Town of Landgrove
Hazard Mitigation Plan

September 29, 2015

Town of Landgrove
88 Landgrove Road
Landgrove, VT 05148

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I. Introduction

A. Purpose

Hazard mitigation is intended to reduce potential losses from future disasters. Hazard mitigation plans identify natural hazards that could affect a community such as flooding, landslides, wildland fire, and similar events and provide an array of specific projects and actions to reduce risks and damage from those hazards (FEMA 2011).

This plan is intended to identify, describe and prioritize potential natural hazards that could affect the Town of Landgrove in Bennington County, Vermont and measures to reduce or avoid those effects. The Federal Emergency Management Agency, within the U.S. Department of Homeland Security and the Vermont Division of Emergency Management and Homeland Security 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 a list of planning committee members 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, 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 Local Emergency Operations 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), Landgrove identified and prioritized mitigation actions that are specifically described in Section V.D.

II. Town Profile

Landgrove is a small rural town located in Bennington County, and is situated on the eastern slope of the Green Mountains in Southern Vermont. The town is bordered by Weston to the north and east, Londonderry to the southeast, Winhall to the southwest, and Peru to the west (Map 1). The Town is 5,696 acres and is located in the Green Mountains/Berkshire Highlands ecoregion, which is characterized by steep terrain and primarily northern hardwood forests. Landgrove is also located within the Connecticut River watershed (Landgrove Town Plan 2012, U.S. EPA 2015). The town's topography is defined by the level land in the Utley Flats area, a significant rise in elevation in the northeastern part of town, a prominent hill south of Route 11 and several stream valleys (Landgrove Town Plan 2012).

The town was legally chartered in 1780 with its municipal limits being determined largely by the boundaries of adjacent towns. Most development is located in the Village along Utley Brook at the lower end of Utley Flats (Map 1). The architecture and orientation of buildings in Landgrove continue to reflect the traditional New England village character that is an important part of the town's appeal (Landgrove Town Plan 2012). The Meetinghouse (built in 1857) and the Farmers and Mechanics Hall (built in 1874) are important structures to the town. These two buildings were recently expanded into one building, which is now the Landgrove Town Hall. The Town Hall is located north of the Village, at the edge of Utley Flats and remains an important community asset today (Landgrove Town Plan). Table 1 summarizes the number of structures by type in Landgrove.

Table 1. Number of buildings by type. Source: VCGI 2014 E911 data	
Type	Number
Single-family residential	139
Mobile home (E911 data showed 2 mobile homes, planning committee identified only 1)	2
Other residential	2
Commercial	2
Commercial Farms	1
Lodging	4
Camp	19
Town Hall	1
Accessory Building (Maintenance Garage)	1
House of Worship	1
Other	5
Total	176

The Town of Landgrove has a current population of 158 residents (Census 2010). The town has thirteen businesses, employing 50 people (Landgrove Town Plan 2012). There are an estimated 105 residents in the workforce (American Community Survey 2008-2012). Most commute to work, with a mean travel time of 17 minutes, indicating that many residents work in the general area (American Community Survey 2008-2012). There are also 34 residents that work from home (Landgrove Town Plan 2012).

The Green Mountain National Forest owns over 700 acres of forestland in Landgrove (Landgrove Town Plan 2012). Most of Landgrove is forested, consisting primarily of northern hardwood forests but also of conifer forests with spruce-fur (Landfire Data Distribution Site 2014). Land cover can be seen in Map 2. Soils in Landgrove are formed in glacial till and tend to be shallow and/or wet, thereby limiting the potential for on-site wastewater disposal systems and limiting development in a number of areas (Landgrove Town Plan 2012). Landgrove has three town forests – Lynn Pitcher Memorial Forest is approximately 10 acres, Bobby Comfort Town Forest is approximately 13 acres, and Wendy Evarts Memorial Forest (acreage is currently unknown). The Fontain Trust and the Vermont Land Trust manages conservation land. There are also numerous parcels and there is also current-use land or use value assessment (UVA) lands, which are maintained as forest or agricultural lands by private owners in exchange for property tax assessment as it is currently used (VNRC 2013).

Landgrove has just over 15 miles of public roads (Vermont Agency of Transportation 2013). None of the roads in Landgrove are paved; except for VT Route 11, which is the only state highway in town and travels through the southern end of town for less than a mile before crossing the town boundary. Table 2 lists the roads in Landgrove. Class 2 Town Highways serve as principle travel routes throughout town and connect to bordering towns and Route 11, Class 3 Town Highways primarily provide direct access to individual properties, and Class 4 segments are not maintained for vehicular use (Landgrove Town Plan 2012). Roads and their classes can be seen in Maps 1 and 2.

Table 2. Roads in Landgrove by type. Source: Vermont Agency of Transportation 2015	
Road Type	Miles
State Highways	0.821
Class 1 Town Highways	0.00
Class 2 Town Highways	4.820
Class 3 Town Highways	9.55
Class 4 (not maintained)	1.50
Total amount of roads	**15.191** (Class 2, 3 and State Highway)

There is one identified critical facility in Landgrove, the Town Hall, though close, it is not in the floodplain, and one identified service in town, The Landgrove Inn. However, the Inn does not provide goods to the residents of Landgrove. There are no schools, childcare or elderly care facilities located in Landgrove. Children typically attend the Flood Brook School, located near the Landgrove/Londonderry town line on Route 11 in Londonderry, for kindergarten through eighth grade, then various schools in the area for high school.

There are no emergency services located in Landgrove. There is an agreement between Landgrove and Londonderry for emergency services, including the use of their shelter when needed. The town typically receives emergency services from the Londonderry fire department, the Londonderry Rescue Squad and the Vermont State Police from the Rockingham barracks (Landgrove Town Plan 2012). However, the town can also receive assistance from the Peru and Weston fire departments. Health care is available at the Mountain Valley Medical Center, located near the Landgrove/Londonderry town line on Route 11. Other health services in the area are the Vermont Center for Independent Living, and the Mental Health Service of Southeast Vermont. The nearest hospitals are located in Springfield, Rutland, and Bennington. The closest emergency shelter is located in Londonderry at the Flood Brook School (2.6 miles). The shelter is a Red Cross shelter and is a warming (evacuation) shelter and an overnight shelter. The shelter can hold up to 340 people for an evacuation, and 125 people overnight. The school doesn't have a generator but the Town of Londonderry is working on an HMGP grant to install a generator. If Landgrove residents were unable to get to the Flood Brook School, the Landgrove Town Hall could possibly be used as a shelter, but the building is not currently set up to be a shelter.

III. Planning Process

The Town of Landgrove has never had a Hazard Mitigation Plan. The Bennington County Regional Commission began discussions with the town on developing a Hazard Mitigation Plan in July 2014. The Landgrove Hazard Mitigation planning committee consisted of the members listed in Table 3 below.

Table 3. Planning committee members	
Name	Affiliation
Jeremiah Evarts	Select Board Chair
John Ogden	Select Board
Greg Eckhardt	Select Board
Andrea Ogden	Treasurer
Chrystal Cleary	Town Clerk

Table 4. Dates of planning meetings, and public and agency review	
Meeting	Date (s)
Select Board initiates planning process	July 24, 2014
Planning Committee meeting	August 14, 2014
Planning Committee meeting	September 11, 2014
Planning Committee meeting	September 25, 2014
Planning Committee meeting	October 9, 2014
Final Planning Committee meeting	October 23, 2014
Draft made available for public and agency review by the planning committee	November 20, 2014
Select Board approved the plan for release	December 23, 2014

The above meetings were warned and comments were solicited from members of the public, business owners and other stakeholders. During each meeting, certain areas of the plan were discussed and information was gathered from the select board and others present at the meetings. Some of the information gathered at the meetings included past weather events, areas of damage from past weather events, high accident locations, types of buildings and critical facilities, town programs, recent studies and reports, emergency services, condition of bridges, condition of roads and culverts, sensitive areas, and hazard mitigation goals and actions. The planning committee answered the majority of, if not all, the questions. Members of the public that attended the meetings had equal opportunity to comment during each discussion. Each meeting was discussion based and if anyone had input, they were encouraged to share it with the planning committee and the BCRC staff present. John Ogden was the point of contact between the town and the BCRC. If members of the public wanted to provide feedback, they could contact John Ogden, and the feedback would be passed on to the BCRC. There was no feedback received from the public.

Information was collected from the Road Commissioner about various problem areas: roads, culverts, steep grades and beaver dams. Information was also collected from the Emergency Management Director of Londonderry about emergency services and the Flood Brook School shelter.

The draft plan was posted to the Bennington County Regional Commission and Town of Landgrove websites, and notices sent out to members of the public informing them that they could review the plan on the town website or in the Town Hall in Landgrove. The plan was sent to the neighboring towns of Weston, Londonderry, Winhall and Peru, and the Windham Regional Commission for comments. The plan was also sent to Local Emergency Planning

Committee 7, which includes Landgrove, for comment. The Vermont Department of Emergency Management and Homeland Security then reviewed the plan. No comments were received.

The plan was submitted for review by the Federal Emergency Management Agency on _____. Following FEMA review, the Landgrove Select Board adopted the plan 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 storm events database (most recent data from the ftp site), the FEMA list of past disaster declarations, the Vermont Department of Forests, Parks, and Recreation for data on wildfires, HAZUS runs for potential earthquake damage, drought indices from the National Oceanographic and Atmospheric Administration (NOAA), the Vermont Agency of Natural Resources (VT ANR) for hazardous materials spills, the Vermont Department of Health for infectious disease outbreaks, VT ANR for invasive species information, the Vermont Hazard Mitigation Plan, and local knowledge.

In addition to the data sources above, the National Weather Service Cooperative Observer Station (Station Name: PERU VT US, COOP: 436335) in Peru, Vermont was used to gather information on past weather events for Landgrove. This station is located just west of the Landgrove/Peru town line at Latitude 43.2667, Longitude -72.9. This station provides precipitation and snow data from 1940 to present. Furthermore, two high water marks on Flood Brook from Tropical Storm Irene were located and mapped by the USGS, which was taken into consideration when addressing flood hazards.

With the exception of the high water marks, past natural hazard and weather related information has not been documented specifically for Landgrove; records regarding this information do not exist for the town. Because of this, the above referenced data from the state, county and nearby towns (i.e. the Peru Cooperative Observer Station) was used to convey the history of hazards addressed in this plan.

With respect to the NCDC data, there have been numerous changes to the database in the last few years. While NCDC data goes back to 1950, there was a dramatic change in 1996 in the way data was collected. The number of events recorded in years prior to 1996 is far less than from 1996 onward. Therefore, to use the best reliable data, only data from 1996 onwards was used. Cooperative weather observers for Peru, Sunderland and Pownal have the most consistent long-term data and the only stream gauge in Bennington County is for the Walloomsac River in Bennington near the New York border (over 36 miles southwest of Landgrove). There are no stream gauges located in or near Landgrove.

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 streams. 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. 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 mid-winter thaws in January and February and in March and April as spring approaches. Flash floods can occur after spring melt of mountain snow, following large storms such as Tropical Storm Irene, or after significant thunderstorms.

