Climate Resilience Design Standards (CRDS) Tool:

A resource for mainstreaming climate resilience in Massachusetts projects.

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Executive Office of Energy and Environmental Affairs

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Presentation to the Massachusetts Water Resources Commission
January 9, 2025

Overview

- EEA Office of Climate Science
- What is the CRDS tool?
- Tool recommendations by climate hazard
- Tool recommended precipitation design standards
- Data deep dive> Climate-Informed Design Precipitation for Massachusetts
- Q&A

ResilientMass Plan Action: Launch an Office of Climate Science to…

- Serve as an authoritative resource, provide subject matter expertise on statewide climate data and models, and support consistent application of climate change information across agencies.
- Convene the academic climate science community and identify opportunities to partner with universities on climate science needs and next steps.

climatescience@mass.gov

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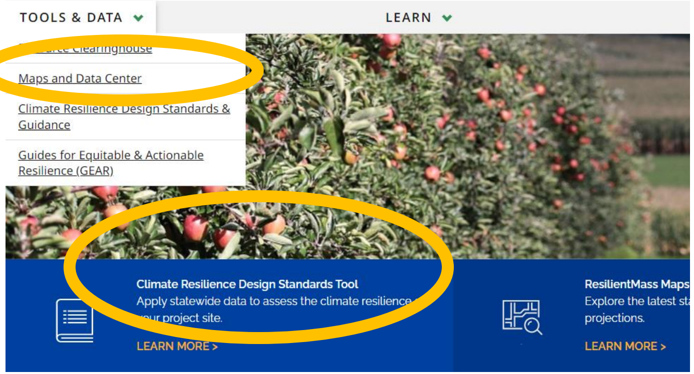
Climate Resilience Design Standards Tool: Overview

- Makes preliminary climate resilience analysis **more broadly accessible**
- Provide recommendations based on **consistent use** of state's climate data
- Provide a unified planning and design **support tool** that state agencies can use to administer grant programs



When to use this tool:

- Improving a state grant application
- Project siting
- Project planning and design/procurement

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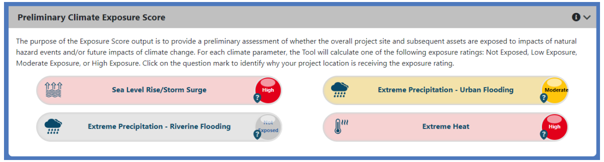
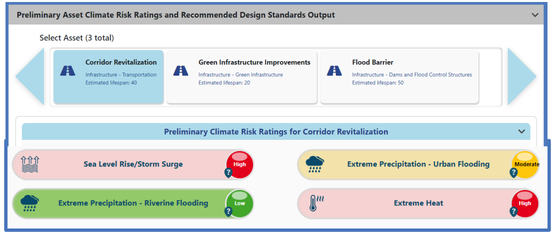
Climate Resilience Design Standards Tool: Overview

Project information



Exposure Scores for project site

Risk Ratings for each asset



Target Planning Horizon: 2070

Intermediate Planning Horizon: 2050

Return Period: 50-yr (2%)

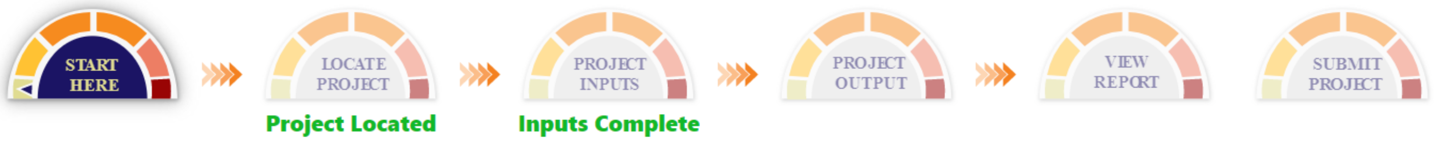
Preliminary Design Standards

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(ft - NAVD88)		
Pump Station	2050	2% (50-Year)	12.1	12.0	12.0
	2070		13.9	13.8	13.8

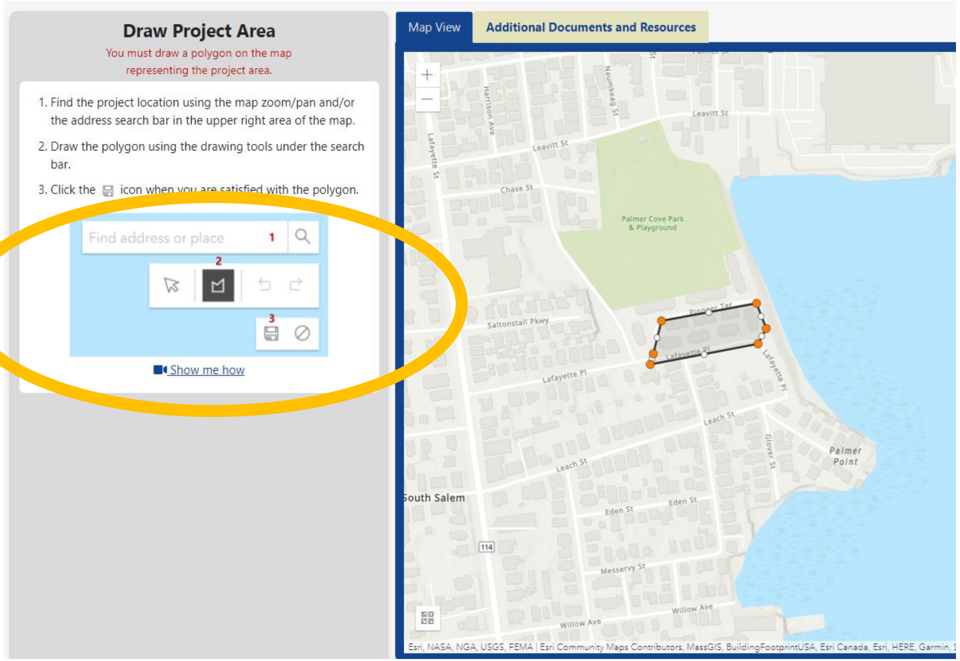
Recommended design considerations

CRDS Tool: Overview

Tool Reporting Workflow



Draw project footprint



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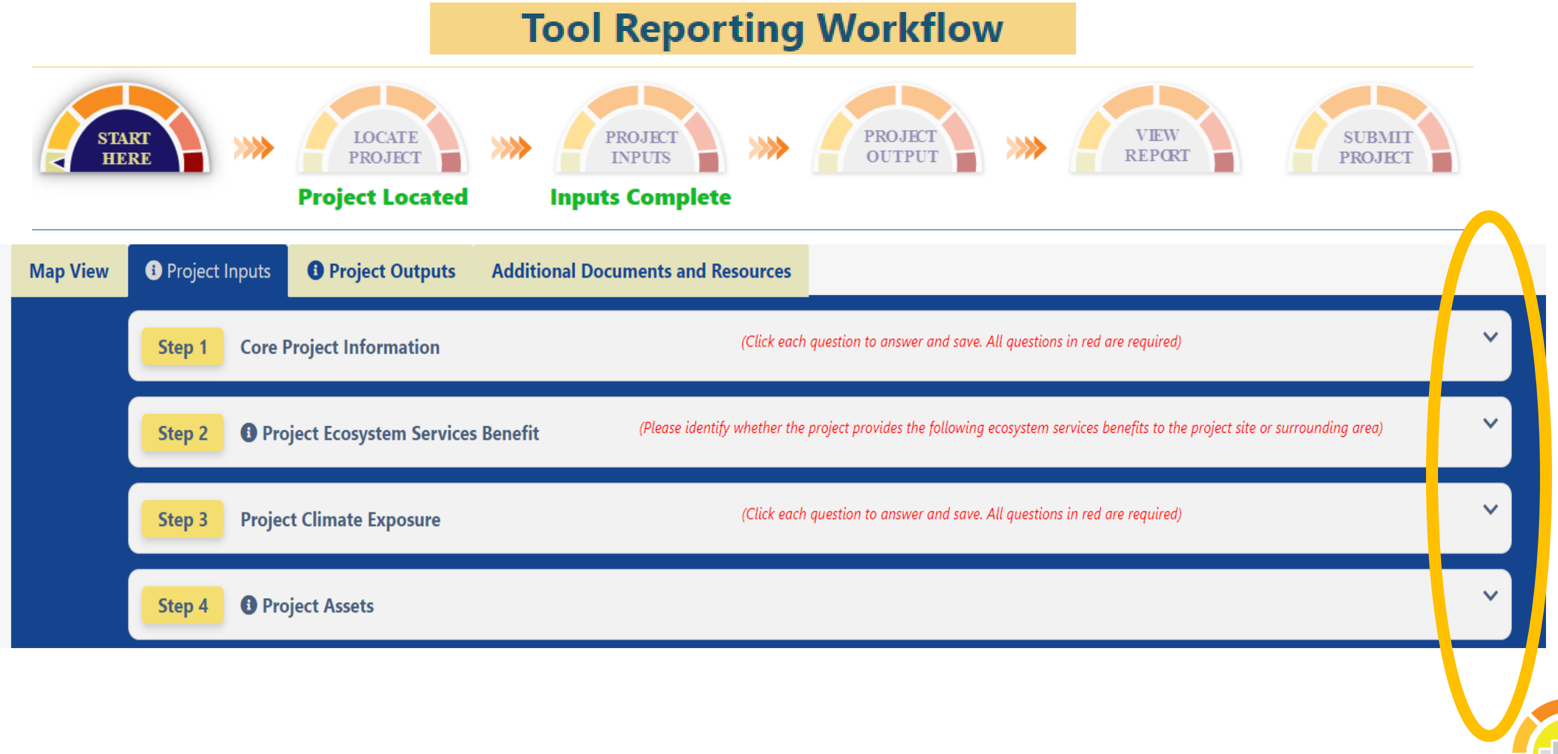
CRDS Tool: Project Inputs



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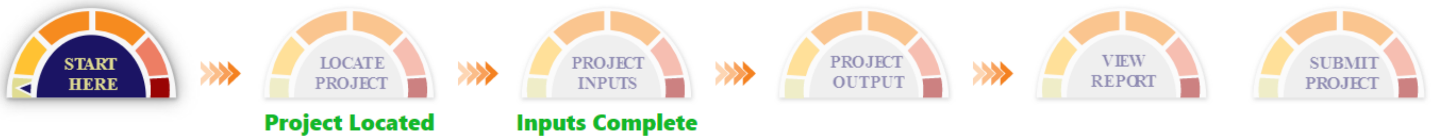
CRDS Tool: Project Inputs

Tool Reporting Workflow



Step 2 Project Ecosystem Services Benefit

Provides flood protection through green infrastructure or nature-based solutions	No
Provides storm damage mitigation	No
Provides groundwater recharge	No
Protects public water supply	No
Filters stormwater	No
Improves water quality	No
Promotes decarbonization	Yes
Enables carbon sequestration	Yes
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	No
Protects fisheries, wildlife, and plant habitat	No
Protects land containing shellfish	No
Provides pollination	No
Provides recreation	No

Step 3 Project Climate Exposure

Does the project site have a history of coastal flooding?	Yes
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	No
Does the project result in a net increase in impervious area of the site?	No
Does the project site have a history of riverine flooding?	No
Are existing trees being removed as part of the proposed project?	No

Step 4 Project Assets

Building/Facility Add
UserGuide Building

Infrastructure Add
N/A

Natural Resources Add
N/A

Selected Asset:	UserGuide Building
Asset Type:	Typically Occupied
Asset Sub-Type:	Residential building - Public Housing
Construction Type:	Maintenance (critical repair)
Construction Year:	2025
Useful Life:	15

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.	Building must be accessible/operable at all times, even during natural hazard event
Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.	Impacts would be limited to local area and/or municipality
Identify the population directly served that would be affected by the permanent loss of use or inoperability of	Less than 1,000 people

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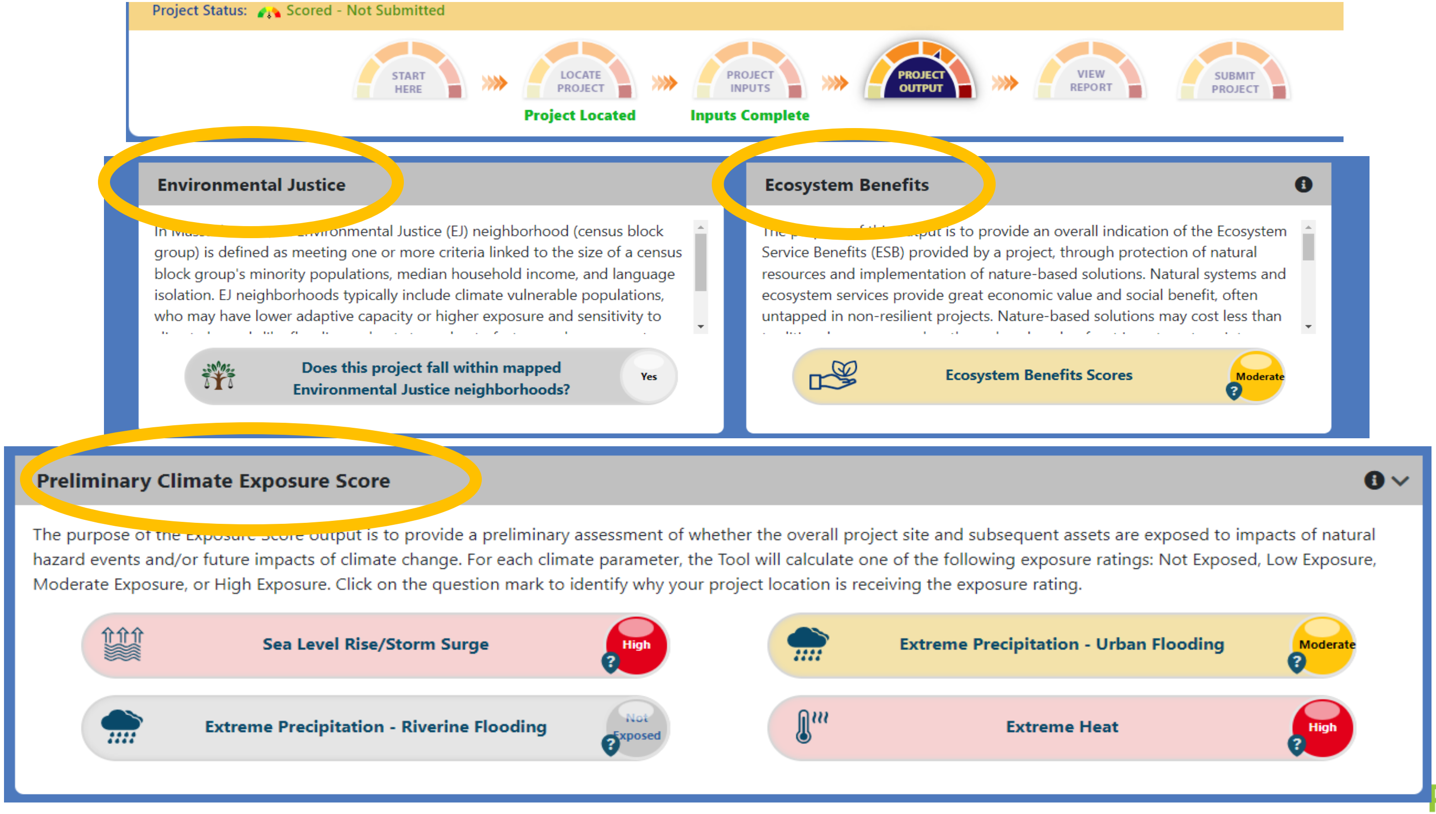
CRDS Tool: Project Outputs

Tool Reporting Workflow



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CRDS Tool: Project Outputs

Project Status: Scored - Not Submitted

START HERE » LOCATE PROJECT » PROJECT INPUTS » PROJECT OUTPUT » VIEW REPORT » SUBMIT PROJECT

Project Located | Inputs Complete

Additional Details Provided

Primary factors influencing High Exposure **Sea Level Rise/Storm Surge** score

- Exposed to the 1% annual coastal flood event as early as 2030
- Historic coastal flooding at project site
- Located within the 0.1% annual coastal flood event within the project's useful life

Preliminary Climate Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. Click on the question mark to identify why your project location is receiving the exposure rating.

