



July 2023 Flood in Vermont Preliminary Flood Frequencies at USGS Streamgages

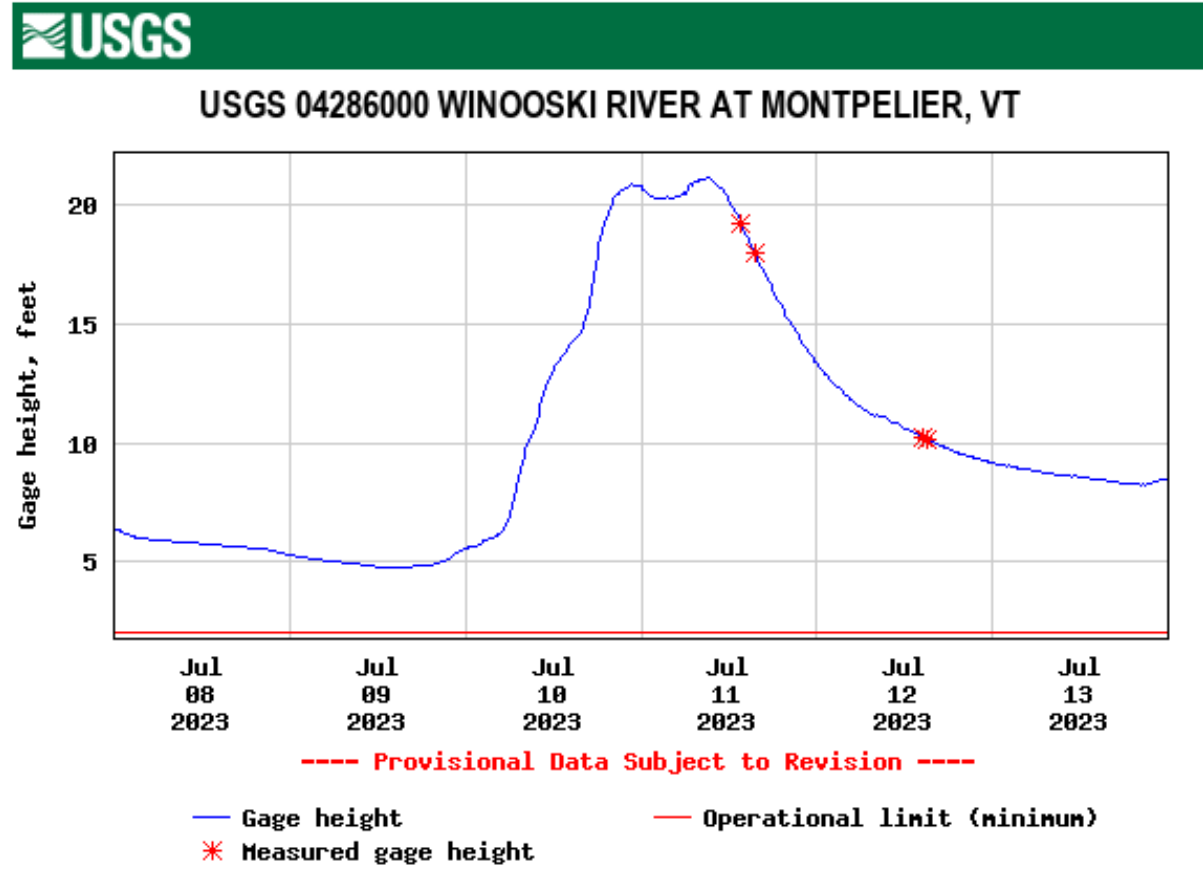
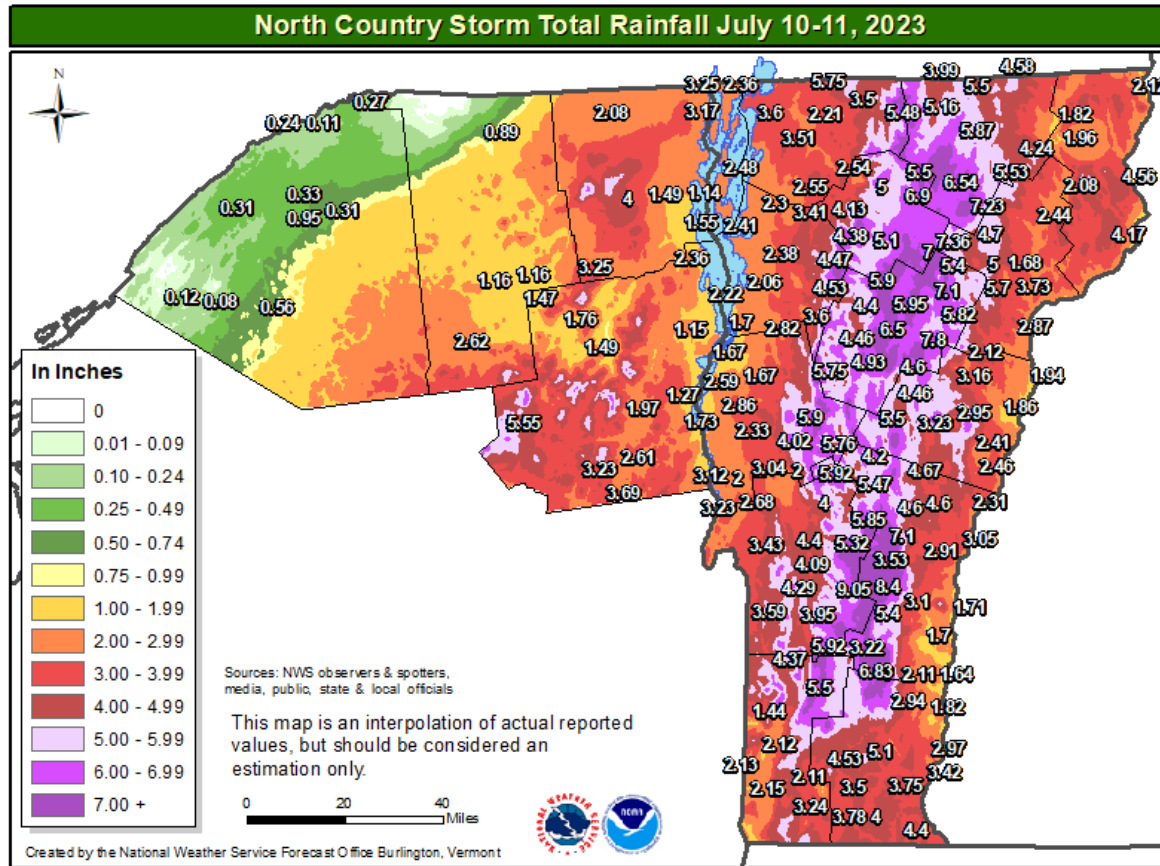
Flooding at the Winooski River, Montpelier, VT.



