Resilient Ecosystems: Quantifying the Co-benefits of Green Infrastructure

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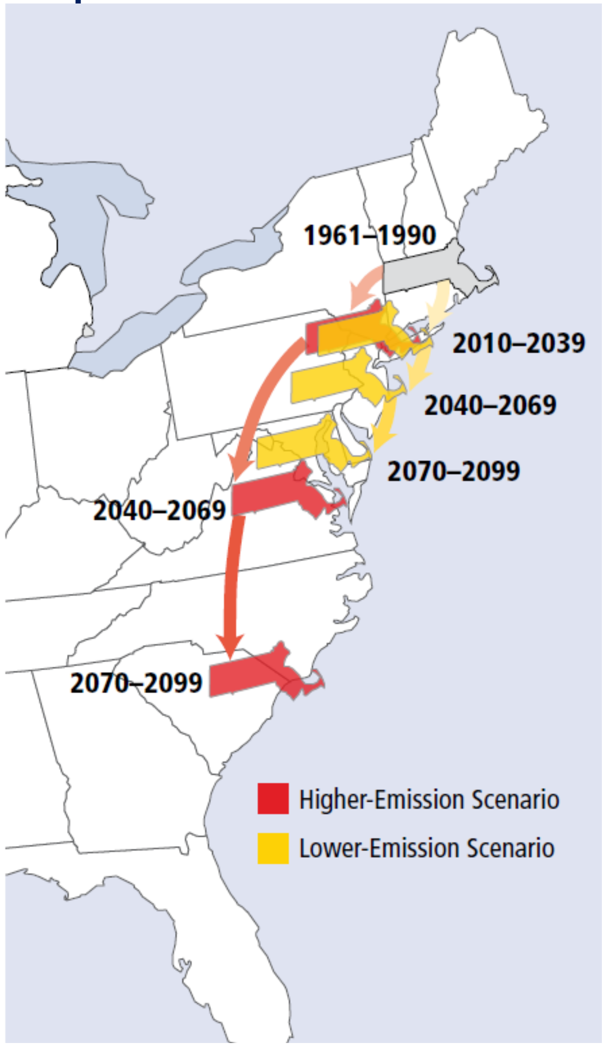
Overview

- Climate change impacts to Cambridge
- Types of resiliency strategies being considered
- Objectives of the green infrastructure analysis
- Conceptual design by landuse type
- Quantification of
  - Flood reduction benefits
  - Water quality improvement
  - Urban heat island mitigation for both green infrastructure and urban forest canopy
- Conclusions

How climate change may affect Cambridge

Temperature

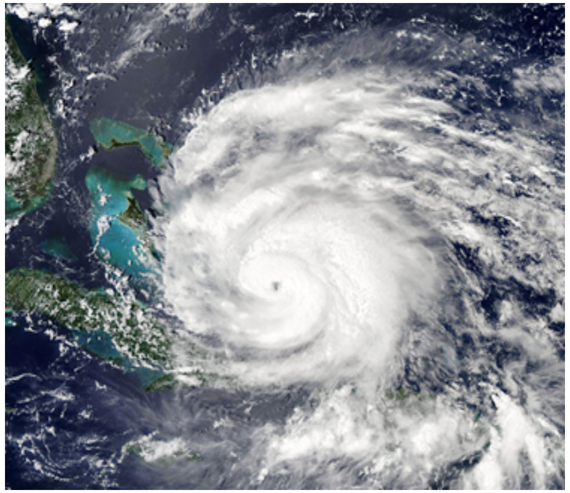


Source: Army Corps of Engineers

Precipitation

[Friends of Alewife Reservation (FAR)]

More extreme events



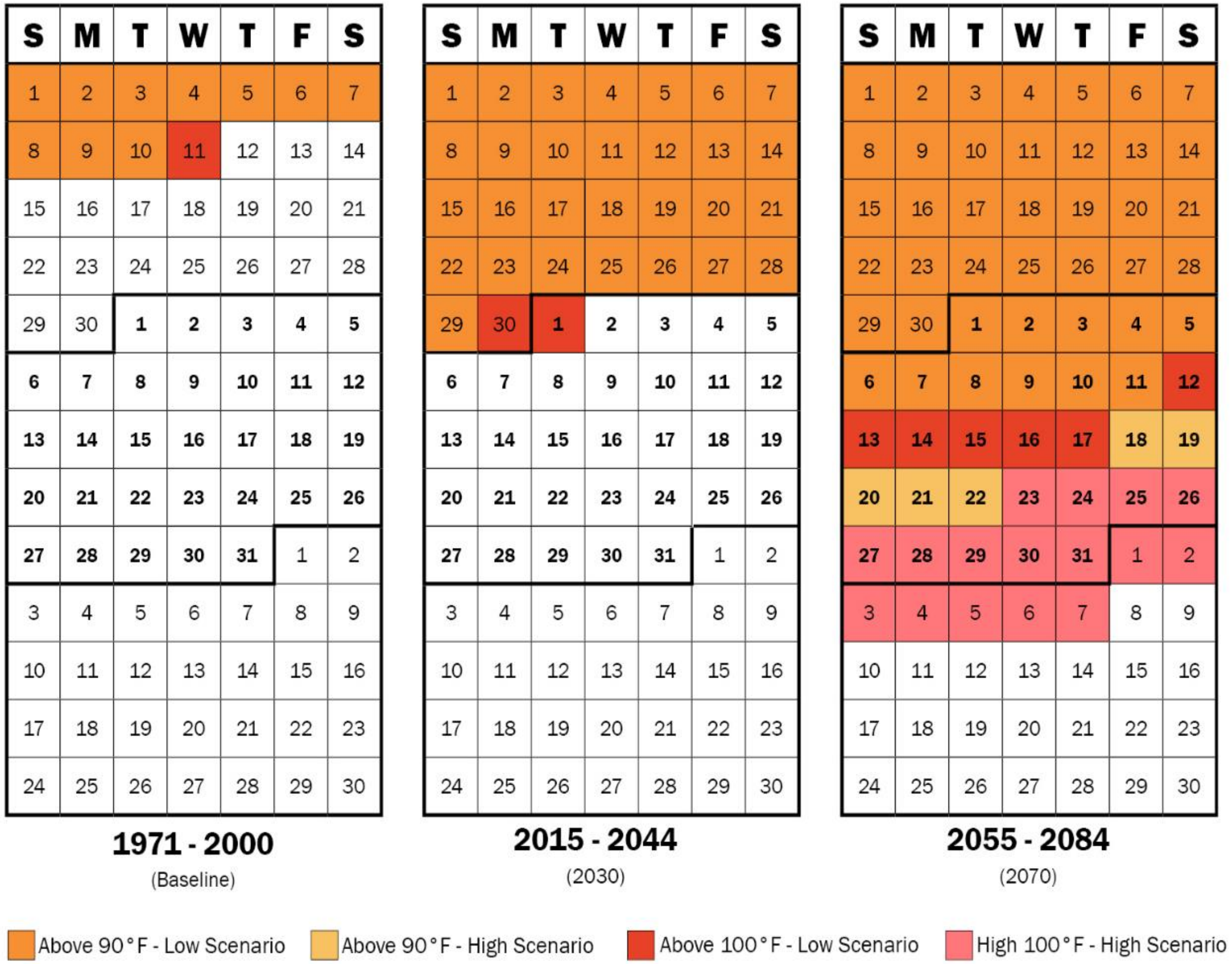
Sea Level Rise and Storm Surge (SLR/SS)

Amelia Earhart Dam (Source: MaUSHarbors.com)

Charles River Dam (Source: New England District, US Army Corps of Engineers, 2015)

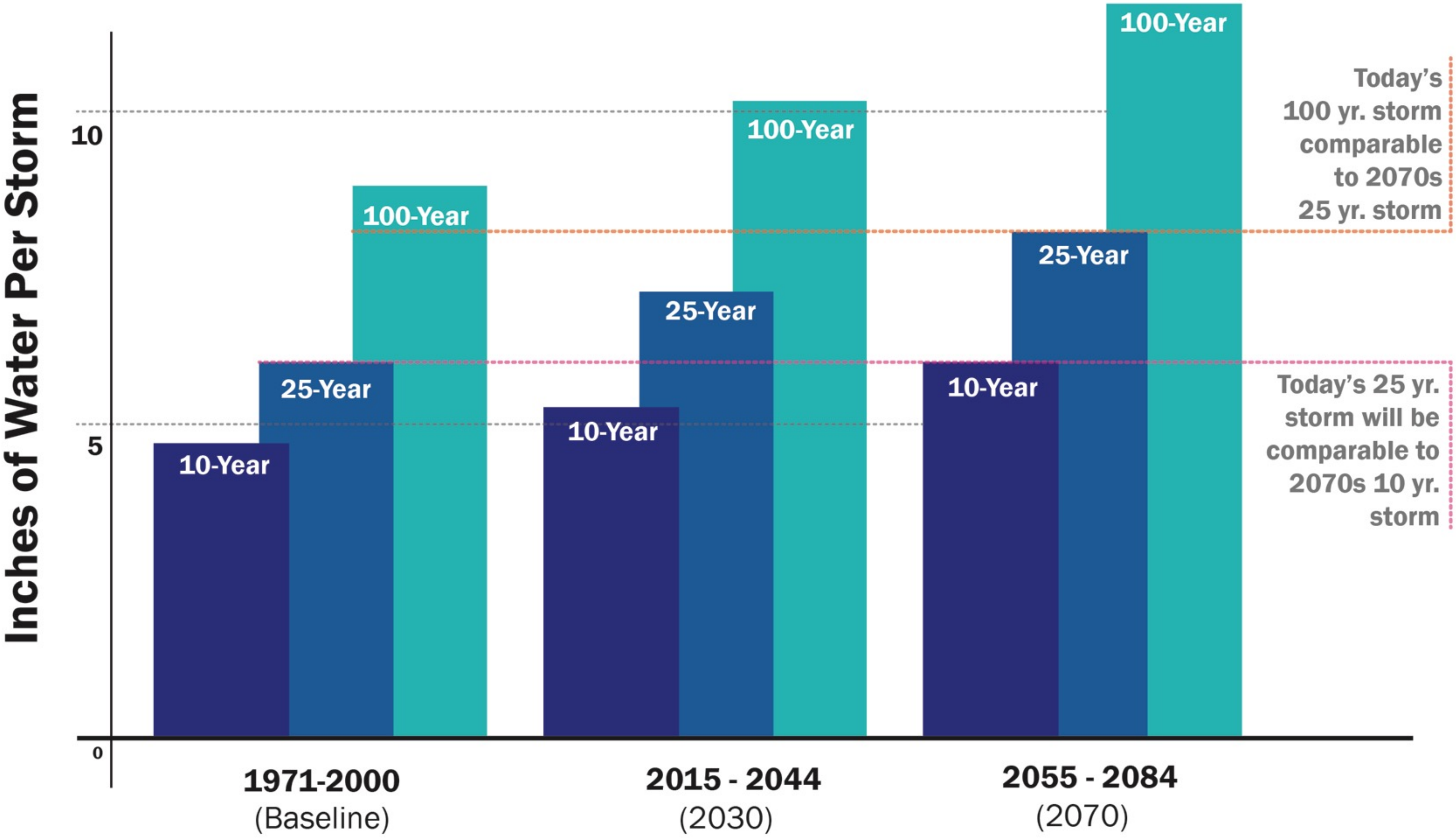
Increasing Temperatures – Increasing Heat Vulnerability

