Transcending Municipal Boundaries - Implementing Resiliency at Watershed Scale

2024 NEWEA Spring Meeting

Indrani Ghosh, Ph.D.

May 22, 2024
Newport, Rhode Island

Charles River Watershed Association

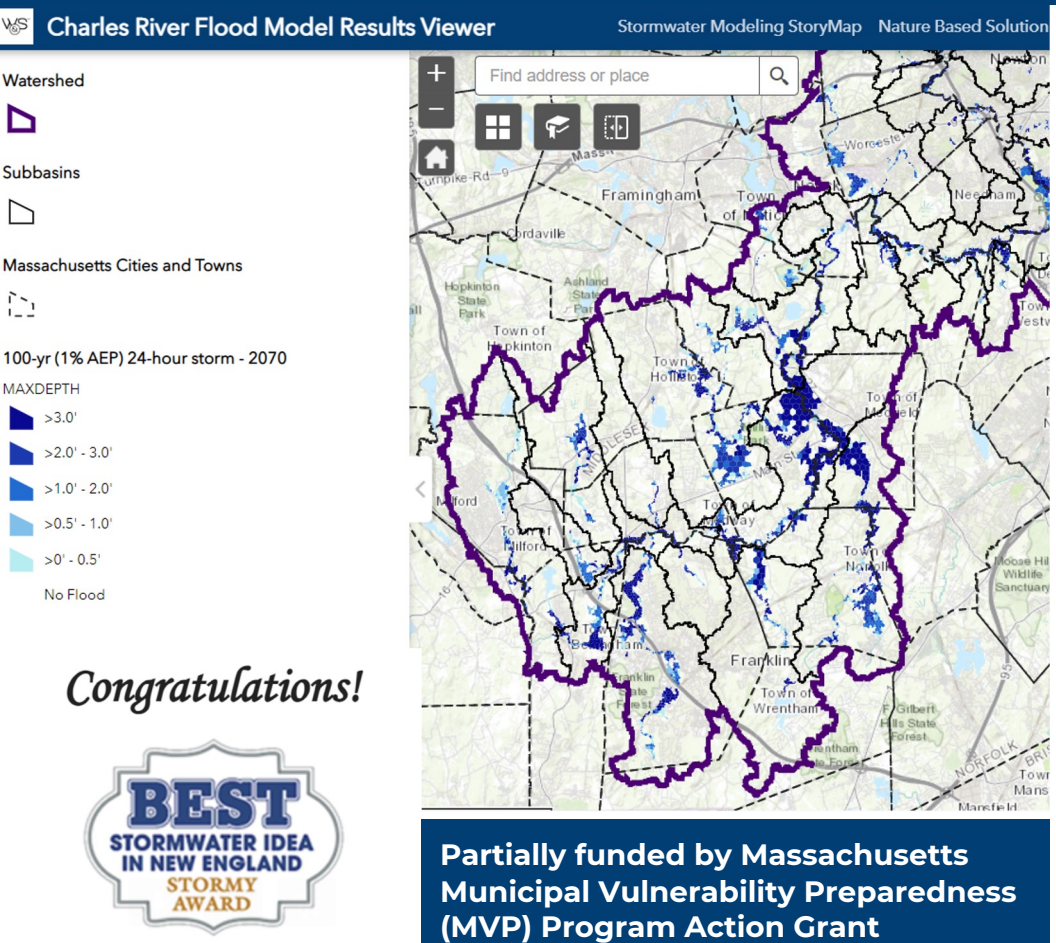
Charles River Climate Compact

Weston & Sampson

Charles River Flood Model

Weston & Sampson

Charles River Watershed Association



Partially funded by Massachusetts Municipal Vulnerability Preparedness (MVP) Program Action Grant

PROJECT TEAM:

Charles River Climate Compact

CREW Communities Responding to Extreme Weather

Weston & Sampson

Charles River Watershed Association

- Arlington
- Belmont
- Boston
- Brookline
- Cambridge
- Dedham
- Dover
- Franklin
- Medfield
- Medway
- Millis
- Natick
- Needham
- Newton
- Sherborn
- Waltham
- Watertown
- Wellesley
- Weston
- Wrentham

Presentation Outline

- Our Approach
- Public Engagement
- Model Development
- Flood Risk Results
- Flood Mitigation Solutions
- Next Steps





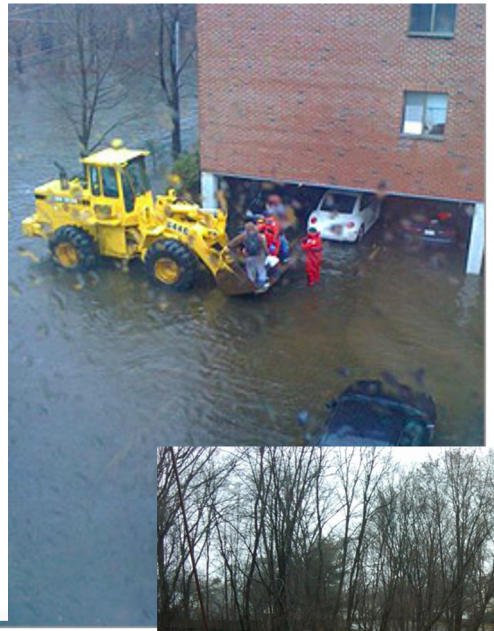
Climate change isn't coming —it's here.

Weston & Sampson℠

Charles River Watershed Association

Photo by Yari Korchnoy

99 Linden St., Waltham



Godfrey Brook, Milford

Charles River, Newton

Mill River, Norfolk

Our Approach

How do we plan for what's coming if we don't know what's coming?

- In Massachusetts, land use decisions are almost exclusively made at the local level.
- The Charles River watershed, just 308 square miles, includes 35 different municipalities, that is 35 different decision making processes
- The **watershed scale is the most appropriate** geographic scale to consider when investigating precipitation-based flooding impacts.
- Taking a watershed view provides the **opportunity to equitably address flooding** concerns by considering upstream impacts on downstream communities.

Community Engagement

Weston & Sampson℠

Charles River Watershed Association

MEETING THE MOMENT

2021 (Phase I)

Upper Charles River

Middle Charles River

Lower Charles River

ALL VIRTUAL!!

COVID Pandemic

Virtual, regional events

2022 (Phase 2)

Re-emergence / Cautious connection

Return to in-person; already existing events; local approach

2023 (Phase 3)

Invited to and presented at regional conference - Cross-pollination! Learning from others!

