26-27 April 2011 Flash Flood Event

Overview

Heavy rainfall and snowmelt combined to generate significant and devastating flash flooding the evening of 26 April 2011 through 27 April. Moderate rainfall across the region 24 hours earlier saturated soils, enhanced snowmelt, and brought area rivers and streams to bankfull. The subsequent flood-producing heavy rainfall came in three waves, causing swollen rivers and streams to quickly flood. The onset of the event was characterized by flash flooding, then during transitioned to a river flood event by the morning of the 27th.

Damages exceeded $9 Million, and FEMA declared major disasters for counties in Northeast New York and northern Vermont. The Ausable and Bouquet River basins in Essex County New York as well as the Lamoille River basin in Vermont were particularly hard hit. Floodwaters inundated areas that had not seen flooding in hears. Homes and businesses were flooded, and flood waters washed out bridges. Roads were damaged by flood waters or covered by mudslides.

This case provides some hard lessons on the conditions that can lead to devastating flash flooding. Situational awareness is critical to recognize that saturated soils and elevated river flows from previous rain and snowmelt contribute to the speed and severity of the flash flooding. It also illustrates that classic heavy rain-producing synoptic patterns can be present outside of the typical warm season.

Antecedent Conditions, 23-25 April 2011

By late April, the spring snowmelt was in full swing and very warm temperatures in the days leading up to the event accelerated snowmelt and runoff. At Burlington International Airport, the period from April 23 through 26 was characterized by high temperatures in the 50s and 60s (Fig. 1), with low temperatures in the 40s and even 50s (Fig. 2).

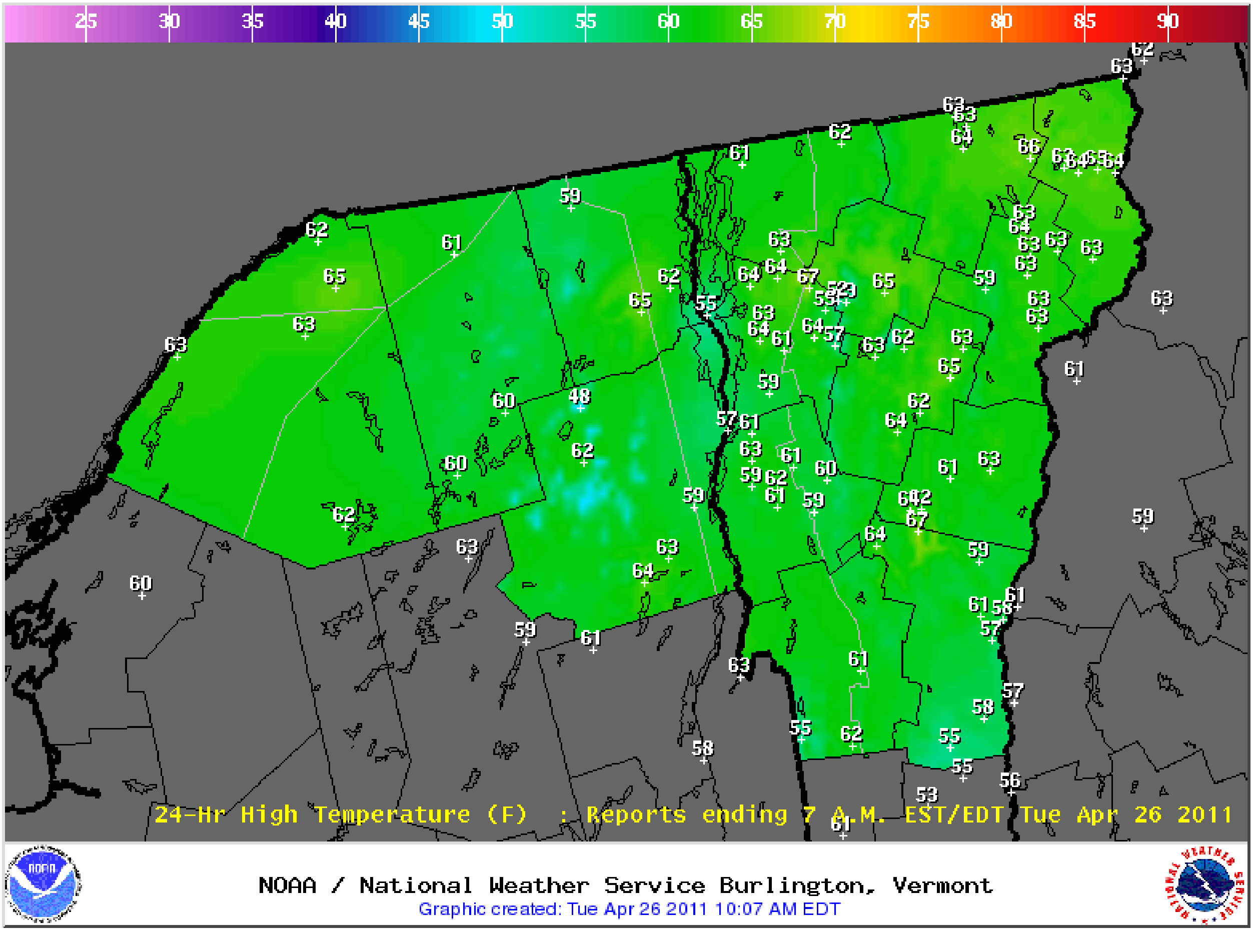

Figure 1. Observed Maximum Temperatures, 12 UTC 25-26 April 2011.

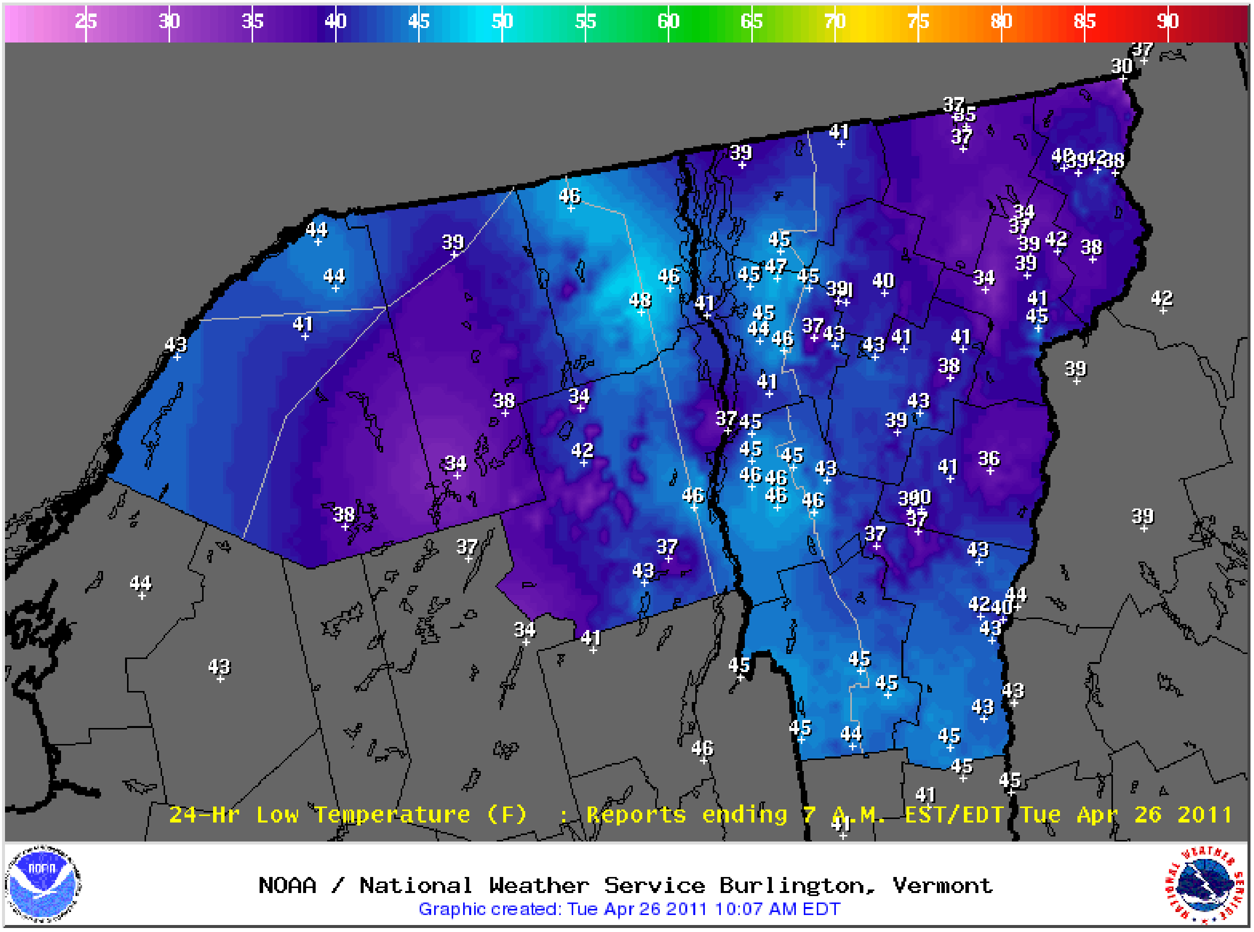

Figure 2. Observed Minimum Temperatures, 12 UTC 25-26 April 2011.

