Marlborough, Massachusetts

Resilience Design Guidance

Funded Through the Massachusetts Vulnerability Preparedness (MVP) Program

OVERVIEW

Climate change is occurring globally, but the City of Marlborough is already experiencing the impacts of climate change at the local level. Climate trends across the Commonwealth show an increase in the intensity and frequency of extreme weather. The observed increase temperatures and high intensity rainfall are expected to continue and worsen with time. The increased temperatures will be apparent as heat waves and days over 90 degrees Fahrenheit become more frequent. Rising temperatures will impact natural systems and the built environment. Increased temperatures could result in an increase in invasive species and pests, infrastructure malfunctions due to overheating, and heat-related illnesses. Moreover, more intense rainfall may result in more frequent riverine flooding (out of banks) and stormwater flooding (when drainage infrastructure becomes overwhelmed). Stormwater from more intense or longer duration precipitation events can increase the number of pollutants washed into water bodies.

The City of Marlborough updated its regulations to include measures to address climate change. Regulations significantly influence human-changes to the natural and built environments. The role of regulations is to set standards so that there is quality control in these changes, human health and safety is preserved, and the local character of the city is protected. As climate change continues to cause increasing impacts to our world through extreme temperatures, precipitation events, storms, and other hazards it is important that the role of regulations in protecting human safety is expanded to include protection from climate impacts. The City of Marlborough completed a Hazard Mitigation and Climate Adaptation Plan in 2020 that extensively details the climate change projections and associated vulnerabilities in Marlborough. One recommendation from that plan, was to examine ways to expand the city's regulatory language to incorporate climate adaptation measures.

The City of Marlborough is experiencing a period of tremendous growth. A development boom has included many large-scale commercial and residential projects. City Officials, in their review and evaluation of each successive project have attempted to ensure that the designs incorporate low-impact development principles and other climate-resiliency measures, but without clear regulations and guidelines this becomes difficult. Marlborough received a Municipal Vulnerability Preparedness (MVP) Action Grant to assess the gaps and opportunities to incorporate climate adaptation and resilience within regulations. The gaps and opportunities analysis resulted in numerous recommendations to support Marlborough in preparing for climate impacts. The analysis primarily focuses on utilizing natural resources and the built environment to build climate resilience. Climate resilience refers to the ability of a community to thrive despite the impacts of climate change and climate adaptation means changing practices and implementing solutions to adjust to a new reality to lessen those impacts.

Proponents can use this document as guidance for how to incorporate resilience and adaptation into new development projects, retrofits, and site designs.

This document encourages proponents to adopt or integrate climate adaptation measures, through flexible performance-based recommendations. While proponents do not have to adopt every measure outlined in the guidance, the city reviewer will use this document to determine whether the applicant has adequately addressed climate impacts on site and may require that the applicant enhance their response to these impacts if they have not been adequately addressed.

The document is organized into three parts.

- **Site Design and Site Plan Review Requirements**
- **Best Practices with reference to which regulations they might apply.**
- **Glossary of Climate Resilience and Adaptation Terms**

CLIMATE RESILIENCE DESIGN STANDARDS TOOL

Applicants should use the the State Climate Resilience Design Standards Tool published by the Massachusetts' Executive Office of Energy and Environmental Affairs to understand the climate vulnerabilities of their site.

The Resilient MA Action Team (RMAT) "Climate Resilience Design Standards and Guidelines" project developed guidance for projects to enhance how the Commonwealth assesses climate resilience and provides:

- a preliminary climate change exposure and risk rating;
- recommended climate resilience design standards for projects with physical assets; and,
- guidelines with best practices to support implementation.

The proponent should begin by inputting their project into the Climate Design Standards Tool. The state's site has detailed instructions on how to do this. The core information you will need includes the following:

PROJECT DETAILS	**Project Name**
	Location of Project
	Estimated Project Capital Cost
	Who is the submitting entity?*
	Is this project being submitted as part of a state grant application?**
	Which grant program?*
	What stage are you in your project lifecycle?
	Is climate resiliency a core objective of this project?**
	Is this project being submitted as part of the state capital planning process?**
	Is this project being submitted as part of a project review process or permitting?**
	Brief Project Description

Source: Massachusetts Executive Office of Energy and Environmental Affairs

*Inputs will be pre-populated dropdown options for users to select based on respective lists for state agency, funding mechanisms, and grant programs.

** Inputs will be pre-populated dropdown options for users to select based on either Yes/No

The applicant should also be prepared to answer questions about climate exposure. You can use your best judgement and accessible information available to answer the following questions.

USER QUESTIONS FOR PROJECT CLIMATE EXPOSURE	**Does the project site have a history of coastal flooding?**
	Does the project site have a history of riverine flooding?
	Does the project site have a history of flooding during extreme precipitation events?
	Does the project result in a net increase in impervious area of the site?
	Are existing trees being removed as part of the proposed project?

Source: Massachusetts Executive Office of Energy and Environmental Affairs

The applicant should also be prepared to answer questions about how your development will address climate vulnerabilities and mitigate their impact. If you are in the planning phases of the project, answer to the best of your ability based on what you are planning to incorporate. Ecosystem Service Benefits refer to the direct and indirect benefits because of ecosystems within site designs.

ECOSYSTEM SERVICES BENEFITS	**Provides flood protection through nature-based solutions**
	Reduces storm damage
	Recharges groundwater
	Protects public water supply
	Filters stormwater using green infrastructure
	Improves water quality
	Promotes decarbonization
	Enables carbon sequestration
	Provides oxygen production
	Improves air quality
	Prevents pollution
	Remediates existing sources of pollution
	Protects fisheries, wildlife, and plant habitat
	Protects land containing shellfish
	Provides pollination
	Provides recreation
	Provides cultural resources/education

Source: Massachusetts Executive Office of Energy and Environmental Affairs

When using the Tool, the applicant will be asked to also input planned and existing assets within the project site, their criticality, intended use, and useful life. More detailed instructions are located here.

The Climate Resilience Design Standards Tool will provide the following information as an 'output' after you entered the information described above.