Flood Resilience is a statewide goal (24 VSA Chapter 117 § 4302 (14)) and achieving that goal requires protection of both the floodplain and river corridors. The main streams in Landgrove are Utley Brook and Flood Brook. Utley Brook, and several small tributaries, flow through the northern section of town. Flood Brook is in the southern part of town and flows under VT Route 11. Within Landgrove, areas along Utley Brook and Flood Brook fall within the A zone which represents the area where there is a one percent chance of a flood event in any given year, but the necessary hydraulic studies to create base flood elevations have not been completed (Map 1).

River corridors, also shown on Map 3, have been mapped by the Vermont Agency of Natural Resources. Fluvial erosion is erosion caused by streams and rivers. Fluvial erosion can be catastrophic when a flood event causes a rapid adjustment of the stream channel size and/or location. Most disaster damage in Vermont is related to flooding and fluvial erosion. When river channels become encroached and channelized, their erosive power cuts down in the channel and can prevent high flows from flooding (and slowing) and simultaneously increasing erosive and damaging stream power. River corridors provide the lateral space for stream and river channel adjustments as needed to maintain fluvial geomorphic equilibrium, allowing the channel to avoid down-cutting, maintain access to its floodplains, and reduce the velocity and damaging power of high flows.

River corridors include the meander belt of the channel and a fifty-foot buffer to allow for stable bank conditions adjacent to structures. On smaller streams, with watersheds of less than two square miles, the corridor dimension is considered protected by a setback from the top of the bank. River corridors were previously called fluvial erosion hazard (FEH) areas and the Landgrove Town Plan discusses these areas. River corridors are protected through state permits that the state issues directly and that have bearing on river corridor protection. These include Act 250, Section 248 and proposals exempt from municipal regulation. Communities are not required to protect river corridors, but the Emergency Relief and Assistance Fund (ERAF) provides an incentive for municipalities that take steps to become more flood resilient by adopting local bylaws that protect river corridors. Currently, Landgrove does not have river corridor bylaws.

Landgrove is a part of the National Flood Insurance Program (NFIP) and does not have any repetitive loss structures. Digital Flood Insurance Rate Maps were produced by FEMA using LIDAR mapping technology in 2012. The proposed flood hazard area maps are going through the public review process. DFIRM maps will become effective in December 2015, with adoptions expected shortly after. Map 3 shows the location of the existing 100-year floodplain and the proposed 100-year floodplain. There are no buildings located in the proposed special flood hazard areas, however, there are five buildings located in the existing FIRM's dated September 18, 1985. There are also seven structures, including the town hall, located in the river corridor.

There are two bridges on Utley Brook, the Hapgood Pond Road Bridge (Bridge Number 4L), a two-span bridge built in 1934, and the Landgrove Road Bridge (Bridge Number 5), a three-span bridge built in 1930 (Map 3). When Utley Brook floods, it is common for erosion to occur at the base of the Hapgood Pond Road Bridge. The Hapgood Pond Road Bridge is currently known as the most hazardous structure in Landgrove, as the river is changing its course and is creeping towards the southern buttress. A support wall was built pre-Irene to protect the bridge but suffered severe erosion during the tropical storm. The wall is still keeping the buttress from being exposed to the river, however, it is suspected that the support wall and bridge will be seriously damaged during one of the next major storm events.

b. Previous Occurrences

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" to 9". Following a rainy October, this storm occurred from November 2 through November 4, causing extensive flooding. Both of the bridges in Landgrove were built shortly after this storm, so it is likely that the storm washed the bridges out.

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. In 1973, two roads that exit the town were washed out and Hapgood Pond Road was flooded from heavy rains. The roads were out for a few days.

Table 5 shows a total of 49 flood events in Bennington County from 1996 to 2014, using NCDC data. These have been primarily minor and affected either specific streams or towns, not all have been countywide. Table 6 describes eleven moderate and extreme events that have occurred since 1990, using the National Weather Service (2010) categories, which likely affected Landgrove. These events were described in the National Climate Database records (2014). 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. Total number of flood events by type and year for Bennington County. Source: NCDC 2014

Year	Flash Flood	Flood	Total
1996	3	6	9
1997			
1998	1	3	4
1999	2		2
2000	4	1	5
2001			
2002	1		1
2003		2	2
2004	1	5	6
2005		5	5
2006		1	1
2007	1	1	2
2008			
2009	2		2
2010			
2011	3	3	6
2012			
2013	4		4
2014			
Total	22	27	49

Table 6. Significant flood events affecting Bennington County. Source: NCDC 2014					
Dates	Type	Description	Area	Category	FEMA
19-20 Jan 1996	Flood	An intense area of low pressure located over the Mid-Atlantic region produced unseasonably warm temperatures, high dew points and strong winds. This resulted in rapid melting of one to three feet of snow. In addition to the rapid snowmelt 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 0.90" of rain in Peru.	Countywide	Moderate	DR-1101 19 Jan to 2 Feb 1996
11-12 May 1996	Flood	A low-pressure system tracked across New York State and New England, moved to the east coast and 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 3.13" of rain in Peru from May 11-13.	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. There was no Cooperative Weather Observer data recorded in Peru during January 1998, but a Cooperative Weather Observer in Sunderland recorded 3.81" of precipitation.	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 5.75" of rain in Peru from September 16-18.	Countywide	Moderate	DR-1307 16-21 Sept 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 4.48" of rain in Peru from July 15-17.	Northeast Bennington County Southern Bennington County Arlington Bennington Shaftsbury	Moderate	DR-1336 14-18 July 2000
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. There was no Cooperative Weather Observer data recorded in Peru during December 2000.	Peru Dorset West Rupert	Moderate	DR-1358 16-18 Dec 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). There was no Cooperative Weather Observer data recorded in Peru during July 2003, but 6.36" of rain was recorded from August 2-7, .88" from August 10-13, and 2.69" from August 18-19.		Moderate	DR-1488 21 July to 18 Aug 2003

Table 6. Significant flood events affecting Bennington County. Source: NCDC 2014					
Dates	Type	Description	Area	Category	FEMA
31 Mar to 2 Apr 2004	Flood	Three inches of rain and melting snow caused flooding along the Batten Kill and Walloomsac Rivers. A Cooperative Weather Observer recorded 1.77" of rain in Peru from April 1-2.	Arlington Bennington	Minor	
16-17 Apr 2007	Flood	An intense coastal storm spread heavy precipitation across Southern Vermont, starting as a mixture snow, sleet and rain that later changed to all rain. Liquid equivalent precipitation totals ranged from three to six inches leading to minor flooding across portions of Southern Vermont. A Cooperative Weather Observer recorded 3.92" of rain in Peru.	Arlington	Minor	DR-1698 15-21 Apr 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. This resulted in widespread flash flooding and river flooding across Southern Vermont. 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. Route 9, the main route across Southern Vermont, was closed. The town of Bennington was inaccessible for a period of time. Record flooding occurred on the Walloomsac River at Bennington. No Cooperative Weather Observer data was recorded in Peru from August 28-30, but 5.6" of rain was recorded on August 31. 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. Note: Tropical Storm Irene is also listed under the High Wind Events section of this plan, as Landgrove had reported downed trees from the storm.	Statewide Countywide	Extreme	DR-4022 27 Aug to 2 Sept 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. This heavy rainfall, combine with saturated soil from excessive rains, led to widespread minor to moderate flooding across Southern Vermont. A Cooperative Weather Observer recorded 4.25" of rain in Peru from September 5-8.	North Bennington Countywide	Moderate	

In addition to the above observations, a Cooperative Weather Observer in Peru recorded 8.34" of rain from August 6 to 14, 1990, 12.12" from October 8 to 27, 2005, 6.45" from September 28 to October 8, 2010 and 9.46" from June 24 to July 11, 2013, but no damage was recorded.

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. Landgrove has been subjected to two major tropical storms in the past twenty years but luckily has not sustained much damage.

c. Extent and Location

Damage from past floods has been minimal in Landgrove. The town does not experience as much flooding from major storms as nearby towns because it is near the top of the Connecticut River watershed. The town's location makes the likelihood of a storm causing severe flood damage relatively low. There have been no NFIP-designated repetitive losses in Landgrove.

During Irene, flooding was not major but Utley Brook jumped the bank and washed away a local farmers hay bales. The storm caused downed trees and some minor road damage. The Buffum Hill segment of Landgrove Road suffered some erosion along the sides, and Uphill Road was damaged when a beaver dam blew out on a small, unnamed creek (Map 3). Flood Brook flooded upstream but didn't cause any damage in Landgrove.

Two high water marks on Flood Brook were located and mapped by the USGS after Tropical Storm Irene. One mark was within the 100-year floodplain; the other was slightly outside but not enough to be noteworthy. In other words, the new FEMA floodplain maps appear to be accurate because flooding was in line with the 100-year floodplain.

During major storms or heavy rains, there are several locations in Landgrove where the roads experience erosion. Sometimes the roads even become impassable. Road erosion in Landgrove is typically caused where beaver dams alter flow, near springs or where culverts may be undersized or have become eroded. These locations are shown also on Map 3. Road erosion on Cody Road is located in the town of Londonderry but was included in Map 3 because Landgrove maintains the road.

In addition to the above events, the Peru, Pownal and Sunderland Cooperative Observer recorded precipitation. Table 7 shows those months by year where that value exceeded the 90th percentile. Several events of that magnitude have occurred where damage was not recorded in NCDC records or local knowledge, but this does provide additional information on potential flooding extent.

Table 7. Months where rainfall exceeded the 90th percentile of monthly precipitation at the **Peru, Pownal and Sunderland** Cooperative Observer Stations from 1990 to 2013. Years in ***bold italics*** corresponded with events in Table 6.

	Sunderland	Pownal	Peru
Month	Year	Year	Year
January	1990, ***1998***, 1999	***1996***, ***1998***, 1999	1990, 1999
February	2002, 2008, 2011	1990, 2008	2000, 2002, 2008
March	2001, 2007, 2008	1999, 2001, 2007	2001, 2008
April	1993, 1996, 2002, ***2007***, 2011	1990, 1993, 1996	1996, ***2007***
May	1990, 2000, 2006	1990, 2013	1990, 2012
June	1998, 2002, 2006	1998, 2000, 2002, 2013	1998, 2006, 2011, 2013
July	1996, 2004, 2008	2004, 2010	1996, ***2000***, 2013

Table 7. Months where rainfall exceeded the 90th percentile of monthly precipitation at the **Peru, Pownal and Sunderland** Cooperative Observer Stations from 1990 to 2013. Years in ***bold italics*** corresponded with events in Table 6.			
August	1990, ***2003***, ***2011***	1990, 1991, ***2003***, 2011	1990, 2003, ***2011***
September	***1999***, 2003, ***2011***	***1999***, 2004, 2011	***1999***, 2003, ***2011***
October	2005, 2007, 2010	1995, 2003, 2010	1995, 2005, 2006, 2010
November	2002, 2004, 2005	2005	2002
December	1996, 2003, 2008	1990, 2003, 2011	1996

Map 3 shows the following areas potentially affected by flooding:

Special Flood Hazard Areas: These are areas mapped by FEMA and using the LIDAR derived areas currently under review. Table 8 shows the number of structures, by type, in the special flood hazard area and river corridor shown in Map 3.