The warm overnight temperatures kept snowmelt processes going unabated. Modeled snowmelt for the 3 days leading up to April 26 from the [National Operational Hydrologic Remote Sensing Center (NOHRSC)] indicate one to two inches of snowmelt at low elevations in Essex County NY, with two to three inches of snowmelt over the higher terrain. In Vermont, the Lamoille River basin had areas with up to two inches of snowmelt (Fig. 3).

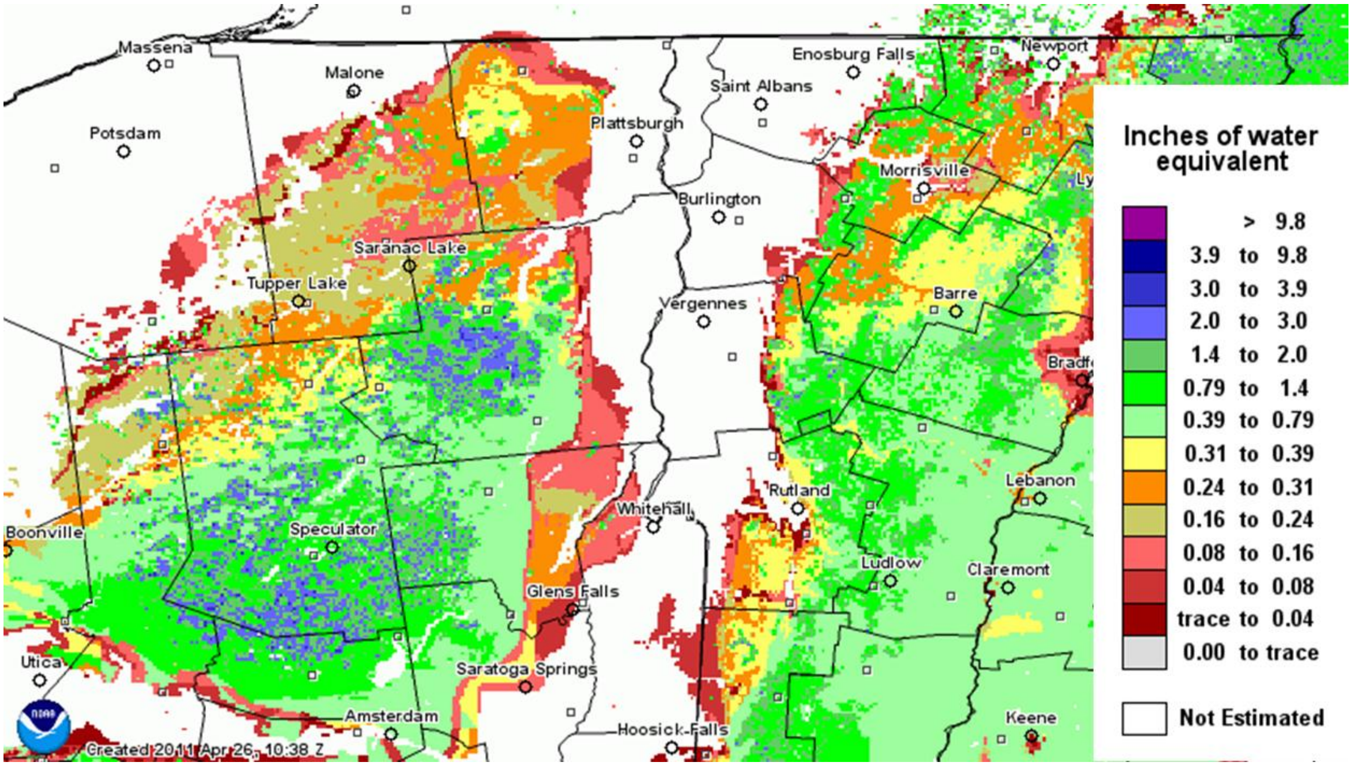

Figure 3. Total Modeled Snowmelt 72 hours ending 05 UTC 26 April 2011.

Snowmelt and rainfall earlier in the month created very wet soil moisture conditions, which enhance rainfall and snowmelt runoff. Soil moisture conditions for late April 2011 were in the 95th or greater percentile (Fig. 4). These saturated soils would convert additional rainfall and snowmelt directly to runoff.

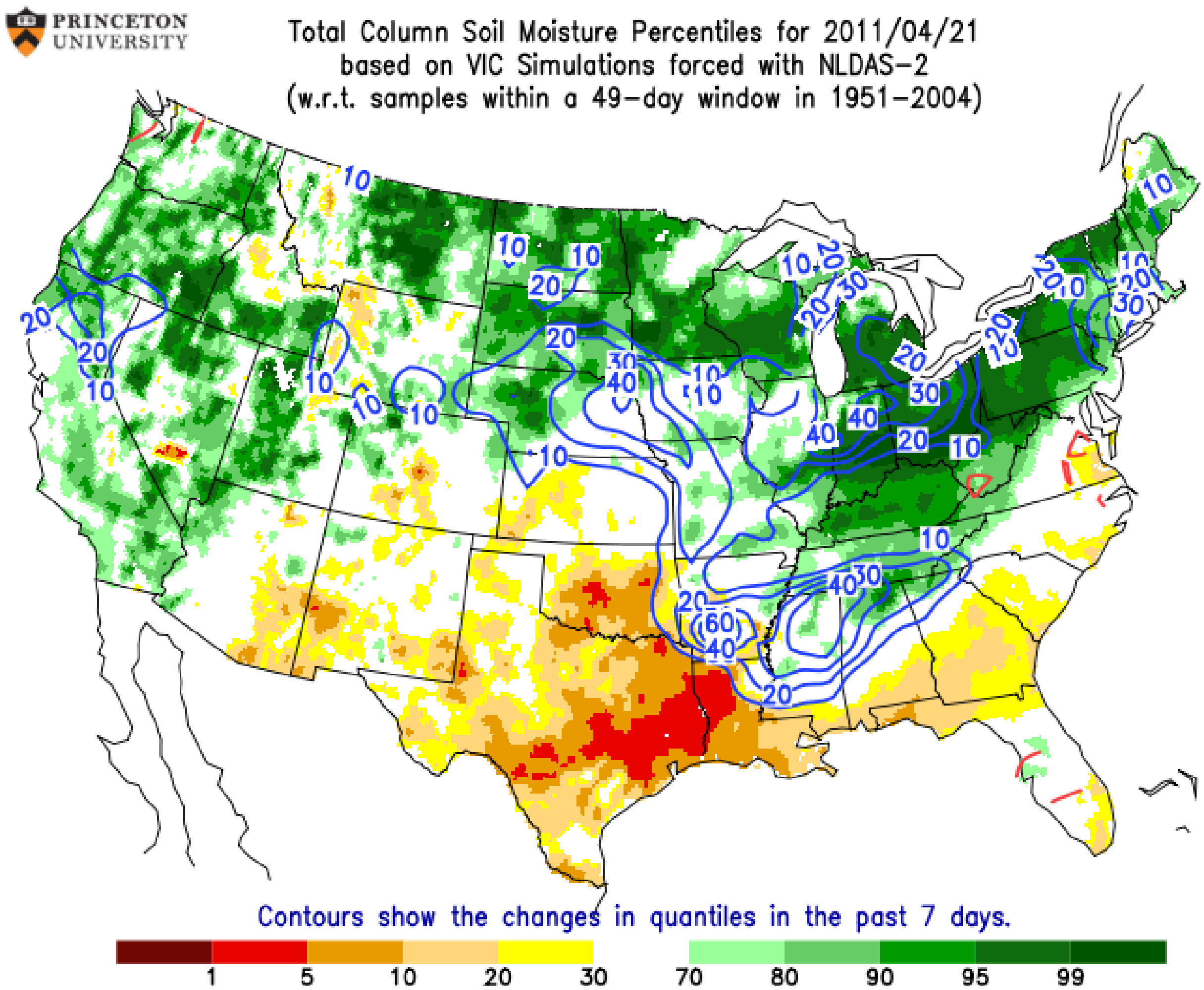

Figure 4. Soil moisture percentiles valid 21April 2011.

An area of showers and thunderstorms moved through the region during the overnight hours of 25-26 April 2011. The heaviest rainfall passed mainly across southern Vermont and the southern Adirondacks, however a half to one inch of rain fell in the areas that would flood on the following night (Figs. 5, 6).

