Coastal Flood Resilience Design Guidelines & Zoning Overlay District

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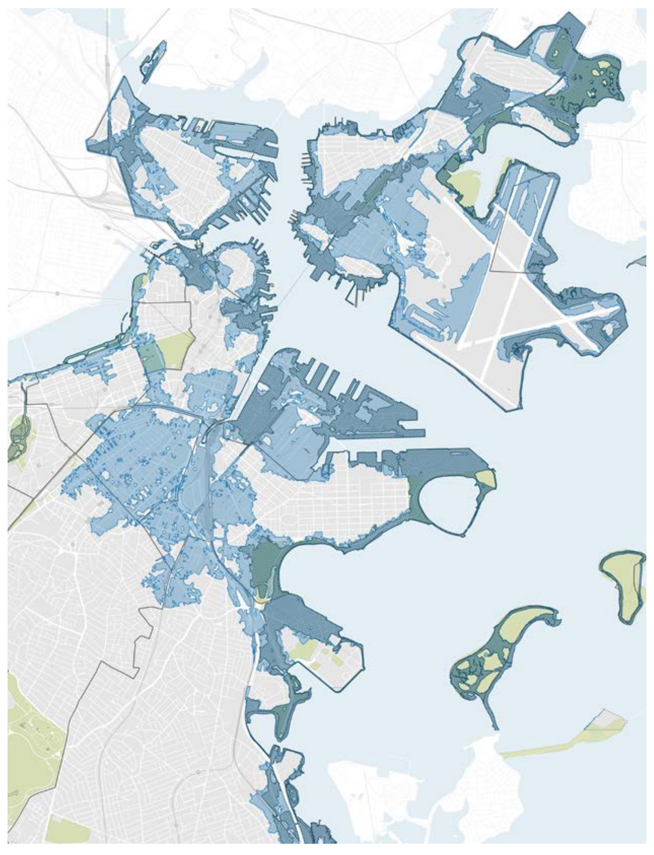
Boston, Massachusetts

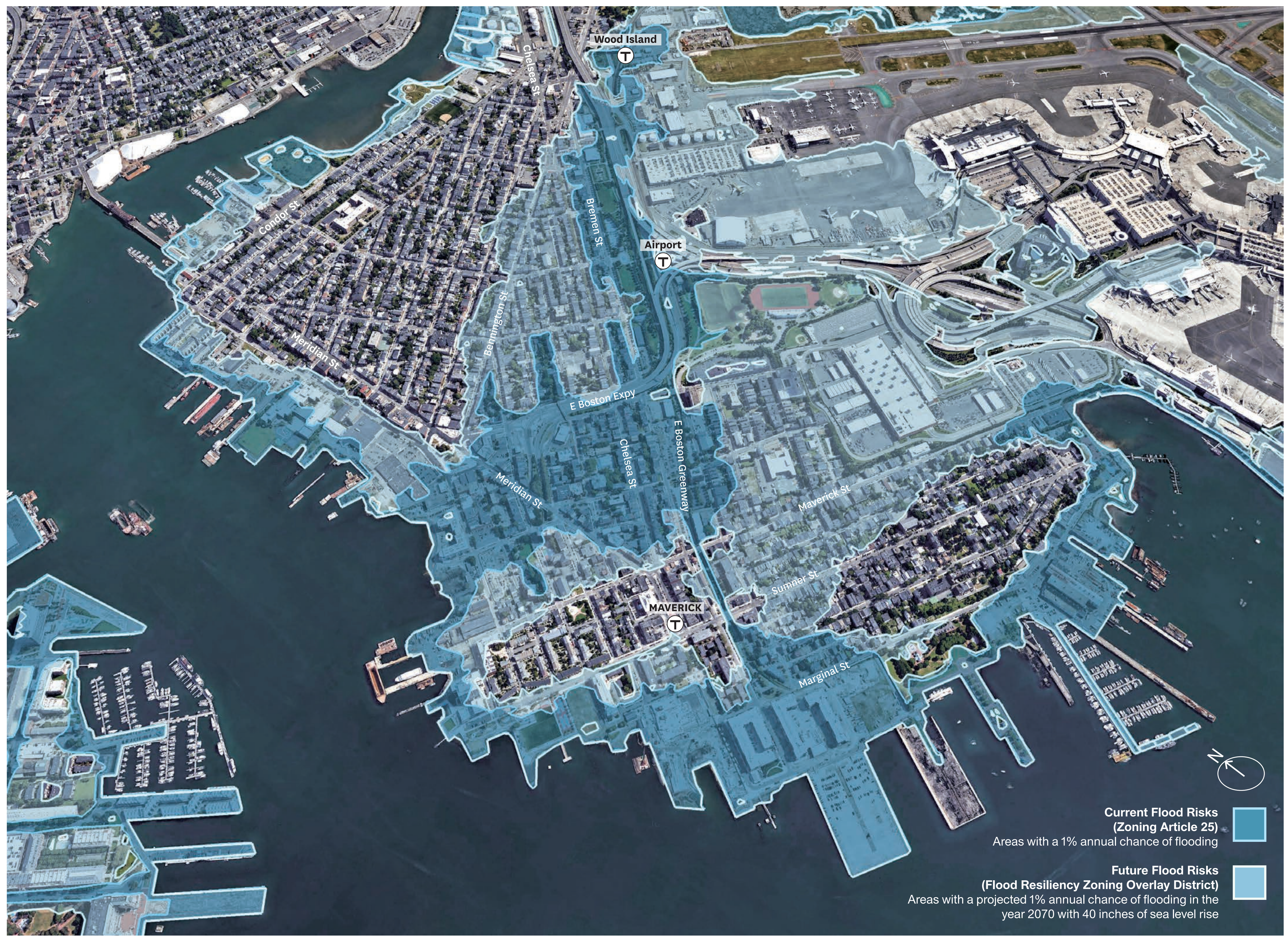
A comprehensive, citywide resource that promotes building resilience against coastal flood risk.