Climate parameter	Rating
Sea Level Rise/Storm Surge	High
Extreme Precipitation - Urban Flooding	Moderate
Extreme Precipitation - Riverine Flooding	Not Exposed
Extreme Heat	High

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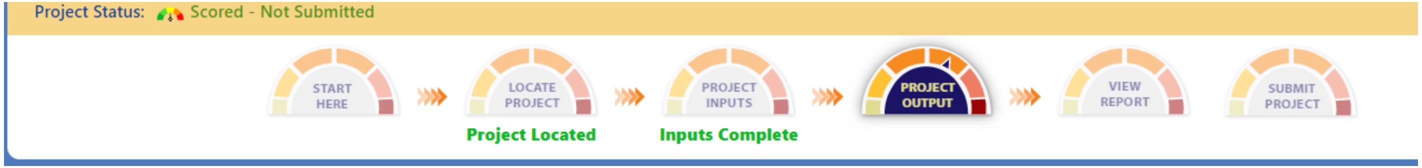
CRDS Tool: Project Outputs



Tool projects can accommodate multiple assets

*Will receive **climate risk** rating for **each asset** entered*

While it is possible to get a "no exposure" **project** score for "Sea Level Rise/Storm Surge" or "Extreme Precipitation – Riverine Flooding" because geographically dependent, the tool will still give an **asset risk score** (low).

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CRDS Tool: Project Outputs

Recommended Design Standards for test

Climate Resilience Design Standards are recommended for each asset and climate parameter. Tiered methodologies, or methodologies to calculate design criteria values, are intended for projects that will be designed for today's climate and plan for the future. The three tiers represent various recommended levels of effort for determining design criteria values, dependent upon the consequences of failure of an asset as a function of scope, time, and severity.

Sea Level Rise/Storm Surge | Extreme Precipitation | Extreme Heat

Target Planning Horizon: 2030

Percentile: 50th Percentile

Design Criteria Applicable for test

Projected Annual/Summer/Winter Average Temperatures

Definition

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.*

How to Estimate Projected Annual/Summer/Winter Average Temperatures Values

Asset Name	Recommended Planning Horizon	Recommended Percentile	Tiered Methodology	Step-by-Step Methodology
test	2030	50th	Tier 1	Downloadable Methodology PDF

*Note: Projected Annual/Summer/Winter Average Temperatures are not currently available through this Tool. Users should follow the step-by-step instructions outlined in the downloadable methodology PDF to estimate the projected Annual/Summer/Winter Average Temperatures based on the recommended planning horizon, percentile, and tiered methodology. The three tiers represent various anticipated levels of effort for calculating design criteria values, dependent upon the consequences of failure of an asset as a function of scope, time, and severity and useful life of the asset.

How Annual/Summer/Winter Average Temperatures may inform Planning

How Annual/Summer/Winter Average Temperatures may inform Early Design

How Annual/Summer/Winter Average Temperatures may inform Project Evaluation

*Will receive recommended standards and design criteria for **each asset** entered:*

- Average temperature (annual/seasonal)
- Days per year over 90F
- Days per year over 95F
- Days per year under 32F
- Cooling, Heating, and Growing Degree-Days
- Heat index (instructions to calculate)

***2024 Updates** in queue for deployment*

***Guidance** for how to consider outputs*

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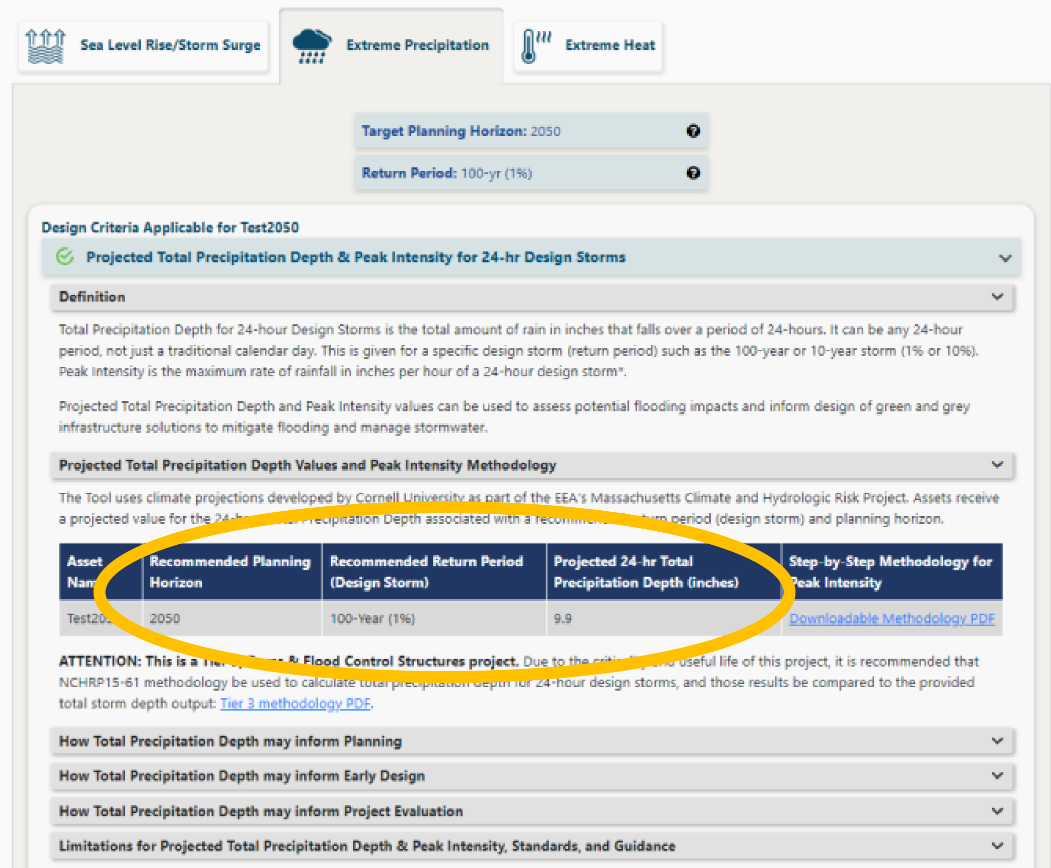
CRDS Tool: Project Outputs



*Will receive recommended standards and design criteria for **each asset** entered:*

- What 24-hour design storm return period?
- Recommends considering alternative storm durations as relevant to project

*Explore **additional design storm precipitation values** on external dashboard*

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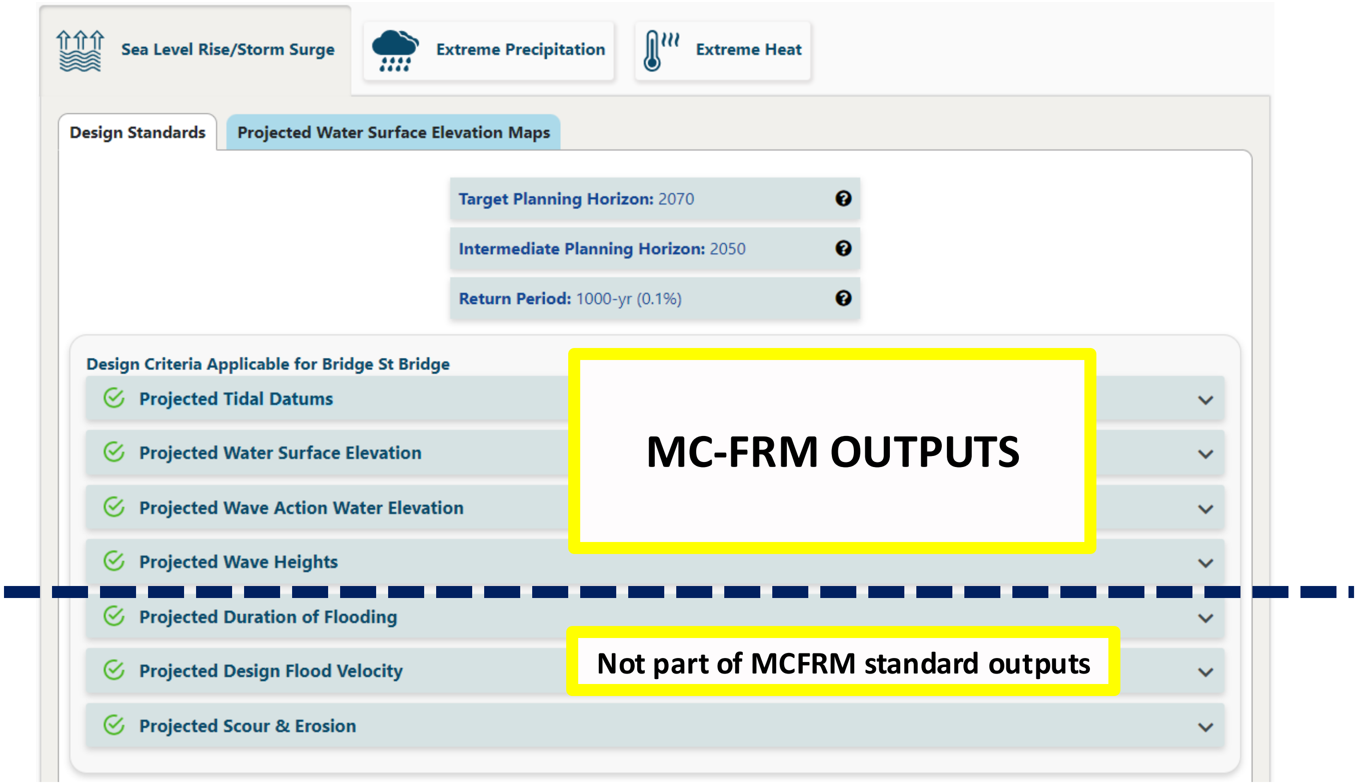
CRDS Tool: Project Outputs



*Most of the coastal design criteria projected values are sourced from the **Massachusetts Coast Flood Risk Model (MC-FRM)***

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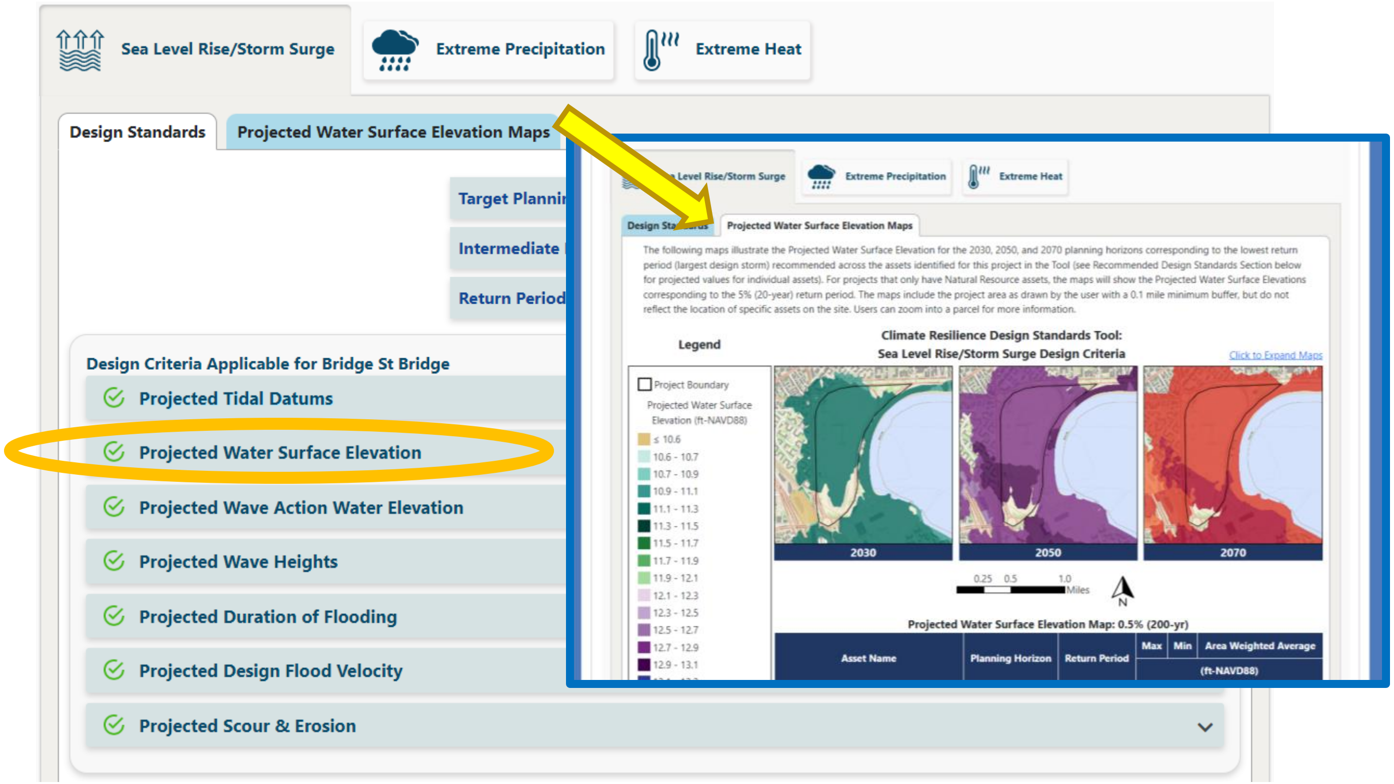
CRDS Tool: Project Outputs



Most of the coastal design criteria projected values are sourced from the ***Massachusetts Coast Flood Risk Model (MC-FRM)***

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CRDS Tool: Version History

Beta Tool (April 2021)

- MVP and Massworks requested Tool reports in grant applications

Version 1.0 (February 2022)

- Climate exposure updates
- Ecosystem service benefits updates
- Additional in-tool guidance

Version 1.1 (April 2022)

- **MC-FRM Level 2 outputs** (dynamic tables for applicable coastal design criteria)
- MA Climate Hydrologic Risk Project outputs (dynamic tables for applicable extreme precipitation design criteria)

Version 1.2 (July 2022)

- **MC-FRM Projected Water Surface Elevation Maps** (interactive in-tool interface and printed maps in project report)

Version 1.3 (2023)

- Update to Environmental Justice neighborhood dataset to reflect 2020 Census

Version 1.4 (2025) – In progress

- Updates to temperature design standards
- Additional MC-FRM maps
- Bug fixes

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CRDS Tool: Support & Documentation

Key available resources:

Log in or register below to use the Tool (Version 1.2).