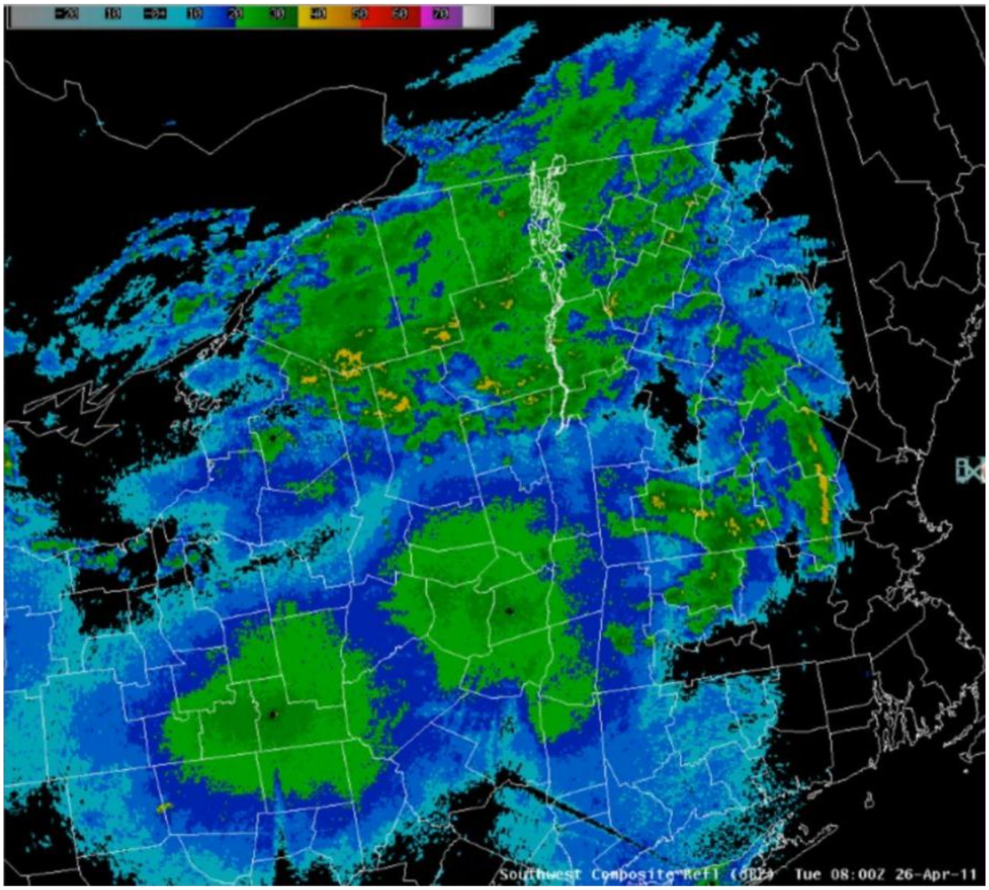

Figure 5. Radar Reflectivity loop 00-08 UTC 26 April 2011. (Click image to animate)

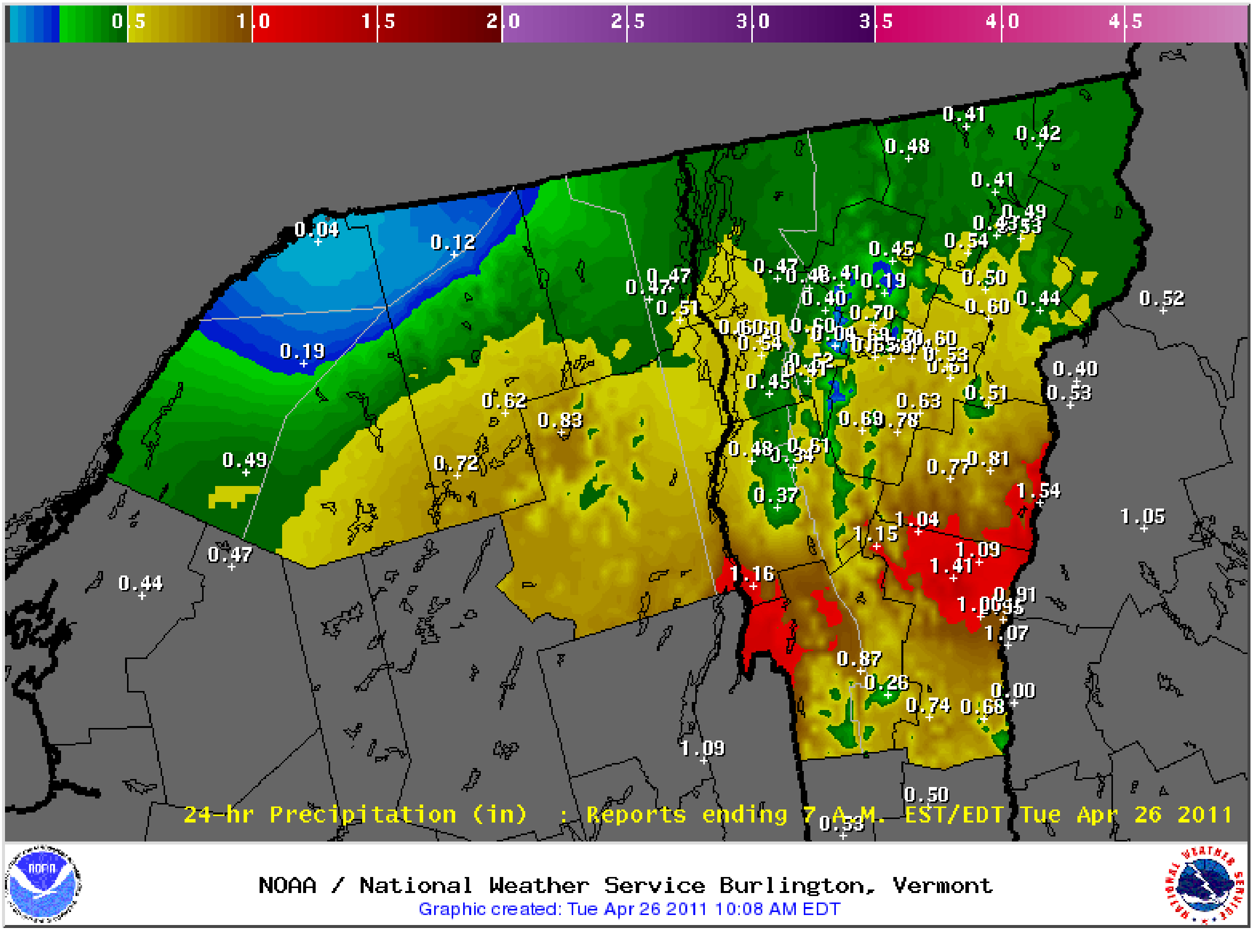

Figure 6. 24 hour precipitation ending 12 UTC 26 April 2011.

Although rivers remained below flood stage, they responded sharply to the overnight rainfall due to ongoing snowmelt and saturated soils. The Ausable River near Ausable New York rose to nearly a foot within flood stage (Fig. 7), and the Lamoille River at Johnson Vermont climbed 5 feet, cresting 3 feet below its flood stage (Fig. 8). The proximity to flood levels would set the stage for the following night's heavier rainfall.

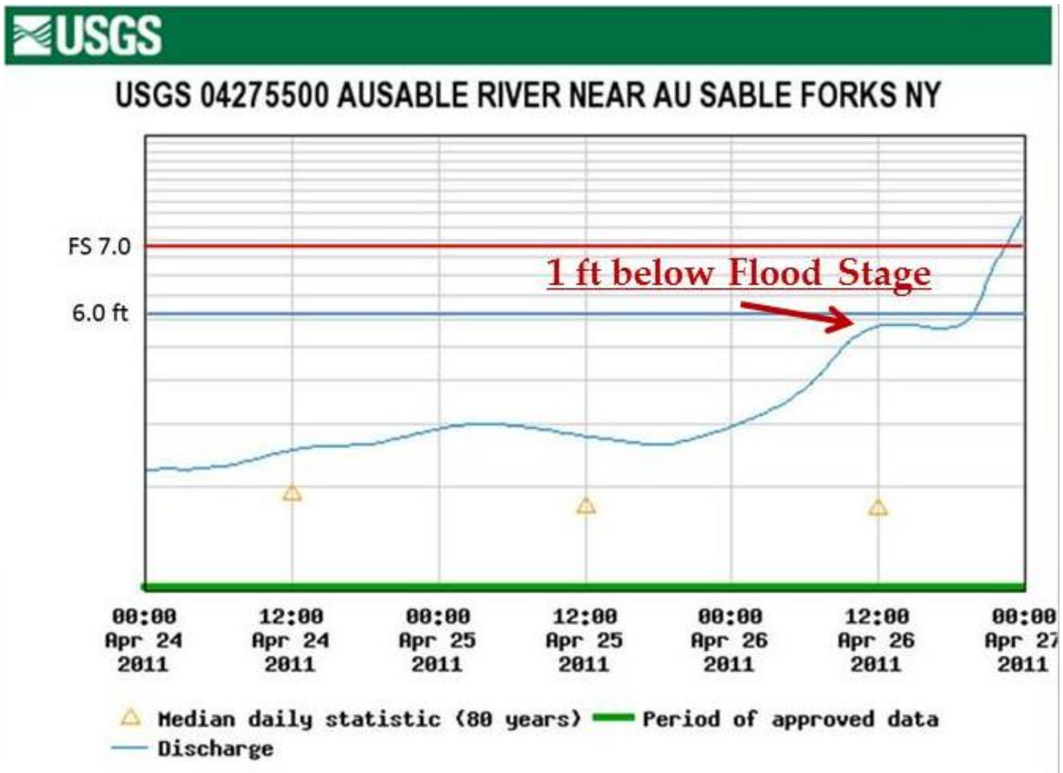

Figure 7. Hydrograph of the Ausable River near Ausable Forks NY.

Figure 8. Hydrograph of the Lamoille River at Johnson VT.

