

Major riverine floods and climate change— more complicated than you may think



Glenn Hodgkins, USGS New England Water Science Center

Outline

- Historical flood and precipitation trends
 - Focus on Northeast and Maine
 - USGS has been measuring streamflow in Maine for over 100 years
- Why are trends in historical heavy precipitation different than trends in flood flows?
- What will the future bring?

Historical flood trends

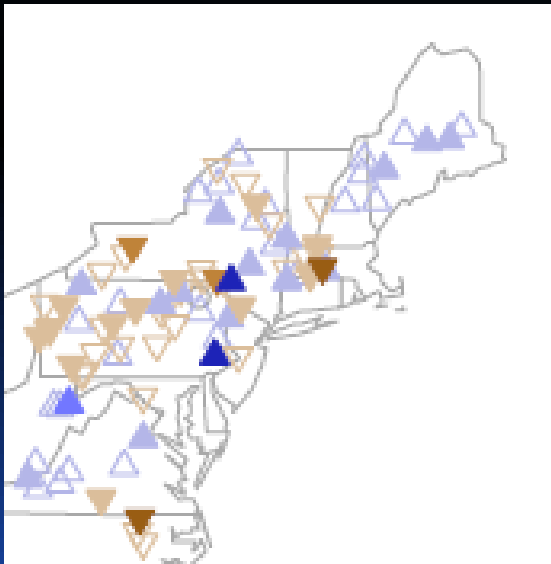
- Most flood-trend studies are based on annual peak flows or peaks over a threshold
- Annual peak flows tend to be mostly minor floods, with some moderate floods, and a few major floods



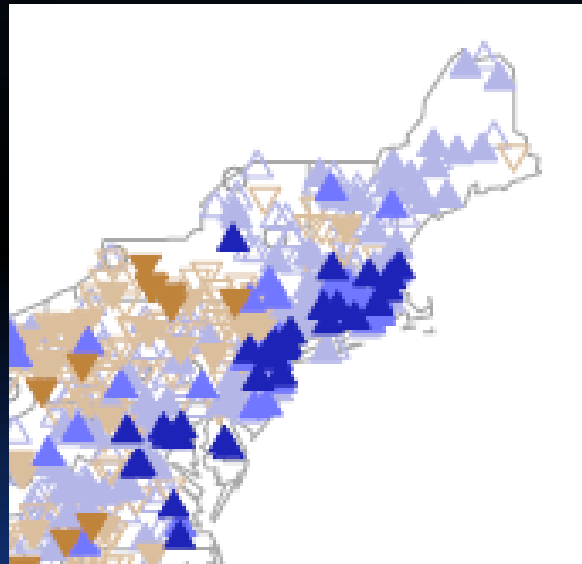
Trends in annual peak-flow magnitude

- Largely increases in Maine (some of them significant)
 - Blue triangles, increases; brown triangles, decreases
 - Open symbols, < 25%; light solid, increases 25-50%; Medium solid, 50-75%; dark solid, > 75%

