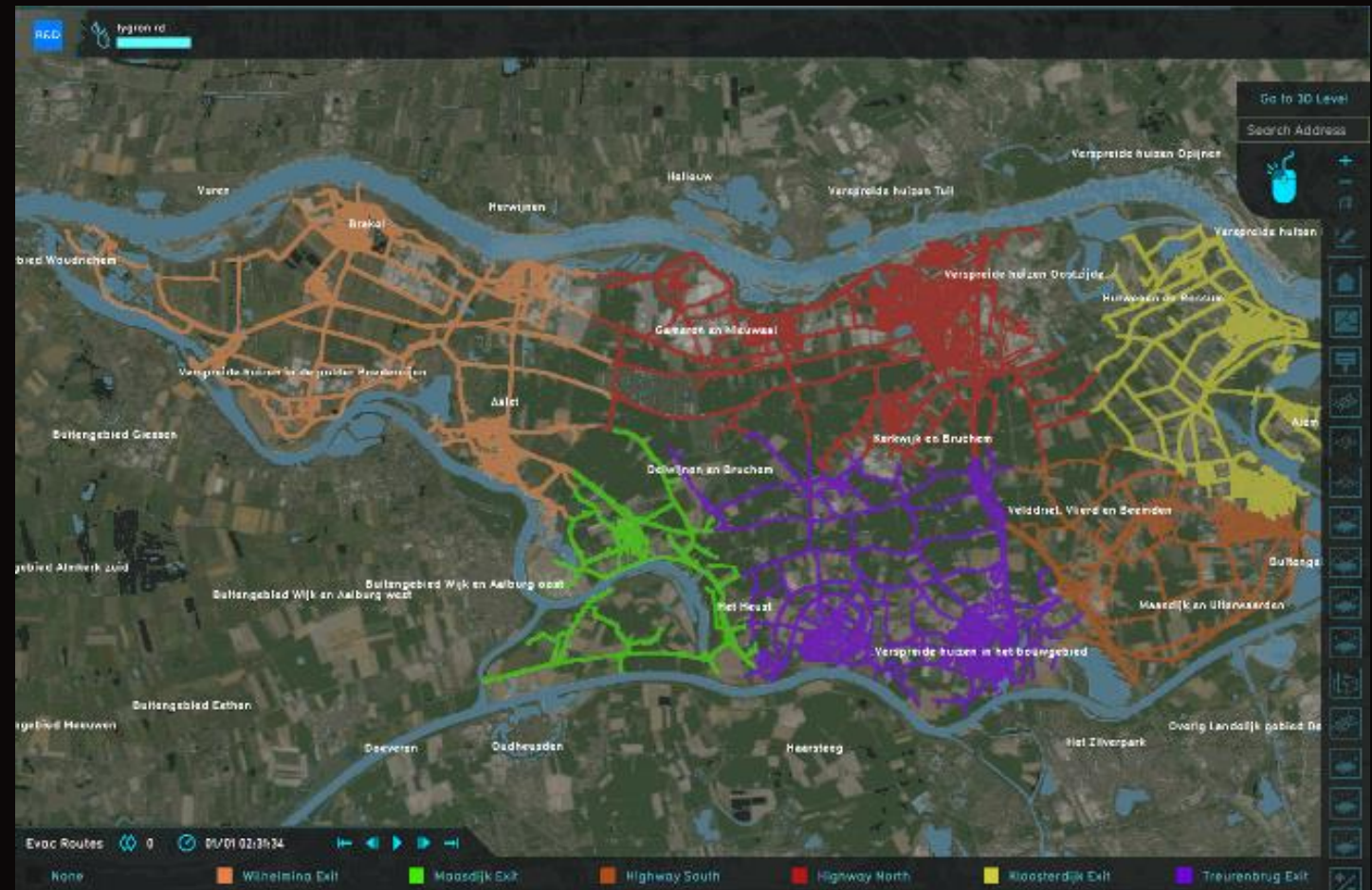
- **Residential areas**
- **Ecological corridors**
- **Attractive public area**
- **Recreation / sport facilities**
- **...**



# Analytic Capabilities

The Tygron digital twin hydro-software can handle additional layers, such as those listed below. The video shows a demonstration of the road access functionality in the Netherlands.