In cooperation with Federal Emergency Management Agency

Background

- Heavy rainfall July 10-11, 2023 across VT (left image) caused high streamflows (shown by gage height, right image) and widespread flood damage
 - 3 - 9 inches of precipitation were reported within 48 hours
 - Montpelier received comparable precipitation totals (5.28 inches) as with Hurricane Irene (5.27 inches)
- ([The Great Vermont Flood of 10-11 July 2023: Preliminary Meteorological Summary \(weather.gov\)](#))



National Weather Service map (left) providing precipitation data for July 10-11 ([The Great Vermont Flood of 10-11 July 2023: Preliminary Meteorological Summary \(weather.gov\)](#)). High precipitation resulted in high streamflows, as recorded at USGS streamgage 04286000 Winooski River at Montpelier, VT (right, [Winooski River at Montpelier, VT - USGS Water Data for the Nation](#)).

Flood damage from the Black River as a result of the July 2023 storm (right image) shown at Carlton Road in Cavendish, VT, compared to pre-storm conditions (left image).



February 2022



July 2023

USGS Flood Response

- In response to catastrophic flooding, the U.S. Geological Survey (USGS):
 - Tagged, surveyed, and analyzed high-water marks (HWMs)
 - HWMs are historical records that provide a measure of water-surface elevation during a flood and are used to verify streamgage measurements
 - Peak streamflows were recorded and used to determine recurrence intervals at USGS gages, including continuous gages and crest-stage streamflow gages (CSG)
 - Data provide insight to the extent of flooding and crucial information to understanding future flood risk

The white high-water mark disk on the tree shows how high the Ottauquechee River in Bridgewater, VT, reached ([High-Water Mark at the Ottauquechee River | U.S. Geological Survey \(usgs.gov\)](https://www.usgs.gov/locations/northeast/ottauquechee-river/high-water-mark))

