Town of Sunderland
Hazard Mitigation Plan

December 9, 2013
Revised January 22, 2014

Town of Sunderland
PO Box 295
East Arlington, VT 05252

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I. Introduction

A. Purpose

Hazard mitigation is intended to reduce potential losses from future disasters. Hazard mitigation plans identify potential natural hazards that could affect a community and the projects and actions that a jurisdiction can undertake to reduce risks and damage from natural hazards such as flooding, landslides, wildland fire, and similar events (FEMA 2011).

This plan is intended to identify, describe and prioritize potential natural hazards that could affect the Town of Sunderland and measures to reduce or avoid those effects. The Federal Emergency Management Agency, within the U.S. Department of Homeland Security and the Department of Vermont Emergency Management both advocate the implementation of hazard mitigation measures to save lives and property and reduce the financial and human costs of disasters.

The format of this plan is as follows. Section II provides a profile of the town, including a discussion of the environmental setting, demographics and settlement patterns. Section III describes the planning process along with lists of members of the planning committee and dates of meetings and public and agency review. Section IV analyzes the following natural hazards:

- Floods and Flash Floods
- Winter Storms
- High Wind Events
- Hail
- Temperature Extremes
- Drought
- Wildfire
- Landslides and Debris Flow
- Earthquake
- Hazardous Materials Spill
- Infectious Disease Outbreak
- Invasive Species

B. Mitigation Goals

The Town identified the following mitigation goals:

1. Significantly reduce injury and loss of life resulting from natural disasters.
2. Significantly reduce damage to public infrastructure, minimize disruption to the road network and maintain both normal and emergency access.

3. Establish and manage a program to proactively implement mitigation projects for roads, bridges, culverts and other municipal facilities to ensure that community infrastructure is not significantly damaged by natural hazard events.
4. Design and implement mitigation measures so as to minimize impacts to rivers, water bodies and other natural features, historic structures, and neighborhood character.
5. Significantly reduce the economic impacts incurred by municipal, residential, industrial, agricultural and commercial establishments due to disasters.
6. Encourage hazard mitigation planning to be incorporated into other community planning projects, such as Town Plan, Capital Improvement Plan, and Town Basic Emergency Operation Plan
7. Ensure that members of the general public continue to be part of the hazard mitigation planning process.

Based on the above goals and the assessment of hazards (Section IV), Sunderland identified and prioritized mitigation actions which are specifically described in Section V.D.

II. Town Profile

The Town of Sunderland is located in Bennington County, Vermont in the southwest portion of the state. The Town is bordered by Manchester on the north, Arlington on the south, Stratton on the east and Glastenbury on the south (Map 1), and is approximately 45.5 square miles in area. Approximately 80% of the town is within the Green Mountain National Forest, so most development occurs in the western portion along US Route 7, Vermont State Route 7A and local roads between Manchester Center and Arlington. This represents the valley between the Green Mountains to the east and the Taconics to the west. This valley contains the major roads and a railroad as well as portions of the Batten Kill. A major tributary of the Batten Kill is the Roaring Branch which flows from the national forest (Map 1). The total population in the 2010 census was 956 in 393 households.

Table 1. Number of buildings by type. Source: VCGIS 2013 E911 data

Type	Number
Single-family residential	441
Mobile home	33
Multi-family	1
Commercial/Industrial	27
Lodging	5
Camp	29
Government	2
Education	1
House of Worship	2
Other	15

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Most of Sunderland is forested, consisting primarily of northern hardwood forests but also of conifer forests, generally at higher elevations (Map 2).

III. Planning Process

The Bennington County Regional Commission began discussions with the Town on developing a hazard mitigation plan in 2012. The Sunderland Select Board decided to initiate planning in January of 2013. This is the first hazard mitigation plan for Sunderland. The planning team consisted of members listed in Table 2 below

Table 2. Planning committee members

Name	Affiliation
Dave Kiernan	Planning Commission and Select Board
Steve Bendix	Select Board
John Stuermer	Planning Commission/Zoning Administrator
Peter Luca	Planning Commission

Table 3. Dates of planning meetings and public and agency review

Meeting	Date (s)
Select Board initiates planning process	
Planning committee organization meeting	
Planning committee meetings	
Draft made available for public and agency review by the planning committee	
Select Board approved the plan for release	
Redraft of plan again made available for public and agency review	

The above meetings were warned and comments were solicited from members of the public who attended. The draft plan was put online on the Bennington County Regional Commission and Town of Sunderland websites, and notices sent out to members of the public informing them that they could review the plan at that website or in the Town Hall in Sunderland, VT.

Comments and information on the draft plan were also solicited from the Town Road Commissioner and volunteer fire personnel and a meeting was held by the Select Board to solicit comments from the public. The plan was also sent to the neighboring towns of Arlington, Glastenbury, Manchester, Sandgate, Shaftsbury, Somerset, Winhall and to Local Emergency Planning Committee #7, which includes Sunderland for comment. The plan was also reviewed by the Vermont Department of Emergency Management and Homeland Security.

The plan was submitted for review by the Federal Emergency Management Agency on _______.

IV. Hazard Analysis

A. Hazard Assessment

This section addresses each of the potential natural hazards based on data from the National Climate Data Center (NCDC 2013), the National Weather Service river gauge web site (www.water.weather/ahps/), the Federal Emergency Management Agency list of disasters (http://www.fema.gov/femaNews/disasterSearch.do), the Vermont Department of Forests, Parks, and Recreation and local knowledge. There are no stream gauges located on the Battenkill in or near Sunderland. There is a National Weather Service Cooperative Observer Station (SUNV1) west of US Route 7 at Longitude -73.1244, Latitude 43.0908 with data from January 1, 1990 to the present. Information from other observers was incorporated where relevant. Earthquake data came from a run of HAZUS completed by Jon Kim of the Vermont Geological Survey.

1. Floods and Flash Floods

a. Description

Flooding is the most frequent and damaging natural hazard in Vermont. The National Weather Service (2010) defines a flood as "any high flow, overflow, or inundations by water which causes or threatens damage." A flash flood is …"a rapid and extreme flow of high water into a normally dry area, or a rapid water rise in a stream or creeks above a predetermined flood level." These are usually within six hours of some event, such as a thunderstorm, but may also occur during floods when rainfall intensity increases, thereby causing rapid rise in flow. The NWS uses the following impact categories:

- Minor Flooding - minimal or no property damage, but possibly some public threat.
- Moderate Flooding - some inundation of structures and roads near stream. Some evacuations of people and/or transfer of property to higher elevations.
- Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.
- Record Flooding - flooding which equals or exceeds the highest stage or discharge observed at a given site during the period of record keeping.

Floods may reach these magnitude levels in one or more reaches, but not necessarily all. Runoff from snowmelt in the spring, summer thunderstorms, and tropical storms and hurricanes can all result in flooding in Sunderland. Ice jam flooding can occur on Vermont rivers when substantial ice forms followed by several days of warmth, snowmelt and any rainfall leading to ice breakup. As the ice breaks up on the rivers, chunks of ice form jams which cause localized flooding on main stem and tributary rivers. Ice jams are most prevalent during the January thaw (late January) and in March and April as spring approaches.

Flash floods are can occur after spring melt of mountain snow, following large storms such as Tropical Storm Irene, or after significant thunderstorms. Digital flood zone maps have been prepared and are currently under review. Map 3 shows the location of both flood hazard zones and fluvial erosion hazard zones.

Photo 1. Damage from fluvial erosion

Most development along streams in Sunderland is along the Battenkill in the northwestern part of the town and the Roaring Branch and Kelly Stand Road. Both of these streams can be very flashy, and while some flood losses are the result of inundation, more often flood losses are caused by fluvial erosion. This can range from gradual bank erosion to catastrophic changes in the location of the river channel (Vermont River Management Program 2010).

b. Previous Occurrences

Table 4. Total number of flood events by type and year for Bennington County. Source: NCDC 2012

Year	Flash Flood	Flood	Total
1996	3	6	9
1998	1	3	4
1999	2		2
2000	4	1	5
2002	1		1
2004	1	5	6
2005		5	5
2006		1	1
2007	1	1	2
2009	2		2
2011	3	3	6
Total	18	27	45

Ludlum (1996) describes numerous storm events that have affected Vermont since settlement, but the local impacts of these are difficult to trace. The 1927 flood was the largest disaster in the history of the state. The state received over six inches of rain, with some areas receiving 8-9 inches. Following a rainy October, this storm occurred from November 2nd through the 4th causing extensive flooding. Two storms occurred in March of 1936. Heavy rains and snowmelt caused significant flooding. Two years later, the 1938 hurricane caused both flooding and extensive wind damage.

Hurricanes and tropical storms that form in tropical waters have historically affected New England, but are relatively infrequent. Besides the 1938 storm, Tropical Storm Belle brought significant rains to Vermont in 1976 and Hurricane Gloria brought rain and wind damage in 1985. Sunderland has been subjected to two major tropical storms in the past twenty years.

Table 4 shows a total of 45 flood events in Bennington County from 1990 to 2011, using NCDC data. These have been primarily minor and affected either specific streams, such as the Batten Kill and the Walloomsac or specific towns.

Table 5 describes ten moderate and extreme events that have occurred since 1990, using the National Weather Service (2010) categories, which likely affected Sunderland. These events were described in the National Climate Database records (2012). It should be noted that only the January 1996 event occurred in the winter, with all other events in the spring, summer or fall. Ice jam flooding does occur and one instance of damage is described below.

Table 5. Significant flood events affecting Bennington County. Source: NCDC 2012

Dates	Type	Description	Area	Category	FEMA
19-20 Jan 1996	Flood	An intense area of low produced unseasonably warm temperatures, high dew points and strong winds resulting in rapid melting of one to three feet of snow. One to three inches of rain fell as the system moved northeast along the coast. This resulted in numerous road washouts and the flooding of several homes across the county. A Cooperative Weather Observer recorded 0.94" of rain in Sunderland.	Countywide	Moderate	DR-1101 1/19 to 2/2 1996
11-12 May 1996	Flood	A low pressure system intensified creating a prolonged period of precipitation. Over two inches of rain fell over much of western New England resulting in flooding along the Walloomsac River in Bennington County. A Cooperative Weather Observer recorded 3.5" of rain in Sunderland from May 10-13.	Bennington	Moderate	
8-10 Jan 1998	Flood	Mild temperatures and rain combined to cause small stream flooding throughout Bennington County The Batten Kill rose over eight feet at the Arlington gage, and the Walloomsac River crested nearly two feet above flood stage at Bennington. The main impact was extensive flooding of fields and roadways. Route 7A north of Arlington was closed due to flooding. A Cooperative Weather Observer recorded 3.81" of precipitation in Sunderland from January 5-10.	Arlington; Bennington; Countywide	Moderate	
16-17 Sept 1999	Flood	The remnants of Hurricane Floyd brought high winds and heavy rainfall (3-6 inches) to southern Vermont. Many smaller tributaries reached or exceeded bankfull. Estimated wind gusts exceeded 60 mph, especially over hilltowns. Power outages occurred across southern Vermont. A Cooperative Weather Observer recorded 4.94" of rain in Sunderland.	Countywide	Moderate	DR-1307 9/16-21 1999
14-17 Jul 2000	Flash Flood	Thunderstorms caused torrential rainfall with flash flooding washing out sections of roadways in northeast Bennington County and southern Bennington County. Routes 7 and 67 were closed. A Cooperative Weather Observer recorded 3.39" of rain in Sunderland.	Northeast Bennington County; Southern Bennington County; Arlington; Bennington; Shaftsbury	Moderate	DR- 1336 7/14-18 2000

Table 5. Significant flood events affecting Bennington County. Source: NCDC 2012

Dates	Type	Description	Area	Category	FEMA
17 Dec 2000	Flood	Unseasonably warm and moist air brought a record breaking rainstorm to southern Vermont. Rainfall averaged 2-3 inches. The heavy rain, combined with snowmelt and frozen ground, lead to a significant runoff and flooding. A Cooperative Weather Observer recorded 3.38” of precipitation in Sunderland.	Peru; Dorset: West Rupert	Moderate	DR-1358 12/16-18 2000 (Severe Winter Storm)
21 July to 18 Aug 2003		Severe storms and flooding affected Vermont including Bennington County. (Note: this event does not appear in the NCDC data.) A Cooperative Weather Observer recorded sporadic and sometimes large amounts of precipitation during that period in Sunderland.			DR-1488 7/21-8/18 2003
16-17 Apr 2007	Flood	An intense coastal storm spread heavy precipitation across southern Vermont, starting as a mixture snow, sleet and rain which changed to all rain. Liquid equivalent precipitation totals ranged from three to six inches leading to minor flooding across portions of southern. A Cooperative Weather Observer recorded 3.54 of rain in Sunderland.	Arlington	Minor	DR- 1698 4/15-21 2000
28-29 Aug 2011	Flood/Flash Flood	Tropical Storm Irene produced widespread flooding, and damaging winds across the region. Rainfall amounts averaged four to eight inches and fell within a twelve hour period. A Cooperative Weather Observer recorded 5.16” of rain in Sunderland. In Bennington County, widespread flash flooding and associated damage was reported countywide, with many roads closed due to flooding and downed trees and power lines. Strong winds also occurred across southern Vermont, with frequent wind gusts of 35 to 55 mph, along with locally stronger wind gusts exceeding 60 mph. The combination of strong winds, and extremely saturated soil led to widespread long duration power outages.	Countywide	Extreme	DR-4022 8/27-2 2011
7 Sept 2011	Flood	Large amounts of moisture from the remnants of Tropical Storm Lee interacted with a frontal system producing heavy rainfall with total rainfall amounts ranging from three to seven inches. led to widespread minor to moderate flooding across southern Vermont. A Cooperative Weather Observer recorded 4.63” of rain between September 5th and 9th.	North Bennington; Countywide	Moderate	

A Cooperative Weather Observer recorded 6.86” of rain from August 6 to 14, 1990, 10.94” from October 8 to 27, 2005 and 6.11” from September 28 to October 8, 2010, but no damage was recorded.

c. Extent and Location

The primary damages from past events have been from flooding and fluvial erosion with secondary damage from wind. There have been no NFIP-designated repetitive losses within the jurisdiction. There are no dams within the Town. Table 6 shows the number of structures, by type, in the special flood hazard and fluvial erosion hazard zones that are shown in Map 3.