Meteorology

The synoptic pattern for this event strongly resembled the Maddox Frontal flash flood archetype (Maddox et al, BAMS Vol 60 No 2). In this pattern, a west-to-east stationary surface boundary provides a lift mechanism for warm moist flow from the south as it rides up and over cooler air to the north. At 500 hPa, a ridge of high pressure is the dominant feature, with a weak shortwave trough moving through the crest of the ridge and along the surface boundary (Fig. 9).

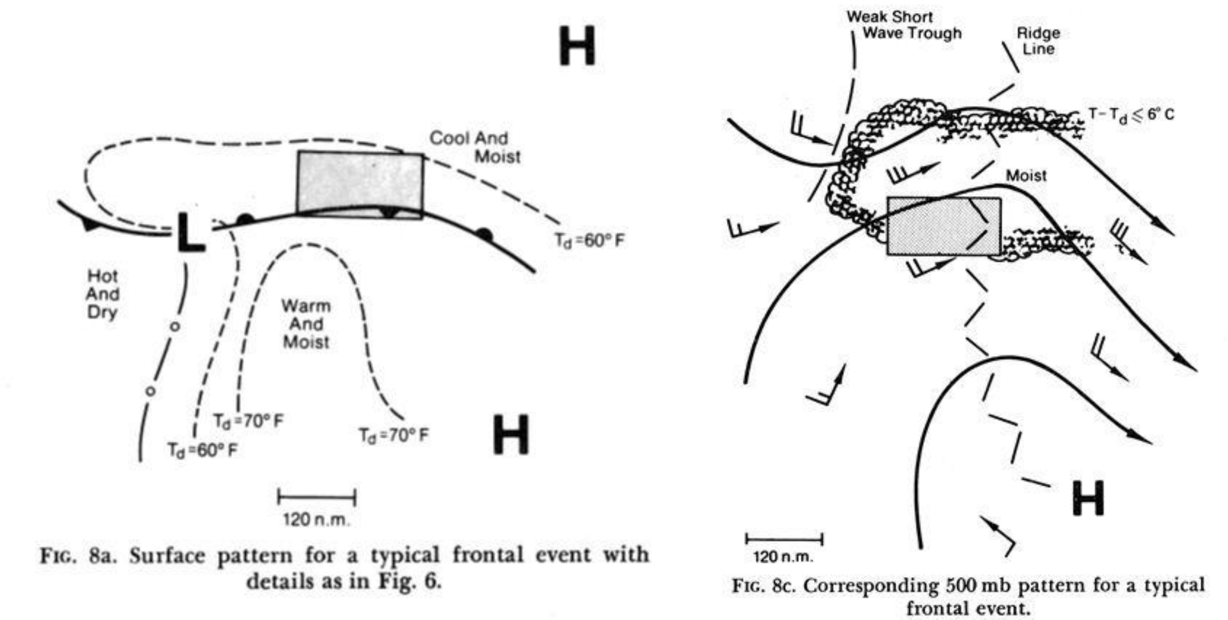

Figure 9. Maddox Frontal Archetype, from Maddox et al, Bulletin of the American Meteorological Society Vol 60 No 2.

At 500 hPa, high pressure was centered just east of Bermuda, with a ridge extending northwest into the northeast US and eastern Canada. A closed low was centered just west of the Great Lakes, with a series of weak shortwave troughs riding up over the ridge (Fig. 10). At the surface, a low pressure system was centered over eastern Wisconsin, and a stationary front extended east across the Great Lakes, central New York, and southern New England. Southerly surface flow fed low level moisture in from the Atlantic (Fig. 11).

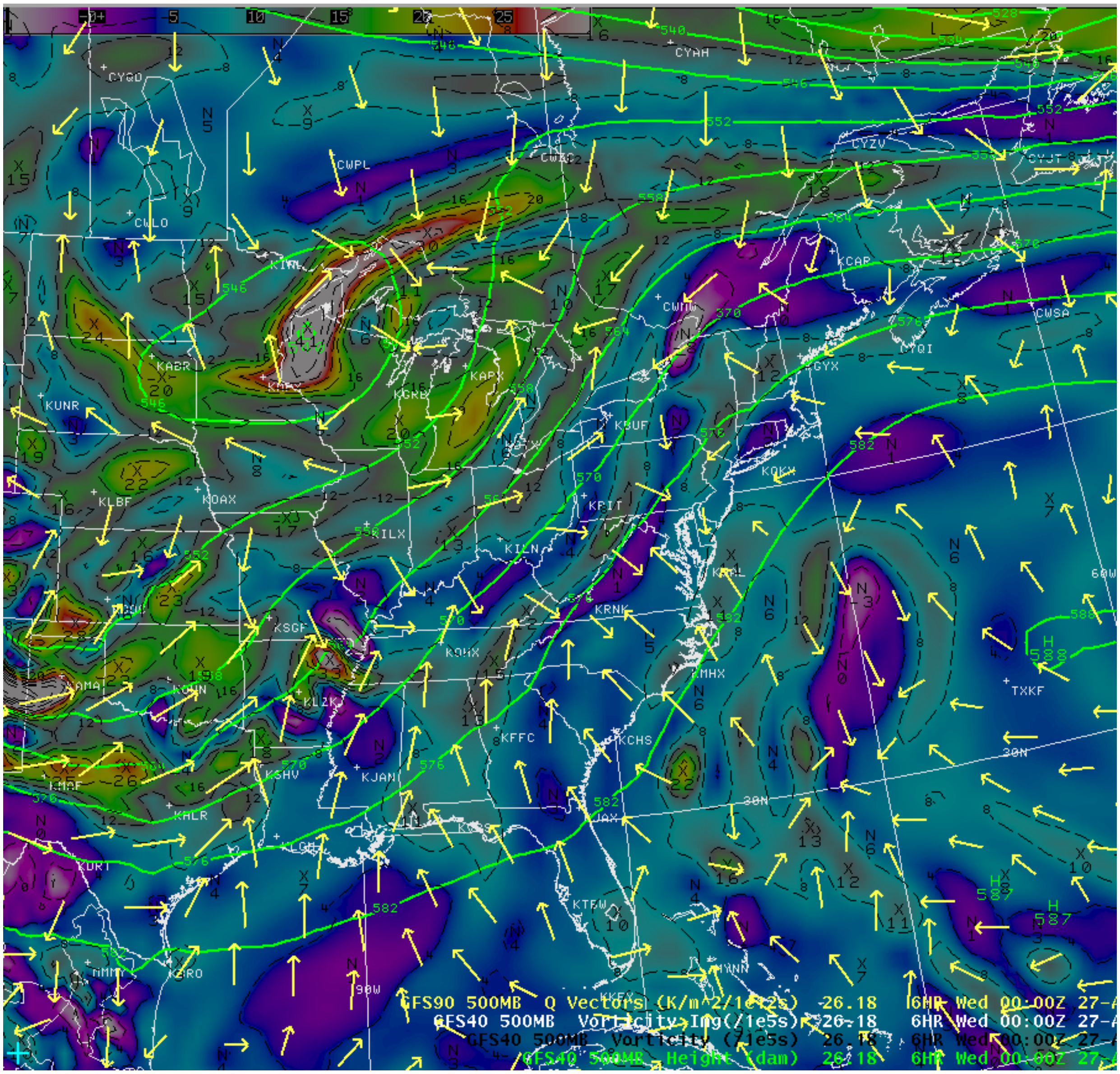

Figure 10. 500-hPa heights (green), vorticity (image and black dashed), and Q-vectors (yellow) valid 00 UTC 27 April 2011.

