RESILIENTMASS ACTION TEAM (RMAT)

CLIMATE RESILIENCE DESIGN STANDARDS & GUIDANCE

GLOSSARY OF TERMINOLOGY

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GLOSSARY OF TERMINOLOGY

The terms provided in the table below are used in the Climate Resilience Design Standards and Guidance and in the Climate Resilience Design Standards Tool. Options or examples are provided where applicable. The definitions used in this Glossary are tailored specifically for the Climate Resilience Design Standards and Guidance and are not inclusive of more general industry definitions.

Glossary Legend:

Climate Resilience Design Standards and Guidance Project - specific terms
Industry-accepted climate resilience terms

Terms	Description	Options or Examples
100-year floodplain	Area with a 1% annual chance of flooding (or 1 in 100 chance)[1]. Also known as a 1% Annual Exceedance Probability (AEP) flood event (see definition for Annual Exceedance Probability below).	Flood Insurance Rate Maps (FIRM) show the extent of the FEMA-defined 100-year floodplain. See definition for Flood Insurance Rate Map below.
500-year floodplain	Area with a 0.2% annual chance of flooding (or 1 in 500 chance).[1] Also known as a 0.2% Annual Exceedance Probability (AEP) flood event (see definition for Annual Exceedance Probability below).	Flood Insurance Rate Maps (FIRM) show the extent of the FEMA-defined 500-year floodplain. See definition for Flood Insurance Rate Map below.
Accommodate	Adaptation strategy that mitigates the potential impact of a hazard by making space for, or buffering, the associated climate condition.	Wet floodproofing, elevation of critical infrastructure.
Adaptation	An action that seeks to reduce vulnerability and risk to an anticipated climate impact. For the Tool, this term is focused on the design of physical assets only.	Flood barriers, stormwater infiltration, living shorelines, elevated infrastructure, increased tree canopy.

[1] Federal Emergency Management Agency (FEMA), "Flood Zones." https://efotg.sc.egov.usda.gov/references/public/NM/FEMA_FLD_HAZ_guide.pdf

Terms	Description	Options or Examples
Air Quality Improvement	Project components that mitigate adverse impacts from increased atmospheric greenhouse gas concentrations and other toxic air pollutants.	For instance, the restoration or protection of woodlands and urban tree planting can improve air quality through the uptake of ozone, ammonia and particulates.
Annual Exceedance Probability (AEP)	Probability of a flood event being equaled or exceeded in a given year.	The 0.2% AEP flood event has a 1 in 500 chance of being equaled or exceeded in any year (return period of 500 years, "500-year flood").
Annual/ Summer/ Winter Average Temperatures	Average Temperatures represent the daily average temperature over a period of time: Annual represents January through December, Summer represents June through August, and Winter represents December through February. Annual Temperatures are anticipated to increase with climate change, but the rate of change varies depending upon the season.	
Anticipated Useful Life	The useful life represents the estimated number of years before the project will require significant reconstruction or renovation to continue performing its normal function(s). This differs from the design life, which is typically shorter (see definition below). Considering the anticipated useful life of an asset can help inform decisions about resilience-related investments.	A park's typical anticipated useful life is 30 years.
Asset	Assets are major physical components of a project and organized into three main Asset Categories (see definition below). Also known as Physical Assets (see definition below).	In the Draw 7 Park case study project, the park and living shoreline are assets.
Asset Category	Division of Physical Assets into high-level primary groups for a project.	Building/Facility, Infrastructure, and Natural Resources.

Terms	Description	Options or Examples
		In the Draw 7 Park case study project, both the park and living shoreline belong to the Natural Resources Asset Category.
Asset Type	Assets organized by Asset Categories (Buildings, Infrastructure, or Natural Resources)	Buildings: typically occupied/unoccupied. Infrastructure: Transportation, utility, flood control, etc. Natural Resources: coastal resource area, forested ecosystem, aquatic ecosystem, etc. In the Draw 7 Park case study project, the living shoreline is an example of a coastal wetland resource area Asset Type.
Asset Sub-Type	Sub-categories or sub-classes under each Asset Type	Buildings: hospitals, maintenance facility, etc. Infrastructure: roads, culverts, dams, etc. Natural Resources: salt marsh, upland forest, streams, etc. In the Draw 7 Park case study project, the living shoreline is an example of a coastal wetland Asset Sub-Type.
ATTENTION – Sea Level Rise / Storm Surge	Attention messages that appear after design criteria value output tables, when the project polygon is located in an area that is influenced by wave overtopping, is influenced by combined effect of direct flooding and wave overtopping based flooding, intersects dynamic landform areas, or intersects areas that are low probability flooding	ATTENTION: This project intersects areas influenced by wave overtopping based flooding These areas are where flooding is caused by intermittent pulses that come from wave run-up and overtopping at a coastal structure. Additional site analyses are