LOG-IN / REGISTER >

State Users Log-in >

For st... requesting first time ... please email rmat@mass.gov

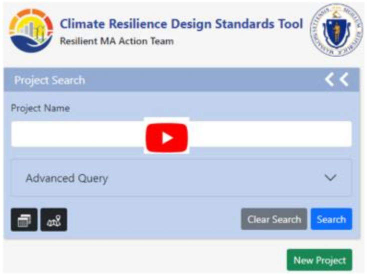
Tool User Guide | Tool Training Video

User guide

Climate Resilience Design Standards Tool
Version 1.2, July 2022

Table of Contents

Trainin g video



Tool (V1.2) Training Video - February, 2023

Guidance and Best Practices

The Climate Resilience Design Guidance provides general design guidance to consider while implementing resilience principles that are not specific to project type or climate hazards, and are illustrated through exam the Guidance considerations and document decision making throughout the planning process.

Guidance and Best Practices PDF

Additional forms include:

- Site Suitability
- Regional Coordination
- Flexible Adaptation Pathways

Table 1.1. Climate Resilience Design Guidance Best Practices

Considerations	Best Practice
Site Suitability (SS)	1. Reduce exposure to climate hazards 2. Mitigate adverse climate impacts and provide benefits 3. Protect, conserve, and restore critical natural resources on-site and off-site
Regional Coordination (RC)	1. Assess regional context of vulnerability 2. Evaluate impacts beyond site-specific design 3. Optimize capital investment opportunities 4. Prioritize services and assets that serve vulnerable populations
Flexible Adaptation Pathways (AP)	1. Embed future capacity and design for uncertainty 2. Design for incremental change 3. Encourage climate mitigation and other co-benefits 4. Prioritize nature-based solutions 5. Prepare for current and future operational and maintenance needs

Climate resilience design guidance and best practices

Documentation and training for technical data inputs

- Massachusetts Coast Flood Risk Model (MC-FRM) FAQ (April 6, 2022)
- Massachusetts Coast Flood Riks Model (MC-FRM) Online Trainings (April-May 2023)
- EEA's Climate and Hydrologic Risk Project - Weather Generator Technical Document (April, 2022)
- EEA's Climate and Hydrologic Risk Project - IDF Curves Technical Document (December, 2021)

https://resilient.mass.gov/rmat_home/designstandards/

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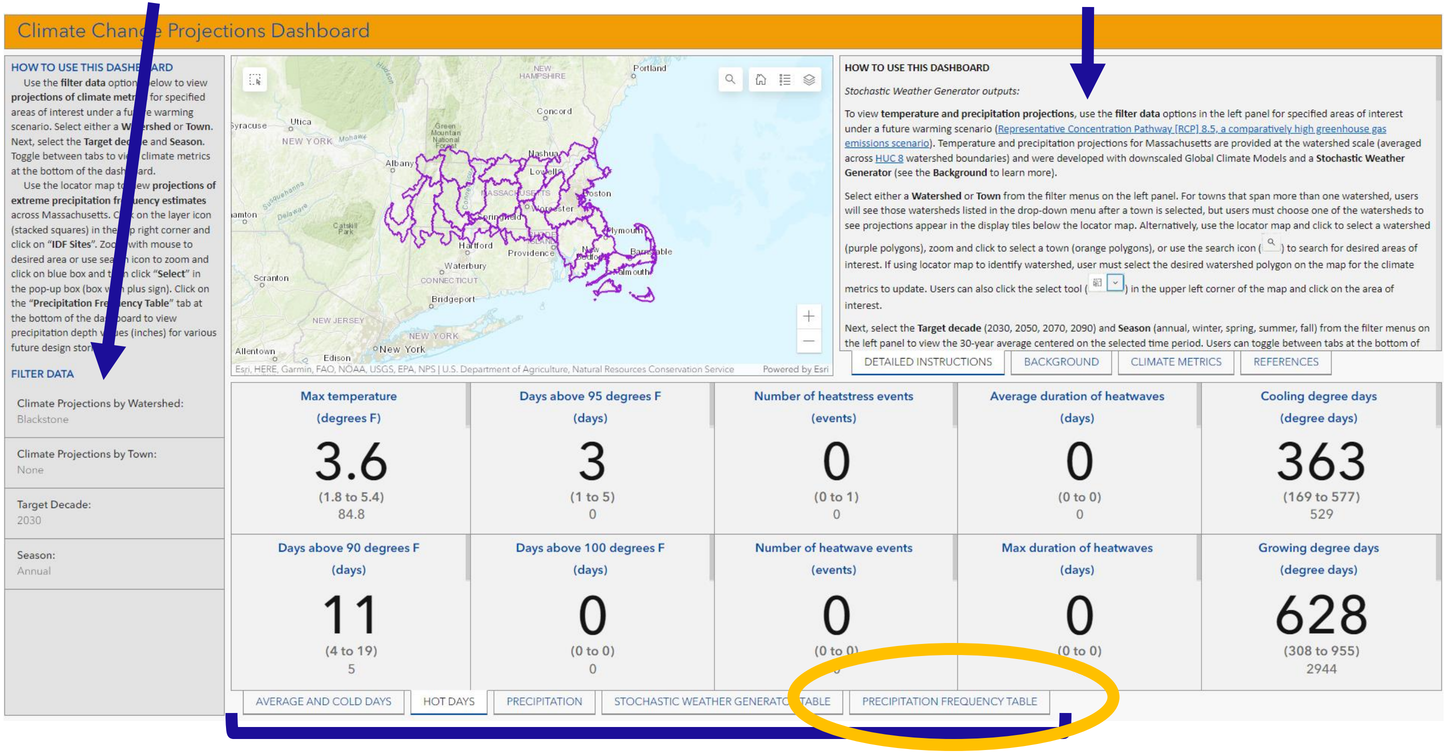
Additional projections data: Climate projections dashboard

Get projections by location

Read about how metrics were made



See projected metrics of interest

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Climate projections dashboard: Planned Updates

Climate-Hydrologic Risk Project Projected Temperature & Precipitation Statistics

TEMPERATURE

Minimum, average & maximum
Number of days over 90F, 95F & 100F
Number of days under 32F & 0F
Number of cold & heat wave events
Number of heat & cold stress events
Heating & cooling degree days
Growing degree days
Heat Index
Dew Point (0.4%, 1%, 2%)
Minimum & maximum heat index
Minimum & maximum dew point
Maximum Dew Point
Heating dry bulb (99% & 99.6%)
Cooling dry bulb (0.4%, 1%, 2%)
Mean coincident wet bulb (0.4%, 1%, 2%)
Date of first & last frost
Number of freeze/thaw events

Durations:

Average heat & cold wave duration
Annual maximum heat & minimum cold wave duration

PRECIPITATION

Total
Maximum 24-hour
90^{th} & 99^{th} percentile 24-hour
Number of days with more than 1", 2", & 4"
Proportion of precipitation as rain vs. snow

Annual Return Periods:

2-, 5-, 10-, 20-, 50-, 100-, 200-, and 500-year 24-hour & 48-hour
1000-year 24- & 48-hour

Average number of consecutive:

Wet days
Dry days

STREAMFLOW

Low-flow:

7q10
7q2

High-flow:

Peak discharge for 2-, 5-, 10-, 25-, 50-, 100-, and 500-year return periods

KEY

Existing Parameters from Phase 1
New parameters expected via Phase 2

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Climate projections dashboard: Precipitation Frequency Table

Climate Change Projections Dashboard

HOW TO USE THIS DASHBOARD

Use the **filter data** options below to view **projections of climate metrics** for specified areas of interest under a future warming scenario. Select either a **Watershed** or **Town.** Next, select the **Target decade** and **Season.** Toggle between tabs to view climate metrics at the bottom of the dashboard.

Use the locator map to view **projections of extreme precipitation frequency estimates** across Massachusetts. Click on the layer icon (stacked squares) in the top right corner and click on "**IDF Sites**". Zoom with mouse to desired area or use search icon to zoom and click on blue box and then click "**Select**" in the pop-up box (box with plus sign). Click on the "**Precipitation Frequency Table**" tab at the bottom of the dashboard to view precipitation depth values (inches) for various future design storms.

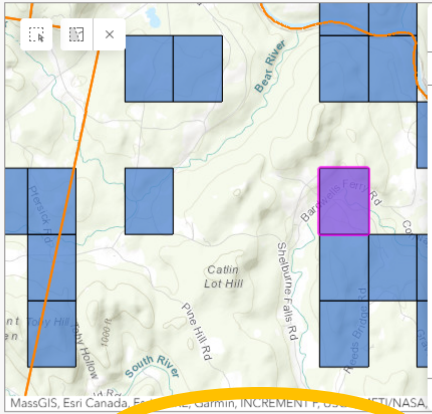
FILTER DATA

Climate Projections by Watershed:
Blackstone

Climate Projections by Town:
None

Target Decade:
2030

Season:
Annual



IDF Site 1884

Zoom to | Pan

Basin_ID	20.00
HU_8_NAME	Deerfield
HUC_8	01080203
SITE	Site 1884

2 of 2

HOW TO USE THIS DASHBOARD

Stochastic Weather Generator outputs:

To view **temperature and precipitation projections,** use the **filter data** options in the left panel for specified areas of interest under a future warming scenario (Representative Concentration Pathway [RCP] 8.5, a comparatively high greenhouse gas emissions scenario). Temperature and precipitation projections for Massachusetts are provided at the watershed scale (averaged across HUC 8 watershed boundaries) and were developed with downscaled Global Climate Models and a **Stochastic Weather Generator** (see the **Background** to learn more).

Select either a **Watershed** or **Town** from the filter menus on the left panel. For towns that span more than one watershed, users will see those watersheds listed in the drop-down menu after a town is selected, but users must choose one of the watersheds to see projections appear in the display tiles below the locator map. Alternatively, use the locator map and click to select a watershed (purple polygons), zoom and click to select a town (orange polygons), or use the search icon ( ) to search for desired areas of interest. If using locator map to identify watershed, user must select the desired watershed polygon on the map for the climate metrics to update. Users can also click the select tool ( ) in the upper left corner of the map and click on the area of interest.

