Urban Water Transformation:
Designing Infrastructure for a Livable Future

Charles River Watershed Association

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CRWA: Working to Restore Nature by Learning from Nature

- ***<u>Resource-to-Waste-to-Resource</u>*** - There are no wastewater treatment plants or landfills in nature; each waste product becomes another resource.
- ***<u>Keep Water Local</u>*** - Water is slowed down, infiltrated, and used several times.
- ***<u>Flexibility, Adaptability, Interconnectedness</u>*** - Nature handles catastrophic events by lending the capacity of each to all others.
- ***<u>Promote and Support Rich Diversity</u>*** - Nature celebrates diversity as a strength, a way for communities to be more adaptable, more resilient, and to gain strength through evolution.

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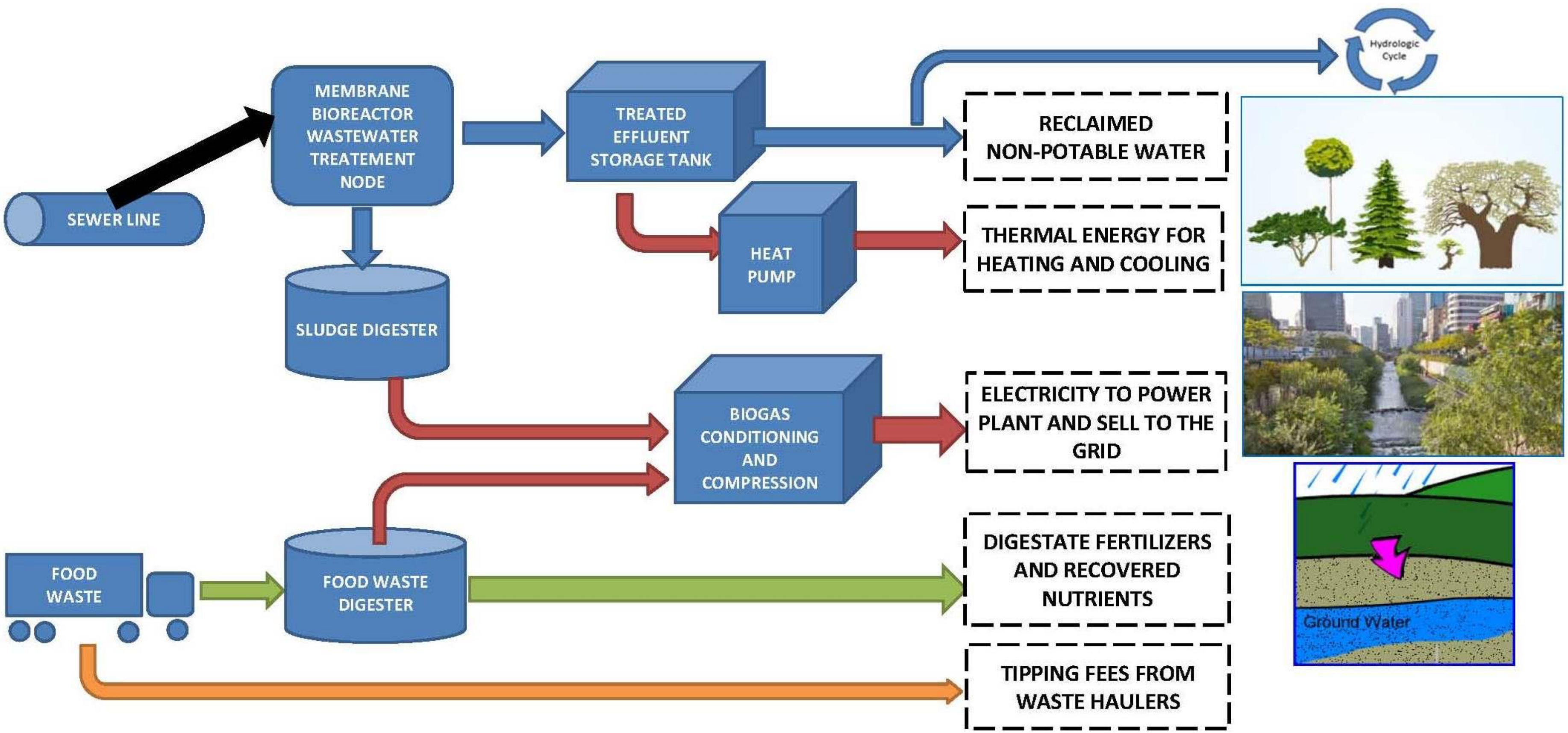
Resource-to-Waste-to-Resource

Maximizing Water and Energy Resources



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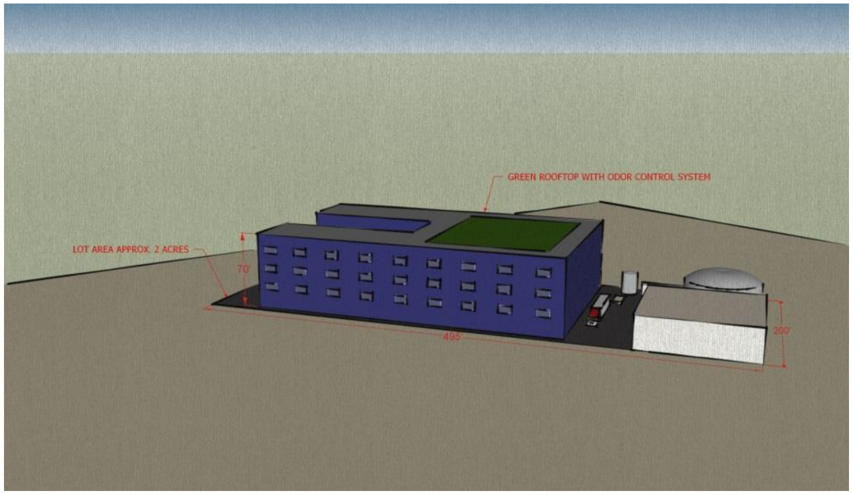
Community Water and Energy Resource Center = CWERC