Terms	Description	Options or Examples
	zones with minimal flood risk and small depth of flooding.	recommended to establish design values associated with design criteria.
ATTENTION – Extreme Precipitation	Attention messages that appear after design criteria value output tables, when an asset is a Tier 3 Dams & Flood Control Structures asset, or an asset is a Tier 1 asset.	ATTENTION: This is a Tier 3, Dams & Flood Control Structures project. Due to the criticality and useful life of this project, it is recommended that NCHRP15-61 method be used to calculate total precipitation depth for 24-hour design storms, and those results be compared to the provided total storm depth output: Tier 3 estimation methods PDF.
Base Flood Elevation (BFE)	The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year.[2]	The BFE is typically provided within the 100-year flood extent shown on FEMA Flood Insurance Rate Maps (FIRM).
Best Practices	Successful activities exemplified in case studies. Available to provide examples for how the Guidance are best applicable to a project.	Downloadable resources and case studies, such as Boston Public Works Department Climate Design Guidance, or the Draw 7 Park case study project example.
Boston Harbor Flood Risk Model (BH-FRM)	A hydrodynamic model created in 2015 to identify projected flood risk and depth from coastal storms and sea level rise.	
Buildings	Structures that are typically occupied or unoccupied. Buildings are an asset category in the Tool.	Typically Occupied asset sub-types: Hospitals Typically Unoccupied asset sub-types: Pump Station

[2] FEMA - National Flood Insurance Program Terminology Index, 2020. https://www.fema.gov/flood-insurance/terminology-index#:~:text=any%20given%20year.-,Base%20Flood%20Elevation%20(BFE),level%20in%20any%20given%20year.

Terms	Description	Options or Examples
Carbon Sequestration	Project components that enable the uptake of carbon containing substances, in particular carbon dioxide, in terrestrial or marine reservoirs.	Nature-based climate solutions which may serve as carbon sinks or reservoirs include restoration or protection of woodlands, peatlands and salt marshes along with improved agricultural practices to manage the use of synthetic fertilizers and planting cover crops on croplands.
Case Study	Real-world project that was used to illustrate application of guidance.	DCR's Draw Seven Park in Somerville, MA
Climate Change	According to the Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) climate change refers to "a change in the state of the climate that can be identified by statistical changes of its properties that persist for an extended period, whether due to natural variability or as a result of human activity."[3]	Temperatures are increasing, rainfall events are becoming more frequent and intense, and sea levels are rising.
Climate Resilience Design Guidance (the Guidance)	The Guidance are supplemental resources that provide useful instructions and best practices for implementing the Standards (see definition for Climate Resilience Design Standards below).	The Guidance constitute design principles related to site suitability, flexible adaptation strategies and regional coordination that are illustrated through forms and specific "best practices," which may include case studies and/or existing published resources that exemplify the Guidance.
Climate Resilience Design Standards Tool (the Tool)	The Tool provides Climate Risk Screening (preliminary exposure rating and risk rating) and Climate Resilience Design Standards (see definition below) based on Project Inputs.	

[3] Massachusetts State Hazard Mitigation and Climate Adaptation Plan, 2018. https://www.mass.gov/service-details/massachusetts-integrated-state-hazard-mitigation-and-climate-adaptation-plan

Terms	Description	Options or Examples
Climate Resilience Design Standards (the Standards)	A Climate Resilience Design Standard is a scientifically based process or method that produces a consistent outcome, which uniformly guides users in the selection of planning horizons, return period, and flexible design criteria, by climate parameter. The Standards provide "what you design to" in a project.	For example, the Climate Resilience Design Standards for the Draw 7 Park case study project include recommended target planning horizon of 2070, 1% AEP for return period, and design criteria of peak flood elevation for sea level rise/storm surge corresponding to design criteria value of 13.9 ft-NAVD88 determined from the Massachusetts Coast Flood Risk Model (MC-FRM).
Climate Parameters	The primary climate hazards referenced by the Standards.	Sea level rise and storm surge, extreme precipitation, and extreme heat.
Climate Vulnerable Populations	Climate vulnerable populations are those who have lower adaptive capacity or higher exposure and sensitivity to climate hazards like flooding or heat stress due to factors such as access to transportation, income level, disability, racial inequity, health status, or age.	Climate vulnerable populations could include people with disabilities, people experiencing homelessness, elderly residents, children, and others.
Consequence of Impact	According to SHMCAP, Consequence is defined as "the effect of a hazard occurrence. Consequence is demonstrated by the impact on population, physical property (e.g., state facilities, local jurisdiction assets and general building stock, and critical facilities), responders, operations, the environment, the economy, and public confidence in state governance. A consequence analysis meets the EMAP standard for hazards identified in state plans."[4]	For example, the public health and safety impact for an infrastructure asset could be that loss of infrastructure may result in severe injuries, possible loss of life.

[4] Massachusetts Integrated State Hazard Mitigation and Climate Adaptation Plan, 2018. https://www.mass.gov/service-details/massachusetts-integrated-state-hazard-mitigation-and-climate-adaptation-plan

Terms	Description	Options or Examples
	Consequence of Impact is evaluated as part of severity in the Criticality calculation of the Tool.	
Construction Type	Proposed type of project related to asset construction.	Reconstruction, Rehabilitation, New Construction, Major Repairs
Cooling Degree Days & Heating Degree Days (base = 65°F)	Cooling Degree Days (CDD) is a metric used to inform the energy consumption needed to cool indoor spaces for occupancy comfort when outside temperatures exceed 65°F. CDD measures the difference between the average daily temperature and 65°F. For example, if the average temperature for the day is 95°F, the difference between 65°F results in 30 CDD for that day. Heating Degree Days (HDD) is a metric used to inform the energy consumption needed to heat indoor spaces for occupancy comfort when outside temperatures are below 65°F. HDD measures the difference between the average daily temperature and 65°F. For example, if the average temperature for the day is 35°F, the difference between 65°F results in 30 HDD for that day.	
Criticality	Score that expresses the consequences of failure of an asset as a function of scope, time, and severity. Criticality is an internal metric in the Tool and is expressed as low, medium, or high. See definitions for scope, time, and severity below.	A hospital located in the 100-year floodplain would have a higher criticality.
Cultural Resources/Education	Project components that 1) provide opportunities for environmental education, scientific study or research, or 2) protect important archaeological or historic sites, areas with unique biological communities, geologic or	