Table 6. Structures by type in flood hazard zones in Sunderland, VT. Source: Vermont Center for Geographic Information www.vcgi.org		
Type	Number in special flood hazard zone	Number in fluvial erosion hazard zone
Commercial	2	1
Residential	1	10
Mobile Home	1	2
Camp	0	1

Tropical Storm Irene caused significant damage including:

- Damage to the road and culverts along Kelly Stand Road and the loss of three houses on that road.
- Culvert damages on Sunderland Hill Road, North Road, South Road and Prouty Hill Road.
- A series of avulsions and debris jams along the Roaring Branch and the Batten Kill.

In all, eight bridges/culverts were damaged. There were five bank erosion incidents, five debris jams and nine landslides. Map 4 shows the locations of these damages.

d. Probability, Impact, and Vulnerability

Based on data from 1996 to 2012, ten moderate or major flood events have affected Bennington County, resulting in a 50% chance of such an event occurring. However, these have not all directly affected Sunderland, so that probability should range from 10 to 50%. Sunderland has a total of 441 single family residences, 33 mobile homes, 25 commercial, 29 camps, establishments and a small number of multi-family, government, church and school buildings. As shown in Table 6, there are four structures in the special flood hazard area and 14 in the fluvial erosion hazard zone. Therefore, the potential proportion damaged within the town from severe flooding would range from 1-10% with injuries of 1-10%. Most services would be recovered in less than seven days, though help for specific property owners may take significantly longer.

2. Winter Storms

a. Description

Winter storms are frequent in Vermont. Winter storms may consist of heavy snow, mixed precipitation, or ice storms and all may be accompanied by strong winds. Potential damages can include power outages, traffic accidents, and isolation of some areas. For example, the October 4, 1987 storm stranded travelers in the area and knocked out power for several days. In rare cases, the weight of snow may collapse roofs and cause other structural damage. Wind can also accompany snowstorms increasing the effect of the snow damages. In addition to snow, ice storms occur when the lower levels of the atmosphere and/or ground are at or below freezing, and rain is falling through warmer air aloft. The precipitation freezes upon contact with the ground, objects on the ground, trees and power lines.

b. Previous Occurrences

Table 7. Total number of winter storm events by type and year for Bennington County. Source: NCDC 2012

Year	Blizzard	Heavy Snow	Ice Storm	Winter Storm	Winter Weather	Totals
1996		5		2		7
1997		1		7	2	10
1998				2	1	3
1999				4		4
2000		1		6		7
2001				6		6
2002				5		5
2003				5		5
2004				2		2
2005	1	3		2		6
2006		0	0	0		0
2007		3	1	6	4	14
2008		4	2	1	11	17
2009		3		1	10	14
2010		3		1	2	6
2011				5	5	10
2012				3	1	4
Totals	2	23	3	58	36	120

Table 7 summarizes the 120 winter storm events that have occurred in Bennington County since 1996. As can be seen, a high numbers of events occurred in 1997, 2007, 2008, and 2009. Using NCDC data, we categorized the extent of each storm with storms ranked as “High” if they produced more than twelve inches of snow or were categorized by the NCDC as producing heavy or record snows or blizzards or significant icing. The Blizzard of 1993 was categorized as “Extreme.” Table 8 describes these events.

Table 8. Significant winter storm events in Bennington County and Sunderland. Source: NCDC 2012

Dates	Type	Description	Category	Area
13-14 Jan 1993	Heavy Snow	Snowfall amounts across the state ranged from six to sixteen inches. A Cooperative Weather Observer recorded 10.0” in Pownal.	High	Statewide
16-17 Feb 1993	Heavy Snow	Snowfall amounts ranged from 6 to 18”. A Cooperative Weather Observer recorded 6.0” in Pownal.	High	Statewide

Table 8. Significant winter storm events in Bennington County and Sunderland. Source: NCDC 2012				
Dates	Type	Description	Category	Area
13-14 Mar 1993	Blizzard	The "Blizzard of 93", one of the worst storms this century virtually shut down Vermont on the weekend of March 13-14 forcing the closure of roads and airports. This was one of the most powerful snowstorms on record. Snowfall amounts ranged from 10 to 28 inches across the state. A Cooperative Weather Observer recorded 13.0" in Pownal.	Extreme	Statewide
2-4 Mar 1994	Heavy Snow	Snowfall amounts across the state ranged from 8 to 22 inches with snowfall rates as high as three to four inches per hour during the storm. A Cooperative Weather Observer recorded 8.0" in Pownal.	High	Statewide
4-5 Feb 1995	Heavy Snow	A low pressure system tracked up the east coast on dumping heavy snow across Vermont. Snowfall amounts ranged from 6 to 20 inches.	High	Statewide
27-28 Feb 1995	Snow Freezing Rain	A mixture of snow, sleet, and freezing rain fell across Vermont. Snow accumulations ranged from four to eight inches across much of northern Vermont with localized amounts of 8 to 12 inches in Vermont's Green Mountains. A Cooperative Weather Observer recorded 14.0" in Pownal.	High	Central; Southern VT
2-3 Jan 1996	Heavy Snow	Heavy snow fell across southern Vermont with the average snowfall ranging from 10 to 12 inches.	High	Southern Vermont
12-13 Jan 1996	Heavy Snow	Heavy snow fell across southern Vermont with snowfall totals ranging from 6 to 10 inches with a few locations reporting up to one foot. A Cooperative Weather Observer recorded 7.0" in Pownal.	High	Southern Vermont
26 Nov 1996	Winter Storm	Snow and freezing rain downed trees and power lines, with 10,000 customers without power across southern Vermont.	High	Southern Vermont
7-8 December 1996	Winter Storm	A major storm dumped heavy, wet snow across Bennington and Windham Counties. Approximately 20,000 customers lost power. Cooperative Weather Observers reported 14.5 inches in Pownal and 12.8 inches in Sunderland during the period.	High	Southern Vermont
31 March 1997 to 1 April 1997	Winter Storm	A late season storm that changed from rain to snow brought 12 inches in Shaftsbury, 12 inches in Peru and 23 inches in Bennington. Power outages were widespread, and Route 9 between Bennington and Brattleboro was closed.	High	Southern Vermont Bennington, Shaftsbury, Peru
29-30 December 1997	Winter Storm	Heavy snow and gusty winds downed caused power outages across southern Vermont. Route 7 in Bennington County was closed and there was damage to a mobile home park and cinema in Bennington.	High	Southern Vermont Bennington, Peru
14-15 January 1999	Winter Storm	Snow, followed by sleet and freezing rain , along with very cold conditions resulted in heavy accumulations	High	Bennington County, Dorset
18-19 February 2000	Winter Storm	Eight to fourteen inches of snow fell in Bennington and Windham Counties. 14.3 inches were recorded in Peru	High	Southern Vermont, Peru
5-6 Mar 2001	Winter Storm	This was considered the largest storm since the Blizzard of 93 with two feet of snow in some areas. Cooperative Weather Observers measured 20.0 inches in Peru, 25.0 inches in Pownal and 18.1 inches in Sunderland.	High	Southern Vermont, Pownal, Peru
30-31 March 2001	Winter Storm	Heavy wet snow resulted in 9.8 inches in Sunderland and 15.0 inches in Peru while Windham County had similar amounts	High	Southern Vermont, Sunderland, Peru
6-7 January 2002	Winter Storm	A snowstorm produced over a foot of snow across southern Vermont with 17 inches recorded in Peru, 15 inches in Pownal and 14 inches in Sunderland by Cooperative Weather Observers.	High	Southern Vermont, Pownal

Table 8. Significant winter storm events in Bennington County and Sunderland. Source: NCDC 2012

Dates	Type	Description	Category	Area
17 November 2002	Winter Storm	A storm started with 2-4 inches of storm but changed to freezing rain and gusty winds. There were power outages from Arlington into New York	High	Southern Vermont, Arlington
25-26 December 2002	Winter Storm	Snow fell at a rate of 1-3 inches/hour for a time with 16..2 inches in Sunderland, 10.5 inches in Pownal and 16.5 inches in Windham County	High	Southern Vermont
6-8 Dec 2003	Winter Storm	The first major storm of the season produced 10-20 inches across Southern Vermont. Cooperative weather observers measured 21.5" in Pownal and 21.3 inches in Sunderland.	High	Southern Vermont, Pownal
28 January 2004	Winter Storm	Extreme southern Vermont experienced 7-13 inches of snow with 12.6 inches in Sunderland, 9 inches in Pownal and 7.5 inches in Windham County	High	Southern Vermont, Sunderland
23 Jan 2005	Blizzard	Frequent whiteout conditions were observed by plow crews. Whiteout conditions were most prevalent across the Green Mountains. Cooperative Weather Observers recorded 8.0" in Pownal and Sunderland and 14.0 inches in Peru.	High	Countywide
15-16 Jan 2007	Ice Storm	Significant icing occurred from the freezing rain leading to widespread power outages Strengthening winds in the wake of the storm continued to exacerbate power outages across the region.	High	Southern Vermont
2 March 2007	Winter Storm	A mix of snow and sleet fell with over one foot in higher elevations and some freezing rain.	High	Southern Vermont, Woodford, Landgrove
16-17 Mar 2007	Heavy Snow	This storm brought widespread snowfall amounts of 10 to 18 inches across southern Vermont.	High	Southern Vermont
15-16 April 2007	Winter Storm	A heavy wet snow accumulated to 8 -12 inches with 12 inches in Woodford, 10.5 inches in Landgrove and 11 inches in Windham County. Gusty winds brought down power lines causing widespread outages. Damaging winds were reported by a Cooperative Weather Observer in Sunderland.	High	Southern Vermont
16-17 Dec 2007	Winter Storm	Snow, sleet and freezing rain, with total snow and sleet accumulations of 8-14 inches affected Bennington County and resulted in traffic problems and power outages. The Cooperative Weather Observer reported 12.4 inches in Sunderland along with damaging winds while 14 inches was reported in Woodford and 11.5 inches in Landgrove.	High	County wide
30-December 2007 to 2 January 2008	Heavy Snow	This storm brought heavy snow to eastern New York and western New England totaling from 6 to 12 inches across southern Vermont. Snowfall amounts ranged from 6 to 11 inches. This led to treacherous travel conditions and the closings, or delayed openings of numerous schools and businesses. A Cooperative Weather Observer reported just over 12 inches in Sunderland.	High	Southern Vermont
4-5 Mar 2008	Ice Storm	This storm system spread freezing rain and sleet across higher elevations of east central New York and portions of southern Vermont, resulting in significant ice accumulations of one half, to locally up to one inch in the higher elevations of western Windham county and one quarter to less than one half of an inch in lower elevations.	High	Southern Vermont

Table 8. Significant winter storm events in Bennington County and Sunderland. Source: NCDC 2012

Dates	Type	Description	Category	Area
11-18 Dec 2008 FEMA DR-1816	Winter Storm	A series of snowstorms (two events reported by NCDC from 17-20 December) hit eastern New York and western and southern New England during this period resulting in 3-9 inches per storm, but accumulating to over a foot during the period.19 inches were reported by a Cooperative Weather Observer in Sunderland. Icing conditions followed on December 24th	High	Southern Vermont
1-3 Jan 2010	Heavy Snow	This storm brought widespread snowfall to southern Vermont along with blustery conditions, resulting in blowing and drifting of the snow. Snowfall totals across Bennington and western Windham counties ranged from about 10 inches, up to just over two feet. A Cooperative Weather Observer recorded 19.1" in Pownal from January 1-4 and another CWO reported 21.5 inches in Sunderland.	High	Southern Vermont
23-24 Feb 2010	Heavy Snow	This system blanketed the area in a heavy wet snow that resulted in treacherous travel conditions and widespread power outages across southern Vermont. Generally 1 to 2 feet of snow accumulated with the highest amounts above 1500 feet. A Cooperative Weather Observer recorded 16.2" in Pownal.	High	Southern Vermont
26-27 Feb 2010	Heavy Snow	A powerful storm brought heavy rainfall and a heavy wet snow resulting in widespread power outages and dangerous travel conditions across southern Vermont. Strong and gusty winds developed along the east facing slopes of the Green Mountains of southern Vermont with gusts up to 50 mph. Snowfall totals of 1 to 2 feet were reported across the higher terrain, with lesser amounts of 3 to 6 inches below 1000 feet. A Cooperative Weather Observer recorded 23.1" in Pownal.	High	Southern Vermont
26-27 Dec 2010	Winter Storm	A nor'easter brought snow and blizzard conditions to southern Vermont. A Cooperative Weather Observer measured in Sunderland measured 26.0 inches while the Pownal observer measured 20.0 inches.	High	Southern Vermont,
12 January 2011	Winter Storm	Heavy snow fell across southern Vermont with snowfall accumulations ranging from 14 inches up to 3 feet with snowfall rates of 3 to 6 inches an hour for a time. A cooperative weather observer measured 20.6" in Pownal.	High	Southern Vermont, Pownal
1-2 February 2011	Winter Storm	Snow fell at a rate of 1-2 inches/hour with totals of 12-17 inches in southern Vermont. Cooperative Weather Observers reported 7 inches in Pownal and 8 inches in Sunderland.	High	Southern Vermont
29-30 October 2011	Winter Storm	An early storm produced 5-14 inches in Bennington County and 10-16 inches in Windham County.	High	Southern Vermont
29 February 2012	Winter Storm	A complex storm resulted in 8-16 inches of snow and sleet across southern Vermont between February 29th and March 1st with 4-8 inches across southeastern Bennington County.	High	Southern Vermont,

A Cooperative Weather Observer recorded 18.8" in Sunderland between February 14 and 15, 2007 and 19.0" on December 27, 2010, but no damage was reported.

c. Extent and Location

The average annual snowfall in Bennington County is 64.4 inches, with December, January, February and March as the primary months for snowfall. Extreme snowfall events for one, two and three day events have ranged from 12 to over 20 inches (NOAA/National Climate Data Center 2012 Cooperative Weather Observer reports).

The skill of road crews in Vermont means that only the heaviest snowstorms (>12 inches) or ice storms affect the populations.

d. Probability, Impact and Vulnerability

There is a greater than 100% probability of a moderate or greater snowstorm affecting Bennington County, including Sunderland in any given year. These are large-scale events, though local impacts may vary greatly. Roads and power lines are most vulnerable, with traffic accidents the most likely to create injuries. Power outages could be short term or last seven or more days. Some roads may remain impassable for long periods as well.