- Treat and resell a portion of the water (MBR)
- Capture and use/sell thermal energy (heat pump/exchange)
- Produce and use/sell biogas through co-digestion (CHP)
- Capture nutrients (N) for resale
- Produce compost for resale (2 tiers, separating sludge and SSO streams)

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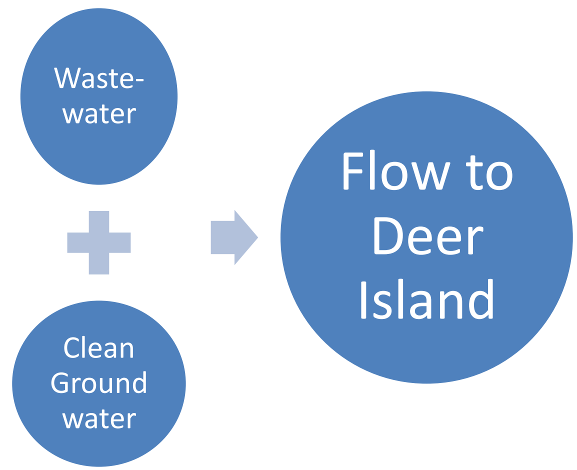
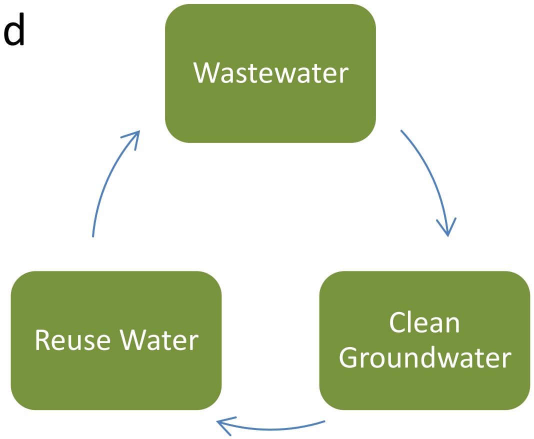
Keep Water Local

- Offset the impacts of infiltration and inflow: about 40% of flow to Deer Island is relatively clean groundwater or rainwater
- Reduce potable water demand from Quabbin or local sources

Existing



Proposed



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Flexible, Adaptable, Interconnected *and* Promote and Support Rich Diversity

- A decentralized or distributed network of CWERCs to serve our water and energy needs
  - Resilient and redundant
  - Equitable
  - Efficient
- Integrated stormwater management using green infrastructure, wetland restoration and stream daylighting

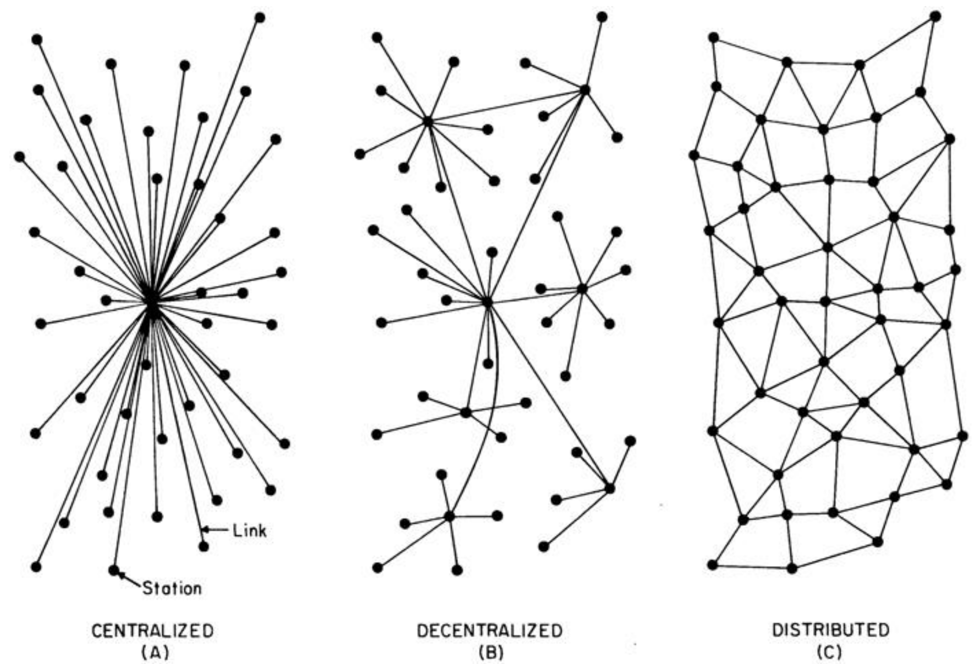
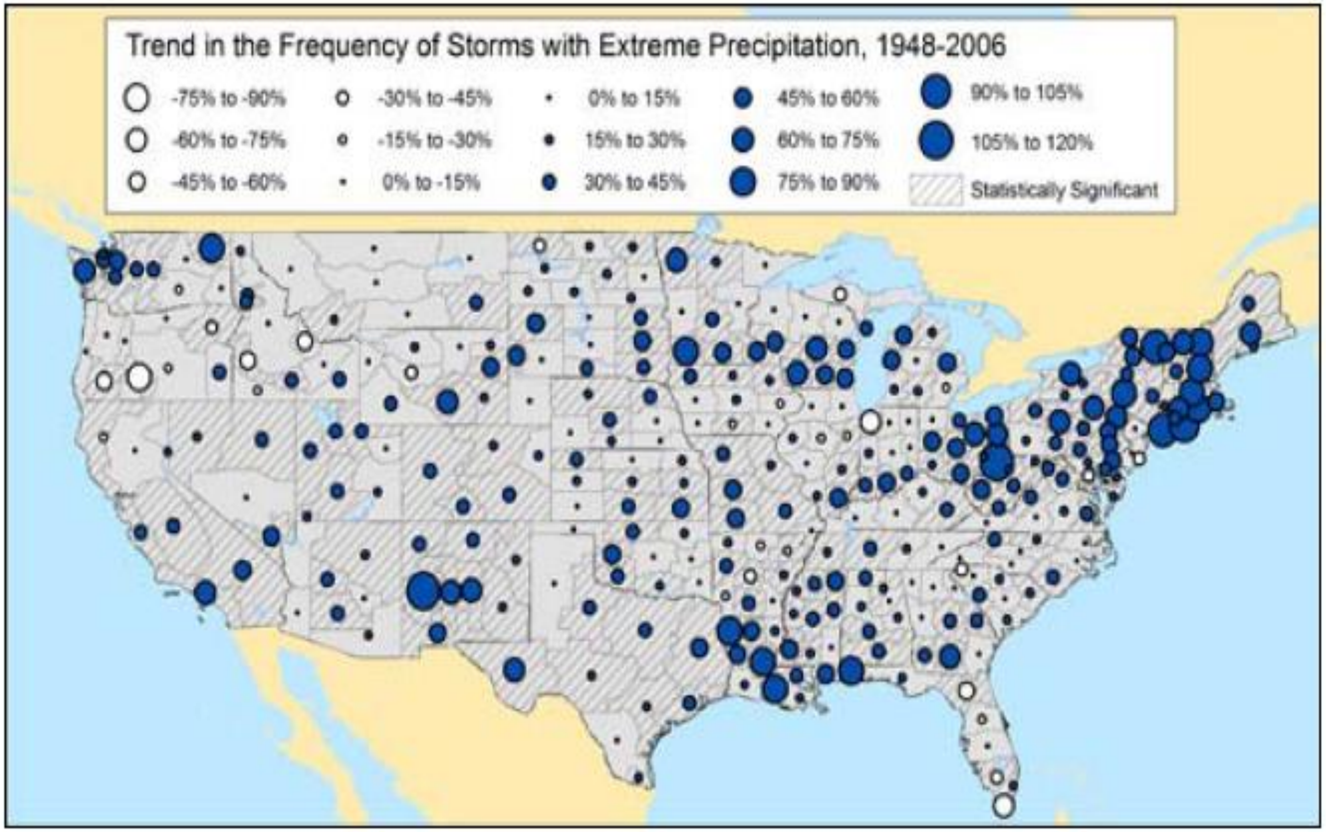


