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Hartford: Green Infrastructure for a More Resilient and Sustainable Future

July 2018

Sponsored by a grant from the Connecticut Institute for Resilience and Climate Adaptation.

The mission of the Connecticut Institute for Resilience and Climate Adaptation (CIRCA) is to increase the resilience and sustainability of vulnerable communities along Connecticut's coast and inland waterways to the growing impacts of climate change on the natural, built, and human environment.

More information about CIRCA can be found at circa.uconn.edu.

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Executive Summary

The City of Hartford is grateful for assistance from CIRCA to support the hire of a Green Infrastructure staff person for 18 months. Hartford sought this assistance in the context of its rigorous, comprehensive climate resiliency effort – the Climate Stewardship Initiative – that aims to improve our quality of life through environmental stewardship, while advancing our economy, improving public health outcomes, and promoting social equity. Through the CSI, Hartford has collaborated with corporations, private foundations, and state and federal government agencies to make significant strides in a number of areas. In the six action areas encompassed by the CSI – energy, food, landscape, transportation, waste, and water – the City had the least expertise, and the most need, in the area of water, and more specifically, in managing stormwater through green infrastructure. A Green Infrastructure Assistant helps Hartford not only respond to water quality issues and other public health concerns, but also helps proactively strategize for the future.

As an inland city, Hartford experiences severe challenges related to stormwater management. First, Hartford is a densely populated, developed city, with high concentrations and large quantities of impervious surfaces. For example, about 80% of the federally-designated North Hartford Promise Zone (which is deeply distressed economically) is highly developed with significant amounts of impervious surface. The amount of impervious surface in the central business district – which is nearly devoid of trees and in-ground vegetation – is even higher. Second, clay soils in much of the city prevent absorption of stormwater, exacerbating runoff and resulting in localized flooding. Flooding in homes and business, even from relatively minor storm events, is already commonplace. Third, the city's levee system, which protects the city from a rising Connecticut River, has been given a near-failing rating by the U.S. Army Corps of Engineers (USACE), though the City has since entered the USACE System Wide Improvement Framework (SWIF) Program in an attempt to receive a higher rating. A levee breach could flood 25% of Hartford's land base – approximately 3,000 acres of highly developed residential, commercial, and industrial areas. Affected areas would include the North Hartford Promise Zone, home to Hartford's most vulnerable citizens, and the MDC Hartford Water Pollution Control Facility, the largest such facility in the state which is currently undergoing over $200 million in upgrades and expansion. While the Green Infrastructure Assistant does not lead the team addressing the levee system, she understands this challenge. The more stormwater that is managed on-site through green infrastructure, the less water that goes into the Connecticut River, reducing the potential for a levee breach.

Ultimately, the work funded by the CIRCA grant has allowed Hartford to move forward in addressing these challenges using stormwater management and green infrastructure. Through new partnerships, technical analyses, and increased public outreach, the Green Infrastructure Assistant has been able to provide technical assistance to city staff and boards, collaborate with key stakeholders to implement programs and workshops, and educate and increase public awareness on stormwater management and green infrastructure. In doing so, this work has paved the way for additional progress such as continued programming for residents, tools for future monitoring and forecasting efforts, new funding for project implementation, and strides towards systematic stormwater-related changes in city operations and regulations.

Project Background and Context

Due to the City's financial hardships and increasing burdens on a limited number of staff, the ability to focus on these critical challenges has diminished. Historically, the City had lacked the capacity to evaluate or advance green infrastructure projects. Yet interest in stormwater management is as high as it has ever been in Hartford. Working in the Office of the Mayor, the Sustainability Coordinator spearheads the Climate Stewardship Initiative, which, as noted above, focuses in part on stormwater management. Significantly, the Metropolitan District Commission has indicated that it may invest in green infrastructure as a part of its regional Long Term Control Plan (LTCP) update.

In response to this interest as well as other stormwater-related challenges that affect Hartford, City Hall needed its own green infrastructure staff member to build on existing grants and partnerships, take advantage of new political and institutional interest, and complete the various tasks detailed in the four-point workplan below. Lessons learned in Hartford will inform other inland cities. Longer-term, the hope is that this position will become permanent to assist further sustainability efforts in Hartford.

Project Description, Goals and Methods

The Green Infrastructure Assistant worked with City staff, CIRCA, the Metropolitan District Commission, community groups, and others to advise on, educate on, and facilitate green infrastructure projects. This work involved research, analysis, education, and project implementation to understand local conditions and further green infrastructure solutions. More specifically, the new staff member has been involved in:

Workplan Item	Activities	Work Product
Technique Assessment	Assessed various green infrastructure techniques suitable for a) Hartford’s built and natural environments, b) position along a vital inland waterway, and c) population.	Stormwater Runoff Calculator, Cost-Benefit Tool, Conditions Maps
Relationship Development	Coordinated with City staff, boards and commissions, and the MDC in its efforts to advance green infrastructure strategies.	Retain the Rain residential pilot project.
Best Management Practices	Collaborated with the City Department of Public Works and contractors to review best practices nationally, and contribute to updated City specifications	Best Management Practices guide; Partnerships with DDS and DPW on stormwater regulations and priorities
Complete Streets Working Group	Worked with the City’s Bicycle/Pedestrian Coordinator and affiliated Complete Streets Working Group members to identify green improvements for City roads and walkways.	EPA Green and Complete Streets Workshop and Memo; Ongoing participation and collaboration with working group partners
Community Outreach	Conducted outreach to community groups in Hartford, as well as other cities in coordination with CIRCA to discuss best practices around the state and country regarding stormwater-related green infrastructure and impact on resilience and sustainability.	Outreach to over 200 residents, presentation at a CIRCA symposium, and production of a suite of informational materials

Through the CIRCA grant, the Green Infrastructure Assistant was charged with completing the workplan activities listed above. With the assistance of various city departments, local and regional partners, and community stakeholders, all of the activities have been fulfilled. With the major workplan at completion, the GI Assistant and the Office of Sustainability have been working to complete additional stormwater work, going above and beyond to produce additional materials and implement new green projects.

Relationship with CIRCA Mission and Priority Areas

As identified in our original workplan, the Green Infrastructure Assistant serves a critical, two-fold purpose, which goes hand in hand with the mission of CIRCA. First, she assists with implementation of both policy changes and green infrastructure pilot projects. These long-term changes will increase the resilience and sustainability of Hartford's most vulnerable residents, protect the built and natural environments, and prepare Hartford to better address the potential for severe flooding from our major inland waterway, the Connecticut River.

Second, the Green Infrastructure Assistant has as a core responsibility for processing, assembling, and disseminating the very best practices for a highly-developed inland city. We believe that the role of the Assistant in coordinating efforts between internal departments and outside partners, such as the MDC, will serve as a model of cooperation for the rest of the state. More broadly, the Assistant will be a spokesperson for the need to commit to resiliency strategies at the local level. CIRCA's outreach efforts and need to provide models, not just for coastal communities but also for inland communities, closely aligns with these efforts.

The items identified in the workplan of the Green Infrastructure staff member address multiple CIRCA priorities.

1. "*Develop and deploy natural science, engineering, legal, financial, and policy best practices for climate resilience*." The Assistant's work reviewing national best practices on green infrastructure and then sharing that information in the form of a manual with other communities will not only make best use of best practices in Hartford, but spread those findings to other communities along the Connecticut River and region.

2. "*Undertake or oversee pilot projects designed to improve resilience and sustainability of the natural and built environment along Connecticut's coast and inland waterways.*" The Assistant's work to guide and assist both MDC and the City in identifying, developing, and carrying out at least one green infrastructure stormwater pilot project will improve resilience and sustainability in the immediate project area, reduce pressure on our aging levee system, and provide data that will be invaluable in identifying more projects and materials that will be well-suited to make a measurable impact in reduction of untreated stormwater into the Connecticut River.

3. "*Foster resilient actions and sustainable communities- particularly along the Connecticut coastline and inland waterways – that can adapt to the impacts and hazards of climate change.*" The

Assistant's work in changing City policy around the regular use of green infrastructure materials in City projects will have long-term impacts on our city and help the surrounding region better adapt to severe storms and the challenges of stormwater infiltration. Furthermore, outreach to community groups will help spread the word about the changes that the City and its partners, like MDC, are making and raise awareness of the impact these changes can have on our resiliency and sustainability.

4. "*Reduce the loss of life and property, natural system and ecological damage, and social disruption from high-impact events*." In many areas of our city, flooding and resulting property damage are regular occurrences, even stemming from relatively minor storm events. The Assistant's work in identifying places such as these, where green infrastructure can have the most impact from a property loss standpoint, will help address this priority. Furthermore, reduction of untreated stormwater released to the Connecticut River during high-impact events will have untold benefits for the ecology of this critical inland waterway.

Hartford Climate Stewardship Initiative

Project Outcomes and Lessons Learned

- **Technique Assessment**

  There are four key projects led by our Green Infrastructure Assistant, and these include a residential rainwater capture project, development of two analytical tools, research support for new policies, and educational outreach.

  Retain the Rain. With funding from CIRCA, the Office of Sustainability launched a residential downspout disconnection pilot project called Retain the Rain (RtR). Disconnecting residential downspouts located in the combined sewer areas of Hartford is a low-cost approach recommended in the EPA Next Steps Memo for Hartford, as well as by Metropolitan District (the region's water utility) and their green infrastructure consulting team. Just one disconnection has the potential to divert hundreds of gallons of stormwater during peak summer months, and this Do-It-Yourself project is a cost-effective approach to stormwater management. Prior to the implementation of this program, it was necessary to select a target area for the pilot.

Figure 1. Retain the Rain Flyer for Residents.

The target area selection process began with research into other examples of downspout disconnections programs. Connecticut Department of Energy and Environmental Protection (DEEP) produced a state stormwater manual that provided helpful guidelines on roof size and soil type. Portland and Washington D.C. also had programs that were specific to combined sewer system areas. Using this information, the following factors were used to narrow down potential pilot areas: roofs less than 5,000 square feet (as directed by the CT DEEP stormwater manual), preferably located within an A or B type soil area (as directed by the CT DEEP stormwater manual), and within 0.25 miles of the combined sewer system (to target an area with a combined sewer system). Using ArcMap, an analysis was completed to determine the number and location of impervious structures that met the three characteristics. Five neighborhoods (Frog Hollow, Blue Hills, Upper Albany, Clay Arsenal, and

Northeast) were found to have higher percentages of potentially eligible structures. All three of the North Hartford Promise Zone (NHPZ) Neighborhood Revitalization Zones (Upper Albany, Clay Arsenal, and Northeast) were included within these five high potential neighborhoods. Clay Arsenal, Northeast, and Upper Albany were initially chosen as the final three neighborhoods for the pilot project. However, as the program progressed, it became clear that the target area would have to expand to the entire city to attract more participants. Further analysis shows that scaling this project up to all NHPZ structures that meet the major requirements could divert over 2 million gallons from a single 1" rain event.

Outreach occurred through organizations working in the North Hartford Promise Zone (NHPZ) as well as through the neighborhood community groups. Reaching more than 200 residents through presentations at neighborhood meetings, a climate action session, and the Office's RtR workshop, the Green Infrastructure Assistant encouraged residents to accept an RtR kit to disconnect gutter downspouts from the combined sewer and redirect the rainwater to gardens and lawns. The kit, which is free to residents, includes a splash block, gutter extension, and sewer cap. The project garnered interest across the city and catalyzed the reestablishment of a rain barrel program. In collaboration with the MDC, the City's Retain the Rain program is entering phase 2, which involves providing between 100 to 200 rain barrels for Hartford residents. Phase 2 will include community engagement through the assistance of the Youth Service Corps as well as additional outreach through educators and other stakeholders. Positioned as a win-win for residents, the MDC and the environment, the Retain the Rain program has helped reduce stormwater issues while also providing residents with useful information and equipment for their homes.

More information on Retain the Rain downspout disconnection program can be found at: https://hartfordclimate.org/water/retaintherain/retaintherain-downspoutdisconnection/

Analytical Tools. To get a sense of both the scope of stormwater management issues and the potential for green infrastructure to benefit the city, the Green Infrastructure Assistant created a runoff analysis tool to provide calculations and conservative estimates of stormwater diversion and baseline conditions. The tool takes into account Hartford's existing land cover and soil types and allows for calculations based on existing weather history or individual storm events. This tool can be utilized for individual sites as well. Data and formulas have been drawn from various sources such as the US Department of Agriculture's Natural Resources Conservation Service, US Geological Survey, the City of

Hartford, and the Metropolitan District (MDC). Further notes on this tool can be found in the appendices. In addition, the Office of Sustainability worked with a group of students at the University of California at Berkeley to a develop cost-benefit analysis tool to help city staff and others evaluate future project costs for green infrastructure work.

Policy Support. The Office of Sustainability provided research support for the elimination of parking minimums and a stormwater fee in lieu provision in the zoning code. The elimination of parking minimums is groundbreaking: Hartford is only the second major American city to do this. This step also has the potential to dramatically improve stormwater management, reduce polluted runoff, make our neighborhoods more walkable, and increase tax revenue. The Stormwater fee in lieu provision requires developers to manage the first inch of rainwater on their properties or pay into a fund. The City has since received its first payment into this fund, which will allow future green infrastructure projects to move forward.

Urban Tree Canopy. The Green Infrastructure Assistant works closely with the Tree Advisory Commission and the City Forester to support conservation and protection efforts related to the Urban Tree Canopy (UTC). The UTC is an EPA green infrastructure best management practice and is considered a critical part of Hartford’s existing GI. With more than 560,000 trees in the city, just one dedicated tree warden, a volunteer commission, and a very limited budget, the City is faced with an extensive challenge as it relates to the UTC. Key related efforts have included:

- *Tree List.* In partnership with the Tree Commission, the GI team has also been working to develop a comprehensive list of trees appropriate for Hartford’s climate and land cover. The tree list is of particular importance as it catalogues over 80 species by 20 different characteristics, which include a section on stormwater benefits. Special considerations concerning potential pest risk have been added, as pests have become a critical issue for the City. An approaching threat, the Asian Longhorned Beetle (ALB) has the potential to decimate nearly half of the city’s trees, which would drastically affect public health and safety in terms of Urban Heat Island, tree hazards, loss of air and water quality services, etcetera. As such, the list has been adjusted to reflect the caution needed for ALB host trees. This list will be critical for communicating planting recommendations to developers, residents, and city staff, making it vital to provide this information.

- *Tree Canopy Forecast Model:* With extreme weather, ageing, and invasive species adversely affecting Hartford's trees, it has become critical to understand how to manage and maintain the urban canopy cover. Beginning in the summer of 2018, the Tree Advisory Commission Chair and the Office of Sustainability Green Infrastructure Assistant have worked together to oversee a Trinity intern, who has been working to model and forecast changes in Hartford's tree canopy. The intern is currently working through calculations for several different planting scenarios and will provide final results by the end of the summer. These findings are intended to inform the City's overall forestry management strategy.
- *Tree Tags.* In celebration of Earth Day and Arbor Day, the GI Assistant carried out an educational Tree Value Tag Activity, which was intended to communicate the value of trees to residents. The tagged trees were state champion trees, the largest trees of their species in the state. Part of this work involved mapping and iTree valuation of 49 specimens across the city. The most impressive tree, a Bur Oak, was found to have provided over $17,000 in services in its lifetime. The tree tag effort gained some traction on social media, and the story was also picked up by Fox61 news.

Figure 2. City Forester Heather Dionne and GI Assistant Grace Yi with an Tree Tag

- **Relationships.**

  As depicted in the graphic here, the Sustainability Office works with stakeholders from across the community. These groups include: The Hartford Climate Stewardship Council, colleges and universities, government agencies at all levels, local utilities, nonprofits, and resident-run boards and commissions.

  Figure 2. Office of Sustainability Partnership Model

  For work related to green infrastructure, our team works closely with City staff from the Department of Public Works and Development Services, the regional water utility, MDC, and its consulting team, to identify ways in which green infrastructure can be included in future street or schools projects. The GI team communicates regularly with MDC and their consultants.

  The team also learns from colleagues locally and across the state, including those affiliated with UConn's CLEAR and NEMO programs, CT Department of Energy and Environmental Protection, the Hartford Tree Advisory Commission, Planning and Zoning Commission, Parks and Recreation Advisory Commission, and nonprofits such as KNOX, Keney Park Sustainability Project, and The Nature Conservancy.

  To expand its bandwidth, the Office of Sustainability has worked with Trinity College, Central Connecticut State University, University of Connecticut, and University of California at Berkeley interns on sustainability topics, including expanding communications efforts on landscape and weather quality issues through an increased social media presence, blogging, and the creation of a sustainability calendar. In addition to this communications assistance, the GI team continues to directly use social media, including Twitter, blogging, and newsletter updates, to promote programs, highlight progress, and engage the community.

The Office of Sustainability also participates in Sustainable CT, which is an innovative municipal environmental certification program. The certification program includes completing actions related to watershed protection and urban forest restoration, and receiving Sustainable CT certification will acknowledge Hartford's leadership and successes in sustainability and climate action, including those related to the team's CIRCA efforts. The Office supports Sustainable CT staff with hosting events, and also participates on the Sustainable CT Board.

- **Best Management Practices.** There has been significant progress made on the Best Management Practices (BMP) Guide, which provides information on six GI techniques and two specific tree treatments (stormwater tree boxes and structural soil). This Spring, a team of graduate University of California at Berkeley graduate students created a cost-benefit analysis on five of these techniques, and these values will be included in the guide. Moreover, as the intended audience for this guide is City staff, particularly the Department of Public Works (DPW), the Office co-hosted a Green Infrastructure and Stormwater Management workshop for City staff in April 2018. The Office brought in UConn Nonpoint Education for Municipal Officials (NEMO) representatives to share their extensive experience with the GI installations on the Storrs campus and in municipalities across the state. The intention of the workshop is to increase awareness and understanding of the value of green infrastructure and allow engineers and operations staff the opportunity to ask questions in regards to installation and maintenance.