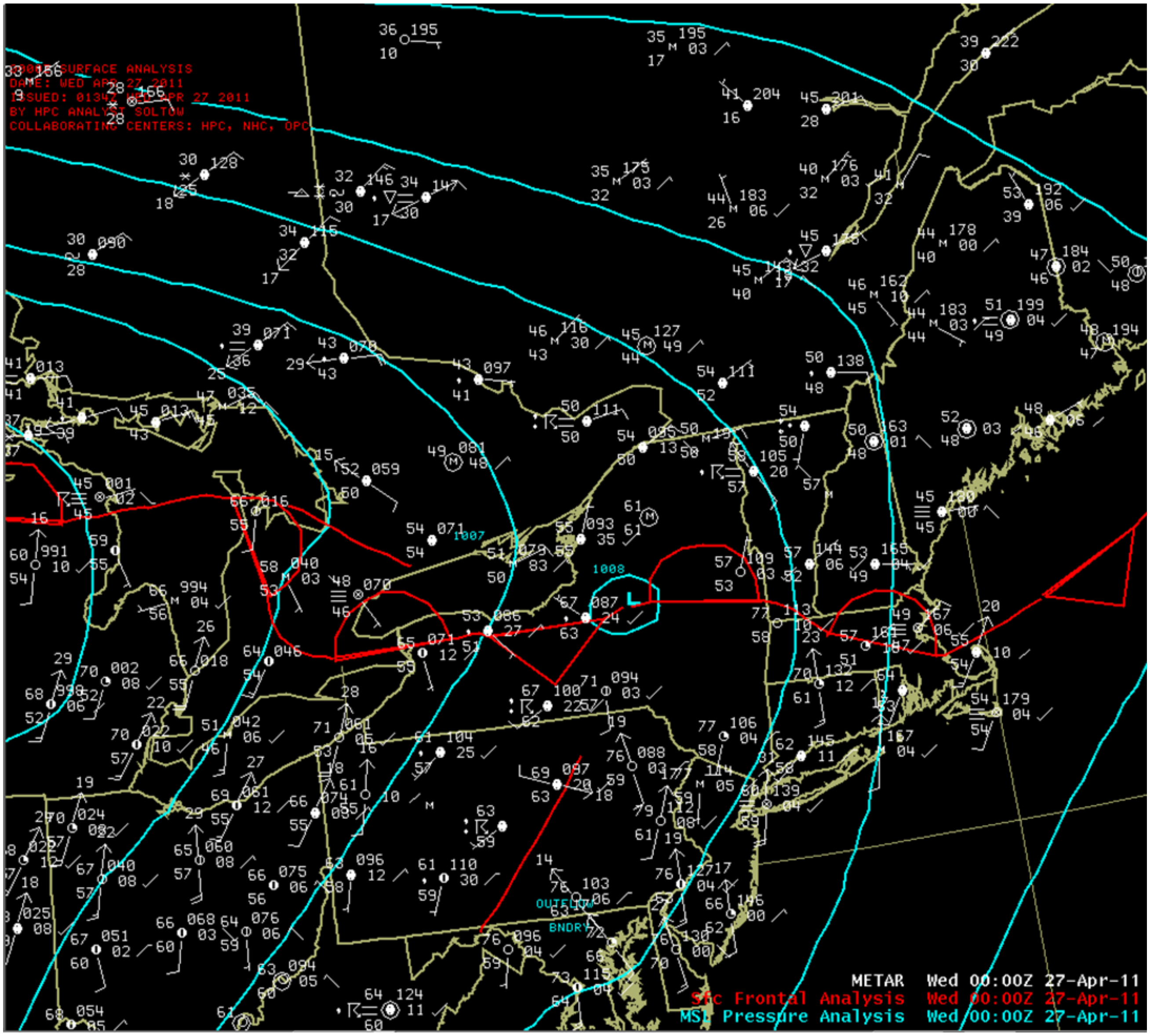

Figure 11. Surface pressure (blue) and frontal analysis (red), and station plot valid 00 UTC 27 April 2011.

At 850 hPa, the overall pattern echoed the surface pattern, although the 850-hPa stationary front was shifted north across southern Canada. This indicated warm, moist air overrunning the surface boundary which would provide low level lift (Fig. 12).

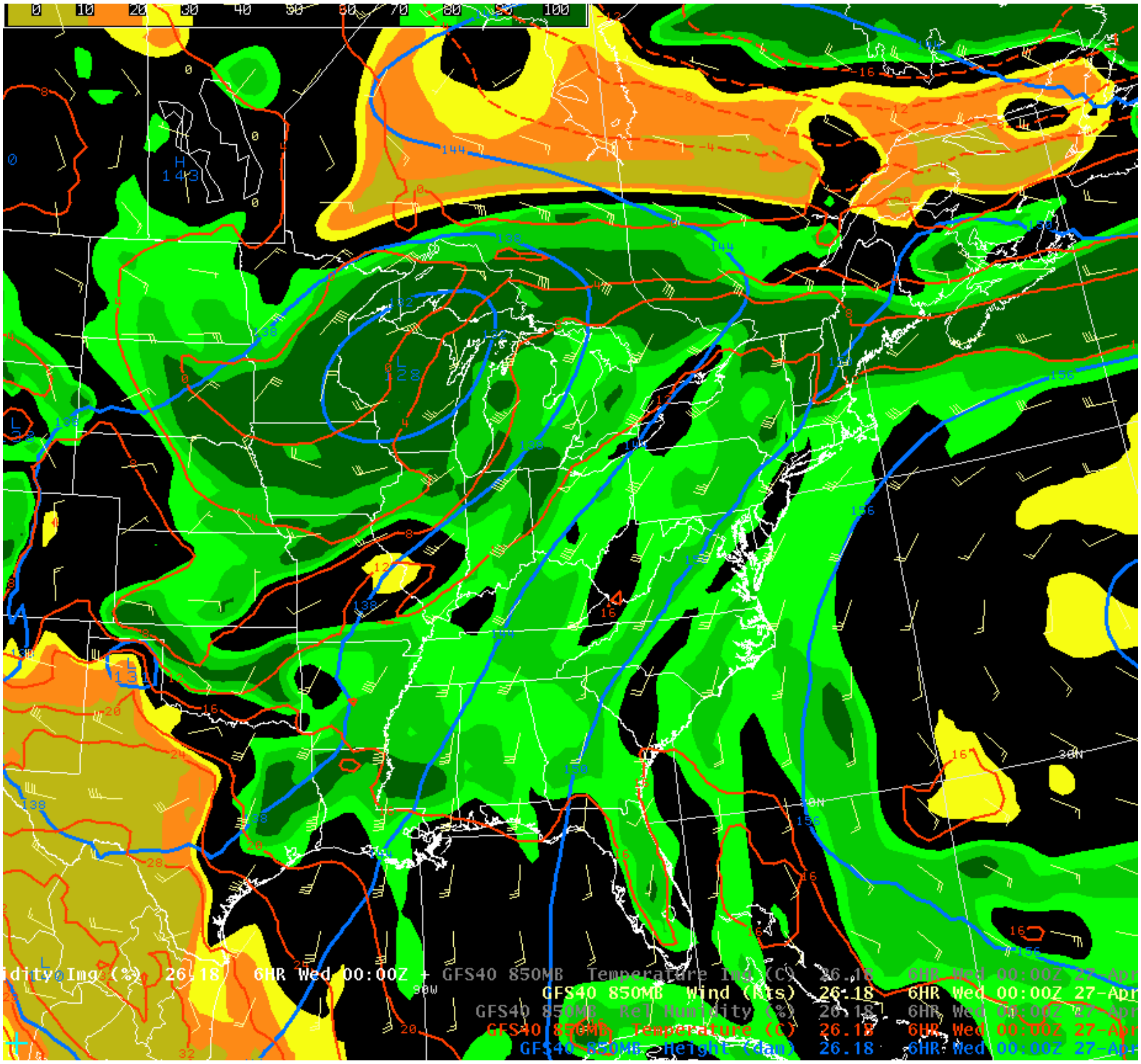

Figure 12. 850 hPa height (blue), temperature (red), wind (yellow), and relative humidity (image) valid 00 UTC 27 April 2011.

The low level frontal inversion was evident on the Burlington, VT (KBTV), North American Model NAM) sounding. (Fig. 13). Other forecast parameters pointing to a heavy rain threat included MBE vectors below 10 knots, a warm cloud depth almost to 3 km, a tall narrow cape, and warm air advection in the veering low level wind profile. When compared to climatological normals for the nearest upper air site at Albany NY, the NAM forecast precipitable water value around 1.25 inches was nearly two standard deviations above normal for late April (Fig. 14).