Partnered with language services and provided support for 10 events (in-person, virtual, translated materials)

Expansion / Exploration

New partnerships, methods, events; Cross-watershed collab

CREW Communities Responding to Extreme Weather

Model Development

1 Dimensional Framework

Generate **runoff**; convey non-flood **flows**

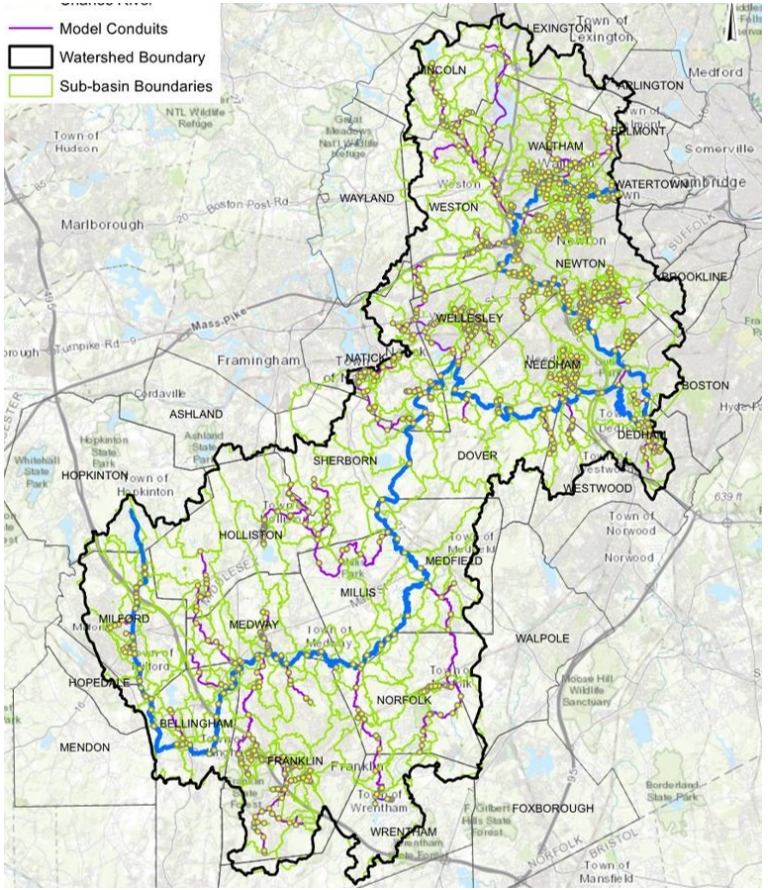
272 square miles of the watershed

Over **1,400** junctions

1,279,838 LF of dams, culverts, bridges, crossings, drains, overtopping conduits modeled

Over **700** sub-catchments

Over **30** storage volumes



Field Verification

6 days of site visits

119 junctions/nodes

25 dams

298 crossings

442 structures field verified

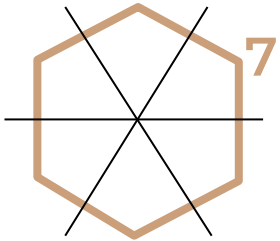
Used ArcGIS Collector App to record notes, measurements, and take photos

Model Development

Weston & Sampson

Charles River Watershed Association

2 Dimensional Cells



7,748 – 2D cells created from LiDAR

Identify appropriate resolution

Convey flood flows; provide floodplain storage

Define boundary areas

Weston & Sampson

Model Calibration

Calibrated to the March 2010 Storm

Based on 15-min data from the USGS gage on Stony Brook

8.99 inches

58.5 hrs

Peak intensity

0.68 in/ hr

Approximately a **65**-yr

48-hr event

*Flooding was close to **100-yr** or even worse in places due to the saturated ground, preceding rainfall, and snowmelt*

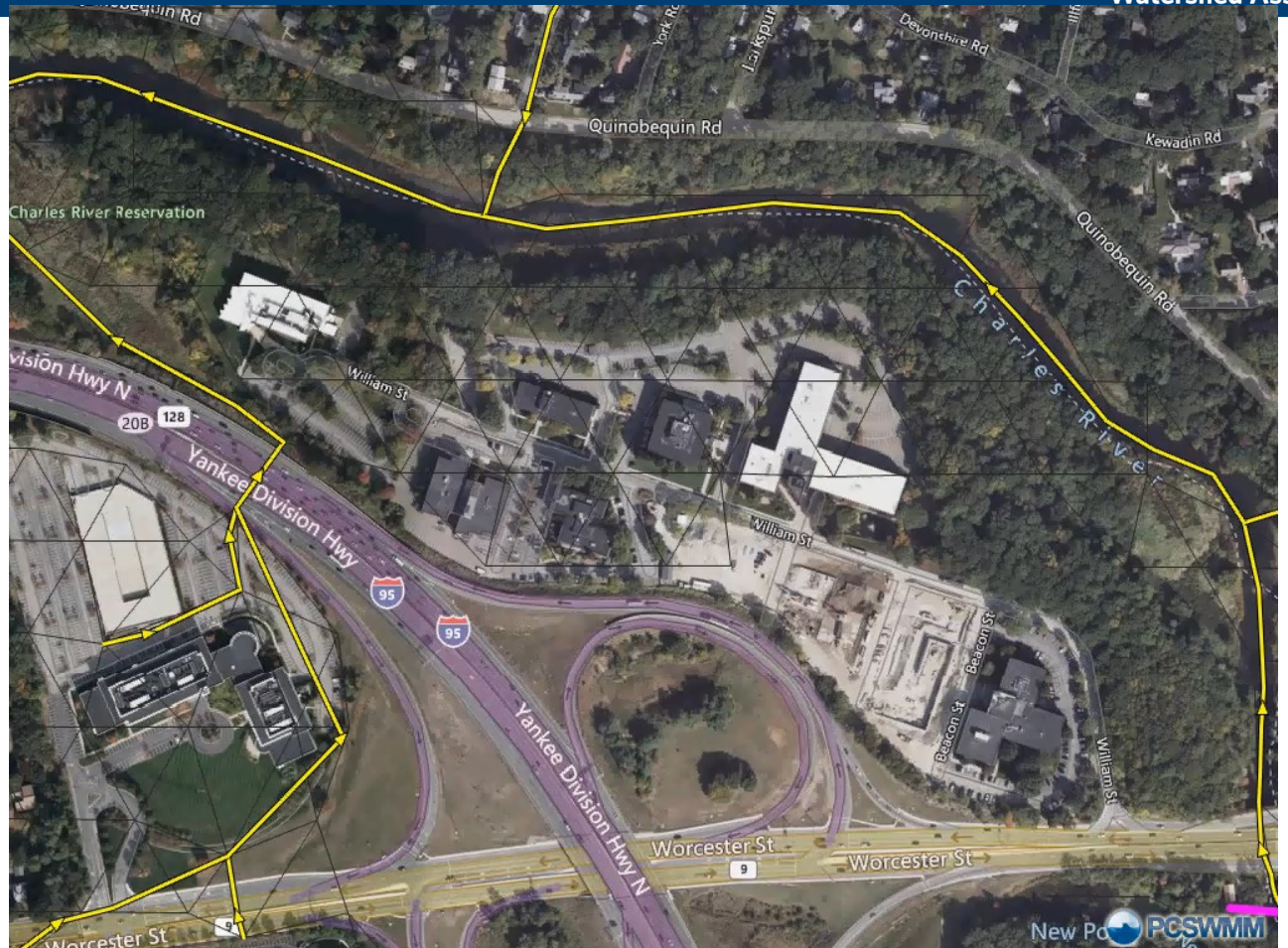
Model was calibrated at 5 locations for **3 parameters**

(runoff volume, peak flow, timing of peak)