2.2 GREEN ROOFS

BENEFITS:
Water Quality
Air Quality
Stormwater Control
Habitat Creation
Heat Island Effect
Energy Savings

CONSTRAINTS:
Poorly Draining Soils
Space Limitations
Steep Slopes
Retrofit Use

SUITABLE FOR:
Buildings
Streets
Landscapes

CAPITAL COST:
$1-40+/square foot

MAINTENANCE:
Annual Labor: 4 hrs/1,000 ft²
Tasks:
Watering (dry months)
Cleaning out debris
Weeding
Trimming
Other (mulch/mow/etc.)

KEY:
Most Appropriate
Moderately Appropriate
Least Appropriate

WHAT IS A GREEN ROOF?

A green roof is a vegetated roof that provides environmental, economic, health, and social benefits. Green roofs have been around the U.S. since 1930, and they are becoming more common thanks to the many co-benefits they provide. For example, a green roof can be a cost-effective stormwater management alternative that also features green space and offers substantial energy savings.

BENEFITS OF A GREEN ROOF

- Reduced Heat Island Effect
  - Green roofs capture heat, preventing much of the heat from entering the building and surrounding areas.
- Cost Savings
  - Green roofs generate enough lifetime savings (primarily in energy and stormwater) to exceed the initial installation costs.
  - Green roofs have over double the average life expectancy in comparison to standard roofs
  - Green roofs reduce heat transfer and act as insulators, which cuts both cooling and heating energy needs.
- Improved Air and Water Quality
  - The vegetation filters the air and the water, capturing greenhouse gases, emissions, and other pollutants.
- Ecological Benefits
  - Rooftop gardens create habitat, food, and protection for pollinator species.
- Public Green Space
- Stormwater Management
  - Green roofs capture stormwater, decreasing stormwater fees and reducing pressure on the combined sewer system.

Draft | Sources: Portland, EPA, GSA

Figure 3. Our BMP Guide Reviews Different GI Techniques Appropriate for Local Conditions.

- **Complete Streets Working Group.** The Green and Complete Streets group has been meeting on a monthly basis. Major topics include public safety to pedestrians and cyclists as well as increasing education and awareness. The Capitol Region Council of Governments, a participant in the working group, is currently developing a complete streets plan, which includes a location-based survey that allows for resident input concerning the street experience. The GI team and Office of Sustainability also communicates with its Complete Streets partners, such as BiCi Co and the Department of Development Services, on a regular basis. The Office of Sustainability also attended the EPA Technical Assistance workshop for Green and Complete Streets. The workshop brought together stakeholders from various areas including transportation, landscape, and water. The resulting memo has informed the City of next steps to make its streets safer and greener for pedestrians and cyclists, not just automobiles.

- **Community Outreach.** The GI team has been working to engage Hartford residents in water quality and landscape topics at Hartford's local Neighborhood Revitalization Zone (NRZ) meetings and at Hartford Homeowners' Resource Events. The team featured Retain the Rain work at the Office's Landscape / Water Climate Action meeting, during which multiple community partners also discussed their work. There were about 30 people in attendance, and afterwards, participants offered feedback, which included: "I learned so much about all the different climate action projects. It was exciting to hear about the good work being done, and what we have to look forward to and work for!"
  The Green Infrastructure Assistant has attended and presented the RtR program at seven of these events, directly reaching approximately 200 residents. In addition, social media releases on the RtR program gained traction within the first two days of the campaign. As the program progresses, it is expected to increase public awareness of not only downspout disconnection, but water quality and green space issues as a whole. Furthermore, the GI team also led an April Retain the Rain workshop, which directly engaged local partners and community members in sharing the benefits and successes of downspout disconnection and the importance of active stewardship on landscape and water issues.

Figure 4. Landscape and Water Climate Action Meeting for Residents at KNOX.

Final Project Schedule

		2017				2018			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Boards and Commissions	Parks and Recreation Advisory Committee, Tree Advisory Commission, Neighborhood Revitalization Zones, Complete Streets								
Projects	Retain The Rain								
	Best Management Practices Guide								
	Stormwater Runoff Calculator								
	Green Design Competition								
	Tree Canopy Forecast Model (with Tree Advisory Commission/Intern)								
	GI Cost-Benefit Calculator								

Budget Summary

Category	Title	CIRCA Funding
Staff		$93,000
Projects	Retain The Rain	$3,000
	Green Design Competition (To be launched)	$4,000
Total		$100,000

Appendices

Relevant Datasets and Resources

Table 2: Datasets, Sources, and Relevance		
Datasets	**Source**	**Description/Purpose**
Existing Green Infrastructure	Climate Stewardship Council CT NEMO	Shows existing green infrastructure (including low mow zones)
City Boundaries/Streets	COH - MHIS	Delineates the boundaries, streets, neighborhoods
Basin/Watershed	CT DEEP	Delineates the boundaries of the local basins and sub-watersheds and shows the direction of flow within local basins
Soils	USDA SSURGO	Provides soil characteristics such as hydrologic class; used to determine target downspout disconnection areas
Zoning	COH - DDS	Shows existing zoning uses; allows for the differentiation of areas by neighborhood/commercial/industrial uses
311 Flood/Catchment Calls	COH 311 via PublicStuff.com	Lists the public complaints concerning flooding and catchment concerns; may indicate potential problem areas
Sewer System (includes outfalls)	COH - MHIS MDC	Shows the sewer network; differentiates among combined, sanitary, and storm sewers; used to determine priority areas
Trees	COH - DDS COH - MHIS KNOX American Forests UConn - Hort	Partial existing tree count and past tree survey; also used to cross-reference recommended tree species
Demographics	ACS 2015	Used to determine the community characteristics of relevant areas (% poverty, race, education, etc.)
Runoff Generated by Surface	USDA SSURGO Lancaster County, PA	Formula used to determine runoff produced depending on soil and surface type
Land Cover*	UConn CLEAR COH - DPW	Used in combination with runoff formula to determine runoff generated by surface type
Impervious Areas	COH - DPW	Used in combination with runoff formula to determine runoff generated on impervious areas; also used to determine number of structures within downspout disconnection areas
Cost Estimates – Water	MDC	Cost of water usage and treatment
ESRI Basemap*	ESRI	Used to show city streets and surrounding areas
Urban Heat Island*	COH - DPW American Forests	Display priority planting spaces to reduce temperatures in urban areas
Asthma (by census tract)*	CT DEEP	Possibly link priority planting spaces to asthma cases

*Maps produced by other parties

Table 3: Software Programs Used in Data Assessment		
Program	**Source**	**Function**
ArcMap/Catalog	ESRI	Geospatial Analysis
Microsoft Excel	Microsoft	Quantitative Analysis
Microsoft Publisher	Microsoft	Document Design
National Stormwater Calculator	EPA	Runoff/GI Capture Projections
Google Earth	Google	Area/Distance Estimates Conversion of ESRI files to Google Map formats

Table 4: Other Tools and Relevant Online Applications		
Tool	**Source**	**Function**
Google Maps	Google	Display target pilot area and relevant locations online Streetview images for reference
Green Values Stormwater Management Calculator	Green Values	GI Runoff Capture Potential
Stormwater Management Model	EPA	Stormwater Model
Web Soil Survey	USDA NRCS SSURGO	Soil Data Visualization and Downloads
Opti-Tool Spreadsheet	EPA	GI Runoff Capture Potential
Vectr	Vectr	Online Vector Graphics Software

Basic Runoff Analysis - Hartford	
Weather Data Period:	10/1/16-9/30/17
Total Precipitation (in)	35.16
Total Precipitation (gal) including over water	11,063,321,219.04
Total Runoff (gal) -conservative estimate	3,034,104,695.26
% of Total Runoff produced by impervious surfaces	95%
Ratio of Runoff to Precipitation	27%
Potential Treatment Costs of Runoff	$ 1,926,656.48

Cost Variables	
Water Treatment Cost ($/gal)	$ 0.000635
Cost of Potable Water ($/gal)	$ 0.003703

			Information from Past Weather (Tab 2)		
Soil Type	Surface Type	Area Citywide (square feet)	Past Year Runoff total (gal)	Runoff Water Treatment ($)	Potential Avoided Cost of Potable Water Usage ($)
All	Paved Impervious Surface	213,725,290.94	2,874,471,714.86	$ 1,825,289.54	$ 10,644,768.25
A	Open Space	758,976.97	-	$ -	$ -
B	Open Space	47,473,418.47	6,695,854.09	$ 4,251.87	$ 24,796.14
C	Open Space	62,273,176.51	51,460,203.65	$ 32,677.23	$ 190,567.87
D	Open Space	19,938,563.63	34,097,175.03	$ 21,651.71	$ 126,268.95
A	Bare Soil	76,840.19	16,918.15	$ 10.74	$ 62.65
B	Bare Soil	4,309,730.67	5,155,332.54	$ 3,273.64	$ 19,091.27
C	Bare Soil	1,932,660.22	4,894,473.12	$ 3,107.99	$ 18,125.25
D	Bare Soil	1,618,762.24	5,464,525.82	$ 3,469.97	$ 20,236.28
A	Tree Canopy	2,999,102.54	-	$ -	$ -
B	Tree Canopy	35,932,516.39	2,082,239.81	$ 1,322.22	$ 7,710.97
C	Tree Canopy	65,794,225.40	33,076,202.55	$ 21,003.39	$ 122,488.08
D	Tree Canopy	13,246,558.27	16,690,055.65	$ 10,598.19	$ 61,806.76
Unaccounted for (Mixed Soils, Open Water, and Unknown)		34,716,641.35			
Total		504,796,463.79	3,034,104,695.26	$ 1,926,656.48	$ 11,235,922.47

Hover over red corners to see sources and comments.

If the runoff that was produced was captured in its entirety, this column represents how much money that could have been saved in treatment costs. This number is primarily useful if one is assuming that most of the water will be captured (e.g. none of the water was discharged into the local rivers via CSOs).

Surfaces as defined by the USDA's NRCS. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf

Information was provided by MDC in 2017.

Strictly for Hartford's Water Treatment Facility, the HWPCF, treatment/transport costs were valued at $635/MG in 2012.

MDC Water Usage Rate: $2.77/748 gallons

https://themdc.org/assets/uploads/files/billing%20services/2017-water_rates-web.pdf

In Hartford, there are combination soils B/D and C/D that could not be calculated as there were no appropriate curve numbers. There were also areas with no soil type associated with them. Open water was also disregarded as no runoff is produced on open water. The rainwater becomes a part of the volume of the stream. For estimates as to how much rain falls on Hartford's open water, a simple volume formula (area of open water x depth of precipitation) should suffice.

Total runoff on a given area (gallons) = Total square feet of impervious area x number of inches of rain x 1/12 x 7.48

Conversion to gallons:
http://www.stormwaterguide.org/static/HomeownersGuide.pdf

Soil data was pulled from ->
https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Land cover data was pulled from the City of Hartford's GIS database.

Curve numbers (CN) used were computed for impervious areas comprised of dirt (including right of way). The only other option for bare soil was for fallow land, which does not fit Hartford's urban context. See source document or the cell formula for the values.

Source: USDA NRCS document: link in the B6 comment.

Associated Curve Number (CN) was 98. This value applies to parking lots, hence its selection.

Source: USDA NRCS document: link in the B6 comment.

If the runoff that was produced was captured and reused in its entirety, this column represents how much money that could have been saved as a result of using rainwater in lieu of potable water. This number is primarily useful if one is assuming that most of the water will be captured (e.g. if a paved space were to be converted into a stormwater infrastructure technique of the same capacity).

For context, the USGS rainfall calculator (https://water.usgs.gov/edu/activity-howmuchrain.php) finds that on 16 square miles of area, 30 inches of rain will produce 8,341,708,800 gallons. 50 inches of rain translate to 13,902,848,000 gallons. The runoff value calculated should be less than the amount of rainfall. Every year has a different amount of rainfall. To find the total inches of rain for the specific time period mentioned in this spreadsheet, add up the relevant cells in column C. In general, during 1971-2000, Hartford's annual average precipitation was 46.16 inches (http://drought.unl.edu/archive/climographs/pdf/Hartford.pdf). Note that the USGS calculator was orginally intended for a one storm event, but it uses the same basic volume formula that can be used to estimate total rainfall (i.e 30 inches).

Also, it should be noted that the amount of total runoff estimated is a conservative value. Not only are there areas that are not included in the analysis (mixed soils and unknown), but 50% tree coverage curve numbers are used for the tree canopy analysis. This means that these numbers will produce much lower runoff numbers even though Hartford's tree canopy includes street trees or other isolated trees in impervious areas.

Ultimately, these estimates have been produced with the most appropriate values available, and the numbers here are useful for a basic understanding of runoff generation.

Cuve numbers (CN) used were computed for areas with 50% trees and 50% grass cover. This may be an overestimate for Hartford as the city's tree canopy includes street trees or other trees not located in the woods. Associated Curve Number was calculated from the average of the three coverage values (Poor, Fair, and Good). See source document or the cell formula for the values.

Source: USDA NRCS document: link in the B6 comment.

Associated Curve Numbers for open space was calculated from the average of the three coverage values (Poor, Fair, and Good) that are also based on soil type. See source document or the cell formula for the values. This value applies to lawns, parks, golf courses, cemeteries, etc., and it is also equivalent to the values for pasture as well.

Source: USDA NRCS document: link in the B6 comment.

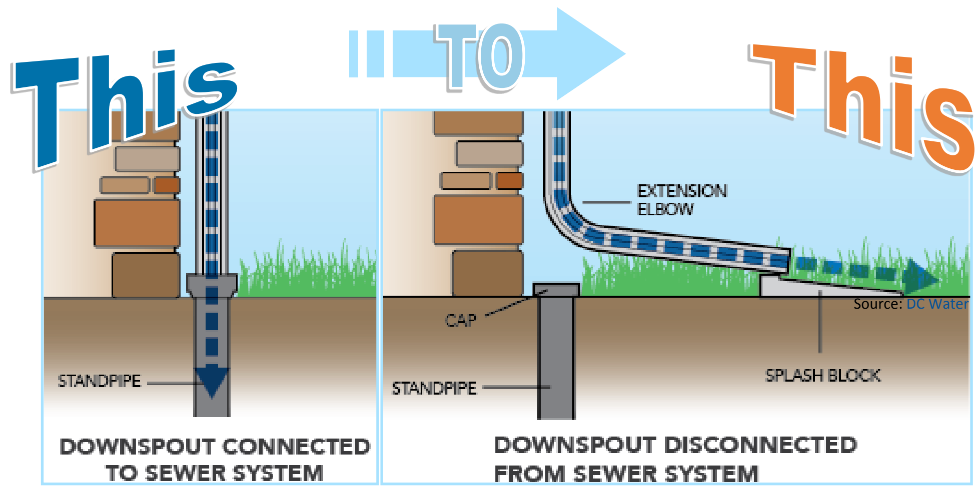
RETAIN THE RAIN

STORMWATER MANAGEMENT PILOT PROGRAM

Sponsored by the Connecticut Institute for Resilience and Climate Adaptation

How would you like to save money on water costs and help the environment at the same time?

A great way to do this is to disconnect your downspout! The City of Hartford is giving out ***FREE*** downspout disconnection kits so you can go from…



Benefits For You!

Downspout disconnection, in combination with rain gardens, has already been implemented at Keney Park and in the West End and Blue Hills neighborhoods.

At the Keney Park House, the Keney Park Sustainability Project (KPSP) teamed up with the Long Island Sound Study and the Farmington River Watershed Association to disconnect the building's downspouts.

Now KPSP benefits from free water for the lawn and gardens, a dry basement, and reduced erosion.

Photos Courtesy of Keney Park Sustainability Project

Free Kit for Participants!

You may qualify for a ***FREE*** downspout disconnection kit if you:

- ☐ Own a home in the Northeast, Upper Albany, or Clay Arsenal neighborhoods
- ☐ Have a connected downspout (see diagram above)
- ☐ Have a roof at least as large as your lawn
- ☐ Have a lawn that slopes away from your home

If you checked all four boxes, request a kit online at hartfordclimate.org/contact or by phone at 860-757-9739.

Did You Know?

1/2 BILLION GALLONS of sewage/stormwater mix are discharged into our rivers every year. Help prevent sewage overflows and backups by capturing or diverting rain to your lawn and gardens.

DRAFT

Disconnecting Your Downspout

Disconnecting your downspout is an easy process. The City of Hartford can help by providing you with a free disconnection kit, if you are eligible! This kit includes:

- Splash block
- Cap and Hose Clamp
- Flexible Downspout Extension

Source: Home Depot

INSTALLATION TIME

30

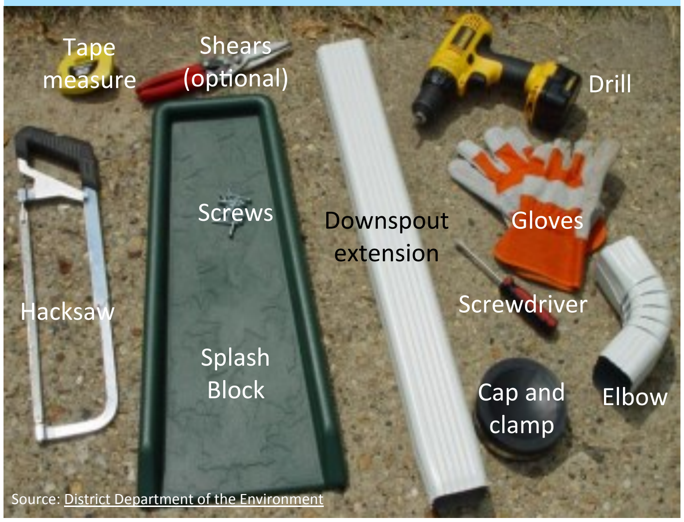
minutes

COST OF MATERIALS

$25

(or FREE for eligible homes)

Tools and Materials*

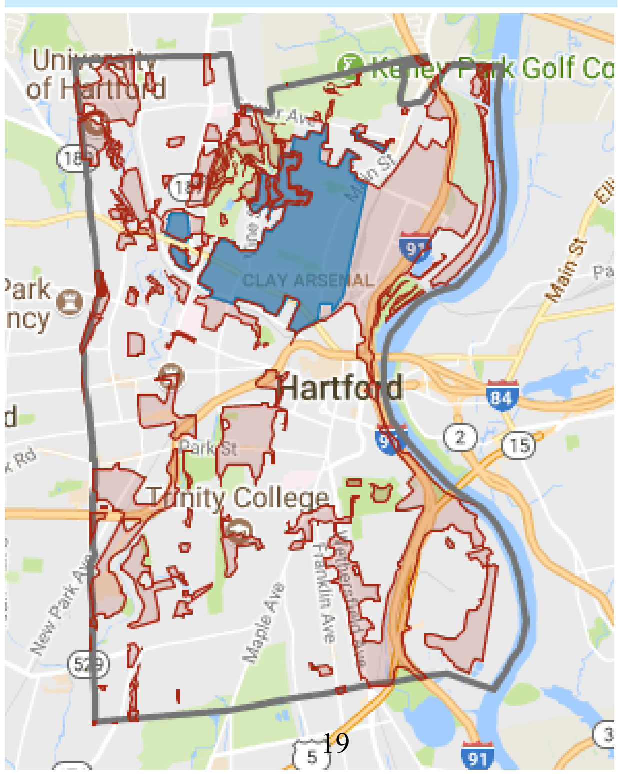


Source: District Department of the Environment

*Items shown above not included in the free kit.