By 2030, the number of days above 90 F could triple



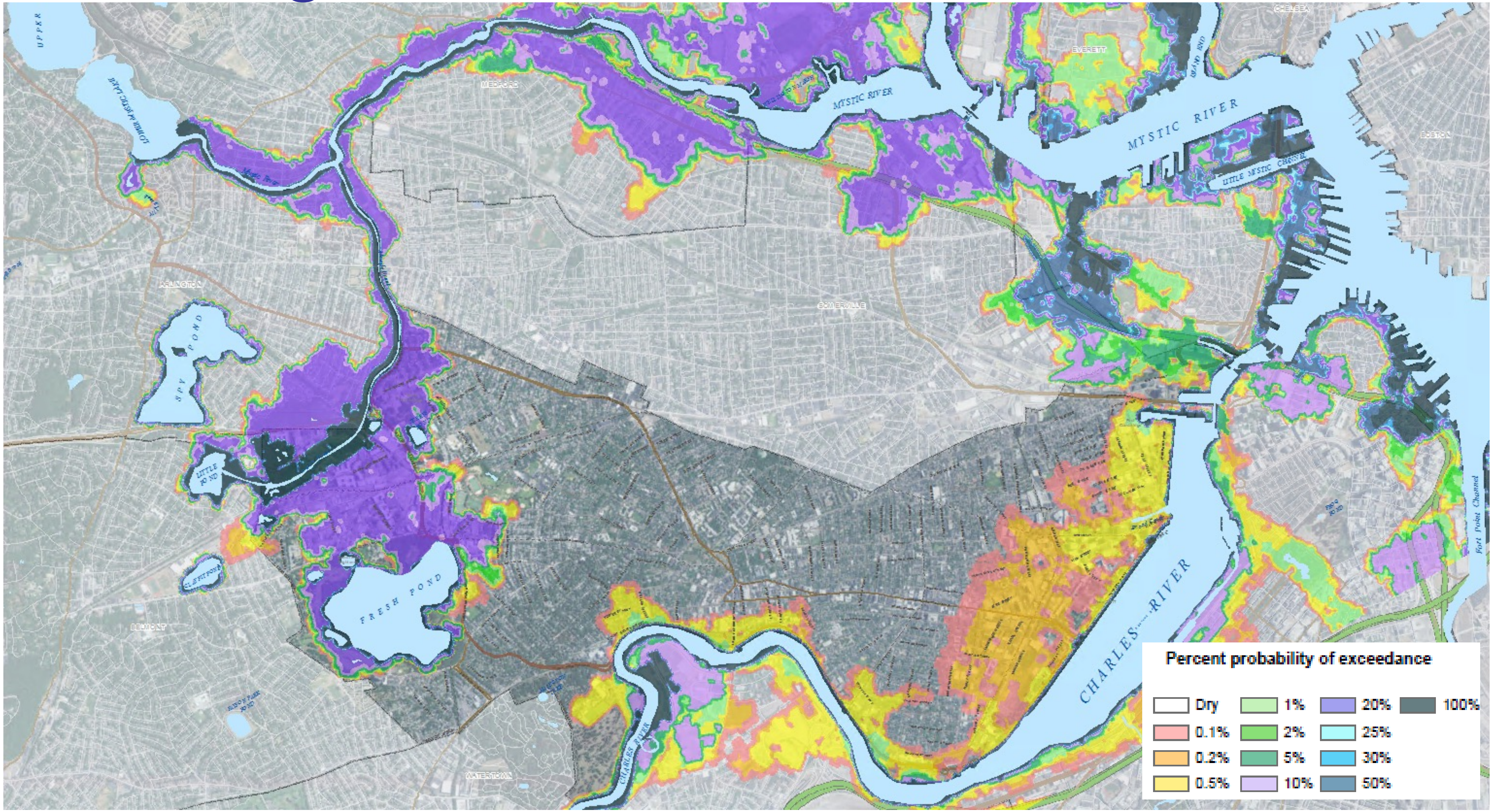
*Summer is considered to be the 91 days of June through August

Increasing Intensity of Precipitation - Flooding



Precipitation projections, CCVA Part 1, City of Cambridge *(Source: Kleinfelder based on ATMOS projections, Nov.2015)*

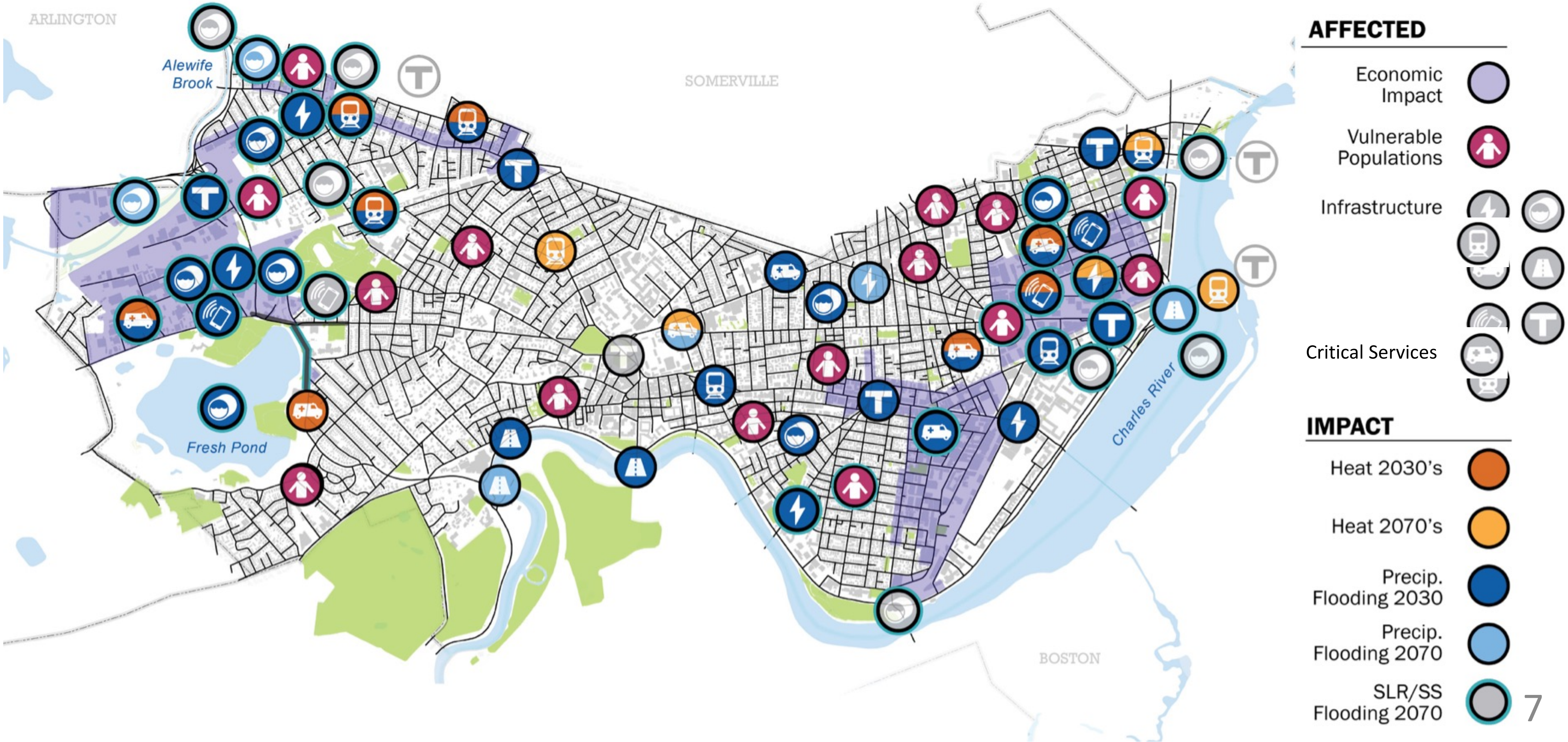
Storm Surges from Boston Harbor



Source: *Kleinfelder & Woods Hole Group for the City of Cambridge, February 2017*

Sea Level Rise/Storm Surge Risk - 2070

Critical assets, resources & vulnerable populations most at risk for Climate Change impacts



CCPR
CLIMATE CHANGE PREPAREDNESS & RESILIENCE

Vision

Protect the lives and livelihoods of members of the Cambridge community that are at risk from climate change impacts.

In the process, enhance the well-being of the Cambridge community.

CCPR Resilience Strategies

(A) **Prepared Community:** Strategies to strengthen community, social, and economic resilience.

(B) **Adapted Buildings:** Strategies to protect buildings against projected climate change impacts.

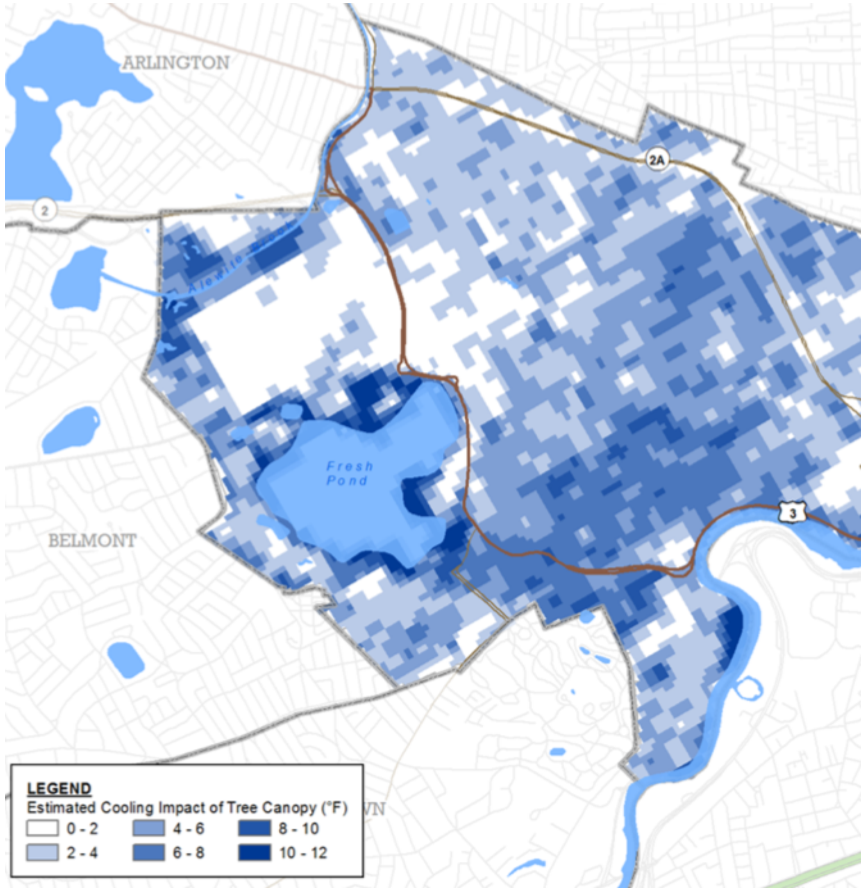
(C) **Resilient Infrastructure:** Strategies to ensure continued service or a speedy recovery from community-wide infrastructure systems.

(D) **Resilient ecosystems:** An enhanced living environment integrating air quality, waterways, green infrastructure, and the urban forest as a system resilient to climate impacts.

D Resilient Ecosystems

an enhanced living environment integrating air quality, waterways, green infrastructure and the urban forest as systems resilient to climate impacts.

- Parts of the Alewife area that lack vegetation will experience greater heat vulnerability exacerbated by the UHI effect.
- Pedestrian networks and bike routes in the Alewife area are directly exposed to heat.