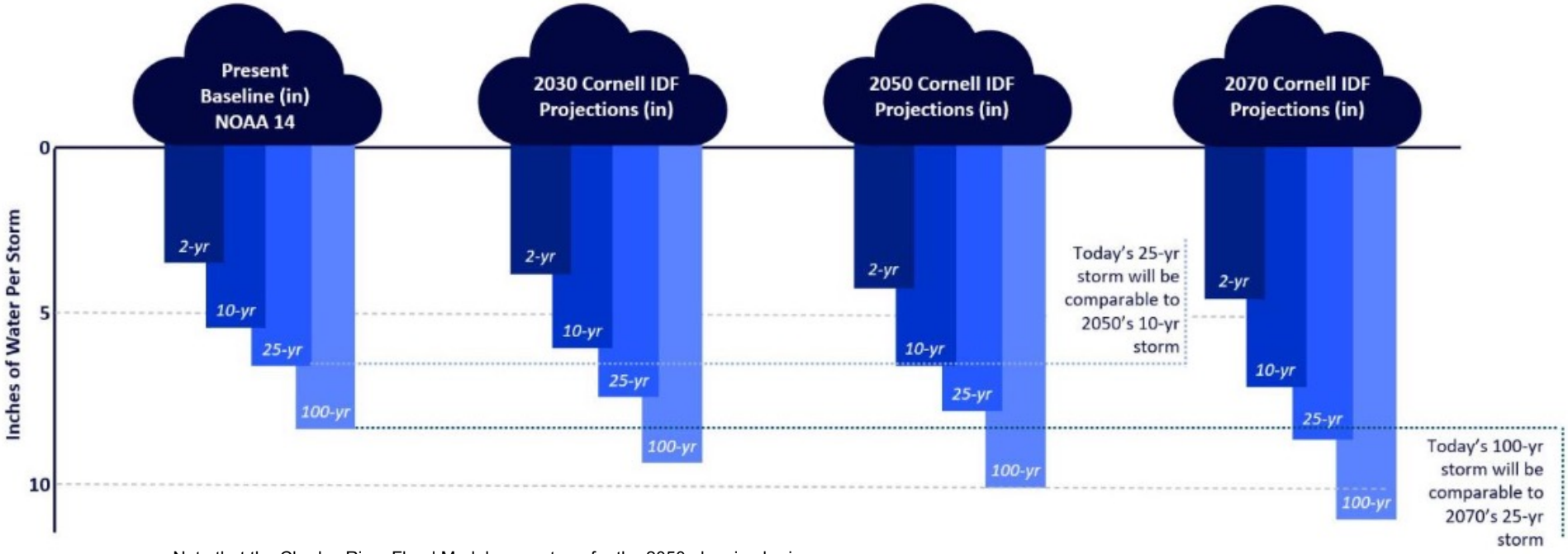
Weston & Sampson

Model Calibration

2D Flood Model Results – William St, Wellesley



Results



Note that the Charles River Flood Model was not run for the 2050 planning horizon

Just a few more inches of rainfall could **increase the Charles River's volume by millions of gallons** during a heavy storm.

Projections developed by Cornell University for EEA's Massachusetts Climate and Hydrologic Risk Project, integrated into EEA's Climate Resilience Design Standards Tool (version 1.2)

Results

Weston & Sampson℠

Charles River Watershed Association

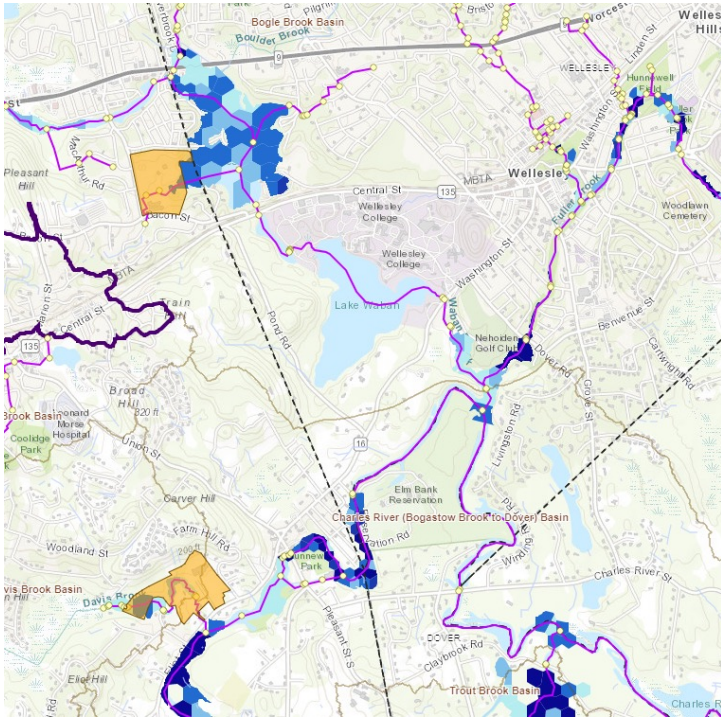
Model Results: 100-year Storm Comparison

Legend

10-yr (10% AEP) 24-hr storm Max Depth

- >3.0’
- >2.0’ – 3.0’
- >1.0’ – 2.0’
- >0.5’ – 1.0’
- >0’ – 0.5’
- No Flood

- Model Conduits
- Watershed
- Subbasins
- All Site Parcels



100-yr Storm Present
(8.2 inches in 24 hrs)