FIG. I — Centralized, Decentralized and Distributed Networks

Climate Change will bring the Northeastern United States
More Large Storms and Floods

Figure ES-2: Trend in Frequency of Extreme Precipitation by Climate Division



Source: *When It Rains, It Pours*. Environment America Research and Policy Center, December 2007

Selecting pilot neighborhoods and developing conceptual CWERC design

INITIATION PHASE

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Task 1: Neighborhood Selection *Methodology*

Level 0: Screen Possible Sites

- Many ("unlimited") Sites
- Cursory Screen

Level 1: Compare and Narrow

- 23 sites
- More in depth analysis

Level 2: Select Sites

- 5 sites
- In depth analysis and site visit

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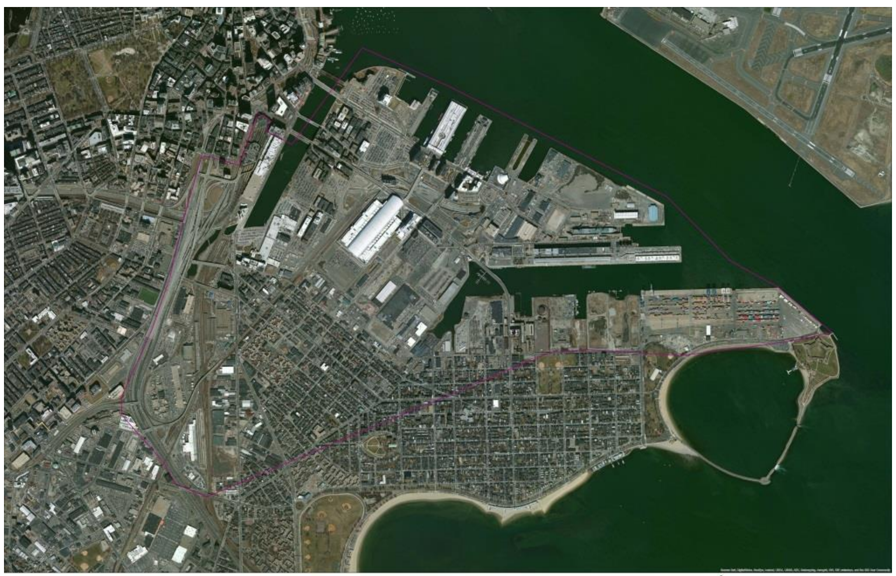
Pilot Neighborhood Selection and Assessment

Pilot Neighborhood #1: Expanded Innovation District



Pilot Neighborhood #2: Lower Stony Brook

Critical Siting Elements: Access to adequate sewage volume
Available space
Opportunities for reuse of treated water

Technical Inputs/Outputs and Business Model Scenarios for CWERC

MODELING

Modeling CWERC Inputs and Outputs

Neighborhood	1	2
WW Reclamation (MGD)	2	3
Water for Hydrologic Restoration (MGD) (% total)	0.5 (25%)	1 (33%)
Food Waste Processing (Tons/Day)	80	54
Food Waste Tipping Fee ($/Ton)	80	60
Electric Rate based on energy production vs. parasitic load	$0.12/kWh	$0.15/kWh
Wastewater Treatment Fee (% Boston Retail Treatment Fee)	0	0 – 31%
Water Reuse Fee (% Boston Potable Water Retail Fee)	30%	50 – 100 %
Approximate Facility Footprint	2 acres	2.5 acres