- Damage and casualties
- Evacuation
  - Accessibility
  - Evacuation time
- Cascade effects during flood events
  - Road access
  - Electricity and communications



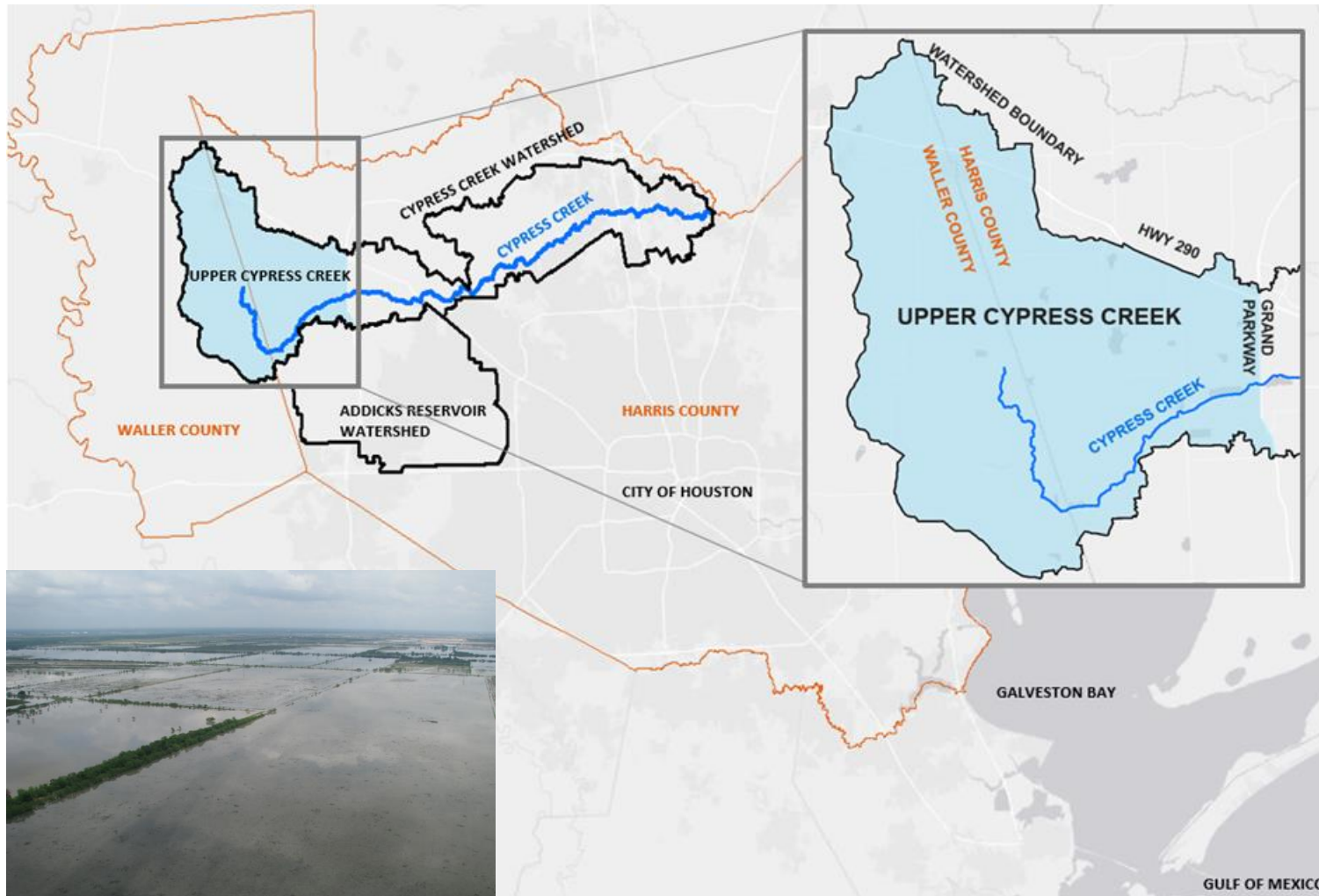


# Houston Post-Harvey Upper Cypress Creek / Addicks Reservoir Shallow Storage Areas





# Project Goals



Evaluate feasibility of shallow storage areas

Reduce overflow to Addicks reservoir

Reduce peak flow rates to Middle Cypress Creek

Compare to Plan 3 / Plan 5 reservoirs (\$650M)

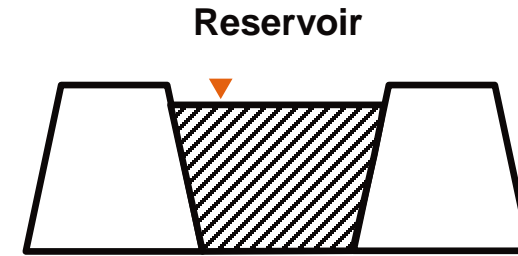
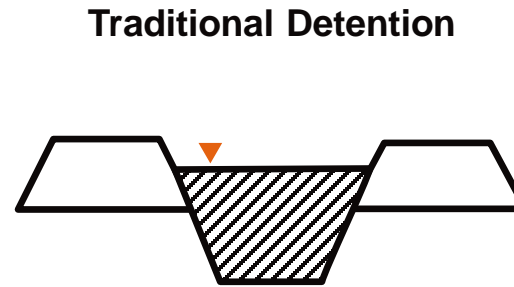
Feasibility only, not implementation