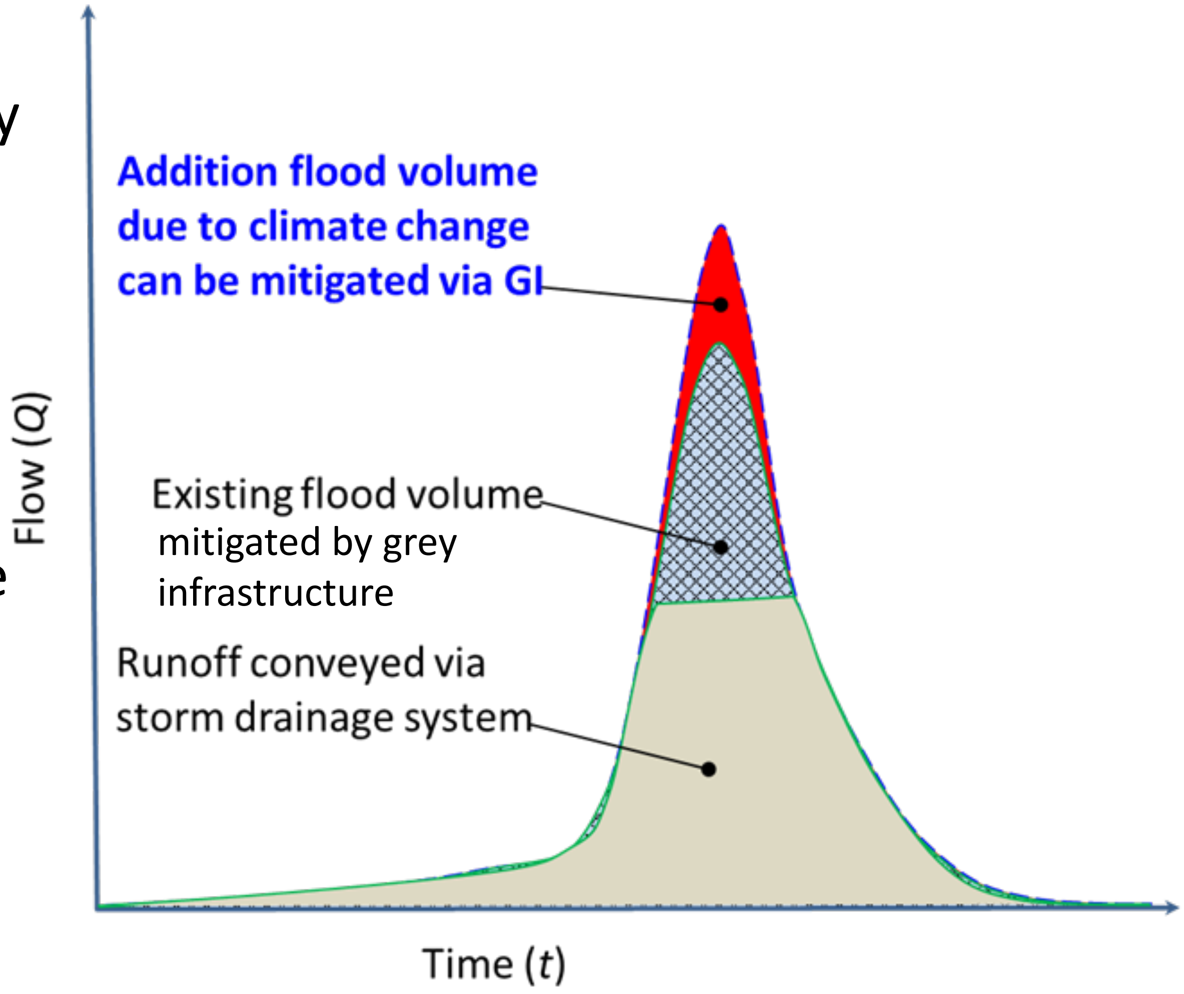
Cooling impact of tree canopy *[CCVA, 2015]*

What are We Trying to Achieve?

- Assess if green infrastructure can be used to capture the additional flood volume brought by climate change.

- Estimate how green and grey infrastructure need to be combined to mitigate flooding

- Quantify the co-benefits of green infrastructure



Use Ecosystems to Transform a Neighborhood

Model for GI / complete street design: Western Avenue Cambridge

Street representative of Alewife Quadrangle character

North Point Park in eastern Cambridge

Resilient Ecosystems – Best Practices

Open-space planning in North Shore [Source: Rivers in Synergy, Pittsburgh, PA]

Portland Green Street [Source: Environmental Services, City of Portland]

Tree planters and bioretention basin at parking lot of Irving School in Roslindale, Boston. [Source: BWSC and Greenovate City of Boston]

Green wall on a building in Concepción, Chile (left) and a green wall on a small business building on Shin Koenji street in Tokyo, Japan (right). [Sources: ihabitat.com; tokyogreenspace.com]

Chicago Green Roof. Photo credit: Conservation Design Forum

Green roof system at Ryerson University [Source: Toronto.ca – Green Roofs]

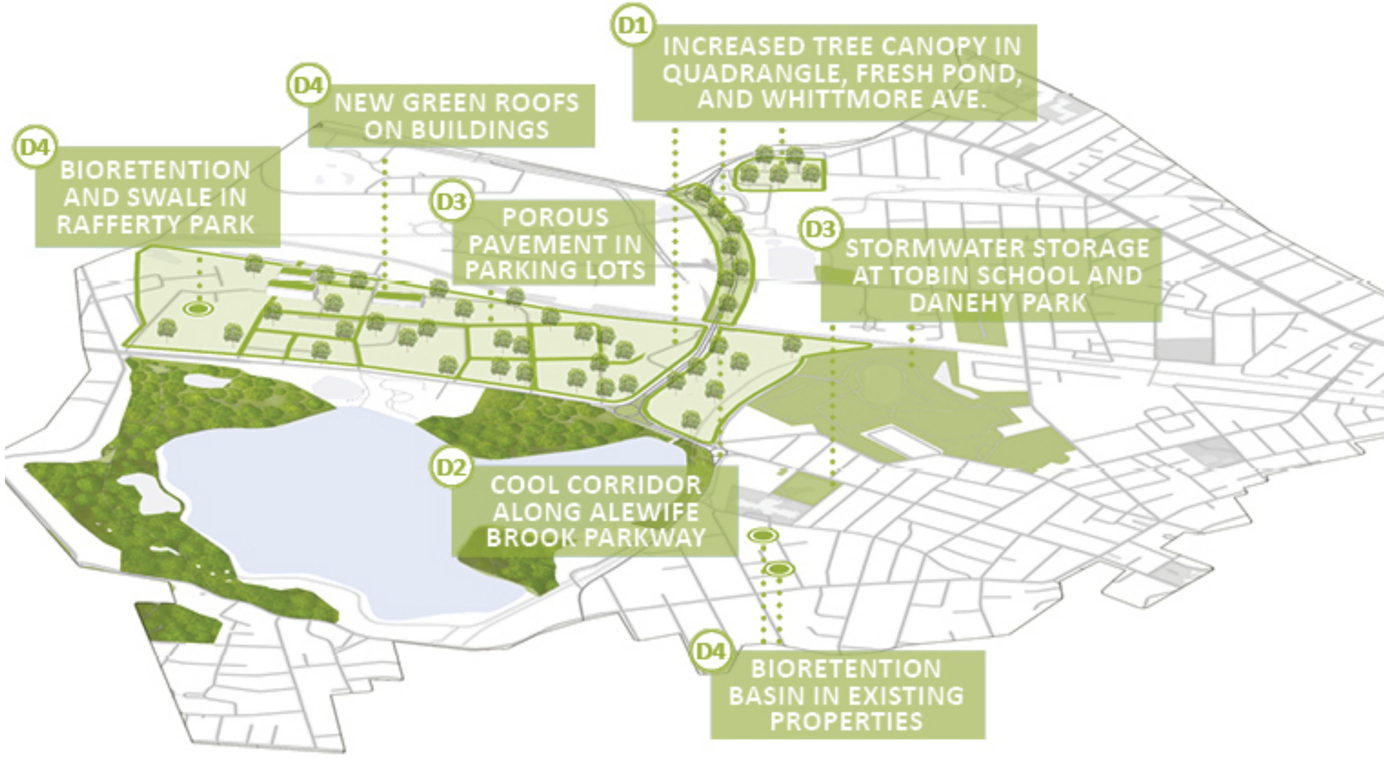
Benefits of Resilient Ecosystems

Strategies will:

- Provide additional stormwater-storage capacity
- Protect water quality
- Reduce the urban heat island (UHI) effect
- Preserve air quality

Table D.1 List of Strategies for Resilient Ecosystems

STRATEGY	TITLE	DESCRIPTION
D1	RESILIENT URBAN FOREST	Reduce the UHI effect by increasing the urban forest canopy, developing a comprehensive urban forest management plan, and continuing urban forest maintenance efforts.
D2	ENHANCED OUTDOOR THERMAL COMFORT	Develop "cool corridors" aligned with bike and pedestrian routes and MBTA bus stops to enhance outdoor thermal comfort for transit users.
D3	REDUCE IMPERVIOUS AREA	Reduce impervious area of upstream parcels to limit flooding at downstream parcels. Evaluate the implementation of a combination of grey and green infrastructure in parcels upstream of flood-prone areas to reduce runoff from impervious areas.
D4	GREEN INFRASTRUCTURE OPPORTUNITIES	Implement Green Infrastructure (GI) to improve water quality and reduce flooding impacts from smaller rainfall events and mitigate urban heat islands (UHI)

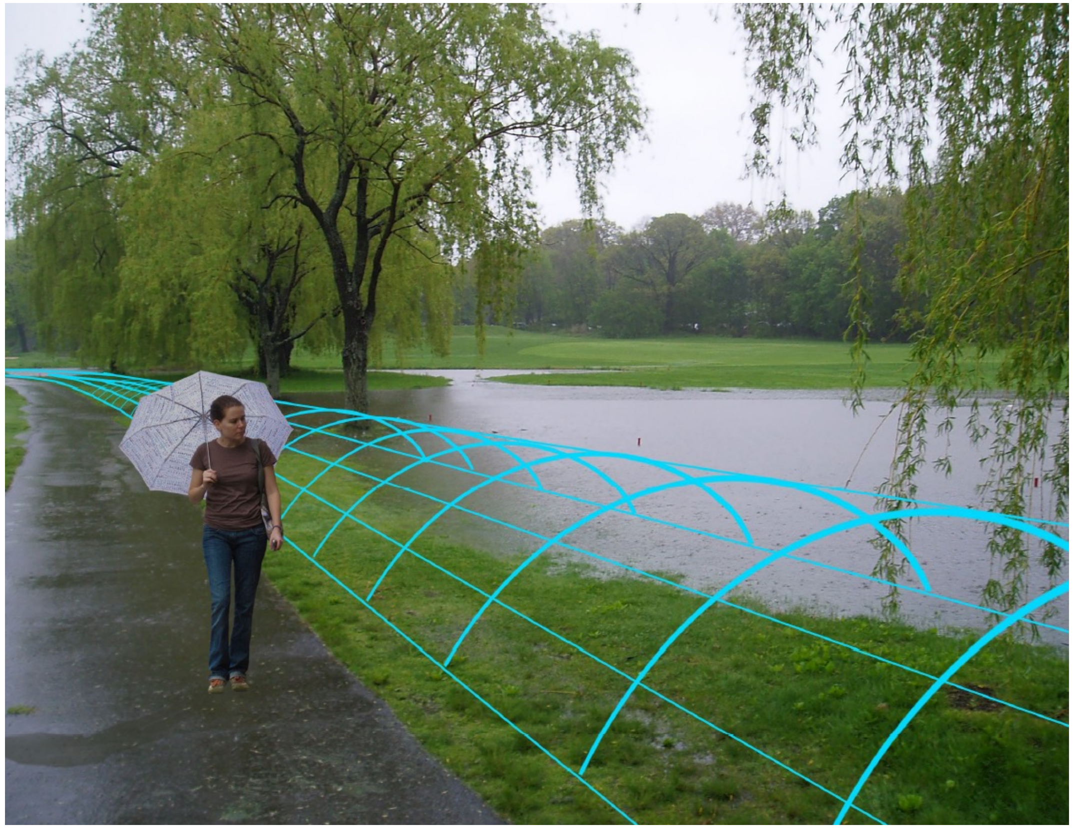


Implementation of Green Infrastructure in Existing Projects

Hummocks at community garden at 23.1 elev.

Build a vegetated berm at elevation 23.1 ft-CCB *(Cambridge city-based datum)* along Fresh Pond. This strategy could protect the Fresh Pond Reservoir for the projected 2070 100 year sea level rise / storm surge flooding.