Want to see if you live in the program target area? Check out our online map for a closer look. Visit hartfordclimate.org/ retaintherain

Target Area Map



Contact Information

Email the Office of Sustainability through our website (hartfordclimate.org/contact) or call 860-757-9739 for more information.

550 Main St. Hartford, CT 06103

INSTALLATION PROCESS

Measure

Cut

Cap

Attach

Screw

Place

Source: District Department of the Environment

______ Species ______________________

Learn more at
hartfordclimate.org/trees

This tree has given us

$ ______________________

i-Tree Design @ design.itreetools.org

worth of benefits in its current lifetime

Benefits include:

Water Quality **Air Quality** **Carbon Reduction**

Interested in learning more?

Flip this tag over to find out how Hartford's trees help our community.

Sponsored in part by:

CIRCA
Connecticut Institute for Resilience and Climate Adaptation

Breathe easy.

Hartford's trees help clean our air.

HARTFORD CLIMATE STEWARDSHIP INITIATIVE

CITY OF HARTFORD TREE ADVISORY COMMISSION

Did you know?
Hartford's trees provide
$5,487,213
in citywide annual benefits!

Number of Trees: 568,000 **Total Replacement Cost:** $590 million

Energy savings	$277,665
Air Quality Improvements	$256,090
Carbon Reduction	$225,280
Rainwater Services	$4,728,178

2014 Hartford Urban Tree Canopy Assessment and 2007 Hartford's Urban Forest—the Challenge

Keep it cool with trees.

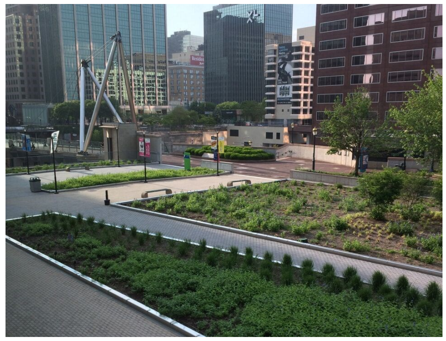
Our trees provide shade, saving energy and keeping us cool.

COOL, GREEN, AND SOLAR ROOFS: FACT SHEET

WHAT ARE COOL/GREEN/SOLAR ROOFS?

Low Sloped Cool Roof. Source: EPA

Cool Roof: A roof that reflects more sunlight and absorbs less heat than a standard roof; it requires a highly reflective material that can be a type of paint, sheet covering, tile, or shingle.



Constitution Plaza Green Roof

Green Roof: The area on roof that is open to the sky and is surfaced with soil and living plants in order to retain rainwater and absorb heat from sunlight.

Rooftop Solar in Hartford

Solar Panels are mechanical devices that convert sunlight into electricity. They can easily be mounted on flat roofs.

WHY CHOOSE THESE ROOFS?

COOL ROOF

- Energy Savings
- Reduced Heat Island Effect
- Short Payback Period
- Fewer Emissions

GREEN ROOF

- Energy Savings
- Longer Lifetime Use
- Improved Air and Water Quality
- Stormwater Management

SOLAR ROOF

- Energy Generation
- Reduced Emissions
- Increased Resiliency

OTHER EXAMPLES

Hartford's trying its best to become a more sustainable city. Check www.hartford.gov/climate for our Climate Action Plan. Read below for some examples of other municipal programs:

- **NYC Cool Roofs Program**
  - Over 5.7 million sf of cool rooftop since 2009
  - 10-30% reduction of cooling costs
- **Revolutionary Building Code in San Francisco**
  - San Francisco is the first U.S. city to require solar and living roofs on most new construction

APPLYING FOR A ZONING PERMIT?

You might be required to consider cool roofs, green roofs, and solar panels — and explain your thought process in your application. An explanation is required for projects that:

⇒ Have a parapet or flat roof

⇒ Have a use other than a 1-, 2-, or 3-Unit Dwelling

⇒ Have a use other than a Retail or Service that uses less than 10,000 square feet

Your explanation may be simple, like a statement that you received price quotes from your roofing contractors.

INTERESTED IN LEARNING MORE?

For useful links and other helpful tools on cool, green, and solar roofs, visit www.hartfordclimate.org/roofs.

For more information about zoning requirements and permits:

* Visit Hartford's Planning Department website at www.hartford.gov/DDS-pz
* Contact _________ by phone (XXX-XXX-XXXX) or by email (XXXX@hartford.gov)

Sources: DOE; EPA; NREL; NYC Cool Roofs; San Francisco

Phoenix Plaza Green Roof

GREEN INFRASTRUCTURE HANDBOOK

Best Management Practices in Hartford, Connecticut

Office of Sustainability

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Citywide, approximately 42% of Hartford's land area is covered in impervious surfaces, and much of the rest of the city is covered in soils with high clay content and low infiltration rates. Together, these conditions prevent effective absorption of stormwater, exacerbate runoff, and result in localized flooding, sewer backups, and sewage overflows into local waterways. Green infrastructure (GI) is an alternative approach to stormwater management that protects, restores, or mimics the natural water cycle, using water as a resource. Widespread adoption of GI techniques can help reduce the cost of eliminating sewer backups and localized flooding, while providing many co-benefits such as cleaner air, cooler city streets, increased public greenspace, and enhanced wildlife habitat, all of which improve the quality of urban life.

Hartford is particularly vulnerable to Urban Heat Island and poor air quality given the large amounts of impervious surface. This can have severe consequences on human health and safety by degrading air and water quality and contributing to aggravated asthma and heat-related illness or death. Green infrastructure, in the form of vegetation like trees and other plants, can help reduce the impacts of these problems by capturing pollutants such as particulate matter (a major asthma trigger) and cooling the area with shade and evapotranspiration.

To date, other than urban tree canopy, there have been a limited number of green infrastructure best management practices implemented within the City. The majority of these practices are green roofs within the downtown area. The Capitol Building also has eight different uses of GI on its grounds. However, other than visual checks, the efficacy of these projects has not been measured.

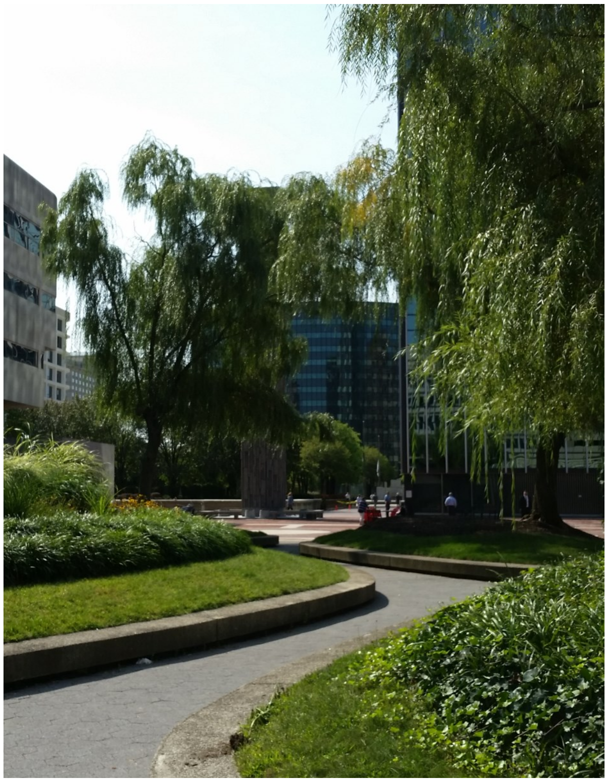
Barriers to the implementation of GI in Hartford include concerns that the city's clay-heavy soils (which cover 60% of the city) make these techniques impractical. However, GI can be effectively utilized within Hartford despite the high percentage of clay-heavy soils. An EPA study completed in Madison, WI revealed that pilot rain gardens were able to capture 99% of the stormwater that they had received, regardless of soil or vegetation type. Moreover, the USDA NRCS's Soil Survey indicates that Hartford has a substantial amount of Type B soils (Over 25% of the city), which have infiltration rates suitable for GI.

Another common concern is the cost of implementation and maintenance. As with any new project, there are initial construction costs for the design and installation of GI practices. These initial costs should be considered in the context of the numerous benefits GI techniques provide. In addition to green space and stormwater capture, GI also often extends the lifespan of the surrounding infrastructure such as sidewalks and roofs. In streetscape projects, green infrastructure can provide multiple uses beyond stormwater capture such as providing green space and calming traffic.

Incorporating GI BMPs will maximize economic, environmental, and social benefits and improve Hartford's climate resiliency. There are several actions that are recommended to facilitate widespread GI implementation and improve the efficiency of the city's existing infrastructure. The adoption of standardized GI guidelines (such as the National Association of City Transportation Officials Street Stormwater Guide) for streetscapes will ensure that future GI projects will be consistently structured throughout the city. Another recommendation includes the promotion of GI on private property. Rain barrels, cisterns, trees, and rain gardens are all practices that can be effective on properties of varying sizes.

As urban tree canopy is the primary source of green infrastructure benefits in Hartford at this time, it is crucial to maintain and care for trees to allow them to grow to a larger size, which will reap benefits in the short and long term. Using techniques such as structural soil or tree filtration boxes can enhance the contributions of trees and maximize their potential, while saving money in maintenance and replacement costs. In downtown Storrs, CT and within the UConn-Storrs Campus, precast stormwater planter boxes were successfully used to treat stormwater runoff coming from impervious areas. Tree care and education is also included in as a strategy.

Ultimately, it is vital to implement and maintain GI in Hartford in order to provide critical stormwater capture, pollution control, and public green space.



Constitution Plaza Green Roof

2.1 RAINWATER HARVESTING (RAIN BARRELS/CISTERNS)

BENEFITS:

- Water Quality
- Air Quality
- Stormwater Capture
- Habitat Creation
- Heat Island Effect
- Water Supply

CONSTRAINTS:

- Poorly Draining Soils
- Space Limitations
- Steep Slopes
- Retrofit Use

SUITABLE FOR:

- Buildings
- Streets
- Landscape

MAINTENANCE:

Tasks:

- Watering (dry months)
- Cleaning out debris
- Weeding
- Trimming
- Other (mulch/mow/etc.)

KEY:

- Most Appropriate
- Moderately Appropriate
- Least Appropriate

Herb Virgo, Director of Keney Park Sustainability Project (KPSP), teaches residents about rainwater harvesting at the site

WHAT IS RAINWATER HARVESTING?

Rainwater harvesting is the collection of rainwater from impervious surfaces for later use. Rainwater collection systems require diverting roof downspouts to cisterns or rain barrels. Rain barrels and cisterns are the containers that hold the stormwater captured. Rain barrels are typically used for smaller properties such as private residences whereas cisterns are typically used for larger properties.

BENEFITS OF RAINWATER HARVESTING

- Provides water for irrigation or other non-potable uses
- Captures stormwater, decreasing urban runoff, pollution, and sewer overflows
- Reduces erosion in urban environments
- Helps reduce peak summer demands
- Diverts usage from drinking water supplies
- Helps save money on water bills, particularly during peak summer months

Rain barrels collect water for the aquaponics system at KPSP

Upcycled Rain Barrel

LOCAL EXAMPLES

In 2012, the Metropolitan District (MDC) launched a rain barrel program as a part of the Clean Water Project, which is designed to reduce local sewer backups and overflows into the Connecticut River. The rain barrel program was a success, with over 1,300 rain barrels distributed to the utility's customers. Each rain barrel can help the average homeowner save 1,300 gallons of water during the peak summer months.

As a part of the Green Capitols Project, MDC also engineered and installed the cistern at the State Capitol. Rainwater collected from the roof is stored in the cistern for future irrigation.

Keney Park Sustainability Project (KPSP), a local nonprofit, has also taken advantage of the benefits of rain barrels. Rainwater harvested from the roofs of greenhouse and aquaponics facility are used to irrigate the urban agriculture site.

To keep the rainwater clean and mosquito-free, KPSP uses goldfish to eat the mosquito larvae and algae. The fish provide an innovative and natural pest solution.

Rain Barrel Demonstration of the Hartford Public Library; Courtesy of MDC

COSTS

With their large capacity, cisterns are more likely to be suitable for larger buildings, whereas rain barrels are more appropriate for small buildings such as single family homes.

- Rain barrels can range from $35-$150 depending on size and features. You can make a rain barrel or purchase one at your local hardware store or online.
- Cisterns can range from $1,500 to over $10,000 depending on size. Cisterns can be purchased online or from a supplier. Larger cisterns can be complex and often require a professional to install. Ask your supplier whether they include installation or initial maintenance with your purchase

MAINTENANCE

Rain barrels and cisterns are fairly low maintenance. They require the following tasks:

⇒ Using the water stored your rain barrel or cistern to make room for the rainfall from the next storm

⇒ Periodically inspecting your barrel/cistern for leaks or clogging

⇒ Cleaning and sanitizing your cistern annually to remove sediment or any other contaminants

⇒ Winterizing your rain barrel (drain, disconnect, clean, and store it for the winter)

SUITABLE LOCATIONS

Rainwater harvesting is particularly useful for buildings with sloped roofs that may also require irrigation for landscaping needs. Appropriate sites may include schools or commercial buildings with landscaping.

- Rain barrels are affordable and can be installed by hand at most homes without any major constraints
- Larger cisterns require greater planning and design. Make sure to consult a certified contractor when considering a large or complex cistern system

INTERESTED IN LEARNING MORE?

- Visit the EPA *Soak Up the Rain webpage* for more resources about rain barrels
- Learn from MDC about how you can install and maintain your rain barrel. Read more here
- The EPA also has a literature review on rainwater harvesting. Check it out here

2.2 GREEN ROOFS

BENEFITS:

- Water Quality
- Air Quality
- Stormwater Control
- Habitat Creation
- Heat Island Effect
- Energy Savings

CONSTRAINTS:

- Poorly Draining Soils
- Space Limitations
- Steep Slopes
- Retrofit Use

SUITABLE FOR:

- Buildings
- Streets
- Landscapes

MAINTENANCE:

Annual Labor: 4 hrs/1,000 ft^2

Tasks:

- Watering (dry months)
- Cleaning out debris
- Weeding
- Trimming
- Other (mulch/mow/etc.)

KEY:

- Most Appropriate
- Moderately Appropriate
- Least Appropriate

Green Roof at Phoenix Plaza

WHAT IS A GREEN ROOF?

A green roof is a vegetated roof that provides environmental, economic, health, and social benefits. Green roofs have been around the U.S. since 1930, and they are becoming more common thanks to the many co-benefits they provide. For example, a green roof can be a cost-effective stormwater management alternative that also features green space and offers substantial energy savings.

BENEFITS OF A GREEN ROOF

- **Reduced Heat Island Effect**
  - Green roofs capture heat, preventing much of the heat from entering the building and surrounding areas.
- **Cost Savings**
  - Green roofs generate enough lifetime savings (primarily in energy and stormwater) to exceed the initial installation costs.
  - Green roofs have over double the average life expectancy in comparison to standard roofs
  - Green roofs reduce heat transfer and act as insulators, which cuts both cooling and heating energy needs.
- **Improved Air and Water Quality**
  - The vegetation filters the air and the water, capturing greenhouse gases, emissions, and other pollutants.
- **Ecological Benefits**
  - Rooftop gardens create habitat, food, and protection for pollinator species.
- **Public Green Space**
- **Stormwater Management**
  - Green roofs capture stormwater, decreasing stormwater fees and reducing pressure on the combined sewer system.

Draft | Sources: Portland, EPA, GSA

COSTS

Initial green roofs costs range from $10-$20 more than conventional roofs to install. However, green roofs more than compensate for these startup costs through energy savings and the increased life expectancy of the roof (over twice the typical lifespan). Over a 50-year period, green roofs generate enough stormwater, energy, carbon dioxide, and community earnings to offset and exceed the increased cost of installation, maintenance, and replacement.

MAINTENANCE

Green roofs require low to moderate maintenance (4 hours of labor for every 1,000 sf) depending on the type of plants and depth of soil medium. Typical maintenance includes:

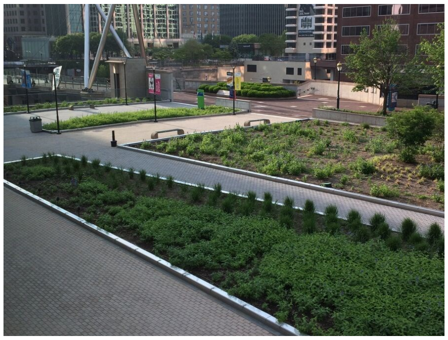
⇒ Watering during dry periods (less than 1.5 inches of rainfall in a six week period)

⇒ Occasional weeding

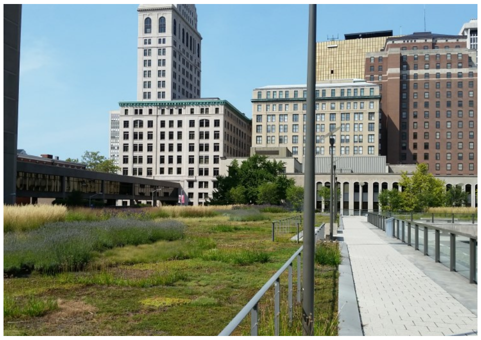
⇒ Cleaning up litter and debris

LOCAL EXAMPLES

Green roofs have been growing in popularity in Hartford since the 1960s. Hartford's green roofs can be found at Constitution Plaza, Phoenix Plaza, Connecticut Science Center, Travelers Plaza, the Hollander, the State Capitol, and Aetna. These green roofs provides spaces for people to enjoy nature within the city, while also capturing stormwater and saving energy.