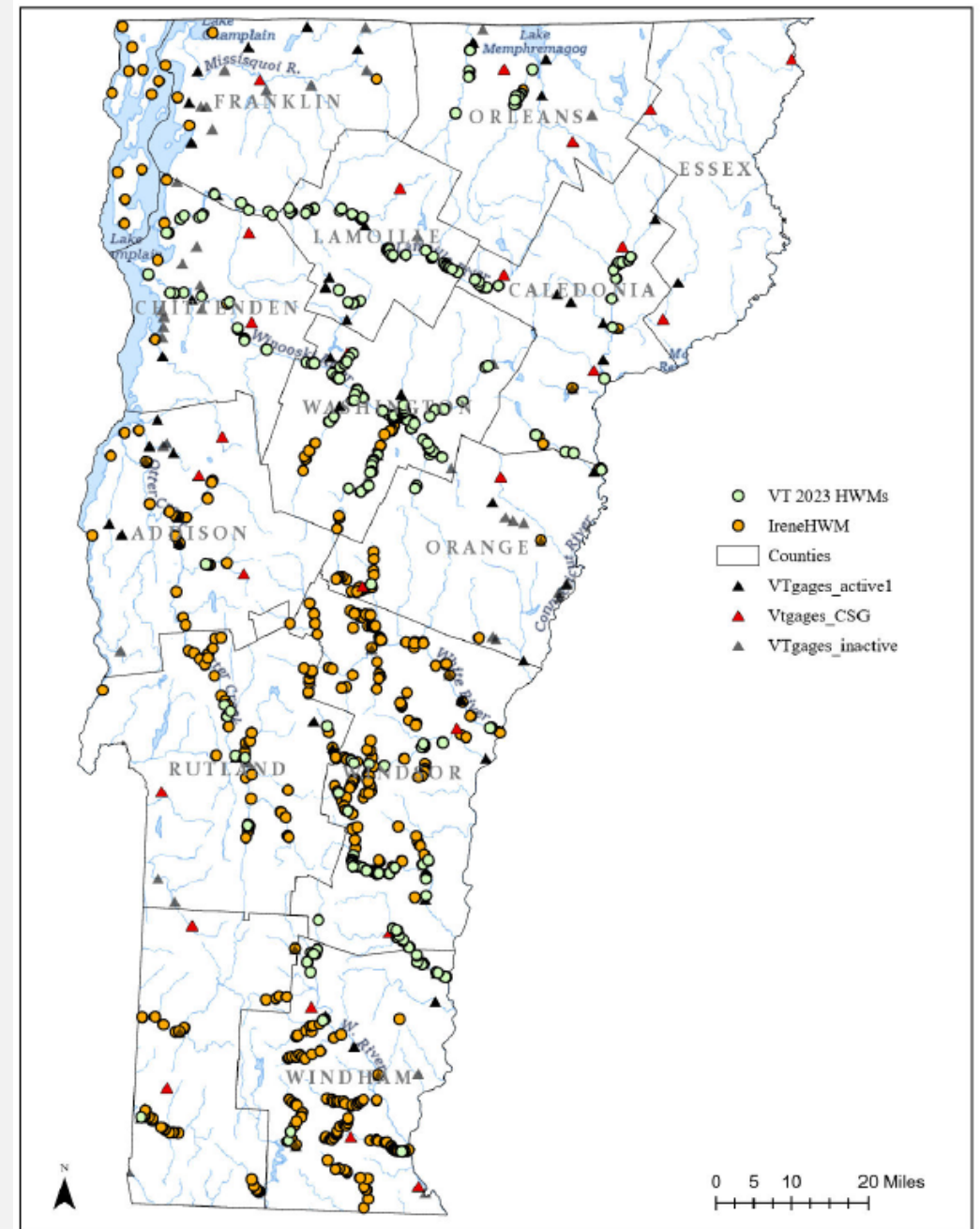


Surveyed HWMs

HWM survey campaign:

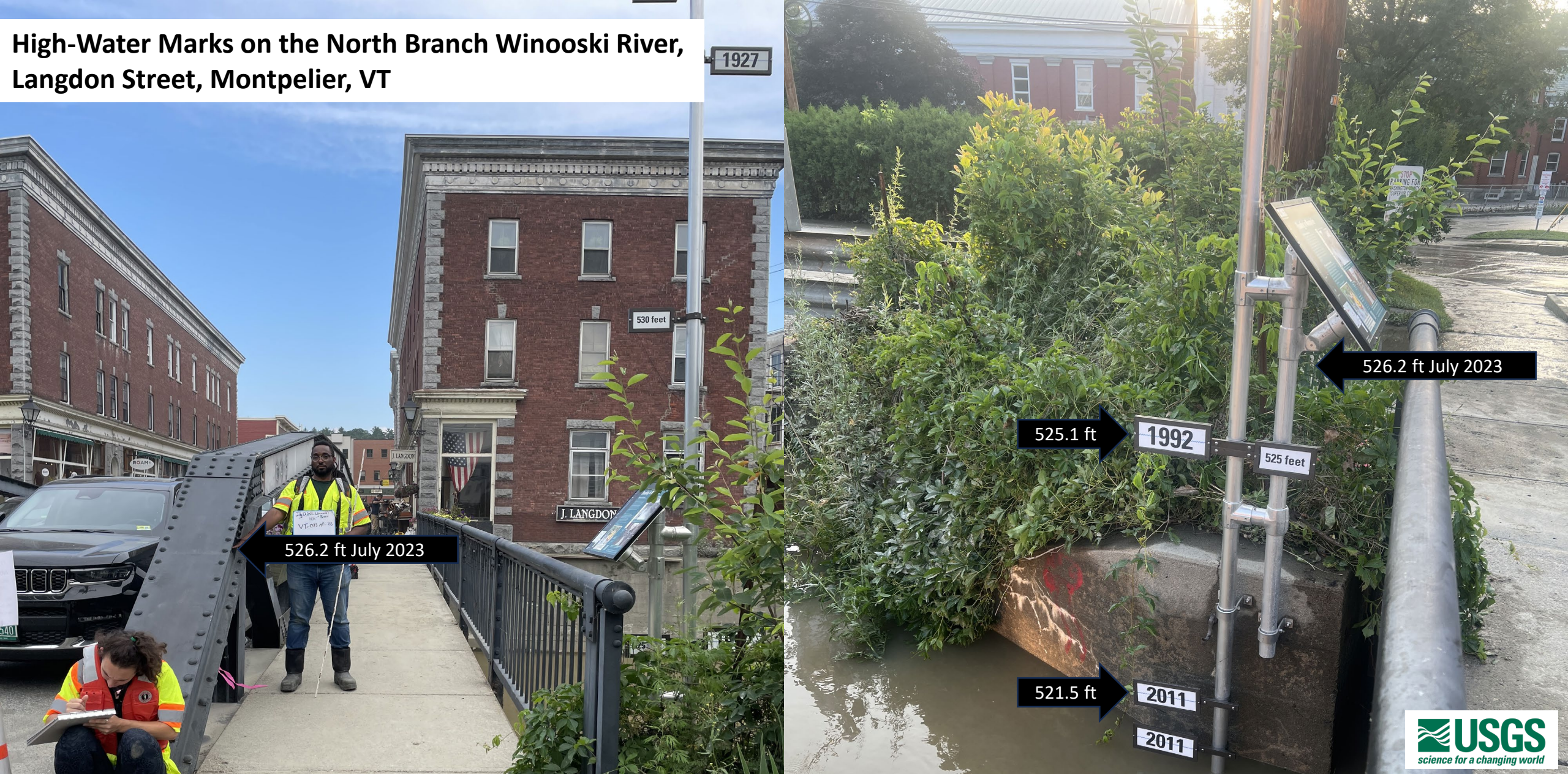
- 547 HWMs were tagged and surveyed in July 2023
- July 2023 HWMs were co-located with Tropical Storm Irene HWMs where possible to provide direct comparison between events
- Surveyed HWM data are available on USGS Flood Event Viewer ([Flood Event Viewer \(usgs.gov\)](https://www.usgs.gov/flood-event-viewer))