River Corridors: In Vermont, most rivers flow through relatively confined valleys, but still meander over time across the floodplain. River corridors provide an area within which a river can move across the landscape as it dissipates energy and transports and deposits sediments. In 2014, the Vermont Agency of Natural Resources developed a procedure for flood hazard and river corridor protection, which defines both of those areas, involves towns in protection and management and provides best management practices, including model bylaws for regulating development in those areas. River corridors were determined by calculating the "meander belt width" or area within which a river would move, using information on stream size and adding a buffer component. River corridors will be used in Act 250 reviews, in stream alteration permits, in activities not regulated by towns and in town ordinances if river corridors are regulated. Mapping of river corridors was accomplished primarily using geospatial data and will be modified by VT ANR river scientists using available field data. Currently, the river corridor is not regulated by the town.

Fluvial Erosion Hazard Areas: These areas were developed prior to the statewide river corridor map through the stream geomorphic assessments involving both geospatial analyses and collection and analysis of field data. However, this data was not developed in Landgrove.

Table 8. Structures by type in flood hazard areas in Landgrove, VT. Source: Vermont Center for Geographic Information www.vcgi.org		
Type	Number in Special Flood Hazard Area	River Corridor
Residential	0	5
Town Hall	0	1
Other	0	1
Total	0	7

d. Probability, Impact, and Vulnerability

Based on data from 1996 to 2014, nine moderate or major flood events have affected Bennington County, resulting in a 50% chance of such an event occurring in any given year. However, these have not all directly affected Landgrove, so that probability should range from 10-50% each year. Based on information from the Vermont Center for Geographic Information and town knowledge, there are no structures in the special flood hazard area but there are seven structures located in the river corridor. Therefore, the potential proportion of town damaged from severe flooding would range from 1-10%, with injuries of 1-10%. There are no town services that would need to recover quickly after a storm for the town to function again. However, help for specific property owners may take quite a while depending on the severity of the storm and road conditions.

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. The "Blizzard of 93", one of the worst storms on record virtually shut down Vermont on the weekend of March 13-14 forcing the closure of roads and airports. Snowfall amounts ranged from 10” to 28” across the state.

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 9 summarizes the 135 winter storm events that have occurred in Bennington County between 1996 and 2014. As can be seen, a high numbers of events occurred in 1997, 2007, 2008, 2009, and 2011. 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 93” was categorized as “Extreme”. Table 10 describes these events.

Table 9. Total number of winter storm events by type and year for Bennington County. Source: NCDC 2014

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						
2007		3	1	6	4	14
2008		4	1	1	11	17
2009		3		1	10	14
2010		3		1	2	6
2011				5	5	10
2012				4	2	6
2013		2		1	4	7
2014		2		4		6
Totals	1	27	2	64	41	135

Table 10. Significant winter storm events in Bennington County and Landgrove. Source: NCDC 2014

Dates	Type	Description	Category	Area
2-3 Jan 1996	Heavy Snow	Heavy snow fell across Southern Vermont with the average snowfall ranging from 10-12". A Cooperative Weather Observer recorded 12" in Peru from January 2 to 4.	High	Southern Vermont
12-13 Jan 1996	Heavy Snow	Heavy snow fell across Southern Vermont with snowfall totals ranging from 6-10" with a few locations reporting up to 12". A Cooperative Weather Observer recorded 9" in Peru on January 13.	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. There was no Cooperative Weather Observer data recorded during November 1996.	High	Southern Vermont
7-8 Dec 1996	Winter Storm	A major storm dumped heavy, wet snow across Bennington and Windham Counties. Approximately 20,000 customers lost power. A Cooperative Weather Observer reported 19.8" in Peru from December 7 to 9.	High	Southern Vermont
31 Mar to 1 Apr 1997	Winter Storm	A late season storm that changed from rain to snow brought 12" of snow to Shaftsbury and 23" to Bennington. A Cooperative Weather Observer recorded 12.5" of snow in Peru on April 1. Power outages were widespread, and Route 9 between Bennington and Brattleboro was closed.	High	Southern Vermont Peru Bennington Shaftsbury
29-30 Dec 1997	Winter Storm	Heavy snow and gusty winds 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. A Cooperative Weather Observer reported 14.5" in Peru from December 30 to 31.	High	Southern Vermont Peru Bennington
2-3 Jan 1999	Winter Storm	Sleet and freezing rain resulted in significant ice accumulations across the county.	Moderate	Southern Vermont

Table 10. Significant winter storm events in Bennington County and Landgrove. Source: NCDC 2014

Dates	Type	Description	Category	Area
14-15 Jan 1999	Winter Storm	Snow, followed by sleet and freezing rain, along with very cold conditions resulted in heavy accumulations. A Cooperative Weather Observer reported 8" in Peru on January 15.	High	Countywide Dorset
18-19 Feb 2000	Winter Storm	Bennington and Windham Counties received 8-14" of snow. A Cooperative Weather Observer reported 14.3" in Peru from February 19 to 20.	High	Southern Vermont Peru
30-31 Dec 2000	Winter Storm	6-12" of snow fell, with 13" recorded in Pownal and 8" in Bennington. There was no Cooperative Weather Observer data recorded in Peru for December 2000.	Moderate	Southern Vermont
5 Feb 2001	Winter Storm	Heavy snow fell resulting in 12" in Bennington, 14" in Pownal Center, and 9.6" in Sunderland. A Cooperative Weather Observer reported 12" of snow in Peru.	Moderate	
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 25" of snow in Pownal and 18.1" in Sunderland. A Cooperative Weather Observer recorded 20" in Peru from March 5 to 7.	High	Southern Vermont Peru Pownal
30-31 Mar 2001	Winter Storm	Heavy wet snow resulted in 9.8" of snow in Sunderland. A Cooperative Weather Observer recorded 15" in Peru from March 30 to 31. Windham County had similar amounts.	High	Southern Vermont Peru Sunderland
6-7 Jan 2002	Winter Storm	A snowstorm produced over a foot of snow across Southern Vermont with 15" of snow recorded in Pownal, and 14" in Sunderland by Cooperative Weather Observers. The Cooperative Weather Observer in Peru recorded 17" from January 7-8.	High	Southern Vermont Pownal
17 Nov 2002	Winter Storm	A storm started with 2-4 inches of snow but changed to freezing rain and gusty winds. There were power outages from Arlington into New York.	High	Southern Vermont Arlington
25-26 Dec 2002	Winter Storm	Snow fell at a rate of 1-3" per hour for a time with 16.2" recorded in Sunderland, 10.5" in Pownal, and 16.5" in Windham County. There was no data for Peru for December 2002.	High	Southern Vermont
6-8 Dec 2003	Winter Storm	The first major storm of the season produced 10-20" across Southern Vermont. Cooperative weather observers measured 21.5" in Pownal and 21.3" in Sunderland. The Cooperative Weather Observer in Peru recorded 11" of snow from December 6 to 7.	High	Southern Vermont Pownal
28 Jan 2004	Winter Storm	Extreme Southern Vermont experienced 7-13" of snow with 12.6" in Sunderland, 9" in Pownal, and 7.5" in Windham County. Only 3.7" was reported in Peru from January 28 to 29.	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. A cooperative Weather Observer recorded 14" of snow 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 Mar 2007	Winter Storm	A mix of snow and sleet fell with over one foot in higher elevations and some freezing rain. Landgrove reported 15"and Woodford reported 12". A Cooperative Weather Observer recorded 11.2" of snow in Peru from March 2 to 3.	High	Southern Vermont Woodford Landgrove
16-17 Mar 2007	Heavy Snow	This storm brought widespread snowfall amounts of 10-18" across Southern Vermont. A Cooperative Weather Observer recorded 13.5" of snow in Peru from March 17 to 18.	High	Southern Vermont

Table 10. Significant winter storm events in Bennington County and Landgrove. Source: NCDC 2014

Dates	Type	Description	Category	Area
4-5 Apr 2007	Winter Storm	A mix of rain, sleet and freezing rain changed to snow by the evening. Snow fell overnight, heavy at times, before ending in the morning. Snowfall amounts of 10" were reported in Landgrove and Woodford.	Moderate	Southern Vermont Woodford Landgrove
12 Apr 2007	Winter Storm	A swath of heavy wet snow spread across portions of Southern Vermont. Snowfall amounts were greatest across higher elevations of eastern Bennington and western Windham Counties. Landgrove reported 9" of snow and Woodford reported 9.5". The heavy snowfall led to downed tree limbs and power lines, resulting in power outages.	High	Southern Vermont
15-16 Apr 2007	Winter Storm	A heavy wet snow accumulated 8-12" with 12" in Woodford, 10.5" in Landgrove, and 11" in Windham County. A Cooperative Weather Observer recorded 11" of snow in Peru on April 16. Gusty winds brought down power lines causing widespread outages. Damaging winds were reported by a Cooperative Weather Observer in Sunderland.	High	Southern Vermont
2-3 Dec 2007	Winter Storm	Snow fell moderate to heavy, with some sleet and freezing rain mixing at times. Snow accumulations were 8-12" with 12.5" reported in Landgrove.	High	Southern Vermont Landgrove
16-17 Dec 2007	Winter Storm	Snow, sleet and freezing rain, with total snow and sleet accumulations of 8-14", affected Bennington County and resulted in traffic problems and power outages. A Cooperative Weather Observer reported 12.4" in Sunderland along with damaging winds, 14" in Woodford, and 11.5" in Landgrove. The Cooperative Weather Observer in Peru recorded 11" of snow.	High	Countywide
30 Dec 2007 to 2 Jan 2008	Heavy Snow	This storm brought heavy snow to eastern New York and western New England totaling from 6-12" across Southern Vermont. Snowfall amounts ranged from 6-11". This led to treacherous travel conditions and the closings, or delayed openings, of numerous schools and businesses. A Cooperative Weather Observer reported 17.2" of snow in Peru from December 31 to January 2.	High	Southern Vermont
4-6 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
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" of snow per storm, but accumulating to over a foot during the period. A Cooperative Weather Observer recorded 29" of snow in Peru from December 12 to 22. Icing conditions followed on December 24.	High	Southern Vermont
12-23 Feb 2009	Heavy Snow Winter Storm	Several events were recorded by NCDC with snowfall amounts of 6-12", especially in higher elevations. There were isolated amounts of up to 12" reported in Landgrove and Woodford where snow squalls were more persistent. Over that time period, a Cooperative Weather Observer recorded 19.2" of snow in Peru.	Moderate	Southern Vermont Higher elevations Landgrove Woodford

Table 10. Significant winter storm events in Bennington County and Landgrove. Source: NCDC 2014