Built in 1962, Constitution Plaza is Hartford's oldest green roof. It is a 3.8 acre green space that provides lush public areas open to both building inhabitants and the community.



Phoenix Plaza has one of the most extensive green roofs in the city, with landscaped areas making up 42% of the property. These areas are self-sufficient and require irrigation only during periods of prolonged drought.

As a part of the Green Capitols Project, a green roof was installed at the Connecticut State. The area consists of vegetated modular trays that include a growing medium planted over a waterproof membrane.

SUITABLE LOCATIONS

Connecticut Science Center

UConn at Storrs—Laurel Hall. Courtesy of UConn CLEAR

Green roofs can be retrofitted on flat roofs in a variety of settings such as residential, commercial, and public buildings. Commercial plazas and parking garages are two types of structures that are common in downtown Hartford and that may benefit from green space. Public buildings such as schools are other potential options for green roofs.

INTERESTED IN LEARNING MORE?

- Use the ASU Green Roof Energy Calculator to see how much you can save with a green roof
- See how green roofs can reduce the Heat Island Effect: EPA's Reducing Urban Heat Islands: Green Roofs
- Find out about other green roofs in The International Greenroof & Greenwall Projects Database
- Read the US General Services Administration's Report on Green Roofs on Public and Commercial Buildings

Draft | Sources: GSA, DEEP, Sasaki, Phoenix, EPA | Images: NEMO

2.3 URBAN TREE CANOPY

BENEFITS:

- Water Quality
- Air Quality
- Stormwater Capture
- Habitat Creation
- Heat Island Effect
- Energy Savings

CONSTRAINTS:

- Poorly Draining Soils
- Space Limitations
- Steep Slopes
- Retrofit Use

SUITABLE FOR:

- Buildings
- Streets
- Landscape

MAINTENANCE:

Tasks:

- Watering (dry months)
- Cleaning out debris
- Weeding
- Trimming
- Other (mulch/mow/etc.)

KEY:

- Most Appropriate
- Moderately Appropriate
- Least Appropriate

Bushnell Park on Trumbull Street

WHAT IS URBAN TREE CANOPY?

Urban tree canopy (UTC) consists of the leaves and branches of the trees that cover the ground when viewed from above. Trees are among the most prevalent forms of green infrastructure found in urban areas, offering a multitude of benefits that improve the quality of life within communities. Many cities have recognized the value of trees and have set canopy goals to restore and protect their urban forests. Residents, businesses, and community groups can make a difference by planting and caring for trees.

BENEFITS OF TREES

- **Reduced Heat Island Effect**
  - Trees provide shade, which can cool the surrounding area by between 4°F - 14°F and increase the longevity of the adjacent pavement
- **Cost Savings**
  - Trees generate enough lifetime benefits and savings to exceed the initial installation costs
  - Landscaping with trees can increase property values by 20%
  - Trees can reduce A/C needs by 30% and save 20-50% of the energy used for heating
- **Improved Air and Water Quality**
  - Trees filter the air and the water, capturing greenhouse gases, emissions, and other pollutants
- **Ecological Benefits**
  - Hartford's urban forest provides habitat, food, and protection for various species
- **Public Green Space**
  - Trees improve the quality of life in a community. Spending time near trees increases energy level and decreases blood pressure and stress
- **Stormwater Management**

Draft | Sources: Portland, USFS, iTree, FAO

COSTS

Trees can vary in cost depending on the size and the species of trees. Trees purchased at local nursery or home improvement store can cost as little as $15. In contrast, larger caliper trees (>2") for commericial landscaping can cost upwards of $250. Note that smaller trees tend to establish more successfully than larger trees.

MAINTENANCE

Trees require some maintenance in the establishment period to ensure their longevity. These tasks include watering during dry periods (less than 1.5 inches of rainfall in a six week period), pruning, and mulching (avoid excess mulching).

LOCAL EXAMPLES

Trees provide vital services that improve the quality of life in our communities. Trees provide shade, which cools our buildings and neighborhoods and reduces energy costs. They remove various pollutants, improving our air and water quality. Trees also capture stormwater runoff, reduce noise pollution, and increase property values. Based on these qualities, Hartford's trees provide over $5 million in services each year. This includes the removal of 147,780 pounds of pollutants and 11,264 tons of carbon from the air and the interception of over 590 million gallons of stormwater. Moreover, as trees mature and increase in size and canopy, the benefits they provide also increase. As 10% of Hartford's largest trees (20 inches or greater in diameter) make up 50% of the city's canopy, it is crucial to care for and maintain our urban forest so that our trees can provide the same benefits for future generations.

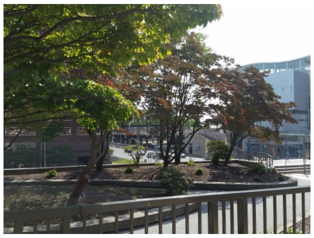
To read more about how the city benefits from its trees, check out the 2014 study that American Forests completed on Hartford's Urban Tree Canopy.

Scion of the Charter Oak - The first-generation descendant of the famous Charter Oak

Aerial view of trees in Downtown Hartford and Bushnell Park, which is an arboretum of over 450 trees and 76 species

SUITABLE LOCATIONS

Bushnell Park North Promenade Street Trees



Trees at Constitution Plaza

Trees are among the most versatile of green infrastructure techniques. They can be planted alongside buildings and streets and within landscaping for parks and other uses. With a wide variety of trees suitable for Hartford's climate, a diverse array of trees can be planted by size, shape, color, and more. In addition, trees can be used with other green infrastructure practices such as at MDC's permeable pavement project on Main Street. Trees can also be planted in rain gardens and bioswales as well as on green roofs such as at Constitution Plaza.

INTERESTED IN LEARNING MORE?

- Want to plant your own tree? Look through the city's list of permitted trees in the Zoning Regulations (page 205)
- Proper tree maintenance is crucial in tree health and performance; learn about tree care from Casey Trees
- MyTree is specifically designed for mobile browsers, so check out this tool to see what your tree can do
- Find out how much your trees boost your property values and calculate the energy, stormwater, and air quality benefits your trees can offer using the National Tree Benefit Calculator

Draft | Sources: American Forests, Connecticut's Notable Trees

ALTERNATIVE PLANTING METHODS: TREE BOXES

DEFINITION:

Tree boxes are precast tree pits specifically designed to collect and treat stormwater.

ADDITIONAL BENEFITS:

- Longer Life Expectancy
- Increased stormwater capture

SUITABLE LOCATIONS:

Buildings

Streets

Landscape

CAPITAL COST:

$12,000+ per unit

MAINTENANCE:

Annual Cost: $100-500/unit

Tasks (2 times a year):

- Clean out debris
- Check proximity of the trunk to the grating

KEY:

Most Appropriate

Moderately Appropriate

Least Appropriate

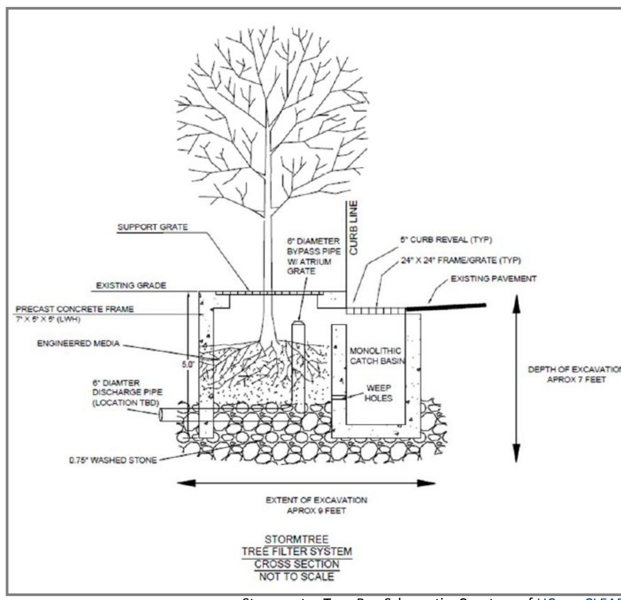
Stormwater Tree Box at UConn-Storrs. Courtesy of UConn CLEAR

UNIVERSITY OF CONNECTICUT AT STORRS: STORMWATER TREE BOXES

Tree boxes are precast tree pits specifically designed to collect and treat stormwater. In urban or built-out areas where space is limited, these tree boxes can fit within a small existing footprint as retrofit projects.

The University of Connecticut at Storrs has implemented a variety of green infrastructure techniques around campus, including three pre-cast stormwater boxes. These tree boxes treat 23,795 ft^2 of impervious area despite being only a fraction of the space (105 ft^2). These tree boxes are also highly effective at filtering pollution, with removal rates ranging from 50-85% for pollutants such as suspended solids, phosphorus, nitrogen, metals, and oil/grease.

The maintenance requirements for these tree boxes are typically limited to the removal of sediment, litter, and other debris in the spring and in autumn. Performance efficiency correlates with maintenance, which can cost as little as $100 year per tree. These tree boxes have a lifespan of 25 years.



Stormwater Tree Box Schematic. Courtesy of UConn CLEAR

2.4 BIORETENTION (RAIN GARDENS/BIOSWALES)

BENEFITS:

- Water Quality
- Air Quality
- Stormwater Capture
- Habitat Creation
- Heat Island Effect
- Energy Savings

CONSTRAINTS:

- Poorly Draining Soils
- Space Limitations
- Steep Slopes
- Retrofit Use

SUITABLE FOR:

- Buildings
- Streets
- Landscape

MAINTENANCE:

Annual: 20.7 hrs/acre treated

Tasks:

- Watering (dry months)
- Cleaning out debris
- Weeding
- Trimming
- Other (mulch/mow/etc.)

KEY:

- Most Appropriate
- Moderately Appropriate
- Least Appropriate

Bioswale at UConn School of Law

WHAT IS BIORETENTION?

Bioretention is the use of vegetation and soils to capture and filter stormwater runoff. A rain garden is a form of bioretention typically used in landscaping; it is a depressed area that collects rain water and allows it to soak into the ground. A bioswale is an urban rain garden with additional storage underneath; this technique can be installed along streets and parking lots.

BENEFITS OF RAIN GARDENS AND BIOSWALES

- **Reduced Heat Island Effect**
  - Replacing impervious areas with green space helps reduce the heat that pavement typically radiates
- **Improved Air and Water Quality**
  -Plants filter the air and the water, capturing greenhouse gases, emissions, and other pollutants
- **Ecological Benefits**
  - Rain gardens and bioswales can provide habitat for various species
- **Public Green Space**
  - Greenery improves the quality of life in a community. Spending time near trees increases energy level and decreases blood pressure and stress
- **Stormwater Management**
  - Bioswales and rain gardens capture stormwater and excess runoff, which reduces pressure on the city's combined sewers and subsequently decreases the frequency of flooding and drainage issues such as combined sewer overflows

Draft | Sources: Portland, EPA[1], EPA[2]

COSTS

Simple rain gardens can cost as little as $5 per square foot. More complex designs requiring a contractor can cost up to $45 per square foot. UConn NEMO has developed a rain garden cost calculator to estimate potential costs (find link below).

Due to a lack of standard specifications, bioswales in the right-of-way or on private property may require engineering designs or other additional capital costs. EPA's Opti-tool estimates that bioretention costs $15.46 per square foot. This includes the cost of construction and a 35% design/engineering/ contingency cost.

MAINTENANCE

Once established, rain gardens and bioswales typically require little maintenance. EPA's Opti-tool estimates maintenance needs to be 20.7 hours per year for every acre of impervious cover treated (rain gardens can treat impervious areas six times their size).

- During the establishment period, plants should receive an inch of water per week for 1-2 months if it does not rain
- Remove any weeds, invasive species, dead branches or dead vegetation
- Avoid adding excessive amounts of mulch as it can inhibit water flow or storage
- Inspect for erosion or sediment buildup, adding rocks or removing sediment as needed

LOCAL EXAMPLES

In Hartford, rain gardens and bioswales have been placed at residential, commercial, public areas. The Classical Magnet School and UConn's School of Law in West End boasts two rain gardens each. The Keney Park Sustainability Project (KPSP) also has two rain gardens on site, one of which has edible plants like blueberries, and thyme. These gardens, in combination with the addition of gutters and downspout disconnection, have resolved chronic basement flooding issues.

Volunteers installing a rain garden. Courtesy of KPSP

Completed Edible Rain Garden. Courtesy of KPSP

SUITABLE LOCATIONS

Rain Garden at CT State Capitol

Rain gardens are highly adaptable and can be installed in any area that is unpaved. Rain gardens can be added to schools, parks, and in the yards of homes. Rain gardens can also be planted with native and edible plants, allowing for harvesting and educational opportunities.

Bioswales can occupy spaces as narrow as one foot, which makes this green infrastructure technique particularly adaptable to streetscape projects. Other cities such as New York and New Haven are installing bioswales by the hundreds in order to reduce issues such as combined sewer overflows and localized flooding.

INTERESTED IN LEARNING MORE?

- Download NEMO's rain garden mobile app to design your own rain garden
- Check out New York City's Bioswale Care Handbook to understand what it means to care for a bioswale in the right of way
- See what design guidelines the National Association of City Transportation Officials recommends in their Urban Street Stormwater Guide

2.5 PERMEABLE PAVEMENT

BENEFITS:

- Water Quality
- Air Quality
- Stormwater Capture
- Habitat Creation
- Heat Island Effect
- Water Supply

CONSTRAINTS:

- Poorly Draining Soils
- Space Limitations
- Steep Slopes
- Retrofit Use

SUITABLE FOR:

- Buildings
- Streets
- Landscape

MAINTENANCE:

Annual: 6 hours/acre

Tasks:

- Watering (dry months)
- Cleaning out debris
- Weeding
- Trimming
- Other (Vacuum)

KEY:

- Most Appropriate
- Moderately Appropriate
- Least Appropriate

Porous Asphalt at the Connecticut State Capitol

WHAT IS PERMEABLE PAVEMENT?

Traditional pavement is impervious and exacerbates urban runoff whenever it rains. Permeable pavement is an alternative option that helps capture and infiltrate stormwater runoff and snowmelt, reducing pollution to local waterways. Permeable pavement can be a cost-effective drainage approach in urban areas.

BENEFITS OF PERMEABLE PAVEMENT

- Increases infiltration and recharges groundwater
- Captures stormwater, decreasing urban runoff and filtering pollutants such as phosphorous, nitrogen, and metals
- Reduces erosion in urban environments

Pervious concrete and permeable pavers at the entrance of the CT State Capitol

Pervious concrete path at the CT State Capitol

Draft | Sources: Portland, EPA, DEEP

COSTS

Costs for permeable pavers vary by type.

EPA's Opti-tool estimates that porous asphalt costs $5 per cubic foot of runoff storage (including design/engineering/contingency costs) whereas pervious concrete costs $18 per cubic foot.

MAINTENANCE

Permeable pavement is considered one of the most affordable GI techniques to maintain, requiring the vacuuming and removal of sediment once or twice a year. Annually, this translates to six hours of labor per acre. Note that these cleanings are necessary for performance efficiency. Sediment buildup will reduce or impair the performance of the product. Other considerations include:

⇒ Avoid sanding and salting in the winter as this can lead to sediment buildup or product deterioration. In many cases, permeable pavement requires less deicing as much of the snowmelt infiltrates rather than freezes.

⇒ Some pre-cast pavements will only require a power washer for cleaning.

LOCAL EXAMPLES

Hartford has several examples of permeable pavement in the city. Bushnell Park features permeable pavement both within the park and along its north promenade. In Fall 2017, MDC also installed a demonstration project on Main Street using flexi-pave, which is made of recycled material such as tires.

The most extensive example of permeable pavement in Hartford is at the State Capitol. Nearly 40,000 square feet of permeable pavement was installed onsite, including permeable pavers, porous asphalt, and pervious concrete. Porous asphalt makes up the bulk of the parking lot and driveway, whereas pervious concrete is used for the majority of the walkways. Permeable pavers are used for entrances and other pedestrian areas.

Porous asphalt parking lot and path with permeable pavers and pervious concreate on a rainy day at the CT State Capitol

POTENTIAL LOCATIONS

Porous Concrete

Permeable Pavers

Permeable pavement is extremely useful in a multitude of locations where pavement is required. The variety of permeable pavement options available (such as porous concrete and permeable pavers) allow for a greater diversity in function and aesthetics.

It is recommended that permeable pavement be used in areas with low to moderate traffic (less than 500 daily trips) to prevent sediment buildup in the system. Potential locations include park paths, sidewalks, and parking lots.

INTERESTED IN LEARNING MORE?

- Take a self-guided tour of the State Capitol's green infrastructure to see three different kinds of permeable pavement
- Find more details and design considerations can be found in CT DEEP's Stormwater Manual, Chapter 11
- The National Association of City Transportation Officials provides basic recommendations and design considerations in their Urban Street Stormwater Guide

2.6 NO MOW/LOW MOW AREAS

BENEFITS:

- Water Quality
- Air Quality
- Stormwater Capture
- Habitat Creation
- Heat Island Effect
- Energy Savings

CONSTRAINTS:

- Poorly Draining Soils
- Space Limitations
- Steep Slopes
- Retrofit Use

SUITABLE FOR:

- Buildings
- Streets
- Landscape

MAINTENANCE:

Annual Mowing in Autumn

Tasks:

- Watering (during establishment)
- Weeding (establishment)
- Trimming
- Other (Mow/etc.)

KEY:

- Most Appropriate
- Moderately Appropriate
- Least Appropriate

Low Mow Meadow at Keney Park

WHAT IS NO MOW/LOW MOW?