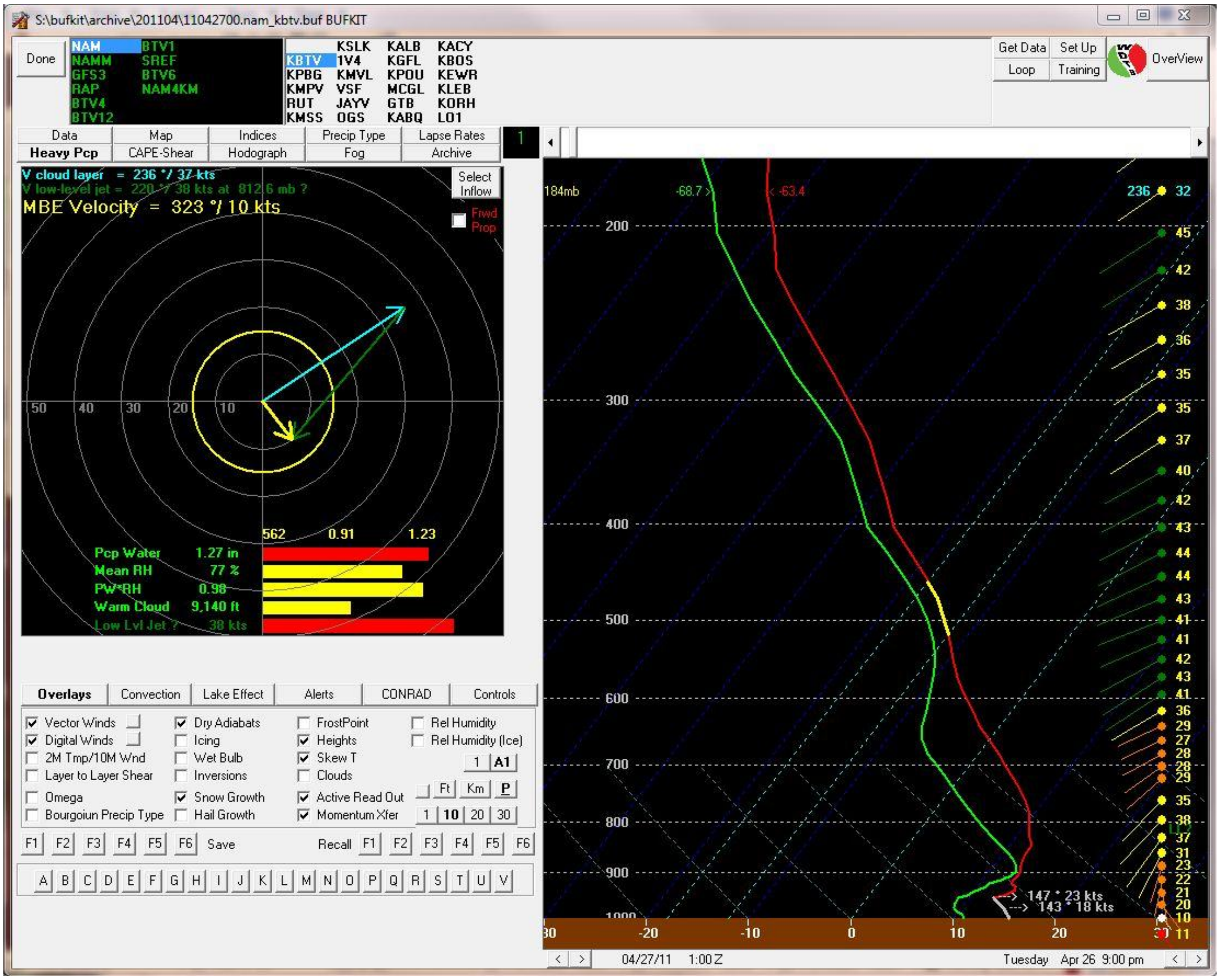

Figure 13. NAM sounding for KBTV valid 01 UTC 27 April 2011.

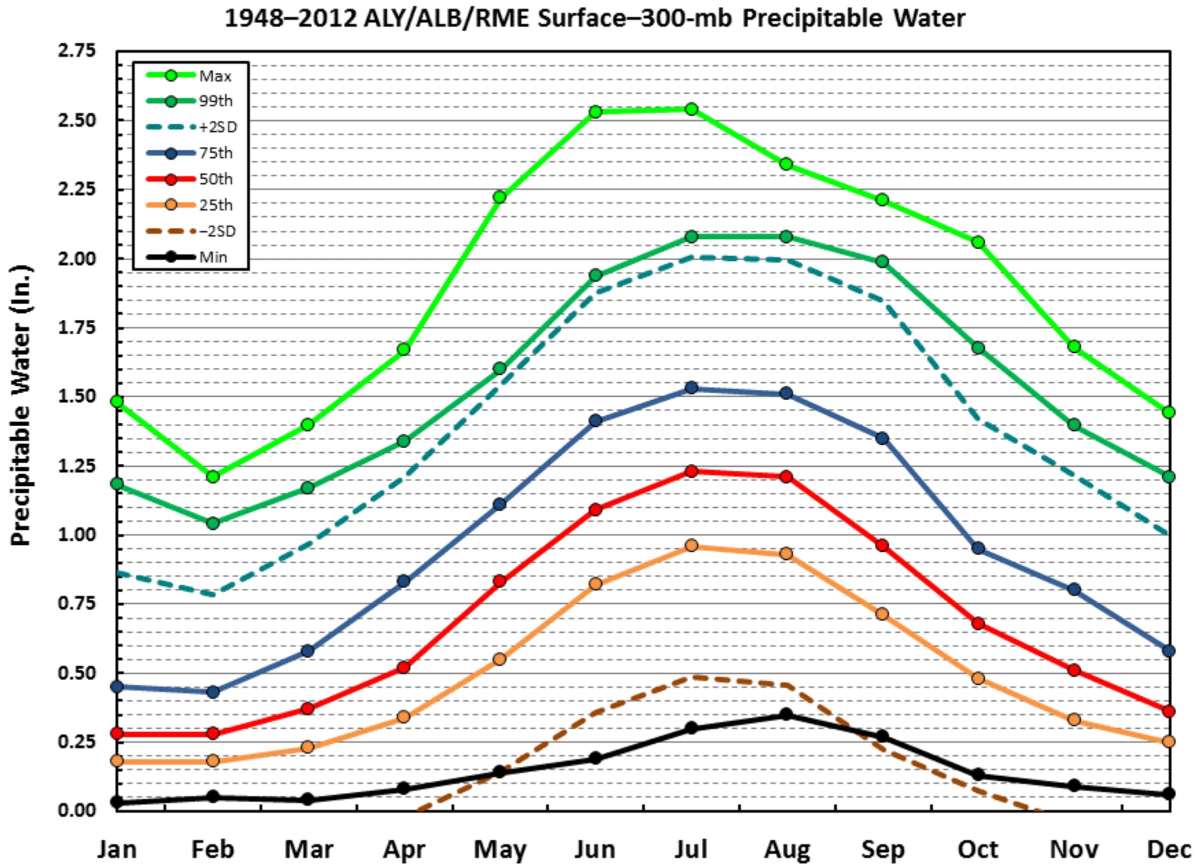

Figure 14. Precipitable Water climatology courtesy National Weather Service Rapid City SD.

<u>Rainfall Event</u>

The rainfall event unfolded from the afternoon of 26 April through the early morning hours of 27 April (Fig.15). The first line of thunderstorms began as a small cluster of storms that moved off eastern Lake Ontario shortly after 18 UTC, and became an organized line oriented northeast to southwest, across Clinton and western Essex Counties in New York by 21 UTC. This northeast to southwest orientation of the line allowed for some training of cells as the line propagated eastward into the Lamoille River valley in Vermont through 00 UTC. The second round of storms was a north-south line that moved across western New York and southern Ontario into the Adirondacks around 00 UTC. Similar to the first line, as it moved into the northeast Adirondacks its orientation became northeast to southwest, and it followed virtually the same path as the first line of storms a few hours earlier. With the first two lines of storms, radar reflectivity values were over 50 dBZ, indicating heavy rainfall. The episode ended with an area of rain associated with a meso-vortex that moved out of the Catskill Mountains, across the eastern Adirondacks, and into the Lamoille River Valley. Although reflectivity was 40 to 50 dBZ with this feature, past experience with meso-vortex flash flood events have shown that they can be heavy rain producers (http://www.erh.noaa.gov/btv/events/06Aug2008/).

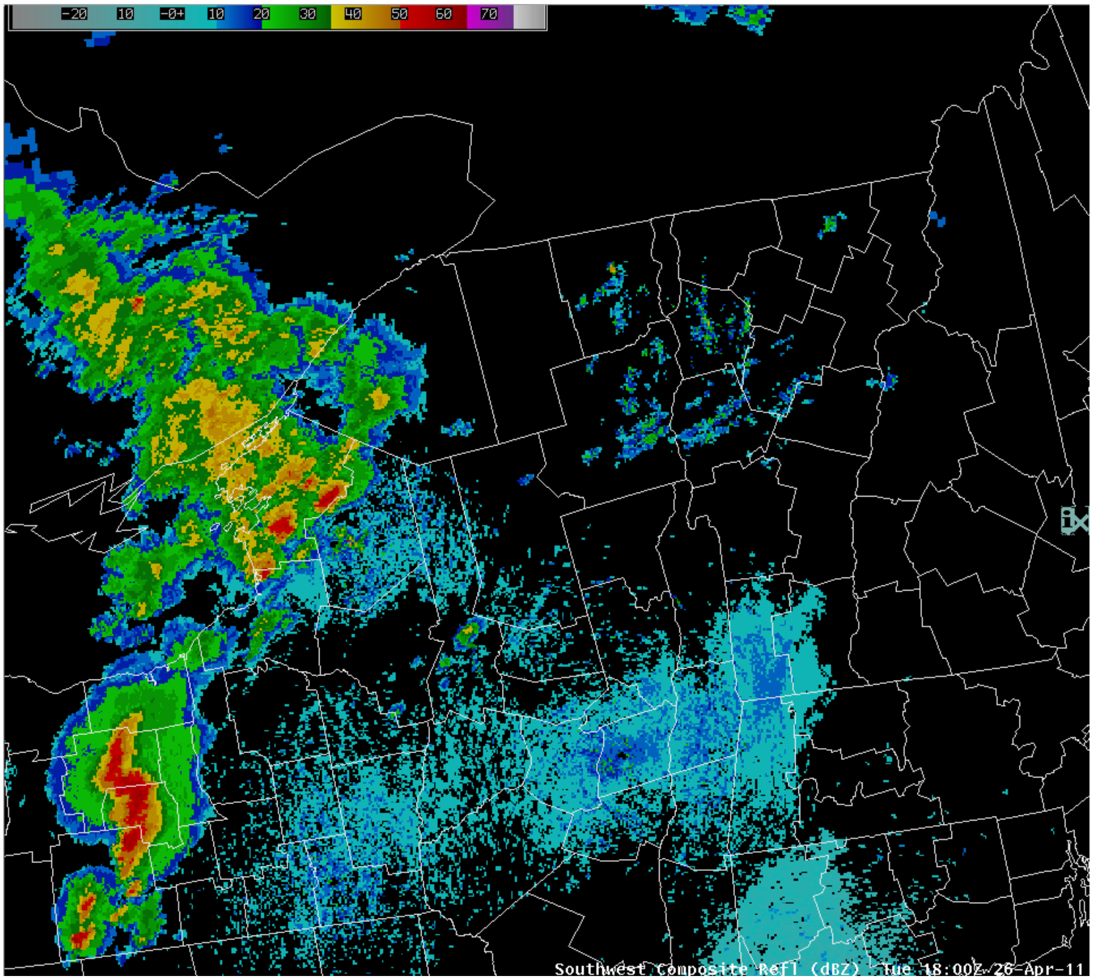

Figure 15. Radar Reflectivity Loop 18 UTC 26April 2011 to 06 UTC 27April 2011. (Click image to animate)

Flood Impacts

Rivers responded immediately to the heavy rainfall, rose above flood stage within a few hours, and reached moderate to major flood crests. Additionally, small creeks and streams became raging torrents, washing away roads and bridges. The East Branch of the Ausable River at Ausable Forks NY rose to 10.20 feet, its highest level since 1997 (Fig. 16), and there was widespread flooding throughout the valley from Keene to Ausable Forks and downstream through Keeseville. Additional rainfall the following day pushed the Ausable even higher, cresting at 11.48 feet on the 28th.