Next, select the **Target decade** (2030, 2050, 2070, 2090) and **Season** (annual, winter, spring, summer, fall) from the filter menus on

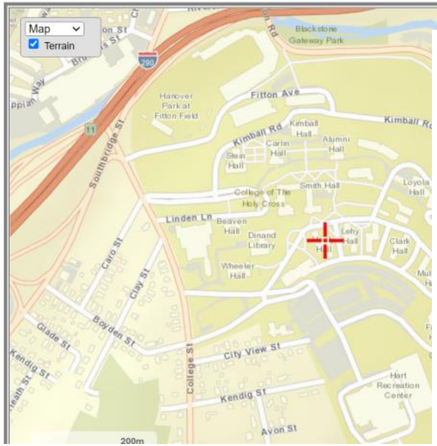
DETAILED INSTRUCTIONS | BACKGROUND | CLIMATE METRICS | REFERENCES

Site	Year	Duration	RI_ yr_50th	RI_2yr_5 h	RI_5yr_50th	RI_10yr_50th	RI_25yr_50th	I_50yr_50	RI_100yr_50th	RI_200yr_50th	RI_500yr_50th	RI_1000yr_50th
Site 1884	[illegible]	[illegible]	0.4 (0.4 - 0.4)	0.4 (0.4 - 0.5)	0.5 (0.5 - 0.6)	0.6 (0.6 - 0.7)	0.7 (0.7 - 0.8)	0.8 (0.8 - 0.9)	0.9 (0.9 - 1)	1 (1 - 1.1)	1.1 (1.1 - 1.2)	1.2 (1.2 - 1.3)
Site 1884	2030	10m	0.5 (0.5 - 0.6)	0.6 (0.6 - 0.6)	0.7 (0.7 - 0.8)	0.9 (0.8 - 0.9)	1 (1 - 1.1)	1.1 (1.1 - 1.2)	1.3 (1.2 - 1.4)	1.4 (1.4 - 1.5)	1.6 (1.5 - 1.7)	1.7 (1.7 - 1.9)
Site 1884	2030	15m	0.6 (0.6 - 0.6)	0.7 (0.7 - 0.8)	0.9 (0.8 - 0.9)	1 (1 - 1.1)	1.2 (1.2 - 1.3)	1.4 (1.3 - 1.4)	1.5 (1.4 - 1.6)	1.7 (1.6 - 1.8)	1.9 (1.8 - 2)	2 (2 - 2.2)
Site 1884	2030	60m	1.1 (1 - 1.2)	1.3 (1.2 - 1.4)	1.6 (1.5 - 1.7)	1.8 (1.8 - 1.9)	2.2 (2.1 - 2.3)	2.4 (2.3 - 2.6)	2.7 (2.6 - 2.9)	3 (2.9 - 3.2)	3.4 (3.2 - 3.6)	3.7 (3.5 - 3.9)
Site 1884	2030	02h	1.4 (1.3 - 1.5)	1.6 (1.6 - 1.7)	2 (1.9 - 2.1)	2.3 (2.2 - 2.5)	2.8 (2.7 - 3)	3.1 (3 - 3.3)	3.5 (3.3 - 3.7)	3.8 (3.7 - 4.1)	4.4 (4.2 - 4.7)	4.8 (4.7 - 5.2)
Site 1884	2030	03h	1.6 (1.5 - 1.7)	1.9 (1.8 - 2)	2.3 (2.2 - 2.5)	2.7 (2.6 - 2.9)	3.2 (3.1 - 3.4)	3.6 (3.5 - 3.8)	4 (3.9 - 4.3)	4.5 (4.3 - 4.8)	5.1 (5 - 5.5)	5.7 (5.5 - 6.1)

AVERAGE AND COLD DAYS | HOT DAYS | PRECIPITATION | STOCHASTIC WEATHER GENERATOR TABLE | PRECIPITATION FREQUENCY TABLE

ResilientMass Projected Design Storms: Basis

Intensity-Duration-Frequency (IDF) Statistics Reference: NOAA Atlas 14



AMS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Annual exceedance probability (1/years)								
	1/2	1/5	1/10	1/25	1/50	1/100	1/200	1/500	1/1000
5-min	**0.371** (0.297-0.457)	**0.487** (0.389-0.604)	**0.576** (0.456-0.717)	**0.692** (0.527-0.906)	**0.780** (0.580-1.04)	**0.869** (0.624-1.21)	**0.964** (0.656-1.39)	**1.10** (0.714-1.65)	**1.20** (0.761-1.85)
10-min	**0.525** (0.421-0.648)	**0.690** (0.551-0.856)	**0.815** (0.646-1.02)	**0.980** (0.747-1.28)	**1.10** (0.821-1.48)	**1.23** (0.883-1.72)	**1.37** (0.928-1.97)	**1.55** (1.01-2.34)	**1.70** (1.08-2.62)
15-min	**0.618** (0.495-0.761)	**0.812** (0.648-1.01)	**0.959** (0.761-1.20)	**1.15** (0.879-1.51)	**1.30** (0.966-1.74)	**1.45** (1.04-2.02)	**1.61** (1.09-2.32)	**1.83** (1.19-2.75)	**2.00** (1.27-3.08)
30-min	**0.841** (0.673-1.04)	**1.11** (0.883-1.37)	**1.31** (1.04-1.63)	**1.57** (1.20-2.06)	**1.77** (1.32-2.37)	**1.98** (1.42-2.76)	**2.19** (1.49-3.16)	**2.49** (1.62-3.75)	**2.73** (1.73-4.21)
60-min	**1.06** (0.852-1.31)	**1.40** (1.12-1.74)	**1.66** (1.31-2.06)	**1.99** (1.52-2.60)	**2.24** (1.67-3.01)	**2.50** (1.80-3.49)	**2.78** (1.89-4.01)	**3.16** (2.06-4.75)	**3.46** (2.19-5.33)
2-hr	**1.36** (1.09-1.66)	**1.80** (1.44-2.22)	**2.14** (1.70-2.65)	**2.58** (1.98-3.36)	**2.91** (2.18-3.90)	**3.26** (2.36-4.56)	**3.65** (2.49-5.24)	**4.22** (2.75-6.31)	**4.70** (2.98-7.18)
3-hr	**1.55** (1.26-1.90)	**2.08** (1.68-2.55)	**2.48** (1.98-3.06)	**3.00** (2.31-3.90)	**3.38** (2.55-4.52)	**3.79** (2.77-5.31)	**4.27** (2.92-6.11)	**4.98** (3.25-7.42)	**5.58** (3.55-8.50)
6-hr	**1.95** (1.59-2.37)	**2.64** (2.14-3.22)	**3.17** (2.55-3.89)	**3.86** (3.00-5.00)	**4.37** (3.32-5.82)	**4.91** (3.62-6.86)	**5.56** (3.81-7.90)	**6.54** (4.28-9.68)	**7.38** (4.70-11.2)
12-hr	**2.41** (1.98-2.91)	**3.32** (2.71-4.02)	**4.00** (3.24-4.88)	**4.91** (3.83-6.32)	**5.56** (4.25-7.37)	**6.28** (4.64-8.71)	**7.12** (4.90-10.1)	**8.40** (5.52-12.3)	**9.49** (6.07-14.3)
24-hr	**2.87** (2.37-3.45)	**4.00** (3.28-4.81)	**4.85** (3.96-5.87)	**5.97** (4.69-7.64)	**6.79** (5.21-8.93)	**7.67** (5.70-10.6)	**8.72** (6.02-12.2)	**10.3** (6.82-15.1)	**11.7** (7.52-17.5)
2-day	**3.30** (2.74-3.93)	**4.61** (3.82-5.52)	[illegible] (4.61-6.75)	**6.92** (5.47-8.82)	**7.88** (6.09-10.3)	[illegible] (6.68-12.3)	**10.2** (7.05-14.2)	**12.1** (8.03-17.6)	**13.8** (8.90-20.5)
3-day	**3.58** (2.99-4.25)	**5.00** (4.16-5.96)	**6.08** (5.01-7.29)	**7.50** (5.94-9.51)	**8.52** (6.61-11.1)	**9.64** (7.25-13.2)	**11.0** (7.65-15.3)	**13.1** (8.71-19.0)	**15.0** (9.66-22.1)
4-day	**3.84** (3.21-4.54)	**5.33** (4.44-6.33)	**6.46** (5.34-7.72)	**7.95** (6.32-10.1)	**9.02** (7.02-11.7)	**10.2** (7.68-13.9)	**11.6** (8.10-16.1)	**13.9** (9.20-20.0)	**15.8** (10.2-23.2)
7-day	**4.54** (3.82-5.34)	**6.16** (5.16-7.28)	**7.39** (6.14-8.79)	**9.02** (7.19-11.3)	**10.2** (7.95-13.2)	**11.5** (8.64-15.5)	**13.0** (9.08-17.9)	**15.3** (10.2-22.0)	**17.3** (11.2-25.4)

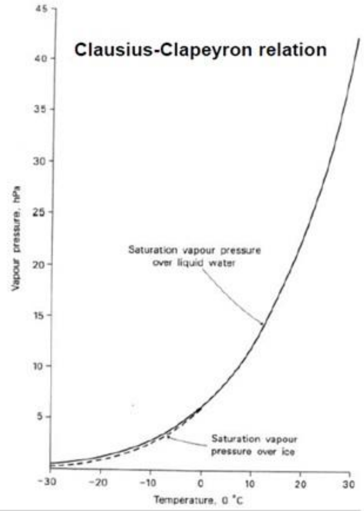
ResilientMass Projected Design Storms: Basis

If NOAA Atlas 14 precipitation values are based on historic storms, how rare would the same events be today or in the future?

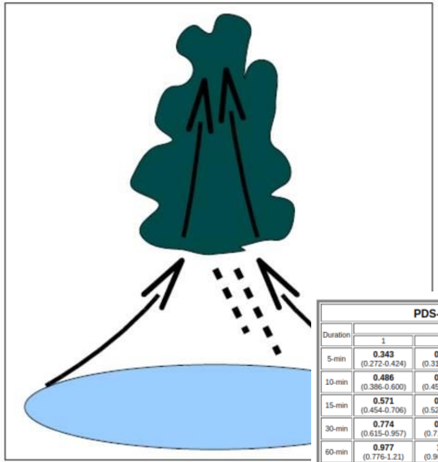
ResilientMass Projected Design Storms: Basis

Massachusetts' Future IDF curves

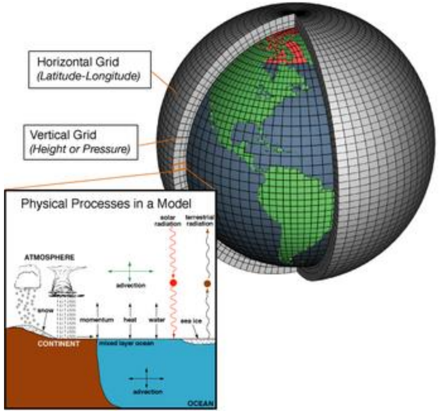
Theoretical: 7% increase in atmospheric moisture-holding capacity per degree Celsius of warming.



Source: Water Environmental Change.



Source: Koninklijk Nederlands Meteorologisch Instituut.



Global climate model

Scenario, decade, and projected warming

- RCP 8.5, 2050 → 2 degrees Celsius

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

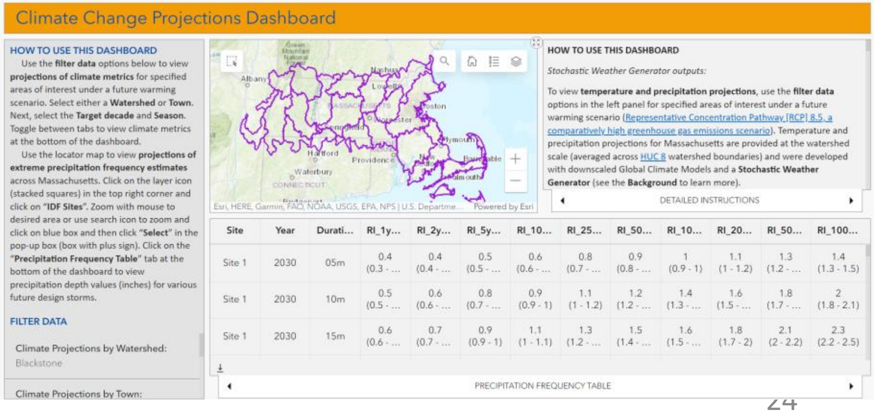
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.343** (0.272-0.424)	**0.400** (0.318-0.495)	**0.494** (0.391-0.614)	**0.572** (0.449-0.714)	**0.679** (0.514-0.890)	**0.761** (0.563-1.02)	**0.845** (0.603-1.18)	**0.936** (0.634-1.35)	**1.06** (0.690-1.59)	**1.16** (0.735-1.78)
10-min	**0.486** (0.386-0.600)	**0.567** (0.450-0.702)	**0.700** (0.553-0.870)	**0.810** (0.637-1.01)	**0.962** (0.729-1.26)	**1.08** (0.797-1.45)	**1.20** (0.855-1.67)	**1.32** (0.898-1.91)	**1.50** (0.976-2.25)	**1.65** (1.04-2.52)
15-min	**0.571** (0.454-0.706)	**0.667** (0.529-0.825)	**0.824** (0.651-1.02)	**0.953** (0.749-1.19)	**1.13** (0.857-1.48)	**1.27** (0.938-1.70)	**1.41** (1.01-1.96)	**1.56** (1.06-2.25)	**1.77** (1.15-2.65)	**1.94** (1.23-2.97)
30-min	**0.774** (0.615-0.957)	**0.905** (0.718-1.12)	**1.12** (0.884-1.39)	**1.30** (1.02-1.62)	**1.54** (1.17-2.02)	**1.73** (1.28-2.31)	**1.92** (1.37-2.67)	**2.12** (1.44-3.06)	**2.41** (1.56-3.61)	**2.63** (1.67-4.04)
60-min	**0.977** (0.776-1.21)	**1.14** (0.907-1.41)	**1.41** (1.12-1.76)	**1.64** (1.29-2.05)	**1.95** (1.47-2.55)	**2.18** (1.61-2.93)	**2.42** (1.73-3.38)	**2.68** (1.82-3.87)	**3.04** (1.98-4.56)	**3.33** (2.11-5.11)
2-hr	**1.24** (0.988-1.52)	**1.46** (1.17-1.79)	**1.82** (1.45-2.25)	**2.13** (1.68-2.64)	**2.54** (1.94-3.32)	**2.86** (2.13-3.83)	**3.19** (2.31-4.46)	**3.57** (2.43-5.12)	**4.13** (2.70-6.16)	**4.61** (2.92-7.02)
3-hr	**1.41** (1.13-1.73)	**1.68** (1.34-2.05)	**2.11** (1.69-2.59)	**2.47** (1.96-3.06)	**2.97** (2.28-3.87)	**3.33** (2.50-4.46)	**3.73** (2.72-5.22)	**4.20** (2.86-6.00)	**4.91** (3.21-7.30)	**5.51** (3.51-8.38)
6-hr	**1.76** (1.42-2.14)	**2.11** (1.71-2.57)	**2.69** (2.17-3.29)	**3.17** (2.54-3.90)	**3.83** (2.96-4.97)	**4.32** (3.27-5.76)	**4.85** (3.56-6.77)	**5.50** (3.76-7.80)	**6.48** (4.24-9.56)	**7.32** (4.67-11.0)
12-hr	**2.17** (1.76-2.61)	**2.63** (2.14-3.17)	**3.38** (2.74-4.10)	**4.01** (3.23-4.89)	**4.87** (3.78-6.28)	**5.51** (4.18-7.29)	**6.20** (4.57-8.59)	**7.03** (4.83-9.92)	**8.30** (5.45-12.2)	**9.39** (6.01-14.1)
24-hr	**2.57** (2.11-3.08)	**3.14** (2.57-3.77)	**4.08** (3.32-4.91)	**4.85** (3.93-5.88)	**5.91** (4.62-7.57)	**6.70** (5.12-8.82)	**7.56** (5.60-10.4)	**8.59** (5.92-12.0)	**10.2** (6.70-14.8)	**11.5** (7.39-17.1)
[illegible]	**2.94**	**3.61**	**4.70**	**5.60**	**6.85**	**7.77**	**8.77**	**10.00**	**11.9**	**13.5**

= 4.91*(1.07^2)

= 5.62”

How can I use the scaled IDF dataset?

