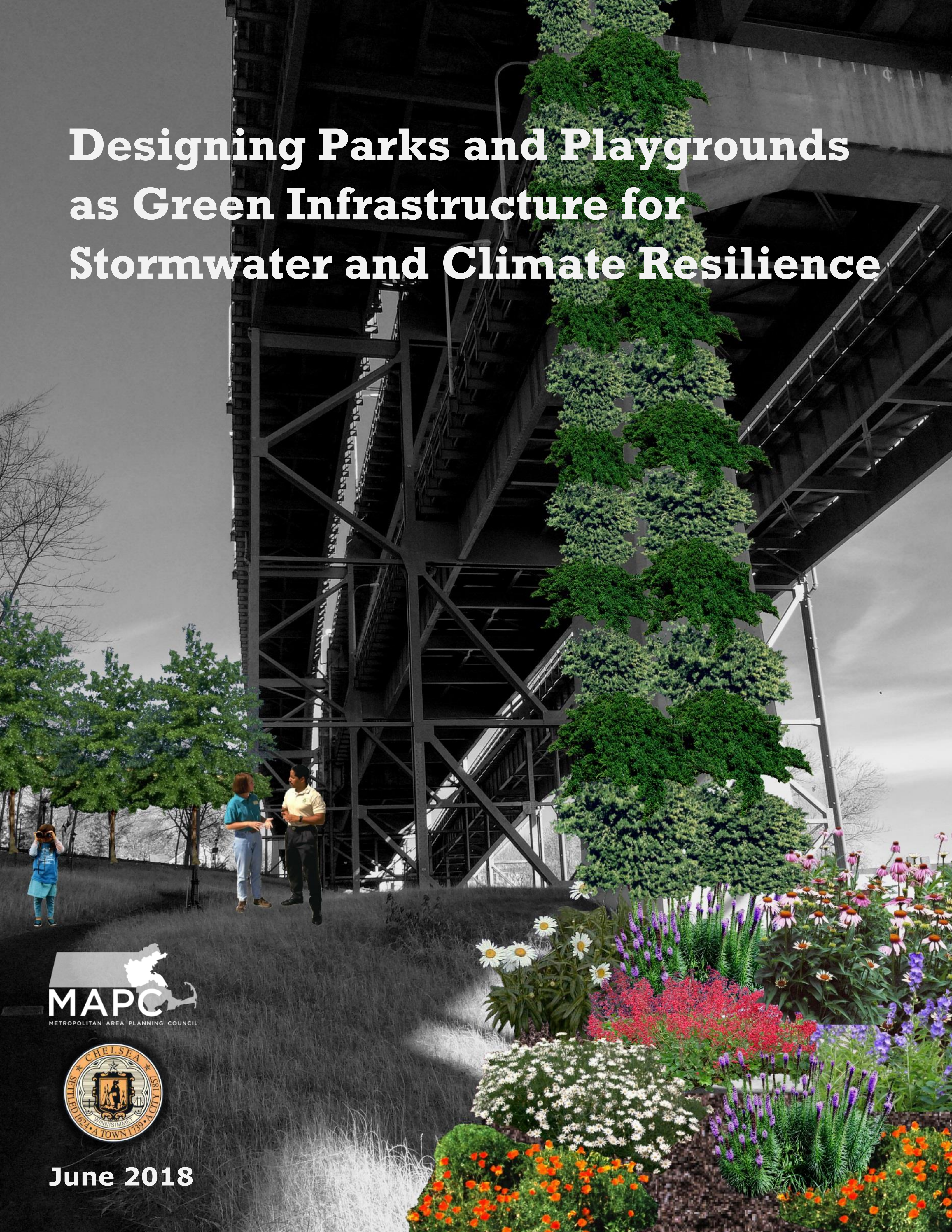

Designing Parks and Playgrounds as Green Infrastructure for Stormwater and Climate Resilience

MAPC
METROPOLITAN AREA PLANNING COUNCIL

June 2018

Acknowledgements

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Introduction

To date, Chelsea has completed important planning for stormwater management, coastal flooding with climate change, waterfront visioning and parks and open space planning. The intent of this plan is to build upon existing efforts and create a frame work for implementing green infrastructure through retro fits and/or re-development for Chelsea's park and open space system.

Parks and open space are integral to the City's "Fundamentals" or core principals where finance, economic development, public safety, neighborhood enhancement, and community and civic engagement relate their importance in enacting livable communities.[1] Driven by these fundamentals, in 2016, Chelsea voted to enact the Community Preservation Act, a dedicated source of funds for parks, recreation, affordable housing, and historic preservation. In 2017-2018, Chelsea worked with the Metropolitan Area Planning Council (MAPC) to update its Open Space and Recreation Plan (OSRP), creating an action plan to integrate parks and open space into the city fabric, and in the last 7 years, Chelsea has completed 14 parks projects for reconstruction, improvements, and access.[1] It is renowned for its success in securing the EEA Parkland Acquisitions and Renovations for Communities grant administered by the State Executive Office of Energy and Environmental Affairs, on an almost yearly basis.[2] Despite the physical and environmental challenges Chelsea faces with density, soil suitability, and topography,[3] the City is well-poised to mitigate stormwater, inland flooding, and urban heat island with green stormwater infrastructure and nature-based climate resilience into the City.

Several cities have taken great strides to operationalize green infrastructure solutions, particularly for stormwater management but also public health and community livability, into planning and redevelopment. Cities that have implemented these at scale are ones that pursued a programmatic approach that includes marketing, public engagement, policy, and dedicated funding. Particularly in dense urban environments with competing demands for constrained space, the following are identified as key strategies for successful green infrastructure in park system planning:

1. Engaging communities on the benefits and designs of green infrastructure;
2. Maximizing the benefits of green infrastructure solutions within a physically connected network;
3. Enabling equitable access to parks and green infrastructure within system planning; and
4. Specifying actions and funding sources to effectively implement at scale.[4]

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[1] Chelsea Open Space and Recreation Plan 2017-2024 DRAFT. MAPC. June 2017

[2] Personal Communication. Kurt Gaertner, Executive Office of Energy and Environmental Affairs. September 2017.

[3] EPA Region 1 Green Infrastructure Partnership with the City of Chelsea: Technical Support Document to Assist the City to Further Encourage and Promote the Use of Green Infrastructure. Horsley Witten Group. December 2012

[4] National Recreation and Parks Association. Resource Guide for Planning, Designing, and Implementing Green Infrastructure in Parks. 2017.

Existing Conditions- Climate Change and Green Infrastructure in Parks

Many studies document the ancillary benefits of green infrastructure, from parks and living shorelines, to rain gardens and green roofs. These structures serve not only to capture and infiltrate stormwater but also serve to cool cities and reduce energy demands during extreme heat events. Green infrastructure is also an important mechanism for climate resilience where nature-based solutions work in tandem and emulate engineered systems that serve to mitigate stormwater, flooding, and extreme heat. This section will provide a brief overview of relevant historic and climate change projection data as it pertains to future design of green infrastructure in parks.

Sea Level Rise and Coastal Parks

In 2017, the Woods Hole Group completed the Boston Harbor Flood Risk Model (BH-FRM), a comprehensive hydrodynamic model that incorporates hydrology, topography, infrastructure, and other local landscape data with future sea level rise (SLR) and storm surge scenarios to ascertain the future impact on Chelsea's waterfront. Because Chelsea is low-lying and sheltered from wave energy, the geographic extent of sea level rise does not increase over time, but the depth increases. Overall, Chelsea could experience, relative to mean SLR in 2000, an additional eight inches of SLR by 2030, additional two feet by 2070 and approximately four feet by 2100.[5] In addition, approximately 20% of Chelsea is within a current flood zone where 0.5-2 feet could occur in a 1% Annual Chance Flood, particularly in key vulnerable areas such as Island End River, Upper Chelsea Creek and Lower Chelsea Creek. The depth of this flooding could increase to 2.5 feet in 2030 and there is a greater probability of that depth of flooding occurring more frequently.[6]

Coastal flooding is important in considering future design and redevelopment of new and existing waterfront parks. Coastal parks can serve as a resilient strategy to coastal flooding but sea level rise could also negatively affect future efficacy of infiltration structures in parks in flood zones in areas where Chelsea has a high groundwater table. When sea level rises, it could potentially raise the water table, reducing the depth to groundwater and subsequently the depth of infiltration space required to adequately capture stormwater and rainfall. For example, rain gardens require two -six feet of depth to bedrock or groundwater for best function.[7,8]

Precipitation

For the last fifty years, precipitation in Massachusetts has increased by approximately 10%[9] and 71% in the Northeast in the amount of rain that falls in the top 1% of storm events.[10] Projections for future precipitation suggest an increase in total precipitation, changes in precipitation patterns, and increased frequency of extreme storms such as hurricanes and nor'easters. For example, a 100-year storm is defined as a storm that would have a 1% chance of occurring in

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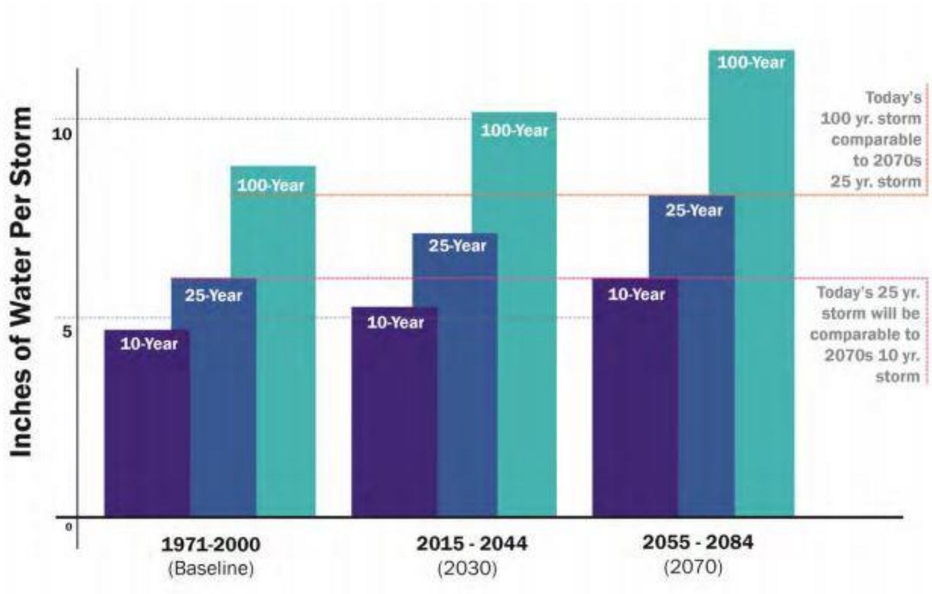
[5] Northeast Climate Science Center. UMass Amherst. Massachusetts Climate Change Projects. January 2018.
[6] Designing Coastal Community Infrastructure for Climate Change. Stantec and Woods Hole Group, January 2017
[7] Stormwater Best Management Practices: Guidance Document for Boston Water and Sewer Commission. Geosyntec Consultants. January 2013
[8] City of Lancaster Green Infrastructure Plan. PA DCNR and Lancaster County Planning Commission. February 2011. http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_004822.pdf
[9] Massachusetts Climate Adaptation Report. 2011. Executive Office of Energy and Environmental Affairs. pp.
[10] Horton, R., G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe, and F. Lipschultz, 2014: Ch. 16: Northeast. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 16-1-nn.

any given year or consecutive years. Historically this could create 8.9 inches of rain, but that could increase to 10 inches of rain by 2044 and 11.7 inches of rain by 2084 (Figure 1).[11]

Figure 1 Precipitation Projections



Precipitation projections. Modeling from Kleinfelder and ATMOS indicates more rain in any given storm event above the baseline into the end of the century. Source: Cambridge Climate Vulnerability Assessment 2015. Kleinfelder based on ATMOS projections November 2015

However, the actual amount of increased precipitation or number of extreme weather events per year is difficult to ascertain, largely due to localized climate variability and greenhouse gas emissions into the future.[12,13] The Northeast Climate Center at UMass Amherst predicts an increase in total annual precipitation from 46 inches today up to approximately 50 inches by 2030, 54 inches by 2070, and 55 inches by the end of the century.[14] Nonetheless, climate scientists still anticipate some periods of drought. Warming temperatures can cause greater evaporation in the summer and fall as well as earlier snowmelt, [15] and this could cause nearly 20 consecutive dry days in the Boston Harbor Basin by the end of the century.[13] Additionally, though scientists anticipate overall decrease in snowfall, they anticipate the Boston region will continue to experience significant snow events through 2100.[12]

Planning and design for green infrastructure in Chelsea's parks need to carefully consider vegetation resilience to water stress and infiltration design that accommodates future precipitation projections. Trees and shrubs may experience long periods of pooling during and after major storms. Water storage in parks may be an important green infrastructure component for extreme precipitation events to alleviate stress on the stormwater and/or sewer system where combined

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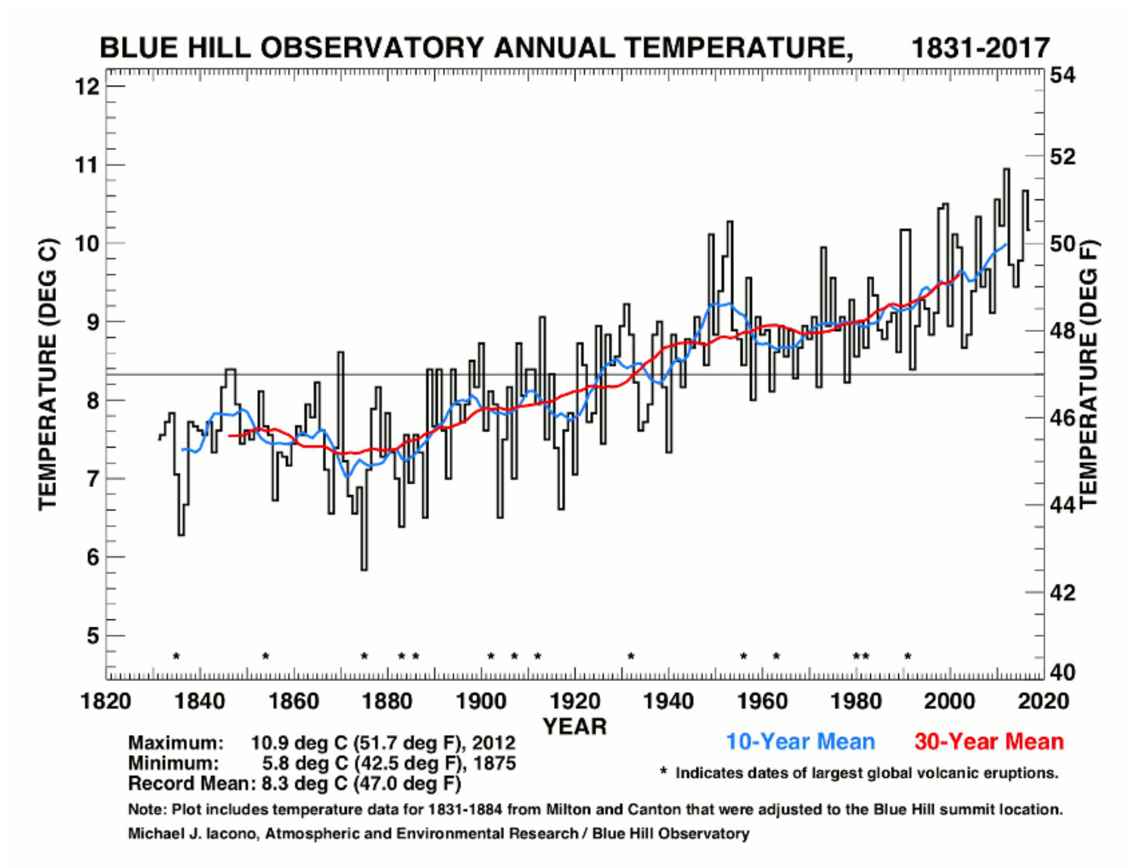
[11] City of Cambridge, Climate Change Vulnerability Assessment, (City of Cambridge, 2015), Temperature and Precipitation Projections (http://www.cambridgema.gov/CDD/Projects/Climate/~/media/A9D382B8C49F4944BF64776F88B68D7A.ashx)
[12] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016
[13] Horton, R., G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe, and F. Lipschultz, 2014: Ch. 16: Northeast. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 16-1-nn
[14] Northeast Climate Science Center, UMass Amherst. Massachusetts Climate Change Projections. January 2018.
[15] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016

flows could contaminate rivers directly with untreated discharge. Furthermore, storage systems could provide opportunities for localized park irrigation, reducing water and energy costs, particularly in periods of drought.

Temperature

According to the US National Climate Assessment 2017, temperatures in the Northeast US have increased by almost two degrees Fahrenheit between 1895 and 2016. Data from the Blue Hill Observatory in Milton located 17 miles from Chelsea, reflects this trend (Figure 2).