July 2023 HWM (white disk) did not reach the same elevation as the Tropical Storm Irene HWM (green disk) on the Ottaquechee River in Bridgewater, VT ([Item \(3024x4032\) \(usgs.gov\)](https://www.usgs.gov/flood-event-viewer)).



Map showing the locations of surveyed HWMs for Tropical Storm Irene and the July 2023 flood in VT.

High-Water Marks on the North Branch Winooski River, Langdon Street, Montpelier, VT



The July 2023 HWM is visible on the garter of the bridge (left image, [Item \(3024x4032\) \(usgs.gov\)](#)) and is higher than HWMs recorded for previous events, as shown on the pole of the North Branch Winooski River USGS streamgage 04285800 at Langdon Street at the confluence with the Winooski River (right image, [Langdon Street Bridge stream gage 04285800 on the North Branch Winooski River | U.S. Geological Survey \(usgs.gov\)](#)). Elevation value for the 1992 level was obtained from [Summary of floods in the United States, January 1992 through September 1993 \(usgs.gov\)](#).

Flood Frequencies at USGS Streamgages

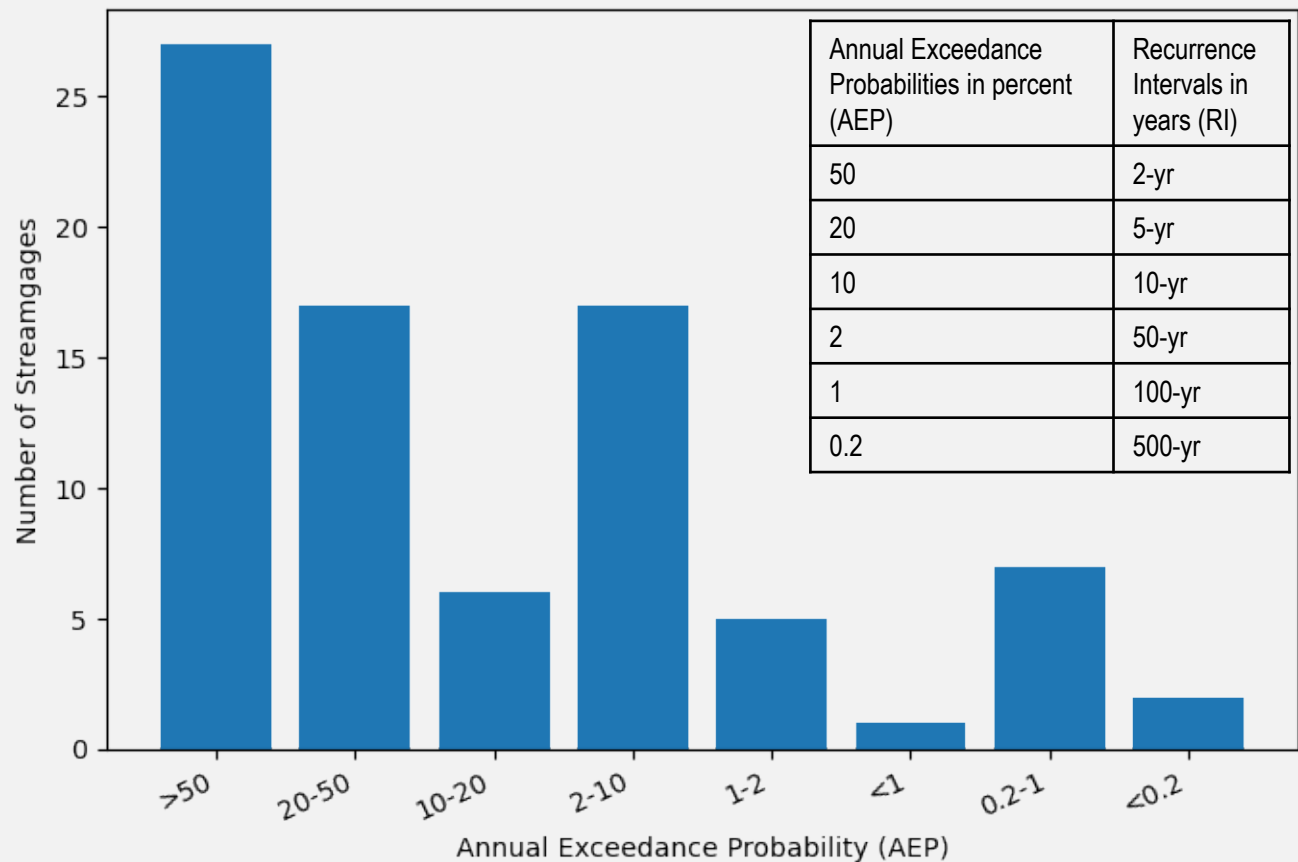
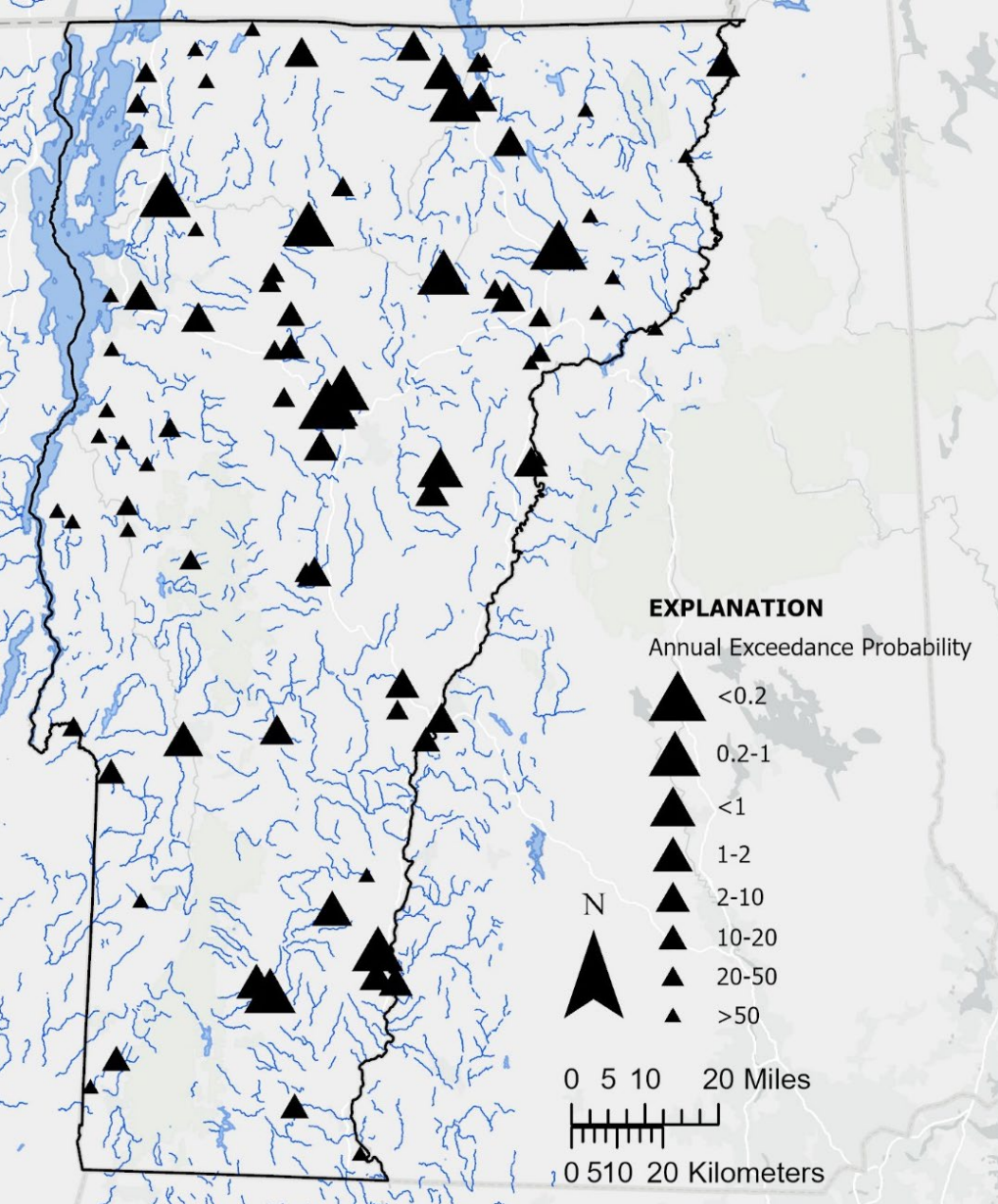
- Streamflow peaks recorded at 82 USGS Streamgages in Vermont (and the New Hampshire side of the Connecticut River):
 - 52 continuous streamflow gages (continuously measure and record stage)
 - 27 crest-stage streamflow gages (measure and record peak stage)
 - 1 discontinued streamflow gage
 - 2 continuous lake gages
- 56 streamgages recorded peak flow for 2023 water year
- Flood frequencies were calculated for peak streamflows for July 2023, and reported as Annual Exceedance Probabilities and Recurrence Intervals
- More information on flood frequencies can be found here: [Flood Frequency Reports | U.S. Geological Survey \(usgs.gov\)](https://www.usgs.gov/streams/flood-frequencies)