Terms	Description	Options or Examples
	aesthetic features, or cultural heritage values.	
Cumulative Probability	Cumulative probability is the measure of the total probability that a certain event will happen during a given period of time. (Commonly referred to as cumulative risk.)	For a 1% annual chance flood event (the 100-year flood) the cumulative probability during the average 30-year mortgage is actually about 25% (or a 1 in 4 chance).
Days Per Year With Maximum Temperature > 95°F, >90°F, <32°F	Temperatures above 90°F and above 95°F are considered heat and extreme heat events in New England, respectively. Temperatures below 32°F are considered freezing events. An increase in Number of Days Per Year with Maximum Temperature above 90°F and 95°F may lead to an extended summer season. A decrease in Number of Days per Year with Minimum Temperatures below 32°F may lead to less snowfall and a shorter "traditional" New England winter season.	
Decarbonization	Projects that reduce overall carbon emissions through strategies such as using heat pumps for heating and cooling of buildings, or renewable energy sources for electric supply. Projects proponents should refer to the DOER Leading by Example program[5] for additional guidance on decarbonization strategies.	
Design Criteria	Recommended parameters to incorporate into design of physical assets based on asset type and location.	Base flood elevation, cooling degree days, 24-hour rainfall depth, and more.
Design Criteria Value	A numeric value of a design criterion provided by the Climate Resilience Design Standards tool or calculated by the user, based on the Climate	Example: the projected 2070, total precipitation 24-hr rainfall depth is 8.2 inches.

[5] https://www.mass.gov/orgs/leading-by-example

Terms	Description	Options or Examples
	Resilience Design Standards recommended methods.	
Design Flood Velocity	Flood Velocity describes the speed and direction of floodwaters in terms of distance/time (for example feet per second or miles per hour). Flood Velocity is important for assessing the flood-induced forces on different structures, i.e., low flow/static flooding will place different stressors on a structure than high speed flows. The projected Flood Velocity is the estimated velocity associated with the recommended return period and planning horizon.	
Design Life	The life expectancy of a project as typically used for design.	This is also known as service life and is generally less than a project's "anticipated useful life" (see definition above).
Design Storm	The magnitude and temporal distribution of precipitation from a storm event defined by probability of occurrence (e.g., five-year storm) and duration (e.g., 24 hours), used in the design and evaluation of stormwater management systems.[6]	The present day 10-year 24-hour design storm for Worcester, MA is 4.9 inches of rainfall depth according to NOAA Atlas 14.
Duration of Flooding	Duration of Flooding is the length of time from when the tide surpasses the mean higher high water (MHHW) tidal datum to when it recedes below the MHHW. Duration of Flooding is important because it correlates to the level of impact of the flood (e.g., the amount of damage done, the amount of time power is out, etc.).	
Ecosystem Services	The direct and indirect benefits as a result of ecosystems provided by natural resources.	Flood protection, stormwater infiltration, pollution protection,

[6] Philadelphia Stormwater Management Guidance Manual, Version 3.1., 2018. By the Philadelphia Water Department. https://www.pwdplanreview.org/manual/appendices/a.-glossary

Terms	Description	Options or Examples
		oxygen production, wildlife habitat, etc.
Ecosystem Benefits (EB) Score	Evaluation of the ecosystem services provided by natural resources and the benefits to natural ecosystems for the overall project (Low, Medium, or High). EBs are ranked on a points scale, and project evaluation will result in a Low, Medium, or High score. The types of ecosystem services and benefits evaluated include the following: 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.	The EB score is determined by summing the points for all "Yes" responses provided for the ecosystem benefits and services. A response of "No" to the ecosystem benefits results in zero points. The total possible points equal 100, and the thresholds for low, moderate, and high are: Low EB Score (Less than or equal to 30 points) Moderate EB Score (31 to 59 points) High EB Score (Greater than or equal to 60 points)
Environmental Justice Populations	Environmental justice populations typically include climate vulnerable populations, who may have lower adaptive capacity or higher exposure and sensitivity to climate hazards like flooding or heat stress due to factors such as access to transportation, income level, disability, racial inequity, health status, or age.[7]	Environmental Justice populations include areas where: • 25% or more of the population identifies as a person of color • 25% or more of households have limited English fluency • Households with an annual median income equal to or less than 65% of the state median

[7] https://mass-eoeea.maps.arcgis.com/apps/webappviewer/index.html?id=1d6f63e7762a48e5930de84ed4849212