Figure 2. Observed Temperature Change



Future temperature projections for the Northeastern US show a greater increase in average summer temperatures relative to winter and are projected to increase at an accelerated rate.[16] A number of local temperature projection models for Massachusetts and the Boston region also demonstrate an increasing likelihood of heat waves, as indicated by the increased number of days over 90 and 100 degrees each year.[17,18,19] Whereas Chelsea today averages approximately eight days above 90° annually, that may increase to 23 days by the 2030s, 37 days in the 2070s, and 75-90 days by the end of the century.[16,17] The impact of increasing

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[16] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016
[17] Under RCP 4.5 conditions. City of Cambridge, Climate Change Vulnerability Assessment, (City of Cambridge, 2015), http://www.cambridgema.gov/CDD/Projects/Climate/climatechangeresilianceandadaptation.aspx cited in BRAG.
[18] Boston Indicators, "Trends in Climate Change, Metro Boston and New England," http://www.bostonindicators.org/indicators/environment-and-energy/5-4clean-energy-and-climate-stability/5-4-1trends-in-climate-change-metro-boston, accessed March 25, 2017
[19] Northeast Climate Science Center, UMass Amherst. Massachusetts Climate Change Projections. January 2018.

temperatures is a shorter winter and longer growing season. For example, scientists expect five-17 fewer winter days by the 2070s and nine-34 fewer winter days by the end of the century.[20]

Chelsea is already experiencing extreme temperatures during the summer due to significant heat-trapping substrates such as asphalt and nominal tree canopy. Green infrastructure is a critical mechanism to cooling cities through shading of tree canopies, evapotranspiration, and increased albedo effect. Parks present a great opportunity to increase the City's tree canopy, especially where street and sidewalk width are too constrained to incorporate street trees.

Stormwater Infrastructure

Approximately 70% of the City if serviced by a Combined System Overflow (CSO) and Chelsea's wastewater and stormwater is transported to the Massachusetts Water Resource Authority's Deer Island Treatment Plant, treated, and then discharged. However excessive stormwater and rainwater in a given event, such as a severe rain storm, can exceed the capacity of the wastewater/stormwater infrastructure. During this time, the CSO, an overflow safeguard, can releases excess flow to local water bodies to prevent backflow into homes, businesses, and other buildings.[21] CSO flows are untreated potentially carrying debris, street pollutants from stormwater runoff, and potentially untreated wastewater. The CSOs are activated yearly raising concerns from residents that climate change could exacerbate existing challenges before stormwater infrastructure upgrades and improvements are completed.[22]

Chelsea has a discharge permit from the U.S. Environmental Protection Agency authorizing this discharge. CSO discharge areas include (i) Winnisimmett Street discharging to Chelsea River, (ii) Pearl Street discharging to the Chelsea River, and (iii) Eastern Avenue discharging to the Chelsea River. Chelsea permanently closed one of its CSO discharging to Boston Inner Harbor and has been aggressively constructing sewer separation to reduce the quantity of stormwater into the CS0. In 2015, it completed over 10 sewer separation and other utility improvements and designed seven future projects. These are funded by Chelsea's capital improvement plan and other grant and loan programs.[23]

In 2015, the City activated two of its three CSOs, the Winnisimmet Street CSO three times totaling 551,935 gallons and the Eastern Avenue CSO 13 times totaling 1,181,189 gallons. Chelsea's most significant challenges are (i) the high costs and time required to separate the CSO, (ii) the quantity of stormwater in the CSO, and (iii) water quality issues in nearby waterways, a significant concern for the City and community. Implementing green infrastructure solutions can bring water back into the ground before going into storm drains, minimizing the need for the CSO but also saving the City the expense of treatment at Deer Island.

[20] Under RCP 4.5 conditions. City of Cambridge, Climate Change Vulnerability Assessment, (City of Cambridge, 2015), http://www.cambridgema.gov/CDD/Projects/Climate/climatechangeresilianceandadaptation.aspx cited in BRAG.

[21] City of Chelsea Combined Sewer Overflows.
https://www.chelseama.gov/sites/chelseama/files/uploads/combined_sewer_overflow._city_of_chelsea.pdf

[22] MAPC. 2018. *City of Chelsea Municipal Vulnerability Preparedness Program. Community Resilience Building Workshop Summary of Findings*.

[23] R.H.. White Construction, Weston & Sampson, and Flow Assessment Services, LLC. City of Chelsea, MA Combined Sewer Overflow Calendar Year 2015 Annual Report.

Implementing Green Infrastructure in Parks-Case Studies

Managing stormwater with green infrastructure is a well-accepted and encouraged practice, particularly under regulatory drivers such as consent decrees or MS4 permits. Cities across the U.S. are implementing innovative programs that not only maximize natural system stormwater capture but also community partnerships, beautification, and air and water quality improvements.

Overall, MAPC's research indicates that cities that implement a programmatic approach, which includes both public outreach/marketing as well as regulatory drivers, for installing green infrastructure have had demonstrated success city-wide. Building public support, marketing multiple benefits, and connecting residents to projects and nature help secure funding for operationalizing green infrastructure at the city scale. For example, the City of Portland, OR instituted a Grey to Green (G2) Initiative in part for compliance for its National Pollutant Discharge Elimination System stormwater permit. The initiative includes ecoroofs (green roofs), green streets, tree planting, invasive species removal and revegetation, acquiring undeveloped land, and planting in natural areas. The result of this initiative has not only reduced the amount of stormwater entering its sewer system but also provided multiple benefits of improving livability, carbon sequestration, greenhouse gas reduction, and cooling.[24] The City quantified these benefits to understand their efficacy and justify further investment. They found that 43 acres of ecoroofs enabled 60% peak flow reduction and 95% reduction of metals in runoff. It also removed 0.58 tons of CO_2 per acre per year and reduced emissions 6.48 tons per acre per year per ecoroof.[24]

Overall, one popular mechanism for implementing green infrastructure in parks at city-scale is through greening schoolyards into water-smart parks. This program has gained popularity and momentum across the U.S. including Boston (i.e., the first demonstration park opened October 2017), Philadelphia, New York City, Newark, and Chicago. These serve the multiple purpose of removing impervious surface, engaging students in design, education, monitoring, and management of natural features in their school yard, enhancing water and air quality while providing shade, beautifying neighborhoods and in some cases reducing crime. Programs utilize public private partnerships that include Water and Sewer Departments, School Departments, Parks and Recreation Departments, Public Facilities, and private non-profits. More information on these programs can be found at Healthy Schools Campaign (www.healthyschoolscampaign.org).

This section will review two programmatic approaches to implementing green infrastructure in parks and a case study on an innovative green infrastructure park in a small dense, urban city with contaminated soils.

[24] Entrix, Inc. *Portland's Green Infrastructure: Quantifying the Health, Energy, and Community Livability Benefits*. City of Portland Bureah of Environmental Services. February 2010.

Case Study I: Riverfront Park/Wetland Construction in Former Industrial Site.

Renaissance Park in Chattanooga, Tennessee was once a highly contaminated industrial site of manufacturing plants. Located on the shores of the Tennessee River, it contained an intermittent stream draining over 175 acres of urban watershed contributing significant pollution to the River. The City re-designed the 23.5 acre space into natural area restoring ecosystem and flood plain function while creating an important cultural, historic, and recreational amenity to residents and visitors (Figure 3).[25]

Figure 3 Before and after photos of Renaissance Park in Chattanooga, TN.

Source: https://landscapeperformance.org/case-study-briefs/renaissance-park

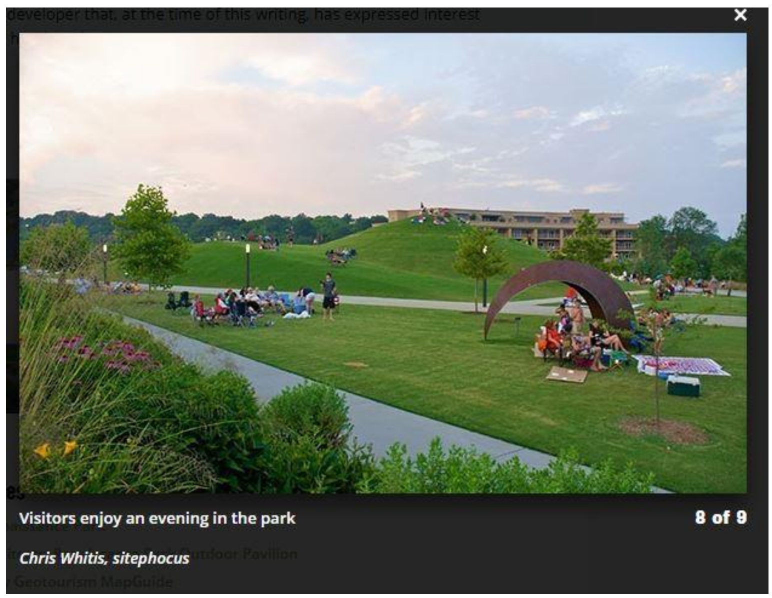
The site of the park once contained appliance manufacturing plant and enameling facility that had left significant post-industrial waste. As part of an environmental site assessment, the project leaders identified semi-volatile organic compounds and heavy metals within a 1% Annual Chance Flood Zone and leaching into the groundwater. The industrial waste was disposed onsite in receiving cells, capped once filled. The City of Chattanooga explored hard-engineering solutions to manage the contaminated soils and groundwater contamination such as asphalt caps and subterranean groundwater diversion wells, but these were approximately 25% more expensive than the implemented “green” solutions. Overall, the project team managed approximately 30,000 cubic yards of contaminated soil onsite.

Approximately 18,000 cubic yards were excavated, reformed into iconic cone landforms above the 1% Annual Chance Flood zone and capped and sealed. The project team used turf grass on the cone landforms to minimize maintenance and degradation from public use. The cone

[25] http://www.hargreaves.com/work/chattanooga-renaissance-park/

landforms are an attractive topographic features of the park, adding topography, river views, and a new recreational area for "sledding" (Figure 4).

Figure 4 Cone landforms at Renaissance Park, TN.



Source: https://landscapeperformance.org/case-study-briefs/renaissance-park#/sustainable-features

The excavated void was transformed into a one-acre constructed wetland with native plants and trees treating stormwater before entering the Tennessee River. This wetland increased water storage capacity of the floodplain by 9.32 acre feet. The constructed wetland is lined with a geo-synthetic clay liner to prevent groundwater contamination and the project leaders added two feet of freeboard between the wetlands average pool level and stream discharge areas. The stream is lined with gabions and wetland plantings to create an artful path of the stream to the constructed wetland (Figure 5).[26]

The remaining 12,000 cubic yards of contaminated soil was remediated onsite, which was 75% less expensive than hauling the soil offsite to a proper landfill. The project team also incorporated many other sustainability features into park development. They reused approximately 18,000 cubic yards of concrete factor floor, crushed for fill, providing a cost-savings of over $1 million. They removed approximately 21% of the impervious surface transforming into meadows, grassy open space, and wetlands. Also, the new park provided erosion control for the banks of the Tennessee River and intermittent stream; banks contained rip-rap, gabions, seeded coir erosion control blankets, logs, root wads, and live stakes.[26]

[26] Landscape Performance Series. Case Study Briefs: Renaissance Park. Landscape Architecture Foundation. https://landscapeperformance.org/case-study-briefs/renaissance-park#/sustainable-features

Figure 5 Constructed wetlands at Renaissance Park, TN.

Source: http://www.hargreaves.com/work/chattanooga-renaissance-park/

Renaissance Park Economics

The total cost of the park project was $8 million. The cost of managing all the contamination did preclude the opportunity for other park amenities, such as a proposed playground and nursery. However, the City saved $1,080,000 in construction cost by salvaging the onsite concrete and reusing it as fill. And the site design reduces long-term maintenance costs by approximately $4,500 in comparison to comparable large parks with lawns and decorative plantings.

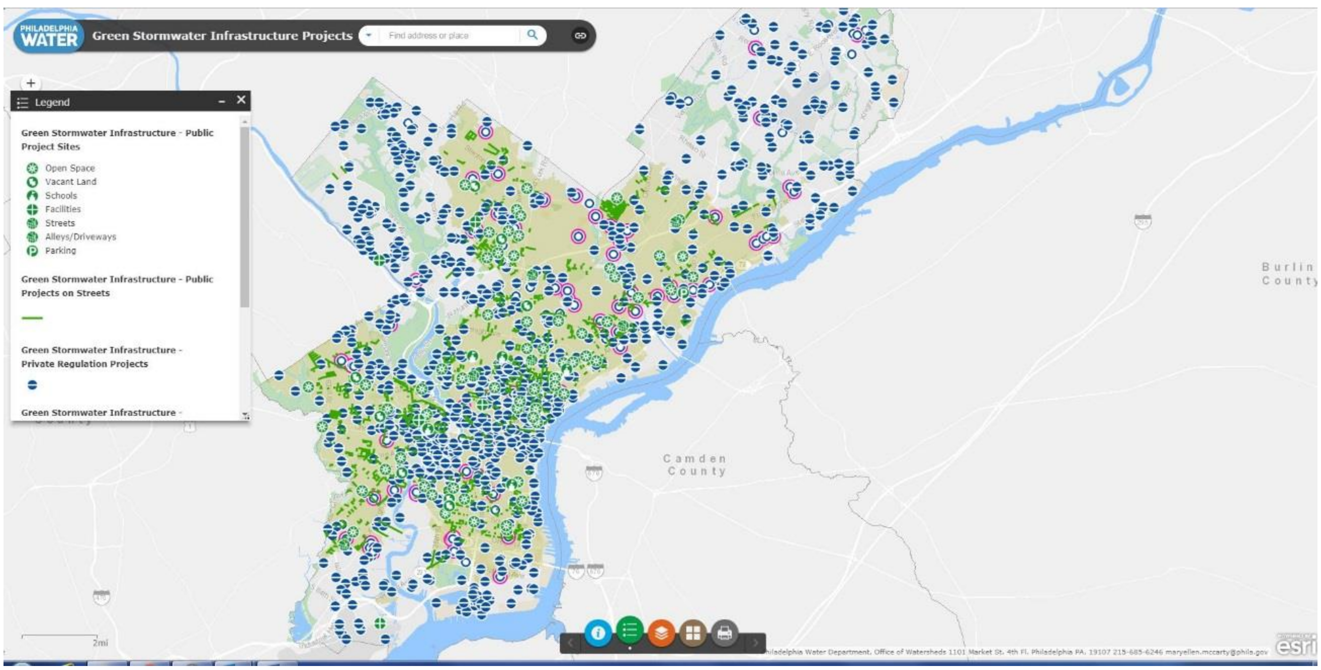
Additional amenities to the park provide ancillary economic benefits as well. The City installed a 490-seat amphitheater, a boat ramp for canoers and kayakers, and an interpretive trail with signage and cell-phone audio tour. The interpretive trail educates the public on the important stormwater and flood mitigation features of the site as well as historic assets from the Civil War and Trail of Tears. The park has an estimate 145,000 visitors annually, 89% of whom shop or dine within ½ mile of the park. It has also leveraged new residential development. The park was completed in 2007, and from 2005-2013, two redevelopment projects worth $55 million adjacent to the park have been completed and five more additional properties within ¼ mile have been redeveloped.[27]

[27] Landscape Performance Series. Case Study Briefs: Renaissance Park. Landscape Architecture Foundation. https://landscapeperformance.org/case-study-briefs/renaissance-park#/sustainable-features

Case study II: Philadelphia Green City, Clean Water

City of Philadelphia created its *Green City, Clean Water* program as a mechanism for meeting its 2011 Environmental Protection Agency Consent decrees to reduced combined sewer overflows by 85%. The program is entirely focused on using green infrastructure to weave the fabric of nature into the city, bring the water into the ground, and creating water ways that are cleaner and more beautiful than its early history.[28] The city uses a combination of public right of ways, parking areas, open space, public facilities, driveways, etc. for green infrastructure and since its inception, they have constructed over 1,100 green infrastructure interventions (Figure 6). The 25-year plan seeks to prevent cost increases to rate-payers, create healthy, livable neighborhoods, attract new business, support green jobs, and enhance public space and schools. Green infrastructure is less expensive and the program minimizes capital expenditures to gray infrastructure upgrades that would be required to improve and separate their current system.[28]

Figure 6. Green infrastructure interventions in Philadelphia.