- Preliminary Exposure Rating for the project for each climate parameter: sea-level rise/ storm surge (*not applicable to Marlborough*), extreme precipitation, and extreme heat
- Preliminary Risk Rating for each building and infrastructure asset for each climate parameter: sea-level rise/ storm surge (*not applicable to Marlborough*), extreme precipitation, and extreme heat
- An evaluation of whether the project falls within a mapped Environmental Justice (EJ) population
- An Ecosystem Services Benefits Score for the overall project

CLIMATE IMPACT STATEMENT

Proponents must provide a public 'climate impact statement' describing their preliminary exposure rating for extreme heat and extreme precipitation from the Climate Resilience Design Standards Tool, which FEMA flood zone the site is in, whether planned activities will result in significant site disruptions, earth removal, or removal of existing large-canopy trees, and how the planned development or redevelopment will incorporate climate adaptation and resilience strategies. New developments should not intensify impacts to adjacent sites. For example, a planned building development that will take up most of a property, may result in displaced and intensified stormwater impacts to adjacent properties and urban heat island impacts due to the increase in impervious surfaces. Therefore, the impact statement should state how stormwater will be stored and discharged onsite, and how the new building will incorporate high solar reflectance materials, such as a cool roof.

Sample Climate Impact Statement

ADDRESS is a planned mixed-used development including 25-residential units, (3) at grade retail spaces and parking lot with 30 spaces. The site received the following exposure scores from the Climate Resilient Design Standards Tool:

- Extreme Precipitation (Urban Flooding) – *High Exposure*
- Extreme Precipitation (Riverine Flooding) – *Low Exposure*
- Extreme Heat – *High Exposure*

The planned development addresses the site's high exposure to extreme urban precipitation by providing x amount of volume of stormwater storage onsite through bioswales along the parking lot and an underground tank. The planned building is built to the design flood elevation of x, with a ramped entry into the commercial spaces. Critical systems are located on the roof. The building has a cool roof system to reduce urban heat island impacts and increase summer energy savings. The new development will leave (3) large-canopy trees 16'-0" canopy or larger undisturbed.

OVERVIEW

The following section includes examples of climate resilience and adaptation strategies that can be employed by proponents to meet the requirements and recommendations of the City of Marlborough's regulations.

The strategies have a key, indicating which climate hazards, impacts, or benefits are provided by the measure.

KEY

NATURE-BASED SOLUTIONS

URBAN HEAT ISLAND AND HEAT STRESS

STORMWATER IMPACTS + FLOODING

ENERGY SAVINGS

HUMAN HEALTH

Each strategy is also accompanied by high-level cost estimate, which gives proponents an example of what costs may be. Additionally there is a reference to which regulations the strategy might pertain to. Look for a box like this!

RELEVANT REGULATIONS

Additional resources can be found on the final page of this section of the guidance document, to learn more about best practices!

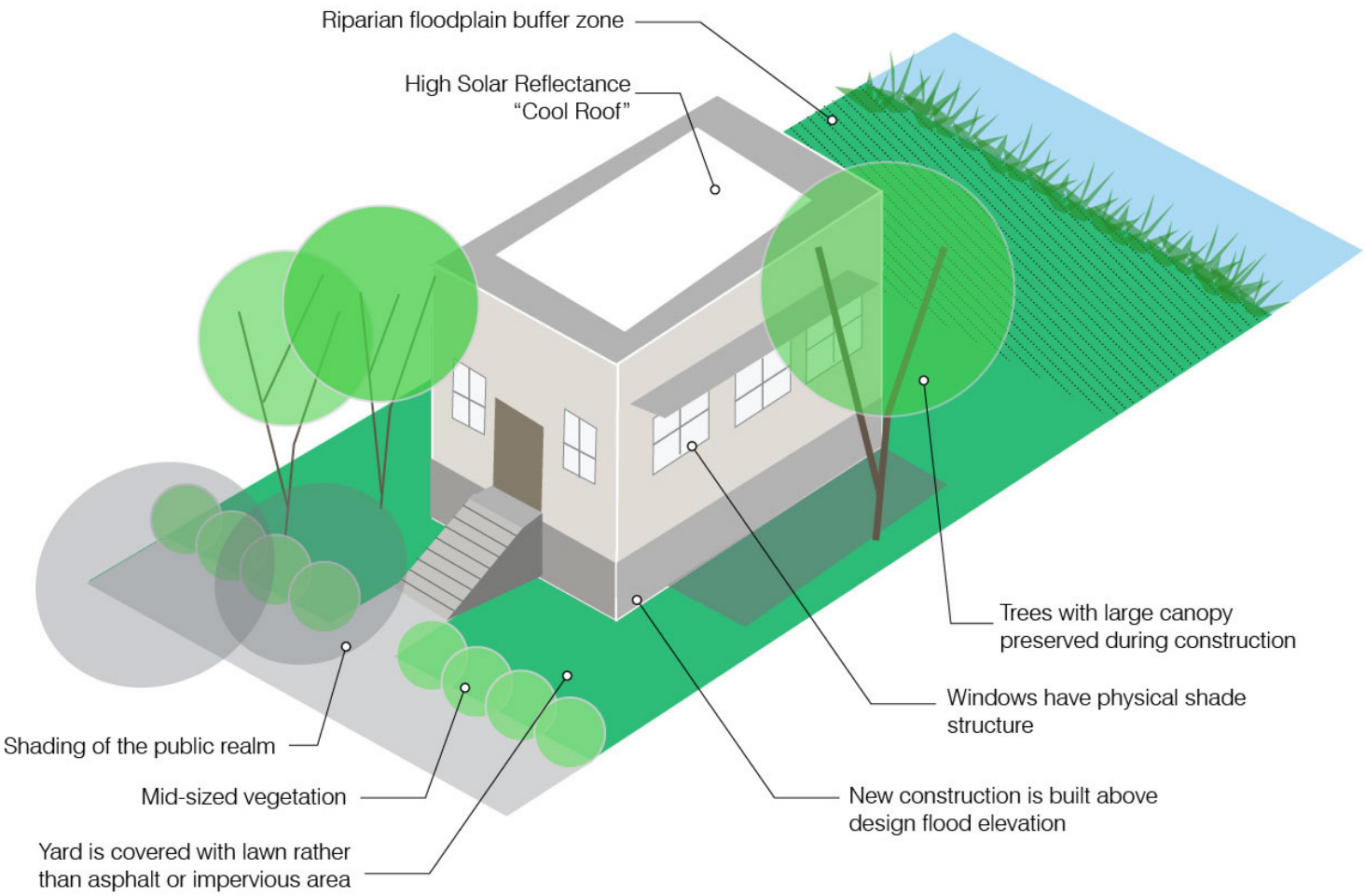
PERFORMANCE-BASED REGULATIONS

Proponents are encouraged to utilize the types of strategies illustrated in this document, however the City of Marlborough has not made any particular strategy a requirement. Alternatively, proponents must use a variety of strategies specific and feasible to their property to achieve climate resilience and adaptation goals.