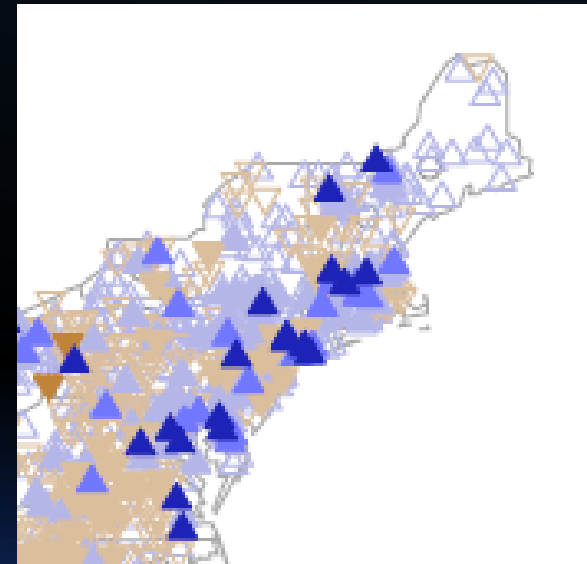
1916-2015



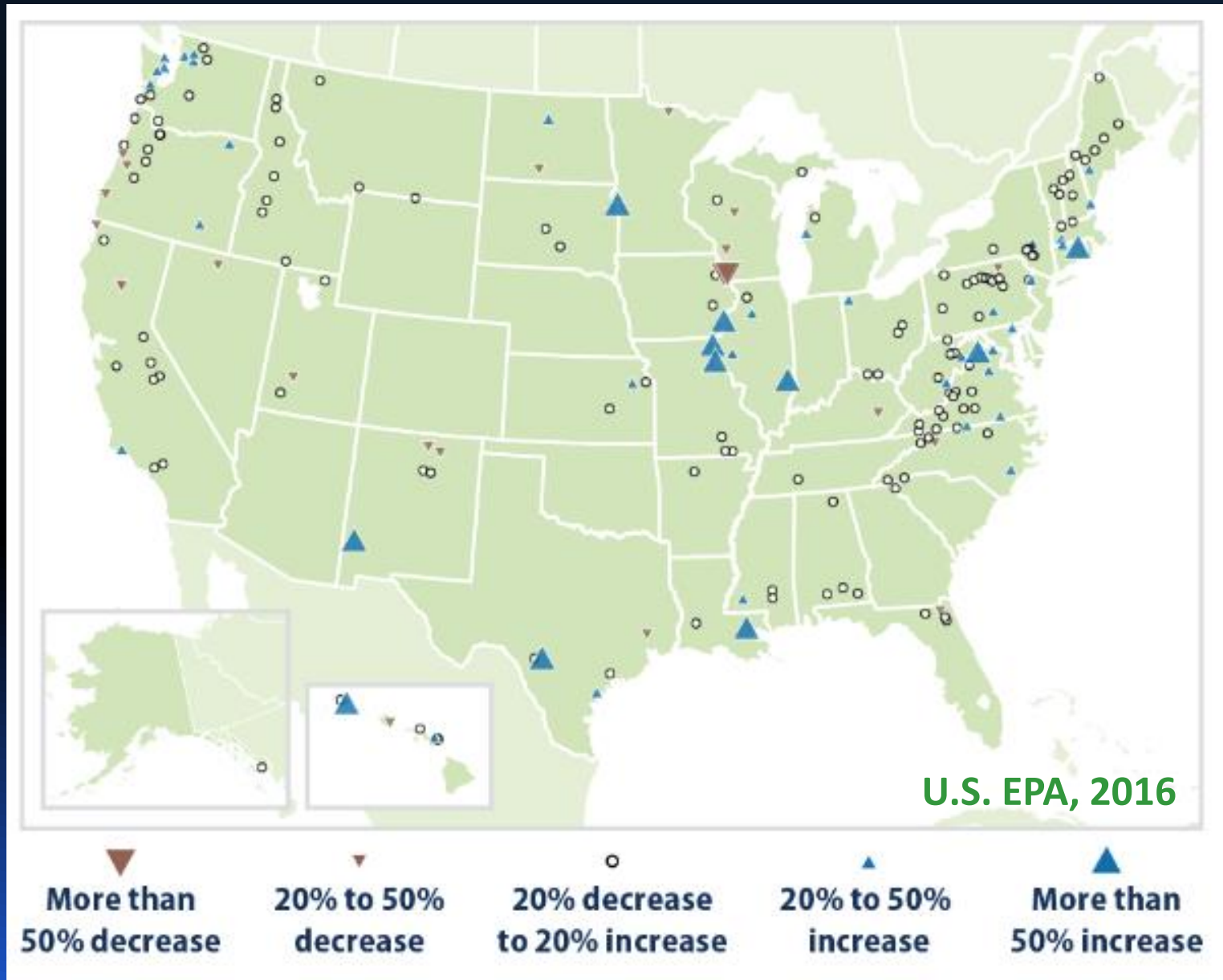
1941-2015



1966-2015

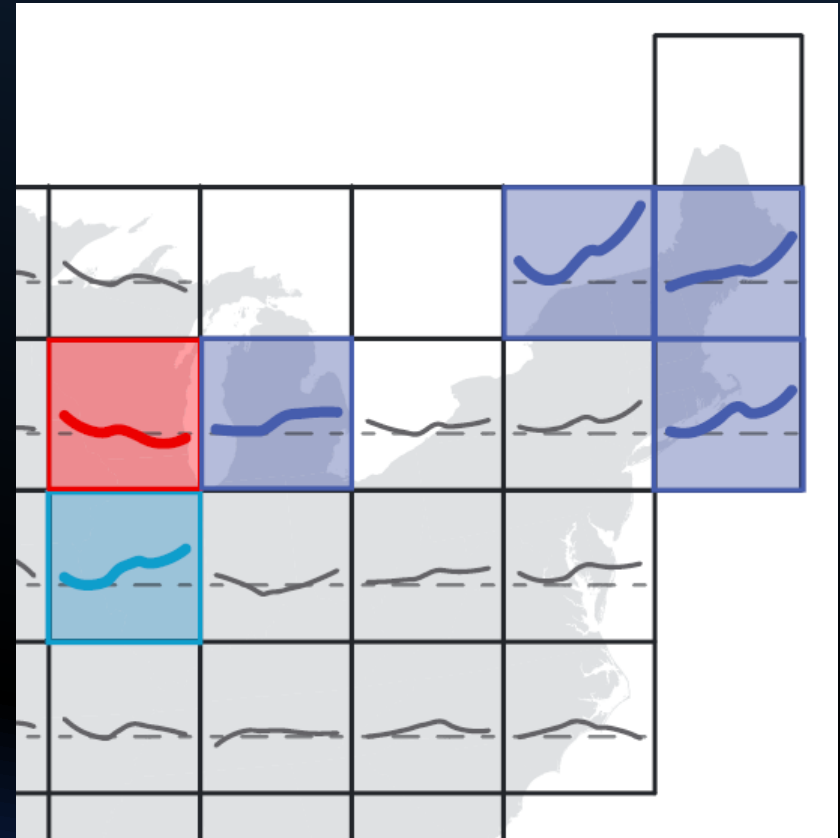


Trends in 3-day peak flows, 1940-2014

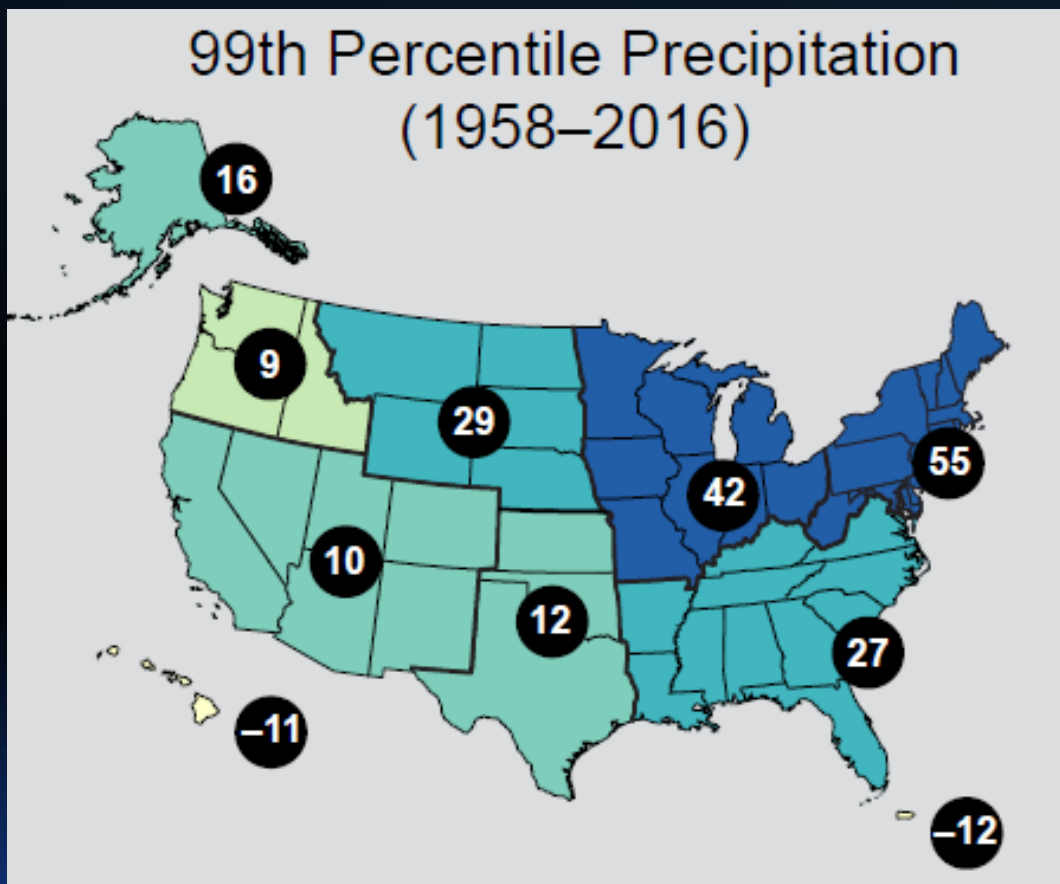


Historical trends: Peaks over threshold

- Average of 2 peaks per year at each streamflow gage at each streamflow gage
- Gages grouped within grid cells
- Increasing *number* of peaks over threshold in Maine from 1940 to 2013
- Shaded grid cells represent significant trends



Historical precipitation trends



- Large increases (55%) in daily heavy precipitation in Northeast
- Why haven't flood flows increased this much?

Easterling et al., 2017, 4th National Climate Assessment, Climate Change Special Report, Chapter 7

Why aren't flood increases as big as heavy-precipitation increases?