Hybrid approach with regional retention



# Flood Risk Management Techniques

Through Permanent Retention and Temporary Detention



**Maintain Site Function  
Avoid Dam Jurisdiction**

**Assets Outside of Berm**

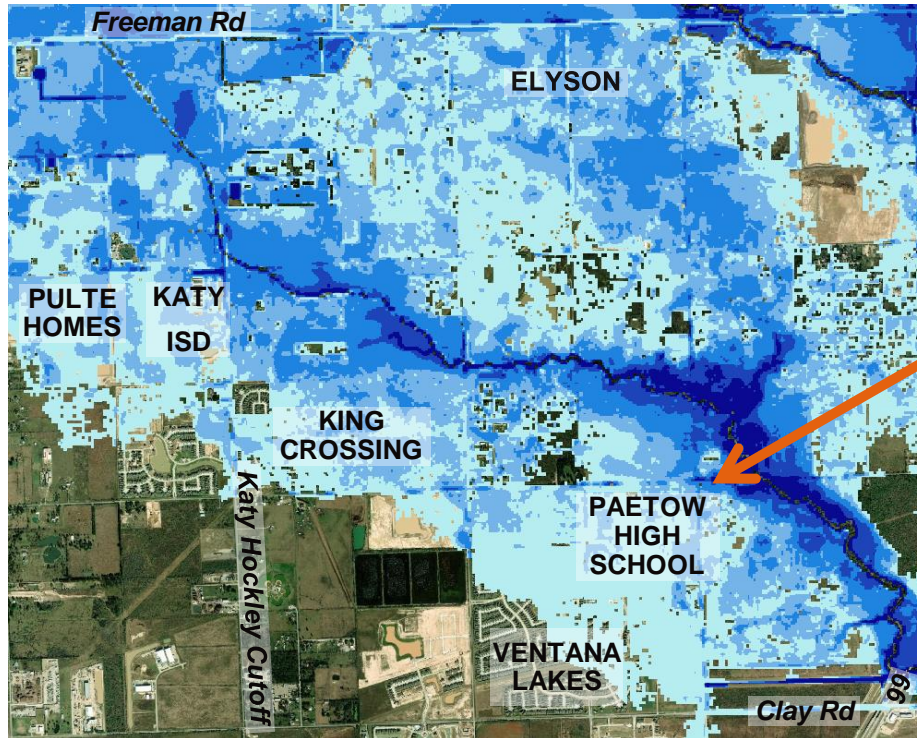




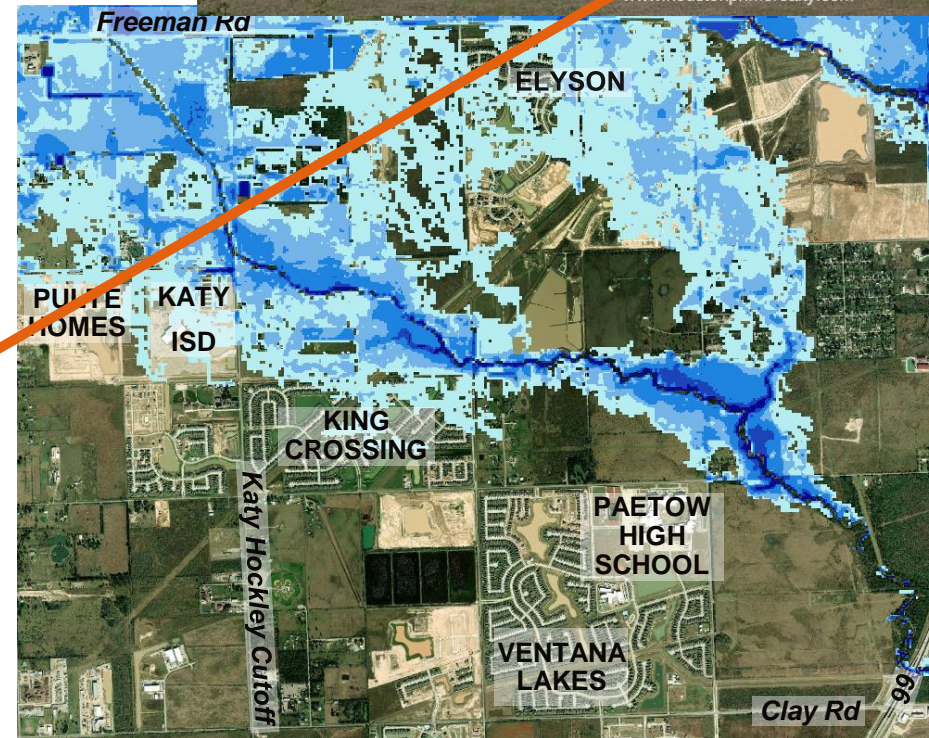
# 100-Year Property Benefits



## 100-Year Overflow



Existing performance