100-Year Storm, *Present Day*

8.19 inches

in 24 hours

IMPACT

11,991 acres of flooding

18,644 million gallons (MG) of runoff

61 critical facilities

100-Year Storm, *2070*

11.11 inches

in 24 hours

IMPACT

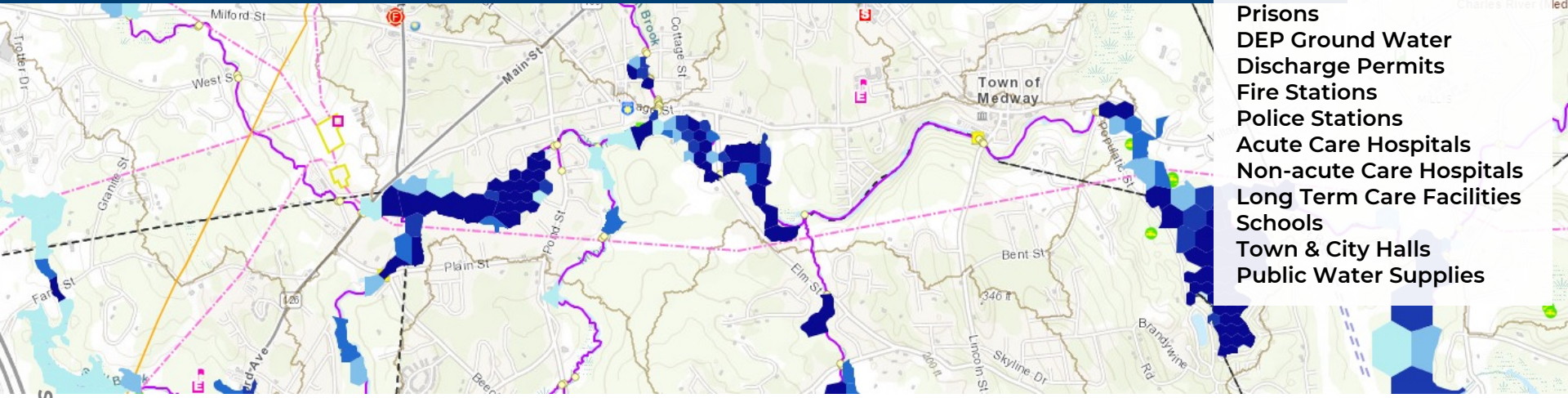
14,605 acres of flooding

29,925 million gallons (MG) of runoff

77 critical facilities

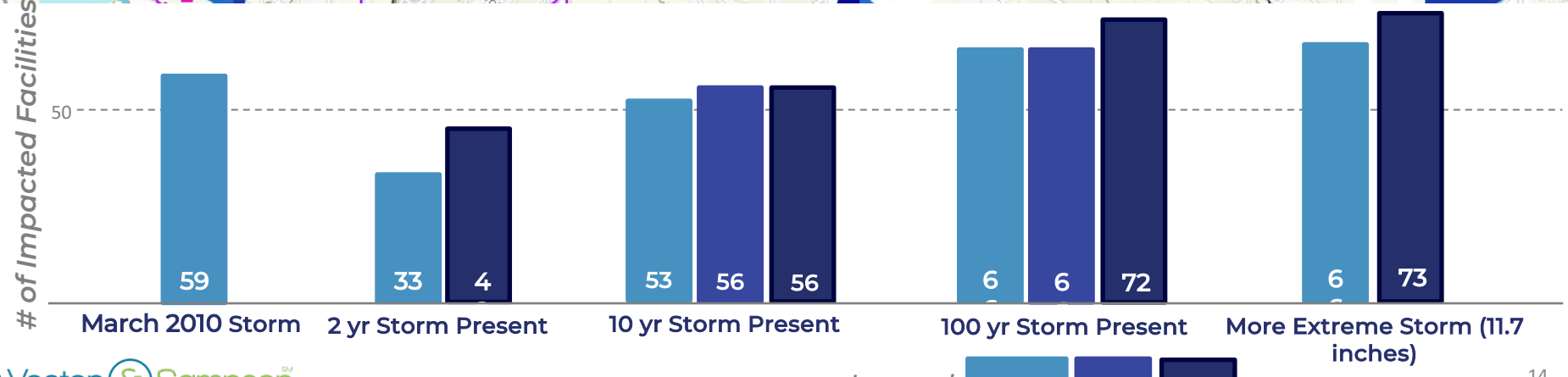
March 2010 Storm (8.99 in)	10,446 acres of flooding	20,831 MG of runoff

Flood Impacts on Critical Facilities



Type of Facilities

- Colleges & Universities
- Prisons
- DEP Ground Water Discharge Permits
- Fire Stations
- Police Stations
- Acute Care Hospitals
- Non-acute Care Hospitals
- Long Term Care Facilities
- Schools
- Town & City Halls
- Public Water Supplies



Weston & Sampson

Climate Impacts to Solutions

Weston & Sampson℠

Charles River Watershed Association

BY 2070, A 100-YEAR STORM WOULD CAUSE:

100-year storms have a **1% chance** of occurring every year.

61%

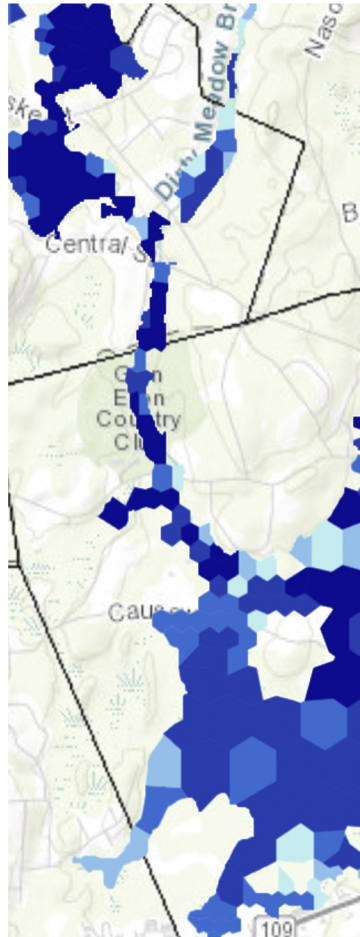
increase in runoff + 11 inches of precipitation

2,600+

acres that don't currently flood to see severe flooding

50+

critical facilities like hospitals, schools, + highways impacted



WAYS TO PREPARE FOR FUTURE FLOODING:

BUILD GREEN INFRASTRUCTURE

INCREASE TREE CANOPY

PROTECT & RESTORE WETLANDS

CONSERVE OPEN SPACE

Watershed-Wide Nature Based Solutions

Weston & Sampson℠

Charles River Watershed Association

Category	Scenario Number	Suggested: Phase 2
Green Stormwater Infrastructure	1A	GSI stores the 2-yr event (4.5 inches) from 50% of all impervious area
	1B	Target all large buildings & parking lots (public & private) for rooftop infiltration/disconnection (>5 acres) to store the difference between the (2070) 25-yr & 2-yr
Reduce Impervious Cover	2	25% reduction
Upland/Pond Storage	3	Add sites (14 sites, >20 ac.) & increase storage volume
Wetland Restoration	4	Increase wetland area around existing wetlands; increase of 20%
Land Conservation	5A	15% of remaining undeveloped/ unprotected land is developed
Regulatory	5B	Store the difference between (2070) 25-yr & 2-yr for 50% of assumed “new development”
Dam Removal	Alt B	Remove all dams other than active flood control (just remove recreation dams)

GSI = Green stormwater infrastructure

Watershed-Wide Nature Based Solutions

Scenario 1A: Use green stormwater infrastructure (GSI) to store the 2070 2-year storm (4.5") runoff from 50% of all impervious cover

Climate Scenario	Percent Change in Watershed-wide Total Runoff Volume (MG) between Scenario 1A and No Action	
	2-year event	10-year event
Baseline (Present Day)	-47%	-20%
2070	-26%	-12%

This strategy is likely to mitigate:

- Approx **1,600 MG of flooding** for the present day (baseline) 2-yr storm
- Approx **1,660 MG of flooding** for the 2-yr storm by 2070