- It's not just about heavy rainfall
 - Snowpack and antecedent conditions can be important to floods in the Northeast
- Precipitation increases can be in seasons that don't typically produce a lot of floods (Small et al., 2006; Frei et al., 2015)
- 99th percentile precipitation results in 99th percentile flow 36% of time in U.S. (Ivancic and Shaw, 2015)
 - 62% of time during wet periods
 - 13% of time during dry periods
- Different durations of heavy rainfalls are important for different sized basins

Potential future changes in design riverine peak flows in coastal Maine

- Example output from detailed rainfall-runoff model
 - Change in 100-year peak flows for Narraguagus River (Eastern Maine) based on selected temperature and precipitation changes compared to modeled peak flows with no changes

Temperature change

		0° F	+3.6° F	+7.2° F	+10.8° F
Precip Change	0 %	0 %	-12 %	-21 %	-20 %
	+15 %	+26 %	+11 %	0 %	+4 %
	+30 %	+55 %	+39 %	+28 %	+32 %

Potential future changes in design peak flows in Maine

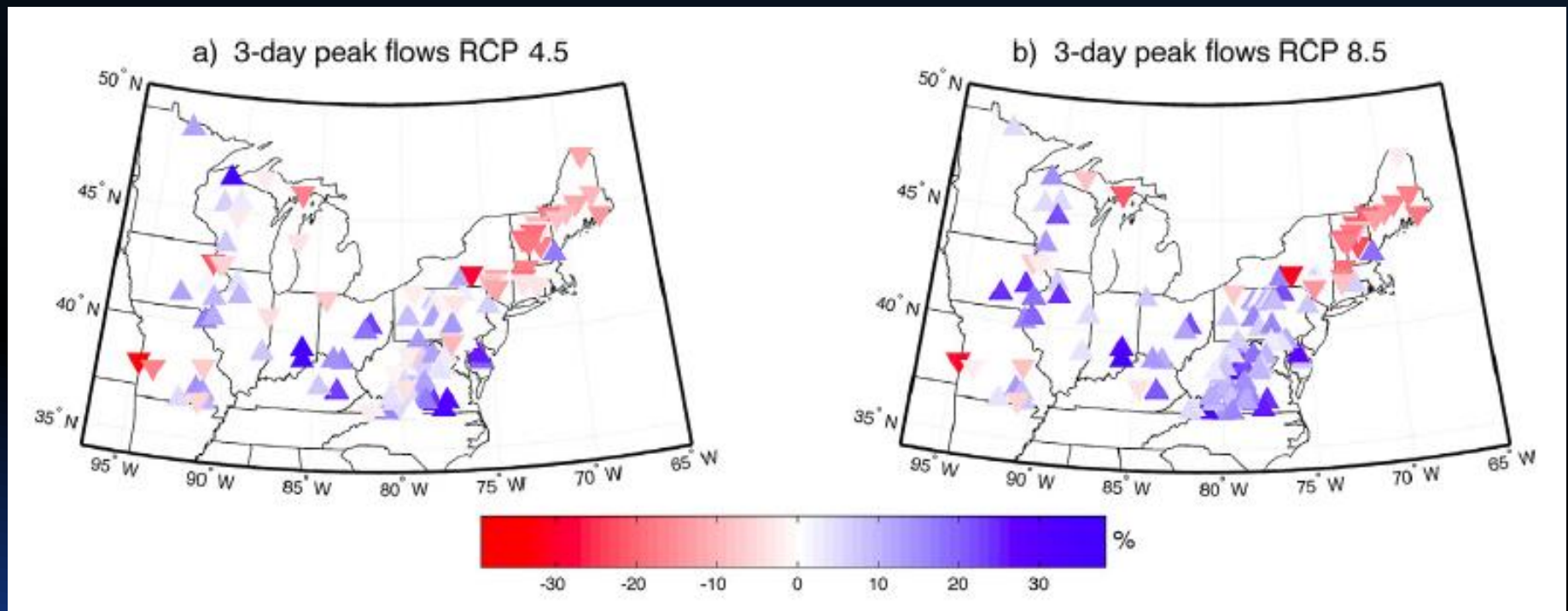
- Why do flood flows decrease with increasing temperature?
- Modeled maximum annual snowpack water-equivalent changes in Narraguagus River watershed

Temperature change

		0° F	+3.6° F	+7.2° F	+10.8° F
Precip Change	0 %	0 %	-42 %	-72 %	-89 %
	+15 %	+17 %	-33 %	-67 %	-87 %
	+30 %	+33 %	-22 %	-62 %	-86 %

Projected 100-year, 3-day peak flows

Trends in magnitude by mid-century for different climate scenarios



Calculating Peak flows using StreamStats

The screenshot displays the USGS StreamStats web application. At the top left is the USGS logo and the text "StreamStats". On the top right, there are links for "? HELP", "i ABOUT", and "REPORT". The main interface is divided into a left sidebar and a main map area. The sidebar has a blue header "SELECT A STATE / REGION" with a right-pointing arrow. Below this is a grey box with the text: "Step 1: Use the map or the search tool to identify an area of interest. At zoom level 8 or greater State/Region selection will be enabled". Underneath is a "Location Search" input field with a green "Go!" button and a blue circular icon with a question mark. Below the search field are three dropdown menus: "IDENTIFY A STUDY AREA", "SELECT SCENARIOS", and "BUILD A REPORT". At the bottom of the sidebar, it says "POWERED BY WIM". The main map area shows a topographic map of North America, including Alaska, Canada, and the United States. The map is zoomed in on the eastern United States, showing states like New York and Pennsylvania. Various geographical features are labeled, such as the Arctic Circle, Tropic of Cancer, and the Mid-Atlantic Ridge. The map also shows major bodies of water like the North Atlantic Ocean and the Gulf of Mexico.

Pam Lombard, USGS New England Water Science Center

USGS StreamStats

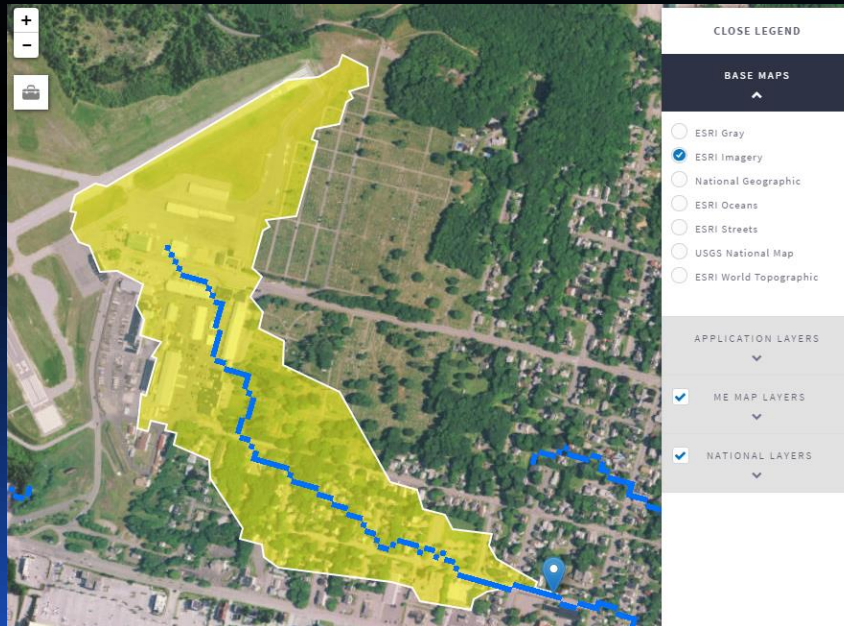
<http://streamstats.usgs.gov>

GIS-based Web application for calculating basin characteristics and streamflow statistics for user-selected sites on streams