Performance with shallow storage



5 - Day Simulation Volume

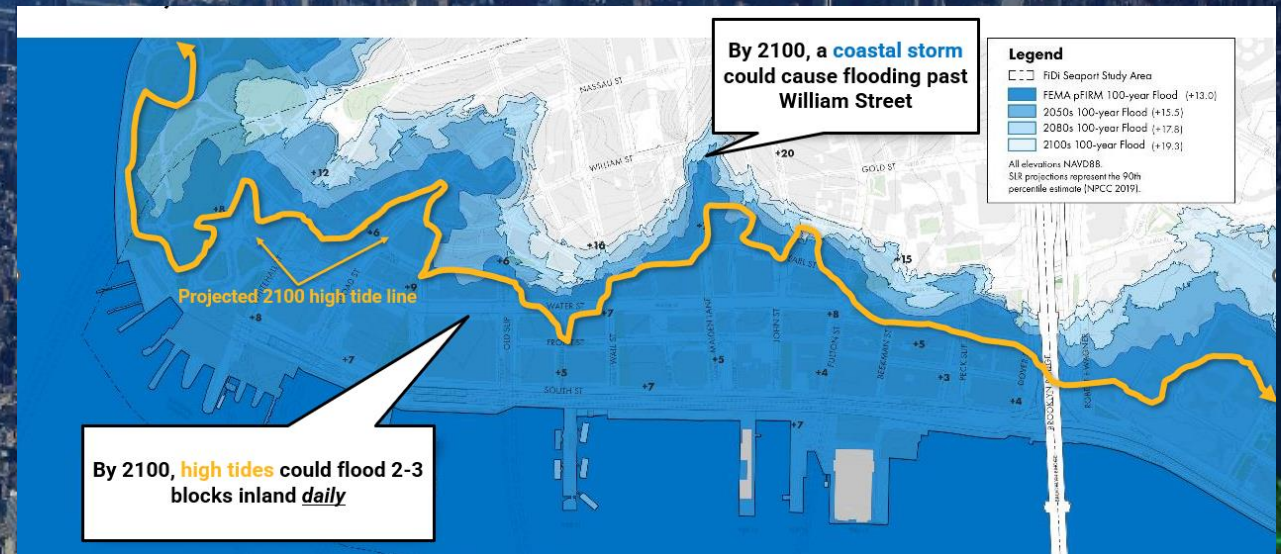


# Manhattan's BIG U Flood Protection Plan





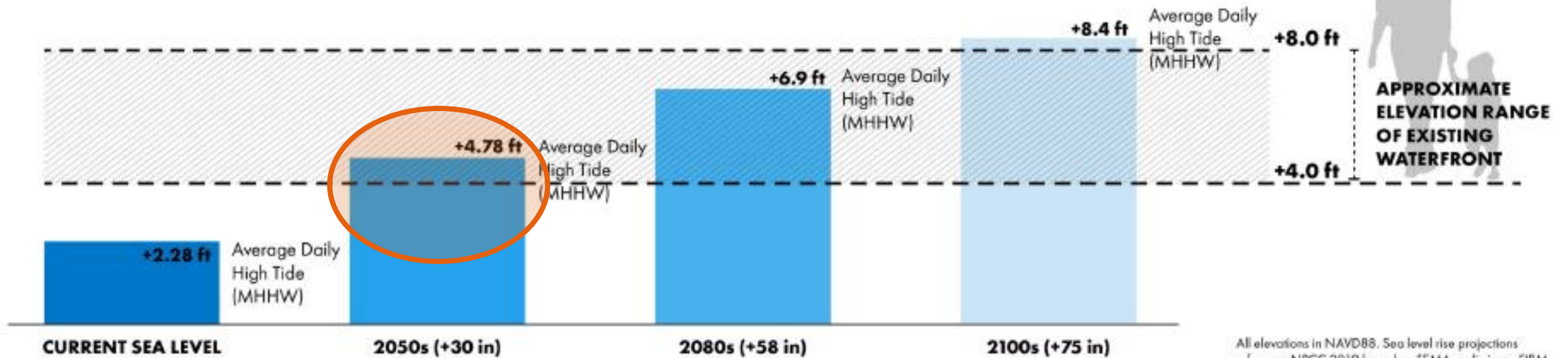
**Two types of climate risks** - daily tidal flooding and coastal storms, Financial District, Manhattan.