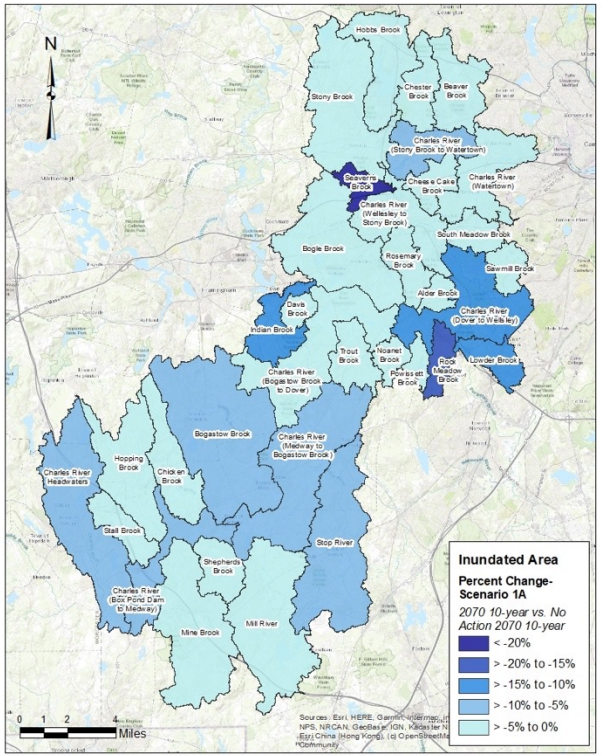
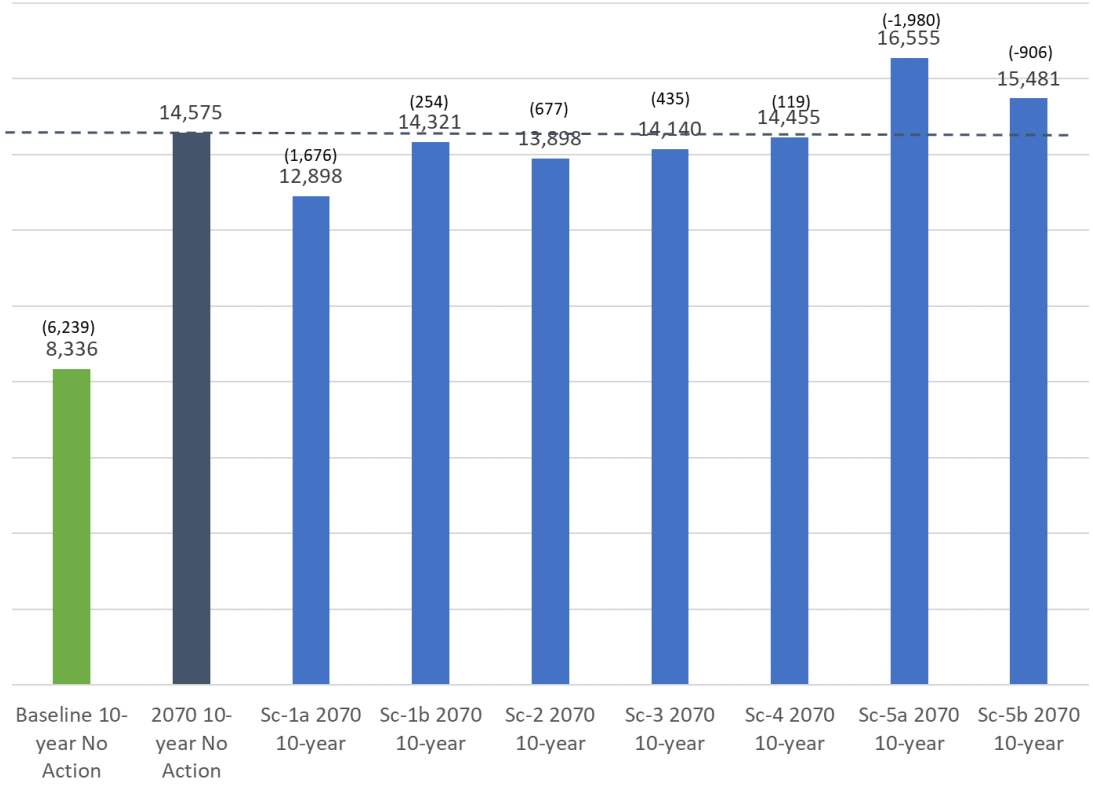


Figure: Map of the percent decrease in inundation area for Scenario 1A during the 2070 10-year event versus a No Action condition, by subbasin.

Results

Summary of Watershed-Wide Strategies

Total runoff volume during the 2070 10-year event



Building Resilience Across the Watershed

Weston & Sampson℠ | Charles River Watershed Association

Site-scale Results

Tier 1

- Site Feasibility
- Flood Reduction
- Community Support

Tier 2

- Biodiversity
- Recreation
- Permitting Feasibility
- Regional co-benefits

Example Priority Site - Solutions Explored

Weston & Sampson℠

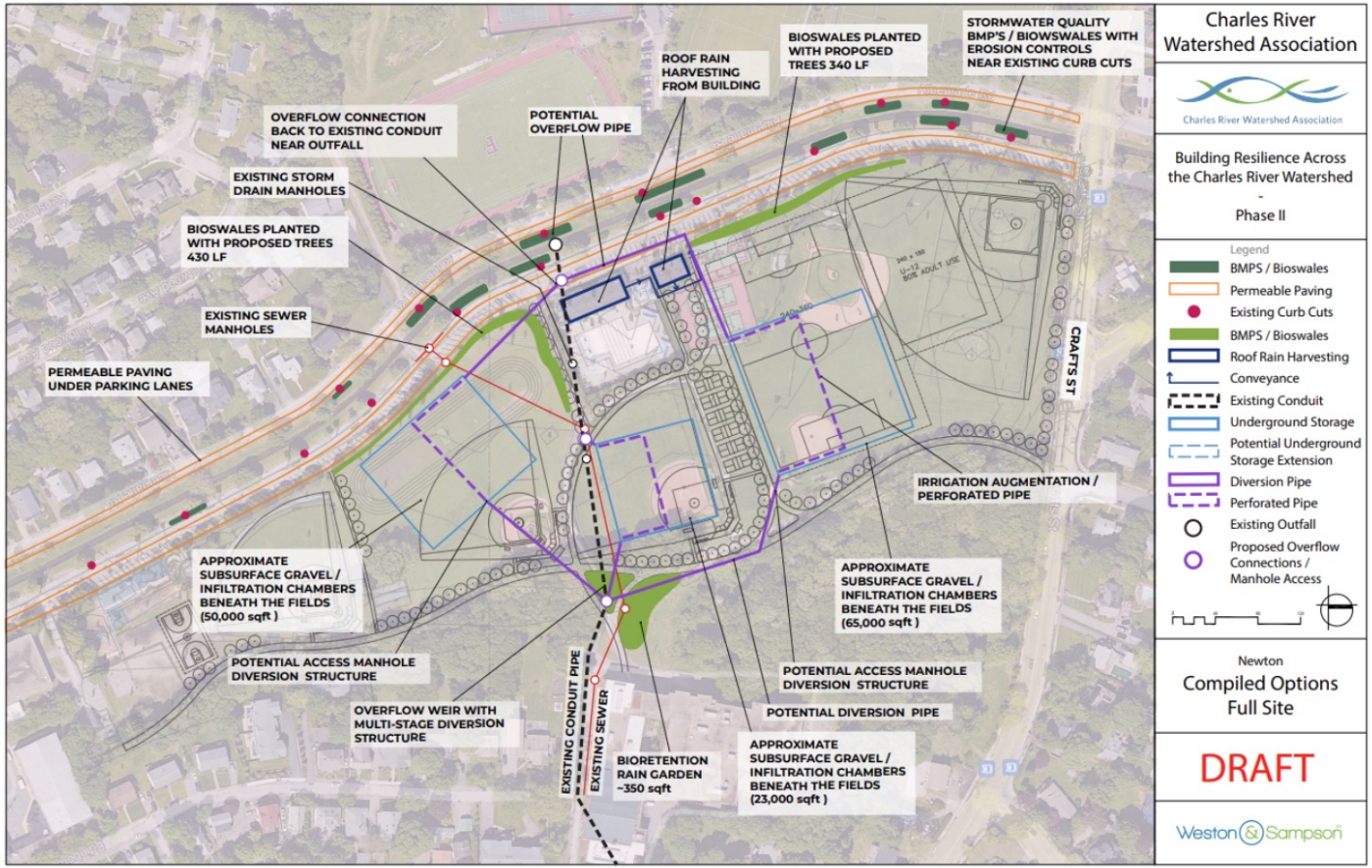
Charles River Watershed Association

Albemarle Field, Newton
Large athletic field/recreation complex for soccer, baseball, tennis and basketball.