Utile led the development of the City of Boston's first ever citywide zoning overlay district and design guidelines to promote resilience from coastal flood risk for existing buildings and new construction. The zoning overlay district extends over areas with a 1% chance of flooding in 2070 at 40" of sea level rise and is a critical step in advancing the City of Boston's Climate Ready Initiative.

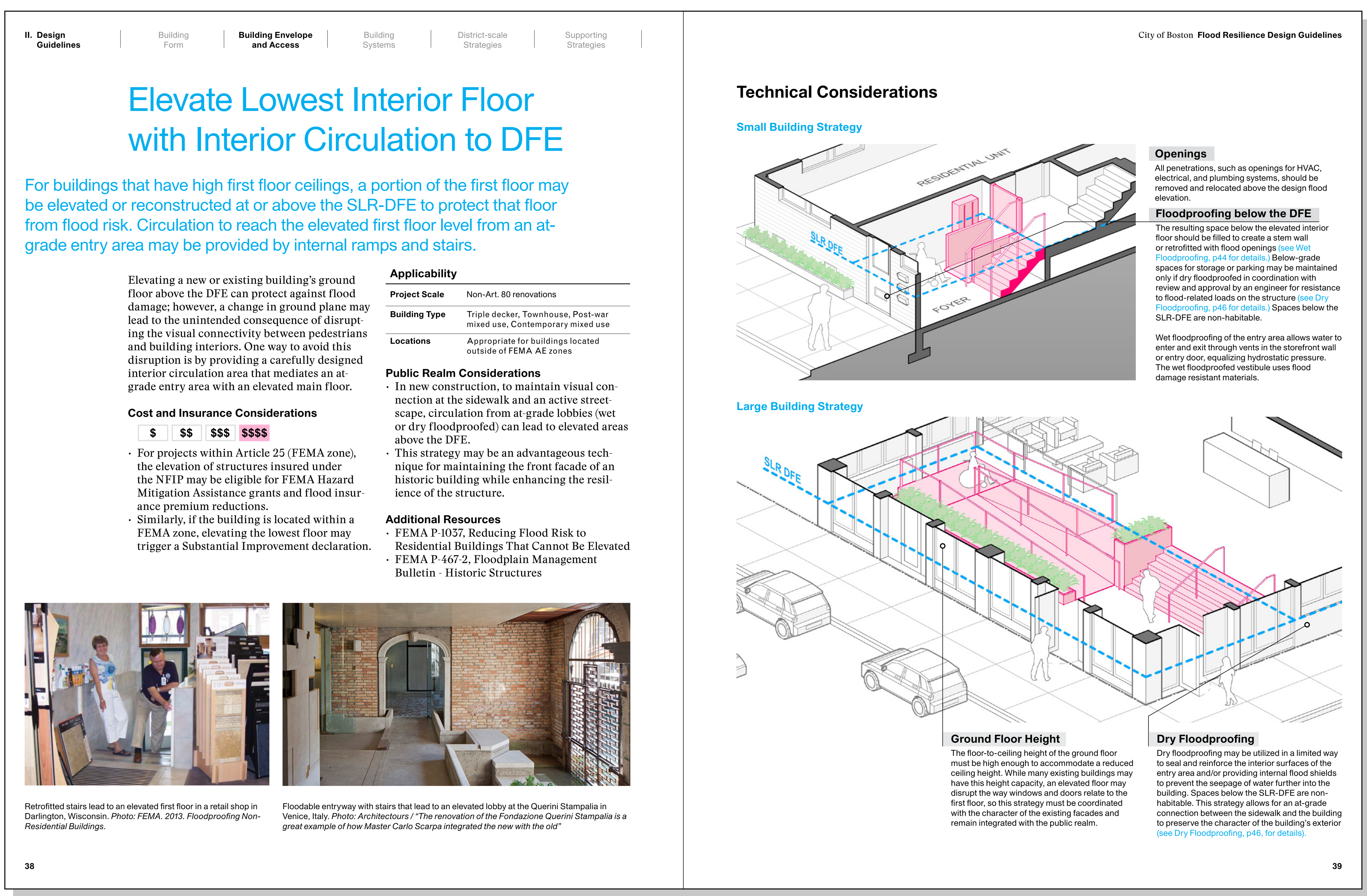
Working with a team of experts, this multi-faceted project integrates a study in national best practices, existing regulations, analysis of Boston's built form, community input, and expertise in cutting-edge building technology to identify effective, consensus-driven revisions to the zoning code.

This project makes Boston one of the first few communities nationally to take a proactive approach toward promoting coastal flood resilience. It sets a higher standard for protection and compliance compared to existing federal regulations by choosing to adopt future projections as the new threshold for risk. The zoning overlay will not only require all new construction be resilient, it will also ensure that renovations to existing buildings are performed in compliance with these guidelines. Together the guidelines and zoning overlay create a robust armature to promote preparedness across a range of neighborhoods, building conditions, and communities.