"A REGULATORY APPROACH THAT FOCUSES ON DESIRED, MEASURABLE OUTCOMES, RATHER THAN PRESCRIPTIVE PROCESSES, TECHNIQUES, OR PROCEDURES."

Source: https://www.nrc.gov/reading-rm/basic-ref/glossary/performance-based-regulation.html

EXAMPLE OF A CLIMATE ADAPTED SITE



FLOOD PROTECTION SYSTEMS

OVERVIEW

Flood protection systems and strategies can be used to keep flood waters out of sites and buildings or allow these areas to be flooded without signifcant damges to structures or critical systems. When preparing for future flood events, it is important to understand the project extents and depths of flooding.

Flood protection can be categorized as two types:

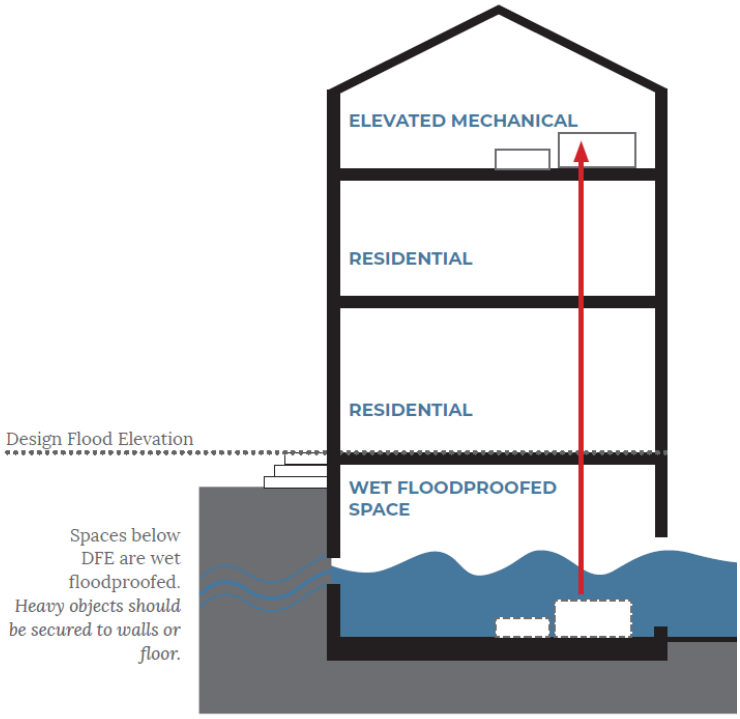
- Wet floodproofing
- Dry floodproofing
- Flood barrier

WET FLOODPROOFING

"Wet Floodproofing is a design method that allows water to move in the enclosed parts of a home's lower area, such as the crawlspace or an unoccupied area, and then out when water recedes. Materials and components used in these areas are selected for their ability to become wet, sustain minimal damage, dry, and be restored. The advantage of wet floodproofing is that, as floodwaters come into the prepared enclosed areas they will reach the same level as the outside water. This equalizes the water pressure on both the inner and outer walls and may prevent structural damage caused by unequal pressure on the structure's walls.

All the materials below the design elevation must be resistant to flood or water damage. The materials and components of wall and floor systems should encourage drying in at least one direction."

Source: Federal Emergency Management Agency, Homeowners' Guide to Retrofitting



Source: Developed for City of Boston, Environment Department by Bella Purdy

NOTE
To wet floodproof a vulnerable space, critical systems such as mechanical systems, must be elevated above the Design Flood Elevation to avoid damages. This often involves moving these systems from a below grade, basement space to an upper level or to the roof of a building.

$3 to **$6**
per square foot
Costs of wet flood-proofing buildings per foot of wet flood-proofing height

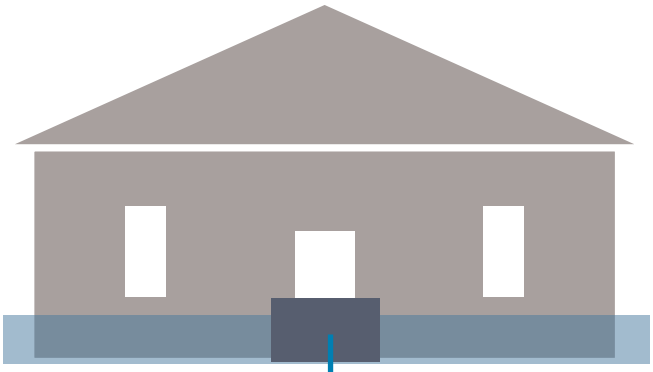
Source: Adapted from Aerts et al

FLOOD PROTECTION SYSTEMS

DRY FLOOD PROOFING

"Dry floodproofing includes measures that make a structure watertight below the level that needs flood protection to prevent floodwaters from entering. This type of floodproofing is often used to protect non-residential structures, water supplies, and sewage systems."

