

## **Flood Resilience (completely new chapter)**

What does “resilience” mean and more importantly, what is meant by “flood resilience”? Very broadly, “resilience” means that an entity—a person, neighborhood, town, state, region or society— when faced with a particular situation or event, has the ability to effectively return to its previous state or adapt to change(s) resulting from the situation or event without undue strain. As such, “resilience” is not necessarily an action that is taken, but an overall enhanced state of being in relation to an ongoing or future specific situation or event.

When applying the term to hazards, it is important to further articulate the meaning of “resilience.” In this context, “resilience” is often discussed in terms of being resistant to the effect(s) of one or multiple hazards that could reasonably be expected to occur in a specific area. For our purposes, flood resilience will mean *the ability of the region to effectively understand, plan for, resist, manage and, in a timely manner, recover from flooding.*

### **A. Background**

#### **Types of Flooding**

Generally speaking, there are two types of flooding that impact communities in the state of Vermont—flooding caused by inundation and flash flooding. Inundation flooding occurs when rainfall over an extended period of time and over an extended area of the river’s basin leads to flooding along major rivers, inundating previously dry areas. This type of flooding occurs slowly, but flood waters can cover a large area. Inundation flooding is slow and allows for emergency management planning if necessary. However, unlike during a flash flood, it may take days or weeks for inundation flood waters to subside from low areas, which may severely damage property.

Flash flooding occurs when heavy precipitation falls on the land over a short period of time. Precipitation falls so quickly that the soil is unable to absorb it and infiltrate it into the ground, leading to surface runoff. The quick-moving runoff collects in the lowest channel in an area—upland streams, in small tributaries, and in ditches—and the water level rises quickly and moves further downstream. Flash flooding typically does not cover a large area, but the water moves at a very high velocity and the flooding manifests quickly, making flash floods particularly dangerous. Due to the velocity of the water, a flash flood can move large boulders, trees, cars, or even houses.

The collecting of water in channels in steep areas also causes fluvial channel erosion, which can severely damage roads and public and private property. Fast moving water in the stream

channel may undermine roads and structures and change the river channel itself, predisposing other roads and structures to future flooding damage. Flash floods can also mobilize large amounts of debris, plugging culverts and leading to even greater damage. In Vermont, most flood-related damage is caused by flash flooding and fluvial erosion (erosion of stream banks). Due to the topography of Vermont and of the TRORC region, most, if not all, of the towns in our region are vulnerable to flash flooding and fluvial erosion.

### **Causes of Flooding**

Flooding in our region is caused by a small number of distinctive types of weather, and also by the cumulative impact of a weather event and the conditions on the land at the time the flooding occurs. By far the most common type of weather event to occur in our region is a severe storm. Severe storms may include thunder, lightning, hail, high winds, and precipitation with varying degrees of intensity. Severe storms with particularly heavy precipitation have the ability to create flash flood conditions. However, over an extended period of time, severe storms may cause inundation flooding due to the cumulative effects of continuous rain, saturated soils and a high water table/high aquifer levels. As with any weather system, pockets of a severe storm may be more severe than others, leading to variability of observed impacts across the region. During the spring and early summer of 2013, constant severe storms over the TRORC region caused localized flash flooding after each individual storm, but also caused inundation flooding along some of the major rivers in the region over time, including the White River.

The main hazards associated with hurricanes and tropical storms are high winds and flooding. By the time most hurricanes reach Vermont, they have been downgraded to tropical storms, but that is not to say they are less dangerous. Due to the steep slopes and narrow valleys in our region, heavy precipitation from a hurricane or tropical storm tends to cause severe flash flooding and widespread destruction. The speed that the hurricane or tropical storm is moving across the area and pockets of varying severity has an impact on the rainfall totals observed from town to town. For example, Tropical Storm Irene dropped 6"+ over much of the White River Valley (9" in Rochester, according to local reports), causing extensive flooding damage. However, the towns in our region along the Connecticut River received 3-5" and experienced minimal flood damage. Storm impacts can be greatly magnified by previous rains. Tropical Storm Floyd in 1999 was very similar to Irene, but fell on dry ground and was hardly remembered.

Both severe storms and hurricanes/tropical storms occur during the summer and into the fall months, but ice jams and the combination of melting snow and rain leave our region vulnerable to the impacts of flooding in the winter and early spring. Ice jams typically occur during the spring when river ice begins to break up and move downstream, but may occur during a thaw

period in the winter months. Sheets of ice become hung up on a narrow portion of the stream or river, such as under a bridge, culvert or another obstruction, creating a “dam” and additional ice and water begin to back up behind the hung-up ice sheets. This creates inundation flooding immediately adjacent to the site of the “dam,” and additional inundation flooding upstream. Once the “dam” breaks free, flash flooding may occur downstream as well. Ice jams in our region typically cause minimal damage, but they can damage road infrastructure, and flood homes and businesses. The First and Third Branches of the White River (Chelsea and Randolph, respectively), the Waits River (Bradford), and Rowell Brook (Bradford) have all experienced ice jams or are vulnerable to them. Finally, the combination of melting snow and rain, can lead to flooding in the region.

Flooding is worsened by land uses that create hard surfaces that lead to faster runoff, and past stream modifications that have straightened or dredged channels, creating channel instability.

### **Implications of Climate Change and Flooding**

According to a white paper produced by Vermont Agency of Natural Resources (VT ANR)’s Climate Change Team<sup>1</sup>, climate change will likely bring about conditions that exacerbate flooding in Vermont. The summer season is expected to lengthen overall, and the total precipitation is expected to increase in all seasons except during the fall.<sup>2</sup> The frequency of heavy precipitation events is likely to increase in all seasons, with the heaviest precipitation events occurring during the summer months.<sup>3</sup> Perhaps more importantly, precipitation will likely occur in shorter, more intense bursts and, consequently, will produce precipitation that runs off the land more than it filters into it.<sup>4</sup> These increases in heavy precipitation events will be in addition to already occurring impacts of climate change that have made extreme events more frequent. This provides additional opportunities for flash flooding and inundation flooding to occur, and places the state and region at greater risk for flood-related damage. In addition, the expected increase in precipitation during the winter months may lead to added snowmelt and flooding in the spring.

The impacts of climate change on a specific area or region (and globally) are informed by temperature and precipitation models that are used to predict future conditions. Precipitation models are important because they are used in designing and building road infrastructure, informing policy decisions, and in regulating the location where structures and facilities are built. Our understanding of the impact of global and regional climate change is constantly evolving, and precipitation models are becoming more detailed and refined as well. It is

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<sup>1</sup> Alan K. Betts, “Climate Change in Vermont.” June 2011 (edited 10/29/2011).

<http://www.anr.state.vt.us/anr/climatechange/Pubs/VTCCAdaptClimateChangeVTBetts.pdf>

<sup>2</sup> *Id.* at page 9

<sup>3</sup> *Id.*

<sup>4</sup> VT ANR Climate Change Adaptation Framework, pages ii-iv, 14-16. Presentation by Dr. Cameron Wake.

imperative to use new precipitation models when planning, designing, and constructing new infrastructure, structures and facilities to reflect the increase in frequency of heavy precipitation events. Road infrastructure, including culverts and bridges, designed and built using old precipitation models will likely be undersized in the future, or may even be undersized as-built. New structures and facilities designed and built using old precipitation models will be less likely to withstand and adapt to future precipitation events and trends (and the flooding that is likely to result).

### **The Regional Economic Impact of Flooding**

Flooding in the region causes immediate impacts such as eroded river banks, road closures, flooded structures, and crop damage. However, once the stress of the initial flooding impacts has subsided, the more long-term impacts begin to show, especially after major flooding events. One long-term impact is the effect of flooding on the region's economy. For the most part, flooding may economically impact a handful of homeowners and business owners with washed out private culverts or roads, flooded basements, lost (or gained) riparian property, or it may impact municipalities with road and culvert repairs. While these initial flood-related impacts have economic ramifications, major flooding events, like Tropical Storm Irene, have the ability to have lasting economic impacts on the entire region's economy.

Economically speaking, Tropical Storm Irene struck at a very inopportune time in 2011. At the end of August 2011, the year's crops were ready for harvest or would be ready in a few weeks. Because many of the region's farms and agricultural lands are located in the floodplain, crop damage was widespread. Of 476 documented agricultural producers impacted by Irene in the state, 76 producers (and 1,659 acres of land) were located in Windsor County, and 23 (and 943 acres of land) were located in Orange County.<sup>5</sup> Due to the fact that Irene was a statewide flood event and the potential for water contamination was great, flooded produce was considered "adulterated" by the U.S. Department of Agriculture and the Vermont Agency of Agriculture and, therefore, the sale of these crops was prohibited.<sup>6</sup> As a result, approximately \$2 million in vegetable crops alone were destroyed or left to decompose statewide.<sup>7</sup> Unofficially, the economic estimate for flood damage to farms statewide has been estimated at \$20 million (includes hay, corn, pasture, soybeans vegetables and fruit).<sup>8</sup> Finally, the loss of livestock was widespread and devastating.