3. High Wind Events

a. Description

High wind events can occur during tropical storms and hurricanes, winter storms and frontal passages. Thunderstorms can produce damaging winds, hail and heavy rainfall, the latter potentially producing flash floods. The NCDC recorded 52 thunderstorms with damaging winds in Bennington County since 1990. Events categorized as “strong wind” tended to occur during the winter months.

Tornadoes are formed in the same conditions as severe thunderstorms. Intense, but generally localized damage can result from the intense winds. The primary period for tornado activity in New England is mid-summer (Zielinski and Keim 2003).Tornadoes will generally follow valleys in the northeast and dissipate in steep terrain. The NCDC recorded three tornadoes in Bennington County since 1990.

b. Previous Occurrences

Table 9 below summarizes the total number of significant wind events including thunderstorms, strong winds, and tornadoes from 1990 to 2011.

Wind speed data is not available for wind events due to the lack of weather stations. NCDC data (2011) did not always include estimates of wind speed. Generally, wind speeds of greater than 55 miles per hour are considered damaging (NOAA Undated). Therefore, events were categorized based on damage assessments in the NCDC database. Damage greater than

$10,000 and tornados were categorized as moderate. Most events resulted in minor damage. Significant events are described in Table 11.

Table 9. Summary of wind events in Bennington County. Source: NCDC 2012

Year	High Wind	Strong Wind	Thunderstorm Winds	Tornado	Totals
1996	5				5
1997	2	2	6		10
1998	1		8	1	10
1999	2		4		6
2000	1		1		2
2001			3		3
2002	1		3	1	5
2003	1			1	2
2005	1		3		4
2006	3		3		6
2007	3		6		9
2008		3	5		8
2009	2		1		3
2010	5		3		9
2011	1		8		9
2012			3		3
Totals	28	5	57	3	94

Table 10. Significant wind events in Bennington County. Source: NCDC 2012

Dates	Type	Description	Area	Category
21 Aug 97	Strong Wind	Winds gusting to 40 mph downed trees in Dorset, North Bennington and Sandgate. Approximately 1,000 customers lost power.	Countywide	Moderate
1 Nov 97	High Wind	Strong and damaging winds caused power outages in Windham and Bennington Counties with approximately 1,000 customers losing power	Southern Vermont	Moderate
27 Nov 97	High Wind	Passage of a cold front resulted in winds of 40-50 mph and downed trees and power lines in Windham and Bennington counties	Southern Vermont	Moderate
31 May 1998	Thunderstorm Wind Tornado	Several lines of thunderstorms formed ahead of a front. An F2 tornado that originated in Saratoga and Rensselaer Counties followed Route 67 through North Bennington and South Shaftsbury. Damaging winds were reported by a Cooperative Weather Observer in Pownal. Large hail was reported in Shaftsbury	Countywide; Bennington North Bennington Shaftsbury	High
6 July 1999	Thunderstorm Wind	A cold front generated thunderstorms in Southern 'Vermont. Power lines and trees were downed in Pownal and Stamford and significant rain fell in Sunderland. Winds were estimated to gust at 90 mph. Damaging winds were reported by the Pownal Cooperative Weather Observer.	Southern Vermont	Moderate
16 Sept 1999	High Wind	Winds from remnants of hurricane Floyd gusted to over 60 mph across Southern Vermont. Significant rains fell in Bennington, Peru and Sunderland	Southern Vermont	Moderate
31 May 2002	Thunderstorm Wind	Thunderstorms caused damage across Bennington County. Cooperative Weather Observers reported damaging winds in Sunderland and Pownal.	Countywide	Moderate

Table 10. Significant wind events in Bennington County. Source: NCDC 2012				
Dates	Type	Description	Area	Category
5 Jun 2002	Thunderstorm Wind Tornado	Thunderstorms that initially developed in New York produced a macroburst in extreme eastern New York and moved into southern Vermont. The storms spawned two tornados, one in Woodford Hollow, Bennington County assessed as an F1with winds of 80-100 mph and the other one near Wilmington, Windham County that was stronger with winds of 125-150 mph. Non-tornadic thunderstorm winds blew some trees down in the town of Pownal. Lightning struck a home in North Bennington causing a very small fire with minimal damage to the structure of the house.	Southern Vermont North Bennington; Pownal, Woodford	Moderate
21 July 2003	Tornado	A tornado touched down in Pownal, moved through Bennington and continued into western Windham County.	Sunderland Bennington Pownal	Moderate
16 April 2007	High Wind	Low pressure created strong winds resulting in extensive tree damage in Dorset. Damaging winds were reported by a Cooperative Weather Observer in Sunderland.	Dorset	Moderate
16 Dec 2007	High Wind	A storm brought sleet and snow as well as high winds resulting in downing of trees and power lines. Damaging winds were reported by a Cooperative Weather Observer in Sunderland.	Countywide	Moderate
9 Dec 2009	Wind	A strong low pressure system tracked northeast, into the eastern Great Lakes region creating strong east to southeast winds developed across southern Vermont during Wednesday morning, before gradually diminishing by Wednesday evening.	Countywide; Bennington, Pownal, Shaftsbury, Sunderland, Sandgate, Manchester, Dorset	Moderate
22 Aug 2010	Wind	Strong and gusty east to southeast winds occurred across southern Vermont, with the higher terrain of the southern Green Mountains being impacted the hardest. Trees and wires were reported down due to high winds in Arlington, Sunderland, Shaftsbury and Bennington. Power outages occurred across Bennington County.	Arlington, Sunderland, Shaftsbury, Bennington; Countywide	Moderate
29 May 2012	Thunderstorm Wind	Strong thunderstorm winds affected Southern Vermont. Falling trees blocked a road in Dorset	Southern Vermont	Moderate

c. Extent and Location

Damaging winds, including the previous occurrences described above, are those exceeding 55 miles per hour (NOAA 2006, NOAA undated). During December 2009 event, winds were measured at 59 mph at the Morse Airport in Bennington. Higher winds were likely created during the two tornadoes. High wind events could strike anywhere, but the majority of development is close to Route 7A. Where storms are funneled up this valley, damage could be significant, but most likely less than 10% of structures would be affected. Again, power outages could last up to seven or more days.

d. Probability, Impact and Vulnerability

Wind events causing moderate or greater damage occur almost every other year (40-50%) in Bennington County, so the potential expected probability would be 10-100% in Sunderland.

4. Hail

a. Descriptions

Hail is frozen precipitation that forms in severe thunderstorms. Hailstones can range in size from ¼" (about the size of a pea) to over four inches (grapefruit sized), though most hail is in the smaller categories of less than 1.5 inches. The strong up and downdrafts within thunderstorms push to freeze and down to collect water and this repeated cycle results in accumulation of ice until gravity pulls the hailstone to Earth.

b. Past Occurrences

NCDC (2012) and Cooperative Weather Observer reports eighteen hail events since 1996. Table 11 lists all, which were highly localized with little damage.

Table 11. Hail events in Bennington County. Source: NCDC 2012

Date	Description	Area
31 May 1998	A severe thunderstorm at Shaftsbury in Bennington County produced large hail. This was the same event involving a tornado described above.	Shaftsbury
18 July 2000	Across southern Vermont, scattered thunderstorms developed ahead of a cold front during the midday. In Bennington county, dime size hail fell at Sunderland, and nickel size hail fell at Bennington.	Bennington Sunderland
4 July 2001	Half dollar sized hail (1.25") fell in Sunderland.	Sunderland
27 June 2002	Thunderstorms, developing ahead of a cold front, moved into southern Vermont during the late afternoon and early evening. One cell deposited one inch hail in the North Bennington.	North Bennington
24 May 2004	No description	Bennington
6 June 2005	One-inch hail was reported by a trained weather spotter.	Dorset Sunderland West Rupert
1 August 2005	No description	East Dorset
19 June 2006	A trained spotter reported penny-sized hail in Sunderland	Sunderland
10 May 2007	Numerous showers and thunderstorms occurred, some became locally severe, and quarter sized hail in Arlington.	Arlington
21 June 2007	A strong cold front moved through east central New York and western New England producing numerous thunderstorms, some of which were locally severe. Nickel sized hail was reported in Sunderland	Sunderland
3 August 2007	Numerous and strong thunderstorms developed over eastern New York and western New England. Ping pong ball sized hail was reported in Shaftsbury.	Shaftsbury
10 June 2008	A cold front approaching from the west, along with a hot, moist and unstable air mass in place, led to the development of strong thunderstorms across eastern New York and western New England. Nickel size hail was reported near Rupert	Rupert
24 June 2008	The passage of an upper level trough, and weak cold front produced isolated to scattered thunderstorms during the afternoon. Large hail accompanied some of these thunderstorms with ¼" sized hail reported in Pownal	Pownal
6 August 2008	A low pressure system tracked east across northern New England during the morning hours. An upper level disturbance in the wake of this system, combined with a moist and unstable air mass in place, led to the development of isolated severe thunderstorms across portions of southern Vermont. Quarter size hail fell approximately 4 miles north northeast of Arlington.	Sunderland

Table 11. Hail events in Bennington County. Source: NCDC 2012		
Date	Description	Area
15 June 2009	The combination of a passing upper level trough, and unusually cold air in the mid and upper levels of the atmosphere, led to the development of numerous thunderstorms across southern Vermont, many of which contained large quantities of hail. Quarter size hail was measured at the Bennington Morse State Airport in Bennington. In addition, nickel to quarter size hail was also reported in the city of Bennington.	Bennington
7 July 2009	A closed upper level low, and pool of unusually cold air in the mid and upper levels of the atmosphere moved over the region, leading to the development of thunderstorms across southern Vermont. Penny size hail was reported in Bennington during a thunderstorm.	Bennington
17 July 2010	A pre-frontal boundary and upper level disturbance moved across the region creating a cluster of strong to severe thunderstorms developed and moved across southern Vermont. Quarter size hail was reported during a thunderstorm in Bennington.	Bennington
1 June 2010	Multiple lines and clusters of strong to severe thunderstorms developed during the afternoon and evening hours. Half dollar size hail was reported in Arlington. Multiple reports of large hail were reported during a thunderstorm in Shaftsbury. Hail stones of 3.25 inches and 2.75 inches in diameter were measured.	Arlington Shaftsbury

Hail was also reported by a Cooperative Weather Observer on August 4, 2001, June 2, 2002 and August 1, 2008 in Sunderland and on May 8, 2001 in Peru.

c. Extent and Location

Hail can cover wide areas and has the potential for damaging crops, automobiles or glass within structures as well as cause injury. Generally, however, hail storms affect relatively small areas as they form in thunderstorms which are localized.

d. Probability, Impact and Vulnerability

Hail storms are generally local, affecting subareas within the town, though a group of thunderstorms could cause hail in multiple locations over a wide area. From past occurrences, one thunderstorm per year generates hail that was recorded. So, the possibility of hail occurring in Sunderland could range from 10-100%, but impacts would be localized.

5. Temperature Extremes

a. Descriptions

Temperature extremes entail periods of either excessive heat or extreme cold. Excessive heat is generally defined as periods when the normal high temperature is exceeded by ten degrees. So, in the summer, this would equal 88-89 degrees in Sunderland. Excessive heat is recorded at other times, but does not have the health consequences of summer periods. In addition, the heat index, which factors in the high relative humidity levels of summer, is also a factor.

Extreme cold is not well defined. For those involved in outdoor activities, extreme cold, accompanied by wind, is when exposed skin would be subject to frostbite. However, for periods of power outages that might accompany winter storms, extreme cold could be thought of as when temperatures fall below freezing as that would not only affect health, but could result in pipes freezing and the loss of water supplies.

Table 12. Sunderland normal temperatures and precipitation for 1981 to 2010. Source: National Climate Data Center: http://www.ncdc.noaa.gov/land-based-station-data/climate-normals/1981-2010-normals-data

Month	High Temperature (^{0}F)	Low Temperature (^{0}F)	Mean Temperature (^{0}F)	Precipitation (in)
January	28.5	9.5	19.0	3.44
February	33.7	11.2	22.5	2.82
March	40.9	19.5	30.2	3.55
April	54.3	31.0	42.7	3.47
May	65.8	41.3	53.5	4.33
June	75.3	49.6	62.5	4.66
July	78.5	54.5	66.5	4.55
August	77.1	53.0	65.0	4.40
September	69.6	44.2	56.9	3.83
October	57.3	34.4	45.8	4.28
November	45.9	27.9	36.9	3.98
December	34.4	17.2	25.8	3.95
Annual	55.1 (Avg)	32.8 (Avg)	43.9	47.26

The station normal report for the Cooperative Weather Observer in Pownal indicates an average of just approximately one day per year when the maximum temperature would equal 90 degrees, 55 days when the maximum temperature would be less than 32 degrees and 172 days when the minimum temperature would be less than 32 degrees.

c. Extent and Location

Extreme temperature is a widespread phenomenon. The populations affected could be small if one is considering outdoor workers or the entire town in a power outage.

d. Probability, Impact and Vulnerability

Extreme heat is relatively rare with approximately occurrences of less than one day a year. Extreme cold, here defined as less than freezing temperature, is a frequent phenomenon in Vermont. Impacts of either type of event could be widespread, and vulnerability is dependent on the populations exposed.

6. Drought

a. Description

There are several types and definitions of drought: meteorological, climatological, atmospheric, agricultural and hydrological. The latter is based on stream flow and groundwater availability and is probably most important from a natural hazard assessment perspective. Reductions in water availability can be critical in rural communities like Pownal where residents are dependent on groundwater for potable water. Reductions in precipitation over long enough periods, particularly during the growing season when plants take up moisture, can result in hydrologic drought.

b. Past Occurrences

Data on the Palmer Hydrologic Data Index for western Vermont indicates forty months since 1980 when that index was below -2.00 (Table 13). Levels less than -2.00 indicate that reservoirs and groundwater supplies are likely to be low. NCDC data shows ten recorded periods of drought and extreme heat, so this may occur more frequently.