Longer-term Adaptation Considerations

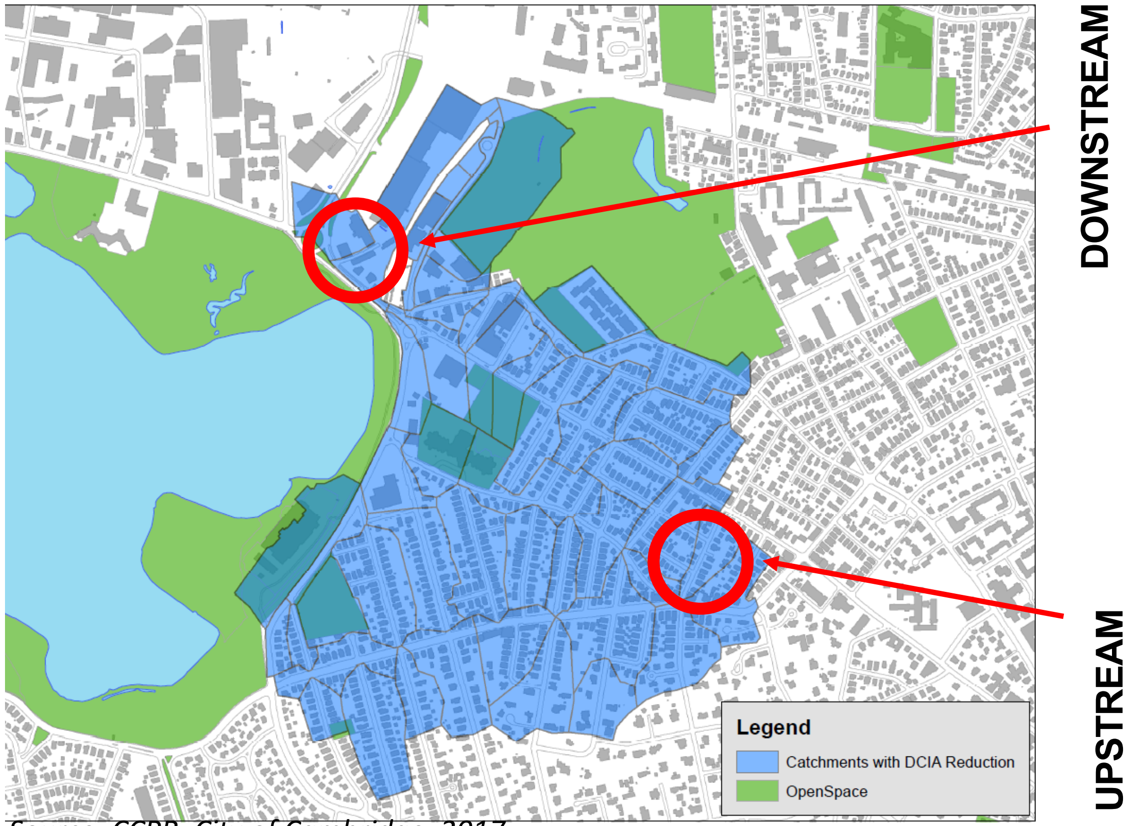


Sketch of the proposed berm height (elev 23.15 ft-CCB) at the Fresh Pond Golf Course,

Sketch of the proposed wall height (4.5’) at Fresh Pond,

Green Infrastructure can Reduce Impervious Area

Reduce Impervious Area (DCIA) of upstream parcels to limit flooding of downstream parcels



Source: CCPR, City of Cambridge, 2017

Create incentives for catchment overlay districts for encouraging and supporting implementation of GI in strategic locations where they will have most impact

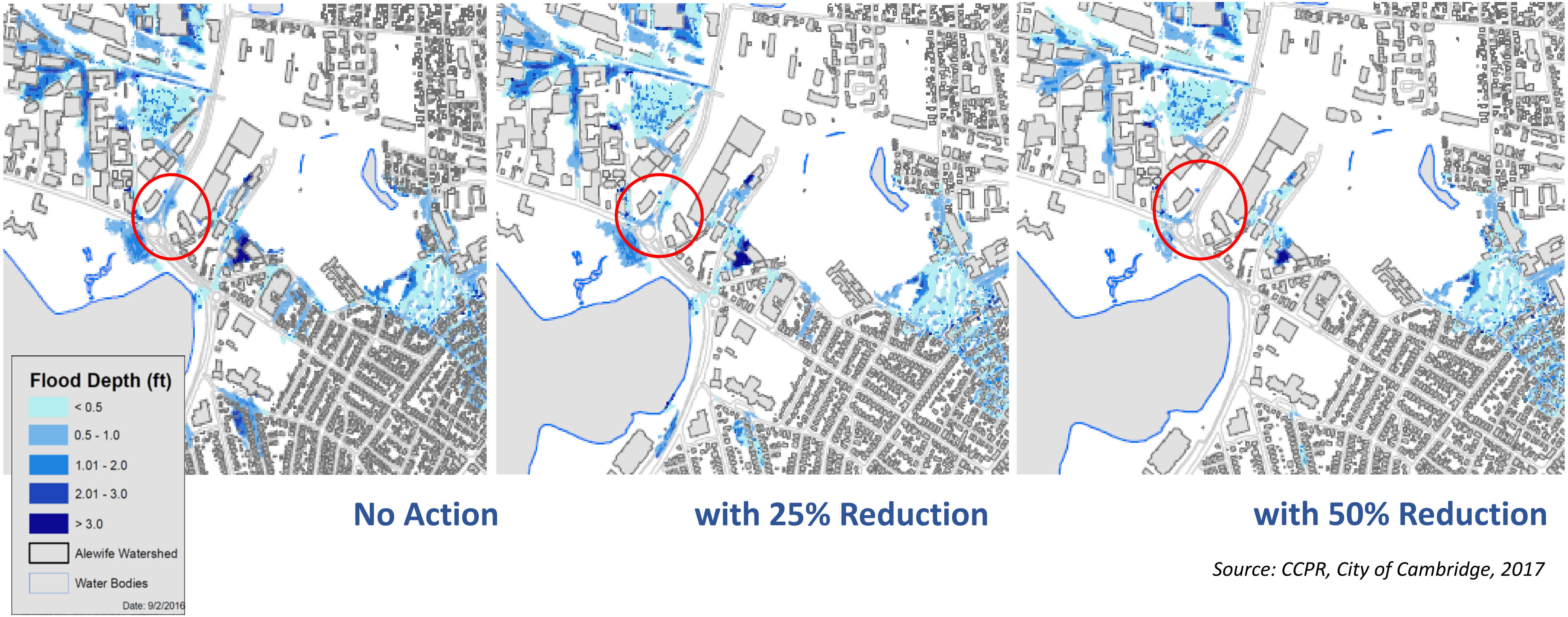
GI Storage Options:

1. Bioretention Basin
2. Rain Barrel
3. Above-Ground Planter
4. Other GI Storage Options

How Impervious Area Reduction can Reduce Flooding

Reduce Impervious Area (DCIA) of upstream parcels to limit flooding of downstream parcels

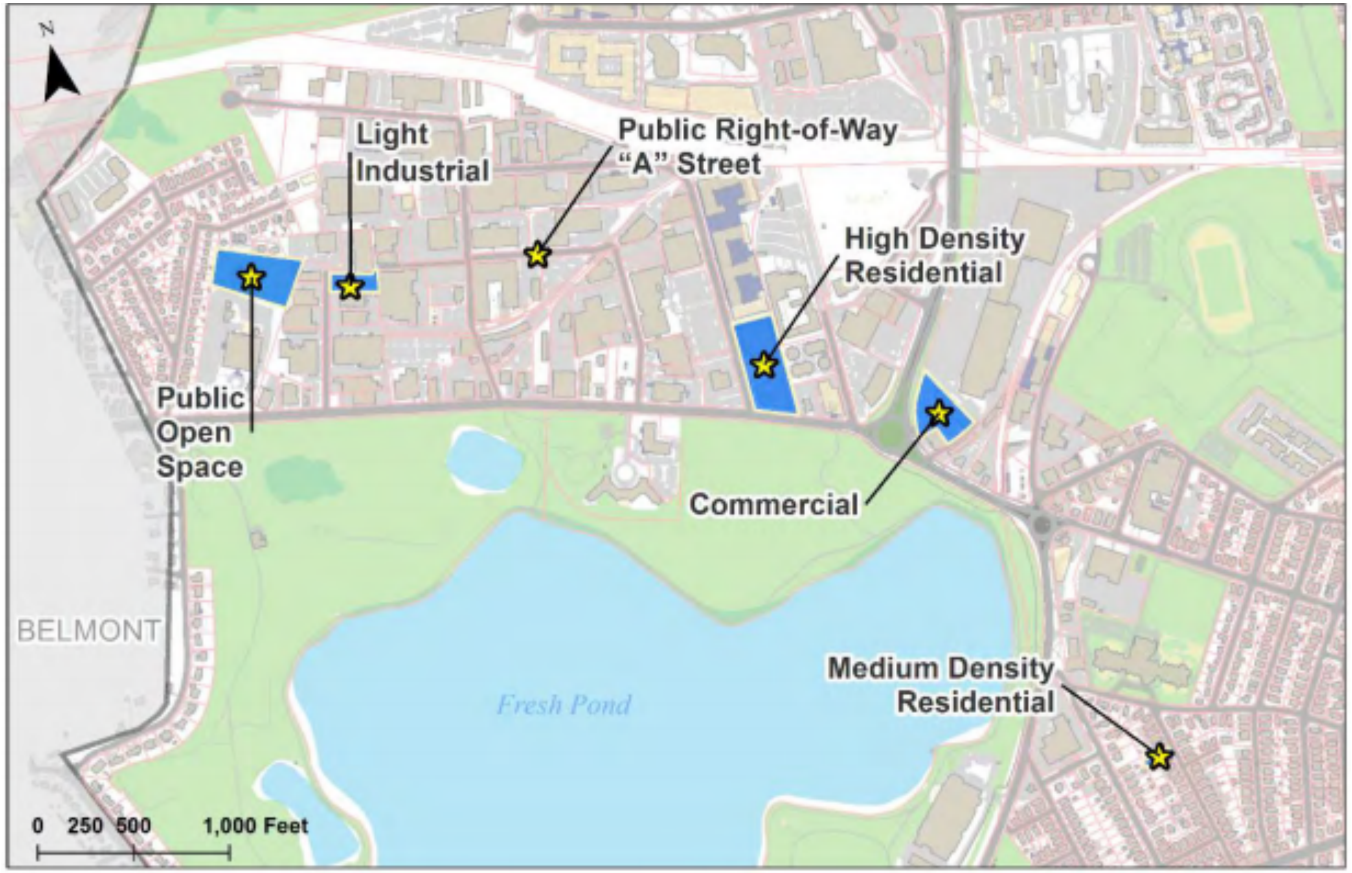
Reduction of 25-50% in impervious surface diminishes flooding for the 2030 10-yr storm



No Action **with 25% Reduction** **with 50% Reduction**

Source: CCPR, City of Cambridge, 2017

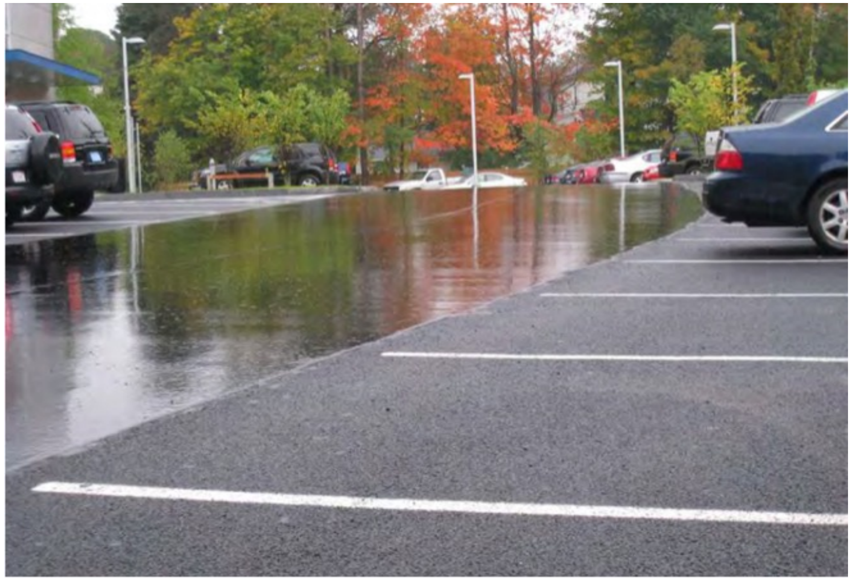
Choosing Green Infrastructure by Land Use Type and Ownership



GI solution types	Bioretention Basin	Porous Pavement	Green Roof	Subsurface Infiltration Chamber
Medium-density Residential	✓	✓		
High-density Residential	✓		✓	✓
Commercial			✓	✓
Public Open Space	✓			
Public ROW	✓	✓		
Light Industrial	✓		✓	

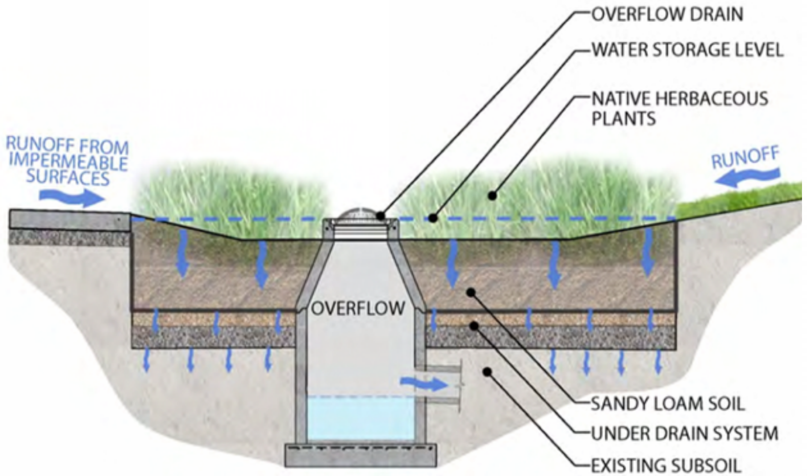
Choosing Green Infrastructure by Land Use Type