Extent of the citywide overlay



Current and Future Coastal Flood Risk Areas in East Boston



II. Design Guidelines | Building Form | **Building Envelope and Access** | Building Systems | District-scale Strategies | Supporting Strategies

Elevate Lowest Interior Floor with Interior Circulation to DFE

For buildings that have high first floor ceilings, a portion of the first floor may be elevated or reconstructed at or above the SLR-DFE to protect that floor from flood risk. Circulation to reach the elevated first floor level from an at-grade entry area may be provided by internal ramps and stairs.

Elevating a new or existing building's ground floor above the DFE can protect against flood damage; however, a change in ground plane may lead to the unintended consequence of disrupting the visual connectivity between pedestrians and building interiors. One way to avoid this disruption is by providing a carefully designed interior circulation area that mediates an at-grade entry area with an elevated main floor.

Cost and Insurance Considerations

$ | $$ | $$$ | $$$$

- For projects within Article 25 (FEMA zone), the elevation of structures insured under the NFIP may be eligible for FEMA Hazard Mitigation Assistance grants and flood insurance premium reductions.
- Similarly, if the building is located within a FEMA zone, elevating the lowest floor may trigger a Substantial Improvement declaration.

Applicability

Project Scale	Non-Art. 80 renovations
Building Type	Triple decker, Townhouse, Post-war mixed use, Contemporary mixed use
Locations	Appropriate for buildings located outside of FEMA AE zones

Public Realm Considerations

- In new construction, to maintain visual connection at the sidewalk and an active streetscape, circulation from at-grade lobbies (wet or dry floodproofed) can lead to elevated areas above the DFE.
- This strategy may be an advantageous technique for maintaining the front facade of an historic building while enhancing the resilience of the structure.

Additional Resources

- FEMA P-1037, Reducing Flood Risk to Residential Buildings That Cannot Be Elevated
- FEMA P-467-2, Floodplain Management Bulletin - Historic Structures

Retrofitted stairs lead to an elevated first floor in a retail shop in Darlington, Wisconsin. *Photo: FEMA. 2013. Floodproofing Non-Residential Buildings.*

Floodable entryway with stairs that lead to an elevated lobby at the Querini Stampalia in Venice, Italy. *Photo: Architectours / "The renovation of the Fondazione Querini Stampalia is a great example of how Master Carlo Scarpa integrated the new with the old"*

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City of Boston **Flood Resilience Design Guidelines**

Technical Considerations

Small Building Strategy

Openings
All penetrations, such as openings for HVAC, electrical, and plumbing systems, should be removed and relocated above the design flood elevation.

Floodproofing below the DFE
The resulting space below the elevated interior floor should be filled to create a stem wall or retrofitted with flood openings (see Wet Floodproofing, p44 for details.) Below-grade spaces for storage or parking may be maintained only if dry floodproofed in coordination with review and approval by an engineer for resistance to flood-related loads on the structure (see Dry Floodproofing, p46 for details.) Spaces below the SLR-DFE are non-habitable.

Wet floodproofing of the entry area allows water to enter and exit through vents in the storefront wall or entry door, equalizing hydrostatic pressure. The wet floodproofed vestibule uses flood damage resistant materials.

Large Building Strategy

Ground Floor Height
The floor-to-ceiling height of the ground floor must be high enough to accommodate a reduced ceiling height. While many existing buildings may have this height capacity, an elevated floor may disrupt the way windows and doors relate to the first floor, so this strategy must be coordinated with the character of the existing facades and remain integrated with the public realm.

Dry Floodproofing
Dry floodproofing may be utilized in a limited way to seal and reinforce the interior surfaces of the entry area and/or providing internal flood shields to prevent the seepage of water further into the building. Spaces below the SLR-DFE are non-habitable. This strategy allows for an at-grade connection between the sidewalk and the building to preserve the character of the building's exterior (see Dry Floodproofing, p46, for details).

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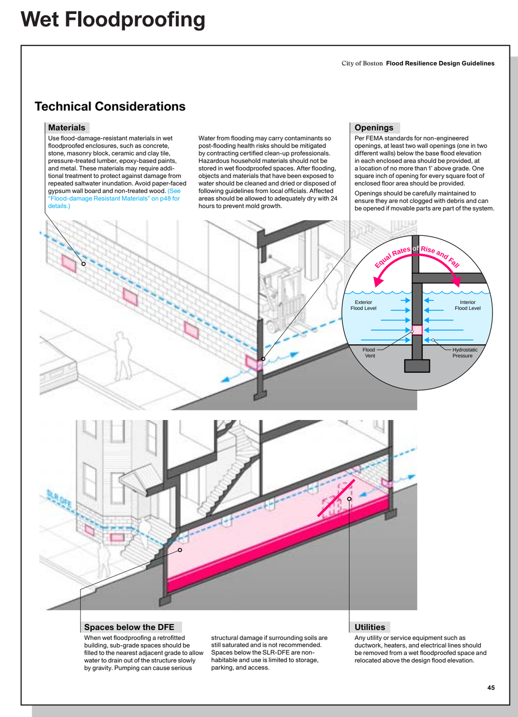
Design Guidelines

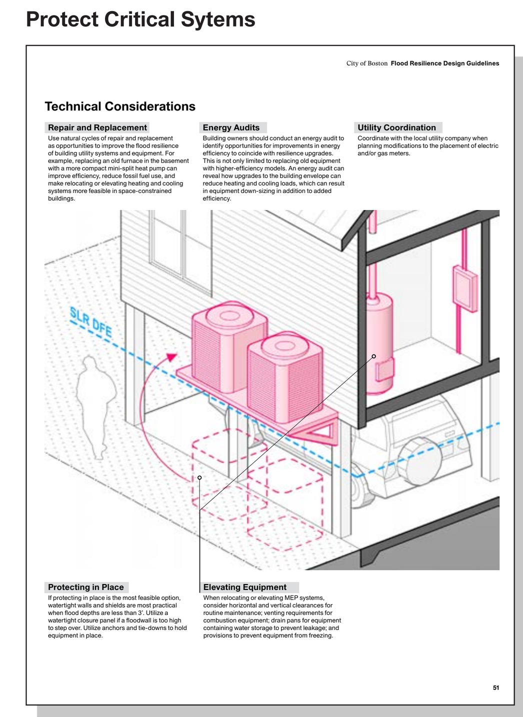
An innovative kit-of-parts easily adaptable to Boston's unique and diverse building stock.