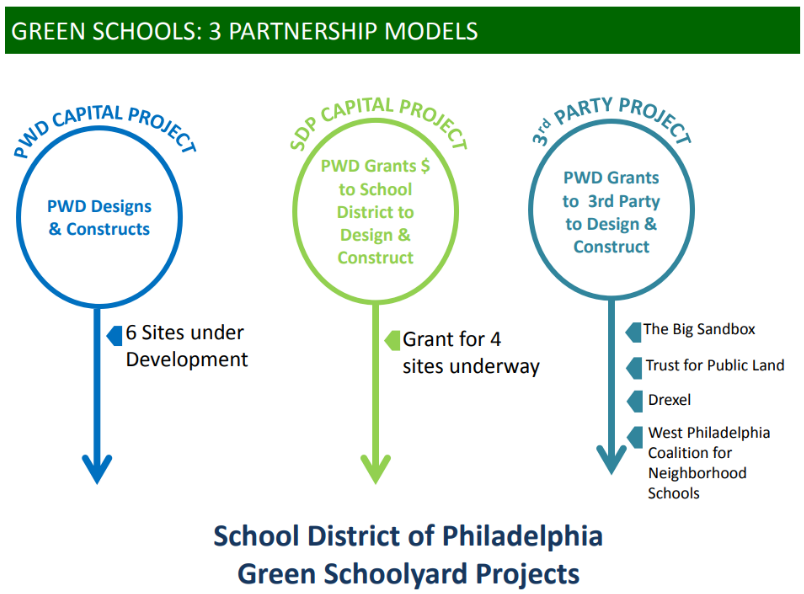
The Philadelphia Water Department and Recreation Department have been leading this effort with community partners to educate, maintain, and engage in green infrastructure solutions. For example, they provide free rain barrels to all residents for water management.[29] They also provide education programs with the students on the urban water cycle.

Most recently, they have expanded their partnership to develop the Philadelphia Green Schools program. The Water Department calculated it had over 1,000 acres of impervious surface from their school properties and set a goal to create a long-term partnership with the School Department to create 550 acres across public, private, and charter schools.[30] In October 2015, the School Department announced plans to invest $5 million to create 20 new green school yards.

[28] http://phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan).
[29] http://phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan).
30 https://www.epa.gov/sites/production/files/2015-10/documents/urbanwatersgreenschoolspres_20150512-.pdf

In combination with funding from the *Green City, Clean Water* program and private funding from non-profit partners such as the BigSandBox, Philadelphia Schools Alliance, and The Trust for Public Land, their investment will leverage $20 million in new park and green infrastructure investments. In conjunction with the program, five schools are participating in the greenSTEM for student monitoring, nine schools are participating in the Fairmount Water Works Urban Watershed Curriculum, and 50 schools are using the guidelines for the Urban Watershed Curriculum.[31] Figure 7 describes the roles and responsibilities in the public private partnership.

Figure 7 Philadelphia Green Schools stakeholder matrix.



Philadelphia is greening 550 of over 1,000 acres of impervious surface in all schools across the City.
Source: The U.S. Environmental Protection Agency

Finally, the Philadelphia Water department offers two incentive programs to advance its goals for implementing green infrastructure at the city-scale. These include the Stormwater Management Incentives program that provides up to $100,000 per acre of impervious surface removed to non-residential property owners to implement green infrastructure for stormwater infiltration. Typical applicants include public and private schools, non-profits, apartment/condo buildings, etc. The Greened Acre Retrofit Program provides funding to contractors, companies, or aggregates to retrofit multiple properties (minimum acreage is 10 acres) with green infrastructure interventions in the areas of the combined system only.

Green City Clean Waters Economics

Econsult Solutions in 2016 performed a return on investment study on the five-year progress and economic implications of the Green City, Clean Water program in Philadelphia. The Philadelphia Water Department has projected investing $1.2 billion in stormwater projects over the 25- year program life.[32] They are leveraging additional projects with the private sector through incentives

31 https://www.epa.gov/sites/production/files/2015-10/documents/urbanwatersgreenschoolspres_20150512-.pdf

32 The Economic Impact of Green City, Clean Waters: The First Five Years. 2016. Econsult Solutions, LLC. For the Sustainable Business Network of Philadelphia. January 2016.

and regulation for additional projects. For example, as of 2016, there were 363 planned or constructed public projects in comparison to 674 planned or constructed private projects. And as of 2016, these projects have supported 430 jobs generating nearly $1 million in tax revenue. Projects supported by the Stormwater Incentives Programs range from $57,000 for retrofits in schoolyards to $630,000 for a two-phased larger project. There are approximately 100 projects throughout the City, mostly in the combined sewer service area, completed with the Stormwater Incentives Program.

Over the 25-year program, the Philadelphia Water's investment are projected to produce a $3.1billion economic impact, supporting 1,000 jobs and $2 million in local annual tax revenue.[33]

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[33] The Economic Impact of Green City, Clean Waters: The First Five Years. 2016. Econsult Solutions, LLC. For the Sustainable Business Network of Philadelphia.

Case Study III: Northeast Ohio Regional Stormwater District-Green Infrastructure Policy

In 2010, the EPA and the Northeast Ohio Regional Stormwater District (NEORSD) agreed on a settlement on Clean Water Act violations for discharges into waterways and Lake Erie. NEORSD serves 62 communities, more than one million people, and 350-square miles, and their agreement will capture and treat 98% of wet weather flows entering the combined sewer system.[34] Green Infrastructure is a major component of their strategy. To date, they have spent approximately $118,560,417 on Sewer District implemented or funded green infrastructure projects, some of these are new parks or retrofitted in existing parks. NEORSD implements green infrastructure parks via funding from a stormwater utility fee but implement green infrastructure in a variety of ways such as through capital improvement plans, regulatory review of new development/discharge permits, grant programs, or their own construction. Some innovative projects are underway or completed as a result of this effort.

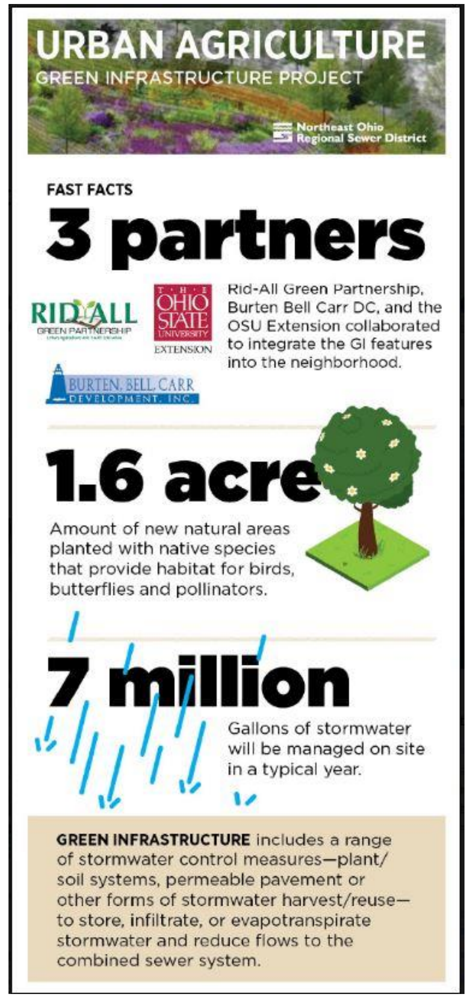


Photo Source: http://neorsd.blogspot.com/2015/08/projects-urban-agriculture-project.html

Urban Agriculture Innovation Zone. The City of Cleveland, and Burton, Bell, Carr Community Development Corporation, created the "Urban Agriculture Innovation Zone," a 28-acre urban revitalization project that is transforming vacant land in an inner-city neighborhood into the one of the largest urban agriculture districts in the US. Land is redeveloped and leased to local farmers, such as the Ohio State University Extension program, a tilapia farm, an orchard, outdoor classroom, and community events. NEORSD is supporting development of green infrastructure in its redevelopment controlling 12.4 million gallons of stormwater in a year by installing four bio-retention systems throughout the zone.

Buckeye Shaker Plaza. With construction underway in 2017, NEORSD partner with LAND studio, Buckeye Shaker Square Development Corporation, and the Greater Cleveland Regional Transit Authority to transform an underutilized space between roads into a park, festival ground, transit waiting area, and public art. The new park is part of a larger redevelopment vision to use arts as a tool for neighborhood revitalization. NEORSD is supporting the installation of detention basins and raingardens for managing stormwater.[35] The basin will encompass 1.6 acres overall with native plants attracting birds, butterflies, and pollinators. One basin will parallel a new pathway that connects to the RTA Station and the other forms an elaborate entry feature to the space (Figure 8).[36]

[34] https://www.neorsd.org/I_Library.php?SOURCE=library/GI_201707_Policy_web.pdf&a=download_file&LIBRARY_RECORD_ID=7240

[35] http://buckeyeshaker.org/visit/public-art-or-galleries

[36] http://www.bbcdevelopment.org/development/streetscape/green-infrastructure/

Figure 8 Buckeye Shaker redevelopment with green infrastructure.

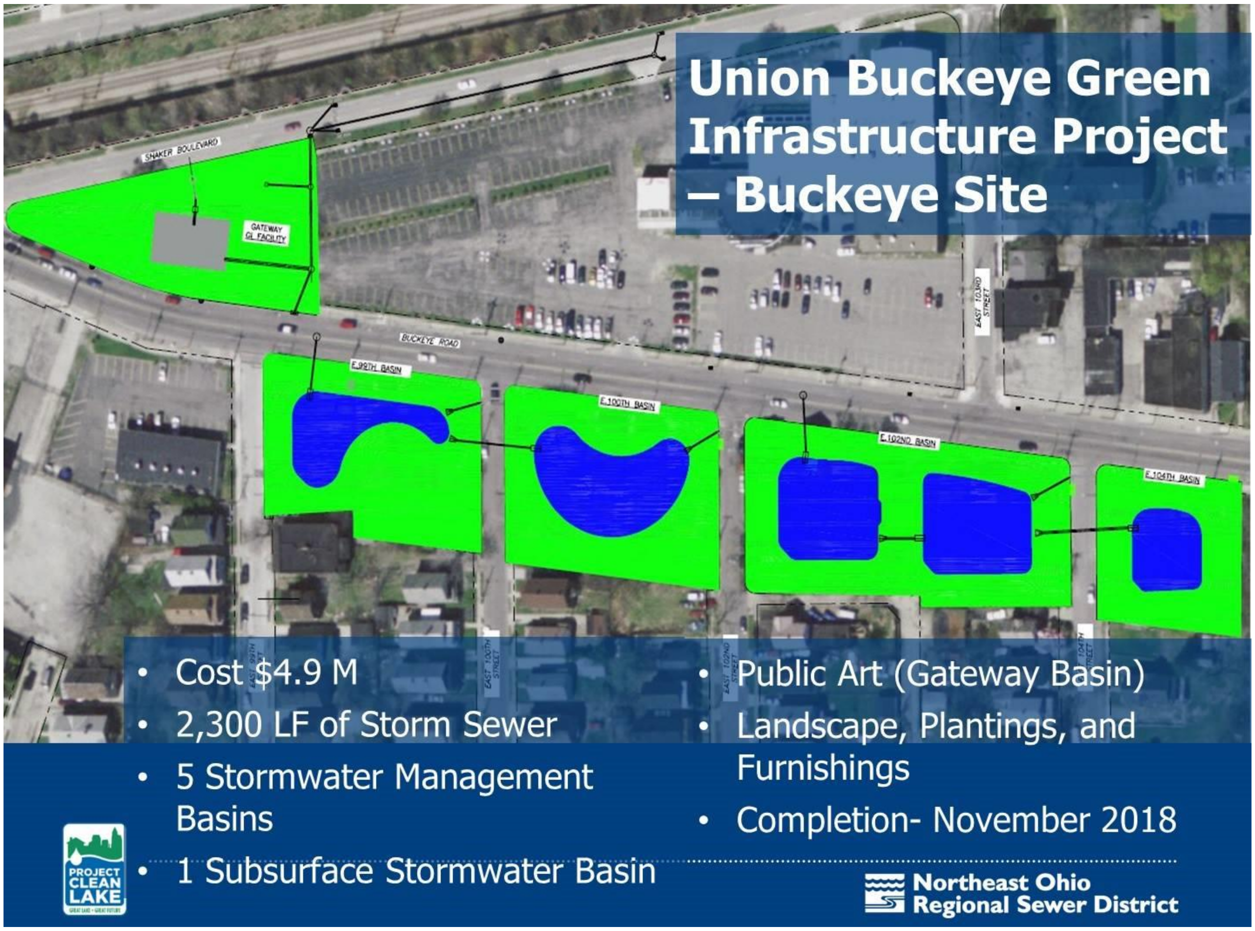


Photo credit NORDS, Project Clean Lake.

Acacia Reservation. Through its Water Resource Restoration Sponsor Program, NEORSD is able to reduce its interest payments on state loans by funding non-profit groups to restore and preserve natural areas that manage stormwater and improve water quality in their service area. The Acacia Reservation is a Cleveland Metropark project designed to restore stream channel and tributary flow of Euclid Creek. Ecological restoration efforts include reconnecting the floodplain and creating wetlands. Acacia Reservation also has regenerative swales designed to capture, treat, and slowly convey stormwater runoff to Euclid Creek.

NEORSD Green Infrastructure Economics

To minimize flows into its CSOs, NEORSD has committed $42 million in green infrastructure projects for its CSO Long-Term Control Plan and its National Pollution Elimination System permit (NPDES) with the EPA. A total of nine projects are already or will be constructed and fully operational by 2019.[37]

Eight green infrastructure projects completed by NEORSD were completed by 2016 and the District performed a co-benefits analysis on their performance on community, environmental, and

[37] Northeast Ohio Regional Sewer District. 2016. *Comprehensive Annual Financial Report*.

financial benefits. NEORSD analyzed eight completed GI projects, two of these are described above. The GI projects captured 192 million gallons of stormwater, created 25 acres of new public space, repurposed 19 acres of distressed properties, planted 1,500 new trees, avoided 189 metric tons of reduced greenhouse gas emissions from wastewater treatment, and saved $145,528 of annual energy costs savings due to avoided wastewater treatment. Specific details related to the GI examples above are described in Table 1.

Table 1 Economic benefits of two green infrastructure projects completed by NEORSD.

Project Details and Benefits	Urban Agriculture	Buckeye
GI Project Size	4.8 acres	3.2 acres
Stormwater Managed Annually	7.0 million gallons	10 million gallons
Drainage Area Managed	61 acres	22 acres
Net Present Value of Life Cycle Costs	$11 million for 30 years	$8.3 million
Annual Energy Savings Avoided Wastewater Treatment	$8,960	$5,200
Green Jobs	0.5 Full Time Equivalent	0.33 FTE
Economic Development	$21,961 annual indirect	$31,359 annual indirect
Air Pollution Mitigation (avoided wastewater flows)	65.8 kilograms	48.2 kilograms
Reduced Greenhouse Gas Emissions (avoided wastewater flow)	11.4 tons	5.8 tons

Park Selection and Design Recommendations

This section provides a summary of our green infrastructure suitability analysis, prioritization methodology, and park by park design recommendations for implementing green infrastructure for stormwater management and climate resilience. It also provides site characteristics and regulatory considerations important to consider when pursuing green infrastructure. Parks that have undergone recent construction or renovation, we have included some retrofit opportunities for now or for future consideration.

Suitability Analysis

MAPC utilized several methods to ascertain site suitability of green infrastructure design in Chelsea's parks.

1. Two site visits to Chelsea's Parks.
2. Green Infrastructure Site Assessment Checklist by Rutgers University.[38]
3. Metro Mayors Climate Smart Region Decision Support Tool.[39]

Prioritization analysis of parks for implementing and/ or renovating with green infrastructure.

Figure 9 The Trust for Public Land Climate Smart Cities™ strategies. Applied in the Metro Mayors DST.

Trails and transit lines provide carbon-free transportation and link residents to popular destinations and each other.

Shady green spaces reduce the urban "heat island" effect, protect people from heat waves, and reduce summer energy use.

Water-smart parks, playgrounds, and green alleys absorb rainfall, reduce flooding, and recharge drinking water supplies while saving energy for water management.

Shoreline parks and natural lands protect vulnerable infrastructure, neighborhoods, and residents from riverine flooding.

