The Major Snowmelt and Flooding Event of December 18-19, 2023

by John Goff, Senior Service Hydrologist

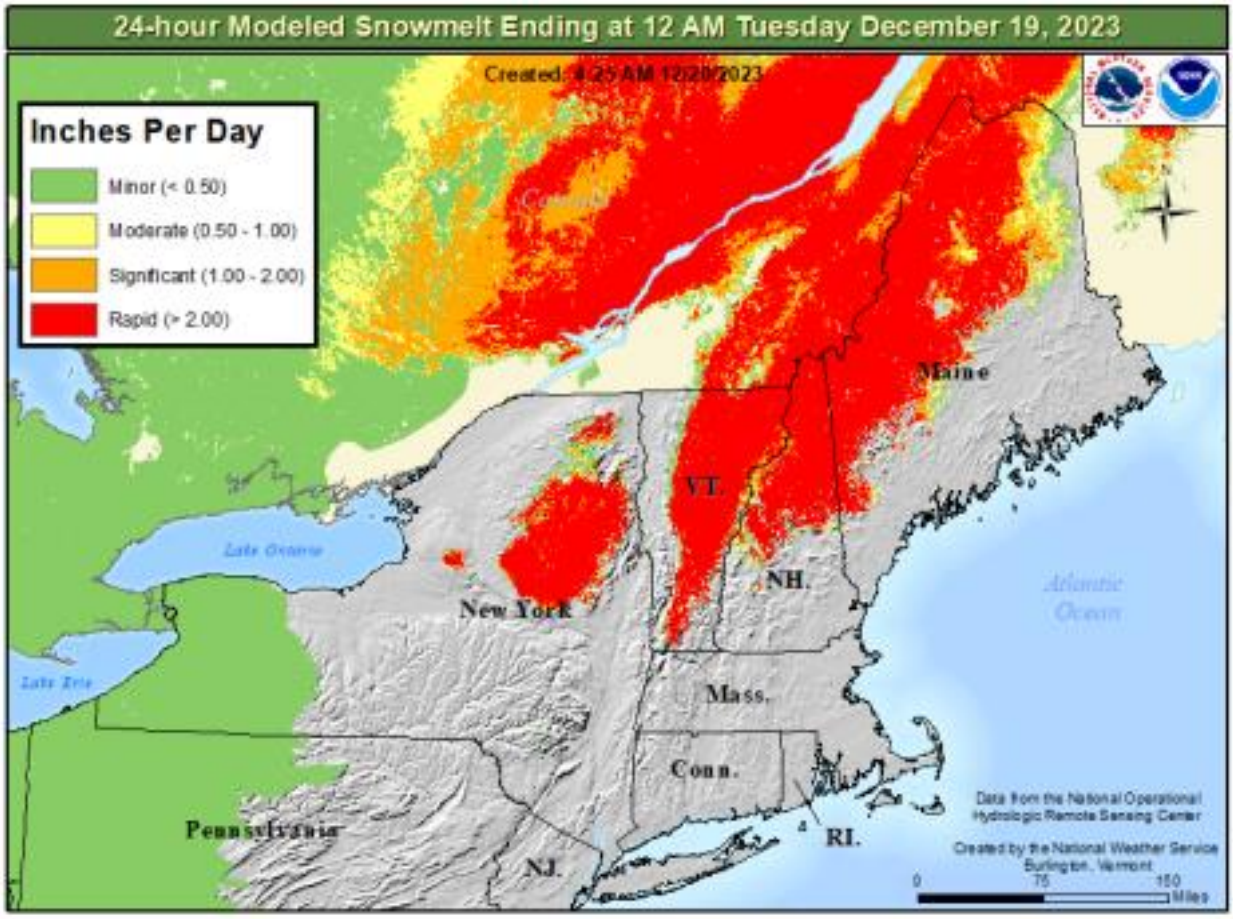
Overview

On December 18-19, 2023, portions of the Northern Adirondack Mountains and much of Vermont were affected by moderate to major flooding as strong low pressure tracked across the region. For Vermont, it was the second severe flooding event in six months, marking a stark reality that the state is increasingly susceptible to more frequent and extreme flooding events due in part to climate change. While high water was a common theme between this and last July's severe flood event, the causes were different in December with flooding being primarily driven by non-convective (i.e. no thunderstorms) heavy rainfall and rapid snowmelt. Many watersheds were affected by high water, most notably the Ausable, Lamoille, Otter Creek, Passumpsic and Winooski River basins.