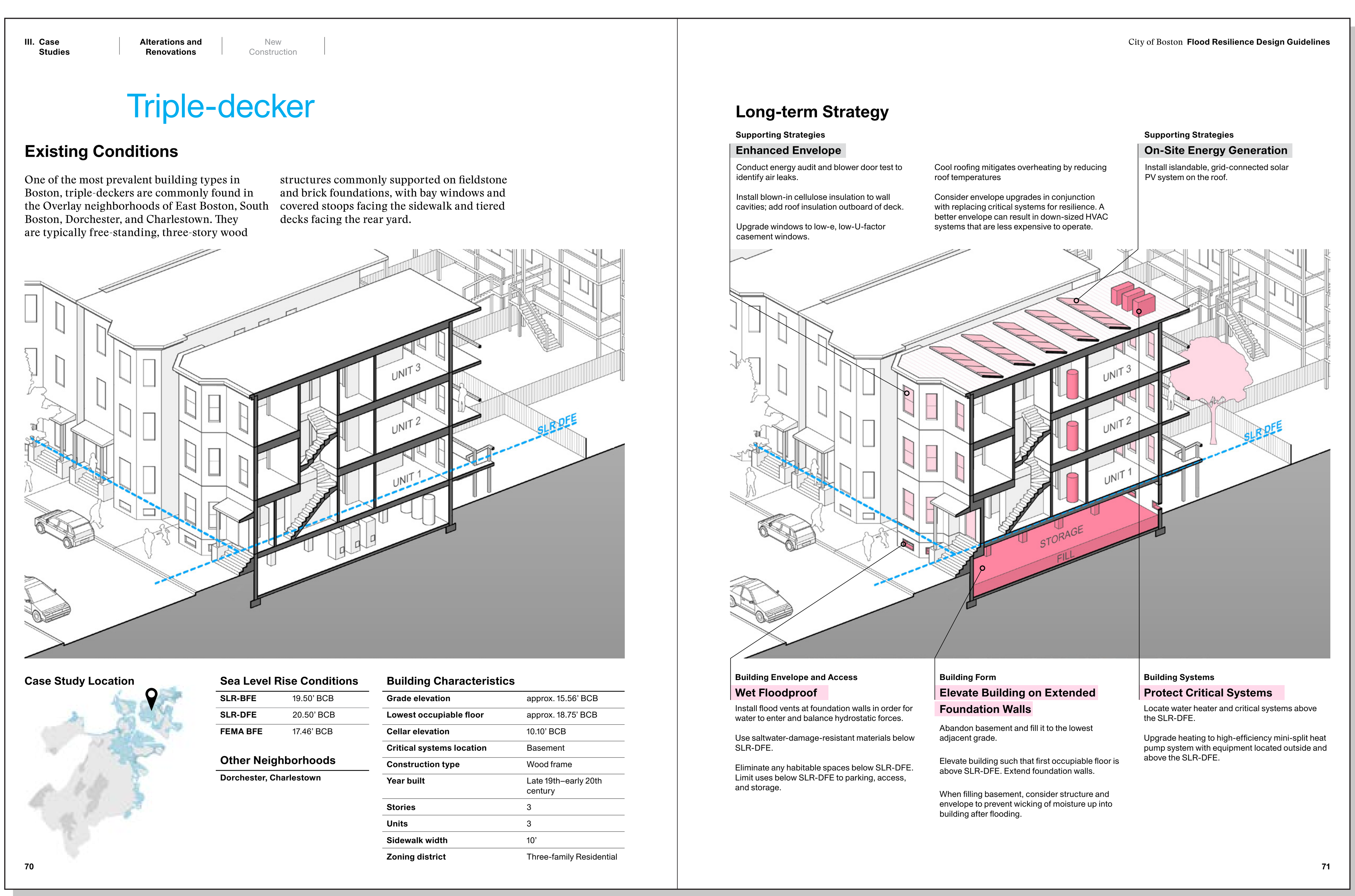
The design guidelines serve as a point of reference for residents, business owners, developers, and design professionals to translate flood resilience best practices into strategies suited for their specific building types. The guidelines place a direct emphasis on impacts to the public realm and provide solutions for maintaining the continuity of the street and sidewalk.

Wet Floodproofing



Protect Critical Sytems





III. Case Studies | **Alterations and Renovations** | New Construction

Triple-decker

Existing Conditions

One of the most prevalent building types in Boston, triple-deckers are commonly found in the Overlay neighborhoods of East Boston, South Boston, Dorchester, and Charlestown. They are typically free-standing, three-story wood structures commonly supported on fieldstone and brick foundations, with bay windows and covered stoops facing the sidewalk and tiered decks facing the rear yard.