# Sea Level Rise & High Tide

High tide flooding is anticipated to cause up to four feet of flooding by the 2100s, the same height as the storm surge from Hurricane Sandy in this area.



Rockaways  
Bronx  
Coney Island  
Newton Creek  
Jamaica Bay etc.

All elevations in NAVD88. Sea level rise projections reference NPCC 2019 based on FEMA preliminary FIRM data. MHHW is based off of the 2001 NOAA National Tidal Datum Epoch (NTDE). Additional modeling / wave studies to be completed later in Phase II.



# East Side Coastal Resilience – Concept to Realization





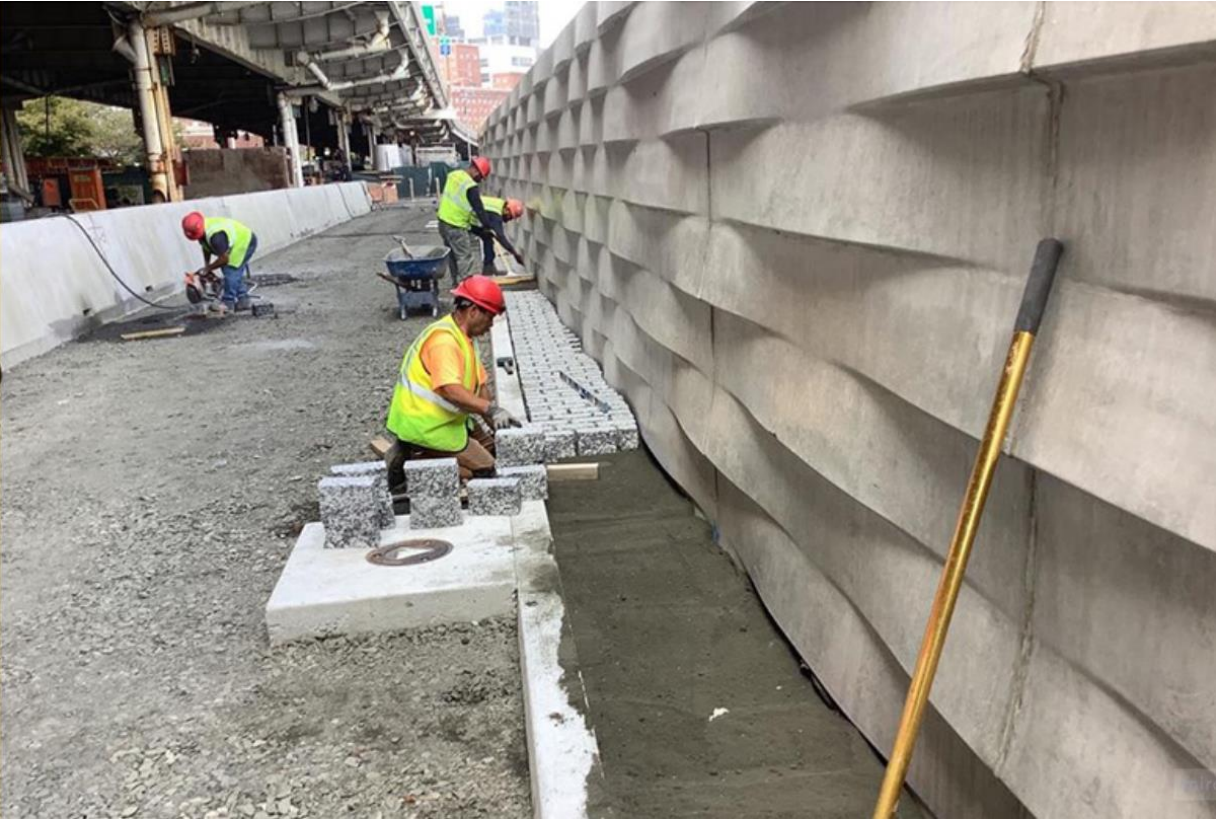
# INSTALLATION OF NORTHERN CLOSURE GATE



Source: NYC DDC



# WALL ALIGNMENT AND NEW PARK AT EAST 23<sup>RD</sup> STREET





# UN WATER CONFERENCE - DUTCH ROYAL HIGHNESS VISITS ESCR







# Financial District and Seaport Climate Resilience Master Plan

**NYC/EDC**

**NYC**

Mayor's Office of Climate &  
