VERMONT STRONGER

2018 Vermont State Hazard Mitigation Plan

Making Vermont safer and more resilient in the face of climate change and natural disasters

Plan Prepared by: Vermont Emergency Management

I: EXECUTIVE SUMMARY

Hazard mitigation is any sustained action that reduces or eliminates long-term risk to people and property from natural hazards and their effects.

The impact of anticipated yet unpredictable natural events can be reduced through community planning and implementation of cost effective, preventive mitigation efforts.

The State of Vermont understands that it is not only less costly to reduce vulnerability to disasters than to repeatedly repair damage, but that we can also take proactive steps to protect our economy, environment and most vulnerable citizens from inevitable natural hazard events. This Plan recognizes that communities have the opportunity to identify mitigation strategies during all phases of emergency management (preparedness, mitigation, response, and recovery) to more comprehensively address their vulnerability. Though hazards themselves cannot be eliminated, Vermonters can reduce our vulnerability to hazards by improving our understanding of both the natural hazards we face and their potential impacts.

Mission: to protect life, property, natural resources and quality of life in Vermont by reducing our vulnerability to climate change and natural disasters.

The 2018 Vermont State Hazard Mitigation Plan (SHMP) presents the hazard impacts most likely to affect Vermont and a mitigation strategy to reduce or eliminate our most significant vulnerabilities. This SHMP is a complete rewrite of the 2013 Plan, both in the content of the Plan document and its mitigation actions. Vermont Emergency Management, along with key stakeholders, completed a thorough review of the 2013 SHMP at the beginning of the update process to ensure that nothing developed in previous versions would be lost in this rewrite process.

Audience and Use:

The 2018 Vermont SHMP was developed to help the State of Vermont and local governments identify all natural hazards facing our communities and establish actions that reduce risk. The planning process for this update was much broader than previous mitigation planning efforts in order to better integrate the work of State agencies with those of regional and local governments, as well as nonprofit and private partners. The SHMP will serve as a resource for State agencies and other resilience stakeholders to better understand Vermont's exposure to natural hazards and collectively implement actions that reduce our vulnerability.

While the Vermont Division of Emergency Management (VEM) produced this Plan, a large network of stakeholders across Vermont have worked together to develop the capability inventory and actions. Accordingly, few of the actions in the 2018 SHMP fall solely on VEM to implement; most will require ongoing, concerted engagement by multiple stakeholders over the next five years.

This Plan is also intended to be a valuable resource for Local Hazard Mitigation Plan (LHMP) development. The capabilities list and disaster history spreadsheet are examples of resources that can be pulled directly from the SHMP for use in LHMPs. Further, several of the mitigation actions in this Plan aim to simplify the LHMP development process.

ACKNOWLEDGEMENTS

Though there was a great deal of stakeholder engagement during the planning process, we would like to extend a special thanks to the following individuals for their technical assistance during Plan development:

- **Mike Kline** | Rivers Program Manager | ANR Department of Environmental Conservation
- **Rob Evans** | State Floodplain Manager | ANR Department of Environmental Conservation
- **Jared Ulmer** | Climate and Health Program Coordinator | Vermont Department of Health
- **Rose Paul** | Director of Critical Lands and Conservation Science | The Nature Conservancy
- **Marjorie Gale** | State Geologist | ANR Department of Environmental Conservation
- **Joe Segale** | Policy, Planning & Research Bureau Director | Vermont Agency of Transportation
- **Ben Green** | Dam Safety Engineer | ANR Department of Environmental Conservation

Thank you also to our committee members and the individuals who participated in the Working Groups and Focus Groups.

Photo Credit: Stephanie Smith, VEM

THE PROCESS

In previous iterations of Vermont SHMPs, Plan development was the responsibility of VEM and sister State agencies. Recognizing that resilience efforts in Vermont are far more expansive than the work carried out solely by State government, this SHMP represents a robust, inclusive planning process that better addresses and incorporates statewide mitigation initiatives.

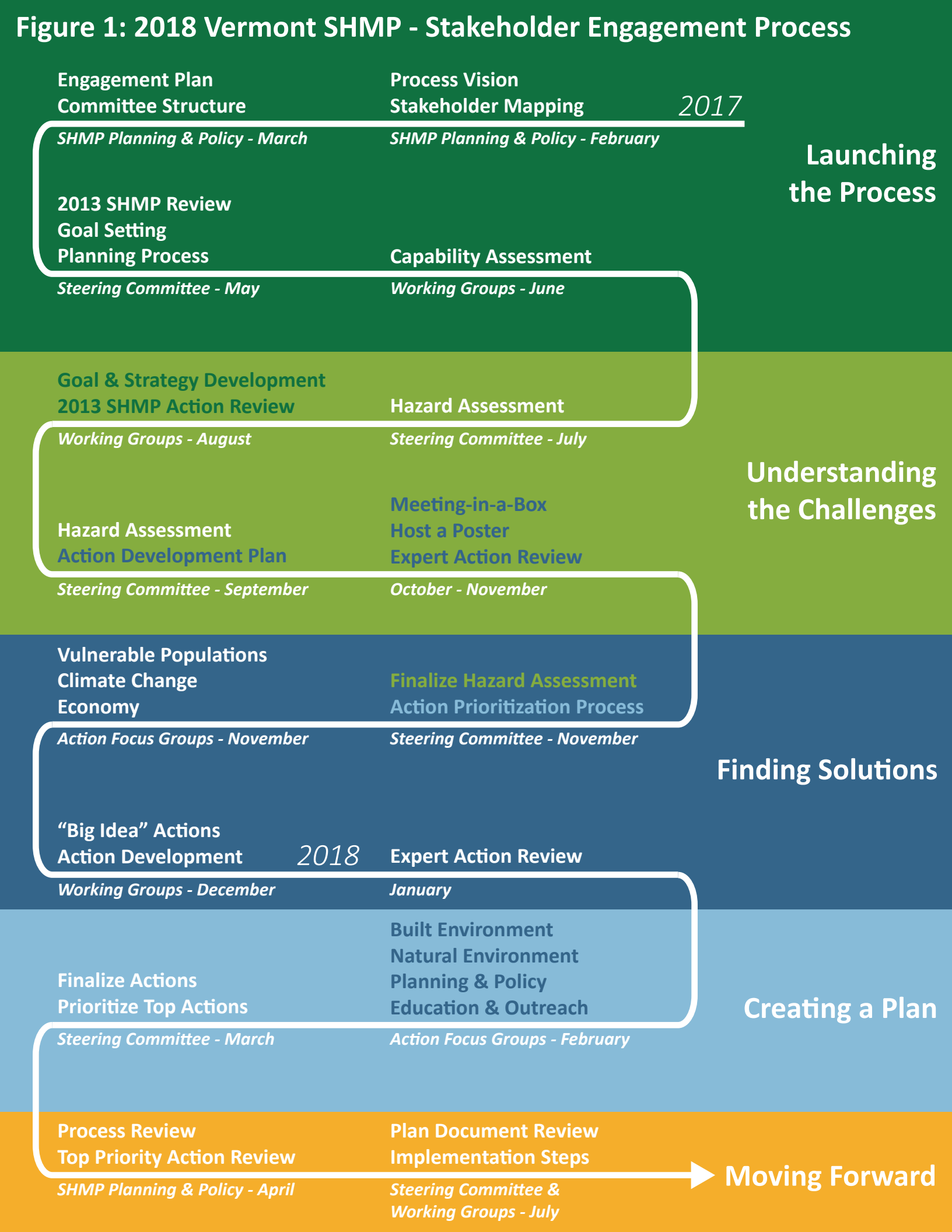
Table 1: State Hazard Mitigation Planning & Policy Committee	
Secretary Susanne Young	Agency of Administration
Secretary Julie Moore	Agency of Natural Resources
Secretary Michael Schirling	Agency of Commerce and Community Development
Secretary Joe Flynn	Agency of Transportation
Commissioner Chris Cole	Buildings and General Services
Secretary Anson Tebbetts	Agency of Agriculture, Food and Markets
Director Erica Bornemann	Vermont Emergency Management

In early 2017, the State Hazard Mitigation Planning & Policy Committee (SHMPPC) addressed the need for involving a more diverse group of stakeholders by authorizing the creation of the State Hazard Mitigation Plan Steering Committee to guide the Plan update process and engage a larger audience. The Steering Committee is comprised of members from Federal and State government, as well as the nonprofit and private sectors. Other partners were also involved in SHMP development through Working Group and Focus Group opportunities.

VEM mitigation staff (Lauren Oates, State Hazard Mitigation Officer, and Stephanie Smith, Hazard Mitigation Planner) coordinated the overall planning process and Plan development. Community Workshop facilitated and designed the stakeholder engagement process. For more information on Plan development, see: Planning Process.

Table 2: State Hazard Mitigation Plan Steering Committee	
Ben Rose	Vermont Emergency Management
Bob Costantino	Vermont Agency of Human Services
Catherine Dimitruk	Northwest Regional Planning Commission *Appointed by VAPDA to represent Regional Planning Commissions*
Chris Cochran	Vermont Agency of Commerce and Community Development
Gaye Symington	High Meadows Fund
Greg Hanson	National Weather Service
Jen Hollar	Vermont Housing and Conservation Board
Jenna Koloski	Vermont Council on Rural Development
Joe Segale	Vermont Agency of Transportation
Karen Horn	Vermont League of Cities and Towns
Mike Kline	Vermont Agency of Natural Resources
Richard Kehne	Vermont Buildings and General Services
Rose Paul	The Nature Conservancy
Steve Libby	Vermont River Conservancy
Tara Kulkarni	Norwich University
Tim Schmalz	Vermont Agency of Agriculture, Food and Markets

Figure 1: 2018 Vermont SHMP - Stakeholder Engagement Process



KEY CAPABILITY IMPROVEMENTS

This Plan conveys an array of mitigation capabilities that exist within Vermont. The capabilities section and its extensive inventory address both the improvements of existing capabilities, as well as new capabilities that have been developed since the 2013 SHMP. The most significant improvements or additions to Vermont's mitigation efforts are identified below. For information on all capabilities identified through this process, see: State & Local Capabilities.

2018 SHMP Planning Projects:

VEM was awarded funding through FEMA's Hazard Mitigation Grant Program (HMGP) to develop the 2018 Vermont SHMP. As part of this planning grant, VEM received funding for three planning efforts to be carried out by the Agency of Natural Resources (ANR), the Agency of Transportation (VTrans) and Buildings & General Services (BGS), each of which significantly enhances the State's mitigation capabilities. These planning tasks represent a new level of proactive coordination and program integration among State agencies, which are part of an effort to institutionalize hazard mitigation and resilience efforts within State government and expand ownership of the 2018 State Hazard Mitigation Plan.

ANR Project | Statewide River Corridors Risk Analysis and Hazard Mitigation Prioritization Tool: ANR modified Vermont's Statewide River Corridor Base Map to develop the map as a risk analysis, mitigation and conservation prioritization tool for use by State, regional and local governments. ANR aimed to increase understanding of the risks of fluvial erosion and to identify specific mitigation actions for reducing vulnerability. Using the template project table developed as part of this project, ANR, Regional Planning Commissions and VEM will endeavor to increase the use of project tables in municipal planning and capital improvement efforts Statewide.

VTrans Project | Methods and Tools for Transportation Resilience Planning: VTrans developed a Methods and Tools for Transportation Resilience Planning (TRPT) application that identifies the specific road infrastructure sites most vulnerable to damage from flooding in three pilot watersheds. The tool also estimates risk based on both the vulnerability and criticality of road segments and identifies a list of potential mitigation measures that can be taken to reduce infrastructural vulnerability. Though currently only available for three watersheds, this Plan's mitigation actions include expanding the tool to all watersheds across Vermont and including other critical infrastructure, such as utilities.

BGS Project | State Facility Inventory and Assessment: BGS completed a vulnerability assessment of all State buildings in order to better understand their respective risks from flooding. The resulting building inventory tool will serve State planners in prioritizing the most cost-effective flood mitigation needs and opportunities to reduce future damages and increase resilience for existing State facilities.

Emergency Relief & Assistance Fund:

Vermont's Emergency Relief & Assistance Fund (ERAF) provides State funding to match FEMA Public Assistance grants following a federally-declared disaster. In 2014, the ERAF criteria were revised to incentivize communities to be more proactive prior to disasters. The default rate for State contribution towards non-federal Public Assistance match following a declared disaster dropped to 7.5%, requiring municipalities to cover the other 17.5% for Public Assistance projects. However, municipalities that take the following proactive measures are awarded 12.5% State match:

1. Participate in the National Flood Insurance Program (NFIP),
2. Adopt Town Road and Bridge Standards that meet or exceed the VTrans 2013 template,
3. Adopt a Local Emergency Operations Plan annually, and
4. Submit a Local Hazard Mitigation Plan to VEM for review

Municipalities that wish to further decrease their cost share to 7.5%, with a 17.5% State match, must also meet one of the following criteria:

5. Adoption of ANR's River Corridor bylaws, or
6. Enrollment in the Community Rating System (CRS), whereby the community must earn credit under Activity 430

A priority mitigation action in the 2018 SHMP is to assess the effectiveness of the current iteration of the ERAF rule in incentivizing proactive mitigation measures, and to revise the rule to improve it, if needed.

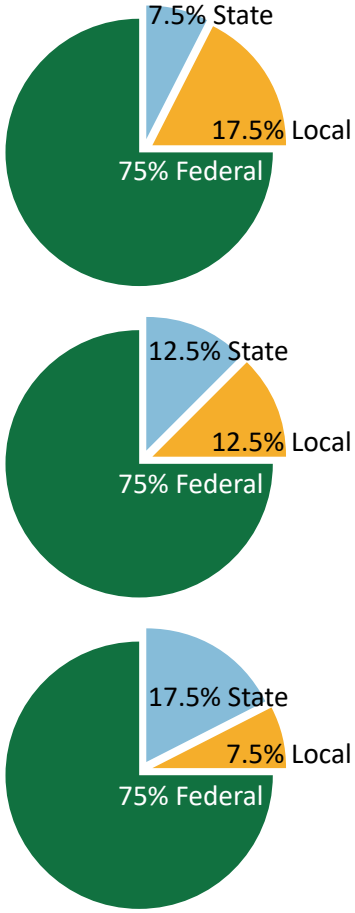


Figure 2: Vermont Emergency Relief & Assistance Fund rates

Vermont Stream Alteration General Permit (SAGP) Revision:

A notable advancement in hazard mitigation initiatives during the past few years has been the revision of Vermont's Stream Alteration General Permit (SAGP), and FEMA's subsequent recognition of the new general permit as "codes and standards" for purposes of future Public Assistance repairs. For several disasters following Tropical Storm Irene in 2011, VEM, ANR and VTrans worked with FEMA Region I on a case-by-case basis to have upsized drainage structures deemed fully-eligible for Public Assistance funding under Section 406 hazard mitigation of the Stafford Act. Beginning with DR-4330, which was declared in 2017, structure replacements that fall under the jurisdiction of the SAGP, and are required to meet the standards of the SAGP, are presumed to be PA-eligible and do not require approval by FEMA prior to construction, though certain projects may require environmental planning and historic preservation (EHP) review before breaking ground. This significant improvement allows Vermont to more quickly and appropriately address vulnerable infrastructure in a more sustainable way than has typically been implemented during the immediate response and recovery phase following a disaster.

Hazard Mitigation Assistance Projects:

Since Tropical Storm Irene, Vermont has been proactive in addressing its vulnerability to natural hazards. Through various funding sources, primarily the Hazard Mitigation Assistance (HMA) grant programs, we have acquired and demolished nearly 150 flood-vulnerable properties, completed approximately 70 infrastructure improvement projects, developed LHMPs for 142 municipalities and carried out a handful of 5% Initiative projects. Since the 2013 SHMP, VEM mitigation staff have been more aggressive in applying for Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance (FMA) funding as a supplement to Hazard Mitigation Grant Program (HMGP) disaster funding. Most notably, through coordinated efforts with State, regional and local project developers, Vermont has been prioritizing larger mitigation initiatives that more comprehensively address vulnerability, like floodplain restoration efforts in Middlebury, Cambridge, Brattleboro and Waterbury.

Greenway Trail Bridge in Cambridge, VT was replaced and the floodplain restored to reduce future flooding in historic downtown Jeffersonville
Photo Credit: Seth Jensen, LCPC

HAZARD ASSESSMENT

VEM staff used several methods to identify risks in Vermont, including the evaluation of historical data, consideration of our changing climate trends, and feedback from stakeholders during the hazard assessment process. The most significant change from the 2013 SHMP to the 2018 SHMP is the way hazards are assessed. Instead of continuing to view hazards as events (e.g. hurricanes), this Plan assesses the impacts of events (e.g. inundation flooding, fluvial erosion, and wind as impacts of a hurricane event), as it is the impacts, not the events, that can be mitigated.

The results of the hazard assessment ranking by the Steering Committee are found in Table 3. As with the previous SHMP, fluvial erosion and inundation flooding continue to be the first and second most significant natural hazards in Vermont, respectively. For more information on all hazards addressed, see: Hazard Assessment.

Table 3: Hazard Assessment

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Fluvial Erosion	4	4	3	4	4	3.75	15
Inundation Flooding	4	4	3	4	2	3.25	13
Ice	3	3	3	3	2	2	8.25
Snow	4	1	3	2	1	1.75	7
Wind	4	2	2	1	1	1.5	6
Heat	3	1	3	2	2	2	6
Cold	3	1	3	2	2	2	6
Drought	3	1	2	2	3	2	6
Landslides	3	3	2	1	2	2	6
Wildfire	2	3	3	3	2	2.75	5.5
Earthquake	2	3	3	3	2	2.75	5.5
Invasive Species	2	1	1	2	3	1.75	3.5
Infectious Disease Outbreak	2	1	3	2	1	1.75	3.5
Hail	3	1	1	1	1	1	3

*Score = Probability x Average Potential Impact

Snowmobile bridge near Waterbury, VT flexes as debris and water rush past following Tropical Storm Irene
Photo Credit: www.mansfieldheliflight.com/flood

Table 4: Hazard Assessment Ranking Criteria		
	Frequency of Occurrence: Probability of a plausibly significant event	**Potential Impact:** Severity and extent of damage and disruption to population, property, environment and the economy
1	Unlikely: <1% probability of occurrence per year	Negligible: isolated occurrences of minor property and environmental damage, potential for minor injuries, no to minimal economic disruption
2	Occasionally: 1–10% probability of occurrence per year, or at least one chance in next 100 years	Minor: isolated occurrences of moderate to severe property and environmental damage, potential for injuries, minor economic disruption
3	Likely: >10% but <75% probability per year, at least 1 chance in next 10 years	Moderate: severe property and environmental damage on a community scale, injuries or fatalities, short-term economic impact
4	Highly Likely: >75% probability in a year	Major: severe property and environmental damage on a community or regional scale, multiple injuries or fatalities, significant economic impact

Climate Change:

Warming temperatures, shrinking winters and increasing incidence of intense storm events are beginning to have a significant impact on Vermont's economy, people and environment and require immediate attention across all planning efforts at the local, regional, state, federal and global levels. Accordingly, and as a guiding principle of this Plan, we have aimed to recognize and include the impacts of climate change throughout Plan development, most notably reflected in the hazard profiles and mitigation actions. Both direct and indirect impacts of climate change are addressed within pertinent hazard profiles, as well as the potential for compounding impacts. An example of a concerning compounding impact of climate change is that warming temperatures (Figure 3) will allow for increased survivability of forest pests, such as the Emerald Ash Borer. This invasive species can decimate Vermont's ash population, not only shifting the composition of our forests, but also creating additional debris that may exacerbate impacts of other hazards, such as flooding or wildfire.

Vermont's Annual Maximum and Minimum Temperatures (1960-2015)

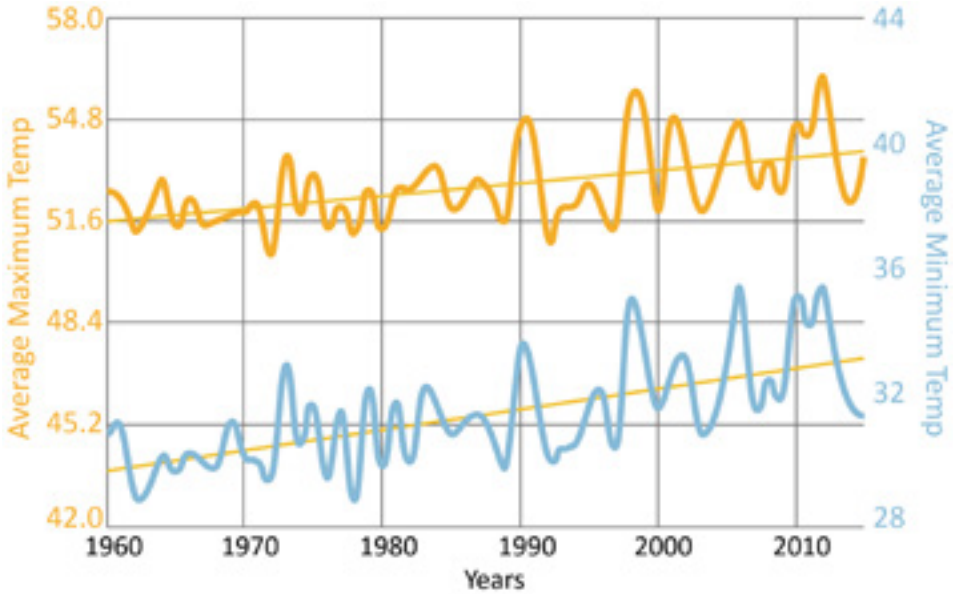


Figure 3: Vermont's annual maximum and minimum temperatures (1960-2015)
Data Source: climatechange.vermont.gov

MITIGATION STRATEGY

At the request of the SHMPPC in early 2017, the Steering Committee worked to develop a mitigation strategy that would be implementable, leverage cross-sector resources and effectively and efficiently reduce Vermont's vulnerability to natural hazards. To do this, the Steering Committee first developed the following four goals of the 2018 SHMP:

Protect, restore and enhance Vermont's natural resources to promote healthy, resilient ecosystems.

Enhance the resilience of our built environment – our communities, infrastructure, buildings, and cultural assets.

Develop and implement plans and policies that create resilient natural systems, built environments, and communities.

Create a common understanding of – and coordinated approach to – mitigation planning and action.

Using these goals, Working Groups and Focus Groups developed a significant list of mitigation actions. These actions were sorted by goal and then further sorted according to similar themes, called "strategies". The Steering Committee then prioritized the list of 96 mitigation actions based on each individual action's Impact and Feasibility. This prioritization process yielded 24 priority actions, which were then further prioritized into the following top five priorities by the Steering Committee:

- ***Develop a cross-sector buyout program***
- ***Inventory and protect critical headwater and floodplain storage areas***
- ***Collaborate across flood resilience, water quality and habitat connectivity programs and funding***
- ***Audit State programs to assess and improve their support of mitigation goals***
- ***Coordinate State programs to promote development, sharing and maintenance of hazard-related data and mapping***

The majority of the mitigation actions identified in this Plan require collaboration between multiple organizations. Though this will necessitate significant coordination, we believe it also broadens ownership, and therefore improves the implementation potential of the 2018 SHMP. For the full list of mitigation actions, see: Mitigation Strategy.

Photo Credit: Stephanie Smith, VEM

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2: Planning Process

Vermont Emergency Management (VEM) was the lead agency responsible for updating the 2018 Vermont State Hazard Mitigation Plan (SHMP), along with partners at the Agency of Natural Resources (ANR), the Agency of Transportation (VTrans), and Buildings and General Services (BGS), who were tasked with completing key planning projects. For more information on these projects and their planning processes, see: State & Local Capabilities and Appendix to Section 3.

Since approval of the 2013 SHMP, Vermont has taken strides to improve coordination between State agencies, regional planning partners and the private sector. The 2018 SHMP update process significantly expanded stakeholder engagement with the intent of creating an action plan that can be implemented collaboratively with relevant stakeholders across Vermont.

Hazard Mitigation staff at VEM (Lauren Oates, State Hazard Mitigation Officer, and Stephanie Smith, Hazard Mitigation Planner) were responsible for managing the planning process to include: convening various groups and providing logistical support; providing subject-matter expertise in hazard mitigation, planning, and FEMA review; researching and writing the Plan document; and making day-to-day decisions on operations throughout the process.

VEM kicked off the 2018 SHMP update in the fall of 2016 with an internal review of the 2013 SHMP and the status of 2013 SHMP actions, coordinating with members of the State Hazard Mitigation Planning & Policy Committee (SHMPPC) and other key stakeholders who were previously involved in implementation for updates on Plan actions.

VEM contracted with Community Workshop in January 2017 to develop concept and materials for stakeholder engagement and communications, facilitate the engagement process and meetings, and provide subject matter expertise on engagement and communications.

Figure 4: 2018 Vermont State Hazard Mitigation Plan process timeline

State Hazard Mitigation Planning & Policy Committee

The State Hazard Mitigation Planning & Policy Committee (SHMPPC) is responsible for coordinating State policy and agency action around hazard mitigation. During the 2018 SHMP update, this committee was responsible for sending delegates to participate on various groups, staying apprised of the SHMP update process, and making recommendations to the Steering Committee on overall coordination with State government. The SHMPPC will be tasked with implementation of Plan actions that are the responsibility of State government. This committee met three times throughout the planning process - twice in the beginning to frame the process, and once towards the end to review Plan progress and discuss next steps.

Table 5: State Hazard Mitigation Planning & Policy Committee	
Secretary Susanne Young	Agency of Administration
Secretary Julie Moore	Agency of Natural Resources
Secretary Michael Schirling	Agency of Commerce and Community Development
Secretary Joe Flynn	Agency of Transportation
Commissioner Chris Cole	Buildings and General Services
Secretary Anson Tebbetts	Agency of Agriculture, Food and Markets
Director Erica Bornemann	Vermont Emergency Management

State Hazard Mitigation Plan Steering Committee

Under the direction of the State Hazard Mitigation Planning and Policy Committee (SHMPPC), the Steering Committee was responsible for the high-level decision-making and overall guidance of the SHMP update process. Given the interdisciplinary and cross-sector nature of hazard mitigation work, the Steering Committee included a diverse range of cross-sector partners from across Vermont. The Steering Committee members were chosen with the following goals in mind: to ensure that hazard mitigation efforts beyond State government were incorporated into the Plan update; to better coordinate ongoing hazard mitigation work between State agencies and private sector partners; and to build buy-in, relationships and understanding needed to effectively implement the Plan.

The Steering Committee developed the Plan scope and process, assisted in the development of the stakeholder engagement and outreach plan, determined the Working Group topics and structure, identified and prioritized hazards for inclusion, approved and assisted in the development of mitigation actions, set the prioritization process for actions, reviewed and approved the Plan document, and as individuals, provided subject matter expertise throughout Plan development. Steering Committee members were appointed by the VEM Director based on recommendations from the SHMPPC.

Table 6: State Hazard Mitigation Plan Steering Committee	
Ben Rose	Vermont Emergency Management
Bob Costantino	Vermont Agency of Human Services
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Tara Kulkarni	Norwich University
Tim Schmalz	Vermont Agency of Agriculture, Food and Markets

Working Groups & Focus Groups

The Steering Committee created four Working Groups, representing each of the major Plan goals: built environment, environment and natural systems, education and outreach, and plans and policies. The Steering Committee tasked the Working Groups with performing an in-depth analysis of state capabilities, mitigation challenges and needs; providing subject matter and technical expertise; developing mitigation strategies and actions for each mitigation goal; and making recommendations to the Steering Committee throughout Plan development. Working Group meetings were open, and VEM staff directly invited dozens of stakeholder organizations to send representatives and posted meetings publically. Membership was informal and flexible, primarily based on meeting attendance. In order to ensure continuity in the midst of many meetings and complex tasks, several Steering Committee members also participated in the Working Group meetings. Three rounds of Working Group meetings were held in 2017, involving 72 individual participants, representing 53 organizations. Participants represented a diverse range of sectors and roles, including agency staff members, private funders, nonprofit leaders, academic researchers, and interested local community members.

Additionally, the Steering Committee created Focus Groups with invited participants, in order to convene expert stakeholders around key topics. VEM coordinated three Focus Groups in the fall of 2017 to discuss the overarching Plan principles, and to explore whether the emerging draft actions were effectively supporting them. These Focus Groups addressed climate change, vulnerable populations, and economic development, and included underrepresented voices and groups in the planning process alongside subject matter experts. VEM coordinated a second set of Focus Groups in the spring of 2018, tasked with thoroughly reviewing, revising, and prioritizing the draft actions developed by the Working Groups. These Focus Groups consisted of subject matter experts and professionals deeply involved in hazard mitigation implementation. Together, they ensured that the actions adequately addressed each goal, and that they were reasonable and practical. The two rounds of Focus Groups meeting included 36 individual participants representing 31 organizations.

Stakeholder Engagement Process & Plan Development

This section aims to address the robust 2018 SHMP update engagement process by providing an overview of the many meetings that were held, including meeting goals, structure and deliverables.

February 1, 2017 SHMPPC Meeting — Process Vision & Stakeholder Mapping:

The SHMPPC initially met in February 2017 to develop a vision for the planning process and begin identifying stakeholders and planning for outreach and engagement. Due to a gubernatorial administration change in early 2017, this meeting was attended by representatives of each agency who had previously participated in the SHMPPC and in the development or implementation of the 2013 SHMP, to ensure consistency during the administrative transition.

The SHMPPC defined the following significant stakeholder groups and discussed appropriate involvement and messaging for each group: high-level public decision makers, State government workers, networks/associations and other statewide groups with constituents, regional planning groups and other entities that support municipalities, and public services and utilities. That initial stakeholder mapping exercise led to a stakeholder diagram (Figure 5), which was used to ensure robust representation on the Steering Committee and to identify potential participants and invitees for Working Group and Focus Group sessions.

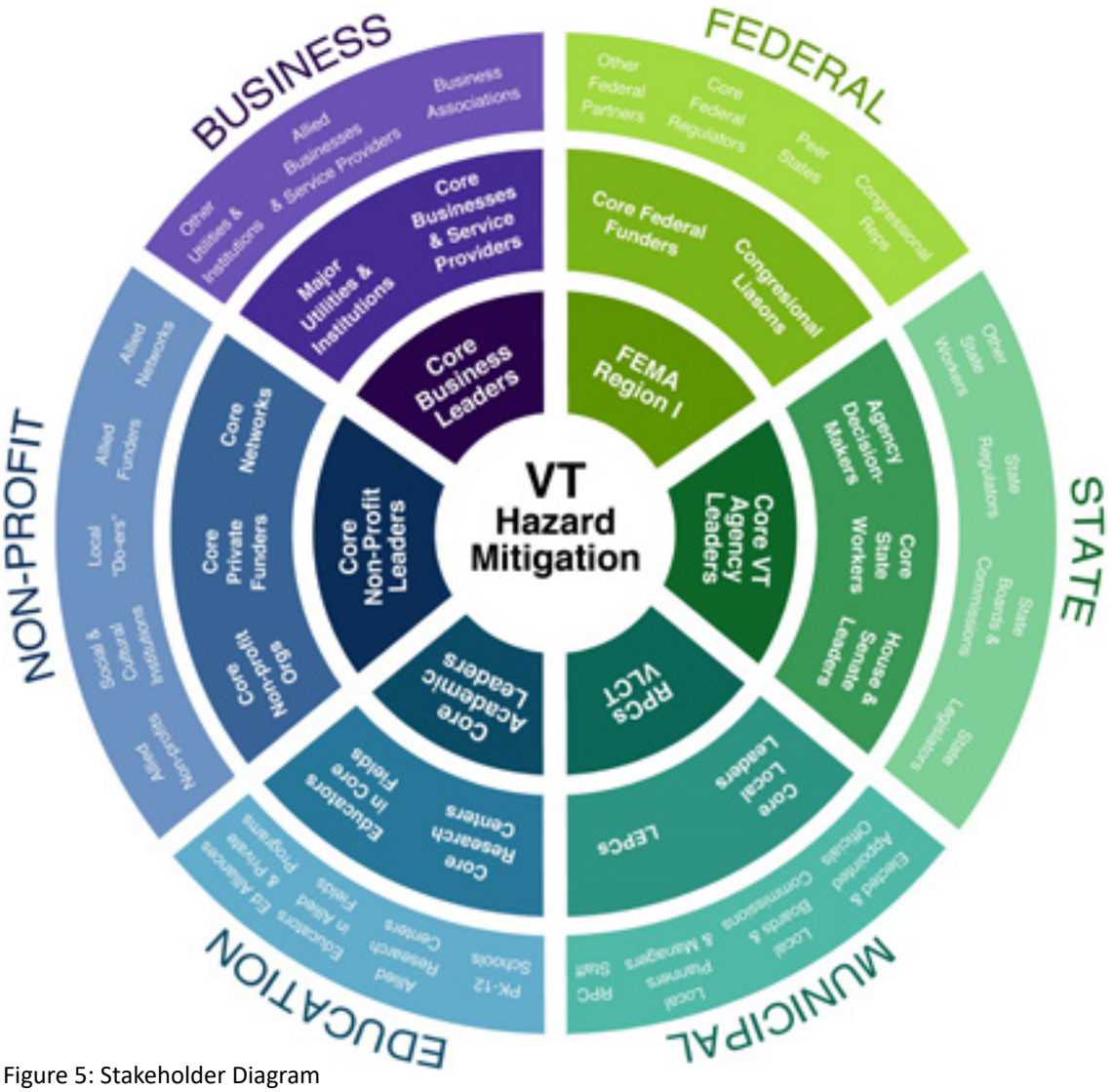

Figure 5: Stakeholder Diagram
Source: Community Workshop

March 16, 2017 SHMPPC Meeting — Engagement Plan & Committee Structure:

Prior to the March 2017 meeting, the VEM Director notified newly appointed SHMPPC members of their role on the SHMPPC. This meeting was a kick-off for new committee members, along with their staff members who had previously represented each agency. The meeting included an introduction to mitigation and hazard mitigation planning, a discussion of the draft outreach and engagement plan, the proposed committee structure (based on input from the previous SHMPPC meeting), and a discussion of the proposed Steering Committee composition.

The SHMPPC approved the creation of the Steering Committee and development of a more collaborative process, which would involve stakeholders beyond State agencies to increase ownership of the Plan and partnerships for implementation. The SHMPPC also discussed the effectiveness of the 2013 SHMP, with a review of the implementation process and priority actions from 2013. State agency staff members who had participated in the 2013 SHMP noted that while that process significantly improved the hazard analysis components of the 2010 SHMP, the development of the mitigation strategy was rushed, which led to less-than-ideal actions and a lack of momentum to carry them out. Accordingly, the SHMPPC instructed the Steering Committee to focus the stakeholder engagement process on developing a robust, implementable mitigation strategy (see: Mitigation Strategy).

After reviewing the 2013 process and priority actions, the SHMPPC agreed to remove preparedness actions from the 2018 SHMP in order to focus on Vermont's long-term mitigation needs.

Given the process goals (listed below) and the interest in engaging diverse stakeholders, VEM and Community Workshop staff created an engagement framework (Figure 6) with several distinct avenues for cross-sector participation, led by the Steering Committee.

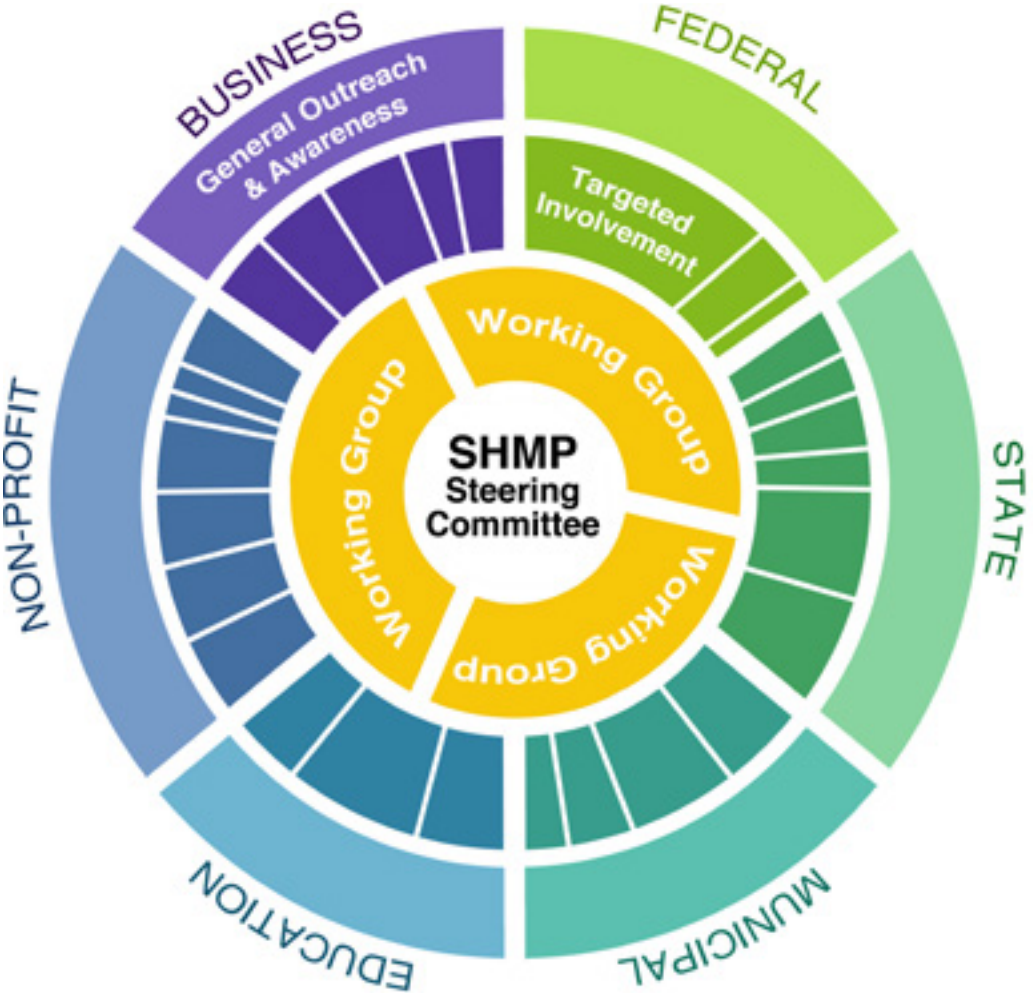

Figure 6: Engagement Framework Diagram
Source: Community Workshop

The Steering Committee used input from the SHMPPC to develop the following goals for stakeholder engagement and a process vision to guide the Plan update.

Stakeholder Engagement Goals:

- Identify the full range of stakeholders who play a role in hazard mitigation – within and beyond State government and across sectors.
- Design a planning and decision-making processes that includes representation from – and builds relationships between – stakeholders in all sectors and groups.
- Design a planning process to educate stakeholders and Vermonters about hazard mitigation – its importance, strategies, and statewide impacts.
- Make the planning process and Plan documents transparent and accessible to a full range of stakeholders.

Vision for the Updated Plan:

- Focused and Clear: clear plan purpose, succinct plan document, simple action prioritization process.
- Ambitious, Actionable and Doable: big goals and outcomes, realistic and measurable targets, poised for coordinated implementation.
- Engaging and Educational: makes the case for hazard mitigation investment, explains hazard mitigation to a variety of end users, and is a document that people want to read.
- Inclusive and Collaborative: public-private and inter-agency planning process, building a culture of ownership, with a focus on equity and inclusion of those impacted by hazards.
- Creative, Flexible and Adaptable: accounts for uncertainty, while creating resources and strategies for a variety of outcomes.

May 9, 2017 Steering Committee — Launching Steering Committee & Initial Planning Elements:

The first Steering Committee meeting was held in May 2017 to review guidance from the SHMPPC and to refine and approve initial planning elements. The Steering Committee discussed the process and the stakeholder engagement plan developed by VEM and Community Workshop and approved the engagement framework (Figure 6). The Steering Committee discussed and finalized terms of reference for its own governance, for the Working Groups, and for VEM staff.

Branding and messaging was discussed and the idea of using "Vermont Stronger" was approved as a means to carry forward the Vermont Strong[1] identity of Irene recovery. The logo was developed by Community Workshop.

The Steering Committee reviewed the hazards identified in the 2013 SHMP, along with the criteria for the 2013 hazard assessment. The Steering Committee decided to remove man-made hazards from the Plan and agreed to remove hazards identified in the 2013 SHMP as having never been addressed.

The Steering Committee then developed the vision and mission for the Plan (below) and created goals for mitigation around the topics of the environment and natural systems, the built environment, education and outreach, and plans and policies. These goal areas became topics for the four Working Groups.

VISION: Vermont will be safe and resilient in the face of climate change and natural disasters.

MISSION: To protect life, property, natural resources and quality of life in Vermont by reducing our vulnerability to climate change and natural disasters.

The Steering Committee also adopted a set of guiding principles (below) to highlight overarching concepts that the Steering Committee wanted to see addressed throughout the Plan, across all goals, and considered during action development.

1 http://www.vermontdisasterrecovery.com/donate/plates

Guiding Principles for Mitigation Planning and Action:

- We will ensure that hazard mitigation work strengthens and protects Vermont's economy and affordability.
- We will reduce the risks and impacts of hazards on vulnerable populations.
- We will ensure that hazard mitigation action accounts for – and helps us adapt to – climate change.
- We will work to build relationships and partnerships for action across sectors and disciplines.

June 15, 2017 Working Groups — Capability Assessment & Goal Setting:

The first round of Working Group gatherings consisted of three consecutive meetings, one in each of the initial three goal areas: environment and natural systems, the built environment, and plans and policies. VEM staff sent a packet of background materials out prior to the meetings. Each meeting began with a brief presentation on mitigation and mitigation planning.

These first Working Group meetings involved developing an inventory of existing state capabilities, identifying capability needs and gaps, revising mitigation goals, and developing objectives under each goal. The groups completed the capability assessment in two rounds, with participants first adding existing capabilities to posters within the following areas: data, technology and tools; funding and incentives; policies and regulations; technical assistance and education; and action projects and models. Participants then assessed what currently exists in Vermont, what's working well, and what needs to be changed or improved upon. Subsequent Working Groups built on the capabilities list developed by the previous groups.

In the second part of the capability assessment, each Working Group then defined capabilities that are needed within each of the same areas in order to meet the goal for their group. VEM staff circulated the full list of capabilities identified in these meetings to the stakeholder email list in order to solicit any additional input on missing capabilities, gaps and needs. Additionally, VEM solicited significant one-on-one stakeholder input from key subject matter experts, which was incorporated into the final capabilities list. For the full list, see: State & Local Capabilities.

Photo Credit: Stephanie Smith, VEM

Each Working Group was also given a draft goal from the Steering Committee, asked to provide input on it and then define objectives in smaller breakout groups.

Following the meeting, VEM staff updated the draft goals and objectives and sent a survey to Working Group participants asking for any final input, whether they supported the revised goal and objectives, and whether any information was missing or in need of revision. Based on recommendations from the Working Groups, VEM staff proposed to the Steering Committee the creation of a fourth goal and Working Group around education and outreach. The survey also asked for input on that additional goal, which the Steering Committee refined at their July meeting. Survey respondents overwhelmingly supported the modified goals and objectives, and VEM staff incorporated their minor suggestions and language changes.

July 12, 2017 Steering Committee — Hazard Assessment & Prioritization:

In July, the Steering Committee reviewed the updated goal language and objectives developed at the June Working Group meetings. Based on recommendations from the Working Groups, the Steering Committee approved the creation of one new goal and Working Group on the topic of education and outreach, resulting in the following final goals:

Protect, restore and enhance Vermont's natural resources to promote healthy, resilient ecosystems.

Enhance the resilience of our built environment – our communities, infrastructure, buildings, and cultural assets.

Develop and implement plans and policies that create resilient natural systems, built environments, and communities.

Create a common understanding of – and coordinated approach to – mitigation planning and action.

Continuing to make progress on the risk assessment, the Steering Committee also reviewed a modified hazard list and potential hazard re-organization based on comments from the previous meeting. Prior to this meeting, VEM staff pulled historic data on hazard occurrences and FEMA Public Assistance data by hazard for consideration during hazard assessment development. The Steering Committee reviewed and modified the hazard ranking criteria from the 2013 SHMP. For the final criteria and hazard assessment, see: Hazard Assessment.

August 22, 2017 Working Groups — Goal & Strategy Development, 2013 Action Review:

In preparation for this meeting, VEM staff reviewed all actions from the 2013 SHMP, including actions that were added to the 2013 list from the 2013 Vermont Roadmap to Resilience[2] (see: Plan Maintenance & Implementation) and action ideas resulting from the June Working Group meetings. VEM removed any actions that were considered complete or that focused on preparedness, reorganized the remaining actions by the 2018 SHMP objectives, and individually labeled actions with their corresponding goals and objectives (Figure 7).

2 https://resilientvt.files.wordpress.com/2013/12/vermonts-roadmap-to-resilience-web.pdf

Figure 7: Action cards reviewed and categorized during the August Working Group meetings

The Working Group meeting began with a welcome and updates, followed by two rounds of breakout sessions to review and discuss revised goals and objectives, as modified by the Steering Committee. Participants chose to attend either the built environment or natural systems session in the first round, followed by either the plans and policies or education and outreach session. Within each session, participants reviewed the corresponding goal and objectives, then broke out into smaller groups by objective to review and sort existing actions into the categories below, as well as to develop new actions to fill any identified gaps.

CONTINUE	LAUNCH	EXPLORE	DISCARD
Existing programs or actions that should be continued	Previous recommendations or commitments that should be launched	Previous recommendations or new ideas that should be explored and considered	Previous recommendations, actions or ideas that are no longer relevant or should not be considered

Following the breakout sessions, the groups came back together to assess their support for each goal and corresponding objectives and begin prioritizing objectives. Using keypad polling (an audience response system), participants ranked objectives under each goal and voted on action prioritization criteria for the Steering Committee's consideration.

September 14, 2017 Steering Committee — Hazard Assessment & Action Development Plan:

In September, the Steering Committee reviewed a reorganized list of proposed hazard impacts based on discussions during previous meetings, finalized the updated criteria for the hazard assessment, and began assessing the individual hazards.

The Committee also reviewed updated goals and objectives and incorporated input from the Working Groups. The Steering Committee had a specific conversation on the inclusion of people and communities in the goal language, which resulted in the word "community" being added to several goals. Additionally, the Committee recognized that people are part of the natural ecosystem and that the built environment goal is focused around protecting people and their inhabited structures.

The Steering Committee discussed the methodology for gathering additional input on the development of draft actions, deciding on the following tactics: Focus Groups around Plan principles, expert reviews of the proposed actions, and a meeting-in-a-box or poster kit that enabled groups or organizations to offer input remotely. Lastly, the Steering Committee discussed the 2013 action prioritization process and decided to modify the process to simply rank the impact and feasibility of each action.

October-November, 2017 — Additional Outreach on Action Development:

Expert Reviews:
VEM staff updated the objectives and their corresponding actions based on input from the July Working Group meeting and from the Steering Committee, and then sent out sets of actions to expert reviewers (organized by objective) for additional input. Expert reviewers were selected based on expertise in each topic area and potential responsibility for or interest in implementation.

Meeting-In-A-Box and Posters:
All Steering Committee and Working Group participants were invited to host a meeting-in-a-box or a set of posters to gather input on mitigation actions among their colleagues, organizations, or other stakeholder groups. Community Workshop developed a kit with instructions on how to select groups, choose a time and venue, plan and prepare for the event, and facilitate the conversation, as well as equipped interested participants with an agenda for a 30-minute conversation, background information, and tools for capturing input. VEM staff sent the kits to all interested parties. The Central Vermont Regional Planning Commission and Buildings and General Services each held a meeting-in-a-box and relayed input back to VEM staff.

Posters were also available for interested stakeholders to incorporate into an existing meeting (Figure 8). These two posters explained the SHMP update process and provided an area for comments on what is working, what is needed, and who can help. Posters were customized by Community Workshop based on specific topic areas of interest and sent out to stakeholders that requested them: Conservation Law Foundation, Vermont Department of Health, and the Mad River Valley Planning District.

Additionally, VEM staff led a presentation at VEM's Emergency Preparedness Conference in September to gather stakeholder input on what the State can be doing to support mitigation and mitigation planning at the local level. Participants included town officials and planners from several Regional Planning Commissions.

Figure 8: Example of posters used for additional input on actions
Source: Community Workshop

November 7, 2017 Steering Committee — Final Hazard Assessment & Action Prioritization Process:

In November, the Steering Committee assessed the process to-date, what seemed to be working, and opportunities for improvement moving forward. The Committee finalized the hazard assessment scoring (see: Hazard Assessment) and the process and criteria for prioritizing actions (see: Mitigation Strategy).

The Steering Committee also requested that Focus Groups, including specific subject-matter experts for each of the guiding principles, be convened to review the draft Plan actions.

November 2017 Focus Groups — Guiding Principles:

Participants at the Focus Group meetings reviewed the draft action list to see how well their respective principles were addressed and to provide recommendations for revising or adding actions. VEM staff later incorporated recommended changes into the draft action list.

The Vulnerable Populations Focus Group discussed who in Vermont is most vulnerable, to which hazards they are most vulnerable, the impact of hazards on these populations, the underlying challenges they face, and potential solutions to reduce vulnerability. Participants included stakeholders from the Department of Health, University of Vermont, Champlain Valley Office of Economic Opportunity, Agency of Human Services, American Association of Retired Persons (AARP), Vermont Association of Hospitals and Health Systems, and Hurricane Flats Farm.

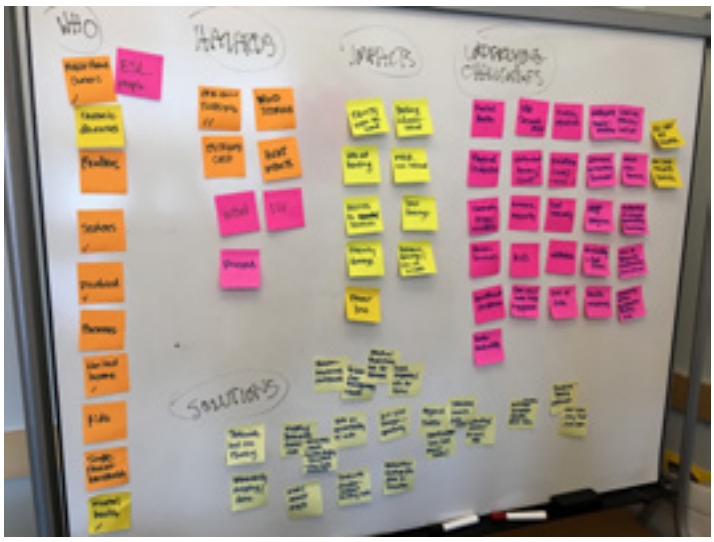

Photo Credit: Stephanie Smith, VEM

The Climate Change Focus Group discussed climate challenges in Vermont, how the changing climate will impact priorities in the future, existing data gaps, what Vermont should be doing to address and adapt to these expected changes, what is already being done, and what statewide action is needed. Much of the discussion focused on short-term needs versus long-term solutions to those hazards that unfold slowly (i.e. the "creeping hazards" that will result from a warming climate). Participants included stakeholders from the Agency of Natural Resources, Norwich University, Vermont Geological Survey, U.S. Geological Survey, The Nature Conservancy, USDA Natural Resources Conservation Service, National Oceanic and Atmospheric Administration, Vermont River Conservancy, University of Vermont, Vermont Realtors, and Vermont Emergency Management.

The Economy Focus Group discussed natural hazard impacts on the economy, how hazard mitigation impacts the economy, expected future changes, how to use mitigation work to advance the economy, what is already happening in Vermont, and the most important mitigation steps the State should pursue to minimize economic disruption. While acknowledging the challenge of including economy-specific mitigation actions, this Focus Group felt strongly that all actions which improve resilience within Vermont are in support of the Vermont economy. Participants included stakeholders from Vermont Council on Rural Development, Agency of Commerce and Community Development, USDA Rural Development, Vermont Small Business Development Center, Agency of Transportation, Green Mountain Power, and Vermont Emergency Management.

December 13, 2017 Working Groups — "Big Idea" Action Development:

Prior to the December Working Group meeting, VEM staff compiled all previous input on action development. Several major themes or complex strategies ("big ideas") emerged, which the Working Groups explored during the meeting.

The meeting began with an update on the action development process to-date, a review of the "big idea" concepts and an opportunity to identify any missing big ideas. Participants then selected which ideas they wanted to further develop based on individual interests and preferences, and broke out accordingly into three rounds of small group working sessions. Breakout groups defined what would be required to implement the actions by identifying critical stakeholders, how the action could be accomplished, and the first step. Following the breakout sessions, all of the big idea actions were posted for review and each participant had a chance to review all of the actions and vote for the three they thought were the most important to address.

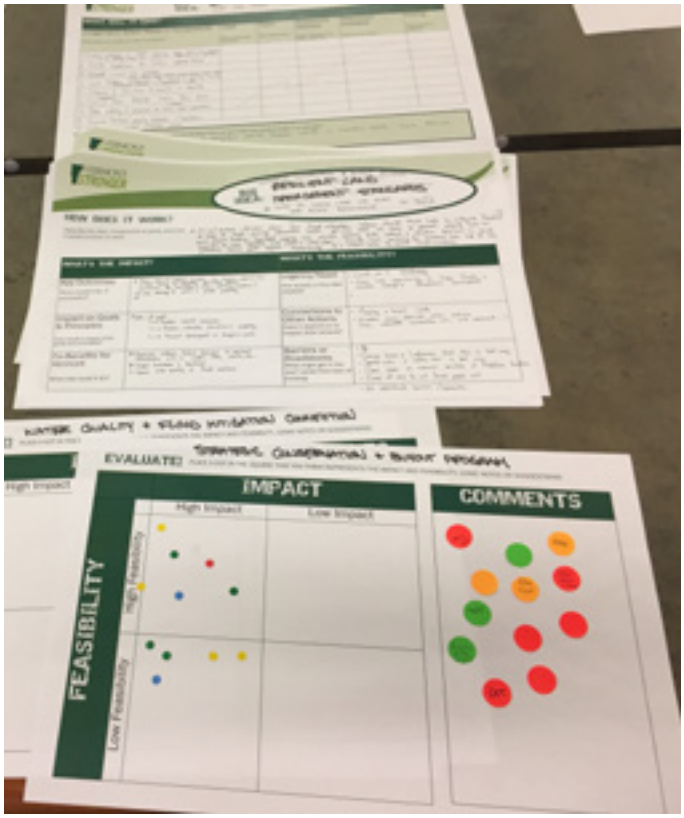

Photo Credit: Rebecca Stone, Community Workshop

January 2018 — Expert Review of Actions:

Following the December Working Group meeting, VEM staff again updated the action list and sent it out to expert stakeholder reviewers in January for final revisions, prior to the second round of Focus Group meetings.

February 2018 Focus Groups — Goal Areas:

The second round of Focus Group meetings was split by goal area. Each Focus Group made final updates to the actions, prioritized them by defining their level of impact and feasibility, and identified top priorities. For the final list of actions, priorities, and prioritization criteria, see: Mitigation Strategy.

The Environment and Natural Resources Focus Group included stakeholders from the Agency of Natural Resources, Vermont River Conservancy, The Nature Conservancy, Vermont Dam Safety, and Forest Parks and Recreation.

The Built Environment Focus Group included stakeholders from the Agency of Transportation, Division for Historic Preservation, State Geological Survey, Agency of Commerce and Community Development, Champlain Valley Office of Economic Opportunity, and Two Rivers-Ottauquechee Regional Commission.

The Planning and Policy Focus Group included stakeholders from the Agency Commerce and Community Development, Mad River Valley Planning District, Conservation Law Foundation, Agency of Natural Resources, and Vermont Emergency Management.

The Education and Outreach Focus Group included stakeholders from the Vermont Council on Rural Development, Department of Health, University of Vermont, Community Resilience Organizations, Agency of Human Services, and Vermont Emergency Management.

March 26, 2018 Steering Committee — Finalize Actions & Top Priorities:

Following the final round of Focus Group meetings, the Steering Committee met in March to make final updates to the action list and to discuss next steps, including the FEMA approval process. The Steering Committee reviewed the action list, analyzed the prioritization scores from the Focus Groups, and discussed and confirmed top Plan priorities. Similar to the Focus Groups, each Steering Committee member individually listed their top three priorities, which resulted in the following Steering Committee top priorities:

- Develop a cross-sector buyout program.
- Inventory and protect critical headwater storage areas.
- Collaborate across flood resilience, water quality and habitat connectivity programs and funding.
- Audit State programs to assess and improve their support of mitigation goals.
- Coordinate State programs to promote development, sharing and maintenance of hazard related data and mapping.

For more information on the action prioritization process and criteria, see: Mitigation Strategy.

April 2, 2018 SHMPPC Meeting — Process & Top Priority Action Review:

Once the Steering Committee and Working Groups completed the action development, VEM staff convened the SHMPPC for a review of the complete, year-long planning process. They provided the SHMPPC with an update on the remaining process and timeline, and asked them to review the 24 priority actions, as proposed by the Steering Committee. Based on conversation at this meeting, VEM staff made updates to the action list and sent it back to the Steering Committee for their final review.

March - June 2018 Plan Development and Review:

In the spring of 2018, VEM mitigation staff compiled the information and input received over the course of the planning process for the risk assessment and hazard profiles, capability assessment, and mitigation strategy to develop the first draft of the Plan. VEM sent out sections of the individual hazard profiles, the capability list, and the capability section to expert stakeholders for review and incorporated their edits. Following this expert review, VEM staff sent the first draft of the Plan to the Steering Committee to review, and then submitted the draft 2018 SHMP to FEMA in June 2018.

Participants & General Outreach

Throughout the Plan development process, 107 individuals participated in meetings to assist in the development of the Plan, representing 70 distinct organizations (not including the meeting-in-a-box and poster outreach). VEM staff continually provided updates on the planning process and opportunities for involvement on the VEM website[3] and through the VEM newsletter, the RPC list-serve, the Resilient Vermont email list, the Flood Ready list-serve, and in one-on-one emails to key stakeholders, organizations or expert reviewers. VEM maintained a full list of all participants who were involved or expressed interest at any point and sent out regular updates to that list. Events and news were also shared periodically on Facebook.

Table 7: 2018 State Hazard Mitigation Plan Participants	
American Association of Retired Persons Vermont	Two Rivers-Ottaquechee Regional Commission
Addison County Regional Planning Commission	United States Geological Survey
Army-Corps of Engineers	University of Vermont
Bethel Selectboard	USDA Natural Resources Conservation Service
Central Vermont Regional Planning Commission	USDA Rural Development
Champlain Valley Office of Economic Opportunity	Vermont Agency of Administration
Chittenden County Regional Planning Commission	Vermont Agency of Agriculture
Community Resilience Organizations	Vermont Agency of Commerce & Community Development
Community Workshop	Vermont Agency of Human Services
Community-Resilience.org	Vermont Agency of Natural Resources
Composting Association of Vermont	Vermont Agency of Transportation
Conservation Law Foundation	Vermont Arts Council
Craftsbury Conservation Commission	Vermont Association of Hospitals and Health Systems
Franklin County Natural Resources Conservation District	Vermont Buildings & General Services
Front Porch Community Planning & Design	Vermont Council on Rural Development
Green Mountain Power	Vermont Department of Environmental Conservation
High Meadows Fund	Vermont Department of Environmental Conservation - Dam Safety
Hurricane Flats Farm	Vermont Department of Environmental Conservation - Geological Survey
Irasburg Planning Commission	Vermont Department of Forests, Parks & Recreation
Lake Champlain Basin Program	Vermont Department of Health
Lamoille County Planning Commission	Vermont Division of Historic Preservation
Mad River Valley Planning District	Vermont Emergency Management
Memphremagog Watershed Association	Vermont Housing & Conservation Board
Milone and MacBroom	Vermont Land Trust
National Oceanic and Atmospheric Administration	Vermont League of Cities & Towns
National Weather Service	Vermont Natural Resources Council
Northwest Regional Planning Commission	Vermont Realtors
Norwich University	Vermont River Conservancy
Saint Michael's College	Vermont Rural Water Association
Southern Windsor County Regional Planning Commission	Vermont Ski Area Association
The Nature Conservancy	Vermont Small Business Development Center
Town of Irasburg	Vermont Voluntary Organizations Active in Disaster
Town of Northfield	Watersheds United Vermont
Town of Waterbury	White River Partnership

3 http://vem.vermont.gov/plans/SHMP

Thank you to the above organizations (Table 7) for participating in this planning process.

In addition to the outreach and stakeholder involvement opportunities listed above, regular updates were given on the planning process at Vermont Silver Jackets' quarterly meetings, as well as at VEM Chiefs' meetings and VEM full-staff meetings.

Implementation Kick-Off July 2018

In July 2018, the Norwich University Center for Global Resilience & Security (CGRS) and Vermont Emergency Management hosted the SHMP Implementation Kick-Off Meeting in conjunction with the Resilient Vermont Network. The meeting reconvened stakeholders who had participated in the previous year's planning efforts, as well as new participants interested in addressing the actions developed in the 2018 SHMP.

This meeting began with an overview of the Draft 2018 State Hazard Mitigation Plan and an opportunity for input. This opportunity for input on the 2018 SHMP was the first of two public hearings on the Draft Plan. Since the majority of those in attendance had already been involved with the development of the Plan, there were no additional comments during this meeting.

The main focus of the meeting was to kick-off implementation of seven of the highest priority actions in the 2018 SHMP, through two rounds of break-out working groups:

- Development of a statewide buyout program
- Evaluation and updates to the Emergency Relief and Assistance Fund (ERAF) rule
- Development of an Academic Resilience Collaborative (ARC)
- Vulnerable populations data gathering and analysis
- Development of public education and outreach materials around hazard mitigation
- State policy audit to assess support for mitigation across State programs
- Update the Resilient Vermont Roadmap and connect to the 2018 SHMP actions

Following the meeting, these working groups will continue to meet, based on need, to collaboratively achieve Plan actions. As working groups wrap up, additional actions that require a significant amount of collaboration will begin to meet with support from VEM mitigation staff.

August 2018 Public Hearing and Comments on the Draft Plan

The Draft 2018 SHMP was posted on the Vermont Emergency Management website (vem.vermont.gov/plans/SHMP) on August 1, 2018 for review. Several minor comments were received from Lamoille County Planning Commission, Windham Regional Commission, Vermont Agency of Commerce and Community Development, and the City of Montpelier. All comments received were reviewed and incorporated into the Draft Plan, where applicable.

The second public hearing on the Draft SHMP was noticed on July 18, 2018 including the Draft Executive Summary section and a note that the full Draft SHMP would be up on the VEM website in the coming weeks. This public hearing was held in Waterbury on August 20, 2018. Planners from the Chittenden County Regional Planning Commission and Rutland Regional Planning Commission attended the hearing and provided feedback. During the meeting, attendees discussed how best to incorporate comments, and the Plan was updated to reflect this conversation.

3: State & Local Capabilities

STATE CAPABILITIES

This section and the corresponding table identify the funding and incentives, tools and data, technical assistance and training, and regulations that influence hazard mitigation in Vermont. Since inundation flooding and fluvial erosion remain the top priority hazards to which Vermont is vulnerable, the majority of State policies and programs aimed at improving mitigation are centered on inundation flooding and fluvial erosion.

In 2017, a thorough review of the capabilities within the State that directly or indirectly support hazard mitigation efforts was developed. Input from stakeholders was solicited during a Working Group meeting and information compiled from that meeting was disbursed to key individuals and focus groups for further input (see: Planning Process). The result of this robust process is the State capability inventory, which also identifies changes from the 2013 Vermont State Hazard Mitigation Plan, areas for improvement and any strategies or actions that address the capability in this Plan update (see: State Capabilities List).

Though this table addresses capability-specific areas for improvement, two mitigation strategies identified as top priorities in this Plan that will result in both improved existing and new capabilities are worthy of mention here. First, ensuring that State programs support hazard mitigation goals through a comprehensive audit of all State and Federal funding and technical assistance programs will allow partners to develop a set of planning principles to resolve potential conflicts and create synergies between these programs. Second, the 2017 review of capabilities identified a large number of data gaps that inhibit Vermont's ability to more comprehensively understand and, therefore, more effectively address hazard vulnerability. Accordingly, implementing the strategy to coordinate hazard mitigation mapping, data and research will have significant, positive impacts on improving existing capabilities and potentially creating new capabilities where Vermont is otherwise lacking.

Administration of specific programs, including Hazard Mitigation Assistance, Public Assistance, National Flood Insurance Program and Community Rating System are further detailed throughout this section.

Hazard Mitigation Assistance Program

The Hazard Mitigation Assistance (HMA) and Public Assistance (PA) Programs are administered in the State by Vermont Emergency Management's Recovery & Mitigation Section, overseen by the Recovery & Mitigation Section Chief. Both the HMA and PA Programs have two full-time employees. The State Hazard Mitigation Officer is responsible for administering the HMA Program, to include the three HMA grant programs (Hazard Mitigation Grant Program, Pre-Disaster Mitigation and Flood Mitigation Assistance), while the Hazard Mitigation Planner is responsible for Local Hazard Mitigation Plan (LHMP) technical assistance and review. The State Hazard Mitigation Plan is updated and maintained by both the State Hazard Mitigation Officer and Hazard Mitigation Planner.

Following Tropical Storm Irene, the Vermont State Hazard Mitigation Committee, with representatives from various State agencies, was formed to review HMA applications prior to FEMA submittal. In 2014, recognizing the need for elevation of mitigation priorities at the State policy level, the Vermont State Hazard Mitigation Committee was split into two distinct groups: the State Hazard Mitigation Project Review Committee (SHMPRC), a technical committee tasked with HMA application review, prioritization and submittal to FEMA, and the State Hazard Mitigation Planning & Policy Committee (SHMPPC), chaired by the former Deputy Secretary of Administration and comprised of Secretary- and Commissioner-level appointed staff to discuss

mitigation goals and policies at the decision-making level. The SHMPPC is addressed in more detail in Planning Process and Plan Maintenance & Implementation sections, while the SHMPRC is discussed in detail below.

State Hazard Mitigation Project Review Committee:

The State Hazard Mitigation Project Review Committee (SHMPRC) includes the following agencies and their representatives, if position specific: Vermont Emergency Management (SHMO), Agency of Natural Resources (State Floodplain Manager & State Geologist), Agency of Transportation, Department of Historic Preservation and two (2) Regional Planning Commission staff. This technical group is in charge of thorough review and scoring of all HMA applications submitted to VEM for consideration. In 2015, the SHMPRC met to revise the State's mitigation selection criteria to better reflect current mitigation strategies, goals and objectives across the State. In addition to these competitive criteria, the revised selection criteria also identified five threshold criteria that must be met for the committee to begin competitive scoring:

1. Is this a mitigation project (deferred maintenance is ineligible)?
2. Does the proposal conform to No Adverse Impact Standards in the State Flood Hazard Area & River Corridor Rule and the State Stream Alteration Rule, where relevant?
3. Does the community have a Local Hazard Mitigation Plan in place, or a commitment to write one?
4. Does the community have a Local Emergency Operations Plan in place?
5. Is the community in good standing with the National Flood Insurance Program?

Provided an application meets all of the above threshold criteria, the SHMPRC will then score the application based on 16 competitive criteria (see: Appendix to Section 3). These 16 criteria are broken out into four (4) topic areas:

VI. **Effectiveness:** assessment of technical feasibility, cost effectiveness and sufficiency, ability to implement and achieve the objective, consideration of climate change and overall intent (i.e. reduce or avoid vulnerability).
VII. **Impact:** assessment of the repetitive loss of the structure/location, the reduction in risk, and the project's impacts to the environment, economy and cultural/historic features.
VIII. **Proactivity:** assessment of the community's previous mitigation actions, policies and plans.
IX. **Unique Circumstances:** assessment of the project's special qualities, consideration of community support and whether the project demonstrates significant cost effectiveness.

The SHMPRC typically selects priority areas for mitigation grants based upon the following criteria:

- Repetitive loss areas as indicated by past history and documented prior losses
- Mitigation measures which remove vulnerability (e.g. acquisition/demolition, road relocation) versus those that only reduce vulnerability (e.g. structural elevation)
- Areas chronically affected by severe flooding, ice jams, River Corridor erosion, landslides and other natural disasters
- Areas within which river corridor protection strategies will most effectively mitigate future flood loss in comparison with other alternatives
- Strong benefit-cost ratio (i.e. greater than 1.0) in accordance with FEMA Benefit-Cost Analysis (BCA) guidelines
- Towns impacted by strong development pressures or otherwise demonstrating a critical or urgent mitigation need
- Communities traditionally underserved by State and Federal grant programs (e.g. small and impoverished communities)

- Measures that are commensurate with preserving the natural features of rivers, streams, mountain ranges, forests, open spaces and other aspects of the natural landscape (e.g. floodplain restoration)
- Local efforts to be proactive and ability to meet the 25% match requirement

The SHMPRC meets at least once annually for the non-disaster grant program application review, but will also be convened for separate meetings if HMGP funding is available to the State. The SHMO will send out all application materials to the SHMPRC at least one week prior to meeting to allow members to individually review applications before the more formal scoring process, the latter of which takes place at the in-person meeting.

Given the relatively small size of Vermont, overlap between projects, agencies and shared goals/priorities is significant. Accordingly, there is a significant amount of project coordination that takes place interagency to ensure that efficiencies in both goals and funding can be achieved. Those projects that are deemed to be priority projects for multiple State agencies typically score well with the SHMPRC and are better able to leverage multiple forms of resources and funding.