Dates	Type	Description	Category	Area
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" up to just over two feet. A Cooperative Weather Observer recorded 38.03" of snow in Peru from January 1-3. A Cooperative Weather Observer recorded 19.1" of snow in Pownal from January 1-4 and another Cooperative Weather Observer reported 21.5" 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 one to two feet of snow accumulated with the highest amounts above 1500 feet. A Cooperative Weather Observer recorded 16.2" of snow in Pownal. There was no Cooperative Weather Observer data for Peru from February 23 to 24.	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 one to two feet were reported across the higher terrain, with lesser amounts of 3-6" below 1000 feet. A Cooperative Weather Observer recorded 22.4" of snow in Peru from February 25-27.	High	Southern Vermont
26-27 Dec 2010	Winter Storm	A nor'easter brought snow and blizzard conditions to Southern Vermont. Cooperative Weather Observers measured 26" of snow in Sunderland and 20" in Pownal. The Cooperative Weather Observer in Peru recorded 14" from December 27-28.	High	Southern Vermont
12 Jan 2011	Winter Storm	Heavy snow fell across Southern Vermont with snowfall accumulations ranging from 14" up to 36", with snowfall rates of 3-6" an hour for a time. A Cooperative Weather Observer measured 20.6" in Pownal. In Peru, 11.5" was recorded from January 12-13.	High	Southern Vermont Pownal
1-2 Feb 2011	Winter Storm	Snow fell at a rate of 1-2" per hour with totals of 12-17" in Southern Vermont. A Cooperative Weather Observer reported 11.6" of snow in Peru from February 2-3.	High	Southern Vermont
25 Feb 2011	Winter Storm	Across Southern Vermont, 12-17" of snow accumulated. No data was recorded from the Cooperative Weather Observer in Peru on February 25.	High	Southern Vermont
29-30 Oct 2011	Winter Storm	An early storm produced 5-14" in Bennington County and 10-16" in Windham County.	High	Southern Vermont
29 Feb to 1 Mar 2012	Winter Storm	A complex storm resulted in 8-16" of snow and sleet across Southern Vermont from February 29 to March 1. A Cooperative Weather Observer reported 14.7" of snow in Peru from February 29 to March 2.	High	Southern Vermont
26-27 Dec 2012	Winter Storm	Snow fell across much of Southern Vermont from December 26 into December 27. Total storm snowfall amounts varied from a few inches to 27" in the Green Mountains. In addition, southeast winds were strong and gusty. Woodford gusted to 43 mph and Bennington Airport gusted to 46 mph. A Cooperative Weather Observer reported 13.4" of snow in Peru from December 27-28.	High	Southern Vermont

Table 10. Significant winter storm events in Bennington County and Landgrove. Source: NCDC 2014

Dates	Type	Description	Category	Area
27-28 Feb 2013	Winter Storm	Moderate to heavy snow fell across the higher terrain of the southern Green Mountains. Higher elevations across the southern Green Mountains saw between 8" and 19" of snow. A Cooperative Weather Observer reported 10.4" of snow in Peru from February 27-28.	Moderate	Southern Vermont
18-19 Mar 2013	Heavy Snow	Steady snow fell from the evening of March 18 through March 19. At the end of the storm, snowfall amounts ranged from 10" to 17" across the high terrain of the southern Green Mountains. A Cooperative Weather Observer reported 13.2" of snow in Peru from March 19-20.	Moderate	Southern Vermont
14-15 Dec 2013	Heavy Snow	Snow fell at a rate of 1"to 3" per hour. In addition, gusty southeast winds occurred with a few gusts of 40-55 mph. The highest snowfall amounts occurred across the southern Green Mountains, with up to 18" occurring in Woodford. A Cooperative Weather Observer reported 15.3" of snow in Peru from December 14-15.	High	Southern Vermont
2-4 Jan 2014	Heavy Snow Wind Chill	Moderate snow fell during the daytime with temperatures in the single digits. On January 3, snowfall amounts ranged from 8" to 17". Wind chill values dropped below -20 degrees. Wind chill values were -20 to -40 degrees. A Cooperative Weather Observer reported 11" of snow in Peru from January 2-3.	High	Southern Vermont
13-14 Feb 2014	Winter Storm	A winter storm impacted all of Southern Vermont. Snow fell at rates of up to 3" per hour. Sleet and freezing rain mixed in the snow in a few spots. Lightning and thunder accompanied the precipitation in a few areas. When the snow ended, 8" to 21" of snow was reported in Southern Vermont. Gusting winds as high as 40 mph occurred and led to the blowing and drifting of snow. A Cooperative Weather Observer reported 13.7" of snow in Peru from February 14-15.	High	Southern Vermont

In addition to the above, a Cooperative Weather Observer in Peru recorded 16.0" of snow from February 14 to 15, 2007.

c. Extent and Location

The average annual snowfall in Bennington County is 64.4", 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" (NOAA National Climatic Data Center 2014 Cooperative Weather Observer reports). Typically, Landgrove is at the high end of this average but the town is rarely affected by snowfall that is over 20" because it is a common occurrence. Landgrove has a knowledgeable road crew and the proper equipment to manage large amounts of snow on a regular basis. The skill of road crews across Vermont means that only the heaviest snowstorms or ice storms affect the populations. Nevertheless, the entire town is equally at risk to blizzards, heavy snow, ice storms, winter storms and winter weather.

d. Probability, Impact and Vulnerability

There is a greater than 100% probability of a moderate or greater snowstorm affecting Bennington County, including Landgrove 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, with the latter potentially producing flash floods. The NCDC recorded 48 thunderstorms with damaging winds in Bennington County since 1996. 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 1996.

b. Previous Occurrences

Table 11 below summarizes the total number of significant wind events including thunderstorms, strong winds, and tornadoes from 1996 to 2014. NCDC data (2014) did not always include estimates of wind speed. Generally, wind speeds of greater than 55 miles per hour are considered damaging (NOAA 2011). 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 12.

Table 11. Summary of wind events in Bennington County. Source: NCDC 2014

Year	High Wind	Strong Wind	Thunderstorm Winds	Tornado	Funnel Cloud	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

Table 11. Summary of wind events in Bennington County. Source: NCDC 2014						
Year	High Wind	Strong Wind	Thunderstorm Winds	Tornado	Funnel Cloud	Totals
2003	1			1		2
2004						
2005	1		3			4
2006	6		4			10
2007	3		6			9
2008		3	5			8
2009	2		1			3
2010	5		3		1	9
2011	1		8			9
2012	2		3			5
2013			6			6
2014			3			3
Totals	33	5	67	3	1	109

Table 12. Significant wind events in Bennington County. Source: NCDC 2014				
Dates	Type	Description	Area	Category
27 Jan 1996	High Wind	Damaging winds downed trees, limbs and power lines.	Southern Vermont	Moderate
21 Aug 1997	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 1997	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 1997	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
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 F1 with 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

Table 12. Significant wind events in Bennington County. Source: NCDC 2014				
Dates	Type	Description	Area	Category
21 July 2003	Tornado	A tornado touched down in Pownal, moved through Bennington and continued into western Windham County.	Sunderland Bennington Pownal	Moderate
2 July 2006	Thunderstorm Wind	On July 2, low pressure moved across the southern Quebec Province. A cold front over the eastern Great Lakes at dawn moved into western New England late in the day. The air mass over western New England became marginally unstable enough to generate a few late-afternoon thunderstorms in western New England. A tight pressure gradient over the Northeast was associated with widespread brisk surface wind. A few thunderstorms enhanced the wind locally. A thunderstorm in Stamford became severe late in the afternoon. Strong wind gusts associated with the thunderstorm blew down trees along Route 100 near the Stamford-Readsboro line.	Stamford Readsboro	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
25 Aug 2007	Thunderstorm Wind	A 50-foot tall maple tree landed on a van located on Route 8 in Stamford due to strong thunderstorm winds. The van sustained significant damage to the roof and windshield.	Stamford	Low
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.	Countywide Arlington Sunderland Shaftsbury Bennington	Moderate
9 June 2011	Thunderstorm Wind	A very warm and humid air mass was in place across the east central New York and adjacent western New England, including Southern Vermont. A series of discrete storms developed into a broken line, which eventually evolved into an organized line of severe storms. Hail and damaging winds were the main threat. Trees and power lines were reported down in Landgrove Town Center by a weather observer due to strong thunderstorm winds.	Southern Vermont North Landgrove	Moderate
28 Aug 2011 FEMA DR-4022	Tropical Storm High Wind	Tropical Storm Irene produced widespread flooding and damaging winds across the eastern New York and western New England. In Landgrove Center, an observer reported a measured wind gust of 41 mph.	Statewide	Extreme
29 May 2012	Thunderstorm Wind	Strong thunderstorm winds affected Southern Vermont. Falling trees blocked a road in Dorset.	Southern Vermont	Moderate
4 July 2012	Thunderstorm Wind	Numerous trees and power lines were reported downed in Manchester.	Southern Vermont Manchester	Moderate
8 Sept 2012	Thunderstorm Wind	Trees were reported down due to thunderstorm winds approximately 3 miles southeast of North Landgrove. Trees and wires were also downed in Bennington.	Southern Vermont Landgrove Bennington	Moderate

Table 12. Significant wind events in Bennington County. Source: NCDC 2014				
Dates	Type	Description	Area	Category
29 Oct 2012	High Wind	Wind gusts of 40-60 mph were reported as a result of the passage of "Superstorm" Sandy.	Western Vermont Woodford	Low
2 June 2013	Thunderstorm Wind	Minor damage was reported in Bennington.	Southern Vermont Bennington	Low
19 July 2013	Thunderstorm Wind	Trees were downed in Manchester.	Southern Vermont Manchester	Low
11 Sept 2013	Thunderstorm Wind	Trees were downed in Arlington.	Southern Vermont Arlington	Low
17 June 2014	Thunderstorm Wind	Severe thunderstorms caused damage to trees in a few locations.	Southern Vermont Pownal	Low
3 July 2014	Thunderstorm Wind	A line of thunderstorms developed with a few producing strong winds, causing damage to trees and power lines.	Southern Vermont East Arlington Dorset	Low

c. Extent and Location

Damaging winds, including the previous occurrences described above, are those exceeding 55 miles per hour (NOAA 2006, NOAA 2011). During the December 2009 event, winds were measured at 59 miles per hour at the Morse Airport in Bennington. Higher winds were likely created during the tornado events. Damage from high wind events 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. The entire town is equally at risk for damage from high wind, strong wind, thunderstorm winds and tornados. Most major wind events are widespread, but local events from thunderstorms or tornadoes are possible and the extent difficult to predict.

d. Probability, Impact and Vulnerability

Wind events causing moderate or greater damage occur almost every other year (40-50%) in Bennington County. However, few have affected Landgrove, so the potential expected probability would be 10-50% in any given year.

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 (2014) and Cooperative Weather Observers report eighteen hail events since 1996. Table 13 lists all hail events, which were highly localized with little damage.