Environmental Justice

**ARCADIS**

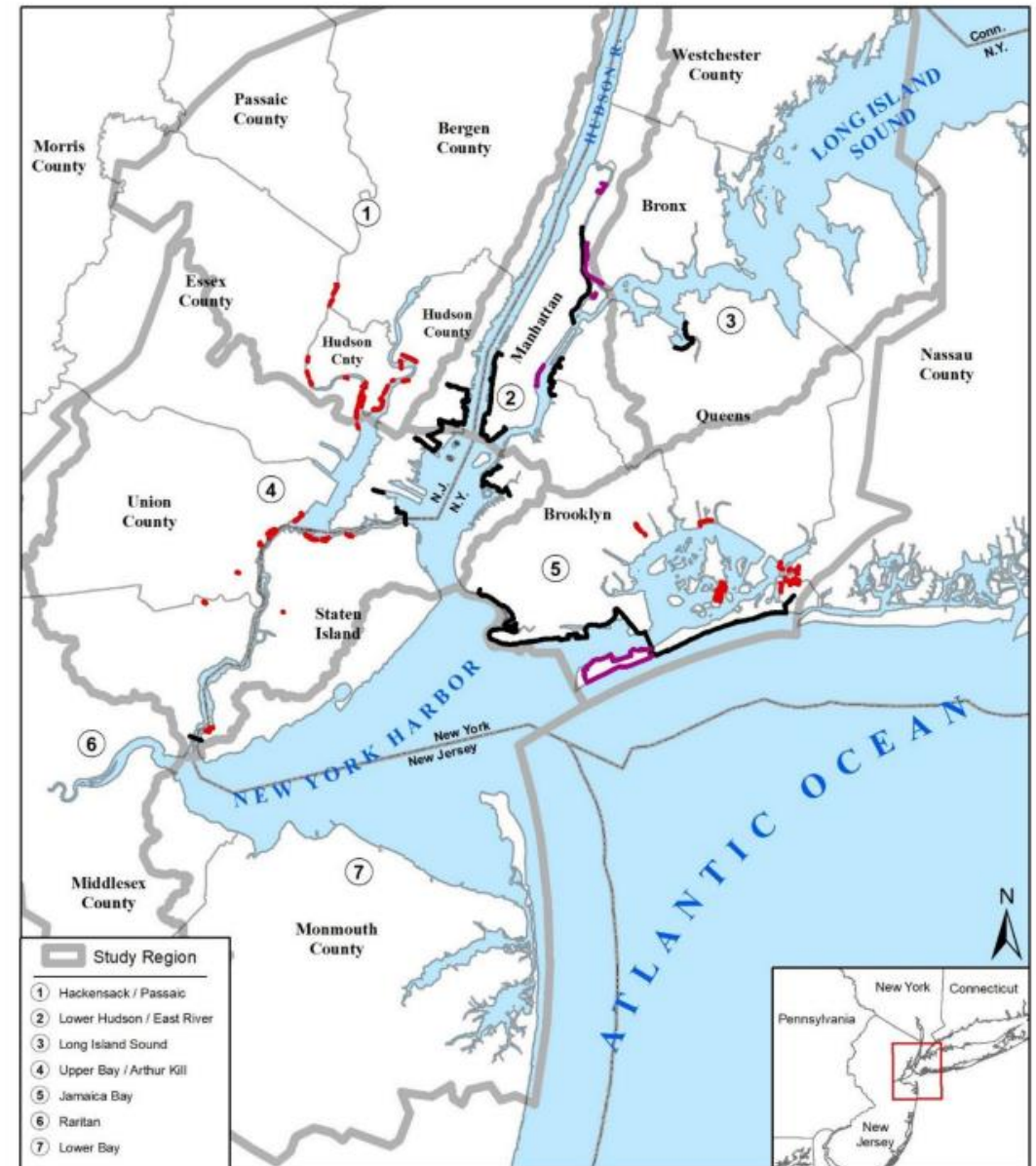




US Army Corps  
of Engineers®

# NY District HATS Observations

- Plan components show high level of integration with existing / planned strategies, a systems approach that gives the study regional potential.
- Coastal protection through shore based and off shore barrier solutions aiming to protect long waterfront stretches of exposed communities.
- The evaluation of applying storm surge barriers has matured.
- The work does not stop if “3B” were to be implemented, what plan components from other strategies may apply over time?
- Drainage outfall and backflow issues, causing severe high tide inundation of low lying communities?
- What is the plan for waterfront communities who currently don't and may not get have a plan, what will the process of retreat look like?