Table 13. Palmer drought indices from 1980 to 2012 for western Vermont (including Bennington County). Months shown were when Palmer Hydrologic Drought Index (a measure of groundwater and reservoir levels) is <=-2.00. Source: http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp

Year	Month	Precipitation Index	Temperature Index	Palmer Drought Severity Index	Palmer Hydrologic Drought Index
1980	Jan	0.91	20.80	-2.93	-2.93
1980	Feb	0.67	16.70	-3.47	-3.47
1980	Mar	3.05	30.10	-2.77	-2.77
1980	Apr	2.34	44.30	-2.94	-2.94
1980	May	1.54	56.50	-3.53	-3.53
1980	June	2.62	61.90	-3.63	-3.63
1980	July	4.40	69.70	-3.18	-3.18
1980	Aug	4.58	69.00	-2.75	-2.75
1980	Sept	4.09	57.50	-2.23	-2.23
1980	Oct	2.54	44.80	-2.07	-2.07
1981	Jan	0.59	8.50	-2.64	-2.64
1987	Apr	1.99	48.00	-2.32	-2.32
1987	May	2.01	55.30	-2.70	-2.70
1987	Aug	2.73	65.10	-2.21	-2.21
1988	June	2.28	62.50	-2.13	-2.13
1988	July	3.61	71.60	-2.34	-2.34
1988	Sept	1.83	56.60	-2.46	-2.46
1988	Oct	2.01	43.30	-2.77	-2.77

Table 13. Palmer drought indices from 1980 to 2012 for western Vermont (including Bennington County). Months shown were when Palmer Hydrologic Drought Index (a measure of groundwater and reservoir levels) is <=-2.00. Source: http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp

Year	Month	Precipitation Index	Temperature Index	Palmer Drought Severity Index	Palmer Hydrologic Drought Index
1988	Nov	5.15	38.30	-2.06	-2.06
1988	Dec	1.11	21.70	-2.59	-2.59
1989	Jan	0.82	22.70	-3.12	-3.12
1989	Feb	1.28	18.40	-3.26	-3.26
1989	Mar	2.66	27.30	-2.81	-2.81
1989	Apr	2.20	40.50	-2.80	-2.80
1989	May	4.17	58.20	0.17	-2.35
1995	June	1.32	66.00	-2.85	-2.85
1995	July	4.04	71.60	-2.90	-2.90
1995	Aug	4.42	67.20	-0.02	-2.62
1995	Sept	3.67	55.20	0.03	-2.32
1999	June	2.15	67.50	-2.23	-2.23
1999	July	3.46	71.10	-2.52	-2.52
1999	Aug	2.50	66.00	-3.11	-3.11
2001	Aug	2.61	69.90	-2.43	-2.43
2001	Sept	3.20	59.20	-2.56	-2.56
2001	Oct	1.52	49.20	-3.33	-3.33
2001	Nov	2.28	40.30	-4.24	-4.24
2001	Dec	2.07	31.90	-4.74	-4.74
2002	Jan	1.85	27.00	-4.58	-4.58
2002	Feb	3.23	25.70	0.78	-3.33
2002	Mar	2.74	31.40	0.86	-2.83
2002	Apr	4.12	45.50	1.25	-2.05

c. Extent and Location

Moderate droughts (PHDI -3.0 to -4.0) occurred in 1999 and 2001 and severe droughts (<-4.0). Droughts would most likely affect those properties with shallow wells. Map 4 shows private and public well locations as well as groundwater source protection areas, rivers and streams and wetlands mapped as part of the National Wetlands Inventory. Twenty-six private wells are less than 100 feet in depth, and these are scattered throughout the area where wells have been developed (VT ANR 2013).

d. Probability, Impact and Vulnerability

Based on the Palmer Drought Severity data, there is a 3% chance of a drought occurring in any one year. Groundwater resource mapping has not been completed, and areas that could be affected by drought are unknown, but any houses with shallow wells are most likely to be affected. Drought may affect the potential for wildfire, which is discussed below.

7. Wildfire

a. Description

Wildfire or wildland fire is any unplanned fire affecting open lands including forests, grasslands or other features. The potential for wildland fire is dependent on fuel types, which vary with vegetation, topography and weather. Fire intensity, measured by the amount of energy released in a fire and exhibited by the length of flames, and rates of spread dictate the degree of wildland fire hazard and methods of control.

Sunderland participated with the Towns of Arlington, Sandgate, Shaftsbury and Glastenbury to complete a community wildfire protection plan in 2013 (Batcher and Henderson 2013). The information from that plan has been incorporated into this section.

Table 14 shows how wildfires can be categorized based on size.

Table 14. Wildland fire size classes. Source: NWCG 2011

Magnitude (Size)	Description	Probability
Class A	< ¼ acre	High
Class B	¼ to 10 acres	High
Class C	10 to 100 acres	Moderate
Class D	100 to 300 acres	Low
Class E	300 to 1000 acres	Very low
Class F	1000 to 5000 acres	Very low
Class G	>5000 acres	Very low

In the northeastern United States, forests tend to be dominated by northern hardwood species such as sugar maple (*Acer saccharum*), birch (*Betula* spp.), white pine (*Pinus strobus*) and hemlock (*Tsuga canadensis*). These species tend to create relatively low flammability fire, so that surface fires have low intensity and rates of spread, thereby limiting fire hazard (Anderson 1982). Map 5 shows fuel types mapped as part of the Community Wildfire Protection Plan for Arlington, Glastenbury, Sandgate, Shaftsbury and Sunderland (2013). Most of the land area is covered by broadleaf litter fuels that exhibit fires of low intensity and slow rates of spread.

In both forested and open settings, structures may be threatened by even small wildfires. These wildland-urban interface areas are the most likely areas where resources will be needed to suppress wildland fire and to reduce potential hazards.

Fire behavior is most extreme during periods when the relative humidity is low, generally less than 35-45%. These conditions are most prevalent in the spring, following snow melt, between March and late May or early June. After that, vegetation becomes increasingly green, and the resulting moisture in the live vegetation (fuel) reduces flammability significantly. Precipitation and evapotranspiration increase ambient relative humidity levels so that fires in the summer are generally rare and limited in size.

Fall again brings drying fuels and weather conditions increasing fire hazard. However, relative humidity levels increase after dark, and shorter days also limit the amount of time for fuels to dry and intense, fast moving fires to occur (North Central Research Station 2005).

b. Past Occurrences

According to records from the Vermont Department of Forests, Parks and Recreation, from 1992 to 2010, 156 wildfires occurred in Bennington County, three of which occurred in Sunderland, all less than one acre in area (Map 5).

c. Extent and Location

The three fires were all Class A or B. Low intensity fires with slow rates of spread could occur in forested areas, nearly all of which is in Green Mountain National Forest Throughout the town there may be pockets of heavier fuel loads, such as brush, or more flammable fuels, such as cured herbaceous vegetation and shrubs. These are shown as Grass and Grass-Shrub Fuels on Map 5, and are generally located in the valleys near developed areas.

d. Probability, Impact and Vulnerability

Natural fire return intervals in most forests in Vermont are greater than 50 years (Malamud et al. 2005), and more likely greater than 200 years, as reported in Landfire data for this area. Recurrence is likely related to precipitation rather than the buildup of fuels, so drought recurrence is already factored into these interval estimates. Therefore, the potential for large fires is very limited due to the fuel characteristics. However, large roadless areas and steep topography can make suppressing wildland fires that do occur very difficult. Settled areas have a low vulnerability to fire.

8. Landslide and Debris Flow

a. Description

Landslides are typically associated with periods of heavy rainfall or rapid snow melt and tend to worsen the effects of flooding that often accompanies these events. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly. Gravity is the force driving landslide movement. Factors that allow the force of gravity to overcome the resistance of earth material to landslide movement include saturation by water, steepening of slopes by erosion or construction, and alternate freezing or thawing. Table 15 shows how landslides can be categorized.

Table 15. Landslide and debris flow types. Source: USGS 2006

Magnitude	Description	Probability
Localized	Falls: abrupt movements of rocks and boulders, generally on steep slopes	Low to moderate
Topples	Topples: movements involving some forward rotation as material moves downhill	Low to moderate
Flows	A range of land movement generally involving a mass of loose soil, rock, organic matter, air and water moving downhill rapidly and possibly covering a wide area One form called creep involves slow movement of material and is often recognizable by trees growing so as to remain vertical while bent near the ground as they grow to keep up with the slow material flow.	Highly variable but can be fairly common.

b. Past Occurrences

c. Extent and Location

All of the mapped landslides would be categorized as localized. Map 4 shows locations of damages, including landslides that occurred during Tropical Storm Irene. No rockfalls were identified in Sunderland by the Vermont Agency of Transportation (Eliason and Springston 2007).

d. Probability, Impact and Vulnerability

Previous landslides occurred during a major storm event, Tropical Storm Irene, and were located along the Roaring Branch and Batten Kill. Impacts can include destabilization of roads and debris jams as material that has slid from slopes then flows downstream. The probability of occurrence would be the same as for flooding with the potential proportion damaged within the town ranging from 1-10% and injuries of 1-10%. Most services would be recovered in less than seven days, though repair to some infrastructure may take significantly longer.

9. Earthquake

a. Description

Vermont has no active faults, but has experienced minor earthquakes. Table 13 below shows the most recent occurring within the state, though there have been others, located outside, that have been felt in Vermont (Springston and Gale 1998). The U.S. Geological Survey predicts a two percent probability of an earthquake causing considerable damage in Vermont sometime in the next 50 years (Springston and Gale 1998).

b. Past Occurrences

Table 16. Earthquakes in Vermont. Source: Vermont Geological Survey: http://www.anr.state.vt.us/dec/geo/EBEL.htm consisting of excerpts from: A Report on the Seismic Vulnerability of the State of Vermont by John E. Ebel, Richard Bedell and Alfredo Urzua, a 98 page report submitted to Vermont Emergency Management Agency in July, 1995.

Location	Date	Magnitude	Mercalli Intensity
Swanton	July 6, 1943	4.1	Felt by nearly everyone; many awakened with some dishes and windows broken and unstable objects overturned
Brandon	March 31, 1953	4.0	Felt indoors by many, but by few outdoors. Sensation would be similar to a heavy truck striking a building
Middlebury	April 10, 1962	4.1	Felt by nearly everyone; many awakened with some dishes and windows broken and unstable objects overturned

c. Extent and Location

In 2003, the Vermont Geological Survey completed simulations using FEMA HAZUS software of potential damage within Bennington County from a 500 year recurrence earthquake centered in Middlebury, VT, Tamworth, NH and Goodnow, NY. The results indicated minimal damage and injury from any of these events to Sunderland (Kim 2003).

d. Probability, Impact and Vulnerability

Based on the 2003 HAZUS analyses, both the probability and impact of an earthquake of a magnitude that could potentially occur in Vermont are low. However, earthquake prediction science is very limited.

10. Hazardous Materials Spill

a. Descriptions

Hazardous wastes are materials that are flammable, corrosive, toxic, flammable or labeled with warning or caution labels. These materials are used in industry, in the home or on farms and are transported regularly.

b. Past Occurrences

The Vermont spill site list indicates there have been 12 spills reported in Sunderland since 1979, and these are listed in Table 19 below.

Table 17. Hazardous materials spills in Sunderland.
Source: http://www.anr.state.vt.us/WMID/Spills.aspx

Report #	Year	Facility Name	Address	Responsible Party	Date Reported	Date Closed	Incident
WMD771	2011	Sunderland Goo	228 Schoolhouse Woods Road	Unknown	10/13/2011	11/30/2011	Orange goo on water
WMD327	2010	Casella Transfer Station	4561 Sunderland Hill Rd	Casella Waste	6/30/2010	6/30/2010	3.5 gallons (unspecified) spilled due to hose failure
WMD380	2007	CVPS Service Center	193 Old Camp Rd	CVPS	9/4/2007	9/4/2007	Cooling system leak
WMD324	2007	N/A	Rte 7	Vtrans	7/27/2007	7/27/2007	2 gallon hydraulic spill from mowing equipment
WMD360	2005	N/A	Barney Orchard Rd	CVPS	10/7/2005	10/7/2005	1.5 gallon transformer leak
WMD323	2003	Line 264, Pole 32	South Rd	CVPS	10/20/2003	10/21/2003	7 gallon leak due to storm damage
WMD369	1998	Casella Waste Mgmnt	Sunderland Hill Rd	Casella Waste	9/23/1998	9/23/1998	5 gallon diesel spill during refueling
WMD191	1998	Rt 7a	Rt 7a, North Of Arlington	LMS Distributing	5/20/1998	6/29/1998	2 gallon spill due to truck accident
WMD187	1997	Morse Residence	North Rd	N/A	5/24/1997	5/26/1997	House burned for fire training
199	1992	Schmaler Brothers Construction	Bacon Hollow Rd	Schmaler Bros Construction	7/23/1992	7/24/1992	Construction debris dumping
76	1982	N/A	Creative Concepts	N/A	4/22/1982	1/1/2000	Burning plastics and lacquer
22	1974	N/A	Penocks Store	N/A	2/22/1974	1/1/2000	Gasoline leak from car hitting gasoline pump

c. Extent and Location

All of the spills listed above affected small sites or areas. Routes 7 and 7a carry substantial traffic, and a spill on one of those roads could affect a large portion of the town. Of particular concern in any hazardous materials spill would be the impact on water resources. Map 6 shows the transportation system in relation to surface waters including streams and wetlands and groundwater including wells and source protection areas. In the late 1980's, Lincoln Applied Geology mapped a larger source protection area for the Arlington Water Company wells, and this is shown on that map. For the transportation system, high accident intersections have been identified by the Vermont Agency of Transportation. The planning committee also identified the intersection of Hill Farm Road and Route 7A as a hazardous intersection. Roads with average grades greater than 10% for a segment also present hazards, particularly when roads are wet or during winter storms. Finally, the railroad along the Batten Kill is a potential source of a spill.

d. Probability, Impact and Vulnerability

Given the number of past spills, hazardous materials spills occur less than annually and affect very small areas. Increased truck traffic also increases the possibility of a major spill. However, many areas are vulnerable due to the extensive transportation system and proximity of surface and groundwater resources to that system. Most hazardous materials are transported via Routes 7 and 7A. However, local roads carry materials that could spill and affect aquatic resources as well as individual wells.

The overall likelihood of a hazardous materials spill on an annual basis is probably between one and ten percent. Injuries, except in the case of direct injuries from a traffic accident, are likely low. However, the long term impacts of a spill could be extensive if aquatic resources and/or water supplies were affected.