Picture of USGS streamgage on Otter Creek in Central Rutland, VT during high flows ([Streamgage on Otter Creek in Central Rutland, Vermont | U.S. Geological Survey \(usgs.gov\)](https://www.usgs.gov/streams/flood-frequencies)).

Flood Frequencies

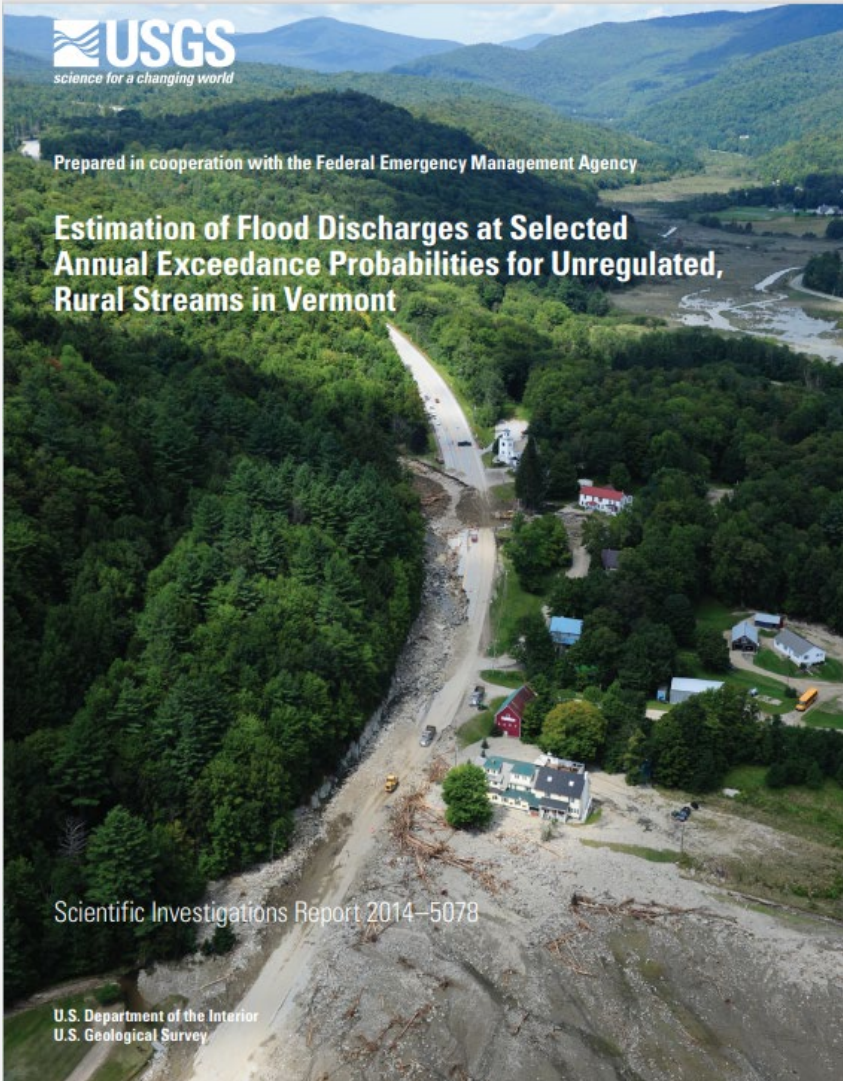
Annual Exceedance Probabilities



Map of annual exceedance probabilities (AEPs, left) calculated for the 82 USGS streamgages in Vermont for the July 2023 flooding and a plot showing the number of streamgages that recorded each AEP. The table correlates AEPs to their corresponding Recurrence Interval (RI). The majority of streamgages recorded flows lower than or equal 2% AEP, or 50-year RI, representing lower magnitude flows. Preliminary data presented here are available in tables in the subsequent slides.

These data are preliminary or provisional and are subject to revision. They are being provided to meet the need for timely best science. The data have not received final approval by the U.S. Geological Survey (USGS) and are provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the data.