Terms	Description	Options or Examples
Existing Sources of Pollution Remediation	Project components that remove existing pollutants or contaminants on-site.	Project examples may include aquatic habitat restoration through the dredging of contaminated sediments or removal of contaminated soil as part of a brownfield redevelopment.
Exposure	The extent to which something is in direct contact with climate parameters or their related climate change impacts. Exposure is often determined by examining the number of people or assets that lie within a geographic area affected by a climate parameter, or by determining the magnitude of the climate change impact.	For example, measurements of flood depth outside a building or number of heat waves experienced by a county are measurements of exposure.
Exposure Rating	The exposure rating is calculated based on the project location, useful life, and questions related to exposure.	Not exposed (for coastal and riverine only), low exposure, moderate exposure, and high exposure.
Exposure Service Life	Length of time within the design life or anticipated useful life that the asset is projected to be exposed to coastal flooding.	Exposure Service Life can be easily determined by evaluating the MC-FRM probability flood risk maps. For example, if a building with a 50-year anticipated useful is proposed to be built in 2020, but is not exposed to flooding until 2050, has an exposure service life of 20 years. See definition for MC-FRM below.
Filtering of Stormwater using green infrastructure	Projects that absorb and filter stormwater, such as through rain gardens, swales, or bio basins.	
Fisheries, Wildlife, and Plant Habitat Protection	Project components that preserve, enhance, or restore habitats important for conservation of fish, wildlife, and plant abundance and diversity.	

Terms	Description	Options or Examples
	Increasing habitat complexity within degraded systems typically leads toward greater production and higher levels of biodiversity. Incorporating or protecting critical habitat features for species of concern, managing invasive populations and providing connectivity to other habitat types are important considerations.	
Flexible Adaptive Pathways (AP)	Guidance category aimed at evaluating project design strategies that are able to adapt over time and respond to changing climate conditions, while encouraging climate mitigation, prioritizing nature-based solutions, and preparing for current and future operations and maintenance needs.	Imagine a major coastal roadway that needs to be elevated in the short-term. The design for this site could also include long-term approaches such as reducing impervious area, increasing tree canopy, and creating a living shoreline. Learn more by checking out the "Route 28 and Falmouth Harbor" Case Study.
Flood Insurance Rate Map (FIRM)	Official map of a community on which FEMA has delineated the Special Flood Hazard Areas (SFHAs), the Base Flood Elevations (BFEs), and the risk premium zones applicable to the community, based on historic information.[8] See definitions for 100- and 500-year floodplains, and BFE, above.	FIRMs are available on the FEMA Flood Map Service Center online.
Flood Protection (through nature-based solutions)	Project components that prevent or reduce inland or coastal flooding and flood damage to project assets (or other natural areas or infrastructure), through water infiltration, retention, redirection, or buffering of water flow using nature-based solutions. Nature-based solutions are adaptation measures focused on the protection, restoration, and/or management of ecological systems to safeguard public	Examples of nature-based solutions may include floodplain restoration through to reconnection of a floodplain to the waterway, restoration or protection of stream-side wetland systems, riparian zones and buffers.

[8] FEMA National Flood Insurance Program Terminology Index, 2020. https://www.fema.gov/flood-insurance/terminology-index

Terms	Description	Options or Examples
	health, provide clean air and water, increase natural hazard resilience, and sequester carbon.	
Forms	Questions provided to guide users through design considerations, document design, and decision-making based on Guidance. Serves as documentation for inputs/outputs from the Tool, the design criteria values calculated from recommended tiered estimation method, and overall project information and costs.	An example of a Form question related to site suitability is, "Does the site currently function as the primary asset type?"
Freeboard	Freeboard is a factor of safety usually expressed in feet above a flood level for purposes of floodplain management.[9]	Freeboard is typically recommended to be at least 1 ft., but FEMA regulations may require additional freeboard requirements based on criticality and asset type.
Geographic Area	Geographic area affected by the permanent loss or inoperability of the asset.	For example, loss of a bridge could be a local impact, or a regional impact based on the location of the bridge and alternative routes.
Groundwater Recharge	Project components that promote the infiltration of surface waters to the groundwater table such as through stormwater infiltration and retention using green infrastructure or nature-based solutions. Co-benefits of this practice include reduction in flooding, contributions to stream base flow and drought amelioration.	
Growing Degree Days	According to the Climate Smart Farming program at Cornell University, Growing Degree Days (GDD) "measures heat accumulation to help agricultural producers predict when a crop will reach important developmental	

[9] NH Coastal Flood Risk Science and Technical Advisory Panel (2020). New Hampshire Coastal Flood Risk Summary, Part II: Guidance for Using Scientific Projections. Report published by the University of New Hampshire, Durham, NH.

Terms	Description	Options or Examples
	stages. It can also be used to help predict potential pest and disease threats." Growing Degree Days (GDD) are a measure of heat accumulation that can be correlated to express crop maturity (plant development). GDD is calculated by subtracting a base temperature of 50°F from the average of the maximum and minimum temperatures for the day. Minimum temperatures less than 50°F are set to 50, and maximum temperatures greater than 86°F are set to 86. These substitutions indicate that no appreciable growth is detected with temperatures lower than 50° or greater than 86°. Increases in daily average temperatures over 50°F will result in an increase in GDD.	
Heat Index	The National Weather Service (NWS) Heat Index or the "real feel" is based on temperature and relative humidity. The Heat Index is what the temperature feels like to the human body when relative humidity is combined with the air temperature and is measured in °F. The NWS Heat Index considers shady and light wind conditions but does not account for strong winds or full sun exposure. Exposure to full sunshine can increase Heat Index values by up to 15°F and strong wind of very hot dry air can be detrimental to public health and safety. The NWS uses the Heat Index to issue warnings and advisories relevant to public health considerations when daytime heat indices is more than 100°F for two or more hours.	
History of Flooding	Projects that have evidence of flooding since 1990, as indicated by State and/or local hazard mitigation plans, the NOAA Storm Events Database, or Town/ local historical records. Flooding should not include utility damages (sewer, water, etc.)	Coastal flooding examples include inundation of roads, infrastructure, or structures due to spring tides, King tides,