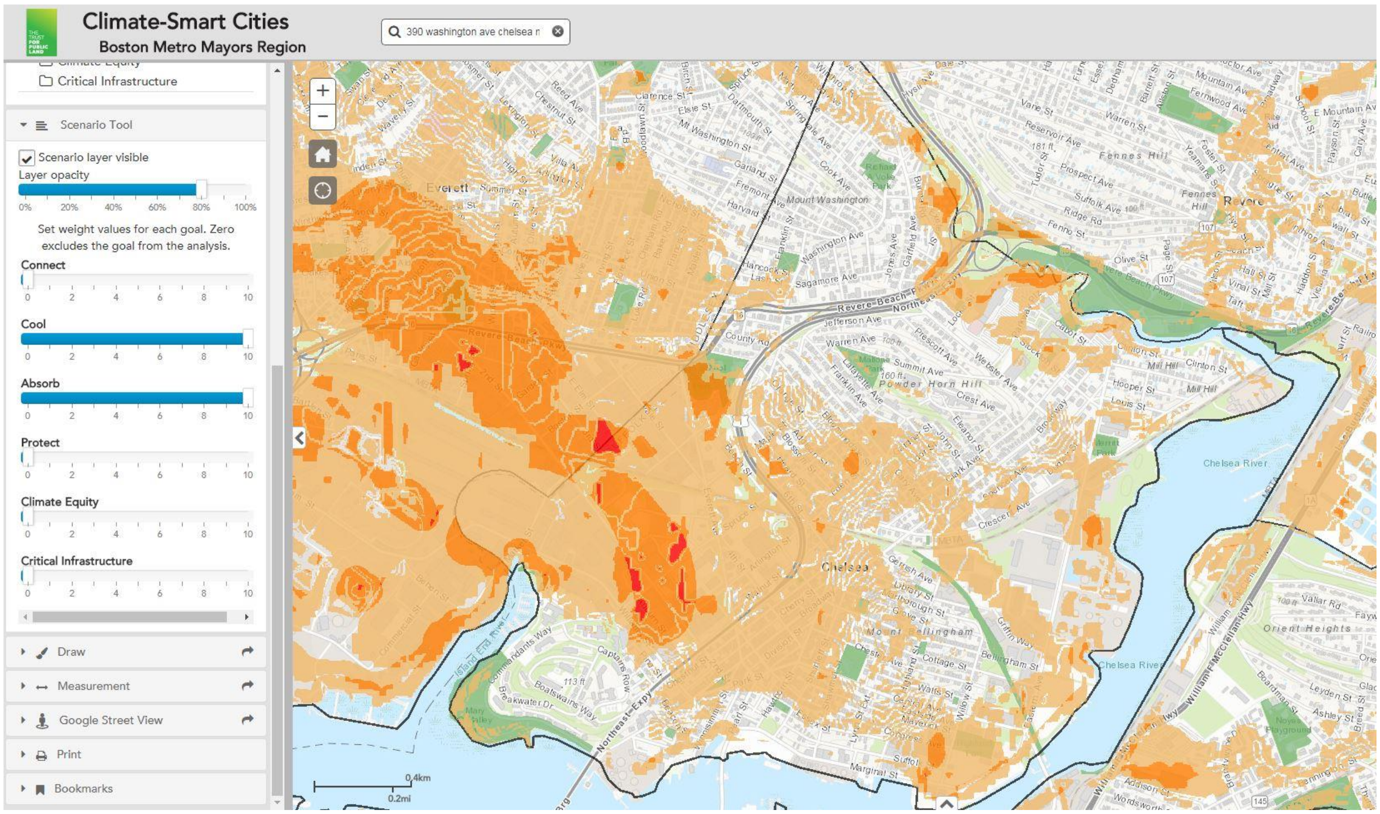
Credit: The Trust for Public Land (www.tpl.org)

In 2017, the Metropolitan Area Planning Council and The Trust for Public Land released the Metro Mayors Climate Smart Region decision support tool (the "Metro Mayors DST") for planning for climate resilience. The tool, open to the public, is a planning guide that illustrates the intersection of climate risk and opportunity for utilizing green infrastructure and nature-based solutions for climate resilience in the 14 municipalities of the Metro Mayors Coalition, including Chelsea (Figure 9). MAPC did a preliminary assessment with the decision support tool to identify key park locations that can serve to manage runoff, flooding, and urban heat. We then performed a park site reconnaissance of most of Chelsea's parks. The first site visit on September 22, 2017, the conditions were variably rainy. The second site visit on October 19, 2017, the conditions were clear, sunny, and warm. On site visits, we consulted the Rutgers University Green Infrastructure Site Assessment Checklist, recommended by the National Recreation and Park Association for

[38] http://www.water.rutgers.edu/Projects/Newark/Objective%201/Green%20Infrastructure%20Site%20Assessment%20Checklist.pdf
[39] https://web.tplgis.org/metromayors_csc/

evaluating green infrastructure in parks.[40] The checklist served to inform Best Management Practices in design recommendations and suitability. MAPC assessed park amenities, users, infrastructure, slope, sinks, pooling, stormwater drains, vegetation, evidence of erosion and/or runoff, and date of last renovation.

Figure 10 Metro Mayors Climate Smart Region DST scenario results.



After completing the park site analysis, we utilized the Metro Mayors DST to further green infrastructure suitability to refine siting and design opportunities. We utilized the DST green infrastructure suitability tool as an addition measure to prioritize parks in need or most suited to implement green infrastructure opportunities. Using the Metro Mayors DST, we performed a scenario analysis with Cool and Absorb at 10 and Protect at a level eight. From the scenario results, we identified parks that qualified as a high or medium high priority for green infrastructure (Figure 10). Since all data in the Metro Mayors DST is tagged to the parcel, we further investigated site characteristics the selected parks, including priority areas for Cool, Absorb, Protect, soil properties, locations near 21E sites, depth to bedrock and groundwater, slope, current and future flood zones, and estimated runoff potential. If the parcel contained characteristics agreeable toward implementing green infrastructure, they were assigned a one or they were assigned a zero if they did not qualify. If a park is within 500 feet of a 21E site, it was assigned a negative one value or if not, a positive one value. The parcel characteristics and value

[40] National Recreation and Park Association. Resource Guide for Planning, Designing and Implementing Green Infrastructure in Parks. 2017. http://www.nrpa.org/contentassets/0e196db99af544bbba4f63f480c1316b/gupc-resource-guide.pdf

determinations are listed in Table 2. One important consideration to note is that depth to bedrock and depth to water table data was not available for the entire City of Chelsea.

Table 2 Prioritization method for scoring parks for green infrastructure suitability.

Parcel Characteristics	"Yes" Value	"No" Value
Absorb Priority	1	0
Cool Priority	1	0
Protect Priority	1	0
Climate Equity Priority	1	0
Sinks	1	0
Estimated Runoff Potential	1	0
FEMA Flood Zone	1	0
BH_FRM Flood Zone 2013	1	0
Within 500 feet 21 E	-1	1
Slope	1	0
Soil Permeability (A or B SSURGO Hydro Group)	1	0
Depth to Bedrock (≥61 cm)	1	0
Depth to Groundwater (≥ 61cm)	1	0

Results

Analysis from the Metro Mayors DST indicates there is significant demand for green infrastructure and nature-based solutions for managing inland and coastal flooding, urban heat island, and general overall city-greening (Figure 9). However, several geomorphological environmental characteristics narrow the scope in green infrastructure design based upon the Metro Mayors DST Green Infrastructure suitability analysis. These include poorly drained soils across much of the City SSURGO Hydro Soil Groups C and D), shallow depth to groundwater and shallow depth to bedrock. These geomorphological characteristics limit the infiltration capabilities. In addition, the distribution of 21E sites across the City also presents further study and/or modified design strategies to ensure any remaining contaminants remain in place to prevent groundwater contamination.

We found 15 City-owned parks within the scenario modeling for green infrastructure priority areas for Cool, Absorb, Climate Equity, and Green Infrastructure Suitability. Table 3 lists the parks and their prioritization value-i.e., ones that are the most important and most accessible to implementing green infrastructure due to their climate risks and green infrastructure suitability. Appendix A illustrates the values of each park, green infrastructure characteristics, and values.

Figure 11 Green Infrastructure suitability geographic analysis.

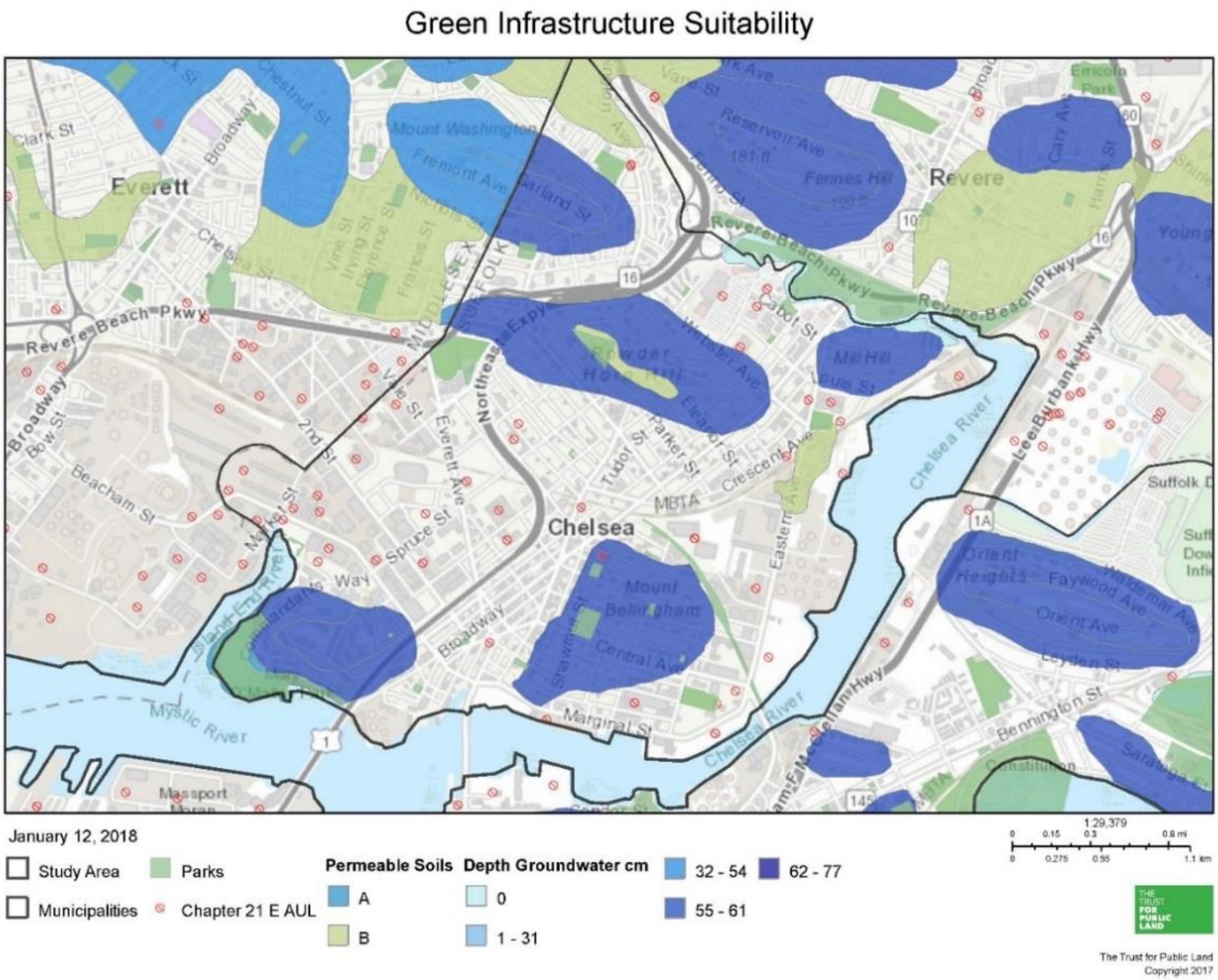


Table 3. Chelsea Parks and score for priority to implement green infrastructure.

Park	Total GI Priority Score
Merrit Park/Burke School Playground	10
Mill Creek Riverwalk	8
High School Carter Park	8
Paul A. Dever Park	7
Island End Park	7
Highland Park	7
Chelsea Greenway	7
John Ruiz Park	7
Eden Street Park	6
Quigley Park	6
Palonia Playground	5
Washington Park	4
Bosson Park	4
Mystic River Overlook Park	3
Ciepiela Park	3
Kayem Park	3
Winnisimmet Park/Chelsea Square	2

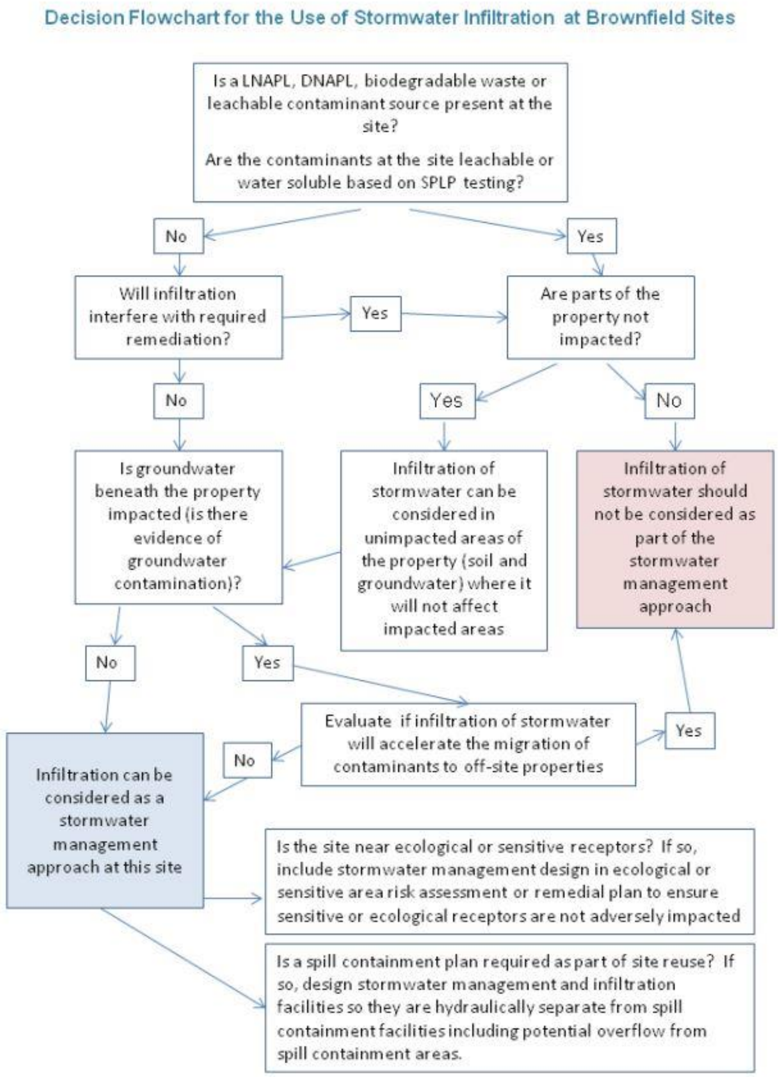
Score based upon need due to climate and stormwater risks as well as opportunity due to green infrastructure suitability.

Stormwater Infiltration and Brownfields

As an industrial city with an active working waterfront, Chelsea has many 21E sites located throughout the City. The feasibility for stormwater infiltration on any given park will depend on environmental site investigations, type of contaminants, and soil drainage type. In this plan, we note whether a park within 500 feet of a 21 E site but the design recommendations in this plan do not take into consideration the presence of contamination in the site soil or groundwater. Depending on the results of site specific environmental investigations, infiltration may or may not be an appropriate recommendation, depending on its water solubility, density, and mobility. The Environmental Protection Agency provides recommendations and guidance on implementing stormwater infiltration on brownfields including a decision flow chart (Figure 12).[41]

[41] Environmental Protection Agency. Case Studies for Stormwater Management on Compacted, Contaminated Soils in Dense Urban Areas. EPA-560-07-232. April 2008

Figure 12 U.S. EPA decision flow chart on implementing green infrastructure on brownfields.[42]



For example, stormwater detention, retention and bio-filtration are generally acceptable green infrastructure solutions in contaminated soils though pervious pavers and raingardens are not generally suitable for sites with residual contamination.[43] However, there are mechanisms to use infiltration that ensures contaminants do not enter the groundwater or further leach into soils, when soil contaminants concentrations are low and do not cause public health issues. Figure 13 illustrates how rain gardens can be used in contaminated soils, with a perforated pipe that leads to the sewer system and an impermeable environmental barrier at the base underground. This ensures some infiltration and reducing the amount of runoff entering the stormwater system. Other mechanisms include green roofs, vertical green walls, water harvest systems, cisterns, etc.

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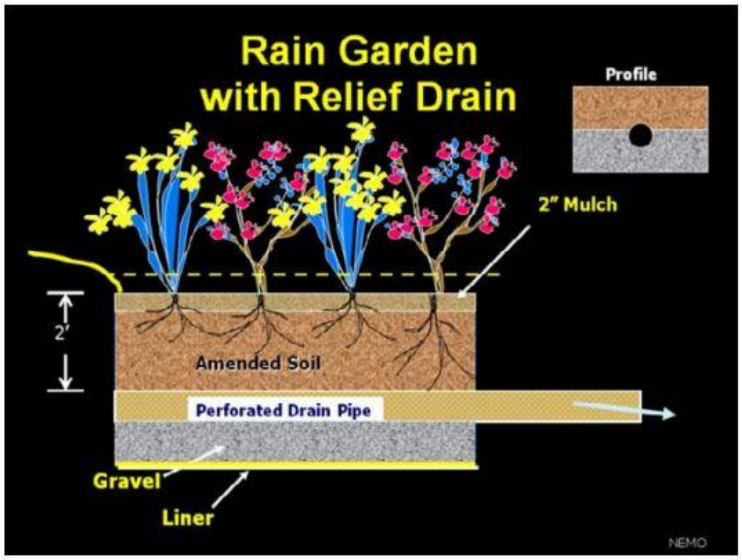
[42] http://www.epa.state.il.us/water/watershed/publications/implementing-stormwater-infiltration-practices.pdf

[43] U.S. Environmental Protection Agency. Implementing Stormwater Infiltration Practices at Vacant Parcels and Brownfield Sites. 905-F13-001. June 2013

Figure 13 Stormwater management without infiltration for brownfields.



Rain Garden with liner and underdrain. Designs such as this allow for filtration and evapotranspiration, but prevent infiltration into subsoils.