The screenshot shows the USGS StreamStats application homepage. At the top left is the USGS logo with the tagline "science for a changing world". To the right of the logo are navigation links for SCIENCE, PRODUCTS, NEWS, CONNECT, and ABOUT. A search bar is located on the right side of the header. Below the header, the text "Water Resources" is displayed, followed by the "StreamStats" title. The main content area features a map of the United States with the text "StreamStats Application" and a button labeled "Access application". At the bottom of the page, there is a navigation menu with links for Overview, Results, Related Science, Publications, Data and Tools, Multimedia, and News.

StreamStats 4.0

- Provides published basin characteristics & streamflow statistics at gaged locations
- Calculates basin characteristics & streamflow statistics at ungaged locations
 - Delineates watershed
 - Generates statistical flows using USGS peak flow regression equations



Maine StreamStats

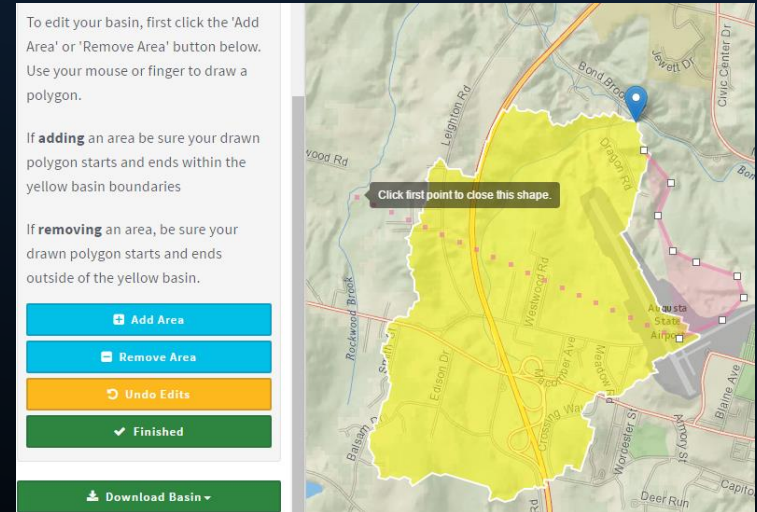
- Delineate/Edit basin boundary
- Select/Modify basin characteristics
- Print map
- Measure distance between selected points
- Elevation plots between selected points
- Network navigation tools

To edit your basin, first click the 'Add Area' or 'Remove Area' button below. Use your mouse or finger to draw a polygon.

If **adding** an area be sure your drawn polygon starts and ends within the yellow basin boundaries

If **removing** an area, be sure your drawn polygon starts and ends outside of the yellow basin.

Click first point to close this shape.

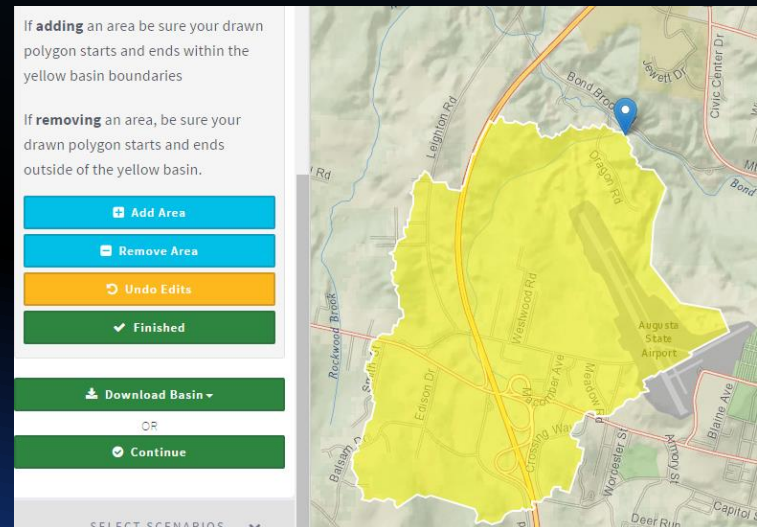


If **adding** an area be sure your drawn polygon starts and ends within the yellow basin boundaries

If **removing** an area, be sure your drawn polygon starts and ends outside of the yellow basin.

OR

SELECT SCENARIOS



Basin Characteristics (currently in StreamStats)

- Drainage Area
- % NWI wetlands
- % Sand & Gravel Aquifers
- Mean and Max Basin Elevation
- Mean Annual Precip
- Basin Centroid
- % Open Water
- Mean Basin Slope
- % of Hydrologic Soil Type A (STATSGO)
- % Urban Land (NLCD Land Class)
- % Impervious Area (NLCD)

Basin Characteristics

Select All Basin Characteristics

<input checked="" type="checkbox"/>	DRNAREA	Area that drains to a point on a stream
<input type="checkbox"/>	STORNWI	Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory
<input type="checkbox"/>	ELEV	Mean Basin Elevation
<input type="checkbox"/>	PRECIP	Mean Annual Precipitation
<input type="checkbox"/>	SANDGRAVAP	Percentage of land surface underlain by sand and gravel aquifers
<input type="checkbox"/>	COASTDIST	Shortest distance from the coastline to the basin centroid
<input type="checkbox"/>	CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates
<input type="checkbox"/>	CENTROIDY	Basin centroid vertical (y) location in state plane units

Streamflow Statistics (currently in StreamStats)

- Peak flows (such as 100-year flood)
- Mean and median annual & monthly flows
- Lowflows: 7-day, 10-year low flow (7Q10)
- Flow durations (such as 90% duration flow)
- Bankfull (partial area of state)