Potential:
Underground and surface storage, with stream buffer improvements

Example Priority Site - Solutions Explored

- Diverting stormwater from an existing conduit
- Sub-surface gravel infiltration chambers beneath the playing surfaces
- Bioswales with trees



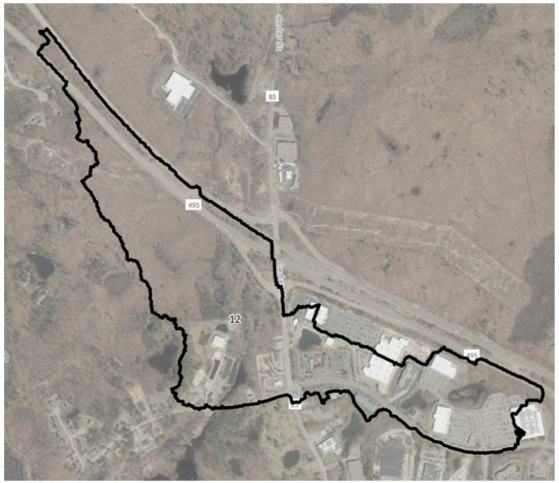
Concept plan for Albemarle Field, Newton created by Weston & Sampson

Priority Impact Areas

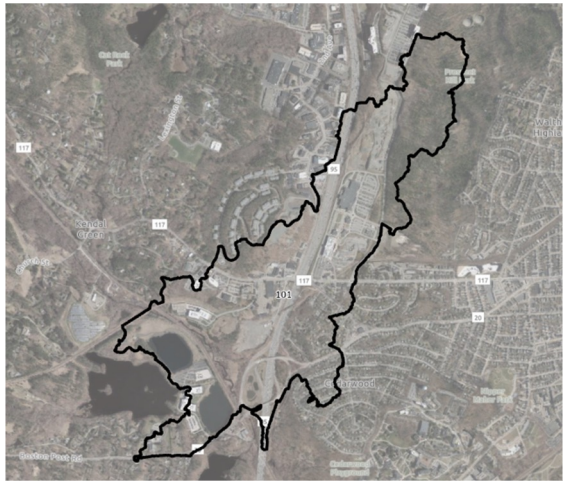
Weston & Sampson℠

Charles River Watershed Association

Upper & Lower Watershed Priority Impact Areas



Milford



Waltham/Weston

Data source: Weston & Sampson GIS & MassGIS 2019 Aerial Imagery

CURRENT PRIORITY PROJECTS:

WALTHAM

Restoring wetlands in Hardy Pond to store floodwaters in extreme weather and designing green infrastructure, infiltration, and de-paving in the priority impact area of west Waltham.

NEWTON

Building green infrastructure + infiltration chambers on Albemarle Field to reduce flash flooding of nearby channelized stream, Cheesecake Brook.

WESTON

Maximizing benefits of green infrastructure, pervious pavement, infiltration, and flood storage in the priority impact area of Weston Town Center.

WELLESLEY

Restoring Longfellow Pond and Rosemary Brook using wetland restoration, and culvert repair to prevent flooding on Rt. 9 + surrounding neighborhoods.

NATICK

Constructing infiltration chambers, adding rain gardens, and restoring wetlands to prevent future flooding at Natick High School.

MEDWAY

Building green infrastructure + flood storage in Oakland Park to build climate resilience, restore groundwater, and reduce flooding.

MILFORD

Maximizing benefits of protected open space, constructed wetland, stream restoration, de-paving, and permeable pavement in the priority impact area of north Milford.

Approach to Choosing Solutions

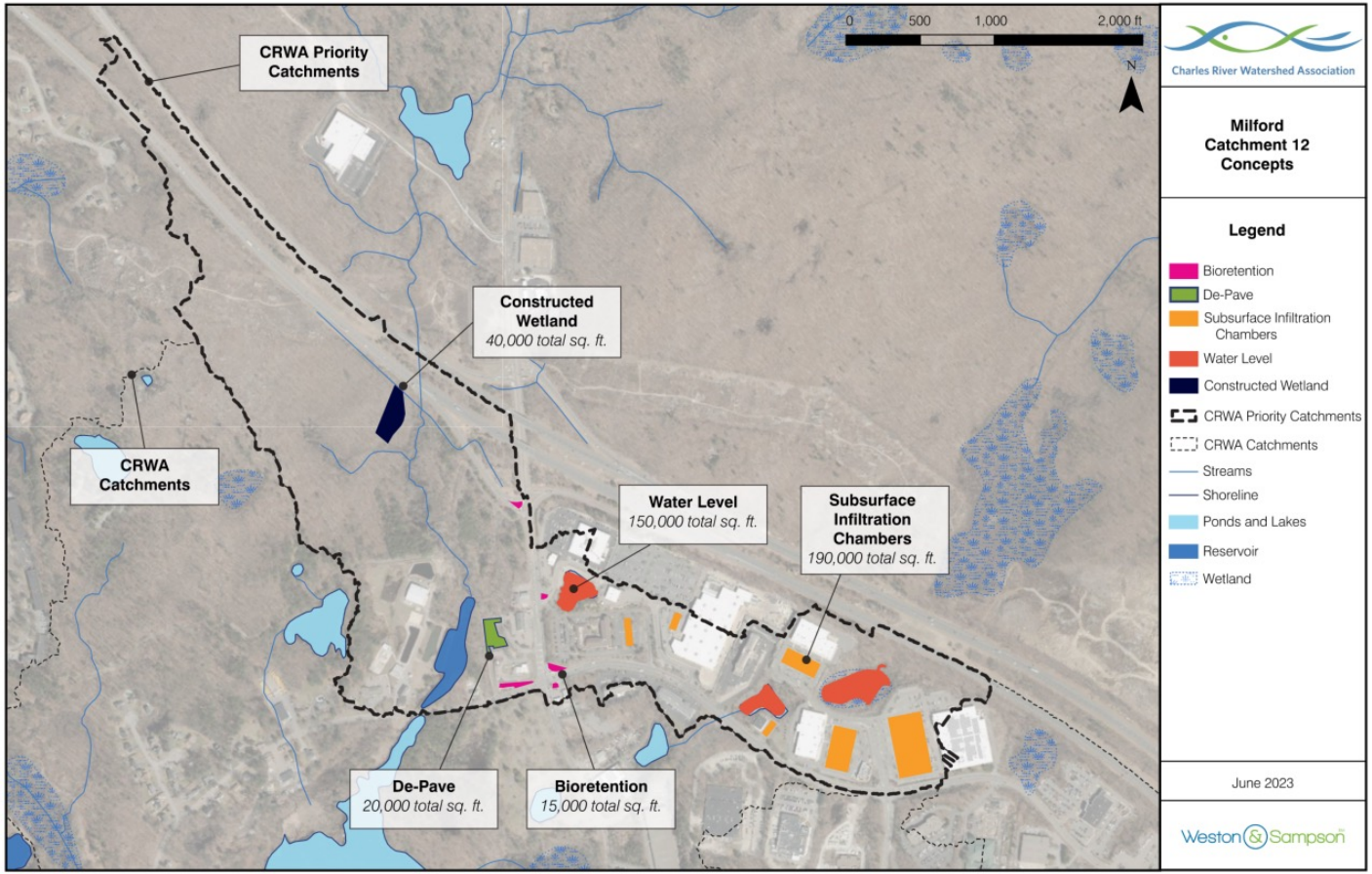
Weston & Sampson℠ Charles River Watershed Association

WAYS TO PREPARE FOR FUTURE FLOODING:

In developing concepts for Impact Areas and Priority Sites, the goal was to maximize the potential use of nature-based solutions and green stormwater infrastructure (beyond "maximum extent practicable").