In Vermont, the Lamoille River experienced flooding not seen since 1995, cresting at 16.97 feet at Johnson (Fig. 17) and 454.21 feet at Jeffersonville (Fig. 18). There was extensive flooding along the Lamoille and its tributaries such as the North Branch of the Lamoille, the Gihon, and Browns River which flooded nearby low lying homes and roads. Homes and businesses in Johnson and Jeffersonville were inundated, forcing dozens of evacuations.

Outside the heaviest rain areas, the Saranac River in New York and the Missisquoi, Winooski, and Passumpsic Rivers in Vermont also experienced minor to moderate flooding.

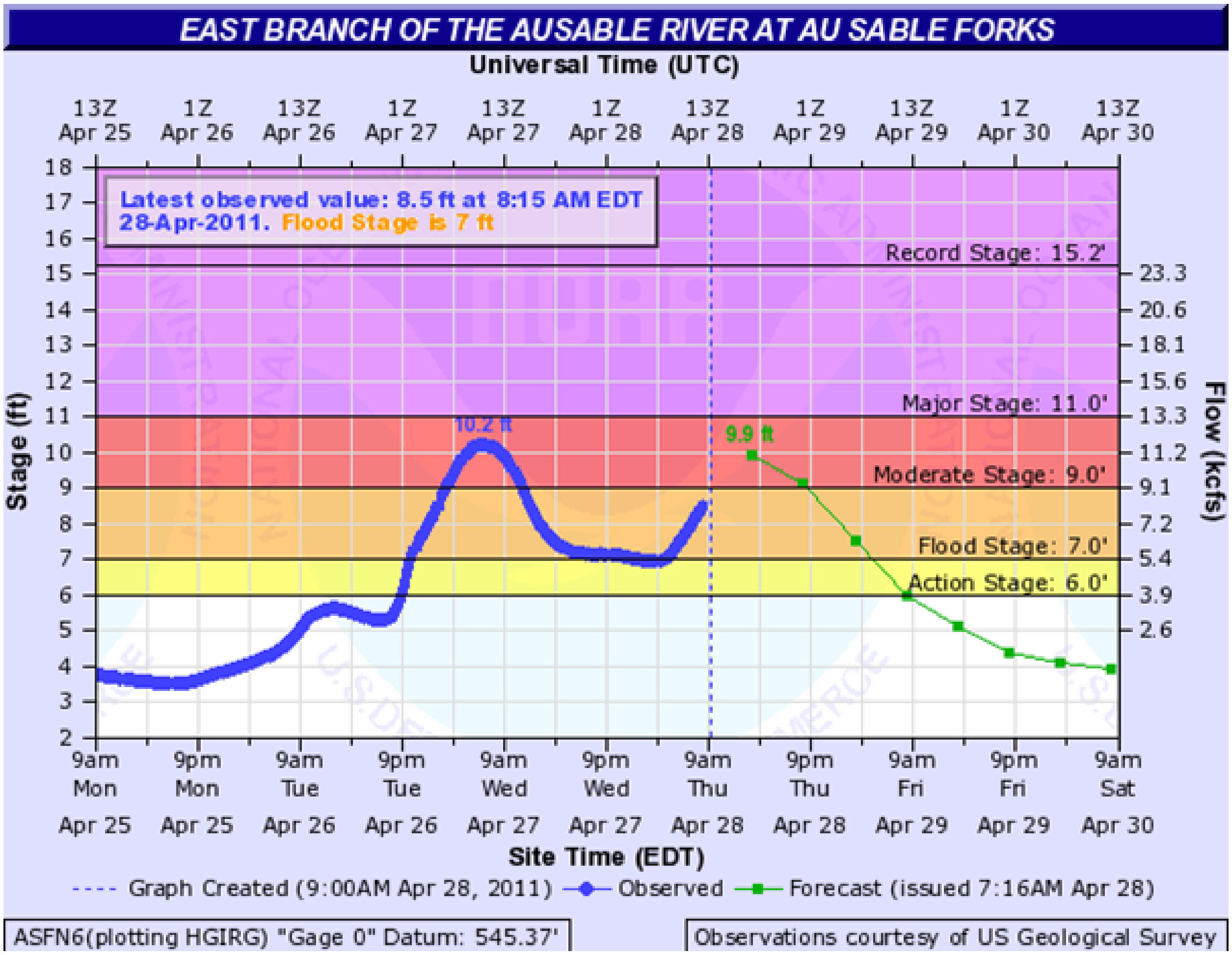

Figure 16. Hydrograph of the East Branch Ausable River at Ausable Forks, NY.

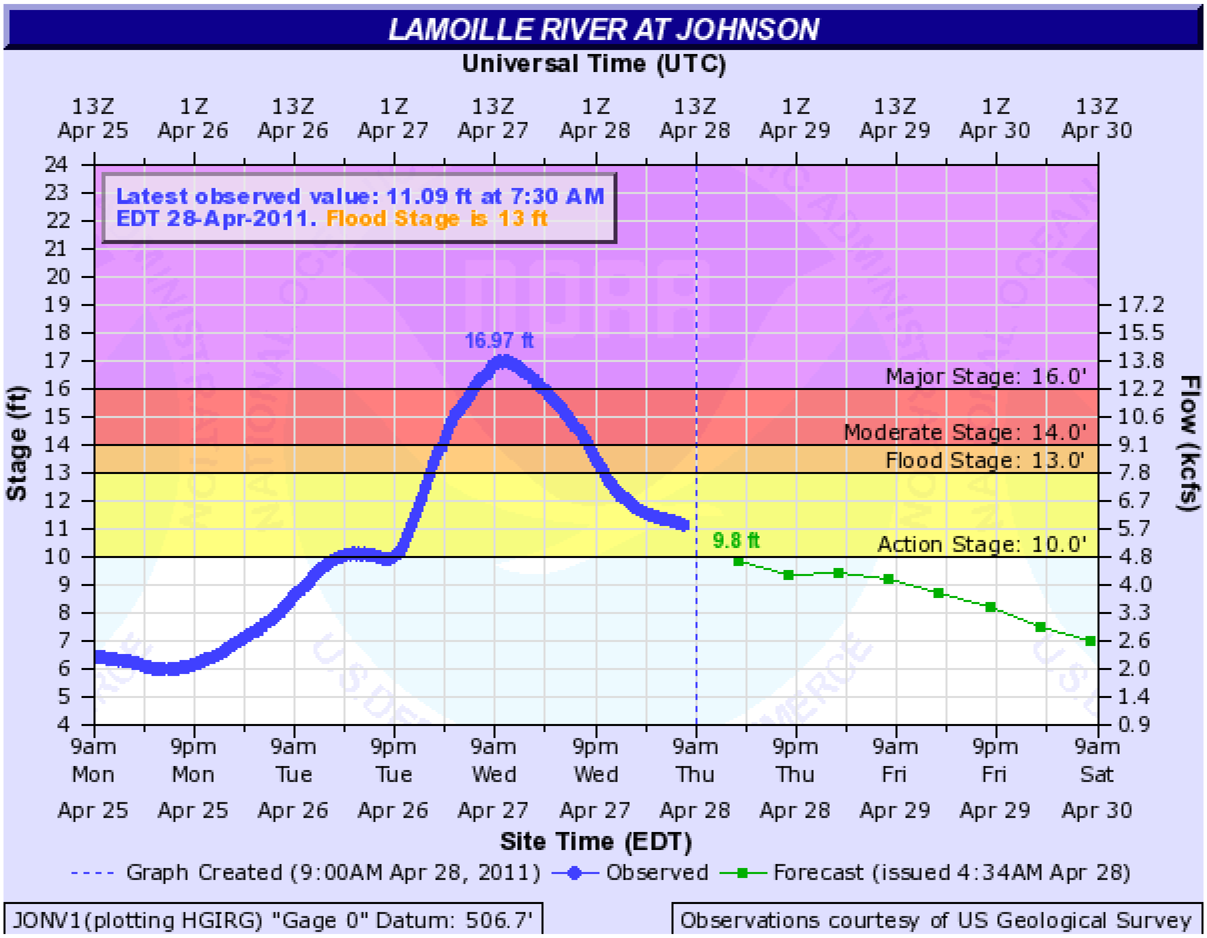

Figure 17. Hydrograph of the Lamoille River at Johnson, VT.