IDENTIFY A STUDY AREA
BASIN DELINEATED ▼

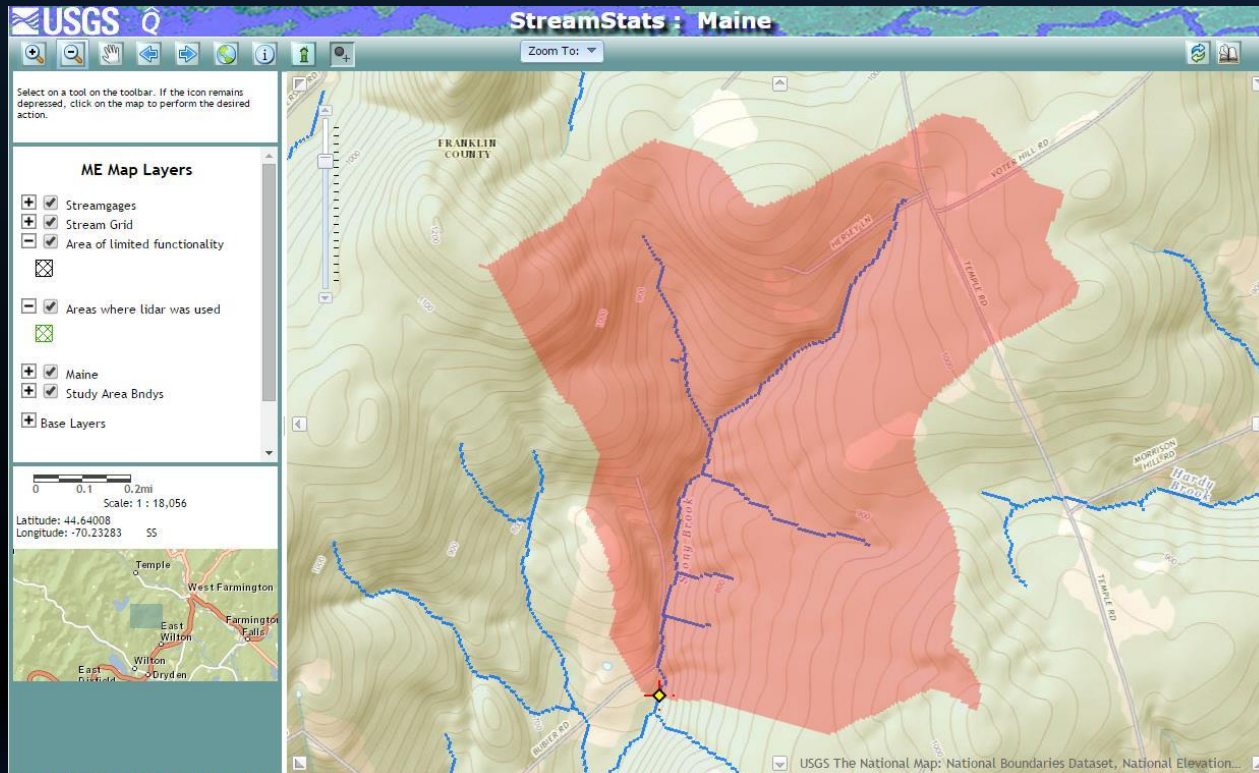
SELECT SCENARIOS >

Step 2: click "Continue" to proceed.

Regression Based Scenarios ⓘ

- Bankfull Statistics
- Peak-Flow Statistics
- Low-Flow Statistics
- Flow-Duration Statistics
- Annual Flow Statistics
- January Flow-Duration Statistics
- Monthly Flow Statistics
- February Flow-Duration Statistics
- March Flow-Duration Statistics
- April Flow-Duration Statistics
- May Flow-Duration Statistics

StreamStats Data

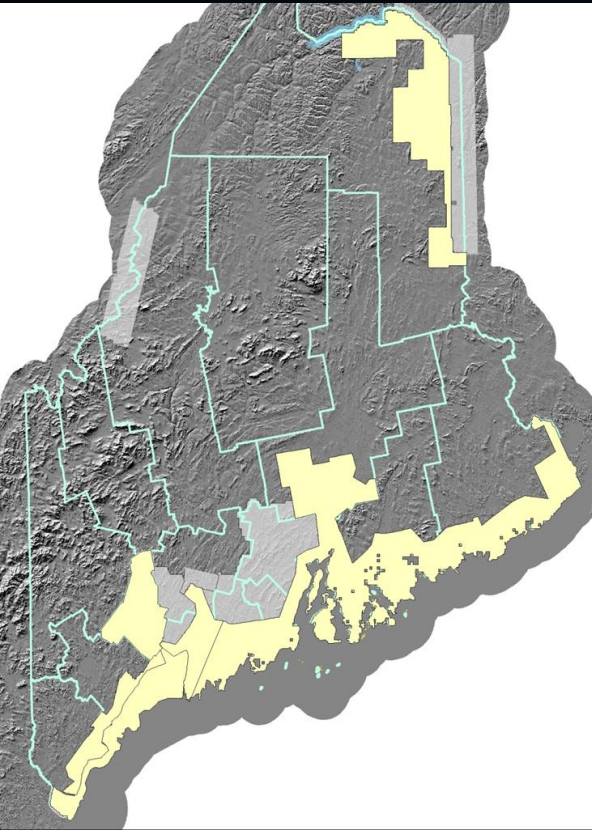


Delineates basins based on:

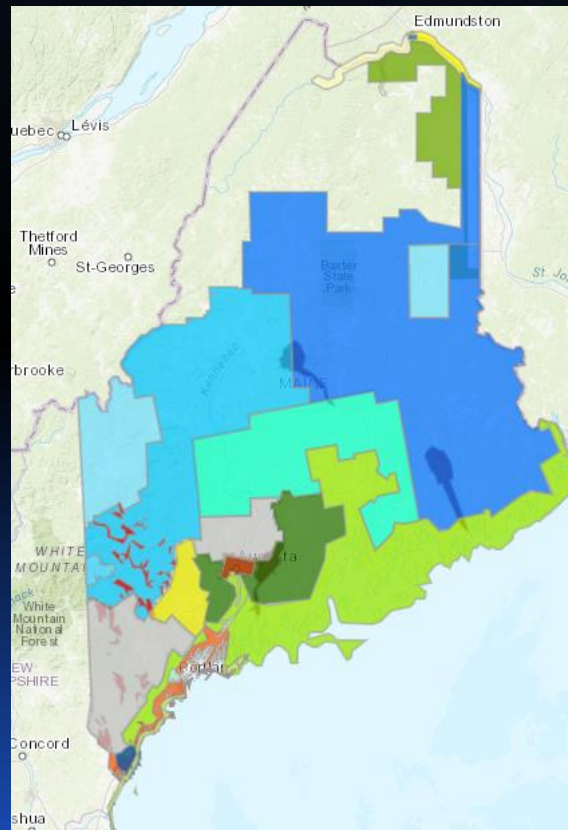
- 24K NHD
- 24K WBD
- 10M DEM or lidar

Lidar Availability in Maine

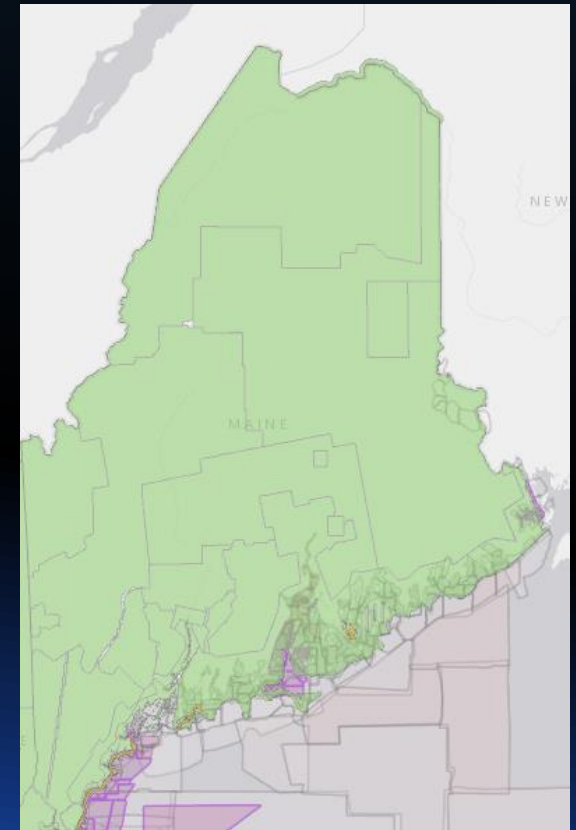
Currently in Streamstats



2019



Projected 2020



StreamStats Version 4

USGS StreamStats ? HELP i ABOUT REPORT

SELECT A STATE / REGION >

Step 1: Use the map or the search tool to identify an area of interest. At zoom level 8 or greater State/Region selection will be enabled

Location Search **Go!** ?

IDENTIFY A STUDY AREA ▾

SELECT SCENARIOS ▾

BUILD A REPORT ▾

The screenshot shows a map of the United States with various cities and states labeled. A red arrow points to the 'Location Search' input field.

USGS StreamStats ? HELP i ABOUT REPORT

SELECT A STATE / REGION >

Step 2: You have zoomed in sufficiently to select a state or regional study area. Your selection will dictate the data used to perform basin delineation and flow statistics calculation.

Select a State or Regional Study Area Below

Maine ?

New Hampshire ?

Location Search **Go!** ?

IDENTIFY A STUDY AREA ▾

SELECT SCENARIOS ▾

BUILD A REPORT ▾

The screenshot shows a zoomed-in view of a study area in Maine, with a red circle highlighting the 'Maine' button in the state selection list.

SELECT A STATE / REGION
MAINE ⓘ

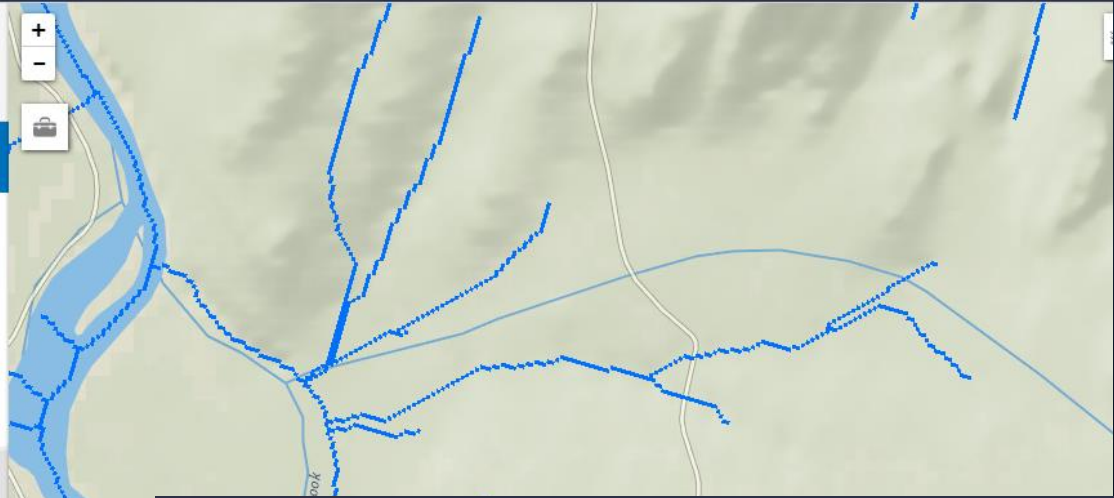
IDENTIFY A STUDY AREA >

Step 2: Click the 'Delineate' button to activate the delineation tool

Delineate

SELECT SCENARIOS ▾

BUILD A REPORT ▾



Base Maps

- National Map
- Gray
- Dark Gray
- Imagery
- National Geographic
- Shaded Relief
- Streets
- World Topographic

Application Layers ▾

- National Layers ▾

To edit your basin, first click the 'Add Area' or 'Remove Area' button below. Use your mouse or finger to draw a polygon.

If **adding** an area be sure your drawn polygon starts and ends within the yellow basin boundaries

If **removing** an area, be sure your drawn polygon starts and ends outside of the yellow basin.

Add Area

Remove Area

Undo Edits

Finished

Download Basin ▾

OR

Continue



Edit Basin Boundary

SELECT A STATE / REGION
Maine

IDENTIFY A STUDY AREA
Basin Delineated

Step 5: Your delineation is complete. You can now clear, edit, or download your basin, or choose a state or regional study specific function (if available). Click **continue** when you are ready.

Clear Basin

Edit Basin

Download Basin

OR

Continue

SELECT SCENARIOS

BUILD A REPORT

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Zoom Level: 14
Map Scale: 1:36,111
Lat: 44.3022, Lon: -69.8583

USGS StreamStats

IDENTIFY A STUDY AREA
Basin Delineated

Step 5: Your delineation is complete. You can now clear, edit, or download your basin, or choose a state or regional study specific function (if available). Click **continue** when you are ready.

Clear Basin

Edit Basin

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adding an area be sure your drawn polygon starts and ends within the yellow basin boundaries

removing an area, be sure your drawn polygon starts and ends outside of the yellow basin.

Add Area

Remove Area

Undo Edits

Zoom Level: 14
Map Scale: 1:36,111
Lat: 44.3164, Lon: -69.8718

USGS StreamStats

SELECT A STATE / REGION
Maine

IDENTIFY A STUDY AREA
Basin Delineated

Step 5: Your delineation is complete. You can now clear, edit, or download your basin, or choose a state or regional study specific function (if available). Click **continue** when you are ready.

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Add Area

Zoom Level: 14
Map Scale: 1:36,111
Lat: 44.2859, Lon: -69.8706

Clear Basin

Edit Basin

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If **removing** an area, be sure your drawn polygon starts and ends outside of the yellow basin.