Table 13. Hail events in Bennington County. Source: NCDC 2014

Date	Description	Area
31 May 1998	A severe thunderstorm in Shaftsbury 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-sized hail fell in Sunderland, and nickel-sized hail fell in 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 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 Aug 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. Quarter-sized hail was reported 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 Aug 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-sized 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 .25 inch sized hail reported in Pownal.	Pownal
6 Aug 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-sized hail fell approximately 4 miles north/northeast of Arlington.	Sunderland
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-sized hail was measured at the Bennington Morse State Airport in Bennington. In addition, nickel to quarter-sized hail was also reported in 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-sized hail was reported in Bennington during a thunderstorm.	Bennington

Table 13. Hail events in Bennington County. Source: NCDC 2014		
Date	Description	Area
17 July 2010	A pre-frontal boundary and upper level disturbance moved across the region creating a cluster of strong to severe thunderstorms that moved across Southern Vermont. Quarter-sized 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 sized hail was reported in Arlington. Multiple reports of large hail were reported during a thunderstorm in Shaftsbury. Hailstones of 3.25 inches and 2.75 inches in diameter were measured.	Arlington Shaftsbury
1-2 June 2011	Multiple lines and clusters of strong to severe thunderstorms developed during the afternoon and evening hours. Half-dollar sized hail was reported in Arlington. Multiple reports of large hail were reported during a thunderstorm in Shaftsbury. Hailstones of 1 inch and 3 inch diameters were measured.	Arlington Bennington Shaftsbury
24 June 2013	Thunderstorms produced quarter-sized hail in Manchester.	Manchester

A Cooperative Weather Observer also reported hail 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 and glass within structures, as well as cause injury. However, hailstorms typically affect relatively small areas as they form in thunderstorms, which are localized. In addition, hailstorms are such that any area can be affected equally.

d. Probability, Impact and Vulnerability

Hailstorms 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 Landgrove could range from 10-100% in any given year, 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, primarily in the summer, when the normal high temperature is exceeded by ten degrees. In addition, the heat index, which factors in the high relative humidity levels of summer, is also a factor. Health injuries caused by excessive heat, such as heat exhaustion and heat stroke, can cause damage to the brain and vital organs, and can lead to death if not treated.

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. Hypothermia could also be an issue in periods of cold weather.

Table 14 shows the normal temperature and precipitation for Sunderland. The Sunderland Cooperative Weather Observer was used because it was the closest station to Landgrove with this type of data available. The Sunderland data is useful as the planning team advised that Landgrove is, on average, 8-10 degrees cooler than Sunderland on any given day. Therefore, the approximate normal temperatures for Landgrove can be identified with this data.

Table 14. 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 Sunderland indicates an average of 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 occurrences of approximately less than one day per 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. Hydrological drought 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 Landgrove 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

The Palmer Hydrologic Index (PHDI) is an indicator of potential surface and groundwater availability based on climatic conditions. The categories of drought include moderate drought, severe drought and extreme drought. Table 15 shows periods when the index showed severe and extreme droughts using data from 1985 to 2013, though no severe or extreme droughts have been recorded since 2002.

Table 15. Years and number of months when the PHDI indicated severe or extreme droughts from 1895 to 2014. Source: NCDC 2014 and ftp://ftpncdd.noaa.gov/pub/data/cirs/climdiv/ (Richard Heims, verbal communication)

Year	Severe	Extreme
1907	1	
1908	3	2
1909	3	1
1910	2	
1911	9	5
1912	2	
1913	5	
1914	5	
1915	4	
1921	2	

Table 15. Years and number of months when the PHDI indicated severe or extreme droughts from 1895 to 2014. Source: NCDC 2014 and ftp://ftpncdd.noaa.gov/pub/data/cirs/climdiv/ (Richard Heims, verbal communication)

Year	Severe	Extreme
1922	1	
1930	1	
1931	4	
1941	5	
1942	2	
1947	1	
1949	1	
1953	2	
1957	1	
1959	1	
1963	3	
1964	7	1
1965	9	8
1995	2	
1999	1	
2001	3	2
2002	2	1

c. Extent and Location

The National Climate Data Center calculates this index back to 1895. Since then, severe droughts occurred in 27 years or 22.5% while extreme drought occurred in 8 years or 6.7%. Severe and extreme droughts have been of short duration, except occurrences in the early 1960s. Mild to moderate droughts have been more frequent. Severe and extreme droughts are likely to affect those properties with shallow wells, and could also affect rural fire protection where water sources are ponds, streams and dry hydrants. Based on well data from the Vermont Agency of Natural Resources (2014), there are four wells in Landgrove with depths of 100 feet or less. These wells would be the most vulnerable during drought conditions.

d. Probability, Impact and Vulnerability

Based on past Palmer Hydrologic Drought Index data, there is a 20-25% chance of a severe drought occurring in any one year. Drought may also affect wildfire, which is discussed in the next section.

The bedrock in Landgrove is comprised of fine to medium-grained biotitic gneiss; wells in this type of bedrock have a mean yield of 14 gallons per minute (gpm) (Vermont Agency of

Natural Resources, 2008). There are various types of bedrock in Vermont with different yields ranging from 2 gpm to 34.57 gpm (Vermont Agency of Natural Resources, 2008). According to the Statewide Groundwater Analyses, the mean yield for wells in Vermont is 13.76 gpm. There is no required minimum gallon per minute for private wells. However, ANR recommends that private wells yield at least 1 gpm (Ken Yelsey, verbal communication). This means that the bedrock allowing a mean yield of 14 gpm in Landgrove is more than enough water for households.

All Landgrove residents receive water from private wells. Map 4 shows the locations of these wells, along with four public water systems located in Landgrove, which serve specific businesses.

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 varies 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. Table 16 shows how wildfires can be categorized based on size.

Table 16. 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

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

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.

In Vermont, 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 the fire hazard (Anderson 1982). In addition, most of the land area is covered by broadleaf litter fuels that exhibit fires of low intensity and slow rates of spread.

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. However, none of these fires occurred in Landgrove.

c. Extent and Location

There have been no recorded wildfires in Landgrove. Map 5 shows areas at risk from wildfire determined by the wildland urban interface areas. The majority of the town is shown as low risk. The high-risk areas are those where the density of structures are in close proximity to the forest cover. Areas of moderate risk and high risk are spotted around Landgrove. However, this area is relatively small when compared to the low risk areas. Risk areas can be seen in Map 5.

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 (Map 5). 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. Landgrove, in general, has a relatively low risk of wildfire as shown in Map 5.

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 include saturation by water, steepening of slopes by erosion or construction, and alternating freeze-thaw periods. Table 17 shows how landslides can be categorized.

Table 17. 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

There have been no identified landslides, rockslides, or debris slides in Landgrove, according to the planning committee.

c. Extent and Location

Landslides are more likely to occur on steep slopes along rivers and streams, which represents a very small portion of Landgrove. The steep section along Cody Road that is just over the town boundary in Londonderry (Map 3 and Map 4) could be more susceptible to a landslide than other areas of town. There is a spring known to wash the road out during heavy rains in this area, if conditions are right, this area could generate a landslide. However, there has never been a landslide at this location. Therefore, the overall extent for landslides, rockslides and debris slides is minimal in Landgrove.

d. Probability, Impact and Vulnerability

The Green Mountains province, where Landgrove is located, consists of erosion-resistant low-to medium-grade metamorphic rocks of widely varying ages (Eliason and Springston 2007). Most high hazard sites in this area display toppling, a mass of material rotating outward from a steep slope face, and plane failures, when a layer of unstable material gives way or there is an increase of water pressure on the plane (Eliason and Springston 2007). However, since Landgrove has not experienced this type of hazard, the probability of this occurring is quite small. Therefore, the impact and vulnerability are minimal.

9. Earthquake

a. Description

Vermont has no active faults, but has experienced minor earthquakes. Table 18 below shows the most recent occurring within the state, though there have been others located outside the state 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 18. 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 (USGS 2013)
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 Landgrove (Kim 2003). In addition, Landgrove is a relatively small town and all areas would be equally affected if an earthquake were to occur.

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 2 spills reported in Landgrove since 1979, and these are listed in Table 19 below.

Table 19. Hazardous materials spills in Landgrove.
Source: Vermont Department of Environmental Conservation:
http://www.anr.state.vt.us/WMID/Spills.aspx

Report #	Year	Facility Name	Address	Responsible Party	Date Reported	Date Closed	Incident
WMD322	2001	Residence	Nichols Rd.	Mike Jeffery	8/20/2001	8/31/2001	Brown spot on lawn.
WMD899	2011	Roadside	186 Cody Rd.	CVPS	12/21/2011	12/21/2011	8 gallons of antifreeze leaked onto pavement from a CVPS truck. The cause was a failed antifreeze hose.

c. Extent and Location

The spills listed above affected small sites or areas. Route 11 crosses through the southern end of town for less than a mile and is a well-traveled route for all types of vehicles. An accident on this segment of road would not heavily impact Landgrove. However, if the accident caused a hazardous materials spill, the contamination of Flood Brook would be of particular concern because it flows directly under the highway (Map 4). A hazardous materials spill near any of Landgrove's streams would be of concern for the town due to the impact on water resources.

High Risk Rural Roads data (2013) and the planning committee identified Hapgood Pond Road as the road most frequented by accidents. Hapgood Pond Road, near the Peru/Landgrove border, switches from a paved road in Peru to an unpaved road in Landgrove, and then makes a sharp left turn (Map 4). Accidents along this segment of road are typically caused by drivers traveling too fast, or not expecting the unpaved road and curve ahead. The planning committee and road commissioner also identified the intersections of Landgrove Road and Hesseltine Road, Cody Road and Landgrove Road, Cody Road and Old County Road East as areas

where accidents typically occur. Each location is shown on Map 4. The planning committee added that none of these areas are high hazard areas, just areas where accidents are more common. The road commissioner included that Ridge Road, where it meets Route 11, is also dangerous because cars tend to go faster on this segment of Route 11 due to the downhill grades in each direction as it approaches Ridge Road (Map 4).

Roads that have steep grades can also be troublesome to drivers in the winter, spring and during freeze/thaw periods. The road commissioner identified the Buffum Hill segment of Landgrove Road, the south end of Cody Road, Old County Road West where it meets Landgrove Road, Jaquith Road where it turns left, and Old County Road East to be areas with steep grades that typically cause problems during these times. These areas are shown on Map 4. These roads can become rutted and impassable at times.

d. Probability, Impact and Vulnerability

Given the number of past spills, hazardous materials spills occur much less than annually and affect very small areas. However, many areas in Landgrove are vulnerable to spills due to the proximity of surface and groundwater resources throughout the town. Most hazardous materials are transported via Route 11. 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 is 1-10% in any given year. Injuries are likely to be low, except in the case of direct injuries from a traffic accident. However, the long-term impacts of a spill could be extensive if aquatic resources and/or water supplies are 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 (2015) lists seven different diseases occurring in Bennington County as of April 25, 2015 with Hepatitis C the highest with 10 cases and Lyme disease the second highest with 7 cases.

c. Extent and Location

In general, individuals and families are most affected by infectious diseases, so the entire town would be equally susceptible to this hazard.

d. Probability, Impact and Vulnerability

Infectious diseases are ongoing, but affect a small portion of the population. 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 already 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 (VT ANR 2010).