Terms	Description	Options or Examples
		nor'easters, tropical storms, etc. Riverine flooding examples include inundation of roads, infrastructure, or structures due to overbank flooding, flash flooding, etc. Urban/stormwater flooding examples overwhelmed drainage capacity, excessive stormwater runoff, inundation of built structures, etc.
Hydrodynamic	Hydrodynamics refers to the science which deals with the movement of liquids. Hydrodynamic models rely on this science, as well as mathematical and statistical analysis, to forecast storms and coastal flooding (related to storm surge and tides).[10]	
Infrastructure	Infrastructure is an Asset Category in the Tool. Refer to definition for Asset Category above.	Examples of infrastructural asset sub-types include transportation, flood control, utilities, solid and hazardous waste.
Intermediate Planning Horizon	Recommended Interim Planning Horizon if the Target Planning Horizon is not achievable in design (i.e., a 2070 target planning horizon, but a 2050 intermediate planning horizon).	For example, if an asset is expected to last through 2065, 2070 should be the target planning horizon for its design. However, if design considerations of the asset are not able to accommodate the 2070 climate projections due to site-specific restrictions or other design limitations,

[10] NOAA, Hydrodynamic Models. https://nauticalcharts.noaa.gov/learn/hydrodynamic-model-development.html

Terms	Description	Options or Examples
		then it is recommended that the asset be at least designed to the intermediate 2050 climate projections.
Land Containing Shellfish Protection	Project components that preserve, enhance, or restore coastal habitats important for conservation of shellfish abundance and diversity. As an important component of coastal ecosystems, shellfish support both commercial and recreational fisheries, provide nutrient mitigation, reduce shoreline erosion, provide nursery habitat, and support recreation and cultural heritage values.	Project examples may include living shorelines or breakwaters and oyster reef restoration.
Massachusetts Coast Flood Risk Model (MC-FRM)	The projected sea level rise / storm surge data values provided through the Tool are based on the Massachusetts Coast Flood Risk Model (MC-FRM) outputs as of 9/13/2021, which included GIS-based data for three planning horizons (2030, 2050, 2070) and six return periods (0.1%, 0.2%, 0.5%, 1%, 2%, 5%). These values are projections based on assumptions as defined in the model and the LiDAR used at the time, for a hydrodynamic, probabilistic model that considers hundreds of thousands of historic and simulated storms. For additional information on the MC-FRM, review the additional resources provided on the Start Here page.	
Natural Resources	Natural Resources is an Asset Category in the Tool, which is a high-level primary group of physical assets. Refer to definition for Asset Category above.	Examples of natural resources asset sub-types include coastal resource areas, forested ecosystems, aquatic ecosystems, wetland resource areas (inland), agricultural resources, and open space.

Terms	Description	Options or Examples
Nature-based Solutions	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.	For example, a traditional engineered solution for urban flooding due to extreme precipitation may be retrofitted urban storm-water drainage systems. An alternative nature-based solution would be green roofs, bio swales, or rain gardens to filter, absorb, and manage stormwater runoff, further reducing flows into a main drainage system.
NOAA Atlas 14	Precipitation frequency estimates data server, provided by NOAA.[11]	
Number of Heat Waves Per Year & Average Heat Wave Duration	A Heat Wave is defined as three or more consecutive days with maximum temperatures of 90°F or above. Number of Heat Waves represents number of events (with one event representing at least three consecutive days with maximum temperatures of 90°F), and Average Heat Wave Duration represents the number of days for the average duration of each event over the year. Heat Waves are a public health and safety threat that may result in heat-related deaths. According to World Health Organization (WHO), Heat Waves, "can burden health and emergency services and also increase strain on water, energy and transportation resulting in power shortages or even blackouts. Food and livelihood security may also be strained if people lose their crops or livestock due to extreme heat."	
Oxygen Production	Project components that generate oxygen through photosynthesis by	Project examples may include green roofs and

[11] NOAA Atlas 14 Point Precipitation Frequency Estimates: Northeastern States; NOAA Atlas 14, Volume 10, Version 3