The Importance of Snowmelt and Runoff Processes

The snowmelt aspect of this most recent event is worthy of discussion and is important in the context of winter/early spring high water events when an extant snowpack lies across the area. Additionally, snowmelt flooding is not an alien concept to those who live in our region, with similar events occurring as recent as January 2018 and April 2019. One of the more important concepts to understand is the process of condensation. Condensation adds heat into a system, which is opposite of evaporation which removes heat from a system. From a physics perspective, when extremely mild temperatures and dewpoints flow across a snowpack, air in contact with the snow will cool and condense on the pack leading to a process called latent heating. This heating of the snowpack is typically gradual during days which climb marginally above freezing, but under certain conditions, especially when air and dewpoint temperatures are above 45 degrees and rain is falling, this latent heating effect can be extreme. This is exactly what happened during the December event. From our best estimates, much of the existing snowpack below 1,500 feet was rapidly melted off, adding between two and three inches of runoff into area rivers and streams. This runoff, combined with the estimated two to four inches of rain that fell, led to an overall storm event of 4 to 7 inches.

Another important metric to consider when assessing flood potential is the rapidity in which runoff moves into area watersheds. The faster runoff occurs, the less efficient river and area streams can route the excess water downstream. This concept is critically important to understand during summer when intense convective rainfall from thunderstorms can lead to flash flooding in small watersheds. If an area receives three inches of rain in one hour, it is much more susceptible to flash flooding than if it receives just one inch in that same time frame. While these excessive rates were not observed this past December, the concept still holds true in this case since the majority of the flooding occurred on larger streams and rivers which affect much broader watershed regions. Additionally, the December excessive rainfall and snowmelt loss generally occurred in just 12 to 18 hours. While this typically wasn't enough to produce flash flooding, it was more than enough to cause significant to severe riverine flooding, especially considering the time of year and the lack of water uptake/absorption by vegetation.