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

Table 20. 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/; BCRC staff observations

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
*Euonymus 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 20. 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/; BCRC staff observations

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 21. 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 geminate	Didymo

b. Past Occurrences

Invasive species represent a continual event.

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 parsley) 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 the movement of firewood.

d. Probability, Impact and Vulnerability

The likelihood of increased abundance of invasive species is 75-100% in any given year, 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. Table 22 summarizes the potential impacts from each hazard.

Table 22. Hazard impact summary

Hazard	Potential Impacts
Floods and flash floods	Damage or loss of structures and infrastructure Loss of life and/or 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/or injury Water supply loss
Drought	Water supply loss Crop damage or loss
Wildfire	Damage or loss of structures and infrastructure Loss of life and/or injury Loss of forest resources
Landslide and debris flow	Damage or loss of structures and infrastructure Loss of life and/or injury Road closures Power outages
Earthquake	Damage or loss of structures and infrastructure Loss of life and/or injury Road closures Power outages Water supply loss
Hazardous materials spill	Loss of life and/or injury Road closures Water supply loss
Infectious disease outbreak	Loss of life and/or injury

Table 22. Hazard impact summary	
Hazard	Potential Impacts
Invasive species	Road closures Power outages (fallen trees) Loss of forest resources

Table 23 summarizes probabilities, areas 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, children or those who might be particularly affected by power outages or isolation during storm events. Mobile homes can be especially vulnerable to hazards (Vermont Department of Housing and Community Development 2013).

Table 23. Summary of Hazards Potentially Affecting Landgrove								
Hazard	Date/Event (# events)	Recurrence Interval	Geographic Area Affected	Proportion of town damaged	Injuries/ Deaths	Loss of facilities/services	Vulnerable Facilities/Populations	Warning Time
Flood/Flash Flood	47 events from 1996 to 2012	10-50% probability in next any given year	Community to statewide within special flood hazard areas and river corridors	<10%	1-10%	Minimal to seven days and roads may become impassable and power outages in some areas	Roads, bridges and culverts town wide	>12 hours
Winter Storm (Snow and Ice)	119 events from 1996 to 2012	100% probability in any given year	Community to statewide, the entire town would be equally effected	<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
High Wind Event	99 events from 1996 to 2012	10-50% occurrence in any given year	Community to region-wide, the entire town would be equally effected but certain events (thunderstorms and tornadoes) could be more localized	<10%	<=1%	Minimal for the entire town, but may be significant in localized areas and power outages may occur	Power lines primarily	3 to >12 hours
Hail	20 events from 1996 to 2013	10-100% probability in any given year	Subarea of community, small and localized areas	<=1%	<=1%	Minimal	Minimal	3 to 12 hours

Table 23. Summary of Hazards Potentially Affecting Landgrove								
Hazard	Date/Event (# events)	Recurrence Interval	Geographic Area Affected	Proportion of town damaged	Injuries/ Deaths	Loss of facilities/services	Vulnerable Facilities/Populations	Warning Time
Drought	Severe droughts have occurred in 27 years form 1895 to 2013	20-25% probability in any given year	Community to statewide, populations with shallow wells	<10%	<=1%	Minimal but water could be unavailable for significant lengths of time	Homes with shallow wells lose water	>12 hours
Wildfire	None between 1992 and 2010	1-10% probability in any given year	Subarea of community, in areas with moderate to high risk forest fuels and where structures are in close proximity to forest cover	<10%	<=1%	Minimal	Likely confined to the National Forest	None or minimal
Landslide/Debris Flow	None	1-10% probability in any given year	Subarea of community, steep slopes along rivers and the steep section along Cody Road	<10%	<=1%, but traffic accidents possible	Minimal depending on scale and ability to remove material	Limited as affecting one road	None or minimal
Earthquake	None	<1% probability in any given year	Community to region-wide, the entire town would be equally effected	<10%	<=1%, but larger in a significant earthquake	Minimal	Town wide	None or minimal

Table 23. Summary of Hazards Potentially Affecting Landgrove								
Hazard	Date/Event (# events)	Recurrence Interval	Geographic Area Affected	Proportion of town damaged	Injuries/ Deaths	Loss of facilities/services	Vulnerable Facilities/Populations	Warning Time
Hazardous Materials Spill	2 events from 1979 to 2013	1-10% probability in any given year	Community to region-wide, at residences, or along Route 11 or identified common vehicle accident areas	<=1%	<=1%	Minimal	Water supplies and aquatic resources	None or minimal
Infectious Disease Outbreak	Annual	100% probability in any given year	Community to state-wide, the entire town would be equally effected	<=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, susceptible areas are not yet known	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 Landgrove

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, 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 the Local Emergency Operations 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 Landgrove

1. Landgrove Town Plan

The Town Plan, adopted in 2012, lists the following objectives and policies that support hazard mitigation.

a. Avoid soil erosion, surface or ground water contamination, and damage to other important natural resources (p. 4).

b. Landgrove relies on clean groundwater for domestic water supplies; therefore, groundwater recharge areas must be protected from incompatible development and contamination (p. 4).

c. Climate change and acid deposition will affect species composition and overall forest health, and may also promote the spread of forest pests and invasive

species that have an adverse affect on native plants. Efforts to mitigate such damage and to adapt to inevitable ecological changes should be supported (p. 12).

d. Development in floodplain areas is inherently dangerous due to hazards associated with flood water inundations and to the increased flooding that may occur downstream when developed floodplains are no longer capable of retaining flood waters. Such development also can interfere with the function and quality of floodplain wetlands. The town has enacted flood hazard area zoning regulations to control development in those areas. Erosion impacting land, roads, and buildings adjacent to streams (whether or not those features are within a mapped floodplain) can be an even more severe hazard, as demonstrated throughout Vermont during Tropical Storm Irene in August 2011. The town should determine whether any significant "fluvial erosion hazard areas" exist along streams and take appropriate measures to protect roadways and limit future property damage in these areas (p. 14-16).

e. The natural characteristics and values of Landgrove's streams, ponds, and wetlands should be preserved. New development should not disturb these resources or associated vegetation; wherever possible, a natural buffer of at least 50 feet should be maintained between developed areas and streams or wetlands. The Agency of Natural Resources should study the affect of siltation on area streams and recommend remediation measures (p. 18).

f. Development in floodplains must be carefully controlled in accordance with flood hazard area regulations. Additional study of potential fluvial erosion hazard areas should be conducted (p. 18).

g. Development in the regulatory flood hazard area is controlled to reduce the risk of damage to property or the environment, personal injury, and unnecessary costs to the public (p. 25).

h. Heavy rain events, such as the August 2011 tropical storm can inflict heavy damage, washing out culverts and vulnerable sections of roadway. The town should identify areas that have been, or are likely to be, impacted by such events and make sure that culverts and drainage systems are adequately sized and constructed; if they are not, replacements or reconstruction should be included in short and long range improvement plans (p. 28).

i. Retain the current system of unpaved town roads. Maintenance activities should focus on efficiency, economy, and prevention of deterioration rather than on facilitation of greater traffic speeds (p. 28).

j. Develop a long-term plan for roadway improvements focusing especially on roadway segments, culverts, and bridges that may be vulnerable to future severe weather events (p. 28).

2. Bennington Regional Plan Policies and Actions (adopted March 19, 2015

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

a. Several policy recommendations emphasizing protecting natural resources, maintaining village and urban centers and avoiding development on sensitive lands including areas of steep slope and wetlands along with the protection of surface and groundwater resources and forested lands (Sections VII and VIII).
b. A flood resilience section (IX) as required by Vermont statute that identifies hazards from flooding and fluvial erosion. The section encourages avoiding development in flood hazard areas, reconstruction of bridges and culverts that impede flows, undisturbed buffer areas along streams to provide for lateral movement and attenuation of overland flow, participation in the National Flood Insurance Program, updating of flood bylaws, adoption of up to date road and bridge standards and participation in the community rating system.

3. Vermont Hazard Mitigation Plan (2013)

The Vermont Hazard Mitigation Plan identified a series of hazards shown in Table 24 below, along with those we considered in this plan. The Landgrove plan tracks the state plan except some hazards are combined and a few, including Temperature Extremes and Nuclear Power Plant Accident, were not considered.

Table 24. Comparison of hazards considered in the draft Vermont Hazard Mitigation Plan vs. the Landgrove 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*
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

Table 24. Comparison of hazards considered in the draft Vermont Hazard Mitigation Plan vs. the Landgrove Hazard Mitigation Plan	
VT Hazard Mitigation Plan	Alternative
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 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 Landgrove.

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. Landgrove participates in the National Flood Insurance Program (NFIP) and has bylaws in place to implement the program. This program is overseen by the Town Zoning Administrator. Currently there are two NFIP polices in effect for a total value of $530,000. No claims have been made since 1978 and there are no repetitive loss structures.

Landgrove's river corridor maps became available through VT ANR in early 2015. In some cases, land may fall into the river corridor but not in the flood areas identified in the FEMA flood map. Therefore, property owners who own land in the river corridor 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, bridges and culverts with funding set aside in the town budget. Landgrove has also adopted the most current Town Road and Bridge Standards. The town has been fortunate not to have many problems with their roads, bridges or culverts. When there is a stretch of road or infrastructure that is causing frequent problems,

the town has been able to repair the area so that it is no longer a problem. One tactic has been the lowering and clearing of ditches each year. This has helped keep the roads in better shape throughout the year.

Recently, there was a Roadway Drainage Improvements and Capitol Budget Plan completed through the Better Back Roads Small Grant Program. The plan assessed several locations throughout town, and identified problem areas, as well as the description of current maintenance, suggested solutions, design standards and cost estimates. In the near future, Landgrove would like to complete more studies on the condition of infrastructure in town. Landgrove plans to keep improving troublesome areas as they occur and to reduce damage from future hazards.

Table 25 below lists the capabilities of Landgrove and the parties responsible for implementing those capabilities. The Select Board is the legislative authority and develops the town budget, oversees staffing, appoints the Emergency Management Director and members of the Planning Commission, and adopts bylaws and ordinances. Vermont has a town meeting form of government, and voters approve the budget at town meeting day.

Table 25. Landgrove Capabilities for Hazard Mitigation

Town Capability	Responsible Party/Parties
Development of an annual town budget	Select Board
Emergency management	Select Board; Emergency Management Director
Outreach to residents and businesses through mailings, website and newsletters	Town Clerk; Select Board; Emergency Management Director
Town road, bridge and culvert construction and maintenance	Road Commissioner
Implementation and update of the Town Plan	Planning Commission; Select Board
Implementation of land use, including flood bylaws	Town Zoning Administrator; Planning Commission

Landgrove is a small town with limited ability to expand services. However, many capabilities can be expanded with the assistance from other support services located outside of Landgrove. The town can receive support from the Vermont Division of Emergency Management and Homeland Security and the Bennington County Regional Commission on emergency management, planning and assistance. The Local Emergency Planning Committee #7 can provide emergency and disaster management information and training. The US Forest Service has capabilities in wildfire management and the Vermont Agency of Transportation provides training and maintains state roads. In addition, members of the Select Board and the Bennington County Regional Commission can assist the Town Clerk in developing outreach materials. All of these support organizations can assist Landgrove in developing a program to serve their residents.