- Add as guidance/optional stretch reference in local stormwater ordinance
- Use to show future benefits in FEMA benefit-cost analysis
- Climate-informed stormwater infrastructure & BMP design



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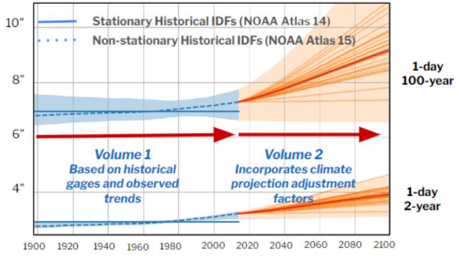
Next Steps & Open Questions

- Update scaled IDF dataset to reflect CMIP6 projected temperatures
- Investigate shifts in storm tracks, regional storm typologies, and storm frequencies
- Track NOAA Atlas 15 planned methods and milestones

NOAA Atlas 15

New National Precipitation Frequency Standard



Historical and future intensity-duration-frequency estimates (IDFs)

2022/2023
- **Feb. - Aug 2022** - Published methodology and briefed stakeholders.
- **Sept. 2022** - Distributed Public Notification Statement (PNS) and collect public feedback.
- **Jan. 2023** - Hosted technical workshop with federal partners.
- **Apr. 2023** - Award contracts and grants and initiate product development.

2024
- **Development** - Evolve framework. Create Quality Controlled National Precipitation Database. Evaluate Climate Model Projections.
- **Pilot** - Deliver Atlas 15 Vol. 1 and Vol. 2 pilot over Montana.

Collect and adjudicate feedback on preliminary estimates and Web dissemination strategies.

2025
- **CONUS** - Initiate 60-day peer review for Atlas 15 Vol. 1 and Vol. 2 for CONUS (lower 48 states).

Collect feedback and adjudicate comments on product.

2026
- **CONUS** - Complete Atlas 15 Vol. 1 and Vol. 2 and deliver estimates, documentation and supplementary products to stakeholders.
- **oCONUS** - Initiate peer review for oCONUS (e.g. Hawaii, Alaska, Puerto Rico, U.S. Virgin Islands, Guam).

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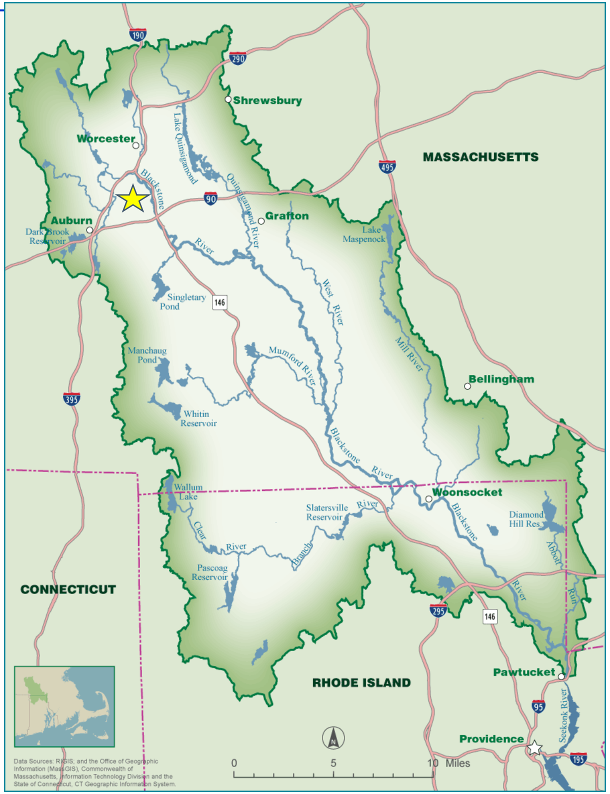
MA Climate-Scaled Precipitation Design Values

Overview

- Evolving extreme precipitation in New England
- Data resource introduction: MA Climate-Scaled IDF Curves
- Example: Leominster 9/11/23 flooding
- NOAA Atlas 15: What we know now
- Next Steps



Source: Blackstone River Watershed Association
http://www.thebrwa.org/map.htm

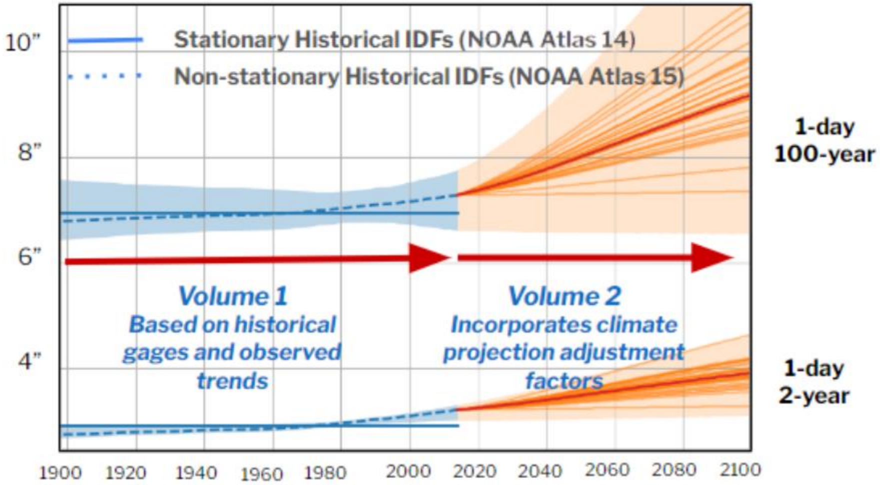
MA Climate-Scaled Precipitation Design Values

What is Atlas 15?

- **Bipartisan Infrastructure Law (BIL) provides funding for NWS' Office of Weather Prediction (OWP) to**
  - Update Atlas 14 methods explicitly accounting for climate change
  - Update precipitation depth/duration/frequency values across the US
- **NOAA Atlas 15 Volume 1: Historic trends in observed values**
- **NOAA Atlas 15 Volume 2: Adjustment factors for Volume 1 values to reflect future climate projections**

NOAA Atlas 15

New National Precipitation Frequency Standard



Historical and future intensity-duration-frequency estimates (IDFs)

MA Climate-Scaled Precipitation Design Values

NOAA Atlas 15 timeline

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MA Climate-Scaled Precipitation Design Values

AMS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]									
Duration	Annual exceedance probability (1/years)								
	1/2	1/5	1/10	1/25	1/50	1/100	1/200	1/500	1/1000
6-hr	**1.85** (1.48-2.28)	**2.55** (2.03-3.14)	**3.07** (2.43-3.80)	**3.77** (2.89-4.86)	**4.27** (3.22-5.62)	**4.82** (3.54-6.58)	**5.50** (3.75-7.49)	**6.55** (4.30-9.17)	**7.47** (4.78-10.6)
12-hr	**2.36** (1.91-2.87)	**3.22** (2.60-3.94)	**3.88** (3.10-4.76)	**4.74** (3.67-6.05)	**5.37** (4.07-6.99)	**6.05** (4.46-8.16)	**6.86** (4.72-9.28)	**8.11** (5.35-11.3)	**9.18** (5.90-13.0)
24-hr	**2.85** (2.33-3.44)	**3.89** (3.17-4.71)	**4.67** (3.78-5.68)	**5.71** (4.46-7.21)	**6.47** (4.94-8.33)	**7.28** (5.40-9.71)	**8.24** (5.70-11.1)	**9.68** (6.41-13.4)	**10.9** (7.04-15.3)
2-day	**3.26** (2.70-3.90)	**4.47** (3.69-5.36)	**5.39** (4.41-6.49)	**6.60** (5.20-8.26)	**7.48** (5.78-9.56)	**8.43** (6.31-11.2)	**9.55** (6.66-12.7)	**11.2** (7.49-15.4)	**12.7** (8.22-17.6)

?

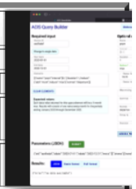
Washed out road in Leominster, CBS Boston September 2023

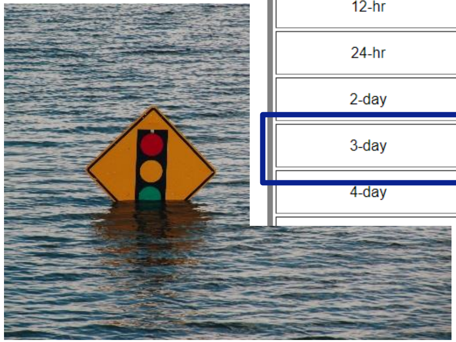
*"…dropped nearly **ten inches of rain in six hours…** the rainfall was "a 200-year event", says Matthew Belk, a meteorologist with the National Weather Service in Boston."* CBS News, Boston

MA Climate-Scaled Precipitation Design Values

AMS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Annual exceedance probability (1/years)								
	1/2	1/5	1/10	1/25	1/50	1/100	1/200	1/500	
5-min	**0.351** (0.279-0.439)	**0.489** (0.388-0.614)	**0.594** (0.467-0.749)	**0.732** (0.555-0.964)	**0.834** (0.620-1.12)	**0.941** (0.678-1.32)	**1.06** (0.720-1.51)	**1.24** (0.806-1.82)	
10-min	**0.497** (0.395-0.622)	**0.693** (0.549-0.869)	**0.841** (0.662-1.06)	**1.04** (0.787-1.36)	**1.18** (0.878-1.59)	**1.33** (0.961-1.86)	**1.51** (1.02-2.14)	**1.76** (1.14-2.58)	
15-min	**0.585** (0.465-0.732)	**0.816** (0.646-1.02)	**0.990** (0.780-1.25)	**1.22** (0.925-1.61)	**1.39** (1.03-1.87)	**1.57** (1.13-2.19)	**1.77** (1.20-2.52)	**2.07** (1.34-3.04)	**2.32** (1.47-3.46)
30-min	**0.809** (0.644-1.01)	**1.13** (0.898-1.42)	**1.38** (1.09-1.74)	**1.70** (1.29-2.24)	**1.94** (1.44-2.61)	**2.19** (1.58-3.07)	**2.48** (1.68-3.52)	**2.90** (1.89-4.26)	**3.26** (2.06-4.87)
60-min	**1.03** (0.823-1.30)	**1.45** (1.15-1.82)	**1.77** (1.39-2.23)	**2.19** (1.66-2.88)	**2.49** (1.85-3.36)	**2.82** (2.03-3.94)	**3.19** (2.16-4.53)	**3.74** (2.43-5.49)	**4.20** (2.66-6.28)
2-hr	**1.33** (1.07-1.65)	**1.90** (1.52-2.36)	**2.33** (1.85-2.91)	**2.89** (2.22-3.79)	**3.31** (2.48-4.43)	**3.75** (2.74-5.23)	**4.27** (2.91-6.02)	**5.06** (3.30-7.36)	**5.73** (3.65-8.49)
3-hr	**1.55** (1.25-1.91)	**2.21** (1.77-2.73)	**2.70** (2.16-3.37)	**3.36** (2.59-4.38)	**3.84** (2.90-5.13)	**4.36** (3.20-6.06)	**4.98** (3.40-6.98)	**5.91** (3.87-8.56)	**6.71** (4.28-9.89)
6-hr	**2.00** (1.63-2.45)	**2.82** (2.28-3.46)	**3.43** (2.76-4.24)	**4.25** (3.30-5.49)	**4.84** (3.68-6.40)	**5.48** (4.05-7.55)	**6.24** (4.29-8.68)	**7.40** (4.87-10.6)	**8.39** (5.38-12.3)
12-hr	**2.56** (2.10-3.11)	**3.53** (2.88-4.29)	**4.26** (3.45-5.21)	**5.22** (4.08-6.67)	**5.92** (4.53-7.75)	**6.68** (4.95-9.09)	**7.56** (5.23-10.4)	**8.89** (5.88-12.6)	**10.0** (6.46-14.5)
24-hr	**3.09** (2.56-3.72)	**4.24** (3.50-5.12)	**5.11** (4.18-6.20)	**6.27** (4.94-7.94)	**7.11** (5.48-9.22)	**8.01** (5.98-10.8)	**9.07** (6.31-12.4)	**10.7** (7.10-15.0)	**12.0** (7.78-17.3)
2-day	**3.50** (2.92-4.17)	**4.89** (4.06-5.84)	**5.94** (4.90-7.14)	**7.33** (5.82-9.23)	**8.34** (6.49-10.8)	**9.44** (7.12-12.7)	**10.8** (7.52-14.5)	**12.8** (8.54-17.8)	**14.5** (9.44-20.6)
3-day	**3.79** (3.18-4.50)	**5.28** (4.41-6.28)	**6.41** (5.31-7.66)	**7.90** (6.30-9.88)	**8.98** (7.01-11.5)	**10.1** (7.69-13.6)	**11.6** (8.12-15.6)	**13.7** (9.21-19.1)	**15.6** (10.2-22.1)
4-day	**4.06** (3.42-4.79)	**5.60** (4.70-6.63)	**6.76** (5.63-8.05)	**8.30** (6.65-10.3)	**9.42** (7.38-12.0)	**10.6** (8.07-14.1)	**12.1** (8.51-16.2)	**14.3** (9.62-19.8)	**16.2** (10.6-22.8)





Town of North Attleborough Facebook, September 2023

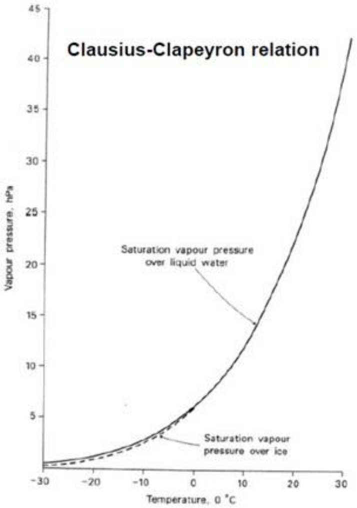
"…about ten inches in the past 72 hours…" MassLive, September 2023

"…nearly five inches of rain in four hours…" CBS News, Boston September 2023

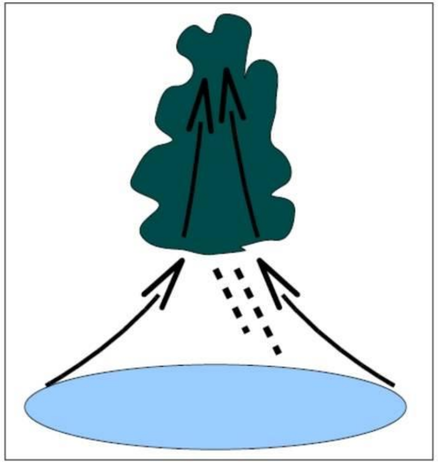
MA Climate-Scaled Precipitation Design Values

Massachusetts' Future IDF curves

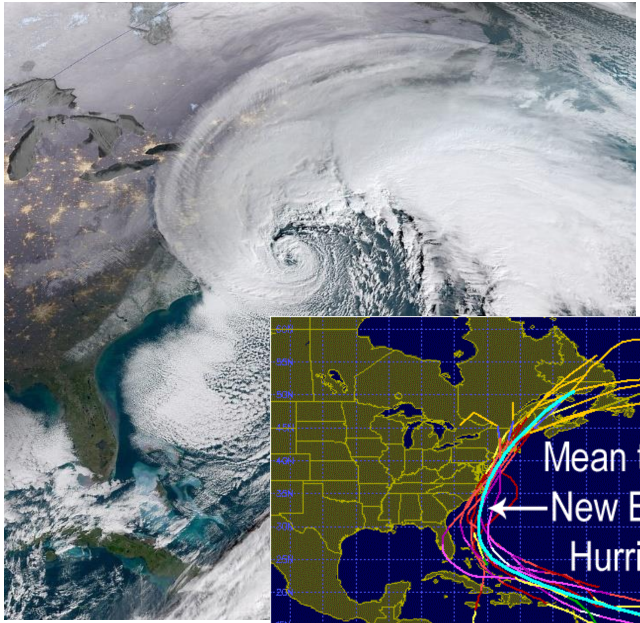
Theoretical: 7% increase in atmospheric moisture-holding capacity per degree Celsius of warming.