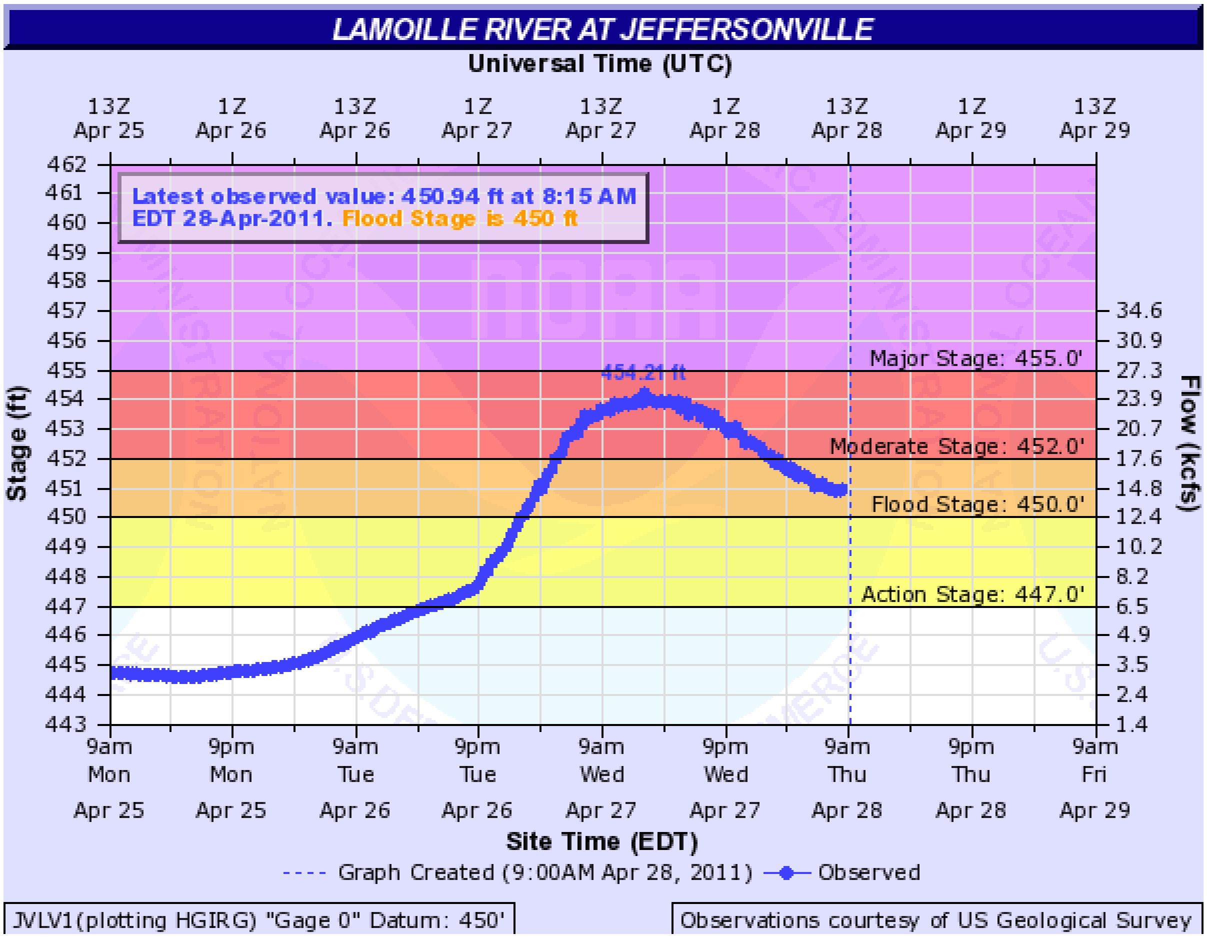

Figure 18. Hydrograph of the Lamoille River at Jeffersonville, VT.

Photographs of flooding in Figures 19 through 27 show the extent and severity of the flooding. Flash flooding caused the undermining of a bridge in Moriah NY (Fig. 19) and a debris flow in Jay NY (Fig 20). Figures 21 through 27 depict the inundation of sections of roadways to entire communities on the Ausable and Lamoille Rivers.

Figure 19. Broad Street bridge collapse, Moriah, NY.

Figure 20. Debris slide, Stickney Bridge Road Jay, NY.

Figure 21. US Route 9N east of Stickney Bridge Rd Jay, NY.

Figure 22. The Grand Union, Johnson Vermont

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Figure 23. Main Street Jeffersonville, VT.

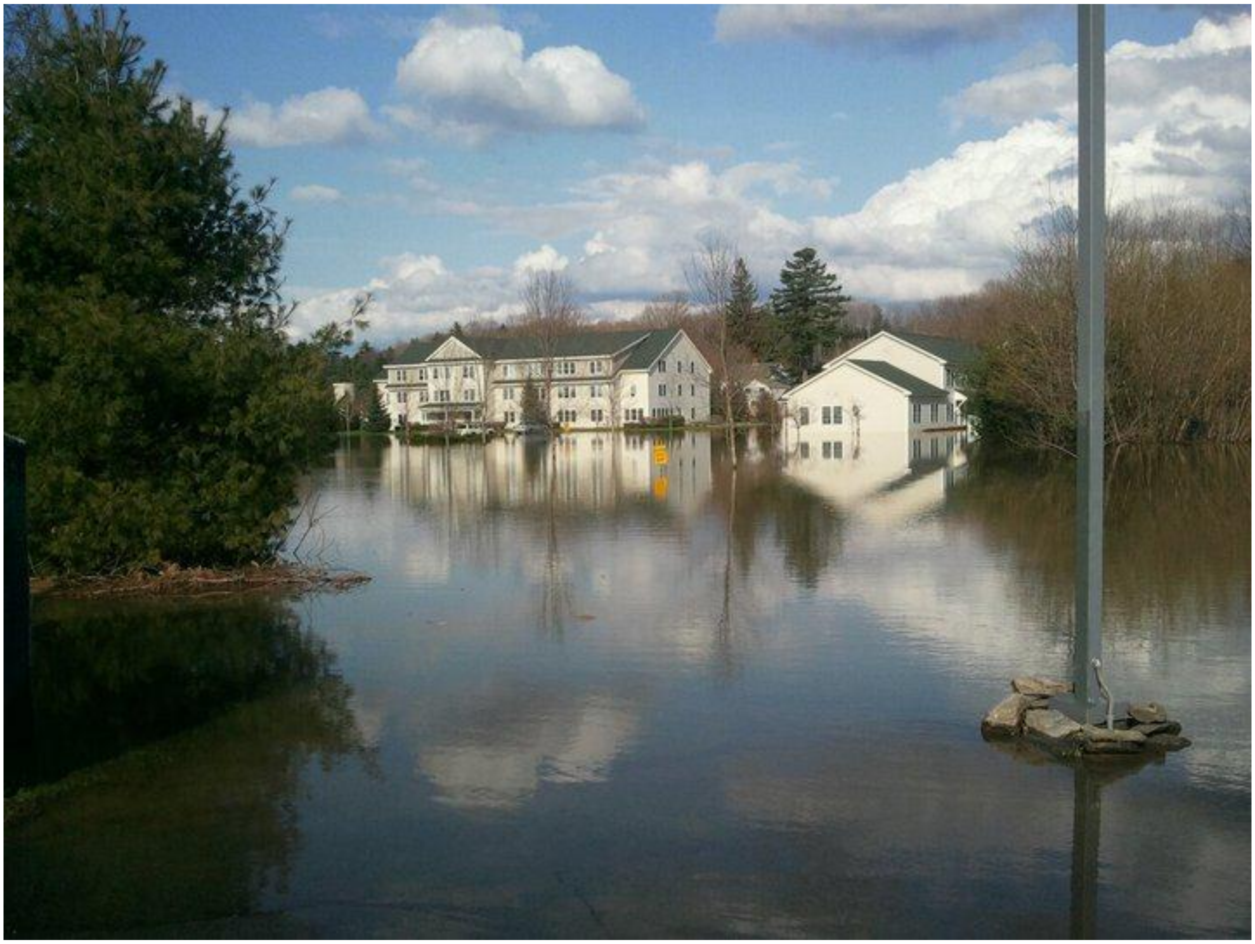

Figure 24. Mann's Meadow Jeffersonville, VT.

Figure 25. Route 15 approach to the "Wrong Way" Bridge, Cambridge Village side, Cambridge, VT.

Figure 26 Jeffersonville, VT.

Figure 27. Cambridge Village. VT.

Summary

Existing river flows were very high at the onset of the 26 April flash flood event, soils were saturated, and snowmelt was ongoing. Convection began to form in the afternoon, and moved into an area with meteorological parameters that were conducive to heavy rainfall. Flash flooding at the onset of the event caused bridge washouts and mudslides, then the transition to main stem riverine flooding inundated communities with flood waters.

2011 was a very active flood year for the North Country, which included not only the 26-27 April 2011 flash flooding, but also a high end severe thunderstorm and flash flood event in May, the Lake Champlain flooding from April through June, springtime Saranac Lake and Raquette River flooding, and was capped off with Tropical Cyclone Irene in late August. Although likely overshadowed by other floods, the 26-27 April flood is an excellent example of the need to be mindful of antecedent conditions, snowmelt, and archetypical heavy rain producing patterns.