Hazard Mitigation Assistance Grant Lifecycle - Application Submittal, Implementation & Subgrant Closeout:

Applications that are deemed both eligible and competitive by the SHMPRC are then submitted by VEM to FEMA for funding consideration. All HMGP applications are sent both digitally and in hard copy to Region I, while PDM and FMA applications are submitted via the eGrants Mitigation Portal. During FEMA review of HMA applications, Requests for Information (RFIs) are submitted to the applicant (VEM), should the need for supplemental information arise.

Subapplicants are notified by VEM upon receipt of award from FEMA Region I. The Financial Administrator within the Department of Public Safety (DPS) tasked with Hazard Mitigation Assistance will develop subgrant agreements using both the FEMA-approved budgets and scopes of work, as well as the standard State of Vermont grant agreement provisions and requirements (see: Appendix to Section 3), which require signatures from authorized representatives of the subrecipients and the Department of Public Safety Commissioner or his/her designee prior to implementation of award.

Following execution of the subgrant agreement, subrecipients are able to carry out approved scopes of work. VEM mitigation staff are available for support during implementation, if needed or requested. Upon completion of a project, a closeout visit between VEM and the subrecipient is conducted to ensure conformance with the approved scope of work. VEM mitigation staff are then tasked with developing a subrecipient closeout package, which includes relevant photo documentation from the final site visit, a programmatic summary of the completed work, pertinent forms and documents (differ based on project type), and a financial summary of the project's budget details.

The specifics of the process by which VEM manages the HMGP following a declared disaster are identified within the State of Vermont HMGP Administration Plan, which is a document requiring update and approval by both VEM and FEMA Region I prior to disbursement of HMGP funds.

Table 8: HMGP Financial Summary: DR-1995 (April-May 2011) through DR-4232 (June 2016)

	TOTAL	Buyouts	Infrastructure	Planning	5% Initiative	Advanced Assistance
Lock-In Amount	$41,026,478	--	--	$2,871,854	$2,051,324	--
Application Total (75%)	$42,367,695	$21,235,357	$15,571,796	$2,512,317	$2,571,769	$476,456
Approved	$31,205,778	$17,303,145	$10,041,976	$2,498,607	$1,264,550	$97,500
Pending	$5,298,861	$298,118	$4,849,071	--	$151,673	--
Total Remaining	$8,124,206	--	--	$301,018	-$573,589	--

Table 9: HMGP Project Summary: DR-1995 (April-May 2011) through DR-4232 (June 2016)					
Status	**Buyout**	**Infrastructure**	**Planning**	**5% Initiative**	**Advanced Assistance**
Approved	73	69	22	7	1
Pending	2	9	0	2	0

- **Buyouts:** 73 approved applications (135 properties); 2 pending applications (2 properties)
- **Infrastructure:** 69 approved - 32 drainage, 9 elevations, 17 generators, 1 road relocation, 1 demolition (4 buildings), 9 floodproof/mitigation; 9 pending - 5 elevation, 1 generator, 3 floodproof/mitigation
- **Planning:** 22 approved applications (142 towns & SHMP)
- **5% Initiative:** 7 approved - 2 projects, 2 plans, 3 buyouts (5 homes), 1 warning siren; 2 pending projects

Financial (top) and project (bottom) summaries for all HMGP disasters in Vermont between April 2011 and June 2016; note that these tables do not include withdrawn or denied projects.

Public Assistance Program

The Public Assistance Program is administered in the State by Vermont Emergency Management's Recovery & Mitigation Section. The Recovery & Mitigation Section Chief oversees the Public Assistance (PA) Program, which is administered by the Public Assistance Officer (PAO).

In the event of a disaster, VEM will initiate the Local Liaison Procedure, whereby emergency management staff within each Regional Planning Commission (RPC) are activated to reach out to all of their municipalities for a status update on essential elements of information. Based on the information received in these reports, which are shared with and validated by pertinent sister agencies, VEM staff are able to conduct internal Initial Damage Assessments (IDAs), which are then shared with FEMA when requesting Preliminary Damage Assessments (PDAs). If the State believes it is close to or has exceeded the PA disaster threshold amount (it is during these PDAs that it is *critical* for potential applicants to request hazard mitigation opportunities through 406 funding in order to more effectively address long-term reduction in vulnerability to the damaged infrastructure), PA staff within VEM will develop a request for a federal disaster declaration, which is then submitted to FEMA Region I by the Governor.

Upon receipt of a federal disaster declaration, Applicant Briefings are held in affected areas to discuss the PA Program and provide technical assistance to municipalities. Project Worksheets (PWs) are developed by deployed FEMA personnel, which are then entered into the Emergency Management Mission Integrated Environment (EMMIE) system. FEMA Hazard Mitigation Assistance (HMA) staff use the data in EMMIE to develop Hazard Mitigation Grant Program (HMGP) "lock-in" letters, which are based on a percentage of the estimated total federal public assistance under the Stafford Act. VEM mitigation staff then use these lock-in letter amounts to determine approximate total share of HMGP funding under the disaster prior to convening the State Hazard Mitigation Project Review Committee (SHMPRC) to review applications for funding consideration (see: Hazard Mitigation Assistance Program).

Maps of Public Assistance expenditures by disaster are included in the relevant hazard sections: Inundation Flooding & Fluvial Erosion, Snow Storm & Ice Storm, and Wind.

Emergency Relief and Assistance Fund (ERAF):

Prior to 2014, the Emergency Relief and Assistance Fund (ERAF) rule provided a default 12.5% State match to municipalities for Public Assistance projects following a federally-declared disaster, with an incentive to increase that State match to 17.5% for municipalities who had taken certain, proactive steps prior to the disaster. In January 2014, after consideration of the ERAF rule's efficacy in encouraging municipalities to be more proactive, the Secretary of Administration sent a letter to all municipal officials in Vermont notifying them of new changes in incentives, which would go into effect in October 2014 (see: Appendix to Section 3). These changes are incorporated into the current iteration of the ERAF rule, which is still in effect as of the date of this Plan. Currently, the default for State match following a declared disaster is 7.5%, with 17.5% covered by municipalities receiving Public Assistance funding. In order to achieve 12.5% match status, a municipality must meet the following requirements:

1. Participate in the National Flood Insurance Program (NFIP)
2. Adopt Town Road and Bridge Standards that meet or exceed the 2013 template[1]
3. Adopt a Local Emergency Operations Plan (LEOP) annually after Town Meeting Day and before May 1
4. Submit a Local Hazard Mitigation Plan (LHMP) to Vermont Emergency Management for review

For municipalities that wish to decrease their required match to 7.5%, thereby increasing the State match to 17.5%, the one of the following must be met[2]:

5. Adoption of River Corridor bylaws
6. Enrollment in the National Flood Insurance Program's (NFIP) Community Rating System (CRS), whereby the community must earn credit under Activity 430

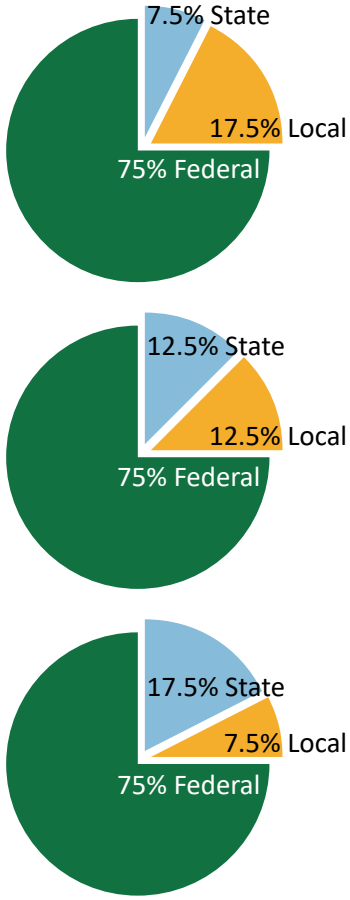

Figure 9: Vermont Emergency Relief & Assistance Fund rates

The intent of the ERAF rule is to encourage municipalities to take action to improve their community's resilience to future disaster impacts before the next event, which will save taxpayer expenses over time.

Municipalities can access information regarding their current ERAF status through their community reports, located online at http://floodready.vermont.gov (colloquially referred to as "FloodReady"), a website maintained by the Department of Environmental Conservation (DEC). Thirty (30) days after the date of the disaster declaration, Vermont Emergency Management (VEM) Public Assistance staff will take a snapshot of the community reports on FloodReady, which is then used to determine the State match rate for municipalities seeking Public Assistance. It is important to note that this is the process that is currently followed for all federally-declared disasters in Vermont, regardless of disaster type.

As nearly four years have passed since the current ERAF rule went into effect, this Plan identifies review of the efficacy of ERAF, including potential revision to the rule, as a top priority mitigation strategy (see: Mitigation Strategy).

1 http://vtrans.vermont.gov/sites/aot/files/operations/TheOrangeBook.pdf

2 http://floodready.vermont.gov/sites/floodready/files/documents/ERAF_Criteria_17%205%25_June2018.pdf

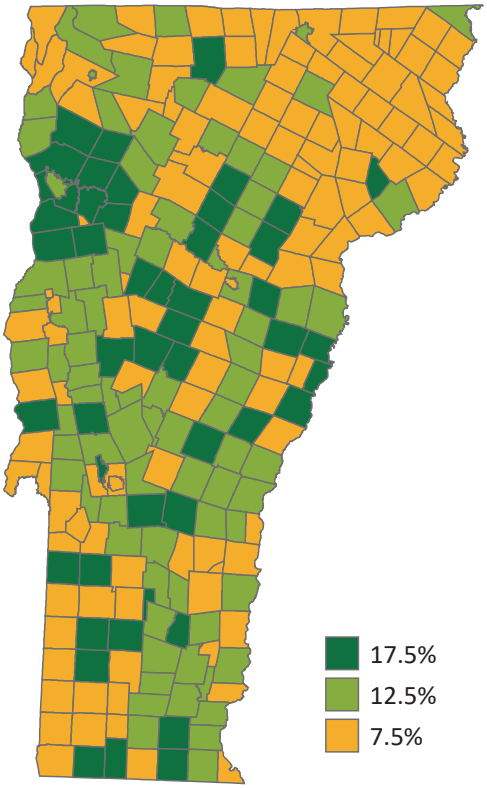

Figure 10: ERAF rate map by municipality (September 10, 2018)
Data Source: http://floodready.vermont.gov

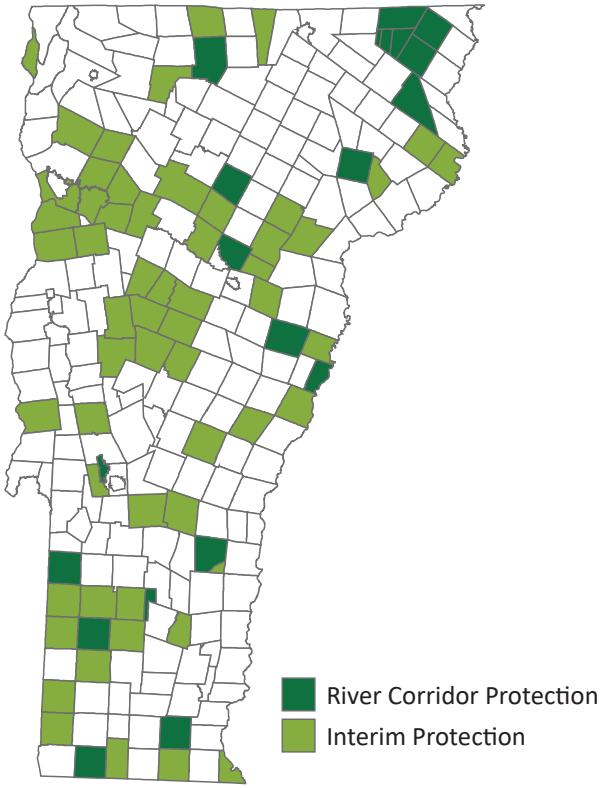

Figure 11: Map of Vermont municipalities with current and interim River Corridor Protections (May 31, 2018)
Data Source: http://floodready.vermont.gov

Vermont Stream Alteration General Permit (SAGP) Revision:

A notable advancement in hazard mitigation during the past few years has been the revision of Vermont's Stream Alteration General Permit (SAGP), and FEMA's subsequent recognition of the new general permit as "codes and standards" for purposes of future Public Assistance repairs (in a letter from the FEMA Region I Administrator to the Secretary of the Agency of Natural Resources, dated November 9, 2016). For several disasters following Tropical Storm Irene in 2011, VEM, Agency of Natural Resources (ANR) and Agency of Transportation (VTrans) worked with FEMA Region I on a case-by-case basis to have upsized drainage structures deemed fully eligible for Public Assistance funding under Section 406 hazard mitigation of the Stafford Act. Beginning with DR-4330, which occurred in July 2017 and was declared in August 2017, structure replacements that fall under the jurisdiction of the SAGP, and are required to meet the standards of the SAGP are presumed to be PA-eligible and do not require prior approval by FEMA before construction, which is otherwise required for 406 hazard mitigation projects. Prior to construction, applicable projects may still need to go through the environmental planning and historic preservation (EHP) review process.

Culverts destroyed in DR-4330 were replaced based on codes and standards in Warren, Granville (3), Waterford, and Wallingford. Culverts destroyed in DR-4356, a severe storm and flooding event on October 29-30, 2018, are being replaced based on codes and standards in Dover and Halifax.

This significant improvement allows Vermont to more quickly and appropriately address vulnerable infrastructure in a more sustainable way than has typically been implemented during the immediate response and recovery phase following a disaster.

New Capabilities from 2018 SHMP Planning Grant Sub-Projects

As part of Vermont Emergency Management's Hazard Mitigation Grant Program (HMGP) application to develop the 2018 State Hazard Mitigation Plan, the Agency of Natural Resources (ANR), Agency of Transportation (VTrans) and Buildings & General Services (BGS) developed three sub-projects considered to be essential for hazard mitigation planning at the State level. These projects considered vulnerability of the State to fluvial erosion through a robust mapping effort (ANR), vulnerability of the State's infrastructure to inundation flooding and fluvial erosion through an innovative web-based application (VTrans), and vulnerability of State-owned and -leased buildings to inundation flooding and fluvial erosion through an inventory and risk assessment process (BGS). Each of these projects, funded in part through FEMA's HMGP, have resulted in new data and tools that improve Vermont's ability to address vulnerability, and are explained in more detail below.

ANR Project - Statewide River Corridors Risk Analysis and Hazard Mitigation Prioritization Tool:

ANR modified Vermont's Statewide River Corridor Base Map to develop the map as a risk analysis, mitigation and conservation prioritization tool for use by State, regional, and local governments to better understand fluvial erosion risks and identify specific mitigation and conservation actions for reducing risk in the most vulnerable locations.

In conjunction with the map updates, ANR developed local-attribution procedures for use with the new Statewide River Corridor layer. Pilot projects were completed and draft guidance was developed for creating municipal hazard mitigation project tables and working with municipalities to do administrative changes to the statewide river corridor map. Following the pilots, all eleven Regional Planning Commissions (RPCs) worked with two municipalities within their region to complete Project Readiness Workbooks.

Using the template project table created by this project, ANR, RPCs and VEM will endeavor to expand project tables to all municipalities, which will aid in their mitigation and capital improvement planning efforts. In connecting the project tables with Local Hazard Mitigation Plans (LHMPs), development of grant applications and access to funding will be more swift, and the likelihood of reducing vulnerability will increase.
More information on this project, the planning process and the tools developed can be found in Appendix to Section 3.

VTrans Project- Transportation Flood Resilience Planning Tool (TRPT):

The Transportation Flood Resilience Planning Tool (TRPT) is a web-based application that identifies bridges, culverts and road embankments that are vulnerable to damage from floods. The tool also estimates risk based on both the vulnerability and criticality of roadway segments and identifies potential mitigation measures based on the factors driving vulnerability. A thorough list of potential mitigation project types was incorporated into the tool's algorithm, which can be used for all road segments in one of the three pilot watersheds. Those mitigation measures that are most feasible, have the highest impact and are the most cost-effective are then displayed for local, regional and State planners to consider.

The TRPT was developed and tested in three pilot watersheds (headwaters of the White River, the Whetstone Brook, and the North Branch of the Deerfield River) and is ready to be applied throughout Vermont to inform project scoping, capital programming and hazard mitigation planning. Since the TRPT web application is now considered complete, new data from other watersheds can be folded into the tool, which is available to the public[3]. Documentation is under development and will provide the details on how to upload new vulnerability and criticality data to the TRPT.

This Plan identifies expansion of the TRPT to all watersheds across Vermont as a top priority (see: Mitigation Strategy). After discussions with several State partners, it was also determined that the algorithms used to develop the TRPT can be applied to other critical infrastructure, such as utilities, to more comprehensively understand Vermont's vulnerability to hazards and develop a list of potential mitigation measures that can be implemented to reduce vulnerability. More information on this project, the planning process and the tools developed can be found in Appendix to Section 3.

BGS Project - State Facility Inventory and Assessment:

Many facilities and buildings owned by the State of Vermont are located in flood hazard areas where they face significant risk of flood damage from inundation and erosion. Between 2016 and 2018, the Vermont Department of Buildings and General Services (BGS) oversaw a vulnerability assessment of all State buildings in order to determine which are the most vulnerable to flood hazards. Those buildings that are significantly vulnerable and that play a critical role in the functioning of State government were prioritized for further assessment through field surveys. Specific mitigation strategies to lessen those risks were then developed for priority buildings, which also considered an assessment of the benefits and costs of implementation. Implementing the recommended, cost-effective strategies for these high priority buildings has been identified as an action in this Plan (see: Mitigation Strategy).

The BGS building inventory tool will serve State planners in prioritizing flood mitigation efforts for existing structures. Having access to an accurate BGS inventory will result in more disaster resilient buildings that will significantly reduce or eliminate future damages from natural disasters. In addition, the resulting prioritized list of mitigation projects can be used to develop grant applications for Pre-Disaster Mitigation (PDM) and Hazard Mitigation Grant Program (HMGP) funding, as well as existing State resources, and will support capital budget planning in all agencies with State building assets. More information on this project, the planning process and the tools developed can be found in Appendix to Section 3.

LOCAL CAPABILITIES

Local municipalities have the greatest authority to implement comprehensive hazard mitigation programs for their community. Title 24 Chapter 117 clearly articulates that the right to determine which ordinances and bylaws will be adopted, what is included in those local regulations, and what is included in municipal plans rest largely with the local community. State agencies can suggest that certain provisions be incorporated into local regulations, and Act 250 and the NFIP provide State and Federal influence; however, the towns typically develop their own rules for development and land use, including in flood and erosion hazard areas. Towns are also responsible for issuance and review of municipal permits for compliance with their own municipal bylaws. Some municipalities in Vermont still choose to have no zoning. All Vermont communities have the option to develop and adopt different kinds of plans, including comprehensive plans, capital improvement plans, economic development plans, emergency operations/response plans, continuity of operations plans, and Local Hazard Mitigation Plans (LHMPs). Vermont municipalities have the power to levy taxes and assessments for

3 http://vtrans.stone-env.net/#/map

Table 10: Flood Ready Report Categories
Number of buildings in the Special Flood Hazard Area (SFHA)
Flood insurance policies in SFHA (Zone A, AE, AO, A 1- 30)
Percent of buildings in the SFHA with flood insurance
Number of critical or public structures in SFHA or 0.2% flood hazard area
Percent of buildings in the SFHA
National Flood Insurance Program (NFIP) Enrollment Date
Flood Insurance Rate Map Standard (Digital FIRM, Rough Digital, Paper)
Community Rating System (CRS) participation
Local Hazard Mitigation Plan (LHMP) status
River Corridor Protection status
Municipal Plan status
Zoning Adoption / Amendment Date
Hazard Area Regulation Adoption / Amendment Date
2013 Road and Bridge Standards adoption

special purposes. All of these authorities have, or potentially could have, an impact on local hazard mitigation.

More information on local capabilities by community can be easily found in the Community Reports available on Vermont's Flood Ready website[4] by community (Table 10).

Regional Planning Commissions:

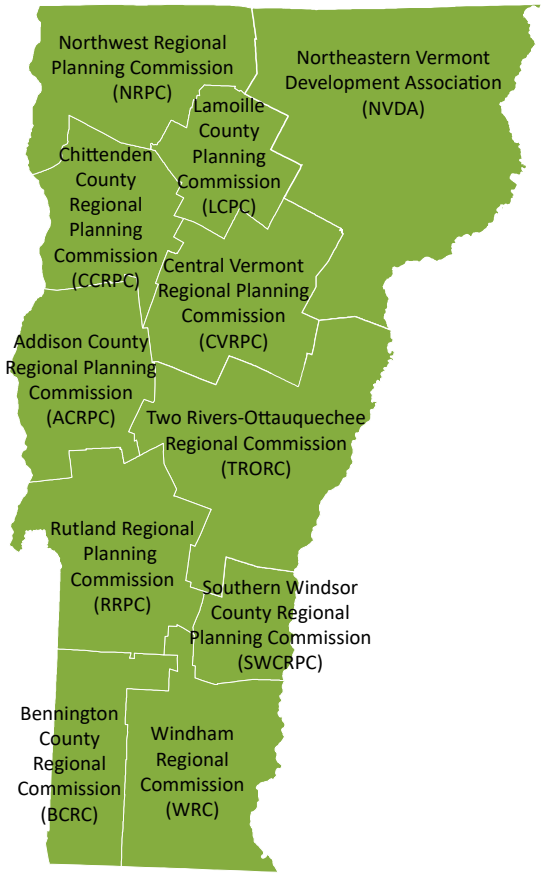

Figure 12: Vermont's 11 Regional Planning Commissions map
For information on the RPCs and their towns, see www.vapda.org

Vermont's eleven Regional Planning Commissions (RPCs) were created by statute as nonprofit political subdivisions of the State (Figure 12) with boards of directors appointed by their member communities. In practice, they provide a variety of tasks at the regional level and in assistance to towns, often acting in certain capacities in lieu of county government.

The RPCs and local communities are in the best position to determine their own mitigation needs; therefore, the State relies on these entities to provide information to advance mitigation goals and priorities. Through a collaborative arrangement, VEM, RPCs, and towns identify and prioritize local mitigation needs. These issues are regularly discussed during monthly meetings between RPCs and VEM.

RPCs help towns determine the most appropriate mitigation policy and planning. RPCs work with local town officials to draft floodplain ordinances, complete paperwork required for NFIP membership, and provide direct grant writing and administrative assistance to local town officials to help implement HMGP mitigation projects.

Given the rural nature of Vermont's communities, town capacity to develop, manage and implement appropriate mitigation plans and measures is often insufficient. Accordingly, many towns across the State require assistance from their RPC and/or various State agencies to appropriately address hazard vulnerability.

4 http://floodready.vermont.gov/

Local Hazard Mitigation Planning

Local and State mitigation efforts are closely coordinated and integrated for project and planning purposes. Being a small state works to Vermont's advantage when bringing together the various regions, as they often share common vulnerabilities and challenges, as well as goals and initiatives pertaining to hazard mitigation.

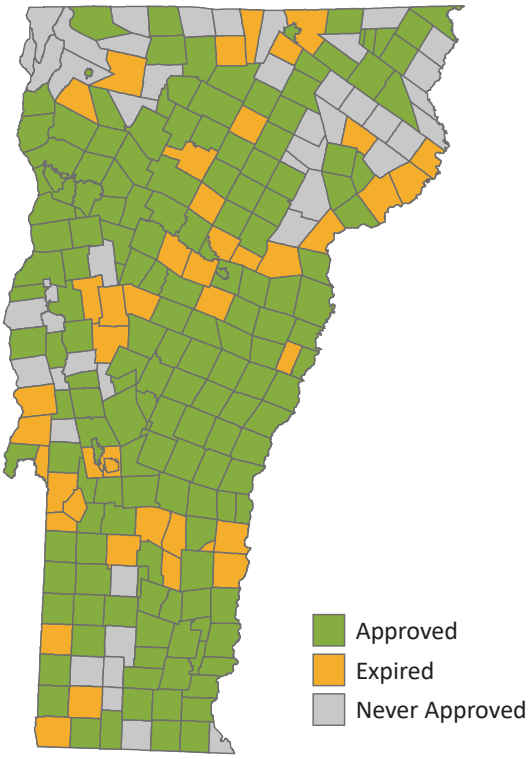

Figure 13: Local Hazard Mitigation Plan status by municipality map (September 10, 2018)
Data Source: http://floodready.vermont.gov

In Vermont, the majority of Local Hazard Mitigation Plans (LHMPs) are developed by the RPCs. The State Hazard Mitigation Officer and Hazard Mitigation Planner at VEM work closely with RPCs and their municipalities, providing technical support in local hazard mitigation planning. In coordination with VTrans and ANR, VEM assists the RPCs in identifying potential vulnerabilities, such as roadway infrastructure located within designated flood or landslide hazard areas, and developing mitigation activities that can then be prioritized.

As of September 10, 2018 Vermont had:
- 179 (63.7%) Approved LHMPs
- 50 (17.8%) Expired LHMPs
- 52 (18.5%) Municipalities that have never had an approved LHMP

At the same time, 200 municipalities (71.2%) met the ERAF requirement of having an LHMP, meaning those communities either had a currently-approved LHMP or a draft LHMP somewhere in the State or Federal review process.

Local Hazard Mitigation Plan Review Process:

- The local community, a consultant, or the RPC develop the LHMP. Plan developers are encouraged to contact the VEM Hazard Mitigation Planner during the plan development process for any technical assistance needs or to review components of the LHMP as it is being developed.
- Once a draft is completed, the LHMP and FEMA Review Tool[5] are submitted to the Hazard Mitigation Planner for review, who typically returns LHMPs within two weeks of receipt with comments on how to meet the FEMA requirements. The Hazard Mitigation Planner is available to answer questions or meet with the plan developer to review comments.
- Once the plan developer has completed any necessary revisions, the plan is submitted back into State review. If all requirements are met, the LHMP is submitted by the State to FEMA.
- LHMPs are typically returned from FEMA to the State within the required 45-day review period, either with required revisions noted in the review, or to notify the State that the plan is Approvable Pending Adoption (APA).
- If a plan is returned with required revisions, the Hazard Mitigation Planner adds notes within the Review Tool with additional guidance on how to meet the FEMA requirements and returns the Review Tool to the plan developer. Again, the Hazard Mitigation Planner is available to answer questions or meet with the plan developer to review comments.

5 https://www.fema.gov/media-library-data/20130726-1809-25045-7498/plan_review_guide_final_9_30_11.pdf

- When a plan receives APA status from FEMA, the plan developer makes any remaining necessary updates and works with the local jurisdiction to adopt the LHMP.
- Following local adoption, the plan developer submits the final plan to the State. VEM will verify that any necessary revisions have been made and then submit the plan to FEMA for formal approval.
- FEMA then formally approves the LHMP and sends the approval letter to VEM. The community then has five years from the date of FEMA approval to implement the LHMP before the plan expires and an updated plan is due for approval.

Funding & Development of Local Hazard Mitigation Plans:

VEM works with each RPC and their municipalities to develop LHMPs across the State. Until recently, municipalities within an RPC area would develop local annexes that identified town-specific policy recommendations and mitigation capital improvements, which would then be added to a larger, multi-jurisdictional mitigation plan. These multi-jurisdictional planning efforts were largely funded using PDM planning grants that were matched with State planning dollars. In addition, VEM has also provided financial assistance in plan development to RPCs through the Emergency Management Performance Grant (EMPG) that the RPCs match with other State planning funds and local, in-kind resources.

Today, RPCs, as the lead LHMP developers in Vermont, typically approach LHMPs as single-jurisdictional documents. This shift in process is largely due to plan expiration issues, as the 5-year expiration clock begins on the date that the first municipality receives formal approval from FEMA. Other municipalities who may require time to edit or adopt their plan are then left with a shorter shelf-life. The one RPC that is still producing a multi-jurisdictional plan is the Chittenden County Region Planning Commission (CCRPC), which completed a county-wide multi-jurisdictional LHMP in 2017.

RPCs now receive funding for updating and developing LHMP through FEMA's PDM and HMGP, VEM and the local towns. Several communities are still developing LHMPs as part of a large DR-4022 planning grant that was awarded in 2014 to develop 102 LHMPs across Vermont. A 2017 PDM planning grant is currently under review to fund LHMPs for 16 municipalities.

Funding LHMP development with FEMA mitigation grants has been a challenge in Vermont. Historically, RPCs would apply for funding as subrecipients and develop LHMPs for their municipalities. In 2014, FEMA Region I notified VEM that subrecipients would be unable to cover indirect rates, and as planning efforts are largely indirect, RPCs were unable to cover a significant amount of their true cost in assisting Vermont's rural communities with LHMP development. Though the Department of Public Safety was able to fund the 25% match under the DR-4022 planning grant for 102 LHMPs as a result of the indirect rate issue, future applications for federal funding to develop LHMPs will require match from alternative sources.

VEM continues to seek resolution to the indirect rate issue in order to ensure that communities are covered by LHMPs. Accordingly, determining an appropriate way to fund mitigation planning in Vermont was developed as a strategy in this Plan (see: Mitigation Strategy).

Local Hazard Mitigation Plan Coordination & Barriers:

RPCs develop LHMPs that are tailored to address local needs. Given the partnership between VEM and the RPCs, regional involvement in the SHMP update process was significant, which allowed for careful consideration and incorporation of LHMPs into this Plan (see: Planning Process). Technical assistance and training is also provided by VEM mitigation staff on LHMP development to RPCs as well as direct assistance to communities developing LHMPs without the support of their RPC.

Recognizing that climate change is likely to increase the frequency and severity of a number of Vermont's hazards, VEM strongly encourages local mitigation planning processes to consider climate change impacts and actions when developingn LHMPs. Climate change is a critical factor to consider when assessing future hazard vulnerability and developing mitigation and resilience strategies, which should be reflected in LHMPs. Impacts of climate change on natural hazards are addressed in the Vermont Profile & Hazard Assessment.

Vermont continues to discuss opportunities to integrate LHMPs into the town planning process. Unfortunately, many small, rural towns in Vermont find it challenging to develop both a town plan and an LHMP, even with assistance from the RPC. Coordination of municipal development plans and LHMPs is also encouraged through 24 V.S.A. 117, the Vermont Planning and Development Act, which requires town plans to include a flood resilience element. Additionally, FEMA's review of LHMPs includes a component addressing how the LHMP will be integrated into other municipal planning efforts.

From an RPC survey developed as part of this SHMP update, the majority of RPCs noted that the LHMP is tied in with other planning mechanisms by reference only or through specific technical assistance from the RPC due to their involvement in municipal planning processes. In the same survey, RPCs noted that their most significant challenges to developing LHMPs included:

- Lack of municipal capacity or interest
- Redundancy and lack of coordination with other planning activities
- Finding data on town-specific historical occurrences
- Insufficient public participation
- Lack of sufficient funding to develop plans
- Overly prescriptive FEMA requirements
- FEMA review process and timing for LHMP review
- Developing mitigation actions
- Lack of a Vermont data repository

These barriers were discussed during SHMP 2018 action development and are addressed through the following SHMP actions, which have been included to better integrate local planning efforts with State mitigation planning, under the objective to improve local hazard mitigation planning:

- Create a working group to assess statutory updates to the municipal planning requirements to better coordinate municipal plans and local hazard mitigation plans.
- Develop a model of an integrated municipal plan and local hazard mitigation plan that meets the requirements of both planning processes.
- Create intuitive Local Hazard Mitigation Plan templates (single and multi-jurisdictional) and development resources, including local engagement tools.
- Develop a Vermont-based potential mitigation actions list for Local Hazard Mitigation Plans from the findings of the ANR subgrant.
- Host annual or biannual Local Hazard Mitigation Planning workshops and skill-shares.
- Request approval from FEMA to participate in Program Admin by State to expedite Local Hazard Mitigation Plan (LHMP) approvals.
- Support RPCs in implementing municipal hazard mitigation project tables developed through the ANR subgrant (bake into annual work plans from ANR and VEM funding).

Additionally, many of the actions under the education and outreach goal would benefit plan development by providing resources for RPCs and local communities around mitigation.

Local Hazard Mitigation Plan Review for SHMP:

In addition to the significant stakeholder engagement process to develop the 2018 SHMP, which included participation from 10 of Vermont's 11 RPCs and several municipalities (see: Planning Process), all approved LHMPs were reviewed by VEM staff to inform Plan development. The review process began in early 2017 and ended in early 2018, including all 170 LHMPs that were FEMA-approved as of December 31, 2017. LHMPs were assessed for the hazards they addressed, vulnerabilities, local capabilities, mitigation strategies, overall plan priorities, and changes in development, which were tracked and summarized. Prior to the first Steering Committee meeting in May 2017, all LHMPs that were approved as of April 2017 were reviewed and summary information was made available for consideration at this Steering Committee meeting and future meetings, where applicable. Once additional LHMPs were approved, they were added to the tracking lists and summaries.

Since hazards are categorized similarly across communities, this was the simplest metric to accurately summarize. For the summary table of hazards addressed in LHMPs, see: Hazard Assessment. Most plans develop priorities around reducing vulnerability to their most significant hazards, making the hazard assessment relevant for priorities as well. The summary of hazards addressed was reviewed and considered by the Steering Committee during the development of the risk assessment (see: Planning Process).

How vulnerability is addressed in LHMPs varies significantly between communities. Overall, infrastructure challenges and vulnerability due to power outages from flooding, ice, wind, or snow events emerged as the most significant vulnerabilities addressed in Vermont LHMPs. These vulnerabilities translate to the mitigation actions most often included by communities to upgrade infrastructure (i.e. culvert upsizing or bridge replacement, drainage and ditching projects, and road improvements) and to install generators in critical facilities. Several of the more recent plans have also included actions in support of water quality work happening throughout the State, including riparian plantings and land conservation. Connecting mitigation and water quality work is a priority action of this Plan (see: Mitigation Strategy).

Many non-mitigation actions are often included in LHMPs as well, including tree trimming around power lines to prevent outages, alert systems for residents during events, shelter development, and education for residents on preparedness. While support for these efforts is not directly called out in Plan actions, many of the actions under the education and outreach goal would assist with these efforts.

Development of mitigation actions has been recognized as a challenge for Vermont communities. Several actions developed for this Plan are also intended to help communities develop better mitigation actions at the local level, such as expansion of the VTrans transportation resilience app, incorporation of project tables from the ANR subgrant into LHMPs, and development of a Vermont-specific list of potential mitigation actions. Many actions within the Plan are intended to more broadly improve support for local communities in mitigation planning and project development, including several tools and resources for LHMP development.

In terms of local capabilities, LHMPs predominately asses the efficacy of their Selectboard, Planning Commission, Zoning Administrator, Emergency Management Director or Coordinator, Town Clerk or other municipal staff or boards (if applicable), Municipal Plan, Capital Budgeting Plan, Local Emergency Operations Plan (LEOP), and NFIP compliance. Overall, these capabilities are functioning to maintain current efforts; however, undertaking more significant mitigation action can strain many Vermont communities. See comments above on the barriers Vermont municipalities face when applying for grants under HMA and developing LHMPs.

National Flood Insurance Program (NFIP)

The National Flood Insurance Program (NFIP) aims to reduce the impact of flooding on public and private structures by both providing insurance and encouraging proactive adoption and enforcement of floodplain management regulations[6]. Though a federal program, the NFIP is largely administered by municipal floodplain managers in participating communities. Program oversight and technical assistance is provided by the State Floodplain Manager & NFIP Coordinator at the Agency of Natural Resources' Department of Environmental Conservation (DEC). Permitting support for locals is provided through their DEC regional floodplain manager, of which there are five across Vermont[7]. Vermont is unique, in that State statute requires communities to submit floodplain development permit applications to DEC for review and comment. DEC regional floodplain managers provide technical review and written comments to assist communities in administration and enforcement of their adopted flood hazard regulations. The Vermont NFIP Coordinator also works with other State agencies including VEM and the Department of Financial Regulation, as well as with the RPCs, participating municipalities, and the FEMA Region 1 Floodplain Management and Insurance Branch.

Acts 138 (2012) and 107 (2014) required the Agency of Natural Resources to adopt a flood hazard area and river corridor rule to regulate activities exempt from municipal regulation and ensure that the State is compliant with the NFIP. Activities regulated under the rule include State-owned and operated institutions and facilities, required agricultural and silvicultural practices, and power generating and transmission facilities regulated under the Public Utility Commission. The Flood Hazard Area & River Corridor (FHARC) rule[8] went into in effect in 2015, and exceeds NFIP minimum standards. Specifically, the FHARC rule employs a No Adverse Impact set of standards, that includes a 2-foot freeboard requirement, a compensatory flood storage standard, and a river corridor performance standard in consideration of riverine erosion hazards. The standards in the rule served as the framework for the 2018 update to the State model flood hazard regulations discussed below.

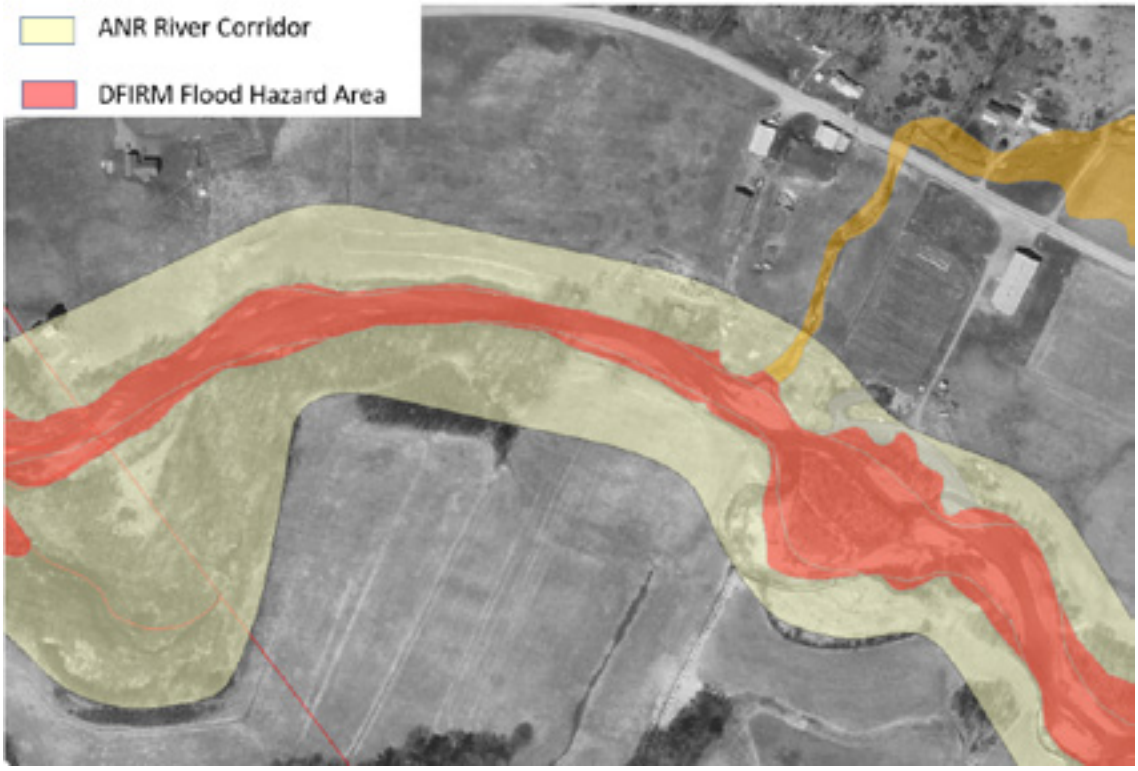

Figure 14: Browns River in Underhill demonstrates the true vulnerability (i.e. River Corridor area) versus the FEMA-mapped vulnerability (DFIRM Flood Hazard Area)

6 https://www.fema.gov/national-flood-insurance-program
7 http://dec.vermont.gov/watershed/rivers/river-corridor-and-floodplain-protection/floodplain-managers
8 http://dec.vermont.gov/sites/dec/files/documents/wsmd-fha-and-rc-rule-adopted-2014-10-24.pdf

In addition to providing insurance, the NFIP is also responsible for developing Flood Insurance Studies (FISs) and Flood Insurance Rate Maps (FIRMs), which are used as the basis for identifying flood hazard areas where floodplain management and mandatory flood insurance purchase requirements apply. Given their regulatory authority, these FISs and FIRMs are not available in certain areas of the State and are highly variable and often inaccurate in others, making access to the NFIP difficult for some, while creating an unnecessary burden for others. For example, a community whose FIRM was last updated in the 1980s may not consider how the river has meandered over the decades, effectively removing some structures from flood hazard areas while including others that were previously not considered vulnerable. Additionally, the FIRMs are static maps depicting inundation hazards at the time of study. FIRMs do not consider the River Corridor – or the minimal land area needed by the river to be least erosive and store floodwater, sediment, and debris. Accordingly, these communities are unable to understand their true vulnerability to flood hazards.

Figure 14 shows a typical situation where the river corridor is much wider than the FIRM-defined flood hazard area due to the river being incised and not having access to its floodplain. This is a particularly dangerous situation whereby the river is highly energized and erosive due to most of the base flood being contained within the channel, yet the FIRM portrays very little risk outside the channel. The river corridor shows the area where the river will continually try to meander and thus, where flood-related erosion is very likely to occur. For more information on River Corridors, see: Inundation Flooding & Fluvial Erosion.

The NFIP has historically been the standard for floodplain management in Vermont. Unfortunately, the NFIP minimum standards adopted by most towns allow continued encroachment in floodplains and further degradation of the natural and beneficial floodplain functions, and therefore are insufficient at ensuring community resilience against flooding. In 2008, the NFIP Coordinator's Office within the DEC developed a suite of model flood hazard bylaws that went well beyond federal minimum standards. Following nearly a decade of implementation of those bylaws, DEC formed an external stakeholder working group in 2017 to review and provide feedback on new model bylaws that take into account best available data and lessons learned from the previous iteration. These bylaws, released in early 2018, significantly improve upon federal (NFIP) minimum standards and more appropriately address Vermont communities' risk to flooding. The DEC has developed a comparison of the NFIP minimum standards and the model bylaw higher standards, complete with a rationale for each of the State standards[9]. The overarching goal of the higher standards is for communities to manage for inundation flooding *and* fluvial erosion hazards via a No Adverse Impact strategy that ensures development is flood resilient, does not increase flood hazards, and protects remaining floodplain resources to store and convey floodwater. As of May 31, 2018, 86 communities have adopted a combination of higher inundation and erosion standards.

As of May 31, 2018, 88% of Vermont communities participate in the NFIP (Figure 15) and most of those non-participating communities are in very low population areas with limited social capital or have limited mapping products available. Since the previous Plan was adopted in November 2013, six communities have joined the NFIP, while thirty communities remain non-participatory.

Based on current best available data in Vermont, around 8,000 structures are already exposed to flooding with a 1% annual chance or greater. Of these structures, 3,669 carry flood insurance and of those, 2,167 (or 27%) are located within high risk Flood Hazard Areas.

FEMA's National Flood Insurance Program Repetitive Loss (RL) data provide an overview of areas of the State that are vulnerable to repeated flood loss and damages. More information about Repetitive Loss can be found in Inundation Flooding & Fluvial Erosion.

9 http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_ModelFloodHazardBylaws_HigherStandardsCrosswalk_2018.pdf

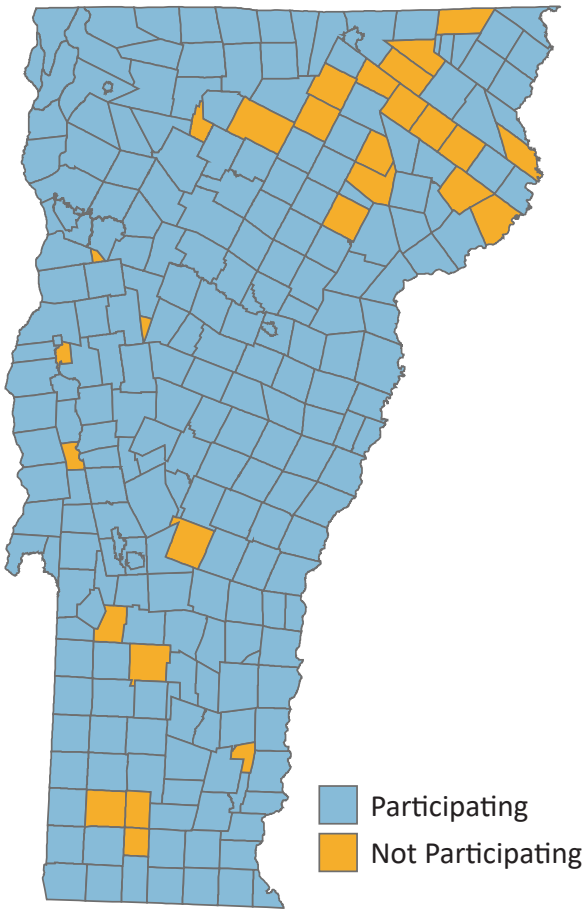

Figure 15: NFIP participation by municipality map (May 31, 2018)
Data Source: http://floodready.vermont.gov

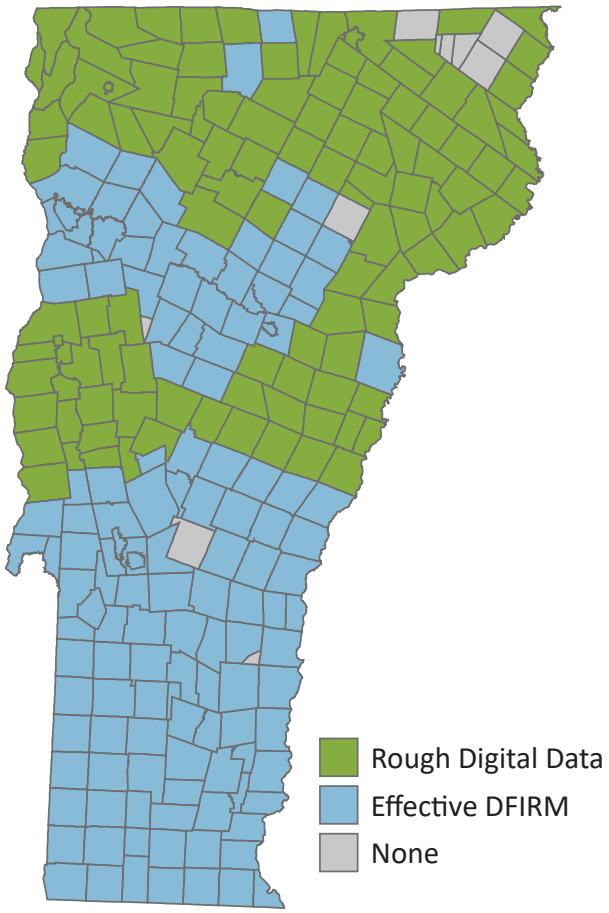

Figure 16: Risk Map status by municipality map (May 31, 2018)
Data Source: http://floodready.vermont.gov

Risk Mapping, Assessment and Planning (Risk MAP):

FEMA began updating Flood Insurance Studies and providing digital FIRMs (DFIRMS) in 2005 through its Map Modernization and Risk MAP programs. DFIRM data is available for six counties (Windham, Windsor, Rutland, Chittenden, Washington and Bennington) and seven communities (Bradford Village, Hardwick, Jay, Montgomery, Newbury, Stowe and Wolcott) (Figure 16). In 2017, FEMA Region I and the U.S. Geological Survey initiated the restudy of flooding sources in Franklin and Orleans counties and co-hosted Risk MAP discovery meetings in St. Albans, Enosburg, and Newport, with the ultimate goal of updating the FIS and FIRM data. Though these data will likely not be available for several years given ongoing uncertainty with respect to FEMA's annual mapping budget, digitizing Vermont's flood hazards is considered imperative for all watersheds/ counties.

Vermont now has statewide LiDAR coverage and looks forward to scheduling additional map updates with FEMA as soon and funding is made available. In addition, Vermont may be interested in piloting FIS and FIRM updates through the Cooperating Technical Partners (CTP) Program. The Region 1 CTP budget has largely been insignificant in recent years and there has not been enough Risk MAP activity for DEC to pursue program management funding. Should Region 1 dedicate more funding to the CTP program, the NFIP Coordinator is interested in exploring CTP opportunities to update Vermont's large percentage of antiquated FIRMs.

DFIRM data are readily available through the ANR Natural Resources Atlas web mapping application[10].

10 http://anrmaps.vermont.gov/websites/anra/

Community Rating System:

A voluntary incentive program under the NFIP, the Community Rating System (CRS) recognizes and encourages proactive floodplain management activities that exceed the minimum NFIP requirements[11]. Communities that apply for and are admitted into the CRS receive discounted NFIP premium rates for property owners in their jurisdiction in 5% increments, with those communities adopting the most stringent floodplain management policies and activities achieving greater discounts. The three goals of the CRS are to reduce flood damage to insurable property, strengthen and support the insurance aspects of the NFIP, and encourage a comprehensive approach to floodplain management.

Since the 2013 SHMP, three new communities have joined the CRS in Vermont. As of October 2017, Vermont has six CRS-participating communities, four of which meet the Class 9 standards (Waterbury, Montpelier, Berlin and Bennington) and two that have achieved Class 8 status (Colchester and Brattleboro)[12].

Recognizing the need to expand proactive floodplain management activities and policies across the State, the Vermont Emergency Relief and Assistance Fund (ERAF) criteria allow for greater allotment of State share following a declared disaster for communities that participate in the CRS, among several other standards (see: ERAF). During the mitigation strategy development process of this Plan update, the Working Groups and Steering Committee identified promotion of participation in the CRS as an ongoing action to reduce community vulnerable to flood hazards (see: Mitigation Strategy). Unfortunately, given the rural nature of Vermont, with low town capacity and a lack of statewide adoption of the International Building Code, meeting the CRS requirements for even achieving base-level (Class 9) status is extraordinarily difficult.

11 https://www.fema.gov/national-flood-insurance-program-community-rating-system

12 https://crsresources.org/files/100/maps/states/vermont_crs_map_october_2017.pdf

Table 11: 2018 State Hazard Mitigation Plan Capabilities

Capability	Description	Type	Category	Improvement Opportunity
FEMA - Pre-Disaster Mitigation (PDM) Grants	Annual funding providing baseline support for mitigating natural hazards and planning. Relies on annual allocations from Congress and requires a 25% local match.	Federal	Funding	Funding for engineering to develop strong applications is lacking, but phased projects are not eligible. The 3-year Period of Performance (POP) for PDM begins when the application period opens, which is often many months before projects are awarded, significantly reducing the time in which the scope of work can be achieved. Management Costs under PDM are not released until awards are made, despite significant work being requested pre-award. The State should improve outreach to towns and RPCs to encourage application development and submission.
FEMA - Flood Mitigation Assistance (FMA) Grants	Annual funding providing baseline support for mitigating flood hazards. Funding is through the National Flood Insurance Program (NFIP) and only available to towns participating in NFIP. Requires a 25% local match.	Federal	Funding	PDM 2017 supported Technical Assistance applications, previously identified as an area for improvement. Technical Assistance should continue to be supported and expanded. Syncing the NFIP and HMA SRL/RL lists to ensure that those properties most at-risk to flooding can access FMA funds.
FEMA - Hazard Mitigation Grant Program (HMGP)	Available following a disaster at 15% of the total Public Assistance funding allocated in a disaster. Requires a 25% match. Up to 7% of funding is available for planning.	Federal	Funding	HMGP is only available following a disaster, but could better serve affected communities as a block-style grant program (similar to FEMA's Project Impact in 1999). The time between application submittal and award needs to be reduced in order to prevent towns from being deterred from the program by wait times - recommended changes include streamlining the EHP/SHPO and programmatic review processes; developing a single, complete Request for Information (RFI); and increasing the number of technical assistance trainings offered at the Regional- and State-level. Post-disaster outreach to affected towns needs to be improved.
FEMA NFIP - Increased Cost of Compliance	Following a flood, a damaged home or business may be required to meet certain building requirements to reduce future flood damage before you repair or rebuild. The ICC is available to cover the costs of meeting those requirements for policy holders. Eligible projects include elevation, relocation, demolition or flood-proofing.	Federal	Funding	Up to $30,000 is available through ICC, but the funding can only be used during the demolition phase of an acquisition/demolition project. Eligiblity should be expanded to allow funds to help offset the local match for an acquistion/demolition, which will significantly increase the number of property owners interested in participating in a buyout.
FEMA - 5% Initiative (HMGP)	Up to 5% of HMGP funding is available to fund mitigation activities that do not meet the required BCA threshold using a FEMA-approved methodology.	Federal	Funding	The 5% Initiative under HMGP is specifically tailored to those projects whose cost-effectiveness is difficult to determine under the FEMA BCA process, but VEM and its subapplicants have been largely unsuccessful in having 5% projects awarded.
FEMA - Advance Assistance (HMGP)	Up to 25% of HMGP funding is available to provide States with resources to develop mitigation strategies and obtain data to prioritize, select and develop complete HMGP applications.	Federal	Funding	VEM needs to create a retainer contract with a list of qualified contractors to more rapidly access and deploy Advance Assistance funds across the State following a Declaration, which will improve application quality and overall interest in the program.
FEMA - Public Assistance Program (406 Mitigation)	406 funding provides discretionary authority to fund mitigation measures in conjunction with the repair of the disaster-damaged facilities.	Federal	Funding	Improving coordination of Vermont's real mitigation needs with FEMA Public Assistance field staff in the immediate post-disaster timeframe. Better accessing these funds will have the added benefit of increasing the HMGP allocation, which will further promote mitigation and reduce vulnerability.
HUD - Community Development Block Grant-Disaster Relief (CDBG-DR)	Flexible grants available following a disaster to help cities, counties, and States recover from declared disasters. Funding can be used as local match for FEMA grants.	Federal	Funding	Only available following a disaster.
HUD - Community Development Block Grant (CDBG)	Flexible program that provides communities with resources to address a wide range of unique community development needs. Funding can be used as local match for FEMA grants.	Federal	Funding	Need to make the use of CDBG funds to match federally-funded mitigation projects a more formal agreement between the State funding agencies, to ensure and promote continued success.
FEMA - Community Rating System (CRS)	Voluntary incentive program that encourages community floodplain management activities that exceed the minimum NFIP requirements.	Federal	Incentive	The incentive program is designed to accommodate more populous areas than the average Vermont town, with limited town capacity to undergo the necessary application and maintenance requirements; a "light" version should be offered for more rural areas, which still incentivize proactive mitigation, but which do not penalize.
EPA - Brownfields Grant Funding	Funding for Brownfields assessment, cleanup, revolving loans, and environmental job training.	Federal	Funding	Need to develop a way to combine clean-up efforts through EPA Brownfields & mitigation project; many grant programs will not fund Brownfields until after cleaned.
U.S. Army Corps of Engineers - Silver Jackets	Team of State and Federal partners facilitate collaborative solutions to state flood risk priorities.	Federal	Funding; Technical Assistance	Need to improve communications with USACE on mitigation projects throughout the State; as well as improve on the State's understanding of the Silver Jackets Pilot program (e.g. project eligiblity) in order to better capitalize on it.
USDA-NRCS Programs (EQIP, CSP, RCPP, ACEP)	Financial and technical assistance to agricultural producers for soil improvements, riparian buffers, and other water quality work. Funds also support conservation easements for wetland restoration and farmland preservation.	Federal	Funding	Increase funding opportunities by leveraging conservation partner resources to help with outreach, planning, design, and implementation which in turn would allow greater financial investments.
USDA - Emergency Watershed Protection Program	Provides technical and financial assistance for relief from imminent hazard in small watersheds.	Federal	Funding; Technical Assistance	Increase coordination with towns through outreach and informational meetings with towns and project sponsors ahead of disaster events.
USDA - Emergency Conservation Program	Provides emergency funding and technical assistance to farmers and ranchers to rehabilitate farmland damaged by natural disasters and to implement emergency water conservation measures in periods of severe drought.	Federal	Funding; Technical Assistance	More information on this program needed.
USDA - Emergency Farm Loans	Provides emergency loans to help producers recover from production and physical losses due to drought, flooding and other natural disasters.	Federal	Funding	More information on this program needed.

Capability	Description	Type	Catagory	Improvement Opportunity
USFS - Landscape Scale Restoration	Annual funding to assist State Forestry agencies in achieving their respective state forest action plans.	Federal	Funding	Vermont Forest Action Plan updated in 2017; no need for improvement at this time.
Vermont Emergency Relief and Assistance Fund (ERAF)	State funding to match Federal Public Assistance after declared disasters. Incentivizes municipalities to take specific steps to reduce flood damage to receive an increased State share. 20 V.S.A. Chapter 1 Section 45. **Accomplished action from 2013 SHMP.**	State	Incentive; Funding	ERAF rule needs to be reconsidered, after analyzing several years' worth of data and failure/success stories. The current rule is not viable for some Vermont communities, and does not necessarily promote the type of mitigation that the State is encouraging. Rewriting the rule with these considerations could greatly improve mitigation success. **Revision of ERAF identified as a high priority action in 2018 SHMP.**
DEC - Vermont Ecosystem Restoration Grant Program	Fund priority projects that restore and protect rivers, streams, lakes, ponds, and wetlands from nonpoint source runoff and associated nutrient and sediment pollution.	State	Funding	Currently limited to water pollution-based projects and should be expanded to cover a wider reach of water-related mitigation projects. Need to better connect this State-funded grant program with federally-funded grant programs to fund eligible, competitive projects at 100% cost.
VTrans - Better Roads Program	Provides technical support and grant funding to municipalities to promote the use of erosion control and maintenance techniques to protect water quality.	State	Funding; Technical Assistance	Need to better connect this State-funded grant program with federally-funded grant programs to fund eligible, competitive projects at 100% cost; VEM and VTrans need to improve communications to make this project coordination happen.
DEC - Vermont Watershed Grants	Grants available to protect and restore watersheds. Funded through half of the sales of the Vermont Conservation License Plate.	State	Funding	This grant program is not widely known across grant-funding agencies; potential to combine efforts with federally-funded mitigation projects to ensure project success, but communication between agencies needs to be improved/ realized.
ACCD - Municipal Planning Grants	Funds local planning initiatives that support statewide planning goals and revitalization for local municipalities in Vermont.	State	Funding	Not enough funding; becoming inaccessible for small and rural communities. Can be used as match.
VTrans - Better Connections Program	Annual program of local investments to increase transportation options, build resilience, and strengthen economic vitality in community centers.	State	Funding	Tie in with hazard mitigation projects in designated downtowns (e.g. stormwater plan implementation) to increase efficiencies.
DEC - Clean Water State Revolving Fund	Funding for Vermont's Clean Water Projects in the form of low interest loans to muncipalities.	State	Funding	Risk associated with these loans is potentially too great for more rural communities to take on, and therefore the resource is not capitalized on as much as it should be.
ACCD - Rehabilitation Tax Credits	Tax credits support general rehabilitation, code compliance, and exterior improvements for commercial and nonprofit owned buildings in Designated Downtowns and Village Centers.	State	Incentive	Greater flexibility to use for structural elevations (or 25% match for FEMA-funded structural elevation).
River Corridor Easement Program	Provides a financial incentive to landowners to allow for passive restoration of channel stability, where the landowner sells their river channel management rights within the meander belt of sensitive and erosive streams to reduce conflict with unstable streams and maximize the public benefits associated with geomorphically stable streams and floodplains. 10 V.S.A. Chapter 49 and 24 V.S.A. Chapter 117.	State	Funding; Technical Assistance	River Corridor Easement Program needs to be expanded. **Identified as a high priority action of the 2018 SHMP.**
High Meadows Fund - Watershed Collaboration Grant Program	Funding for cross-community collaboration on watershed projects upstream/downstream.	Nonprofit	Funding	This is not a reliable funding source, as priorites within HMF change annually. Need to highlight the success of the pilot projects funded under this program and connect with other mitigation initiatives being funded by other orgranizations/agencies to garner support for watershed collaboration efforts.
Lake Champlain Basin Program - Grants	Grants to support implementation of local projects that benefit the Lake, and funds scientific research that drives resource management in the Basin.	Nonprofit	Funding	Faced with loss of federal funding/support.
VHCB - Housing Program	Deferred loans for the acquisition, rehabilitation and construction of affordable housing. Funding has been used to cover the 25% local match for FEMAbuyout grants.	Nonprofit	Funding	Funding has been extraordinarily useful in the post-Irene buyout program in Vermont, but the funding is not consistently available. **Identified as an action of the 2018 SHMP.**
Vermont Disaster Relief Fund	Established to coordinate resources and raise and deliver donor dollars to those in need following a disaster.	Nonprofit	Funding	Only via disaster case management; too few case managers & no access to funds to pay them.
Vermont Arts Council - Cultural Facilities Grant	Funding for nonprofits and municipalities to enhance, create, or expand the capacity of an existing building to provide cultural activities for the public.	Nonprofit	Funding	Potentially underutilized resource.
The Nature Conservancy - Wetland & Floodplain Restoration Fund	Not yet running - program under development.	Nonprofit	Funding; Technical Assistance	Program under development; once created, outreach efforts need to be dovetailed with other mitigation efforts in order to leverage this non-federal funding source.
FEMA - Map Service Center	Public source for flood hazard information in support of the National Flood Insurance Program.	Federal	Tool	Tool underutilized by municipalities when trying to determine location of parcels/structures with respect to the FEMA-mapped Special Flood Hazard Areas. Outreach/technical assistance for using this tool should be incorporated into mitigation application development training, and other trainings that may include floodplain planning/mapping.
FEMA - Risk Map	Limited hydrologic and hydraulic restudy and digitization of existing data to facilitate floodplain regulation, flood insurance rating, land use planning, and project planning.	Federal	Data	FIRMs need updating; very inaccurate in some places but banks rely on them for insurance; large gaps in coverage across the State and the RiskMAP process is very lengthy. FIRMs do not consider fluvial erosion hazards.
USGS - Stream Gauge Data	Real-time data on stream levels.	Federal	Data	Need greater density of coverage; sustained funding; consistency between data platforms (NOAA vs USGS) is lacking or misunderstood.
FEMA - Benefit-Cost Analysis Software	Tool for determining the Benefit-Cost ratio required for FEMA grant programs.	Federal	Tool	Need more consideration of ecosystem service beyond acquisitions; method/waiver erosion hazards. **Identified as a high impact action in the 2018 SHMP.**

Capability	Description	Type	Category	Improvement Opportunity
USGS - Flood Inundation Mapper	Mapping tool including National Weather Service radar and flooding status.	Federal	Tool	Needs to be made accessible to community planners.
NRCS - RUSLE2 Erosion Prediction Technology	Tool to guide conservation planning, inventory erosion rates and estimate sediment delivery.	Federal	Tool	The process is often slow and clunky and needs revision to be made more accessible.
FEMA - HAZUS Software	Software models for estimating potential losses from earthquakes, floods, and hurricanes.	Federal	Tool	This can be costly and is often not an effective tool for mitigation planning at the local level.
Vermont - HMA Project Review Form	Newly drafted in 2015, the HMA Project Review Form addresses State priorities for funding mitigation projects. **Accomplished action from 2013 SHMP.**	State	Tool	Needs to be continually revised as mitigation-related priorities change across State government.
BGS - State-Owned Facility Inventory (Appendix to Section 3)	Thorough assessment of flood-vulnerable (inundation flooding & fluvial erosion) state-owned and leased buildings, which also identifies mitigation options for the priority buildings identified by a committee. Data currently under development. **Action from 2013 SHMP under development.**	State	Tool	Currently under development so new areas for improvement not yet identified. **Implementation of the to-be-determined recommendations identified as as an action in the 2018 SHMP.**
Flood Ready Website	Compilation of Vermont flood information. **Accomplished action from 2013 SHMP.**	State	Tool	Outreach/education efforts on the utility of this website need to continue at the local level.
ACCD - Mobile Home Park Risk Assessment Tool	Excel spreadsheet containing flood hazard information, water and wastewater systems and State permits, and lot rent and vacancy changes for mobile home parks. **Accomplished action from 2013 SHMP.**	State	Tool	Needs to be more widely publicized for use in other State planning and implementation efforts. **Use of this tool identified in several actions of the 2018 SHMP.**
VTrans Transportation Resilience Application (Appendix to Section 3)	Still under development. Only available for 3 watersheds as a pilot.	State	Tool	This is a new capability, funded in part through the SHMP 2018 HMGP Planning Grant, which has garnered a great deal of interest and support from other State Agencies and engineering firms. The Application needs to be expanded to cover all watersheds in Vermont and education/outreach on how to use the tool needs to take place. Expansion of the tool identified as a high priority action of the 2018 SHMP.
VTrans Hydraulics Manual	Manual was updated in 2015 to incorporate performance standards from the Stream Alterations Regulations. **Accomplished action from 2013 SHMP.**	State	Tool	Continued collaboration between ANR-DEC, VTrans and VEM necessary during future iterations of the model to ensure newest shared goals and policies are incorporated.
Vermont LiDAR Coverage	Full LiDAR coverage data and map under development.	State	Data	Inconsistent data quality throughout state.
DEC - Landslide Hazard Online Reporting Tool	Allows the general public to report landslides online.	State	Tool	Not widely known to the general public; would benefit from increased outreach to increase awareness.
DEC - Water Shortage Online Reporting Tool	Allows the general public to report water shortages online.	State	Tool	Not widely known to the general public; would benefit from increased outreach to increase awareness.
Vermont Climate Change Mapping and Data Tool	Mapping tool and data grapher that is just being launched.	State	Tool	The Mapping Tool needs a champion, as it does not currently reside within any single Department. Without a staff person assigned to maintenance of the Tool, it may go overlooked and/or unused.
Vermont Climate Change Website	General climate change information.	State	Tool	The Climate Change website needs a champion, as it does not currently reside within any single Department. Without a staff person assigned to maintenance of the website, it may go overlooked and/or unused.
ANR - Natural Resources Atlas	Geographic information about environmental features in Vermont.	State	Tool	Natural Resources Atlas trainings should be expanded.
AHS - Heat Vulnerability Index	Vulnerability to heat related illness data by town.	State	Tool	Not enough awareness that this exists.
ACCD - Vermont Economic Resilience Initiative (VERI)	Initiative developed for six communities in the State that considers various approaches to mitigating the economic effects of flooding. **Accomplished action from 2013 SHMP.**	State	Tool	Ideally, this would be expanded to other communities. Implementation of the suggested measures for the six communities selected should be explored through various funding efforts to capitalize on the work done in the report.
ACCD - Consolidated Plan	Plan adresses State priorities for funding, replacement, development, preservation or relocation of at-risk mobile home parks. **Accomplished action from 2013 SHMP.**	State	Tool	Not enough awareness that this exists.
VDH - Environmental Public Health Tracking	Provides data in maps, charts and tables. **Accomplished action from 2013 SHMP.**	State	Tool	Need to make the tracking tool more widely known so that it is accessed/used more frequently, which will provide better data for research and mitigation purposes.
AHS - Social Vulnerability Index	Planning tool to evaluate the relative vulnerability of populations in different parts of the State.	State	Tool	Not enough awareness that this exists.
The Nature Conservancy - Vermont Water Quality Blueprint	Tool to help watershed managers and conservation practitioners prioritize areas that provide the most benefit to water quality and conservation goals.	Nonprofit	Tool	Currently lacks headwater storage prioritization but is currently being incorporated. **Will be used to implement a high priority action of the 2018 SHMP.**
The Nature Conservancy - Vermont Dam Screening Tool	Assessment of the ecological impact of dams to fish passage in the Vermont portion of the Lake Champlain basin. Prioritizes dams for removal based on ecological impact.	Nonprofit	Tool	Dam condition can be added for further screening; data currently insufficient. **Expansion of this tool identified as a high priority action of the 2018 SHMP.**
SHELDUS	County-level hazard data for natural hazards such thunderstorms, hurricanes, floods, wildfires, and flash floods, heavy rainfall.	Nonprofit	Tool	SHELDUS data is typically only available at the County level, though LHMPs require the best available local data; recently, SHELDUS has become fee-based, making the platform less accessible and therefore less useful.