11. Infectious Disease Outbreak

a. Descriptions

Infectious diseases are caused by bacterial infections, viruses, fungi and other organisms that can spread through the human population.

b. Past Occurrences

Infectious diseases are a regular occurrence. The Vermont Department of Health (2013) lists ten different diseases occurring in Bennington County as of June of 2013 with Lyme disease the highest with sixteen cases.

c. Extent and Location

In general, individuals and families are most affected by infectious diseases, but schools could be affected as well.

d. Probability, Impact and Vulnerability

Given past history, there is a low probability of a disease affecting a large portion of the town, but high probability of continued, isolated occurrences.

12. Invasive Species

a. Descriptions

Invasive species are organisms that are not native to a geographic area and which could or do cause economic or environmental harm. Invasive species are characterized by organisms that spread rapidly, can displace native species, and have few or no predators to keep their populations in check. At the same time, they have characteristics that may reduce the value and use of natural resources. For example Japanese barberry (*Berberis thunbergii*) can become a dominant, short shrub in some forests and, given that this is a thorny plant, can reduce the use of an area for recreational purposes (Vermont Agency of Natural Resources 2010).

Vermont has two invasive species lists: Class A species are on the Federal Noxious Weed List but are not known to occur in Vermont. There are listed in 7 C.F.R. 360.200, a section of the Code of Federal Regulations. Class B species are known to occur in the state and are considered a threat.

Table 18. Designated Class B noxious weeds in Vermont. Source: Vermont Agency of Agriculture, Food and Markets: http://agriculture.vermont.gov/plant_pest/plant_weed/invasive_noxious_weeds/noxious_weeds_list
Those with a * have been identified in Bennington County. Source: Early Detection and Mapping System: http://www.eddmaps.org/tools/query/

Scientific Name	Common Name
*Acer ginnala**	Amur maple
Acer platanoides	Norway maple
*Aegopodium podagraria**	Bishop's goutweed
Ailanthus altissima	Tree of heaven
*Alliaria petiolata**	Garlic mustard
*Berberis thunbergii**	Japanese barberry
*Berberis vulgaris**	Common barberry
Butomus umbellatus	Flowering rush
*Celastrus orbiculatus**	Oriental bittersweet
*Euonymous alatus**	Burning bush
Fallopia japonica	Japanese knotweed
Hydrocharis morsus-ranae	Frogbit
*Iris pseudacorus**	Yellow flag iris
Lonicera japonica	Japanese honeysuckle
Lonicera maackii	Amur honeysuckle
*Lonicera morrowii**	Morrow honeysuckle

Table 18. Designated Class B noxious weeds in Vermont. Source: Vermont Agency of Agriculture, Food and Markets: http://agriculture.vermont.gov/plant_pest/plant_weed/invasive_noxious_weeds/noxious_weeds_list Those with a * have been identified in Bennington County. Source: Early Detection and Mapping System: http://www.eddmaps.org/tools/query/	
Scientific Name	Common Name
*Lonicera tatarica**	Tartarian honeysuckle
*Lonicera x bella**	Bell honeysuckle
*Lythrum salicaria**	Purple loosestrife
*Myriophyllum spicatum**	Eurasian watermilfoil
Najas minor	European naiad
Nymphoides peltata	Yellow floating heart
*Phragmites australis**	Common reed
Potamogeton crispus	Curly leaf pondweed
*Rhamnus cathartica**	Common buckthorn
*Rhamnus frangula**	Glossy buckthorn
Trapa natans	Water chestnut
Vincetoxicum nigrum	Black swallow-wort

In addition, the Agency for Natural Resources lists the following as aquatic invasive species

Table 19. Aquatic invasive species in Vermont. Source: Watershed Management Division, Vermont Department of Environmental Conservation: http://www.vtwaterquality.org/lakes/htm/ans/lp_ans-index.htm	
Scientific Name	Common Name
Dreissena polymorpha	Zebra mussel
Alosa pseudoharengus	Alewife
Orconectes rusticus	Rusty crayfish
Didymosphenia geminata	Didymo

b. Past Occurrences

Invasive species are present and represent a continuous hazard that will vary with their abundance and their impacts on structures and infrastructure.

c. Extent and Location

The extent has not been fully mapped. In addition to the species listed above, the following are potential invasive species:

Pastinaca sativa (Wild parsnip) is abundant along roadsides and can cause skin burns when chemicals in the plant on exposed skin interact with sun. *Anthriscus sylvestris* (cow parsely also dominates roadsides and can invade meadows. *Phalaris arundinacea* (reed canary grass) can invade wetlands and crowd out native plants.
Adelges tsugae (Hemlock wooly adelgid) has dramatically reduced hemlock trees south of Vermont and was recently found in Pownal, Vt. *Agrilus planipennis* (Emerald Ash Borer) is a significant threat to forests as it kills all ash species. Borers are often dispersed through movement of firewood.

d. Probability, Impact and Vulnerability

The likelihood of increased abundance of invasive species is 75-100% and potential impacts to forested areas are very high. Invasive insects that can cause tree death, particularly the emerald ash borer, could result in road closures, power outages and property damage.

B. Vulnerability Analysis

The vulnerability assessment combines the results of data summarized in the previous section along with local knowledge. Table 20 summarizes the potential impacts from each hazard.

Table 20. Hazard impact summary	
Hazard	Potential Impacts
Floods and flash floods	Damage or loss of structures and infrastructure Loss of life and injury
Winter storms	Power outages Road closures
High wind events	Power outages Road closures
Hail	Property damage Crop damage or loss
Temperature extremes	Loss of life and injury Water supply loss
Drought	Water supply loss Crop damage or loss
Wildfire	Damage or loss of structures and infrastructure Loss of life and injury Loss of forest resources
Landslide and debris flow	Damage or loss of structures and infrastructure Loss of life and injury Road closures Power outages

Table 20. Hazard impact summary	
Hazard	Potential Impacts
Earthquake	Damage or loss of structures and infrastructure Loss of life and injury Road closures Power outages Water supply loss
Hazardous materials spill	Loss of life and injury Road closures Water supply loss
Infectious disease outbreak	Loss of life and injury
Invasive species	Road closures Power outages Loss of forest resources

Table 21 summarizes probabilities, area affected and likely warning times for each hazard. Floods and flash floods have caused the greatest damage in the past and are likely to be the priority hazard in the future. In addition, threats to water supplies such as drought or hazardous materials spills could affect large portions of the community. Other hazards would likely be very localized, but could affect vulnerable populations such as the elderly, the young or those who might be particularly affected by power outages or isolation during storm events. Mobile homes, particularly mobile home parks, can be particularly vulnerable to hazards (Vermont Department of Housing and Community Development 2013). There are 33 mobile homes in Sunderland, but these are scattered and none are in mobile home parks.

Table 21. Vulnerability assessment for the Town of Sunderland.

Hazard	Date/Event (# events)	Recurrence Interval	Geographic Extent	Proportion of town damaged	Injuries/ deaths	Loss of facilities/services	Vulnerable Facilities/Populations	Warning Time
Flood/Flash Flood	1927 1987 1996 (2) 1998 1999 2000 (2) 2003 2007 2011 (2)	10-100% probability in next ten years	Community to statewide	<10%	1-10%	Minimal to seven days. Roads may become impassable and power outages in some areas	Roads, bridges and culverts town wide	>12 hours
Winter storm (snow and ice)	1987 (Oct) 1993 (2) 1994 1995 (2) 1996 (4) 1997 (2) 1999 2000 2001 2002 (3) 2003 2004 2005 2007 (5) 2008 (3) 2010 (4) 2011 (3) 2012	100% probability in any given year	Community to statewide	<10%	1-10% primarily traffic accidents	Minimal to seven days with some areas impassable and power outages in some areas	Primarily power supplies but also roads	>12 hours

Table 21. Vulnerability assessment for the Town of Sunderland.								
Hazard	Date/Event (# events)	Recurrence Interval	Geographic Extent	Proportion of town damaged	Injuries/ deaths	Loss of facilities/services	Vulnerable Facilities/Populations	Warning Time
High Wind Event	1995 1997 (3) 1998 1999 (2) 2002 2003 2007 (2) 2010 2012	10-100% occurrence in next ten years	Community to region-wide	<10%	<=1%	Minimal for the entire town, but may be significant in localized areas. Power outages may occur.	Power lines primarily	3 to > 12 hours
Hail	2010 (2) 2009 (2) 2008 (3) 2007 (3) 2006 2005 (2) 2004 2002 2001 2000 1998	1-10% probability in any given year	Subarea of community	<=1%	M=1%	Minimal	Minimal	3 to 12 hours
Temperature Extremes	Annual >90 F	1-10% probability in any given year	Community to statewide	100%	<=1%	Minimal	Elderly and ill individuals without adequate heating or air conditioning	>12 hours
Drought	1980 1981 1987 1988 1989 1995 1999 2001 2002	1-10% probability in any given year	Community to statewide	<10%	<=1%	Minimal but water could be unavailable for significant lengths of time.	Homes with shallow wells lose water	>12 hours

Table 21. Vulnerability assessment for the Town of Sunderland.								
Hazard	Date/Event (# events)	Recurrence Interval	Geographic Extent	Proportion of town damaged	Injuries/ deaths	Loss of facilities/services	Vulnerable Facilities/Populations	Warning Time
Wildfire	1994 1998	1-10% probability in any given year	Subarea of community	<10%	<=1%	Minimal	Likely confined to the National Forest	None or minimal
Landslide/Debris Flow	Small scale events along Route 9 Several small post-Irene slides	1-10% probability in any given year	Subarea of community	<10%	<=1%, but traffic accidents possible	Minimal depending on scale and ability to remove material	Areas along Route 9 could result in accidents or the blocking of Route 9.	None or minimal
Earthquake	2011	<1% probability in any given year	Community to region-wide	<10%	<=1%, but larger in a significant earthquake	Minimal	Town wide	None or minimal
Hazardous Materials Spill	2011 2010 2007 (2) 2005 1998 (2) 1997 1992 1982 1974	1-10% probability in any given year	Community to region-wide	<=1%	<=1%	Minimal	Water supplies and aquatic resources	None or minimal
Infectious Disease Outbreak	Annual	1-10% probability in any given year	Community to state-wide	<=1%	<=1%	Minimal	Varies with type of infectious disease	None or minimal
Invasive Species	Ongoing	100% probability in any given year	Community to state-wide	1-10%	<=1%	Power outages from tree fall	Forests, roadsides, water bodies and streams	>12 hours

V. Mitigation Programs

A. Mitigation Goals for the Town of Sunderland

The Town identified the following mitigation goals:

1. Significantly reduce injury and loss of life resulting from natural disasters.
2. Significantly reduce damage to public infrastructure, minimize disruption to the road network and maintain both normal and emergency access.
3. Establish and manage a program to proactively implement mitigation projects for roads, bridges, culverts and other municipal facilities to ensure that community infrastructure is not significantly damaged by natural hazard events.
4. Design and implement mitigation measures so as to minimize impacts to rivers, water bodies and other natural features, historic structures, and neighborhood character.
5. Significantly reduce the economic impacts incurred by municipal, residential, industrial, agricultural and commercial establishments due to disasters.
6. Encourage hazard mitigation planning to be incorporated into other community planning projects, such as Town Plan, Capital Improvement Plan, and Town Basic Emergency Operation Plan
7. Ensure that members of the general public continue to be part of the hazard mitigation planning process.

B. Review of Existing Plans and Programs that Support Hazard Mitigation in Sunderland

1. Sunderland Town Plan

a. Goals:

One of the goals of the plan is 3.12 which states:
“Encourage protection and wise use and management of the Batten Kill for its outstanding resource waters (ORW) values: fish habitat, wildlife habitat, scenic areas and sites, recreational and educational use and access, water quality, and other natural values” (p. 5).

b. 4.2 Topography

Protecting steep slopes is important to avoiding damage from landslides. The plan states that “Residential development should be carefully planned in areas where the natural slopes are greater than 10%. On slopes greater than 20%, residential development should not be permitted. No road or driveway serving a subdivision serving two or more homes shall be constructed on a slope in excess of 9% at any point along its length" (p. 7).

c. Rivers, Streams and Flood Hazard Areas

Section 4.3 lists policies for stream protection intended to reserve the natural state of streams by maintaining existing vegetation, protecting adjacent wetlands and natural areas, and minimizing erosion and contamination. The plan also discourages public investments that could have an adverse impact on streams and the protection of open space along main and feeder streams (p. 8).

The Town has adopted a flood hazard bylaw. In addition, development should be directed away from the fluvial erosion hazard zone. The following policies are intended to guide development:

"1) Development or filling in the floodplain should be avoided and not allowed in a flood way.
2) The storage of hazardous materials, waste products, or other materials that can contaminate surface and ground water should not be allowed in any floodplain zone classification.
3) Development and hazardous materials should avoid locating in high risk fluvial erosion hazard areas" (p. 9).

Section 5.5.5 describes both flood hazard areas (FHA) and fluvial erosion hazard (FEH) areas intended to mitigate flood damages through the following policies:

"1) In the floodplain, encourage open air uses (recreation, agriculture, etc.) versus structural uses, obstructions or fill, in order to maintain the capacity of the channel and adjacent land to carry the 100 year flood.
2) Permit uses as provided for in local zoning bylaws in the floodway fringe, but require appropriate flood proofing and/or elevation to minimize flood damage.
3) Avoid impacts to the special qualities of the river environment. Such qualities may include: fisheries and habitat, plant life and natural vegetation, scenery, open space and rural setting, water quality, recreation experience and river use, etc.
4) Restrict development and filling in of floodplains and wetlands along (the main) stream channels to protect their recharge and water storage benefits as they relate to flooding and to protect them as wildlife habitats.
5) Encourage appropriate setbacks from streams in areas where soil conditions might result in pollution, soil erosion, and sedimentation.
6) Encourage the protection of the natural state of streams except when there is a potential threat against life and property.
7) Encourage the provision of appropriate and carefully planned access to and along the main streams.

8) Avoid development in and protect high risk fluvial erosion hazard areas and their ability to maintain natural flows during peak flooding events" (p. 20).

d. Wetlands

Protection of wetlands is identified as important, particularly along the Batten Kill (p. 8).

e. Floodplains/Fluvial Erosion Hazard Areas

The Town has adopted a flood hazard bylaw that regulates development in both the special flood hazard area and the fluvial erosion hazard zone. Policies in the plan advocate avoiding development in these areas. (p. 9).

f. Groundwater

The Town intends to take a more conservative set of policies to protect groundwater than provided in state regulations:

"1) Aquifers and aquifer recharge areas shall be protected from activities or development
that would adversely affect the quantity or quality of available groundwater.
2) The municipal subdivision and health regulations must be strictly enforced to protect individual water supplies.
3) Groundwater withdrawal for non-municipal commercial processing is not appropriate in the Town when there is the potential to impact the quantity and quality of supplies for existing land use and future growth" (pp. 9-10).