Other Assumptions:

- WW content based on influent at DI WWTP
- Reuse water buyer is onsite or nearby
- Thermal energy sold at $9.77/MMBTU
- Food waste producer location and availability based on MassDEP estimates (no overlap b/t neighborhood #1 and #2 suppliers)
- No discharge to sewer
- SSO 20% solids as received

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Resource Recovery CWERC Modeling Neighborhood #1 Technical Results

	Unit Cost/Fee Assumed	Total Volume Produced	Total Value Produced	Volume Used Onsite
Reuse Water Sales	$2.20/1000 gallons	1.5 MGD	$1,201,000/yr	None
Thermal Energy Capture	$9.77/MMBTU	292,981 MMBTU/yr*	$2,494,000/yr** ($715,000 net)	188,466 MMBTU/yr**
Biogas Conditioning and CHP	$89/MWh ($0.089/KWh) (sale)	7,480 MWh/yr	$665,700/yr	3,870 MWh/yr *($121/MWh rate for usage)*
Sludge Digester Compost	$25/cu. yds.	770 cu. yds./yr	$19,200/yr	None
Food waste Digester Compost	$12/cu. yds.	12,650 cu. yds./yr	$151,800/yr	None
Nitrogen Recovery	$0.70/lb N	85,100 lbs-N/yr	$59,600/yr	None
Food Waste Tipping Fees	$80/wet ton ($0.04/lb)	80 ton/day accepted	$2,336,000/yr	All
Renewable Energy Credits	$65.27/MWh		$439,400	

* Includes heat capture from CHP unit

**Includes energy to run heat pump which is available as output but is a cost to the plant

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Resource Recovery CWERC Modeling Neighborhood #2 Technical Results

	Unit Cost/Fee Assumed	Total Volume Produced	Total Value Produced	Volume Used Onsite
Reuse Water Sales	$3.25/1000 gallons	1.99 MGD	$2,365,300/yr	None
Thermal Energy Capture	$9.77/MMBTU	421,926 MMBTU/yr	$3,591,900/yr	279,536 MMBTU/yr
Biogas Conditioning and CHP	$89/MWh ($0.089/KWh)(sale)	5,295 MWh/yr	471,300 $/yr	4,929 MWh/yr *($147/MWh rate for usage)*
Sludge Digester Compost	$25/cu. yds.	1,150 cu. yds./yr	$28,700/yr	None
Food waste Digester Compost	$12/cu. yds.	8,540 cu. yds./yr	$102,500/yr	None
Nitrogen Recovery	$0.70/lb N	57,500 lbs-N/yr	$40,200/yr	None
Food Waste Tipping Fees	$60/wet ton ($0.03/lb)	54 ton/day accepted	$1,182,600/yr	All
Renewable Energy Credits	$65.27/MWh		$311,100	
Wastewater Treatment Fee	$0-$2.87/1000 gallons	3 MGD	$0-3,144,700	

Community Water and Energy Resource Center
Capital Cost and Revenue Summary

- Total capital cost: $46.8 million
  - headworks, MBR, storage tank, heat pump, anaerobic digestor for municipal sludge, food waste digestor, dewater biosolids, dewatering food solids, food receiving station, digester storage tanks (2, 100K gallon tanks) digester pumps, CHP unit, nutrient recovery, composting
  - does not reflect prevailing wage requirements
- Annual O&M costs: $4.9 M
  - wastewater treatment, pumping, energy, chemicals, labor, misc. supplies
  - does not take into account the value of any energy produced on site.
- Annual product fees/revenues: $7.4M

- Conducted financial modeling to determine project viability under various ownership scenarios

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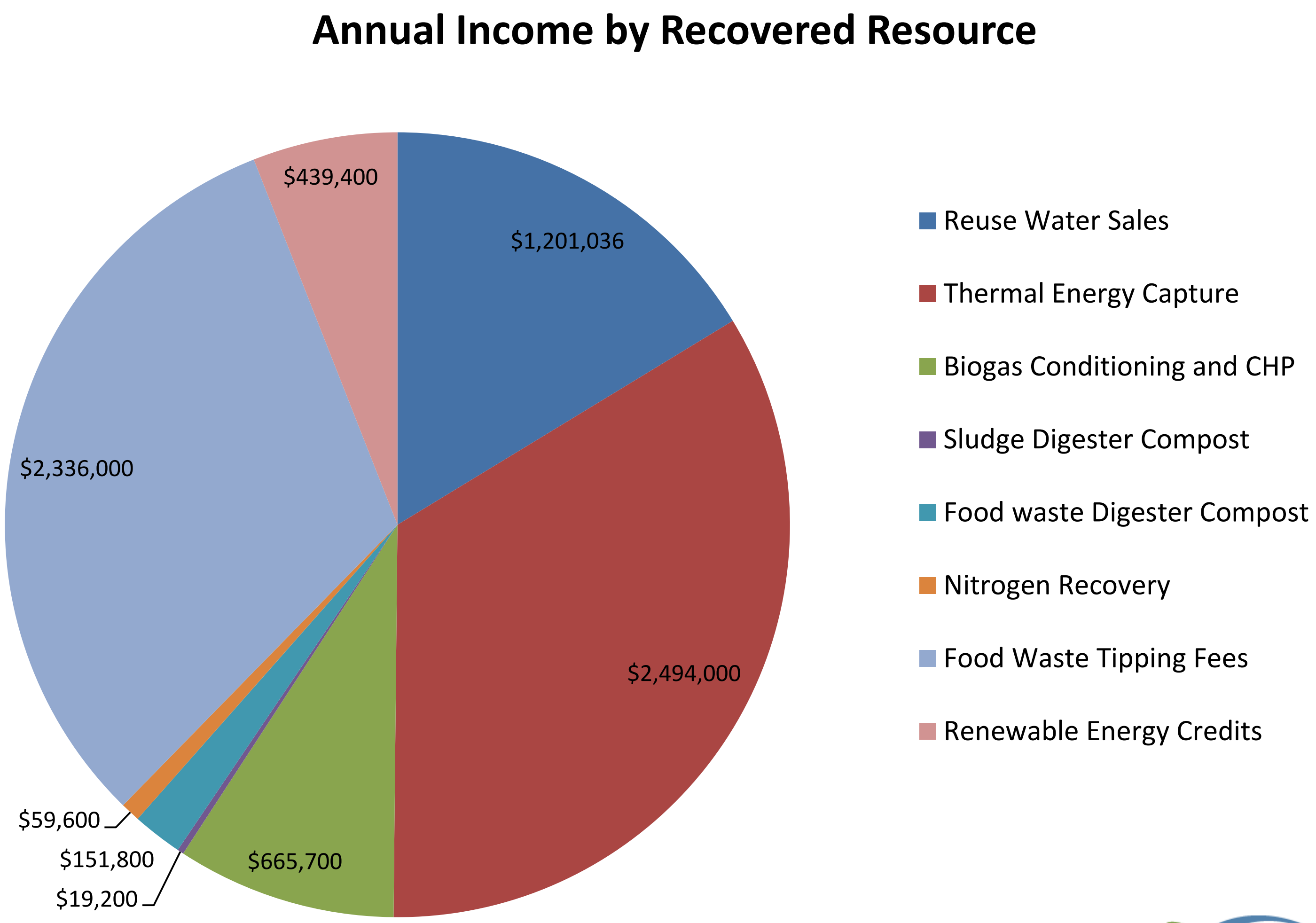
Neighborhood 1 CWERC Output