Capability	Description	Type	Category	Improvement Opportunity
UVM - Vermont Mobile Home Park Community Data	Resources for exploring data and maps to support Mobile Home Park emergency preparedness and mitigation.	Nonprofit	Tool	Need to secure funding to continue the development and maintenance of this resource; having access to accurate data regarding Vermont's vulnerable populations is critical for State and local planning efforts. **Identified as a tool to implement a high priority action of the 2018 SHMP.**
FEMA - Hazard Mitigation Technical Assistance Program (HMTAP)	To provide technical assistance to improve emergency management practices nationwide.	Federal	Technical Assistance	Not easily accessible; funding is relatively scant.
NRCS - Conservation Technical Assistance	Conservation technical assistance to land-users, communities, government, and other Federal agencies in planning and implementing conservation systems.	Federal	Technical Assistance	Knowledge of the NRCS funding opportunities is not well known to the hazard mitigation community; more collaboration between NRCS needs to take place in order to access best-use funds for mitigation projects.
Vermont Standard River Management Principles and Practices	Aim to support more effective flood recovery implementation, improve the practice of river management and codify best river management practices in Vermont. Also includes language regarding debris removal. Accomplished action from 2013 SHMP.	State	Technical Assistance	Continued collaboration between ANR-DEC, VTrans and VEM necessary during future iterations of the SRMPP to ensure newest shared goals and policies are incorporated.
DEC - Green Infrastructure	Green Infrastructure Collaborative (GIC) is a parternship between VT DEC and Lake Champlain Sea Grant Program at UVM. GIC promotes Low Impact Development and Green Stormwater Infrastructure practices in Vermont watersheds to manage stormwater runoff from developed lands.	State	Technical Assistance	Guidelines and tools developed from GIC are still new, so improvements have yet to be identified.
DFPR - County Forester Program	County Foresters provide forest management and forest stewardship information, technical assistance, and outreach to landowners in Vermont.	State	Technical Assistance; Training	Underutilized resource for potential hazard mitigation education/outreach (e.g. headwater storage identification and forest management). **Improving headwater storage through various actions was identified as a mitigation strategy in the 2018 SHMP.**
ANR - Rivers and Roads Training	Three tier training program to considering the river in the design, construction and maintenance of transportation infrastructure.	State	Training	Outreach and exposure to the Rivers and Roads Training has expanded since SHMP 2013, with increased course enrollment and training opportunities. Should be expanded further to the "Tier III" level (work on developing Tier III began in 2017). Identified as an action in the 2018 SHMP.
ANR - Municipal Day	Annual conference put on by ANR, VTrans, and ACCD, including poster presentations and workshops, the opportunity to engage with Agency staff members and municipal colleagues from across the State.	State	Training	There needs to be a Hazard Mitigation workshop session with VEM, ANR, VTrans and ACCD staff to highlight a few hazard mitigation projects in the State and to explain how various funding sources can be leveraged to reduce vulnerability at the regional, local or watershed level. **Increasing public knowledge of hazards and mitigation is identified as a mitigation strategy in the 2018 SHMP.**
UVM - Climate Controls on Air Quality Paper	Report published in Atmospheric Environment in 2015 that analyzed the the climatological factors associated with hihg ozone events in the Northeastern US. Accomplished action from 2013 SHMP.	State; Academia	Technical Assistance	As a technical paper to be used as a resource, there is no area for improvement at this time.
VLCT - Town Fair	Networking and training event for members which attracts more than 500 attendees due to training opportunities and displays of vendors that provide an array of services to municipalities.	Nonprofit	Training	There needs to be a Hazard Mitigation breakout session at the VLCT Town Fair to discuss what hazard mitigation looks like across the State and to share success stories with the audience. Ability to promote hazard mitigation at the table setting is limited. **Increasing public knowledge of hazards and mitigation is identified as a mitigation strategy in the 2018 SHMP.**
ASFPM - Certified Floodplain Manager Program	National program for certifying floodplain managers to enhance the knowledge and performance of floodplain management professionals.	Nonprofit	Training	Lack of funding available to support the exam and membership fees for ASFPM for staff who develop and review hazard mitigation project applications.
UVM Extension - Center for Sustainable Agriculture	Technical assistance to farmers on water quality improvements.	Nonprofit	Technical Assistance	Underutilized for hazard mitigation projects.
UVM Extension - Town Officers Education Conferences (TOEC)	Bi-annual seminars to help town clerks, planners, listers, select board members and other officials do their jobs more effectively by providing updates on tax laws and regulations, municipal recordkeeping and effective strategies for handling planning, zoning and other town issues.	Nonprofit	Training	VEM mitigation staff have yet to participate in the UVM Extension TOEC and are, therefore, missing an opportunity to promote hazard mitigation at the local level.
FEMA - National Flood Insurance Program (NFIP)	Providing insurance to property owners and by encouraging communities to adopt and enforce floodplain management regulations.	Federal	Regulation	NFIP does not cover all affected properties, and does not take into account fluvial erosion risk. NFIP also allows development in special flood hazard areas. Since Biggert-Waters, premiums have increased drastically, making iti unaffordable for many flood-vulnerable property owners and less enticing for structures located just outside of the SFHA. NFIP SRL and RL lists do not match the FEMA HMA lists - this lack of consistency causes issues for funding mitigation opportunities.
FEMA - Local Hazard Mitigation Plans	FEMA approved Local Hazard Mitigation Plan is required in order to apply for FEMA Hazard Mitigation Assistance grant programs. Shelf-life is 5 years.	Federal	Regulation	The FEMA LHMP Review Tool is directed towards county-level or highly-populated cities, making the process and subsequent approval for small towns very difficult. The funding for these plans is inconsistent; leveraging funding for and inclusion in the municipal planning process would greatly increase mitigation planning exposure, funding opportunities and likelihood of plan implementation. An LHMP template for towns should be developed by VEM mitigation staff. **Improvement of LHMPs identified as a strategy of the 2018 SHMP.**
DEC - Model Flood Hazard Areas Bylaws	These models contain standards that exceed NFIP minimum requirements and approximate the standards adopted by the State in its regulation of floodplains and river corridors	State	Regulation	As these were released in early 2018, areas for improvement are not yet identified. **Promotion of adopting bylaws identified as an action in the 2018 SHMP.**

Capability	Description	Type	Category	Improvement Opportunity
AAFM - Required Agricultural Practices	Practices and management strategies to which all types of farms must be managed to reduce the impact of agricultural activities to water quality.	State	Regulation	As these were released in early 2017, areas for improvement are not yet identified.
VTrans - Road and Bridge Standards	State approved standard for town roads and bridges.	State	Regulation	Generally more difficult for smaller towns to adopt these standards, as one size does not fit all.
VTrans - Municipal Road General Permit	Requires significant reductions in stormwater-related erosion from paved and unpaved municipal roads and merges stream stability requirements under DEC Stream Alteration General Permit, where applicable.	State	Regulation	More advertisement and show-casing of successful projects necessary to promote work being done and adherence to the permits.
DEC - Stormwater Permit	Regulatory oversight and technical assistance to ensure proper design and construction of stormwater treatment and control practices to minimize the adverse impacts of stormwater runoff to surface waters.	State	Regulation	Education/training regarding the DEC Stormwater Environmental Research Tool (ERT) needs to be expanded so that more complete, better-researched stormwater permits are being submitted for review.
DFPR - Acceptable Management Practices for Maintaining Water Quality on Logging Jobs	Provide measures for loggers, licensed foresters, and landowners to utilize, before, during, and after logging operations to comply with the Vermont Water Quality Standards under the Federal Clean Water Act and to minimize the potential for discharge from logging operations.	State	Regulation	AMP outreach should be included in hazard mitigation educational materials. **Identified as a strategy in the 2018 SHMP.**
DEC - Stream Alteration Rules and Permits	Regulates activities that take place in or along streams to prevent the creation of flood hazards, protect against damages to aquatic life, and protect the rights of neighboring landowners. 10 V.S.A. Chapter 41.	State	Regulation	Need to improve the DEC-SEOC communication process to ensure that work being done during and immediately following a riverine disaster is complying with the Stream Alteration Rules and Permits, including the Emergency Protective Measures (EMPs) via Act 138. DEC Rivers staff need to be named as potential SEOC (SSF11) personnel. **Identified as an action in the 2018 SHMP.**
Act 138	Legislation aimed at minimizing and preventing the loss of life and property, the disruption of commerce, the impairment of the tax base and the extraordinary public expenditures and demands on public service that result from flooding. The new Flood Hazard Area and River Corridor Rules were adopted in 2014. **Accomplished action from 2013 SHMP.**	State	Regulation	Need to improve the DEC-SEOC communication process to ensure that work being done during and immediately following a riverine disaster is complying with the Stream Alteration Rules and Permits, including the Emergency Protective Measures (EMPs) via Act 138. DEC Rivers staff need to be named as potential SEOC (SSF11) personnel. **Identified as an action in the 2018 SHMP.**
Act 162	Grants authority to municipality to declare condemned to be destroyed a property that is damaged in a declared disaster. **Accomplished action from 2013 SHMP.**	State	Regulation	List of post-disaster condemned structures needs to be shared across pertinent agencies to more quickly facilitate potential mitigation actions (e.g. buyouts). **Identified as an action in the 2018 SHMP.**
Act 8	Grants authority to ACCD relating to mobile home parks' habitability standards and compliance. **Accomplished action from 2013 SHMP.**	State	Regulation	Training of public officers needs to be expanded.
DEC - Vermont Stormwater Management Manual	To protect, maintain, and improve the waters in conformance with the Vermont Water Quality Standards, by requiring the most effective stormwater treatment practices. **Accomplished action from 2013 SHMP.**	State	Regulation	Better education/outreach needed; needs to be dovetailed with other water quality best practices and planning efforts.
Vermont Dam Safety Program	Increases regulatory authority of the Vermont Dam Safety Program's inspection and inventory of dams across the State.	State	Regulation	Act 161 passed on 5/22/18, so areas for improvement not yet identified. **Improving dam resilience identified as a strategy of the 2018 SHMP.**
Act 250: State Land Use and Development	Act 250 regulates land use permitting decisions for development applications of a certain size. The relevant section of Act 250 that mitigates natural hazard risk is §6086, which requires ANR to review Act 250 permit applications for flood inundation and erosion impacts. ANR and specifically the floodplain managers within the Rivers Management Program make case-by-case determinations on whether a permit application is for a project within a "floodway" or "floodway fringe". Vermont Supreme Court established that in Vermont the designation of "floodway" within Act 250 is much broader than the FEMA minimum standard, and can include fluvial erosion analyses in addition to the FEMA-mapped floodway. As a result, new developments requiring an Act 250 permit are not typically allowed within the FEH corridor as determined and mapped by ANR. 10 V.S.A. Chapter 151, §6086(a)(1)(D).	State	Regulation	Special exemptions exist for designated downtowns, allowing for development in the regulated floodway and Special Flood Hazard Area. **Identified as a strategy of the 2018 SHMP.**
Vermont Shoreland Protection Act & Permitting	Regulates shoreland development within 250' of a lake's mean water level for all lakes and ponds greater than 10 acres in size	State	Regulation	No area for improvement at this time.
Vermont Aboveground Storage Tank Rules	Aboveground Storage Tank rules were updated by ANR-DEC to include specific requirements for ASTs in flood-prone areas. **Accomplished action from 2013 SHMP.**	State	Regulation	No area for improvement at this time.
Permitting Planting Projects in Flood Hazard Areas	"This act provides that a planting project in a flood or other hazard area or river corridor protection area shall be considered to have a municipal land use permit by operation of law. However, a planting project will not be considered to have a permit by operation of law if it is part of a larger undertaking that includes construction or other physical disturbance of land, or is a forestry operation or a component of such an operation. (Act No. 4 (H.53), 2017)	State	Regulation	No area for improvement at this time.

Capability	Description	Type	Category	Improvement Opportunity
Title 10 Chapter 32: Flood Hazard Areas	This law defines what a flood hazard area is and how to map it, and establishes that the State will provide assistance to local governments to help manage flood-prone lands; coordinate federal, state, and local management activities; and encourage local governments to manage flood hazard areas and flood-prone lands. Furthermore, it provides that Vermont will "maintain the agricultural use of flood-prone lands" and "carry out a comprehensive statewide flood hazard area management program for the State in order to ensure eligibility for flood insurance," 10 V.S.A §751.	State	Regulation	Adoption of river corridor bylaws by municipalities is low; education/outreach efforts for the bylaws are ongoing by ANR-DEC Rivers staff, but municipalities see the bylaws as too development-restrictive. **Identified as an action in the 2018 SHMP.**
Title 10 Chapter 39: Watershed Protection and Flood Prevention	This statute empowers Vermont's Governor to take any necessary actions to mitigate flood damage, authorizes the DEC to utilize State funds to operate and maintain flood prevention structures, and provides eminent domain authority.	State	Regulation	A potentially underutilized resource for hazard mitigation and public safety issues.
Title 24 Chapter 83: Building Inspectors and Regulation of Buildings	This statute requires that when any municipality adopts a building code, it shall impose requirements consistent with the current Vermont Fire Prevention & Building Code, as adopted by the Commissioner of Public Safety. 24 V.S.A. §3102	State	Regulation	No area for improvement at this time.
Title 24 Chapter 117: Municipal and Regional Planning and Development	This State statute enables municipal planning and land use regulation and was modified in 2014 to include a required "flood resilience element" in municipal and regional plans. 24 V.S.A. §4348(a)(11)(A)	State	Regulation	No area for improvement at this time.
State Hazard Mitigation Planning & Policy Committee	Committee comprised of policy-level appointees from all State agencies to create shared goal of hazard mitigation across Agency missions, goals, grant programs and policies. **Accomplished action from 2013 SHMP.**	State	Implementation	Needs to be convened more frequently to increase visibility and understanding of hazard mitigation across Agency efforts.
Resilient Vermont	A new collaboration of organizations and agencies in Vermont that are working to advance climate resilience. The Network is working to improve alignment, coordination, communication and strategic impact across a range of issues related to climate resilience.	Nonprofit	Implementation	Needs to promote itself among stakeholders to increase visibility and promote increased coordination, ultimately leading to greater implementation of flood resilience efforts across Vermont. **Identified as an action in the 2018 SHMP.**

4: Vermont Profile & Hazard Assessment

Vermont Profile

Vermont is located astride the Green Mountains at the center of three ranges of the Appalachians, with the Adirondacks to the west and the White Mountains to the east. Vermont encompasses 9,250 square miles of landmass.

Population Trends:

Geographically, Vermont is the sixth smallest state and the second least populated. The population of Vermont was 625,741 based on the 2010 Census and is estimated to have decreased to 623,657 in 2017, a decline of approximately 0.3%. As the maps below indicate (Figures 17 & 18), there have been relatively minor changes in population statewide since 2010. Some counties have experienced slight gains (most notably Chittenden, +3,965), and other counties have experienced decreases (most notably Rutland, -1,509).

Most Vermonters live in small, rural communities with populations of several hundred to several thousand people. The largest city is Burlington, with a population of 42,556 (2016 ACS estimate).

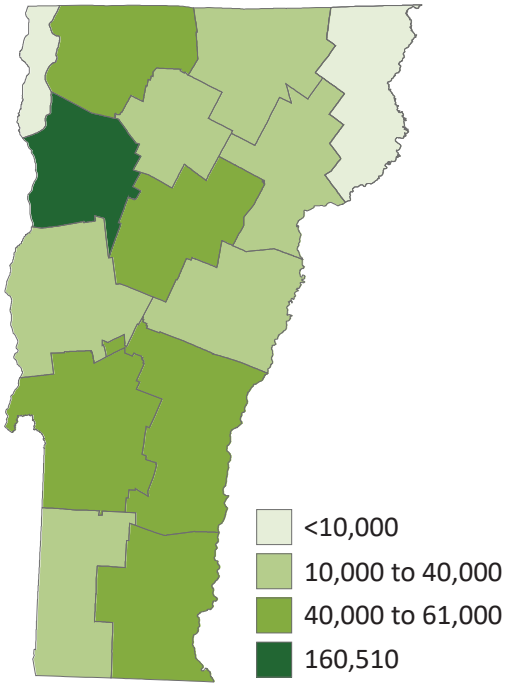

Figure 17: Vermont population by county map (2016)
Source: 2016 ACS 5-year estimates

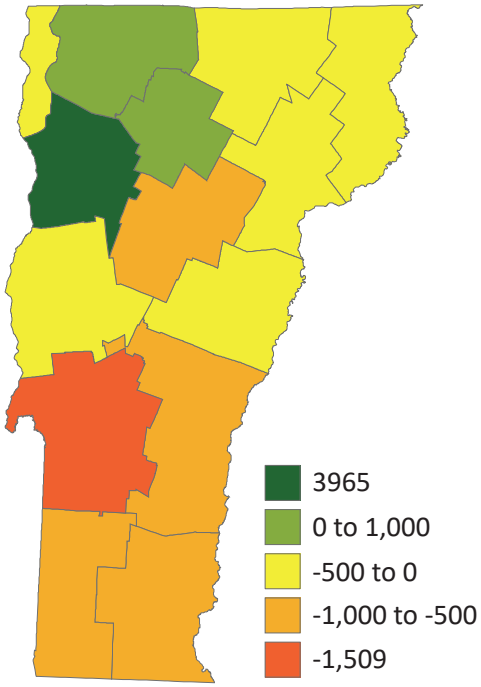

Figure 18: Vermont population change by county map (2010-2016)
Source: 2016 ACS 5-year estimates

Development Trends:

Historically, communities and infrastructure have often been sited in valleys and near water bodies, both globally and in Vermont. This development pattern was based on the assumption that rivers and coastlines would not shift or change course, which in turn relied on an assumption that climate conditions would remain relatively static. Today, with climate change models predicting increased precipitation and stronger storms in New England, many communities now find themselves and their infrastructure increasingly vulnerable to natural disasters like flooding. With the benefit of time, it is now understood that rivers and water bodies naturally adjust and change course, again threatening much of the infrastructure that lies in their path.

Between 2000 and 2010, there were no large-scale increases in either commercial or residential development in Vermont, with a total net increase of 28,157 housing units statewide. From 2010-2016, there has only been an estimated increase of 4,273 housing units (2016 ACS estimate) (Figure 20). Though this updated figure represents a shorter period of time for development, this trend, combined with population trends, suggests that the rate of new housing development in Vermont is declining.

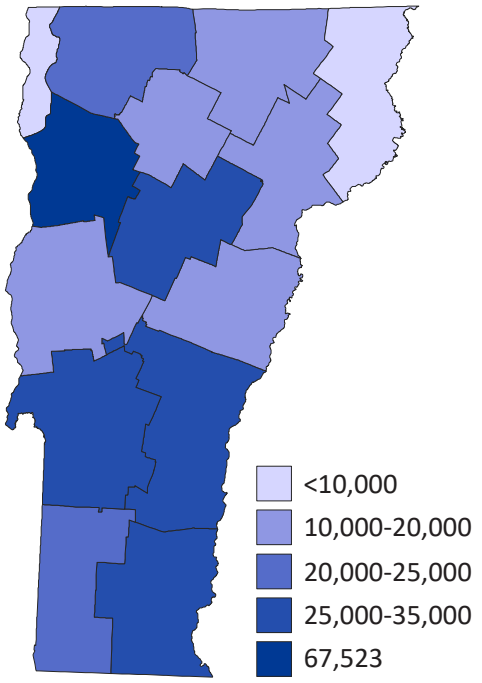

Figure 19: Housing units by county map (2016)
Source: 2016 ACS 5-year estimates

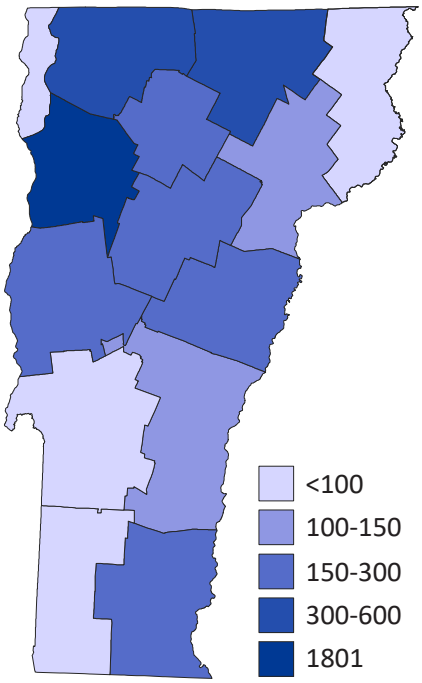

Figure 20: Housing unit change by county map (2010-2016)
Source: 2016 ACS 5-year estimates

A review of all Local Hazard Mitigation Plans that were approved by FEMA as of December 31, 2017 shows that the vast majority of communities report very little development, if any, since the 2013 State Hazard Mitigation Plan and that vulnerability has remained the same and is not projected to change. To get a better understanding of local development, VEM staff asked Regional Planning Commissions (RPCs) to note significant changes in development trends within their regions over the past five years and their impact on vulnerability, included in Table 12 below. Regions reporting no significant changes in development are not included.

In addition to the feedback from RPCs, several communities were added to Table 12 below based on the review of currently approved LHMPs (for more information on this review process, see: State & Local Capabilities). Predominately, LHMPs report that little, if any, development has taken place since their previous Plan and that vulnerability has remained the same and is not projected to change.

Table 12: Changes in Development by Region

Region	Munipality	Changes in Development & Vulnerability
ACRPC	Middlebury	Mitigation project in East Middlebury creates a false sense of security. Development of athletic fields in the floodplain increased flood depths downtown.
BCRC	Bennington	Putnam Block hotel project will increase development downtown in the floodplain, though the project will include flood-proofing of new and existing buildings and is supporting a downtown.
CCRPC	Montpelier	Several developments are planned in the City of Montpelier within the floodplain, including a hotel and a distillery. All new development will be required to follow Montpelier's NFIP standards.
CCRPC	Jeffersonville Village	Vulnerable has been reduced due to FEMA-funded projects, including the Greenway Trail Bridge replacement project and floodplain restoration, and drainage improvements downtown that are currently underway.
CCRPC	Grand Isle	There has been a decline in agricultural use of land, a small amount of additional residential development along existing roadways and the shoreline, and some commercial development along Route 2. This development has not occurred in hazard-prone areas.

Continued on pg. 41

Region	Munipality	Changes in Development & Vulnerability
CVRPC	Barre City, Northfield, Middlesex	Home buyout projects have restored the floodplain to reduce and eliminate risk from flooding.
CVRPC	Plainfield	Home buyouts at risk from landslide and fluvial erosion have eliminated risk for specific properties.
NVDA	Concord, Maidstone, Westmore, Barnet	Conversion of seasonal homes to year-round use causes more use of old septic systems close to lakes – creating potential for contamination to surface waters. Roads that used to only be used seasonally are now used year-round.
RRPC	Brandon	Box culvert was built to allow the Neshobe River to pass through downtown during heavy flows and reduce vulnerability in town.
TRORC	Woodstock	Major infrastructure was rebuilt in floodplain after Irene; the village area is highly vulnerable to inundation and fluvial erosion.
WRC	Brattleboro	While no significant development has happened in Brattleboro according to their most recent LHMP, a pending Pre-Disaster Mitigation project for property buyouts and floodplain restoration on the Whetstone Brook will lower flood levels in Brattleboro.
WRC	Dover	Changes are expected due to Mount Snow Resort development, possibly including changes to flood patterns due to snowmaking water in a different watershed.
WRC	South Newfane	Home sales are lagging, due perhaps to flooding issues; the town may begin to depopulate.

The only significant development within State-owned buildings since 2013 was the Waterbury State Office Complex, which was awarded LEED Platinum designation in December of 2017. The complex was significantly damaged during Tropical Storm Irene in 2011 and was redeveloped to accommodate future flood predictions. The buildings now lie above the 0.2% annual flood level and incorporate dry flood-proofing to provide further protection from future flooding.

Transportation:

Vermont owns approximately 3,100 miles of State highway and there are 772 miles of federal highway within the State (Figure 21). Transportation systems that run north to south within the State are I-89 (northwestward from White River Junction to the Canadian border, serving both Montpelier and Burlington), I-91 (northward from the Massachusetts border to the Canadian border, connecting Brattleboro, White River Junction, St. Johnsbury, and Newport), and I-93 (northern terminus at I-91 in St. Johnsbury, connecting the northern part of Vermont with New Hampshire).

Other significant routes include U.S. Route 5 (running south to north along the eastern border of Vermont, parallel to I-91 for its entire length in the State), U.S. Route 7 (running south to north, along the western border of the State, connecting Burlington, Middlebury, Rutland, and Bennington) and Vermont Route 100 (running south to north almost directly through the center of the State, providing a route along the full length of the Green Mountains).

East-west routes include U.S. Route 2 (crossing northern Vermont from west to east, and connecting the population centers of Burlington, Montpelier, and St. Johnsbury), U.S. Route 4 (crossing south-central Vermont from west to east, from the New York border in the Town of Fair Haven, through the City of Rutland, and across to Killington and White River Junction), U.S. Route 302 (traveling east from Montpelier and Barre, into New Hampshire and Maine), Vermont Route 9 (running across the southern part of the State from Bennington to Brattleboro), and Vermont Route 105 (crossing the northernmost parts of Vermont and connecting the cities of St. Albans and Newport).

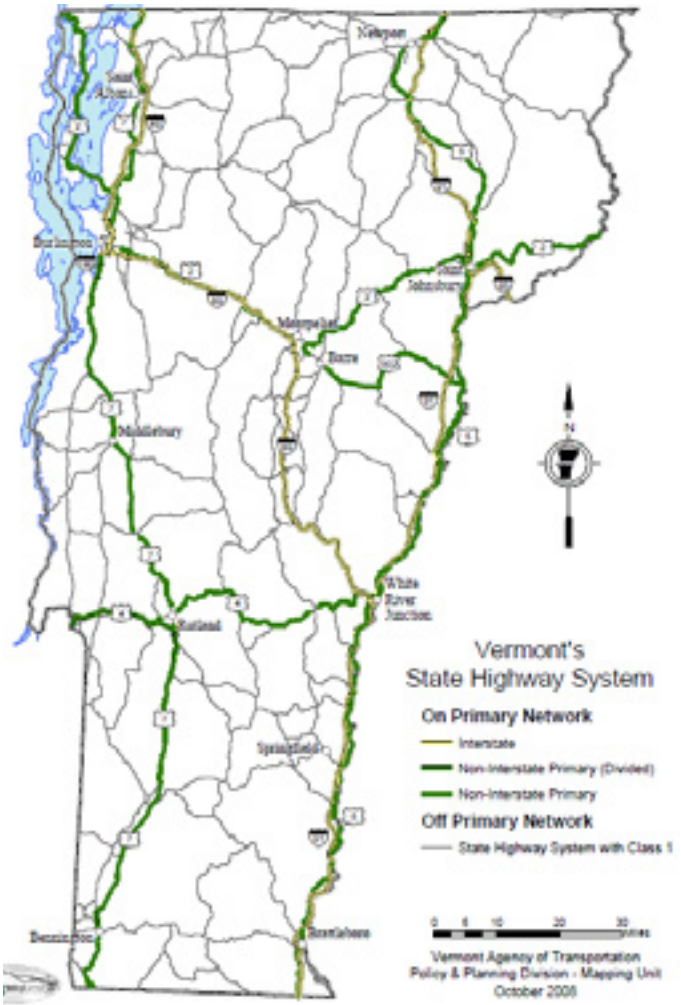

Figure 21: Vermont's state highway system map
Source: Vermont Agency of Transportation

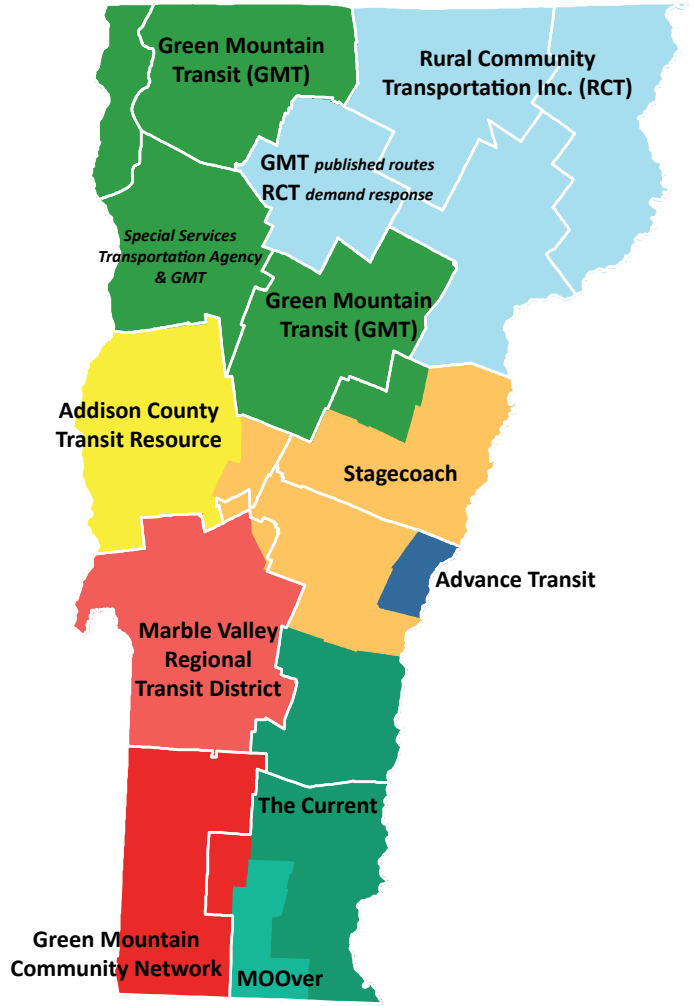

Figure 22: Vermont public transportation service areas map
Data Source: Vermont Public Transportation Association

A VTrans survey conducted in 2016 found that the vast majority of Vermonters (91%) travel in a personal vehicle frequently, with 88% commuting to work in a personal vehicle or carpool. The next largest transportation category was walking, with 45% of respondents walking as a means of transport multiple times per week or month[1]. Fourteen percent reported biking frequently, while 8% noted frequent use of public transportation.

Vermont is served by the Burlington International Airport (BTV). Vermont has eleven different bus companies (Figure 22), two ferry companies and three rail service lines throughout the State. The State of Vermont also has a program called Go Vermont[2], which is a resource for travelers who want to reduce the cost and environmental impact of driving. It provides information on bus routes, biking, or walking and features a free carpool/vanpool matching service and ridesharing tips. The State is served by Amtrak's Vermonter and Ethan Allen Express passenger lines, the New England Central Railroad, the Vermont Railway, and the Green Mountain Railroad. The Ethan Allen Express serves Rutland and Castleton, while the Vermonter serves Saint Albans, Essex Junction, Waterbury, Montpelier, Randolph, White River Junction, Windsor, Bellows Falls, and Brattleboro, with a planned extension to Canada.

1 http://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/Existing%20Conditions%20%20Future%20Trends%206-7-17.pdf
2 https://www.connectingcommuters.org/

Vulnerable Populations:

Natural hazards can affect everyone in Vermont, but some populations may be more vulnerable to certain types of events or more significantly impacted during events. The Social Vulnerability Index (SVI)[3] defines overall vulnerability by summarizing four themes: socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Figure 23 depicts this overall score by census block, broken into four relative categories of overall vulnerability.

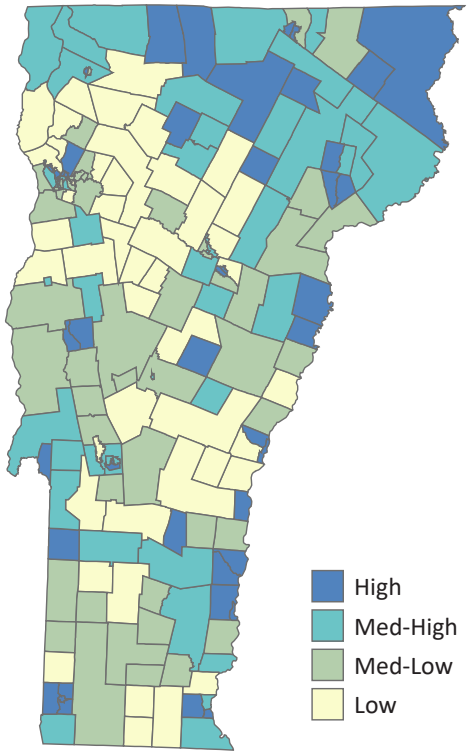

Figure 23: Social Vulnerability Index map (2016)
Source: https://svi.cdc.gov/map.aspx

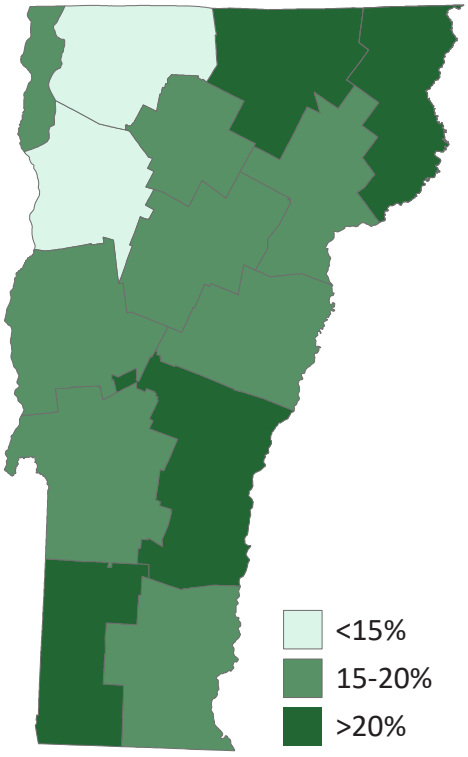

Figure 24: Vermont population over 65 map (2016)
Source: 2016 ACS 5-year estimates

Vermonters over the age of 65 is a specific demographic that is potentially more vulnerable to certain events, such as extreme heat. In 2016, 17% of Vermont was over the age of 65 based on estimates from the U.S. Census, above the national average of 14.5%. Figure 24 the percent population over 65 by county, with the most significant population in Essex County (23%, 1,408 people).

Vulnerability can also be economic. Vermont's median household income was estimated at $56,104 in 2016, slightly above the national average of $55,322. To better account for cost of living in Vermont, Vermont's Joint Fiscal Office develops a report biennially that determines a livable hourly wage for Vermonters[4]. This analysis estimates how much an individual would need to make, at a minimum, in order to live in Vermont based on a variety of family configurations and assuming employer-sponsored healthcare. The overall livable wage rate in 2016 was defined as $27,102 in individual income for a full-time worker in a two-person household without children. That equates to a household income of $54,205, which is just below the median household income for Vermont. The below table includes the various household types considered in the report and their corresponding livable wage figures.

Table 13: 2016 Basic Needs Budget Wages, Per Earner – Vermont's Basic Needs Budget

Family Type	Urban Annual Salary	Rural Annual Salary	Urban Household Salary	Rural Household Salary
Single Person	$36,691.20	$32,780.80	$36,691.20	$32,780.80
Single Person, Shared Housing	$30,076.80	$26,998.40	$60,153.60	$52,996.80
Single Parent, One Child	$61,360.00	$52,228.80	$61,360.00	$52,228.80
Single Parent, Two Children	$79,372.80	$67,641.60	$79,372.80	$67,641.60
Two Adults, No Children	$28,163.20	$26,020.80	$56,326,40	$52,041.60
Two Adults, Two Children (one wage erner)	$67,870.40	$63,793.60	$67,870.40	$63,793.60
Two Adults, Two Children (two wage erners)	$45,697.60	$42,328.00	$91,395.20	$84,656.00

Source: http://www.leg.state.vt.us/jfo/reports/2017%20BNB%20Report%20Revision_Feb_1.pdf

3 https://svi.cdc.gov/map.aspx
4 http://www.leg.state.vt.us/jfo/reports/2017%20BNB%20Report%20Revision_Feb_1.pdf

Climate Change

Over the past several decades, there has been a marked increase in the frequency and severity of weather-related disasters, both globally and nationally. Most notably, the Earth has experienced a 1°F rise in temperature, which has far-reaching impacts on weather patterns and ecosystems. This statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer), is known as climate change[5].

The Intergovernmental Panel on Climate Change (IPCC) forecasts a temperature rise of 2.5°F to 10°F over the next century, which will affect different regions in various ways over time. Impacts will also directly relate to the ability of different societal and environmental systems to mitigate or adapt to change[6]. Increasing temperatures are forecasted to have significant impacts on weather-related disasters, which will also increase risk to life, economy and quality of life, critical infrastructure and natural ecosystems. The IPCC notes that the range of published evidence indicates that the costs associated with net damages of climate change are likely to be significant and will increase over time. It is therefore imperative that recognition of a changing climate be incorporated into all planning processes when preparing for and responding to weather-related emergencies and disasters.

Most of the natural hazards identified below are likely to be exacerbated by changes in climate, either directly or indirectly. This section begins to review changes in our global and regional climate, which are further addressed in the hazard profiles, including:

- **Precipitation:** Inundation Flooding & Fluvial Erosion; Drought; Wildfire; Landslides; Snow Storm & Ice Storm
- **Temperature:** Extreme Cold; Extreme Heat; Drought; Wildfire; Invasive Species; Infectious Disease; Snow Storm & Ice Storm
- **Snow Cover:** Snow Storm & Ice Storm; Drought; Wildfire

The National Aeronautics & Space Administration (NASA) reports that global climate change has already had observable effects on the environment: glaciers are shrinking, sea ice is disappearing, sea level rise is accelerating, heat waves are occurring more frequently and intensely, river and lake ice is breaking up earlier, plant and animal ranges have shifted, and trees are flowering sooner. Though climate change is expected to have global reach, the impacts differ by region. While the southwestern United States is expected to experience increased heat, wildfire, drought and insect outbreaks, the northeastern region is predicted to experience increases in heat waves, downpours and flooding. Accordingly, consideration of climate change was identified as a key guiding principle of the 2018 SHMP, addressed in each of the pertinent hazard profiles and incorporated into all relevant mitigation actions.

Vermont's Annual Maximum and Minimum Temperatures (1960-2015)

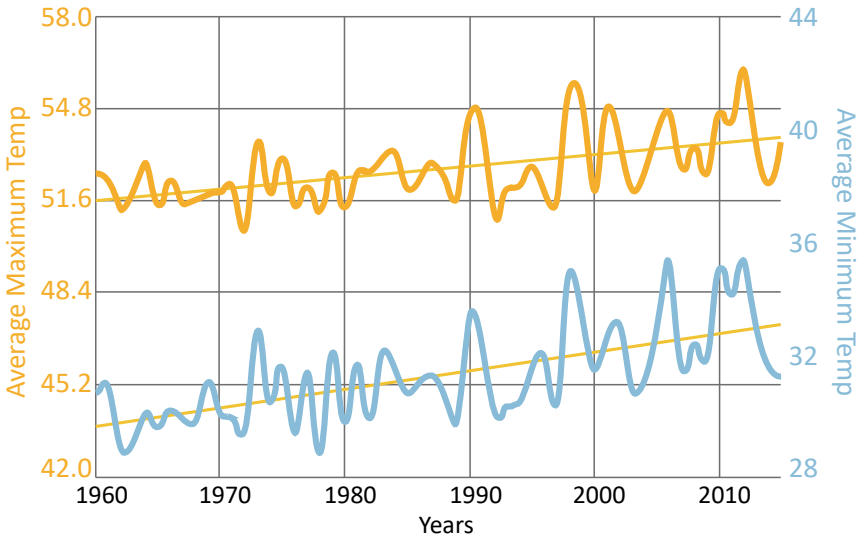

Figure 25: Vermont's annual maximum and minimum temperatures (1960-2015)
Data Source: climatechange.vermont.gov

5 http://www.ipcc.ch/
6 https://climate.nasa.gov/effects/

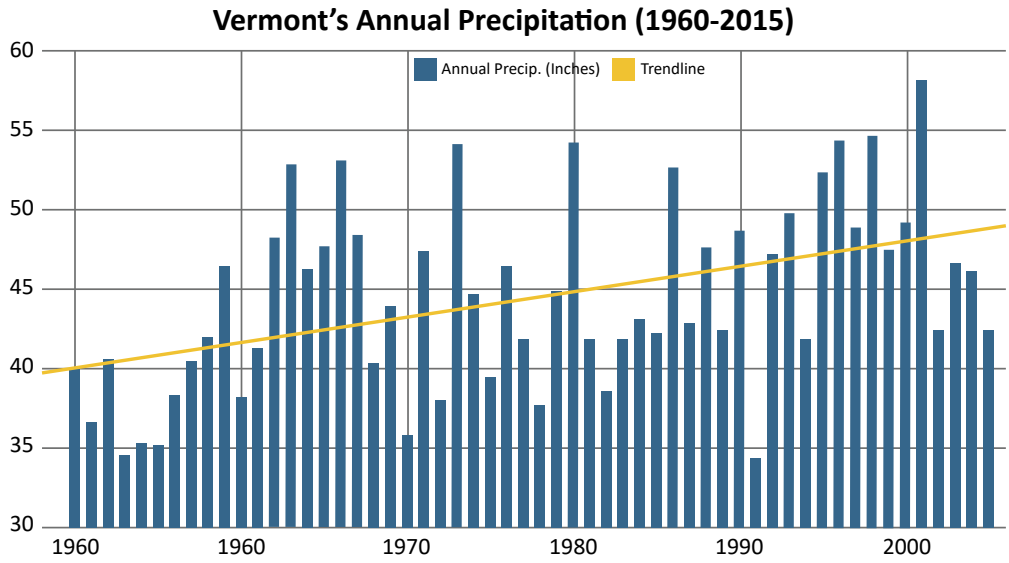

Figure 26: Vermont's annual precipitation (1960-2015)
Source: climatechange.vermont.gov

Table 14: Observed Climate Trends – Vermont's 2017 Forest Action Plan

Parameter	Trend	Projections
Temperature		
Annual Temperature	Increase	By 2050, projected increase in average annual temperature by 3.7-5.8° F; by 2100, increase by 5.0-9.5° F.
Seasonal Temperature	Increase	By 2050, projected increase in average winter temperature (December, January, February) by 4.3-6.1° F; average summer temperature (June, July, August) by 3.8-6.4° F
Hot Days > 90°F	Increase	More frequent and more intense; by the end of the century, northern cities can expect 30-60+ days with maximum daily temperatures >90° F
Cold Days < 0°F	Decrease	Reduction in days with minimum daily temperatures <0° F
Variability	Increase	Greater variability (more ups and downs)
Hydrology		
Annual Precipitation	Increase	By the end of the century, projected total increase of 10% (about 4" per year)
Season Precipitation	Variable	More winter rain, less snow; by 2050, winter precipitation could increase by 11-16% on average; little change expected in summer, but projections are highly variable
Heavy Rainfall Events	Increase	More frequent and intense
Soil Moisture	Decrease	Reduction in soil moisture and increase in evaporation rates in the summer
Snow	Decrease	Fewer days with snow cover (by the end of the century, could lose one-fourth to more than one-half of snow-covered days); increased snow density
Spring Flows	Earlier, Reduced Volume	Earlier snowmelt, earlier high spring flows with reduced volume; could occur ten days to >2 weeks earlier
Summer Low Flows	Increase	Extended summer low-flow periods; could increase by nearly a month under high emissions scenario
Ice Dynamics	Changing	Less ice cover and reduced ice thickness
Extreme Events		
Flood Events	Increase	More likely, particularly in winter and particularly under the high emissions scenario
Number of Short-Term Droughts	Increase	By the end of the century, under high emissions scenario, short-term droughts could occur as much as once per year in some places
Storms	Increase	More frequent and intense (ice, wind, etc.)
Fire	Increase	More likely
Phenology		
Growing Season	Increase	By the end of the century, projected to be 4-6 weeks longer
Onset of Spring	Earlier	By the end of the century, could be 1 to almost 3 weeks earlier
Onset of Fall	Later	By the end of the century, could arrive 2-3 weeks later

Source: fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Vermont_Forests/Library/2017_VT_ForestActionPlan.pdf

Since 1960, the average annual maximum temperature in Vermont increased about 0.4°F per decade, while the average minimum temperature rose at 0.6°F per decade (Figure 25). Similarly, the average annual precipitation has risen 0.7" per decade since 1895 and 1.5" per decade since 1960[7] (Figure 26), suggesting increasing trends in both temperature and precipitation.

According to the 2014 National Climate Assessment, the average annual precipitation in the United States has increased by approximately 5%[8]. Of particular note, the Assessment also identifies the northern U.S. as being more likely to experience above average precipitation in the winter and spring, with even wetter conditions expected under a high greenhouse gas emissions scenario. In addition to higher annual precipitation in both the observed record and projected models, the northeastern United States is also projected to experience more frequent, heavier rainfall events. Since 1991, the incidence of these heavy precipitation events has been 30% above average[9].

Another climate change concern in Vermont is the potential for climate refugees. As portions of the U.S. become more arid and as sea levels continue to rise, Vermont may begin to see significant increases in population. One study on sea-level rise displacement projects over 4,000 migrants to Vermont from across the U.S., most predominately in Chittenden County. This study does not account for people moving from increasingly arid areas within the U.S. or from outside of the U.S., which may also increase net immigration. Based on the unpredictable nature and potential impact of an influx of climate refugees into the State, the Steering Committee decided to acknowledge climate refugees as a potential future hazard facing Vermont, to be reassessed during the next SHMP update.

HAZARD ASSESSMENT

A risk assessment is used to measure the potential loss of life, personal injury, economic impact, and property damage resulting from natural hazards by analyzing the vulnerability of people, the built environment, the economy and the natural environment. VEM staff used several methods to identify risks in Vermont, including the evaluation of historical data, consideration of changing climate trends, and feedback from stakeholders. This examination involved an extensive review of natural disasters in Vermont, both declared and undeclared. Man-made and technological hazards are covered extensively in the 2018 Vermont State Emergency Management Plan (SEMP), which follows a risk assessment methodology similar to that used in this Plan. Accordingly, the following sections of the risk assessment identify the natural hazards that Vermonters can expect to face over the next fifty years and beyond, and the mitigation strategies section reviews the actions underway or planned to address these hazards and risks. As noted in the 2013 SHMP, and confirmed again in this 2018 SHMP, the natural hazards not incorporated are coastal erosion, expansive soils, Karst topography, sinkholes, tsunamis and volcanoes. These hazards are considered non-significant, unlikely hazards in Vermont and therefore do not warrant extensive review and consideration in this Plan. Table 19 explains how each hazard addressed in the 2013 SHMP was considered in this Plan.

Hazard Events

One of the most significant changes from the 2013 Plan to the 2018 Plan is the way hazards are assessed. Instead of continuing to view hazards as events (e.g. hurricanes), the 2018 SHMP assesses the impacts of events (e.g. inundation flooding, fluvial erosion, and wind as impacts of a hurricane event), as it is the impacts, not the events, that can be mitigated. Table 15 represents the initial analysis of hazard events by the Steering Committee, which informed the creation of the hazard impact assessment.

7 http://climatechange.vermont.gov/our-changing-climate/dashboard/more-annual-precipitation
8 https://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change
9 https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing

Table 15: Hazard Events Assessment			
Hazard Events	**Hazard Type**	**Probability**	**Hazard Impacts**
Rainstorm/Thunderstorm	Meteorological	Highly Likely	Erosion; Inundation; Wind; Hail; Lightning
Winter Storm	Meteorological	Likely	Snow; Ice; Wind
Landslide	Geological	Likely	Inundation; Erosion
Drought	Meteorological	Likely	
Tropical Storm/Hurricane	Meteorological	Occasionally	Erosion; Inundation; Wind
Ice Jam	Meteorological	Occasionally	Inundation; Erosion
Tornado	Meteorological	Occasionally	Hail; Wind
Wildfire	Meteorological	Occasionally	
Earthquake	Geological	Occasionally	

Hazard Impacts

The Steering Committee ranked the natural hazard impacts associated with the events listed above. Table 16 presents that ranking, including the probability of occurrence and potential impact to infrastructure, life, economy and the environment. Table 17 details the hazard assessment ranking criteria.

Table 16: 2018 Hazard Assessment							
Hazard Impacts	**Probability**	**Potential Impact**					**Score*:**
		Infrastructure	Life	Economy	Environment	**Average:**	
Fluvial Erosion	4	4	3	4	4	3.75	15
Inundation Flooding	4	4	3	4	2	3.25	13
Ice	3	3	3	3	2	2	8.25
Snow	4	1	3	2	1	1.75	7
Wind	4	2	2	1	1	1.5	6
Heat	3	1	3	2	2	2	6
Cold	3	1	3	2	2	2	6
Drought	3	1	2	2	3	2	6
Landslides	3	3	2	1	2	2	6
Wildfire	2	3	3	3	2	2.75	5.5
Earthquake	2	3	3	3	2	2.75	5.5
Invasive Species	2	1	1	2	3	1.75	3.5
Infectious Disease Outbreak	2	1	3	2	1	1.75	3.5
Hail	3	1	1	1	1	1	3

*Score = Probability x Average Potential Impact

Table 17: Hazard Assessment Ranking Criteria		
	Frequency of Occurrence: Probability of a plausibly significant event	**Potential Impact:** Severity and extent of damage and disruption to population, property, environment and the economy
1	Unlikely: <1% probability of occurrence per year	Negligible: isolated occurrences of minor property and environmental damage, potential for minor injuries, no to minimal economic disruption
2	Occasionally: 1–10% probability of occurrence per year, or at least one chance in next 100 years	Minor: isolated occurrences of moderate to severe property and environmental damage, potential for injuries, minor economic disruption
3	Likely: >10% but <75% probability per year, at least 1 chance in next 10 years	Moderate: severe property and environmental damage on a community scale, injuries or fatalities, short-term economic impact
4	Highly Likely: >75% probability in a year	Major: severe property and environmental damage on a community or regional scale, multiple injuries or fatalities, significant economic impact

The hazards and explanations of their relative probability and impact scores are detailed in the individual hazards assessment sections below. While these hazards are profiled individually, this Plan and the hazard assessment sections recognize that hazards do not occur in silos; many of the hazards are inter-related and often occur in tandem. To highlight the most significant relationships, the fluvial erosion and inundation flooding assessments were combined, as well as the ice and snow storm assessments. Each individual hazard assessment section also references the other pertinent hazards and their content, when applicable.

Table 18: Causal Relationships Between Hazard Impacts

Primary Hazard (Causal) \ Secondary Hazard Impact (Result)	Fluvial Erosion	Inundation Flooding	Ice	Snow	Wind	Heat	Cold	Drought	Landslides	Wildfire	Earthquake	Invasive Species	Infectious Disease	Hail
Fluvial Erosion	■	■							■			■		
Inundation Flooding	■	■												
Ice			■											
Snow				■										
Wind					■									
Heat						■		■		■		■	■	
Cold							■							
Drought								■		■				
Landslides									■			■		
Wildfire										■				
Earthquake									■		■			
Invasive Species									■			■	■	
Infectious Disease													■	
Hail														■

Beyond the potential of simultaneous occurrence, several of the hazards also have the potential to *cause* other hazards. Causal relationships are identified in Table 18 (with causal hazards identified in green and resulting hazards identified in blue) and further addressed in pertinent hazard assessment sections. Combined with the projected increases in both precipitation and temperature, this assessment highlights the more significant compounding impacts that Vermont can anticipate in the future due to climate change.

Table 19: Hazard Assessment Changes from the 2013 SHMP

Hazards Addressed in 2013	**Hazards Addressed in 2018**
Flooding and Fluvial Erosion	**Inundation Flooding; Fluvial Erosion**
Terrorism	Man-made hazards removed.
Earthquakes	**Earthquake**
Infectious Disease Outbreak	**Infectious Disease**
Hurricanes/Tropical Storms	Hazard impacts seperated (**Inundation Flooding; Fluvial Erosion; Wind**)
Tornadoes	Hazard impacts seperated (**Wind; Hail**)
Nuclear Power Plant Failure	Man-made hazards removed. Vermont's only nuclear power plan has been decommissioned.
Landslides/Rockslides	**Landslides**
Severe Thunderstorms	Hazard impacts seperated (**Inundation Flooding; Fluvial Erosion; Wind; Hail**)
Wildfires	**Wildfire**
Dam Failure	Hazard impacts seperated (**Inundation Flooding; Fluvial Erosion**)
Severe Winter Storms	Hazard impacts seperated (**Ice; Snow**)
Hail	**Hail**
Ice Jams	Hazard impacts seperated (**Inundation Flooding; Fluvial Erosion**)
Drought	**Drought**
Rock Cuts	Man-made hazards removed.
Invasive Species	**Invasive Species**
Extreme Temperatures	Hazard impacts seperated (**Heat; Cold**)

Jurisdictional Vulnerability

In conjunction with the risk assessment, VEM staff conducted a vulnerability assessment, which predicts the extent of damage that may result from a hazard event of a given intensity in a given area and considers damage to the existing and future built environment, the natural environment, and populations within Vermont. Vulnerability was determined by identifying the threats posed to people, property, the environment, and the economy. Hazard-specific vulnerability is detailed further in the individual hazard profiles.

Though a small state, Vermont's topography and mountainous setting can result in geographic isolation during severe storms, which can have significant localized impacts. A localized storm can drop a significant amount of water into a small watershed, devastating one town or cutting it off from the rest of the State, while causing no damage to an adjacent town on the other side of a mountain. The mountainous areas in Vermont vulnerable to these phenomena are numerous. Because of the steep mountain topography, damage from frequently occurring extreme weather events in any specific location may occur often or only once in a lifetime, which makes it difficult to plan for and responding to events.

Coupled with this topographic isolation, the rural nature of the State can also result in isolation from necessary emergency response efforts. Most communities in Vermont have an identified local Emergency Operations Center (EOC) and/or shelter for its residents, should an event warrant their opening and often require a back-up energy source, typically in the form of generators. In order to keep these critical facilities functioning in times of need, VEM is regularly contacted for equipment and training requests and financial assistance. Other critical facilities that have applied for funding through the State are wastewater treatment plants and fire departments, which require back-up energy sources during events that may result in community-wide power loss (e.g. flooding, wind storm, ice/snow storm), or which require flood-proofing to reduce vulnerability to flood damage.

Jurisdictional Risk Assessments:

In an effort to validate the risk assessment completed by the Steering Committee, and as one of the metrics used to assess local vulnerability, VEM staff asked RPCs to rank the same list of hazards based on the perceived

Table 20: Hazard Assessment Ranking by Regional Planning Commission

Hazard Impact	Average	ACRPC	BCRC	CCRPC	CVRPC	LCPC	NRPC	NVDA	RRPC	SWCRPC	TRORC	WRC
Inundation Flooding	**2.2**	9	1	2	1	2	1	1	2	1	2	2
Fluvial Erosion	**2.3**	3	2	1	2	4	3	5	1	2	1	1
Snow	**4.5**	12	3	4	3	1	5	2	7	3	6	3
Ice	**4.6**	1	9	6	4	5	2	3	4	9	3	5
Wind	**5.1**	2	4	3	6	6	4	6	3	6	4	12
Cold	**7.4**	17	8	5	5	3	13	4	5	4	10	10
Invasive Species	**8.0**	4	6	10	10	9	11	13	8	--	5	4
Landslides	**8.4**	7	12	13	8	7	6	8	10	7	8	6
Wildfire	**8.8**	6	11	9	7	11	9	10	13	5	9	7
Drought	**9.3**	11	7	11	12	10	8	9	11	8	7	8
Hail	**9.5**	10	14	12	9	8	7	7	6	11	11	9
Infectious Disease	**10.0**	5	5	7	14	12	10	12	12	--	12	11
Heat	**11.1**	8	10	8	13	13	14	11	9	10	13	13
Earthquake	**13.1**	12	13	14	11	14	12	14	14	12	14	14

Table 21: Hazards Addressed in Local Hazard Mitigation Plans Approved as of December 31, 2017		
Hazard	**Approved LHMPs**	**Percent of Approved LHMPs**
Flooding	165	97.1%
Winter Storms	132	79.4%
Fluvial Erosion	122	71.8%
Ice Storm	95	55.9%
High Wind	87	51.2%
Flash Flood	69	40.6%
Wildfires	47	27.6%
Hurricanes/Tropical Storms	42	24.7%
Thunderstorms	42	24.7%
Hail	39	22.9%
Landslides	39	22.9%
Extreme Cold	36	21.2%
Ice Jams	36	21.2%
Lightning	31	18.2%
Dam Failure	29	17.1%
Infectious Disease Outbreak	29	17.1%
Earthquake	27	15.9%
Drought	24	14.1%
Invasive Species	22	12.9%
Tornado	20	11.8%
Extreme Temperatures	19	11.2%

vulnerability in their respective regions. RPCs ranked vulnerability on a scale from 1-14, with 1 being the most significant and 14 being the least significant. Table 20 represents the responses from each RPC, with an average score based on all responses, ordered from most to least significant. The results of this analysis closely matched the hazard ranking completed by the Steering Committee, further confirming Vermont's most significant hazards (i.e. Fluvial Erosion, Inundation Flooding, Ice and Snow).

At the end of 2017, 170 of the 281 jurisdictions in Vermont had FEMA-approved Local Hazard Mitigation Plans (60.5%). In a review of these approved plans, VEM mitigation staff identified natural hazards that were addressed by more than 10 individual jurisdictions (Table 21). The analysis also confirms that the most significant concerns at the State level are consistent with reality at the regional and local levels, with Flooding, Winter Storms and Fluvial Erosion and Ice Storm ranking as the most significant hazards.

In addition to ranking hazard significance, RPCs also listed the communities within their regions that are most vulnerable to natural hazards and explained what makes them vulnerable. The responses are represented in Table 22. VEM staff used this local vulnerability information to inform the assessment of each hazard and the mitigation strategy (see: Mitigation Strategy).

Table 22: Local Vulnerability by Regional Planning Commission		
RPC	**Municipality**	**Vulnerability**
ACRPC	Bristol	Village was built on unstable gravel deposit prone to landside; large forest products industry threatened by invasive species.
ACRPC	Goshen	Most of town is within the Green Mountain National Forest and vulnerable to wildfire.
BCRC	Bennington	Significant amount of structures in floodplain, including downtown Bennington, vulnerable to flooding and fluvial erosion.
BCRC	Pownal	Over 100 mobile homes in the floodplain, vulnerable to flooding and erosion.
BCRC	Manchester	Second largest town in the region, which was cut off during Irene and is still vulnerable to flooding and fluvial erosion.
BCRC	Woodford	Over 40 homes in river corridor that are not in the flood zone. Town has not adopted river corridor protection and is vulnerable to erosion.

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RPC	Municipality	Vulnerability
CCRPC	Bolton, Huntington, Richmond, Underhill, Westford	Steep roads vulnerable to fluvial erosion and flooding.
CVRPC	Barre City, Montpelier	Downtowns in floodplain prone to flooding and ice jams, vulnerable populations at risk due to cold, critical facilities potentially at risk, limited capacity to handle and store large volumes of snow.
CVRPC	Plainfield	Vulnerable to flooding due to topography and soils, debris jam potential, and public infrastructure in need of upgrade. Limited transportation routes and potential for isolation. Proximity to the Marshfield Dam.
CVRPC	Duxbury	Vulnerable to flooding due to topography and soils. 90% forested landcover, which is at risk of wildfire. Lack of dry hydrants; rural community with remote locations and vulnerable populations; potential for long-term power outages.
CVRPC	Waterbury Town/Village	Downtown location and critical facilities prone to flooding and near Waterbury Dam, age and condition of infrastructure, vulnerable populations, potential for long-term power outages.
LCPC	Johnson	Vulnerable to flood inundation and ice jams due to low lying downtown.
LCPC	Jeffersonville/Cambridge	Population in the floodplain vulnerable to inundation flooding and ice jams.
LCPC	Stowe	More densely developed along river, vulnerable to flood inundation and wind.
NRPC	Highgate	Forested land cover at risk of inundation and fluvial erosion, power lines vulnerable to ice, winds from the west gain strength over lake.
NRPC	Montgomery	Soils and topography create risk of flooding and erosion, power lines vulnerable to ice, remoteness and forested land cover, winds from the west gain strength over lake.
NRPC	Enosburgh Town	Fluvial erosion and inundation risk, power lines vulnerable to ice, forested land cover, winds from the west gain strength over lake.
NRPC	Isle La Motte	Island landform vulnerable to flood inundation, one road connects island to neighboring town, remote, power lines vulnerable to ice, winds from the west gain strength over lake.
NRPC	Swanton Town/Village	Pre-flood regulations development at risk of flood inundation, power lines vulnerable to ice, winds from the west gain strength over lake.
NVDA	Hardwick, Lyndonville, St. Johnsbury	Regional centers with high amount of development subject to flooding and fluvial erosion.
NVDA	Concord, Brownington, Barnet	Development and Infrastructure (roads) in flood zone and river corridor vulnerable to flooding and fluvial erosion.
RRPC	Mendon, Brandon, Pawlet, Rutland City	Infrastructure in the river corridor vulnerable to flooding and fluvial erosion.
SWRPC	Cavendish	Location and topography cause risk of inundation and erosion.
SWRPC	Chester	Critical facilities and infrastructure at risk of inundation and slope failure.
SWRPC	Windsor, West Windsor	Critical facilities vulnerable to inundation, erosion and drought.
SWRPC	Ludlow	Location puts infrastructure at risk from flooding.
TRORC	Stockbridge	Steep slopes that were damaged by Irene at risk of fluvial erosion, road infrastructure located near water bodies vulnerable to inundation risk.
TRORC	Woodstock, Newbury and Village of Wells River, Granville	Major public and private infrastructure located near waterways and vulnerable to erosion and inundation.
TRORC	Rochester	Major public and private infrastructure located near waterways and easily isolated during storm events, at risk of inundation and erosion.
WRC	Jamaica, Newfane	Historic development pattern cause vulnerability to fluvial erosion and inundation.
WRC	Marlboro	Topography and development patterns create a risk of fluvial erosion.
WRC	Wilmington, Wardsboro	Location of downtown and historic development pattern cause a risk of flooding and fluvial erosion.

Vermont Economic Resiliency Initiative (VERI) Priority Areas:

In 2015, the Agency of Commerce and Community Development (ACCD) completed the Vermont Economic Resiliency Initiative (VERI) report[10]. The report was developed to help Vermont communities better manage their flood risk and included an analysis that defined the top 32 communities where flooding risk is high, based on economic activity, at-risk infrastructure, and at-risk non-residential buildings. ACCD completed more detailed analyses for the top six communities, for which projects were defined that would reduce vulnerability and prioritize investment: Barre City and Town, Brandon, Brattleboro, Enosburg Village and Town, and Woodstock. In additional to these top communities, many of the priority areas have seen increased investment in mitigation work, as noted Table 23.

Table 23: Economic Centers with Infrastructure and Commercial Buildings at Risk (VERI)

Municipality	Economic Activity Ranking	2011 Population Estimate	Infrastructure Vulnerability Ranking	Vulnerable Commercial Buildings	Notes	Mitigation Progress in 2018
Brattleboro	4	11,978	6	73	Designated Downtown, Critical Employer	Buyout of Melrose Terrace and subsequent floodplain restoration along Whestone Brook underway
Montpelier	7	7,868	11	300	Designated Downtown, Critical Employer	USACE Silver Jackets VT team awarded funding for updating floodmapping in 2017
Hartford	10	9,952	7	45	Designated Downtown	Several buyouts post-Irene
Barre City	15	9,066	12	169	Designated Downtown	Several buyouts, drainage upgrade projects
Ludlow	16	1,963	43	84	Tourism	Large drainage improvement project and several buyouts
Morristown	17	5,277	51	46	Designated Downtown, Critical Employer	N/A
Woodstock	19	3,047	24	140	Tourism	N/A
Cambridge	20	3,695	26	35	Tourism	Large floodplain restoration and drainage improvement projects underway
Enosburg	57	2,800	65	10	Agriculture	Drainage project along Tyler Branch
Hardwick	65	3,003	22	55	Agriculture	N/A
Essex	22	19,713	66	12	Critical Employer	N/A
Brandon	24	3,943	30	26	Designated Downtown	Large drainage improvement project and several buyouts
Castleton	27	4,695	63	21		N/A
Rockingham	28	5,255	45	14	Designated Downtown	N/A
Arlington	31	2,308	8	15	Critical Employer	Large flood mitigation project at a camp along the Battenkill
Barton	32	2,805	3	68		N/A
Berlin	33	2,886	9	61	Critical Employer	Buyout post-Irene
Chester	34	3,153	16	24	Critical Employer	Several buyouts

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10 http://accd.vermont.gov/community-development/flood/veri

Municipality	Economic Activity Ranking	2011 Population Estimate	Infrastructure Vulnerability Ranking	Vulnerable Commercial Buildings	Notes	Mitigation Progress in 2018
Randolph	36	4,788	36	22	Designated Downtown	N/A
Springfield	37	9,373	19	154	Downtown, Critical Employer	N/A
St. Johnsbury	39	7,594	23	126	Designated Downtown, Critical Employer	Buyout
Lyndon	44	5,971	21	39	Critical Employer	N/A
Barre Town	48	7,937	61	29		N/A
Londonderry	50	1,758	42	31		Several buyouts, generators and flood-proofing projects
Richmond	51	4,108	52	21		Several structural elevation projects
Bradford	54	2,804	5	16	Designated Downtown	N/A
Cavendish	55	1,367	14	11		N/A
Northfield	59	6,221	28	40	Critical Employer	Significant buyouts along Dog River
Burke	63	1,751	48	22	Tourism	N/A
Bethel	70	2,022	1	38	Critical Employer	Several buyouts post-Irene
Fairfax	71	4,319	17	12		N/A
Johnson	74	3,472	41	57	Critical Employer	N/A

Source: http://accd.vermont.gov/community-development/flood/veri

Vulnerability of State-Owned Buildings:

Buildings and General Services (BGS), through a 2018 SHMP subgrant, is the lead agency for a statewide assessment of State-owned buildings located either in the FEMA-mapped floodplain and/or the river corridor. This assessment, which included all State-owned and leased properties, considered both criticality of the buildings' functions and the vulnerability of the structures based on location.

As the two most significant hazards identified in this Plan, the BGS risk assessment project focused primarily on fluvial erosion and flood inundation vulnerability. Further, assessing risk based on these hazards was fairly straightforward, as BGS could access both State and FEMA mapping data specific to fluvial erosion and inundation flooding. Using these data, BGS assessed vulnerability of an individual structure according to its proximity to the FEMA-mapped 100- and 500-yr floodplains, as well as the river corridor. An overall vulnerability score was assigned to each structure using a point system outlined in the Appendix to Section 3. Structures were then assessed according to their criticality to the following State functions:

- Emergency Operations
- Government Operations
- Public Safety
- Public Health
- Public Service
- Economic Activity
- Cultural Resources

BGS then used the scores for criticality and vulnerability to determine building prioritization for developing mitigation measures. The risk assessment also includes information on each building's current function, construction type and year, number of floors, building replacement cost, cost of personal property and cost of computer equipment. A detailed description of this risk assessment, prioritization process and alternatives analysis for the top priority State-owned structures can be found in the Appendix to Section 3.

Though the BGS project focused primarily on fluvial erosion and inundation flooding, the data acquired are pertinent to all natural hazards profiled in this Plan that could impact State-owned or leased structures. That is, a building's replacement cost will be the same regardless of what hazard was responsible for its destruction. Similarly, a building's criticality score does not differ hazard-to-hazard. Further, without high fidelity hazard mapping data for all natural hazards, determining true vulnerability of a structure based on proximity to a clearly delineated hazard area is very difficult. The full list of all State-owned buildings and their replacement costs as defined above in is the Appendix to Section 4.

4-1: Inundation Flooding & Fluvial Erosion

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Fluvial Erosion	4	4	3	4	4	3.75	15
Inundation Flooding	4	4	3	4	2	3.25	13

*Score = Probability x Average Potential Impact

Flooding is the most common recurring hazard event in Vermont. In recent years, flood intensity and severity appear to be increasing. Flood damages are associated with inundation flooding and fluvial erosion. Data indicate that greater than 75% of flood damages in Vermont, measured in dollars, are associated with fluvial erosion,[1] not inundation. These events may result in widespread damage in major rivers' floodplains or localized flash flooding caused by unusually large rainstorms over a small area. The effects of both inundation flooding and fluvial erosion can be exacerbated by ice or debris dams, the failure of infrastructure (often as a result of undersized culverts), the failure of dams, continued encroachments in floodplains and river corridors, and the stream channelization required to protect those encroachments.

Inundation flooding is the rise of riverine or lake water levels, while **fluvial erosion** is streambed and streambank erosion associated with physical adjustment of stream channel dimensions (width and depth). Both inundation flooding and fluvial erosion occur naturally in stable, meandering rivers and typically occur as a result of any of the following, alone or in conjunction:

- **Rainfall:** Significant precipitation from rainstorm, thunderstorm, or hurricane/tropical storm. Flash flooding can occur when a large amount of precipitation occurs over a short period of time.
- **Snowmelt:** Melted runoff due to rapidly warming temperatures, often exacerbated by heavy rainfall. The quantity of water in the snowpack is based on snow depth and density.
- **Ice Jams:** A riverine back-up when flow is blocked by ice accumulation. Often due to warming temperatures and heavy rain, causing snow to melt rapidly and frozen rivers to swell.

Inundation and fluvial erosion may both increase in rate and intensity as a result of human alterations to a river, floodplain, or watershed. For instance, when a dam fails there may be significant, rapid inundation which can occur without warning. Public and private structures and infrastructure become vulnerable when they are located on lands susceptible to inundation and fluvial erosion.

Riverine Inundation Flooding:

The land area where inundation flooding occurs is known as the floodplain. During high water events, water flows out of the river bank and spreads out across its floodplain. FEMA defines the portion of the floodplain inundated by the 1% annual chance flood as the Special Flood Hazard Area (SFHA); the area where the National Flood Insurance Program (NFIP) floodplain management regulations must be enforced and where the mandatory purchase of flood insurance applies for federally-secured loans.

Inundation flooding on larger rivers and streams typically occurs slowly, over an extended period of time but can spread out over a large area of land. Due to the slower onset of inundation flooding on larger rivers, there is time for emergency management planning (e.g. evacuations, electricity shut-off considerations, etc.) to take

1 http://floodready.vermont.gov/RCFAQ#4

Table 24: National Weather Service Stream Gauge Status	
	Major Flooding
	Moderate Flooding
	Minor Flooding
	Near Flood Stage
	No Flooding

place. Though the inundation floodwaters are slower to hit, they often take time to recede as well, and exposure to water for an extended period of time can result in significant property damage. U.S. Geological Survey's (USGS) National Water Information System monitors real-time streamflow gaging stations in Vermont (Table 24).

Fluvial Erosion:

In Vermont, most flood-related damage is due to fluvial erosion. Erosion occur when the power of the flood (i.e. the depth and slope of the flow) exceeds the natural resistance of the river's bed and banks. Rivers that have been overly straightened or deepened may become highly erosive during floods, especially when the banks lack woody vegetation, or when the coarser river bed sediments have been removed. In areas where rivers are confined due to human activity and development, they have become steeper, straighter, and disconnected from their floodplains. The more trapped the river is, the greater power it will gain, which eventually results in a greater degree of damage to critical public infrastructure such as roads and stream-crossings, as well as homes, businesses, community buildings and other man-made structures built near rivers. Fluvial erosion is also increased downstream when all the eroded materials (i.e. sediment and debris) come to rest in a lower gradient reach, clog the channel, and cause the river to flow outside its banks. When severe enough, fluvial erosion can also be the cause of Landslides (see: Landslides). The land area that a river accesses to meander and overtop its banks to release flood energy without excessive erosion is known as the River Corridor.