As we received feedback from municipal staff and the public, constraints and limitations that would affect implementation were conveyed, and concepts were updated accordingly.

Upper Watershed Impact Area



Solutions Explored

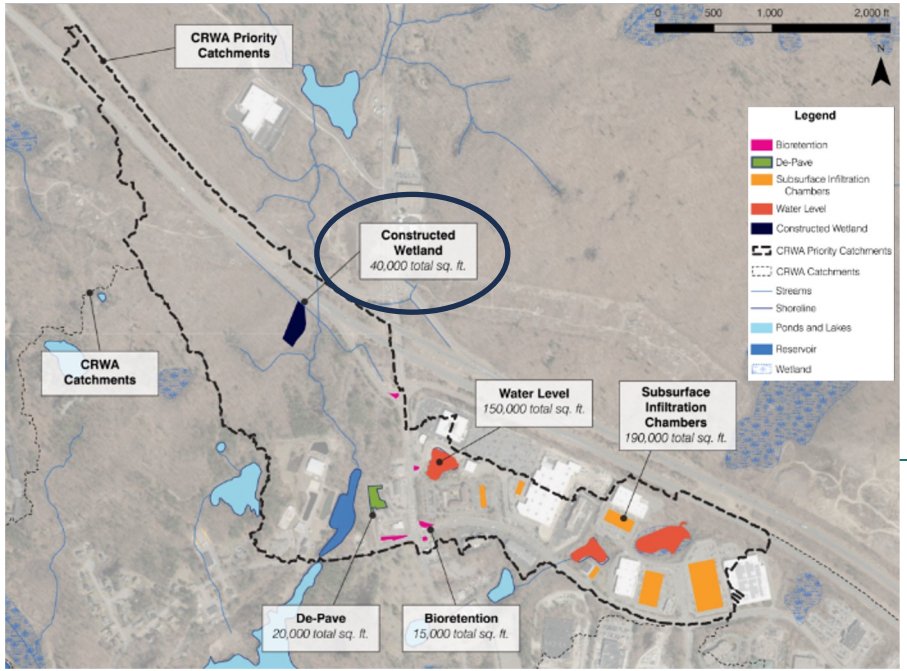
- Subsurface infiltration and storage underneath parking stalls
- Retrofit stormwater ponds to increase capacity
- Stream restoration
- Bioretention
- Approx. **9.5 ac** available in the catchment area where NBS/GSI can be implemented