Vermont is a destination for travelers coming from the Boston, New York and Montreal areas. Due to the damaged road infrastructure throughout the state, particularly in the TRORC region,

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<sup>5</sup> Economic Impact Assessment- Vermont DR-4022. Page 12.

[http://vtstrong.vermont.gov/Portals/0/Documents/Vermont\\_Econ\\_Impact\\_Final%20-%2042312.pdf](http://vtstrong.vermont.gov/Portals/0/Documents/Vermont_Econ_Impact_Final%20-%2042312.pdf)

<sup>6</sup> Impact of Irene on Vermont Agriculture. University of Vermont Extension. January 5, 2012. Page 1.

<sup>7</sup> *Id.*

<sup>8</sup> *Id.*

travel was difficult. Finding an east-west route was especially difficult as many of the major roads in the region had been damaged at one section or another, including Routes 4, 100, 107 and 125. With the fall season approaching, travel to areas not directly off the major highways was slow or impossible. Woodstock was among the most hard-hit areas in the state for room sales, reporting -68.4% in September 2011 and -20.4 in October.<sup>9</sup> In addition, a number of small businesses were impacted by flooding with varying degrees of damage. These businesses are the life-blood of the economy of Vermont, and unquestionably of the TRORC region. In an attempt to help businesses in our region that were impacted by flooding, or are at risk of future flood damage, TRORC completed 41 Continuity of Operations Plans (COOP) following Tropical Storm Irene.

### **Flooding in Our Region**

Flooding is the worst current natural threat to residents and infrastructure in the TRORC region. Past instances of flooding in the region have included rain and/or snowmelt events that caused flooding in the major rivers' floodplains and intense rainstorms over a small area that caused localized flash flooding. Both events can be worsened by the build-up of ice or debris, which can contribute to the failure of important infrastructure (such as culverts, bridges, and dams).

Significant flooding events have occurred in the TRORC region throughout recorded weather-history. Due to the topography of the region, it is likely that large scale or widespread localized flooding have been occurring for hundreds or thousands of years. Please see Appendix A for a table outlining the flooding events that have occurred in the TRORC region over the past 100 years, beginning with the worst flooding event to hit the TRORC and the Vermont, the "Great Flood of 1927." Appendix A is not intended to capture the details of every flood event in the region. It is intended to provide a snapshot of the more significant flooding events, and is an attempt at beginning to build a consolidated record of these events in our region. In addition, it is an attempt to demonstrate the severe damage that can be caused by flooding in our region. These data are also presented to help towns in future flood resilience-planning endeavors. Finally, it is important to note that weather events, particularly from long ago, lack the details we have available to us today.

Because flooding and flood damage are spatial in nature, we can begin to identify areas in the TRORC region that are most vulnerable to flooding through spatial analysis. By compiling flood data from multiple events over time, we can begin to see the areas that are consistently flooded with little damage to property and life, and which areas have repeatedly sustained significant flood damage. The flood hazard and fluvial erosion hazard areas that continually pose risks to life, private property and public infrastructure should be considered "high-hazard" or "hot spot" areas.

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<sup>9</sup> Economic Impact Assessment- Vermont DR-4022. Page 22.

## **B. Flood Hazard and Fluvial Erosion Hazard Areas in the TRORC Region**

### **Flood Hazard Areas**

There are two sets of official maps which can govern development in the floodplain in Vermont. They are the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps (FIRMs) and VT Agency of Natural Resource's river corridor area maps. The FIRMs show the floodplain that FEMA has calculated which would be covered by water in a 1% chance annual inundation event, also referred to as the "100 year flood" or base flood. This area of inundation is called the Special Flood Hazard Area (SFHA). FIRMs may also show expected base flood elevations (BFEs) and floodways (smaller areas that carry more current). Every town in our region has areas of mapped flood risk by FEMA. FIRMs are only prepared for larger streams and rivers.

Recent studies have shown that a significant portion of flood damages in Vermont occur outside of the FEMA mapped areas along smaller upland streams, as well as along road drainage systems that fail to convey the amount of water they are receiving. Since FEMA maps in the region are only concerned with inundation, and these other areas are at risk from flash flooding and erosion, these areas are often not recognized as being flood-prone. Property owners in such areas outside of SFHAs are not required to have flood insurance. Flash flooding in these reaches can be extremely erosive, causing damage to road infrastructure and to topographic features including stream beds and the sides of hills and mountains, and also creating landslide risk. The presence of undersized or blocked culverts can lead to further erosion and stream bank/mountainside undercutting. Change in these areas may be gradual or sudden. Furthermore, precipitation trend analyses suggest that intense, local storms are occurring more frequently.

Vermont ANR's river corridor maps will show the area needed to address these erosion hazard areas, which may be inside of FEMA-mapped areas, or extend outside of this area. In these areas, the lateral movement of the river and the associated erosion is more of the threat than inundation by floodwaters. Elevation or floodproofing alone may not be protective of structures in these areas as erosion can undermine structure. Some of the region already has river corridors mapped, but Vermont ANR is set to issue statewide river corridor maps in the later part of 2014.

### **Flood Hazard Regulations**

In order to enable property owners to be eligible for federal flood insurance through the National Flood Insurance Program (NFIP), municipalities must adopt and enforce a floodplain management ordinance, often called "flood hazard bylaws," "flood hazard area regulations," or

“flood hazard overlay districts” in Vermont. A community’s flood hazard regulations must apply to at least the Special Flood Hazard Areas (SFHA) identified by FEMA. The regulations regulate new structures in the floodplain and places restrictions on other types of activities within the floodplain. They also specify land, area and structural requirements to be adhered to within the SFHA. Paradoxically, using only the minimum required regulations can *increase* flood risk, as they allow filling in flood zones.

Municipalities can seek to reduce the threat of flood damage within their jurisdiction by not allowing new structures in the floodplain and through enacting stricter standards than the minimum, such as including river corridor areas as well, and through the proper administration and enforcement of their flood hazard regulations. Lax enforcement of these laws can place lives at risk of injury or death, place infrastructure and property at risk of damage or destruction, and can even create liability on the part of the community. With that being said, there are some circumstances that make the administration, and to a degree, the enforcement, of flood hazard regulations problematic.

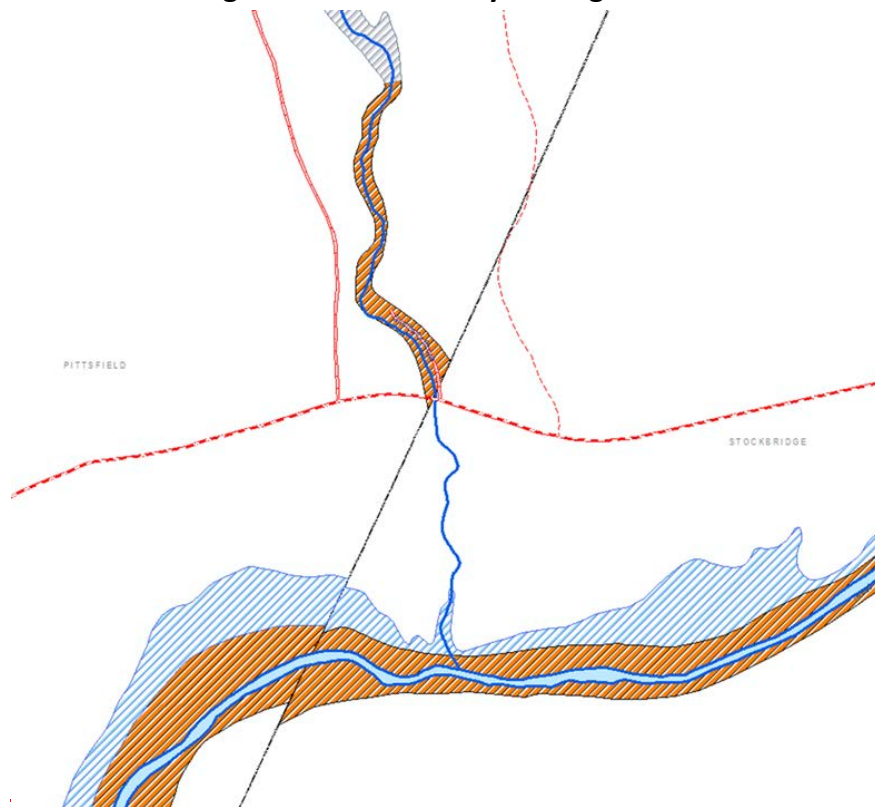
For example, the FIRMs used by the towns in the TRORC region may be old or outdated and/or do not document any changes in a stream’s course. For areas impacted by Tropical Storm Irene, this updated information is particularly important and useful (especially when the Irene-flooded areas are not documented on a town’s FIRMs or the information between the FIRM and the real-world conditions is contradictory). Flood Insurance Rate Maps (FIRMs) for many towns within Orange County date to the early 1990’s and as far back as 1978. The outdated information on these FIRMs provides challenges for administering a town’s flood hazard regulations as the physical conditions on the ground may have changed since the FIRMs were issued. In any case, the town must still use the currently effective FIRMs until new FIRMs are issued by FEMA, unless a Letter of Map Amendment (LOMA) is granted for specific properties in the interim.