Bioretention basin in medium density residential

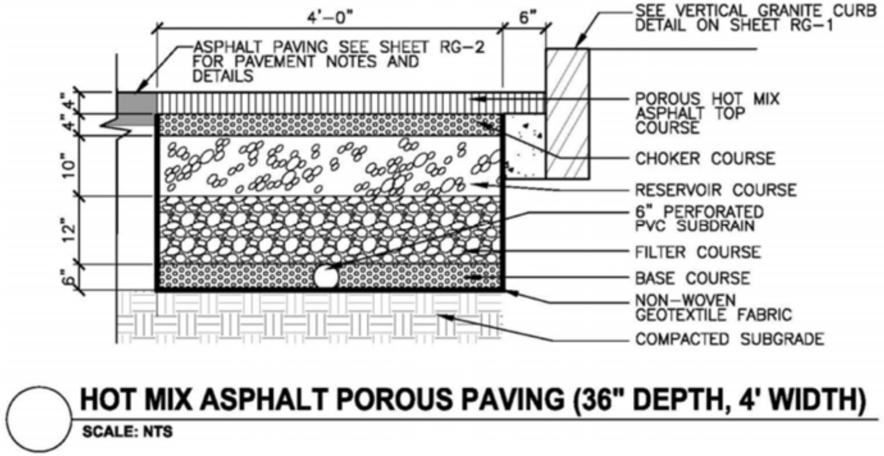


Porous asphalt in commercial parking stalls

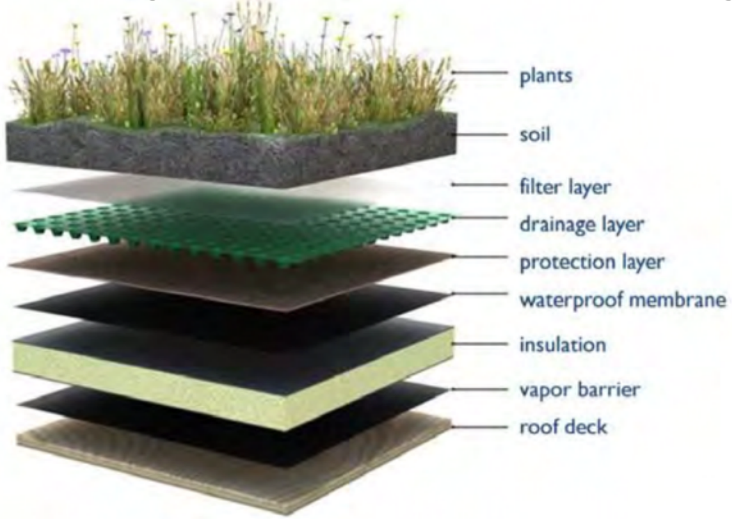
Extensive green roof on commercial buildings



Typical section of a bioretention basin



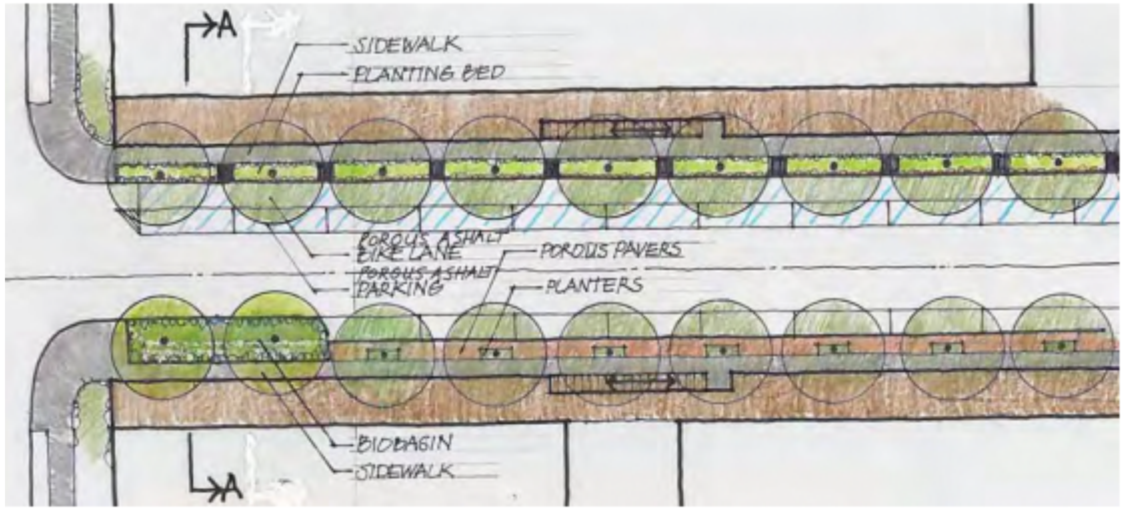
Typical porous pavement detail



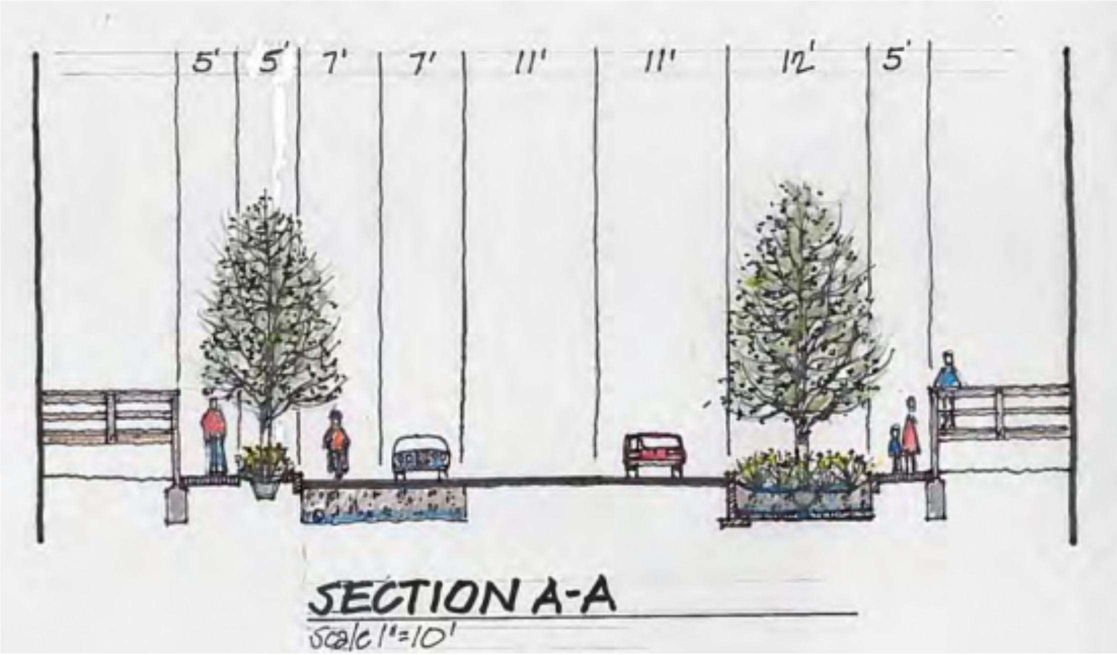
Typical green roof section

Choosing Green Infrastructure by Land Use Type

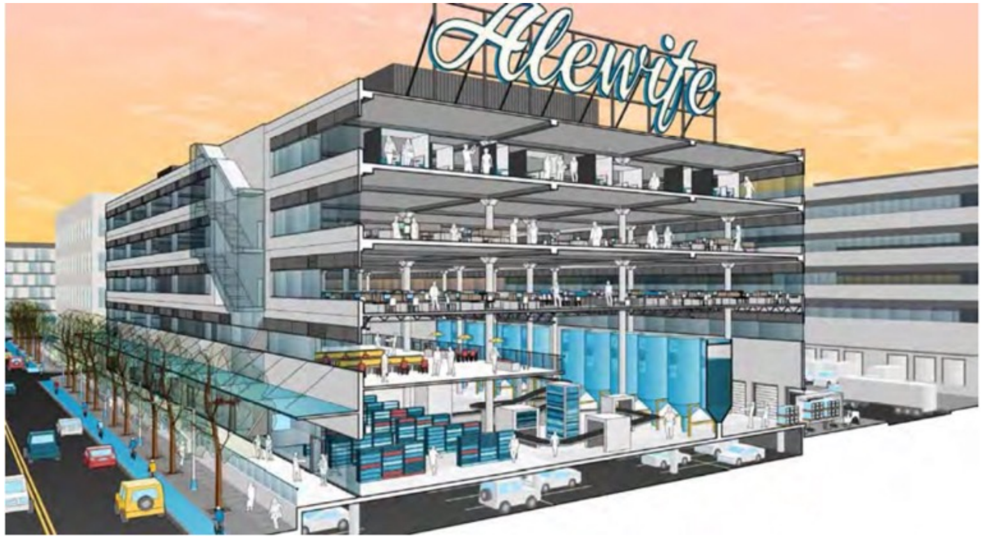
Proposed public-right of way in flood prone areas



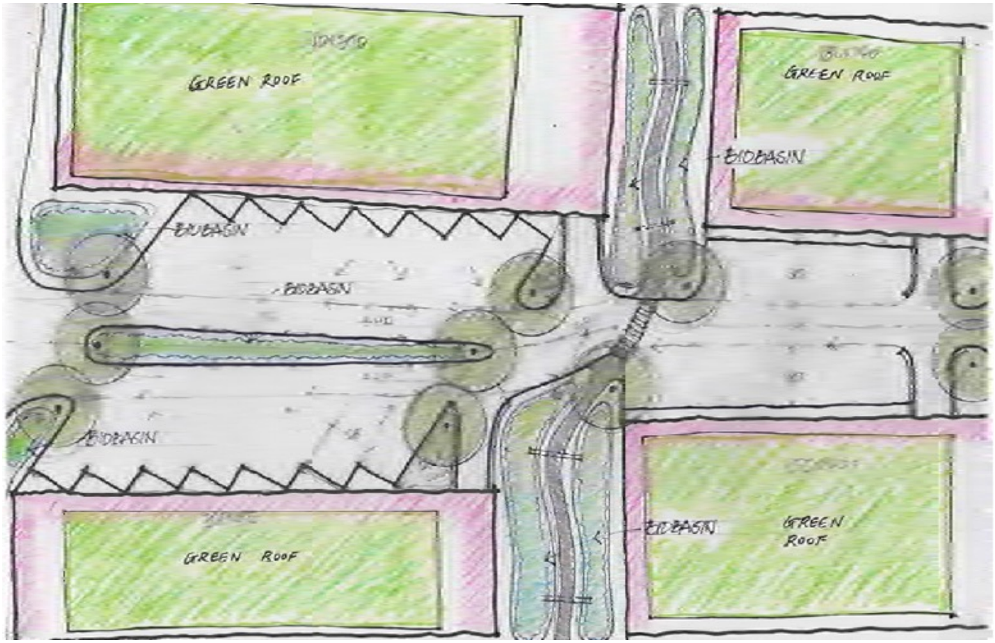
Green infrastructure concept for public right of way in flood prone areas