Low mow zones are areas planted with meadow plants instead of traditional turf, saving valuable staff time and money on lawn maintenance while increasing runoff absorption and habitat creation. Less mowing reduces the usage of fuel and equipment, leads to fewer carbon dioxide emissions, protects the atmosphere, and saves money.

BENEFITS OF MEADOWS

- **Improved Air Quality**
  - Low mow meadows filter the air, capturing greenhouse gases, emissions, and other pollutants
  - Choosing low mow grasses over regular turf or lawn reduces mowing, which decreases the cost of maintenance and related fossil fuel consumption and subsequently reduces the suspension of dust and allergens
- **Ecological Benefits**
  - Low mow meadows increase and diversify wildlife habitat by promoting wildflower and grassland growth, which attracts pollinator species of insects and birds
- **Public Green Space**
- **Stormwater Management and Improved Water Quality**
  - Meadows capture stormwater and excess runoff more effectively than turf, filtering pollutants and allowing rain to infiltrate and recharge into the groundwater supply

COSTS

Creating low mow meadows requires the purchasing and planting of meadow mix, estimated to be $10 per pound of seed. While meadow mix seeds may differ in cost from traditional turf, once established, they require much less maintenance and care.

MAINTENANCE

The initial meadow mix must be watered and maintained until the grasses have been established. After this point, meadows require no other maintenance other than mowing once a year, typically in the fall.


Low mow meadow at Batterson Park; Courtesy of Tom Baptist

LOCAL EXAMPLES

Low mow areas were first established in Hartford's parks in 2014. These areas are mowed once a year, usually in the fall. At the closed landfill, the city's largest low mow area by far, hawks, plovers, and sandpipers have been found living in the meadows.

Low mow areas can be found at the following locations around the city:

- Decommissioned Landfill (35 acres)
- Keney Park (11 acres)
- Goodwin Park (5 acres)
- Pope Park (4 acres)
- Colt Park (1 acres)
- Elizabeth Park (1 acres)
- Brackett Park (2 acres)


Keney Park Great Meadow; Courtesy of Tom Baptist

POTENTIAL LOCATIONS


35 acres of low mow meadow at Hartford's closed landfill

Low mow areas can be applied to a variety of landscaped areas across the city. Individual homes can incorporate low mow areas into their yards, reducing excess mowing and watering needs. Commercial properties can add meadow mix to their landscaping, increasing stormwater capture potential and reducing maintenance needs. Vacant lots and underutilized properties like the closed landfill can be transformed into vibrant habitats for plants, butterflies, and birds. Low mow meadows can also be extended within the existing areas of the parks system, saving the city time and money.

INTERESTED IN LEARNING MORE?

- Other cities have no mow zones too! Check out Philadelphia's tips for a no mow backyard buffer
- For maintenance guidelines, read University of Minnesota's *There is Maintenance to No Mow, Low Input Areas*
- Read Yale University and NRDC's collaborative paper *Toward Sustainable Landscapes: Restoring the Right NOT to Mow*, which describes potential legal obstacles to no mow landscapes

GI Cost Effectiveness Calculator

May 2018

Default size of project (sq ft)	1000

ID	Techniques	Installation & Materials Costs	Estimated Maintenance Costs Per Year: Annual Long Term Maintenance Hours	Estimated Annual Equipment Cost	Estimated Annual Maintenance Costs	Total Maintenance Costs	Total Installation and Projected Maintenance Costs	Stormwater Capture for 1" rain	Lifetime
1	Low Mow	773.78	0.05	0	1.2325	123.25	773.78	623.376	100
2a	Porous Asphalt	2,140.00	6	0	49.5154179	1,237.89	3,377.89	498.7008	25
2b	Pervious Concrete	2,160.00	6	0	49.5154179	1,237.89	3,397.89	498.7008	25
2c	Permeable Interlocking Concrete Pavement	2,550.00	6	0	49.5154179	1,237.89	3,787.89	498.7008	25
3	Urban Tree Canopy*	127.42	5	0	2.178004413	217.80	345.22	N/A	100
4	Bioretention	15,661.92	0	0	0	0.00	15,661.92	280.5192	30

*Urban Tree Canopy stormwater capture is measured by average annual interception, whereas stormwater capture for all other techniques is measured through the infiltration rate; therefore, the amount of water captured in a particular storm for UTC is indeterminate.

Low Mow Costs

Lifetime	100	years			
	Costs	Units	Variables	Assumptions	Data Source
Mowing	123.25	$	Area, lifetime, wage, mowing work time, mowing equipment, gasoline price, gasoline equipment	Assume mowing occurs once a year.	
Watering	8.21	$	Area, wage, water price, water usage, watering work time, watering equipment		
Seeding	26.10	$	Area, wage, seed price, seed quantity, seeding work time, seeding equipment		
Removal of existing turf	616.22	$	Area, wage, land removal equipment, land removal work time		
Total cost	**773.78**	**$**			

	Number	Units	Notes	Data source
Area	1,000	square feet	1 acre = 43560 square feet	No data source
Lifetime	100	years	Only mowing is annual cost; watering and seeding are initial costs. Based on lifetime estimates for native plants and turf.	GI BMP Brief
Wage	22	$/hour	Wage rate from Hartford Office of Sustainability, based on DPW figures.	Hartford Local 1716 CBA
Mowing work time	0.00005	hours/sq ft	Conservative mowing estimate: one acre per hour for a standard commercial mower.	The Lawn Institute
Mowing equipment	0	$	Assume use of pre-existing equipment (mower).	No data source
Gasoline price	2.65	$/gallon	Average price of diesel in Hartford (3/6/2018).	GasBuddy - Hartford
Gasoline quantity	1	gallons/hr	Assume mower powered by 1 gallon of diesel/hour.	Grass Hopper Mower Fuel Calculator
Water price	0.01	$/gallon	Based on estimate that 15,000 gallons of water costs approximately $150.	Connecticut Water - rates
Water usage	0.62337	gallons/sq ft	27,154 gallons/acre equivalent to one inch of rainfall (US Geological Survey).	USGS - rain estimates
Watering work time	0.00009	hours/sq ft	Assume 4 hours per acre based on mowing work time estimates and assumption that watering may take additional time to provide proper watering of new plants.	No data source
Watering equipment	0	$	Assume use of pre-existing equipment (hoses, sprinklers, watering cans).	No data source
Seed price	10	$/lbs	Based on price of meadow mix seeding.	GI BMP Brief
Seed quantity	0.0025	lbs/sq ft	Based on recommended seeding for low maintenance orchards. Double for lawns.	Prairie Nursery No Mow Fact Sheet
Seeding work time	0.00005	hours/sq ft	Estimate equivalent to mowing work time since both activities require movement across the area at an even pace.	No data source
Seeding equipment	0	$	Assume use of pre-existing equipment (seeding buckets).	No data source
Land removal work time	0.02801	hours/ sq ft	Estimate 1,220.1 hours to remove one acre of lawn.	homewyse Lawn Removal Calculator
Land removal equipment	0	$	Assume use of pre-existing equipment for removal of soil.	No data source

Low Mow Water Management

Lifetime	100	years			
	Value	**Units**	**Variables**	**Assumptions**	**Data Source**
Runoff reduction	279,453.23	gallons	Area, Annual Rainfall		
Avoided treatment cost	41.84	$	Runoff reduction, Water Treatment Cost, Lifetime, Discount rate		
Avoided maintenance cost	17.82	$	Runoff reduction, Stormwater Infrastructure Variable Cost, Lifetime, Discount rate		
Avoided Capital Improvement cost	105.73	$	Runoff reduction, Capital Improvement Cost, Lifetime, Discount rate		
Avoided flood cost		$	Flood probability, flood damage, flood volume		
Total Water Management Benefit	**165.39**	**$**			

	Number	Units	Notes	Data Source
Area	1000	square feet		No data source
Lifetime	100	years		GI BMP Brief
Discount rate	0.04		This can be changed depending on what forecasting is being examined.	EPA Cost Estimation
Curve Number	58.00		Based on curve number for "meadow"	WinTR-55 User Guide
Annual Rainfall	46.16	inches		Basic City Runoff Analysis
Rainfall Growth Rate	0.073	inches/year		UNHSC Extreme Precipitation Trends
Water Treatment Cost	0.000635	$/gallon		Basic City Runoff Analysis
Stormwater Infrastructure Variable Cost	0.000271	$/gallon		Estimated from MDC Budgets 2013-2018
Capital Improvement Cost	0.001604774	$/gallon		Estimated from MDC Capital Improvement Plans 2015-2018
Flood Probability			Not enough available data to estimate. Values can be input depending on location of projects.	No data source
Flood Damage		$	Not enough available data to estimate. Values can be input depending on location of projects.	No data source
Flood Volume		cubic feet	Not enough available data to estimate. Values can be input depending on location of projects.	No data source

Green = Yes/Applicable
Yellow = US Native
Orange = Pest Risk Concern

* See Notes

Size	Common Name	Scientific Name	Height	Spread	Species Characteristics						Eco Benefits			Site Selection Characteristics							
			Mature Size		CT Native (US native in yellow)	Salt Tolerant	Urban Tolerant	Potential Pest Risk	Positive Past Performance	Not Readily Available in the Trade	Stormwater	Heat Island	Air Quality	Residential	Commercial	Full Sun	Part Shade	Can Be Under Wires	Needs Offset	Street Tree	Small pit okay
SMALL	speckled alder	Alnus incana subsp. rugosa	20	var.																	
	Shadbush,serviceberry	Amelanchier canadensis	15	var.																	
	Apple Serviceberry, Hybrid Serviceberry	Amelanchier x grandiflora 'Autumn brilliance'	23	23																	
	American Hornbeam	Carpinus caroliniana	25	25																	
	Eastern Redbud	Cercis canadensis	25	30					*												
	silky dogwood	Cornus amomum	8	8																	
	Flowering Dogwood	Cornus florida	20	20					*												
	Kousa Dogwood	Cornus kousa	25	25					*												
	eastern red cedar	Juniperus virginiana	45	15						*											
	Amur maackia	Maackia amurensis	25	25						*											
	Prarie Crabapple	Malus ioensis	25	25																	
	Sourwood	Oxydendrum arboreum	28	20						*											
	Cherry Plum	Prunus cerasifera	23	20																	
	Purple Leaf Plum	Prunus cerasifera Thunderleaf	20	20																	
	Kwanzan Cherry	Prunus serrulata	63	var.																	
	Japanese/Deciduous Stewartia	Stewartia pseudocamellia	30	30						*											
	Japanese Tree Lilac	Syringa reticulata	25	20																	
	Bald Cypress	Taxodium distichum	60	25																	
	Northern White Cedar	Thuja occidentalis	50	13																	
MEDIUM	Hackberry	Celtis laevigata	45	45																	
	yellowwood	Cladrastis kentukea	40	50																	
	Hardy rubber tree	Eucommia ulmoides	50	50																	
	honey locust	Gleditsia triacanthos	50	50																	
	Black gum, tupelo	Nyssa sylvatica	40	25																	
	eastern hophornbeam	Ostrya virginiana	35	30																	
	Amur corktree	Phellodendron amurense	40	40																	
	Eastern White Pine	Pinus strobus	65	30																	
	fastigiate oak	Quercus robur f. fastigiata	55	15												*					
	pagoda tree	Styphnolobium japonicum	60	60																	
LARGE	European hornbeam	Carpinus betulus	50	40																	
	Pignut hickory	Carya glabra	55	30																	
	Shagbark Hickory	Carya ovata	70	35																	
	Mockernut hickory	Carya tomentosa	55	25																	
	Turkish hazelnut (filbert)	Corylus colurna	45	25																	
	ginkgo	Ginkgo biloba	65	var.																	
	coffee tree	Gymnocladus dioicus	70	45						*											
	Larch, Tamarack	Larix laricina	60	25																	
	sweet gum	Liquidambar styraciflua	70	45																	
	tuliptree	Liriodendron tulipifera	80	45																	
	cucumber tree magnolia	Magnolia acuminata	65	65						*											
	bigleaf magnolia	Magnolia macrophylla	15	15																	
	umbrella magnolia	Magnolia tripetala	25	25																	
	Dawn Redwood	Metasequoia glyptostroboides	85	25																	
	Yoshino Cherry	Prunus yedoensis	45	45																	
	white oak	Quercus alba	70	70					*							*					
	swamp white oak	Quercus bicolor	55	55					*							*					
	scarlet oak	Quercus coccinea	70	45					*							*					
	shingle oak	Quercus imbricaria	55	55						*											
	Overcup Oak	Quercus lyrata	50	50						*											
	bur oak	Quercus macrocarpa	75	75																	
	pin oak	Quercus palustris	65	35																	
	willow oak	Quercus phellos	50	35						*											
	chestnut oak	Quercus prinus	65	65					*	*						*					
	English Oak	Quercus robur	50	50						*											
	red oak	Quercus rubra	70	70					*	*						*					
	Shumard oak	Quercus shumardii	50	50						*											
	American linden	Tilia americana	70	30																	
	littleleaf linden	Tilia cordata	65	40																	
	silver linden	Tilia tomentosa	60	35																	
	Japanese zelkova	Zelkova serrata	70	70																	

Species Susceptible to Asian Longhorn Beetle- Plant with caution

Green = Yes/Applicable
Yellow = US Native
Orange = Pest Risk Concern

* See Notes

Size	Common Name	Scientific Name	Height	Spread	Species Characteristics						Eco Benefits			Site Selection Characteristics							
			Mature Size		CT Native (US native in yellow)	Salt Tolerant	Urban Tolerant	Potential Pest Risk	Positive Past Performance	Not Readily Available in the Trade	Stormwater	Heat Island	Air Quality	Residential	Commercial	Full Sun	Part Shade	Can Be Under Wires	Needs Offset	Street Tree	Small pit okay
SMALL	Paperbark Maple	Acer griseum	25	25				ALB													
MEDIUM	trident maple	Acer buergerianum	30	20				ALB		*											
	hedge maple	Acer campestre	30	30				ALB		*											
	red horsechestnut	Aesculus x carnea	35	35				ALB		*											
	river birch	Betula nigra	55	50				ALB	*	*											
	black willow	Salix nigra	45	45				ALB													
	lacebark elm	Ulmus parvifolia	45	45				ALB		*											
	Goldenrain tree	Koelreuteria paniculata	35	35				ALB													
LARGE	yellow buckeye	Aesculus flava	70	40				ALB													
	horse chestnut	Aesculus hippocastanum	65	var.				ALB	*	*											
	Katsuratree	Cercidiphyllum japonicum	50	50				ALB													
	London planetree	Platanus hybrida	85	75				ALB													
	eastern cottonwood	Populus deltoides	90	65				ALB		*											
	American elm	Ulmus americana	70	40				ALB	*												
	slippery elm	Ulmus rubra	50	40				ALB													
	common hackberry	Celtis occidentalis	50	50				ALB		*											
	American sycamore	Platanus occidentalis	85	85				ALB													

Sources

1. Urban Tree Canopy Assessment & Planting Plan - Hartford, CT by Davey Resource Group. This is the source of ecosystem benefit indicators. - http://www.americanforests.org/wp-content/uploads/2015/04/AF-Community-ReLeaf-%E2%80%94-Hartford-UTC-Assessment.pdf
2. City of Hartford Zoning Code section 6.0, page 201. This is the source of the "size" labels - http://www.hartford.gov/images/DDS_Files/Plan_Zoning/Zoning_Regs/Zoning_Regulations_032817_LR.pdf
3. Connecticut Stormwater Quality Manual plant list - http://www.ct.gov/deep/cwp/view.asp?a=2721&q=325704&deepNav_GID=1654#chapter (Salt tolerant/Native)
4. UConn College of Agriculture, Health and Natural Resources Plant Database. This is another source of the Salt and Urban Tolerant and Native characteristics -http://hort.uconn.edu/search
5. iTree Species. This is the major source of the ecosystem benefit indicators and the hardiness zone. iTree species can provide the Top 10% of species suitable for for streamflow reduction, overall pollutant removal, or UV radiation reduction. Though the terminology may be different, these functions can correspond with the intent of the stormwater, UHI, and air quality columns. *indicates uncertainty on hardiness zone (Hartford is 6) - https://species.itreetools.org/
6. Common Previously Planted' species refers to the species most commonly planted in Hartford's streets and parks during 2012-2017. This information along with that of Street Tree suitability is from DPW's Forestry Division.
7. Tree Site Types Characteristics were pulled from URI's Site Types graphic.
8. Tree height and spread data is derived from Dirr's Encyclopedia of Trees & Shrubs
9. Where height and spread were not found in Dirr's Encyclopedia, Morton Arboretum was used. Morton Arboretum was also used to fill in some blanks for soil salt/salt spray, residential/utility line siting, and pest/disease issues. http://www.mortonarb.org/trees-plants/tree-and-plant-selection
10. The USDA/USFS/UVM report on ALB host trees was also used as a reference to determine ALB-susceptible species (http://www.nyis.info/user_uploads/files/alb-and-host-trees-09-12-2012.pdf). UVM has an annotated list of ALB host trees based on recorded ALB reports. While Tilia, Malus, Quercus, and Alnus genera are not listed in this report as hosts, there have been reports of ALB in these trees, making these "questionable" ALB hosts. Notes on this questionable risk have been added, but these genera will not be specifically marked for ALB risk for the purposes of this list. http://www.uvm.edu/albeetle/hosts.htm
11. "Not Readily Available in the Trade" refers to tree species that are not commonly available at nurseries. This information as well as past permonace notes are courtesy of the tree planting partner KNOX's efforts.

Other Notes

Genera information (like Crataegus spp. and Magnolis spp.) is highly variable as species within specific genus can have very different characteristics. Individual species should be researched instead of accepting ecological benefits and species characteristics wholesale from this chart. There were also instances where specific characteristic information (like eco benefits) for some species were not found in the corresponding databases/sources above. These unknowns are listed in a separate document. Request for more information.