Source: http://www.epa.state.il.us/water/watershed/publications/implementing-stormwater-infiltration-practices.pdf

Finally, because urban soils are typically urban fill, soil classifications used in this analysis are from the best information available. However, we recommend site specific testing of soil, its drainage properties, and rate of infiltration for each green infrastructure installation.

Park Design Recommendations

Merritt Park/Berkowitz/Burke Elementary Complex School Playground

Merritt and Berkowitz/Burk Elementary School Park is a large and intensely used play recreation area, particularly for the 570 elementary students who attend the Berkowitz Burke Elementary Schools. The play area is currently undergoing a re-design process with CBA Architects. This site is the highest priority and opportunity for green infrastructure scoring a 10 on our analysis.

Park Site Considerations

- The park contains 271,594 square feet of impervious surface totaling 70% of the park area;
- It contains mature trees along the park perimeter at Crescent Avenue and Eastern Avenue creating a 16% canopy cover;
- It lies within 500 feet of a 21E site;
- The park is susceptible to flooding of 0.5-1.5 feet in 2013 along Eastern Ave and Crescent Ave and onto the baseball diamond.
- It is susceptible to flooding of 0.5-2.5 feet of the entire park area by 2030 (Figure 14).[44]
- Park contains compacted and degraded soils around trees at the playground area.
- Park contains poured-in-place rubber safety surface with potentially outdated play equipment.

[44] Designing Coastal Community Infrastructure for Climate Change. Stantec and Woods Hole Group, January 2017

- Merritt Park is well-maintained, attractive area with a baseball diamond, sports shed, walking path, sitting areas, and perimeter tree canopy.

Figure 14 Coastal Flooding in 2030 for a 1% Annual Chance Storm at the School Complex.

Source: Woods Hole Group BH-FRM and TPL Metro Mayors DST.

Design Recommendations

- Merritt Park is in good condition with well-maintained fields and healthy, mature tree canopy. We suggest only to design/develop a small green roof on the small outbuilding. A green roof will reduce stormwater flowing onto the field and promote additional evapotranspiration for cooling.
- For the Berkowitz/Burke Elementary Schools playground, we recommend pursuing an overall redesign/redevelopment park project. Consider landscape architects and engineers experienced in green infrastructure for stormwater management/climate resilience and experience in working with youth in participatory design processes.
- Enable a student/teacher participatory design process for the park master plan. Use the design process as a platform to educate students on stormwater management, urban heat island, locally grown food, climate change and/or also building consensus.
- Replace asphalt and poured rubber safety surface with a permeable surface. Given the intense use of the site, we recommend a pervious artificial turf with an environmentally friendly/healthy subsurface and perforated pipes that direct excess, non-infiltrated runoff into the sewer system (Figure15). Perforated pipes allow a slow infiltration of stormwater into the ground reducing the amount entering the sewer system. Rather than using a rubber-crumb subsurface, which tends to be controversial, utilize more ecologically friendly infills such as sand, coated silica sand, TPE, or Nike Grind.[45],[46]

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[45] Mayer, R. 2016. "If Not Crumb-Rubber, Then What? 7 Alternative Infills." Sportsfield Management. https://www.sportsfieldmanagementmagazine.com/maintenance/artificial-turf/crumb-rubber-alternatives/

[46] http://www.woodardcurran.com/blog/alternatives-to-crumb-rubber-for-synthetic-turf-fields

Figure 15 Artificial Turf with Perforated Pipe for Water Infiltration.

Photo credit The Trust for Public Land

- Consider increasing the tree canopy to 75% of the site with 10 years. Given artificial turf can exacerbate the urban heat island effect, strategically sites additional trees to ensure turf is shadowed throughout the day. Also consider turf and engineering solutions that enables evapotranspiration for cooling.
- Work with students to design and install community gardens in raised and/or container beds (Figure 16). Consider having gardens open during the summer months for year-round Use a geotextile barrier at the base of the raised/container beds. Import new high-organic content soils to fill the raised/container beds.
- Create rain gardens and/or vegetated bioswales around storm drains to minimize water entering the system.
- Consider creating earthen berms and/or topographic "cones" within and around the park to create a topographic, natural play feature, strategy to direct stormwater to gardens or other infiltration features, and to mitigate coastal flooding and sea level rise.
- Consider salt water resistant trees, shrubs, and plants acclimated to endure periodic coastal flooding.
- Use pervious pavers that allow for infiltration for walking paths. Where vehicles are required for safety, ensure that any stormwater runoff generated from asphalt of impervious surface is captured onsite.

Figure 16 Container gardens for growing food at a NYC school playground.

Photo Credit: The Trust for Public Land

- Incorporate a design strategy and/ or barrier that minimizes trampling on tree roots for trees on the Crescent Street side. Replenish and enrich the soil with more organic content for greater permeability and water retention. Minimize park design that would encourage trampling of roots.

Mill Creek Riverwalk/Creekside Commons

Photo Credit Darci Schofield

The Mill Creek Riverwalk is an approximate 0.6 acre park along Mill Creek on property managed by Chelsea Commons, LLC and owned by multiple entities including Chelsea Housing Authority, Chelsea Commons LLC, Parkway Plaza Venture, LLC and the Commonwealth of Massachusetts. The Commonwealth owns Mill Creek and its floodplain. Mill Creek received a nine score for green infrastructure opportunity/priority, and is worthy of recommendations despite being owned by multiple entities. It is one of the few parks with the significant nature-based experience and has tremendous opportunity to increase resident connections to the waterfront, encourage biking, protect critical infrastructure in the floodplain, and create park amenities for teen and older youth, a priority defined in the 2018 OSRP.

Park Site Considerations

- Creekside Commons and Mill Creek Greenway is within a 1% Annual Chance Storm in 2013, according to the BH-FRM with depths of 0.5-1.0 feet.
- A chain link fence separates the park user on the path from experiencing or viewing Mill Creek.
- Significant trash and litter on the creek side of the chain link fence, where the fence itself seems to encourage dumping.
- Floodplain is overgrown with invasive and exotic species and is a degraded ecosystem.

- The site contains priority areas for green infrastructure solutions as determined by the Metro Mayors DST for Absorb, Cool, Protect, and Climate Equity.
- The entrance is located adjacent to housing owned by the Chelsea Housing Authority, making it an important Climate Equity opportunity.
- The Greenway and Creekside Commons produce runoff during a one-inch storm event.
- The site is located within 500 feet of a 21E site.

Figure 17 Photo of a pump track in Redding, CA.

Pump tracks promote youth biking at many levels and social connectedness. Photo Credit: Ride Redding

Design Recommendations

- Collaborate with the Commonwealth of Massachusetts on ecological restoration of the floodplain, including invasive and exotic species removal, forest management, habitat and marsh restoration to ecological function of the marsh and upland areas as important barriers to flooding. Restoration should also consider planting salt resistant shrubs and trees.
- Given the residents of Chelsea in their 2018 OSRP indicated a desire to have better connections to their waterfront, consider removing the fence between the greenway path and the creek. This combined with floodplain ecosystem restoration can significantly enhance the beauty, integrity and experience along the Greenway and Creekside Commons. Consider lighting and sighting in design.
- Dredge Mill Creek for better flow, river habitat, and floodplain protection. If sediments are determined non-toxic, use sediment to build earthen berms along the shoreline and at Creekside Commons to minimize future flooding. Use earthen berms as an elevated walking path along the creek.

- To encourage more Greenway use and develop recreational amenities for older youth and teens, consider creating a pump track/park along underutilized areas on the Greenway and Creekside Commons. [47] The pump track can also have the dual function of protecting infrastructure from riverine flooding as well as capture stormwater runoff from adjacent pervious surfaces (Figure 17) by creating infiltration bioswales in between the berms and rolls of the pump track.[48]

[47] Pump Tracks are off-road terrain for bikes consisting of banked turns, berms, and rollers designed to be ridden by riders creating momentum by up and down movements or "pumping". Relatively simple and inexpensive to construct, serve a wide-range of rider skills, and easier to maintain (Wikipedia, 2018).

[48] The City of Providence is creating a teen adventure park with bike trails and pump track along the dense, highly urbanized Woonasquatucket River. https://www.tpl.org/our-work/woonasquatucket-river-adventure-park#sm.001512ahrmwldks11rx287vxsvjsi

Island End Park

Photo credit Darci Schofield

In January 2017, CAM, Stantec, Woods Hole Group, WPI, and Woods Hole Sea Grant created a conceptual plan for renovating Island End Park and restoring the Island End river shoreline and salt marsh. Island End park received an eight for green infrastructure priority/opportunity in our analysis and we encourage the City of Chelsea to pursue this effort, generally with the recommendations put forth in the aforementioned report.

Park Considerations

- Access to the park is unclear and park amenities are view obstructed by overgrown invasive species.
- The shoreline on Market Street is degraded with compacted soils and is fully exposed to street allowing stormwater runoff to enter directly into Island End River.
- The park is a priority area for green infrastructure according to the Metro Mayors DST for Absorb, Cool, Protect, and Climate Equity.
- The site produces runoff in a one-inch storm.
- The site is within a BH-FRM 1% Annual Chance Flood for 2013 subject to 1.5- 5 feet of flooding.
- The site is within 500 feet of a 21E site.

Design Recommendations

- Perform a robust, community-based participatory design process for the re-design and development of Island End Park.
- Consider sightlines as a baseline park requirement preventing the "nooks and crannies" effect for safety and offering park users a more profound visual experience with the waterfront, a goal identified in the 2018 OSRP.
- Enhance the visibility of park entrances.
- Pursue the recommendations for climate and flood resilience put forth in "Designing Coastal Community Infrastructure for Climate Change" including invasives/exotics removals, shoreline restoration of Island End River at Market Street, and earthen berms for critical infrastructure protection within the floodplain.
- Create design features that provide space for flooding, create wetlands, utilize innovative recreation amenities with water, and provide a greater experience to the waterfront (Figure 18).

Figure 18 Urban park wetlands to accommodate flooding and pathways for walking/biking.

Photo Credit The Trust for Public Land

- CAM et. al suggest salt marsh restoration at the shoreline of Island End Park. Because salt marshes are highly susceptible to degradation from non-point pollution, stormwater, and other water quality impairments, install a floating wetland in addition or as an alternative to salt marsh restoration, since both Mystic and Island End Rivers are impaired waters.[49]

Floating Wetlands (Figure 19) can:

[49] Massachusetts Department of Environmental Protection, 2014 List of Integrated Waters.

- Provide additional measure of shoreline protection to infrastructure.
- Increase marine species habitat and biodiversity.
- Withstand tidal inundation and sea level rise.
- Absorb pollutants such as Nitrogen.
- Provide surface area for beneficial root bacteria to clean water.
- Mitigate water turbidity.[50]

Figure 19 Floating Wetland in Chesapeake Bay, Baltimore and schematic.

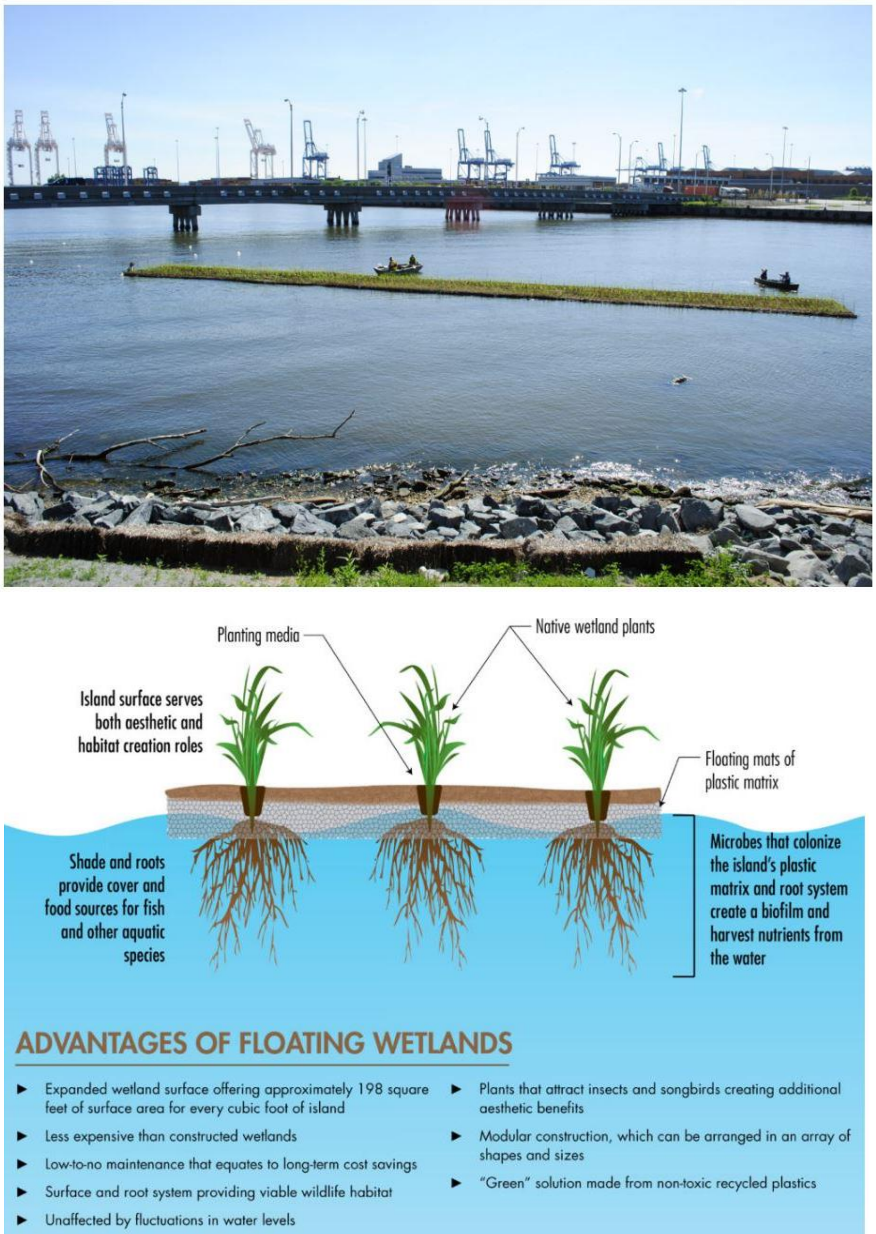


Photo Credit KCI

[50] Haynes, Andrea. A Floating Wetlands Handbook for San Francisco's Southeast Waterfront. https://issuu.com/andreahaynes/docs/patri_booklet_issuu

Highland Park

Photo Credit City of Chelsea

Highland Park is one of Chelsea's most popular recreation facilities and intensely used park. It currently contains a regulation-sized artificial turf soccer field, concession stand, play equipment, seating, and a parking lot. The City has completed a schematic design and received public input on this on April 27, 2017. Highland Park scored eight for priority/opportunity for green infrastructure installations.

Park Site Considerations

- The proposed redesign of the park contains a parking lot consuming approximately 50% of the site.
- Currently, 30% of the park area is impervious surface, and 18% of the park contains tree canopy cover. The new design incorporates additional trees to the site.
- The park is a priority area for green infrastructure according to the Metro Mayors DST for Absorb, Cool, Protect, and Climate Equity.
- Located within a BH-FRM 1% Annual Chance Flood Zone for 2013 with 0.5-1.0 feet of flooding.
- Will produce runoff in a one-inch rain storm.
- Is located within 500 feet of a 21E site.

Design Recommendations

- Ensure that all stormwater is captured onsite.
- Consider creating a “green” parking lot. Benefits include stormwater infiltration, enhanced evapotranspiration to “cool” the park, beautification and air quality mitigation from vehicle emissions (Figure 20). Utilize engineered materials capable of supporting vehicle traffic for travel and parking.

Figure 20 Green Parking Lots that capture stormwater and promote evapotranspiration for cooling the urban heat island.

Photo Credit Ecoterr.com

- An alternative “green” parking lot is using pervious pavers and directing runoff to the trees and vegetation in the proposed plan. Using tree wells provides maximizes water storage and minimizes soil compaction. A small trench within the parking lot promotes slow speeds and directs stormwater to infiltration areas such as the tree wells and vegetation alleviating stormwater into the storm system (Figure 21).

Figure 21 Parking lot design that promotes infiltration and directs runoff to adjacent vegetation.

Pratt Institute parking lot retrofit, Brooklyn, NY. *Photo credit Inhabitat.*

- Use pervious pavers for walking paths around the park, in seating areas, and around basketball courts.
- For the proposed water feature, create a system that harvests and stores the water for irrigation reuse or infiltration. For example, used water from the spray feature could be stored in an underground tank that allows slow infiltration into the ground (but still connected to the stormwater system in the event of overflow). Another option is to create a small wetland, gravel area that creates a natural space that stores the spray waste water (Figure 22).

Figure 22 Created wetland that stores, cleans, and infiltrates spray feature wastewater.