Section 5.5.7 identifies the following policies for well head protection:

"1) Discourage land development that would impair or endanger watersheds and well head protection areas supplying public or private water supply systems.
2) Any land use, storage, disposal, or transport of any material or liquid that could present a threat to the quantity or quality of water obtained from the well head protection area-aquifer shall be carefully evaluated for potential impact. Such uses should be allowed only when there is a high degree of certainty that pollution will not result.
3) Those uses with greater potential for groundwater contamination shall make provision for remedial actions necessary to abate such pollution. This policy is not a substitute to avoidance of uses which present a potential threat" (p. 21).

2. Community Wildfire Protection Plan for the Towns of Arlington, Glastenbury, Sandgate, Shaftsbury and Sunderland

A community wildfire protection plan (Batcher and Henderson 2013) was completed by the Bennington County Regional Commission for the towns of Arlington, Glastenbury Sandgate, Shaftsbury and Sunderland in 2013. The plan was developed in cooperation with the Arlington and Shaftsbury Fire Departments, the Vermont Department of Forests, Parks and Recreation, the fire wardens from each town, Bennington County Mutual Aid and Green Mountain National Forest. Presentations were made to the planning commissions of each town to gather their input as well.

The plan includes actions for education and outreach, improvements to water resources for wildland and structural fire protection, and fuel reduction projects. These have been incorporated in this plan as well. Fire hazard was mapped based on fuel types, slope, aspect and topographic characteristics that affect fuel moisture. Map 7 shows the locations of potential fuel treatments and areas where water resources need to be enhanced. Fuel treatments should be focused on areas along the Kelly Stand where residences abut lands of Green Mountain National Forest and fields where structures are often proximate to grass and shrub dominated fields which can carry high intensity, fast moving fires.

3. Bennington Regional Plan Policies and Actions (adopted May 17, 2007)

The Bennington Regional Plan lists the following policies and actions supporting hazard mitigation:

a. Intensive development should be directed to areas where physical conditions such as elevation, slope, and soils are most capable of supporting such development. (p. 13).

b. Growth should be restricted in areas of high elevation, steep slopes, or poor soils where environmental damage is likely to occur as a result of development. Special attention must be given to the need to prevent soil erosion, contamination of surface and ground water, and degradation of natural ecological communities in these areas (p. 13).

c. Development in floodplains must be carefully controlled in accordance with flood hazard are regulations. Development is strongly discouraged in flood hazard areas (p. 48).

d. Aquifers and ground water recharge areas (including all designated source protection areas) must be protected from activities or development that would adversely affect the quantity or quality of available ground water. Municipal subdivision and health ordinances and the regulations of the Vermont Agency of Natural Resources must be strictly enforced to protect individual water supplies (p. 48).

e. The surface waters of the Bennington region are extraordinarily valuable natural resources that must be protected from incompatible development and land uses. The natural characteristics and values of these resources should be preserved. An undisturbed buffer of at least 50 feet in width should be maintained, wherever possible, between any developed area and a river, stream, lake, pond, or wetland to ensure that water quality and natural ecosystems are protected. Greater buffer distances often will be required depending on the nature of the land and affected waterway (p. 47).

f. New roads, driveways, and drainage systems should be designed, constructed, and maintained in accordance with the municipal subdivision regulations, street standards, and other local and state requirements (p. 75).

4. Draft Vermont Hazard Mitigation Plan (2013)

The draft Vermont Hazard Mitigation Plan as of September of 2013 identified a series of hazards shown in Table 23 below along with those we considered in this plan. The Sunderland plan tracks the state plan except some hazards are combined and a few, including nuclear plant accident, were not considered.

Table 22 Comparison of hazards considered in the draft Vermont Hazard Mitigation Plan vs. the Sunderland Hazard Mitigation Plan

VT Hazard Mitigation Plan	Alternative
Atmospheric Hazards	**Natural Hazards**
Drought	Drought
Earthquake	Earthquake
Flooding	Flooding/Flash Floods/Fluvial Erosion/Ice Jams
Fluvial Erosion	*See Flooding/Flash Floods/Fluvial Erosion/Ice Jam*
Hail	Hail
High Winds	High Winds
Hurricane/Tropical Storm	*See High Winds and Flooding/Flash Floods/Fluvial Erosion/Ice Jams*

Table 22 Comparison of hazards considered in the draft Vermont Hazard Mitigation Plan vs. the Sunderland Hazard Mitigation Plan	
VT Hazard Mitigation Plan	Alternative
Ice Storm	*See Severe Winter Weather/Ice Storm*
Ice Jams	*See Flooding/Flash Floods/Fluvial Erosion/Ice Jam*
Infectious Disease Outbreak	Infectious Disease Outbreak
Landslide/Debris Flow	Landslide/Debris Flow
Severe Thunderstorm	*See High Winds and Flooding/Flash Floods/Fluvial Erosion/Ice Jams*
Severe Winter Weather	Severe Winter Weather/Ice Storm
Temperature Extremes	Temperature Extremes
Tornado	*See High Winds*
Wildfire	Wildfire
Technological Hazards	**Technological Hazards**
Dam Failure	Dam Failure
Hazardous Materials Spill	Hazardous Materials Spill
Invasive Species	Invasive Species
Nuclear Power Plant Accident	Not addressed
Rock Cuts	*See Landslide/Debris Flow*
Terrorism	Not addressed

The draft Vermont Hazard Mitigation Plan identified flooding and fluvial erosion, winter storms, high winds and severe thunderstorms as high risk for Bennington County and radiological accident risk and hazardous materials spills as moderate risk. There are no vulnerable state facilities in Sunderland.

C. Current Programs

Vermont, municipalities have the authority to regulate development in flood hazard areas under 24 Vermont Statues Annotated (VSA), Chapter 91. Under 10 VSA, Chapter 32, the Secretary of the Agency of Environmental Conservation has the authority to designate flood hazard areas and to assist the towns with flood hazard regulations. Sunderland participates in the National Flood Insurance Program (NFIP) and has bylaws in place to implement that program. This program is overseen by the Town Zoning Administrator. Currently there are nine polices in effect for a total value of $2.375 million. Two claims have been made since 1978 totaling $182,853. The Town also has a fluvial erosion zone hazard ordinance. In some cases, land may fall into a fluvial erosion hazard zone but not in the flood zones identified in FEMA flood map. Therefore, property owners who own land in the fluvial erosion hazard zone should be encouraged to purchase flood insurance.

The Town bylaws have been reviewed and amended to reflect changes in the flood insurance maps prepared by FEMA. The current FIRM is dated September 18, 1985. More recently, DFIRM maps have been developed using LIDAR, a technology that can be used to develop highly accurate elevations and, thereby, predict potential flood elevations from different storm events (FEMA 2010).

The Town has an active program to maintain roads and bridges and has upgraded all of the bridges and culverts based on hydraulic studies completed by the Agency of Transportation. The Town has investigated using Sunderland Elementary as a shelter, but has an agreement with Arlington to use their shelter. These include the existing Town Hall, the new Town Hall, currently under construction, the Town Highway Garage and the Sunderland Elementary. The new Town Hall will have utilities placed underground and will be constructed to conform to the latest Vermont building requirements. The locations of critical facilities are shown on Maps 3, 5, and 7.

D. Mitigation Projects

Table 23 below lists mitigation actions for each of those hazards. Some will be implemented by the Town of Rupert and others by agencies such as the Vermont Agency of Transportation. Mitigation actions are listed by the type of hazard. The following criteria were used in establishing project priorities, with ranking based on the best available information and best judgment as these proposed projects would need further study and design work:

1. The overall assessment of the potential damage from a given hazard.
2. Whether the proposed action reduce potential damage from the hazard.
3. Consistency of the proposed action consistent with the goals of the town.
4. Whether the action could be implemented within the specified time frame.
5. Whether the proposed action was technically feasible.
6. Whether the action could be implemented to reduce potential damage at a reasonable economic cost while avoiding or mitigating potential impacts to natural, cultural, social and economic resources?

Prior to the implementation of any action, a benefit-cost analysis would be completed to assure the action would be feasible and cost-effective.

Table 23. Mitigation actions

Hazard	Type[1]	Actions	Responsible Parties	Time Frame	Funding Source(s)	Priority
All Hazards	Education and Outreach	Provide a "be prepared" section of the Town website with links to information for residents	Town	2014	Town	High
All Hazards	Local Planning and Regulations	Encourage proper construction techniques and use of appropriate materials to address hazards, particularly flooding, winter storms, wind events, earthquakes, landslides and wildfire	Town	2014	Town	High
All Hazards	Education and Awareness	Identify and develop methods to communicate with populations vulnerable to potential hazards, particularly drought, extreme temperatures and infectious diseases, but also those in need of assistance for evacuation and/or sheltering	Town	2014	Town	High
All Hazards	Local Planning and Regulations	Assess need for driveway standards to assure adequate emergency access particularly to assure adequate access in winter storms, floods and for wildfire protection	Town	2014	Town	High
Floods and Flash Floods	Education and Awareness	Educate owners on importance of securing propane tanks and other items that could float or blow away in storms	Town	2014	Town	Medium
Floods and Flash Floods	Local Planning and Regulations	Adopt and enforce updated flood hazard and fluvial erosion hazard zone bylaws	Town	2013	Town	High
Floods and Flash Floods	Local Planning and Regulations	Participate in the Community Rating System to help reduce flood insurance premiums	Town	2014	Town	High
Floods and Flash Floods	Local Planning and Regulations	Encourage appropriate stormwater and erosion control measures in new developments	Town	Ongoing	Town	High
Floods and flash floods	Local Planning and Regulations	Prepared draft contract for company to provide services if debris pile up bridges and culverts to prevent blockages and resulting flooding.	Town	2014	Town	High
Floods and flash floods	Structure and Infrastructure Projects	Road crew should regularly survey culverts for blockages including photographs and records of damages and costs	Town	2014	Town	High

[1] Follows FEMA 2013 Mitigation ideas; a resource for reducing. Federal Emergency Management Agency, U.S. Department of Homeland Security, Washington, DC

Table 23. Mitigation actions						
Hazard	Type[1]	Actions	Responsible Parties	Time Frame	Funding Source(s)	Priority
Floods and flash floods	Structure and Infrastructure Projects	Adopt the 2013 and updates to the Vermont Town Road and Bridge Standards	Town	2014	Town	High
Floods and flash floods	Structure and infrastructure projects	Identify and replace culverts and bridges that do not meet current Vermont Town Road and Bridge Standards	Town	2014-2018	Town/State of Vermont/ FEMA	High
Floods and flash floods	Structure and infrastructure protection	Encourage property owners in flood or fluvial erosion hazard zones to consider selling their properties (buy out) or implementing flood proofing including elevating structures	Town	2014-2018	FEMA	High
Floods and flash floods	Structure and infrastructure protection	Implement corridor protection, buffer plantings, structure and berm removal and other projects listed in the 2007 Batten Kill corridor plan (Field 2007)	Town	2014 - 2019	FEMA	Medium to High
Floods and flash floods	Natural Systems Protection	Acquire lands or work with conservation organizations to acquire lands subject to frequent flooding or wetlands within or adjacent to flood prone areas to provide flood storage	Town	2014-2018	State of Vermont/non profit organizations	Medium
Winter storms	Education and Outreach	Provide educational materials on sheltering in place and preparation for winter storms, including long-term power outages	Town	2014	Town	High
Winter storms	Education and Awareness	Provide materials for residents on methods to protect property from wind events	Town	2015	Town/FEMA	High
Winter storms	Local Planning and Regulations	Develop agreements with adjacent towns for sharing of highway equipment	Town	2014	Town	High
Winter storms	Structure and Infrastructure Projects	Place utilities underground for critical facilities	Town	2015	FEMA	Medium
High wind events	Education and Outreach	Provide educational materials on sheltering in place and preparation for winter storms, including long-term power outages	Town	2014	Town	High
High wind events	Local Planning and Regulation	Require boats, propane tanks and other items stored outdoors to be secured	Town	2015	Town	High
High wind events	Local Planning and Regulation	Encourage appropriate plantings to avoid future damage from downed trees	Town	2015	Town	Medium

Table 23. Mitigation actions						
Hazard	Type[1]	Actions	Responsible Parties	Time Frame	Funding Source(s)	Priority
High wind events	Local Planning and Regulation	Encourage protection and planting of wind breaks in new developments	Town	2015	Town	Medium
High wind events	Structure and Infrastructure Projects	Retrofit existing buildings to withstand high winds including protection of power lines and other utilities	Town	2017	FEMA	Medium
High wind events	Structure and Infrastructure Projects	Place utilities underground for critical facilities	Town	2015	FEMA	Medium
Hail	Structure and Infrastructure Projects	Retrofit existing buildings to minimize hail damage	Town	2017	FEMA	Low
Temperature extremes	Education and Awareness	Identify vulnerable community members through a survey and outreach	Town	2014	Town/FEMA	High
Temperature extremes	Local Planning and Regulation	Develop cooperative agreement with Arlington for sheltering of vulnerable populations	Town	2014	Town	High
Drought	Local Planning and Regulation	Monitor drought conditions	Town	Ongoing	Town	High
Drought	Education and Awareness	Provide educational materials on dealing with drought	Town	2015	Town/FEMA	Medium
Drought	Natural System Protection	Develop improved assessment of groundwater sources and amend bylaws to assure their protection	Vermont Geological Survey Town	2017	FEMA/State of VT	Medium
Drought	Local Planning and Regulation	Incorporate planning for droughts in the emergency management plan	Town	2014	Town	High
Wildfire[2]	Education and Outreach	Acquire materials from Firewise for homeowners and provide to Sunderland to make available for landowners	BCRC	2014	BCRC	High
Wildfire	Education and Outreach	Provide information on outdoor burning safety prior to the spring and fall fire seasons	Fire wardens	Ongoing	Fire wardens	High