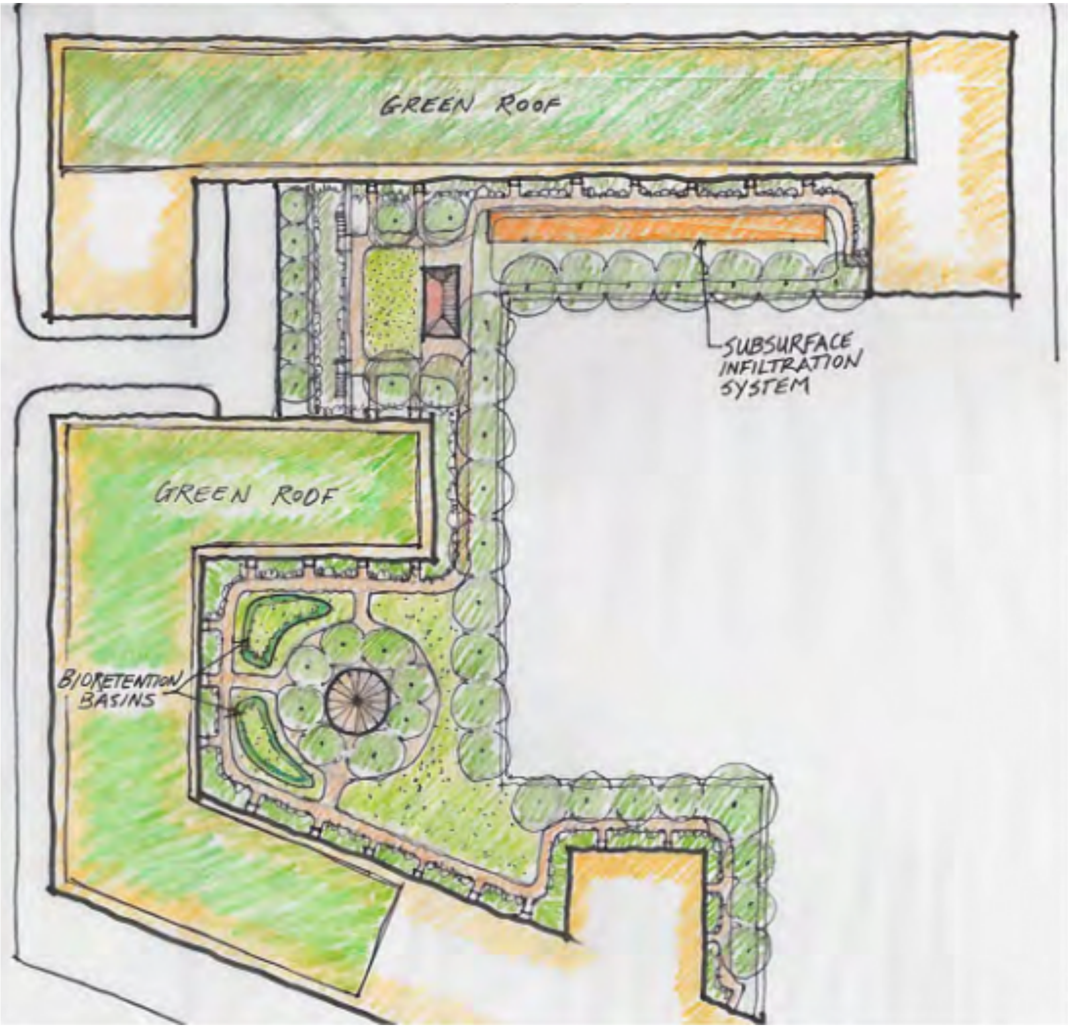
Choosing Green Infrastructure by Land Use Type



Rendering of proposed light industrial building



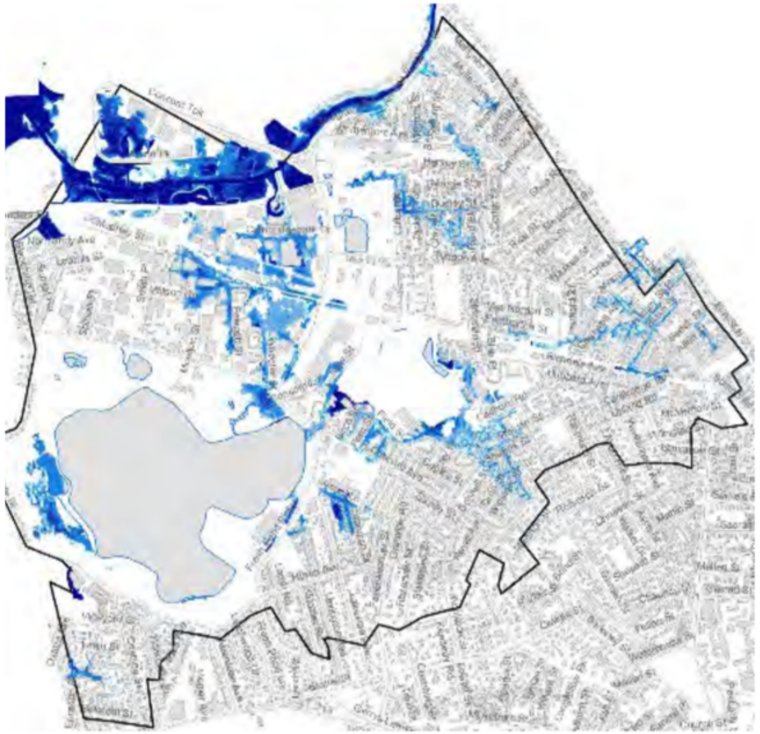
Green infrastructure concept for light industrial parcel



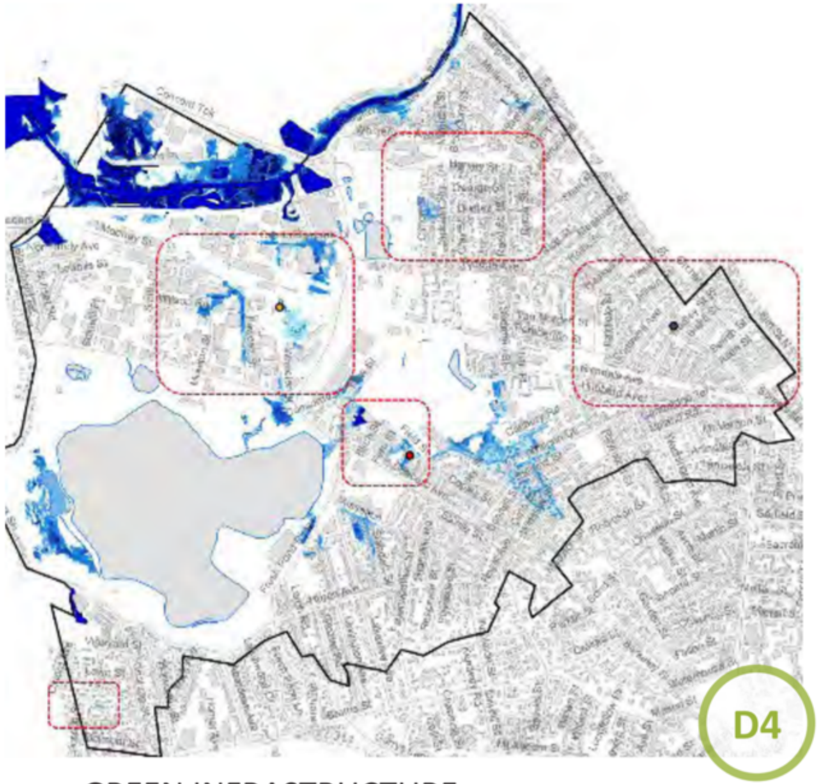
Green infrastructure concept for high-density residential parcel

Flood Reduction from Collective Implementation Of Green Infrastructure

10-YEAR FLOODING IN 2070



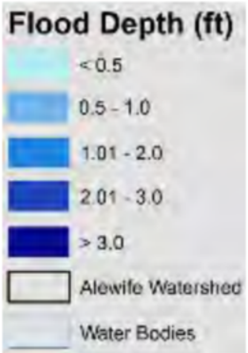
AS-IS INFRASTRUCTURE



GREEN INFRASTRUCTURE

GREEN INFRASTRUCTURE TO MITIGATE FLOODING

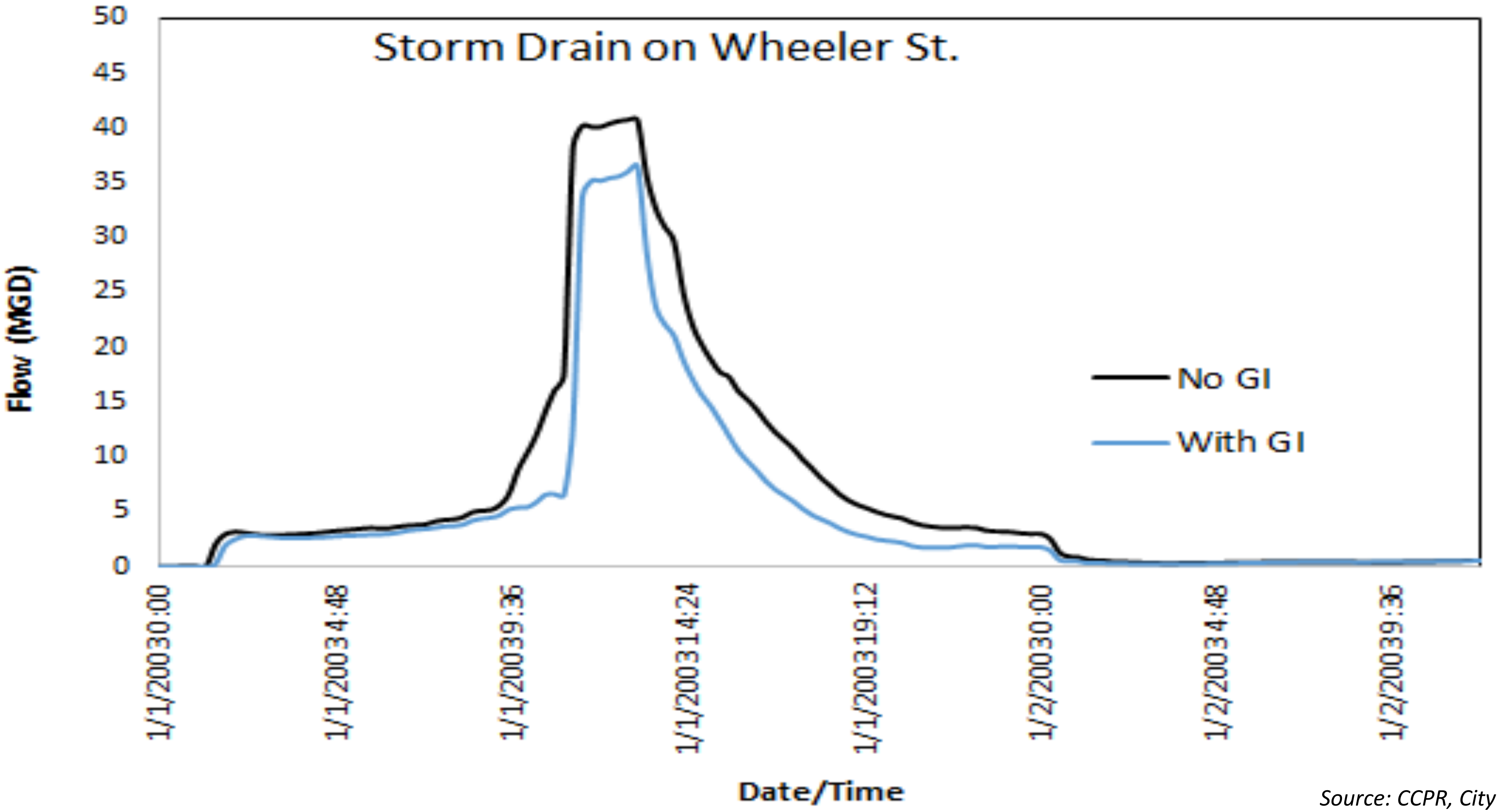
Flood volume for the 10-year 24-hour storm in the Alewife area is projected to increase from approximately 13 MG in the present to 33 MG by 2070. Implementation of the green infrastructure solutions at the Maximum Extent Practicable (MEP) scale in the Alewife area can reduce flooding extent by 37% to approximately 21 MG of flood volume.