Hartford Tree Recommendations - DRAFT - May 2017

	Tree Species		Other Characteristics		Source									Notes
Size	Scientific Name	Common Name	Hardiness Zone	Possible Pest Risks	Davey	Zoning code	CTSW	iTree	UConn	Dirr's	Morton	URI	USFS	
SMALL	Alnus incana subsp. rugosa	speckled alder	3 ~ 6	Alder aphids, Japanese beetles, and leaf miners			X			X	X			
	Amelanchier canadensis	Shadbush,serviceberry	3 ~7(8)*				X		X	X	X			Hardiness zone information from Dirr's Encyclopedia, not iTree
	Amelanchier spp.	Shadbush, serviceberry	5 ~ 8*			X		X	X	X		X		Amelanchier laevis (Allegheny Serviceberry) is a specific US native species. Shadblow Serviceberry/Thicket Serviceberry (Amelanchier canadensis) is a specific salt tolerant species. iTree notes that there is moderate uncertainty concerning the hardiness zone.
	Amelanchier x grandiflora 'Autumn brilliance'	Apple or Hybrid Serviceberry	4(5) ~ 8(9)*							X	X			Hardiness zone information from Dirr's Encyclopedia, not iTree.
	Carpinus caroliniana	American Hornbeam	3 ~ 9*			X			X	X	X	X		Hardiness zone information from Dirr's Encyclopedia, not iTree.
	Cercis canadensis	Eastern Redbud	4 ~ 9*	Borers		X			X	X	X	X		This species must be planted at a wet site. Hardiness zone information from Dirr's Encyclopedia, not iTree. Good for residential planting, not for tree lawns
	Cornus amomum	silky dogwood	4 ~ 8*				X		X	X	X			Hardiness zone information from Dirr's Encyclopedia, not iTree. Grows more like a shrub.
	Cornus florida	Flowering Dogwood	5 ~ 9			X	X	X	X	X	X	X		Previously planted varieties include 'cher. brave.' This species must be planted ata wet site. Good for residential planting not for tree lawns
	Cornus kousa	Kousa Dogwood	(4)5 ~ 8*	Borers		X			X	X	X			Previously planted varieties include 'Milky Way.' Hardiness zone information from Dirr's Encyclopedia, not iTree. Good for residential planting not for tree lawns
	Cornus spp.	Dogwood	5 ~ 8*			X*		X	X	X		X		These species must be planted at a wet site. Tatarian Dogwood (Cornus alba), Kousa Dogwood (Cornus kousa), Cornelian Cherry Dogwood (Cornus mas), Gray Dogwood (Cornus racemose), Stellar Series Dogwood (Cornus Rutgers Hybrids), and Redosier Dogwood (Cornus sericea) are urban tolerant. Only Flowering dogwood and Kousa dogwood are in the zoning code. Cornus florida, Cornus kousa, Cornus florida cher. Brave, Cornus kousa ‘Milky way’ are common previously planted species. Moderate uncertainty to hardiness zone. Some species can be planted as street trees, but not Cornus florida. Good for residential planting not for tree lawns.
	Juniperus virginiana	eastern red cedar	4 ~ 9	Cedar rusts (cedar-apple, cedar-hawthorn and cedar-quince) and bagworm are common.			X	X	X	X	X			Purchase Availability: Order before March
	Maackia amurensis	Amur maackia	4 ~ 7*			X			X	X	X	X		Hardiness zone information from Dirr's Encyclopedia, not iTree. Rare
	Malus ioensis	Prairie Crabapple	4 ~ 8	Gypsy Moth, Winter Month				X			X			Height and spread from Morton Arboretum, not Dirr's Encyclopedia.
	Malus spp.	Crabapple	6*	Many species are vulnerable to Gypsy moth and/or Winter moth		X		X	X	X	X	X	.	Japanese Flowering Crabapple (Malus floribunda), Tea Crabapple (Malus hupehensis), Hybrid Crabapple (Malus hybrids), Sargent Crabapple (Malus sargentii), and Flowering Crabapple (Malus x zumi) are urban tolerant. Prairie crabapple (Malus ioensis) is a common previously planted species. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6. Height from Morton Arboretum, not Dirr's Encyclopedia.
	Oxydendrum arboreum	Sourwood	5 ~ 8			X		X	X	X	X			Slow growing, expensive, and not readily available
	Prunus cerasifera	Cherry Plum	6 ~ 8			X		X	X	X		X		***
	Prunus cerasifera Thunderleaf	Purple Leaf Plum				X			X	X		X		
	Prunus serrulata	Kwanzan Cherry	6 ~ 8					X	X	X	X			Previously planted varieties include 'Kwanzan' and 'Snowgoose.'
	Prunus spp.	Stone Fruit Trees	6*	A number of species (but not all) are vulnerable to Gypsy moth or Winter moth		X		X	X	X				American Plum (Prunus americana), Schip Laurel/Cherry laurel (Prunus laurocerasus 'Schipkaensis'), Beach Plum (Prunus maritima), Purpleleaf Sand Cherry (Prunus x cistena) are the salt tolerant species. Kwanzan Flowering Cherry (Prunus serrulata), Higan Cherry (Prunus subhirtella 'Pendula'), Purpleleaf Sand Cherry (Prunus x cistena) are urban tolerant species. Black Cherry (Prunus Serotina) has air pollutant removal benefits. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Prunus spp. -Cherry Species-	Cherry	6*	Some species are vulnerable to Winter moth				X	X	X		X		Black Cherry (Prunus serotina) has UV radiation Reduction/UHI and air quality benefits. Kwanzan Flowering Cherry (Prunus serrulata), Higan Cherry (Prunus subhirtella 'Pendula'), and Purpleleaf Sand Cherry (Prunus x cistena) are urban tolerant. Schip Laurel/Cherry laurel (Prunus laurocerasus 'Schipkaensis') and Purpleleaf Sand Cherry (Prunus x cisterna) are salt tolerant. Prunus yedoensis, Prunus serrulata, Prunus serrulata ‘snowgoose,’and Prunus ‘kwanzan’ are common previously planted species. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Stewartia pseudocamellia	Japanese/Deciduous Stewartia	4(5) ~ 7*			X			X	X		X		This species needs to be planted at a wet site. It is slow growing, very expensive, and not readily available
	Syringa reticulata	Japanese Tree Lilac	3 ~ 7*			X			X	X	X	X		Hardiness zone information from Dirr's Encyclopedia, not iTree.
	Taxodium distichum	Bald Cypress	4 ~ 10					X	X	X	X			
	Thuja occidentalis	Northern White Cedar	3 ~ 7					X	X	X	X			Previously planted varieties include 'Emerald.'
MEDIUM	Celtis laevigata	Hackberry	5 ~ 10			X		X	X	X		X		
	Cladrastis kentukea	yellowwood	5 ~ 8*			X		X	X	X	X			
	Crataegus spp.	Hawthorne	6*	Gypsy Moth, Winter Moth		X	X	X	X	X		X		Previously planted species include Green Hawthorn (Crataegus viridis). Washington Hawthorn (Crataegus phaenopyrum) and Green Hawthorn (Crataegus viridis) are the two species that are urban tolerant. Cockspur Hawthorn (Crataegus crusgalli) and Singleseed Hawthorn (Crataegus monogyna) are two salt tolerant species. Many crataegus species are susceptible to the pest 'Gypsy Moth,' and a handful are vulnerable to 'Winter Moth.' While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Eucommia ulmoides	Hardy rubber tree	5 ~ 7			X		X	X	X		X		
	Gleditsia triacanthos	honey locust	4 ~ 8			X	X	X	X	X		X		Previously planted varieties include 'Shademaster' and 'Skyline.' This species tolerates wet site conditions and some salting.
	Nyssa sylvatica	Black gum, tupelo	5 ~ 9			X	X	X	X	X		X		This species must be planted at a wet site.
	Ostrya virginiana	eastern hophornbeam	4 ~ 9	Gypsy Moth	X	X		X	X	X		X		
	Phellodendron amurense	Amur corktree	4 ~ 8		X			X	X	X	X			
	Pinus strobus	Eastern White Pine	4 ~ 7	Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle, White Pine Blister Rust			X	X	X	X	X			
	Quercus robur f. fastigiata	fastigiate oak				X			X	X				Susceptible to mildew
	Styphnolobium japonicum	pagoda tree	4 ~ 7			X		X	X	X		X		AKA Sophora japonica. This species tolerates some salting.
LARGE	Carpinus betulus	European hornbeam	5 ~ 7		X	X		X	X	X		X		ZC lists as medium; Previously planted varieties include 'Fastigiata.' This species has a narrow canopy.
	Carya glabra	Pignut hickory	5 ~ 9					X	X	X	X		.	Do not plant near driveways or roads.
	Carya ovata	Shagbark Hickory	4 ~ 9					X	X	X	X			
	Carya spp.	Hickory	5 ~ 9*				X	X	X	X			.	Moderate uncertainty to hardiness zone. Carya ovata is a common previously planted species. Do not plant near driveways or roads.
	Carya tomentosa	Mockernut hickory	5 ~ 9*					X	X		X			Moderate uncertainty to hardiness zone. Height and spread from Morton Arboretum, not Dirr's Encyclopedia. Do not plant near driveways or roads.
	Corylus colurna	Turkish hazelnut (filbert)	5 ~ 7		X			X	X	X		X		ZC lists as a medium-sized species. This species has a narrow canopy.
	Ginkgo biloba	ginkgo	4 ~ 8			X		X	X	X		X		This species tolerates some salting and has a narrow canopy.
	Gymnocladus dioicus	coffee tree	4 ~ 8*			X		X	X	X		X		Purchase Availability: Not rare, but also not common
	Larix laricina	Larch, Tamarack	1 ~ 4(5)*	Larch case-bearer, larch sawfly			X		X	X				Hardiness zone information from Dirr's Encyclopedia, not iTree
	Liquidambar styraciflua	sweet gum	6 ~ 9	Gypsy Moth		X		X	X	X	X			
	Liriodendron spp.	Tuliptree	5 ~ 9*					X	X	X		X		There are two species in this genus: tulipifera and chinense. Both have stormwater and air quality benefits. The hardiness zone for both species is the same, but there is moderate uncertainty concerning the chinense. The Chinense is not on UConn Horticulture's database, so there is no salt or urban tolerance information for that species.
	Liriodendron tulipifera	tuliptree	5 ~ 9		X	X		X	X	X	X			
	Magnolia acuminata	cucumber tree magnolia	4 ~ 8		X	X		X	X	X	X			Previously planted varieties include 'Magnolia Butterflies,' a hybrid between M. acuminata x M. denudata. The hybrid is commonly available for purchase in the trade.
	Magnolia macrophylla	bigleaf magnolia	5 ~ 8		X	X		X		X				
	Magnolia spp.	Magnolia	6*		X	X		X	X	X	X			Southern Magnolia/Bull Bay (Magnolia grandiflora) is the specific species that is salt-tolerant. The Cucumber tree magnolia (Magnolia acuminata) provides stormwater and air quality benefits. Bigleaf magnolia (Magnolia macrophylla) and umbrella magnolia (Magnolia tripetala) both provide stormwater benefits. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Magnolia tripetala	umbrella magnolia	5 ~ 8		X	X		X	X	X	X			
	Metasequoia glyptostroboides	Dawn Redwood	5 ~ 8					X	X	X	X			
	Prunus yedoensis	Yoshino Cherry	6 ~ 8					X	X	X				
	Quercus alba	white oak	4 ~ 9	Gypsy Moth, Oak Wilt, Winter Moth	X	X	X	X	X	X		X		
	Quercus bicolor	swamp white oak	4 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth		X	X	X	X	X		X		
	Quercus coccinea	scarlet oak	4 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth		X		X	X	X		X		
	Quercus imbricaria	shingle oak	4 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth		X		X	X	X		X		Purchase Availability: Common, but only sold in small quantities
	Quercus lyrata	Overcup Oak	6 ~ 9	Gypsy Moth, Oak Wilt, Winter Moth				X		X				Purchase Availability: Common, but only sold in small quantities
	Quercus macrocarpa	bur oak	3 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth	X	X		X	X	X		X		
	Quercus palustris	pin oak	4 ~ 8	Gypsy Moth, Oak Wilt, Sudden Oak Death, Winter Moth		X	X	X	X	X		X		This species tolerates wet site conditions.
	Quercus phellos	willow oak	5 ~ 9	Gypsy Moth, Oak Wilt, Winter Moth		X		X	X	X		X		Purchase Availability: Order early on in the year
	Quercus prinus	chestnut oak	4 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth		X		X	X	X		X		Purchase Availability: Common, but only sold in small quantities
	Quercus robur	English Oak	5 ~ 8	Gypsy Moth, Oak Wilt, Polyphagous Shot Hole Borer		X		X	X	X		X		Purchase Availability: Common, but only sold in small quantities
	Quercus rubra	red oak	4 ~ 8	Gypsy Moth, Oak Wilt, Sudden Oak Death, Winter Moth		X	X	X	X	X		X		This species tolerates some salting. Purchase Availability: Common, but only sold in small quantities
	Quercus shumardii	Shumard oak	6 ~ 9	Gypsy Moth, Oak Wilt, Winter Moth	X			X	X	X		X		This species tolerates some salting. Purchase Availability: Common, but only sold in small quantities
	Tilia americana	American linden	4 ~ 9	Gypsy Moth, Winter Moth	X	X		X	X	X		X		
	Tilia cordata	littleleaf linden	4 ~ 7	Gypsy Moth	X	X		X	X	X		X		
	Tilia spp.	Linden	6*	Many species are vulnerable to Gypsy moth; Tilia Americana is also at risk from Winter moth	X	X		X	X	X				The little leaf linden (Tilia Cordata), Silver linden (tilia tomentosa), and American Linden (Tilia Americana) provide both stormwater and air quality benefits. Bigleaf Linden (Tilia platyphyllos) provides stormwater and UHI benefits. Littleleaf Linden (Tilia cordata), Silver Linden (Tilia tomentosa), and Crimean Linden (Tilia x euchlora) are urban tolerant. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Tilia tomentosa	silver linden	5 ~ 7	Gypsy Moth	X	X		X	X	X		X		
	Zelkova serrata	Japanese zelkova	5 ~ 8		X	X		X	X	X	X			

Species Susceptible to Asian Longhorn Beetle- Plant with caution

					Source									
Size	Scientific Name	Common Name	Hardiness Zone	Possible Pest Risks	Davey	Zoning code	CTSW	iTree	UConn	Dirr's	Morton	URI	USFS	Notes
Small	Acer griseum	Paperbark Maple	4 ~ 7	Asian Longhorned Beetle		X		X	X	X	X		X	Expensive
medi	Acer buergerianum	trident maple	5 ~ 9	Asian Longhorned Beetle		X		X	X	X		X	X	This species has a narrow canopy. Purchase Availability: Order early on in the year
medi	Acer campestre	hedge maple	5 ~ 8	Asian Longhorned Beetle		X		X	X	X		X	X	Purchase Availability: Order early on in the year
medi	Aesculus x carnea	red horsechestnut	5 ~ 7	Asian Longhorned Beetle	X			X	X	X	X		X	Purchase Availability: Order early on in the year
medi	Betula nigra	river birch	4 ~ 9	Asian Longhorned Beetle, Gypsy Moth, Large Aspen Tortrix, Winter Moth	X		X	X	X	X			X	The multistem variety is readily available and has performed well in Hartford. The single stem version is less common.
medi	Koelreuteria paniculata	Goldenrain tree	6 ~ 8	Potential Host of Asian Longhorned Beetle		X		X	X	X		X	X	
medi	Salix nigra	black willow	4 ~ 8	Asian Longhorned Beetle, Aspen Leafminer, Gypsy Moth, Large Aspen Tortrix, Winter Moth			X	X		X	X		X	Purchase Availability: Order early on in the year
medi	Ulmus parvifolia	lacebark elm	6 ~ 10	Asian Longhorned Beetle, Gypsy Moth		X		X	X	X		X	X	This species has a narrow canopy and tolerates wet site conditions.
large	Aesculus flava	yellow buckeye	4 ~ 8	Asian Longhorned Beetle	X			X	X	X	X		X	
large	Aesculus hippocastanum	horse chestnut	4 ~ 7	Asian Longhorned Beetle		X		X	X	X		X	X	Purchase Availability: Common, but only sold in small quantities. Vulnerable to vandalism in Hartford.
large	Celtis occidentalis	common hackberry	3 ~ 9	Potential Host of Asian Longhorned Beetle	X		X	X	X	X	X		X	Purchase Availability: Order early on in the year
large	Cercidiphyllum japonicum	Katsuratree	5 ~ 8	Asian Longhorned Beetle	X	X		X	X	X	X		X	
large	Platanus hybrida	London planetree	5 ~ 8*	Asian Longhorned Beetle	X	X		X	X	X			X	AKA Platanus x acerifolia
large	Platanus occidentalis	American sycamore	5 ~ 9	Potential Host of Asian Longhorned Beetle	X		X	X	X	X	X		X	
large	Populus deltoides	eastern cottonwood	3 ~ 9	Asian Longhorned Beetle, Winter Moth			X	X	X	X	X		X	Rare
large	Ulmus americana	American elm	3 ~ 9	Asian Longhorned Beetle, Dutch Elm Disease, Winter Moth		X		X	X	X		X	X	Previously planted varieties include 'Valley Forge' and 'Princeton,' which have done well in Hartford in the past. This species tolerates wet site conditions.
large	Ulmus rubra	slippery elm	4 ~ 9*	Asian Longhorned Beetle, Dutch Elm Disease, Winter Moth			X	X		X	X		X	

CLIMATE STEWARDSHIP INITIATIVE AND GREEN INFRASTRUCTURE

City of Hartford
Office of Sustainability

TODAY'S PRESENTATION

Climate Stewardship Initiative

- Climate Action Plan: What we do, and how
- Working Together: Our Team and Stakeholders