Unnumbered or approximate A Zones (labeled “Zone A”) on a town’s FIRM also present issues in the administration of a town’s flood hazard regulations. In these areas, the base flood elevation, the computed elevation to which floodwater is anticipated to rise during the base flood (sometimes called the “100-year flood”) has not been determined. As a result, the map does not provide or help provide the elevation to which a structure must be elevated or floodproofed. For permit applications within an unnumbered A Zone, the floodplain administrator will be required to use a few methodologies to determine the appropriate elevation to which the structure must be elevated or floodproofed. This presents the potential for inconsistency in the administration of a town’s flood hazard regulations over time, and among adjacent towns sharing a body of water. Regardless, a town is responsible for ensuring

that new development within unnumbered A Zones is constructed using methods that will minimize flood damage.

While towns are only responsible for administering their own flood hazard regulations, one of the ultimate goals for the NFIP is to reduce flood damage and make communities safer along the length of a body of water. Therefore, it is important for towns to properly administer and enforce their flood hazard regulations to not only protect their own community, but to help prevent damage to downstream communities. When reviewing and comparing the FIRMs' for adjacent towns, the flood zones indicated on the FIRMs are not always consistent and may produce results like the one shown below. Mismatched FIRMs can make working or planning on a multiple-town or regional scale challenging.

**Figure 1: Inconsistency Among FIRMs**



### **Regional Flood Hazards**

Please see the table in Appendix B for a summary of both the flood hazards and fluvial erosion hazards in the Two Rivers-Ottawaquechee region. The Vermont Department of Environmental Conservation is working to complete a statewide analysis of fluvial erosion hazards. The results of this endeavor should be completed in 2014. The fluvial erosion hazard data presented in the table is the result of work completed by Phase II Stream Geomorphic Assessments, from which fluvial erosion hazards can be derived. This information will be replaced by the VT ANR data once it is available, as it will be more up-to-date and will be available for all towns.



## **Home/Property Buyouts**

Following the flood damage caused by the 2011 spring flooding and Tropical Storm Irene, a number of property owners in Vermont applied for property buyouts, which were funded by FEMA's Hazard Mitigation Grant Program (HMGP) and HUD's Community Development Block Grants for Disaster Recovery (CDBG-DR). Over the course of this process, over 130 damaged or destroyed residential properties in the state of Vermont will be bought out with this grant funding. As a stipulation of the HMGP funding, FEMA requires that the structure(s) on each buyout property be demolished, and ownership of the empty parcel of land then be transferred to the town/municipality. Future development on these sites will be restricted.

The home/property buyout process has both positive and negative impacts on a town and the community at large. The TRORC region was particularly hard hit by the flooding caused by Tropical Storm Irene, and had the greatest number of property buyout applicants in Vermont. As of early 2014, there were 60 properties in the TRORC region involved in the buyout process. The towns in our region with buyout properties include; Bethel, Braintree, Bridgewater, Granville, Hartford, Pittsfield, Plymouth, Rochester, Royalton, Sharon, and Stockbridge. Most of these towns are located on the White River and its tributaries. As of early 2014, 21 residential properties spread across these towns were purchased with FEMA's HMGP funds. Because the properties eligible for a buyout were heavily damaged by flooding, the buyout process is an effective way to reduce a community's vulnerability to flooding and therefore improve the community's overall resilience to flooding. As a result, a number of communities in our region have been made safer.

However, while the buyout process of an at-risk home makes a community less vulnerable to flooding, there is an inherent conflict between home buyouts and the tax and housing base of a town. For many towns in our region, a fiscal issue may arise with the loss of a few homes or properties from their tax base. As a result, some towns may need to raise taxes for the remaining landowners in order to maintain the town's level of service provided to the community. Higher taxes may make a specific town less attractive to some potential home buyers.

Another consequence of home buyouts is the loss of a town's housing base. Many towns in Vermont and in our region are located in valleys surrounded by steep slopes. Some homes are built on the hillsides, but due to topographic constraints, many homes are built in the valleys, near rivers and streams. This location places the structure and inhabitants at risk of flooding damage or injury caused by either inundation flooding or by fluvial erosion. Often times,

affordable or low-income housing is located in these higher risk areas. So, during a major flooding event, these homes have a higher probability of being damaged or destroyed, and therefore may be good candidates for a home buyout. However, when the structure is razed as part of the buyout process, it is removed from a town's housing base and in addition, may be removed from a town's affordable housing base. This situation may present challenges to the town in the future.

Generally speaking, the buyout of homes at high-risk of flood damage is an important step in improving the resilience of a town and community to flood damage. If a town's home buyouts have significantly impacted the housing base, it is important that the town have a thoughtful and creative approach to rebuilding its housing base that will maintain its improved flood resilience and conform to the town's future land use visions or settlement patterns.

### **Lands Which Help To Prevent Flooding**

#### Wetlands

Wetlands are a vital component for maintaining the ecological integrity of land and water. In addition, they provide an array of functions and values that support environmental health and provide benefits to humans. Benefits provided by wetlands include: flood and storm water control, maintenance of surface and ground water quality, open space and aesthetic appreciation, fish and wildlife habitat (including a large number of threatened and endangered species), ecological research and educational opportunities, and sources of nutrients for freshwater food chains.

Draining, filling, and development have resulted in the loss of more than thirty-five percent (35%) of Vermont's original wetland acreage, primarily due to agricultural and large-scale development projects. At present, roughly four percent (4%) of Vermont's lands are classified as wetlands, totaling 244,000 acres. The Vermont Wetlands Office estimates that an additional 80,000 acres of wetlands exist that have not been identified, which brings the actual total to about five or six percent of the state's land. The current rate of wetland loss in Vermont has been estimated at eight (8) acres a year through incremental destruction by numerous smaller projects, many of which are less than one acre, with serious implications for short- and long-term values associated with wetlands. Although methods exist for creating areas that have many wetland characteristics, it is not possible to replicate the intricate complexities of a wetland formed over decades or hundreds or thousands of years.

The State of Vermont defines wetlands as "those areas of the state that are inundated by surface or ground water with a frequency sufficient to support significant vegetation or aquatic life that depend on saturated or seasonally saturated soil conditions for growth and

reproduction.” Such areas include but are not limited to marshes, swamps, sloughs, potholes, fens, river and lake overflows, mud flats, bogs and ponds.

The Vermont Wetlands Rules (1990) (10 VSA Chapter 37) classify all wetlands into three categories. Class 1 wetlands are those identified as “exceptional or irreplaceable in their contribution to Vermont’s natural heritage.” No Class 1 wetlands have been designated in the TRORC region. Class 2 wetlands are those shown on the National Wetlands Inventory, as well as any wetlands contiguous to these mapped wetlands. Most wetlands considered as Class 2 have areas of at least three acres. Class 3 wetlands are those that have not been evaluated or are not considered by the Water Resources Panel of the Natural Resources Board (formerly Water Resources Board) to be significant.

The purpose of the Vermont Wetlands Rules is “to identify and protect significant wetlands and the values and functions which they serve in such a manner that the goal of no net loss of such wetlands and their functions is achieved.” Although only wetlands designated as “significant” are protected under the Wetlands Rules, the Rules state, “Wetlands not designated as significant under these rules should be assumed to have public value, and therefore may merit protection under other statutory or regulatory authority.”

In the region, just over one percent (1.2%) of the land area has been identified by the State of Vermont as “significant” wetlands, eligible for state protection under the Vermont Wetlands Rules. However, there are a large number of smaller wetlands that may qualify for protection. According to the Wildlife Management Institute in Washington, D.C., “ten one-acre wetlands provide habitat for many more duck pairs than does one 10-acre wetland. Small wetlands also thaw faster and provide more high-protein foods for nesting hens than larger wetlands.” They are also critical in the flight paths of migrating mallards, pintails, teals, gadwalls, and shovelers. Forested wetlands have been recognized as containing critical spring food sources for black bears.

Examples of wetlands in the TRORC region that help to attenuate floodwaters and reduce flooding damage include the Class 2 wetlands through the Killington Flats area. Due to the topography, large wetlands are somewhat lacking in the TRORC region. However, there are a number of smaller wetlands in the towns of Newbury, Thetford, Corinth, West Fairlee, and Randolph. For areas with degraded wetlands, flooding events may be more damaging and cause problems for a town. For these reasons, it is important to preserve or enhance wetlands throughout the region, large or small, to provide flood mitigation, water quality benefits and wildlife habitat.