Source: Water Environmental Change.

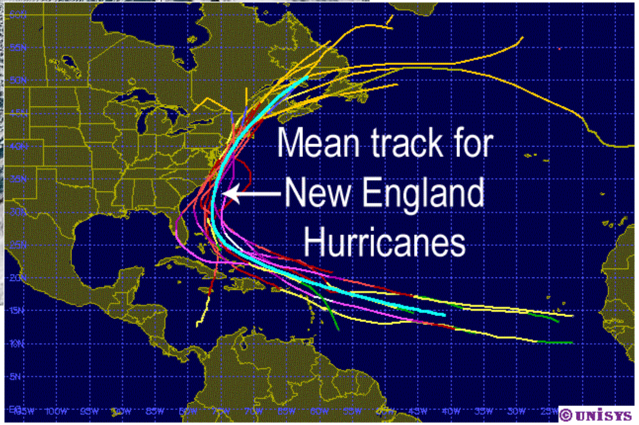


Source: Koninklijk Nederlands Meteorologisch Instituut.



Source: GOES-16 (NOAA)

Reality: ???



Source: Quincy Vagell, 2014

MA Climate-Scaled Precipitation Design Values

Massachusetts' Future IDF curves

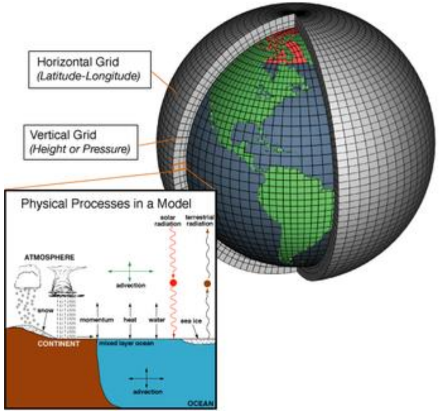
How does precipitation scale with temperature or dew point? Does precipitation increase more than theory would suggest? Less?

- Annually?
- Seasonally?
- Daily?
- Under different weather regimes?

NO

We can use a 7% per degree Celsius precipitation scaling rate.

Lenoir, Najibi, and Steinschneider (2023)



Global climate model

Scenario, decade, and projected warming

- RCP 8.5, 2050 → 2 degrees Celsius

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

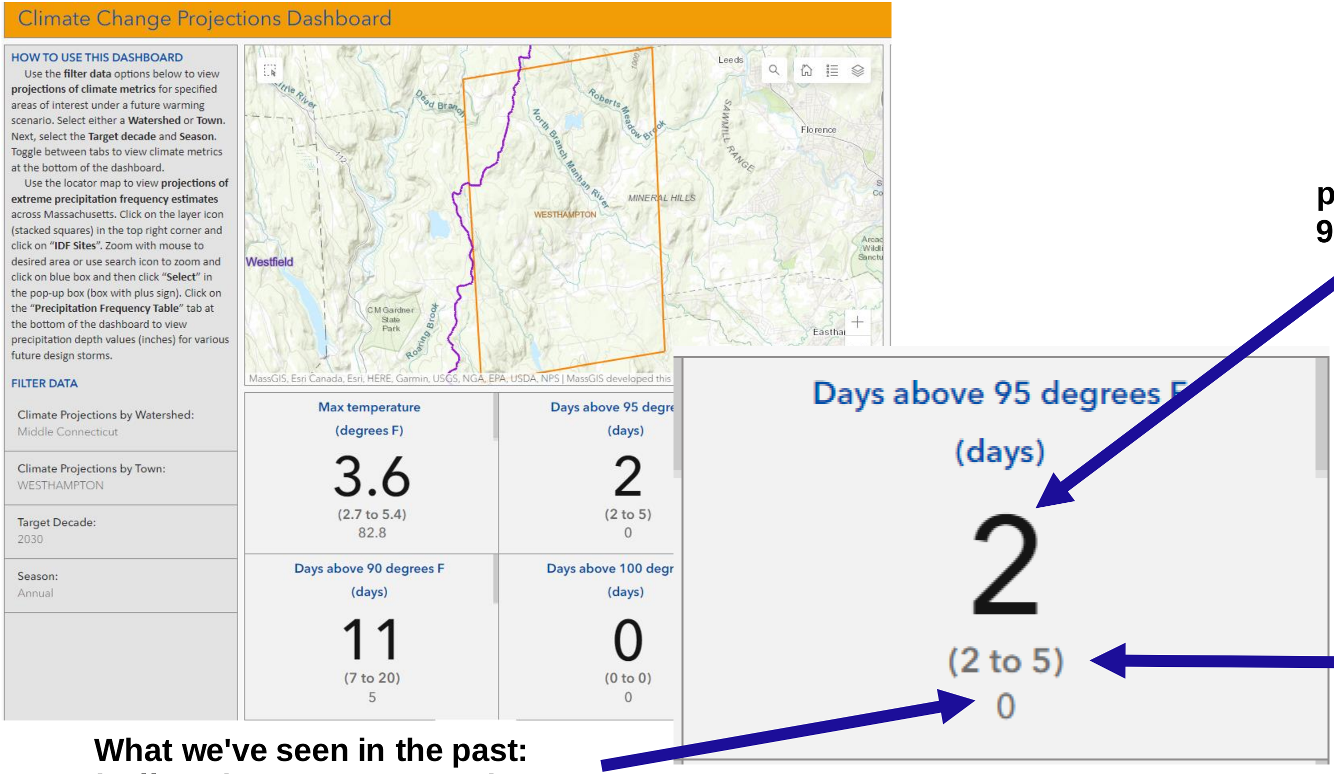
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.343** (0.272-0.424)	**0.400** (0.318-0.495)	**0.494** (0.391-0.614)	**0.572** (0.449-0.714)	**0.679** (0.514-0.890)	**0.761** (0.563-1.02)	**0.845** (0.603-1.18)	**0.936** (0.634-1.35)	**1.06** (0.690-1.59)	**1.16** (0.735-1.78)
10-min	**0.486** (0.386-0.600)	**0.567** (0.450-0.702)	**0.700** (0.553-0.870)	**0.810** (0.637-1.01)	**0.962** (0.729-1.26)	**1.08** (0.797-1.45)	**1.20** (0.855-1.67)	**1.32** (0.898-1.91)	**1.50** (0.976-2.25)	**1.65** (1.04-2.52)
15-min	**0.571** (0.454-0.706)	**0.667** (0.529-0.825)	**0.824** (0.651-1.02)	**0.953** (0.749-1.19)	**1.13** (0.857-1.48)	**1.27** (0.938-1.70)	**1.41** (1.01-1.96)	**1.56** (1.06-2.25)	**1.77** (1.15-2.65)	**1.94** (1.23-2.97)
30-min	**0.774** (0.615-0.957)	**0.905** (0.718-1.12)	**1.12** (0.884-1.39)	**1.30** (1.02-1.62)	**1.54** (1.17-2.02)	**1.73** (1.28-2.31)	**1.92** (1.37-2.67)	**2.12** (1.44-3.06)	**2.41** (1.56-3.61)	**2.63** (1.67-4.04)
60-min	**0.977** (0.776-1.21)	**1.14** (0.907-1.41)	**1.41** (1.12-1.76)	**1.64** (1.29-2.05)	**1.95** (1.47-2.55)	**2.18** (1.61-2.93)	**2.42** (1.73-3.38)	**2.68** (1.82-3.87)	**3.04** (1.98-4.56)	**3.33** (2.11-5.11)
2-hr	**1.24** (0.988-1.52)	**1.46** (1.17-1.79)	**1.82** (1.45-2.25)	**2.13** (1.68-2.64)	**2.54** (1.94-3.32)	**2.86** (2.13-3.83)	**3.19** (2.31-4.46)	**3.57** (2.43-5.12)	**4.13** (2.70-6.16)	**4.61** (2.92-7.02)
3-hr	**1.41** (1.13-1.73)	**1.68** (1.34-2.05)	**2.11** (1.69-2.59)	**2.47** (1.96-3.06)	**2.97** (2.28-3.87)	**3.33** (2.50-4.46)	**3.73** (2.72-5.22)	**4.20** (2.86-6.00)	**4.91** (3.21-7.30)	**5.51** (3.51-8.38)
6-hr	**1.76** (1.42-2.14)	**2.11** (1.71-2.57)	**2.69** (2.17-3.29)	**3.17** (2.54-3.90)	**3.83** (2.96-4.97)	**4.32** (3.27-5.76)	**4.85** (3.56-6.77)	**5.50** (3.76-7.80)	**6.48** (4.24-9.56)	**7.32** (4.67-11.0)
12-hr	**2.17** (1.76-2.61)	**2.63** (2.14-3.17)	**3.38** (2.74-4.10)	**4.01** (3.23-4.89)	**4.87** (3.78-6.28)	**5.51** (4.18-7.29)	**6.20** (4.57-8.59)	**7.03** (4.83-9.92)	**8.30** (5.45-12.2)	**9.39** (6.01-14.1)
24-hr	**2.57** (2.11-3.08)	**3.14** (2.57-3.77)	**4.08** (3.32-4.91)	**4.85** (3.93-5.88)	**5.91** (4.62-7.57)	**6.70** (5.12-8.82)	**7.56** (5.60-10.4)	**8.59** (5.92-12.0)	**10.2** (6.70-14.8)	**11.5** (7.39-17.1)
[illegible]	**2.94**	**3.61**	**4.70**	**5.60**	**6.85**	**7.77**	**8.77**	**10.00**	**11.9**	**13.5**

= 4.91*(1.07^2)

= 5.62”

Additional projections data: Climate projections dashboard

Climate Change Projections Dashboard



Median/50th percentile projection: Two more days over 95F than we've typically seen in the past (so... two)

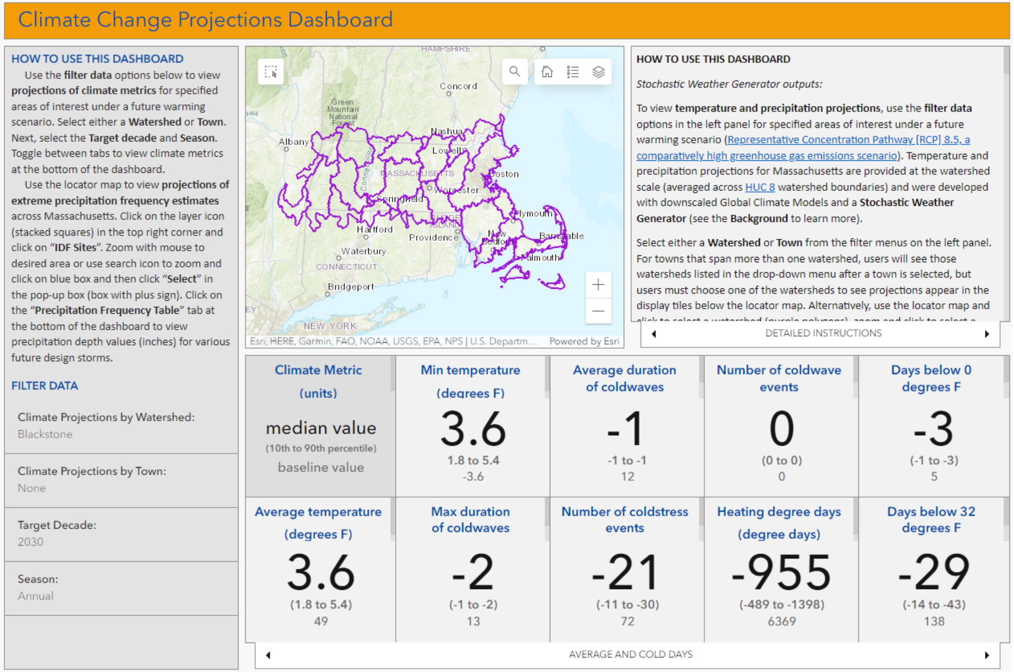
90% of climate models say more than 2 more days per year. 10% of models say 5 or more additional days per year.