Case Study Location

Sea Level Rise Conditions

SLR-BFE	19.50' BCB
SLR-DFE	20.50' BCB
FEMA BFE	17.46' BCB

Other Neighborhoods

Dorchester, Charlestown

Building Characteristics

Grade elevation	approx. 15.56' BCB
Lowest occupiable floor	approx. 18.75' BCB
Cellar elevation	10.10' BCB
Critical systems location	Basement
Construction type	Wood frame
Year built	Late 19th–early 20th century
Stories	3
Units	3
Sidewalk width	10'
Zoning district	Three-family Residential

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City of Boston **Flood Resilience Design Guidelines**

Long-term Strategy

Supporting Strategies
Enhanced Envelope
Conduct energy audit and blower door test to identify air leaks.

Install blown-in cellulose insulation to wall cavities; add roof insulation outboard of deck.

Upgrade windows to low-e, low-U-factor casement windows.

Cool roofing mitigates overheating by reducing roof temperatures

Consider envelope upgrades in conjunction with replacing critical systems for resilience. A better envelope can result in down-sized HVAC systems that are less expensive to operate.

Supporting Strategies
On-Site Energy Generation
Install islandable, grid-connected solar PV system on the roof.

Building Envelope and Access
Wet Floodproof
Install flood vents at foundation walls in order for water to enter and balance hydrostatic forces.

Use saltwater-damage-resistant materials below SLR-DFE.

Eliminate any habitable spaces below SLR-DFE. Limit uses below SLR-DFE to parking, access, and storage.

Building Form
Elevate Building on Extended Foundation Walls
Abandon basement and fill it to the lowest adjacent grade.

Elevate building such that first occupiable floor is above SLR-DFE. Extend foundation walls.

When filling basement, consider structure and envelope to prevent wicking of moisture up into building after flooding.

Building Systems
Protect Critical Systems
Locate water heater and critical systems above the SLR-DFE.

Upgrade heating to high-efficiency mini-split heat pump system with equipment located outside and above the SLR-DFE.

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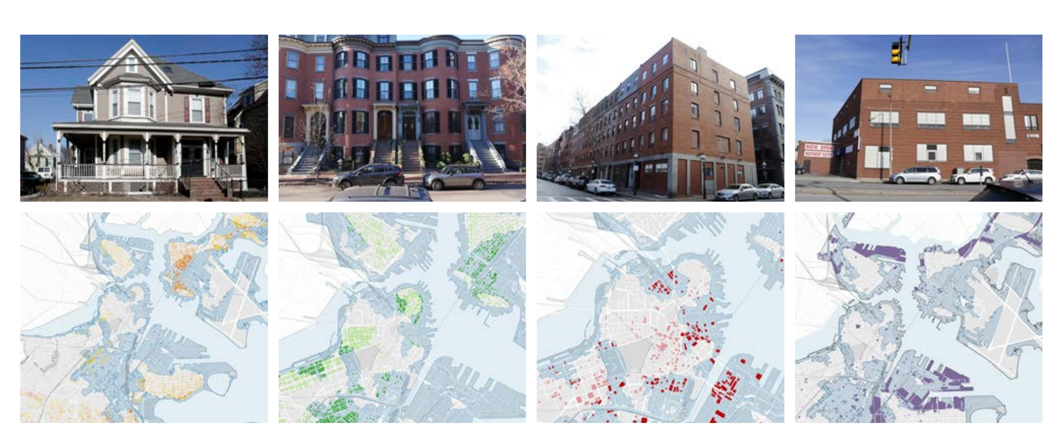
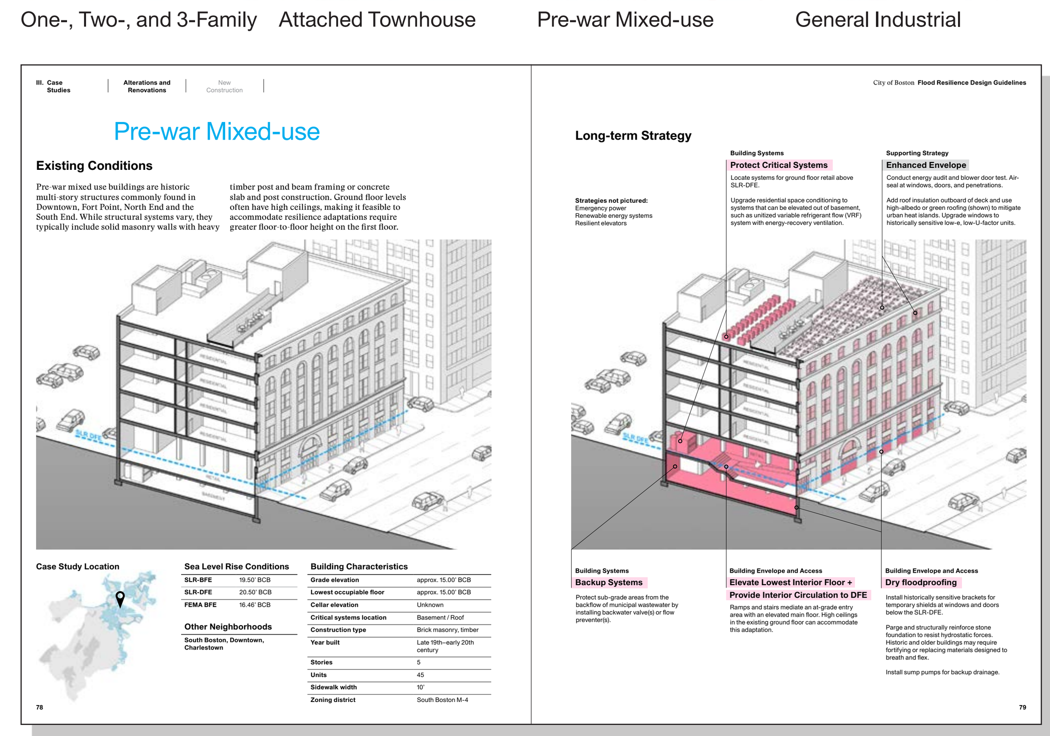
Case Studies

A replicable set of solutions that can inform other communities in the region.