### *Wetlands Identification*

According to the Vermont Wetlands Rules, the boundary between a wetland and an upland shall be delineated by the methodology set forth in the most recent edition of the Federal Manual for Identifying and Delineating Jurisdictional Wetlands. This methodology employs three parameters: vegetation, soils, and hydrology. (See Section 5 of Vermont Wetland Rules for more detailed description of wetlands delineation in terms of function and vegetation.) The Rules state that the most recent edition of The Wetland Plant List of the State of Vermont published by the U.S. Fish and Wildlife Service shall be used to determine the frequency of vegetation occurrence in wetlands. Wetlands must serve at least one of the following functions in order to be protected by the state:

1. Water storage for flood water and storm runoff.
2. Surface and ground water protection.
3. Fisheries habitat.
4. Wildlife and migratory bird habitat.
5. Hydrophilic vegetation habitat.
6. Threatened and endangered species habitat.
7. Education and research in the natural sciences.
8. Recreational value and economic benefits.
9. Open space and aesthetics.
10. Erosion control through binding and stabilizing the soil.

In order to be protected by Criterion 1(G) of Act 250, wetlands must be listed as significant by the state. Municipalities, the Regional Commission, or other interested parties may petition the state Water Resources Panel of the Natural Resources Board (formerly Water Resources Board) to: 1) have a wetland reclassified to a higher or lower classification, 2) determine which functions make the wetland significant, 3) determine whether the size or configuration of a buffer strip associated with a significant wetland should be modified, or 4) determine the final boundaries of any significant wetland. However, wetlands may be protected under several other sections of Act 250, including criteria dealing with water pollution (1), waste disposal (1(B)), floodways (1(D)), streams (1(E)), shorelines (1(F)), erosion control (4), natural areas and aesthetic considerations (8), wildlife habitat (8A), public investments and facilities (9A), and under local and Regional Plans.

The Regional Commission recognizes the critical value of wetlands in relation to the health of the water, wildlife, and plant resources in the region and to the ecosystem as a whole. The Regional Commission supports and encourages communities to identify and inventory wetlands within the region and to adopt mechanisms for their increased protection. This information can increase the effectiveness of the state and federal regulatory process. Towns and communities

have the ability to adopt mechanisms that provide stricter protections than are required by the state.

### *Riparian Buffers and Lands Adjacent to Steams*

Naturally vegetated riparian zones (vegetated buffer strips next to surface waters) are essential for healthy and resilient river corridors. Vegetated riparian buffers provide a number of “ecosystem services” including: floodwater attenuation; providing habitat for aquatic and terrestrial organisms; providing river bank support and stabilization; helping prevent bank undercutting and bank collapse; reducing flood and ice damage to stream channel, and adjacent lands and structures; shading the river channel; intercepting, absorbing, and filtering out pollutants; and slowing surface water runoff. The maintenance and enhancement of streamside and lakeside vegetation is the easiest and most effective means of protecting the many benefits and values associated with surface waters. Setting aside strips of naturally growing grasses, shrubs, and trees is essential to the health of streams and lakes. Appropriately, vegetated shorelines contribute to maintenance of water quality and shoreline protection.

Moving outside of the riparian buffer, lands adjacent to streams also provide benefits, especially during flooding events. Once water overtops the river or stream channel, these areas help to dissipate flood water. This also slows the velocity of the water by allowing the water to expand laterally over the land area, instead of moving down the river or stream channel. Because of their tendency to flood and the deposition of nutrients on the land, these areas tend to be very productive agricultural lands. They also serve to collect ice or debris during floods, helping river or stream channels to stay clear. Unfortunately, this places crops and livestock at risk during flooding events. Of course, much of Vermont and the TRORC region is steep and mountainous and, therefore, does not have an abundance of flat lands surrounding rivers and streams. The importance of these lands was demonstrated during the flooding caused by Tropical Storm Irene. For example, floodwaters carried from Randolph to Bethel by the Third Branch of the White River were able to dissipate along a long stretch of fields between the two towns, helping to attenuate some of the floodwater.

### *Upland Forests*

Upland forests are distinguished by having a nearly continuous canopy cover of 60 percent or more.<sup>10</sup> In Vermont, the important upland forest tree species include: Red and Sugar Maple, Eastern Hemlock, Red Spruce, Yellow and Paper Birch, White Pine, White Ash, and Red and

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<sup>10</sup> Vermont Forests and Woodlands. Vermont Fish and Wildlife Service.

[http://www.vtfishandwildlife.com/books/Wetland,Woodland,Wildland/\\_\\_\\_76\\_to\\_386\\_Part\\_4\\_A\\_Guide\\_to\\_the\\_Natural\\_Communities\\_of\\_Vermont/\\_82\\_to\\_236\\_Upland\\_Natural\\_Communities/\\_84\\_to\\_186\\_Upland\\_Forests\\_and\\_Woodlands/\\_84\\_to\\_103\\_Upland\\_Forests\\_and\\_Woodlands.pdf](http://www.vtfishandwildlife.com/books/Wetland,Woodland,Wildland/___76_to_386_Part_4_A_Guide_to_the_Natural_Communities_of_Vermont/_82_to_236_Upland_Natural_Communities/_84_to_186_Upland_Forests_and_Woodlands/_84_to_103_Upland_Forests_and_Woodlands.pdf)

White Oak.<sup>11</sup> Aside from including these ecologically and economically valuable tree species, upland forests also comprise many small unnamed streams which make up the headwaters of a watershed. These headwater streams are the smallest, yet most abundant streams draining the state of Vermont and the TRORC region. Therefore, the activities occurring in the headwaters can impact an entire watershed.

Healthy and well-managed upland forests can reduce flooding by intercepting rainfall and infiltrating rainwater, thereby slowing the flow of rainwater into small, headwater streams. These streams are notoriously “flashy” and are often responsible for fluvial erosion, particularly within mountainous areas. The Vermont Department of Forests, Parks and Recreation’s Forest Watershed Program emphasizes the importance of healthy forests and sustainable forestry practices as a way to improve or maintain water quality.

The TRORC region is home to many different kinds of forested areas. For instance, the region contains some of the vast unbroken forested ridgelines of the Green Mountain National Forest, as well as several large blocks of conserved forested areas like the Chateaugay No Town Conservation Project, which stretches across the towns of Barnard, Bridgewater, Stockbridge, and Killington. There are also several town forests—for instance, those in Randolph, Fairlee, West Fairlee, Royalton, and Corinth, to name a few. It is our intention to continue to support forest stewardship and work with town planning commissions to help preserve and protect forested land, which not only provide ecological, scenic and economic benefits, but also help mitigate flood damage.

### **Stormwater and Impervious Surfaces**

Impervious surfaces are areas that prevent the infiltration of water into the soil. Man-made impervious surfaces include parking lots, rooftops, roads (even gravel roads) and severely compacted soils. Man-made impervious surfaces exacerbate flooding events by increasing the amount and velocity of stormwater runoff, particularly in areas where these surfaces are prevalent. Because stormwater is not allowed to infiltrate into the ground or is held by vegetation, it flows quickly in sheets over impervious surfaces, and drains into the lowest area. This stormwater then adds to the “flashiness” of localized flooding, especially in heavy rain events.

Impervious surfaces and increased stormwater runoff also negatively impact water quality in a watershed. In fact, studies have demonstrated that a water body begins to demonstrate visible degradation when its watershed reaches 10% imperviousness.<sup>12</sup>

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<sup>11</sup> *Id.*

<sup>12</sup> Vermont Green Infrastructure Initiative, Watershed Management Division of the VT Department of Environmental Conservation. Low Impact Development Fact Sheet; LID Principle #. Reduce Impervious Surfaces. [http://www.anr.state.vt.us/dec/waterq/stormwater/docs/sw\\_gi\\_1.7\\_reduce\\_impervious\\_surfaces.pdf](http://www.anr.state.vt.us/dec/waterq/stormwater/docs/sw_gi_1.7_reduce_impervious_surfaces.pdf)

The percentage of impervious surfaces can be reduced by limiting the number of rooftops and pavement, by using permeable surfacing materials, employing disconnection practices and by implementing Low Impact Development (LID) principles.<sup>13</sup> The terms “LID” and “Green Infrastructure” are often used interchangeably. Overall, they are referencing essentially the same projects with similar goals in mind, but technically, there is a slight difference between the two terms. Low Impact Development refers to the process of designing and implementing practices that can be implemented at the site-level to control stormwater and attempts to replicate the pre-development conditions at that site. Green Infrastructure refers to a broader view at the community or watershed scale, and is focused on implementing LID practices as part of a coordinated effort to reduce impervious surfaces and stormwater runoff.

Green Infrastructure and LID principles seek to mimic conditions present before the development of an area by managing stormwater runoff the way a healthy and in-tact environment would— by slowing it, spreading it and/or sinking the runoff into the ground. Projects implemented with LID and Green Infrastructure principles include; porous pavement, bio-swales, “green” landscaping and vegetated buffers, rain gardens, and rain barrels.

Because stormwater has a profound impact on flooding and water quality, the state of Vermont has regulations in place to control stormwater on larger projects. Vermont’s Stormwater Management Rule outlines the development activities/projects which trigger a stormwater discharge permit in both stormwater-impaired and unimpaired water bodies, as well as exemptions to the Rule. For example, both of the following scenarios trigger a stormwater discharge permit; “discharge from new development equal to or greater than one acre”, and “a discharge from the expansion of existing impervious surface, such that the total resulting impervious surface is equal to or greater than one acre.” The one acre threshold missed most development though, resulting in continual impacts.