D. Mitigation Projects

Table 26 below lists mitigation actions for each of the hazards. Some will be implemented by the Town of Landgrove 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 reduces 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 cost while avoiding or mitigating potential impacts to natural, cultural, social and economic resources. Costs considered include: a) likely capital and maintenance costs of the action, b) potential short and long-term impacts to natural, cultural and scenic resources, and c) potential short and long-term impacts to residents and businesses from implementing the action.

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 26. 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 Select Board	2016 to 2017	Town general fund	High
All Hazards	Education and Awareness	Identify and develop methods to communicate with populations vulnerable to potential hazards and those in need of assistance for evacuation and/or sheltering	Town Emergency Management Director	2016 to 2017	Town general fund	High
All Hazards	Education and Awareness	Identify vulnerable community members through a survey and outreach	Town Emergency Management Director	2016 to 2017	Town general fund	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 Planning Commission	2016 to 2017	Town general fund	High
All Hazards	Local Planning and Regulations	Maintain the Local Emergency Operations Plan annually	Town Select Board; Emergency Management Director	2016 to 2017 then annually	Town general fund	Medium
All Hazards	Local Planning and Regulations	Develop cooperative agreement with Londonderry for sheltering of vulnerable populations	Town Select Board; Emergency Management Director	2016 to 2017	Town general fund	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 Zoning Administrator	2016 to 2017	Town general fund	Medium
Floods and Flash Floods	Local Planning and Regulations	Integrate river corridor protection into the flood hazard bylaws	Town Planning Commission; Zoning Administrator	2016 to 2017	Town general fund	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 Road Commissioner	2016 to 2021	Town highway fund	High

[1] Follows FEMA. 2013. Mitigation Ideas; A Resource for Reducing Risk to Natural Hazards. Federal Emergency Management Agency, U.S. Department of Homeland Security, Washington, DC.

Table 26. Mitigation actions

Hazard	Type	Actions	Responsible Parties	Time Frame	Funding Source(s)	Priority
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 Road Commissioner	2016 to 2021	Town highway fund; VT AOT; FEMA HMGP, PDM, FMA, 406	High
Floods and Flash Floods	Structure and Infrastructure Projects	Construct salt/sand shed so material does not wash into streams	Town	2016 to 2021	Town; VT AOT	High
Winter storms	Education and Outreach	Provide educational materials on sheltering in place and preparation for winter storms, including long-term power outages and transportation disruptions	Town Emergency Management Director	2016 to 2017	Town general fund	High
Winter storms	Education and Awareness	Provide materials for residents on methods to protect property from wind events	Town Emergency Management Director; Zoning Administrator	2016 to 2018	Town general fund; FEMA HMGP, PDM, FMA	High
Winter storms	Local Planning and Regulations	Develop agreements with adjacent towns for sharing of highway equipment	Town Select Board; Road Commissioner	2016 to 2017	Town general fund	High
Winter Storms	Structure and Infrastructure Projects	Planning for and maintaining adequate road and debris clearing capabilities	Road Commissioner; Town Select Board	2016 to 2021	Town general fund; town highway fund	
High wind events	Education and Outreach	Provide educational materials on sheltering in place and preparation for winter storms, including long-term power outages and transportation disruptions	Town Emergency Management Director	2016 to 2017	Town general fund	High
High wind events	Structure and Infrastructure Projects	Retrofitting Town Hall with load-path connectors to strengthen the structural frame	Town	2016 to 2021	Town general fund; FEMA HMGP, PDM, FMA, 406	Low
Hail	Education and Awareness	Distribute weather alert information by email and town website	Town Select Board	2016 to 2017	Town general fund	Medium

Table 26. Mitigation actions

Hazard	Type	Actions	Responsible Parties	Time Frame	Funding Source(s)	Priority
Drought	Education and Awareness	Provide educational materials on preparing for drought	Town Emergency Management Director	2016 to 2018	Town general fund; FEMA HMGP, PDM	Medium
Wildfire	Education and Outreach	Acquire materials about fire safety and make available for landowners and homeowners in Landgrove	Town Select Board; BCRC	2016 to 2017	BCRC	High
Wildfire	Education and Outreach	Provide information on outdoor burning safety prior to the spring and fall fire seasons	Fire warden	2016 to 2021	Fire wardens	High
Wildfire	Structure and Infrastructure Projects	Creating buffers around residential and non-residential structures through the removal or reduction of flammable vegetation	Fire warden	2016 to 2019	Fire wardens	Medium
Landslide and Debris Flow	Local Planning and Regulations	Consider adopting river corridor bylaws	Town Select Board; Planning Commission	2016 to 2017	Town general fund	High
Landslide and Debris Flow	Structure and Infrastructure Projects	Implement visual monitoring in potential landslide areas	Town Emergency Management Director	2016 to 2018	Town general fund	High
Earthquake	Education and Awareness	Educate property owners on proper construction techniques to reduce potential damage from earthquakes	Town Zoning Administrator	2016 to 2018	Town general fund	Medium
Hazardous Materials Spill	Local Planning and Regulations	Complete an assessment of hazardous materials and potential accident locations	LEPC 7	2016 to 2020	Town general fund	Medium
Infectious Disease Outbreak	Local Planning and Regulations	Monitor disease occurrences and potential outbreaks	Town Health Officer	2016 to 2021	Town general fund	High
Infectious Disease Outbreak	Education and Outreach	Provide educational materials in the town hall and on the town web site on potential infectious diseases	Town Health Officer	2016 to 2019	Town general fund; VT Health Department	High
Invasive Species	Local Planning and Regulations	Monitor extent of invasive species, particularly forest invasive species such as Emerald Ash Borer	Landgrove Conservation Commission	2016 to 2021	Town general fund	High

Table 26. Mitigation actions						
Hazard	Type	Actions	Responsible Parties	Time Frame	Funding Source(s)	Priority
Invasive Species	Local Planning and Regulations	Complete surveys for ash trees vulnerable to Emerald Ash Borer	BCRC; Bennington County Conservation District; Landgrove Conservation Commission	2016 to 2021	FEMA HMGP, PDM; VT Department of Forests, Parks and Recreation	Medium
Invasive Species	Local Planning and Regulations	Survey for invasive species (e.g., Japanese knotweed) along streams to identify potential erosion areas	Landgrove Conservation Commission	2016 to 2018	VT Department of Forests, Parks and Recreation	Medium
Invasive Species	Education and Awareness	Provide outreach materials for landowners on using native plants and controlling invasive species	Bennington County Conservation District; Landgrove Conservation Commission	2016 to 2017	Town general fund; VT Department of Forests, Parks and Recreation	High

E. Monitoring and Revising This Plan

1. Annual Monitoring and Continued Public Involvement

Copies of this plan will be kept in the town office and made available for the public through the Landgrove and BCRC websites. During the review and update of this plan, the Select Board will request input from the public. The update process will be much like the development of this plan, all meetings will be warned and the public will be encouraged to provide feedback at the meetings or to a selected member of the Select Board.

This plan will be integrated into existing planning efforts when appropriate, such as the Town Plan. The current Town Plan expires in 2017; when updated, the plan will include a more robust flood hazard section to meet the new Vermont Statute, which is to encourage flood resilient communities. Information from this plan that would be incorporated into the new Town Plan section would be: flood hazard areas and erosion areas including Map 3, actions to mitigate flood hazards, location of the shelter, and a description of emergency services provide assistance to Landgrove.

During the annual budget process, the Landgrove Select Board will review the status of hazard mitigation projects and actions and discuss new projects or actions to be included in the updated plan. Others invited to participate in the update process will be the Road Commissioner, the Vermont Agency of Transportation, the Bennington County Regional Commission, other stakeholders and members of the public. All will be encouraged to provide feedback. If necessary, the plan will be amended to include any new projects or actions. During Town Meeting Day, which occurs each March, members of the public will have another opportunity to comment on the status of any projects or actions and on any needed changes to the hazard mitigation plan.

2. Plan Evaluation and Update

The monitoring of this plan will be the responsibility of the planning committee. The Select Board will be responsible for assigning new planning committee members to monitor and update the plan if current planning committee members withdrawal themselves from the committee. The planning committee will begin the plan review process a year prior to its expiration date. The review process will include:

1. Updating the descriptions and analyses of events using new information since completion of the 2015 draft.
2. Identification of any new buildings or infrastructure, or changes in critical facilities.
3. Estimation of potential probability and extent of hazards based on any new information since completion of the 2015 plan and the updated Town Plan.
4. Review of completed hazard mitigation projects and actions.
5. Identification of new projects and actions, given the revised hazard evaluation.
6. Review of any changes in priorities since adoption of the 2015 plan.
7. Revision of the assessment of risks and vulnerability from identified hazards.

8. Development and use of criteria to assess the potential benefits and costs of identified actions for use in prioritizing those actions.
9. Integration of the updated plan into the Landgrove Town Plan.

The planning committee will hold open meetings to solicit opinions and to identify issues and concerns from members of the public and stakeholders. The planning committee and the Landgrove Select 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. The 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, Landgrove 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 any completed studies.

3. Local Emergency Operations Plan

The Local Emergency Operation Plan (LEOP) provides contact information and lists the steps that should be taken when setting up an incident command structure, assessing risks and vulnerabilities, and providing for resources and support. The plan is to be updated and resubmitted to the Division of Emergency Management and Homeland Security by May 1 each year. During the update process, events of the past year, if any, will be taken into consideration. If events occur that can be mitigated by the actions discussed in this plan, those actions can be incorporated into the LEOP, as well as used to amend this hazard mitigation plan, the Town Plan, road maintenance and the town budget.

VI. References and Sources of Information

A. Literature and Reports

Anderson, H.E. 1982. Aids to Determining Fuel Models for Estimating Fire Behavior. U.S. Forest Service General Technical Report INT-122, Intermountain Forest and Range Experiment Station, Ogden, UT.

Bennington Regional Plan. 2015. Bennington County Regional Commission. Adopted March 19, 2015.

Eliason, T.D. and G.E. Springston. 2007. Rockfall Hazard Rating of Rock Cuts on U.S. and State Highways in Vermont. Research Project RSCH010-974, Vermont Agency of Transportation, Montpelier, VT.

FEMA. 2013. Mitigation Ideas; A Resource for Reducing Risk to Natural Hazards. Federal Emergency Management Agency, U.S. Department of Homeland Security, Washington, DC.

FEMA. 2011. Local Mitigation Plan Review Guide. Federal Emergency Management Agency, U.S. Department of Homeland Security, Washington, DC.

FEMA. 2010. Flood Insurance Study, Bennington County, Vermont and incorporated areas, Federal Emergency Management Agency Study Number 50003CV000A.

Kim, J. 2003. HAZUS Assessments for Bennington County. Report to Lissa Luke, Bennington County Regional Commission from the Vermont Geological Survey.

Landgrove Town Plan. 2012. Town of Landgrove, VT. Adopted September 1, 2012.