Flood Frequency Summary



USGS Scientific Investigations Report 2014-5078
([USGS Scientific Investigations Report 2014-5078: Estimation of Flood Discharges at Selected Annual Exceedance Probabilities for Unregulated, Rural Streams in Vermont](#))

- Majority of streamflow peaks across Vermont were lower magnitude:
 - 82 percent of the streamgages had flows less than or equal to the 2% annual exceedance probability (less than the 50-year recurrence interval)
- High-magnitude peaks were less common
 - Only 10 streamgages had flows greater than 1% annual exceedance probabilities (100 to 500-year Recurrence Intervals)
- Peak-flow regression equations are being updated to incorporate July 2023 peak flows
 - These equations can be used to estimate flood discharge at certain recurrence intervals for unregulated and ungaged streams in Vermont

Preliminary Data Table: Flood Frequencies

July 2023 peak streamflow and annual exceedance probabilities at the Vermont streamgages. Streamflows designated with ^a mark the greatest peak discharge since flood control operations began. ¹ Annual exceedance probabilities are weighted with regional regression equations when applicable (USGS SIR 2014-5078).

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Station Number	Station Name	Drainage Area (mi2)	July 2023 Peak Flow (cubic feet per second) (peak of record in red)	Annual Exceedance Probability ¹ (flow >= 1% AEP in red)	Period of Record
01129420	Capon Brook at VT 102, Near Canaan, VT	4.7	502	2-10	2007-23
01129500	Connecticut River at North Stratford, NH	799	12,200	>50	1931-2023
01131500	Connecticut River Near Dalton, NH	1,514	15,800	>50	1928-2023
01133000	East Branch Passumpsic River Near East Haven, VT	53.8	1,110	>50	1940-45, 1949-79, 1998-2023
01133200	Quimby Brook Near Lyndonville, VT	2.3	2,520	<0.2	1964-74, 1999-2000, 2002-17, 2019-23
01134500	Moose River at Victory, VT	75.2	1,920	>50	1947-2023
01134800	Kirby Brook at Concord, VT	8.1	176	>50	1964-74, 1999-2023
01135100	Pope Brook Tributary (W-9) Near North Danville, VT	0.2	21	20-50	2023
01135150	Pope Brook (Site W-3) Near North Danville, VT	3.3	446	2-10	1991-2023
01135300	Sleepers River Near St. Johnsbury, VT	42.9	2,730	20-50	1991-2023
01135500	Passumpsic River at Passumpsic, VT	436	8,980	20-50	1929-2023
01135700	Joes Brook Tributary Near East Barnet, VT	0.8	27	>50	1964-74, 1999, 2001-23
01138500	Connecticut River at Wells River, VT	2,644	29,100	>50	1950-2023
01139000	Wells River at Wells River, VT	98.4	3,640	2-10	1941-2023
01139700	Waits River Tributary Near West Topsham, VT	1.1	257	<1	1964-74, 1999-2000, 2002-06, 2008-21, 2023
01139800	East Orange Branch at East Orange, VT	9.0	638	2-10	1959-2023
01142400	Third Branch White River Tributary at Randolph, VT	0.8	70	20-50	1964-74, 1998-2011, 2013-23
01142500	Ayers Brook at Randolph, VT	30.5	2,110	2-10	1940-2023
01144000	White River at West Hartford, VT	690	40,000	2-10	1916-2023
01144500	Connecticut River at West Lebanon, NH	4,092	68,800	2-10	1912-76, 1979-2023
01150900	Ottauquechee River Near West Bridgewater, VT	23.4	2,150	2-10	1985-2023
01151200	Ottauquechee River Tributary Near Quechee, VT	0.8	30	20-50	1964-74, 1999-2004, 2007-2023
01151500	Ottauquechee River at North Hartland, VT	221	5,010	10-20	1928, 1931-2023
01153000	Black River at North Springfield, VT	158	2,200	>50	1930-2023
01153300	Middle Branch Williams River Tributary at Chester, VT	3.2	659	1-2	1964-78, 1999-2004, 2007-2016, 2018-20, 2023
01153550	Williams River Near Rockingham, VT	112	18,200	0.2-1	1987-2023
01154000	Saxtons River at Saxtons River, VT	72.2	8,780	2-10	1936, 38, 1941-82, 2002-23
01154500	Connecticut River at North Walpole, NH	5,493	84,400	2-10	1942-2023