Photo Credit: The Trust for Public Land

High School Carter Park

Photo Credit Google Earth

Chelsea High School Carter Park is a nearly 4-acre, active recreation park adjacent to Chelsea High School. It contains baseball diamonds, tot lot, play equipment, running track and football field. It also is the site of the recently restored Massachusetts Department of Conservation and Recreation Vietnam Veterans Memorial Pool, which is an important community amenity especially during hot summer days.[51] Carter Park and Burke are currently undergoing a master design planning process in 2018 and the high school Veterans Stadium will be renovated in 2018. Carter Park received a score of seven for green infrastructure priority/opportunity.

Park Site Considerations

- The site is a priority area for green infrastructure for Absorb, Cool, Protect, and Climate Equity.
- The two parcels on the site owned by the City of Chelsea contain approximately 67% impervious surface and 20% tree canopy cover.
- The parcel contains active recreation amenities that require significant space, openness, and specialized surfaces.
- The site is located within a 1% Annual Chance Flood zone according to the BH-FRM in 2030 with a flood depth of 0.5 feet. Flooding originates from Island End River.
- The site is within 500 feet of a 21E site.

Design Recommendations

[51] http://www.chelsearecord.com/2010/07/08/heat-wave-hits-region-chelsea-prepared/

- The recreation amenities, recently renovated, are anchors to the park itself. There is sufficient space in some small underutilized areas to perform small green infrastructure installations where pooling may occur. We suggest a comprehensive understanding on the flow, infiltration, and runoff of stormwater onsite for best site design within the park.
- Create an opportunity to collect stormwater runoff from the track and football field into an artful and natural amenity for managing stormwater in the non-recreation areas.

Figure 23 "Dry" beds or stream beds that manage stormwater as art installations.

Design by Penn State. Photo Credit Inhabitat (top) and robmaday.com (bottom).

- Create a dry bed that can collect runoff from pervious surfaces that enters into a created stream. Figure 23 illustrates two types created streams. The top photo is a "dry" bed that allows infiltration into the ground and the bottom photo collects water through a system that allows slow infiltration (i.e., such as perforated pipes). Ensure the design enables water infiltration within 72 hours to prevent mosquitos to adhere to local health regulations.

- Seek an artist to create creative, artful storm drains from the roof toward an infiltration area adjacent to the school (Figure 24)

Figure 24 Rain water capture with artistic gutters and rain gardens.

Photo credit Curbed Philly. Artist Stacy Levy (StacyLevi.com).
Springside Chestnut Hill Academy, Philadelphia in parthernship with the Philadelphia Water Department and Philadelphia Horticultural Society, hired artist Stacy Levi to create a system to manage stormwater while creating a space of beauty in an underutilized area on the school campus. The rain water flows from the gutters through PVC pipes decorating the side of the building. It then flows to a graded bio-swale planted with native species (planted by the school children), then to a planted infiltration basin where it slowly infiltrates into the ground.

Chelsea Greenway

Photo Credit Massachusetts Department of Transportation

Chelsea Greenway is a 0.75 mile mixed-use path parallel to the under-construction Silver Line Bus Rapid Transit from Chestnut Street to Eastern Ave. This is a Massachusetts Department of Transportation Project and the Greenway itself is funded in part by the Massachusetts Executive Office of Environmental Affairs. The City of Chelsea has committed to maintain the Greenway. The Greenway opened in April 2018. The Chelsea Greenway received a score of seven for priority/opportunity for implementing green infrastructure in our analysis.

Park Site Considerations

- The site is a priority area for green infrastructure for Cool, Absorb, Protect, and Climate Equity according to the Metro Mayors DST.
- The Greenway, from Eastern Avenue to Cottage Street, could experience 0.5-1.0 feet of flooding in a 1% Annual Chance Strom in 2013 and 2030 according to the BH-FRM.
- The site does have a slope overall.
- The Greenway contains mostly poorly drained soils with low depth to bedrock and depth to water table.
- The City of Chelsea will be installing final landscaping along the Chelsea Greenway in 2018.
- As part of the Greenway/Silverline BRT development, some site clearing required a few substantive trees to be removed.

- The Chelsea Greenway/ Silverline BRT contained the following green infrastructure installations in its recent development:
    - 1,500 linear feet of a vegetated bio-retention swale between the Busway and the Shared Use Path.
    - Stormwater recharge systems, a stormwater detention basin and drainage swales.
    - At the BRT stations, 40 trees and 500 shrubs.[52]

Design Recommendations

- At the terminus of the Greenway at Eastern Ave, consider working with the Commonwealth of Massachusetts to create a skate park that serves to hold and mitigate coastal flooding (Figure 25). This park would serve to address Goal One (providing full range of recreational opportunities and Goal Two (acquire waterfront properties large enough to serve as park nodes) in the 2018 OSRP while also providing a system to protect critical infrastructure and economic centers from coastal flooding. The community of Chelsea also identified this area as a park priority in "A VISION for the Chelsea Waterfront" in October 2016.

Figure 25 Rabalder Park in Roskilde, Denmark.

The skate park serves to help mitigate flooding and hold up to nearly 10 swimming pools of water during a flood event. Photo credit/Source InHabitat. https://inhabitat.com/denmarks-rabalder-park-can-contain-10-swimming-pools-worth-of-floodwater/

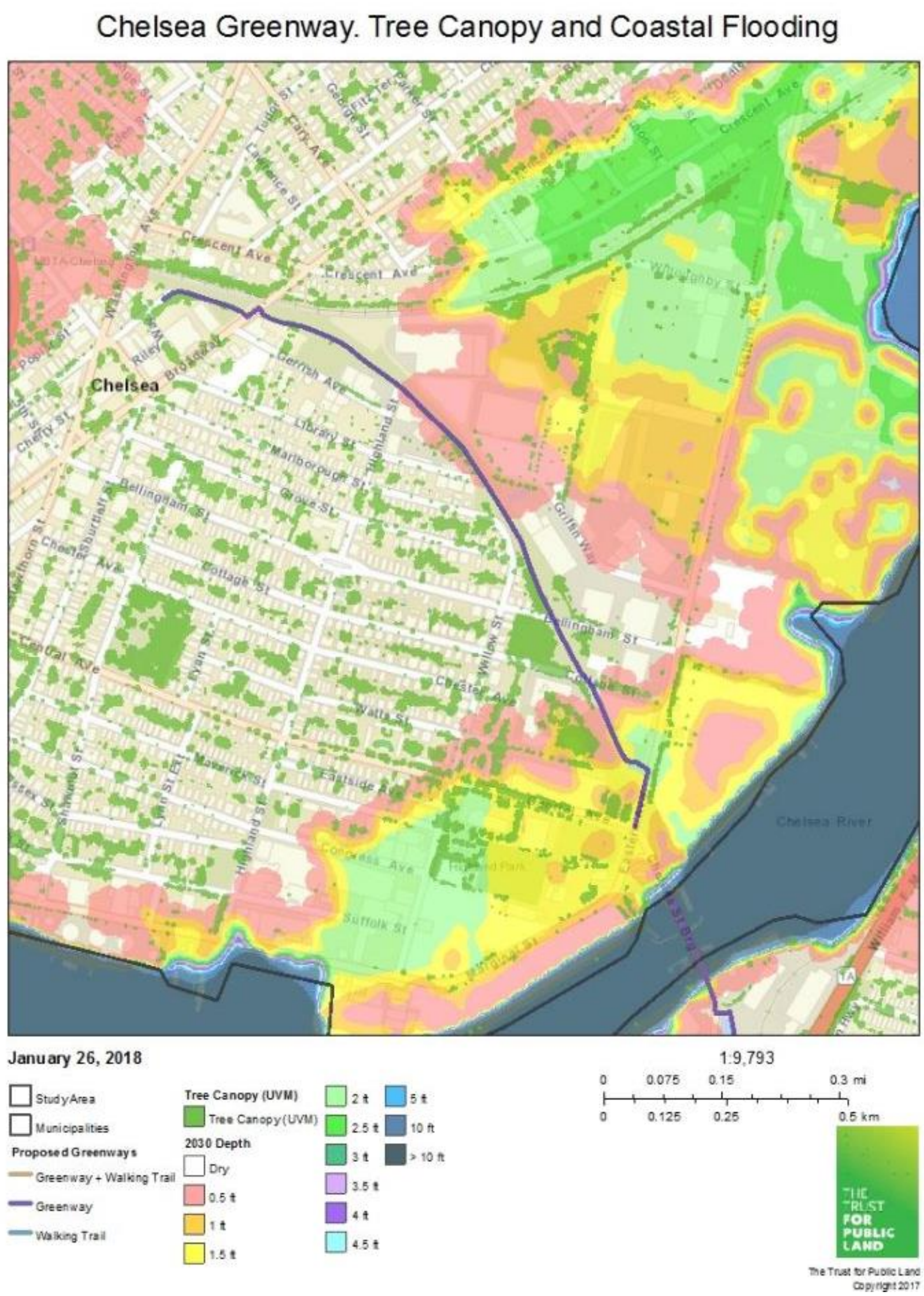
- The Chelsea Greenway is an excellent opportunity to increase Chelsea's tree canopy, particularly do to its adjacency to significant impervious surface, high urban heat island,

[52] Fancis Astone. AECOM. Personal Communication. January 25, 2018.

and minimal tree canopy within the adjacent industrial area (i.e., Logan Pre-Flight Parking Lot, Gulf Oil Terminal, Eagle Air Freight, etc.).

Adding trees to the Greenway will provide a "cool" and pleasant riding and walking experience during very hot days, particularly for those who will use the Greenway for commuting. Figure 26 illustrates Chelsea's tree canopy which was evaluated using LIDAR at one meter resolution.

Figure 26 LIDAR Tree Canopy and Coastal Flooding in Chelsea.



John Ruiz Park

Photo Credit CBA Landscape Architects, LLC

John "The Quietman" Ruiz Park is a 0.2-acre park is dedicated to the Chelsea born and raised, first Latino, and twice won heavyweight champion. This attractive park was renovated and dedicated in 2014 and it contains fitness equipment, water features, playground, walking and sitting areas. Attractive perennial gardens decorate the perimeter of the park. John Ruiz Park scored a six for priority/opportunity for green infrastructure.

Park Site Considerations

- The park is a high priority for green infrastructure for Cool, Absorb, and Climate Equity in the Metro Mayors DST.
- The site is within 500 feet of a 21E site.
- The site has a moderate slope, poorly drained soils, and high water table depth and low depth to bedrock.
- The site is 89.5% impervious. The tree canopy is immature with trees planted in 2014.
- The site produces runoff in a one-inch rain event.

Design Recommendations

- Given the site has significant impervious surface, consider reconstructing garden beds along the perimeter of the park into rain gardens.
- Create decorative trenches that transfers the water feature runoff toward rain garden beds.

- Consider hiring an artist to construct an art installation that harvests rain water that can be used to irrigate the gardens (Figure 27).

Figure 27 Sculpture that harvests and stores rainwater with a spicket at the base for water reuse.

Accumuwater Water Tower

(images via: coroflot)

Doubling as public sculpture, the Accumuwater is like a smaller, household version of the Agua in Situ without the filtering capabilities. The towers independently capture rainwater for those who, for whatever reasons, can't use their roofs; a hose or spigot attaches to the base.

Photo credit EcoFriend.com

Eden Street Park

Photo Credit Google Earth

Eden Street Park is 0.2-acre passive recreation and tot lot that forms an "L" shape connecting Eden and Addison Streets. The park is in good condition and has decorative gardens with roses at the entrances. Also, planters placed on the sidewalk on the Addision Street entrance as well as the showy roses indicate neighborhood care and beautification of the park. A utility box onsite on the Eden Street side, which could inhibit more significant infiltration practices. Eden Street Park scored a seven as a priority/opportunity for green infrastructure.

Park Site Considerations

- The site is a priority area for green infrastructure for Cool, Protect, and Climate Equity.
- The site will be exposed to approximately 0.5 feet of flooding by 2030 according to the BH-FRM in a 1% Annual Chance Flood.
- The site is within 500 feet of a 21E site.
- The soils is poorly drained with low depth to bedrock and groundwater.
- The site contains approximately 51.2% tree canopy cover and 47.2% impervious surface.

Design Recommendations

As a passive park in good condition, we suggest some retrofits to enable greater stormwater management capacity.

- Replace brick walkway with pervious pavers.
- Reconstruct gardens at the entrances as rain gardens that enable some infiltration.
- Gently remove and replant the existing roses in the rain gardens.
- Consider adding stormwater planters to enable the neighbor's gardening and planting interests (Figure 28).

- Consider installing rain harvesters to supply watering to the roses and decorative stormwater planter.

Figure 28 Stormwater Planters used to filter and slowly infiltrate rain water.

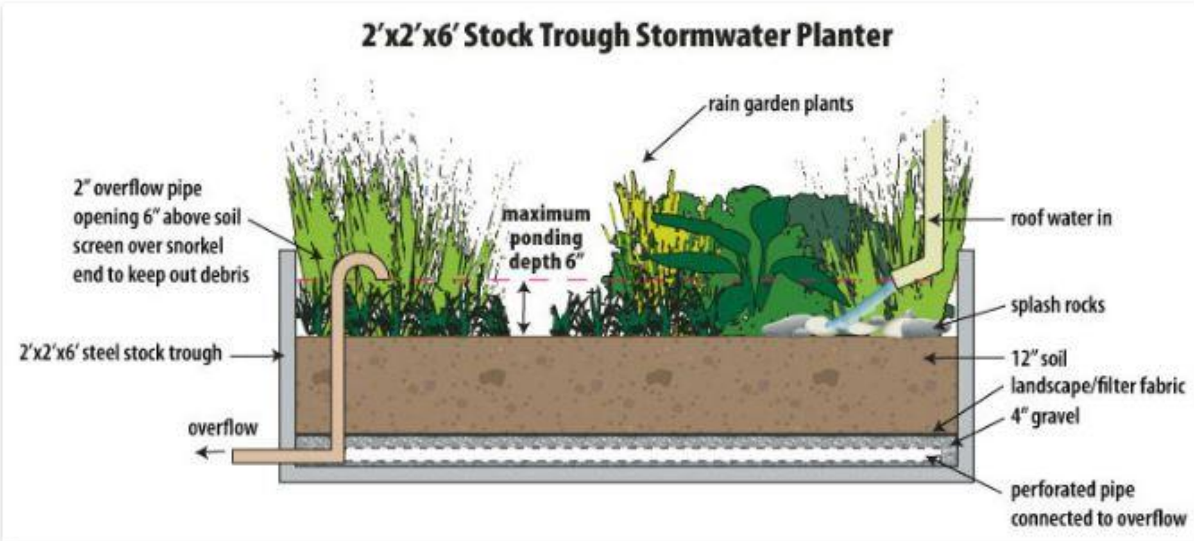


Photo Credit East Multnomah Soil and Water Conservation District

Mystic River Overlook

Photo Credit Darci Schofield

Mystic River Overlook Park is one of Chelsea's newest parks. Located under the Tobin Bridge, the 2.2 acre park contains large open areas providing excellent opportunities for walking, picnicking, community programming such as yoga classes and art installations. It also contains fitness equipment. The park was officially opened in September 2017 and the City of Chelsea mentioned interest in having public art installations be a future amenity. This park scored a six as a park priority/opportunity for green infrastructure.

Park Site Considerations

- The park is a priority area for green infrastructure for Absorb and Climate Equity.
- The site is within 500 feet of a 21E site.
- The site has a steeper slope (4.5), poorly drained soils, and greater 2 feet depth to bedrock.
- The site is adjacent to the Mystic River.

Design Considerations

Because the site was just recently constructed, we suggest retrofits that capture any potential stormwater runoff that could occur once soil is compacted from frequent use. The site has a steeper slope and its adjacency to the Mystic River are important considerations for ensuring stormwater capture onsite for the first inch of rain and potentially stormwater capture from adjacent uphill properties.

- Create infiltration systems along the downslope perimeter areas of the park along the retaining wall at Broadway, areas that are not in recreational use.
- Use the bridge as an additional amenity to the park. Create vertical gardens along the drain pipes along the structural legs of the bridge (Figure 29). Vertical gardens will uptake rainfall and stormwater down the bridge structure, serve to clean the air, create a three-dimensional park space, and cool the park with additional evapotranspiration.

Figure 29 Vertical gardens along the Tobin Bridge piles.