US Army Corps  
of Engineers®







STORM SURGE  
BARRIER LOCATION

Risk Reduction  
Features BEHIND the  
Storm Surge Barriers

Induced Flooding-  
Mitigation Features (as  
applicable) OUTSIDE the  
Storm Surge Barriers

Legend

-  Navigable Passage
-  Auxiliary Flow Gates
-  Dam Section and Tie-in
-  Flood Risk Reduction System (Land Based Measures)

Concept for the Jamaica Bay Storm Surge Barrier - Artist Photo Visualization

This is an artist interpretation of the conceptual design for the Jamaica Bay Storm Surge Barrier. The storm surge barrier configuration shall not be considered a final recommendation or as a requirement for actual design for implementation.







## Summarizing Conclusions

- Urban resilience is now about preparing for the extreme and avoiding loss of life
- Take an (upstream) watershed approach in understanding risk and perform scenario-based stress tests, including tributaries
- Coordinate data analytics and organize consensus
- Prioritize resilience for critical assets, as you plan for the long term - design your process and focus on equity & inclusion
- Future proof and sustainable flood protection plans are multi-functional, adaptive and the result of a participatory planning process
- Find ways to expedite procedures!



# Arcadis

Accelerating a Planet Positive Future



## EDGAR WESTERHOF

Vice President - North America Climate Adaptation  
Solution Lead

- o 718 397 2386
- e [edgar.westerhof@arcadis.com](mailto:edgar.westerhof@arcadis.com)





# Climate Considerations

Navigating environmental challenges is critical for responsible and sustainable financing in the Caribbean. Awareness and proactive management of these issues are essential to ensure the long-term success of financed projects.





# Initiatives to Foster Sustainable Financing in the Caribbean

CIBC Caribbean effectively manages environmental risks, promotes sustainable development, and contributes positively to the economic and ecological well-being of the Caribbean region by implementing these strategies.

**Enhanced Risk Assessment and Management**



**Regulatory Compliance and Collaboration**



**Support for Sustainable Practices**



**Capacity Building**



**Knowledge Sharing**



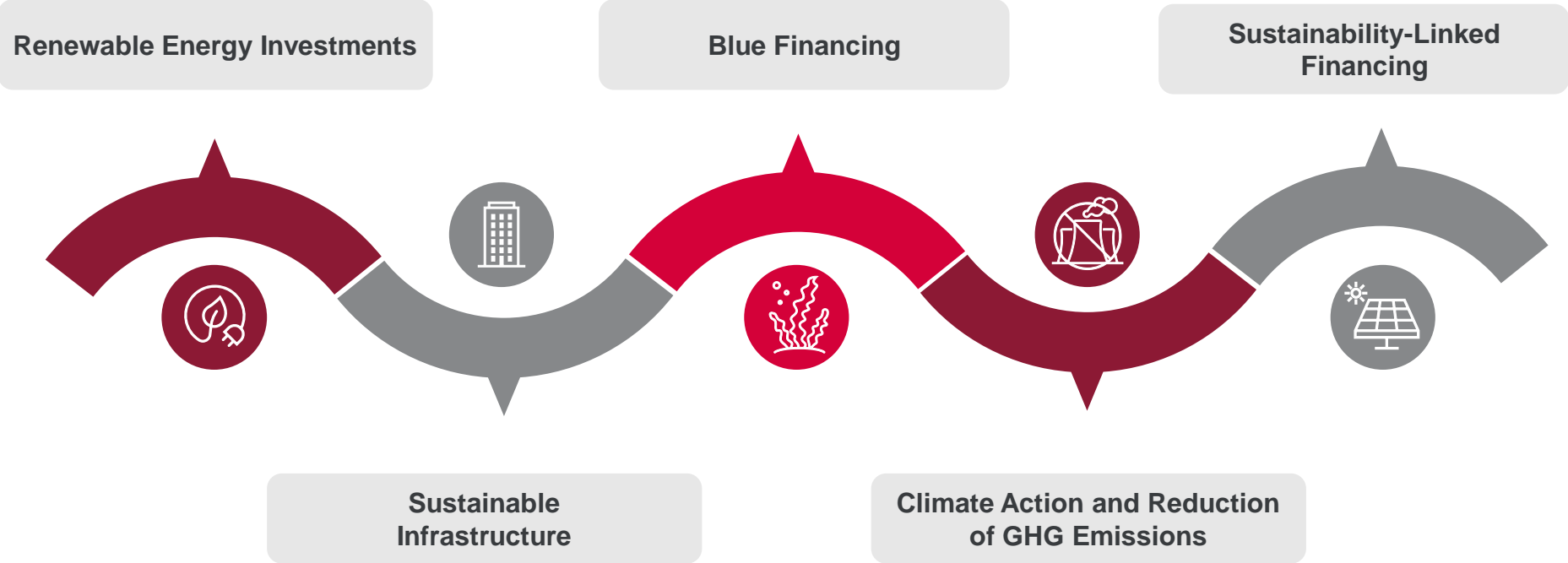
**Sustainable Investment Criteria**





# Our Commitment to Sustainable Financing

CIBC Caribbean champions environmental stewardship and sustainable growth in the Caribbean by prioritizing green investments and initiatives that reduce environmental impact.