Snowmobile bridge near Waterbury, VT flexes as debris and water rush past following Tropical Storm Irene
Photo Credit: www.mansfieldheliflight.com/flood

A river corridor includes the meander belt of a stream or river and a buffer of 50'. The River Corridor, as defined in Vermont statute, is:

> *the land area adjacent to a river that is required to accommodate the dimensions, slope, planform, and buffer of the naturally stable channel and that is necessary for the natural maintenance or natural restoration of a dynamic equilibrium condition, as that term is defined in section 1422 of this title, and for minimization of fluvial erosion hazards, as delineated by the Agency of Natural Resources in accordance with river corridor protection procedures[2].*

Vermont's River Corridor maps (Figure 27) delineate river corridors for larger streams and rivers, and standard setbacks for smaller, upland streams. The setbacks were determined by factoring in the same stable stream slope requirements used when delineating a river corridor using a meander centerline setback. These maps are located on the Vermont FloodReady[3] and Vermont Natural Resources Atlas[4] websites.

Severe damage to Vermont Route 4 in Killington, VT due to fluvial erosion during Tropical Storm Irene
Photo Credit: www.mansfieldheliflight.com/flood

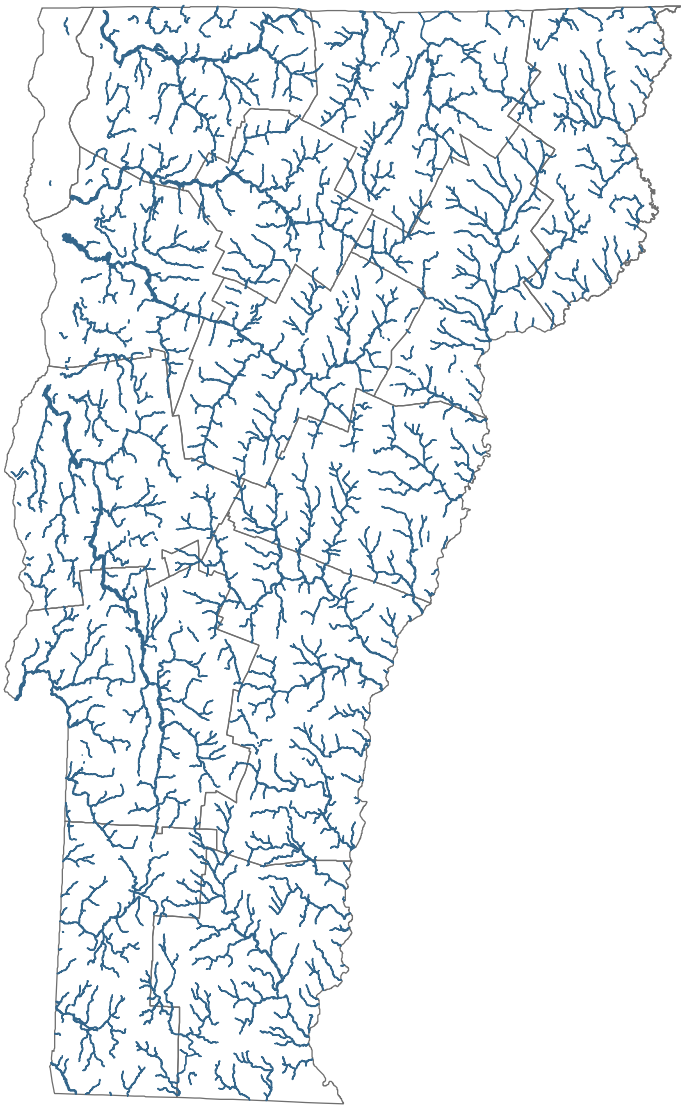


Figure 27: Vermont river corridor map (2015)
Data Source: http://geodata.vermont.gov/

2 https://legislature.vermont.gov/statutes/section/10/032/00752
3 http://floodready.vermont.gov/assessment/vt_floodready_atlas
4 https://anrmaps.vermont.gov/websites/anra5/

Channel adjustments with devastating consequences have frequently been documented wherein such adjustments are linked to historic channel management activities, floodplain encroachments, adjacent land use practices, and/or changes in watershed hydrology associated with conversion of land cover and drainage activities.

Vermont's landscape has historically contributed greatly to the widespread practice of the channelization of rivers and streams to maximize agricultural land uses and facilitate the development of transportation infrastructure. Channelization, in combination with widespread floodplain encroachment, has contributed significantly to the disconnection of as much as 70% of Vermont's rivers from their floodplains. In this unsustainable condition and when energized by flood events, catastrophic adjustments of the channel frequently occur, usually with consequent fluvial erosion damage to adjacent or nearby human investments.

Flash Flooding:

In addition to the inundation flooding and fluvial erosion dangers along rivers and lakes in Vermont, there are significant flash flood dangers near small streams and in alluvial fans. Alluvial fans are areas where streams transition between a steep mountain grade to gentler, flatter valleys below. Flash floods are likely to occur after a severe thunderstorm that produces a large amount of precipitation over a short amount of time. The precipitation falls so quickly that the soil is unable to absorb the water which results in surface runoff that collects in small, upstream tributaries, that then moves quickly downstream at a high velocity. The stream alterations described as increasing fluvial erosion may also exacerbate the effects of flash flooding. Mountainous areas such as Vermont are particularly prone to flash flooding due to the steep terrain. Damage from flooding includes land erosion, property damage, loss of crops, and even human life.

Floods are responsible for more deaths each year than any other hazard in the United States, with the majority being vehicle-related, as the power of moving water is usually underestimated. Flash floods have the power to knock a human off their feet with as little as 6" and move boulders, trees or even houses downstream. This mobile debris can then cause damage to infrastructure, plugging culverts or bridges, further exacerbating damage. Fortunately, in a flash flood, the water will recede quickly, but not before causing damage to properties and structures.

The National Weather Service (NWS) issues a Flash Flood Warning when there is a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within a short timeframe from the onset of heavy rain, or from a dam or levee failure, or water released from an ice jam[5].

Ice Jams:

Ice jams occur when warm temperatures and heavy rain cause snow to melt rapidly. Snowmelt combined with heavy rains can cause frozen rivers to swell, which breaks the ice layer on top of the river. The ice layer breaks into large chunks, which float downstream and pile up near narrow passages or other obstructions, such as bridges and dams. The water underneath the ice then looks for another means to pass, often resulting in road overtopping or damage to structures nearby.

Ice jams include those that form in the early winter as ice formation begins (freeze-up jams); those that form as a result of the breakup of ice covers (break-up jams); and those that contain elements of both (combination jams). Ice events can include ice jams, the formation of an ice cover that raises water levels upstream or decreases water levels downstream, or any other result of ice formation or break-up.

5 https://www.weather.gov/btv/wwa_reference

Vermont's northern latitude means a high likelihood of temperatures dropping sufficiently in the winter to allow freezing of most rivers. It is important to monitor the fluctuations on the State's rivers and potential for these events to occur with the thaws. Human settlement, development, and the associated infrastructure co-exist in proximity to rivers. Residences, buildings, or other infrastructure built within the floodplain will be susceptible to all flood types, including ice jams, especially as they have been identified as an increasingly dangerous hazard in Vermont.

The US. Army Corps of Engineers' Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire, has compiled ice jam information on a regional and national basis[6]. When necessary, VEM and other State mitigation partners contact the nearby USACE office for additional data regarding ice jams. Between 1785 and 2017, there have been 987 ice jams on 102 rivers at 308 locations, ranking Vermont 10th in the country based on number of events (not including the early 2018 ice jams noted in the History section below).

Dam Failure:

While a rare occurrence, dam failure and resulting flooding can be devastating and threaten life and property downstream of dams. Dam failure can occur not only during large storms and high flows, but also during normal, sunny day conditions. While the depths and extents of flooding caused by dam failure are most severe during storms when reservoir elevations and rivers are at their highest, the public is generally conscience of flooding under these conditions. For this reason, it is often the sunny day failure scenario, that occurs with no warning, that is most dangerous.

Dam failure is caused by the overtopping or structural failure of a dam resulting in a significant, rapid release of water, which can lead to flooding. Structural failure can be caused by many factors, such as internal soil erosion in earth embankment dams, sliding or overturning of concrete dams, gate failure, or caused by other means, such as deliberate sabotage.

Dams are classified according to their potential for causing loss of life and property damage in the area downstream of the dam if it were to fail using the general classification system: High Hazard, Significant Hazard, and Low hazard (Table 25). It is important to note that the hazard class is independent of the condition of a dam. Depending on the entity that regulates the dam, these definitions have minor but notable differences. In Vermont, dams are regulated by four distinct entities depending on the purpose and owner of the dam:

- Dams that are part of the production of power (i.e. hydropower) constructed before 1935 (with a few exceptions) are regulated by the State of Vermont Public Utility Commission (PUC). The PUC regulates approximately 25 dams, six of which are considered HIGH hazard and five of which are considered SIGNIFICANT hazard.
- Hydropower Dams constructed after 1935 (with a few exceptions) are regulated by the Federal Energy Regulatory Commission (FERC). FERC regulates approximately 80 dams, 18 of which are considered HIGH hazard and seven of which are considered SIGNFICANT hazard.
- Dams owned by the Federal Government (i.e. United States Army Corps of Engineers, USACE) are essentially self-regulated by that agency. Federal entities regulate approximately 5 HIGH hazard dams and one SIGNIFICANT Hazard dam.
- Non-federal, non-power dams are regulated by the Department of Environmental Conservation, (DEC). The DEC regulates approximately 41 HIGH Hazard Dams and 110 SIGNIFICANT hazard dams.

6 http://icejams.crrel.usace.army.mil/apex/f?p=524:1

Table 25: Dam Hazard Classification - PUC and DEC Regulated Dams		
Hazard Category	**Potential Loss of Life**	**Potential Economic Loss**
High	More than a few	Excessive (Extensive community, industry or agriculture)
Significant	Few	Appreciable (Notable agriculture, industry or structures)
Low	None expected	Minimal (Undeveloped to occasional structures or agriculture)

The classification systems for FERC and Federally-regulated dams are similar to that above, with the exception of that for the SIGNIFICANT hazard classification, their definition indicates no probable loss of human life, but economic loss, environmental damage, disruption of lifeline facilities, and impact to other concerns is anticipated. The difference in life safety relative to the SIGNIFICANT hazard classification should be noted.

Table 26 provides the general, targeted inspection schedule for formal inspections at dams based on the regulating body in Vermont. In general, the depth and extent of inspections vary based on the timing, condition, and risk associated with the dam being inspected.

Table 26: Dam Inspection Schedule - PUC and DEC Regulated Dams				
Hazard Category	**DEC***	**PUC**	**FERC**	**Federal**
High	Yearly	Every 5 years	Yearly	Yearly
Significant	Every 3 to 5 years	Every 10 years	Yearly	Yearly, Varies
Low	Every 5 to 10 years	None required	Every 3 years	Veries

**The DEC inspection program is currently voluntary and requires permission of the dam owner.*

Emergency Action Plans (EAPs) are pre-arranged plans developed by dam owners and emergency responders that serve to safeguard life and property in the event of a dam failure. General components of EAPs include: guidance for emergency detection and classification, notification flow charts, responsibilities and preparedness, and flood inundation maps, which are maps that depict the estimated extent, depth, and velocity of floods caused by simulated dam failures. The aforementioned regulatory agencies in Vermont generally require EAPs and are working towards EAP compliance.

The DEC is coordinating efforts to complete EAPs for all significant and high hazard dams within their jurisdiction, generally completing several per year funded through a dam safety grant from FEMA. Nearly all of the high hazard dams in DEC's jurisdiction currently have EAPs, but many are out of date. The Dam Safety Program is also in the process of developing new dam breach analyses,

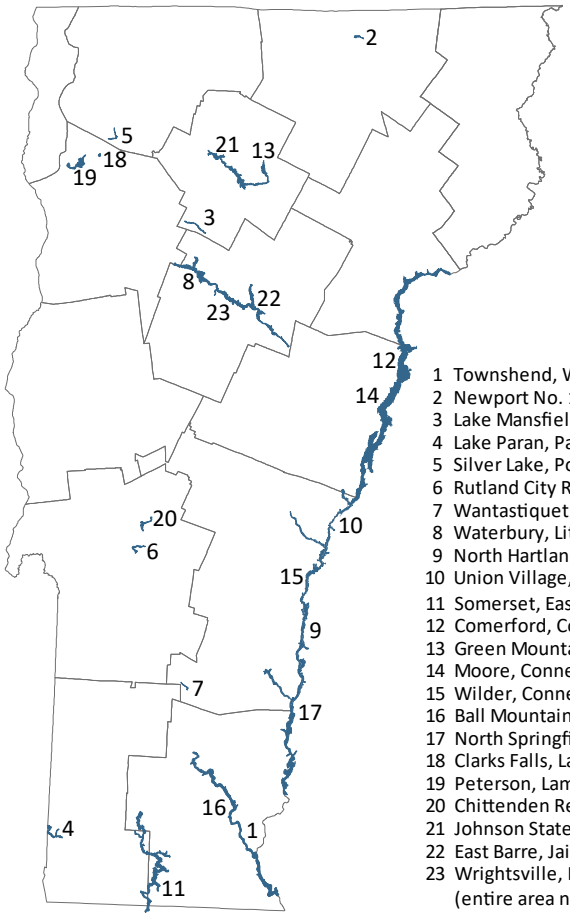


Figure 28: Vermont high-risk dam indundation areas for which there is full or partial* inundation mapping available (*Little River and Wrightsville)

Inundation maps do not account for compounding impacts.
Data Source: http://geodata.vermont.gov/

flood mapping, and EAPs for the three Winooski River Flood Control Dams (Waterbury, Wrightsville and East Barre), which are large, high hazard dams owned by the State.

In 2018, the Vermont State Legislature passed a law updating the existing regulation of dams, Statute 10 V.S.A. Chapter 43 which applies to the DEC and PUC. The purpose of the law is to serve to protect public safety and provide for the public good through the inventory, inspection, and evaluation of dams in the State. The law aims to provide a definition for a dam, update and modernize the State's dam inventory and give the DEC rulemaking authority for items such as exemptions, registration, hazard classifications, EAPs, inspections and design standards. These rules will be developed over the next several years.

Lake Inundation Flooding & Erosion:

The Lake Champlain Basin has a relatively wet climate, averaging approximately 37.5" of precipitation on an annual basis. As the topography within the basin is comprised of steep mountain slopes and narrow river valleys, floodwaters have access to very little flat area to spread out across and on which to be absorbed, leaving much of the excess water to be funneled directly towards Lake Champlain. The lake is considered to be at flood level once the elevation tops over 100' above sea level[7] (Table 27). FEMA's Base Flood Elevation (BFE) of Lake Champlain is 102'. The highest recorded level at the gage in Burlington was 103.27' on May 6, 2011.

Overall, 2011 was a record-breaking year for Lake Champlain water levels in May and September, as illustrated in Figure 29, which shows the maximum recorded lake level throughout the year with the 2011 lake level. It is worth noting that the published BFE and 2011 flood levels shown below are stillwater elevations and do not consider wave action. In 2011, wave action increased flood levels an additional 3-5', depending on location, causing significant flood damage for lakeshore property owners.

Table 27: National Weather Service Lake Champlain Flood Categories

Major Flood Stage:	101.5'
Moderate Flood Stage:	101'
Flood Stage:	100'
Action Stage:	99.9'

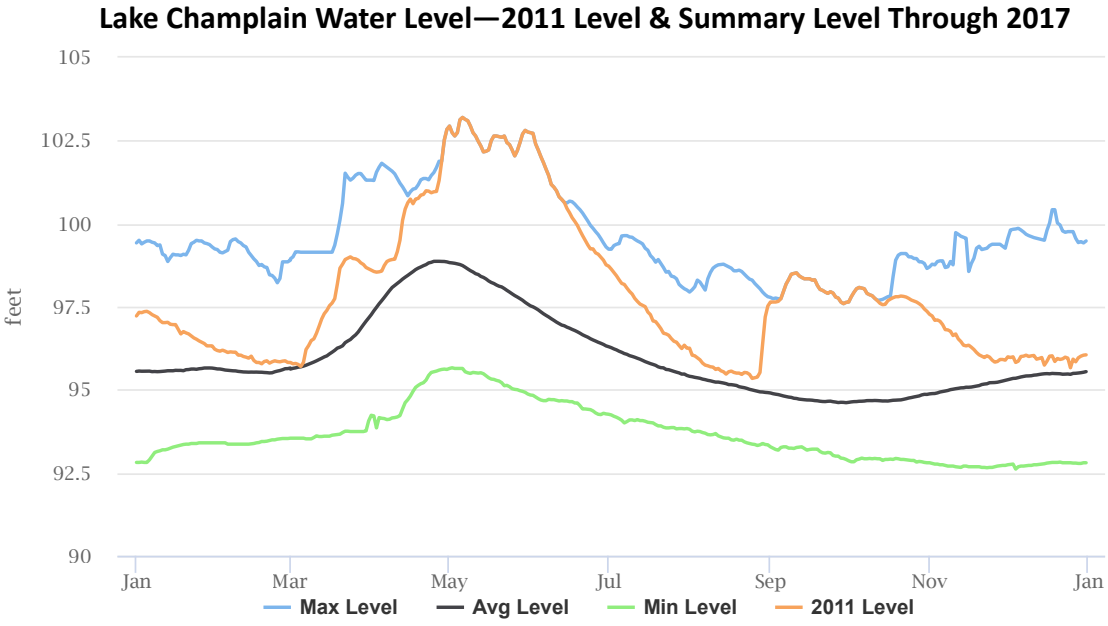


Figure 29: Lake Champlain water level—2011 level and summary level through 2017
Source: https://www.weather.gov/btv/lakeLevel?year=2011

7 http://www.lcbp.org/water-environment/water-quality/flooding/

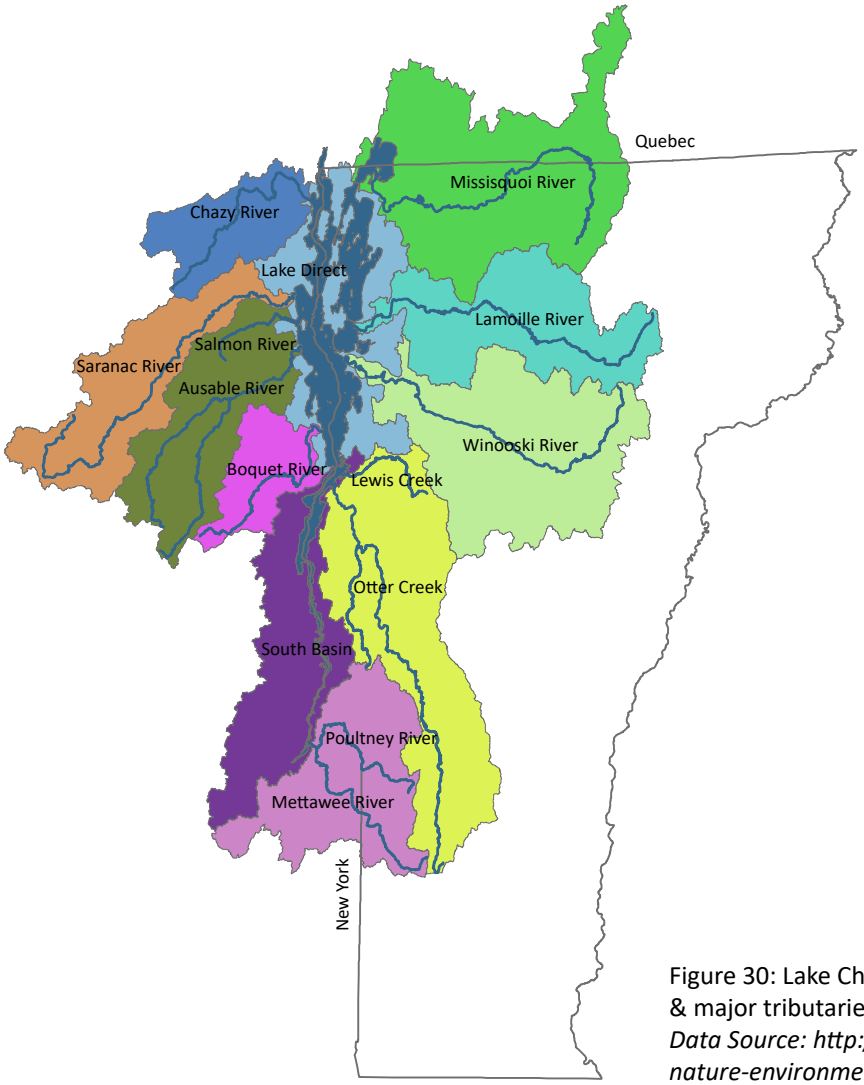


Figure 30: Lake Champlain sub-basins & major tributaries map
Data Source: http://atlas.lcbp.org/nature-environment/lake-champlain/

Inundation Flooding & Fluvial Erosion History

- **Rainfall Event, November 3, 1927:** This event was caused by nearly 10" of heavy rain from the remnants of a tropical storm that fell on frozen ground. The flood claimed 84 lives, more than 1,000 bridges, and hundreds of miles railroads and roads. Over 600 farms and businesses were destroyed. Flooding in the White River valley was particularly violent, with the river flowing at an estimated 120,000 cubic feet per second on the morning of the November 4, 1927.
- **Rainfall & Snowmelt Event, March 13–19, 1936:** Historic flood damage in Vermont occurred in the hamlet of Gaysville, which had a large mill, church, stores, and many residences destroyed during the flood. The worst widespread spring flooding occurred when slow-moving storms with warm air combined to drop around 8" of rain on a late winter snow pack that had a water equivalent of 10".
- **Rainfall Event, September 21, 1938:** A very fast-moving hurricane (known as the "Long Island Express") hit Vermont in the early evening causing severe flooding as a result of more than 4" of rain that accompanied the storm. Buildings were lost, power lines downed, and many trees felled.
- **Rainfall Event, June 28-30, 1973:** Widespread flood when up to 6" of rain fell. A Presidential disaster was declared for the entire State and damage was estimated at $64 million (in 1973 dollars).
- **Rainfall Event, August 9-10, 1976 (DR-518):** Remnants of Hurricane Belle caused significant rain and flooding in portions of Vermont, resulting in $100 million in damages (in 1976 dollars) and 10 associated deaths[8].

8 http://www.trorc.org/wp/wp-content/uploads/2013/08/Appendix_I_Flood-Events-in-the-past-100-years.pdf

- **Ice Jam, Montpelier, March 11, 1992 (DR-938):** Approximated a 100-year event, resulting in nearly $5 million (nominal dollars) in damages to local roads, buildings, private businesses, and homes. This disaster effectively shut down many functions of State government and the State legislature for several days, resulting in indirect losses for which no existing data has been generated. The inundation associated with this jam was of very short duration (less than 12 hours); otherwise, disruption of services could have represented a much more serious economic loss.
- **Rainfall Event, June 17–August 17, 1998 (DR-1228):** Intense summer thunderstorm flood when torrential rain deluged the Warren, Randolph, and Bradford areas. A record amount of precipitation fell in Vermont that summer, with Burlington setting a new annual rainfall record of 50.42".
- **Rainfall from Tropical Storm Floyd, September 16, 1999 (DR-1307):** Flooding and wind damage in parts of Vermont.
- **Rainfall Flash Flood Event, July 14-16, 2000 (DR-1336):** 2-4" of widespread rain fell, with locally higher amounts across higher terrain. Specific amounts included 3" in Bennington and 5" in Wardsboro. This rain produced enough runoff to cause the Battenkill to exceed the 6' flood stage by about a foot at Arlington. The Deerfield River rose 6' above unofficial flood stage in Wilmington. Several roads were reported under water. Thunderstorm rainfall, as well as the earlier rainstorm, dumped in excess of 8" in Newfane. In Shaftsbury, County Route 67 was washed out. U.S. Route 7 was closed due to flooding and rockslides. In Windham County, a five-mile stretch of State Route 30 was closed due to flooding and residents were evacuated. Street flooding was reported at Brattleboro.
- **Snowmelt, December 16-18, 2000 (DR-1358):** Despite the fact that DR-1358 (2000) is officially listed as a winter storm, and DR-1101 (1996) occurred in January, damages in both cases were primarily flood-related, particularly for DR-1101, which was flooding associated with rain and a mid-winter thaw that melted a 30" snow pack in two and a half days.
- **Rainfall Flash Flood Event, July 24-August 13, 2003 (DR-1488):** July 24 saw steady rain during the morning hours, with locally heavy rain associated with thunderstorms later in the day. Scattered showers and thunderstorms erupted during the afternoon hours on August 3. A slow moving storm over Windham County produced estimated rainfalls of 3-4" in about four hours, causing flash flooding. Around $1 million in estimated damages.
- **Rainfall Event, August 12, 2004 (DR-1559):** A frontal boundary from northern Vermont southwest across eastern New York resulted in showers and thunderstorms with very heavy rainfall. Flash flooding in Addison County on August 28 resulted in nearly $2 million of estimated damages due to thunderstorms accompanied by torrential rainfall with 2-5" of rainfall falling on already saturated soil. Numerous smaller roads were flooded or washed out, many homes reported flooded basements.
- **Rainfall Flash Flood Event, May 19, 2006:** In May 2006, Burlington received a record amount of rainfall, almost an inch more than the previous record, set in 1983. Rainfall amounts included: the NWS Burlington office in South Burlington with 3.48", Jericho at 3.75" and Mount Mansfield with 4.79".
- **Rainfall Flash Flood Event, June 26, 2006:** Flooding caused extensive damage to the small town of Athens, Vermont. This flooding was caused by persistent rainfall for the entire month of June, exacerbated by excessive rain caused by one storm system passing through. The damage was mostly suffered in roadways because of flash flooding, which turned a normally placid body of water, Bull Creek, into a raging flow. There were reports of a mudslide in Dummerston, which also caused damage to roadways. The State Emergency Operations Center (SEOC) was activated.
- **Ice Jam, March 15, 2007:** Montpelier experienced a significant ice jam event on the Dog River, resulting in extensive planning and preparations for possible flooding. A significant ice jam had been in place on the Winooski in Montpelier since January 20th, causing the Dog River jam. In early 2007, ice jams also caused problems in the towns of Woodstock and Chelsea, including localized road flooding in some locations.

- **Rainfall Flash Flood Event, July 9, 2007 (DR-1715):** Localized heavy rainfall exceeded 3" within two hours with some localized storm totals approaching 6", causing many roads to be flooding or washed out and an estimated $4 million of property damage.
- **Rainfall Flash Flood Event, June 14, 2008 (DR-1778):** Localized heavy rainfall up to 7" occurred in Ripton (Addison County) and 3-5" in Rutland with an estimated $2 million worth of damage in Rutland County, predominately in downtown Rutland.
- **Rainfall Event, July 24, 2008 (DR-1790):** Widespread rainfall of 1-2" occurred during the afternoon and evening of July 24th with localized amounts that exceeded 3", causing flooding in Washington, Lamoille, Orleans and Caledonia counties.
- **Ice Jams, January 25-February 1, 2010:** Ice jams were reported in Montpelier, Ferrisburg, Shelburne, Berkshire and Stratford, accompanied by minor localized flooding in some locations.
- **Ice Jam, March 6, 2011:** An ice jam formed on the Mad River caused damage to roads and threatened flooding to the area near Moretown and several other towns following heavy rainfall on March 5-6.
- **Snowmelt & Rainfall Events, April and May, 2011 (DR-1995, DR-4043):** 2011 was a record year for flooding in the State of Vermont. A total of four disaster declarations were issued, all attributed to flooding and fluvial erosion. The first floods occurred over a two-week period in April and May. These floods impacted the northern half of the State, including the counties of Addison, Chittenden, Essex, Franklin, Grand Isle, Lamoille, Orleans, Washington, and Windham. The damage totaled over $1.8 million in FEMA assistance. Heavy rains in late March/early April on top of a deep late season snowpack resulted in riverine flooding and sent Lake Champlain well over the 500-year flood elevation. Additional spring runoff events resulted in Lake Champlain being above base flood elevation for more than a month. High lake levels coupled with wind driven waves in excess of 3' resulted in major flood damages for shoreline communities. May 6, 2011 was the highest ever recorded level of Lake Champlain in Burlington at 103.27', one of only two recorded levels above major flood stage (101.5ft).
- **Snowmelt & Rainfall Event, May 26, 2011 (DR-4001):** Although not as severe as floods that occurred earlier in the month, multiple counties were included in the declaration, including Caledonia, Essex, Orange, and Washington counties. The river gage on the Winooski in Montpelier crested at 19.05' (major flood stage is 17.5'), the second highest on record (1927 flood: 27.10').
- **Rainfall from Tropical Storm Irene, August 28, 2011 (DR-4022):** Severe damage statewide from record-breaking rainfall associated with Tropical Storm Irene. The storm impacted the entire State, with Public Assistance designations for every county and Individual Assistance designations for 12 of 14 counties. The highest recorded rainfall during this event was on Mendon Mountain, totaling over 11", making it the greatest single-day rainfall in Vermont's recorded history. Given the significance of this event on the State, more details are below.
- **Rainfall Flash Flood Event, May 29, 2012 (DR-4066):** Severe storms, tornadoes, and flooding occurred on May 29, 2012, impacting Addison, Lamoille, and Orleans counties. Over $1 million worth of damages estimated. Some of these thunderstorms deposited up to 2" of rainfall in portions of north-central and northeast Vermont. The end result was flash flooding in portions of north-central, northeast Vermont and Addison county with estimated storm totals of 3-5".
- **Rainfall Flash Flood Event, May 22, 2013 (DR-4120):** Heavy rain event caused flash flooding, predominately in Chittenden County, washing out bridges, culverts, and roads. Over $2 million worth of damages estimated.
- **Rainfall Flash Flood Event, June 25-July 10, 2013 (DR-4140):** Thunderstorms produced a quick 1-3" of heavy rain in a half hour, causing flash flooding across the State, with over $6 million worth of damages estimated. The most significant impacts were in Windsor and Chittenden Counties.
- **Snowmelt & Rainfall Event, April 15, 2014 (DR-4178):** A combination of heavy rain and snowmelt from late-season snowpack caused flooding across northern and central Vermont with nearly $2 million in estimated damages. 4-6" was released from the snowpack.

- **Rainfall Flash Flood Event, June 11, 2015 (DR-4232):** Thunderstorms with 1-2" of heavy rainfall caused flash flooding in Chittenden and Washington Counties with over $1 million in damages.
- **Rainfall Flash Flood Event, June 29-July 1, 2017 (DR-4330):** Heavy rainfall of 3-4" over several days caused pre-saturated soils across much of central Vermont. During the afternoon of July 1, a series of heavy rain showers and thunderstorms moved in delivering very heavy localized rainfall that caused some scattered flash flooding, with an estimated over $8 million in damages.
- **Ice Jam, January 13, 2018:** Swanton and Johnson as well as several smaller jams formed across Vermont.

Tropical Storm Irene, August 28, 2011 (DR-4022), Continued:

Inundation flooding and fluvial erosion caused by Tropical Storm Irene was catastrophic, destroying property, infrastructure and taking lives.

After a very wet spring, which lead to multiple disaster declarations and saturated soils, Vermonters watched Hurricane Irene move up the Eastern Seaboard of the United States with great apprehension. The hurricane turned into a tropical storm as it made landfall in New York and Connecticut, shortly before moving northward towards Vermont. As the tropical storm moved into the State, dropping as much as 11" of rain (Figure 31), nearly every river and stream flooded and experienced catastrophic fluvial erosion. Extensive transportation damage was reported, with nearly every State highway affected and many local roads washed away. In Vermont, seven people died and many were injured from the floods.

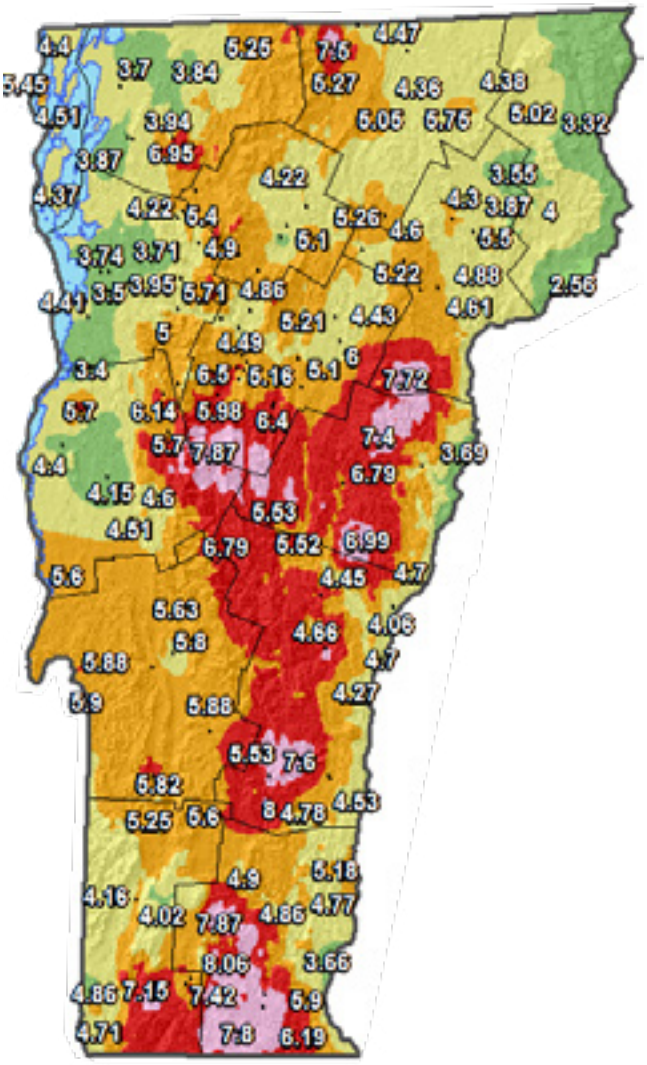


Figure 31: Tropical Storm Irene total rainfall in inches map (August 27-28, 2011)
Source: National Weather Service

During Tropical Storm Irene, flooding originated in headwater streams draining the flanks of the Green Mountains, where rainfall totals were highest. As these high-gradient headwater streams filled quickly, the water rushed down the hillsides and inundated the narrow valleys. These high-gradient streams with minimal floodplain attenuation rose and peaked rapidly in a matter of a few hours, and then receded nearly as quickly. By contrast, larger rivers of lower gradient with wide floodplains and contiguous wetlands were able to attenuate the storm flows. Accordingly, these rivers peaked later and receded more slowly.

Below is a brief look at some of the effects of Tropical Storm Irene, according to the Agency of Natural Resources, which explains the impacts from this particular event and highlights how Vermont is vulnerable during a significant precipitation event.

Transportation:

- Roads: >2500 miles of road, ~480 bridges and 960 culverts damaged. Over $350 million in estimated repairs.
- Railroad: >200 miles of rail and 6 bridges in the State-owned rail system damaged, costing the State an estimated $21.5 million.

Emergency Response:

- Main offices for both VEM and ANR were flooded in Waterbury; disaster response headquarters had to be relocated.
- Extensive road damage meant some areas were initially hard to access; 13 communities were without any passable roads leading in or out of town.

Buildings and Infrastructure:

- Power outages for ~158,800 customers.
- 7,215 individuals and families registered for FEMA assistance (by 11/15/11); >$45.9 million in grants and low interest loans for Vermont residents, businesses, and nonprofit organizations were approved by FEMA and the U.S. Small Business Administration; also, nearly $15 million loaned to businesses and farms by Vermont Economic Development Authority.
- FEMA completed nearly 5,000 property inspections to document damage; ~1,500 residences had significant damage (433 of these residences were mobile homes) and at least 1,405 households were temporarily or permanently displaced.
- Municipal infrastructure (including transportation) required an estimated $140 million in FEMA reimbursements, with $2 million in PA dollars obligated for Tropical Storm Irene as of 12/6/11.
- Waterbury State Office Complex, R.A LaRosa Agriculture and Environmental Laboratory, and Vermont State Hospital severely damaged in flooding, displacing ~1,500 employees; costs to rebuild and upgrade the complex were nearly $130 million.

Public Health and Safety:

- American Red Cross set up 13 emergency shelters and distributed ~16,000 meals, plus thousands of water bottles.
- A food safety advisory was released for any food touched by floodwaters.

Water Supply:

- About 30 public water systems issued Boil Water Notices; in many cases, broken pipes lowered a system's water pressure, which increased the likelihood of harmful contaminants mixing with treated drinking water. Drinking water advisory were issued for wells submerged by floodwater.
- An estimated 16,590 people in Vermont were affected by Tropical Storm Irene-related Boil Water Notices

Hazardous Waste and Fuel Spills:

- Potentially hazardous waste mobilized along rivers, contaminating floodwaters and sediment and soil deposits.
- In the first week after Tropical Storm Irene, hazardous spills reported to State officials increased over

routine levels by a factor of 14; many spills were related to home fuel tank connections breaking as floodwaters moved tanks.
- Both U.S. Environmental Protection Agency (EPA) and Vermont Department of Environmental Conservation (DEC) investigated and assessed hundreds of Irene-related spills; oil-water separators were used to process roughly 300,000 gallons of contaminated waters near the Waterbury State Office Complex.
- Over $2 million in total costs have been incurred to the State to clean up aboveground storage tank oil spills.

Wastewater Treatment:

- Seventeen municipal wastewater treatment facilities (WWTFs) reported compromised operations, with issues ranging from pump station overflows to incomplete processing of sewage (no structural damages, but damages relating to mechanical, electrical, and debris accumulation problems). Most problems were resolved within 24 hours and the vast majority within one week; estimated discharge of partially unprocessed or raw sewage is 10 million gallons during this period.
- On-site septic systems around the State were also damaged by high groundwater levels and river or stream erosion. In the two months following Irene, State officials tallied 17 septic system failures.

Solid Waste Disposal:

- Vermont landfills received an estimated 32,000–42,000 tons of storm-related waste during the months that followed Irene.
- Household hazardous waste collections around the State amassed an estimated 4,385 gallons and 8,464 units* of waste, with ~$82,000 cost incurred (*units refer to disposed items and range from small bottles to five-gallon buckets of material).

Forests:

- High flows and saturated ground conditions undermined tree roots, and floating debris injured tree stems. Brief duration of standing water at most locations prevented further near-term tree damage; however, great amounts of accumulated sediment and debris in some streamside forests or establishment of invasive plants may inhibit tree growth over time.
- Aerial surveys found 9,213 acres with trees exhibiting flood damage symptoms from both spring and Tropical Storm Irene-related flooding.
- Green Mountain National Forest reported multiple trail, recreation site, and road closures.

Agriculture:

- Farm fields and barns were washed out or covered with flood sediments and debris; more than 450 farms filed Farm Loss claims with the U.S. Department of Agriculture (USDA), and roughly 20,000 acres of farmland were affected.
- Food advisories forced farmers to throw away food crops that may have been contaminated by floodwaters. Estimated value of crop losses and damage was >$10 million dollars statewide.
- Producers reported more than 1,000 acres of sugar bush damaged by winds.

Water Resources:

- Intense flooding occurred in at least 10 of Vermont's 17 major river basins, demonstrating record or near record flood crest levels along rivers.
- Otter Creek gage in Center Rutland showed the highest flood crest since the gage began operating 83 years ago—9.21' above flood stage. Mad River gage in Moretown and White River gage in West Hartford both showed second highest flood crests on record – 12.1' and 10.4' above flood stage, respectively.
- Nine stream gaging stations in Vermont recorded peak flows estimated to have a 1% or less chance of occurring or being exceeded in any given year.
- Some river locations appeared relatively unscathed, while others underwent catastrophic channel enlargement, deposition, and relocation; pre-Irene geomorphic studies of many Vermont rivers probably flagged some of these damaged areas as being susceptible to channel adjustment.
- In-stream channel work and gravel removal occurred in multiple locations during Tropical Storm Irene recovery period (largely in the 2-3 months after the flood); in some cases, work occurred without official authorization.

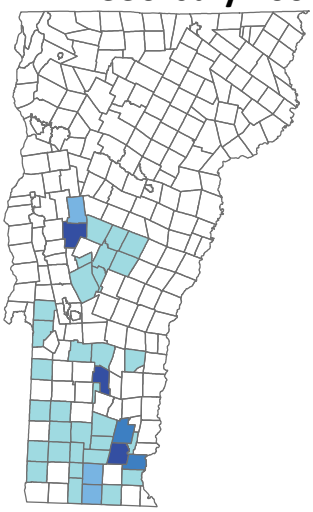
Aquatic Life and Habitat:

- In many locations, daily turbidity of waters (related to in-stream work) and habitat disruption may stress fish and macroinvertebrates (insects, snails, mussels, crayfish, etc.); extreme scour from powerful floodwaters likely reduced total numbers of fish and macroinvertebrates in some rivers, and species composition of fish and macroinvertebrates may shift to species that more readily withstand these stresses. For example, State fish biologists studied wild trout populations in the Mad and Dog River watersheds both before and after major Tropical Storm Irene-related flooding. After the flood, wild trout populations in studied streams were reduced to 33-58% of pre-flood levels.
- Fish and macroinvertebrate populations have a long history of surviving floods when quality stream habitat is available, and reduced numbers are usually temporary, but an increase in flood return rate due to changing climate may have long-term impacts. In addition, where habitat is compromised (due to historic channelization practices, encroachment, or post-Irene channel remediation efforts such as streambed excavation and fallen tree removal), fish populations may be affected over a longer term, depending on how quickly natural stream processes can re-establish habitat features.
- Increased algae growth with ongoing influx of river silts (elevating available nutrient levels).
- Mussel populations (including some rare, threatened, or endangered species) were harmed as sand and silt deposition and bank collapse buried and suffocated individuals.
- Japanese knotweed, an invasive plant that spreads by sprouting from broken plant rhizomes, has been spread with flood debris, threatening riparian forests, future bank stability, and agricultural fields.

Mobile Home Parks:

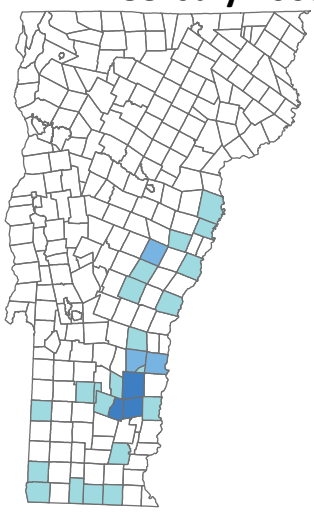
- Mobile homes suffered disproportionately in Irene; mobile homes comprise 15% of the total residences damaged while only accounting for 7% of Vermont's total housing stock.
- 17 mobile home park communities experienced some level of flooding during Irene, with 14 of those parks having at least 1 home destroyed by floodwaters.
- More than 130 mobile homes were completely destroyed.

DR-1336: July 2001



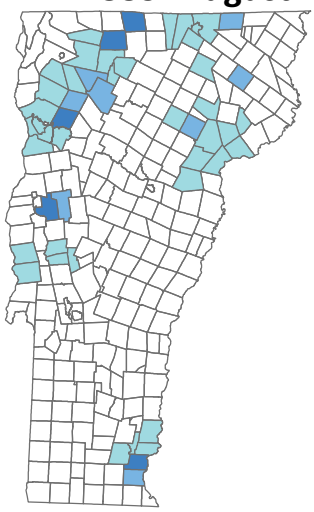
Total: $2,363,000

DR-1488: July 2003



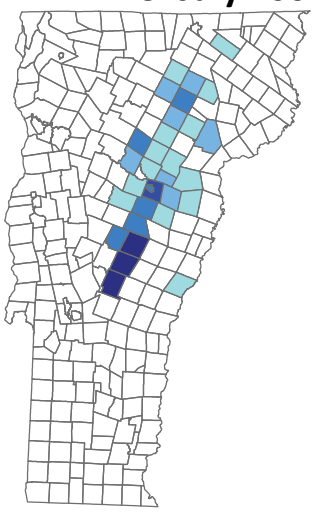
Total: $916,000

DR-1559: August 2004



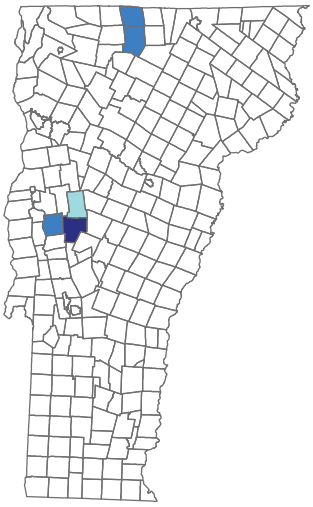
Total: $2,240,000

DR-1715: July 2007



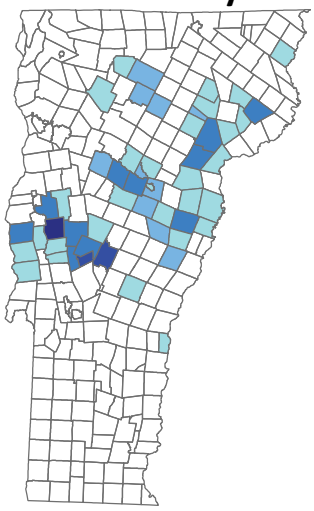
Total: $4,703,000

DR-1778: June 2008



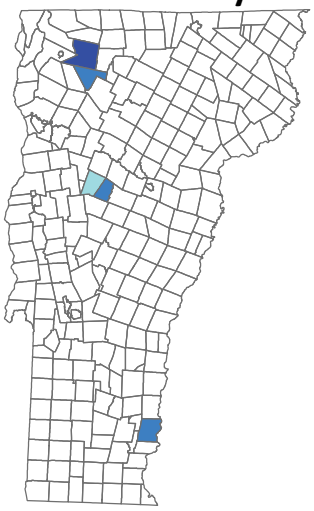
Total: $1,087,000

DR-1790: July 2008



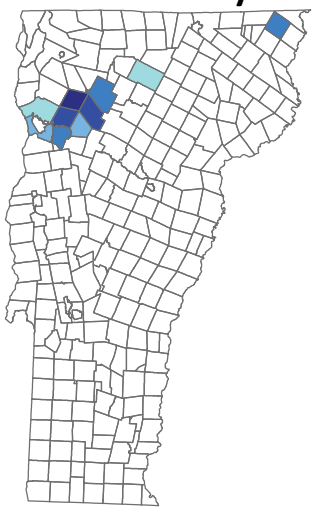
Total: $4,571,000

DR-4043: May 2011



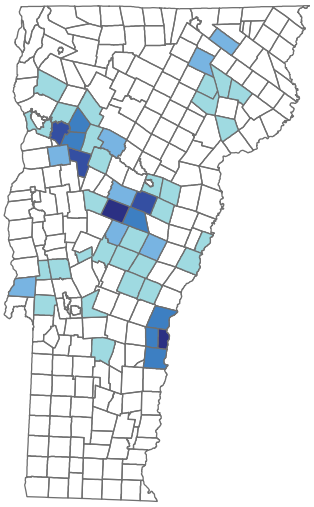
Total: $946,000

DR-4120: May 2013



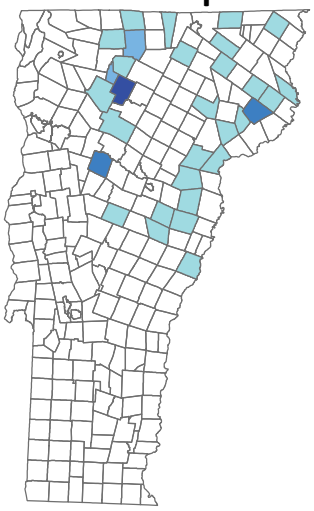
Total: $1,915,000

DR-4140: June 2013



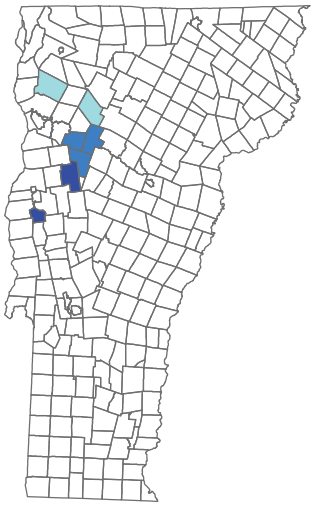
Total: $5,619,000

DR-4178: April 2014



Total: $1,824,000

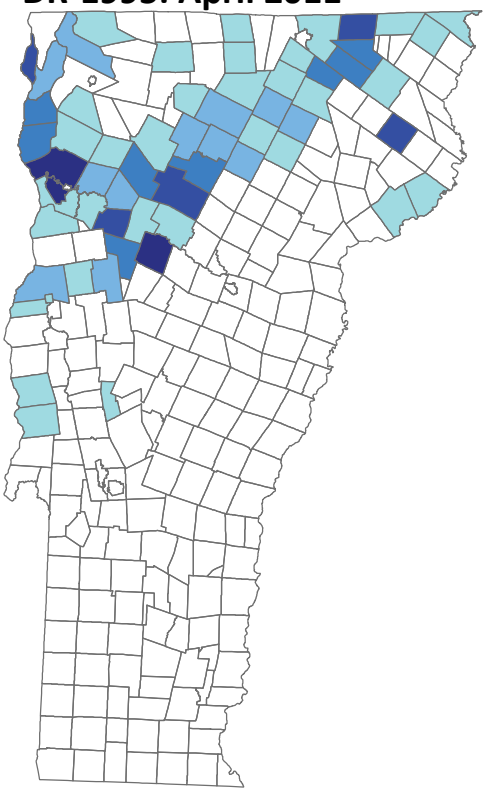
DR-4232: June 2015



Total: $1,227,000

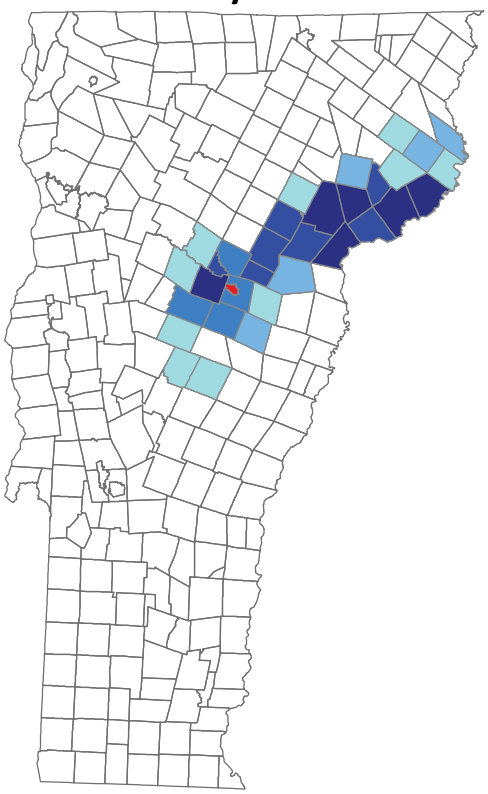
≤ $50,000 | $50,001 - $100,000 | $100,001 - $250,000 | $250,001 - $500,000 | $500,001 - $1,000,000

DR-1995: April 2011



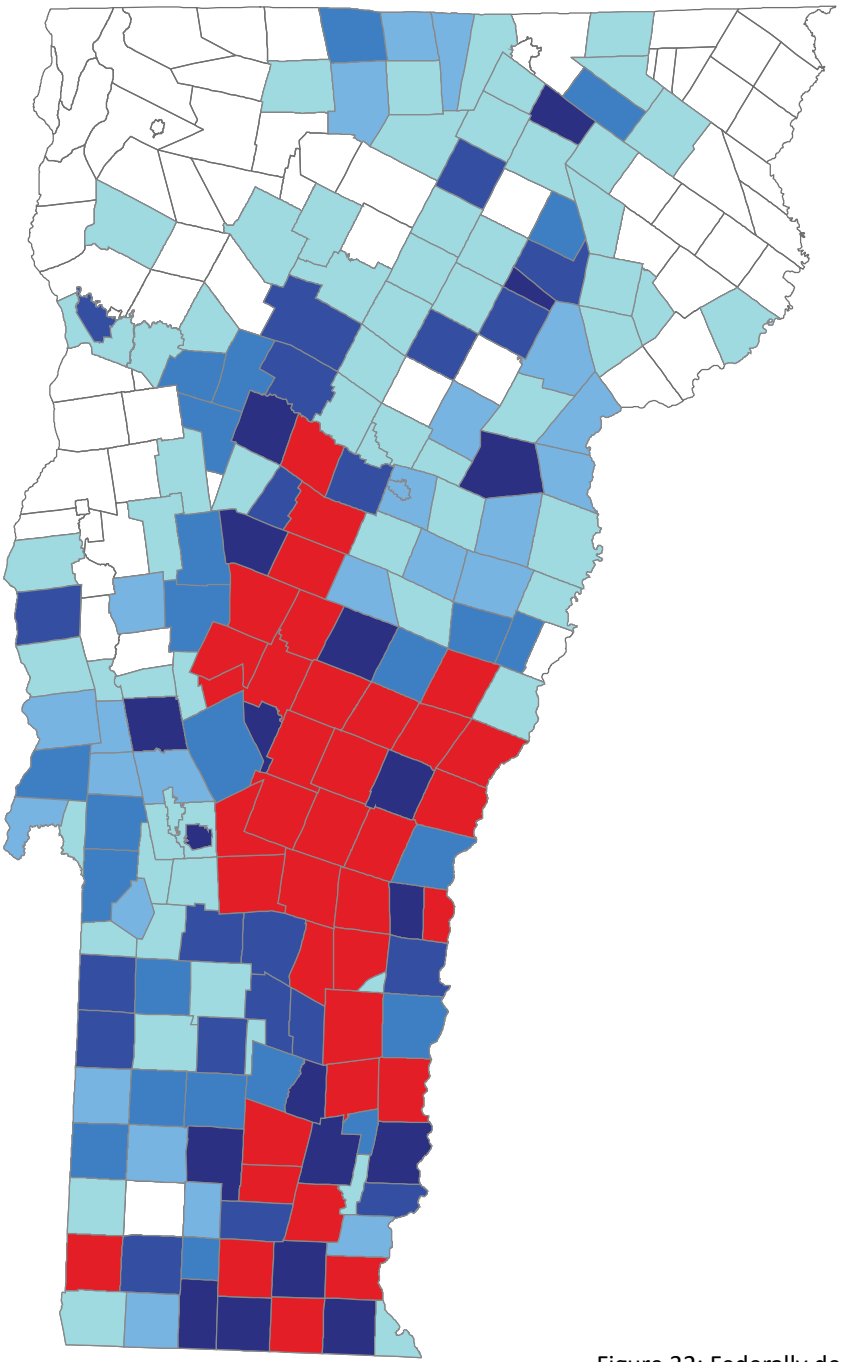
Total: $10,477,000

DR-4001: July 2011



Total: $10,674,000

DR-4022: Tropical Storm Irene, September 2011



Total: $210,461,000

Figure 32: Federally declared flooding disaster public assistance expenditure by municipality (2000-2016)
Data Source: www.fema.gov/openfema

≤ $50,000 | $50,001 - $100,000 | $100,001 - $250,000 | $250,001 - $500,000 | $500,001 - $1,000,000 | ≥ $1,000,001

Inundation Flooding & Fluvial Erosion Trends & Vulnerability

According to the 2014 National Climate Assessment, the average annual precipitation in the United States has increased by approximately 5% (Figures 33 & 34). More specifically, relative to the period from 1901-1960, precipitation in the northeastern region of the country has increased by 8% since 1991[9]. The Assessment goes on to note that the northern U.S. is projected to experience above average precipitation in the winter and spring, with even wetter conditions expected under a high greenhouse gas emissions scenario. In addition to higher annual precipitation in both the observed record and projected models, the northeastern United States is also projected to experience more frequent, heavier rainfall events. Since 1991, the incidence of these heavy precipitation events has been 30% above average[10]. In Vermont, average annual precipitation has risen 0.7" per decade since 1895 and 1.5" per decade since 1960[11], suggesting an increasing trend in increased precipitation (Figure 36).

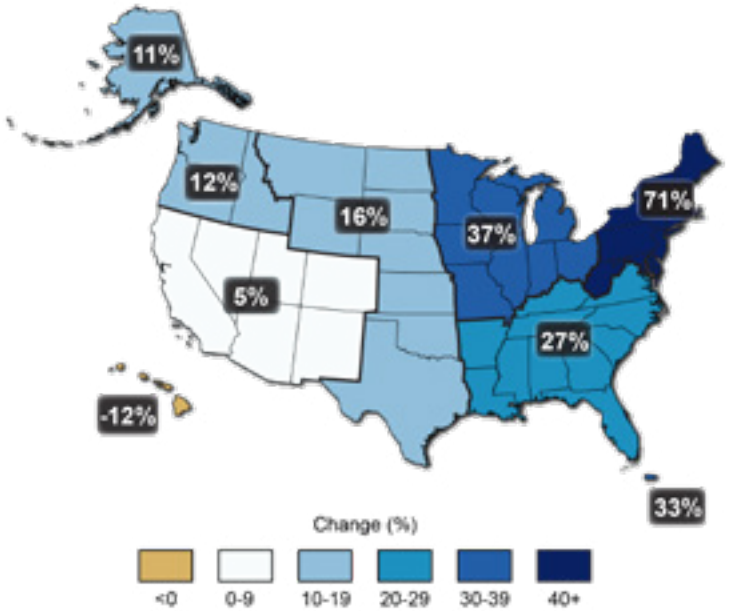


Figure 33: Observed U.S. percent increases in the amount of precipitation falling during very heavy events (defined as the heaviest 1% of all daily events) (1958 to 2012)
Source: https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing

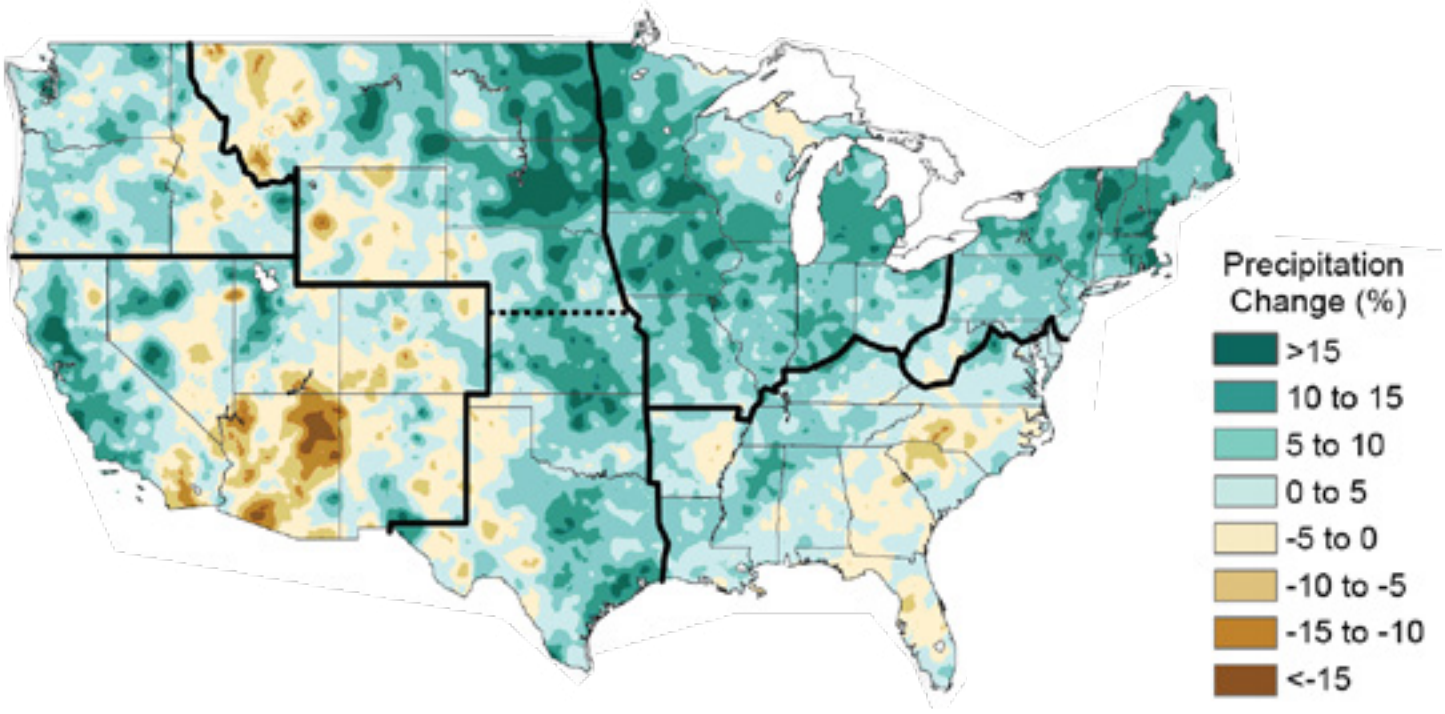


Figure 34: Observed U.S. precipitation change map (1991-2012)
Source: https://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change

9 https://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change
10 https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing
11 http://climatechange.vermont.gov/our-changing-climate/dashboard/more-annual-precipitation

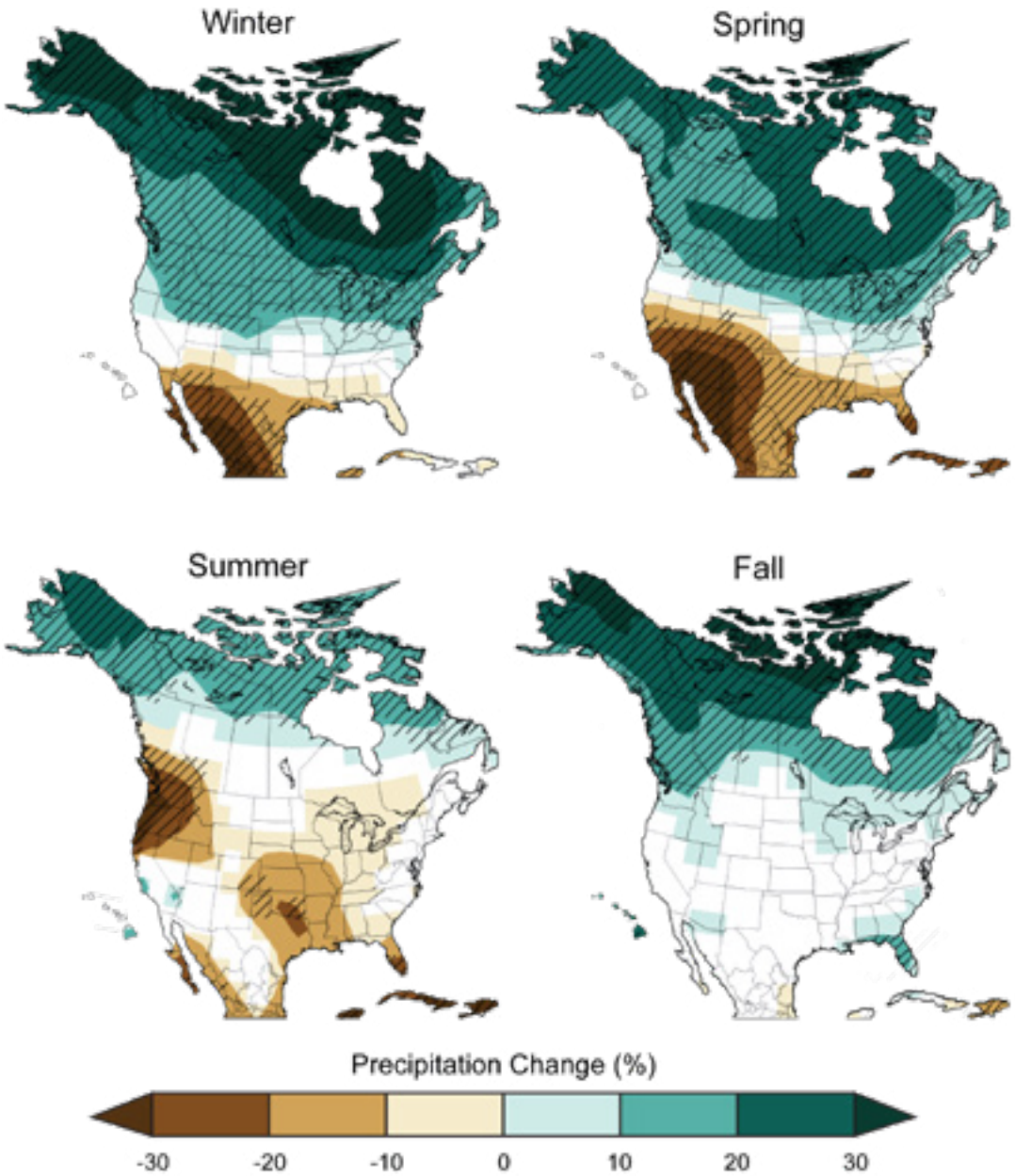


Figure 35: Projected U.S. precipitation change by season, higher emissions scenario (A2)
Source: https://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change

The impacts of both inundation flooding and fluvial erosion are typically far-reaching, disrupting communities by causing damage to the built environment, as well as local and regional economies and ecosystems. Impacts to human life are typically non-fatal, but financial impacts to individuals and families affected by flooding can be significant. Consequently, the State's vulnerabilities to erosion and flooding are numerous.

The anticipated increases in both frequency and magnitude of precipitation in Vermont will lead to alterations of hydrology and water availability. Increased flood inundation, fluvial erosion, and subsequent landslide hazards will result in impacts to ecological and geomorphic integrity of the State's river/floodplain systems, and to the built environment. Vermont's historic settlement pattern, in association with the widespread channelization of rivers and loss of functioning floodplains due to encroachments and fill, make Vermont particularly vulnerable to climate change-related increases in flood frequency and magnitude. Moreover,

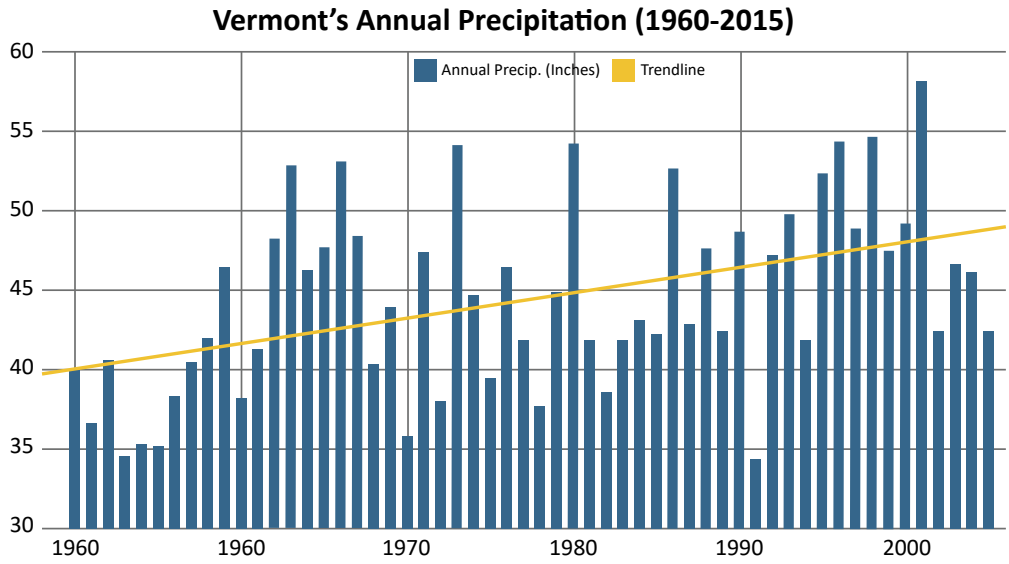


Figure 36: Vermont's annual precipitation (1960-2015)
Source: climatechange.vermont.gov

increases in frequency of periodic drought (see: Drought) will not only lead to greater demand for new and more reliable water supplies, but will also reduce the ability of soils to quickly absorb floodwaters, thereby exacerbating flood-related impacts.

Fluvial Erosion Vulnerability:

Though all areas of Vermont have the potential to suffer equally from fluvial erosion impacts, some have suffered more than others simply because of the location of storm tracks and significant rainfall. Many storm events impact Vermont from southwest to the Northeast.

Transportation infrastructure and agricultural property are the most vulnerable types of human investment affected by fluvial erosion hazards. Residential, commercial, utility infrastructure and municipal properties are also often vulnerable. Because many of Vermont's historic towns and villages were built along the river for trade and energy purposes, these locations are also at risk of fluvial erosion within the river corridor.

Worse off are those locations that have historically channelized streams in an attempt to keep the water away from valued lands and the built environment. These changes in watershed hydrology significantly influence fluvial stability, preventing streams from meandering, thereby increasing stream flow velocities and worsening erosion. Watershed-scale hydrologic changes have been observed in Vermont as a localized phenomenon, most notably in the Moon Brook in Rutland, Stevens Brook in St. Albans City, Morehouse Brook in Winooski, and Centennial Brook and Bartlett Brook in South

Extensive erosion damaging a home along Route 11 outside of Chester, VT.
Photo Credit: www.mansfieldheliflight.com/flood/

Burlington. This channelization trend is also observed in small, rural subwatersheds where clear-cutting of a large percentage of the watershed land area has occurred. More extensive, regional channelization with which extensive flood damages have been associated include the White River, West Branch of the Little River, Mad River, Huntington River, Great Brook, Williams River, and North Branch of the Deerfield River. When human investments and land use expectations include all the land in the valley up to the river banks, there results extreme public interest in maintaining this unsustainable morphological condition despite its great cost and consequential hazard to public safety.