Upper Watershed Impact Area

Weston & Sampson

Charles River Watershed Association

Opportunities



Source: Weston & Sampson GIS

Increase storage and restore natural conditions

Source: Google Earth

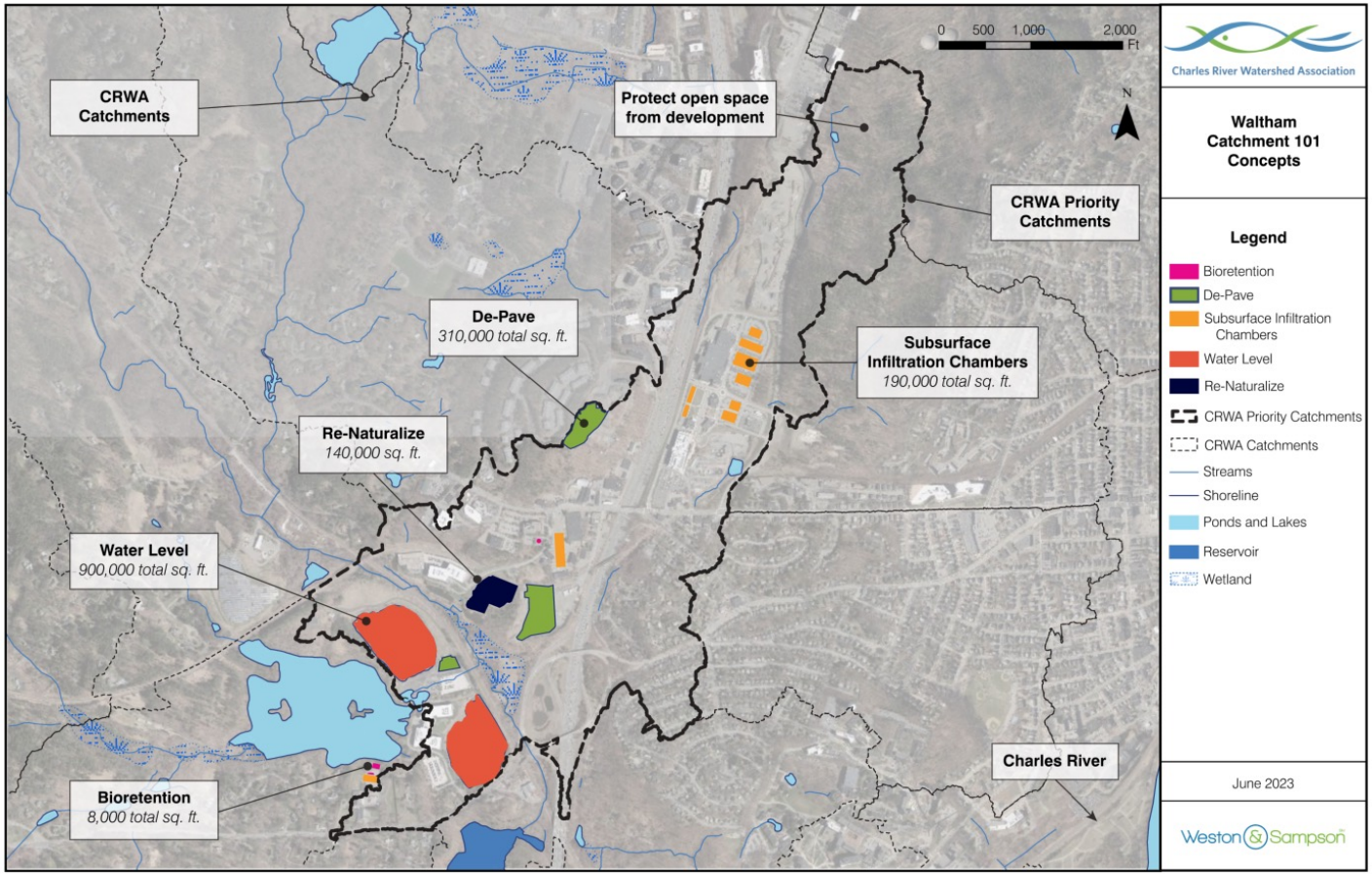
Constructed Wetland

Source: U.S. EPA

Stream Restoration

Source: Weston & Sampson Project with the Town of Arlington

Lower Watershed Impact Area



Solutions Explored

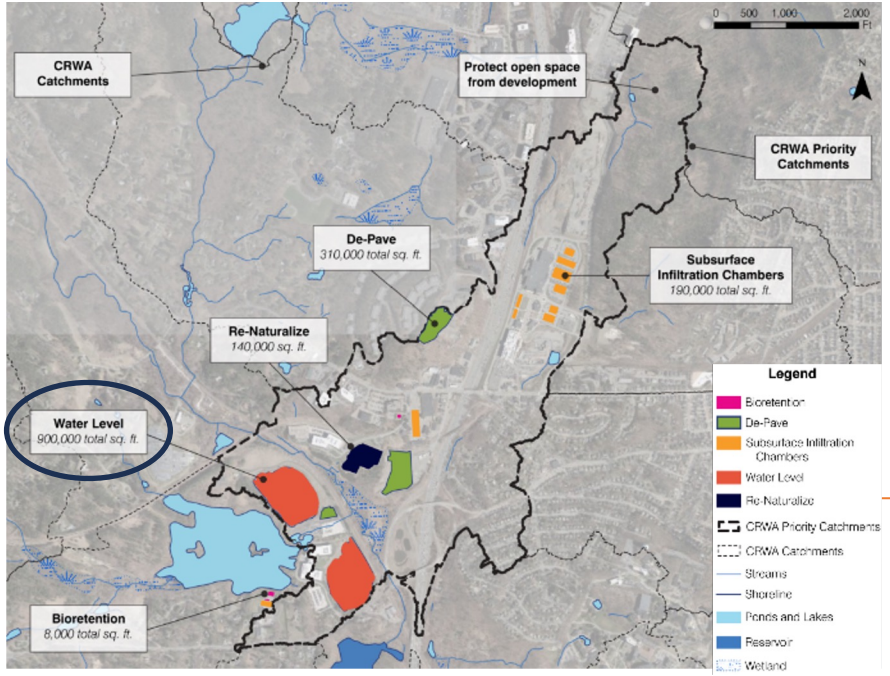
- Subsurface infiltration and storage underneath parking stalls
- Retrofit stormwater ponds to increase capacity
- Stream restoration
- Approx. **35.5 ac** available in the catchment area where NBS/GSI can be implemented

Lower Watershed Impact Area

Weston & Sampson

Charles River Watershed Association

Opportunities



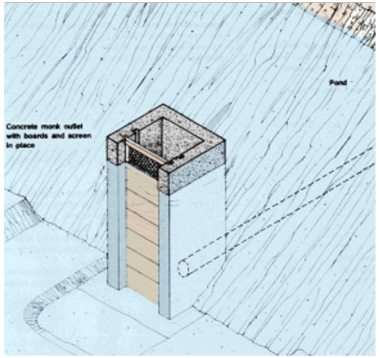
Source: Weston & Sampson GIS

Retention Pond Retrofit

Source: Google Earth

Increase storage by excavating existing basins

Source: U.S. EPA



Example of outlet control

Source: U.N. Food and Agriculture Organization

Impact-area concepts showed great benefits

- For the 2070 10-year storm, proposed solutions for the impact area (catchment) are able to reduce flooding by almost
  - 3.7 MG in the upper watershed area
  - 6.4 MG in the lower watershed area

- These **targeted proposed solutions resulted in a greater flood reduction benefit** for this catchment compared to overall watershed-wide scenario 1A (GSI to store 4.5” of rain from 50% of impervious cover)

Benefits and Co-Benefits



- Improved water quality
- Community education / STEM resource
- Create outdoor spaces (a.k.a. “placemaking”)
- Less-intense and more frequent storms can be managed
- Reduction in “heat islands” in parking lots and paved areas
- Addition of vegetation and potential creation of habitat

Summary of Accomplishments to Date

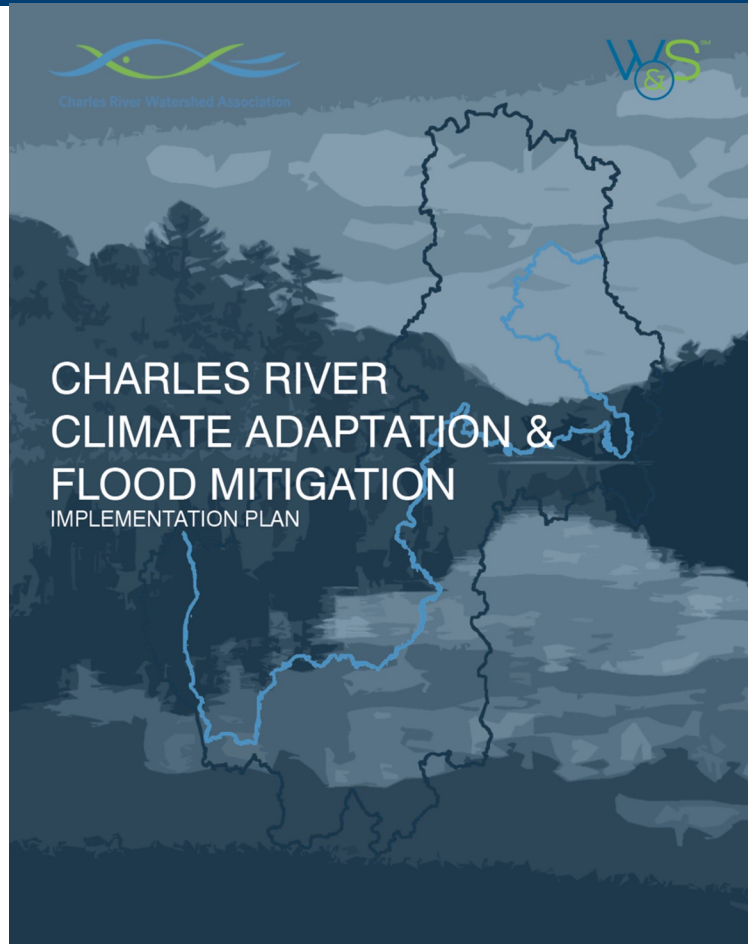
- Developed CRFM: covering nearly 300 square miles
- Over $1M obtained in state funding
- $400,000 obtained in federal funding
- 9 no action (present & future) storm scenarios run
- 8 intervention/"action" scenarios
- Published *Charles River Climate Adaptation Flood Mitigation Implementation Plan*, working on first update
- Concepts designs for 8 priority sites and two subwatersheds
- Additional funding (nearly) secured to advance designs at one priority site
- Semi-annual public webinars which engage over 100 people live, more via recordings
- Multilingual presentations, materials, and in person events

Looking Ahead…

WHAT'S NEXT:

- Building on past modeling work, use the CRFM **to identify and assess various alternative "pathways" that will mitigate flooding down to present day levels** or even further

- **Update the Charles River Climate Adaptation Flood Mitigation Plan** to include additional site scale / impacted area project concepts, flood reduction alternatives analysis, and additional community input



Thank You!

Contact info: ghosh.indrani@wseinc.com; jwood@crwa.org
Website: https://www.crwa.org/watershed-model.html