Source: Federal Emergency Management Agency



Example of flood shield over door opening

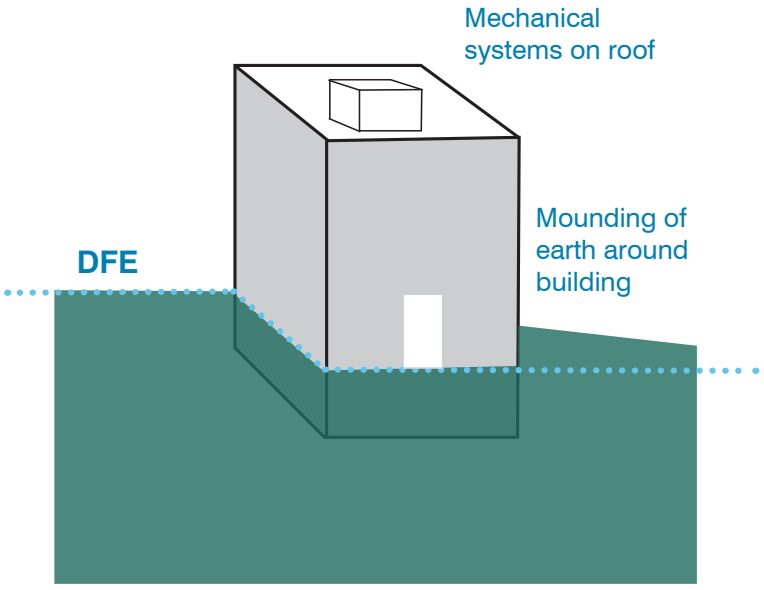
Photo Source: Flood Panel

WHAT IS BASE FLOOD ELEVATION?
The height that floodwaters are projected to reach during a 100-year flood event.

WHAT IS DESIGN FLOOD ELEVATION?
The height of the lowest occupiable floor (when wet flood proofing), or the height of the lowest structural member of an inhabitable floor (when elevating a building). Depending on building type and location, the DFE is usually separated from the BFE by one to two feet of freeboard (as a safety buffer).

SITE STRATEGIES

Properties can also be protected from flooding through site strategies that involve changing topography, creating berms, and adding vegetation. By creating an 'island' by mounding earth around a building up to the design flood elevation, a building can be protected from flooding. Vegetation helps capture and discharge flood waters.



RELEVANT REGULATIONS

Chapter 270 Building and Site Development
Chapter 650 Zoning

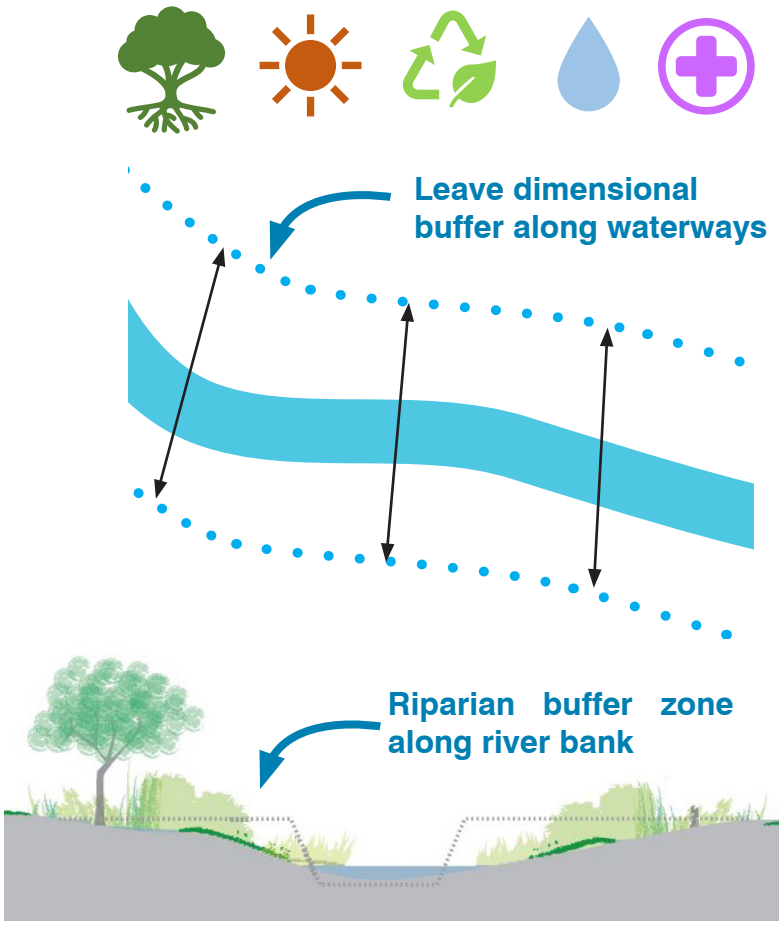
FLOOD PROTECTION SYSTEMS + MANAGEMENT

OVERVIEW

Flood protection and management can also be accomplished through the preservation, protection, and proper management of floodplains. Marlborough's Floodplain and Wetland Protection District.

A floodplain is a low-lying, flat area adjacent to a waterbody that may become submerged during an extreme precipitation event or riverine flood event.

Floodplains can be protected in a number of ways. New developments should leave an adequate buffer around floodplains to allow for inundation during flood events. Floodplains should be vegetated and pervious to properly store and recharge water.



TYPES OF FLOODPLAINS

Riparian Buffer Zone

Riparian buffers are "the natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream."

Source: WV Department of Environmental Protection

Source: https://www.hrg-inc.com/is-a-riparian-forest-buffer-right-for-your-site-development-project/

Wetlands

A wetland is "where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species."

Source: EPA

Source: https://ndcpartnership.org/news/why-wetlands-can-and-should-boost-your-ndc

HIGH SOLAR REFLECTANCE MATERIALS

OVERVIEW

High solar reflectance materials are light colored materials that reflect the sun's thermal energy, reducing surface temperatures of building and site materials.

High solar reflectance materials can contribute to reductions in urban heat island impacts, increased energy savings due to passive cooling, and contribute to human comfort.

Solar reflectance is a measure of reflectance and and emissivity, or ability to release absorbed energy. It is measured with the Solar Reflectance Index (SRI), which is a numeric score of 0 to 100. Black is 0 (low SRI), white is 100 (high SRI).