Stormwater is a major cause of both nitrogen and phosphorus loading. Work is now being done to rewrite the Lake Champlain Total Maximum Daily Load or TMDL (a calculation of the maximum amount of a specific pollutant that an impaired water body can receive and still safely meet its water quality standards) and to rework the Long Island Sound TMDL. We expect that changes to Vermont’s Stormwater Management Rule will be coming in the future to further limit the pollution that enters these water bodies due to stormwater runoff.

While widespread impervious surfaces are detrimental to water quality, impervious surfaces in some areas, such as in village centers and downtowns, are the results of dense development and are important in the fabric of the Vermont landscape. It is critical to maintain the dense

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<sup>13</sup> *Id.*

development of village centers and downtowns for their outright benefits to their community. However, it is also important to understand the stormwater runoff issues that exist and understand the ways to mitigate their effects through various approaches.

As part of Vermont's green infrastructure initiative, TRORC is working to review selected municipal bylaws and ordinances for their ability to allow green infrastructure/LID practices and will prepare preliminary recommendations to overcoming barriers to green infrastructure. TRORC will work with the selected community to draft model green infrastructure ordinance language which will be tailored to the community. Finally, TRORC will assist the municipality to promote the integration of the model language into their local bylaws.

### **The Site-Specific Nature of Flooding**

The risk of flooding in Vermont varies site-by-site, to the point where parcels located adjacent to one another may be impacted differently in a flooding event. The site-specific nature of flood risk can be attributed to a number of factors, such as: topography (the presence of steep slopes or valleys); location of any structures on the site; characteristics of the stream or river, including its course and ability to access its floodplain; soil composition; the presence of riparian buffers and the condition of the buffer, including the type of vegetation; the presence of wetlands nearby and their quality; the path and variability of weather systems; and the characteristics of adjacent and nearby sites; among others. All of these factors can vary widely.

Generally speaking, floodways are extremely dangerous places and the Special Flood Hazard Area and river corridors are high-risk, but each site presents specific issues and a unique set of circumstances. For example, on a site only in the Special Flood Hazard Area, the risk may be solely from inundation and so the specific elevation is a major factor in flood damage. On a site in the river corridor, the risk may be due to lateral erosion and so elevation is less important than whether you are sitting on bedrock. On other sites, the risk may be from both inundation flooding and erosion. The site-specific nature of flooding complicates assessing and planning for flood risks. It is important to understand the specific risks that are present at each site before attempting to mitigate flood damage on that site.

The late Gilbert White, considered the father of floodplain management in the United States, wrote, "Floods are 'acts of God', but flood losses are largely acts of man." By this he meant that flooding is a hazard not simply because it rains hard, but that we have put things in the way that will suffer from that. Historically, Vermont town and village centers were established around water power, and created the densely developed village and town centers we value. Today, the desire to maintain and continue this settlement pattern still holds true—even if the downtown or village center is vulnerable to flood risks. As such, it is important to recognize that there is a desire to have existing downtown/village developments, and even new



development placed in these areas, but there can be trade-offs between flood risk and having compact development. Keeping these areas of compact settlement as safe from flooding as possible, given their location, may require elevation and floodproofing efforts, but will largely depend upon natural flood storage and surface runoff retention in upstream areas.

***\*\*Please note: the terms highlighted below may be changed to reflect the Board's position on specific statements (ex. "shall" v. "should"; "may" v. "will", etc., etc.).***

## **Goals**

1. The citizens, property and economy of the TRORC region and the quality of the region's rivers as natural and recreational resources are protected by using sound planning practices to address flood risks.
2. The Region is able to recover from flooding quickly and in a manner that improves flood resilience.
3. The creation of impervious surfaces and development in wetlands or upland forests is lessened, and where it does occur, is done in a manner that does not worsen flooding.

## **Policies**

\*Mapped areas, unless corrected by FEMA.

1. All new fill and construction of buildings in mapped flood zones\* outside of river corridors increases flood risk and is discouraged, and at a minimum must comply with the Association of State Floodplain Manager's No Adverse Impact policy. *(Policy included in the EC Vermont Climate Resilience chapter).*
2. All new buildings, other than accessory structures, in mapped flood areas\* must have the lowest floor at least one foot above base flood elevation.
3. Natural areas, non-structural outdoor recreational and agricultural uses are the preferred land uses within river corridor areas due to the dangerous erosive nature of these areas. Commercial, industrial, and residential uses within river corridors are strongly discouraged outside of village and town centers. *(taken, and modified slightly, from the Land Use chapter, Wetlands and Floodplains sub-section—Policy 6, page 42)*
4. New buildings within mapped floodways\* shall be prohibited.
5. In order to lessen the conflict between roads and streams, towns and the state should consider moving or abandoning roads when there are more cost effective solutions or other routes.
6. The State and municipalities should only rebuild/install culverts and bridges that are designed at least to VTrans Hydraulics Manual and ANR Stream Alteration Standards *(Policy included in the EC Vermont Climate Resilience chapter).*

7. Emergency services, wastewater treatment plants, power substations, and municipal buildings shall not be built in special flood hazard areas unless floodproofed or elevated to at least 2 feet above the base flood elevation and designed to withstand erosion risk (*Policy modified from that included in the EC Vermont Climate Resilience chapter*).
8. To reduce flood flows and be more protective of existing development, the current one-acre threshold in Vermont's Stormwater Management Rule should be reduced to one-half acre.
9. Vegetated buffer strips should be maintained in riparian zones surrounding streams and rivers. Rock rip-rap and retaining walls should only be used to the extent necessary and when bioengineering techniques may not be adequate to prevent significant loss of land or property (*taken from the Natural Resources chapter, Surface Water section—Policy 6, page 121*).
10. Upland forests and watersheds should be maintained predominately in forest use to ensure high quality valley streams and to ensure that flood flows are absorbed (*taken from the Natural Resources chapter Surface Water section —Policy 10, page 122 and modified*).
11. Outside of areas of existing compact development, new development must preserve vegetated riparian buffer zones that are consistent with state riparian buffer guidelines (*taken from the Natural Resources chapter Wildlife Resources section —Policy 4, page 138*).
12. Municipalities in the region are encouraged to enhance zoning bylaws to protect wetlands that may not be protected under state or federal law (*taken from the Natural Resources chapter—Wetlands section—Recommendation 2, page 130*).
13. All wetlands which provide flood storage functions shall remain undeveloped or have compensatory storage constructed so as to achieve no net loss of such wetland function. In the long term, restoration and enhancement of additional wetlands should be pursued in order to improve the region's flood resilience (*taken from the Natural Resources chapter—Wetlands section—Goal 1, page 129 and modified*).
14. Structural development or intensive land uses shall not occur in Class I and Class II wetlands unless there is an overriding public interest (*taken from the Land Use chapter, Wetlands and Floodplains sub- section—Policy 1, page 42*).
15. Towns and the state are encouraged to adopt road and bridge standards to the 50 or 100 year storm level for identified critical transportation routes.
16. Emergency planning for flood response and recovery is encouraged.

## **Actions**

1. The Regional Commission **should** work with towns to strengthen their Flood Hazard Bylaws in order to mitigate risks to public safety, critical infrastructure, historic structures and municipal investments from inundation and erosion.
2. TRORC **should** work with VTrans on advocating for and improving the flood capabilities of state or town-owned transportation infrastructure.
3. TRORC **should** continue working with the Emergency Coordinators and Selectboards from each town to develop mitigation plans, and emergency preparedness and recovery procedures from flooding.
4. Existing homes and businesses at serious risk of flood damage **should** be identified and prioritized by towns in concert with the ANR River Management Section and the Regional Commission for mitigation actions such as elevation/relocation or purchase and demolition (*Recommendation included in the EC Vermont Climate Resilience chapter*).
5. Areas not designated in either FEMA's maps or in VT ANR's maps, but which are flooded during a weather event **should** be added to local flood regulations.
6. Watershed-level planning **should** be done by towns with assistance from the Regional Commission to evaluate natural and constructed flood storage options upstream of existing areas of concentrated development that are at risk of flooding (*Recommendation included in the EC Vermont Climate Resilience chapter*).
7. TRORC **will** work with the Granville, Stockbridge, Hancock, Rochester, and the U.S. Forest Service to address flooding on a watershed basis for the Hancock Branch, Upper White, West Branch and Tweed River.
8. TRORC will work with ANR, towns and landowners to lessen flood risk by restoring natural channel functions through berm or dam removal or intentional lowering of streambanks.
9. TRORC will work with towns to understand the impact stormwater runoff has on the region and on specific towns, and then work to address impacts from impervious surfaces through increased retention and infiltration.
10. TRORC encourages more consistent, accurate and thorough identification of wetlands areas through the use of best available data and the adoption of local wetlands regulations and updated maps by the municipalities in the region (*taken, and slightly modified, from the Natural Resources chapter, Wetlands section—Action 4, page 129*).