Terms	Description	Options or Examples
	plants, trees, and other vegetation as part of nature-based solutions.	living walls in urban settings, restoration, or protection of woodlands in terrestrial settings, or restoration of submerged aquatic vegetation (eel grass) in coastal areas.
Percentile	Climate projections for heat were developed through EEA's Massachusetts Climate and Hydrologic Risk Project. The downscaled analysis included 20 Global Climate Models (GCMs) to model thermodynamic climate change. More about that project can be found on ResilientMA.org. The resulting climate projections are presented as a range of values based on the uncertainties across the GCMs, with a lower, median, and upper bound. These bounds represent a percentile, which is known as a statistical value in which a certain percentage of numbers falls below that value.	Consider this definition in the context of heat with the following example: The 90th percentile for the number of days greater than 90°F in 2070 is 63 days, whereas the 50th percentile (the median) is 43 days. This means that the average likelihood of days over 90°F in the 2070 planning horizon is 43 days, while only 10 out of 100 times is it expected that the number of days over 90°F in 2070 is expected to exceed 63 days. In other words, there's a 90% chance that there will be 63 or less days in 2070 that are greater than 90°F.
Physical Assets	See definition for Assets above.	See examples for Assets above.
Planning Horizon	A future date to which a project can be designed, which allows the project to incorporate anticipated climate change conditions.	Present (2030), Mid-Century (2050), Mid-late Century (2070), End of Century (2090/2100)
Pollinator Habitat Provider	Project components that provide feeding, nesting, or stopover habitat for pollinators (i.e., hummingbirds, butterflies, moths, beetles, wasps, and most importantly bees). Pollinators are critical for agricultural productivity as well as the many co-benefits provided by a heathy ecosystem.	Project examples may include rain gardens with native shrubs that feed bees.

Terms	Description	Options or Examples
Population Affected	The number of people who directly use or receive services from this asset.	For example, in a residential building, the number of people directly served or affected by the building are the number of residents.
Pollution Prevention	Projects that prevent the release of pollutants, including but not limited to contaminants (atmospheric, groundwater, or soil), wastewater (storm or sewage), or other hazardous waste.	Project examples may include nature-based solutions that protect a landfill from coastal erosion.
Project Inputs	Information provided by the user about the project and project assets.	Inputs could include project details and location, asset information, project exposure questions, and project criticality questions
Protect	Adaptation strategy that blocks/prevents the climate parameter from impact.	Flood barrier, dry floodproofing, reflective roofs, lighter colored paver materials, bio retention basins, infiltration trenches, underground storage tank.
Public Water Supply Protection	Projects that reduce the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption.	Land protection strategies within wellhead protection zones along with other nature-based solutions or green infrastructure designed to reduce pollutant loads from stormwater are examples.
Recreation Provision	Project components that provide active or passive recreational opportunities (such as swimming, paddling, bird watching, hiking or exercise activities) for the public through the use of outdoor spaces.	
Recurrence Intervals	Also known as return period. Please refer to definition of return period.	

Terms	Description	Options or Examples
Regional Coordination (RC)	Guidance category aimed at understanding how coordination and collaboration across regions, as well as State Agencies and jurisdictions, can help strengthen resilient designs and implementation.	Imagine a park sited at a major flood pathway impacting two cities and critical state infrastructure. Resilience design and implementation would need to be coordinated across agencies and jurisdictions. Learn more by checking out the "Draw Seven Park" Case Study.
Representative Concentration Pathways (RCP)	Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its Fifth Assessment Report in 2014. The Representative Concentration Pathways (RCPs), which are used for making projections based on these factors, describe four different 21st century pathways of greenhouse gas emissions and atmospheric concentrations, air pollutant emissions and land use.[12]	The RCPs include a stringent greenhouse gas mitigation scenario (RCP 2.6), two intermediate scenarios (RCP 4.5 and RCP 6.0) and one scenario with very high greenhouse gas emissions (RCP 8.5).
ResilientMass Action Team (RMAT)	An inter-agency team tasked with implementing the State Hazard Mitigation and Climate Adaptation Plan (SHMCAP).[13] Members of the RMAT provided project management for the development of the Tool.	
Return Period	Annual probability of occurrence of an event. Also known as recurrence interval. Used in design based on risk tolerance of the asset.	For example, a critical building, such as a hospital that needs to be functioning at all times, has a lower risk tolerance and hence the 0.1% (or 1000-year) recurrence interval is recommended for design. However, a recreational facility, such as a

[12] Climate Change 2014: Synthesis Report, 2014. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf
[13] Resilient MA Action Team (RMAT) https://www.mass.gov/info-details/resilient-ma-action-team-rmat

Terms	Description	Options or Examples
		recreation center, has a higher risk tolerance and hence the 20% (or 5-year) recurrence interval is recommended for design.
Risk	According to SHMCAP, risk is defined as “the potential for an unwanted outcome resulting from a hazard event, as determined by its likelihood and associated consequences; and expressed, when possible, in dollar losses. Risk represents potential future losses, based on assessments of probability, severity, and vulnerability.”[14]	For example, if a state highway is flooded that also serves as an evacuation route, it will have a high probability of flooding and its consequence of flooding (as measured by its severity, with respect to geographic area and people affected, economic impacts and cascading impacts to other infrastructure) will also be high, which would lead to a high risk rating.
Risk Rating	A preliminary asset-specific screening based on the project’s exposure rating and asset’s criticality, by climate parameter.	Low, Moderate, or High Risk.
Riverine Peak Discharge & Peak Flood Elevation	Riverine Peak Flood Elevation is defined as the elevation of surface water resulting from, or anticipated to result from, the flooding of a river. Riverine Peak Discharge is defined as the highest discharge rate usually displayed as cubic feet per second (CFS). Riverine flooding examples include inundation of roads, infrastructure, or structures due to extreme precipitation resulting in overbank flooding or flash flooding.	
State Hazard Mitigation and Climate Adaptation Plan (SHMCAP)	The SHMCAP for the Commonwealth was adopted on September 17, 2018. This plan, the first of its kind to comprehensively integrate climate	