[Source: CCPR, 2017]

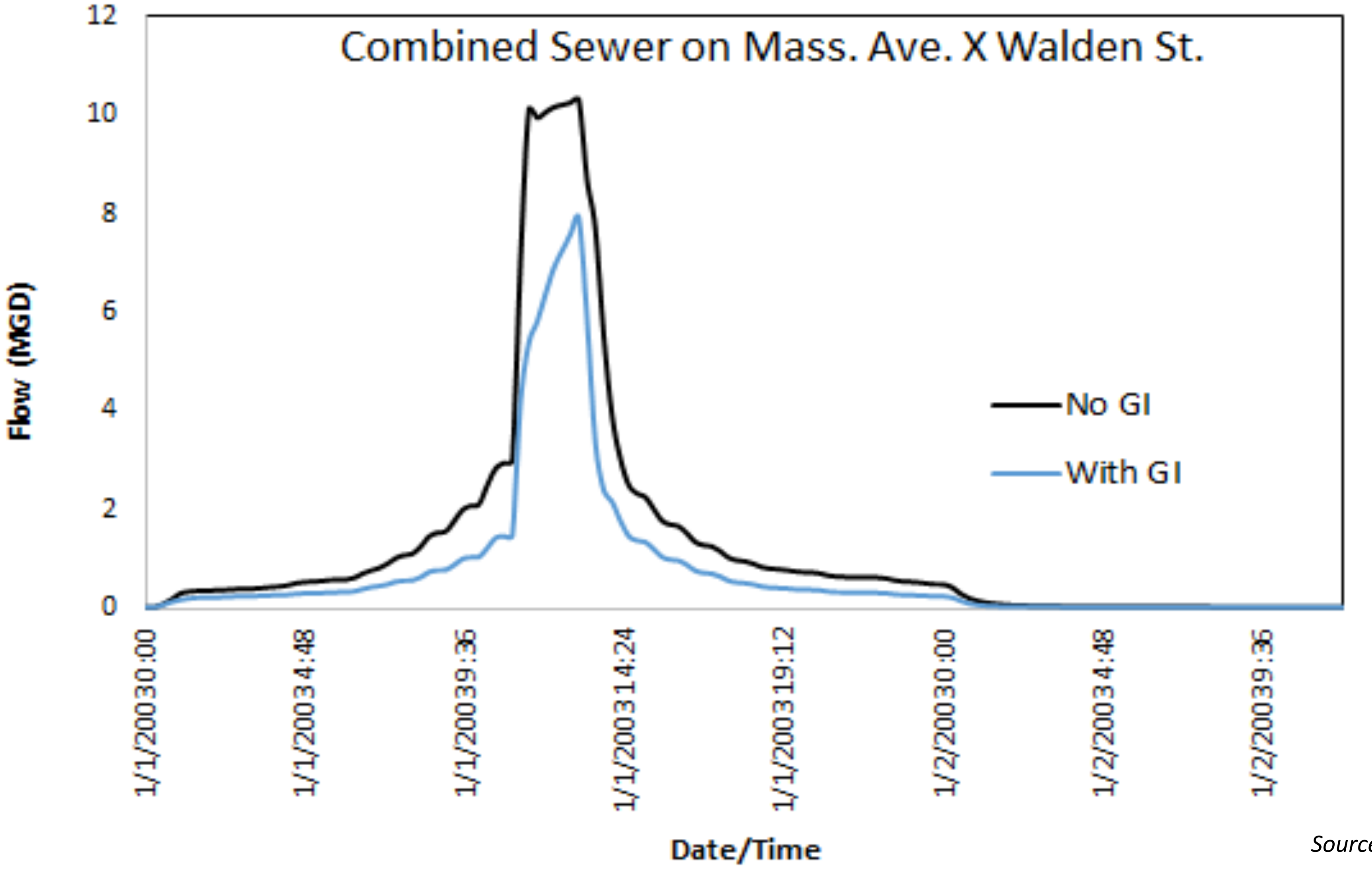
Source: CCPR, City of Cambridge, 2017

Flood Reduction from Collective Implementation Of Green Infrastructure



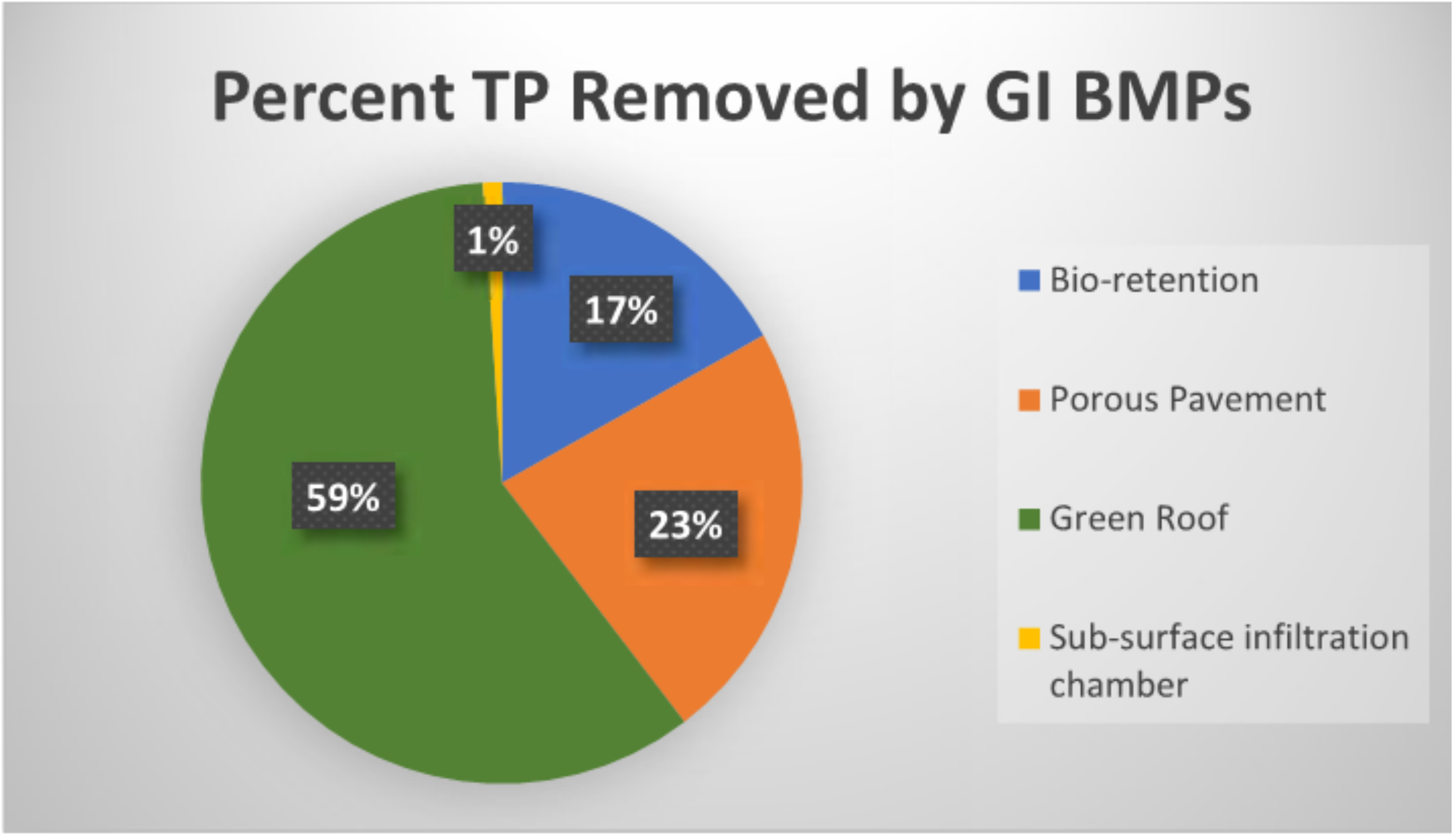
Source: CCPR, City of Cambridge, 2017

Flood Reduction from Collective Implementation Of Green Infrastructure



Source: CCPR, City of Cambridge, 2017

Water Quality Benefits of Green Infrastructure



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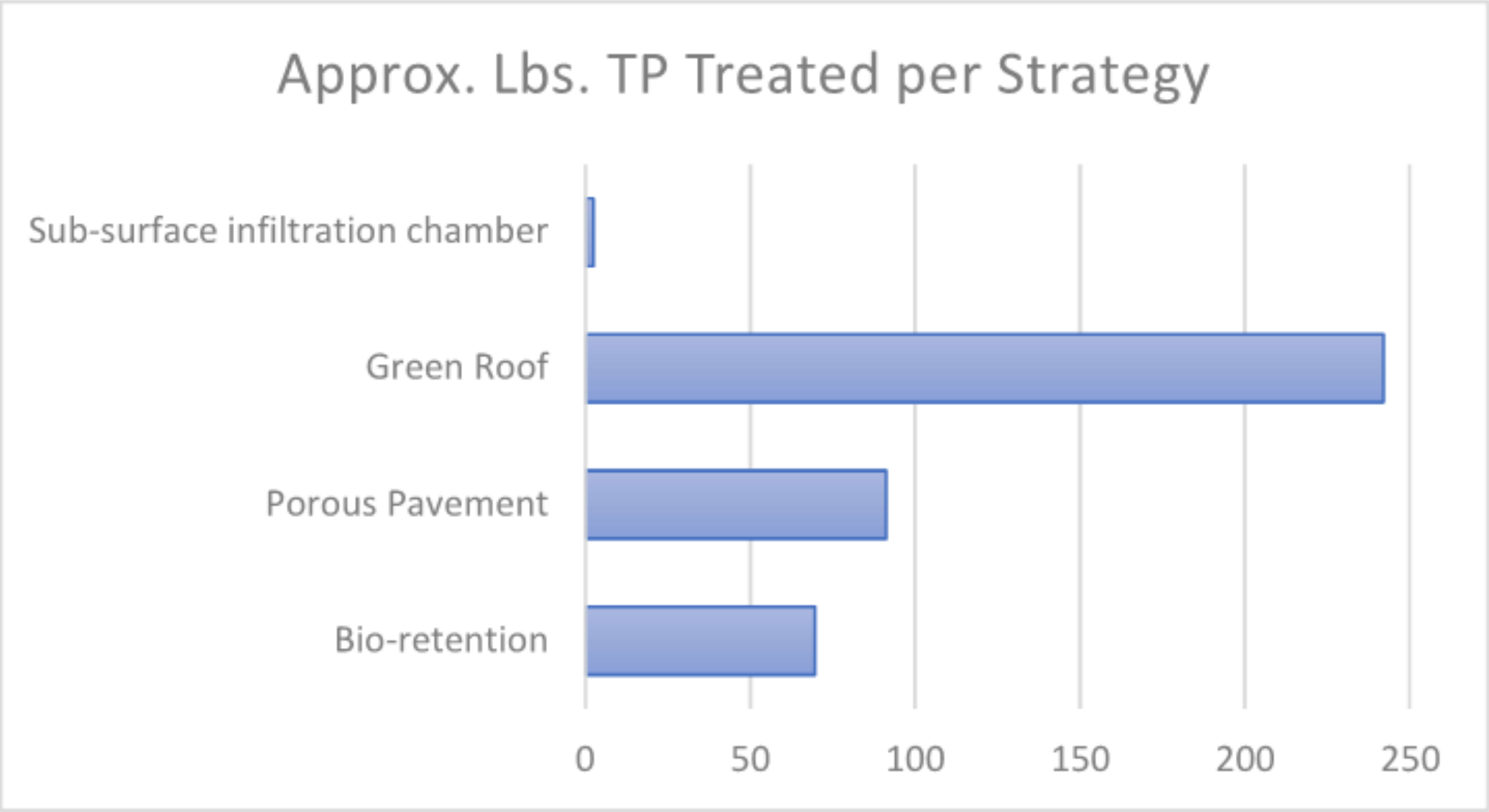
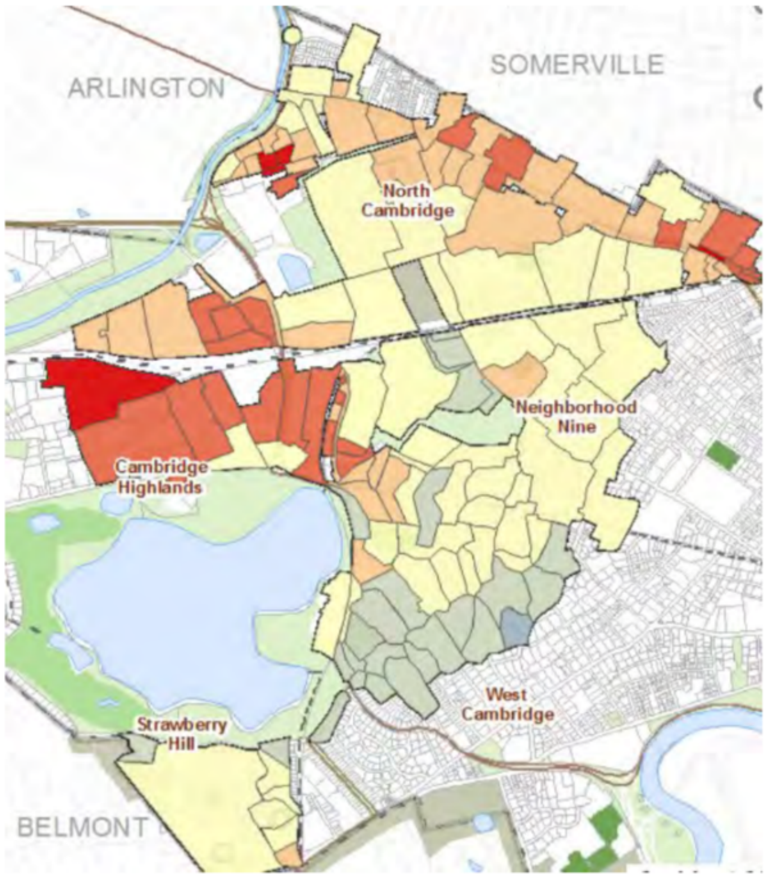