Stream geomorphic assessments and a fluvial geomorphic database maintained by the Agency of Natural Resources (ANR) have identified main stem rivers often channelized from 60-95% of their lengths. This database is mapped on the ANR website for use by the public for planning and project development[12].

The Vermont Agency of Transportation (VTrans) maintains a list of "scour-critical" stream crossing structures endangered by streambed scour. The 2015 VTrans Hydraulics Manual[13] addresses channel stability and scouring at bridges as a primary consideration given the consequences of bridge failure, and a 2017 paper detailing a VTrans scour project notes that scour is the leading cause of bridge failure in the United States, with hydraulic/scour-caused damages accounting for 52% of bridge failures[14]. The paper identifies only 815 of the over 4,000 hydraulic bridges have a hydraulic and scour report on file, with approximately 25% of the 2,249 inspected bridges receiving a scour critical rating, using the Federal Highway Administration's (FHWA) National Bridge Inventory coding guide. Should the remaining 1,750+ bridges that have yet to receive an inspected be included in this inventory, it is the assumption of VTrans hydraulic staff that the number of scour critical bridges would increase. As VTrans continues to inspect bridges and identify those that are scour critical, the State will have a better understanding of where its infrastructural vulnerabilities to fluvial erosion are located.

Many other bridges and culverts are endangered by outflanking or debris jams or channel adjustment processes not associated with the structures themselves. Again, there is no specific geographic pattern of distribution; these problems exist uniformly throughout Vermont.

Often, fluvial erosion can lead to more significant slope failures, resulting in costly repairs and mitigation measures for the built environment. In addition to the acquisition and demolition of several properties across the State following Irene-related erosion, VTrans estimates spending approximately $5.4 million annually on erosion and slope failure projects (see: Landslides).

Significant scour along the Riford Brook in Braintree caused severe damage to Riford Brook Road during Tropical Storm Irene.

12 http://anrmaps.vermont.gov/websites/anra5/?LayerTheme=1
13 http://vtrans.vermont.gov/sites/aot/files/highway/documents/structures/VTrans%20Hydraulics%20Manual.pdf
14 http://vtrans.vermont.gov/sites/aot/files/highway/documents/materialsandresearch/completedprojects/VTrans%20Scour%20Project%20731%20Anderson%20Et%20al%20%28FinalReport%2003-10-17%29.pdf

Ice Jam Vulnerability:

Incidence of ice jams in the State are also on the rise, with more significant fluctuations in temperature and decreased snow pack creating an environment prone to greater ice accumulation. As precipitation trends in the northeast indicate that the most significant increases are occurring during winter months, rain events could lead to more frequent ice jam events.

The Winooski River and Dog River in Montpelier have been identified as particular areas of interest for ice jams, given the history of ice jams and flooding in these locations. More than a dozen serious ice jams events have occurred in Montpelier since 1900. In 1992, an ice jam in Montpelier led to flood inundation in the downtown area, causing more than $5 million in damage to buildings, homes, roads, culverts, and other infrastructure facilities. Ice jams in this location have been identified as far back as the 1700s. It is likely that ice jams will continue to pose a threat to Vermont for the foreseeable future, particularly in the months of January and February.

While other jurisdictions have a history of more frequent ice jam flooding, such as Hardwick, Richford, and Richmond, Montpelier's vulnerability to ice jams may represent the most extreme in the State based on the magnitude of the historic and the potential for future economic loss.

From February through March 2007, December 2008, January 2010, and again in January through February 2018, the City of Montpelier and State agencies carefully monitored a large fragile ice jam on the Winooski River at Cemetery Bend, which threatened to flood downtown Montpelier. Strategically placed gages along the river allowed authorities to monitor the height of the river and rate of rise, alarm systems are in place to warn citizens of impending flooding, and an ice jam breaker is parked permanently over the winter along this vulnerable bend in Montpelier should the need arise to break up thick ice in anticipation of potential jamming. In addition, the U.S. Army Corps of Engineers (USACE) Cold Region Research and Engineering Laboratory (CRREL) have established a website with monitoring equipment and gages indicating level of rise, depth of water, and river temperature. This can be accessed by emergency management officials so that sufficient warning can be given if flooding appears to be imminent[15].

15 http://icejams.crrel.usace.army.mil/apex/f?p=524:1:

Significant ice jamming along the Lamoille River in Johnson in early 2018 led to concerns of inundation flooding in the town, including for the mobile home park in the background.

In 2011, Montpelier completed a FEMA-funded project to install a pump station at the wastewater treatment facility, which is used to pump treated effluent upstream to three fixed discharge points on the river bank near where the ice frequently jams. When the ice conditions begin to pose a threat, the City uses the 45°F treated wastewater to weaken the river ice and create open water channels. The weakened ice pack allows the ice to flow down the river and through the natural constriction when the ice releases upstream. So far, this approach has proved to be effective at reducing Montpelier's ice jam threat.

There are no known State buildings or facilities (other than roadway infrastructure) immediately endangered by ice jams outside the Berlin, Montpelier, and the Waterbury State Office Complex, although no specific inventory or assessment has been performed.

Significant ice jams have occurred on the Winooski River in Montpelier, the Deerfield river north branch in Wilmington and most recently along the Lamoille River in Johnson and the Missisquoi River in Swanton and Highgate.

Water Quality Implications:

In addition to an increase in the frequency and severity of flooding and fluvial erosion, the greater amount of precipitation that climate change is projected to bring to the Northeast may also detrimentally affect water quality. Higher water inflows into lakes and streams increase phosphorus levels, leading to eutrophication, which is the cause of toxic Cyanobacterial blooms (blue-green algae). Cyanobacterial blooms are harmful to the environment, and toxic to animals and people. When considered together, increases in precipitation and temperature exacerbate both the frequency and magnitude of these harmful algal blooms (see: Extreme Heat). Recreationalists accessing Vermont's many lakes need to consider current water quality, and are encouraged to monitor the Vermont Department of Health's Cyanobacteria Tracker Map to check recent lake reports prior to water-based activity[16].

Mobile Home Park Vulnerability:

Mobile home parks are uniquely vulnerable to flooding. This increased risk is related to siting of park communities in flood hazard areas, socioeconomic characteristics of park residents, and limitations of the structures themselves. An assessment completed in 2012 by researchers at the University of Vermont found that one-fifth of Vermont's 247 mobile home parks have at least one lot that is located within a flood hazard area and nearly 12% of all mobile home park lots are located in flood hazards areas.

Two of the major flooding events in 2011 affected 19 mobile home parks across central and southern regions of the State, destroying over 150 mobile homes. Tropical Storm Irene also flooded two parks that are not in mapped flood hazard areas: Barber's Pond Mobile Home Park in Pownal and Tenney's Mobile Home Park in Athens. Both of these parks were located just outside the limit of the mapped flood hazard area.

Lake Flooding Vulnerability:

Because Vermont has no coastal or ocean-front areas, coastal flooding is not an issue; however, increasing development pressures on the lake front in Shelburne, Charlotte and Ferrisburgh may be impacted from erosion, storm water runoff and related pollution. The Lake flooding in spring 2011 impacted a large number of communities, as water levels topped well over the 500-year floodplain and remained above the base flood elevation for over a month.

16 http://www.healthvermont.gov/tracking/cyanobacteria-tracker

As the trends outlined above indicate greater precipitation and more frequent severe rainfall events, swollen rivers in the Lake Champlain basin will continue to cause lake levels to rise, further impacting the nearby built environment vulnerable to inundation, erosion and water quality challenges.

Invasive Species as an Accelerant to Fluvial Erosion:

Fluvial Erosion can be exacerbated by invasive species. Invasive plants are prevalent along Vermont rivers, which can outcompete native species and increase erosion along stream banks.

While the roots of varied native vegetation help to stabilize river banks, Japanese Knotweed can contribute to erosion. Japanese Knotweed spreads quickly once established to crowd out and shade other native species and create a monoculture, with very little other growth below the plant. This leaves bare soil and a shallow root system, which do not support the stability of river banks[17] (see: Invasive Species).

Potential Flood Losses to State Facilities:

In a robust risk assessment completed by Buildings and General Services (BGS), all State-owned and leased buildings were analyzed according to their criticality to government operations and their proximity to the river corridor and FEMA-mapped 100-yr and 500-yr floodplains. Building replacement cost, structures' current use, construction type and year, and costs of personal property and computer systems were also considered during this process. Those structures that received the highest overall score were prioritized for a mitigation alternatives analysis that would reduce the structures' respective vulnerabilities.

The risk assessment methodology, priority structures list and list of potential mitigation actions are located in the Appendix to Section 3.

Repetitive Loss:

FEMA, through the National Flood Insurance Program (NFIP), considers any insurable building for which two or more claims of more than $1,000 were paid by NFIP within any rolling ten-year period since 1978 to be a Repetitive Loss (RL) property. With over 122,000 RL properties nationwide, FEMA estimates that these flood-vulnerable structures have resulted in $3.5 billion in claims. In 2004, the National Flood Insurance Reform Act went further to define Severe Repetitive Loss (SRL) properties as those single family properties covered under NFIP that have incurred flood-related damage for which four or more separate claims totaling at least $5,000 each have been paid out, or when there are two or more losses where claim payments exceed the property's value. FEMA estimates that over 6,000 properties in the nation fall under SRL designation[18].

In Vermont, the following communities have the highest number of Repetitive Loss properties, according to FEMA's NFIP listing: Barre, Lyndon/Lyndonville, Montpelier, and Rutland.

Tropical Storm Irene greatly increased the number of repetitive loss properties in Vermont. According to the 2010 Vermont State Hazard Mitigation Plan (SHMP), there were 65 non-mitigated multiple loss properties in the State of Vermont in 33 towns. In the 2013 Vermont SHMP, there were 139 non-mitigated multiple loss properties in 45 communities. As of early March 2018, of the 176 RL properties in Vermont, 163 non-mitigated multiple loss properties are located within 51 communities.

17 http://www.uvm.edu/~epscor/ds/secure_dir_007.php?file=.staff/open/cwdd/2014%20Symposium/presentations/2_Emily%20Secor_2014.pdf

18 https://www.fema.gov/txt/rebuild/repetitive_loss_faqs.txt

There are also areas within Vermont that present significant losses but do not fall under the FEMA definition of a repetitive loss property. For example, Clover Street in Rutland City is repeatedly flooded by Moon Brook after major rainstorms. It is speculated that the major cause of this flooding is an insufficiently sized culvert under the adjacent railroad bed to the west. The culvert does not meet the cost-benefit ratio to qualify for FEMA Hazard Mitigation Assistance (HMA) funding, but is a significant threat to the community.

The State of Vermont is committed to ensuring that all repetitive loss properties, whether they meet the FEMA definition or not, are monitored and mitigated to prevent future financial loss and loss of life.

A barrier to potential mitigation of these repetitive loss properties is a discrepancy that exists between the NFIP and HMA branches of FEMA, both of whom keep their own, distinct lists of repetitive loss properties. These lists are not aligned with one another, and the HMA-eligible RL property list is significantly smaller than the NFIP repetitive loss database. For example, as of late 2017, the HMA-eligible RL list was comprised of eight properties, whereas the NFIP list from the same time period listed 176 RL properties, which are considered to be equally vulnerable to flooding.

For a complete list of all communities participating in the NFIP, FEMA keeps an up-to-date Community Status Book Report detailing community information, map effective dates and more[19]. Property owners whose communities do not participate in the NFIP do not have access to flood insurance, making them more vulnerable to the financial difficulties following a flood event that damages their property. Additionally, mitigation projects that take place within the FEMA-mapped Special Flood Hazard Area are not eligible for HMA funding if the community applying for funds is not a participating member of the NFIP, which leaves much of the built environment within that community vulnerable to flood damage.

Flood Hazard Area Mapping Deficiencies:

An analysis of digital FIRM data in six counties indicates that 82% of stream miles do not have mapped Special Flood Hazard Areas. There is no mandatory flood insurance requirement as a result, yet flood losses are regularly experienced along these flooding sources. Unfortunately, these losses are not documented by way of a flood insurance claim due to lack of coverage.

Additionally, many towns have antiquated data supporting their mapped flood hazard areas, which do not take into account changes in geomorphology, hydraulics or hydrology, leaving many structures mapped incorrectly or not mapped at all. These mapping deficiencies create additional vulnerabilities to Vermont's built environment, as accurate identification of structures relative to flood hazard areas is difficult to ascertain.

19 https://www.fema.gov/cis/VT.html

Inundation Flooding & Fluvial Erosion Mitigation

As a State with a long history of disasters involving inundation flooding and fluvial erosion, taken together with the increasing trends in both annual precipitation and frequency of significant rainfall events, the Steering Committee considers the probability of a plausibly significant flood inundation or fluvial erosion event to be Highly Likely, with the most significant impacts to the built environment and the economy. Both inundation flooding and fluvial erosion events have a similar, moderate impact to human life. With respect to the natural environment, a significant fluvial erosion event will have major impacts, while inundation flooding will only cause minor damage to the environment. Accordingly, the Steering Committee has ranked fluvial erosion as Vermont's top natural hazard, with inundation flooding ranked second.

Given these rankings, as well as the history of flood-related vulnerabilities in Vermont, the majority of the State's mitigation efforts are focused around inundation flooding and fluvial erosion. Some of the high priority themes and strategies are discussed in detail below; for a complete list of the State's efforts regarding flood mitigation, please visit the Mitigation Strategy and State & Local Capabilities sections.

Buyouts:

Following Tropical Storm Irene, Vermont has been very successful in acquiring and demolishing flood-damaged or flood-vulnerable structures through several funding sources, to include the Hazard Mitigation Grant Program (HMGP), Community Development Block Grant – Disaster Recovery (CDBG-DR), the Vermont Housing & Conservation Board and the Vermont River Conservancy. Nearly 150 properties have been successfully mitigated in what are colloquially referred to across the State as "buyouts". In recognition of this success, and as the State continues to better understand its structural vulnerability to inundation flooding and fluvial erosion, the Steering and Planning & Policy Committees have identified the establishment of a Statewide conservation and buyout program as a top priority of this plan. A similar action was developed and prioritized in the 2013 Vermont SHMP, for which this more detailed strategy is based.

This strategy aims to not only identify structures vulnerable to flooding and fluvial erosion, but to also take a more proactive approach at purchasing and conserving undeveloped land to prevent future structural vulnerability. Also included in this strategy are actions relating to dedicated funding sources and better data acquisition and use to more comprehensively address vulnerability. In order to achieve this top priority strategy, input from the various Committees and subject matter experts has identified the need to establish a dedicated working group tasked with designing a robust cross-sector buyout program. This working group will involve key stakeholders and will be created in late 2018.

Headwater and Floodplain Storage and Water Quality Co-Benefits:

During the planning process, a strong theme regarding a holistic approach to flood- and erosion-related mitigation continued to surface. That is, Vermont should consider the mitigative value of flood storage in both headwater forests and down-valley river corridors and floodplains, as well as water quality and invasive species implications that may also affect inundation flooding and fluvial erosion.

In addition to guiding development outside of floodplains and river corridors, several high priority mitigation actions were developed under the strategy aimed at improving headwater storage. These actions, which include developing an inventory of critical headwater storage areas and completing a pilot project to demonstrate the co-benefits of upland conservation and downstream flooding, try to take into account the

storage capacity of Vermont's hills and forests. If these areas are conserved and managed appropriately, the risk of downstream flooding due to the amount of water and debris from upland can be reduced.

In addition to reducing flood levels due to water and debris runoff from the headwaters and increasing flood storage in valley floodplains, there are water quality co-benefits that can be achieved when river banks become more stable (i.e. due to floodplain connectivity) and less runoff – potentially carrying pollutants and invasive species – makes its way to the rivers. As excess nutrients and chemicals are carried from farms and roads into a river, that river's ecosystem is negatively impacted. Eventually, the river will make its way to larger bodies of water (e.g. Lake Champlain), where those nutrients can lead to harmful algal blooms (see: Extreme Heat). Invasive species, like Japanese knotweed, readily form along waterways, from road ditches to rivers to lakes, and spread very easily. Their shallow root systems lead to greater bank instability and can further exacerbate not only fluvial erosion, but also water quality issues (see: Invasive Species).

Given the above, the Steering Committee and Working and Focus Groups recognized the need for a whole systems approach to flood-related mitigation. The result is a high priority strategy devoted to connecting water quality, flood resilience and native habitat connectivity through recognizing co-benefits of mitigation efforts. There are several grant programs that focus within their own silos, but which could be expanded and leveraged to support these co-benefits. By inventorying the many grant programs and capabilities within the State, new projects supporting both water quality and fluvial erosion mitigation, for example, can be realized.

Education, Outreach & Data:

With all of the initiatives, grant programs, data and mapping supporting flood mitigation, especially post-Irene efforts, the State of Vermont's Department of Environmental Conservation (DEC) developed the Flood Ready website[20] as a resource hub for users to access flood-related information. This website, updated daily by multiple State agencies, has received recognition at national conferences and continues to be a primary platform for disbursing useful information, such as grant opportunities, new legislation and community-based reports as pertains to flooding.

In 2018, DEC, with funding from the Lake Champlain Basin Program, created the Flood Training website[21] which provides a suite of case studies, tools and education materials geared at helping municipal officials protect river corridors and floodplains in their communities.

Because seven years have passed since Tropical Storm Irene brought devastation to the State, flood mitigation outreach is not as impactful as it was in the immediate aftermath of the storm. Many call this phenomenon resilience fatigue, and using language like "100-year" and "500-year" floodplain has led to a lack of understanding of the State's vulnerability to flooding. In an effort to continue outreach efforts and expand education regarding flood risks and the importance of mitigation, the Steering Committee prioritized several education-based mitigation actions as part of this plan update process.

As a primary tool of education and outreach, accurate data and mapping are critical. Accordingly, the Steering Committee has prioritized several actions that fall under the hazard mitigation mapping, data and research coordination strategy, identifying these actions as critical to expand flood resilience by dovetailing research efforts and sharing hazard data. For example, river corridor mapping is used to identify those areas vulnerable to fluvial erosion, identified above as the top natural hazard impacting Vermont. The data used to develop river corridor maps have been compiled over the years through the tireless efforts of DEC and mapped using funding from a myriad of State and Federal sources. Publishing these maps on the Vermont Natural Resources

20 http://floodready.vermont.gov/
21 http://floodtraining.vermont.gov/

Atlas allows the State, municipalities and individuals to better understand fluvial erosion vulnerability and develop steps to address it. It is important to note, however, that without recognition of this river corridor area by all agencies at the State and Federal levels, Vermont remains vulnerable to fluvial erosion. The Academic Resilience Collaborative (ARC), a high priority action of this plan, will be tasked with addressing fluvial erosion data and research needs and potentially creating an algorithm or model for inclusion of fluvial erosion in the FEMA Benefit-Cost Analysis (BCA) software so that Vermont can access mitigation funds for its primary hazard. Vermont has also applied for several FEMA HMGP 5% Initiative applications aimed at accomplishing increased awareness of flood vulnerability and mitigation and will continue to request these funds in the future.

Lake Champlain:

Taking into consideration both the significant lake flooding and erosion along Lake Champlain in 2011 and increased pressures for lake front development, the Vermont Legislature passed into law the Shoreland Protection Act, which regulates activities within 250' of the mean water level of lakes greater than 10 acres in size. The intent of this Act is to allow reasonable development along the shorelands of lakes and ponds while protecting aquatic habitat, improving water quality and reducing erosion hazards by maintaining the natural stability of shorelines[22].

Further considerations of inundation and fluvial erosion vulnerabilities along Lake Champlain are being discussed by the International Joint Commission's (IJC) Lake Champlain and Richelieu River Study Board[23].

Though they do not technically meet the definition of coasts, there is currently an effort to analyze and map the shores of the Great Lakes using analyses and procedures standard along the coasts. Performing a coastal analysis of Lake Champlain would add storm surge and wave height considerations to the existing Base Flood Elevation (BFE), which is based strictly on stillwater inundation levels. Though not a current strategy of this plan, future planning and funding efforts should review the results of the Great Lakes study and consider extending the analysis to Lake Champlain[24].

Dam Resilience:

With over 800 dams in the State, approximately 70 of which are classified as HIGH hazard, the Steering Committee developed several mitigation actions that fall under the dam resilience improvement strategy. In addition to those actions, there are several other mitigation efforts underway in the State to address vulnerability to dam-related hazards.

The DEC staffs two full-time Dam Safety Engineers who review permit applications for new dams, rehabilitation of existing dams, and dam removal, conduct dam safety inspections, and work with dam owners to address operation and maintenance issues and larger deficiencies. In addition, the DEC owns and operates the Winooski River Flood Control Dams (Waterbury, Wrightsville, and East Barre), as well as 11 other dams throughout the State and assists other State Agencies including Fish & Wildlife, Forests Parks and Recreation, and Agency of Transportation, who in total, own approximately 90 dams.

The PUC administers 4,500, Safety of Hydroelectric Dams, rules developed for dams in their jurisdiction. The PUC consists of a team of environmental technicians and lawyers who have the authority to contract with dam safety consultants for assistance on an as-needed basis.

22 http://dec.vermont.gov/sites/dec/files/wsm/lakes/docs/Shoreland/lp_ShorelandHandbook.pdf
23 http://www.ijc.org/en_/Lake_Champlain_Basin
24 http://www.greatlakescoast.org/great-lakes-coastal-analysis-and-mapping/

FERC and Federal Agencies that own dams have robust dam safety staff and guidance backed by nationally accepted standards. The New England District of the USACE own and operate large flood control dams in the Connecticut River drainage basin.

The Vermont Dam Task Force, a group of individuals from both the public and private sector, meet quarterly to discuss dam mitigation, with a primary goal of rehabilitating rivers and improving public safety through dam removal. Finally, The Nature Conservancy of Vermont developed a Dam Removal Screening Tool for the Lake Champlain basin, which categorizes dams by their ecological impact. Recognizing the value of this tool, the Steering Committee prioritized expansion of the tool to other watersheds across the State in this Plan.

Other Initiatives:

In 2015, the Agency of Commerce and Community Development (ACCD), together with VTrans, the Department of Environmental Conservation (DEC), RPCs and the U.S. Economic Development Administration (U.S. EDA) developed a robust mitigation project identification report for five pilot towns[25]. This report, titled Vermont Economic Resiliency Initiative (VERI), is being used by various agencies to plan for and implement community-identified high priority actions to promote their resilience. Of the five pilot towns, four identified mobile home park vulnerability to flood-related hazards as a priority for project and funding consideration. Since the release of the VERI report, the pilot towns have been working with various State agencies to achieve some of these projects, to include structural elevations and acquisition/demolition of the flood-vulnerable mobile home parks.

The Vermont chapter of the United States Army Corps of Engineers (USACE) Silver Jackets was chartered in August 2016, with representation from various Federal (FEMA, USGS, USACE, and NOAA) and State (DEC, VEM, VTrans and ACCD) agencies. The mission of the Vermont Silver Jackets team is to foster innovative and collaborate partnerships that facilitate and contribute to comprehensive and sustainable management of flood risk throughout the State. Following execution of the charter, the Team began working on its first pilot application for improved flood inundation mapping for the City of Montpelier. This application was approved by USACE and work is currently underway. Other projects that the Team is developing in 2018 include new HEC-RAS modeling for the volatile Whetstone Brook in Brattleboro, a project identified in the Brattleboro chapter of the VERI report, and ice jam modeling along the Lamoille River in Johnson and the Missisquoi in Swanton following the significant ice jam events along those two stretches in early 2018. Together with VEM and ANR, the Vermont Silver Jackets Team is identified as a lead entity for the development of a Benefit/Cost Analysis methodology to facilitate buyouts in areas at risk from flood-related erosion and outside of FEMA-mapped Special Flood Hazard Areas.

A plethora of other mitigation efforts, initiatives and capabilities are underway or being developed in Vermont to address the State's top two natural hazards. For more information on these efforts, please see the Mitigation Strategy and State & Local Capabilities sections.

25 http://accd.vermont.gov/sites/accdnew/files/documents/CD/CPR/CPR-VERI-FinalReport.pdf

4-2: Snow Storm & Ice Storm

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Ice	3	3	3	3	2	2.75	8.25
Snow	4	1	3	2	1	1.75	7

*Score = Probability x Average Potential Impact

Strong winter weather can include any of the following, alone or in conjunction:

- **Snow Storms:** a heavy accumulation of snow, which can be accompanied by high wind causing drifting snow, low visibility and hazardous travel.
- **Ice Storms:** ice accretion from freezing rain, which can weigh down trees and power lines, causing outages and potentially occuring in conjunction with flooding (see: Inundation Flooding & Fluvial Erosion).
- **Blizzard:** a storm which contains large amounts of snow and/or blowing snow, with winds in excess of 35mph and visibilities of less than 1/4 mile for an extended period of time (for wind impacts, see: Wind).
- **Extreme Cold:** see Extreme Cold.

Severe winter storms bring the threat of heavy accumulations of snow, cold/wind chills, strong winds, and power outages that result in high rates of damage and even higher rates of expenditures.

A heavy accumulation of snow, especially when accompanied by high winds, causes drifting snow and very low visibility. Sidewalks, streets, and highways can become extremely hazardous to pedestrians and motorists. Severe winter storms develop through the combination of multiple meteorological factors. In Vermont and the northeastern United States, these factors include the moisture content of the air, direction of airflow, collision of warm air masses coming up from the Gulf Coast, and cold air moving southward from the Arctic.

Heavy ice accumulation weighing down mature trees and weighing down power lines in northern, VT 2013.
Photo Credit: Vermont Public Radio

Significant accumulations of ice can cause hazardous conditions for travel, weigh down trees and power lines, and cause power outages. Freezing rain can also be combined with snowfall, hiding ice accumulation and further hindering travel, or with mixed precipitation and potentially ice jams or flooding (see: Inundation Flooding & Fluvial Erosion).

NOAA's Weather Predictions Center is in the process of developing a new prediction tool, the Winter Storm Severity Index (WSSI)[1], to provide an indication of the level of winter event severity and impacts (Table 28). The WSSI does not depict official warnings or exact event timing, but provides severity level over a given period.

Table 28: Winter Storm Severity Index (still under development in 2018)

WSSI Descriptor	General Description of Expected Storm Severity Impacts
None	No snow or ice forecast. No potential for ground blizzard conditions.
Limited	Small accumulations of snow or ice forecast. Minimal impacts, if any, expected. In general, society goes about their normal routine.
Minor	Roughly equates to NWS Advisory Level criteria. Minor disruptions, primarily to those who were not prepared. None to minimal recovery time needed.
Moderate	Roughly equates to NWS Warning Level criteria. Definite impacts to those with little preparation. Perhaps a day or two of recovery time for snow and/or ice accumulation events.
Major	Significant impacts, even with preparation. Typically several days recovery time for snow and/or ice accumulation events.
Extreme	Historic. Widespread severe impacts. Many days to at least a week of recovery needed for snow and/or ice accumulation events.

The WSSI is broken down into six components that are individually weighted based on the WSSI categories and then summarized into overall severity:

- **Snow Amount:** to depict severity due to total amount of snow or rate of snowfall accumulation. (Adjustments are made based on climatology and urban areas, e.g. 4" of snow in Atlanta is more severe than 4" in Minneapolis.)
- **Snow Load:** to depict severity due to total weight of snow on trees and power lines.
- **Blowing Snow:** to depict severity mainly to transportation due to blowing and drifting snow.
- **Ice Accumulation:** to depict severity of transportation and downed trees/powerlines due to the accumulated ice in combination with wind.
- **Ground Blizzard:** to depict severity to mainly transportation of ground blizzards that develop due to a pre-existing snowpack and strong winds.
- **Flash Freeze:** to depict severity primarily to transportation of situations where temperatures rapidly fall below freezing during precipitation.

Snow Storm & Ice Storm History

- **Blizzard, February 15-17, 1958:** More than 30" of snow and 26 deaths in New England.
- **Blizzard, December 26-27, 1969:** Snow amounts between 18–36" in northwestern Vermont and 45" in Waitsfield. Governor Dean Davis declared a State disaster. Drifts of snow from the storm piled up to 30' in places.
- **Ice Storm, January 6, 1998 (DR-1201):** An unusual combination of precipitation and temperature led to the accumulation of more than 3" of ice in many locations, causing closed roads, downed power lines, and damage to thousands of trees. This storm was estimated as a 200-500 year event. Power was out up to 10 days in some areas and 700,000 acres of forest were damaged in Vermont. Vermont suffered no fatalities, unlike Quebec where 3 million people lost power and 28 were killed. Temperatures rose after the storm, causing the ice to melt and permitting crews to reopen roads, which kept many residents from freezing in their unheated homes. Over $6 million worth of estimated property damage.
- **Snow Storm, December 19, 2000 (DR-1358):** Snow amounts between 7-10". A few reports included: Berkshire: 9.7", Eden: 8.2", Jay Peak 8", St. Johnsbury: 7.1", and Worcester: 7".

1 http://www.wpc.ncep.noaa.gov/wwd/wssi/wssi.php

- **Snow Storm, March, 2001:** A string of storms hit Vermont in March 2001, beginning with 15-30" of snow on March 5-6, 10-30" on March 22, and 10-20" on March 30.
- **Snow Storm, February 14, 2007:** The second heaviest snowfall ever recorded in the month of February. Some areas of Vermont received from 28-36" of snow in a 24 to 48-hour period. Heavy snow loads on roofs led to the collapse of at least 10 barns, causing the death of some cows and other livestock. Estimated nearly $3 million in property damage.
- **Ice Storm, December 11, 2008 (DR-1816):** Winter storms and high winds resulted in extensive power outages, primarily in southern Vermont counties. Upward of 40,000 homes were without power for several days during this period.
- **Snow Storm, January 2-3, 2010:** Burlington experienced the most significant snowfall on record from one event with 33.1" of snow.
- **Winter Snow Totals, 2010-2011:** The winter of 2011 was the second snowiest on record for Vermont, with a total of 128.4" of snow. A March blizzard in Burlington brought 25.8" of snow in two days. The storm closed schools for days, and many people were without power. Driving was hazardous due to a 1" layer of ice beneath several inches of snow.
- **Snow Storm, December 28, 2011:** A strong cold front moved across Vermont during the late morning and afternoon hours accounting for a rapid cool down and localized snow squalls with heavy snow. The western slopes of the Green Mountains saw 5-12" of snow along foothill communities. Near white-out conditions in snow squalls and rapidly freezing road ways accounted for numerous vehicle accidents as well as a closure of I-89 between Richmond and Waterbury.
- **Ice Storm, December 20-21, 2013 (DR-4163):** Approximately 1/4-1/3" of ice accumulation from freezing rain on December 20 with an additional 1/2-3/4" of ice accumulation as well as 1- 2" of sleet December 21 in portions of northern Vermont. Very cold temperatures (-10°F to teens) followed the event with no melting, thus ice stayed on trees and utility lines through December, prolonging recovering. The greatest impact was in northwest Vermont, with widespread tree and utility line damage as well as numerous vehicle accidents. More than 75,000 customers were without power from hours to days. Over $4 million in property damage estimated.
- **Snow Storm, November 26, 2014:** The storm began late morning November 26 and increased in intensity, falling at rates at or greater than 1" per hour. Snowfall caused slow and difficult travel the day before Thanksgiving. Snow continued through the day and evening with heavy bands at times and tapered off overnight. By the early morning on Thanksgiving, most of southern Vermont saw snowfall of 8-15" with the heaviest amounts across the higher elevations of the southern Green Mountains.
- **Snow Storm, December 9-13, 2014 (DR-4207):** Rain and wet snow moved into Vermont midday December 9 and changed to a heavy, wet snow during the evening. A band of moderate snowfall impacted much of central and northern Vermont during the afternoon and evening hours of December 10, then scattered snow showers ending on December 11-12. Total snowfall totals across Vermont ranged from 3-6" in Essex County to 12-20" across the Green Mountains into the Champlain Valley. The heavy, wet nature of the snowfall with snow to water ratios of 8:1 or less accounted for snow-loaded trees that resulted in more than 175,000 power outages in the region. This was the 2nd most power outages due to weather in Vermont. Over $4 million in property damages estimated.

Downed tree in Richmond, VT following heavy snowfall in 2014.
Photo Credit: Angela Evancie / Vermont Public Radio

Table 29: Top 20 Greatest Snowstorms in Burlington (NOAA)					
Rank	**Snowfall**	**Month/Year**	**Rank**	**Snowfall**	**Month/Year**
1	33.1”	January 2-3, 2010	11	19.1”	March 16,-17, 1937
2	30.4”	March 14-15, 2017	12	18.8”	December 14-15, 2003
3	29.8”	December 25-26, 1969	13	18.7”	March 12-13, 2014
4	25.8”	March 6-7, 2011	14	18.3”	December 6-7, 2003
5	25.7”	February 14-15, 2007	15	17.8”	January 3-4, 2003
6	24.7”	January 13-14, 1934	16	17.8”	February 4-5, 1995
7	22.9”	March 5-6, 2001	17	17.7”	March 3-4, 1994
8	22.4”	March 13-14, 1993	18	17.2”	February 6-8, 2008
9	20.0”	November 25, 2000	19	17.1”	February 25-26, 1966
10	19.7”	January 25-28, 1986	20	16.9”	December 25, 1978

Data Source: www.weather.gov/media/btv/climo/extremes/top20snow.pdf

Snow Storm & Ice Storm Trends & Vulnerability

Impacts from ice are considered to be more significant than those associated with snow. The Steering Committee considered the probability of a plausibly significant extreme ice event to be Likely, with moderate impacts on infrastructure, people and the economy. A significant snow event has a probability of Highly Likely, with moderate impacts on people and minor impacts on the economy.

There is no specific region of Vermont that is more vulnerable to ice or snow storms. Snow accumulation is highest at the upper elevations of the Green Mountains, including Mt Mansfield, Killington, Mt Ellen, Camel’s Hump, Mt Abraham, Lincoln Peak, Pico Peak, Jay Peak, Bromley, and Stratton Mountain.

Figure 37: Federally-declared ice and snow disaster public assistance expenditure by municipality (2000-2016)
Data Source: www.fema.gov/openfema

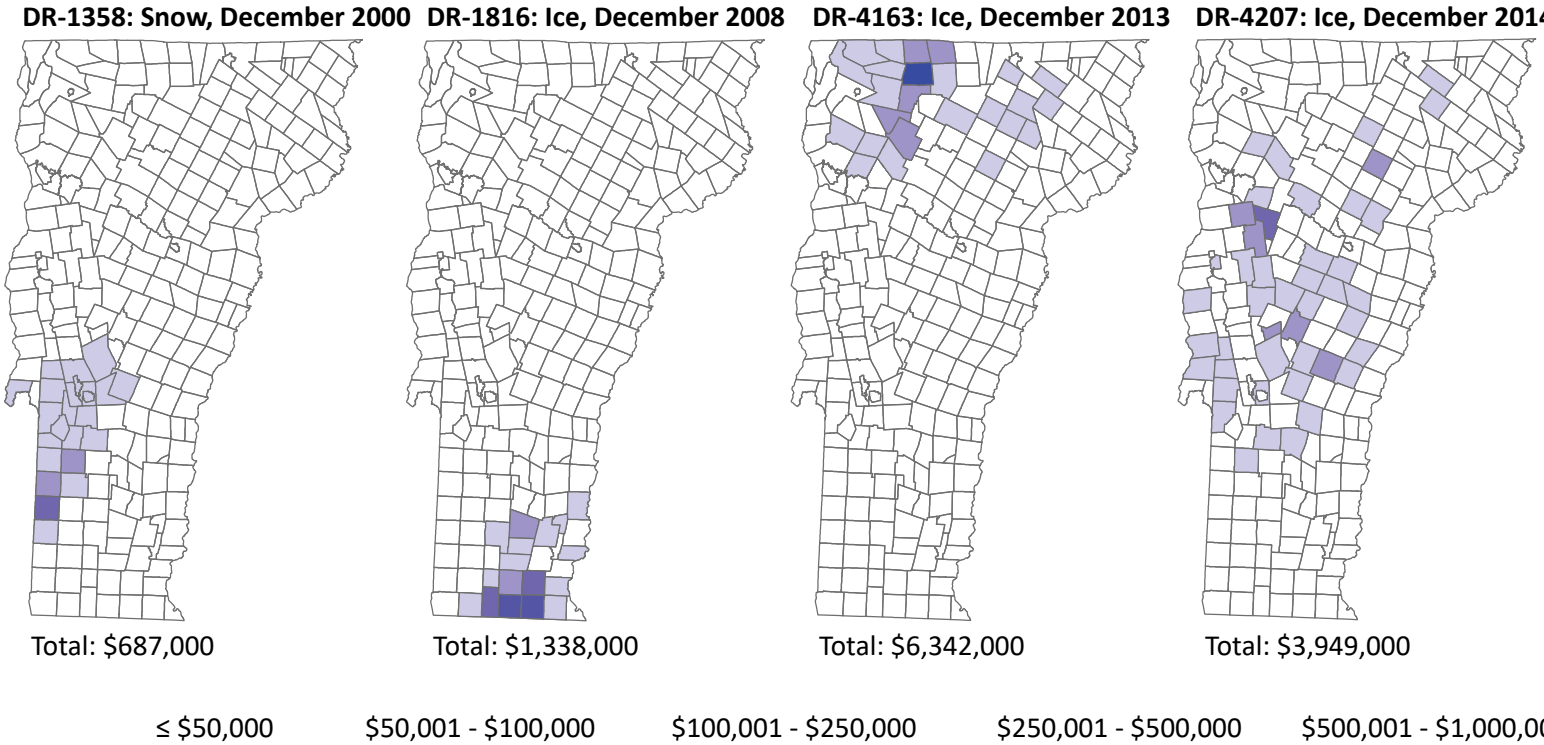


Table 30: Snowfall Extremes by Vermont County — 1-Day, 2-Day and 3-Day Storms						
County	**1-Day**	**Amount**	**2-Day**	**Amount**	**3-Day**	**Amount**
Addison	3/14/1933	25.6”	2/25/2010	28.8”	3/14/1993	28.2”
Bennington	3/14/1984	37.0”	3/14/1984	38.0”	3/5/1947	42.0”
Caledonia	2/25/1969	33.0”	2/26/1969	34.5”	2/26/1969	35.5”
Chittenden	2/14/2007	25.3”	1/3/2010	35.3”	1/3/2010	37.6”
Essex	12/7/2003	24.0”	12/8/2003	43.0”	12/9/2003	43.0”
Franklin	3/14/1993	24.0”	12/27/1969	30.0”	3/18/1937	33.0”
Grand Isle	3/7/2011	19.0”	3/7/2011	23.3”	3/7/2011	23.3”
Lamoille	4/10/2000	25.0”	2/15/2007	36.0”	2/16/2007	36.0”
Orange	3/13/2014	24.5”	12/8/2003	26.0”	12/22/2008	29.2”
Orleans	2/5/1995	42.0”	2/6/1995	48.0”	2/6/1995	48.0”
Rutland	12/7/2003	25.0”	12/7/2003	27.0”	12/8/2003	28.5”
Washington	3/14/1993	31.0”	12/28/1969	36.0”	12/29/1969	44.0”
Windham	12/19/1986	34.0”	12/19/1986	34.5”	3/5/1947	41.0”
Windsor	2/14/2014	30.0”	11/23/1943	39.0”	12/4/1942	41.0”

Source: https://www.ncdc.noaa.gov/snow-and-ice/snowfall-extremes/VT

There are no standard loss estimation models or methodologies for the winter storm hazards. Potential losses from winter storms are, in most cases, indirect and therefore difficult to quantify.

According to the 2014 National Climate Assessment, there is an observable increase in severity of winter storm frequency and intensity since 1950[2]. While the frequency of heavy snowstorms has increased over the past century, there has been an observed decline since 2000 and an overall decline in total seasonal snowfall.

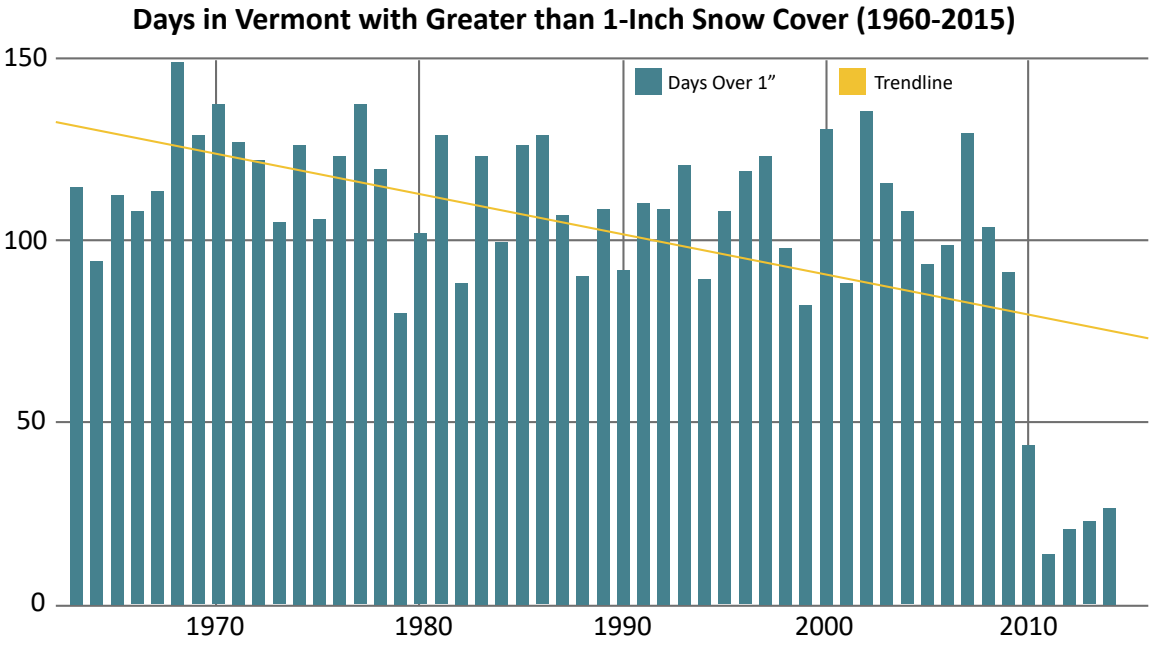


Figure 38: Number of days in Vermont with greater than 1-Inch snow cover (1960-2015)
Data Source: http://climatechange.vermont.gov

2 https://nca2014.globalchange.gov/report/our-changing-climate/changes-storms

The National Centers for Environmental Information within NOAA manage data pertaining to snow coverage across the country[3]. Due to rising minimum temperatures and a shortening winter season, snow cover on the ground has also seen significant decreases. Seven weather stations, located in Bethel, Burlington Airport, Cavendish, Newport, Rochester, Rutland and St. Johnsbury have consistently recorded the number of days with greater than 1" of snow cover since 1963. The results (Figure 38) indicate that this number is trending downward, with the most significant decreases occurring in the past decade. Expected reductions in snow cover leave the exposed ground more vulnerable to freezing during extreme cold events, which can cause significant impacts to building infrastructure (see: Extreme Cold), and also lead to decreased tourism revenues across the State (see: Extreme Heat).

Snow Storm & Ice Storm Mitigation

State facilities and individual towns are generally well prepared to deal with winter storms. VTrans winter maintenance road crews are experienced and well-equipped to keep highways open and municipal road crews are also generally well-prepared. Most critical State facilities have emergency backup generators in case of loss of power due to icing, and in 2014 the State of Vermont applied for a Statewide Generator Project under DR-4022 for local emergency shelters and critical facilities.

This Plan has identified a mitigation strategy to develop resilient design and construction standards (see: Mitigation Strategy) in the form of auditing existing building codes, which would include standards for snow loading and ice accumulation. Additionally, several strategies aimed at increasing public knowledge about hazards and mitigation, supporting vulnerable populations and coordinating hazard mitigation mapping must consider snow and ice storm events during implementation.

This Plan also includes a strategy to identify and protect vulnerable structures and critical infrastructure, with an action to provide technical assistance to utilities in long-range planning for transmission and distribution line upgrades and relocation to improve resilience, which would include impacts due to ice events and snow loading. Additionally, this strategy includes an action to adapt the VTrans Methods and Tools for Resilience project (2018 SHMP subgrant) for use in mapping utilities and identifying vulnerabilities, which should not be a significant lift given that the majority of utility lines in Vermont run along roadways.

Though several towns in the State are considering burying power lines for long-term mitigation against both wind and ice events, a statewide approach to power line burying is not being considered at this time due to being cost prohibitive.

3 https://www.ncdc.noaa.gov/cdo-web/datatools

4-3: Wind

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Wind	4	2	2	1	1	1.5	6

*Score = Probability x Average Potential Impact

High wind can be the result of any of the following:

- **Wind Storm:** high wind event without precipitation.
- **Hurricanes/Tropical Storms:** the most significant impacts from hurricanes/tropical storms in Vermont are inundation flooding and fluvial erosion (see: Inundation Flooding & Fluvial Erosion). Wind implications of hurricanes/tropical storms are addressed below.
- **Thunderstorm:** high wind event with the potential for compounding impacts due to precipitation (see: Inundation Flooding & Fluvial Erosion), lightning (see: Wildfire), and/or hail (see: Hail).
- **Tornado:** a violently rotating column of air extending from a thunderstorm; not common in Vermont.

Table 31: Beaufort Wind Scale

Force	Wind (mph)	WMO Classification	Appearance of Wind Effects	
			On the Water	On Land
0	< 1	Calm	Sea surface smooth and mirror-like	Calm, smoke rises vertically
1	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-7	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move
3	8-12	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	13-18	Moderate Breeze	Small waves 1-4ft becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted, small tree branches move
5	19-24	Fresh Breeze	Moderate waves 4-8ft taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway
6	25-31	Strong Breeze	Larger waves 8-13ft, whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	32-38	Neal Gale	Sea heaps up, waves 13-19ft, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind
8	39-46	Gale	Moderately high (18-25ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks	Twigs breaking off trees, generally impedes progress
9	47-54	Strong Gale	High waves (23-32ft), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	55-63	Storm	Very high waves (29-41ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, considerable structural damage
11	64-72	Violent Storm	Exceptionally high (37-52ft) waves, foam patches cover sea, visibility more reduced	Very rarely experienced on land, accompanied by widespread damage
12	73+	Hurricane	Air filled with foam, waves over 45ft, sea completely white with driving spray, visibility greatly reduced	Devastation

Source: http://www.spc.noaa.gov/faq/tornado/beaufort.html

Damages following a significant wind storm that hit western Vermont in 2017. *Photo Credit: Burlington Free Press*

Wind Storm:

High winds pose a threat to the safety of Vermont's citizens and property. The National Weather Service (NWS) issues a wind advisory when winds are sustained at 31 to 39 mph for at least one hour or any gusts 46 to 57 mph. Sustained winds of 40 to 73 mph or gusts of 58 mph or higher cause the NWS to issue a High Wind Warning[1].

Hurricane/Tropical Storm:

A hurricane is a tropical cyclone with sustained winds that have reached speeds of 74 mph or higher. A storm reaches hurricane status only after strengthening over a period of days or even weeks. A tropical storm has a maximum sustained one-minute wind speed of 39 to 73 mph. As a hurricane moves toward the coast, it loses wind speed and may be downgraded to a tropical storm. This is the case in many of the tropical storms that have reached Vermont. In general, severe hurricanes are not considered likely, nor do they pose a recurring threat for Vermont.

Hurricanes and tropical storms are hazard events that often result in high winds, inundation flooding, and fluvial erosion impacts. The topography and landscape in Vermont contribute to the risk associated with these three hazard impacts. Many of Vermont's villages, towns and cities are located in or proximate to the floodplain and many roads in Vermont run parallel to rivers (see: Inundation Flooding & Fluvial Erosion).

The Saffir-Simpson Hurricane Wind Scale is a categorical rating system between 1 and 5, which corresponds to the sustained wind speed of hurricanes (Table 32). This scale serves as an estimate of potential property damage during hurricanes. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and property damage. The Saffir-Simpson Hurricane Wind Scale serves as a good measure for sustained wind speed; however, this scale does not account for the compounding impacts (i.e. inundation and erosion).

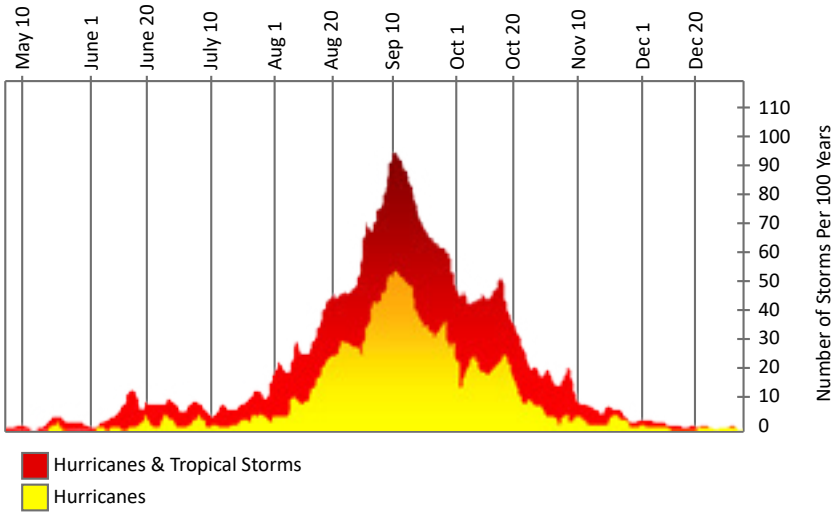


Figure 39: Peak Hurricane Season in the Atlantic Basin
Data Source: https://www.nhc.noaa.gov/climo/

1 https://www.weather.gov/btv/wwa_reference

The Atlantic Ocean hurricane season runs from approximately June 1 through November 30, with the majority of hurricane activity occurring between mid-August through October[2] (Figure 39).

Table 32: Saffir-Simpson Hurricane Wind Scale				
Tropical Depression		≤38 mph, ≤33 knots, ≤62 km/h	**Tropical Storm**	39–73 mph, 34–63 knots, 63–118 km/h
Category	**Wind Speed**	**Types of Damages Due to Hurricane Winds**		
1	74-95 mph 64-82 kt 119-153 km/h	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.		
2	96-110 mph 83-95 kt 154-177 km/h	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.		
3 (Major)	111-129 mph 96-112 kt 178-208 km/h	Devastating damage will occur: Well-built frame homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.		
4 (Major)	130-156 mph 113-136 kt 209-251 km/h	Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.		
5 (Major)	≥ 157 mph ≥ 137 kt ≥ 252 km/h	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.		

Source: https://www.nhc.noaa.gov/aboutsshws.php

Thunderstorm:

Severe thunderstorms are capable of producing high winds (including downdrafts), large hail, lightning, flooding, rains, and tornadoes. Thunderstorm winds are generally short in duration, involving straight-line winds and/or gusts in excess of 50 mph and tend to affect areas of Vermont with significant tree stands as well as areas with exposed property and infrastructure and aboveground utilities. Winds can cause power outages, transportation and economic disruptions and significant property damage, and pose a high risk of injuries and loss of life.

Thunderstorms can produce downburst winds that affect the land immediately beneath a storm. These downburst winds are called mircrobursts and macrobrusts, which move outward from the base of a thunderstorm and can reach speeds in excess of 80 mph. Microbursts (the smaller of the two in terms of area affected) pose an extreme threat to aircraft. The downward wind can exceed the lift component of an aircraft, making it impossible to maintain altitude, which for low flying aircraft (especially during takeoff and landing) is extremely dangerous.

Thunderstorms can range in size and type. An ordinary cell thunderstorm consists of one cell with an updraft and downdraft and produce strong winds, rain, lightning, and even hail. Multicell cluster thunderstorms consist of several ordinary cell thunderstorms in the vicinity of each other. Multicell cluster thunderstorms are extremely prone to causing flash flooding. Squall line thunderstorms move in a line or front that can exceed 100 miles in length, with the strongest rains and winds at the front of the storm. Supercell thunderstorms are the largest, longest lasting, and most devastating thunderstorms. Nearly all tornadoes are formed from supercell thunderstorms. Lightning, hail, flash flooding, and tornadoes are all associated with this type of thunderstorm (see: Hail and Inundation Flooding & Fluvial Erosion).

2 https://www.nhc.noaa.gov/climo/

In Vermont, high winds are most often seen accompanying severe thunderstorms. In fact, straight-line winds are often responsible for most of the wind damage associated with a thunderstorm. These winds are frequently confused with tornadoes because of similar damage and wind speeds; however, they are not rotating like the winds of a tornado.

Thunderstorms and associated hazards can occur anywhere in Vermont at any time of the year; however, spring and summer are the most common times for severe thunderstorms.

Tornado:

A tornado is a violently rotating column of air extending from a thunderstorm to the ground. The most violent tornadoes are capable of tremendous destruction with wind speeds capable of reaching in excess of 250 mph. Damage paths can be in excess of a mile wide and 50 miles long. The Enhanced Fujita Scale is a categorical rating system between EF0 and EF5 for wind speed during a tornado (Table 33).

Since 1950, Vermont has experienced 45 tornadoes, 14 of which were magnitude F2 (significant) and 16 magnitude F1 (moderate) on the Fujita Scale. F2 tornadoes have maximum wind speeds of 113 to 157 mph, while F1 tornadoes range from 73 to 112 mph. Damage from tornadoes has ranged from a few downed trees to seven injuries during a 1970 tornado in Franklin County. These injuries occurred when a waterspout – a tornado that originates over water instead of land – moved from Lake Champlain to the southern part of Swanton, where it struck a cabin. Property damage has totaled over $8.4 million overall in the State of Vermont due to tornado damage. There have been no deaths as a result of a tornado in Vermont since 1950.

Tornadoes typically occur in Vermont between March and August; however, tornadoes can strike at any time of the year if the essential conditions are present[3].

Table 33: Enhanced Fujita Scale

Scale	Wind Speed		Types of Damages Due to Hurricane Winds
	mph	km/h	
EF0	65-85	105-137	*Minor or no damage.* Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.
EF1	86-110	138-177	*Moderate damage.* Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	178-217	*Considerable damage.* Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165	218-266	*Severe damage.* Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations are badly damaged.
EF4	166-200	267-322	*Devastating damage.* Well-constructed and whole frame houses completely leveled; cars and other large objects thrown and small missiles generated.
EF5	>200	>322	*Extreme damage.* Strong-framed, well-built houses leveled off foundations are swept away; steel-reinforced concrete structures are critically damaged; tall buildings collapse or have severe structural deformations; some cars, trucks, and train cars can be thrown approximately 1 mile (1.6 km).

Source: http://www.spc.noaa.gov/efscale/ef-scale.html

3 National Weather Service, http:/www.nws.noaa.gov

Wind History

- **Tornado, May 31, 1998:** Bennington County was hit with an EF2 tornado that damaged homes and property in North Bennington. The tornado originated near Round Lake, New York, and moved rapidly eastward into Vermont, producing damage in North Bennington before dissipating in Shaftsbury. Funnel clouds were also reported that day in the Brattleboro area, but no tornadoes were confirmed to have touched down. Strong straight-line winds also damaged areas of Bennington and Windham Counties. Estimated $630,000 in property damages from this event.
- **Tropical Storm Floyd, September 16, 1999 (DR-1307):** Strong winds reaching 51 mph combined with saturated soils from heavy rain resulted in trees and power lines being blown down, causing power outages. A death occurred when a tree fell on a mobile camper in Randolph. $675,000 in estimated damages from the wind.
- **Tornado, June 5, 2002 (DR-1428):** Thunderstorms spawned two tornadoes, one in Woodford Hollow in Bennington County (EF1) and the other one near Wilmington in Windham County (EF2). The first touchdown produced a swath 150 yards wide and a path length of one-half mile. Many trees as large as a foot in diameter were either knocked over or ripped apart. Trees also fell on three automobiles. The second tornado, four miles Northeast of Wilmington, was even stronger despite a narrower swath of 50 yards.
- **Wind Storm, April 15, 2007 (DR-1698):** High winds during this April storm resulted in many trees down and damage to some private homes and public infrastructure, primarily in southern Vermont. $4.8 million in estimated damages from the wind.
- **Tornado, July 18, 2008 (DR-1784):** A tornado was reported in Bakersfield (EF1), causing localized damages. A tornado with winds reaching 100 mph ripped an apartment's roof off, snapped large trees, and destroyed a barn in the small town of Washington in May 2009. Estimated $150,000 in damages.
- **Wind Storm, December 1, 2010 (DR-1951):** Wind across the higher peaks of the Green Mountains caused strong to damaging down slope winds in excess of hurricane force to the western slope communities and wind gusts approaching 55 mph into the Champlain Valley. Much of this damage was in the form of downed limbs, branches, trees, playground sets and some isolated structural damage in the form of blown off roof shingles. Over 35,000 utility customers lost power with an estimated $3.35 million damages.
- **Tropical Storm Irene, August 28, 2011 (DR-4022):** While the vast majority of the impact from Tropical Storm Irene was due to flooding, damaging north winds of 35 to 45 mph sustained with gusts in excess of 60 mph buffeted Grand Isle county and Lake Champlain. Estimated wave heights of 4-6' and possibly higher damaged boats, moorings and knocked down or uprooted numerous trees with thousands of customers without power. An estimated $1.25 million in property damages is attributed to wind.

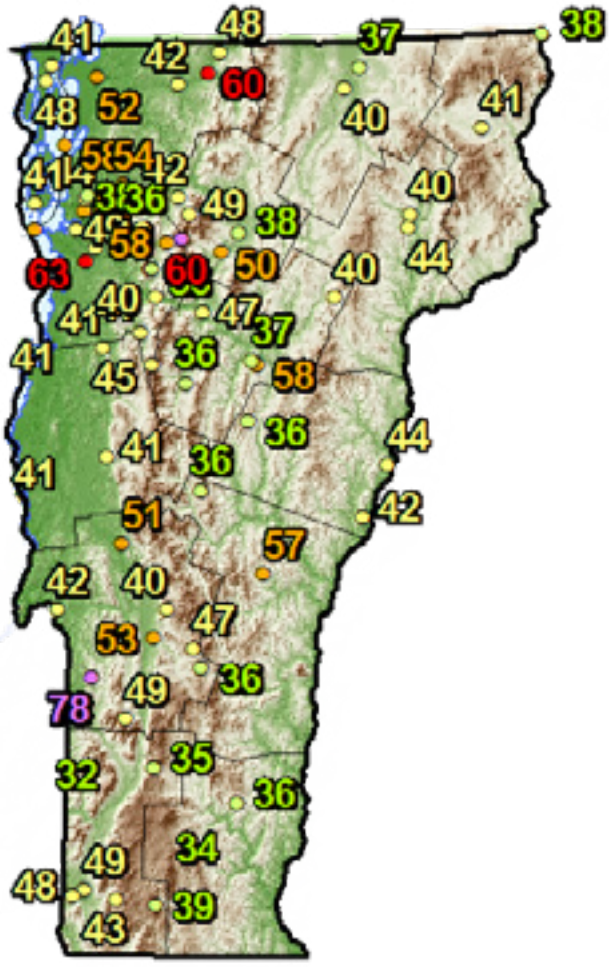


Figure 40: North Country Maximum Wind Gusts, Monday, October 30, 2017 (DR-4356)
Source: NOAA

- **Tornado, May 29, 2012 (DR-4066):** Severe storms rolled through the Northeast portion of the State. The tornado, rated as an EF0 by NOAA, had wind speeds that peaked at 70 mph, tearing 45 trees out of the ground and pelting area house with marble-sized hail. Estimated $10,000 in property damage.
- **Hurricane Sandy, October 29, 2012:** Hurricane Sandy came to the Northeast and did not significantly affect Vermont. Nevertheless, Vermont did experience high winds from the storm, especially in the southern part of the State. All of Vermont's 14 counties experienced electric utility impacts, and approximately 64,600 customers lost power. All customers had their power restored in approximately 56 hours. Estimated damages were under $1 million.
- **Wind Storm, October 30, 2017 (DR-4356):** Numerous tree damage and power outages with wind gusts of 40 to 50 mph, reaching 60 mph in some locations. $2.25 million in property damages is estimated from this event. Maximum wind gusts from this event are mapped in Figure 40.

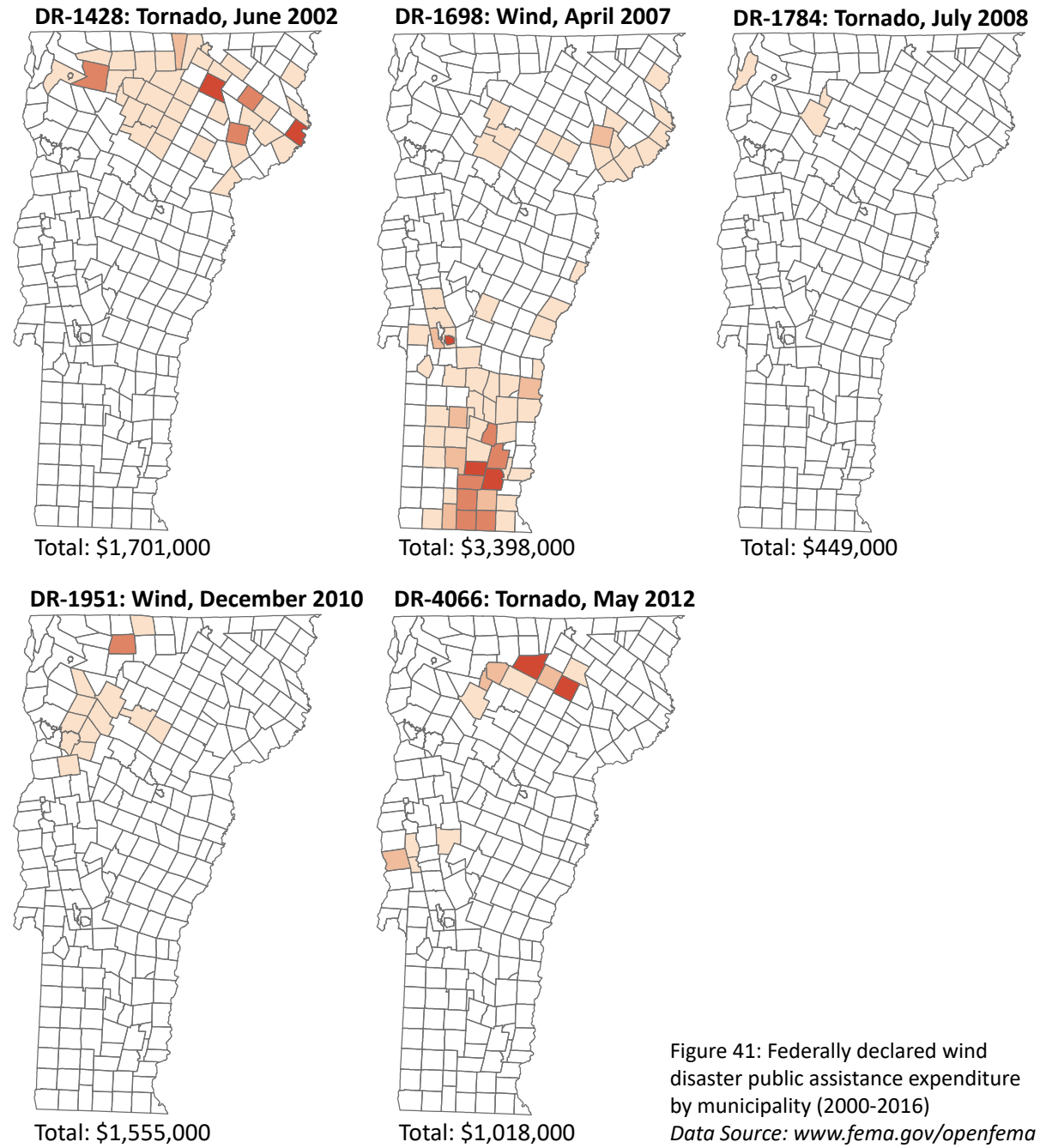


Figure 41: Federally declared wind disaster public assistance expenditure by municipality (2000-2016)
Data Source: www.fema.gov/openfema

Wind Trends & Vulnerability

Overall, wind events are considered by the Steering Committee to be Likely in Vermont. Compared to other hazard impacts, the risk due to wind events is moderate. Wind, which typically flows from west to east across Vermont, is most significant on mountain peaks, where wind speeds are highest. The most significant concern from a wind event is the impact to infrastructure, predominately utilities. High winds pose a serious concern for all electric and telecommunication utilities in Vermont due to the customer outages and damage to infrastructure they may cause. Power outages can have a significant impact on Vermonters, especially if they occur in the winter. Figure 42 shows the electric utility service territory across the State.

According to the 2014 National Climate Assessment, though there is an observable increase in severity of storms, changes in the frequency or severity of tornadoes and wind events are still uncertain but are being extensively studied[4].

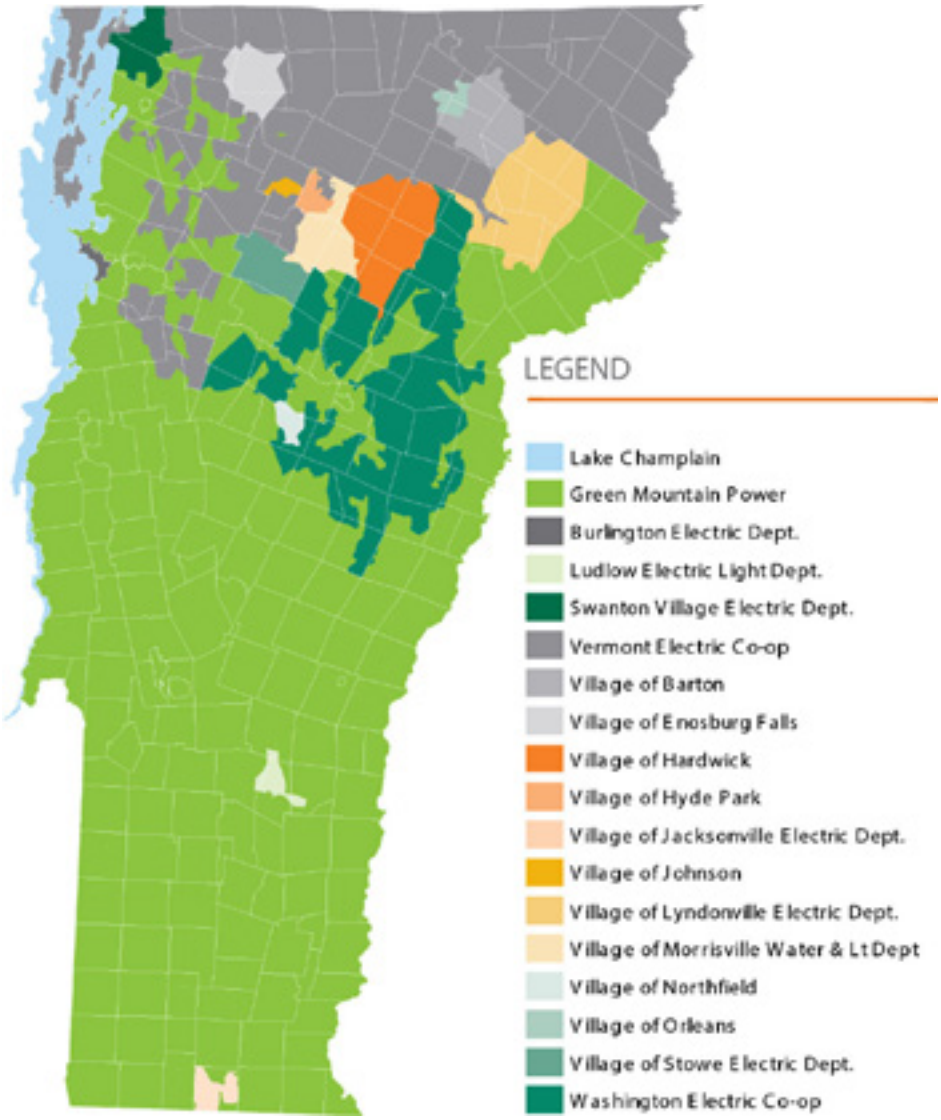


Figure 42: Electric Utility Service territory map from Vermont Public Utility Commission
Source: http://puc.vermont.gov/document/electric-service-territory-map

Wind Mitigation

Several actions within this Plan address wind events (see: Mitigation Strategy), such as the strategy on resilient design and construction standards, including actions around developing sample building standards and educational resources for resilient design and construction.

This Plan also includes a strategy to identify and protect vulnerable structures and critical infrastructure, with an action to provide technical assistance to utilities in long-range planning for transmission and distribution line upgrades and relocation to improve resilience. Additionally, this strategy includes an action to adapt the VTrans Methods and Tools for Resilience project (2018 SHMP subgrant) for use in mapping utilities and identifying vulnerabilities, which should not be a significant lift, given that the majority of utility lines in Vermont run along roadways.

4 https://nca2014.globalchange.gov/report/our-changing-climate/changes-storms

Though several towns in the State are considering burying of power lines for long-term mitigation against both wind and ice events, a statewide approach to power line burying is not being considered at this time due to being cost prohibitive.

4-4: Extreme Cold

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Cold	3	1	3	2	2	2	6

*Score = Probability x Average Potential Impact

Extreme cold temperatures can have significant effects on human health and commercial and agricultural businesses, as well as primary and secondary effects on infrastructure (e.g. burst pipes from ice expansion and power failure). What constitutes "extreme cold" can vary across different areas of the country based on what the population is accustomed to in their respective climates. Exposure to cold temperatures can cause frostbite or hypothermia and even lead to heart attacks during physically-demanding outdoor activities like snow shoveling or winter hiking. When temperatures dip below freezing, incidents of icy conditions increase, which can lead to dangerous driving conditions and pedestrian-related slipping hazards.