The case studies highlight the interplay of different design guidelines on particular building types common to Boston and illustrate options for long- and short-term solutions. They also highlight synergies and conflicts with existing citywide regulations, building materials and systems, and accessibility requirements.


One-, Two-, and 3-Family | Attached Townhouse | Pre-war Mixed-use | General Industrial



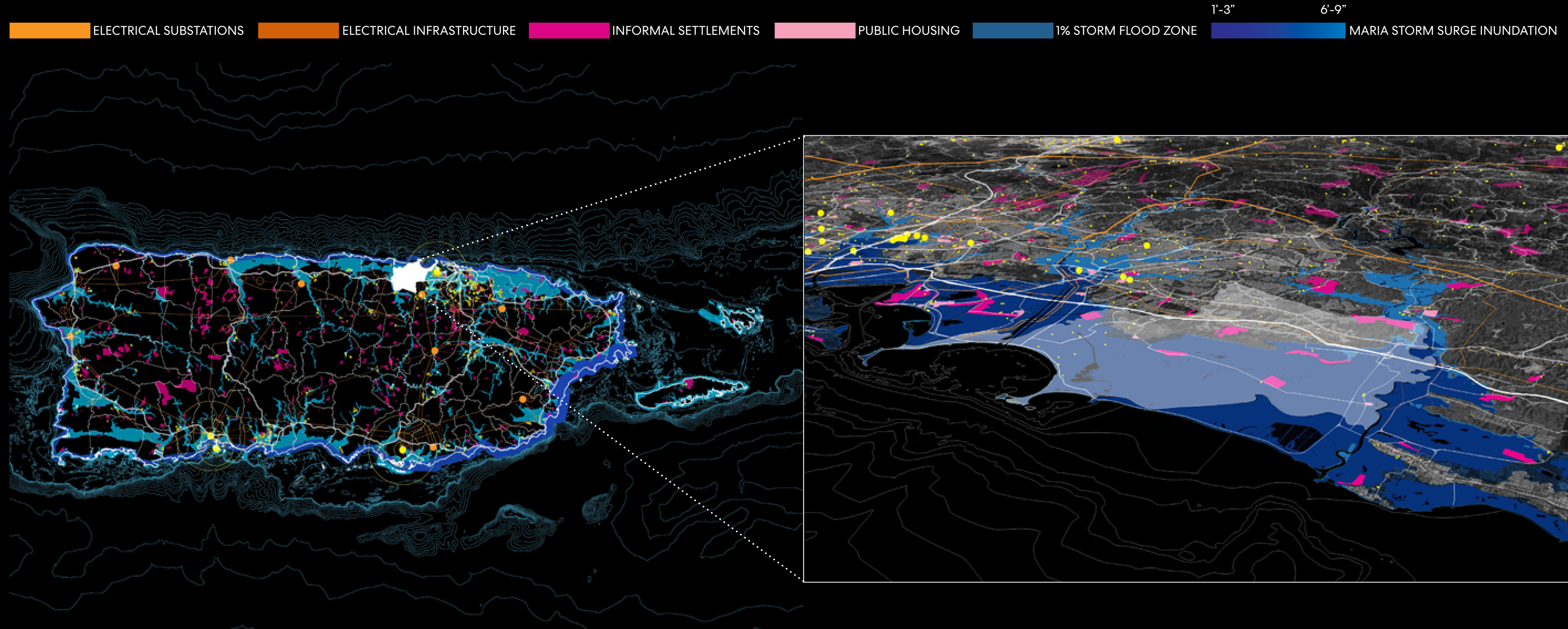
Systems Thinking for Multi-Scale Resilient Planning

ResilientSEE is a global alliance of designers, engineers, academics, nonprofits, and citizens striving to raise awareness, share knowledge, and create lasting, positive change in Puerto Rico. By approaching resilience through social, environmental and economic lenses, we believe communities can be better prepared to manage and recover from cascading consequences of an extreme weather event.

The work below represents an ongoing resilience effort in the municipality of Toa Baja that analyzes relevant data at the island, municipality and community scales.

PROJECT INFORMATION:
- **Name:** Toa Baja Resilient Planning Framework
  Location: Toa Baja, Puerto Rico
- **Sustainability Features:** Social, Environmental and Economic resilience
- **Project team:** resilientSEE-PR.com alliance collaborators
- **Recognition:** Featured in Building Design and Construction and Metropolis publications, and on Union of Concerned Scientists and Power of Good podcasts
- RELi systems thinking methodology