[14] Massachusetts Integrated State Hazard Mitigation and Climate Adaptation Plan, 2018. https://www.mass.gov/service-details/massachusetts-integrated-state-hazard-mitigation-and-climate-adaptation-plan

Terms	Description	Options or Examples
	change impacts and adaptation strategies with hazard mitigation planning, also complies with current federal requirements for state hazard mitigation plans and maintains the Commonwealth's eligibility for federal disaster recovery and hazard mitigation funding under the Stafford Act.[15] The SHMCAP was updated in 2023 under the new name "ResilientMass Plan".	
Sea level rise (SLR)	The worldwide average rise in mean sea level, which may be due to a number of different causes, such as the thermal expansion of sea water and the addition of water to the oceans from the melting of glaciers, ice caps, and ice sheets; contrast with relative sea-level rise.	
Scope	Used to evaluate criticality of an asset and is defined as the geographic area and population that would be affected by the loss or inoperability of that asset.	Affects greater than 10,000 people and vulnerable populations.
Scour & Erosion	Coastal Erosion "is the lowering of the ground surface as a result of a flood [or storm] event [or average tidal conditions], or [is] the gradual recession of a shoreline as a result of long-term coastal processes. Scour refers to a localized lowering of the ground surface due to the interaction of currents and/or waves with structural elements, such as pilings [and seawalls]. Soil [and sediment] characteristics influence an area's susceptibility to scour. Erosion and scour may affect the stability of foundations and filled areas and may cause extensive site damage."[16]	
Sensitivity	The impact on a system, service, or asset when exposed to climate parameters. The level of sensitivity indicates how much or to what extent a	For example, how much a facilities ability to function

[15] https://www.mass.gov/info-details/2023-resilientmass-plan
[16] https://www.fema.gov/sites/default/files/2020-08/fema543_design_guide_complete.pdf

Terms	Description	Options or Examples
	climate parameter would exceed an asset's threshold, such that it would disrupt the ability of the system, service, or asset to continue normal operation.	would be affected if exposed to storm surge.
Severity	Used to evaluate criticality of an asset and is defined as the consequences that are associated from the loss or inoperability of an asset.	For example, a lower severity Public Health and Safety Impact would be that loss of building may result in minor injuries. A higher severity would be that loss of life is expected as a result of loss of building.
Site Suitability (SS)	Guidance category aimed at evaluating how geographic location, existing conditions, and asset placement impact the sites' ability to serve its intended function, before, during, and after climate impacts.	Imagine a critical emergency facility sited in a flood-vulnerable location. When assessing options to update this facility, evaluating the site's risk and suitability early in the process can help reduce future exposure to climate impacts. Learn more by checking out the "MassDOT Fuel Depot Complex" case study.
Standards	The Climate Resilience Design Standards (referred to as Standards in the text) identify the basis of design for an asset. See definition for Climate Resilience Design Standards above.	See example provided with definition for Climate Resilience Design Standards above.
Storm Damage Reduction	Project components that take measures to mitigate the severity and consequence of storm conditions and impacts, including winds, precipitation, storm surge, waves, ice, water flow, erosion, and sediment movement on an asset.	Nature-based solutions in the coastal zone may include living shorelines and the protection or restoration of tidal wetlands, dunes, or oyster reefs.
Storm Surge	An abnormal rise in sea level accompanying a hurricane or other intense storm, whose height is the	Storm surge is usually estimated by subtracting the normal or astronomic

Terms	Description	Options or Examples
	difference between the observed level of the sea surface and the level that would have occurred in the absence of the cyclone.[17]	tide from the observed storm tide.
Tidal Datums	A tidal datum is a standard elevation framework used to track local water levels as measured by a tide gauge station. Tidal datums are often the reference for shoreline or coastal property boundaries where an elevation related to local sea level is needed. Projected tidal datums are used to identify future shoreline locations based on sea level rise. This is provided as a data value output of the Tool from the Massachusetts Coast Flood Risk Model (MC-FRM).	Tidal datums corresponding to present and future tidal elevations are outputs of MC-FRM. For example, the present-day tidal datum for Boston Harbor corresponds to mean higher high water elevation of 4.77 ft-NAVD88.
Tier 1	Tier 1 estimation methods represent the lowest level of effort required to calculate design criteria values and are intended for projects that will be designed for today's climate and plan for the future. Tier 1 is only recommended for low and moderate criticality (as determined by the Tool's criticality questions) assets with a lifespan of less than 10 years.	Using USGS StreamStats Tool[18] to estimate the 1% AEP (100-year) riverine peak flow is an example of a Tier 1 level of effort to determine the design criteria value corresponding to 1% peak discharge.
Tier 2	Tier 2 estimation methods represent the average level of effort required to calculate design criteria values and utilize existing established relationships between current and future climate scenarios and current design criteria to generate future climate design criteria values.	
Tier 3	Tier 3 estimation methods represent the highest level of effort required to use climate projections data and modeling to develop site-specific design criteria values. Tier 3 is	MC-FRM data is an example of a new modeling effort that produces site-specific design criteria values for

[14] Glossary – Storm Surge, 2009. National Weather Service. https://w1.weather.gov/glossary/index.php?word=Storm+Surge
[18] USGS StreamStats. https://streamstats.usgs.gov/ss/