High SRI materials are available in:

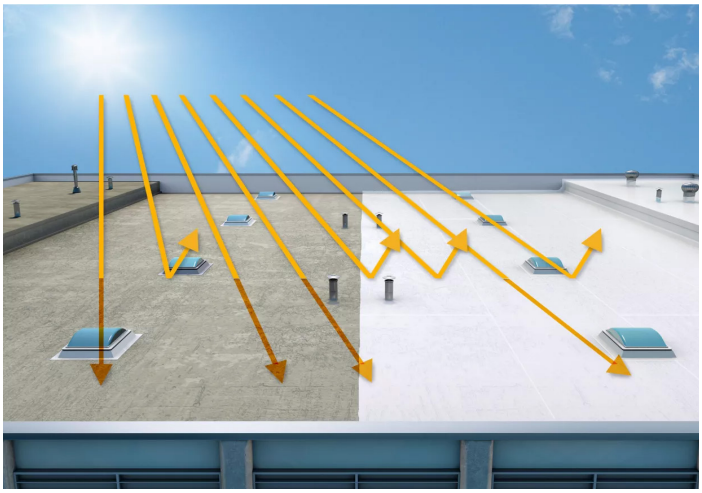
- Roofing material
- Facade materials
- Paving materials

$1.50 to $3
per square foot

estimated cost of Cool Roof
Source: EPA

50-60 F
cooler than conventional materials in peak summer.

Source: EPA



Source:https://www.sika.com/en/knowledge-hub/cool-roofs-and-energy-efficiency.html

Source:https://www.sika.com/en/knowledge-hub/cool-roofs-and-energy-efficiency.html

RELEVANT REGULATIONS

Chapter 270 Building and Site Development
Chapter 650 Zoning

GREEN INFRASTRUCTURE

OVERVIEW

Green infrastructure is a stormwater management approach which is designed to slow down, collect, and treat stormwater where it falls.

It complements and, in some cases, replaces the need for piped infrastructure. Green Infrastructure can also contribute to urban heat island reduction.

Green infrastructure offers a feasible and valuable solution for urban areas facing the challenges of climate change. It connects urban hydrological functions with vegetation systems in urban landscape design, providing overall socioeconomic benefits that are greater than the sum of its individual components.

There are many types of green infrastructure:

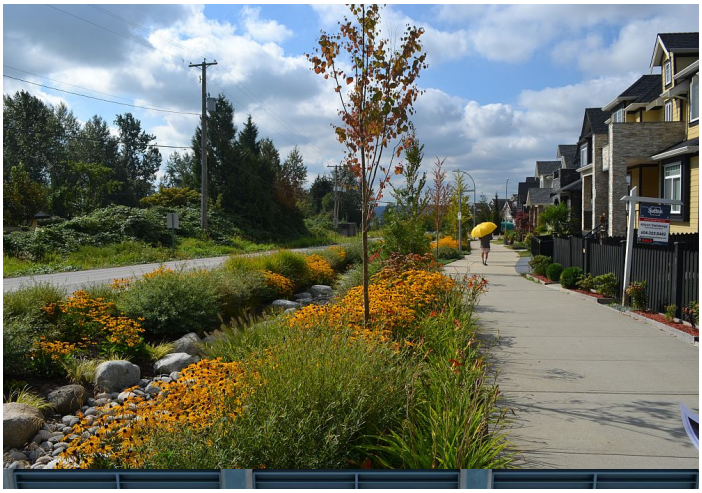
- Bioswales
- Tree box filters
- Pervious paving
- Biorention ponds

$5 to **$30**
per square foot

estimated cost of biorention feature
Source: Massachusetts Clean Water Handbook

total runoff reduction (gal)
can be calculated by =
[annual precipitation (inches) * GI area (SF) *
% retained] * 144 sq inches/SF * 0.00433 gal/cubic inch

Source: Center for Neighborhood Technology



Source:https://waterbucket.ca/gi/2019/11/03/to-ensure-green-infrastructure-has-a-long-future-experts-are-tackling-maintenance-needs-of-the-installations-as-they-arise-often-as-surprises-and-are-working-to-formalize-project-care/

Source: https://commons.wikimedia.org/wiki/File:Green_Infrastructure_Oasi_i_Goret_Nole_Piedmont_LOS_DAMA!.jpg

RELEVANT REGULATIONS

Chapter 270 Building and Site Development
Chapter 511 Storm Sewers
Chapter 650 Zoning

GREEN ROOF + FACADES

OVERVIEW

Green roofs and green facades are exterior envelope systems on buildings that contain vegetation. **Green roof or facade systems provide multiple benefits:**

- Stormwater collection and management
- Urban heat island reduction and cooling
- Carbon sequestration
- Reduced building energy loads due to passive cooling

Additionally, green roofs can be occupiable, providing enjoyable green space for building occupants.

Green roofs and facades can vary in the complexity of their systems. For example, an extensive green roof contains low-maintenance and low-coverage species such as grasses or succulants. These roof systems require less soil-volume load and irrigation. Whereas, an intensive green roof contains heavier soil loads, and may include dense vegeation such as shrugs and trees which require more maintenance.

Source:https://commons.wikimedia.org/wiki/File:Green_Roof_(15456078087).jpg

Source: https://commons.wikimedia.org/wiki/File:Green_Infrastructure_Oasi_i_Goret_Nole_Piedmont_LOS_DAMA!.jpg

$10 to $25
per square foot

estimated cost of green roof
Source: EPA

Green roof temperatures can be 30–40°F lower than those of conventional roofs and can reduce city-wide ambient temperatures by up to 5°F.

Source: EPA

RELEVANT REGULATIONS

Chapter 270 Building and Site Development

Chapter 650 Zoning

TREE CANOPY AND TREE BOX FILTERS

OVERVIEW

Trees are a high value resilience strategy in many ways. Tree canopy contributes to shading and human comfort contributing to urban heat island reduction. Additionally, trees contribute to carbon capture, better air quality, and a more pleasing environment.

Trees also provide important stormwater management features such as erosion control.

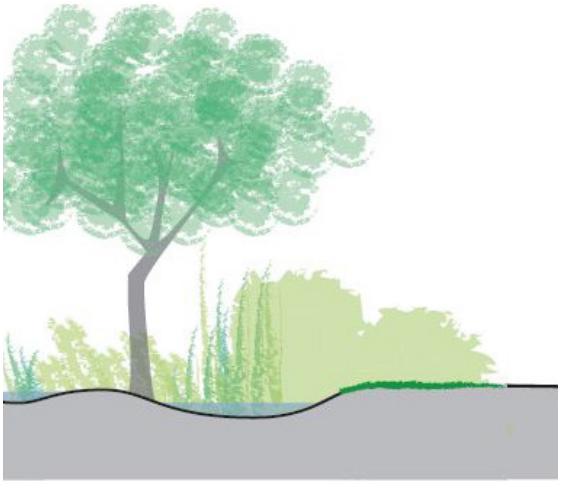
TREE BOX FILTERS

Tree box filters are widely deployed as stormwater treatment Best Management Practices (BMPs). They can be used as pretreatment for infiltration, rainwater harvesting, and detention.