[2] See Batcher, M. and J. Henderson 2013. Community wildfire protection plan for the towns of Arlington, Glastenbury, Sandgate, Shaftsbury and Sunderland. Prepared by the Bennington County Regional Commission, 111 South St., Suite 203, Bennington, VT

Table 23. Mitigation actions						
Hazard	Type[1]	Actions	Responsible Parties	Time Frame	Funding Source(s)	Priority
Wildfire	Education and Outreach	Provide a review of properties where owners request assessment of their properties for wildfire safety and adequate defensible space	BCRC, Arlington Fire Department	Ongoing	BCRC, Arlington FD	Medium
Wildfire	Education and Outreach	Encourage owners to maintain defensible space around structures and to mow fields along road edges to prevent wildfire	Town	Ongoing	Town	High
Wildfire	Local Planning and Regulations	Encourage defensible space around structures	Town	Ongoing	Town	High
Wildfire	Structure and Infrastructure Projects	Assure adequate water supplies are available including areas identified as gaps in the 2013 Community Wildfire Protection Plan	Town, Arlington Fire Department	Ongoing	Town/State of Vermont	High
Wildfire	Natural Systems Protection	Implement fuel reduction, particularly in grass fields and in areas of Green Mountain National Forest	Arlington Fire Department/Green Mountain National Forest	2014 and ongoing	Arlington FD/Green Mountain NF	Medium
Landslide and debris flow	Local Planning and Regulations	Map known landslides and identify potential landslide areas	Town/BCRC/State of Vermont	2015	FEMA	High
Landslide and debris flow	Local Planning and Regulations	Adopt fluvial erosion hazard bylaws	Town	2013	Town	High
Landslide and debris flow	Structure and Infrastructure Projects	Implement visual monitoring in potential landslide areas	Town	2015	Town	High
Landslide and debris flow	Structure and Infrastructure Projects	Stabilize and replant stream corridor areas subject to landslides	Town Batten Kill Conservancy	Ongoing	State of VT	High
Earthquake	Education and Awareness	Educate property owners on proper construction techniques to reduce potential damage from earthquakes	Town	2015	Town	Medium
Hazardous materials spill	Local Planning and Regulation	Complete an assessment of hazardous materials and potential accident locations	Town/LEPC 7	2017	Town	Medium
Hazardous materials spill	Structure and Infrastructure Projects	Work with VT AOT to create adequate crossing warnings at all RR crossings	VT AOT	2017	State	Medium

Table 23. Mitigation actions

Hazard	Type[1]	Actions	Responsible Parties	Time Frame	Funding Source(s)	Priority
Hazardous materials spill	Natural Systems Protection	Identify groundwater source areas and develop ordinances to protect those areas	Vermont Geological Survey	2017	State	Medium
Infectious disease outbreak	Local Planning and Regulations	Monitor disease occurrences and potential outbreaks	Town	Ongoing	Town	High
Infectious disease outbreak	Education and Outreach	Provide educational materials in printed form and on the town web site on potential infectious diseases	Town	2015	Town/State of Vermont	High
Invasive species	Local Planning and Regulations	Monitor extent of invasive species, particularly forest invasive species such as Emerald Ash Borer	Town	2014 and ongoing	Town	High
Invasive species	Local Planning and Regulations	Complete surveys for ash trees vulnerable to Emerald Ash Borer	Town; Bennington County Conservation District	2014	FEMA	Medium
Invasive species	Local Planning and Regulations	Survey for invasive species (e.g., Japanese knotweed)s along streams to identify potential erosion areas	Batten Kill Conservancy	2015	State of Vermont	Medium
Invasive species	Local Planning and Regulations	Encourage use of native species in plantings for commercial and residential development	Town	2014 and ongoing	Town	Medium
Invasive species	Education and Awareness	Provide outreach materials for landowners on using native plants and controlling invasive species	Town/ Bennington County Conservation District	2014 and ongoing	Town/State of Vermont	High

E. Monitoring and Revising This Plan

1. Annual Review

This plan will be integrated into existing planning efforts when appropriate. During the annual budget process, the status of proposed projects as well as any newly identified projects will be reviewed by the Select Board. If necessary, the plan will be amended to include these new projects. During Town Meeting Day, members of the public will be afforded the opportunity to comment on the status of any projects and on any needed changes to the hazard mitigation plan.

Toward the end of the five year period covered by this plan, the Select Board will initiate a review of the plan, by:

1. Updating the analyses of events using new information since completion of the 2014 draft
2. Identification of any new structures
3. Evaluation of potential probability and extent of hazards based on any new information since completion of the 2014 plan.
4. Review of completed hazard mitigation projects
5. Identification of new projects given the revised hazard evaluation

The Select Board will hold open meetings to solicit opinions and to identify issues and concerns from members of the public and stakeholders. The Town of Sunderland elect Board will work with the Bennington County Regional Commission and the State Hazard Mitigation Officer (SHMO) to review and update their programs, initiatives and projects based on changing local needs and priorities. BCRC will assist in any necessary coordination and communication with neighboring towns to assure that mitigation actions address regional issues of concern. The revised plan will be submitted for review by the State Hazard Mitigation Officer and FEMA and revised based on their comments. Following approval by FEMA, the Select Board will adopt the completed plan.

Should a declared disaster occur, Sunderland may undertake special review of this plan and the appropriate updates made. After Action Reports, reviews, and debriefings should be integrated into the update process. The plan should also be updated to reflect findings of the river corridor plan, culvert study and other studies.

2. Emergency Operations Plan

Emergency Operation Plans provide contact information and list the steps to setting up an incident command structure, assessing risks and vulnerabilities, and providing for resources and support.

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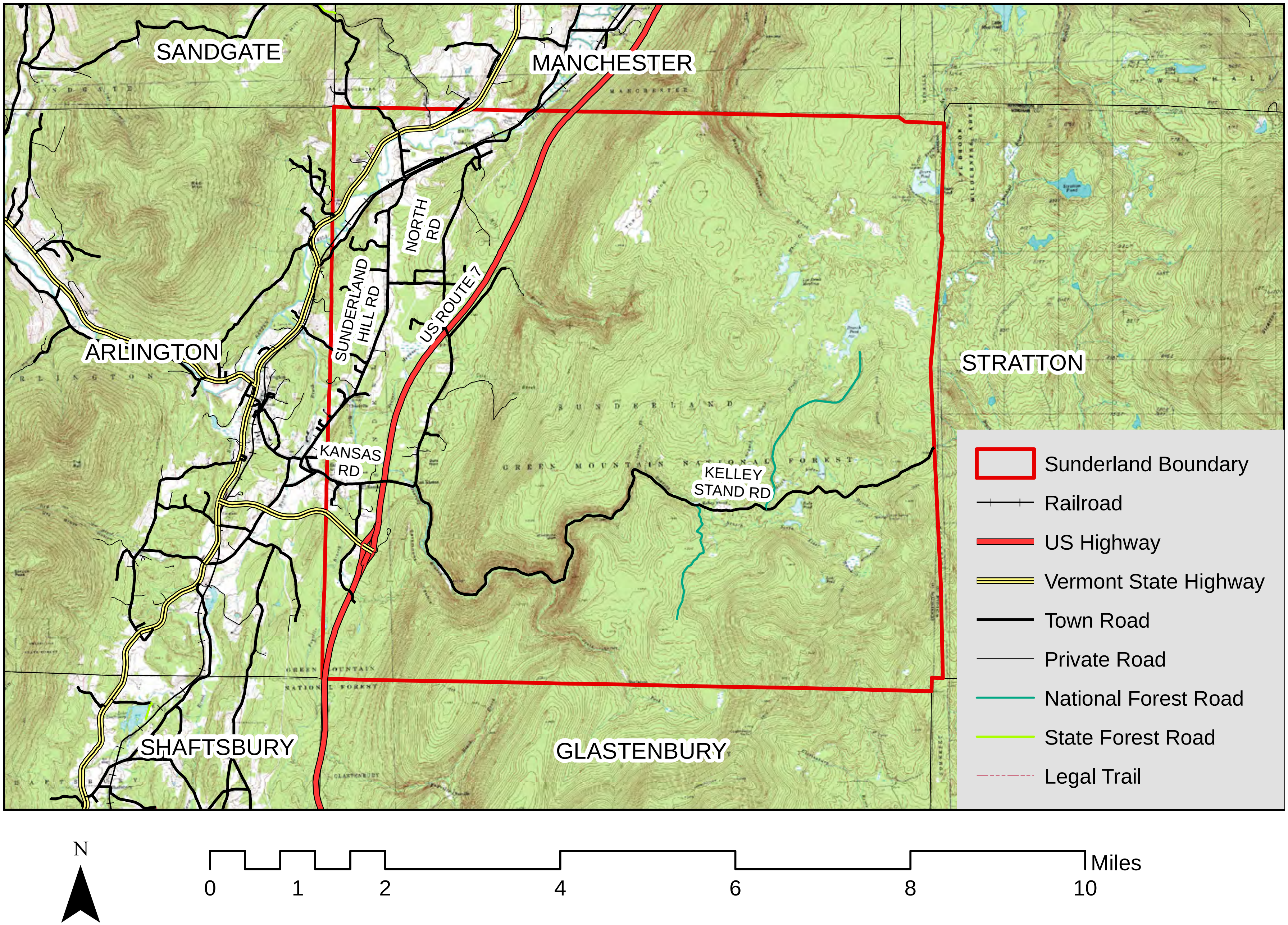
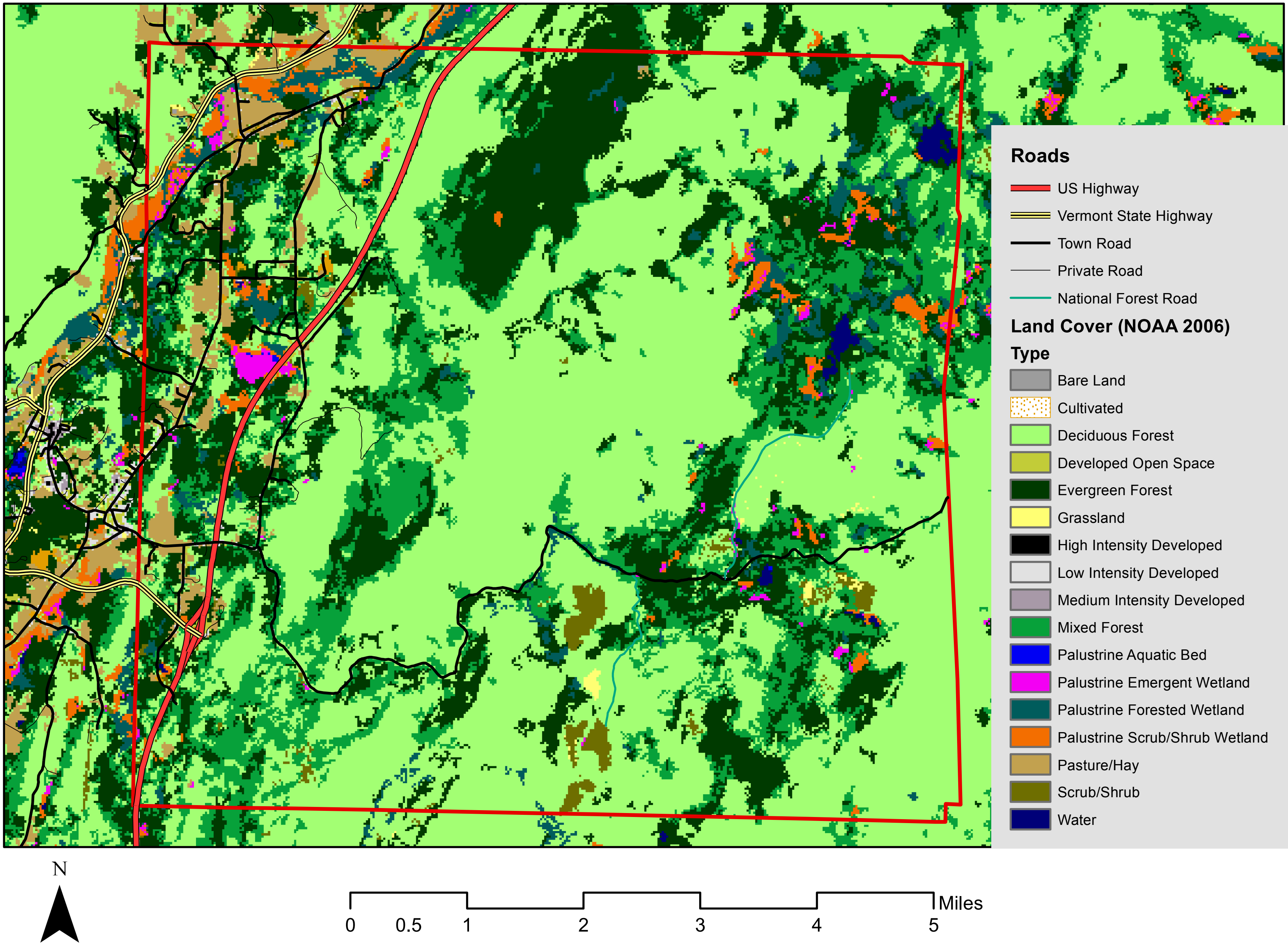
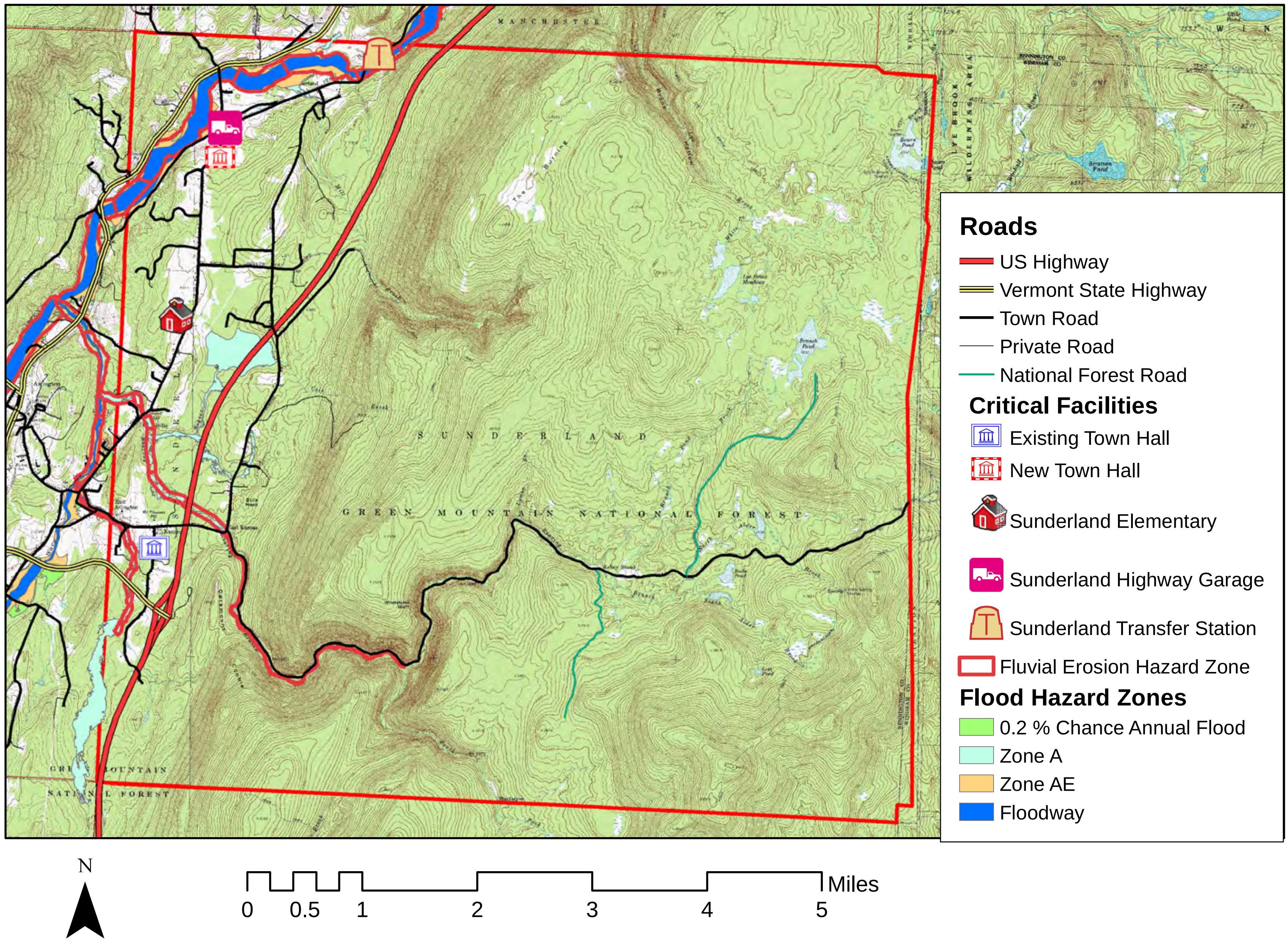
Map 1. Town of Sunderland