# Q&A

Submit questions through the  
Zoom Q&A function

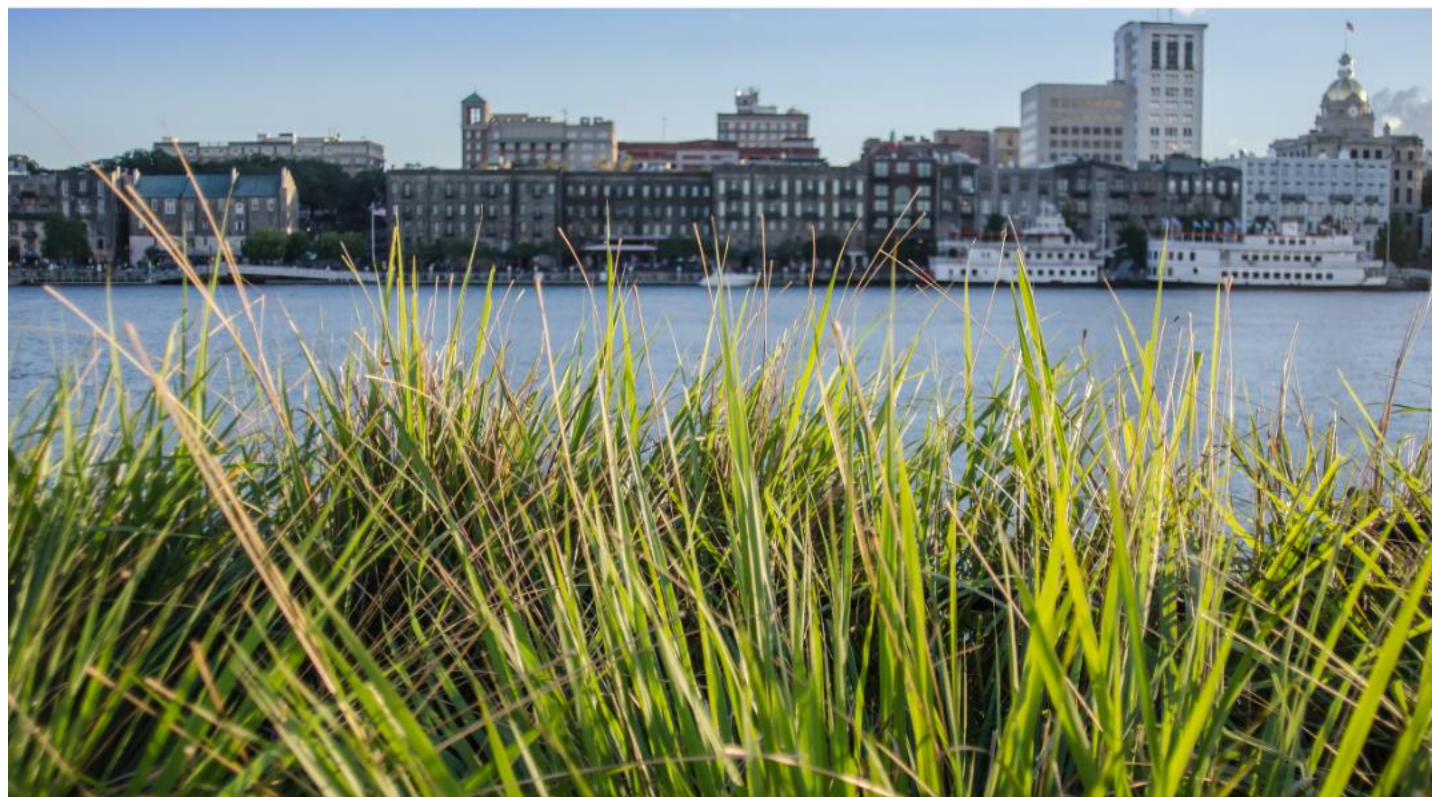




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# SOUTHEASTERN

COASTAL DEVELOPMENT FORUM • MAY 13-14



## SAVE THE DATE

**SOUTHEASTERN COASTAL DEVELOPMENT FORUM**  
MAY 13-14, 2024 | PERRY LANE HOTEL | SAVANNAH, GA





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You can reach us at [resilience@uli.org](mailto:resilience@uli.org).