Source: Stormwater Association

Trees and vegetation lower surface and air temperatures by providing shade and through evapotranspiration. Shaded surfaces, for example, may be 20–45°F (11–25°C) cooler than the peak temperatures of unshaded materials.1 Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 2–9°F (1–5°C).

Source: EPA



Source: Weston & Sampson

Source: https://commons.wikimedia.org/wiki/File:NT_10-25-2020_Looking_up_at_the_tree_canopy.jpg

20-45 F

cooler than unshaded materials in peak summer.

Source: EPA

$125

average cost of medium tree planting

Source: apnursery.com

RELEVANT REGULATIONS

Chapter 270 Building and Site Development
Chapter 511 Storm Sewers
Chapter 650 Zoning

FLOOD STORAGE AND PERVIOUS MATERIALS

OVERVIEW

Green infrastructure can also include non-vegtative strategies that are used to slow down the flow of stormwater, capture, and harvest rainwater for recharge and reuse. Stormwater storage tanks and pervious paving are too examples.

STORMWATER STORAGE TANKS

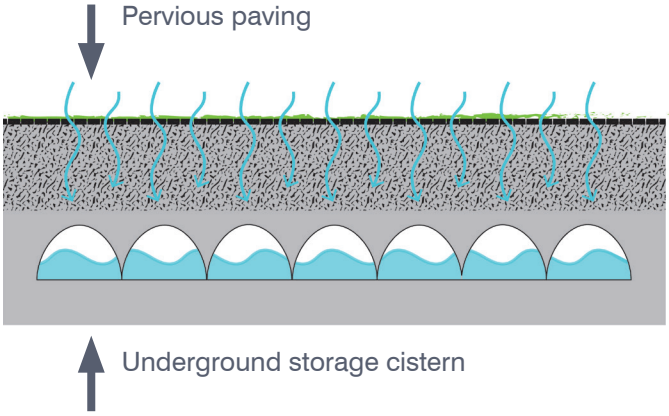
The storage tank is the most important and typically the most expensive component of a Rainwater Harvesting system. Typical cistern capacities range from 50 to 250 gallons, although some commercial applications can be over 30,000 gallons. Multiple tanks or barrels can be placed together and connected with pipes to balance water levels and increase overall storage, as needed.

Typical cistern capacities range from

50 to 250 gallons

Source: https://commons.wikimedia.org/wiki/File:Variety_of_water_storage_tanks_and_rainwater_harvesting_equipment_(4481564110).jpg

DIAGRAM OF PERVIOUS PAVING WITH UNDERGROUND STORAGE



GI RESOURCES

CT NEMO (Nonpoint Education for Municipal Officials)
- **Rain Gardens & Bioretention**

Massachusetts Clean Water Toolkit:
- **Biorention Areas & Rain Gardens**
- **Water Quality Swales**

MAPC Fact Sheets:
- **Biorentention Areas**
- **Vegetated Swales**

University of New Hampshire:
- **Regular Inspection and Maintenance Guidance for Bioretention Systems and Inspection Checklist**

RELEVANT REGULATIONS

Chapter 270 Building and Site Development
Chapter 511 Storm Sewers
Chapter 650 Zoning

CLIMATE RESILIENCE SITE DEVELOPMENT CHECKLIST

The purpose of the Site Development Climate Resilience Checklist is to assist proponents in implementing resilient design opportunities into their project to mitigate potential adverse climate change impacts over the design life of a project (normally at least 30 to 50 years). This checklist serves as guidance for the required documentation that must be submitted to the City.

All development must adhere to the City of Marlborough Zoning By-Law and other applicable federal, state, and local laws and regulations. Smaller projects are exempt from permit review should still comply with the Massachusetts Stormwater Management Standards. Developers are encouraged to use this checklist to produce resilient projects and to facilitate coordination with the City of Marlborough. Completing this checklist does not take the place of project permitting and does not, in any way, ensure or imply that a permit has or will be granted by the City. A public emergency plan for the proposed project site describing the evacuation routes, emergency procedures, and the availability of power, water, and wastewater is also encouraged.

GENERAL PROJECT INFORMATION

Project Name: _____

Project Address: _____

Map: _____ Block: _____ Lot(s): _____

APPLICANT INFORMATION

Applicant: _____

Company/ Organization: _____

Mailing Address: _____

Phone Number: _____

Email Address: _____

OWNER INFORMATION

☐ The owner and applicant are the same.

Owner(s) Name: _____

Company/ Organization: _____

Mailing Address: _____

Phone Number: _____

Email Address: _____

POINT OF CONTACT INFORMATION

☐ Point of contact and owner are the same.

☐ Point of contact and applicant are the same.

Point of Contact Name: _____

Company/ Organization: _____

Mailing Address: _____

Phone Number: _____

Email Address: _____

PROJECT INFORMATION

PROJECT TYPE

Please check all that apply.

- ☐ Nonresidential
- ☐ Residential
- ☐ New Construction
- ☐ Redevelopment

EXISTING

Total building footprint (ft^2): _____

Area of impervious cover (ft^2): _____

PROPOSED

Total building footprint (ft^2): _____

Area of impervious cover (ft^2): _____

Area of disturbance (ft^2): _____

Vegetated area (ft^2): _____

SITE LOCATION

☐ Project is within a known floodplain.

If the project is within a known floodplain, construction should conform to current floodplain regulations, including those established by FEMA and Section 650-23 Floodplain and Wetland Protection District in the Zoning By-Law. Projects should follow the most recent standards set

by the American Society of Civil Engineers (ASCE) Flood Resistant Design and Construction, the Massachusetts Wetlands Protection Act, and Marlborough Wetlands By-Law and Regulation.