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01155350	Trib to West River Tributary at VT30, Near Jamaica, VT	0.9	387	1-2	1964-78, 1999-2023
01155500	West River at Jamaica, VT	179	^a 7,310	0.2-1	1947-89, 1996-2023
01156300	Whetstone Brook Tributary Near Marlboro, VT	1.1	192	10-20	1963-74, 1999-2002, 2004-23
01156450	Connecticut River Tributary Near Vernon, VT	1.1	<44	>50	1964-74, 1999-2023
01333900	Paran Creek Near South Shaftsbury, VT	2.4	162	10-20	1964-78, 1999-2010, 2012-23
01334000	Walloomsac River Near North Bennington, VT	111	2,350	>50	1932-2023
04279400	Poultney River Tributary at East Poultney, VT	1.1	84	10-20	1964-78, 1999-2003, 2005, 2007-23
04280000	Poultney River Below Fair Haven, VT	187	4,040	20-50	1929-2023
04280240	Mettawee River Trib No. 3 at VT30, at East Rupert, VT	2.6	60	>50	2007-2023
04282000	Otter Creek at Center Rutland, VT	307	14,400	1-2	1929-2023
04282300	Brandy Brook at Bread Loaf, VT	2.2	132	20-50	1963-78, 2000-13, 2015-23
04282500	Otter Creek at Middlebury, VT	628	2,820	>50	1904-06, 1911-19, 1928-2023
04282525	New Haven River at Brooksville, Near Middlebury, VT	115	4,980	20-50	1991-2023
04282581	East Branch Dead Creek Near Bridport, VT	13.8	186	>50	2022-23
04282586	West Branch Dead Creek Near Addison, VT	9.9	145	>50	2020-23
04282600	Little Otter Creek Tributary Near Bristol, VT	1.5	35	>50	1964-78, 1999-2023
04282629	Little Otter Creek at Monkton Rd, Near Ferrisburgh, VT	35.9	215	>50	2020-23
04282650	Little Otter Creek at Ferrisburg, VT	57.1	323	>50	1990-2023
04282700	Lewis Creek Tributary at Starksboro, VT	5.3	286	20-50	1963-74, 1999-2023
04282780	Lewis Creek at North Ferrisburg, VT	77.2	1,670	>50	1990-2023
04282795	Laplatte River at Shelburne Falls, VT	44.6	800	>50	1990-2023
04285500	North Branch Winooski River at Wrightsville, VT	69.2	1,320	0.2-1	1928, 1934-2023
04286000	Winooski River at Montpelier, VT	397	^a 23,100	1-2	1912-23, 1928-2023
04287000	Dog River at Northfield Falls, VT	76.1	11,000	2-10	1935-2023
04287300	Sunny Brook Near Montpelier, VT	2.3	--	<0.2	1964-74, 1999-2023
04288000	Mad River Near Moretown, VT	139	7,160	20-50	1928-2023
04288225	West Branch Little River above Bingham Falls, Near Stowe, VT	4.7	679	20-50	2001-2023
04288230	Ranch Brook at Ranch Camp, Near Stowe, VT	3.8	532	20-50	2001-2023

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04288295	Little River Near Stowe, VT	66.6	4,300	10-20	2017-23
04288400	Bryant Brook at Waterbury Center, VT	2.6	214	10-20	1964-78, 1999, 2000, 2002-06, 2009-23
04289000	Little River Near Waterbury, VT	111	2,120	20-50	1936-2023
04289600	Winooski River Tributary Near Richmond, VT	0.7	130	2-10	1964-74, 1999-2023
04290500	Winooski River Near Essex Junction, VT	1,044	35,800	2-10	1928-2023
04290700	Bailey Brook at East Hardwick, VT	2.5	500	0.2-1	1964-78, 1999-2023
04292000	Lamoille River at Johnson, VT	310	24,600	0.2-1	1912-13, 1929-2023
04292100	Stony Brook Near Eden, VT	4.2	406	20-50	1964-74, 1999-2008, 2010-17, 2020-23
04292355	Morgan Brook Trib. at Old No. 11 Road, Near Westford, VT	2.2	100	>50	2007-23
04292500	Lamoille River at East Georgia, VT	686	33,300	0.2-1	1930-2023
04292750	Mill River at Georgia Shore Road, Near St. Albans, VT	22.3	586	>50	2011-23
04292810	Jewett Brook at VT 38, near St. Albans, VT	3.7	222	20-50	2009-23
04293000	Missisquoi River Near North Troy, VT	131	9,910	2-10	1932-2023
04293005	Dunn Brook at VT 100, Near Newport Center, VT	2.9	665	1-2	2007-21, 2023
04293500	Missisquoi River Near East Berkshire, VT	479	17,600	2-10	1912-17, 1919, 1921-23, 1928-2023
04293800	Missisquoi River Tributary at Sheldon Junction, VT	1.7	54	>50	1963-78, 1999-2023
04294000	Missisquoi River at Swanton, VT	850	22,700	20-50	1990-2023
04294140	Rock River Near Highgate Center, VT	11.3	254	>50	2011-23
04294300	Pike River at East Franklin, Near Enosburg Falls, VT	34.5	814	>50	2002-23
04294500	Lake Champlain at Burlington, VT	--	--	>50	1909-59, 1961-65, 1967-2023
04295500	Lake Memphremagog at Newport, VT	--	--	20-50	1932-2023
04296000	Black River at Coventry, VT	122	6,150	0.2-1	1952-2023
04296150	Lord Brook Near Evansville, VT	4.8	355	2-10	1964-78, 1999-2023
04296280	Barton River Near Coventry, VT	155	6,240	2-10	2011-23
04296300	Pherrins River Tributary Near Island Pond, VT	1.1	--	>50	1964-78, 1999-2023
04296500	Clyde River at Newport, VT	142.0	966	>50	1910-19, 1921-24, 1929-36, 1939-2023