## Appendices

### Appendix A: Past Flooding Events in the TRORC Region

**Table 1**

Date	Location	Event Details	Extent of Damages
06/25/2013 – 07/11/2013 (DR-4140 VT)	Orange, Rutland and Windsor Counties; Statewide	A series of heavy rain events caused localized flooding over a two week period.	Route 100 through the Granville Gulf sustained flood damage. \$2,818,588.95 in Public Assistance funding obligated for this disaster declaration period.
08/28/2011 (DR 4022 VT for period of 8/26/2011 – 9/2/2011) Tropical Storm Irene	Addison, Rutland, Orange and Windsor Counties; Statewide	Tropical Storm Irene moved across southeast New York and southwest New England during the morning hours of August 28th and then proceeded to track north along the Connecticut River Valley in Vermont during the afternoon and evening. The main impact from Irene was widespread, devastating flooding, especially for central and southern Vermont. Widespread rainfall amounts of 3-5" occurred across Vermont with 5 to 7+ inches across much of southern, central Vermont and elevations above 1000 feet along the spine of Vermont's Green Mountains and the Worcester range. Flooding along Wells River was extensive, isolating Wells River Village VT. Flooding along the Waits River caused widespread flooding through Corinth VT and downstream to Bradford VT. Heavy rainfall caused devastating flooding along the White and Ottauquechee River and their tributaries. Homes, businesses, and roads were flooded throughout Windsor county. The White River at West Hartford crested at 28.40 feet, about a foot below the record crest of 29.30 feet set in the great flood of 1927."	This flood event will likely rank second to the November 1927 flood in the scope of meteorological and hydrological conditions/impacts as well as loss of life (84 in 1927), but likely first in monetary damage ((approx. \$500 million statewide vs. \$350 million (1927 in 2010 dollars)). There were nearly 2400 roads, 800 homes/businesses, 300 bridges and a half dozen railroad tracks destroyed or damaged from the flooding caused by Irene. Several homes and businesses as well as farms suffered tremendous losses to crops and livestock. A number of towns isolated: Pittsfield, Rochester, Hancock, Granville, and Stockbridge. In the TRORC region, there was extensive flood damage to Routes 4, 12, 12A, 100, 107, 110, 125. County-wide damage from flooding: Addison (\$3.5 million), Orange (\$5 million), Rutland (\$12.5 million) and Windsor (\$35+ million).
05/26/2011 – 05/27/2011 (DR-4001 VT)	Orange County; Central and northern Vermont	A surface low as well as upper atmospheric energy traveled along a quasi-stationary boundary across northern New York and Vermont during the afternoon and evening of May 26th. The air mass ahead of this boundary was moderately to largely unstable and the combination lead to numerous reports of damaging winds and very large hail (up to 2.5 inches in diameter)25,000+ customers lost power during these storms. Straight-line winds in Orange County. 3 -5"+ of rainfall and severe flash flooding and resultant river flooding.	\$10,581,798.62 in Public Assistance funds obligated.

Date	Location	Event Details	Extent of Damages
07/21/2008 - 08/12/2008 (DR-1790 VT)	Addison, Orange and Windsor Counties; Statewide	08/06/2008—Training showers and thunderstorms with very heavy rain across portions of the southern Green Mountains as well as northeast Vermont during the morning into early afternoon hours. 3-5" of rain causing severe localized flash flooding. Robbins and the Hancock Branch of the White River in Hancock were the source of flooding downstream. 08/07/2008—additional slow-moving storms and flooding.	8/6/2008—Numerous road and bridge washouts. The Town of Hancock was particularly hard hit—flood waters caused the failure of the Killoleet Dam and washed out the intersection of Routes 100 and 125. Flash flooding later occurred in Rochester. Portions of Route 100 were flooded in Stockbridge and the road was closed to traffic. 08/07/2008—more scattered flash flooding in Corinth, Chelsea, Sharon (floodwaters covered bridge on Faybrook Road) and in West Norwich. \$4,569,910.02 obligated for DR-1790 VT.
07/09/2007 - 07/11/2007 (DR-1715 VT)	Orange and Windsor Counties. Specific towns referenced include: Braintree, Randolph, Bethel, Stockbridge, Brookfield, Hartland, and Norwich.	A series of severe storms produced high winds, lightning hail and heavy rains. Flash flooding resulted. 5.27" reported in Bethel.	Damage to numerous roads in the region: Routes 12 and 14 washed out in Randolph; Lilliesville Road, River Road, Routes 100 and 107 in Stockbridge and Bethel. Camp structures damaged in area off of Lilliesville Road. \$4,905,985.03 Public Assistance funds obligated for disaster.
04/15/2007 - 04/21/2007 (DR-1698 VT)*	Windsor, Rutland and Orange Counties; Statewide	Severe storms caused heavy rain, snow and high winds. Rain combined with snowmelt caused flooding in the region. Snowfall 4-7" in valleys throughout the county; 13" fell in Randolph.	Nearly \$3.6 million obligated for public infrastructure damages.
09/16/1999 - 09/21/1999 (DR-1307 VT) Remnants of "Hurricane Floyd"	Windsor Rutland and Orange Counties; Statewide	Very large storm—580 mile diameter. Made landfall in North Carolina as a Category 2 hurricane where it dumped up to 20" of rain. 4-7" of rain and strong winds across the state of Vermont. However, due to the dry conditions in Vermont at the time, much of the rain was soaked up and/or flood water dissipated quickly. At a result, flood damage was isolated. <sup>14</sup>	57 deaths attributed to Hurricane Floyd overall, and 1 in Vermont. At the time, the deadliest and most costly hurricane since Hurricane Agnes in 1972. Property damage set at \$1.325 billion. In Vermont, \$1,010,652.61 obligated in Public Assistance grants.
06/27/1998 (Included within DR-1228 VT for the period between 06/17/1998 — 07/13/1998)	Towns of Randolph and Hartford; Orange and Windsor Counties; Upper Connecticut River Valley; northern and central parts of Vermont and New Hampshire	3-6" of rain. Heaviest rain from Bristol, Vermont on western side of the Green Mountains to Bradford, Vermont to the east. Flash flooding occurred along Connecticut River basins in central Vermont on 06/27/1998. Ayers Brook in Randolph peaked at 4,200 cfs (flow greater than the 100-year flood). The White River in West Hartford was flowing at 34,500 cfs (between a 10 year and 25 year event). Wells River flowing at 989 cfs; Ottauquechee River near West Bridgewater flowing at 542 cfs. <sup>15</sup>	Damage localized. The Town of Randolph was particularly hard hit.

<sup>14</sup>

[http://books.google.com/books?id=lvztCLB6g\\_gC&pg=PA11&lpg=PA11&dq=hurricane+floyd+vermont&source=bl&ots=vbywiC\\_m3c&sig=QQomVsZlJzgu73QtYFjtAJudXp8&hl=en&sa=X&ei=nzXUUozlOIqwsQT40ICYDA&ved=0CHYQ6AEwDQ#v=onepage&q=hurricane%20floyd%20vermont&f=false](http://books.google.com/books?id=lvztCLB6g_gC&pg=PA11&lpg=PA11&dq=hurricane+floyd+vermont&source=bl&ots=vbywiC_m3c&sig=QQomVsZlJzgu73QtYFjtAJudXp8&hl=en&sa=X&ei=nzXUUozlOIqwsQT40ICYDA&ved=0CHYQ6AEwDQ#v=onepage&q=hurricane%20floyd%20vermont&f=false)

<sup>15</sup> <http://nh.water.usgs.gov/WhatsNew/newsreleases/floods/flood.jun27.98.html>

Date	Location	Event Details	Extent of Damages
08/09/1976 — 08/10/1976 Remnants of “Hurricane Belle”	Town of Plymouth; statewide	Struck Long Island as a Category 1 hurricane. Skirted the Vermont/New Hampshire border and was considered a minor storm upon arrival. <sup>16</sup> For some areas of Vermont, the precipitation was very heavy and caused extensive flooding.	Road, culvert and bridge damage in Vermont. 10 associated deaths. Caused \$100 million in damages (1976 dollars)
07/06/1973 (DR-397 VT)	Town of Plymouth; Windsor County; statewide	A west moving frontal system and a moist, southeasterly flow from the Atlantic Ocean joined to produce heavy precipitation in some parts of the state not seen since 1927. <sup>17</sup> 5-8” in Windsor County. Connecticut River at Wells River flowing at 57,100 cfs; Wells River flowing at 5970 cfs.	Three people killed in Vermont. Damage estimated at \$64 million—including extensive damage to crop land and \$10 million in state highway damage. <sup>18</sup> State declared disaster (DR-397 VT).
09/21/1938 “The New England Hurricane of 1938”	Vermont; New England and New York	A Category 5 hurricane, made landfall on Long Island as a Category 3. Hit Vermont as a Category 1. Peak flow on the Black River exceeded the peak flow from the 1927 flood. <sup>19</sup>	Total damage: \$4.5 billion (2007 dollars). Death toll at 682, in New England—564 estimated deaths. Demolished tens of thousands of homes. 2 billion trees lost in NY and New England. <sup>20</sup> In Vermont, 5 dead and hurricane-force winds damaged trees, buildings and power lines. 2,000 miles of public road blocked.
11/03/1927 — 11/04/1927 “The Great Flood of 1927”	Statewide, significant rainfall in the TRORC region.	10” of heavy rain fell on frozen ground, caused by remnants of a tropical storm. Flooding in the White River valley was particularly violent, with an estimated 120,000 to 140,000 cubic feet per second (cfs) recorded at West Hartford, Vermont, however, the hardest hit area was likely the Winooski Valley. Areas specifically impacted (with town specific data): Bethel, Chelsea, Hartford, Randolph, Sharon, Stockbridge/Gaysville, and Woodstock.	84 people killed, including the Lieutenant Governor. 1,285 bridges lost. Hundreds of miles of road and railroad track wiped out. Many homes and buildings destroyed (10,000 people left homeless). After the flooding, the U.S. Army Corps of Engineers constructed 3 flood retention reservoirs and dams in Vermont.