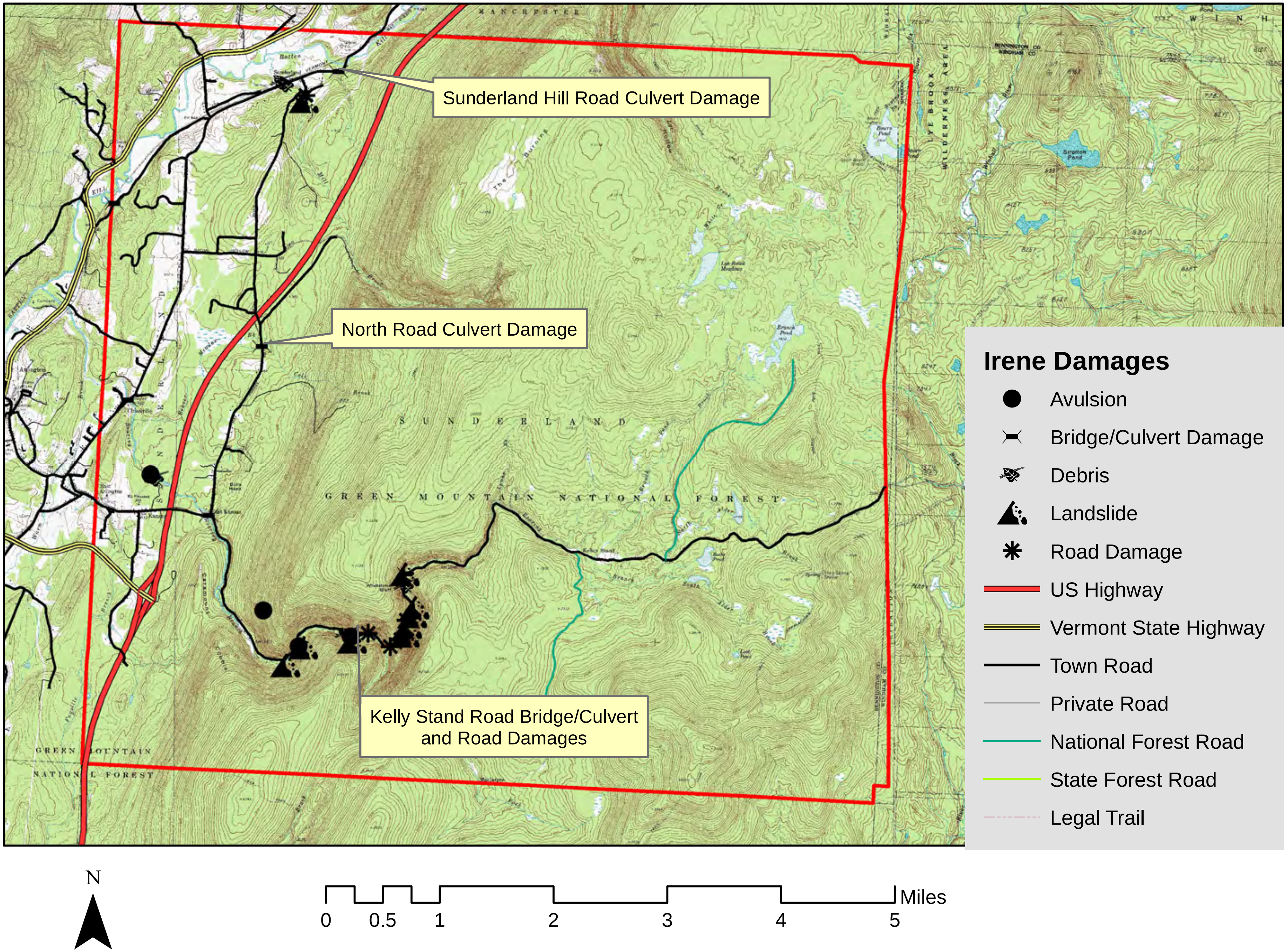
Map 2. Land Cover (NOAA 2006)



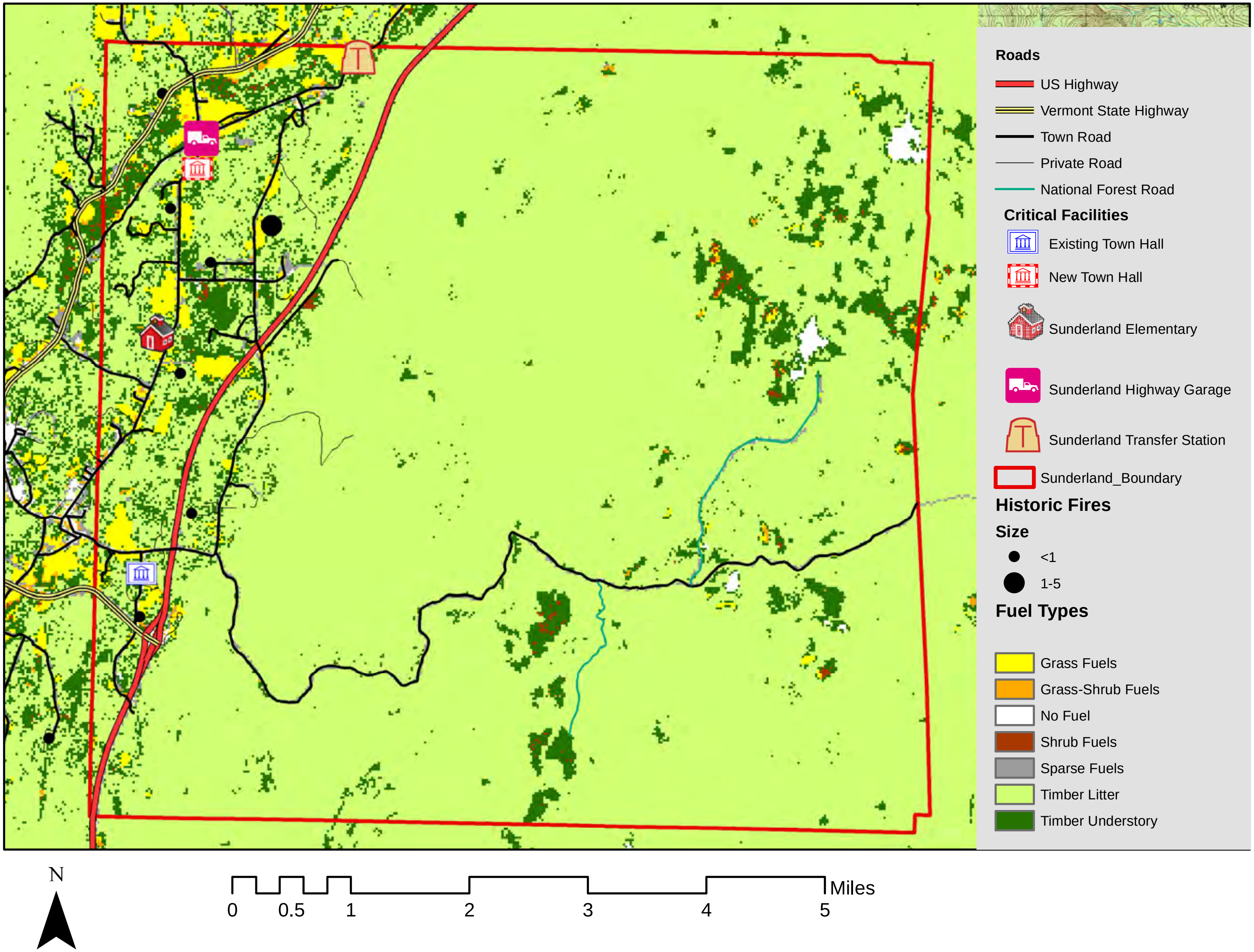
Map 3. Flood Zones and Fluvial Erosion Hazard Zones



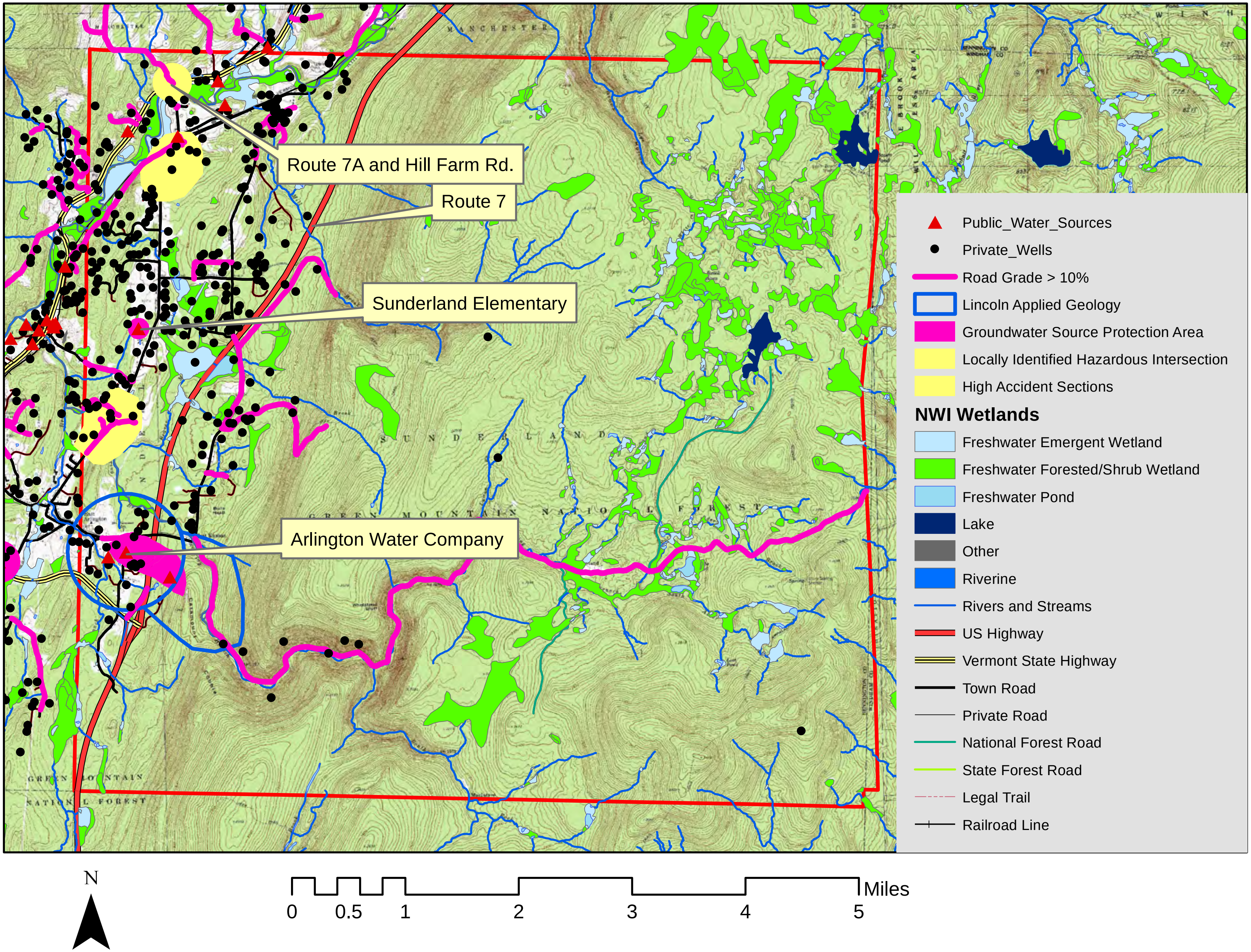
Map 4. Damages from Tropical Storm Irene



Map 5. Historic Wildfire and Major Fuel Types



Map 6. Water Resources and Potential Accident Hot Spots



Map 7. Fuel Treatment Areas