Add Area

Remove Area

Undo Edits

Submit Edited Basin

Download Basin

GeoJSON

Shapefile

ESRI File GDB

Exploration Tools

Zoom Level: 14
Map Scale: 1:36,111
Lat: 44.2975, Lon: -69.8639

Download Basin Delineation

ArcGIS

Untitled - ArcMap

File Edit View Bookmarks Insert Set Selectable Layers... Selection Geoprocessing Customize Windows Help

XTools Pro

1:26,157

RAS Geometry RAS Mapping

Snapping

Table Of Contents

Layers

- GlobalWatershedPoint
- GlobalWatershed
- Basemap
- World Imagery

Zip file sent to download directory

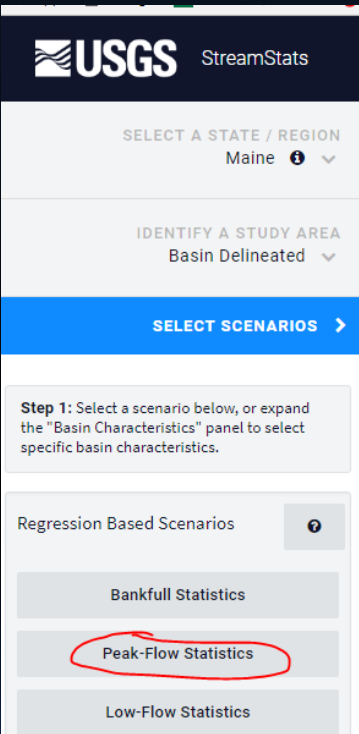
Name	Type	Details
GlobalWatershed.cpg	CPG File	
GlobalWatershed.dbf	DBF File	
GlobalWatershed.prj	PRJ File	
GlobalWatershed.sbn	SBN File	
GlobalWatershed.sbx	SBX File	
GlobalWatershed.shp	SHP File	
GlobalWatershed.shp	XML File	
GlobalWatershed.shx	SHX File	
GlobalWatershedFields	Text Document	
GlobalWatershedPoint.cpg	CPG File	
GlobalWatershedPoint.dbf	DBF File	
GlobalWatershedPoint.prj	PRJ File	
GlobalWatershedPoint.sbn	SBN File	
GlobalWatershedPoint.sbx	SBX File	
GlobalWatershedPoint.shp	SHP File	
GlobalWatershedPoint.shp	XML File	
GlobalWatershedPoint.shx	SHX File	

[SS_ME20180405103902653000.zip](https://streamstats.usgs.gov/streamstatsservices/download?workspaceID=ME20180405...)

<https://streamstats.usgs.gov/streamstatsservices/download?workspaceID=ME20180405...>

[Show in folder](#)

Select Statistics & Basin Characteristics (Scenarios)



USGS StreamStats

SELECT A STATE / REGION
Maine ⓘ ▾

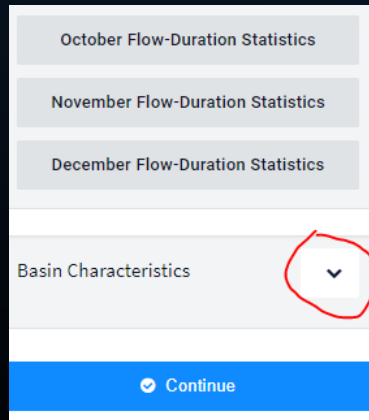
IDENTIFY A STUDY AREA
Basin Delineated ▾

SELECT SCENARIOS >

Step 1: Select a scenario below, or expand the "Basin Characteristics" panel to select specific basin characteristics.

Regression Based Scenarios ⓘ

- Bankfull Statistics
- Peak-Flow Statistics**
- Low-Flow Statistics



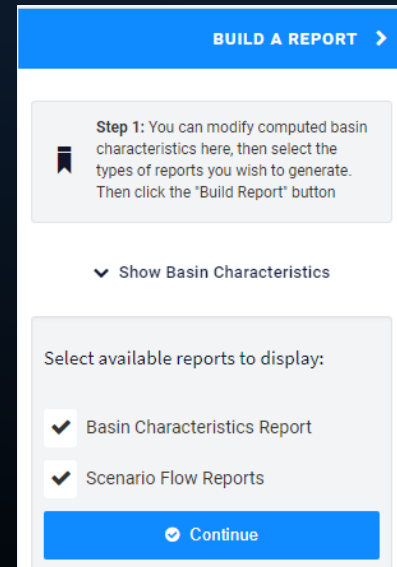
October Flow-Duration Statistics

November Flow-Duration Statistics

December Flow-Duration Statistics

Basin Characteristics ▾

Continue



BUILD A REPORT >

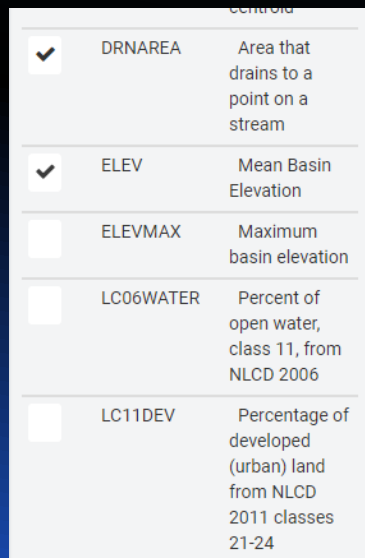
Step 1: You can modify computed basin characteristics here, then select the types of reports you wish to generate. Then click the "Build Report" button

Show Basin Characteristics

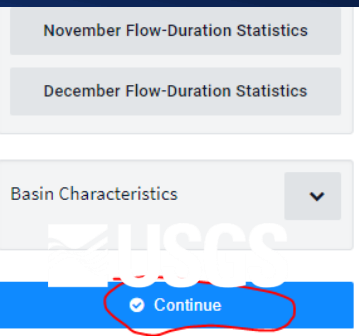
Select available reports to display:

- Basin Characteristics Report
- Scenario Flow Reports

Continue



Parameter	Description
<input checked="" type="checkbox"/> DRNAREA	Area that drains to a point on a stream
<input checked="" type="checkbox"/> ELEV	Mean Basin Elevation
<input type="checkbox"/> ELEVMAX	Maximum basin elevation
<input type="checkbox"/> LC06WATER	Percent of open water, class 11, from NLCD 2006
<input type="checkbox"/> LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24



November Flow-Duration Statistics

December Flow-Duration Statistics

Basin Characteristics ▾

Continue



Hide Basin Characteristics

Basin Characteristics can be edited here

Parameter	Value
DRNAREA	3.4
STORNWI	12.91
ELEV	315

StreamStats Report

Region ID:
 Workspace ID:
 Clicked Point (Latitude, Longitude):
 Time:

ME
 ME20180405103902653000
 44.27587, -69.86695
 2018-04-05 06:39:19 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	3.4	square miles
STORNWI	Percentage of storage (combined water bodies and wetlands) from the Nationa Wetlands Inventory	12.91	percent
ELEV	Mean Basin Elevation	315	feet

Peak-Flow Statistics Parameters [Statewide Peak Flow DA LT 12sqmi 2015 5049]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.4	square miles	0.31	12
STORNWI	Percentage of Storage from NWI	12.91	percent	0	22.2