<sup>16</sup> <http://www.purocleanvt.com/hurricane-season-in-vermont-what-are-the-chances/>

<sup>17</sup> <http://md.water.usgs.gov/publications/wsp-2375/vt/>

<sup>18</sup> <http://md.water.usgs.gov/publications/wsp-2375/vt/>

<sup>19</sup> <http://md.water.usgs.gov/publications/wsp-2375/vt/>

<sup>20</sup> <http://www.islandnet.com/~see/weather/almanac/arc2008/alm08sep3.htm>

## Appendix B: Flood Hazard and Fluvial Erosion Hazard Areas for Towns in the TRORC Region

<b>Table 2</b>				
<b>Town</b>	<b>Flood Hazard Areas</b>			<b>Fluvial Erosion Hazard Areas</b>
	<b>Area</b>	<b>Buildings/Parcels</b>	<b>NFIP Regulated Streams</b>	
<b>Barnard</b>	358 acres of floodplain. Just over 1% of the town is the floodplain. 1% of town (322 acres) may be in the developable portion of the floodplain (not including wetlands).	35 residences, 0 commercial/public buildings in the floodplain with 11 flood insurance policies insuring \$2m.	All of Barnard has approximate flood extents without flood elevations and these areas include Locust Creek and Pond Brook from Silver Lake as well as Broad and Barnard Brooks and Gulf Stream.	
<b>Bethel</b>	667 acres of FEMA NFIP mapped floodplain, 368 acres of which are floodway (the deepest, fastest flowing area in a flood). 2% of the town is the floodplain. 1% of town (299 acres) may be in the developable portion of the floodplain (no wetlands).	20 residences in the floodplain (does not include buyouts from TSI). 6 commercial buildings. 33 flood insurance policies insure \$7m. Approximately 14 parcels completely in the floodplain, most already have at least one house on them. 1 Strafford Meadows, 4 across from Trailer Park, 4 by Bethel Mills, 2 on Miller Dr, 2 in East Bethel, 1 on 107.	The White River and Third Branch include flood elevations while Lilliesville Brook has only approximate flood extents.	
<b>Bradford</b>	850 acres of floodplain, 81 acres of which are floodway. 4% of the town is the floodplain. Less than 1% of town (674 acres) may be in the developable portion of the floodplain (not including wetlands).	10 residences, 11 commercial/public buildings in the floodplain with 10 flood insurance policies insuring \$2.7m.	The Waits and the Connecticut Rivers and all have flood elevations.	Waits River
<b>Braintree</b>	372 acres of floodplain, 212 acres of which are floodway. 1.5% of the town is the floodplain. Less than 2% of town (142 acres) may be in the developable portion of the floodplain (not including wetlands).	7 residences, 4 commercial/public buildings in the floodplain with 8 flood insurance policies insuring \$1.5m.	The Third Branch of the White River has flood elevations.	Ayers Brook
<b>Bridgewater</b>	445 acres of floodplain, 164 acres of which are floodway. 1.5% of the town is the floodplain. Less than 1% of town (280 acres) may be in the developable portion of the floodplain (not including wetlands).	54 residences, 7 commercial/public buildings in the floodplain with 24 flood insurance policies insuring \$6.3m.	The Ottauquechee River and the North Branch, Broad Brook and Pinney Hollow Brook. The Upper North Branch and Upper Broad Brook and Pinney Hollow Brook do not have flood elevation but just extents.	Ottauquechee River, Broad Brook, Reservoir Brook, North Branch Brook, Bridgewater Hollow Brook, Dailey Hollow Brook
<b>Brookfield</b>	654 acres of floodplain, with no mapped floodway. 2% of the town is the floodplain. Less than 2% of town (463 acres) may be in the developable portion of the floodplain (not including wetlands).	17 residences, 2 commercial/public buildings in the floodplain with 3 flood insurance policies insuring \$655,000.	The Second Branch of the White River, and Ayers, Sunny, Sunset and Halfway Brooks are mapped. The Second Branch has flood elevations and 500 year areas but no mapped floodway. The southern end of Ayers Brook has mapped river corridor.	

Town	Flood Hazard Areas			Fluvial Erosion Hazard Areas
	Area	Buildings/Parcels	NFIP Regulated Streams	
Chelsea	265 acres of floodplain, with 36 acres of mapped floodway. 1% of the town is the floodplain. Less than 1% of town (245 acres) may be in the developable portion of the floodplain (not including wetlands).	51 residences, 20 commercial/public buildings in the floodplain with 21 flood insurance policies insuring \$2.7m.	The First Branch White River, Upper Village and Cram Brooks are mapped with the village area having flood elevations.	
Corinth	755 acres of floodplain, 68 acres of which are floodway. 2% of the town is the floodplain. 1% of town (314 acres) may be in the developable portion of the floodplain (not including wetlands).	31 residences, 3 commercial/public buildings in the floodplain with 9 flood insurance policies insuring \$1.3m.	The Waits River as well as the Tabor and South Branches and Meadow Brook and Cookeville Brook wetlands. Only the Waits River has flood elevations.	Waits River, South Branch of the Waits River, Taylor Branch of the Waits River
Fairlee	396 acres of mapped floodplain, with no mapped floodway. 3% of the town is the floodplain. 2% of town (319 acres) may be in the developable portion of the floodplain (not including wetlands).	74 residences, 2 commercial/public buildings in the floodplain with 3 flood insurance policies insuring \$627,000.	Lake Morey, Lake Fairlee, a portion of Mill Pond Brook and the Connecticut River are mapped. Only the Connecticut has flood elevations.	
Granville	363 acres of floodplain. Just over 1% of the town is the floodplain. Less than 1% of town (268 acres) may be in the developable portion of the floodplain (not including wetlands).	31 residences, 6 commercial/public buildings in the floodplain with 13 flood insurance policies insuring \$1.3m.	Granville has flood elevations without floodway designations on the White River and approximate flood extents on the Upper Third Branch in East Granville.	
Hancock	208 acres of floodplain. Less than 1% of the town is the floodplain. 177 acres may be in the developable portion of the floodplain (not including wetlands).	16 residences, 8 commercial/public buildings in the floodplain with 22 flood insurance policies insuring \$2.5m.	Hancock has flood elevations without floodway designations on the White River and the Hancock Branch.	
Hartford	805 acres of floodplain, 205 acres of which are floodway. Almost 3% of the town is the floodplain. 2% of town (576 acres) may be in the developable portion of the floodplain (not including wetlands).	47 residences, 22 commercial/public buildings in the floodplain with 68 flood insurance policies insuring \$14.9m.	The Ottauquechee, White and Connecticut Rivers all have mapped floodplains and flood elevations.	
Hartland	1220 acres of floodplain, 87 acres of which are floodway. 4% of the town is the floodplain. 3% of town (998 acres) may be in the developable portion of the floodplain (not including wetlands).	56 residences, 8 commercial/public buildings in the floodplain with 12 flood insurance policies insuring \$1.9m.	Lulls Brook to the Fieldsville hamlet, the Ottauquechee and the Connecticut have flood elevations. Cady, Densmore, Weed, Alder Meadow, McArthur, Fulling, Harlow and Babcock brooks have just flood extents.	
Newbury	2616 acres of mapped floodplain, with no mapped floodway. 6% of the town is the floodplain. 4.5% of town (1901 acres) may be in the developable portion of the floodplain (not including wetlands).	42 residences, 3 commercial/public buildings in the floodplain with 24 flood insurance policies insuring \$3.6m.	Connecticut and Wells Rivers as well as Scott, Peach and Halls Brooks, wetland off Fish Pond Rd and along Harriman Pond. Just the Connecticut and Wells Rivers have flood elevations.	Wells River
Norwich	597 acres of floodplain, 106 acres of which are floodway. 2% of the town is the floodplain. A little more than 1% of town (414 acres) may be in the developable portion of the floodplain (not including wetlands).	53 residences, 3 commercial public buildings in the floodplain with 31 flood insurance policies insuring \$5.5m.	Blood Brook and the Connecticut have flood elevations. Lower New Boston Brook just has flood extents while Upper New Boston has flood elevations.	Bragg Brook, Blood Brook