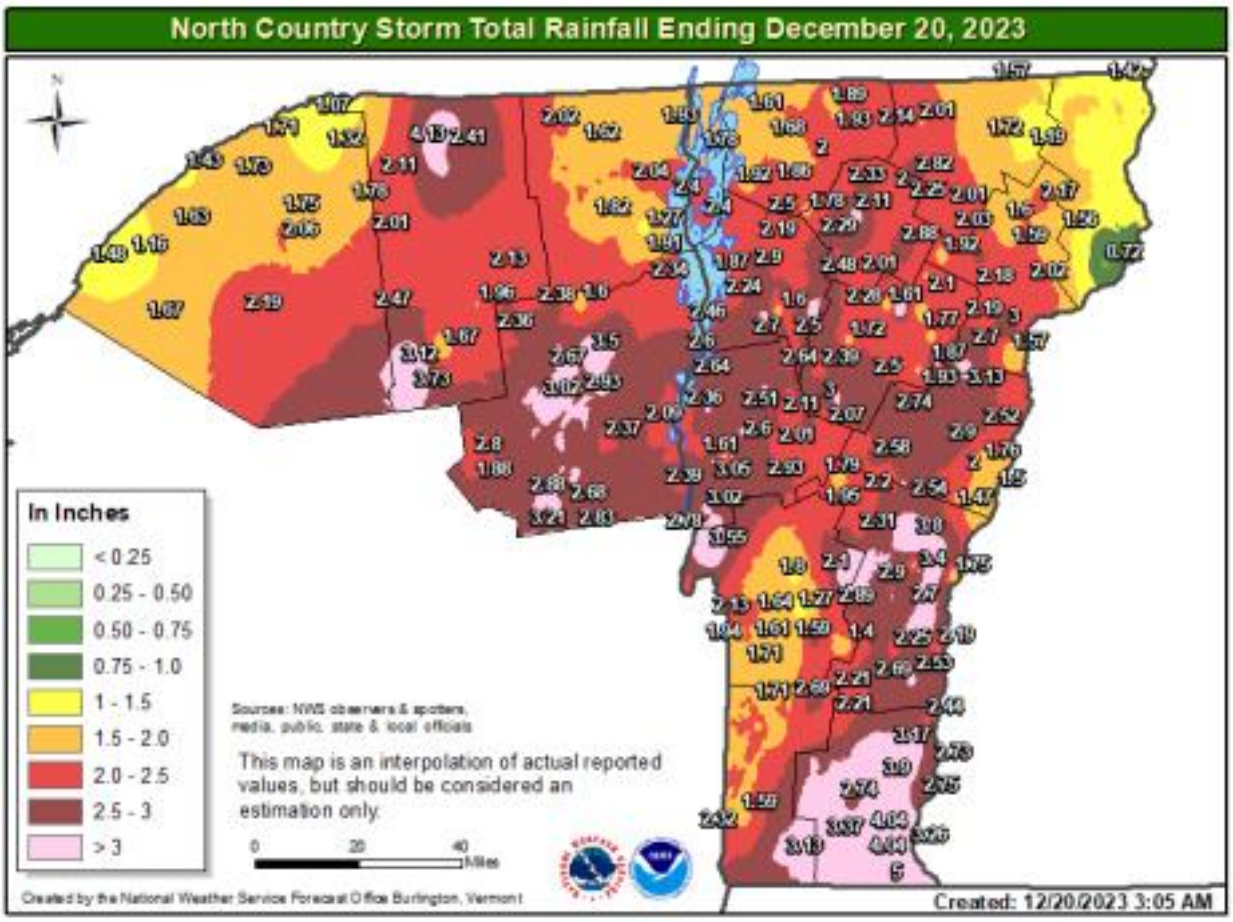


24-hour modeled snowmelt on December 18, 2023. Red colors denote estimations of over two inches of liquid equivalent snowmelt loss.

The Meteorology

The main player responsible for this high impact event was rapidly deepening low pressure which arose out of a cluster of intense thunderstorms across the northeastern Gulf of Mexico and portions of the southeast on December 16 and 17. This cluster produced significant flooding across portions of North Florida and South Georgia during this time. The deepening low then tracked steadily north-northeast along the southeast and Mid-Atlantic seaboard by early on the 18th, and then across Vermont later on the 18th into the early morning hours on the 19th. Copious moisture of Gulf of Mexico and western Atlantic origin streamed northward into our region during this time frame, accompanied by extremely mild air by December standards as temperatures climbed into the 40s and 50s along with dewpoints of similar magnitude. While the system produced impressive rainfall totals in its own right, the rapid and near complete melt-off of the existing snowpack in the low to middle elevations was quite remarkable, especially given it largely occurred within 12 to 18 hours. The combined total water into the stream and river system from rainfall and snowmelt averaged between 4 and 7 inches from the Adirondacks eastward, leading to many areas of stream and river flooding, some severe. By later on the 19th the storm system exited quickly northward into Quebec as rainfall tapered off and

temperatures cooled. Lingering high water and residual runoff continued into the 20th as flood waters receded, leaving a muddy cleanup to follow.



Two-day storm total rainfall (excluding snowmelt input) across Vermont and Northern New York.