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Marrying potable, storm-, waste-, surface and groundwater management to restore the natural water cycle

INTEGRATING STORMWATER MANAGEMENT

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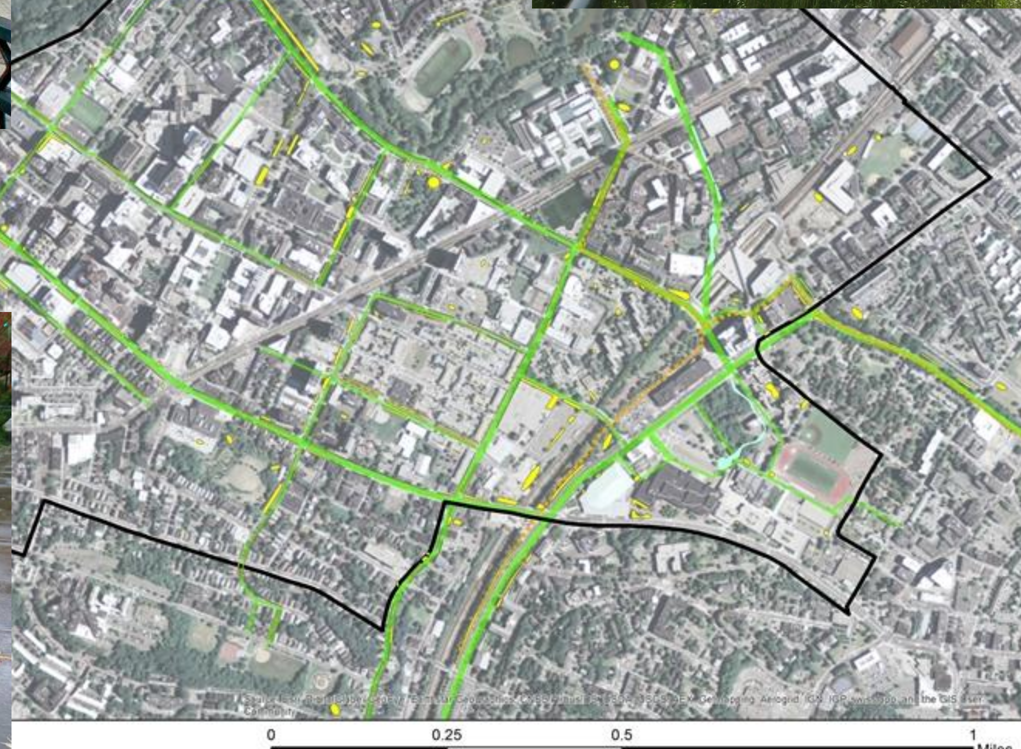
Neighborhood 2 Greening Plan