Background

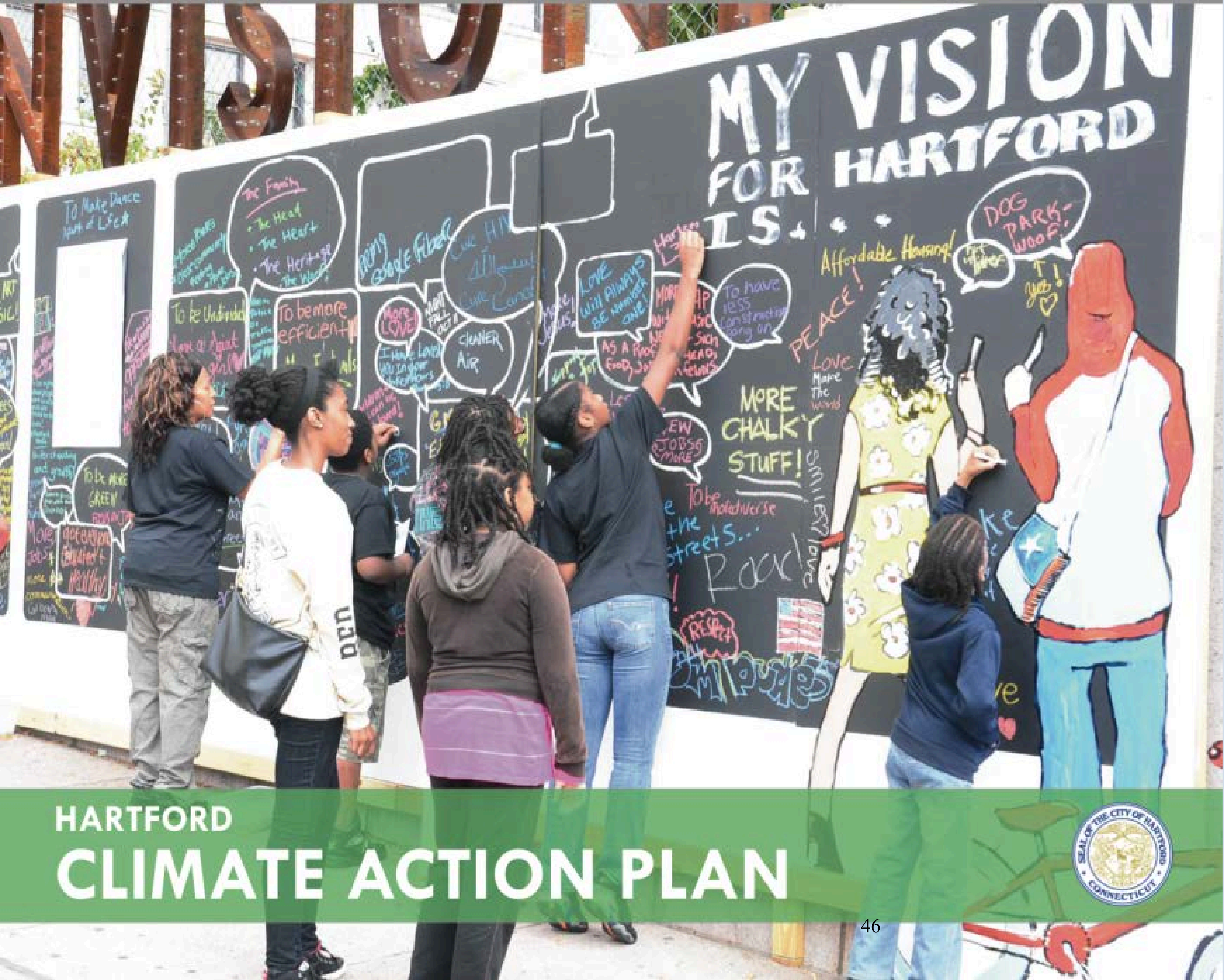
- Climate Change
- Context in Hartford
- What is Green Infrastructure?

Our Approach

- Research
- Policy
- Community Action
- Next Steps

CLIMATE STEWARDSHIP INITIATIVE

Hartford Climate Action Plan
Adopted January 2018



Environmental Work as a Catalyst for…

Increased Economic Development

Public Health Improvements

Social Equity

VISION SUMMARY

We have developed an overall statement of our shared vision for each of the 6 action areas. This language will be repeated on the first page of each section for the 6 action areas.

ENERGY

Cleaner, cheaper, and more reliable energy that reduces the likelihood of power outages during storms, creates green jobs, reduces fossil fuel dependence, and cuts energy costs for all.

FOOD

Nutritious food that is locally grown or non-carbon-intensive, and is readily available across all neighborhoods, leading to improved health and greater resiliency for area families.

LANDSCAPE

Private and public landscapes filled with trees and meadows that together mitigate the effect of high heat days and flooding, provide ecosystem services, offer recreation, and clean our air.

TRANSPORTATION

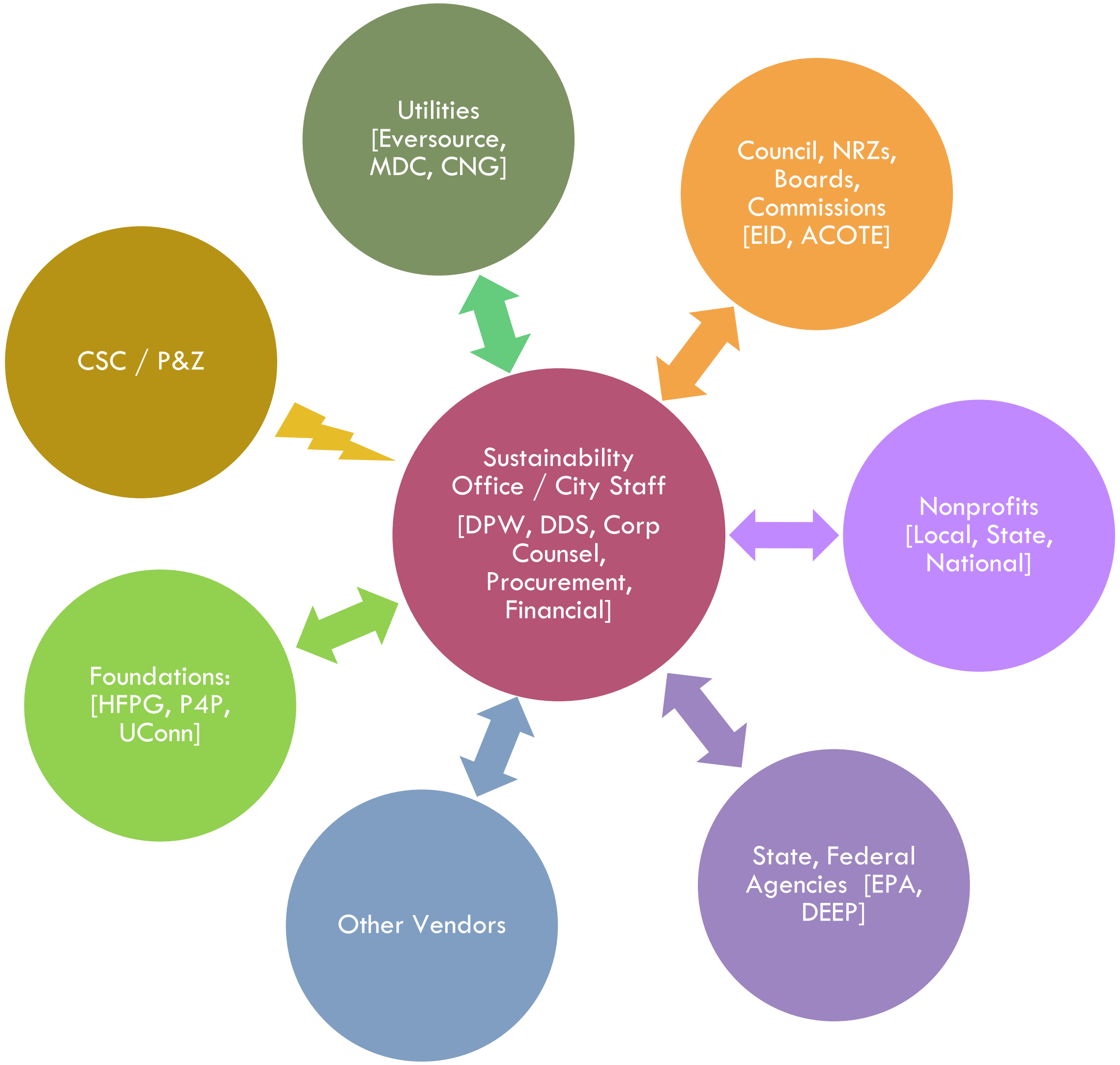
A multi-modal, affordable transportation network with safe biking and walking options and fewer vehicle-related emissions, which improves air quality and cuts asthma rates.

WASTE

Eradication of the worst trash and blight, and public education that boosts diversion, recycling and reuse rates—which in turn cuts costs, related emissions, and environmental degradation.

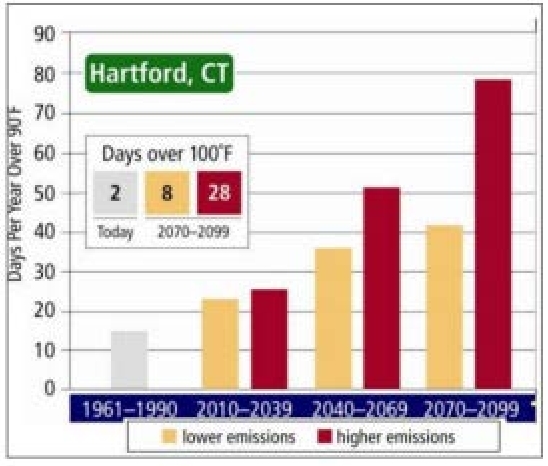
WATER

More efficient use of potable water, better protection against floods and droughts, and waterways made cleaner through green infrastructure that reduces and cleans stormwater runoff.


Utilities [Eversource, MDC, CNG]
Council, NRZs, Boards, Commissions [EID, ACOTE]
CSC / P&Z
Sustainability Office / City Staff
[DPW, DDS, Corp Counsel, Procurement, Financial]
Nonprofits [Local, State, National]
Foundations: [HFPG, P4P, UConn]
Other Vendors
State, Federal Agencies [EPA, DEEP]

IMPACTS OF CHANGING CLIMATE

In CT, "Flooding is likely to be worse during winter and spring, and droughts worse during summer and fall." ~EPA, 2016



Above: The Hartford Fire Department at a cooling tent during a high-heat day. Chart from Frumhoff et al., Northeast Climate Impacts (2007).

IMPACTS OF CLIMATE ON TREES


Decayed Oak (Goodwin Park)


Oak failure due to drought (North End)

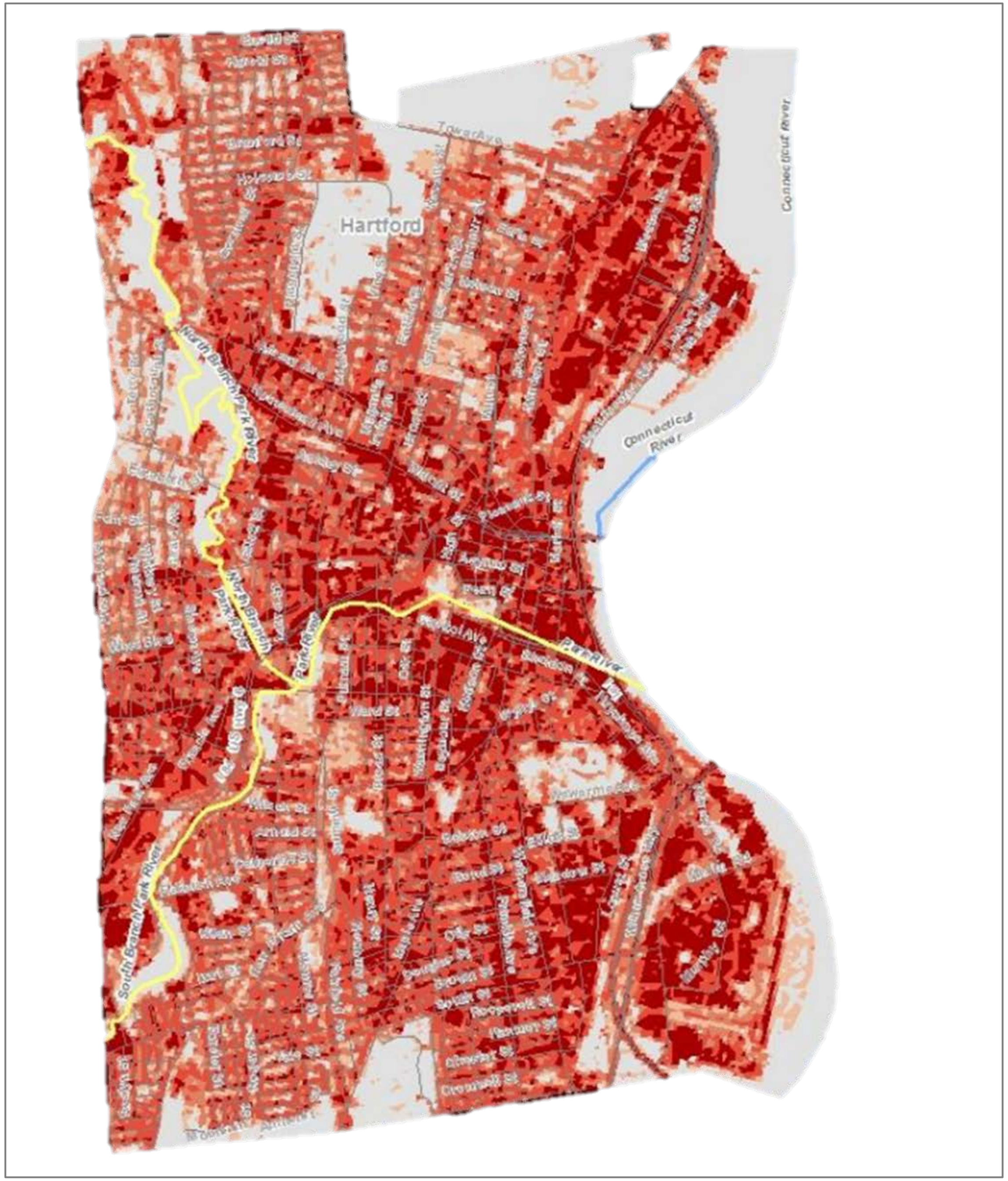

Tree structurally weakened from drought, failed by heavy snow/wind (Simpson St.)


Norway Maple blown over by a recent nor'easter (Sterling St.)


Failing Sugar Maple (Old North Cemetery)

HARTFORD'S IMPERVIOUS COVER

- Degradation of water quality when IC ≥12%
- Impervious Cover over 12%: 80%
- Total Impervious Area Citywide: ~5,000 acres
- More Impervious Area → More stormwater runoff *and* increased Urban Heat Island Effect



Sources: CT DEEP; UConn CLEAR; Hartford
Map from CT DEEP

NEGATIVE IMPACTS OF STORMWATER

- Increased frequency and risk of localized flooding
- 50 Combined Sewer Overflow (CSO) events every year
- CSO: stormwater/sewage discharge into local water bodies
- 76 Sewer Backups from Jan 2009 to July 2012
- 90% of the pollutant load is within the first inch of rain

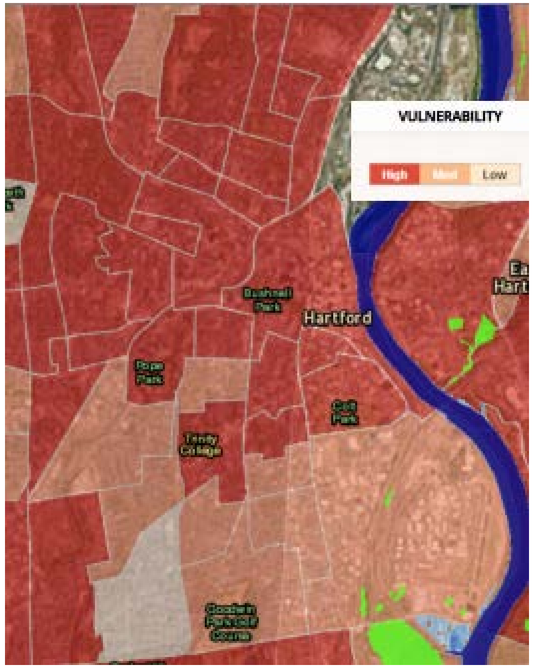

CSO into a neighborhood stream


Flooding on New Park Avenue in Hartford


Cleaning after a sewer backup


Localized flooding in Hartford

Sources: MDC; CT DEEP; EPA; Photo Sources starting clockwise from the top left corner: Green Cities, Blue Waters; WFSB; RestorationEze; Hartford Patch (Tim Jensen)