What we've seen in the past: Typically 0 days over 95F each year

Climate Change Projections Dashboard

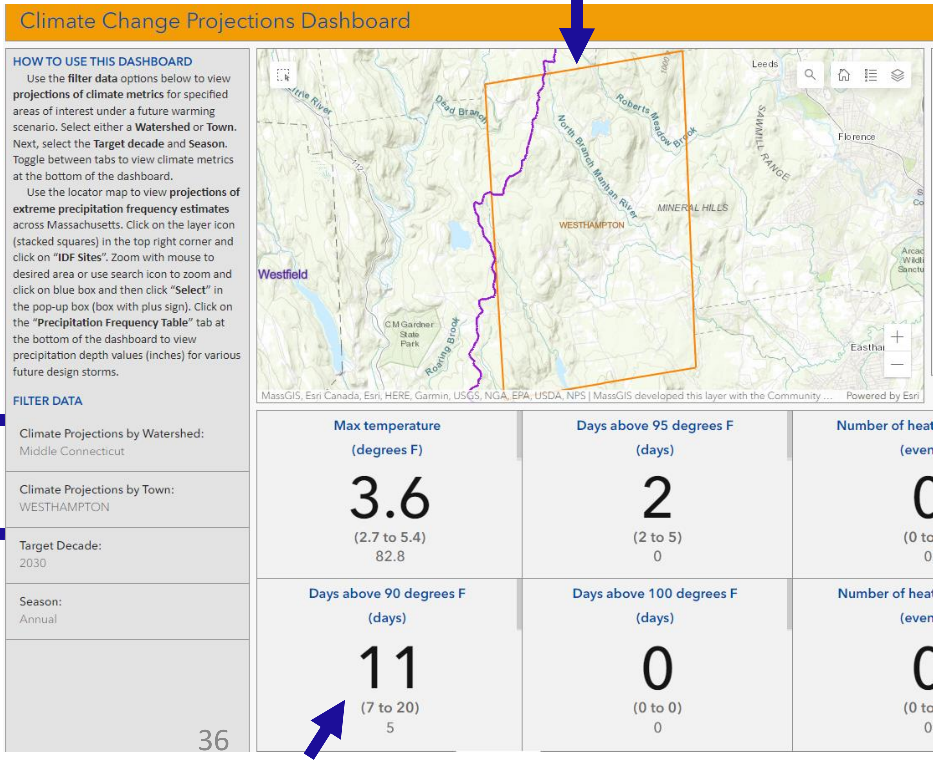
When to use the dashboard?

- **Exploring future climate hazards for adaptation planning**
- **Designing stormwater infrastructure to last**
- **Screening for ecosystem/habitat risks**
- **And more!**



Climate Change Projections Dashboard

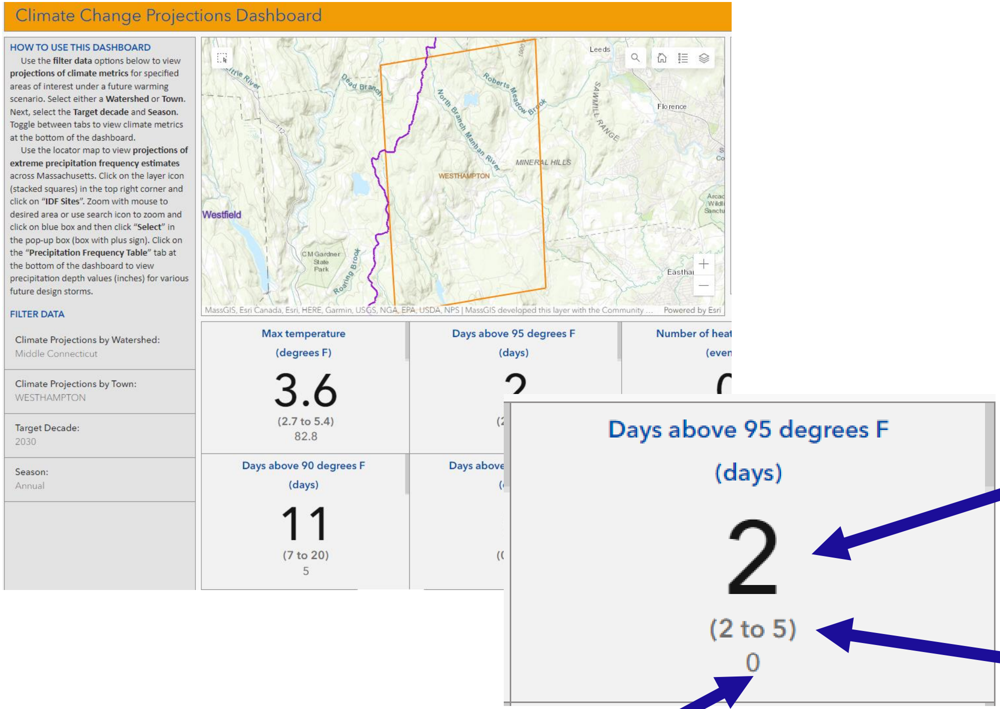
Map zooms to selected area



Select either watershed OR town

Values update in panel

Climate Change Projections Dashboard



Median projection: Two more days over 95F than we've typically seen in the past (so... two)

90% of climate models say more than 2 more days per year. 10% of models say 5 or more additional days per year.

What we've seen in the past: Typically 0 days over 95F each year

Climate Change Projections Dashboard

What you can find

Site	Year	Season	90th percentile (percent change)	99th percentile (percent change)	Consecutive dry days (days)	Consecutive wet days (days)	Cooling degree days (degree days)	Days above 1 inch (days)	Day[illegible]
Middle Connecticut	2030	Annual	0.7 (0.6 - 0.7) 0.4	6.7 (4.4 - 8.8) 1	0 (0 - 1) 31	0 (0 - 0) 45	308 (222 - 498) 382	1 (1 - 1) 4	[illegible]
Middle Connecticut	2030	Fall	0.9 (0.7 - 1.3) 0.4	5.6 (4.5 - 8.4) 1.1	0 (0 - 0) 8	0 (0 - 0) 11	48 (33 - 82) 42	0 (0 - 0) 1	[illegible]
Middle Connecticut	2030	Spring	0.5 (0.5 - 0.7) 0.4	6.7 (2.7 - 9.6) 1	0 (0 - 0) 7	0 (0 - 0) 11	24 (10 - 42) 18	0 (0 - 0) 1	[illegible]
Middle Connecticut	2030	Summer	0 (0 - 0) 0.3	4.7 (2.6 - 6.1) 1	[illegible] 8	[illegible] 11	[illegible] 322	[illegible] 1	[illegible]
Middle Connecticut	2030	Winter	1.2 (0.7 - 1) [illegible]	7.8 (4.5 - 11.6) [illegible]	0 (0 - 0) [illegible]	[illegible] (0 - 0) [illegible]	[illegible] (1 - 4) [illegible]	0 (0 - 0) [illegible]	[illegible]

Downloadable table containing all metrics for location

AVERAGE AND COLD DAYS | HOT DAYS | PRECIPITATION | STOCHASTIC WEATHER GENERATOR TABLE | PRECIPITATION FREQUENCY TABLE

Precipitation Frequency Table:

- Precipitation depth by storm return period (chance of depth being equaled or exceeded in a given year)
- 5-, 10-, 15-, 60-minute storms
- 2-, 3-, 6-, 12-, 24-, and 48-hour storms
- 1-, 2-, 5-, 10-, 25-, 50-, 100-, 200-, 500-, and 1000-year storms
  - 100-year storm: 1% chance of equal or bigger storm occurring in a given year

Average and Cold Days:

- Lowest one-day temperature
- Average temperature
- Number of cold stress events
- Number of cold waves
- Maximum cold wave duration
- Number of days below 0F
- Number of days below 32F
- Heating degree days

Hot Days:

- Number of heat stress events
- Number of heat waves
- Average heat wave duration
- Maximum heat wave duration
- Number of days above 90F
- Number of days above 95F
- Number of days above 100F
- Growing degree days
- Cooling degree days

Precipitation:

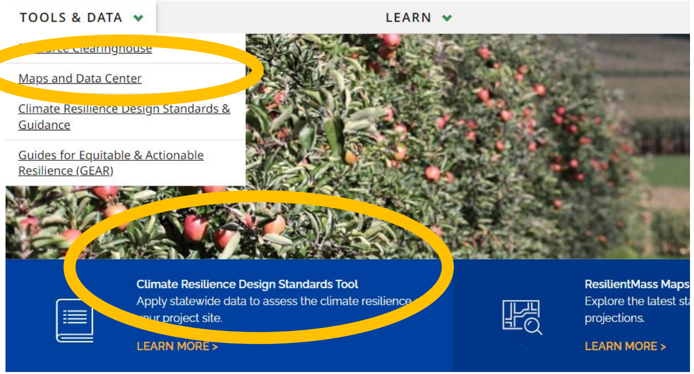
- Total precipitation
- Highest one-day precipitation
- Number of days with >1", 2", 4" precipitation
- Average consecutive number of dry days
- Average consecutive number of wet days
- 90th, 99th percentile storm (out of all days in a year with measurable precipitation)

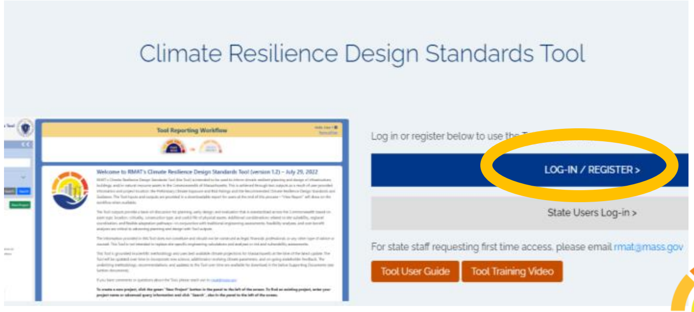
Climate Resilience Design Standards Tool: Overview

Goals:

- Make preliminary climate resilience analysis **more broadly accessible**
- Inform **"climate smart"** capital planning and procurement
- Provide resilience recommendations based on **consistent use** of state's climate data
- Provide a unified planning and design **support tool** that state agencies can use to administer grant programs
- Provide **consistent information to municipalities** hosted on resilient.mass.gov

ResilientMass





https://resilient.mass.gov/rmat_home/designstandards/

ResilientMass

CRDS Tool: Extreme Precipitation Design Values

Washed out road in Leominster, CBS Boston September 2023

"…dropped nearly ten inches of rain in six hours… the rainfall was "a 200-year event", says Matthew Belk, a meteorologist with the National Weather Service in Boston." CBS News, Boston

Town of North Attleborough Facebook, September 2023

"…about ten inches in the past 72 hours…" MassLive, September 2023

"…nearly five inches of rain in four hours…" CBS News, Boston September 2023

Farms flooding along Connecticut River. CBS News Boston, July 2023

FLOODING • SEP 11

Severe flash flooding prompts emergency in Leominster, impacts other parts of Mass.

LEOMINSTER • SEP 12

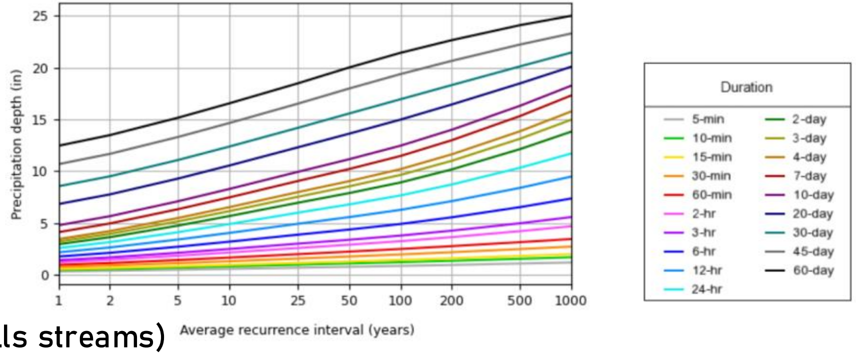
Flooding in Leominster: Dams being shored up, Healey declares Mass. state of emergency

As extreme precipitation flooding impacts Massachusetts, climate-informed design values allow risk-based flood management.

CRDS Tool: Extreme Precipitation Design Values

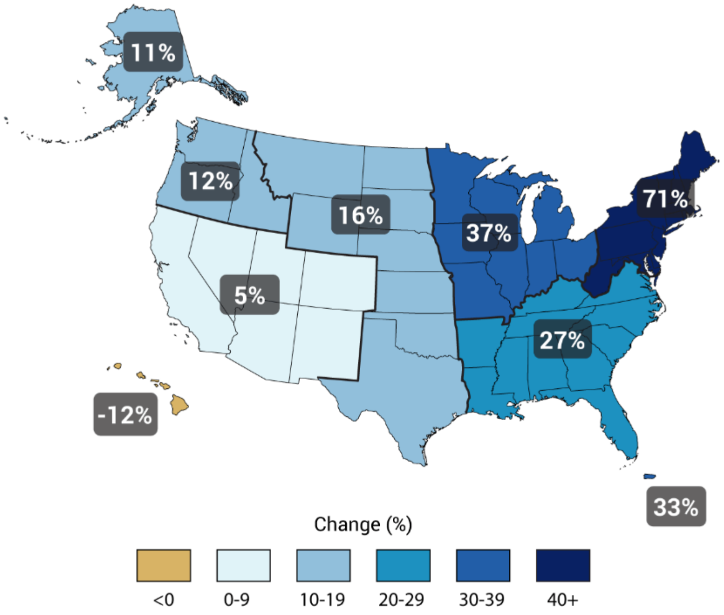
Precipitation intensity-duration-frequency (IDF) relationships

- What is IDF?
  - **Intensity**: How much rain (depth) per time?
  - **Duration**: How long does the storm last?
  - **Frequency**: What is the chance that the same or greater rainfall depth will fall in the same amount of time in a given year?
  - "Return Period" describes the approximate frequency a specific IDF storm could be expected.
- Examples
  - There is a 1 in 10 (10%) chance that a "10 year storm" will be equaled or exceeded in each year
  - There is a 1 in 100 (1%) chance that a "100-year storm" will be equaled or exceeded in each year
  - In Worcester, MA, the 10-year storm is …
    - 4.85" in 24 hours
    - 2.14" in 2 hours
- Used in
  - Stormwater bylaws
  - Stormwater infrastructure & BMP design
  - Flood modelling (urban, flash floods, smalls streams)



MA Climate-Scaled Precipitation Design Values

Observed Change in Very Heavy Precipitation



Source: National Climate Assessment, 2014

Table 4-76: Projected Frequency of Future Annual Extreme Precipitation Events in Massachusetts

	2030	2050	2070	2100
Number of Days >1" precipitation	7-9	8-10	8-10	8-11
Number of Days >2" precipitation	1	1-2	1-2	1-2