A large area of low pressure and cold air surrounding the poles, known as a polar vortex, is strengthened in the winter (Figure 44). When these polar vortex winds are distorted, due to cyclical strengthening and weakening or interaction with high-amplitude jet stream patterns, they have the potential to split into two or more patterns, allowing artic air to flow southward along a jet stream[1]. As this arctic air is able to access more southerly regions, extreme cold conditions can be observed in Vermont, which also have the potential to remain over the region for extended periods.

The NOAA Wind Chill Chart identifies those temperatures and associated wind speeds that may cause frostbite if skin is exposed to the air over a certain period of time (Figure 43).

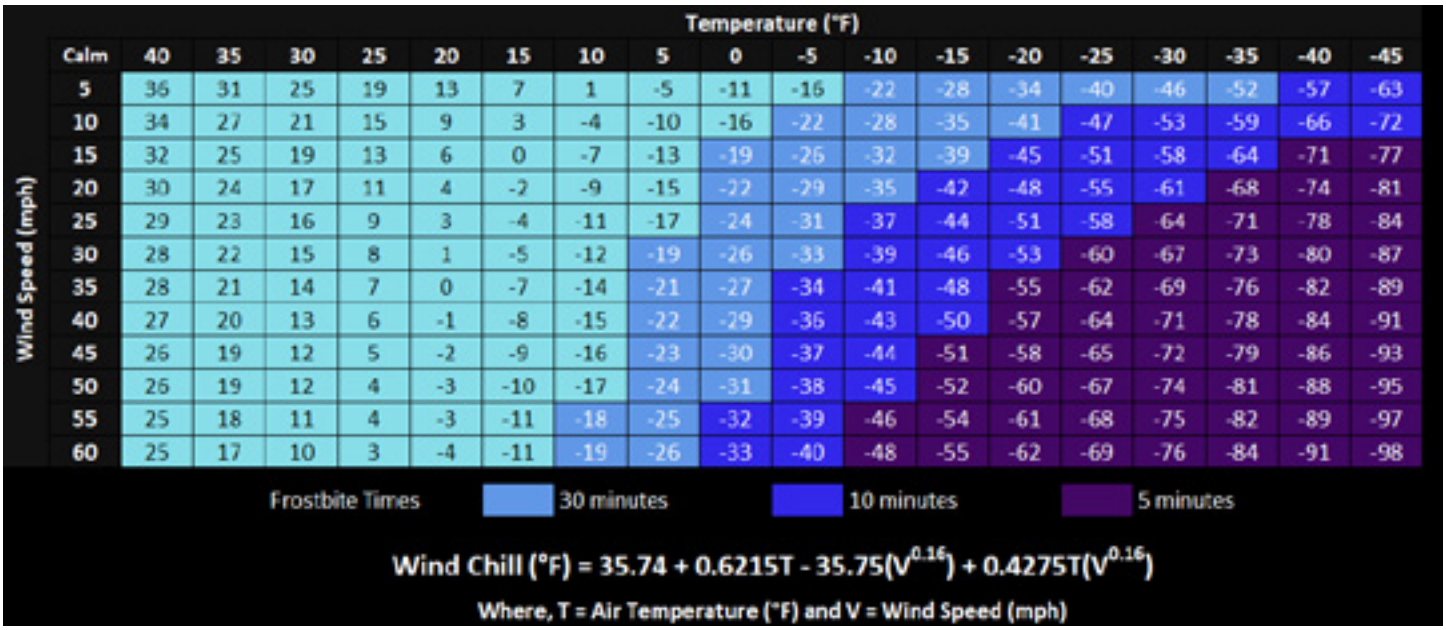


Figure 43: Wind chill temperature index
Source: NOAA

1 http://climatechange.cornell.edu/what-is-a-polar-vortex/

In anticipation of extreme cold temperatures, the National Weather Service may issue the following watches, warnings or advisories[2], which are aimed at informing the general public as well as the agricultural industry:

- **Wind Chill Warning:** Dangerously cold wind chill values are expected or occurring
- **Wind Chill Watch:** Dangerously cold wind chill values are possible
- **Wind Chill Advisory:** Seasonably cold wind chill values but not extremely cold values are expected or occurring
- **Hard Freeze Warning:** Temperatures are expected to drop below 28°F for an extended period of time, killing most types of commercial crops and residential plants
- **Freeze Warning:** Temperatures are forecasted to go below 32°F for a long period of time, killing some types of commercial crops and residential plants
- **Freeze Watch:** Potential for significant, widespread freezing temperatures within the next 24-36 hours
- **Frost Advisory:** Areas of frost are expected or occurring, posing a threat to sensitive vegetation

In the fall, both abrupt cold snaps and record warmth can be observed, where the latter tends to be associated with southerly flow. Similarly, in winter, both extreme cold and record warm conditions occur, which can affect river flow (i.e. ice jam), snow cover, ground insulation and the agricultural industry.

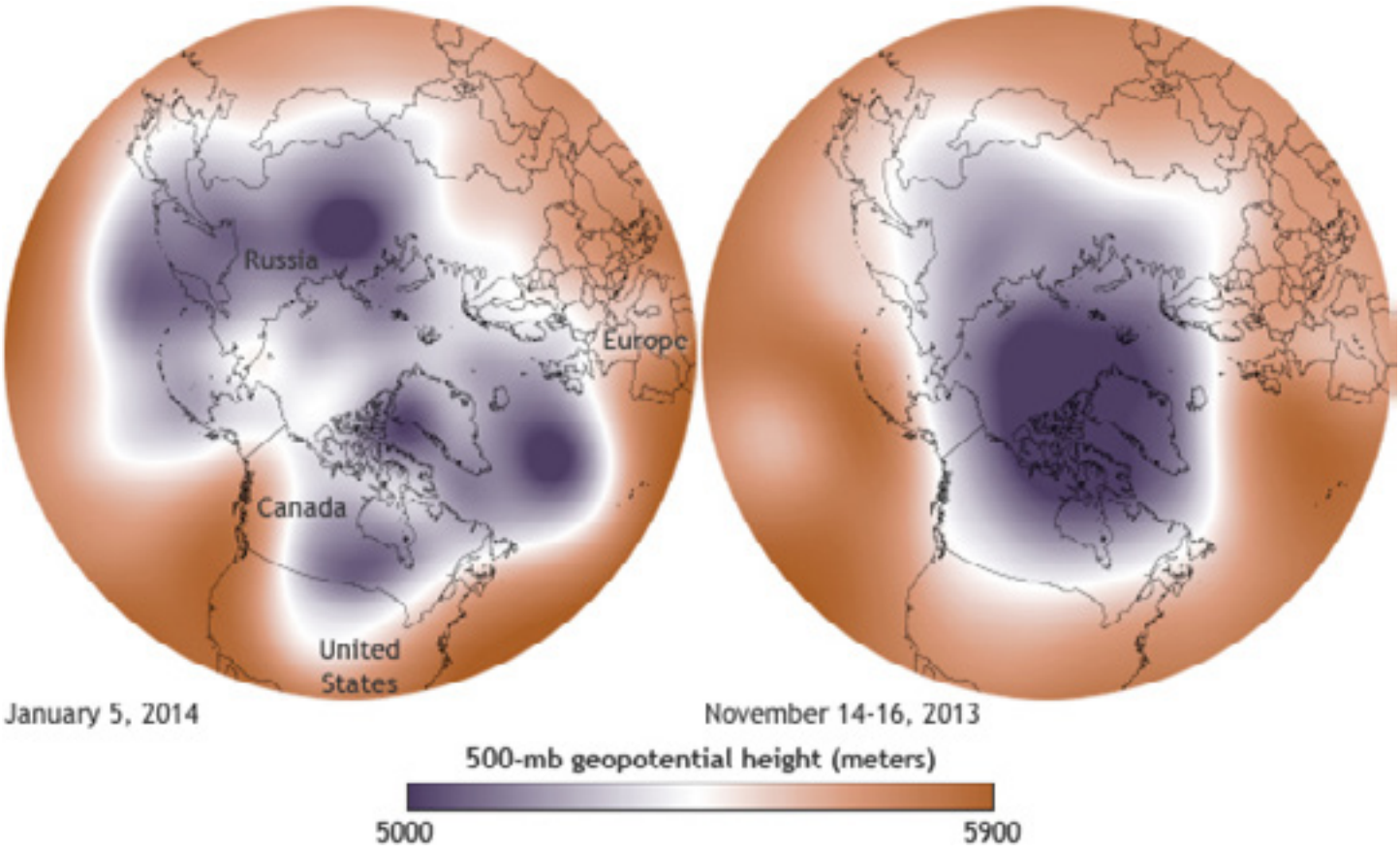


Figure 44: Wavy polar vortex configuration (left) versus more typical, compact configuration (right)
Source: https://www.climate.gov/news-features/event-tracker/wobbly-polar-vortex-triggers-extreme-cold-air-outbreak

2 https://www.weather.gov/safety/cold-wind-chill-warning

Extreme Cold History

The winter of 1933–1934 was particularly cold, and the lowest temperature ever recorded for the State (-50°F) occurred at Bloomfield on December 30, 1933. Prior to this, extreme cold temperatures were widespread on January 4 and December 18, 1835, with -40°F at Montpelier and White River, -38°F at Bradford, -30°F at Rutland and -26°F at Burlington. Following the winter of 1933–1934, more than 20% of the apple trees in Vermont were eliminated, although this figure was less than 2% for the Macintosh variety. Temperature is a very important variable in promoting apple growth. The dwarf trees introduced in the 1860s lacked the winter hardiness needed to be truly viable in Vermont. The severe winter of 1917–1918 destroyed almost all of the Baldwin and other strains. Only the Macintosh variety survived, and it remains the dominant strain grown today. In 2001, temperature fluctuations in the spring produced a different loss. Daily maximum temperatures of at least 90°F followed by minimum temperatures near 20°F accelerated the flowering of the apple blossoms, which were then killed by the low nighttime temperatures.

One of the most prolonged cold episodes lasted from January 18 to February 3, 1969. Maximum temperatures were below 0°F. Water mains and other connections froze and burst in record numbers across the State. Since then, extreme cold has been recorded in February 1993 and again on January 19, 1997. In both cases, cold dense air moving out from an Arctic high-pressure system caused temperatures to plummet. Daytime highs in 1993 were 10°F, while the minimums were -5°F. The winter of 1997 holds the record for longest streak of consecutive days below freezing, without a thaw, at 51 days.

More recently, the winter of 2015 maintained below freezing temperatures for 27 days, while the period between December 24, 2017 and January 8, 2018 (or 16 consecutive days) did not exceed 32°F.

Between the winters of 2000 and 2018, the number of recorded days per year with a daily temperature low of less than or equal to 0°F peaked during the 2015 winter at 31 days in Burlington, 44 days in Montpelier, 55 days in Island Pond and 32 days in Bennington.

NOAA storm event history for Vermont includes several extreme cold/wind chill events since 2000, none of which included any deaths, injuries, or recorded damages:

- **January 17, 2000:** A northwest wind averaging between 15-30 mph across southern Vermont, impacting Bennington and Windham Counties, with the addition of temperatures between 0°F to -10°F, produced dangerously low wind chill values of -50°F to -60°F.
- **January 25, 2007:** An arctic cold front moved across Vermont on January 24, delivering very cold temperatures of 0°F to -25°F by the following morning. A secondary cold front accounted for the combination of brisk northwest winds of 10-15 mph and temperatures -5°F to -20°F with wind chill readings of -25°F to -40°F across the State. Another arctic front pushed across the area on January 29 and brought early morning low temperatures of -10°F to -30°F.
- **March 6-9, 2007:** An arctic cold front swept across the State March 5 causing temperatures to plummet to -5°F to -20°F by dawn March 6. These frigid temperatures, accompanied by winds of 15-30 mph created dangerously cold wind chills of -20°F to -40°F. Brisk winds with temperatures around 0°F continued through the day. The winds subsided after sunset but it remained extremely cold through the morning of March 7. Arctic high pressure settled across New England March 9 with morning lows of -10°F to -34°F across Vermont.
- **January 14, 2009:** An arctic cold front moved across Vermont which delivered some of the coldest temperatures across the region in several years as temperatures dropped over 20°F within several hours, averaging 20°F to 25°F below normal values, which were already at climatological winter minimums.

Nighttime minimums were -10°F to -30°F across Vermont with isolated readings colder than -40°F. These extremely cold temperatures led to numerous cold weather related problems including numerous dead vehicle batteries and broken home/business water pipes.

- **January 23, 2011:** Bitterly cold air settled into the region and temperatures plummeted to -10°F to -25°F below zero across southern Vermont in Bennington and Windham Counties. Brisk westerly winds diminished during the evening, becoming light and variable to calm after midnight, resulting in wind chill readings of -25°F to -35°F.
- **January 8, 2015:** Wind chills colder than -25°F to -40°F were observed overnight January 7, with morning lows of -15°F to -35°F across Vermont, with the coldest temperatures within the southern Green Mountains and observed wind chills in the mountains from -40°F to -70°F. These dangerously cold wind chills lead to delayed school openings of 2 hours or cancelled classes on the morning of January 8.
- **February 15, 2015:** An extremely frigid Arctic air mass pour into the region from the north, beginning during the late morning hours and a strong pressure gradient allowed for very strong winds. Northwest winds frequently gusted over 30 mph, with some gusts as high as 39 mph through the evening. Temperatures fell quickly through the day and dropped below zero for Sunday night into the morning of February 16. Some temperatures were as cold as -20°F with chill values of -20°F to -45°F, predominately in Bennington and Windham Counties. Many towns had warming shelters open and there were reports of bursts water mains and pipes due to the frigid temperatures.
- **February 13, 2016:** Behind an Arctic cold front, very cold temperatures poured into the region upon brisk northwesterly winds, reaching lows of -12°F to -28°F along with winds gusting 20 to 40 mph, wind chill values reached -25°F to -45°F in Bennington and Windham Counties.
- **December 27, 2017-January 1, 2018:** A frigid Arctic air mass poured into the region December 27 with gusty northwesterly winds. Low temperatures fell to as low as -5°F to -14°F with wind chill values as low as -37°F in Bennington and Windham Counties. Temperatures plummeted from -10°F in Windham County to -18°F Bennington County with wind chills ranging from -11°F to -31°F during the early morning hours of New Year's day and dropping to -15°F to -35°F throughout the morning.
- **January 5-7, 2018:** A brutally cold Arctic air rushed southward into Vermont, resulting in an extended period of extremely cold conditions. The coldest wind chills occurred during the mornings of January 6 and 7, when frigid air combined with westerly winds gusting to 30 to 40 mph resulted in widespread wind chills as low as -20°F to -40°F. High temperatures on January 6 were mainly in the single digits above and below zero. Many warming shelters were opened across the Vermont as a result of the cold weather.

Extreme Cold Trends & Vulnerability

The Steering Committee considered the probability of a plausibly significant extreme cold event to be Likely, with the most significant impacts felt by people, followed then by the direct and indirect impacts to the environment and the economy.

Temperature fluctuations are a result of several meteorological processes[3]. Due to the tilt of Earth's axis, regions of the globe receive varying levels of solar radiation. The delta between these levels produces circulation patterns at the global level, which drive air and storm system movement via air masses. Air masses, as defined by NOAA, are thousands of feet thick and extend across large areas of the earth. Air masses that form over tropical ocean regions will become exceptionally hot and humid, while those masses above high latitude continents will become cool and dry. When these air masses meet, a front is created; fronts can either be cold or warm. In addition to these air mass and front-related impacts humans feel at ground level, movement of narrow bands of strong wind high in the atmosphere, known as jet streams, maneuver weather

3 http://www.noaa.gov/resource-collections/weather-systems-patterns

systems below and transfer heat and moisture across the globe. The speed and intensity of the jet stream will affect the duration and temperature associated with a cold or warm front.

According to NOAA Climate Center[4], annual average temperatures for the contiguous United States from 1895-2016 are increasing at a rate of 1.45°F per century (Figure 45). Coupled with EPA data that suggest that both the number of days colder than the 5th percentile and the percent of daily record lows are decreasing in the northeastern United States between 1948 and 2015[5], the probability of extreme cold temperatures in Vermont is decreasing.

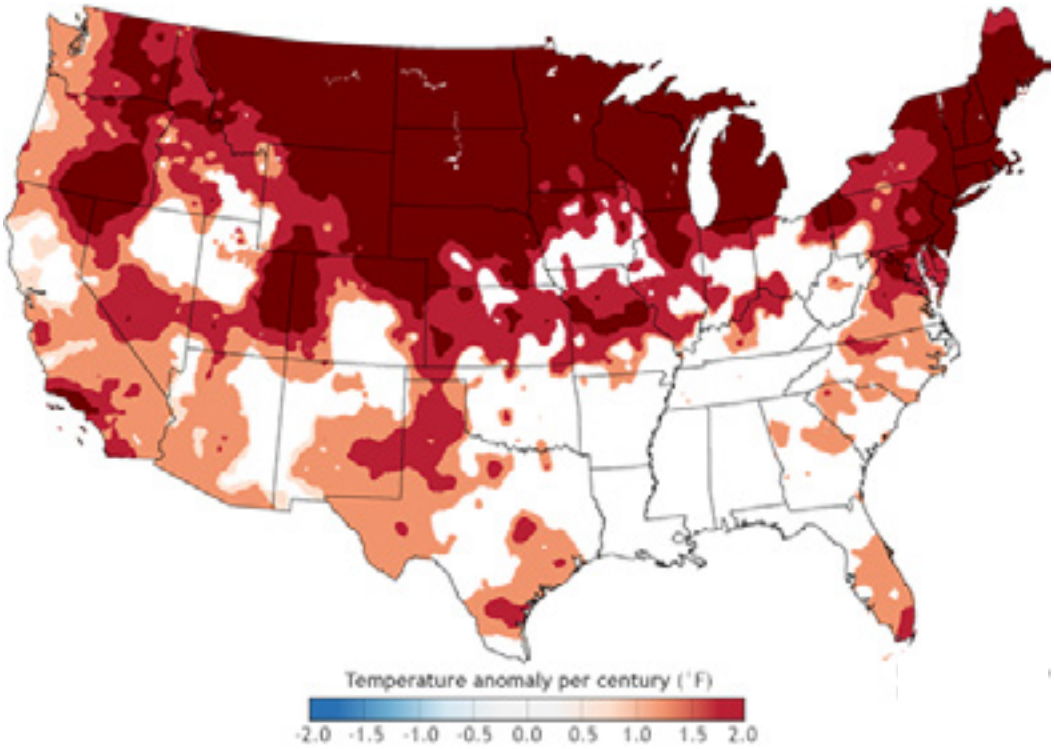


Figure 45: Average mean temperature trends in the U.S. map, February 1895-2016 (95% confidence interval)
Source: NOAA

However, Vermont remains vulnerable to extreme cold temperatures and periods of prolonged cold temperatures, especially in the northeastern portion of the State. This region, colloquially referred to as the Northeast Kingdom, can see temperatures as low as -35°F. Because this area also receives the most snowfall, is the most rural region in the State, and has the oldest average resident age, it is considered to be the most vulnerable to impacts related to extreme cold temperature.

According to the Vermont Department of Health, the average number of cold-related deaths (i.e. deaths caused by exposure to cold air or water temperatures) between 2008 and 2015 was 2.75 persons annually. This number does not take into consideration deaths by drowning following falls through ice or those deaths related to trauma experienced from slipping on ice. This number also does not consider those deaths resulting from ice-related traffic events.

As climate data confirm that the contiguous United State is warming at a rate 50% greater than the global average, with the most significant warming observed in New England in the winter months[6], Vermont is also experiencing a decline in the level of snow cover (Figure 46). During these more frequent, warmer winters, snow, which acts as a protective, insulating layer between the cold air and the ground, is more likely to

4 https://www.climate.gov/news-features/blogs/beyond-data/mapping-us-climate-trends
5 https://www.epa.gov/climate-indicators/climate-change-indicators-high-and-low-temperatures
6 https://www.climate.gov/news-features/blogs/beyond-data/mapping-us-climate-trends

melt. When seasonable, cold air moves back into the region after prolonged exposure to above-freezing temperatures that have melted much of the snow coverage, the exposed ground experiences deeper soil frost, which can negatively impact road infrastructure (i.e. frost heaves), water lines (i.e. burst pipes from water-ice expansion) and perennial crops that rely on the snow for protection from cold temperatures and winds.

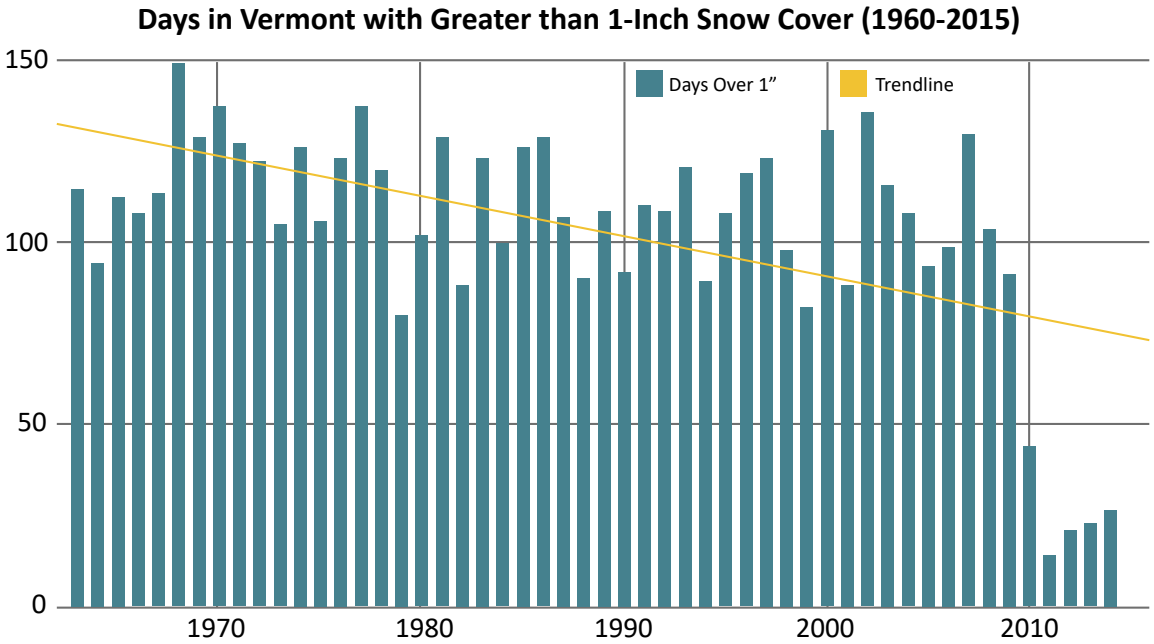


Figure 46: Number of days in Vermont with greater than 1-Inch snow cover (1960-2015)
Data Source: http://climatechange.vermont.gov

In addition to exposed soil, Vermont's rivers and lakes are also impacted from fluctuating periods of warmth and extreme cold. The continued freeze-melt-freeze cycle on rivers leads to increased ice accumulation, which can then be broken into large sheets of mobile ice during the next period of warming. This phenomenon is called ice jamming, which often results in flooding (see: Inundation Flooding & Fluvial Erosion).

Extreme Cold Mitigation

In 2014, Vermont Emergency Management submitted a Statewide Generator Project application under DR-4022 for several emergency shelters and critical facilities to reduce statewide vulnerability to residents experiencing power outage as a result of various hazard events. Because extreme cold temperatures often occur in tandem with winter storms (see: Snow Storm & Ice Storm) or lead to ice jam flooding (see: Inundation Flooding & Fluvial Erosion), residents who lose power during Vermont's coldest months need warm shelters where they can be protected from harsh conditions and reduce the potential for health-related impacts of exposure to cold temperatures, such as hypothermia or frostbite.

This Plan has also identified a mitigation strategy to develop resilient design and construction standards (see: Mitigation Strategy) in the form of auditing existing building codes, which would include standards for cold insulation. Additionally, several strategies aimed at increasing public knowledge about hazards and mitigation, supporting vulnerable populations and coordinating hazard mitigation mapping must consider extreme cold and exposure to prolonged cold weather events during implementation.

4-5: Extreme Heat

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Heat	3	1	3	2	2	2	6

*Score = Probability x Average Potential Impact

This chapter aims to address the history, trends, vulnerability and mitigation efforts associated with extreme heat, prolonged hot weather and rising average annual temperatures. More information on increasing temperatures can be found in the Vermont Profile & Hazard Assessment section and the Extreme Cold section.

Extreme hot temperatures can have significant effects on human health and commercial and agricultural businesses, as well as primary and secondary effects on infrastructure (e.g. damage to asphalt roadways from softening). What constitutes "extreme heat" can vary across different areas of the world based on what the population is accustomed to in their respective climates. An example of this difference in acclimatization can be understood when comparing analyses of excess mortality due to heat: in New York City, the data show that the heat index threshold needs to reach at least 95°F to measure a significant rise in heat-related mortality, whereas the threshold in Montreal, Canada, only 400 miles north, is 91°F and did not need to factor in heat index. Similar epidemiological analyses completed by the Vermont Department of Health suggest that the heat threshold in which hospitals in the State see a rise in heat-related emergency room visits is 87°F[1].

Temperature fluctuations are a result of several meteorological processes[2]. Due to the tilt of Earth's axis, regions of the globe receive varying levels of solar radiation. The delta between these levels produces circulation patterns at the global level, which drive air and storm system movement via air masses. Air masses, as defined by NOAA, are thousands of feet thick and extend across large areas of the earth. Air masses that form over tropical ocean regions will become exceptionally hot and humid, while those masses above high latitude continents will become cool and dry. When these air masses meet, a front is created; fronts can either be cold or warm. In addition to these air mass and front-related impacts humans feel at ground level, movement of narrow bands of strong wind high in the atmosphere, known as jet streams, maneuver weather systems below and transfer heat and moisture across the globe. The speed and intensity of the jet stream will affect the duration and temperature associated with a cold or warm front.

Extremely high temperatures can occur when a high-pressure system (under which air is descending toward the Earth's surface) develops and intensifies. Under such conditions, the potential for a heat wave exists. A heat wave is a period of three or more consecutive days during which the maximum temperature meets or exceeds 90°F.

In anticipation of extreme heat events, the National Weather Service (NWS) may issue the following advisories:

- **Excessive Heat Outlook:** A period of excessive heat is possible within the next 3 to 5 days.
- **Heat Advisory – Take Action:** A period of excessive heat is expected. The combination of hot temperatures and high humidity will create a situation in which heat related illnesses are possible. Heat Advisories are issued when heat indices are expected to reach at least 95°F.

1 http://www.healthvermont.gov/sites/default/files/documents/2017/01/CHPR_Sept7_2016.pdf
2 http://www.noaa.gov/resource-collections/weather-systems-patterns

- **Excessive Heat Watch:** A prolonged period of dangerous excessive heat is possible within about 48 hours
- **Excessive Heat Warning – Take Action:** A prolonged period of dangerous excessive heat is expected within about 24 hours. The combination of hot temperatures and high humidity will create a situation in which heat related illnesses are possible. Excessive Heat Warnings are issued when heat indices are expected to reach at least 105°F.

The Heat Index is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature (Figure 47). For example, if the air temperature is 90°F and the relative humidity is 65%, the heat index – how hot it feels – is 103°F. The red area without numbers indicates extreme danger. The National Weather Service will initiate alert procedures when the Heat Index is expected to exceed 105°F (depending on local climate) for any duration[3].

Extreme heat and prolonged periods of hot weather, as well as significant, projected increases in average annual temperature, also have direct and indirect effects on other hazards, addressed throughout this Plan: Drought, Wildfire, Invasive Species, Infectious Disease.

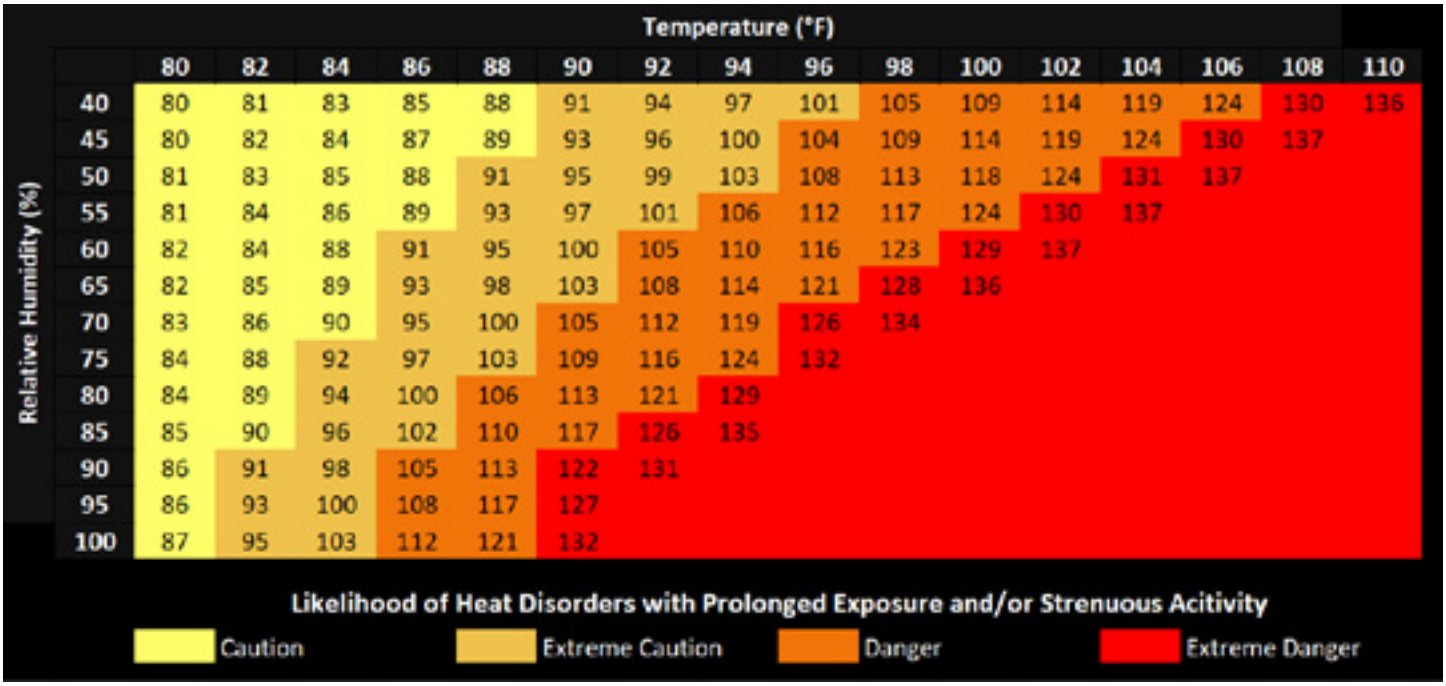


Figure 47: Heat index
Source: NOAA

Extreme Heat History

Fortunately, Vermont has historically experienced a climate where extreme heat is less likely than other regions in the country. However, heat-related events do occur and are beginning to occur in much greater frequency (see: Extreme Heat). In Burlington, the average number of days per year with above 90°F temperatures is nearly eight. In 1999, a drought year, this figure climbed to 19. Extreme maximum temperatures are often observed during drought years, and in many cases, the records that are broken were long-standing and set during previous droughts (see: Drought). It should be noted that a heat wave could be either a boon or a bane depending upon the time of year and the antecedent conditions. For example, the hot conditions of August 1996 followed a cool, wet summer, thereby providing an extra boost for plants.

3 http://www.nws.noaa.gov/om/heat/heat_index.shtml

In July of 1911, Northfield had a 12-day average of 90.75°F. The summer of 1949 was also very hot, with 25 days above 90°F. It is important to note here, however, that hot weather can have health impacts at even lower temperatures, with health risks increasing considerably when temperatures reach the mid-to-upper 80s[4]. Between 2000 and 2017, the number of recorded days per year with a daily temperature high greater than or equal to 85°F peaked during the 2016 summer at 45 days, closely followed by the summer of 2015 at 41 days in Burlington.

March 8-9, 2000 is the only excessive heat event for Vermont on NOAA's records, impacting Windham and Bennington Counties. Temperatures climbed through the 60s to near 70°F on both afternoons. At the Albany International Airport, the high of 66°F on March 8 established a new record high, eclipsing the old record of 64°F set in 1942. On March 9, the temperature reached 68°F, replacing the old daily record high of 66°F set in 1977. Other heat events since 2000 include:

- **August 1-2, 2006:** A heat ridge moved into Vermont during the early morning August 1. Temperatures soared into the 90s but significantly more important were dewpoints that reached the middle to upper 70s to produce excessive heat index values of 100°F to 105°F, some of the highest values in nearly a decade.
- **July 21, 2011:** Temperatures across much of southern Vermont warmed into 90s with dew points in the 70s, combined with the hot temperatures and resulted in heat indices of 100°F to 104°F. This was the 2nd day of a 3 to 4-day heat wave across a large portion of Vermont with heat index values of 100°F to 108°F across the Champlain and Connecticut valleys as well as some interior valleys. One death is attributed to this event in Windsor County.
- **March 17, 2012:** Winter of 2011-12 had temperatures that averaged 4-5°F above normal and snowfall 40-60% of normal. This combination accounted for snow pack across the region to be largely below normal or even non-existent by mid-March. In Vermont, temperatures climbed into the 70s March 18 and low-80s March 19-22. Record heat was recorded across all of Vermont with maximum temperatures 30-40°F above normal and some daily records being broken by 10°F or more. This event caused an estimated reduction of 30% of maple sugar production, resulting in an estimated impact of nearly $10 million. In addition, there was significant loss of ski industry revenue due to a 25-50% reduction in snow loading.

Extreme Heat Trends & Vulnerability

From 1895 to 2015, the average annual temperature in Vermont increased by 2.6°F (or 0.2°F per decade). Data from the National Oceanic and Atmospheric Administration (NOAA) further suggest that Vermont's average annual maximum and minimum temperatures increased by approximately 0.4°F and 0.6°F, respectively, per decade since 1960[5], representing an increasing trend in temperature increases within the State. This significant rise in average temperature is even more profound when comparing the differences between seasons: average maximum temperature in the summer (June-August) has risen 0.15°F per decade, while winter (December-February) has experienced a four-fold increase of 0.64°F per decade.

According to a recent published article[6], the northeast region of the country is the fastest-warming area of the contiguous United States and is warming at a rate 50% greater than the global average. Increases in ground surface temperatures will be further exacerbated by varying levels of greenhouse gases. Climatologists have modeled the projected increases in the number of days over 90°F for both reduced greenhouse gas emissions

4 http://www.healthvermont.gov/environment/climate
5 http://climatechange.vermont.gov/our-changing-climate/dashboard/increasing-max-min-temperature
6 http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0168697

scenario (B1) and those increases in higher greenhouse gas emissions scenario (A2). This modeling suggests that increases in average temperature of 3°F to 6°F in the lower emissions scenario versus 4.5°F to 10°F under higher emissions conditions can be expected by the 2080s[7] (Figure 49). The most significant warming in this region will occur during the winter months, where average temperatures are projected to increase by 4°F, while the increase in summer months will be less severe, at 2°F, but still considered a significant rise.

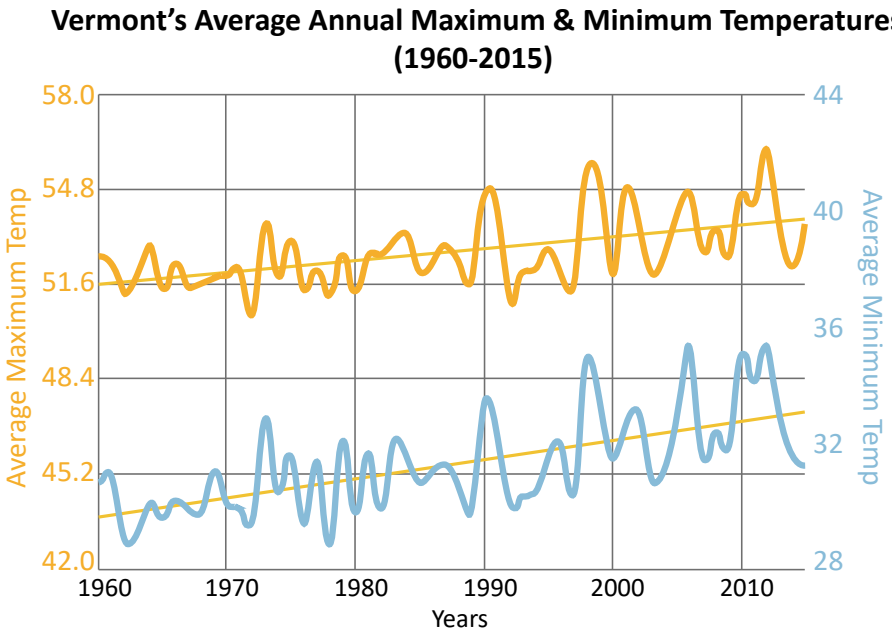


Figure 48: Vermont's average annual maximum & minimum temperatures (1960-2015)
Source: climatechange.vermont.gov

More information for the compounding impacts of increasing gas emissions on increasing temperatures can be found in the 2014 National Climate Assessment[8].

The primary impact of extreme heat or prolonged periods of hot weather is to human life. Hot conditions, especially when combined with sun and high humidity, can limit the body's ability to thermoregulate properly. Prolonged exposure to hot conditions can lead to heat cramps, heat exhaustion, heat stroke, or exacerbate other pre-existing medical conditions. Some of these impacts require medical attention and can be fatal if left untreated.

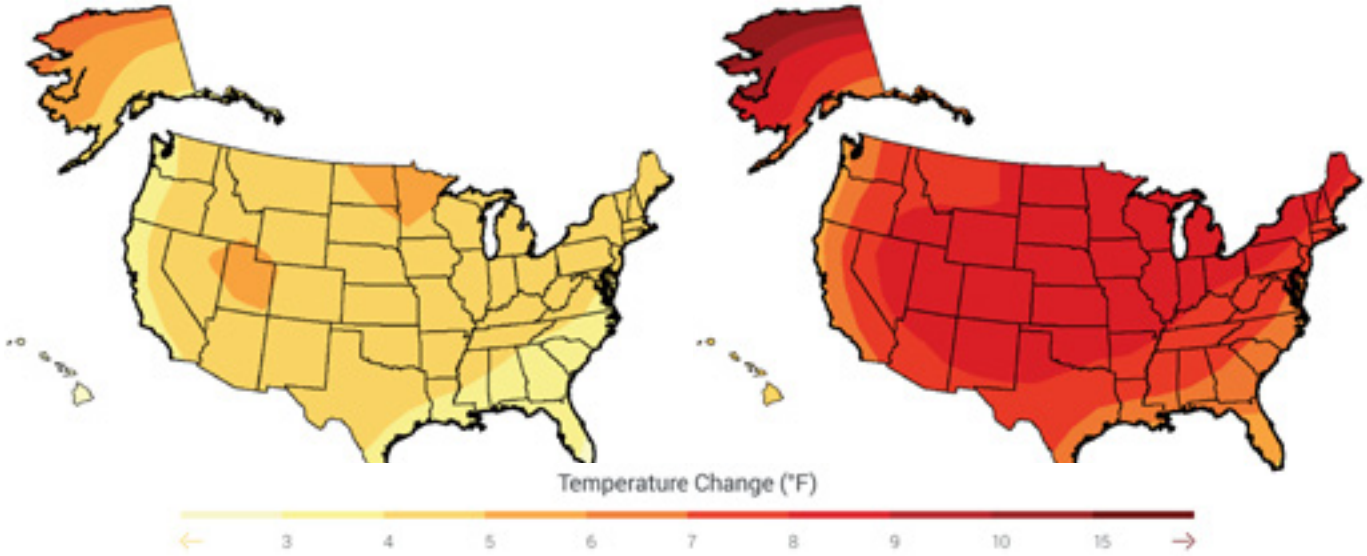


Figure 49: Projected temperature increase under lower emissions scenario, B1 (left) versus under higher emissions scenario, B2 (right)
Maps show projected change in average surface air temperature in the later part of this century (2071-2099) under a scenario that assumes substantial reductions in heat trapping gases (B1) and a higher emissions scenario that assumes continued increases in global emissions (A2) Source: https://nca2014.globalchange.gov/report

7 https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-northeast_.html#Reference%201 http://anr.vermont.gov/sites/anr/files/specialtopics/climate/documents/VTCCwhitepapers/VTCCAdaptAgriculture.pdf
8 https://nca2014.globalchange.gov/report

The Heat Vulnerability in Vermont report[9] suggests that Vermonters are at a greater risk for serious, heat-related illness – potentially even death – when the statewide average temperature reaches or exceeds 87°F (Figure 50). The Health Department's Climate & Health Program has reviewed six heat vulnerability themes (population demographics of a town, socioeconomic status, health status of town residents, environmental characteristics, the ability of town residents to acclimate to hot temperatures and emergency room visits for heat illness) and determined a thematic vulnerability for each.

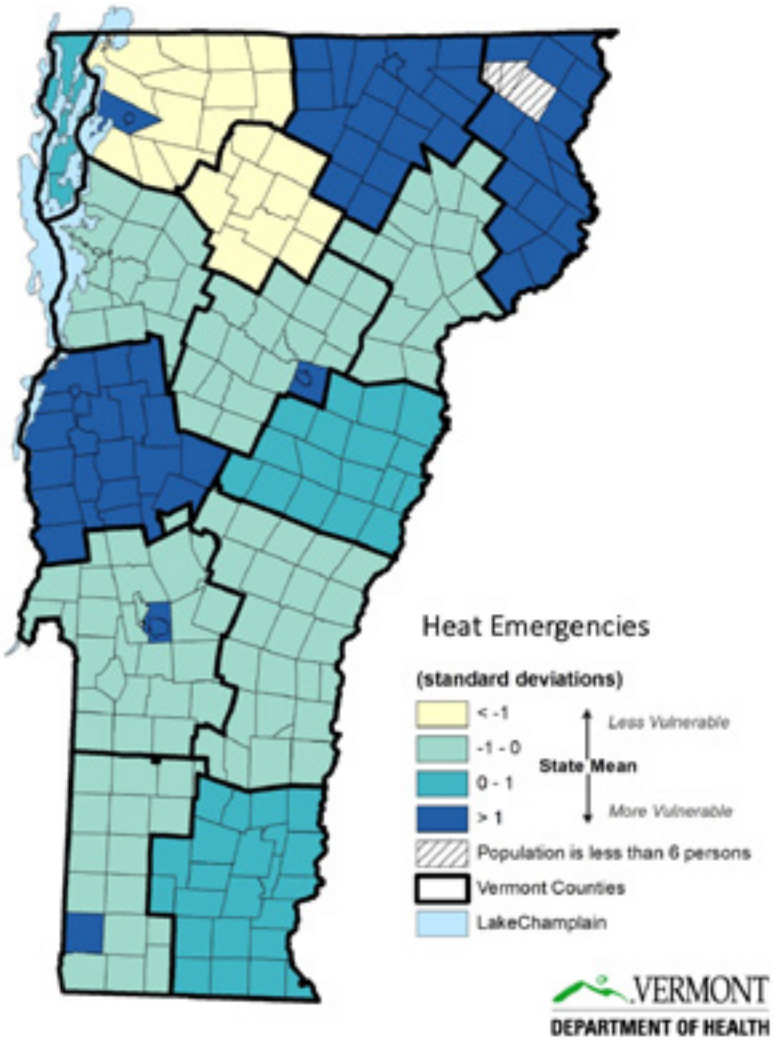


Figure 50: Vermont heat emergencies map by municipality
Source: Vermont Department of Health

In general, those at higher risk during hot weather include older adults and children, people with chronic medical conditions, people active outdoors, people without air conditioning, and people living in more urbanized parts of Vermont. The hot-weather vulnerability maps by theme, and more information regarding the health impacts of increasing temperatures and prolonged periods of hot weather are available at the Department of Health's Climate & Health website: www.healthvermont.gov/environment/climate. Figure 51 shows the overall vulnerability scores across Vermont.

Though higher temperatures are more likely in the southeast region of the State and in more urban areas, this does not translate to a linear relationship between temperature and vulnerability. Historically, relatively high rates of heat illnesses have been experienced in some of the cooler counties in Vermont, which may be a result of underlying population vulnerabilities (e.g. an older population with more pre-existing health conditions) or a lack of acclimation to hotter conditions.

Further, higher concentrations of ground-level ozone are associated with hotter days in the northeast, which can exacerbate heat-related health impacts, particularly for older adults, children, and those with asthma or other respiratory conditions.

9 http://www.healthvermont.gov/sites/default/files/documents/2016/12/ENV_EPHT_heat_vulnerability_in_VT_0.pdf

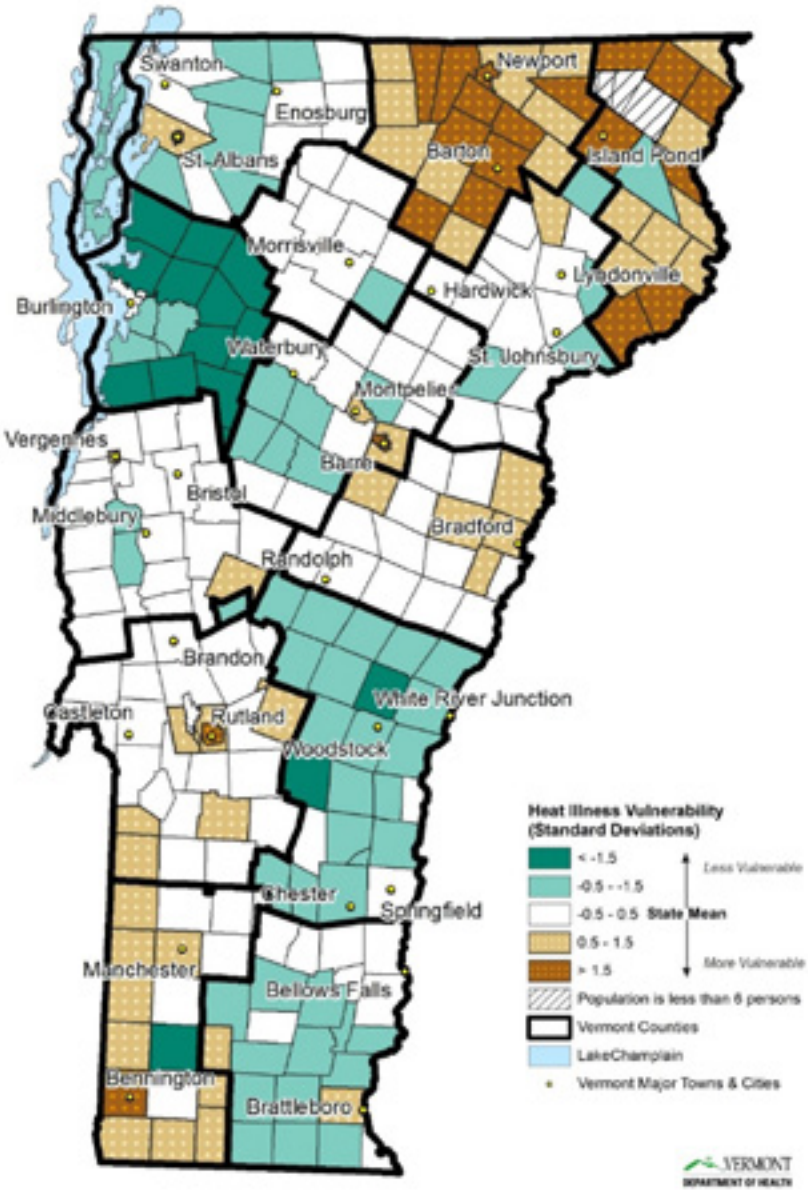


Figure 51: Vermont Heat Illness Vulnerability
Source: Vermont Department of Health

In addition to the direct health impacts associated with extreme heat, data suggest that health impacts are also associated with prolonged hot weather and increasing average temperatures. For example, increases in the incidence of vector-borne diseases (e.g. Lyme, West Nile and Eastern equine encephalitis) in Vermont and New England at-large have been observed and are attributed to warming conditions. The increase in average annual temperatures and shortened winters have allowed mosquitos and ticks to become more active earlier in the spring and remain active later in the fall. Because the incidence of Lyme disease in Vermont is higher than the national average at present, lengthening vector seasons is of great concern to the health community in Vermont. People working in the outdoors – loggers and farmers, for example – are most vulnerable to vector-borne illness (see: Infectious Disease).

Finally, hot weather can increase thermal stratification in water bodies, where shallow water layers are much warmer and do not readily mix with cooler, deeper water layers. Stratified water layers are most common in late summer and early fall, providing more favorable conditions for development of cyanobacteria blooms in Vermont's lakes and ponds. Some types of cyanobacteria can release natural toxins or poisons (called cyanotoxins) into the water, especially when they die and break down. Swimming or wading in water with cyanobacteria may cause minor skin rashes, sore throats, diarrhea, stomach problems, or occasionally more serious health problems. Children and pets are at higher risk of exposure because they are more likely to play near the shoreline and drink water while swimming[10].

The rise in average annual temperature and increased occurrence of prolonged hot weather events will also have impacts on infrastructure, the environment and the economy in Vermont. These impacts are also not exclusive to the extreme heat hazard, but rather will affect many other hazards addressed within this Plan. First, as temperatures continue to rise, there is likely to be a heightened consideration for water supplies, as many individuals in Vermont use private wells for water supplies. Higher temperatures will lead to increased evapotranspiration, soil drying rate and the frequency of short-term droughts, limiting water availability for tree growth (see: Drought).

10 http://www.healthvermont.gov/tracking/cyanobacteria-tracker

Native forests and ecosystems are projected to experience negative impacts of these warming trends, as well[11]. With 76% of the Vermont landscape covered by forest, and more than 50 tree species, increases in average annual temperatures will force these species to adapt. Northern hardwood species like maple, yellow birch and American beech are anticipated to be nearly eliminated in the State, replaced by those tree species that thrive in warmer, drier conditions, like oak and pine. Additionally, the changing climate will allow for greater survival and reproduction of forest pest species, as trees that are stressed due to lower water availability reduce their ability to maintain sufficient defense mechanisms, making them more vulnerable to pest invasion and disease (see: Invasive Species).

With a changing forest complexion and greater levels of evapotranspiration, extreme heat and prolonged hot weather could also lead to an increase in the occurrence of wildfires in Vermont (see: Wildfire).

Global warming projections also consider changes to crops and vegetation, which could drop by nearly 40% in some areas, causing great disruptions on the agricultural sector in Vermont. The Vermont Agency of Natural Resource's Climate Change Adaptation White Paper Series' Agricultural White Paper[12] identifies cold-weather crops, such as field corn, wheat and oats to be the most vulnerable to rising temperatures. The paper continues to note that many fruits grown in Vermont (e.g. blueberries and apples) require approximately 1,000 hours below 45°F to produce profitable yields, and with current climate projections, southern Vermont may not be able to meet these requirements. Maple sugaring, a $200 million industry in Vermont, will need to adapt to changing temperature patterns and adjust tapping schedules, as new estimates suggest that spring is arriving two weeks ahead of the average winter-spring transition. Vermont's dairy industry is responsible for 70-80% of the State's annual agricultural sales. Dairy farmers across the State will need to pay attention to increasing temperatures, as cows can experience heat stress at as low as 75°F, especially on humid days, which can reduce milk production by up to 20%.

Considering the already-observed increase in average annual temperature, the projected rise between 3°F and 10°F by the 2080s, and the impacts of extreme heat or prolonged hot weather, the Steering Committee considered the probability of a plausibly significant extreme heat or prolonged hot weather event to be Likely, with the most significant impacts felt by people, followed then by the direct and indirect impacts to the environment and the economy.

Extreme Heat Mitigation

As mentioned throughout the Extreme Heat hazard profile above, increases in annual average temperatures will have wide-reaching impacts to other hazards addressed in this Plan. Accordingly, many of the mitigation strategies and actions addressing the hazard impacts of Drought, Invasive Species, Wildfire and Infectious Disease can be both directly and indirectly tied to Extreme Heat (see: Mitigation Strategy).

The Vermont Urban & Community Forestry and Climate & Health Programs partnered with the Arbor Day Foundation in 2017 and 2018 to offer an Energy-Saving Trees Program to residents of urban communities in Vermont[13]. Communities were selected based on their relatively high risk for heat illnesses, according to the Vermont Heat Vulnerability Index, where one of their key risk factors was a lack of tree cover. Five hundred trees have been provided to residents in four different Vermont communities – Barre, Bennington, Newport, and Rutland.

11 http://climatechange.vermont.gov/sites/climate/files/documents/Data/VTCCAdaptForestry.pdf
12 http://anr.vermont.gov/sites/anr/files/specialtopics/climate/documents/VTCCwhitepapers/VTCCAdaptAgriculture.pdf
13 https://vtcommunityforestry.org/est

Other strategies that have been identified to address health risks of hot weather include general awareness raising and capacity building among the public, health and emergency service professionals, and home visiting staff and volunteers; building retrofits to help keep buildings cooler and better ventilated; designation of community cooling centers; adoption of workplace, school, and community policies to cancel or modify activities on hot days; and development of a State hot weather emergency communications and response plan.

The primary entity in Vermont devoted to extreme heat and prolonged hot weather mitigation and preparedness is the Vermont Department of Health Climate & Health Program[14]. Over the past several years, this team has developed a wide range of reports and resources used for hot weather planning, which aim to identify populations most vulnerable to heat-related health impacts while taking into consideration a warming climate[15].

14 http://www.healthvermont.gov/environment/climate

15 http://www.healthvermont.gov/sites/default/files/documents/pdf/ENV_CH_WhitePaper.pdf

4-6: Drought

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Drought	3	1	2	2	3	2	6

*Score = Probability x Average Potential Impact

Drought is defined as a water shortage with reference to a specified need for water in a conceptual supply and demand relationship. It is a complex phenomenon that is difficult to monitor and assess because it develops slowly and covers extensive areas, as opposed to other disasters that have rapid onsets and obvious destruction. Also unlike most disasters, the effects of drought can linger long after the drought has ended. Drought is an inherent, cyclical component of natural climatic variability and can occur at any place at any time. It is difficult to determine the onset, duration, intensity, and severity of a drought, all of which affect the consequences and corresponding mitigation techniques. High winds, low humidity, and extreme temperatures can all amplify the severity of the drought.

Types of Drought[1]:

- **Meteorological:** a reduction in rainfall from a normal precipitation pattern in regard to the amount, intensity, or timing of the event as well as changes in the temperature, humidity, and wind patterns. The strict threshold differs for every nation; the United States defines meteorological drought as receiving less than 2.5mm of rainfall in 48 hours. Meteorological drought is the first drought stage detected.
- **Agricultural:** deficient moisture conditions that cause a lasting effect on crops and non-natural vegetation. It is dependent on rainfall, temperature, topography, evapotranspiration, permeability, and porosity of soils, precipitation effectiveness, and vegetative demand. Agricultural drought begins when the available soil moisture supports the actual evapotranspiration rate at only a fraction of the potential evapotranspiration rate.
- **Hydrological:** related to the effects of decreased precipitation on surface or subsurface water supply. It is the last stage of drought and is lagged behind meteorological and agricultural drought because water infiltrates down to the groundwater during the latter portion of the hydrological cycle. Subsurface water supply is the last drought component to return to normal when meteorological conditions and aquifer recharge return.
- **Socioeconomic:** what happens when the consequences of the drought start to affect the socioeconomic sector. It occurs when the demand for an economic good is greater than the available supply due to weather-related drought. Examples of such goods include water, hydroelectric power, food grains, meat, dairy, and much more. Socioeconomic drought affects the associated population both individually and collectively.
- **Ecological:** defined as "a prolonged and widespread deficit in naturally available water supplies — including changes in natural and managed hydrology — that create multiple stresses across ecosystems." More info on Ecological drought: https://snappartnership.net/teams/ecological-drought/.

The severity of a drought depends on the duration, intensity, and geographic extent of the water shortage, as well as the demands on the area's water supply. The USDA rates droughts from D0–D4, depending on the severity of the drought, the amount of time it will take for vegetation to return to normal levels, and the possible effects of the drought on vegetation and water supply (Table 34).

1 http://drought.unl.edu/DroughtBasics/TypesofDrought.aspx

Drought differs from other natural hazards in multiple ways. First, drought is not as obvious as other hazards; it does not have the property destruction of a tornado or hurricane nor the apparent ecological destruction of a wildfire. Second, there is a lack of an exact and universally accepted definition of drought. Finally, the beginning and end of a drought is difficult to determine: though the surface water content may have recovered from a period of drought, the replenishment of groundwater levels is a longer process. In addition, droughts are often spread over a larger geographic area than other natural hazards. These things considered, the economic effects of a drought can be just as devastating as any other natural hazards.

Table 34: Drought Severity Classification

Category	Description	Possible Impacts
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures Coming out of drought: some lingering water deficits pastures or crops not fully recovered
D1	Moderate Drought	Some damage to crops, pastures Streams, reservoirs, or wells low, some water shortages developing or imminent Voluntary water-use restrictions requested
D2	Severe Drought	Crop or pasture losses likely Water shortages common Water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses Widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses Shortages of water in reservoirs, streams, and wells creating water emergencies

Source: http://droughtmonitor.unl.edu/AboutUSDM/DroughtClassification.aspx

Drought History

Vermont has a highly variable, unpredictable climate. Droughts, while low frequency hazards, are of serious concern to the population of Vermont. It is often difficult to recognize the onset of a drought during its preliminary stages, and together with Vermont's variable climate can lead to the disregard for the seriousness of an oncoming drought. Even though the State usually has adequate rainfall, droughts occasionally occur. Several severe droughts have been recorded during the last century, while moderate and mild droughts are much more common. These localized deficiencies of water leave wells dry, cause damage to crops, and cause restrictions on water usages. Droughts cause the loss of potable water when wells run dry. Drought also creates conditions ripe for wildfires (see: Wildfire).

There were two declared statewide droughts in June and July 1995. These droughts were due to a lack of rainfall, which required officials to put restrictions on water usage. Lack of rain combined with some of the highest temperatures led to the loss of crops in some areas. The drought persisted through the summer of 1995, and a third, more severe drought affected Southern Vermont in August of that year.

Since 2000, there have been two significant droughts in Vermont. In 2001-2002, Vermont was affected by a Severe Drought (D2), which peaked at over 14% of the State at the D2 level between November and December of 2001 and nearly 100% of the State in at least Moderate Drought (D1) (Figure 53).

U.S. Drought Monitor – History of Drought in Vermont Percent Area in Drought (2000-2018)

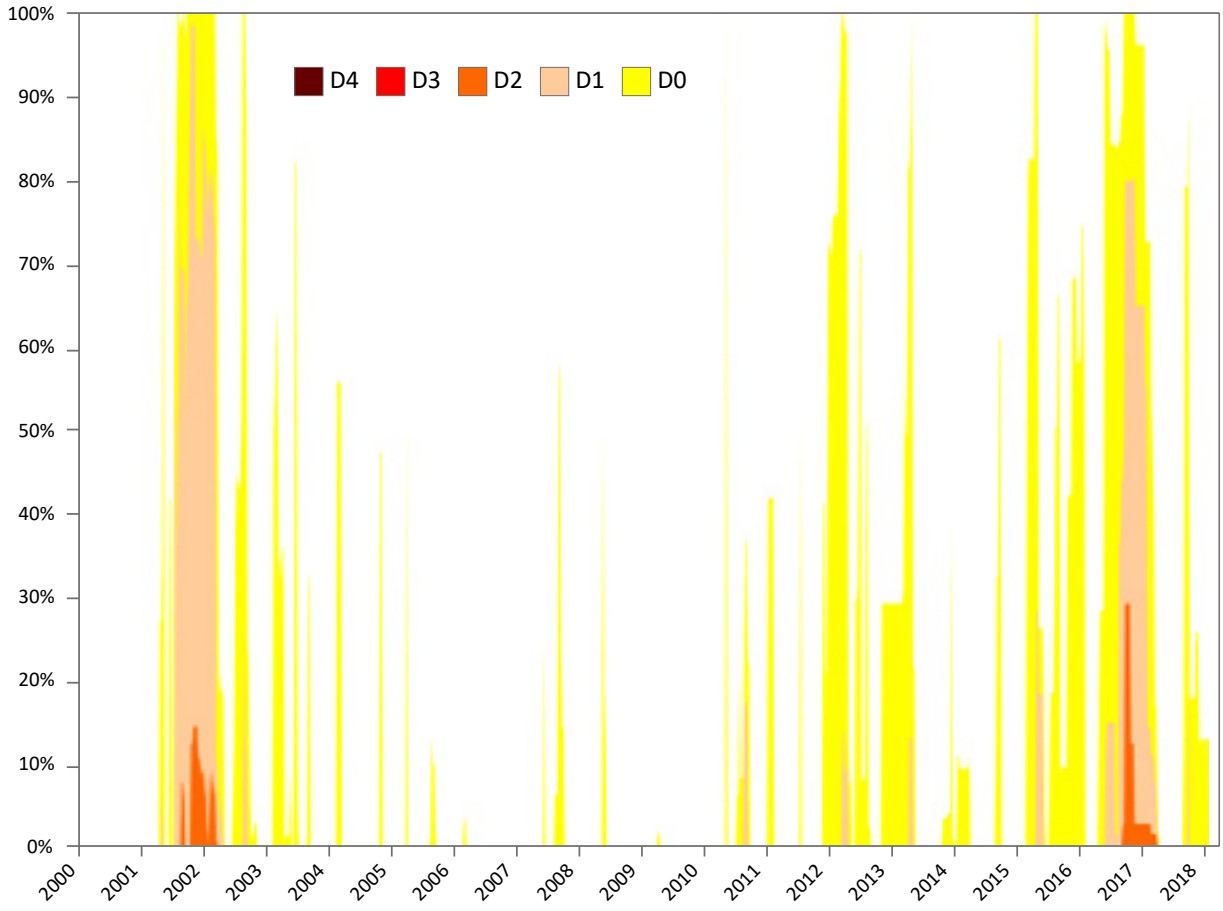


Figure 52: U.S. drought monitor – history of drought in Vermont percent area in drought (2000-2018)
Source: https://www.drought.gov/drought/states/vermont

In response to the 2001-2002 drought, the Vermont Agency of Natural Resources Drought Plan[2] was developed in consultation with VEM to guide its activities in response to droughts and extended periods of dry weather. The plan is a set of operating procedures that outline the responsibilities of various programs, lines of communication to be used, and the general sequence of actions to be followed based on the severity of the situation. Additionally, the plan provides a set of qualitative and quantitative Vermont-specific drought severity indices and recommended actions based on drought level. This drought section was updated and included in the 2013 State Emergency Operations Plan and will be modified again for inclusion in the 2018 State Emergency Management Plan.

In late summer/early autumn of 2007, ground water shortages were evident in several areas of Vermont. This was particularly apparent near shallow wells. The Drinking Water and Groundwater Protection Division in the DEC recently published a Groundwater Management Strategy to help ensure adequate quantity and quality of groundwater, including during periods of drought[3]. The Office of the State Geologist develops groundwater resource maps for towns and conducts ongoing statewide assessments to help towns plan for adequate supply. The resources this program provides are intended for community planning purposes, so that future water supplies can be sited. Communities with groundwater wells that have adequate yields in times of drought have a degree of protection, where low yield areas may be more vulnerable.

Portions of Vermont were in Severe Drought (D2) from October 2016 through April 2017, peaking at 29.15% of Vermont in October and November 2016 and 80% of the State was in at least Moderate Drought (D1) (Figure 53).

2 http://drought.unl.edu/archive/plans/drought/state/VT_2005.pdf
3 http://dec.vermont.gov/sites/dec/files/dwgwp/DW/2018%20Groundwater%20Management%20Plan.pdf

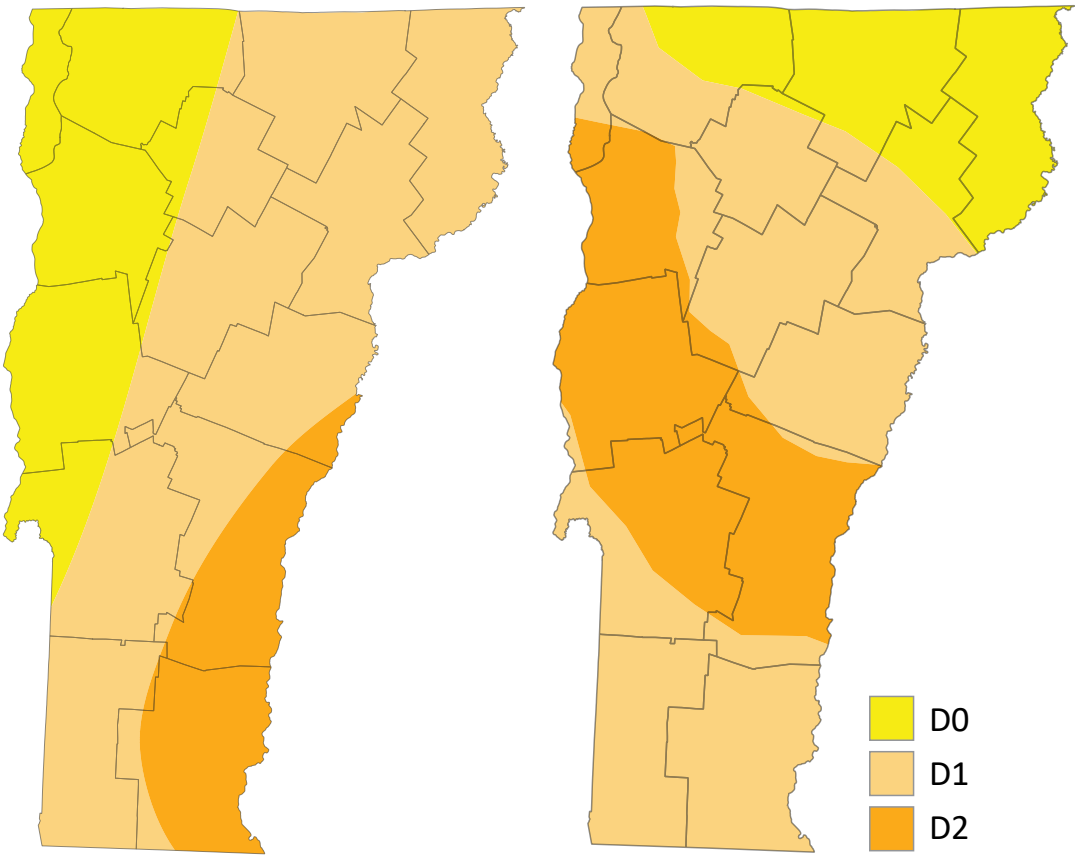


Figure 53: Map of abnormally dry (D0) to severe drought (D2) during significant drought periods in Vermont in late 2001 (left) and late 2016 (right)
Data Source: https://www.drought.gov/drought/states/vermont

Image of Lake Champlain's widening shoreline. *Photo Credit: Charlotte Scott*

Drought Trends & Vulnerability

Vermont is seeing an increase in average annual maximum and minimum temperature (see: Vermont Profile & Hazard Assessment), which is also contributing to an increased likelihood of drought. While Vermont's precipitation trend is an on upward trajectory, having seen increases in precipitation of 1.5" per decade[4] (see: Inundation Flooding & Fluvial Erosion), the precipitation and temperature extremes are expected to be more severe. This, paired with the occurrence of two D2 (Severe Drought) events in the 21st century, led the Steering Committee to consider the probability of a plausibly significant drought event to be "Likely", therefore receiving a Probability score of 3.

Structural impacts of drought are very uncommon, making the risk to State buildings, facilities, infrastructure or governmental functions low. The economic impact of a significant drought event is considered to be greater than the risk to life or property. Though dollar losses from droughts are not estimated to date, certain losses could be investigated, such as the reduction in agricultural production during droughts, the construction of new community water supplies with better storage capability, the replacement of surface supplies and springs with drilled wells during the drought period, and drilled wells that have been deepened to capture additional yields when sustainable yield drops during the drought period.

Relative to other regions of the country, severe droughts are not frequent occurrences in Vermont. However, the USGS estimates that 97% of the rural population of the United States receives their drinking water through groundwater pumping, where access to municipal/village water is unavailable[5]. The Vermont State Climatologist and Vermont State Geologist have been working together to secure funding to map the State's groundwater resources to better understand statewide vulnerability to the hazard. The need for these data are expressed both in this Plan (see: Mitigation Strategy) and the 2018 Vermont Groundwater Management Plan. Though Vermont encompasses a small geographic area, the State has distinct regions that can experience significantly different weather patterns and react differently to the amount of precipitation they receive. According to the U.S. Drought Monitor's archived data, the southeastern portion of the State is more vulnerable to prolonged periods of more significant drought, likely due to its lower elevation and landlocked location[6].

Drought Mitigation

The 2018 Vermont Groundwater Management Plan[7] identifies groundwater protection as a necessary precaution to minimize vulnerability to future fluctuations in groundwater levels due to both anticipated increased precipitation and prolonged drought periods. The plan goes further to note that while groundwater protection is an issue understood at the local, regional, State and Federal levels, careful consideration of it only takes place during times when problems with groundwater levels may arise.