Vulnerabilities Study



Takeaways

PUERTO RICO

$65B total damages

500,000 people (15% of the population) live in areas prone to flooding

250,000 homes severely damaged

TOA BAJA

16% of land is developed

13k+ damaged properties

14k+ flooded houses

$400M property damages

$1.3B total infrastructure and economic damage

$60M total electric infrastructure damage

Toa Baja: Resilient Planning at Multiple Scales

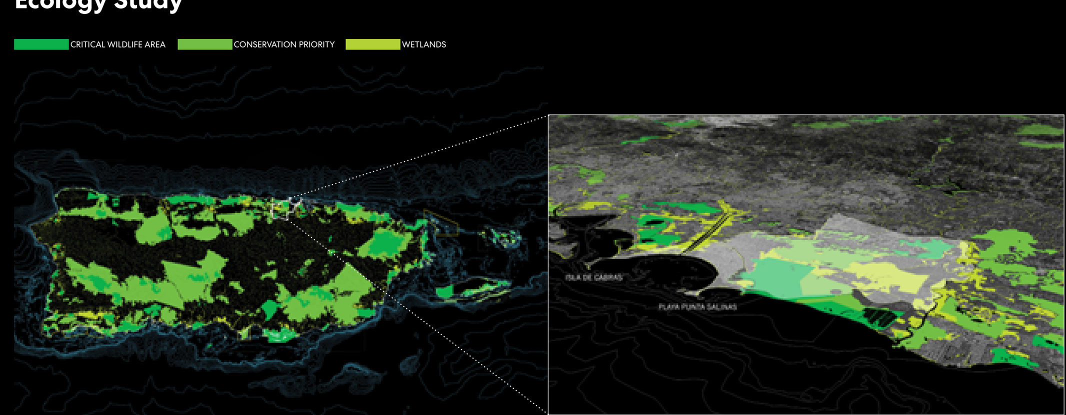
Puerto Rico faces many challenges from a climate resilience perspective. These challenges are complex—they can't be solved in traditional disciplinary silos. The island lacks a comprehensive analysis that contextualizes risks and vulnerabilities, and, at the same time, municipalities like Toa Baja would benefit from understanding how they fit into the larger island ecosystem and region at large. They need to know potential solutions that consider the granularity of community needs.

This analysis is a part of the Resilient Framework Plan for the Autonomous Municipality of Toa Baja. It represents the development of a scalable and replicable resilient planning methodology that considers social, environmental and economic resilience—we call it the "S-E-E" approach. This framework plan is helping the Municipality build consensus, centralize existing information, identify gaps of data and analysis, synthesize analyses into overarching principles, and think strategically about implementable solutions.

Developed Pro Bono by ResilientSEE Partners:

MIT Urban RISK Lab · AD&V Alvarez Diaz & Villalon · Perkins&Will

Ecology Study



Takeaways

PUERTO RICO

60 years of natural tree fall happened in one day after Hurricane Maria

20% of the island is karst zone and consists of alluvial and claylike surface, making it susceptible to landslides and liquefaction

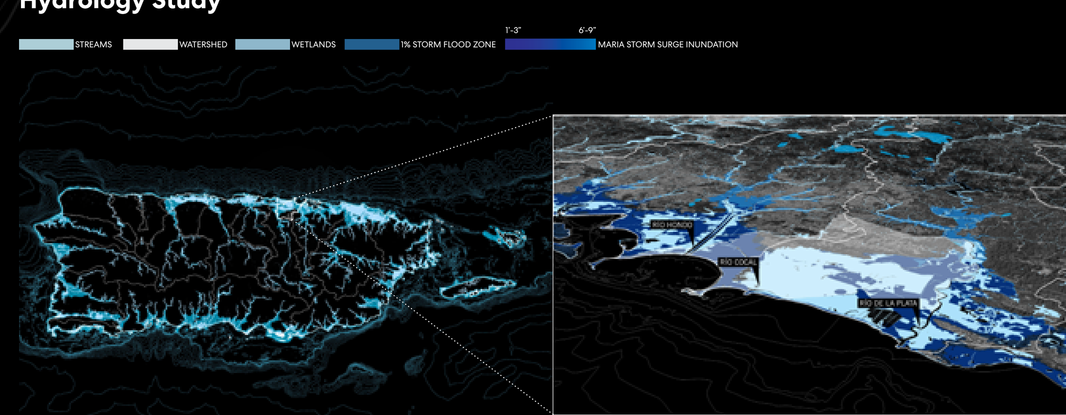
TOA BAJA

16% of land is developed

Fragmented natural reserves

Loss of coastline due to erosion and sea level rise, limiting public access to the coast

Hydrology Study



Takeaways

PUERTO RICO

55% of Puerto Rico's population is living in coastal municipalities

252,748 structures are at risk of flooding

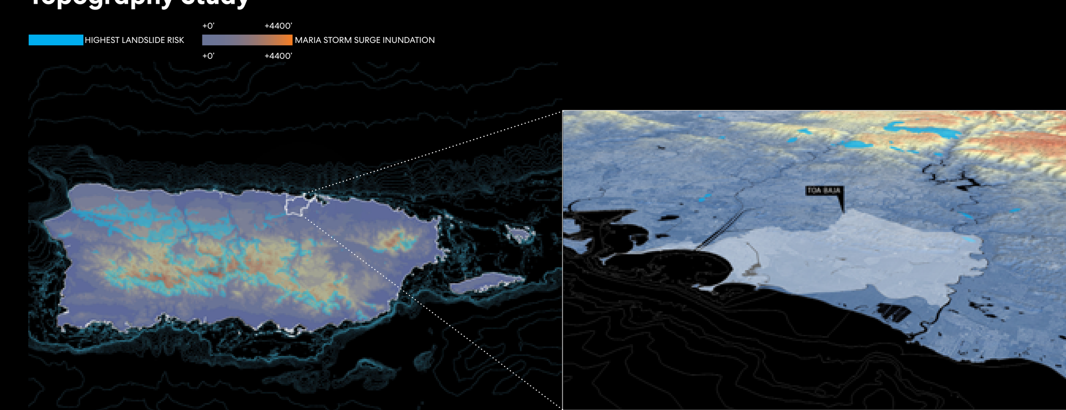
500,000 people (15% of the population) live in areas prone to flooding.