<b>Town</b>	<b>Flood Hazard Areas</b>			<b>Fluvial Erosion Hazard Areas</b>
	<b>Area</b>	<b>Buildings/Parcels</b>	<b>NFIP Regulated Streams</b>	
<b>Pittsfield</b>	300 acres of floodplain, 120 acres of which are floodway. 2% of the town is the floodplain. 1% of town (150 acres) may be in the developable floodplain (no wetlands). 60 acres of the town is in the river corridor protection area that is not in the floodplain.	14 residences, 2 commercial buildings in the floodplain, 6 residences in the river corridor area with 8 flood insurance policies insuring \$1.4m. Approximately 10 parcels completely in the floodplain, most already have at least one house on them (3 just north of Tweed River Drive, 2 on Tweed River Drive, Yoga building and 2 across street, 1 just north of Town Garage, 1 across from South Hill and 3 just north of Hadley Rd).	The Tweed River and the West Branch include flood elevations while Townsend, Guernsey, Jimmy Dean and Johnson Brooks just have approximate flood extents.	Tweed River, West Branch of the Tweed River, South Branch of the Tweed River, Gvernsey Brook
<b>Plymouth</b>	384 acres of floodplain. There is no mapped floodway. 1% of the town is the floodplain. Less than 1% of town (259 acres) may be in the developable portion of the floodplain (not including wetlands).	36 residences, one commercial/ public building in the floodplain, 6 residences in the current river corridor area with 14 flood insurance policies insuring \$2.6m.	The Black River, Lower Pinney Hollow Brook near Bridgewater, Tinker Brook and Twenty Mile Stream. All but the Black River do not have flood elevations.	Buffalo Brook/Reading Pond Brook, Patch Brook, Black River, Great Roaring Brook, Tinker Brook, Reservoir Brook, Pinney Hollow Brook, Broad Brook
<b>Pomfret</b>	521 acres of floodplain. Just over 1% of the town is the floodplain. 1% of town (454 acres) may be in the developable portion of the floodplain (not including wetlands).	38 residences, 7 commercial/ public buildings in the floodplain with 10 flood insurance policies insuring \$2.3m.	All of Pomfret has approximate flood extents without flood elevations and these areas include Barnard and Pomfret Brooks as well as Cloudland Brook and Mill Brook and its tributaries.	Gulf Stream, Barnard Brook, Pomfret Brook, Cloudland Brook
<b>Randolph</b>	1105 acres of mapped floodplain, with 615 acres of mapped floodway. 3.5% of the town is the floodplain. 3% of town (889 acres) may be in the developable portion of the floodplain (not including wetlands).	26 residences, 8 commercial/ public buildings in the floodplain with 21 flood insurance policies insuring \$4.2m.	Second and Third Branches of White River and Ayers Brook. All mapped areas have flood elevations.	Ayers Brook
<b>Rochester</b>	890 acres of floodplain, 424 acres of which are floodway. 2% of the town is the floodplain. 1% of town (466 acres) may be in the developable floodplain (no wetlands). 78 acres of the town is in the river corridor protection area that is not in the floodplain.	8 residences in the floodplain, 8 commercial buildings (5 on Peavine Drive down by the ball fields), 6 residences in the river corridor protection area, 3 commercial. (3 on Peavine, 3 off State Garage 3 on 100 just south State Garage). 14 flood insurance policies insure \$3.2m. Approximately 20 parcels completely in the floodplain, most already have at least one house on them (4 Peavine Dr, 2 across from Kennedy, 4 across from Woodlawn, 3 just south of State Garage Rd, 2 across from River Bend, 3 around Liberty Hill, 1 or 2 up Corporation).	The White River and the West Branch include flood elevations while Marsh, Brook St., Nason, Corporation, Breakneak, and Rogers Brooks just have approximate flood extents.	White River, Granville Branch of the White River, Hancock Branch of the White River

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	<b>Area</b>	<b>Buildings/Parcels</b>	<b>NFIP Regulated Streams</b>	
<b>Royalton</b>	772 acres of floodplain, 345 acres of which are floodway. 3% of the town is the floodplain. 1.5% of town (392 acres) may be in the developable portion of the floodplain (not including wetlands).	22 residences, 7 commercial public buildings in the floodplain with 14 flood insurance policies insuring \$3.8m.	The White River and First and Second Branches have mapped flood elevations while Broad Brook just has floodplain extents.	
<b>Sharon</b>	376 acres of floodplain. 1% of the town is the floodplain. 1% of town (339 acres) may be in the developable portion of the floodplain (not including wetlands). 247 acres of river corridor protection are outside of the floodplain.	30 residences, 6 commercial/public buildings in the floodplain with 13 flood insurance policies insuring \$2.1m.	All of Sharon has approximate flood extents without flood elevations and these areas include the White River as well as Broad, Mitchell, Fay, Whitewater and portions of Quation Brooks.	Fay Brook, Quation Brook, Elmers Brook, Broad Brook, White River
<b>Stockbridge</b>	There are approximately 630 total acres of FEMA NFIP mapped flood hazard area in Stockbridge, (about 2% of the town's acreage) of which about 270 acres are floodway. Approximately 360 acres make up the floodplain, most of which may be developable (not including wetlands).	Approximately 21 residences in the floodplain not including buyouts from Irene. Most are in Chalet Village. Three commercial buildings (2 on 107, 1 on 100). 23 policies insure \$3.5m. Approximately 32 parcels are completely in the floodplain and most already have at least one house on them—twenty parcels are in Chalet Village; two parcels are near the Rochester town line; five are near the Tweed/White River confluence; two are across from Sweet Lane on Route 107; one is at the base of Lilliesville Brook; and two are across from Arnold Mtn. Rd on Route 107.	White and Tweed Rivers include flood elevations while Stony Brook just has approximate flood extents.	
<b>Strafford</b>	600 acres of mapped floodplain, with no mapped floodway. 2% of the town is the floodplain. Less than 2% of town (540 acres) may be in the developable portion of the floodplain (not including wetlands).	26 residences, 3 commercial/public buildings in the floodplain with 8 flood insurance policies insuring \$1.9m.	The West Branch Ompompanoosuc River and Abbott and Old City Falls Brooks as well as several tributaries off the West Branch. All mapped areas do not have flood elevations.	West Branch of the Ompompanoosuc River
<b>Thetford</b>	1677 acres of mapped floodplain, with 58 acres of mapped floodway. 6% of the town is the floodplain. 4.5% of town (1901 acres) may be in the developable portion of the floodplain (not including wetlands).	63 residences, 16 commercial/public buildings in the floodplain with 30 flood insurance policies insuring \$5m.	Ompompanoosuc River as well as the West Branch and Abbott and Lake Fairlee Brooks. Portions of the Ompompanoosuc River as well as the West Branch and Abbott Brooks have flood elevations.	Ompompanoosuc River, West Branch of the Ompompanoosuc River
<b>Topsham</b>	448 acres of mapped floodplain, with 33 acres of mapped floodway. 1% of the town is the floodplain. Less than 1% of town (245 acres) may be in the developable portion of the floodplain (not including wetlands).	14 residences, 2 commercial/public buildings in the floodplain with 5 flood insurance policies insuring \$554,000.	Tabor Branch to the Ompompanoosuc River as well several northern wetlands. All mapped floodplains do not have flood elevations.	

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<b>Tunbridge</b>	350 acres of mapped floodplain, with no mapped floodway. 1% of the town is the floodplain. 1% of town (343 acres) may be in the developable portion of the floodplain (not including wetlands).	10 residences, 1 commercial/public buildings in the floodplain with 8 flood insurance policies insuring \$1.7m.	First Branch White River. All mapped floodplains have flood elevations.	
<b>Vershire</b>	128 acres of mapped floodplain, with no mapped floodway. 1% of the town is the floodplain. 1% of town (128 acres) may be in the developable portion of the floodplain (not including wetlands).	12 residences in the floodplain with 1 flood insurance policy insuring \$35,000.	Ompompanoosuc River. All mapped floodplains do not have flood elevations.	
<b>West Fairlee</b>	374 acres of mapped floodplain, with no mapped floodway. 2.5% of the town is the floodplain. 1% of town (192 acres) may be in the developable portion of the floodplain (not including wetlands).	15 residences in the floodplain with 2 flood insurance policies insuring \$215,000.	Ompompanoosuc River and Blood, Middle, and Beanville Brooks. All mapped floodplains have flood elevations.	
<b>Woodstock</b>	800 acres of floodplain, 408 acres of which are floodway. Almost 3% of the town is the floodplain. 1% of town (377 acres) may be in the developable portion of the floodplain (not including wetlands).	107 residences, 37 commercial/public buildings in the floodplain with 78 flood insurance policies insuring \$19.3m.	The Ottauquechee River, Barnard Brook, Gulf Stream and Kedron Brook all have flood elevations.	Barnard Brook, Gulf Stream, Ottauquechee River, Kedron Brook