As noted in the above section, the Vermont State Climatologist and State Geologist have been pursuing grants to secure funding for groundwater resource mapping. Knowing where the State's groundwater resources are located is considered critical information, necessary to understand the State's vulnerability and then to develop mitigation actions and strategies aimed at reducing drought vulnerability. Groundwater resource mapping, expansion of the number of monitoring wells across the State and a thorough analysis of water level monitoring data have been identified as mitigation actions under the 2018 SHMP's "Promote Drought

4 http://climatechange.vermont.gov/our-changing-climate/dashboard/more-annual-precipitation
5 https://water.usgs.gov/edu/droughtandgw.html
6 https://statesummaries.ncics.org/vt
7 http://dec.vermont.gov/sites/dec/files/dwgwp/DW/2018%20Groundwater%20Management%20Plan.pdf

Resilience" strategy (see: Mitigation Strategy). Further, the 2018 Vermont Groundwater Management Plan identifies "exploring partnerships with FEMA to fund water data acquisition related to drought" as part of its long-term approach to increasing the State's understanding of and resilience to the hazard.

The Vermont Drought Task Force, made up of representatives from several State and federal agencies, is convened quarterly to discuss current drought conditions, share drought-related information, identify data gaps and needs and develop conservation guidance to all citizens, when applicable. The Task Force developed the Drinking Water Drought Reporter[8] online tool, which allows the Agency of Natural Resources to compile drought data and identify areas vulnerable to drought impacts.

Figure 54: ANR's Drinking Water Drought Reporter Map
Source: https://anrmaps.vermont.gov/websites/droughtreporter/

8 https://anrmaps.vermont.gov/websites/droughtreporter/

4-7: Landslides

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Landslides	3	3	2	1	2	2	6

*Score = Probability x Average Potential Impact

Landslides can be the result of the following:

- Slope saturation from intense Rainfall/Snowmelt, see: Inundation Flooding & Fluvial Erosion.
- Oversteeping of slopes due to stream erosion or undercutting, see: Inundation Flooding & Fluvial Erosion.
- Invasive Species, see: Inundation Flooding & Fluvial Erosion; Invasive Species.
- Reduction of material strength due to weathering.
- Addition of excess load onto slopes, often due to human activity.
- Earthquake or artificial vibration, see: Earthquake.

The term "landslide" describes a wide variety of processes that result in the downward and outward movement of slope-forming materials including rock, soil, organic matter, or artificial fill. The materials may move by falling, toppling, sliding, spreading, or flowing and generally move in either a planar fashion, classified as translational, or curved, classified as rotational or slump. They can be as large as several cubic miles or as small as a few cubic yards, and are able to move as quickly as a free fall or as slowly as a multi-century creep[1]. Landslides that move a significant amount of material quickly and over a large area have the capacity to cause substantial damage to infrastructure, buildings and the natural environment, as well as injure or kill people. Factors that can trigger a landslide or a slope failure include fluvial erosion, soil saturation (especially in areas of increased precipitation), the freeze-thaw cycle in soils and bedrock, human modification of a slope due to excavation and development, surface drainage patterns, loss of vegetation, and earthquakes.

Fluvial erosion is an important contributing factor to landslides. In the past, unless an area is identified as hazardous through a fluvial geomorphic assessment and a river corridor plan, these landslide-vulnerable areas have been mis-identified as non-hazardous because they are located well above the elevation that would be designated as hazardous under FEMA flood hazard area maps. The landside mapping protocol is intended to address this shortcoming, though without recognition of fluvial erosion as a significant hazard worthy of inclusion in flood hazard mapping at the federal level, states with a high incidence of landslides and fluvial erosion will be unable to address, and therefore mitigate, their vulnerability to these hazards.

According to the United States Geological Survey (USGS), "Although landslides are primarily associated with mountainous regions, they can also occur in areas of generally low relief. In low relief areas, landslides occur as cut-and-fill failures (roadway and building excavations), river bluff failures, lateral spreading landslides, collapse of mine-waste piles (especially coal), and a wide variety of slope failures associated with quarries and open-pit mines."

1 https://pubs.usgs.gov/circ/1325/pdf/C1325_508.pdf

Landslides History

Minimal data exists on damages associated with landslides. Often, active landslides occur in tandem with periods of significant rainfall and erosion, so disaster declarations and damage estimates specific to landslide-only damages are not well defined.

The Jeffersonville slide on the Brewster River in April 1999 cost nearly $300,000 to restore the channel and floodplain, as well as purchase a vulnerable residence.

In April of 2004, a soil slope failure occurred in Hardwick, resulting in significant engineering and construction, the buyout of a single residence, and ongoing maintenance totaling $1.4 million in costs. Additionally, in December of 2005, a significant rockslide occurred in Montpelier, affecting Elm and Cliff Streets. The Governor issued an emergency declaration and the Federal Highway Administration (FHWA) approved a $2 million project to stabilize the remaining slope and to make repairs to damaged utilities and roadways under the FHWA Emergency Relief (ER) program.

Significant landslides were observed in Smugglers Notch in the summer of 2006 and in subsequent years. In 2009, a detailed assessment of slope stability issues in Smugglers Notch was completed[2]. This report highlighted that rock falls, rock slides, and debris flows have occurred in Smugglers Notch for thousands of years, and can be expected to continue into the future. In fact, road damage information from VTrans included in this report shows that landslides are nearly annual events. Rock falls in this area can involve large individual blocks, the largest block to fall on record was the 11,500-ton piece that fell off the west face north of Easy Gully in July 1983. Debris flows are the other main type of landslide that occur in the Notch, and can be expected to range from a few cubic meters of mud, pebbles, and boulders, up to many thousands of cubic meters. The largest recorded debris flow occurred on the east side in May 1986 and was about 327,000 cubic yards of material. This blocked VT Route 108 and the West Branch near the Cambridge-Stowe line. Future debris flows can also be expected to sweep down to and across Route 108. Even though the largest debris flow occurred on the east side of the Notch, activity appears to be more frequent on the west side. According to recorded landslide history in the Notch, all slides occurred between May and December.

Route 131 in Cavendish devastated by slope failure.
Photo Credit: www.mansfieldheliflight.com/flood/

2 https://anrweb.vt.gov/PubDocs/DEC/GEO/HazDocs/SMuggs2009Rpt2Pls.pdf

Extensive landslide activity occurred as a result of the heavy rains of 2011. In central Vermont, high water conditions resulting from the melting of thick snowpack and heavy spring rains, as well as from a flash flood event in late May, led to an increase in reported landslides. Widespread slope failures also occurred throughout much of central and southern Vermont as a result of Tropical Storm Irene. Many of these landslides appear to have occurred on the sites of earlier slides that were reactivated by the heavy rains and powerful floodwaters (for more information on impacts from Tropical Storm Irene, see: Inundation Flooding & Fluvial Erosion).

As a result of the landslides associated with Tropical Storm Irene, the May 2011 period of heavy precipitation, and previous landslide occurrences, the following properties were subject to continued risk warranting purchase through the Hazard Mitigation Grant Program (HMGP). While fluvial erosion and stream toe erosion of steep slopes are major contributing factors to landslides in Vermont, the Protocol for Identification of Areas Sensitive to Landslide Hazards in Vermont (discussed below) includes larger scale landslides which are not or may not be captured by floodplain mapping. Since low eroding banks are adequately captured by floodplain mapping, a somewhat arbitrary bank height of 3-4 meters is used to differentiate the larger scale landslides. The landslide properties listed in Table 35 have been selected based on the following criteria:

- They were awarded an HMGP grant using FEMA's Landslide BCA Methodology and/or
- The damaged structure sat atop a bank higher than 3 meters.

Table 35: Landslide-Vulnerable Properties Purchased With HMGP, CDBG and/or Vermont Housing & Conservation Board (VHCB) Funds

Name/Time	Town	County	Date of Occurrence	Cost of Buyout
40 School Street	Readsboro	Bennington	8/28/2011	$142,212
42 School Street	Readsboro	Bennington	8/28/2011	$155,668
62 School Street	Readsboro	Bennington	8/28/2011	$191,998
3013 Danby-Pawlet Road	Danby	Rutland	8/28/2011	$76,859
15 Hilltop Avenue	Barre City	Washington	5/29/2011	$227,976
21 Hilltop Avenue	Barre City	Washington	5/29/2011	$152,732
86 Waterman Hill Road	Hartford	Windsor	8/28/2011	$238,219
104 Waterman Hill Road	Hartford	Windsor	8/28/2011	$235,778
36 Town Garage Road	Westminster	Windham	8/28/2011	$58,090
280 Cameron Road	Plainfield	Washington	8/28/2011	$251,700

In 2009, a PDM grant award allowed the Vermont Geological Survey (VGS) to further study landslide-prone areas and develop a useful protocol to assess future risks[3]. The report notes that accurate LiDAR data provides the best starting point for landslide analysis in Vermont; therefore, VGS selected seven sites to attempt to represent conditions in various parts of the State. Since LiDAR coverage was limited in the State, six of these study sites were conducted in Chittenden County and one in Lamoille County. The protocol was found to work best for translational landslides. The report states that, "the most important parameters for identifying translational landslides are slope angle and roughness, although soil type and topographic wetness index are also important at some site areas." The State has since been successful in generating statewide LiDAR data (see: State Capabilities List).

Table 36 lists significant landslides that have impacted the State of Vermont, excluding those associated with Tropical Storm Irene.

3 http://dec.vermont.gov/sites/dec/files/geo/TechReports/VGTR2012-1LandslideProtocol.pdf

Table 36: Significant Landslides in Vermont				
Property Damage (Adjusted for inflation)	**Begin Date**	**End Date**	**Location**	**Fatalities**
$1,433,424.88	04/18/2004	4/18/2004	Hardwick	0
$2,000,000.00	12/26/2005	12/26/2005	Montpelier	0
$360,000.00	Spring 2002	Spring, 2002	Lake Willoughby	0
$300,000.00	4/4/1999	7/4/1999	Jeffersonville	0
$104,000.00	5/23/1986	5/23/1986	Lamoille	0
$91,228.07	5/11/1989	5/11/1989	Bennington	0
$11,304.35	5/2/1983	5/2/1983	Rutland	0

In addition to the information above, over the past five years (March 2013-April 2018), VTrans has spent approximately $27 million protecting banks and slopes near vulnerable infrastructure and $110,000 on small slope repair projects associated with water quality. This amounts to approximately $5.4 million in annual expenditures devoted to public infrastructure landslide mitigation.

Landslide Trends & Vulnerability

Vermont has not previously developed a landslide inventory or an adequate tracking system to establish frequency of this hazard. Slope instability, which can be the result of increased ground saturation due to increased rainfall or significant snowmelt, is further exacerbated by human activity, often in the form of infrastructure construction. Roads that sit along steep slopes near rivers are especially vulnerable to damage or complete failure from a landslide event.

Considering Vermont's increasing precipitation trend since the 1960s of 1.5" per decade[4], which leads to increased slope instability due to ground saturation, coupled with the State's expanding ability to identify locations of landslides through the Vermont Landslides Inventory Reporting Tool[5], the Steering Committee considered the probability of a plausibly significant landslide hazard to occur once every ten years, and for the impact of such an event to be most substantive to the State's infrastructure.

Landslides in Vermont often involve unconsolidated materials and are likely most common along rivers where erosion occurs. Vermont's mountainous areas lie above fractured bedrock with thin soil cover, which lead to increased rock-slope instability. Avalanches of debris, defined as material containing a relatively high percentage of coarse fragments, occur most commonly in the western and central portions of the State, typically on south-facing slopes[6]. With updated LiDAR data, and information

A house sits atop an active landslide in Plainfield, VT. This house was acquired and demolished by the Town using Vermont Housing & Conservation Board funding.

4 http://climatechange.vermont.gov/our-changing-climate/dashboard/more-annual-precipitation

5 https://vtanr.maps.arcgis.com/apps/GeoForm/index.html?appid=505af0d19dd44faaa912ef3d5c80a3b6

6 https://pubs.usgs.gov/bul/2043/report.pdf

received via the Vermont Landslides Inventory Reporting Tool, the Vermont Geological Survey has been developing high resolution landslide hazard maps, county-by-county, as funding is available, which allows the State to better understand locations that are more vulnerable to landslides.

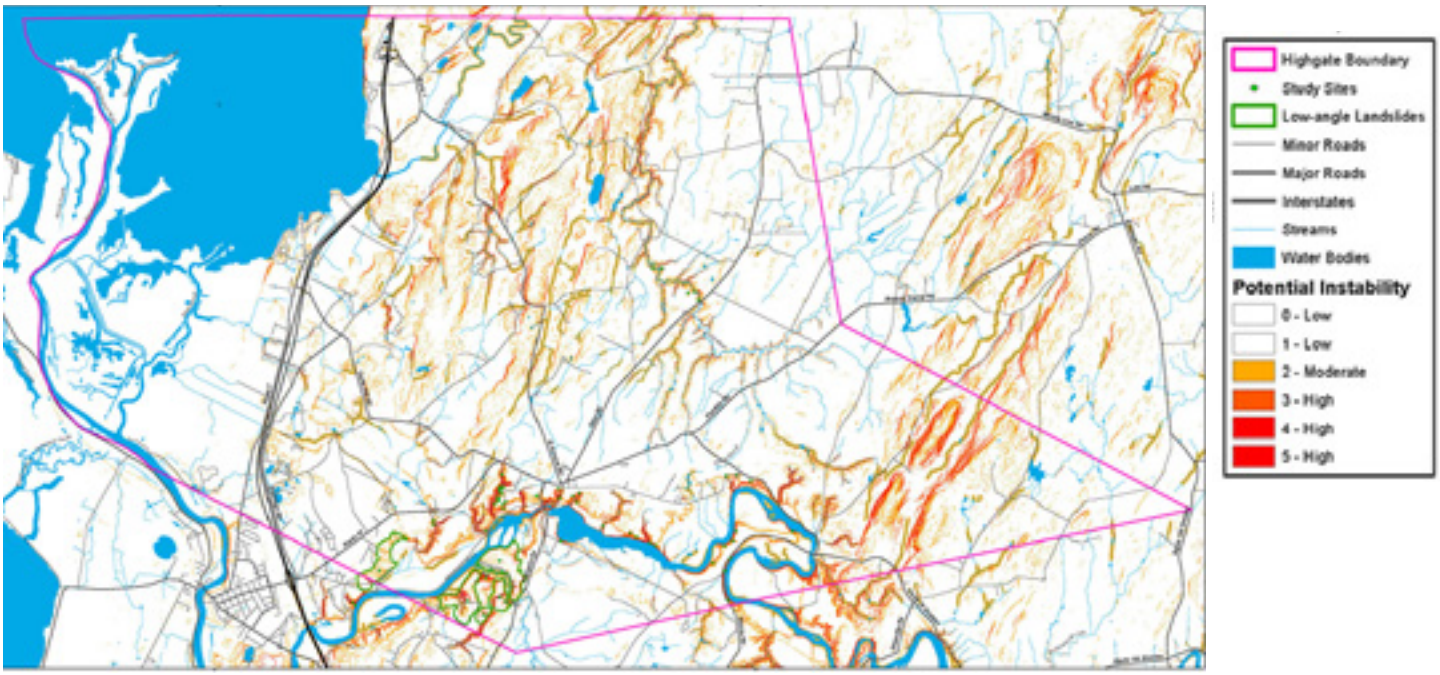


Figure 55: Town of Highgate landslide map
Source: http://dec.vermont.gov/sites/dec/files/geo/TechReports/VGTR2016-1AddisonCtyLS.pdf

Landslides Mitigation

In an effort to reduce Vermont's vulnerability to landslides, the Vermont Geological Survey, a division under the Department of Environmental Conservation (ANR-DEC), has developed a web-based reporting tool[7] for the general public to submit information to the State Geologist regarding potential landslides in real-time. As outreach efforts are made to increase awareness about the tool, the visibility to both known and unknown landslide-prone areas is expanded. This will allow the Vermont Geological Survey team to have access to more data, thereby increasing the ability to predict future slope failures.

The Vermont Geological Survey then use these data to prioritize towns and counties that are in need of high resolution landslide hazard maps, which are being developed currently, as funds are available.

When these landslide data are then overlaid with development in a town or region, vulnerability can be better understood and mitigation strategies defined. Though landslides are identified throughout this Plan's mitigation actions, reducing structural vulnerability to landslide hazards was identified as its own, standalone mitigation strategy with three separate actions created to accomplish the strategy (see: Mitigation Strategy). Those actions identified under the hazard mitigation mapping, data and research strategy have direct implications to landslide mitigation, as the State continues to seek out funding sources to better locate and understand Vermont's vulnerability to the hazard.

Given an increased understanding of landslide hazards and where they exist in Vermont, the Steering Committee considered the probability of a plausibly significant landslide event to be likely, with the most significant impacts to infrastructure.

7 https://vtanr.maps.arcgis.com/apps/GeoForm/index.html?appid=505af0d19dd44faaa912ef3d5c80a3b6

Accordingly, structural and infrastructural landslide mitigation projects are also taking place across Vermont. As mentioned in the history section above, ten landslide-vulnerable houses were purchased and removed as a result of the landslides associated with Tropical Storm Irene (Table 35). Two of these structures were located in the Town of Highgate, whose landslide hazards have been mapped by the Vermont Geological Survey (Figure 55). Using this map to identify vulnerable infrastructure and structures, the Town applied for a landslide slope stabilization project under the HMGP for their transfer station, which was built near a failing slope and requires significant mitigation work. This project is expected to be awarded by FEMA in early 2018 at a cost of approximately $230,000.

The Town of Shrewsbury had to have substantial work done after Tropical Storm Irene due to significant slope failures along the Cold River, including approximately $887,000 in Public Assistance funds for road repair and slope stabilization. The Town, recognizing there were several landslide areas along this stretch that required immediate attention, then submitted a PDM application to relocate a portion of the Upper Cold River Road identified as being an imminent threat of catastrophic failure. This project, approved by FEMA in early 2018, is estimated to cost nearly $750,000 to complete.

Major slope failure along the Cold River in Shrewsbury, VT. *Photo Credit: Alan Shelvey*

4-8: Wildfire

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Wildfire	2	3	3	3	2	2.75	5.5

*Score = Probability x Average Potential Impact

A wildfire is the uncontrolled burning of woodlands, brush, or grasslands. According to FEMA, there are four categories of wildfires that can occur throughout the United States:

- **Wildfires:** Fueled by natural vegetation; typically occur in national forests and parks, where federal agencies are responsible for fire management and suppression.
- **Interface or Intermix Fires:** Urban wildfires in which vegetation and the built environment provide fuel.
- **Firestorms:** Events of such an extreme intensity that effective suppression is virtually impossible; occur during extreme weather and generally burn until conditions change or the available fuel is exhausted.
- **Prescribed Fires and Prescribed Natural Fires:** Fires that are intentionally set or selected natural fires that are allowed to burn for beneficial purposes.

Wildfires can be a result of naturally occurring influences such as lightning, drought and extreme heat (see: Drought, Extreme Heat), and human influences such as a discarded cigarette, improperly extinguished campfire, or a stray spark from nearby railroad tracks. The potential for threat of wildfires is dependent upon topography and slope, surface fuel characteristics, recent climate conditions, current meteorological conditions, and fire behavior. Once a wildfire threatens a community, it is often too late to protect nearby structures, and populations have to be evacuated for their own safety. These fires could have the potential to damage structures and utilities as well as hundreds of acres of woodlands.

The 2017 Vermont Forest Action Plan[1], developed by the Department of Forests, Parks and Recreation, defines "wildland fire" as any non-structure fire that occurs in vegetation or natural fuels, including prescribed fire and wildfire. Most wildland fires in Vermont are quickly reported and contained, though fires burning deep in ground fuels or in remote locations require more time and effort to fully suppress. Town Forest Fire Wardens and local fire departments primarily handle wildland fire control with assistance from other towns and the State, when necessary.

Vermont has a reliable system of local fire suppression infrastructure coordinated at the State-level. Vermont's climate, vegetation type, and landscape discourage major wildfire. The majority of fires in Vermont are caused by burning debris[2].

The National Weather Service (NWS) issues a Red Flag Warning when there is the potential for extreme fire danger within 24 hours based on the following criteria:

- Winds sustained or with frequent gusts > 25 mph
- Relative Humidity at or below 30% anytime during the day
- Rainfall amounts for the previous 5 days less than 0.25" (except 3 days in pre-greenup)
- Lightning after an extended dry period
- Significant dry frontal passage

1 http://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Vermont_Forests/Library/2017_VT_ForestActionPlan.pdf
2 http://fpr.vermont.gov/sites/fpr/files/2017%20Vermont%20Wildland%20Fire%20Program%20Annual%20Report.pdf

- Dry thunderstorms
- Keetch-Byram Drought Index values of 300 or greater (summer only)

Lightning:

In addition to being hazardous to human life, lightning can damage infrastructure, plants, and property, and can start forest fires. According to the NWS, lightning is the first thunderstorm hazard to arrive and the last to leave. Lightning can strike up to 50 miles away from a thunderstorm, carry up to 100 million volts of electricity, and reach temperatures upward of 50,000°F.

Since 1950, there have been 87 documented events of lightning strikes in Vermont, resulting in 4 deaths and 17 injuries[3]. Lightning is an unpredictable and disbursed weather-related event, making it challenging to mitigate.

Wildfire History

The wildfire threat in Vermont is relatively low based on historical occurrences. Wildfire conditions in Vermont are typically at their worst either in spring when dead grass and fallen leaves from the previous year are dry and new leaves and grass have not come out yet, or in late summer and early fall when that year's growth is dry. In drought conditions, this risk is obviously higher. The risk of wildfire due to drought was severe enough to warrant a statewide ban on open burning in 1966. That was the last such statewide ban until one was issued in 1999 due to drought. However, due to a very dry April 2000, the State once again had to declare a temporary burning ban, and at the end of 2001, the State remained in a drought. There was a statewide ban on open burning in October 2005, which was rescinded in April 2006. Most recently, there was a threat of explosive fire growth potential in March 2012. This was due to low humidity, warm temperatures, and strong winds. In addition, dry grass was a wildfire threat during the spring of 2012 due to a mild winter leaving grass exposed through the drier winter months.

Despite the drought in 2016-2017, Vermont's 2017 Wildland Fire Program Annual Report notes that the 2017 fire season was well below normal at 49 acres burned from 51 fires. The average between 2012 and 2016 was 109 fires and 317 acres per year[4]. There has not been a major wildfire in Vermont in the last 50 years. NOAA's Storm Events Database only include one documented wildfire event since 1950. This event was in July of 2002 in Windham and Bennington Counties, with no deaths, injuries, or noted damages:

> "Smoke, from many forest fires across the Nemiscau region of northern Quebec, became trapped under a subsidence inversion, and was transported south across southern Vermont from the evening hours of July 5, to the late evening of July 7. The forest fires were sparked by exceptionally hot and dry weather over that part of Canada followed by an unusual amount of thunderstorm activity, resulting in many lightning strikes. The circulation between high pressure over Hudson's Bay and a low pressure off the Canadian Maritimes transported the smoke southward. The smoke obscured the sky, and even reduced surface visibilities to as low as one mile, especially on the early morning of July 7. Advisories were issued warning people with respiratory problems to remain indoors and all individuals to curb outside activity. No major problems were reported to the National Weather Service as a result of this smoke. By late Sunday, July 7, the low pressure weakened and moved further east, allowing the wind to back into more of a westerly direction, finally dissipating the smoke[5]."

3 https://www.ncdc.noaa.gov/stormevents/
4 http://fpr.vermont.gov/sites/fpr/files/2017%20Vermont%20Wildland%20Fire%20Program%20Annual%20Report.pdf
5 https://www.ncdc.noaa.gov/stormevents/

Wildfire Trends & Vulnerability

Although wildfires are currently uncommon in Vermont, the Steering Committee acknowledged that extended periods of warming due to climate change have the potential to increase the occurrence of wildfire events, thus ranking Wildfire with a probability score of Occasional. Vermont is seeing an increase in average annual maximum and minimum temperature (see: Extreme Heat), which is also contributing to an increased likelihood of drought (see: Drought) and wildfire risk, though an increase in precipitation events (see: Inundation Flooding & Fluvial Erosion) may limit that risk during certain times of the year.

The potential impact from a plausibly significant wildfire event is expected to be Moderate on infrastructure, life and the economy, with a less significant impact on the environment. Given the low probability of wildfire in Vermont, the risk is considered to be relatively low.

The vulnerability to wildfires is constantly changing. Predictive models for fire potential are often generated each month or season. These models incorporate the state of fuels across various areas based on the latest precipitation and soil moisture anomalies, drought, and snow depth data. While giving an overall prediction for each season, models cannot incorporate the daily weather changes that affect fire risks. The Wildland Fire Assessment System is available online from the U.S. Forest Service[6]. This system provides national fire danger ratings that are updated daily. The maps take into account current and antecedent weather, fuel types, and both live and dead fuel moisture.

There is no specific geographic area of the State particularly more vulnerable to wildfire, given that 76% of Vermont is forested[7] – 79% and 21% privately- and publically-owned, respectively[8].

In general, wildfire risk is considered statewide, though a specific location where infrastructure and life are potentially more vulnerable to structural fire is the wildland-urban interface (WUI) (Figure 56). The WUI represents the area where infrastructure interacts with undeveloped land, creating the potential for fire to move from a forested environment to a grassed neighborhood.

The 2017 Vermont Forest Action Plan defines the WUI as a priority landscape, noting that:
"Although the WUI term originates in wildland fire management, the WUI is also a useful indicator of human influence on natural ecosystems. The WUI is an area where people and their homes affect the natural environment, contributing to the loss of habitat for native species, forest fragmentation, the introduction of exotic species, domestic pets that can disturb or prey on birds and other wild animals, and poorer water quality due to runoff from pavement and lawns. These trends will threaten biodiversity and ecosystem health if WUI residents and communities are not attentive to the potential harms and actively caring for the environment around their homes." (pg. 45)[9]

A forest fire in Bolton, VT in 2016 due to dry conditions and warm temperatures. *Photo Credit: Lars Lund*

6 http://www.wfas.net

7 Morin, R.S.; Domke, G.M.; Walters, B.F.; Wilmot, S. 2017. Forests of Vermont, 2016. (http://fpr.vermont.gov/forest/forest_business/forest_statistics/fia)

8 https://www.fs.fed.us/nrs/pubs/ru/ru_fs119.pdf

9 http://fpr.vermont.gov/sites/fpr/files/Forest_and_

Wildfire Mitigation

Several actions within this Plan address wildfire (see: Mitigation Strategy), such as the strategy on resilient design and construction standards, including actions around developing sample building standards and educational resources for resilient design and construction.

Within Vermont, much of the focus around wildfire is in the preparedness and response phases. On the prevention side, per Vermont statute, open burning of natural and untreated wood, brush, weeds, or grass requires a 'Permit to Kindle Fire' from the Town Forest Fire Warden. When there is significant fire danger, open burns can be banned entirely. The drought mitigation strategy (see: Mitigation Strategy) includes actions that will assist in preparedness planning for wildfire, including actions to expand monitoring wells and develop groundwater resource maps.

Large-scale mitigation for wildfire is predominately not feasible in Vermont. The 2017 Vermont Forest Action Plan has a much stronger focus on preventing forest fragmentation, which runs counter to mitigation actions, such as defensible space. The Action Plan including strategies to:

- Strengthen collaborative land use planning and policy efforts with partners to conserve forests, developing strategies to reduce or mitigate the rate of forest conversion and reduce forest fragmentation and parcelization at local, statewide, and regional levels (Strategy 3).
- Prepare for, mitigate, and respond to emergency events such as wildland fires and significant weather events (Strategy 16).
- Provide training and technical support, and maintain partnerships for wildland fire prevention and response (Strategy 53).

On a local level, a number of Regional Planning Commissions (RPCs) have assisted local communities with preparing Community Wildfire Protection Plans (CWPPs), which are aimed at lessening the impacts of interface wildfire. These CWPPs are authorized and defined in Title I of the Healthy Forests Restoration Act (HFRA, PL 108-148, 2003), which does not prescribe the exact form of a CWPP, but states that they should address local forest and range conditions, values-at-risk, and priorities for action. CWPPs are another tool to assist communities in understanding their vulnerability and can inform Local Hazard Mitigation Plans (LHMPs).

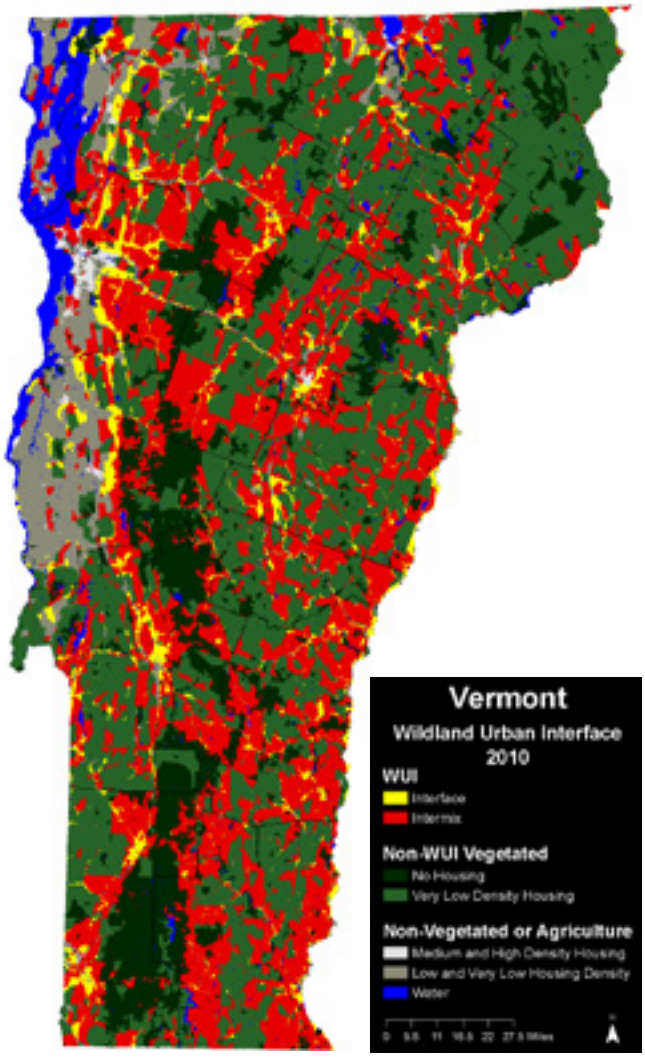


Figure 56: 2010 Wildland Urban Interface (WUI) map for Vermont
Source: http://silvis.forest.wisc.edu/maps/wui/2010/download

Forestry/Vermont_Forests/Library/2017_VT_ForestActionPlan.pdf

4-9: Earthquake

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Earthquake	2	3	3	3	2	2.75	5.5

*Score = Probability x Average Potential Impact

According to the USGS, an earthquake occurs when two blocks of the Earth suddenly slip past one another along what is called a fault or fault plane. As the two blocks slide, stored energy is released producing radiating seismic waves that result in an earthquake. The location below the Earth's surface where the earthquake starts is called the hypocenter, and the location directly above it on the surface of the Earth is called the epicenter.

Earthquakes in the northeastern United States generally have deep foci (>10 km) and are considered to be intraplate. Earthquakes that occur within an intraplate seismic zone are not typically expressed on the ground surface and are, therefore, more difficult to model[1]. Although there are numerous faults exposed at the ground surface in the northeastern United States, there is no evidence for significant motion along these faults.

A computer earthquake damage simulation (HAZUS program) conducted by the Vermont State Geologist's Office in 2012[2] suggests that there is little earthquake risk in Vermont at 100-year and 250-year recurrence intervals; however, there is a potential risk at the 500-year recurrence level. A Report on The Seismic Vulnerability of the State of Vermont[3] postulated six 500-year "strong" earthquake epicenters in the Northeast that could be expected to cause damage in Vermont are located at Middlebury (5.7 magnitude), Swanton (5.7 magnitude), Montreal, Quebec (6.8 magnitude), Goodnow, New York (6.6 magnitude), Tamsworth, New Hampshire (6.2 magnitude), and Charlevoix, Quebec, Canada (6.6 magnitude). Using these epicenters and magnitudes, further HAZUS runs confirmed that five of these earthquakes (absent Charlevoix) could cause ground shaking in certain parts of Vermont sufficient to result in millions of dollars in damage.

Five of these six possible 500-year earthquakes have moment magnitudes and epicenters close enough to Vermont to cause significant damage. These five earthquakes have predicted peak ground accelerations (PGAs), used to measure the amplitude of the largest acceleration at a given site during an earthquake, greater than 0.1g and would cause widespread damage resulting in tens to hundreds of millions of dollars in structural and economic losses and undetermined casualties. The Swanton and Middlebury earthquakes were estimated to have PGAs of 0.4g and total losses exceeding $300 million dollars each (HAZUS-MH projections). In addition to the five postulated 500-year earthquakes that would affect Vermont, the 2002 occurrence of a 5.3 magnitude earthquake near Plattsburgh, New York, indicates that this epicenter should also be considered.

1 Hubenthal M, Stein S, & Taber J. 2011. A Big Squeeze: Examining and Modeling Causes of Intraplate Earthquakes in the Earth Science Classroom. The Earth Scientist, 27 (1), 33-39.

2 https://anrweb.vt.gov/PubDocs/DEC/GEO/HazDocs/HAZUS_VTScenarios_NE.pdf

3 http://dec.vermont.gov/sites/dec/files/geo/HazDocs/Ebell_1995.pdf

Middlebury Scenario:

- Building Damage: HAZUS-MH estimates that over 3,600 buildings will receive at least moderate damage. Of these, 38 buildings will be completely destroyed. This is over 2% of the total number of buildings in the State. For essential facilities, HAZUS-MH also estimates that on the day of the earthquake, 98% of hospital beds will be available and by 30 days, 100% will be operational. One school will receive moderate damage. It is predicted that over 262 families will be displaced from their homes and 62 will need temporary shelter.
- Transportation and Utility Systems: HAZUS-MH estimates minimal disruption of the transportation and utility systems. However, over 2,000 households are expected to be without electrical power for up to 3 days.
- Casualties: The model predicts 69 casualties requiring medical attention, 12 needing hospitalization, and 2 killed by the earthquake.
- Economic Loss: Direct building losses are estimated at greater than $308 million; 10% of these losses are due to business interruption. HAZUS-MH estimates that damage to transportation systems will be $34 million. Approximately $0.21 million would be needed to repair damaged communication systems.
- Government Buildings: 14 structures are predicted to receive slight damage, 6 will receive moderate damage, and 1 will be extensive.

Montreal Scenario:

- Building Damage: HAZUS-MH estimates that over 3,400 buildings will receive at least moderate damage. This is over 2% of the total buildings in the State. Of these, 23 buildings will be completely destroyed. For essential facilities, HAZUS-MH also estimates that on the day of the earthquake, 95% of hospital beds will be available and by 30 days, 100% will be operational. It is predicted that over 229 families will be displaced from their homes and 56 will need temporary shelter.
- Transportation and Utility Systems: HAZUS-MH estimates no disruption of the transportation and utility systems and no households are expected to be without electrical power.
- Casualties: The model predicts up to 70 casualties requiring medical attention, 12 needing hospitalization, and 2 killed by the earthquake.
- Economic Loss: Direct building losses are estimated at greater than $198 million; 17% of these losses are due to business interruption. HAZUS-MH estimates that damage to transportation systems will be $18 million. Approximately $0.03 million would be needed to repair damaged communication systems.
- Government Buildings: 15 structures are predicted to receive slight damage, 7 moderate damage, and 1 extensive.
- Developed in the early 1900s, the Modified Mercalli Intensity (MMI) scale assesses an earthquake's intensity qualitatively, based on the effects that are experienced on the ground. The lower the MMI score, the more likely the earthquake was only felt by people near the epicenter. As the intensity score increases, damage to structures are observed.

Table 37: Modified Mercalli Intensity (MMI) Scale			
Intensity	**Shaking**	**Description/Damage**	**Richter**
I	**Not felt**	Not felt except by a very few under especially favorable conditions.	1.0-3.0
II	**Weak**	Not felt except by a very few under especially favorable conditions.	3.0-3.9
III	**Weak**	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.	
IV	**Light**	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.	4.0-4.9
V	**Moderate**	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.	
VI	**Strong**	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.	5.0-5.9
VII	**Very Strong**	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.	
VIII	**Severe**	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.	6.0 and higher
IX	**Violent**	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.	
X	**Extreme**	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.	
XI	**Extreme+**	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.	
XII	**Extreme++**	Damage total. Lines of sight and level are distorted. Objects thrown into the air.	

Source: https://earthquake.usgs.gov/learn/topics/mag_vs_int.php

Earthquake History

Vermont is classified as an area with low to moderate seismic activity. Since 1900, Vermont has only experienced three earthquakes registering 2.5 or greater on the Richter Scale. The two strongest recorded earthquakes measured in Vermont were of a magnitude 4.1 on the Richter Scale. One was centered in Swanton and occurred on July 6, 1943, and the second occurred in 1962 in Middlebury. The 1962 earthquake was felt throughout New England and resulted in broken windows and cracked plaster, while the Swanton earthquake caused little damage. It is likely that small earthquakes will continue to occur in the coming years.

In addition, earthquakes centered outside the State have been felt in Vermont. Twin earthquakes of 5.5 occurred in New Hampshire in 1940. In 1988, an earthquake with a magnitude 6.2 on the Richter Scale took place in Saguenay, Quebec and caused shaking in the northern two-thirds of Vermont (Ebel, et. al. 1995).

On April 20, 2002, a 5.1 magnitude event in Plattsburgh caused shaking in Vermont with damage near the epicenter in New York. In the last five years, there have been only five earthquakes in the New England/ Northern New York and Southeast Ontario/Southwest Quebec region that recorded 3.0 magnitude or higher on the Richter Scale: 7/4/14 Saint-Andre-Avellin, Quebec, magnitude 3.0; 1/12/15 Wauregan, Connecticut, magnitude 3.3; 7/15/15, Hawkesbury, Canada, magnitude 3.3; 11/18/15, Cornwall, Canada, magnitude 3.2; 10/19/17, Mont-Tremblant, Canada, magnitude 3.1.

Earthquake Trends & Vulnerability

Unlike some natural hazards, it is not currently possible to predict when or where an earthquake may occur in New England. Due to Vermont's intraplate location, earthquakes in this region are not as well understood as those locations that lie along a plate boundary. Given this inability to predict the location and extent of the next earthquake, coupled with our history of relatively minor and very infrequent events, the Steering Committee considered the probability of a plausibly significant event to occur once every one hundred years with moderate impacts to the State's infrastructure, economy and human life.

Though New England sits intraplate, there are areas of the region that record higher rates of peak ground accelerations. The Adirondack region of New York and the geographical region of Canada between Ottawa and Montreal have higher PGAs, which have had recorded earthquakes that caused ground movement in Vermont. Because of this PGA distribution, the northwest region is more vulnerable to earthquake than the rest of the State (Figure 57). Further, as the Vermont Geological Survey continues to better understand the distribution of the State's landslides (see: Landslides), it is currently understood that the northwest region is also more prone to landslide hazards. As earthquakes often cause landslides, these two hazards can have a compounding effect and exacerbate impacts.

Many earthquake events have been recorded outside of the Vermont boundary, but residents can occasionally feel ground movement and have experienced minor non-structural impacts from these events. The USGS has a Did You Feel It? (DYFI) reporting tool that allows users to submit reports of ground movement, which then helps seismologists better understand the extent and impacts of ground movement[4] (Figure 58). This tool can then be used to research past events and increase awareness of a region's vulnerability to earthquake effects, allowing people to then develop mitigation actions accordingly.

Finally, with the expansion of the Vermont Gas pipeline in mid-2017, an additional 41 miles of underground piping was constructed between Colchester and Middlebury. This pipeline, which now spans from the Quebec-Vermont border to Middlebury, is critical infrastructure potentially vulnerable to ground shaking, especially when considering its location along the northwestern and west-central region of the State.

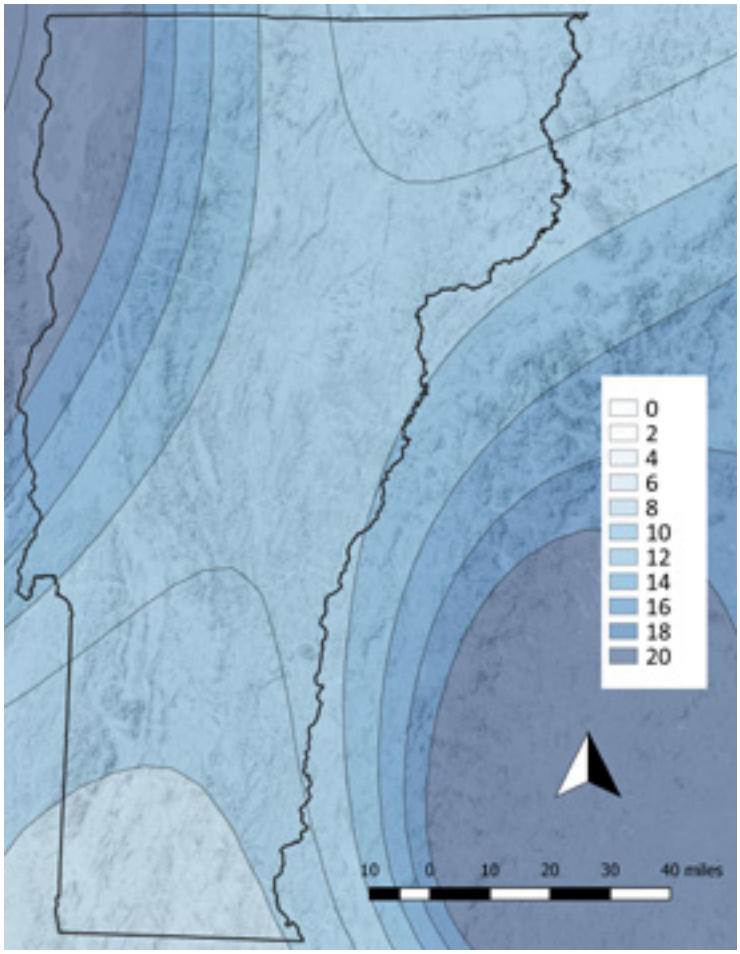


Figure 57: Peak acceleration expressed as a percent of gravity (%g)
Source: https://earthquake.usgs.gov/hazards/hazmaps/conterminous/

4 https://earthquake.usgs.gov/data/dyfi/summary-maps.php

Earthquake Mitigation

Given the low probability of a significant event, earthquake mitigation is often not a high priority at the State, regional or local level; however, as it is well understood by the Steering Committee that a significant event could have substantial impacts to infrastructure and human life, several mitigation actions have been developed as part of the Plan update process. This Plan identifies two actions that need to be taken to better assess the State's vulnerability to seismic hazards, which include conducting seismic analyses of a) bridges using the University of Vermont's seismic vulnerability ranking system; and b) critical facilities and historic sites using HAZUS and ROVER (see: Mitigation Strategy). These analyses will better inform subject matter experts of the State's vulnerability to earthquakes and provide data necessary for mitigation project development.

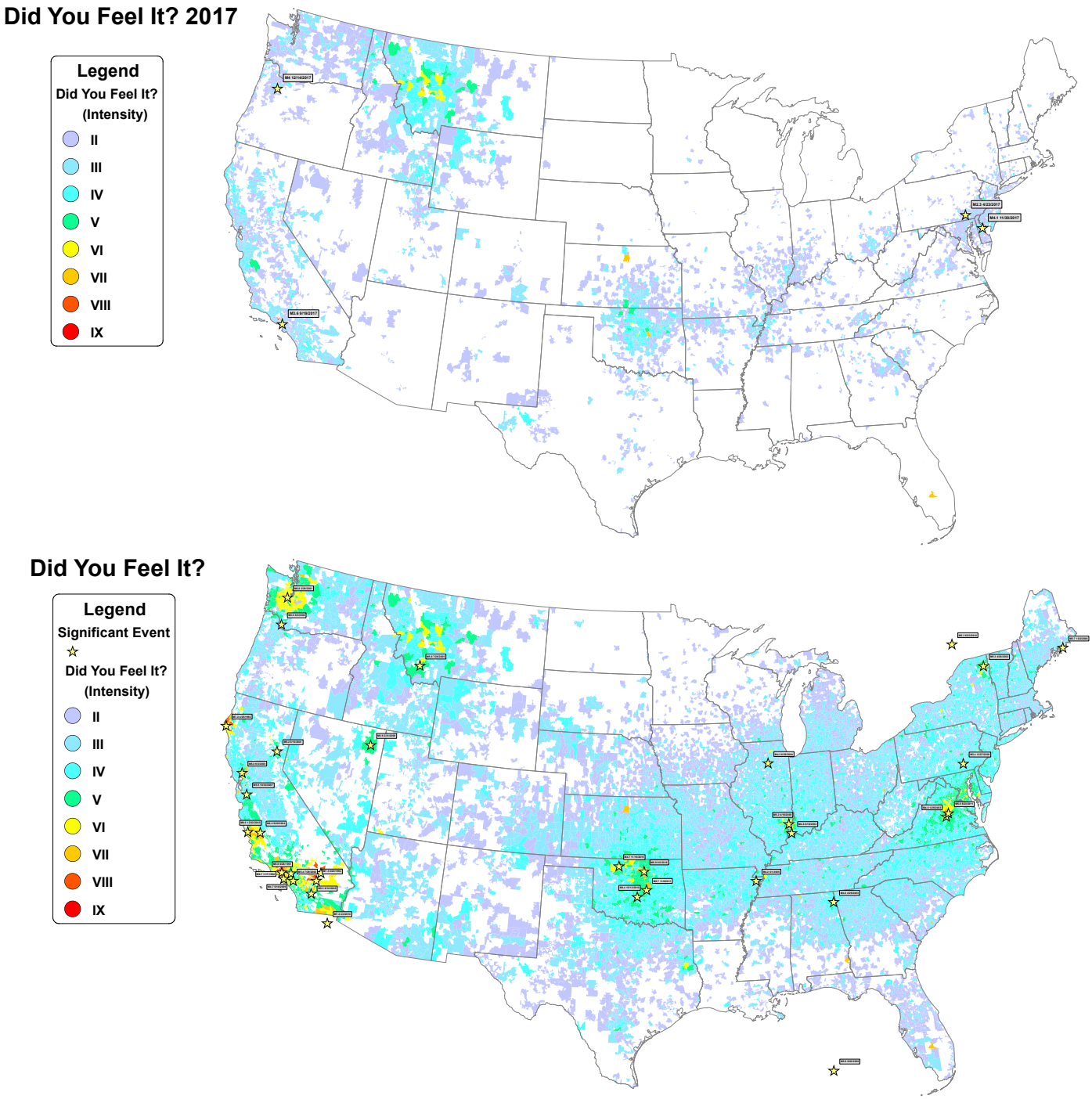


Figure 58: U.S. Earthquake Responses in 2017 (top) and Cumulative (1991-2017)
Source: https://earthquake.usgs.gov/data/dyfi/summary-maps.php

4-10: Invasive Species

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Invasive Species	2	1	1	2	3	1.75	3.5

*Score = Probability x Average Potential Impact

The National Invasive Species Council defines an invasive species as one that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species can overwhelm native species and their habitats, forcing the native species out. They are considered to pose the second greatest threat to biodiversity globally. Invasive plants in Vermont, such as Japanese knotweed, common reed (Phragmites), and purple loosestrife, can change soil composition, change water tables, and disrupt insect cycles. They often lack food value upon which wildlife depends. Some invasive animals prey heavily upon native species while others, such as the alewife and zebra mussel, out-compete native species for food and nutrients with significant impacts reverberating up and down food chains.

The spread of invasive species is primarily caused by human activity. Common examples include[1]:

- **Ships:** Can carry aquatic organisms in their ballast water or on the hull.
- **Wood Products:** Insects can get into wood, shipping palettes, and crates that are shipped around the world as well as travel in firewood.
- **Ornamental Plants:** Some ornamental plants can escape into the wild and become invasive.
- **Pet Trade:** Some invasive species start as pets that are intentionally or accidentally released.

The Nature Conservancy reports that invasive species have contributed directly to the decline of 42% of the threatened and endangered species in the United States. Further, the annual cost to the U.S. economy is estimated at $120 billion per year, with more than 100 million acres suffering from invasive plant infestation. Freshwater ecosystems and estuaries are especially vulnerable to invasion, as these areas are very difficult to contain and reverse[2]. In Vermont specifically, examples of economic impacts of invasive species can be observed in the costs of managing invasive water chestnut in Lake Champlain[3] and payments to private landowners to improve tree regeneration and wildlife habitat by controlling buckthorn and honeysuckle in forests[4]. Water pipes in Lake Champlain must now be cleaned out regularly to rid them of invasive zebra mussels. Invasive pests such as Emerald Ash Borer, first found in Vermont in 2018, will have serious financial implications for forest landowners and municipalities alike, as productive timber is destroyed and trees along roads become potential hazards as they die.

1 https://www.vtinvasives.org/intro-to-invasives/what-are-invasive-species
2 https://www.nature.org/ourinitiatives/urgentissues/land-conservation/forests/invasives-101.xml
3 http://dec.vermont.gov/sites/dec/files/wsm/lakes/ans/docs/2016VTWCFinalReport.pdf
4 https://efotg.sc.egov.usda.gov/references/public/VT/Landowner_Acknowledgment_2016.pdf

Additionally, invasive species can directly or indirectly cause harm to human health. Giant hogweed, wild parsnip and wild chervil are three invasive plant species in Vermont that have phytophototoxic properties, meaning direct contact of their sap with human skin can cause a chemical reaction that makes skin hypersensitive to ultraviolet light. Vermonters have received serious skin burns from the toxicity of the sap of these plants combined with exposure to sunlight. Another example is that of Japanese barberry, which has been proven to increase the incidence of Lyme disease by providing sheltered habitat that increases the abundance of small rodents, which act as hosts to the ticks that carry Lyme disease pathogens[5].

Invasive Terrestrial Plants & Forest Pests:

Vermont's Agency of Agricultural, Food and Markets (VAAFM) maintains a list of invasive plants and regulates their importation, movement, sale, possession, cultivation and distribution[6] based on the following categories:

- **Noxious Weed:** any plant in any stage of development, including all current and subsequent subspecies, varieties, and cultivars, and parasitic plants whose presence, whether direct or indirect, is detrimental to the environment, crops or other desirable plants, livestock, land, or other property, or is injurious to the public health or the economy generally.
- **Class A Noxious Weed:** any noxious weed that is not native to the State, not currently known to occur in the State on the date of listing, and poses a serious threat to the State.
- **Class B Noxious Weed:** any noxious weed that is not native to the State, is of limited distribution statewide, and poses a serious threat to the State, or any other designated noxious weed being managed to reduce its occurrence and impact in the State, including those on the Federal Noxious Weed List[7].

The State also maintains a watch list[8], updated regularly, of non-native plants that have the potential to become invasive in Vermont based on their behavior in northeastern states. One-third of the plant species found in Vermont are not native to the State, but only about 8% have the potential to create environmental and economic harm due to their ability to grow rapidly, profusely, and widely. These are the plant species monitored on the watch list, which acts as a resource for public information and as a means to enlist volunteers to monitor potentially harmful plants in Vermont, although it has no regulatory force.

Vermont's Department of Forests, Parks and Recreation (FPR) is responsible for survey, detection, and management of forest pests in Vermont[9]. Additionally, the Vermont Invasives Gallery of Land Invasives is a resource for identification of invasive plants and forest pests[10].

Aquatic Invasive Species (AIS):

The Department of Environmental Conservation (DEC) has a Vermont Aquatic Invasive Species Program that coordinates management activities associated with both aquatic invasive and nuisance species. The AIS webpage has information about the types of AIS, monitoring, spread prevention, grant opportunities and laws and regulations relating to AIS[11]. The Vermont AIS Program has identified twelve high-priority invasive and nuisance species affecting the State and issues informational pamphlets in an attempt to prevent their proliferation.

5 https://mnfi.anr.msu.edu/invasive-species/JapaneseBarberryBCP.pdf
6 http://agriculture.vermont.gov/plant_pest/plant_weed/invasive_noxious_weeds
7 https://www.law.cornell.edu/cfr/text/7/360.200
8 http://fpr.vermont.gov/forest/forest_health/invasive_plants
9 http://fpr.vermont.gov/forest/forest_health/insects_diseases
10 https://www.vtinvasives.org/gallery-of-land-invasives
11 http://dec.vermont.gov/watershed/lakes-ponds/aquatic-invasives

Invasive Species History

Because invasive species often spread over a long period of time, identification of a hazard event concerning invasive species is rather difficult. Vermont, like much of the eastern United States, has long been susceptible to invasive species brought from overseas – whether they were plants intentionally transported or organisms clinging to vessels[12]. The State has a long history of invasive species infestation at the aquatic (e.g. water chestnut), terrestrial (e.g. Japanese knotweed) and forest pest (e.g. Emerald Ash Borer) levels.

- Most notably, the emerald ash borer, first discovered in Michigan in 2002, has spread to 30 states and three Canadian provinces and was reported and confirmed to be in Vermont in 2017.
- The water chestnut, which spreads rapidly across lakes and ponds, preventing recreation and choking out sunlight from native aquatic species, has been actively managed since 1982.
- Japanese knotweed, an invasive plant that spreads by sprouting from broken plant rhizomes, was introduced into the United States in the 1800s and has been established in New England ever since.

Invasive Species Trends & Vulnerability

Native forests and ecosystems are projected to experience negative impacts of these warming trends, as well[13]. With 76% of the Vermont landscape covered by forest, and more than 50 tree species, increases in average annual temperatures will force these species to adapt. Potential impacts on forests include increased stress on native tree species, shifts in forest composition due to a climate more suitable for southern species, and the potential for isolated species having a reduced ability to migrate and respond to climate change[14]. Of particular concern are the Asian longhorned beetle (not yet detected in Vermont), emerald ash borer and hemlock wolly adelgid, which have killed millions of trees across the U.S. and Canada.

In 2017, the first reported cases of the emerald ash borer occurred in Vermont in Orange, Washington and Caledonia Counties[15]. Emerald ash borer larvae burrow through the inner layer of the ash tree's bark, impeding the tree's ability to conduct water and nutrients throughout the tree[16]. Lacking sufficient water and nutrients,

12 https://docs.google.com/spreadsheets/d/123tCXdNH8yhZ_A7obICfLzAtBos6kBy2qZCmrFDtO_o/edit#gid=0
13 http://climatechange.vermont.gov/sites/climate/files/documents/Data/VTCCAdaptForestry.pdf
14 https://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs173.pdf
15 https://www.vtinvasives.org/land/emerald-ash-borer-vermont
16 https://www.nature.org/ourinitiatives/urgentissues/land-conservation/forests/interactive-media-emerald-ash-borer-slideshow.xml

Adult Emerald Ash Borer and the results of larvae burrowing through the bark of an Ash tree.
Source: https://www.nature.org/ourinitiatives/urgentissues/land-conservation/forests/interactive-media-emerald-ash-borer-slideshow.xml


healthy ash trees can die within 1-4 years of exhibiting first signs or symptoms of ash borer invasion and, because 5% of Vermont's trees are ash, the State's forest composition is extremely vulnerable to this invasive species. It is estimated that the majority of ash trees infested with the emerald ash borer will die, causing public hazards from standing dead trees that may impact structures and infrastructure, as well as add to riverine debris during high precipitation events (see: Inundation Flooding & Fluvial Erosion).

Hemlock wolly adelgid is an invasive pest that feeds on hemlock trees, first discovered in Vermont in 2007 and primarily located in the southern counties. Due to our harsh winters in Vermont, hemlock wolly adelgid has not caused significant mortality among hemlocks; however, south of Vermont where winters are more mild this is a significant concern. Based on Vermont's trend of increasing temperature (see: Extreme Heat), this invasive is expected to be a much more significant concern in the future. In the winter of 2016-2017, a significant portion of the hemlock woolly adelgids were able to survive the winter, which was not the case in the previous three winters[17].

In addition to concerns over Vermont's ash population, northern hardwood species like maple, yellow birch and American beech are anticipated to be nearly eliminated in the State, replaced by those tree species that thrive in warmer, drier conditions, like oak and pine. Additionally, the changing climate will allow for greater survival and reproduction of forest pest species, as trees that are stressed due to lower water availability reduce their ability to maintain sufficient defense mechanisms, making them more vulnerable to pest invasion and disease. As trees die at an increasing rate, concerns regarding wildfire susceptibility also rise (see: Wildfire).

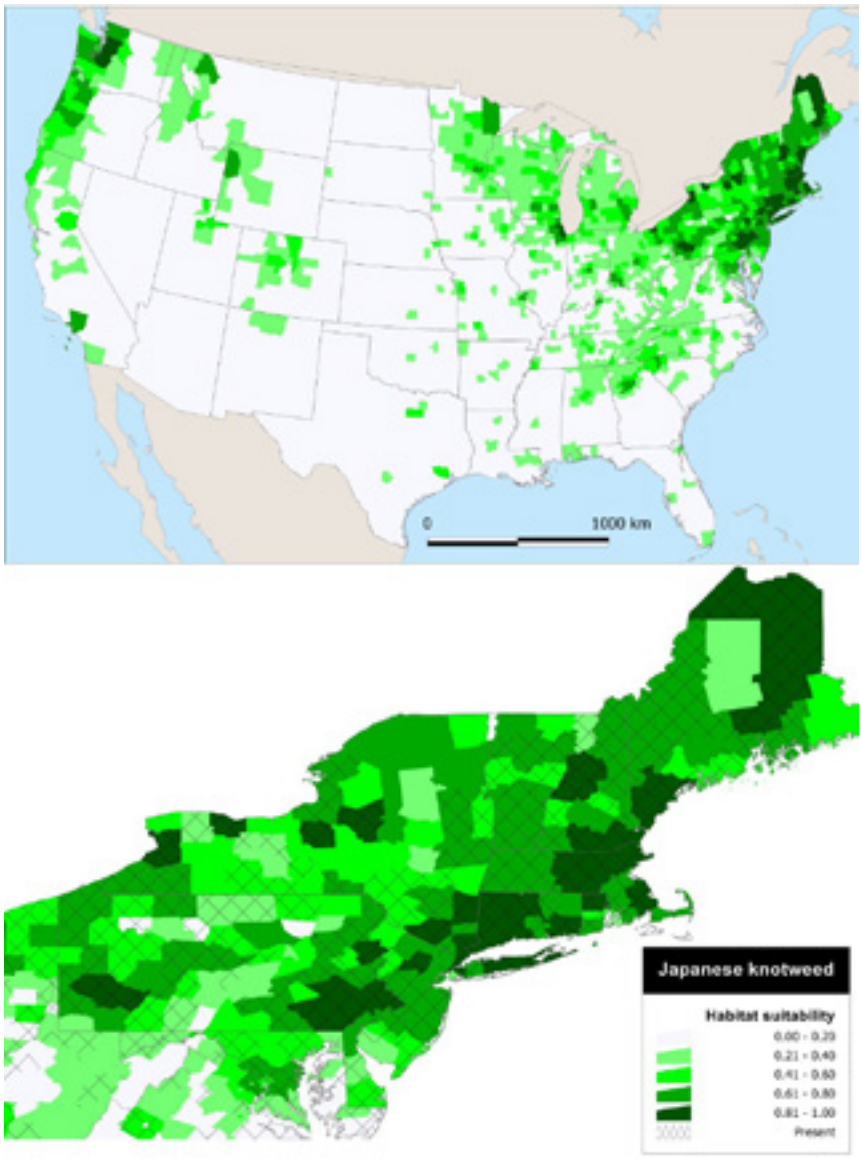


Figure 59: Model Predictions of Habitat Suitability - Japanese Knotweed
Source: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0001635

Along the State's riverbanks, Japanese knotweed continues to spread uncontrollably, negatively affecting native insect populations, and therefore those species like birds, fish and mammals, that rely on those insects as a food source. With shallow root systems, the spread of Japanese knotweed significantly reduces streambank stability, thereby exacerbating fluvial erosion (see: Inundation Flooding & Fluvial Erosion). Road maintenance efforts near ditches infested by Japanese knotweed allow for quick spread of the knotweed's rhizomes and stems. While Japanese knotweed is already prevalent in Vermont, Figure 59 illustrates the area of potential spread based on habitat suitability.

17 https://vtinvasives.org/news-events/news/summer-2017-vermont-hemlock-woolly-adelgid-update

The Steering Committee considered the probability of a plausibly significant extreme invasive species event to be Occasional, with the most significant impacts felt by the environment, followed then by the direct and indirect impacts to the economy.

Invasive Species Mitigation

The Vermont Invasives website maintains a crowd-sourced invasive species map that allows users to upload locations and photos of invasive species, which acts as an aid in determining spread rate and control measures across the State[18]. This comprehensive website also includes information on all of the significant invasive species affecting Vermont, including identification, treatment and prevention measures. The Lake Champlain Basin Program also has information regarding the aquatic invasive species threatening the Lake Champlain Basin and how to prevent their spread[19].

Additionally, Vermont joined the United States Department of Agriculture (USDA)'s 31-state quarantine boundary, aimed at reducing the movement of emerald ash borer-infested ash wood to un-infested regions outside of Vermont's borders[20]. The February 2018 State of Vermont Action Plan for the Emerald Ash Borer identifies the Agency of Agriculture, Foods and Markets and the Department of Forests, Parks and Recreation as the lead agencies responsible for developing a means by which the emerald ash borer can be quickly detected/identified and managed. The intent of the Action Plan is to establish effective lines of communication between pertinent State agencies and to clearly identify the roles and responsibilities of each agency in preventing the spread of the emerald ash borer across Vermont[21]. A first step to actualize this effort will take place in late 2018, when the Department of Forests, Parks and Recreation intends to develop an application for emerald ash borer mitigation education and outreach, as part of FEMA's 5% Initiative Program.

Given the compounding impacts invasive species have on other hazard impacts addressed in this Plan (see: Inundation Flooding & Fluvial Erosion and Wildfire), several of the high priority actions regarding hazard mapping and data sharing are pertinent to invasive species mitigation. Also, as the climate models project increases in both temperature and precipitation, it is anticipated that invasive species infestation in Vermont will continue to grow and, as such, the State's efforts concerning education and outreach of the hazards associated with invasive species need to be bolstered in the years to come. Accordingly, an action to support the education of the general public around invasive species and their role in altering the beneficial functions of natural ecosystems was developed (see: Mitigation Strategy).

18 http://www.inaturalist.org/projects/mapping-for-healthy-forests-vermont
19 http://www.lcbp.org/water-environment/aquatic-invasive-species/
20 https://www.vtinvasives.org/sites/default/files/images/NE_EAB_Quarentine%205.7.18.pdf
21 http://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Forest_Health/Library/State%20of%20Vermont%20Action%20Plan_Emerald%20Ash%20Borer.pdf

4-11: Infectious Disease

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Infectious Disease	2	1	3	2	1	1.75	3.5

*Score = Probability x Average Potential Impact

The Vermont Department of Health defines an infectious disease as one that is caused by micro-organisms, such as bacteria, viruses and parasites. A vector-borne disease is an infectious disease that is transmitted to humans by blood-feeding arthropods, including ticks, mosquitoes and fleas, or in some cases by mammals (e.g. rabies).

According to the Vermont Department of Health, infectious disease dynamics depend on a range of factors, including: land use, human behavior, climate, efficacy of healthcare services, population dynamics of vectors, population dynamics of intermediate hosts and the evolution of the pathogens themselves.

Many of these diseases require continuous monitoring, as they present seasonal threats to the general population. An epidemic emerges when an infectious disease occurs suddenly in numbers that are in excess of normal expectancy. Infectious disease outbreaks put a strain on the healthcare system and may cause continuity issues for local businesses. These outbreak incidents are a danger to emergency responders, healthcare providers, schools, and the public. This can include influenza (e.g. H1N1), pertussis, West Nile virus, and many other diseases.

Table 38: Threat Categories of Vector-Borne and Other Infectious Disease

Threat Classification	Disease
Diseases already present in Vermont that may be exacerbated by climate change	West Nile Virus
	Eastern Equine Encephalitis
	Lyme Disease
	Anaplasmosis
	Babesiosis
	Tularemia
	Powassan
Diseases that may spread to Vermont even without contribution of climate change, whose spread to and transmission of Vermont could be exacerbated by climate change	St. Louis Encephalitis
	Western Equine Encephalitis
	La Crosse Encephalitis
	Ehrilichiosis
	Rocky Mountain Spotted Fever
Diseases with vectors that may spread to Vermont by the end of the century under a higher emission scenario	Dengue
	Chikungunya
Disease that have competent vectors or may in the future have competent vectors in Vermont, but are unlikely to become established in Vermont despite a vector presence	Yellow Fever
	Malaria
	Chagas Disease
	Rift Valley Fever
Diseases that may be present in Vermont or may spraed to Vermont in the future but whose link with climate changes expected in Vermont is tenuous	Batonellosis
	Rabies
	Hanta Virus
	Leptospiriosis
	Plague
	Valley Fever
	Anthrax
	Q Fever

Source: Vermont Department of Health

Upon consideration of five climate and health reviews, The Vermont Department of Health separated vector-borne and other infectious diseases into five threat categories (Table 38). More details on this classification system and the diseases can be found in the 2016 Vermont Climate Health Report[1].

Infectious Disease History

Pandemic influenza, considered to be a global outbreak, spread quickly around the world and was observed in 1918, 1957, 1968 and in 2009 with the novel H1N1 strain. The 2009 H1N1 outbreak, though not considered a serious threat to Vermont, still affected some Vermonters. The great influenza epidemic of 1918 killed millions worldwide and would likely cause hundreds to thousands of deaths in Vermont should a similar outbreak occur today. It is anticipated that a more serious strain of the usual flu will occur some year and that vaccines might not be ready in time to combat rapid spread.

Lyme disease continues to pose a significant threat to Vermonters, as cases (both probable and confirmed) have been tracked by the Vermont Department of health for several decades (Figure 60).

Infectious Disease Trends & Vulnerability

According to the Centers for Disease Control (CDC), the number of reported cases of vector-borne infectious disease has more than tripled between 2004 and 2016[2].

Those infectious diseases that fall into the first threat classification category identified in Table 38 (i.e. currently present in Vermont and which may be exacerbated by climate change) are already exhibiting increased prevalence in New England. For example, with both temperature (see: Extreme Heat) and precipitation (see: Inundation Flooding & Fluvial Erosion) expected to increase in Vermont, West Nile Virus mosquito vector activity will likely increase, as well as the vector's period of activity. Similarly, between 1964 and 2010, counts of Eastern Equine Encephalitis (EEE) have continued to rise in New England, though they remain constant in the southeastern states.

Perhaps the most significant trend in infectious disease vulnerability in Vermont is that of Lyme disease, where Vermont ranks second in highest rate of disease incidence in the nation. The Vermont Department of Health reports that the number of reported cases of Lyme disease have increased dramatically over the last decade, and with shrinking winters, the potential for infection through tick bite continues to grow. Additionally, Vermont's increase in forest cover could provide a more suitable habitat for ticks and their hosts, which may lead to further spread of Lyme disease in the State. Outdoor laborers and recreationalists are especially vulnerable to Lyme disease, as exposure to ticks is greater. The southern and western halves of the State are more vulnerable to Lyme disease, as the warmer climate contributes to longer period of vector activity.

Vermont is typically not vulnerable to diseases such as HIV/AIDS, SARS, cholera, malaria, and resistant tuberculosis, though they are considered to be major disasters in some parts of the world. However, an incident that caused water supplies to become contaminated or resulted in people eating spoiled food could have significant health implications. An animal infected with the rabies virus would be a localized threat. The potential for large-scale infection of Vermont's commercial animal population with foot and mouth disease, bovine spongiform encephalopathy (i.e. Mad Cow Disease), or any number of poultry viruses, while unlikely, could cause widespread economic problems. A health threat might also result from an act of bio-terrorism.

1 http://www.healthvermont.gov/sites/default/files/documents/2017/01/CHPR_Sept7_2016.pdf
2 https://www.cdc.gov/vitalsigns/pdf/vs-0518-vector-borne-H.pdf

Given increasing trends for global travel, several diseases not typically observed in Vermont can make their way back to the State through infected travelers. For example, the Zika virus, transmitted from infected mosquitoes to humans, received international attention during an outbreak in 2015, which persists today. The CDC and Vermont Department of Health recommend pregnant women, or women attempting to become pregnant, not travel to areas of the world where Zika is present[3], as the virus can pass from mother to fetus, causing potentially significant birth defects.

The Steering Committee considered the probability of a plausibly significant infectious disease outbreak event to be Occasional, with the most significant impacts felt by people, followed then by the direct and indirect impacts to the economy.

Infectious Disease Mitigation

Given the Steering Committee's lower ranking of infectious disease outbreak in the hazard assessment, there are no actions in this plan that specifically address the hazard. However, several strategies and actions under the goal to create a common understanding of – and coordinated approach to – mitigation planning and action, focus on data acquisition and dissemination of all hazards, as well as increasing public awareness of the hazards that Vermont faces.

The Vermont Department of Health also regularly updates its website with news, events and reports that users can utilize in consideration of infectious disease mitigation[4].