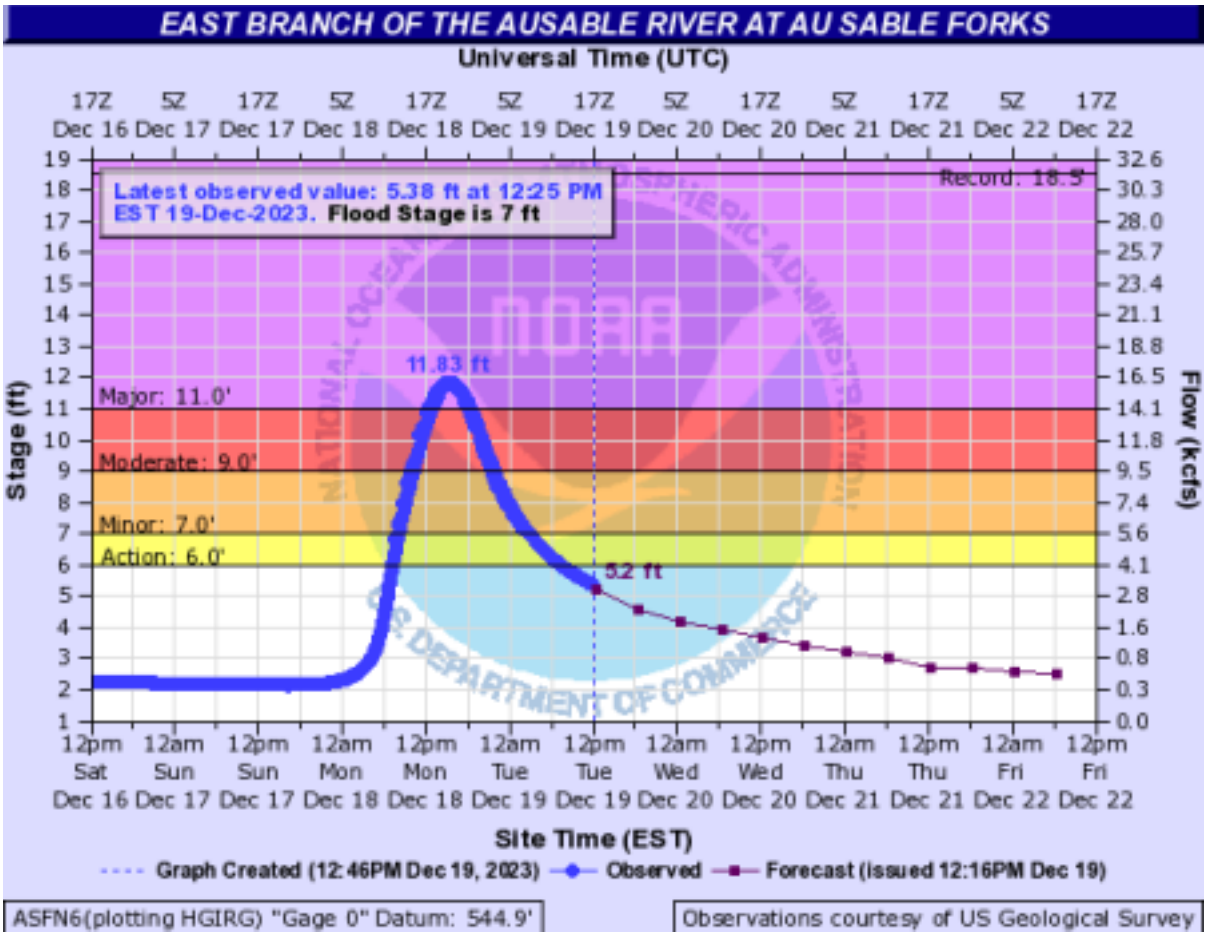
Specific Impacts

As with any weather event, impacts were varied across our region and the degree of flooding severity was highly dependent on 1) overall runoff rates, 2) precipitation amounts, 3) relation to the storm track and 4) specific geographic characteristics of individual stream and river basins. Observational data and flood damage reports collected by the United States Geological Survey (USGS) and NWS Burlington highlighted the Ausable, Lamoille and Winooski River basins as being most severely affected and some of those impacts are discussed briefly below. However, many other parts of our region experienced elevated water levels and in some cases varying degrees of flooding.

A flooded playground in Richmond, VT on December 18, 2023 (photo courtesy of VT Digger)

Ausable River:

The Ausable River basin saw significant to, in some cases, severe flooding, with the main branch cresting at Au Sable Forks, NY at 11.83 feet, or major flood level on the afternoon of December 18. This was nearly five feet above the minor flood threshold, with preliminary analysis showing the peak stage was the 8th highest crest on record since 1924 at the gauge site. Towns from Keene downstream through Jay and Au Sable Forks all experienced flooding of varying severity.



Hydrograph trace of the Ausable River at Au Sable Forks, NY showing a major flood crest of 11.83 feet.