TOA BAJA

$500M have been invested for a flood control project in Tio de la Plata

La Plata River floods Toa Baja every **6-10 years**

Topography Study



Takeaways

PUERTO RICO

49% of the population lives in areas ranging from moderate to high susceptibility for landslides

The coastline is being eroded at a rate of up to **3.3 feet / year**

Growing population density is **higher than Japan** resulting in more construction on vulnerable slopes

TOA BAJA

Low lying areas of Toa Baja are subject to **Subsidence and Liquefaction**

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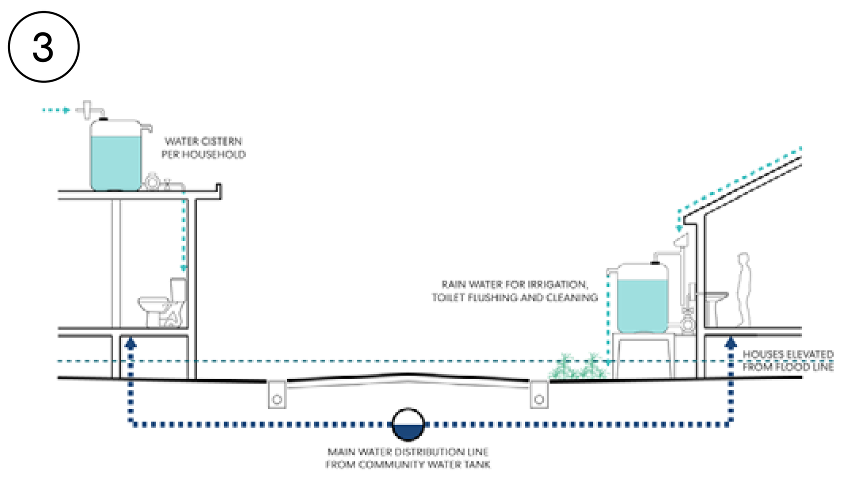

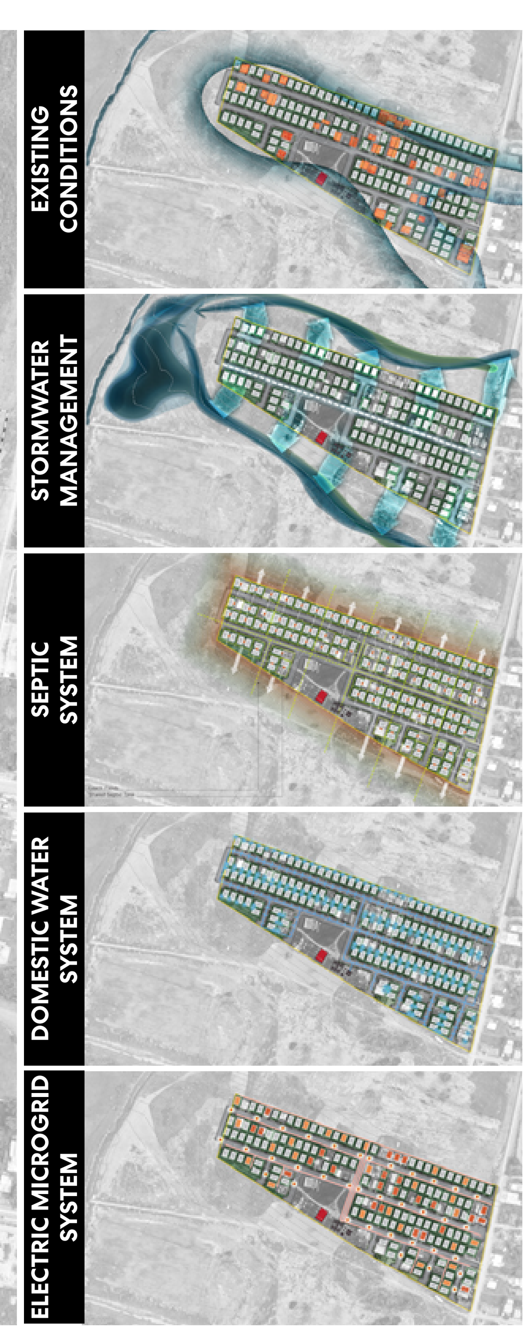

The Villas del Sol Community of Toa Baja: Resilient Planning Framework

Villas del Sol is an immigrant community, originally from the Dominican Republic, that settled on private land. The land owner, with help from the Municipality, asked the community to leave, and the Authority of Land ultimately assigned them to their current location. There is press documentation of the community suffering excessive force by local police, including allegations of violation of human rights that led to intervention of international human rights NGOs. The community became organized as a cooperative, and a regulatory lot plan was developed as an initial framework to resettle in an organized way. The previous Municipal administration promised infrastructure that was never implemented. As a result, families have settled but are extremely vulnerable to climatic events.

This project is a partnership between Sol es Vida, the non-profit cooperative organization of Villas del Sol community, and many ResilientSEE-PR collaborators. The framework plan addresses infrastructure that the community currently lacks, including stormwater management, potable water, electricity, sewage, and green open space. This work impacts 50 families—170 total community members—currently living without basic infrastructure.

Please visit **https://www.resilientsee-pr.com/villas-del-sol-resilient-planning-framework-plan** for the full list of collaborators.