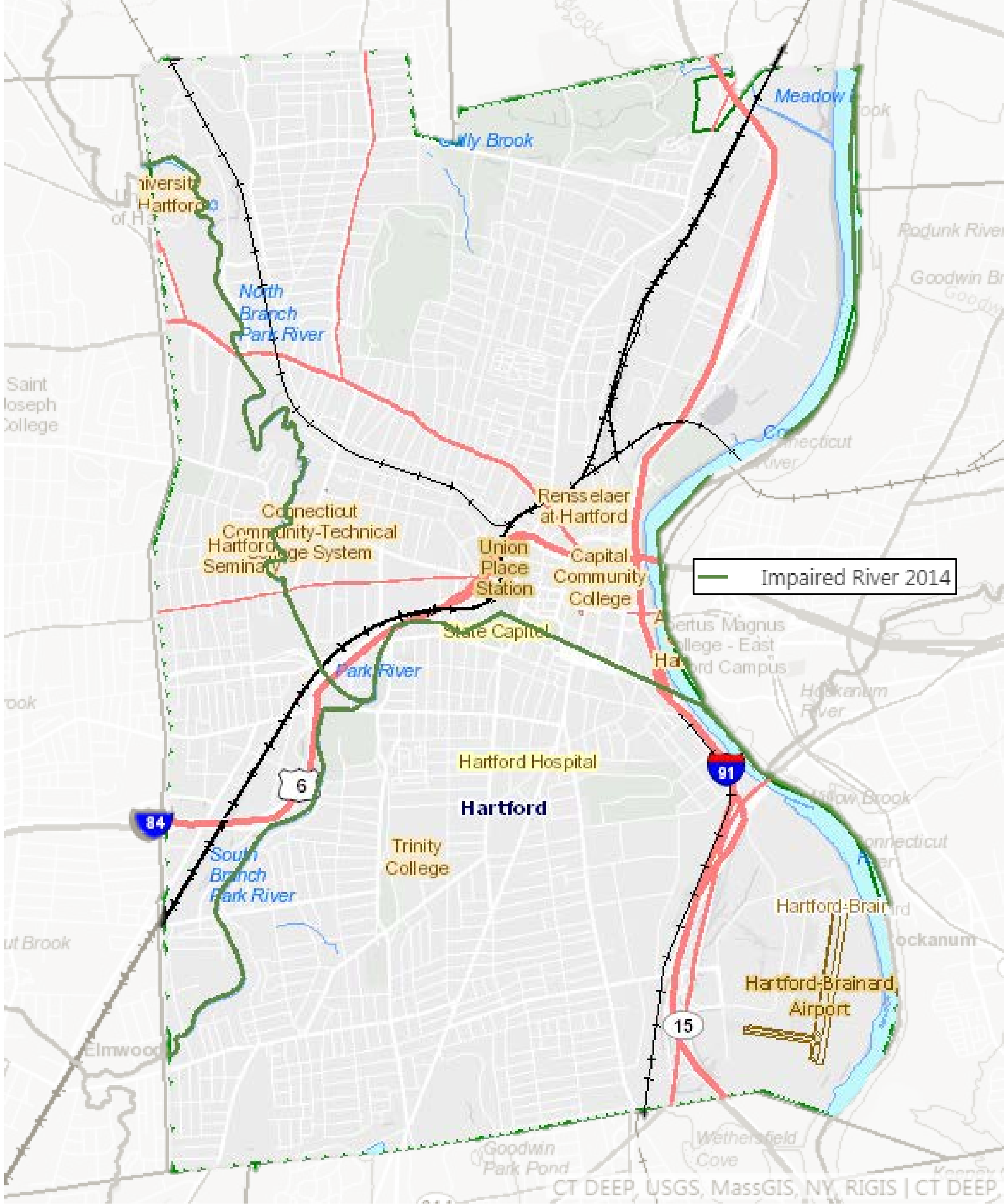


Map from the National Oceanic and Atmospheric Administration "Sea Level Rise Viewer"

Historic River Surges @ Bulkeley Bridge

IMPAIRED WATER BODIES

- The following receiving waterbodies are on the state 303(d) list:
  - Connecticut River
  - Park River
  - North Branch Park River
  - South Branch Park River
- Other impaired water bodies:
  - Folly Brook
  - Kane Brook
  - Wethersfield Cove
- All are affected by CSOs/bacteria



Source: MDC; Map: UConn CT ECO

SOLUTION: GREEN INFRASTRUCTURE

- “Green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits” – EPA
- Benefits:
  - Groundwater Recharge
  - Runoff Capture
    - Fewer sewer overflows
    - Less erosion
    - Reduced severity of flooding
  - Improved Water Quality
  - Improved Air Quality
  - Reduced Urban Heat Island Effect
  - Public Green Space

Bushnell Park North Promenade

Sources: EPA; MDC; Photo: Suisman Urban Design

TYPES OF LID/GI

Connecticut Science Center Green Roof

Bioswale at UConn Law

Urban Tree Canopy – Bushnell Park

Rain Garden at Keney Park

Permeable Pavement (asphalt) at the Capitol

URBAN TREE CANOPY, HARTFORD'S MOST VALUABLE GREEN INFRASTRUCTURE

Stormwater Runoff

PROBLEMS:

- ½ billion gallons of sewage-stormwater mix in local waters
- 50 Combined Sewer Overflows (CSO) a year (¼" of rain trigger)

Hartford's trees:

Intercept 590 million gallons of rain ($4.7 million in runoff reduction services)

Urban Heat Island

PROBLEMS:

- Urban areas can be 22°F warmer than less paved areas
- Hartford's extended heat event deaths will increase from 27 to 40 deaths in 2055 (+48%)

Hartford's trees:

Provide shade and evapotranspiration (respectively cooling by 20-45°F and 2–9°F).

Air Quality

PROBLEMS:

- Highest Asthma Emergency Department Visit Rates in CT
- $16.9 million in asthma hospital costs (2014)

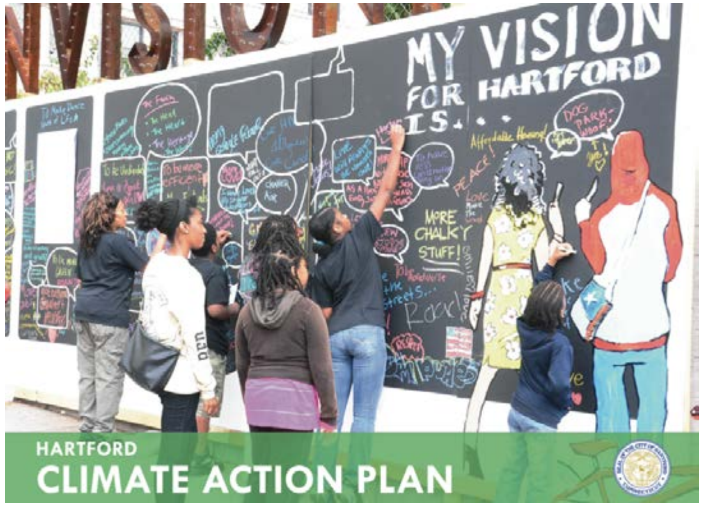
Hartford's trees:

Capture pollutants such as particulate matter (a major asthma trigger). Annually, they removed 15,190 lbs of PM.

Sources: Clean Water Project, American Forests, NRDC, DEEP

GREEN INFRASTRUCTURE AND THE CLIMATE ACTION PLAN

- Hartford's Climate Stewardship Council approved a Climate Action Plan committed to climate resilience
  - Green infrastructure is a way to mitigate landscape and water concerns



GOAL 1: Reduce Discharge Into Sewers and Waterways

PUBLIC HEALTH | ECONOMIC DEVELOPMENT | SOCIAL EQUITY

To have a healthy city, we must have clean waterways. Unfortunately, Hartford has a combined sewer system, which collects and conveys sewage, industrial wastewater, and rainwater runoff in one pipe for treatment and discharge into the Connecticut River. During times of heavy rainfall, this system overflows and discharges untreated water into the River. The Park River alone sees 2,000 gallons of raw sewage annually.

To reduce pollution in our waterways, we must divert stormwater, so that we do not have overflow events. One excellent strategy is "green infrastructure," which is a natural approach to stormwater management that helps to filter and divert runoff before it enters the sewer system. Green infrastructure integrates vegetation and soils in architecture and landscaping. Examples of green infrastructure in the city include the green roof at the Connecticut Science Center, bioswales along the Connecticut River and at the UConn Law School campus, and permeable asphalt around the State Capitol building.

The City already promotes green infrastructure, through a dedicated team in the Mayor's office, support from the EPA, and new zoning regulations. But more can be done.

A "Green and Complete Streets" workshop, sponsored by the EPA in 2017, convened stakeholders from local, state, and federal governments, nonprofits, and the MDC.

#	STRATEGY	TYPE	PURPOSE
a	Inventory Potential for Green Infrastructure to Capture Runoff	Inventory/Assess	Assess how much runoff can be captured citywide.
b	Develop Green Infrastructure Specifications	Policy/Code	Create guidelines for public and private parties to use to develop green infrastructure.
c	Evaluate and Pursue Stable, Innovative Funding for Green Infrastructure	Incentive	Promote green infrastructure financing.
d	Support Separation of Combined Sewer System	Partnership/Advocacy	Reduce the frequency of combined sewage overflow events.
e	Advocate for Green Infrastructure to be Incorporated into Long Term Control Plan	Partnership/Advocacy	Ensure green infrastructure is considered as a strategy by State in managing runoff close to source.

Source: Hartford Climate Stewardship Council

APPROACH

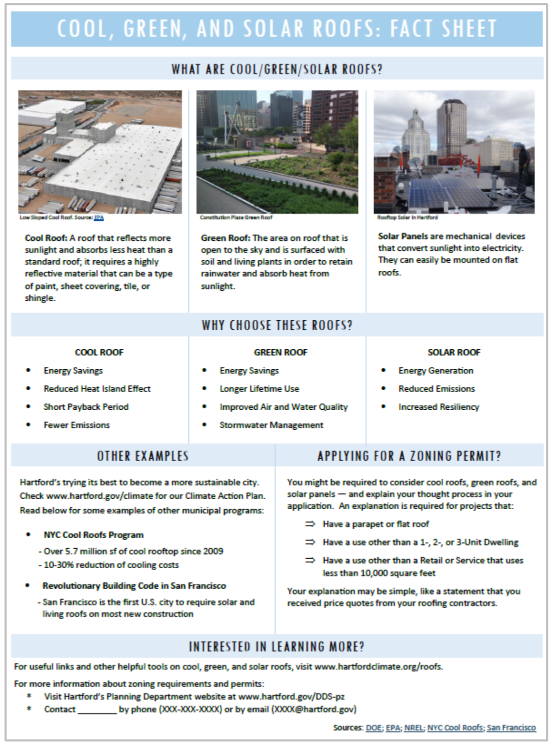
- Research
- Policy
- Community Action

2017 CIRCA Green Infrastructure Workshop in New Haven

TECHNICAL ASSISTANCE

- Research
  - Topic memos/testimony
  - Tree characteristics and benefits
- Analysis
  - Mapping
  - Runoff calculator
  - Canopy cover
- Communications:
  - Design
  - Online platforms
  - Direct Outreach

Soil Type	Surface Type	Area Citywide (square feet)	Past Year Runoff total (gal)
All	Paved Impervious Surface	213,725,290.94	2,874,471,714.86
A	Open Space	758,976.97	-
B	Open Space	47,473,418.47	6,695,854.09
C	Open Space	62,273,176.51	51,460,203.65
D	Open Space	19,938,563.63	34,097,175.03
A	Bare Soil	76,840.19	16,918.15
B	Bare Soil	4,309,730.67	5,155,332.54
C	Bare Soil	1,932,660.22	4,894,473.12
D	Bare Soil	1,618,762.24	5,464,525.82
A	Tree Canopy	2,999,102.54	-
B	Tree Canopy	35,932,516.39	2,082,239.81
C	Tree Canopy	65,794,225.40	33,076,202.55
D	Tree Canopy	13,246,558.27	16,690,055.65
Unaccounted for (Mixed Soils, Open Water, and Unknown)		34,716,641.35	
Total		504,796,463.79	3,034,104,695.26


COOL, GREEN, AND SOLAR ROOFS: FACT SHEET

WHAT ARE COOL/GREEN/SOLAR ROOFS?

Low Sloped Cool Roof. Source: EPA

Cool Roof: A roof that reflects more sunlight and absorbs less heat than a standard roof; it requires a highly reflective material that can be a type of paint, sheet covering, tile, or shingle.

Constitution Plaza Green Roof

Green Roof: The area on roof that is open to the sky and is surfaced with soil and living plants in order to retain rainwater and absorb heat from sunlight.

Rooftop Solar in Hartford

Solar Panels are mechanical devices that convert sunlight into electricity. They can easily be mounted on flat roofs.

WHY CHOOSE THESE ROOFS?

COOL ROOF
- Energy Savings
- Reduced Heat Island Effect
- Short Payback Period
- Fewer Emissions

GREEN ROOF
- Energy Savings
- Longer Lifetime Use
- Improved Air and Water Quality
- Stormwater Management

SOLAR ROOF
- Energy Generation
- Reduced Emissions
- Increased Resiliency

OTHER EXAMPLES

Hartford's trying its best to become a more sustainable city. Check www.hartford.gov/climate for our Climate Action Plan. Read below for some examples of other municipal programs:

- **NYC Cool Roofs Program**
  - Over 5.7 million sf of cool rooftop since 2009
  - 10-30% reduction of cooling costs
- **Revolutionary Building Code in San Francisco**
  - San Francisco is the first U.S. city to require solar and living roofs on most new construction

APPLYING FOR A ZONING PERMIT?

You might be required to consider cool roofs, green roofs, and solar panels — and explain your thought process in your application. An explanation is required for projects that:

⇒ Have a parapet or flat roof

⇒ Have a use other than a 1-, 2-, or 3-Unit Dwelling

⇒ Have a use other than a Retail or Service that uses less than 10,000 square feet

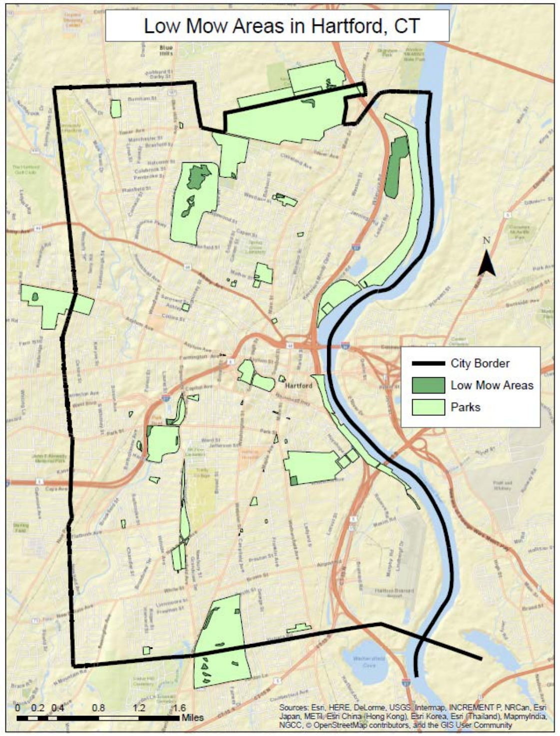
Your explanation may be simple, like a statement that you received price quotes from your roofing contractors.

INTERESTED IN LEARNING MORE?

For useful links and other helpful tools on cool, green, and solar roofs, visit www.hartfordclimate.org/roofs.

For more information about zoning requirements and permits:
* Visit Hartford's Planning Department website at www.hartford.gov/DDS-pz
* Contact _________ by phone (XXX-XXX-XXXX) or by email (XXXX@hartford.gov)

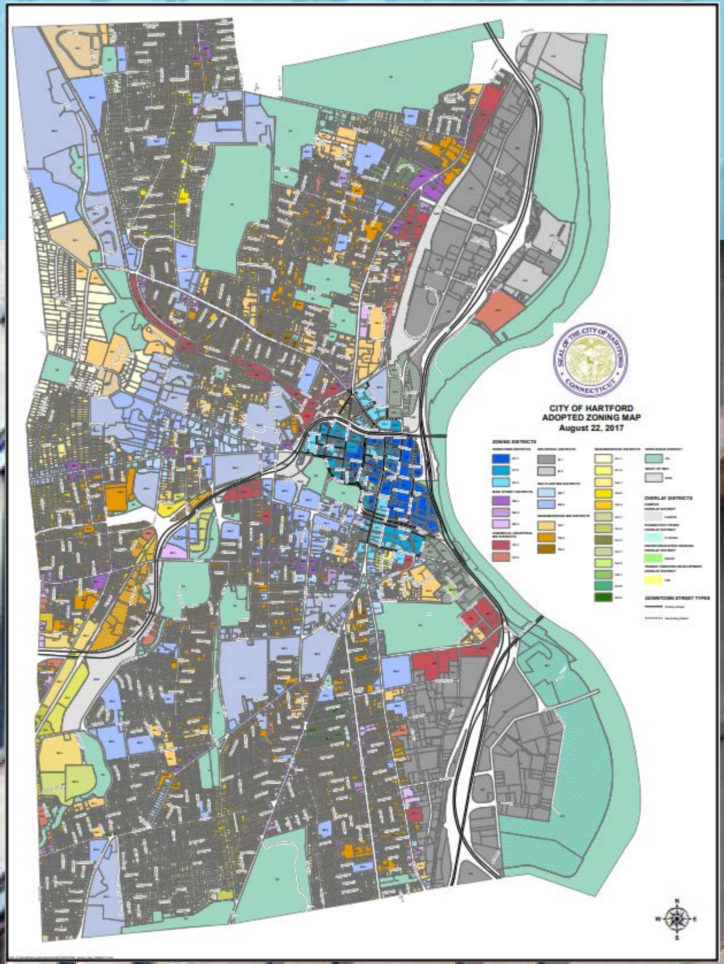
Sources: DOE; EPA; NREL; NYC Cool Roofs; San Francisco



ZONE

HARTFORD

Zoning Regulations



SYSTEMATIC CHANGES

- Zoning Code
  - Stormwater Fee-in-Lieu
  - Removal of Parking Minimums
  - Consideration for Green Roofs
- Best Management Practices Guide
- Staff Stormwater Workshop
- Preferred Tree Species List


2.2 GREEN ROOFS

BENEFITS:

CONSTRAINTS:

SUITABLE FOR:

CAPITAL COST:

MAINTENANCE:

KEY:

WHAT IS A GREEN ROOF?

BENEFITS OF A GREEN ROOF


COSTS

MAINTENANCE

LOCAL EXAMPLES

SUITABLE LOCATIONS

INTERESTED IN LEARNING MORE?

COMMUNITY ACTION

KNOX and The Hartford volunteers plant 36 trees on Arbor Day 2018

Community Action Meeting on Landscape and Water


Photo from Keney Park Sustainability Project
RETAIN THE RAIN
STORMWATER MANAGEMENT PILOT
SPONSORED BY:
CIRCA
Connecticut Institute for Resilience and Climate Adaptation

HOW WE GAIN FROM THE RAIN

Help prevent sewage backups

Water your lawns and gardens at no cost

Help prevent sewage overflows into rivers

Help reduce pollution like motor oil and heavy metals

Recharge the city's groundwater supplies

Did You Know?

1/4"

It can take as little as a 1/4 inch of rain to cause combined sewer overflows

50

Combined Sewer Overflows enter our waters every year

1/2

BILLION GALLONS of sewage/stormwater mix is discharged into our rivers

OUR PROGRAM:
SAVE WATER AND THE ENVIRONMENT!

Cap w/ clamp

Extension

Splash Block

COMMUNITY OUTREACH

- Workshop
- Neighborhood Presentations
- Community Action Meeting

Workshop at Keney Park

FUTURE PLANS

THANK YOU | QUESTIONS?