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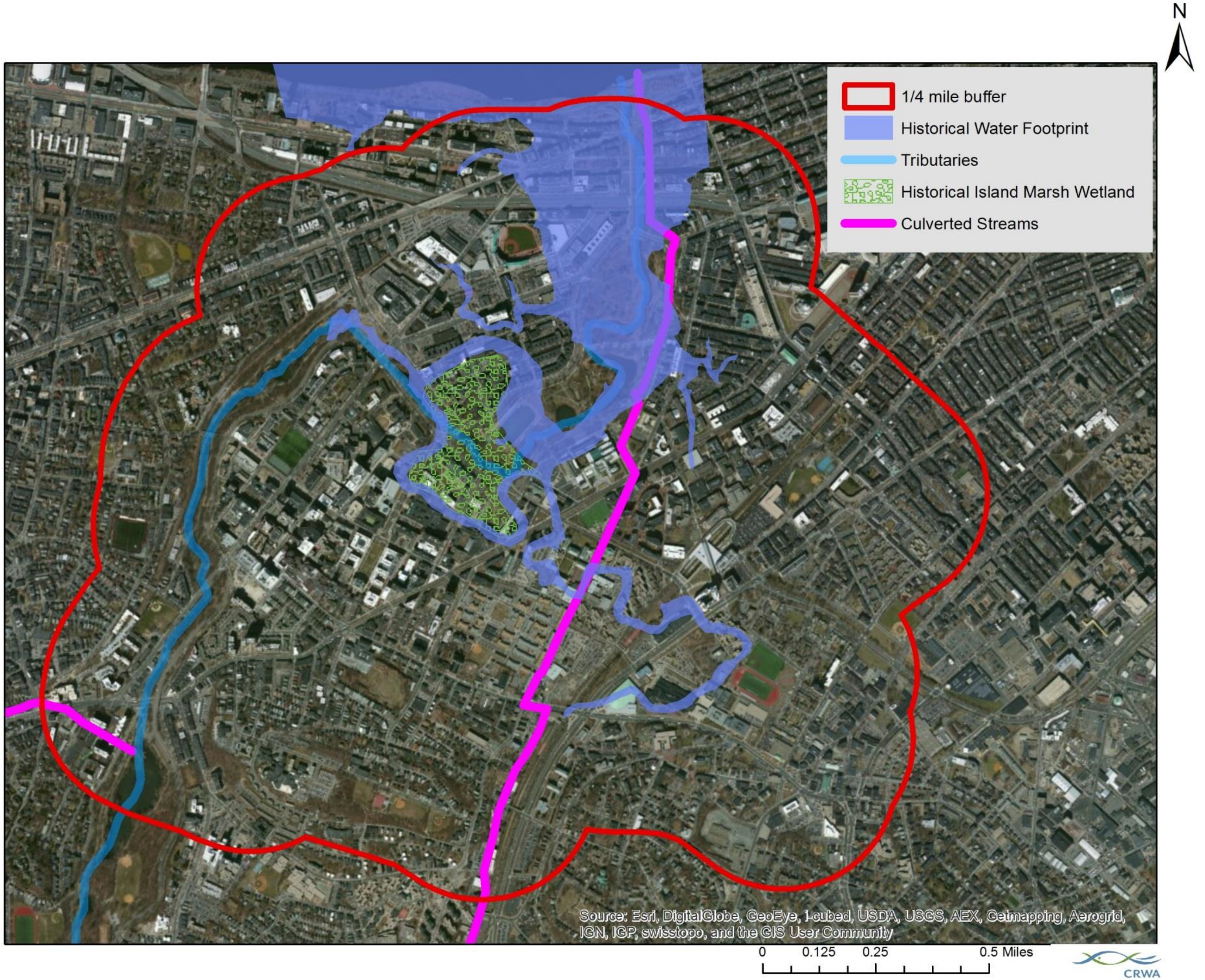
N
1/4 mile buffer
Historical Water Footprint
Tributaries
Historical Island Marsh Wetland
Culverted Streams
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
0
0.125
0.25
0.5 Miles
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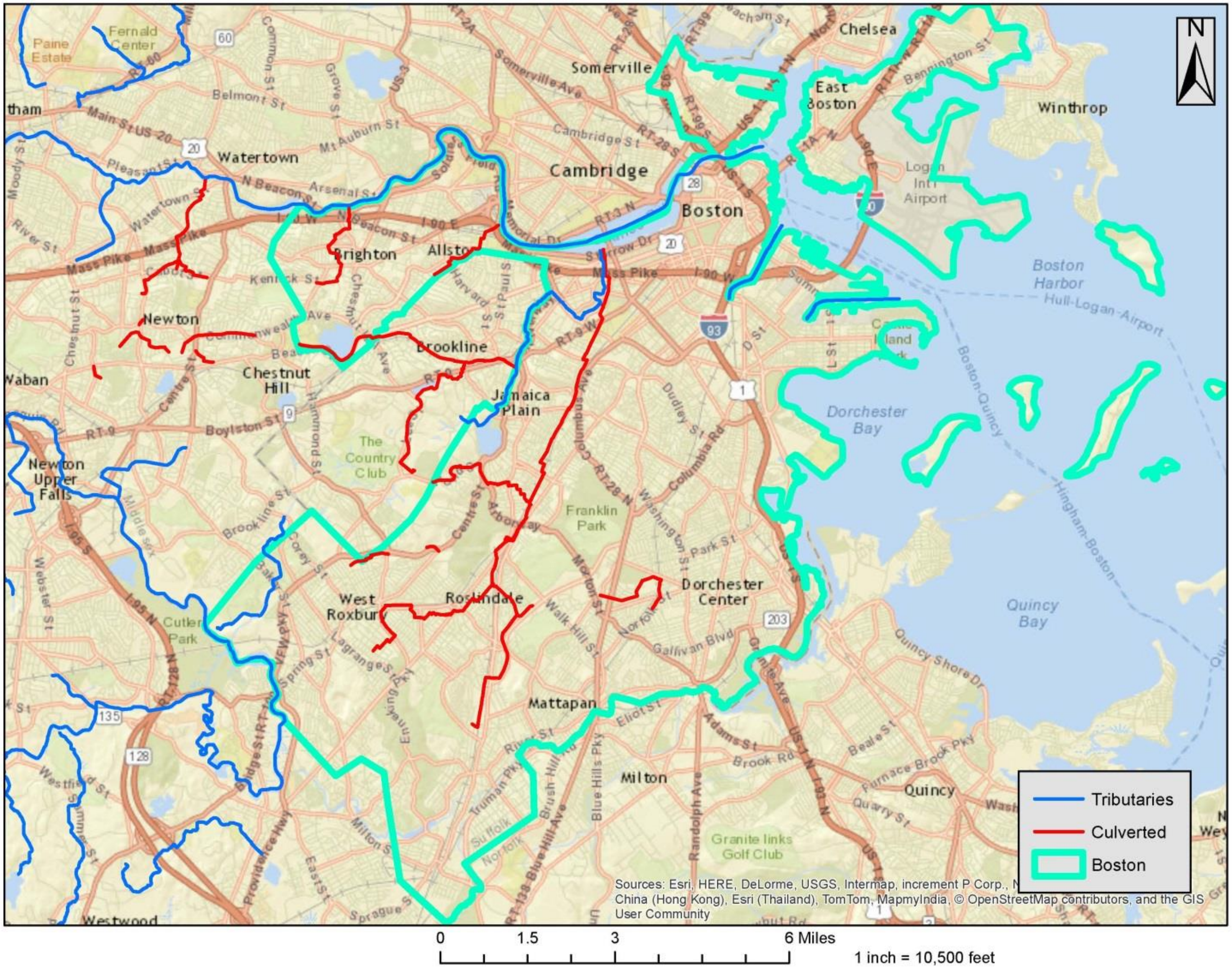
Neighborhood Assessment