Photo and design credit: Darci Schofield

- Host an artist design competition for Mystic Overlook Park that serves to capture, harvest, and infiltrate rain and stormwater while creating public art amenities that celebrate Chelsea's community character. For example, the Philadelphia Water Department, EPA, and Community Design Collaborative hosted "Infill Philadelphia: Soak it UP!" This design competition asked for retrofit designs that managed stormwater with green infrastructure while creating community assets and amenities.[53]

[53] http://planphilly.com/eyesonthestreet/2012/11/26/soak-it-up-green-infrastructure-design-competition

Paul A. Dever Park

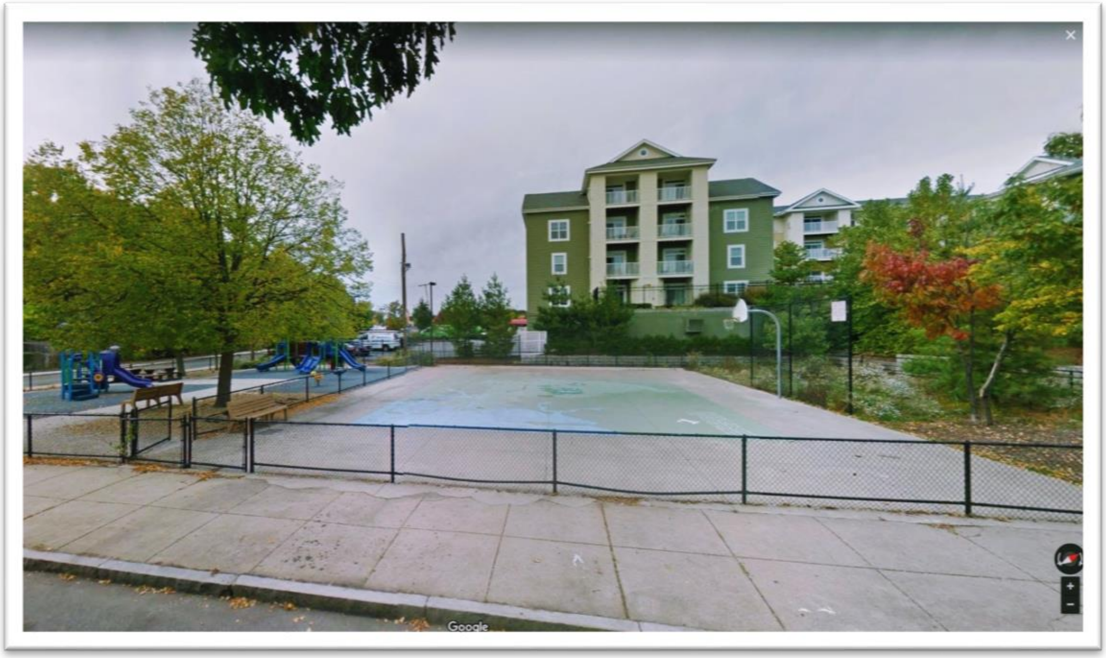


Photo Credit Google Earth

Paul A Dever Park is a 0.28-acre corner park adjacent to the newly developed Parkside Commons, an eco-friendly, higher-end condominium complex. Dever Park contains a basketball court, tot playground equipment, and benches. It also contains gravel around the trees and other surfaces which migrates onto the sidewalk, road, and rubber safety surface under the play equipment. It was rated in fair to poor condition in the 2018 OSRP. The park scores a six for priority/opportunity for implementing green infrastructure.

Park Site Considerations

- The site is a priority area for green infrastructure for Cool, Absorb, and Climate Equity according to the Metro Mayors DST.
- The site has low areas that would tend to pool water (i.e., sinks) and produces runoff in a one-inch rain.
- The site has poorly drained soils and low depth to water table and depth to bedrock.
- The park has 25% tree canopy cover and 65.5% impervious surface.

Design Recommendations

Given the fair to poor condition of the park, we suggest an entire redesign/redevelopment. Enable the community to define the amenities and participate in the design while using the opportunity to highlight climate risks and opportunities for resilience with the park design. Green infrastructure solutions should be complimentary to neighborhood amenities and vision to the plan. In the renovation and/or design, consider:

- Removing invasive/exotic vegetation and/or trees in poor condition.

- Keep mature trees in good condition.
- Plant new trees that will create 100% canopy cover within 10 years. Use tree wells for new trees to prevent soil compaction from trampling/use of the park.
- Utilize pervious pavers for walkways around safety surface and courts to allow some infiltration into the ground.
- Given the poorly drained soils and low depth to bedrock/water table, install permanent decorative planters to minimize stormwater runoff.
- Install artistic rain water harvesters that serve to capture, store, and re-use rainwater for nearby plants, trees, and stormwater decorative planters (Figure 30).

Figure 30 Rainwater harvesters and decorative stormwater planters.

These cisterns contain spickets at the base to allow for re-use of the water. Photo credit American Society of Landscape Architects.

- Direct run off from impervious surfaces, such as courts and rubber safety surfaces to a created wetland/dry pond, such as along the retaining wall at the northeast boundary of the park. This can serve to add more natural beauty to the park while minimizing stormwater runoff into the drains.

Washington Park

Photo Credit Darci Schofield

The 1.7-acre Washington Park is cultural, historic landscape for the City in addition to its beauty and recreational amenities. It is dedicated to General George Washington, the First President of the United States, whose troops were stationed at the area that is the park. The dedicated Pratt family of Chelsea pursued dedicating the area as a park beginning in 1875. The park was recently renovated in 2012 and contains many of the landscape design of the historic park. It is well-used for walking, resting, and playing with the playground area. The park received a score of six for priority/opportunity to implement green infrastructure.

Park Site Considerations

- The park is a priority area for green infrastructure for Cool and Climate Equity according to the Metro Mayors DST.
- The park contains poorly drained soils but a higher depth to water table making it more suitable for infiltration.
- The park has high runoff potential in a 1-inch rain storm due to its mean 2.5 slope.
- The park is within 500 feet of a 21E site.
- Existing terracing design promotes natural infiltration and minimizes stormwater entering the storm drain.

- Twenty-seven percent of the park is covered by tree canopy and only 4.3 % impervious surface.

Figure 31 Zig Zag terracing to managing stormwater at San Martin de la Mar Square urban park in Cantabria, Spain.

ZigZag Arquitetura used permeable paving as an opportunity to create a beautiful design component in this urban park. It consists of terraced geometric platforms with alternating bands of grass, permeable paving, and concrete. Photo Credit Zigzag Arquitectura, © Roland Halbe

Design Recommendations

Given the recent park renovations and the public interest in preserving the historic landscape character, we propose some green infrastructure retrofits that minimize runoff from entering the storm system.

- Replace walking paths with pervious pavers.

- Consider expanding the terrace retaining walls. Design in a switchback /geometric pattern such that water has even greater distance to travel and providing more opportunity to infiltrate prior to entering the storm system (Figure 31). This will be important as soil and turf become compacted with park use.

Figure 32 Downslope storm drain at Washington Park and raingarden installation.

The top photo is Washington Park today. The bottom photo is with recommended plantings and raingardens to capture stormwater before entering drains at the downslope park entrance. Design and Photo Credit: Darci Schofield

- Consider a green infrastructure intervention to capture stormwater running down central walking path to the storm drain at the entrance of the park at Washington Ave., Lyons Square, and Hancock Streets. Plant a tree on either side of the stone perimeter wall at the entrance and add rain garden/native vegetation designed to capture any stormwater prior to entering the drain. (Figure 32).
- Increase the canopy cover to 100% over 10 years. Historic photos indicated more trees in the park than exist today.

Palonia Playground

Photo Credit Google Earth

Palonia Park is a 0.4-acre active, shaded park, one of the few officially friendly to pets. It contains a tot lot, benches, a walking path and a significant tree canopy. According to the 2018 OSRP, the park lawn and pavement are reported in "fair" condition whereas the play equipment and benches are reported in "good" condition. Since the park is pet friendly, capturing the first inch of water onsite is critically important to prevent further impairment to the adjacent Chelsea Creek from dog waste contamination. However, the most downward slope of the park appears to contain a utility box potentially minimizing options for infiltration in that area. The park scored a five as a priority/opportunity to install green infrastructure.

Park Site Considerations

- The park is a priority area for green infrastructure for Cool and Climate Equity.
- The park will produce runoff in a one-inch storm.
- There is a 1.6 average slope, with poorly drained soils with low depth to bedrock/water table.
- Over 75% of the park is covered by tree canopy and only 35% is covered by impervious surface.

Design Recommendations

Given that the park is in good condition, we recommend some green infrastructure retrofits.

- Replace the pavement along walkways with pervious pavers that allows infiltration.
- Add high –organic content soils and mulch around trees to enhance growth and minimize root trampling and soil compaction. Repeat every two years.

Quigley Park

Photo Credit Darci Schofield

Quigley Park is a 0.5-acre vibrant, active recreation area with a baseball diamond, tot and older child play equipment, water feature, trees, and benches. Located on a hill, the site has a retaining wall decorated with a mural. The park contains strategically placed trees around the perimeter and throughout the park. According to the 2018 OSRP, the park equipment, walls, and lawn are in fair condition. Stormwater management is critical at this park because of its location uphill of Chelsea River. It received a score of five for priority/opportunity for green infrastructure installations.

Park Site Considerations

- Quigley Park is a priority area for green infrastructure interventions for Cool and Climate Equity, according to the Metro Mayors DST.
- The site has estimated runoff potential during a one-inch storm.
- Site contains mean 1.6% slope and greater than 2 feet depth to groundwater making it an ideal location for infiltration.
- The site contains approximately 35% tree canopy cover and approximately 66% impervious surface.
- Quigley Park was renovated just prior to 2010 making it an ideal location for retrofits.
- The storm drains are located at the southeast corner of the park, one of the lowest areas, within the baseball diamond playing area (Figure 33).

Figure 33 Storm drain at the southeast, downslope corner of Quigley Park. .

Figure 34 Quigley Park Bioswales and/or raingardens installed upslope of the storm drains but downslope of the park.

Water is directed down slope to the turf between the walls to enter bioswales/raingarden. Plants and mulch infiltrate runoff prior to entering storm drain. *Photo and design credit Darci Schofield*

Design Recommendations

- Perform soil enhancement and reduce trampling to the trees in the park. On a biennial basis, add soil with high organic content to the tree areas and cover with bark mulch. This serves to enhance rain water capture and minimize runoff; the mulch may reduce root damage due to trampling. In additional, installing small fences around the trees will minimize trampling and maximize rain and stormwater absorption.
- Because the lawn is in fair condition, we suggest reconfiguring the baseball diamond revitalizing the turf. A storm drain is located adjacent to the batting area in the southeast corner of the park by Shurtleff Street (Figure 33). Shift the new diamond several feet toward Essex Street. Install bioswales or rain gardens upslope of the storm drains to minimize runoff entering the stormwater system and maximizing infiltration. Direct runoff from the baseball diamond/playing field toward the bioswales.
- Remove the evergreen tree in poor condition, located at the southeast corner of the park by the storm drains. Remove invasive plants along the fence. Add two new trees inside the fence, within the bioswales upslope of the storm drains to maximize stormwater capture (Figure 34).

Bosson Playground

Photo Credit Google Earth

Bosson Playground is a 0.7-acre active recreation park that lies between Bellingham and Grove Streets, making it an active transportation corridor for pedestrians. It contains tot and older youth play equipment, benches, water feature, swings, and a paved court on the Bellingham Street side. On both Bellingham and Grove Streets, the park is supported by retaining walls decorated with murals. The 2018 OSRP reported all equipment and amenities were in good condition and park was renovated just prior to the 2010 OSRP. Bosson Playground scored a five for priority/opportunity to implement green infrastructure.

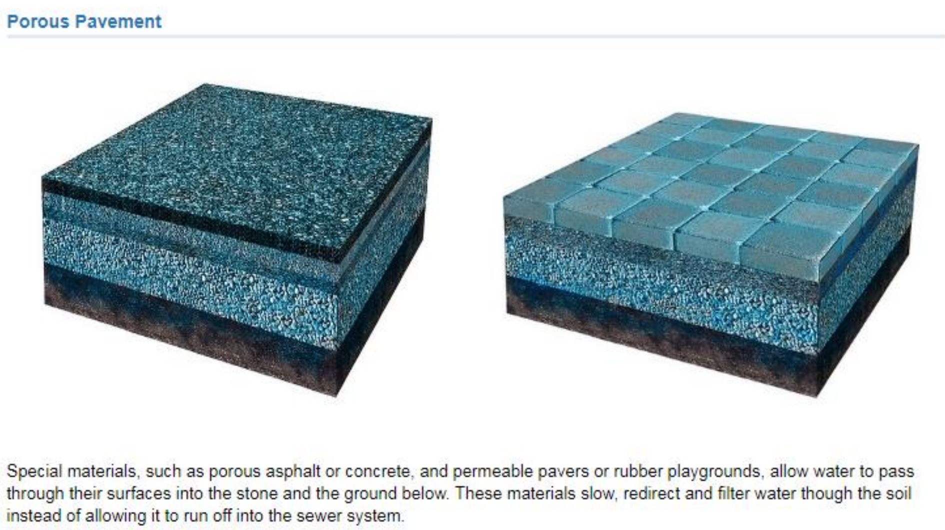
Park Site Considerations

- The park is a priority area for green infrastructure for Cool and Climate Equity according to the Metro Mayor DST.
- The site will produce runoff in a one-inch rain event.
- Though the site contains poorly-drained soils, there is greater than two foot depth to the water table creating ideal conditions to create infiltration features.
- The site is above the grade of the road contained by retaining walls and has a mean 1.7% slope.
- Bosson Park has 78% impervious cover and 39% tree canopy cover.
- The water from the water spray feature pools onsite.

Design Recommendations

- Plant trees along the Grove Street side of the park along the fence by the asphalt court. Use tree wells with mulch to prevent trampling and maximize infiltration with the adjacent active use of the site. This is also the location of the storm drain.
- Replace the walking path with pervious pavers that maximize infiltration (Figure 35).

Figure 35 Cross-section of porous pavement.



Photo/Diagram credit Philly Watersheds (www.phillywatershed.org)

- At the edge of the center walking path that meets the sidewalk, install decorative grates that directs additional stormwater through perforated pipes to the stormwater system. This feature can collect any remaining runoff from the central walking path not absorbed by the pervious pavers but still function to allow additional infiltration prior to entering the stormwater system (Figure 36).

Figure 36 Capture any potential excess runoff through grate at junction of sidewalk and walking path. Gravel and perforated pipe further minimize water entering stormwater system.

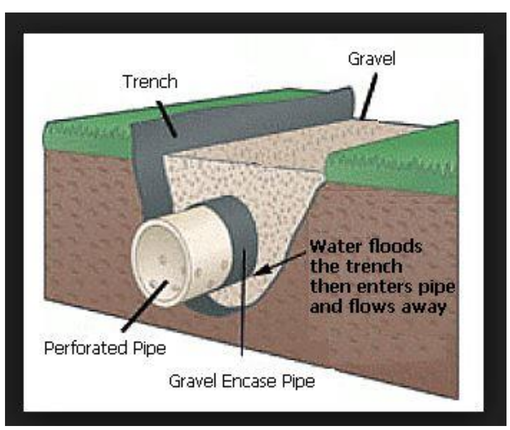


Photo Credit lafayettedirt.com

- Direct water feature runoff water to a stormwater planter planted along the Grove Street southeast side of the park (Figure 37). Any excess water from the stormwater plant allow to infiltrate through perforated pipes to the stormwater system.

Figure 37 Stormwater Planters and perforated pipe. Recommendation for capturing water spray feature and additional runoff.

Photo/Diagram credit Philly Watersheds (www.phillywatershed.org)

Ciepiela Park

Photo Credit Google Earth

Ciepiela Park is a pocket park near Chelsea's waterfront. Ciepiela, Palonia Park and a privately-owned natural area create a natural area corridor in this densely developed area of Chelsea. Ciepiela is a 0.04-acre passive park with benches, walkway and decorative shade gardens. The 2018 OSRP reported the pavement in poor condition, the trees in good condition, and the equipment in fair condition. It scores a five for priority/opportunity for implementing green infrastructure.

Park Site Considerations

- The park has nearly 100% tree canopy cover and contains a brick walkway that could be considered impervious.
- The park is a priority are for green infrastructure for Cool and Climate Equity according to the Metro Mayors DST.
- It contains a slight slope ideal for implementing green infrastructure, though poorly drained soils and low depth to bedrock/water table.
- The park is in high need for green infrastructure to absorb stormwater producing runoff in a one-inch rain event to protect non-point pollution to Chelsea Creek.

Design Recommendations

- The small size of the park makes it an ideal area for the passive shade park that it is today.
- Since the pavement was reported in poor condition, replace the brick/pavement with pervious pavers to add to its permeability and minimize runoff.

- Continue to ensure the shade gardens are maintained to ensure maximum uptake from stormwater runoff (i.e., remove invasives/exotic species and prevent plant overcrowding).

Kayem Park

Photo Credit Google Earth

Kayem is a 0.1-acre park, beloved by the neighborhood, containing trees, benches, public art, and play equipment. The land was donated to the City by Mass Port in 2008 and built in part with the support of Kayem Foods, one of the City's largest employers. The 2018 OSRP reports the park is in overall good condition. This park scored a four for green infrastructure opportunity and need in Chelsea.

Park Site Considerations

- The park is a priority area for Green Infrastructure for Cool and Climate Equity.
- It is within 500 feet of a 21E Site.
- The park contains only 17.8% impervious surface and 54.8% tree canopy cover.
- Though the site has a 0 mean slope and poorly drained soils, it is located within the Mystic River, an impaired River with TDMLs, catchment basin.
- The park is very small and heavily used by the neighborhood.

Design Recommendations

This park was created approximately a decade ago, and due to its recent creation and small size we recommend two green infrastructure retrofit opportunities.