Source: CCPR, City of Cambridge, 2017

UHI Reduction from Collective Implementation Of Green Infrastructure

UHI PER CATCHMENT AREA



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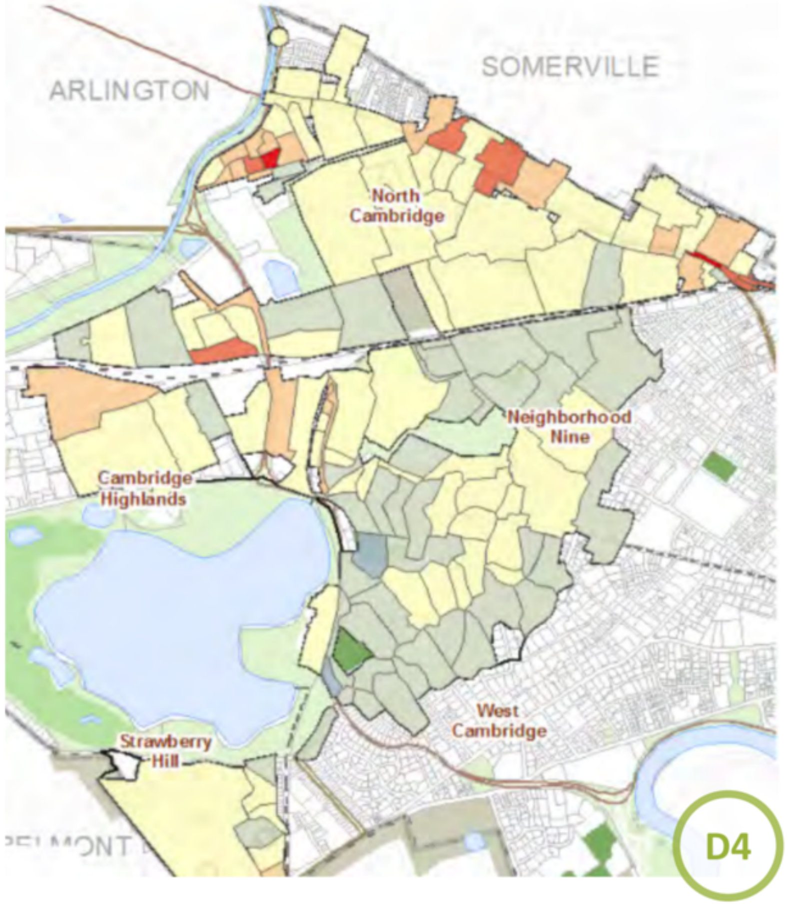
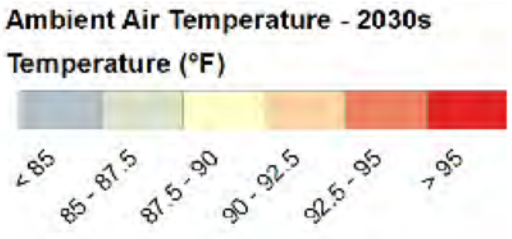


GREEN INFRASTRUCTURE

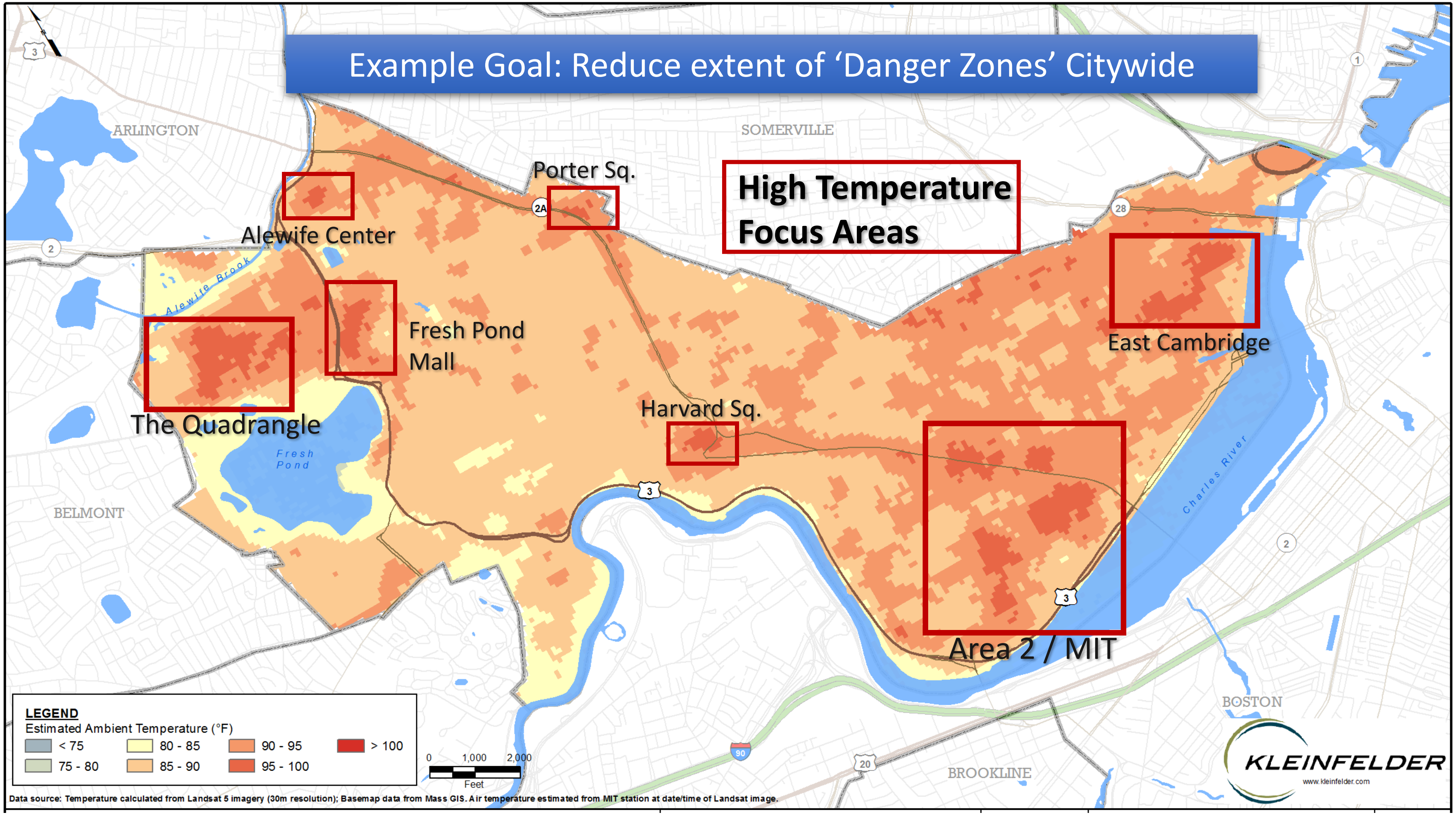
GREEN INFRASTRUCTURE TO MITIGATE URBAN HEAT ISLAND EFFECT

Green Infrastructure such as biodentention basin, porous pavement and green roofs may reduce ambient temperature by 0.1°F - 6°F, with an average temperature decrease of 1.7°F.



[Source: CCPR, 2017]

Impact of Trees as Part of Resilient Ecosystem



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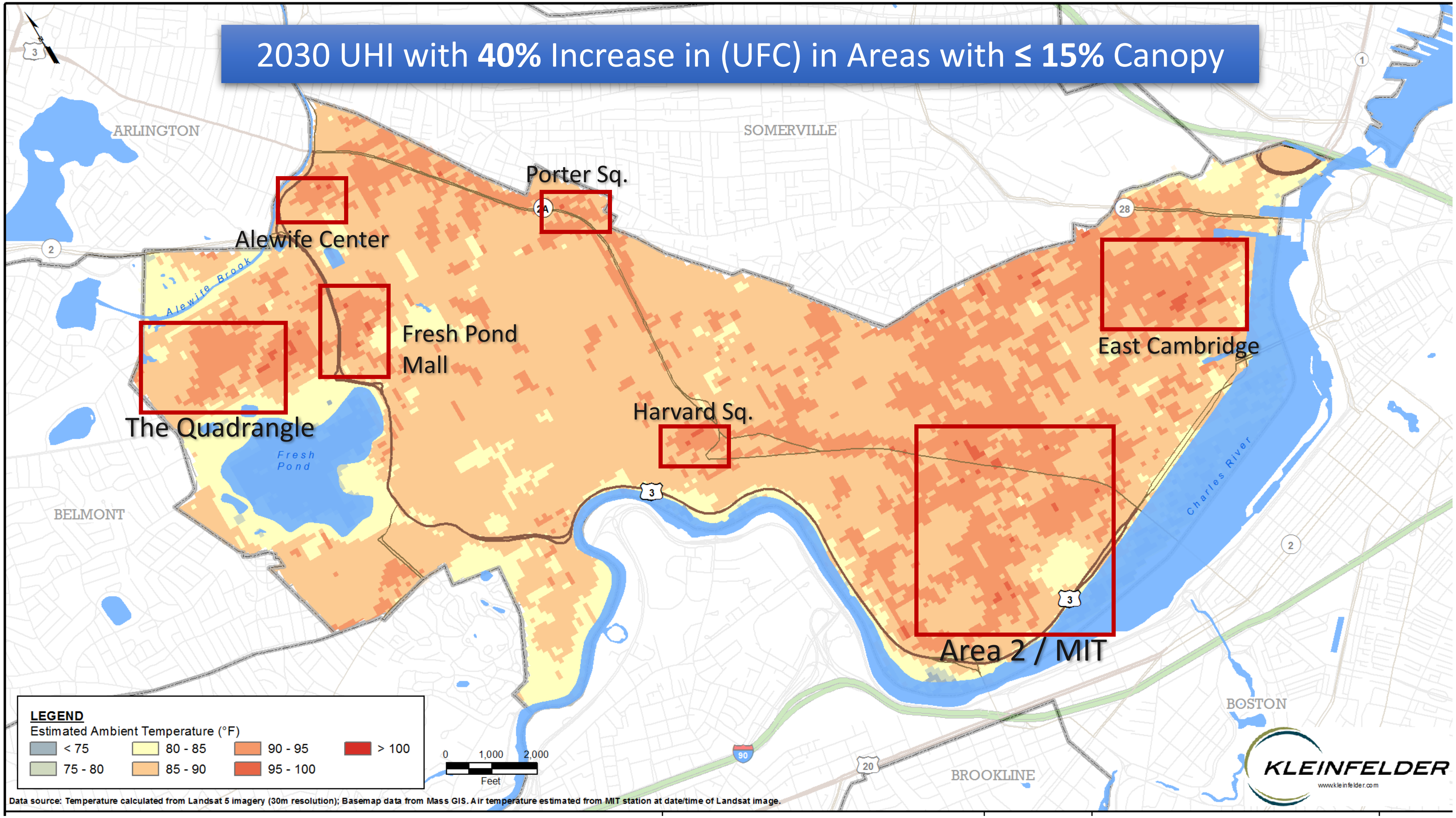

Cooling Impact Relative to Streetscape

A.

B.

C.

Conclusions

- Determine climate change impacts that need to be mitigated and select green infrastructure strategies appropriately.
- Green infrastructure can reduce the risk of flooding by increasing pervious surfaces capable of infiltrating runoff to groundwater, slowing the rate of discharge to existing stormwater infrastructure, and capture of precipitation into green roof and bioretention systems.
- At aggressive levels of implementation, green infrastructure can reduce peak volume of flooding exacerbated by climate change, as well as reduce peak flowrates to combined sewer and stormwater systems. However, grey infrastructure upgrades and building modifications are also needed.
- At aggressive levels of implementation, green infrastructure improves water quality and mitigates urban heat island (UHI) effects.
- Targeted increase of urban tree canopy significantly contribute to mitigate UHI.

Vision for a Resilient Neighborhood

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