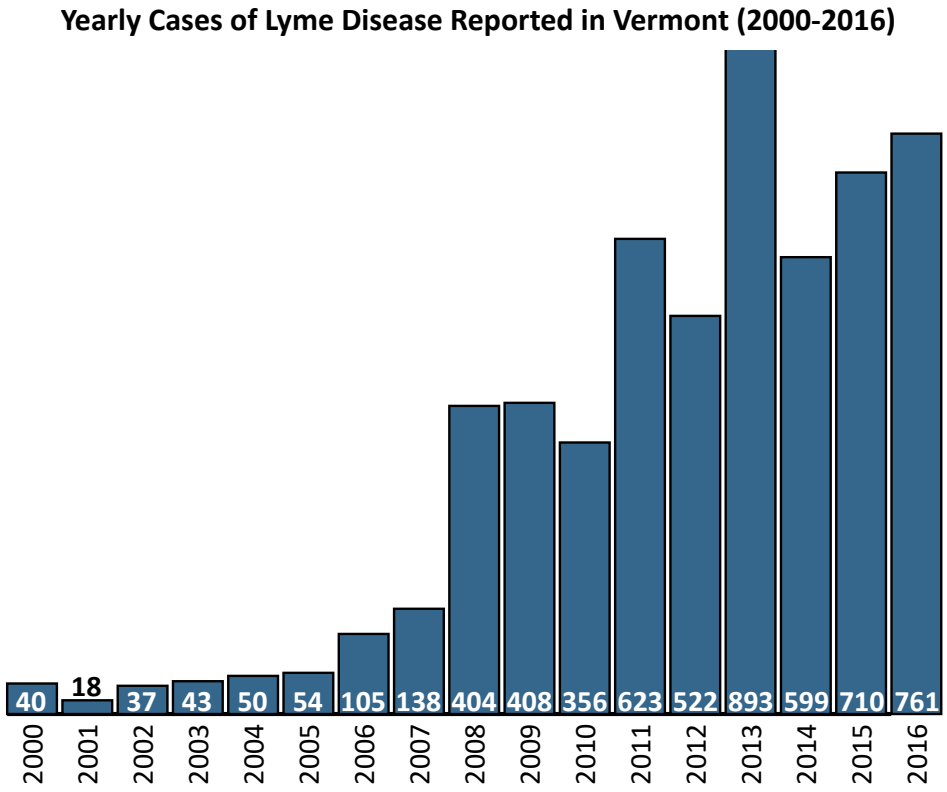


Figure 60: Yearly cases of lyme disease reported in Vermont (2000-2016)
Data Source: https://www.cdc.gov/lyme/stats/index.html

3 https://wwwnc.cdc.gov/travel/page/zika-information
4 http://www.healthvermont.gov/disease-control

Reported Lyme Disease Cases in 1996 and 2014

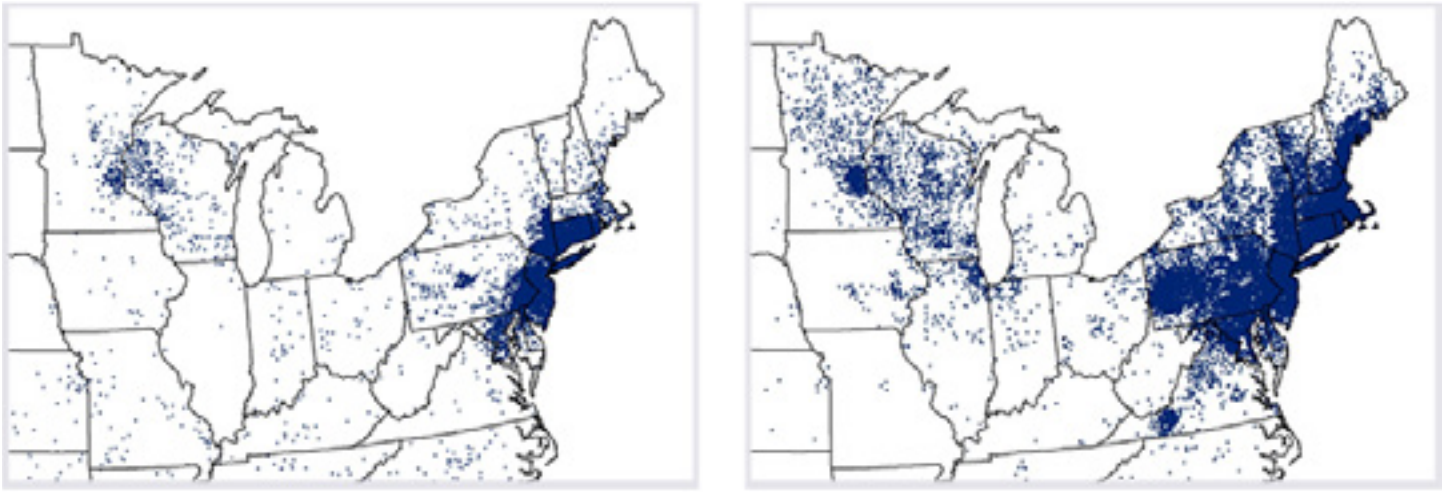


Figure 61: Reported lyme disease cases map 1996 (left) and 2014 (right)
Source: https://www.epa.gov/climate-indicators/climate-change-indicators-lyme-disease

4-12: Hail

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	Average:	
Hail	3	1	1	1	1	1	3

*Score = Probability x Average Potential Impact

Hail is a form of precipitation composed of spherical lumps of ice. Known as hailstones, these ice balls typically range from 5-50 mm in diameter on average, with much larger hailstones forming in severe thunderstorms (see: Wind). The size of hailstones is a direct function of the severity and size of the thunderstorm by which it is produced. No matter the size, hail can damage property, young and tender plants, and cause bodily harm to those unfortunate enough to be caught outside.

Table 39: TORRO Hailstorm Intensity Scale

	Intensity Category	Typical Hail Diameter (mm)	Probable Kinetic Energy (J/m2)	Typical Damage Impacts
H0	Hard Hail	5	0-20	No damage
H1	Potentially Damaging	5-15	>20	Slight general damage to plants, crops
H2	Significant	10-20	>100	Significant damage to fruit, crops, vegetation
H3	Severe	20-30	>300	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4	Destructive	25-40	>500	Widespread glass damage, vehicle bodywork damage
H5	Destructive	30-50	>800	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	40-60		Bodywork of grounded aircraft dented, brick walls pitted
H7	Destructive	50-75		Severe roof damage, risk of serious injuries
H8	Destructive	60-90		Severe damage to aircraft bodywork
H9	Super Hailstorm	75-100		Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	Super Hailstorm	>100		Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Source: http://www.torro.org.uk/hscale.php

Hailstorms usually occur in Vermont during the summer months and generally accompany passing thunderstorms. While local in nature, these storms can be significant to area farmers, who can lose entire fields of crops in a single hailstorm. Large hail is also capable of property damage, to include both structures and vehicles. Hailstone size can range from the size of a pea to the size of a melon (Table 40).

Table 40: Hail Size and Diameter in Relation to TORRO Scale

Size Code	Maximum Diameter (mm)	Description
0	5-9	Pea
1	10-15	Mothball
2	16-20	Marble, grape
3	21-30	Walnut
4	31-40	Pigeon's egg > squash ball
5	41-50	Golf ball > Pullet's egg
6	51-60	Hen's egg
7	61-75	Tennis ball > cricket ball
8	76-90	Large orange > Soft ball
9	91-100	Grapefruit
10	>100	Melon

Source: http://www.torro.org.uk/hscale.php

Hail History

There have been 137 hail events in Vermont since 2000, causing over $550,000 in property damage and $261,000 in documented crop damage[1]. The largest recorded hail was 3.25" in Westford in July 2009, with an estimated $100,000 in damages. The second largest hail event was in June 2011, with recorded hail of 3.25" and 2.75" in Shaftsbury.

Table 41: Hail Events Summary: 2000-2017

Hail Size	Days with an Event	Impacted Jurisdictions	Property Damage	Crop Damage
≥3"	2	2	$50,000	$50,000
2.5"	2	2	$20,000	$20,000
2"	7	7	$45,000	$20,000
1.75"	25	42	$286,000	$1,000
1.5"	19	26	$100,000	$0
1.25"	19	30	$0	$20,000
1"	88	239	$43,000	$150,000
0.88"	59	105	$6,000	$0
0.75"	63	130	$2,000	$0

Source: https://www.ncdc.noaa.gov/stormevents/

Hail is considered a relatively infrequent occurrence in Vermont. Those hail events that do occur tend to be highly localized and limited to a relatively small area. Table 41 is a summary of all hail events between 2000 and 2017.

Hail Trends & Vulnerability

The Steering Committee considers the probability of hail to be Likely, given the frequency with which Vermont has some form of hail event. Relative to Vermont's other hazards, the impact from hail is considered to be negligible to infrastructure, life, the economy and the environment.

Although significant hailstorms occur relatively infrequently, they are still important to consider, given Vermont's primarily agrarian economy. As mentioned above, significant hail events can lead to extensive crop damage, which can negatively impact Vermont's many farms.

While hail can directly damage these crops, other aspects of Vermont's economy may be indirectly affected. There have been reports of hailstorms completely destroying entire hay fields and cornfields. These crops are usually used to feed animals, so dairy farms and other farms that breed livestock can also be affected. This can cause a domino effect increasing prices of feed for livestock, which in turn increases the price of milk and other dairy products, further impacting the economy.

According to the 2014 National Climate Assessment, though there is an observable increase in severity of winter storms, changes in the frequency or severity of hail events are still uncertain but are being extensively studied[2].

Hail Mitigation

Due to the unpredictability of hailstorms and the negligible impacts to infrastructure, life, the economy and the environment, there is little in the way of hail mitigation in Vermont. Most efforts related to hail are in the response and recovery sectors, not mitigation.

However, implementation of certain actions within the Plan will address hail (see: Mitigation Strategy), such as the strategy on resilient design and construction standards, including actions around developing sample building standards and educational resources for resilient design and construction.

1 https://www.ncdc.noaa.gov/stormevents/
2 https://nca2014.globalchange.gov/report/our-changing-climate/changes-storms

5: Mitigation Strategy

The State of Vermont intends to create an efficient, effective, and consistent Hazard Mitigation Strategy that will focus efforts and priorities, enhance mitigation capabilities, and integrate State, regional, and local planning and risk assessment efforts in the short-term and long-term. The goals, objectives and actions stated herein are meant to serve as practical policy guidance for State of Vermont decision-makers in allocating resources for the Pre-Disaster Mitigation (PDM) Program, Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA) Program, and existing and future State resources, among many others. Additionally, this action list is intended to be a resource to VEM and partner agencies, as they continue to collaborate with non-governmental stakeholders throughout Vermont during implementation. As the actions contained within this Plan reach significantly beyond what any one entity would be able to implement or fund, continued collaboration is considered necessary for more effectively leveraging resources, thereby improving likelihood of implementation.

For an overview of the robust stakeholder engagement process undertaken to develop the vision, mission, goals, guiding principles, and actions that follow, see: Planning Process. To better understand how the actions relate to the identified hazards and the specific vulnerabilities created by those hazards, see: Hazard Assessment.

VISION: Vermont will be safe and resilient in the face of climate change and natural disasters.

MISSION: To protect life, property, natural resources and quality of life in Vermont by reducing our vulnerability to climate change and natural disasters.

GOALS

Protect, restore and enhance Vermont's natural resources to promote healthy, resilient ecosystems.

Enhance the resilience of our built environment – our communities, infrastructure, buildings, and cultural assets.

Develop and implement plans and policies that create resilient natural systems, built environments, and communities.

Create a common understanding of – and coordinated approach to – mitigation planning and action.

Guiding Principles for Mitigation Planning and Action:

- We will ensure that hazard mitigation work strengthens and protects Vermont's economy and affordability.
- We will reduce the risks and impact of hazards on vulnerable populations.
- We will ensure that hazard mitigation action accounts for – and helps us adapt to – climate change.
- We will work to build relationships and partnerships for action across sectors and disciplines.

Action Development & Prioritization Process

In a March 2017 State Hazard Mitigation Planning & Policy Committee (SHMPPC) meeting, attendees approved the creation of a Steering Committee to guide the SHMP update process, with the specific instruction to devote considerable time to developing a robust, implementable mitigation strategy. Accordingly, over the course of the next year, using the Plan goals identified by the Steering Committee, Working Groups and Focus Groups developed a significant list of mitigation actions. These actions were sorted by goal and then further sorted according to similar themes, called "strategies".

Given a healthy list of ninety-six (96) mitigation actions, organization by prioritization was necessary. Accordingly, the 96 mitigation actions were ranked based on the below criteria (Table 42), developed by the Steering Committee.

Table 42: Action Prioritization Criteria

	Impact	Feasibility
High	• Significantly benefit the environment, OR • Significantly benefit people/vulnerable populations, OR • Significantly reduce risk in our built environment, OR • Significantly benefit the economy, OR • Create the opportunity to do one of the above (e.g. filling a data gap), AND • **Significantly reduce vulnerability to a high priority hazard** (erosion, inundation, ice, snow)	• Have political and community support, AND • Are consistent with current state laws/policies, AND • Have funding/other required resources available or identified, AND • Are technically/logistically feasible
Medium	• Moderately benefit the environment, OR • Moderately benefit people/vulnerable populations, OR • Moderately reduce risk in our built environment, OR • Moderately benefit the economy, OR • Create the opportunity to do one of the above (e.g. filling a data gap), AND • **Moderately reduce vulnerability to a profiled hazard**	• Have political and community support, OR • Are consistent with current state laws/policies, OR • Have funding/other required resources available or identified, AND • Are technically/logistically feasible
Low	• Minorly benefit the environment, OR • Minorly benefit people/vulnerable populations, OR • Minorly reduce risk in our built environment, OR • Minorly benefit the economy, OR • Create the opportunity to do one of the above (e.g. filling a data gap), AND • **Minorly reduce vulnerability to a profiled hazard**	• Have political and community support, OR • Are consistent with current state laws/policies, OR • Have funding/other required resources available or identified, OR • Are technically/logistically feasible

Using the High, Medium and Low rankings for Impact and Feasibility within the action list, the Focus Groups organized by goal area began the process of defining priority actions under each goal, which were reviewed and modified by the Steering Committee. Any action that received a High Impact and High Feasibility score, and that requires coordination to be implemented, was automatically considered to be a priority action. The Steering Committee decided to also consider inclusion of certain High Impact actions with lower Feasibility scores in the priority action list based on Feasibility being potentially flexible or subject to future change. Those priority actions with lower Feasibility scores were either highlighted by the Focus Groups or added by the Steering Committee. Taken together, this Plan includes twenty-four (24) priority actions, which are highlighted in the complete action list below (Table 44).

For more information on the process for development of the 2018 SHMP actions, the criteria and action prioritization, see: Planning Process.

In addition to these priorities, the Steering Committee also voted individually on their top three actions from the priority list, resulting in the following top priority actions:

- ***Develop a cross-sector buyout program***
- ***Inventory and protect critical headwater and floodplain storage areas***
- ***Collaborate across flood resilience, water quality and habitat connectivity programs and funding***
- ***Audit State programs to assess and improve their support of mitigation goals***
- ***Coordinate State programs to promote development, sharing and maintenance of hazard-related data and mapping***

The complete mitigation action list includes all 96 actions, categorized by similar themes into 24 strategies that then fall under the appropriate overarching goal, of which there are four. The list also identifies the:

- source of the action,
- pertinent category (e.g. technical assistance, data gap),
- hazard(s) that the action addresses,
- entity(ies) responsible for implementing the action,
- potential resources to fund action implementation,
- timeline for completing the action, and
- the overall Impact and Feasibility ratings.

For those actions that use the term “hazard-prone areas”, the Steering Committee aimed to address all hazards to which that specific action may reduce vulnerability. To that end, “hazard-prone areas” can mean a FEMA-mapped Special Flood Hazard Area, an area identified as vulnerable to landslides, or those regions of the State that are more vulnerable to drought or extreme cold, for example.

Though the mitigation action list identifies the hazard(s) addressed, some hazard-specific actions and capabilities can also be found and further explained in the mitigation subsection within each of the hazard profiles (see: Hazard Assessment).

Table 43: 2018 State Hazard Mitigation Plan Actions Acronym List:			
AAFM	Vermont Agency of Agriculture, Food & Markets	NRCD	Vermont Natural Resources Conservation Districts
ACCD	Vermont Agency of Commerce & Community Development	NRCS	USDA Natural Resources Conservation Service
ADS	Vermont Agency of Digital Services	PSD	Vermont Public Services Department
AHS	Vermont Agency of Human Services	RM	Readiness Matrix
ANR	Vermont Agency of Natural Resources	RPC	Regional Planning Commission
AOA	Vermont Agency of Administration	SHPO	Vermont State Historic Preservation Officer
ARC	Academic Resilience Collaborative	SC	Steering Committee
BGS	Vermont Buildings & General Services	TNC	The Nature Conservancy
CDBG	Community Development Block Grant	USDA	United States Department of Agriculture
CLF	Conservation Law Foundation	USDA-RD	USDA - Rural Development
COAD	Community Organizations Active in Disaster	USGS	United States Geological Survey
CRO	Community Resilience Organizations	UVM	University of Vermont
CVOEO	Champlain Valley Office of Economic Opportunity	VAAHM	Vermont Association of Hospitals and Health Systems
DPS	Vermont Department of Public Safety	VCGI	Vermont Center for Geographic Information
EMPG	Emergency Management Performance Grant	VEM	Vermont Emergency Management
EPC	Emergency Preparedness Conference	VHCB	Vermont Housing & Conservation Board
ERAF	Emergency Relief & Assistance Fund	VHS	Vermont Historical Society
EWP	Emergency Watershed Protection Program	VLCT	Vermont League of Cities & Towns
FEMA	Federal Emergency Management Agency	VLT	Vermont Land Trust
FHWA	Federal Highway Administration	VNRC	Vermont Natural Resources Council
GMP	Green Mountain Power	VOAD	Voluntary Organizations Active in Disaster
HWA	FEMA Hazard Mitigation Assistance	VRC	Vermont River Conservancy
HMGP	FEMA Hazard Mitigation Grant Program	VTrans	Vermont Agency of Transportation
HMTAP	FEMA Hazard Mitigation Technical Assistance Programs	WG	Working Group
NESEC	Northeast States Emergency Consortium	WUV	Watersheds United Vermont
NFIP	FEMA National Flood Insurance Program		

Table 44: 2018 State Hazard Mitigation Plan Actions

GOAL: Protect, restore and enhance Vermont's natural resources to promote healthy, resilient ecosystems.

Strategy	Action	Source	Category	Hazard(s) Addressed	Entities	Potential Resources	Timeline	Impact	Feasibility
Promote land management standards for State and private lands	Implement ANR's flood resilience guidelines on ANR Lands.	Aug 2017 WG (1.3.3)	Regulation/ Policy	Inundation; Fluvial Erosion	ANR, ANR's State Lands Sub-Committee	Existing State Resources	2019	Medium	High
	Expand ANR's flood resilience guidelines into a consistent State land management policy to increase and maintain flood storage and attenuation on all state-owned land.	Expert Review (RM #5, 1.3.3)	Regulation/ Policy	Inundation; Fluvial Erosion	ANR, BGS	Existing State Resources	2020	High	Medium
	Support ongoing efforts to identify strategies for funding and assisting private landowners with essential hazard mitigation and clean water projects.	Dec WG / SHMP 2013 (RM #87)	Funding/ Incentive	Inundation; Fluvial Erosion	ANR, VEM, AAFM, VTrans, High Meadows Fund	Existing State and Nonprofit Resources	Ongoing	Medium	High
	Work with land conservation organizations to include river corridor and floodplain protection provisions, and/or headwater storage in conservation easements.	Expert Review	Partnership/ Coordination	Inundation; Fluvial Erosion	ANR, VHCB, VRC, VLT, NRCD	Existing State and Nonprofit Resources	2019	High	High
Improve headwater storage	Develop an inventory of critical headwater and floodplain storage areas that would result in a measurable abatement of flooding.	WG June 2017	Data Gap	Inundation; Fluvial Erosion	ANR, USGS, TNC, VLT, UVM, VRC	TNC, State Resources	2019-2020	High	High
	Complete a pilot project in a strategic watershed, using the above inventory, to prioritize land conservation and determine the cost of averted flood damage.	Focus Group	Data Gap	Inundation; Fluvial Erosion	ANR, USGS, TNC, VLT, UVM, VRC	TNC, HMGP 5% Initiative	2020	High	High
	Conserve land identified in the critical headwater storage inventory through landowner outreach and existing conservation programs.	WG June 2017	Education/ Outreach	Inundation; Fluvial Erosion	ANR, Watershed Groups, RPCs, Land Trusts, VRC	Existing State and Nonprofit Resources	Ongoing	High	Medium
	Identify critical headwater storage areas enrolled in the Current Use program and conduct outreach to inform landowners of the value of protecting these areas during harvesting operations.	Focus Group	Regulation/ Policy	Inundation; Fluvial Erosion	ANR, AAFM, VRC	Existing State Resources	Ongoing	High	Medium
	Identify stormwater-impaired headwater storage areas where stormwater treatment and stream restoration would result in hazard mitigation co-benefits.	Expert Review	Data Gap	Inundation; Fluvial Erosion	ANR, RPCs, VEM, VRC	FEMA HMA	Ongoing	Medium	Medium
Reduce negative impacts of in-stream work	Create a working group to explore potential strategies to reduce negative impacts from heavy equipment operators who work in rivers (i.e., tailored Rivers and Roads Training Tier 3).	Expert Review / SHMP 2013 (3.4.1)	Technical Assistance	Inundation; Fluvial Erosion	ANR, VTrans, VEM, TNC, RPCs	Existing State and Nonprofit Resources	2019	High	Medium
	Develop a rapid-response field task force (river engineers, scientists, restoration specialists, transportation engineers and RPC staff) to provide regulatory, technical and administrative assistance for in-stream reconstruction projects and mitigation measures in the immediate aftermath of major flood disasters.	SHMP 2013 Priority (3.3.1)	Program Development	Inundation; Fluvial Erosion	ANR, RPCs, VTrans, VEM	Existing State Resources	Ongoing	High	Medium
	Institute an effective outreach and training program to assist municipalities in complying with Vermont's new rules for conducting instream emergency protective measures.	Expert Review / SHMP 2013 3.1.4	Program Development	Inundation; Fluvial Erosion	ANR, RPCs, VTrans, VEM	Existing State Resources	Ongoing	High	Medium
	Incorporate ANR's Standard River Management Principles and Practices into in the VTrans Orange Book to ensure municipalities adopt the same standards.	SHMP 2013 (RM #5)	Regulation/ Policy	Inundation; Fluvial Erosion	ANR, VTrans	Existing State Resources	2020	High	Medium
Improve flood resilience of agricultural lands	Create a working group to develop a coordinated assistance strategy (funding mechanisms, technical support, directory of available resources) to further improve the resilience of agricultural lands and their contribution to flood resilience.	SHMP 2013 (RM #31, #33, #88)	Program Development	All Hazards	AAFM, ANR, UVM Extension, NRCS, VLT, High Meadows, NRCDs, VRC, NRCD	Existing State and Nonprofit Resources	2020	High	High
	Expand use of USDA conservation programs to plant riparian buffers and flood chute grassed waterways to reduce future flood damage to farm fields, attenuate flood-borne sediment and debris, and reduce downstream flooding.	Expert Review / SHMP 2013 (3.2.6)	Funding/ Incentive	Inundation; Fluvial Erosion	AAFM, USDA, UVM Extension	USDA	Ongoing	Medium	Medium
Promote drought resilience	Expand the number of monitoring wells (in both bedrock and surficial materials) to include drilled wells which will provide data for tracking water level and responses to precipitation.	Expert Review	Data Gap	Inundation; Fluvial Erosion; Drought	ANR, USGS	USGS, Existing State Resources	Ongoing	Medium	Medium
	Analyze water level/monitoring data to use as predictor of drought and rates of recovery.	Expert Review	Data Gap	Drought	ANR, USGS	Existing State Resources	Ongoing	Medium	Medium
	Develop statewide groundwater resource maps, water use and water level data in order to determine water budgets for local areas in preparation for drought conditions.	SHMP 2013 (5.1.10)	Data Gap	Drought	ANR	HMGP 5% Initiative	2020	Medium	Low

Strategy	Action	Source	Category	Hazard(s) Assessed	Entities	Potential Resources	Timeline	Impact	Feasibility
Connect water quality, flood resilience and native habitat connectivity through co-benefits	Create a "Reconnect Vermont Rivers" initiative (or similar State planning, prioritization, and tracking mechanism) to enhance the funding eligibility and incentives for flood resilience, water quality, and habitat projects as co-benefits.	Expert Review	Partnership/ Coordination	Inundation; Fluvial Erosion	ANR, TNC, AAFM, WUV, VTrans, VLT, VRC, NRCD	Exisiting State and Nonprofit Resources	Ongoing	High	High
	Develop hydraulic and stream power models for a range of flood frequencies to analyze and define valley areas supporting essential floodplains and river corridor functions that would increase the storage of flood flows, sediments, and nutrients.	Expert Review	Technical Assistance, Data Gap	Inundation; Fluvial Erosion	ANR, UVM, TNC, VLT, USGS, NRCD	Exisiting State and Nonprofit Resources	Ongoing	High	High
	Promote the use of Vermont Fish and Wildlife's Conservation Design Plan to achieve and maintain habitat connectivity and havens for Vermont rare, threatened, and endangered species (aquatic and terrestrial).	Expert Review	Education/ Outreach	Invasive Species; Inundation; Fluvial Erosion	TNC, ANR, VHCB, NRCS, Land Trusts, VLCT, RPCs	Existing State Resources	Ongoing	Medium	High

GOAL: Enhance the resilience of our built environment - our communities, infrastructure, buildings, and cultural assets.

Strategy	Action	Source	Category	Hazard(s) Addressed	Entities	Potential Resources	Timeline	Impact	Feasibility
Locate new development outside of hazardous areas	Secure funding to create a permanent all-hazard mapping position at ANR (as created by SHMP 2018 subgrant).	Expert Review / SHMP 2013 (RM #75)	Data Gap	All Hazards	ANR, VEM	USGS, FEMA, State Resources	2019	Medium	Medium
	Develop a mechanism for tracking new structural development in the river corridor so development patterns can be tracked over time.	WG June 2017	Data Gap	Inundation; Fluvial Erosion	ANR, UVM, VCGI, RPCs	NFIP, State Resources	2019	High	Medium
	Research reasonable steps developers can take to site new structural development outside of hazard-prone areas when the State is involved in funding, consistent with State river corridor standards and land use goals.	Dec WG / SHMP 2013 Priority (1.2.1, New 4.2)	Data Gap	Inundation; Fluvial Erosion; Landslide	ANR, AOA, VEM, VTrans	Existing State Resources	Ongoing	High	High
Develop resilient design and construction standards	Develop sample building standards for resilient design and construction (for buildings, construction sites, transportation infrastructure, etc.).	Expert Review	Technical Assistance	All Hazards	ANR, VTrans, RPCs, Norwich	Existing State Resources	2020	High	Medium
	Audit existing building codes to ensure that standards account for anticipated climate change impacts to Vermont, including but not limited to increased temperatures extremes and precipitation.	Expert Review	Data Gap	All Hazards	Norwich, DPS - Fire Safety	Existing State and Academic Resources	2020	Low	Low
	Create educational resources for contractors, municipalities and property owners on resilient design and construction techniques.	Dec WG	Education/ Outreach	All Hazards	Norwich, VTrans, DPS (Partner with Efficiency VT)	Existing State and Academic Resources	2020	Medium	Medium
	Research how applicants can demonstrate they have taken reasonable steps to incorporate resilient design and construction in hazard-prone areas when the State is involved in funding, consistent with the objectives of the funding source.	Expert Review	Data Gap	All Hazards	All State Agencies, RPCs	Existing State Resources	2019	High	Medium
Incorporate flood resilience in transportation planning, engineering and programming	Secure funding to expand the VTrans Methods and Tool for Transportation Resilience application (as developed by the 2018 SHMP subgrant) to all watersheds in the State.	Aug 2017 WG	Data Gap	Inundation; Fluvial Erosion	VTrans, VEM, RPCs	Federal Highway, Existing State Resources, FEMA	2018-2023	High	High
	Incorporate metrics for flood resilience into the VTrans project prioritization process.	Aug 2017 WG	Regulation/ Policy	Inundation; Fluvial Erosion	VTrans, ANR, VEM	Existing State Resources	2019	High	High
	Incorporate river and road resilience principles and practices developed by ANR and VTrans (through 2018 SHMP subgrants) into municipal technical assistance and funding to encourage local road maintenance and upgrades that reduce flood-related vulnerabilities.	Expert Review	Technical Assistance	Inundation; Fluvial Erosion	VTrans, ANR, VEM, RPCs	Existing State Resources	2020	High	Medium
	Identify, evaluate and implement design standards and operational practices for State transportation infrastructure necessary to accommodate extreme weather conditions.	SHMP 2013 (4.1.1, RM #17)	Regulation/ Policy	All Hazards	VTrans, Norwich, RPCs	Existing State Resources, Federal Highway	Ongoing	High	Medium
Assess seismic vulnerability	Conduct thorough seismic analyses of select bridge sites, based on UVM's seismic vulnerability ranking system, and prioritize projects.	SHMP 2013 (5.1.13)	Data Gap	Earthquake; Landslides	VTrans, ANR, UVM Transportation Research Center	USGS, Existing State and Academic Resources	Ongoing	Medium	Low
	Conduct detailed seismic analyses for critical facilities identified in the 2016 NESEC study as well as cultural facilities using HAZUS and ROVER.	SHMP 2013 (3.1.9, 5.1.11)	Data Gap	Earthquake; Landslides	ANR, NESEC, VEM, BGS, SHPO	NESEC, FEMA	Ongoing	High	Medium

Strategy	Action	Source	Category	Hazard(s) Addressed	Entities	Potential Resources	Timeline	Impact	Feasibility
Identify and protect vulnerable structures and critical infrastructure	Adapt the flood vulnerability methods developed by VTrans Methods and Tool for Transportation Resilience project (2018 SHMP subgrant) and the Vermont Economic Resiliency Initiative (ACCD) for use in identifying other structures, utilities, key employment areas, and critical infrastructure that are vulnerable to damage from floods.	SHMP 2013 (3.2.1)	Data Gap	Inundation; Fluvial Erosion	ANR, VTrans, VEM, ACCD, GMP	Existing State Resources, Utilities	2019-2023	High	Medium
	Secure funding to implement the priority mitigation actions list developed by Buildings and General Services (BGS) (2018 SHMP subgrant).	Aug 2017 WG / SHMP 2013 (3.2.1)	Funding/ Incentive	Inundation; Fluvial Erosion	BGS, All Agencies	FEMA HMA	2019-2023	Medium	Low
	Provide technical assistance to utilities in long-range planning for transmission and distribution line upgrades and relocation to improve resilience.	Expert Review	Technical Assistance	Wind; Ice; Snow	PSD, ANR	Existing State Resources	Ongoing	Medium	Low
	Assist Vermont Gas in evaluating the flood and seismic vulnerability of Vermont's natural gas pipeline network through the Integrity Management Program, and identify actions to mitigate this risk.	SHMP 2013 (4.7.1)	Technical Assistance	Inundation; Fluvial Erosion; Earthquake; Landslide	PSD	Existing State Resources	Ongoing	Medium	Low
	Require consideration of river corridors in the State permitting process for water and wastewater facility siting or improvement.	SHMP 2013 (1.1.1)	Regulation/ Policy	Inundation; Fluvial Erosion	ANR	Existing State Resources	2020	High	Medium
	Provide technical assistance to municipalities to assess the flood and erosion risks facing their drinking water and waste water systems and identify potential mitigation improvements.	SHMP 2013 (2.1.3)	Technical Assistance	Inundation; Fluvial Erosion	ANR, RPCs	HMGP 5% Initiative Funding	Ongoing	High	Medium
	Create a process for relocating or retrofitting at-risk mobile home parks at the time of sale or substantial rehabilitation using the DHCD's risk assessment tool.	Expert Review / SHMP 2013 (RM #104)	Data Gap	Inundation; Fluvial Erosion; Landslide	ACCD, CVOEO	FEMA HMA	2019	High	Low
Reduce structural vulnerability to landslide hazards	Provide technical assistance to local planners with using the Protocol for Identification of Areas Sensitive to Landslide Hazards to prioritize landslide projects based on risk and develop mitigation options.	SHMP 2013 (3.2.2, 5.1.7)	Technical Assistance	Landslide	ANR, RPCs	EMPG, Existing State Sources	Ongoing	Medium	Medium
	Expand landslide hazard mapping to statewide coverage.	Focus Group	Data Gap	Landslide	ANR, VEM	EMPG, HMGP 5% Initiative Funding	Ongoing	Medium	Medium
	Educate towns and citizens on reporting observed landslides (rockfalls, debris flows, other mass failures) via the landslide hazard online reporting form.	Expert Review	Education/ Outreach	Landslide	ANR, RPCs	Existing State Sources	Ongoing	Medium	High
Protect cultural and historic resources	Update inventories and mapping of cultural and historic resources located in hazard-prone areas (currently underway at the State level and regionally through FEMA).	Aug 2017 WG / Dec WG	Data Gap	Inundation; Fluvial Erosion	ACCD, VT Arts Council, RPCs, FEMA	FEMA, Existing State Resources	2018	Medium	Medium
	Use the updated cultural and historic resources inventory to identify and secure funding for priority cultural and historic structures that can be relocated out of hazardous locations or flood-proofed.	Aug 2017 WG	Funding/ Incentive	Inundation; Fluvial Erosion	ACCD, BGS, Arts Council, VHS	FEMA HMA	2019	High	Low
	Develop and share best practice guides and tool kits for proactive efforts to protect historic buildings, villages and downtowns in floodplains.	June 2017 WG meeting	Education/ Outreach	Inundation; Fluvial Erosion	ACCD, BGS, VT Arts Council, VHS	Existing State and Nonprofit Resources	2019	Medium	Medium
	Improve communications between mitigation project work and historic preservation review to allow for more rapid approval of shovel-ready projects.	Dec WG	Partnership/ Coordination	All Hazards	SHPO, VEM, ANR, VTrans, FEMA	Existing State Resources	Ongoing	High	High
Establish a statewide conservation and buyout program	Establish a working group to design a robust cross-sector buyout program, considering funding, ownership, use restrictions, incentives, stewardship, prioritization.	SHMP 2013 Priority (RM #91)	Partnership/ Coordination	Inundation; Fluvial Erosion; Landslide	VEM, ANR, VLCT, VRC, VHCB, ACCD, CLF	Existing State and Nonprofit Resources	2018-2019	High	High
	Create a dedicated State fund to support the purchase or local match of hazard-prone properties and the purchase of easements to conserve river corridors, floodplains, and wetlands identified as key flood attenuation areas.	DEC WG	Funding/ Incentive	Inundation; Fluvial Erosion; Landslide	EWP, ACCD, ANR, FHWA, VHCB, FEMA, USDA, NRCS	State, Federal and Nonprofit Resources	2019-2020	High	Low
	Expand the eligibility criteria and increase funding for VHCB's conservation and buyout program, to address any flood-vulnerable structures.	DEC WG	Regulation/ Policy	Inundation; Fluvial Erosion	ANR, VHCB, AOA	Existing State and Nonprofit Resources	2019	High	Medium
	Fund ERAF for non-federal disasters in towns that have adopted floodplain and/or river corridor bylaws and to support the 25% non-federal match for buyouts and develop criteria for distribution when funding is limited.	Aug 2017 WG	Regulation/ Policy; Funding/ Incentive	Inundation; Fluvial Erosion	ANR, VEM, AOA	ERAF, Other State Resources	2021	High	Low
	Create and maintain a database of tax-sale/foreclosed properties located within SFHA and State River Corridor maps to identify flood-vulnerable structures for removal.	2017 EPC	Data Gap	Inundation; Fluvial Erosion	ANR, VEM, VT Realtors	Existing State Resources	2020	High	Low
	Develop a priority list and map of community-identified properties that have been damaged repetitively but are not on the FEMA Repetitive Loss (RL) or Severe Repetitive Loss (SRL) list to be used for buyout/conservation prioritization.	SHMP 2013 (New 5.1)	Data Gap	Inundation; Fluvial Erosion; Landslide	VEM, ANR, RPCs	Existing State Resources	2019	High	Medium
	Develop a Benefit/Cost Analysis methodology to facilitate buyouts in areas at risk from flood-related erosion and outside of FEMA-mapped Special Flood Hazard Areas.	Expert Review (5.1.9)	Data Gap	Fluvial Erosion	VT Silver Jackets, VEM, ANR	HMGP 5% Initiative Funding	2019-2021	High	Low

Improve dam resilience	Conduct and/or update dam breach analyses on significant and high-hazard dams.	2017 EPC	Data Gap	Inundation; Fluvial Erosion	ANR, VEM	Dam Safety Program uses FEMA grant to work on ~3/year	Ongoing	High	Medium
	Develop rules around requiring Emergency Action Plans (EAPs) to be developed and updated annually or every other year (dam safety bill passed in 2018, Act 162).	Expert Review	Regulation/ Policy	Inundation; Fluvial Erosion	ANR, VEM	Dam Safety Program uses FEMA grant to work on ~3/year	2020	Medium	Medium
	Complete development and digitize all dam inundation maps for all high hazard dams and perform tabletop exercises for new Emergency Action Plans (EAPs), once generated.	Expert Review / SHMP 2013 (5.1.2)	Data Gap	Inundation; Fluvial Erosion	ANR, VEM	Existing State Resources, USACE	2018-2020	High	High
	Develop a new Vermont Dam Inventory to better link data and digital inundation mapping, including more robust contact information for owners, ecological information and Emergency Action Plans (EAPs).	Expert Review	Data Gap	Inundation; Fluvial Erosion	ANR, VEM	Interagency/group formed to work on	2019-2021	High	Medium
	Develop guidance documents/criteria for the security improvement of high hazard dams throughout Vermont.	Expert Review	Preparedness	Inundation; Fluvial Erosion	ANR, VEM, DPS	VEM	2019-2021	Medium	Medium
	Utilize updated Dam Inventory to support the expansion of the Dam Removal Screening Tool beyond Champlain Basin.	Expert Review	Data Gap	Inundation; Fluvial Erosion	ANR, VEM, TNC, VNRC, Dam Task Force		2019	High	High

GOAL: Develop and implement plans and policies that create resilient natural systems, built environments and communities.

Strategy	Action	Source	Category	Hazard (s) Addressed	Entities	Potential Resources	Timeline	Impact	Feasibility
Ensure State programs support hazard mitigation goals	Audit all state/federal funding/technical assistance programs to determine the degree to which they directly or indirectly help or hinder the ability of the State to achieve Vermont's State Hazard Mitigation Plan goals.	SHMP 2013 Priority (1.2.1, RM #3)	Data Gap	All Hazards	AOA, ANR, VEM, ACCD, AAFM, CLF	Existing State Resources	2019-2020	High	High
	Following the audit above, develop a set of planning principles and recommendations as a means to align State programs.	Focus Group	Regulation/ Policy	All Hazards	ACCD, ANR, VEM	Existing State Resources	2020-2023	High	Medium
Improve incentives for local hazard mitigation planning and action	Convene a working group of State agencies, academic partners, regional and local stakeholders to review the effectiveness of existing Emergency Relief & Assistance Fund (ERAF) criteria and river corridor bylaws.	Dec WG / SHMP 2013 (RM #43)	Regulation/ Policy	Inundation; Fluvial Erosion	VEM, ANR, VTrans, UVM, RPCs	Existing State and Nonprofit Resources	2019	High	High
	Revise the Emergency Relief & Assistance Fund (ERAF) criteria to more effectively incentivize communities to improve their flood resilience.	Dec WG	Regulation/ Policy	Inundation; Fluvial Erosion	VEM, ANR, VTrans, AOA	Existing State Resources	2020-2023	High	Medium
Improve local hazard mitigation planning	Create a working group to assess statutory updates to the municipal planning requirements to better coordinate municipal plans and local hazard mitigation plans.	Focus Group	Regulation/ Policy	All Hazards	VEM, ACCD, RPCs	Existing State and Local Resources	2019-2020	Medium	Medium
	Develop a model of an integrated municipal plan and local hazard mitigation plan that meets the requirements of both planning processes.	Dec WG	Regulation/ Policy	All Hazards	VEM, ACCD, RPCs	Existing State Resources	2019	Medium	Medium
	Create intuitive Local Hazard Mitigation Plan templates (single and multi-jurisdictional) and development resources, including local engagement tools.	2017 EPC, Dec WG	Technical Assistance	All Hazards	VEM, RPCs	Existing VEM Resources	2019	Medium	High
	Develop a Vermont-based potential mitigation actions list for Local Hazard Mitigation Plans from the findings of the ANR subgrant.	2017 EPC	Technical Assistance	All Hazards	VEM, ANR, VTrans	Existing VEM Resources	2019	Medium	High
	Host annual or biannual Local Hazard Mitigation Planning workshops and skill-shares.	Expert Review	Technical Assistance	All Hazards	VEM, FEMA	Existing VEM Resources	Ongoing	Medium	High
	Request approval from FEMA to participate in Program Admin by State to expedite Local Hazard Mitigation Plan (LHMP) approvals.	VEM	Program Development	All Hazards	VEM	Existing VEM Resources	2019-2020	Medium	Medium
	Support RPCs in implementing municipal hazard mitigation project tables developed through the ANR subgrant (bake into annual work plans from ANR and VEM funding).	Focus Group	Education/ Outreach	Inundation; Fluvial Erosion	ANR, RPCs	Existing State Resources	Ongoing	Medium	High

Strategy	Action	Source	Category	Hazard(s) Addressed	Entities	Potential Resources	Timeline	Impact	Feasibility
Develop solutions to fund hazard mitigation	Host practical, biannual workshop sessions to help applicants prepare Hazard Mitigation Assistance (HMA) grant applications, including sessions on application development, e-Grants, benefit-cost analysis, engineering design and environmental permitting.	SHMP 2013 (2.2.1, RM#21)	Technical Assistance	All Hazards	VEM, FEMA	Existing VEM Resources	Ongoing	Medium	High
	Convene State, federal and private funders annually to identify ways to better leverage existing funding, fill funding gaps, increase funder alignment, and strengthen funding criteria that relate to hazard mitigation and climate adaptation.	Focus Group	Partnership/ Coordination	All Hazards	VEM, ANR, VTrans, USDA RD, High Meadows, VHCB, Resilient VT, FHWA, FEMA	Existing State and Nonprofit Sources	Ongoing	High	High
	Develop a clearinghouse directory of mitigation funding opportunities including details on requirements, deadlines, and timeframes that can be available at the local level to implement mitigation action.	Aug 2017 WG	Technical Assistance	All Hazards	VEM, ANR, VTrans, ACCD, TNC	Existing State Sources	2019	Medium	High
	Implement the Hazard Mitigation Assistance (HMA) requirements of an Enhanced Plan for the 2023 State Hazard Mitigation Plan update in order to increase HMGP share following a disaster.	VEM	Program Development	All Hazards	VEM	Existing VEM Resources	2020-2023	High	Medium

GOAL: Create a common understanding of - and coordinated approach to - mitigation planning and action.

Strategy	Action	Source	Category	Hazard(s) Addressed	Entities	Potential Resources	Timeline	Impact	Feasibility
Improve local leaders' understanding of hazard mitigation	Complete loss-avoidance studies to better understand the positive impact of completed mitigation work, including the value of open space, forested and conserved land.	Focus Groups	Data Gap	All Hazards	VEM, ANR, VTrans, FEMA, TNC, VRC, UVM	FEMA HMTAP, HMA	2020	High	Medium
	Develop case studies to showcase replicable pilot projects that reduce community vulnerability.	June 2017 WG meeting	Education/ Outreach	All Hazards	UVM, Norwich	HMGP 5% Initiative	2019-2020	High	High
	Develop strategic capital budgeting training and materials to incorporate mitigation and water quality projects, explain the cost of no action and include municipal liability concerns.	2017 EPC	Technical Assistance	Inundation; Fluvial Erosion; Landslide	VEM, ACCD, ANR, VTrans, TNC, VHCB, VNRC, VRC, RPCs	CDGB Planning Grant	2020	High	High
	Promote and maintain technical support to communities to adopt river corridor bylaws, limit development in floodplains and river corridors, and participate in the Community Rating System (CRS).	SHMP 2013 Priority (RM, New 4.2)	Education/ Outreach	Inundation; Fluvial Erosion	ANR, ACCD, RPCs, VLCT	Existing State and Nonprofit Resources	Ongoing	Medium	High
	Integrate hazard awareness and disaster resilience education with existing training opportunities throughout the State.	Aug 2017 WG	Technical Assistance	All Hazards	VEM, ANR, VTrans, AHS	Existing State Resources	Ongoing	Medium	High
Increase public knowledge and literacy of hazards and mitigation	Develop an inventory of existing public outreach materials (hazard mitigation opportunities, steps to take following a disaster, etc.), compile or create effective aids and develop a distribution strategy.	Focus Groups	Education/ Outreach	All Hazards	VEM, VDH, ANR, CVOEO, Watersheds United, RPCs	Existing State and Nonprofit Resources	2019	Medium	High
	Develop educational materials and dissemination strategy to increase public literacy regarding river science, floodplain function and benefits.	SHMP 2013 (RM #96)	Education/ Outreach	Inundation; Fluvial Erosion	VEM, ANR, State Floodplain Manager, Norwich, Watersheds United, NRCD	Existing State and Nonprofit Resources	2019-2020	High	High
	Support education of the general public around invasive species and their role in altering the beneficial functions of natural ecosystems.	WG June 2017	Education/ Outreach	Invasive Species	ANR, AAFM, TNC	TNC, Existing State and Nonprofit Resources	Ongoing	Low	Medium
Improve community resilience and local engagement	Develop educational resources to assist local entities and Regional Planning Commissions in creating and maintaining Community Organizations Active in Disaster (COADs).	Dec WG / SHMP 2013 (NEW 3.1)	Education/ Outreach	All Hazards	AHS, RPCs, CROs, COADs	FEMA Disaster Recovery, VOAD	Ongoing	Medium	Medium
	Support the coordination and capacity of community resilience initiatives at the local level (such as Community Resilience Organizations) to reduce community and individual vulnerability to natural hazards.	Aug 2017 WG / SHMP 2013 (NEW 3.1)	Education/ Outreach	All Hazards	AHS, Norwich, Watershed United, RPCs, CROs	FEMA HMP, CROs	Ongoing	High	Medium

Strategy	Action	Source	Category	Hazard(s) Addressed	Entities	Potential Resources	Timeline	Impact	Feasibility
Strengthen networks that support the resilience of vulnerable populations	Develop guidance and technical support for municipalities to identify and map populations that are potentially vulnerable to hazards.	June 2017 WG meeting	Education/ Outreach	All Hazards	VDH, AHS, RPCs, VCGI	Existing State Resources	Ongoing	High	Medium
	Gather and disseminate vulnerable population data and analysis for incorporation into municipal and regional plans so that the needs of Vermont's vulnerable populations are clearly identified and represented.	SHMP 2013 Priority (RM #77)	Technical Assistance	All Hazards	VDH, VEM, AHS, ACCD, RPCs, CVOEO, VCGI	Existing State, Academic and Nonprofit Resources	Ongoing	High	Medium
	Develop statewide database of rental properties using the mobile home database as a model.	Dec WG	Data Gap	All Hazards	CVOEO, DPS, ACCD	Existing State, Academic and Nonprofit Resources	2019-2020	High	Medium
	Support development of coordinated care network to provide consistent messaging on steps individuals can take to prepare for and reduce vulnerability to natural hazards.	Dec WG	Education/ Outreach	All Hazards	AHS, CVOEO, VAHHS	Existing State and Nonprofit Resources	Ongoing	High	Medium
	Support and strengthen the Disaster Case Management (DCM) Network to train case managers working with disaster-affected individuals to aid in their recovery and identify mitigation opportunities.	SHMP 2013 (RM #42)	Technical Assistance	All Hazards	AHS, VEM, VOAD, COADs, Red Cross	Existing State and Nonprofit Resources	Ongoing	High	High
Coordinate hazard mitigation mapping, data and research	Create inventory of available data across State government, universities and organizations to align conflicting information and identify gaps.	Dec WG	Data Gap	All Hazards	ANR, VEM, VTrans, ADS, ACCD, VCGI	Existing State, Academic and Nonprofit Resources	2020	Medium	Low
	Coordinate State programs to promote development, sharing and maintenance of hazard-related data and mapping across a common platform.	Dec WG/ SHMP 2013 (5.1.4)	Partnership/ Coordination	All Hazards	ANR, VEM, VTrans, ADS, ACCD, VCGI, ArmyCorps, NRCD	FEMA, Existing State Sources	Ongoing	High	Low
	Develop a common and consistent statewide platform for collecting local and regional response and recovery data.	Expert Review	Partnership/ Coordination	All Hazards	ANR, VEM, VTrans, ADS, ACCD, RPCs	Existing State and Nonprofit Resources	2018-2019	High	High
	Support the development of an Academic Resilience Collaborative (ARC) of State agencies, academic partners, researchers, students and entities with research needs around hazard mitigation and resilience.	Dec WG	Partnership/ Coordination	All Hazards	Norwich, VEM, ANR, VTrans, High Meadows, RPCs	Existing State, Academic and Nonprofit Resources	2018-2019	High	High
	Host regular meetings to identify and discuss priority research and project needs for SHMP implementation.	Dec WG	Partnership/ Coordination	All Hazards	Norwich, VEM, High Meadows, ARC, Resilient VT	Existing State, Fedreal, Academic and Nonprofit Resources	Ongoing	Medium	High

6: Maintenance & Implementation

The State of Vermont's various agencies have always been invested in mitigation activities, as identified in previous State Hazard Mitigation Plans (SHMPs). The events following Tropical Storm Irene, however, magnified the need for coordination and a comprehensive approach to mitigation and resilience planning statewide. As evidenced throughout this Plan, the results of this have been a multi-stakeholder coordination effort to build a stronger, more resilient Vermont. For information on the stakeholder engagement process and involvement of the State Hazard Mitigation Planning and Policy Committee (SHMPPC), see: Planning Process.

2013 Vermont State Hazard Mitigation Plan Implementation

The 2013 SHMP provided a foundation upon which Vermont could implement identified mitigation projects as well as continue to carry out the extensive Hazard Mitigation Grant Program (HMGP) process following Tropical Storm Irene. Progress made on previously identified mitigation actions is summarized in the Appendix to Section 5. Capabilities that were developed based on 2013 SHMP actions are noted in the State Capabilities List with additional details and significant improvements since 2013 explained in State & Local Capabilities.

Additional mitigation needs identified through the significant stakeholder engagement process are included in the Mitigation Strategy. The State Capabilities List also notes specific needs that have been identified and whether they are addressed by actions in the 2018 SHMP.

Following the approval of the 2013 SHMP, the Deputy Secretary of Administration spearheaded an effort to elevate mitigation priorities at the policy level by separating the then State Hazard Mitigation Committee into two separate entities: the State Hazard Mitigation Project Review Committee (SHMPRC) and the State Hazard Mitigation Planning & Policy Committee (SHMPPC). The former is tasked with the technical review of all Hazard Mitigation Assistance (HMA) grant applications submitted to the State for consideration, while the latter committee is responsible for discussing mitigation goals and policies to ensure cohesion across State agencies (see: State & Local Capabilities).

Following its creation, the SHMPPC met approximately three times per year to review mitigation progress, changes in policies and to reconsider prioritization of the 2013 SHMP actions based on new data. Over the course of several meetings in 2015, the SHMPPC identified 16 top priority actions of the 2013 SHMP that required attention from multiple State agencies. At subsequent meetings, progress on those actions was discussed and documented. Given the post-Irene, somewhat parallel, Roadmap to Resilience effort hosted by the Institute for Sustainable Communities (ISC) as part of the Resilient Vermont Network initiative (RVT), the SHMPPC decided that those actions identified in the Roadmap should be considered in tandem with the other actions identified in the SHMP in order to combine efforts and leverage resources.

In 2017, the focus of the SHMPPC shifted from implementation of the 2013 SHMP to development of the 2018 SHMP (see: Planning Process).

2018 State Hazard Mitigation Plan Implementation:

The previous SHMP provided the guidance and foundation upon which to build the Steering Committee, update this Plan, and give insight into Vermont's continually-evolving approach to mitigation. The 2018 planning process expanded stakeholder engagement with the intent of developing an action plan to be implemented by a broad range of stakeholders throughout Vermont, which led to increased ownership of the

Plan and, consequently, improves the likelihood of implementation success.

Based on their day-to-day functions, the following State entities are responsible for contributing to mitigation of Vermont's hazards (in addition to Vermont Emergency Management):

Table 45: State Entities with Primary Responsibility by Hazard	
Fluvial Erosion	Department of Environmental Conservation; Vermont Agency of Transportation; Buildings & General Services
Inundation Flooding	Department of Environmental Conservation; Vermont Agency of Transportation; Buildings & General Services
Ice	Vermont Agency of Transportation; Public Service Department
Snow	Vermont Agency of Transportation; Public Service Department
Wind	Public Service Department
Heat	Department of Health
Cold	Department of Health
Drought	Department of Environmental Conservation – State Geologist
Landslides	Department of Environmental Conservation – State Geologist; Vermont Agency of Transportation
Wildfire	Department of Forests, Parks & Recreation
Earthquake	Department of Environmental Conservation – State Geologist
Invasive Species	Agency of Agricultural, Food & Markets; Agency of Natural Resources
Infectious Disease	Department of Health
Hail	Public Service Department

Monitoring and Evaluating the 2018 State Hazard Mitigation Plan:

Vermont's 2018 State Hazard Mitigation Plan (SHMP) is a dynamic document. To ensure that the SHMP remains current and relevant to Vermont's actual mitigation needs, it is important for the Plan to be periodically monitored and evaluated. It is the policy of Vermont Emergency Management (VEM) that the SHMP will be monitored and evaluated at least once a year and following a declared disaster. The responsibility for the maintenance and updating of the Plan lies with VEM's State Hazard Mitigation Officer and Hazard Mitigation Planner, in coordination with the SHMPPC.

VEM mitigation staff and the SHMPPC will annually undertake a review of progress and efficacy of the SHMP actions in reaching the stated goals and strategies. Additionally, the SHMP will be reviewed following a declared disaster for any potential changes in vulnerability and to identify priority projects that can be implemented through the Hazard Mitigation Grant Program (HMGP).

To review progress on achieving mitigation goals annually with the SHMPPC, a report will be compiled by VEM mitigation staff defining progress on mitigation actions and SHMP implementation. These detailed reports will include:

- The status of mitigation actions on the full mitigation action list (see: Mitigation Strategy);
- How well each action (completed or in progress) has contributed to the mitigation goals and strategies and reduced vulnerability; and
- A review of the defined mitigation priorities and an assessment of priorities moving forward.

The SHMPPC will carefully review the mitigation action report and make recommendations for amendments or changes to priorities for the following year.

To improve monitoring and track progress of mitigation activities, these annual meetings will be combined with more regular informal exchanges of information among stakeholders, in conjunction with the RVT. The 2018 SHMP will rely on both the SHMPPC and the RVT, as well as the Steering Committee and the Working Groups, to improve implementability of this Plan by expanding stakeholder involvement and leveraging resources across Vermont. The RVT will be managed by staff in the Global Center for Resilience and Security at Norwich University and will play an active role in SHMP implementation.

The RVT will host biannual meetings of the full network to check-in on progress of resilience goals as defined in the Resilient Vermont Crosswalk[1], which was developed in 2013 and is being updated in 2018. This biannual meeting will be held in conjunction with SHMP stakeholders at a check-in on SHMP implementation, starting in 2019. In the opposite years, beginning with the July 2018 SHMP Implementation Kick-Off meeting (see: Planning Process), members of the implementation working groups will be convened to review progress and effectiveness of the 2018 SHMP implementation.

Between these annual meetings, the implementation working groups will continue to meet and make progress on their respective mitigation actions. VEM mitigation staff and Norwich University staff will coordinate these working group meetings and SHMP implementation.

2023 State Hazard Mitigation Plan Update Process

The SHMP update process, completed every 5 years, will incorporate changes in local, State and Federal statutes, changes in development and vulnerability, and changes in mitigation priorities in Vermont. VEM mitigation staff will be responsible for managing the update in close coordination with the SHMPPC. The update process will begin 18 months prior to the expiration of the 2018 SHMP.

A comprehensive update of the SHMP will examine:

- The overall efficacy of the SHMP in addressing real mitigation needs
- Actual savings realized by implementing cost effective projects
- How mitigation efforts support environmental protection regulations
- Areas for organizational and programmatic improvement
- How to more efficiently combine Federal, State, and local resources to implement the most cost effective hazard mitigation projects and planning
- How to better coordinate and implement State, regional and local mitigation efforts

1 https://resilientvt.org/project-documents/

Plan Update Procedures:

1. The State Hazard Mitigation Planning & Policy Committee (SHMPPC) will appoint a Steering Committee to work with VEM mitigation staff to manage the Plan update and the stakeholder engagement process.
2. The Steering Committee will determine if the hazard evaluation criteria are still appropriate or if modifications or additions are needed based on changing conditions since the last update. Data needs will be reviewed and data sources will be identified and collected.
3. VEM mitigation staff and partners will review each section of the SHMP to determine progress achieved in reaching mitigation goals and strategies. The following will be determined:
    i. The status report concerning how well VEM and partners are achieving goals and strategies
    ii. Whether goals and strategies still address current conditions
    iii. Any obstacles in achieving mitigation goals and strategies
    iv. Whether or not revisions to strategies, goals, and actions are warranted
4. A draft report will be prepared by VEM mitigation staff based on these evaluation criteria:
    i. Changes in community and governmental processes, which are hazard-related and have occurred since the last review
    ii. Progress in implementation of Plan initiatives and projects
    iii. Effectiveness of previously-implemented initiatives and projects
    iv. Evaluation of unanticipated challenges or opportunities that have occurred since the previous SHMP was adopted
    v. Evaluation of hazard-related public policies, initiatives and projects
    vi. Review and discussion of the effectiveness of public and private sector coordination and cooperation
5. The SHMPPC and the appointed Steering Committee will review the draft Plan. Consensus will be reached on changes to the draft.
6. VEM mitigation staff will incorporate changes and schedule public hearings in accordance with Vermont Title 3, Chapter 67, Paragraph 4020b.
7. VEM mitigation staff will provide a 30-day advance notice of the public hearings with specific notice to:
    i. Executive director of each Regional Planning Commission (RPC),
    ii. Agency of Commerce and Community Development (ACCD),
    iii. Agency of Natural Resources (ANR),
    iv. Agency of Transportation (VTrans),
    v. The council of Regional Commissions, and
    vi. Business, conservation, environmental, low-income advisory and other community groups or organizations that have requested notice prior to the date the hearing is announced.
8. VEM mitigation staff will accommodate input received at the public hearings and will provide proposed revisions to members of the Steering Committee for consideration.
9. VEM mitigation staff will schedule a second round of public hearings per #6 and #7 above, if necessary.
10. VEM mitigation staff will finalize the Plan and provide it to the SHMPPC and Steering Committee for final concurrence.
11. Upon full SHMPPC concurrence, VEM mitigation staff will forward the updated SHMP to the Governor's Authorized Representative (GAR) for approval and submission to FEMA Region 1.

Post-Disaster Review Procedures:

In the aftermath of a declared disaster, if deemed necessary, a special review may occur in accordance with the following procedures:

1. Within six months of a declared emergency event or when feasible, VEM may initiate a post-disaster review and assessment. Members of the SHMPPC will be notified that the assessment process has commenced.
2. This post-disaster review and assessment will document the facts of the event and assess whether the existing SHMP effectively addresses the hazards and its vulnerabilities.
3. A draft after action report of the review and assessment will be distributed to the SHMPPC.
4. A meeting of the SHMPPC will be convened by VEM mitigation staff to make a determination on whether the Plan needs to be amended. If the SHMPPC determines that no modification is needed, then the report will be distributed to stakeholders.
5. If the SHMPPC should determine that modification of the Plan is needed, VEM mitigation staff will draft an amended Plan that will reflect their recommendations.

Appendix to Section I: Authority & Adoption

Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act Title 44 Code of Federal Regulations (CFR) as amended by Section 102 of the Disaster Mitigation Act of 2000 gives state and local governments the framework to evaluate and mitigate all hazards as a condition of receiving federal disaster funds. Under Section 409, a state was required to update its HMP following every Presidential emergency declaration.

The Disaster Mitigation Act of 2000 (Public Law 106-390 with Interim Final Rules 44 CFR Part 201 and 206) eliminated the update requirement following Presidential declarations. Since November 1, 2004, the Disaster Mitigation Act of 2000 requires that states review and update their plan, with FEMA approval, every three years. Effective in 2014, FEMA changed the submission requirements, allowing states to submit their plans for review and approval every 5 years. The regulations referenced above also provide specific requirements for the contents of the plan, which the state must have to obtain FEMA approval. There are two levels of criteria contained within these regulations: standard and enhanced. The State of Vermont has developed a standard SHMP.

ADOPTION BY THE STATE OF VERMONT

The Vermont's 2018 State Hazard Mitigation Plan (SHMP) will be adopted under the provisions of Vermont Title 3, Chapter 67, Section 4020(b) (State agency planning and coordination). A signed copy of the adoption letter is included below. This paragraph provides for two public hearings to be noticed at least 30 days prior to the public hearings. Specific notice will be given to:

- Executive Director of each Regional Planning Commission
- Agency of Administration
- Agency of Commerce and Community Development (ACCD)
- Vermont Agency of Natural Resources (ANR)
- Vermont Agency of Transportation (VTrans)
- Business, conservation, low-income, advocacy, and other community or interest groups or organizations that have requested notice prior to the date the hearing is warned.

Any of the aforementioned bodies or their representatives may submit comments on the plan, and may appear and be heard in any proceeding with respect to the content of the Plan. All of the stated entities above have already been invited and have participated in the 2018 SHMP planning process and were invited to a July Implementation Kick-Off meeting, which was the first of two public hearings on July 24, 2018 in Northfield. The second public hearing was held in Waterbury on August 20, 2018. For more information on stakeholder involvement and the public hearings, see: Planning Process.

Prior to submission for approval and subsequent updates, the State will ensure that all aspects of Vermont's 2018 State Hazard Mitigation Plan are in accordance with federal statutes and regulations regarding grant funding and planning, in compliance with 2 CFR 200, 44 CFR Section 13.11 (c) and Section 13.11 (d), 44 CFR 201.4, and Section 322 of the Stafford Act. This will be accomplished through a draft submission to FEMA Region I in June 2018, followed by FEMA review and updates to the Plan to ensure compliance with FEMA requirements. Comments were received back from FEMA on August 13, 2018 and necessary updates were incorporated. Prior to an updated Draft Plan being submitted to FEMA, the two public hearings were held, as noted above, and any necessary updates were incorporated. The finalized Draft SHMP was submitted back into

FEMA review on August 24, 2018.

Once FEMA gave the notice of Approval Pending Adoption, on August 31, 2018, the Director of Vermont Emergency Management (VEM) and those partner agencies with primary implementation responsibilities, via the State Hazard Mitigation Planning & Policy Committee, endorsed Vermont's 2018 State Hazard Mitigation Plan. The Governor's Authorized Representative (GAR) adopted the Plan on behalf of the State of Vermont on October 18, 2018. Following the State of Vermont adoption, Vermont's 2018 State Hazard Mitigation Plan received formal approval from FEMA on November 17, 2018.

Vermont Title 3, Chapter 67, Section 4020. State agency planning and coordination:

(a) State agencies that have programs or take actions affecting land use, as determined by Executive Order of the Governor, shall engage in a continuing planning process to assure that those programs and actions are consistent with the goals established in 24 V.S.A. § 4302 and compatible with regional and approved municipal plans, as those terms are defined in that section. This planning process shall be coordinated, in a manner established by Executive Order of the Governor, with the planning process of other agencies and of regional and municipal entities of the regions in which the programs and actions are to have effect.

(b) In the process of preparing plans or amendments to plans, a State agency shall hold at least two public hearings which are noticed as provided in 3 V.S.A. § 839 for administrative rules, but plans shall not be adopted as administrative rules under 3 V.S.A. chapter 25. Specific notice also shall be provided to the following, at least 30 days prior to the public hearing:

(1) the executive director of each regional planning commission;
(2) the Department of Housing and Community Affairs within the Agency of Commerce and Community Development;
(3) the Council of Regional Commissions; and
(4) business, conservation, low-income advocacy, and other community or interest groups or organizations that have requested notice prior to the date the hearing is warned.

(c) Any of the foregoing bodies or their representatives may submit comments on the proposed plan or amendment, and may appear and be heard in any proceeding with respect to the adoption of the proposed plan or amendment. State agencies shall use an informal working format at locations convenient and accessible to the public in order to provide opportunities for all persons and organizations with an interest in their plans and actions to participate. (Added 1987, No. 200 (Adj. Sess.), § 28, eff. July 1, 1989; amended 1995, No. 190 (Adj. Sess.), § 1(a).)

State of Vermont
Agency of Administration
Office of the Secretary
Pavilion Office Building
109 State Street, 5th Floor
Montpelier, VT 05609-0201
www.aoa.vermont.gov

[phone] 802-828-3322
[fax] 802-828-3320

Susanne R. Young, Secretary

October 18, 2018

Mr. Douglas F. Wolcott, Jr., Acting Deputy Regional Administrator
Department of Homeland Security/FEMA Region I, 99 High Street, Sixth Floor
Boston, MA 02110-2132

Dear Mr. Wolcott:

I am pleased to submit the newly updated 2018 State Hazard Mitigation Plan (SHMP) on behalf of the State of Vermont. This 2018 SHMP has been developed in accordance with the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended by the Disaster Mitigation Act of 2000 (Public Law 106-390) and the planning requirements of the Final Rule Title 44 Code of Federal Regulations (CFR) Parts 201 and 206. Also, pursuant to the National Flood Insurance Act of 1968, as amended.

Director Erica Bornemann of Vermont Emergency Management (VEM) and the partner agencies of the State Hazard Mitigation Planning and Policy Committee (SHMPPC) have endorsed the 2018 SHMP submitted to FEMA. Upon having received conditional approval by FEMA, this letter constitutes formal adoption of the Standard SHMP by the State of Vermont. Given formal approval of the 2018 SHMP by FEMA, the State of Vermont will be considered eligible for the 15% level of Hazard Mitigation Grant Program (HMGP) funding in the aftermath of a federally declared disaster. With State adoption of our 2018 SHMP, Vermont will also be eligible for grant funds through Pre-Disaster Mitigation (PDM), Flood Mitigation Assistance (FMA), Fire Mitigation Assistance Grants (FMAG), and Public Assistance Categories C-G (PA C-G).

The State of Vermont will comply with all applicable Federal laws, regulations and statutes regarding hazard mitigation grant funding requirements, as outlined in 44 CFR § 201.4 (c) 7, in compliance with § 13.11 (c). The State will also comply with all provisions of § 201.4 (c) 7 in accordance with all applicable Federal laws, statutes and regulations in effect with respect to periods for which it received grant funding, in compliance with 44 CFR 13.11 (c) and 2 CFR 200. The State will also amend the 2018 SHMP whenever necessary to reflect changes in State and Federal statutes as required in accordance with 44 CFR § 13.11 (d).

The State of Vermont 2018 SHMP has been approved for release by the office of the Secretary of Administration, based upon the endorsement of the Vermont Emergency Management (VEM) Director and member agencies of the State Hazard Mitigation Planning and Policy Committee (SHMPPC). As the Governor's Authorized Representative (GAR), I am authorized to adopt the 2018 SHMP on behalf of the State of Vermont. With my signature below, I am adopting the 2018 Vermont State Hazard Mitigation Plan.

Sincerely,

Susanne R. Young, Secretary of Administration
Governor's Authorized Representative

U.S. Department of Homeland Security
FEMA Region I
99 High Street, Sixth Floor
Boston, MA 02110-2132

FEMA

NOV 2 2 2018

Erica Bornemann, Director
Vermont Emergency Management
45 State Drive
Waterbury, Vermont 05671-1300

Reference: Approval of the Vermont State Mitigation Plan

Dear Ms. Bornemann:

The U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA) Region I Mitigation Division, Risk Analysis Branch has approved the updated 2018 Vermont State Hazard Mitigation Plan effective **November 17, 2018** through **November 16, 2023** in accordance with the planning requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, the National Flood Insurance Act of 1968, as amended, and Title 44 Code of Federal Regulations (CFR) Part 201.

A FEMA-approved State Mitigation Plan is a condition of receiving certain non-emergency Stafford Act assistance and FEMA mitigation grants from the following programs:

- Public Assistance Categories C-G (PA C-G)
- Fire Management Assistance Grants (FMAG)
- Hazard Mitigation Grant Program (HMGP)
- Pre-Disaster Mitigation (PDM)
- Flood Mitigation Assistance (FMA)

State Mitigation Plans must be updated and resubmitted to the FEMA Region I Mitigation Division, Risk Analysis Branch for approval. If the plan is not updated by the date indicated on this FEMA approval letter, the plan is considered lapsed and FEMA will not obligate funds until the mitigation plan is approved by FEMA.

To maintain eligibility for PA C-G, FMAG, HMGP, PDM, and FMA, the State must submit a draft of the next plan update prior to the end of the approval period, and allow sufficient time for the review and approval process, including any revisions, if needed, and for formal adoption by the State following determination by FEMA that the plan has achieved a status of "Approvable Pending Adoption."

Thank you for your continued dedication to public service demonstrated by preparing and adopting a strategy for reducing future disaster losses.

NOV 2 2 2018

If we can be of assistance, please contact Melissa Surette at (617) 956-7559 or Melissa.Surette@fema.dhs.gov.

Sincerely,

Douglas F. Wolcott Jr.
Acting Deputy Regional Administrator

DFW: ms

cc: Lauren Oates, State Hazard Mitigation Officer
Ben Rose, Recovery and Mitigation Section Chief
Stephanie Smith, Hazard Mitigation Planner
Rob Evans, State NFIP Coordinator