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Neighborhood A

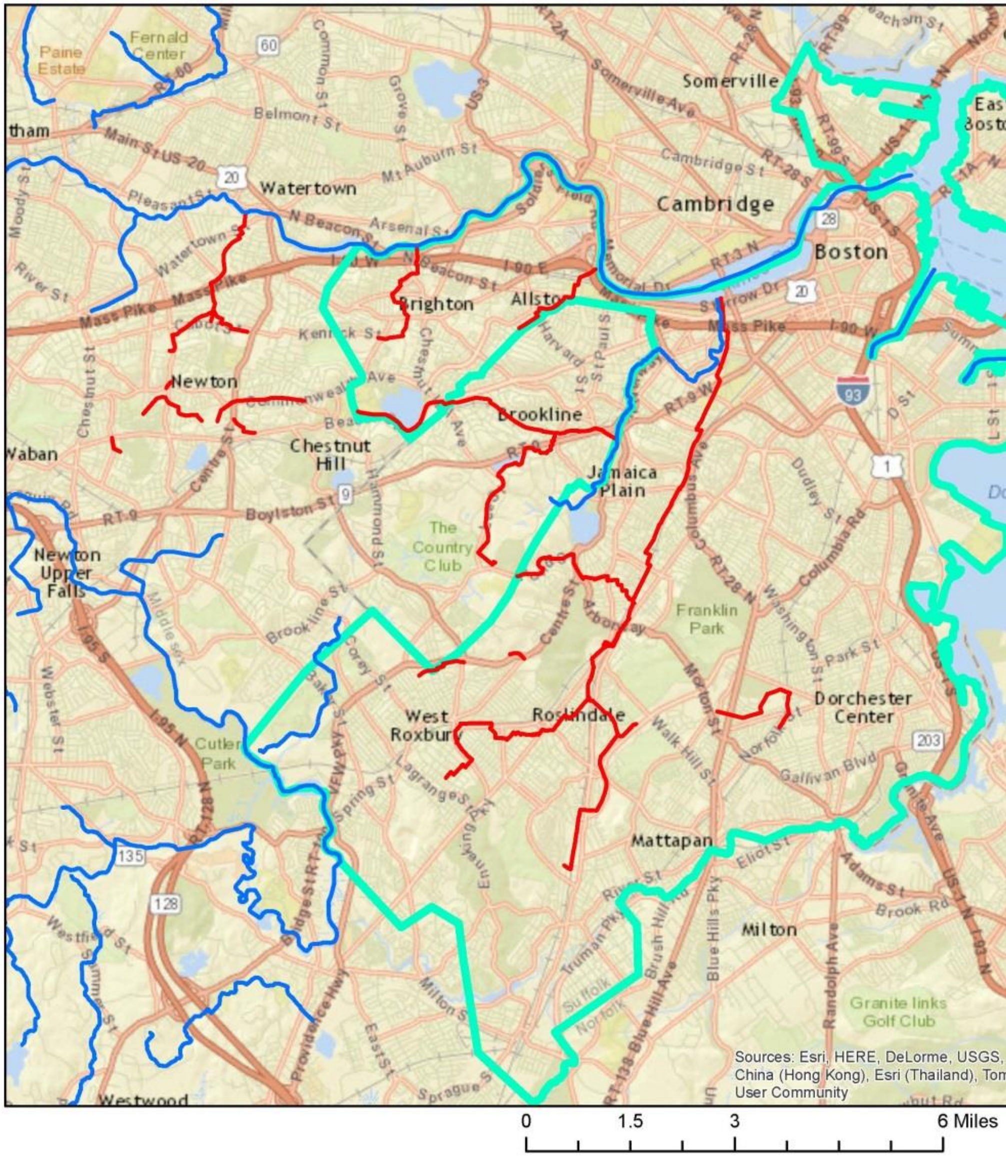

Figure 11. The culverting of Stony Brook at Forest Hills, about 1905.