Terms	Description	Options or Examples
	recommended medium and high criticality (as determined by the Tool's criticality questions) assets with a longer lifespan.	projects. Once the data are available, the level of effort goes down.
Tiered Estimation Method	Recommended methods to establish asset-specific design criteria values by climate parameter. Tiered distinctions indicate level of effort in method approach.	Tier 3 Estimation Method for assessing average temperature at the end of asset's useful life. (MACA data analysis for RCP8.5, Group 1 GCMs.) See definition for Tier 3 above.
Time	Used to evaluate criticality and is defined as the length of time an asset can be inoperable without consequences.	The asset could be inaccessible/inoperable more than a week after natural hazard event without consequences.
Total Precipitation Depth & Peak Intensity for 24-hr Design Storms	Total Precipitation Depth for 24-hour Design Storms is the total amount of rain in inches that falls over a period of 24-hours. It can be any 24-hour period, not just a traditional calendar day. This is given for a specific design storm (return period) such as the 100-year or 10-year storm (1% or 10%). Peak Intensity is the maximum rate of rainfall in inches per hour of a 24-hour design storm.	
User	Person using the Climate Resilience Design Tool and related materials.	The anticipated user for these materials includes a Project Manager, Asset Owners, Technical Consultants, Program Managers, etc.
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.	For example, if the first floor of the building is exposed to flooding from extreme precipitation, and the primary generator is on the first floor, its sensitivity to flooding is high. But, if there is a backup generator on the second floor, the building has a

Terms	Description	Options or Examples
		high adaptive capacity and hence a moderate vulnerability rating.
Water Surface Elevation	Water Surface Elevation is the projected elevation for a specific future flood event, considering storm surge, tides, and wave setup. This is provided as a data value output of the Tool from the Massachusetts Coast Flood Risk Model (MC-FRM).	Water Surface Elevations from the MC-FRM, for an example project site. *Max* = 11.1 ft-NAVD-88 *Min* = 10.8 ft-NAVD-88 *Area Weighted Average* = 10.9 ft-NAVD-88
Water Quality Improvement	Projects that mitigate adverse impacts from increased temperature, nutrient, sediment, and pollutant inputs to waterbodies.	Project examples may include restoration or protection of riparian zones, vegetation filter strips.
Wave Action	Impacts from wave heights that can cause significant damage to structures that are constructed without considering coastal hazards[19].	Areas that experience wave heights of 1.5 ft or higher are subject to higher wave action.
Wave Action Water Elevation	The Wave Action Water Elevation represents the flood elevation with the projected Water Surface Elevation and Wave Heights associated with the recommended return period and planning horizons. This accounts for anticipated sea level rise, tidal datums, storm surge, and storm climatology through the Massachusetts Coast Flood Risk Model (MC-FRM), which is a hydrodynamic, probabilistic model that considers hundreds of thousands of historic and simulated storms.	Wave Action Water Elevations from the MC-FRM, for an example project site. *Max* = 16.2 ft-NAVD-88 *Min* = 10.8 ft-NAVD-88 *Area Weighted Average* = 12.69 ft-NAVD-88
Wave Heights	Wave height is measured in feet, and this value represents the maximum vertical distance between the highest point (crest or peak) and the lowest point (trough) of the wave. This is provided as a data value output of the	Wave Heights from the MC-FRM, for an example project site. *Max* = 7.5 ft *Min* = 0 ft

[19] FEMA Importance of the Limit of Moderate Wave Action Fact Sheet https://www.fema.gov/media-library-data/1436816523486-15e2af5cfc6514c156adacd337d3caed/FPM_1_Page_LiMWA.pdf

Terms	Description	Options or Examples
	Tool from the Massachusetts Coast Flood Risk Model (MC-FRM).	*Area Weighted Average* = 2.8 ft

1.1.1 ACRONYM LIST

AEP: Annual Exceedance Probability

AP: Flexible Adaptation Pathways

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers

BFE: Base Flood Elevation

BH-FRM: Boston Harbor Flood Risk Model

CSSR: Climate Science Special Report

CZM: Office of Coastal Zone Management

DCAMM: Division of Capital Asset Management and Maintenance

DCR: Department of Conservation & Recreation

DFE: Design Flood Elevation

DHCD: Department of Housing and Community Development

EOEEA: Executive Office of Energy and Environmental Affairs

EB: Ecosystem Benefits

FEMA: Federal Emergency Management Agency

FIRM: Flood Insurance Rate Map

GCM: Global Climate Models

GIS: Geographic Information System

GEV: Generalized Extreme Value Distribution

HEC-2: Hydrologic Engineering Center's -2

HEC-RAS: Hydrologic Engineering Center's-River Analysis System

IPCC: Intergovernmental Panel on Climate Change

LOCA dataset: Localized Constructed Analogs

MACA: Multivariate Adaptive Constructed Analogs

MassDOT: Massachusetts Department of Transportation

MC-FRM: Massachusetts Coast Flood Risk Model

MEMA: Massachusetts Emergency Management Agency

NCA4: Fourth National Climate Assessment

NOAA: National Oceanic and Atmospheric Administration

RC: Regional Coordination

RCP: Representative Concentration Pathway

RMAT: ResilientMass Action Team

SCS: Soil Conservation Service

SHMCAP: Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)

SLR: Sea Level Rise

SS: Site Suitability

USGS: United States Geological Survey