Source: resilient MA, 2018

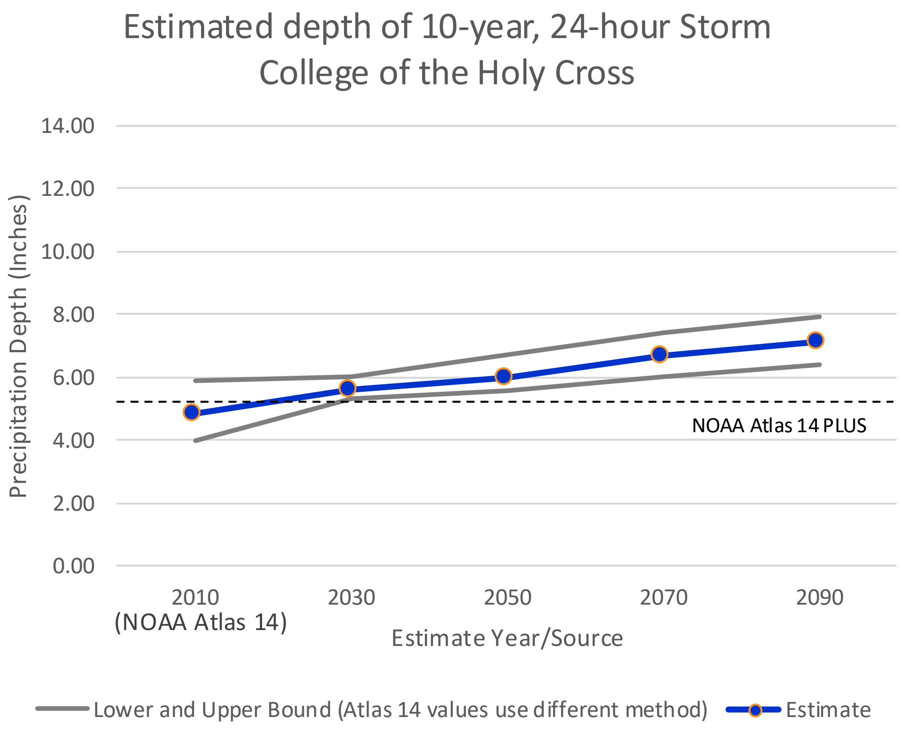
Source: MA State Hazard Mitigation and Climate Adaptation Plan (SHMCAP), 2018.

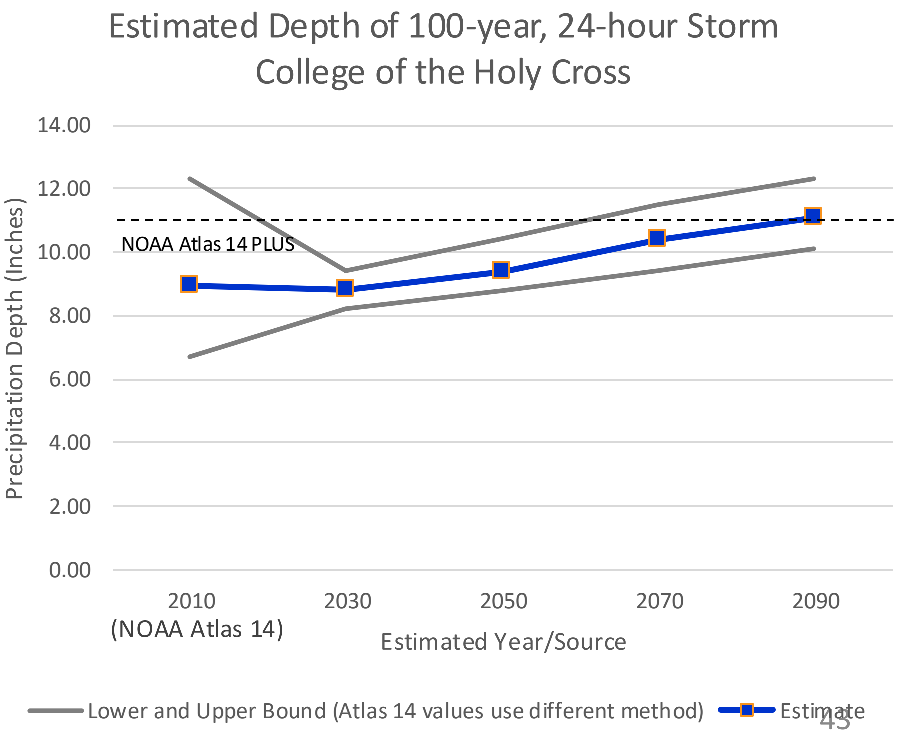
What is the future of extreme precipitation in New England?

- Storms have become more extreme….
  - Between 1958 and 2012, the amount of precipitation which falls in the heaviest 1% of rain events increased 71% across New England
- And projections suggest the changes will continue to grow.
  - Downscaled precipitation projections published in 2016 suggest the number of days with more than 1" in MA will increase from less than 7 to up to 11, on average, each year.

MA Climate-Scaled Precipitation Design Values

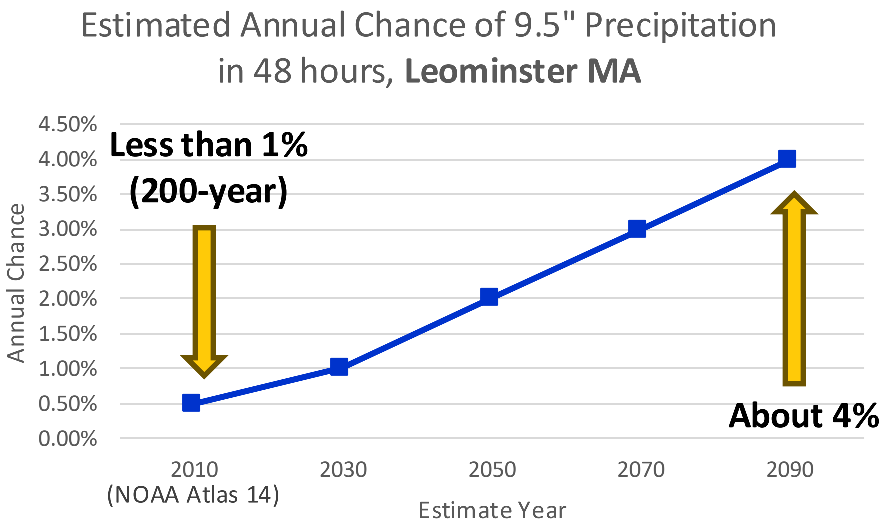
Past and Future Storms at College of the Holy Cross

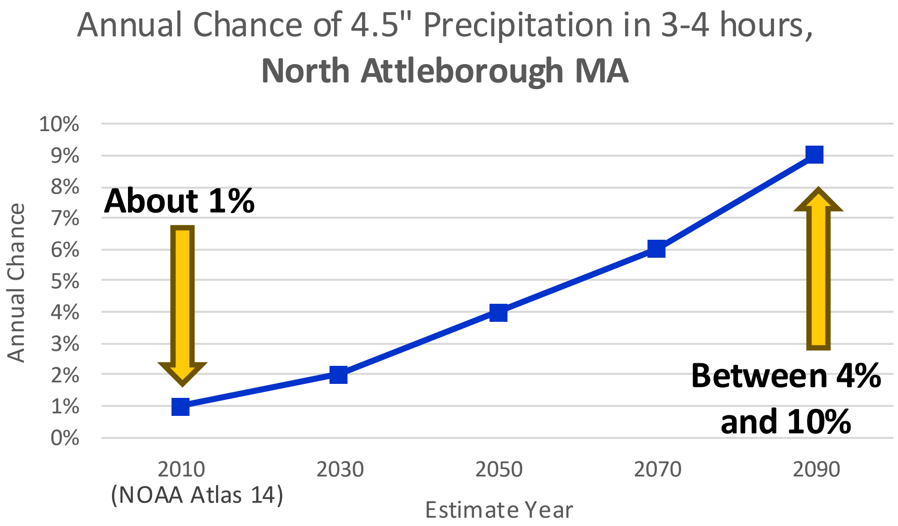




MA Climate-Scaled Precipitation Design Values

What is the future chance of storms like the September 11, 2023 Leominster and North Attleborough storms?





MA Climate-Scaled Precipitation Design Values

IDF reference for future extreme precipitation?

AMS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]									
Duration	Annual exceedance probability (1/years)								
	1/2	1/5	1/10	1/25	1/50	1/100	1/200	1/500	1/1000
5-min	0.371 (0.297-0.457)	0.487 (0.389-0.604)	0.576 (0.456-0.717)	0.692 (0.527-0.906)	0.780 (0.580-1.04)	0.869 (0.624-1.21)	0.964 (0.656-1.39)	1.10 (0.714-1.65)	1.20 (0.761-1.85)
10-min	0.525 (0.421-0.648)	0.690 (0.551-0.856)	0.815 (0.646-1.02)	0.980 (0.747-1.28)	1.10 (0.821-1.48)	1.23 (0.883-1.72)	1.37 (0.928-1.97)	1.55 (1.01-2.34)	1.70 (1.08-2.62)
15-min	0.618 (0.495-0.761)	0.812 (0.648-1.01)	0.959 (0.761-1.20)	1.15 (0.879-1.51)	1.30 (0.966-1.74)	1.45 (1.04-2.02)	1.61 (1.09-2.32)	1.83 (1.19-2.75)	2.00 (1.27-3.08)
30-min	0.841 (0.673-1.04)	1.11 (0.883-1.37)	1.31 (1.04-1.63)	1.57 (1.20-2.06)	1.77 (1.32-2.37)	1.98 (1.42-2.76)	2.19 (1.49-3.16)	2.49 (1.62-3.75)	2.73 (1.73-4.21)
60-min	1.06 (0.852-1.31)	1.40 (1.12-1.74)	1.66 (1.31-2.06)	1.99 (1.52-2.60)	2.24 (1.67-3.01)	2.50 (1.80-3.49)	2.78 (1.89-4.01)	3.16 (2.06-4.75)	3.46 (2.19-5.33)
2-hr	1.36 (1.09-1.66)	1.80 (1.44-2.22)	2.14 (1.70-2.65)	2.58 (1.98-3.36)	2.91 (2.18-3.90)	3.26 (2.36-4.56)	3.65 (2.49-5.24)	4.22 (2.75-6.31)	4.70 (2.98-7.18)
3-hr	1.55 (1.26-1.90)	2.08 (1.68-2.55)	2.48 (1.98-3.06)	3.00 (2.31-3.90)	3.38 (2.55-4.52)	3.79 (2.77-5.31)	4.27 (2.92-6.11)	4.98 (3.25-7.42)	5.58 (3.55-8.50)
6-hr	1.95 (1.59-2.37)	2.64 (2.14-3.22)	3.17 (2.55-3.89)	3.86 (3.00-5.00)	4.37 (3.32-5.82)	4.91 (3.62-6.86)	5.56 (3.81-7.90)	6.54 (4.28-9.68)	7.38 (4.70-11.2)
12-hr	2.41 (1.98-2.91)	3.32 (2.71-4.02)	4.00 (3.24-4.88)	4.91 (3.83-6.32)	5.56 (4.25-7.37)	6.28 (4.64-8.71)	7.12 (4.90-10.1)	8.40 (5.52-12.3)	9.49 (6.07-14.3)
24-hr	2.87 (2.37-3.45)	4.00 (3.28-4.81)	4.85 (3.96-5.87)	5.97 (4.69-7.64)	6.79 (5.21-8.93)	7.67 (5.70-10.6)	8.72 (6.02-12.2)	10.3 (6.82-15.1)	11.7 (7.52-17.5)
2-day	3.30 (2.74-3.93)	4.61 (3.82-5.52)	[illegible] (4.61-6.75)	6.92 (5.47-8.82)	7.88 (6.09-10.3)	[illegible] (6.68-12.3)	10.2 (7.05-14.2)	12.1 (8.03-17.6)	13.8 (8.90-20.5)
3-day	3.58 (2.99-4.25)	5.00 (4.16-5.96)	6.08 (5.01-7.29)	7.50 (5.94-9.51)	8.52 (6.61-11.1)	9.64 (7.25-13.2)	11.0 (7.65-15.3)	13.1 (8.71-19.0)	15.0 (9.66-22.1)
4-day	3.84 (3.21-4.54)	5.33 (4.44-6.33)	6.46 (5.34-7.72)	7.95 (6.32-10.1)	9.02 (7.02-11.7)	10.2 (7.68-13.9)	11.6 (8.10-16.1)	13.9 (9.20-20.0)	15.8 (10.2-23.2)
7-day	4.54 (3.82-5.34)	6.16 (5.16-7.28)	7.39 (6.14-8.79)	9.02 (7.19-11.3)	10.2 (7.95-13.2)	11.5 (8.64-15.5)	13.0 (9.08-17.9)	15.3 (10.2-22.0)	17.3 (11.2-25.4)
	5.22	6.92	8.20	9.90	11.1	12.5	14.0	16.3	18.3

- **NOAA Atlas 14 PLUS** method
  - 10-year, 24-hour storm PLUS = 90% of the 10-year, 24-hour estimate upper bound
  - 10-year, 24-hour storm PLUS = 5.87"*0.9
  - 10-year, 24-hour PLUS = 5.28"
- Some guidelines recommend "**NOAA Atlas 14 PLUS PLUS**" method
  - 10-year, 24-hour storm PLUS PLUS = 10-year, 24-hour storm upper bound
  - = 5.87"

Climate Resilience Design Standards Tool

Recommended planning/design parameter

Based on

Table 4.1. Standard Output Recommendations Provided by the Tool

Standards Output Recommendations	Example	Relationship Driving Recommendation
Planning Horizon[1]	2070	Useful Life
Return Period[2,8]	100-year (1% AEP)	Criticality[3], Asset Type, and Useful/Exposure Service Life[4]
Percentiles[5]	50th percentile	Criticality[3] and Construction Type
Design Criteria[6]	• Projected Total Precipitation Depth for 24-hr Design Storm • Projected Wave Action Water Elevation • Projected Cooling Degree Days, etc.	Asset Type and Location
Tiered Methodology[7] **to estimate projected design criteria values**	Tier 3 – High Level of Effort	Criticality[3] and Useful Life

Longer useful life → later target decade

More critical + longer useful life → higher return period

More critical → higher percentile

More critical + longer useful life → higher level of effort to estimate values