The climate impact statement should provide a summary of the property location, intended use and physical features, outputs from the Climate Design Standards Tool, and how climate impacts will be mitigated or adapted to through site and building design. Please refer to the example Climate Impact Statement on Page 6 and to the design guidance document for example strategies.

Climate Impact Statement

ADDRESS:_____

PROPERTY USE DESCRIPTION:_____

_____

CLIMATE TOOL OUTPUTS (Circle one)

Extreme Precipitation (Urban Flooding)	No Exposure	Low Exposure	Medium Exposure	High Exposure
Extreme Precipitation (Riverine Flooding)	No Exposure	Low Exposure	Medium Exposure	High Exposure
Extreme Heat	No Exposure	Low Exposure	Medium Exposure	High Exposure

DESCRIPTION OF HOW PLANNED DEVELOPMENT MITIGATIONS OR ADAPTS TO CLIMATE IMPACTS

SITE DESIGN ELEMENT: REQUIRED SITE PLAN ELEMENTS

Submitted site plans should show information that helps depict to reviewers the physical and natural characteristics of the site. Applicants should submit an existing and proposed plan.

Site plans should include the information outlined in the table below.

Reviewer will be examining the existing and proposed site plans in comparison with one another to understand:

- Significant changes in topography
- Land distributing activities that will impact groundwater table and erosion
- Removal of existing trees
- Percentage of vegetated area, planned development area

✓	Provide a site plan with the following.
	1 ft. contours and clear documentation of major changes in elevation to the site that could exacerbate flooding
	FEMA flood zone indicated
	Documentation that intensification of flood impacts in the project area or significant changes in the water table are not caused by earthmoving or tree removal
	Key spot elevations designated on site plan.
	Percentage of total lot area for the following surface areas: lawn, dense vegetation, pervious, impervious, high solar reflectance index materials, building.
	Annotations on site plan indicating resilience and adaptation measures that will be incorporated.
✓	**Narrative and documentation with the following.**
	Needs assessment for parking spots or lots
	Climate impact statement.
	Table comparing projected flood elevations with the ground level elevation, basement top of wall elevation, and sill elevations of all openings at ground level or below for proposed buildings.

SITE DESIGN ELEMENT: LANDSCAPING AND VEGETATION

Site planning and design are key components to supporting resilience and can help mitigate stormwater and heat impacts.

High-cover species with dense foliage, like large canopy trees provide the most benefit in terms of cooling. Applicants should take reasonable measures to preserve existing trees on site.

Nature-based solutions, such as bioswales, contribute to stormwater management measures.

Inclusion of vegetated landscapes can:

- Reduce urban heat islands (land temperatures)
- Contribute to human comfort through shading
- Recharge stormwater
- Provide erosion control
- Contribute to air quality
- Mitigate flood impacts by slowing and storing water during events.

Landscaped area refers to an area with vegetative cover including lawn, shrubs, meadowland, forest, wetlands, tree canopy cover, green infrastructure, and stormwater ponds. Site plans should include a range of vegetated strategies to accomplish multiple climate resilience goals, such as those listed in the box above.

Please provide a narrative and landscape plan with the information in the table below.

✓	Provide a narrative and landscape plan including:
	A planting list and landscape plan(s) showing new and existing vegetation.
	A description for the removal of invasive species listed by the MIPAG and comparable native replacements.
	Trees with additional details for tree removal and plantings, including location, type, and caliper.
	A description of proposed drought resistant/low-water consumption landscaping elements, including irrigation systems.
	A description of an increase or decrease in the tree canopy or vegetated shade.
	A description of the maintenance schedule and activities.
	A plan to conserve and manage forested areas or environmentally sensitive areas.
	A description of open space in adjacent lots and plan for contiguity of open space across lots.
	A plan to limit site disturbance and reestablish vegetated areas.
	A plan to avoid soil compaction, erosion, and/or restore soils.

*Invasive Plant List *https://www.mass.gov/files/documents/2016/08/tm/invasive-plant-list.pdf*

SITE DESIGN ELEMENT: STORMWATER MANAGEMENT

Effective stormwater management protects water quality and ensures proper water quantity infiltration into surface and ground water for adequate streamflow and water supply. Stormwater management techniques vary depending upon precipitation amounts. Stormwater is best managed by reducing impervious surfaces and promoting infiltration through Low Impact Development (LID). Please provide a site plan and narrative illustrating the details of the stormwater management system and efforts to reduce the amount of impervious surface (roads, parking lots, sidewalks).

Site Design Element Intent:
- Mitigate flooding
- Increase infiltration of pollutants into the environment
- Protect public safety
- Protect property

STORMWATER MANAGEMENT

✓	Provide a site plan and narrative about that stormwater management system, including;
	A description of how the stormwater best management practices have been applied for: ☐ Bioswale and Rain Garden ☐ Building Planter Boxes ☐ Exterior Window Shade ☐ Flood Barriers ☐ Floodable Spaces ☐ Green Wall ☐ Permeable Pavement/Cool Pavement ☐ Rainwater Harvesting ☐ Site Grading for Flood Management ☐ Soil Protection ☐ Sustainable Roofing Strategies ☐ Tree Box Filters ☐ Vegetation and Shade Trees ☐ Other:_____
	A description of how best management practices have been applied in yards, the center of cul-de-sacs, rotaries, and vegetated strips along sidewalks.
	A description of how street edges allow side-of-road drainage into a vegetated open swale(s).
	A description of how climate change projections and impacts have been considered in the stormwater management design.
	A description of the operation and maintenance of the stormwater best management practices.

IMPERVIOUS SURFACES

✓	Provide a site plan and a narrative about impervious surface reduction efforts, including:
	A description of the impervious surfaces on site (like roads, sidewalks, parking areas) and how the total impervious surface area has been minimized.
	A description of how parking areas (pervious pavement cleaning and vegetation) will be maintained.
	A plan for shared parking and easements (if required) or multi-level parking for larger developments.
	A description of any vegetated walls or screens to protect adjacent properties from headlight glare.