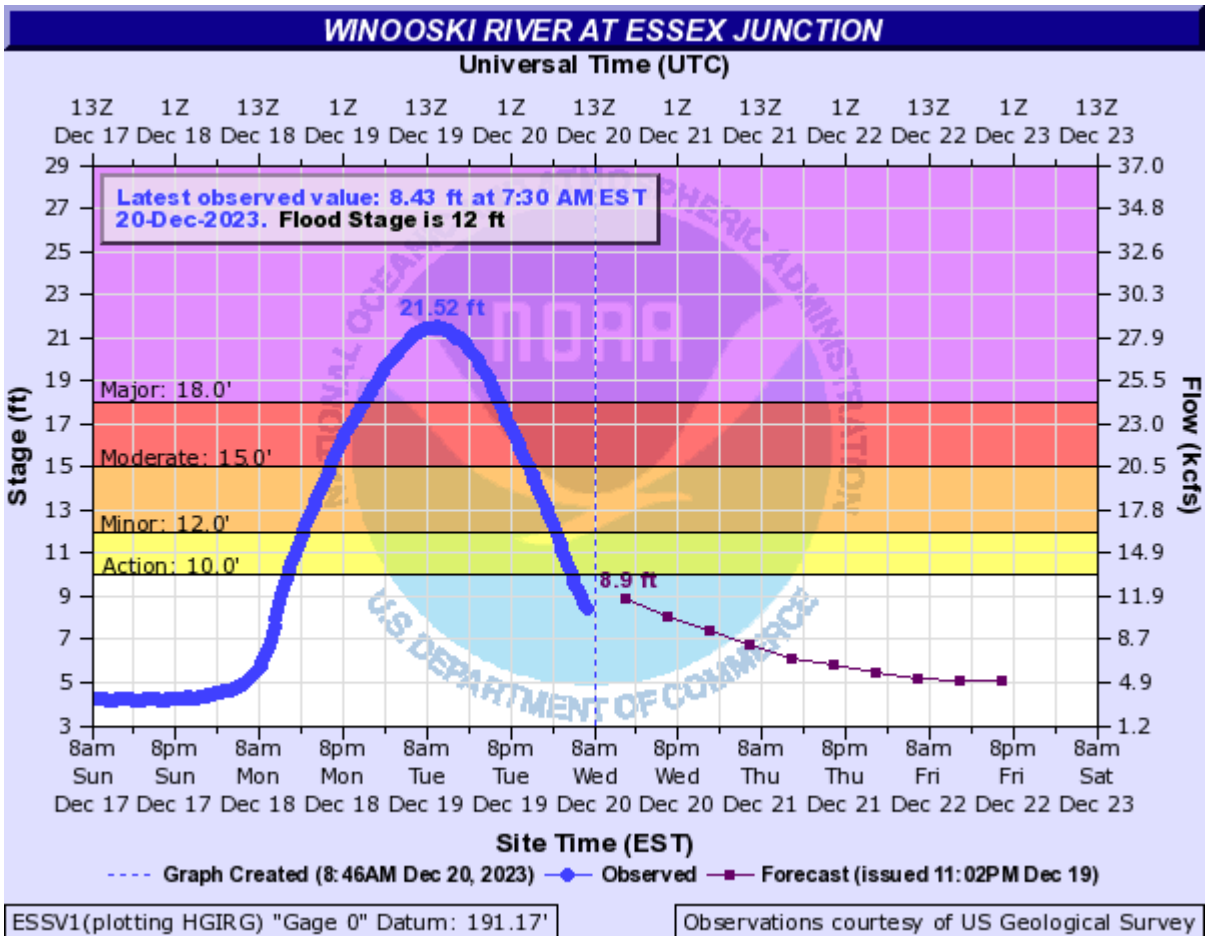
Lamoille River:

Severe flooding also affected many areas along the Lamoille River, especially from Johnson, VT downstream through Jeffersonville and Cambridge, VT. In Johnson, the peak crest of 17.58 feet easily surpassed the major flood stage of 16 feet, and was over 4.5 feet above the minor flood stage of 13 feet. Preliminary data shows this as the 4th highest crest on record, only falling behind the Great Flood of 1927, an event in August 1995 and the most recent flooding of July 2023. Two of the highest four crests on record within six months – Quite remarkable given a period of record of over 100 years, or since 1910 at the gauge site.

Winooski River:

Moderate to severe flooding also affected the Winooski River basin, from Montpelier, VT downstream through Waterbury, Richmond and Essex Junction, VT. The Mad River, a tributary of the Winooski in Washington County also saw significant flooding, with the gauge in Moretown, VT briefly touching major flood stage on the afternoon of the 18th. The cumulative effect of snowmelt in this basin was most evident at the gauge in Essex Junction, VT which crested at 21.52 feet, or 3.52 feet above major flood stage and an impressive 9.52 feet above minor flood level. Preliminary data shows this as the 6th highest crest on record, again quite remarkable given the July 2023 crest now ranks as the third highest crest for a period of record of 96 years, or since 1928.

Floodwaters from the Mad River threaten homes in Waitsfield, VT on December 18, 2023.



Hydrograph trace for the Winooski River at Essex Junction, VT. Preliminary data shows this as the 6th highest crest in history at the gauge site.