Peak-Flow Statistics Flow Report [Statewide Peak Flow DA LT 12sqmi 2015 5049]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
1.01 Year Peak Flood	32.9	ft ³ /s	38
2 Year Peak Flood	110	ft ³ /s	34
5 Year Peak Flood	172	ft ³ /s	35
10 Year Peak Flood	214	ft ³ /s	37
25 Year Peak Flood	281	ft ³ /s	39
50 Year Peak Flood	325	ft ³ /s	41
100 Year Peak Flood	380	ft ³ /s	42
250 Year Peak Flood	426	ft ³ /s	44
500 Year Peak Flood	508	ft ³ /s	47

Peak-Flow Statistics Citations

[Lombard, P.J., and Hodgkins, G.A., 2015, Peak flow regression equations for small, ungaged streams in Maine— Comparing map-based to field-based variables: U.S. Geological Survey Scientific Investigations Report 2015–5049, 12 p.](#)



Download Basin -

Download CSV

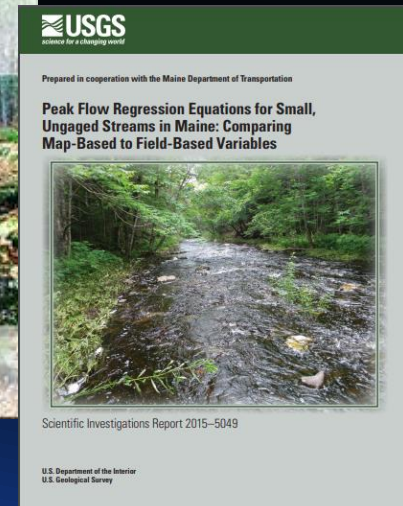
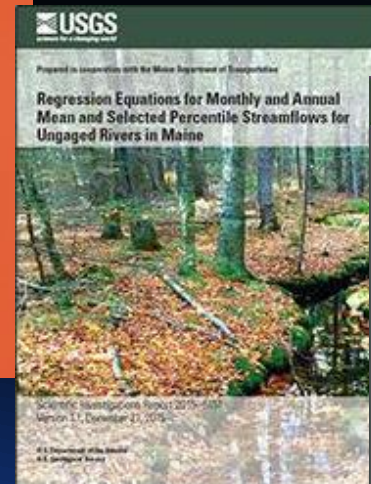
USGS Regression Equations Inform StreamStats

Peakflows: Hodgkins, 1999- currently being updated

Monthly & Annual Mean & Selected Percentile Streamflows: Dudley, 2015

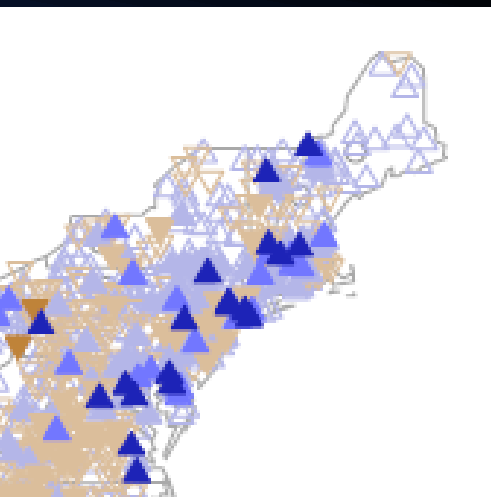
Peakflows for Small Watersheds: Lombard and Hodgkins, 2015

Regional Lowflows: multiple



Peakflow Equations & Climate Change

- Equations assume stationarity (no trends)
 - Estimating largest peaks (100-yr)
 - Statewide equations
 - Some evidence of historical increases
 - Future trends uncertain
- Update equations every 20 years



Precip
Change

Temperature change

	0° F	+3.6° F	+7.2° F	+10.8° F
0 %	0 %	-12 %	-21 %	-20 %
+15 %	+26 %	+11 %	0 %	+4 %
+30 %	+55 %	+39 %	+28 %	+32 %

Maine StreamStats

<http://streamstats.usgs.gov>

Pam Lombard

(207) 626-6630

plombard@usgs.gov



Maine StreamStats—A Water-Resources Web Application

Maine StreamStats (<http://streamstats.usgs.gov>), a geographic information system-based Web application of the U.S. Geological Survey (USGS), is a tool for calculating basin characteristics and streamflow statistics for user-selected sites on streams in Maine.

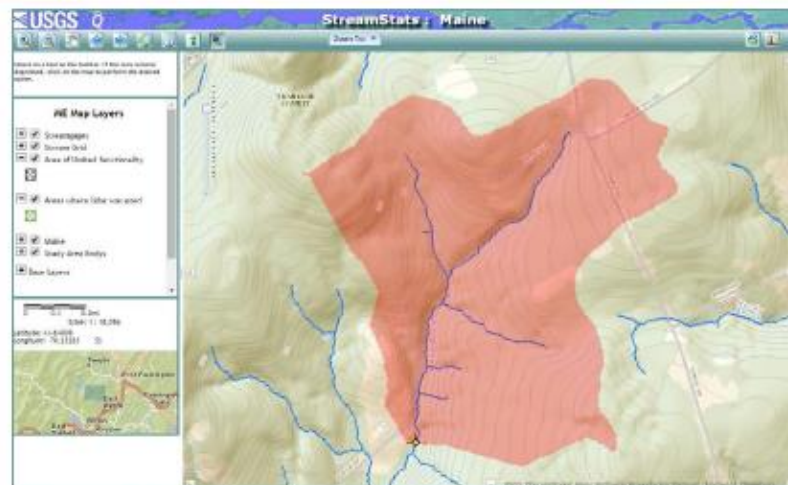


Figure 1. Screen capture from Maine StreamStats Web application showing delineated basin and available map layers.

Introduction

Maine StreamStats is a tool that any user with Internet access can use to delineate a basin on the fly and estimate a wide variety of streamflow statistics for ungaged sites on rivers and streams in Maine (figs. 1 and 2). Estimates are based on regression equations or are from data from similar gaged locations on the stream. Maine StreamStats is based on a national StreamStats application that can be used for streamflow estimates in many other states across the country (Ries and others, 2008).

Reports referenced in this fact sheet present the regression equations used to estimate the flow statistics, describe the errors associated with the estimates, and describe the methods used to develop the equations and to measure the basin characteristics used in the equations. Limitations of the methods are also described in the reports; for example, all of the equations are appropriate only for ungaged, unregulated, rural streams in Maine.

Data Used for Basin Delineations

Basin delineations in StreamStats are based on the integration of the National Hydrography Dataset (24K NHD), the Watershed Boundary Dataset (24K WBD), and the 10-meter resolution digital elevation model (DEM) data from the National Elevation Dataset (NED).

High resolution DEMs from light detection and ranging (lidar) data are available for some areas of Maine and were incorporated into the DEM for the delineating of basins. The DEMs for these areas have a 1-foot vertical accuracy and are much more accurate than the 10-meter DEMs with 10- to 20-foot vertical accuracies with which they are merged. StreamStats indicates where lidar was used. Additional lidar data will be incorporated into StreamStats as they become available.

Flow Estimates and Basin Characteristics

Streamflow statistics that can be output from the tool include peak flows with 1- to 500-year recurrence