SITE DESIGN ELEMENT: BUILDING RESILIENCE

Buildings should consider climate resilience measures above and beyond those required by the Massachusetts State Building Code. Building exteriors can reduce the impact of extreme temperature within and surrounding the building. Buildings can be designed to mitigate climate impacts like flooding and to maintain critical infrastructure during emergencies.

Site Design Element Intent:

- Reduce extreme temperature fluctuations
- Increase infiltration of pollutants into the environment
- Protect public safety
- Protect property

✓	Provide a site plan and description if any of the following are part of the proposed design:
	Green facades
	Sustainable roofing strategies (green, cool, or blue rooftops)
	Drain leaders that are disconnected managed through infiltration and vegetated treatment
	Exterior building design uses heat reflective materials
	Designed to elevate, protect and back up critical infrastructure
	Power system and backup system includes a lower occupancy mode, which powers basic amenities
	Sump pumps, dry flood proofing, or other flood protection strategies

GLOSSARY OF CLIMATE TERMS

100-yr Floodplain: This is the extent of a flood that has a 1% annual chance of occurring or being exceeded.

500-yr Floodplain: This is the extent of a flood that has a 0.2% annual chance of occurring or being exceeded.

Adaptation: Adjustment in natural or human systems in anticipation of or response to a changing environment in a way that effectively uses beneficial opportunities or reduces negative effects.

Climate Change Hazards: In the context of Marlborough regulations, these include flooding, stormwater, heat, wind

Cooling Degree Days: A measure of how hot the temperature was on a given day or during a period of days. A day with a mean temperature of 80°F has 15 CDD. If the next day has a mean temperature of 83°F, it has 18 CDD. The total CDD for the two days is 33 CDD.

Design Flood Elevation: The elevation of the highest flood (generally the base flood elevation plus freeboard) that a retrofitting method is designed to protect against.

Evapotranspiration: Water loss to the atmosphere through both evaporation and transpiration (through plant leaves).

Erosion: The wearing away of the land surface by natural or anthropogenic forces, such as wind, water, ice, gravity, or vehicle traffic and the subsequent detachment and transportation of soil particles.

Erosion Control Measures: Prevention and reduction of movement of eroded soil sediment.

Ecosystem Services: The direct and indirect benefits as a result of ecosystems provided by natural resources.

Extreme Weather Event: Extreme weather events can include significant anomalies in temperature, precipitation and winds and can manifest as heavy precipitation and flooding, heatwaves, drought, wildfires and windstorms (including tornadoes and tropical storms). Consequences of extreme weather events can include safety concerns, damage, destruction, and/or economic loss. Climate change can also cause or influence extreme weather events.

Federal Emergency Management Agency (FEMA): FEMA manages the federal government's response to natural and manmade disasters. FEMA also manages the National Flood Insurance Program (NFIP) and produces Flood Insurance Rate Maps (FIRM).

Floodplain: Any land area susceptible to being inundated by floodwaters from any source.

Flood Barriers: Gate or other barrier for protecting area behind barrier from flooding.

Flood Control: The prevention or reduction of flooding and flood damage.

Special Flood Hazard Area: An area having special flood, mudflow or flood-related erosion hazards and shown on a Flood Hazard Boundary Map (FHBM) or a Flood Insurance Rate Map (FIRM).

Flood Storage: Water is held within the floodplain during flooding events. Compensatory water storage is needed for developments within a floodplain (particularly the 100-yr floodplain).

Green Infrastructure: A sustainable, ecosystem-based approach to replicate a site's pre-development conditions for stormwater management and natural landscape preservation.

Heating Degree Days: A measure of how cold the temperature was on a given day or during a period of days. For example, a day with a mean temperature of 40°F has 25 HDD. Two such cold days in a row have a total of 50 HDD for the two-day period.

Hydraulic and Hydrologic Model: Simulation of rainfall runoff flows to estimate flooding and assess strategies to reduce flooding

Land Subject to Flooding: *TBD by City "Ensure that the definition includes the time horizon reoccurrence interval of the floodplain area. Defining the floodplain area to be that of a 500-year event will minimize confusion, Where National Flood Insurance Program data are unavailable or deemed by the Commission to be outdated or inaccurate, the boundary of said land may be based on the maximum lateral extent of flood water which has been observed or recorded, or other evidence presented and considered by the Commission, such as credible climate change projections. Such areas may or may not be characterized by wetland vegetation or soil characteristics."*

Nature-Based Solution: Nature-based solutions are adaptation measures focused on the protection, restoration, and/or management of ecological systems to safeguard public health, provide clean air and water, increase natural hazard resilience, and sequester carbon.

National Flood Insurance Program: A program managed by the Federal Emergency Management Agency (FEMA) to provide flood insurance to property owners, renters, and businesses via a network of more than 50 insurance companies.

Pervious Surface: A porous or permeable surface that allows water to flow through rather than runoff.

Performance Based Standards: Specified outcomes that can be achieved in a variety of ways. This provides flexibility and potential for innovative, cost-effective strategies unique to each project.

Resilience: Resilience is the ability of a system to prepare for, withstand, and recover quickly from a disaster. Ideally, resilient systems should recover from an event by becoming stronger than they were prior to the stress.

Resource Area Values: Without limitation, public or private water supply, groundwater, flood control, erosion and sedimentation control, storm damage prevention, water quality, water pollution control, wildlife habitat, rare species habitat including rare plant species, and recreation values, climate mitigation and resilience.

Resilient Massachusetts Action Team (RMAT): An inter-agency team that has developed the Climate Resilience Design Standards Tool to implement priority actions from the State Hazard Mitigation and Climate Adaptation Plan.

Storm Damage Prevention: The prevention of damage caused by water from storms, including, but not limited to: erosion and sedimentation; damage to vegetation, property, or buildings; or damage caused by flooding, water-borne debris, or water-borne ice.

Solar Reflectance Index (SRI): A measure from 0 to 100 of a surface's ability to reflect solar energy where a black surface is 0 and a white surface is 100.

Urban Heat Island: Urban areas with higher temperatures than surrounding rural areas.

Vulnerability: The propensity or predisposition to be adversely affected; for example, as applied to building performance (functionality), damage, or the number of people injured. Vulnerability is a function of exposure, sensitivity, and adaptive capacity.

Watershed: The surface area that contributes runoff to a point of interest.