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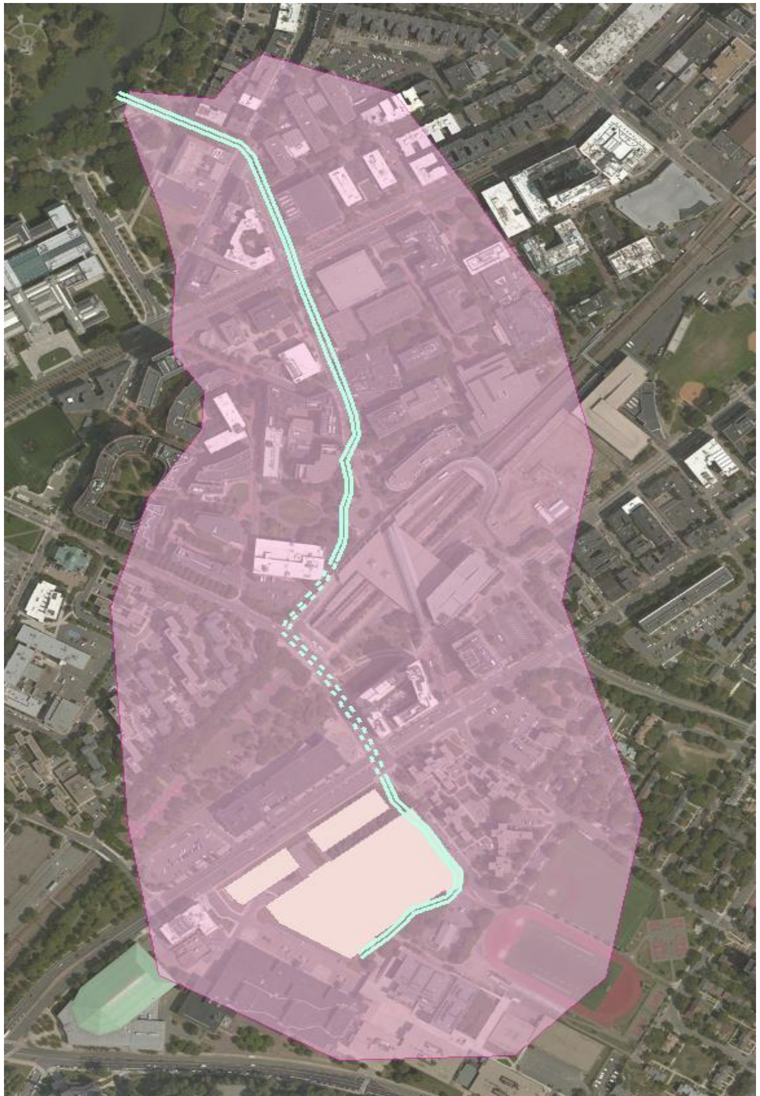
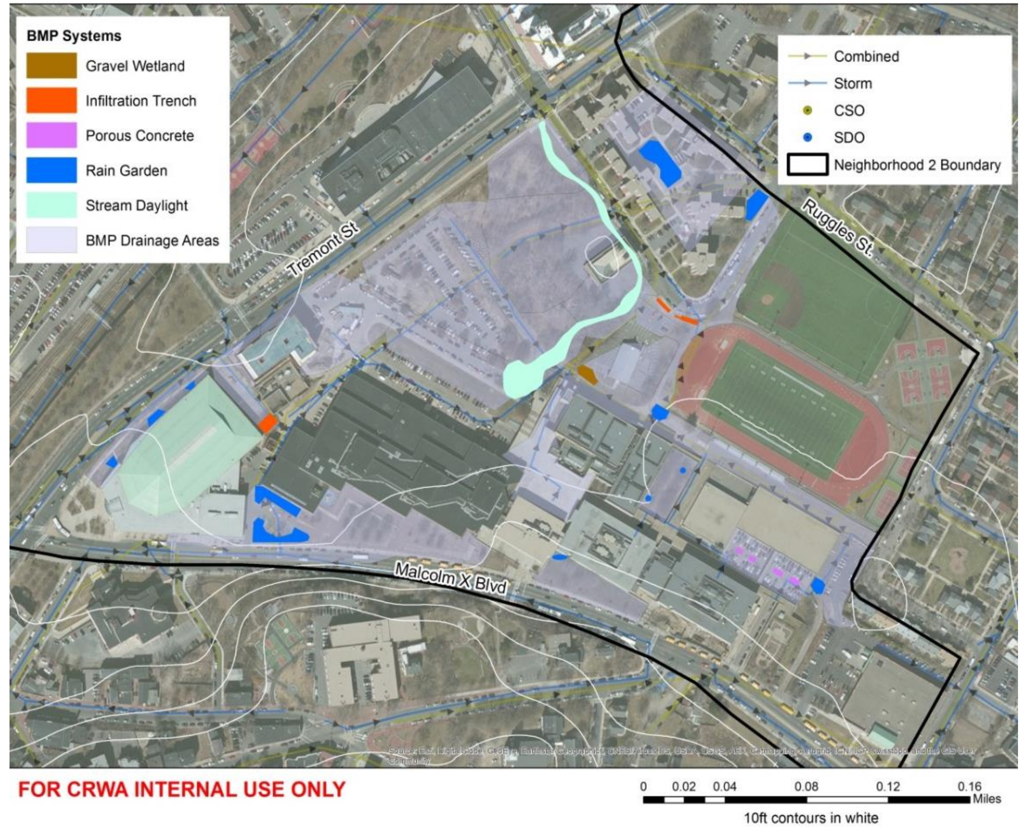
Stream Restoration or Creation





NU Stream Daylighting-Visualization

NU Stream Daylighting-Visualization

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Non-market benefits

SOCIAL WELFARE EVALUATION

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Major Benefit Categories Examined

- Energy benefits
- Emissions reduction and climate change benefits
- Functional open space and other GI benefits
- Distributional benefits

Summary of Annual Benefits

	BENEFIT CATEGORY	VALUE	
		LOWER	UPPER
Additive	Energy Recovery and Energy Savings	$3,727,535	$3,982,105
	Reduced Carbon Emissions	$334,635	$1,722,388
	Reduced Criteria Pollutant Emissions	$55,909	$139,392
	Carbon Sequestration from GI	$3,991	$20,679
	Air Quality Benefits from Greening	$6,755	$16,889
	Avoided Stormwater BMP Costs	$1,572,345	$3,144,689
	Avoided Underpinning Costs	$8,600,000	$22,900,000
	Stream Daylighting Benefits	$139,442	$1,426,351
	TOTAL	**$14,440,612**	**$33,352,494**
Areas of Significant Overlap	Property Value (Street Greening)	**$1,522,778**	**$3,045,556**

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Additional and Ongoing Work

- Technical Advisory Committee and Citizen's Advisory Group
- Advancing toward implementation
- Expansion and Replication to Larger Area
  - Technical challenges of transitioning from centralized to decentralized infrastructure
  - Economic barriers or efficiencies
  - Regulatory, legal and permitting barriers

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WORKING TOWARD A RESILIENT AND EQUITABLE FUTURE FOR HUMANS AND NATURE, JOIN US!

Charles River Watershed Association: www.charlesriver.org

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