- The park has a critical canopy cover for cooling the urban heat island in this part of the City and tree maintenance will be one of the most important green infrastructure interventions for this park. Reduce root and soil compaction from trampling by adding mulch, vegetation, or other conceptual barriers such as tree fences to ensure trees remain for the long-term.
- Remove exotic and/or invasive species at the perimeter of the park by the fence. Install stormwater planters and/or native shrubs at this location in the unused space (Figure 38).

Figure 38 Conceptual barriers to deter tree root trampling and soil compaction in urban area.

Photo Credit Google Earth

- Consider expanding the park along the right of way adjacent to Kayem (Figure 39) to provide additional recreational and artistic amenities as well as expand the green infrastructure opportunities for greater impact on managing stormwater and reducing the urban heat island effect (Figure 40).

Figure 39 Unused Right of Way adjacent to Kayem Park.

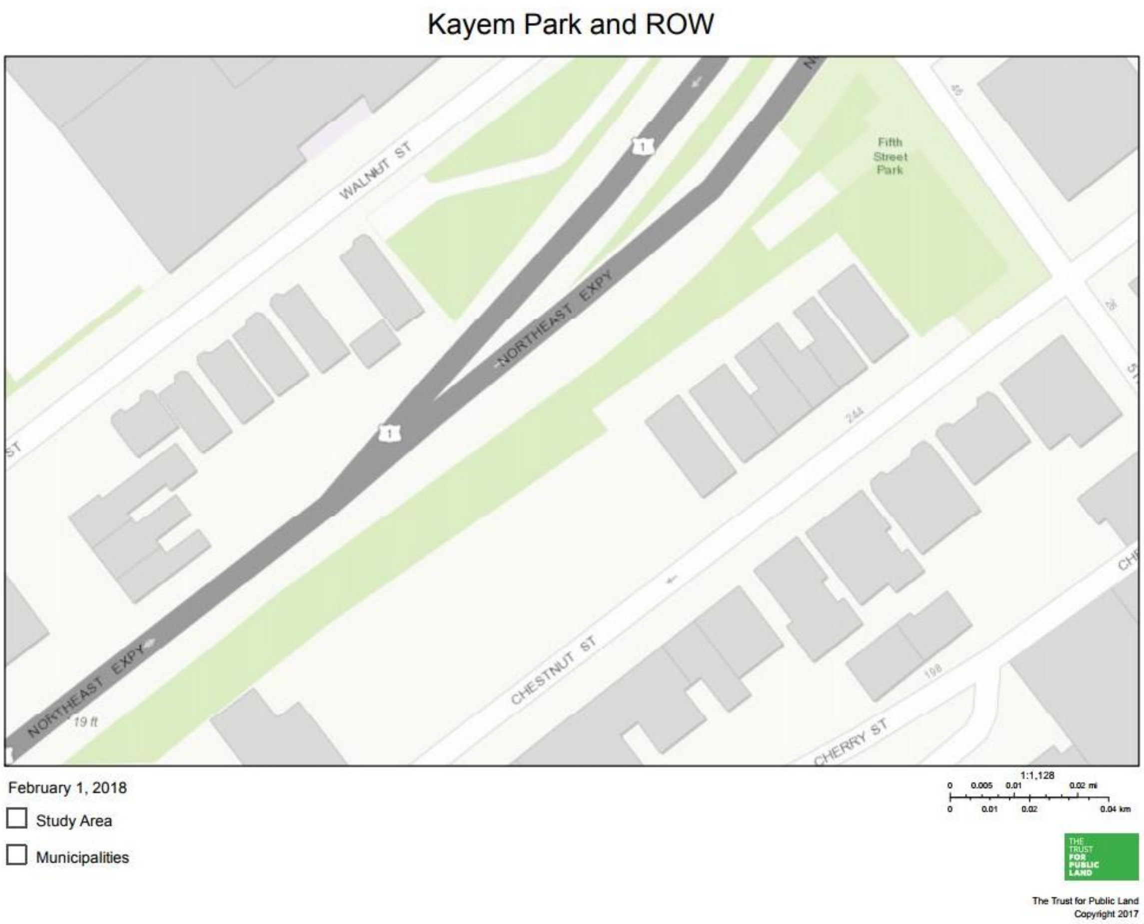


Photo credit Google Earth

Figure 40 Conceptual designs for part of Miami's Underline, a 10-mile linear park in a right of way, incorporating nature, art, and recreation.

Photo Credit TheUnderline.org

Winnisimmet Park/Chelsea Square

Photo credit Google Earth

Winnisimmet Park/Chelsea Square is a pocket park in Downtown Chelsea that contains a Christopher Columbus Monument, walking paths, trees, and benches. Located at the intersection of Broadway, Park and Second streets, the park calms traffic and provides a resting and gathering space for pedestrians downtown. It is a vibrant contribution to the downtown area. The 2018 OSRP reported the pavement (hardscape) in poor condition and equipment in fair condition, but the trees and retaining walls were in good condition. This park scored a three for priority/opportunity to implement green infrastructure.

Park Site Considerations

- The park is a priority area for Cool according to the Metro Mayors DST.
- The park contains approximately 38.5% tree canopy cover and 21.5% impervious surface.
- The site is within 500 feet of a 21E site.
- The site will produce runoff in a one-inch rain event.
- There is a mild slope at the park with poorly drained soils and low depth to bedrock/water table.

Design Recommendations

- Since the pavement/hardscape was reported in poor condition, we suggest replacing the hardscaping with pervious pavers.

- There is additional hardscaping/underutilized space at the Broadway/Park Street corner of the park. We suggest adding stormwater planters in this location to remove some of the impervious surface and minimize runoff into the storm system (Figure 41).
- Continue to maintain the trees in the square and replace dead or damaged street trees.

Figure 41 Stormwater planters at the edge of Chelsea Square to increase stormwater capture in the park.

Photo Credit Google Earth and Design by Darci Schofield (bottom)

Regulatory and Permitting Considerations for Installing Green Infrastructure

Though green infrastructure is becoming a widely accepted practice for managing stormwater and promoting climate resilience, public health, beautification, and livability, local and state regulatory and permitting processes are sometimes outdated with current practices. In September 2012, Horsley Witten Group provided a Memorandum to the City of Chelsea titled "Massachusetts Development Code Review to Promote Green Infrastructure." This report provides a review of development regulations and standards relevant to implementing green infrastructure and Low Impact Development for compliance with the 2010 North Coastal Small MS4 General Permit. It also provides opportunities to increase green design and decrease impervious cover in overall site plans and development. In addition to this report, we reviewed the most recent versions of the following for potential regulatory barriers toward implementing green infrastructure in Chelsea's parks[54]:

1. Chapter 91 The Massachusetts Public Waterfront Act
2. Wetlands Protection Act, MGL Ch. 1313 Sec. 40
3. Code of Ordinances City of Chelsea, Part II Code of Ordinances, Chapter 24 Streets, Sidewalks and Public Ways, Chapter 30 Water and Sewer, Chapter 34 Zoning,
4. Code of Ordinances City of Chelsea, Part III Regulations, Article 1 Board of Health.
5. The Massachusetts State Building Code-Ninth Edition
6. Massachusetts Stormwater Handbook and Stormwater Standards

Horsley Witten provides important recommendations in revising Zoning, Water and Sewer, and Subdivision Regulations to promote more widespread use of green infrastructure. Overall, in Chelsea's Code of Ordinances, there are no explicit barriers to implementing the recommendations provided in this plan that we found. However, any connections to the sewer/stormwater system do require Design Standards approved by the Director of the Department of Public Works. One potential barrier is developing the suggested skate park at Chelsea Bridge at the terminus of the Chelsea Greenway, which is located in the Designated Port Area, requiring State approval. Other potential challenges are through the Wetlands Protection Act for Island End Park for the Floating Wetland, though there is precedent is Massachusetts with the University of Massachusetts Green Harbors Project Floating Wetland in Fort Point.[55] Coastal park recommendations will also require a Chapter 91 License, which creates an additional layer of regulation, but since Chelsea's waterways and future flooding are such critical assets to its community and industry, these regulations are worth pursuing.

Table 4 illustrates regulatory considerations for implementing green infrastructure by regulatory authority and park, based upon design recommendations provided.

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[54] MAPC performed a preliminary analysis on potential regulatory barriers across local and state codes. We recommend consulting a building code consultant when pursuing green infrastructure development.

[55] https://www.umb.edu/ghp/green_harbors/boston_harbor/current_projects/fort_point_channel

Table 4 Regulatory considerations for implementing green infrastructure in Chelsea's parks

Regulatory/Permitting Considerations Consideration		Merrit Park/Berkowitz School Playground	Mill Creek Riverwalk	Island End Park	Highland Park
Chelsea Code or Ordinances					
Chapter 24 Streets, Sidewalks, Public Ways	*Article II Section 24-52 Excavation*	◊	◊	◊	◊
	Section 24-84 Construction	◊	◊	◊	◊
Chapter 34 Zoning	*Section 34-106 (d) (5) Parking*	◊			◊
	Section 34-108 (d) General Landscaping	◊	◊	◊	◊
	Section 34-108 (f) Maintenance	◊	◊	◊	◊
	Section 34-110 Performance Standards	◊	◊	◊	◊
	Section 34-77 Setbacks W Zone				
	Section 34-187 Floodplain Overlay District		◊	◊	
Chapter 30 Water and Sewer	*Section 30-42 Regulation & Codes*	◊	◊	◊	◊
	Section 30-37 (a) Stormwater Application	◊	◊	◊	◊
	Section 30-37 (f) Director Design Criteria	◊	◊	◊	◊
	Section 30-128 Storm Drains/ Connections	◊	◊	◊	◊
	Section 30-219 Discharges	◊	◊	◊	◊
MA Building Code	*Plumbing (roof drains)*				
	Roof Materials	◊			
Wetland Protection Act	*FEMA 1% Annual Chance Flood*	◊	◊	◊	◊
	Riverine Wetlands		◊	◊	
	Coastal Wetlands		◊	◊	
MA DEP Waterways Program Chapter 91 License			◊	◊	
MA DEP/CZM Designated Port Area					

Regulatory/Permitting Considerations Consideration		**High School Carter Park**	**Eden Street Park**	**Chelsea Greenway**	**John Ruiz Park**	
Chelsea Code or Ordinances						
Chapter 24 Streets, Sidewalks, Public Ways	*Article II Section 24-52 Excavation*	◊	◊	◊	◊	
	Section 24-84 Construction	◊	◊	◊	◊	
Chapter 34 Zoning	*Section 34-106 (d) (5) Parking*					
	Section 34-108 (d) General Landscaping	◊	◊	◊	◊	
	Section 34-108 (f) Maintenance	◊	◊	◊	◊	
	Section 34-110 Performance Standards	◊	◊	◊	◊	
	Section 34-77 Setbacks W Zone					
	Section 34-187 Floodplain Overlay District					
Chapter 30 Water and Sewer	*Section 30-42 Regulation & Codes*	◊	◊	◊	◊	
	Section 30-37 (a) Stormwater Application	◊	◊	◊	◊	
	Section 30-37 (f) Director Design Criteria	◊	◊	◊	◊	
	Section 30-128 Storm Drains/ Connections	◊	◊	◊	◊	
	Section 30-219 Discharges	◊	◊	◊	◊	
MA Building Code	*Plumbing (roof drains)*	◊				
	Roof Materials	◊				
Wetland Protection Act	*FEMA 1% Annual Chance Flood*	◊	◊	◊		
	Riverine Wetlands					
	Coastal Wetlands					
MA DEP Waterways Program Chapter 91 License						
MA DEP/CZM Designated Port Area				◊		

Regulatory/Permitting Considerations	Consideration	Mystic Overlook Park	Paul A. Dever Park	Washington Park	Palonia Play ground
Chelsea Code or Ordinances					
Chapter 24 Streets, Sidewalks, Public Ways	*Article II Section 24-52 Excavation*	◊	◊	◊	◊
	Section 24-84 Construction	◊	◊	◊	◊
Chapter 34 Zoning	*Section 34-106 (d) (5) Parking*				
	Section 34-108 (d) General Landscaping	◊	◊	◊	◊
	Section 34-108 (f) Maintenance	◊	◊	◊	◊
	Section 34-110 Performance Standards	◊	◊	◊	◊
	Section 34-77 Setbacks W Zone				
	Section 34-187 Floodplain Overlay District				
Chapter 30 Water and Sewer	*Section 30-42 Regulation & Codes*	◊	◊	◊	◊
	Section 30-37 (a) Stormwater Application	◊	◊	◊	◊
	Section 30-37 (f) Director Design Criteria	◊	◊	◊	◊
	Section 30-128 Storm Drains/ Connections	◊	◊	◊	◊
	Section 30-219 Discharges	◊	◊	◊	◊
MA Building Code	*Plumbing (roof drains)*				
	Roof Materials				
Wetland Protection Act	*FEMA 1% Annual Chance Flood*				
	Riverine Wetlands				
	Coastal Wetlands				
MA DEP Waterways Program Chapter 91 License					
MA DEP/CZM Designated Port Area					

Regulatory/Permitting Considerations Consideration		Quigley Park	Bossom Park	Ciepiela Park	Kayem Park	Winnisimmet Park/Chelsea Square
Chelsea Code or Ordinances						
Chapter 24 Streets, Sidewalks, Public Ways	*Article II Section 24-52 Excavation*	◊	◊	◊	◊	◊
	Section 24-84 Construction	◊	◊	◊	◊	◊
Chapter 34 Zoning	*Section 34-106 (d) (5) Parking*					
	Section 34-108 (d) General Landscaping	◊	◊	◊	◊	◊
	Section 34-108 (f) Maintenance	◊	◊	◊	◊	◊
	Section 34-110 Performance Standards	◊	◊	◊	◊	◊
	Section 34-77 Setbacks W Zone					
	Section 34-187 Floodplain Overlay District					
Chapter 30 Water and Sewer	*Section 30-42 Regulation & Codes*	◊	◊	◊	◊	◊
	Section 30-37 (a) Stormwater Application	◊	◊	◊	◊	◊
	Section 30-37 (f) Director Design Criteria	◊	◊	◊	◊	◊
	Section 30-128 Storm Drains/ Connections	◊	◊	◊	◊	◊
	Section 30-219 Discharges	◊	◊	◊	◊	◊
MA Building Code	*Plumbing (roof drains)*					
	Roof Materials					
Wetland Protection Act	*FEMA 1% Annual Chance Flood*					
	Riverine Wetlands					
	Coastal Wetlands					
MA DEP Waterways Program Chapter 91 License						
MA DEP/CZM Designated Port Area						

Appendix A Green Infrastructure Park Prioritization Scoring

Park	Address	Acres	Absorb Priority	Cool Priority	Protect Priority	Climate Equity Priorit	Sinks	Estimated Runoff Potentia	FEMA 1% Annual Chance Flood	BH_FRM Flood Zone 2013 or 2030	Within 500 feet 21 E	Mean Slope	SSURGO Soil Hydro Grou	Depth to Bedrock (cm)	Depth to Groundwater (cm
Merrit Park/Berkowitz School Playground	300 Crescent Avenue	9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0.6	B	Unknown	61
Mill Creek Riverwalk	Off Locke Street	0.55	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1.3	C	Unknown	Unknown
Island End Park	Justin Drive	0.6	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	1.3	C	Unknown	Unknown
Highland Park	31 Willow Street	3.3	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	0	C	Unknown	Unknown
High School Carter Park	200 Orange	3.9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1.6	C	Unknown	Unknown
Chelsea Greenway	Chestnut St to Eastern	0.75	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Multiple	C	Unknown	Unknown
John Ruiz Park	141 Washington Park	0.2	Yes	Yes	No	Yes	Yes	Yes	No	No	No	1.2	C	Unknown	Unknown
Eden Street Park	26 Eden Street	0.2	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	0.1	C	Unknown	Unknown
Mystic River Overlook Park	Under the Tobin	2.2	Yes	No	No	Yes	No	Yes	No	No	No	4.5	C	Unknown	61
Paul A. Dever	60 Gillolly Road	0.3	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	0	C	Unknown	Unknown
Washington Park	390 Washington Avenue	1.5	No	Yes	No	Yes	No	Yes	No	No	No	2.5	C	Unknown	61
Palonia Playground	37 Tremont Street	0.4	No	Yes	No	Yes	No	Yes	No	No	No	1.6	C	Unknown	Unknown
Quigley Park	25 Essex Street	0.5	No	Yes	No	Yes	No	Yes	No	No	Yes	1.6	C	Unknown	61
Bosson Park	50 Bellingham	0.7	No	Yes	No	Yes	No	Yes	No	No	Yes	1.7	C	Unknown	61
Ciepiela Park	29 Medford	0.04	No	Yes	No	Yes	No	Yes	No	No	No	0.2	C	Unknown	Unknown
Kayem Park	40 Fifth Street	0.1	No	Yes	No	Yes	No	Yes	No	No	Yes	0	C	Unknown	Unknown
Winnissimet Park/Chelsea	171 Broadway	0.4	No	Yes	No	No	No	Yes	No	No	Yes	1	C	Unknown	Unknown