Ludlum, D. M. 1996. Vermont Weather Book. Vermont Historical Society, Montpelier, VT.

Malamud, B.D., J.D.A. Millington, G.L.W. Perry, and D.L. Turcotte. 2005. Characterizing Wildfire Regimes in the United States. Proceedings of the National Academy of Sciences of the United States of America, 102 (13): 4694-4699.

National Weather Service. 2010. Manual 10-950, Hydrologic Services Program 10-9 Definitions and General Terminology. Available via: http://www.nws.noaa.gov/directives/010/010.htm Accessed: September 23, 2014.

NOAA National Climatic Data Center. 2014. Cooperative Weather Observer reports. Available via: http://www.ncdc.noaa.gov/cdo-web/datatools/findstation Accessed: September 1, 2014.

NCDC. 2014. Storm Events Database. National Climate Data Center storms events database. Available via: www.ncdc.noaa.gov/stormevents/
Accessed: September 3, 2014.

NOAA. 2006. National Oceanographic and Atmospheric Administration Damaging Wind Basic. Available via: http://www.nssl.noaa.gov/primer/wind/wind_basics.html
Accessed: September 24, 2014.

NOAA. 2011. National Oceanographic and Atmospheric Administration Weather Spotter's Field Guide. Available via: http://www.nws.noaa.gov/om/brochures/SGJune6-11.pdf
Accessed: September 24, 2014.

North Central Research Station. 2005. Atmospheric Disturbance Climatology: Fire Weather Patterns. Available via: http://www.ncrs.fs.fed.us/4401/focus/climatology/firewx/
Accessed: September 25, 2014.

NWCG. 2011. National Wildfire Coordinating Group Glossary of Wildland Fire Terminology. Available via: http://www.nwcg.gov/pms/pubs/glossary/index.htm
Accessed: September 25, 2014.

Springston, G. and M. Gale. 1998. Earthquakes in Vermont. Vermont Geological Survey Educational Leaflet No. 1.

U.S. EPA 2015. Level III and IV Ecoregions of the Continental United States. Available via: http://www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm. Accessed August 4, 2015.

USGS. 2013. U.S. Geological Survey Earthquake Hazards Program. Available via: http://earthquake.usgs.gov/learn/topics/mag_vs_int.php
Accessed: September 24, 2014.

USGS. 2006. Landslide Types and Processes. U.S. Geological Survey. Available via: http://pubs.usgs.gov/fs/2004/3072/
Accessed: September 24, 2014.

USGS Landfire. 2014. Data Distribution Site. Available via: http://www.landfire.gov/index.php
Accessed: September 22, 2014.

VTrans. 2015. Vermont General Highway Map, Town of Landgrove, prepared by the Vermont Agency of Transportation, Montpelier, VT.

VTrans. 2013. High Risk Rural Road Crashes 2009-2013. Vermont Agency of Transportation, Montpelier, VT.

VT ANR. 2014. Drinking Water and Groundwater Protection Division Website. Vermont Agency of Natural Resources, Department of Environmental Conservation. Available via: http://www.anr.state.vt.us/dec/dwgwp/cfm/WellReportSearchFormi.htm
Accessed: October 7, 2014.

VT ANR. 2013. Flood Resilience Website. Vermont Agency of Natural Resources, River Management Program. Available via: https://outside.vermont.gov/agency/ANR/FloodResilience/Pages/default.aspx
Accessed: September 3, 2014.

VT ANR. 2010. Report on Invasive Species. Agency of Natural Resources, Montpelier, VT.

VT ANR. 2010. Vermont Forest Resources Plan. Vermont Department of Forests, Parks, and Recreation, Agency of Natural Resources, Montpelier, VT. Available via: http://www.vtfpr.org/htm/for_resourcesplan.cfm
Accessed: October 28, 2014.

VT ANR. 2008. Statewide Groundwater Analyses. Vermont Agency of Natural Resources, Department of Environmental Conservation. Available via: http://www.anr.state.vt.us/dec/geo/gwaterSTATEinx.htm
Accessed: October 28, 2014.

Vermont Center for Geographic Information. 2014. Available via: http://vcgi.vermont.gov
Accessed: August 25, 2014.

Vermont Department of Forests, Parks, and Recreation. 2010. Vermont Forest Resources Plan. Agency of Natural Resources, Montpelier, VT. Available via: http://www.vtfpr.org/htm/for_resourcesplan.cfm
Accessed: October 27, 2014.

Vermont Department of Health. 2015. Vermont – Selected Reportable Diseases. Division of Health Surveillance, Infectious Disease and Epidemiology Section, April 25, 2015. Available via: healthvermont.gov/prevent/IDN/archive.aspx
Accessed: May 27, 2015.

Vermont Department of Housing and Community Development. 2013. Report on the Viability and Disaster Resilience of Mobile Home Ownership and Parks. Vermont Agency of Commerce and Community Development, Montpelier, VT.

VEM. 2013. Vermont State Hazard Mitigation Plan. Vermont Emergency Management, Waterbury, VT.

VNRC 2013. Community Strategies for Vermont's Forests and Wildlife: A Guide for Local Actions. Vermont Natural Resources Council, Montpelier, VT. Available via: http://vnrc.org/programs/forests-wildlife/guide/. Accessed August 4, 2015.

Zielinski, G.A. and B.D. Keim. 2003. *New England Weather, New England Climate*, University of New Hampshire Press, Lebanon, NH.

B. Map Source Data

The Vermont Center for Geographic Information (VCGI) provided data on structures (E911), jurisdictional boundaries, and other information. VCGI data was used for each map and downloaded from http://vcgi.vermont.gov/. Data from other sources, used for specific maps, are listed below.

Map 1. Topographic map: USGS, 2013 (downloaded via VCGI). Current public lands data: developed by the UVM Spatial Analysis Lab, BCRC and the Town of Landgrove, 2012. Road data: VTrans, 2013 (downloaded via VCGI). All other data: VCGI.

Map 2. Land cover data: Digital Coast, NOAA Coastal Services Center, 2010 (http://coast.noaa.gov/digitalcoast/tools/lca?redirect=301ocm). Road data: VTrans, 2013 (downloaded via VCGI). All other data: VCGI.

Map 3. Current Flood Insurance Rate Map: mapped by FEMA in 1985, digitized by BCRC in 1995. Digital Flood Insurance Rate Map (DFIRM): produced by FEMA using LIDAR mapping technology in 2012. Beaver dams and road erosion data: developed by the Town of Landgrove and the BCRC. Road data: VTrans, 2013 (downloaded via VCGI). Bridges and culvert data: VTrans, 2010 (downloaded via VCGI). All other data: VCGI.

Map 4. Steep road grades and potential accident location data: developed by the Town of Landgrove and the BCRC. Road data: VTrans, 2013 (downloaded via VCGI). Groundwater Source Protection Area data: VT ANR. Wetland data: VT ANR, 2011 (downloaded via VCGI). Private wells: VT ANR, 2010 (downloaded via VCGI). All other data: VCGI.

Map 5. Wildfire Risk data: Vermont Forest Resources Plan, VT ANR, 2010 (http://www.vtfpr.org/htm/for_resourcesplan.cfm). Road data: VTrans, 2013 (downloaded via VCGI). All other data: VCGI.

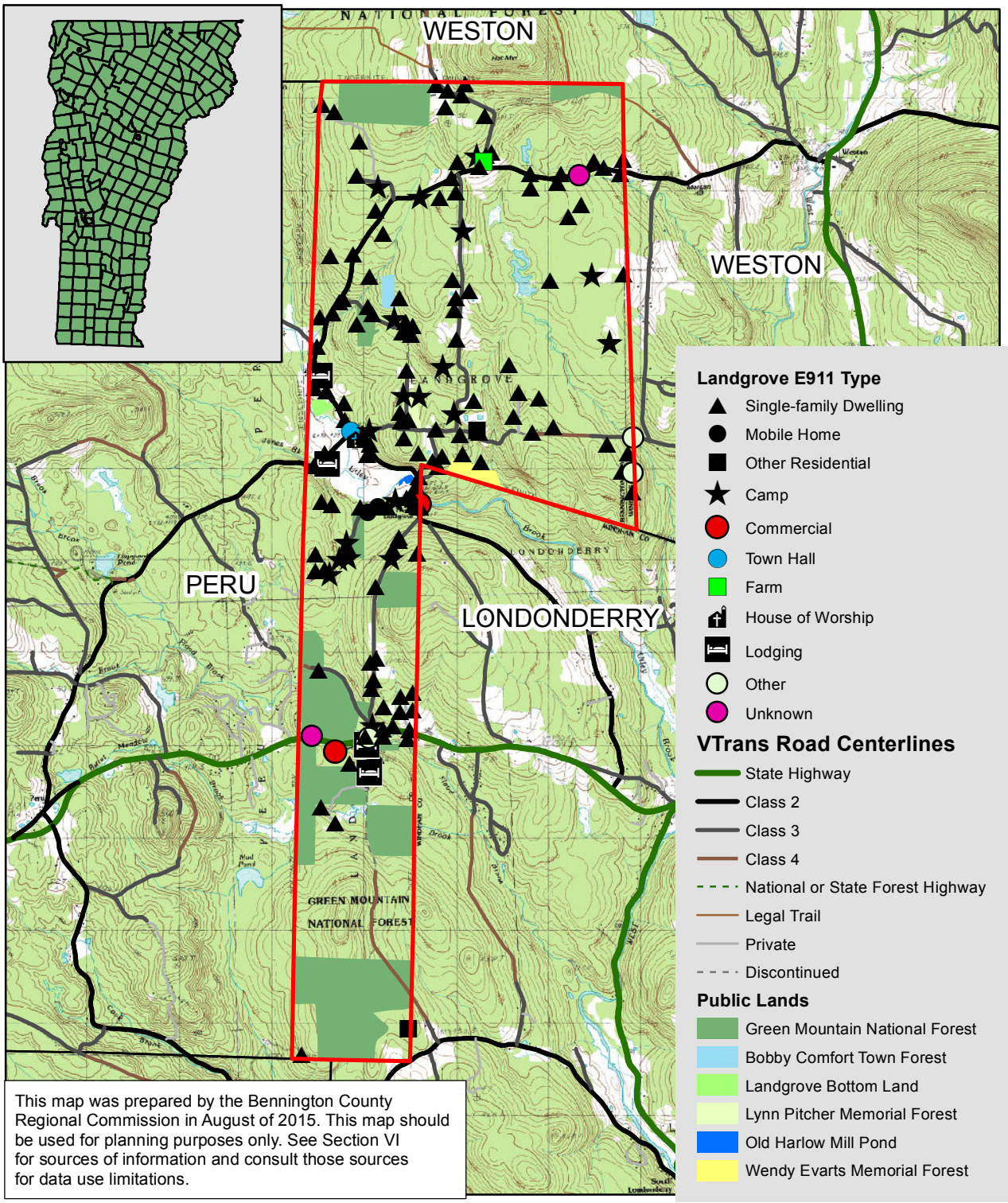
Verbal Communication Sources

Richard Heims, NOAA regarding drought indices, richard.heim@noaa.gov

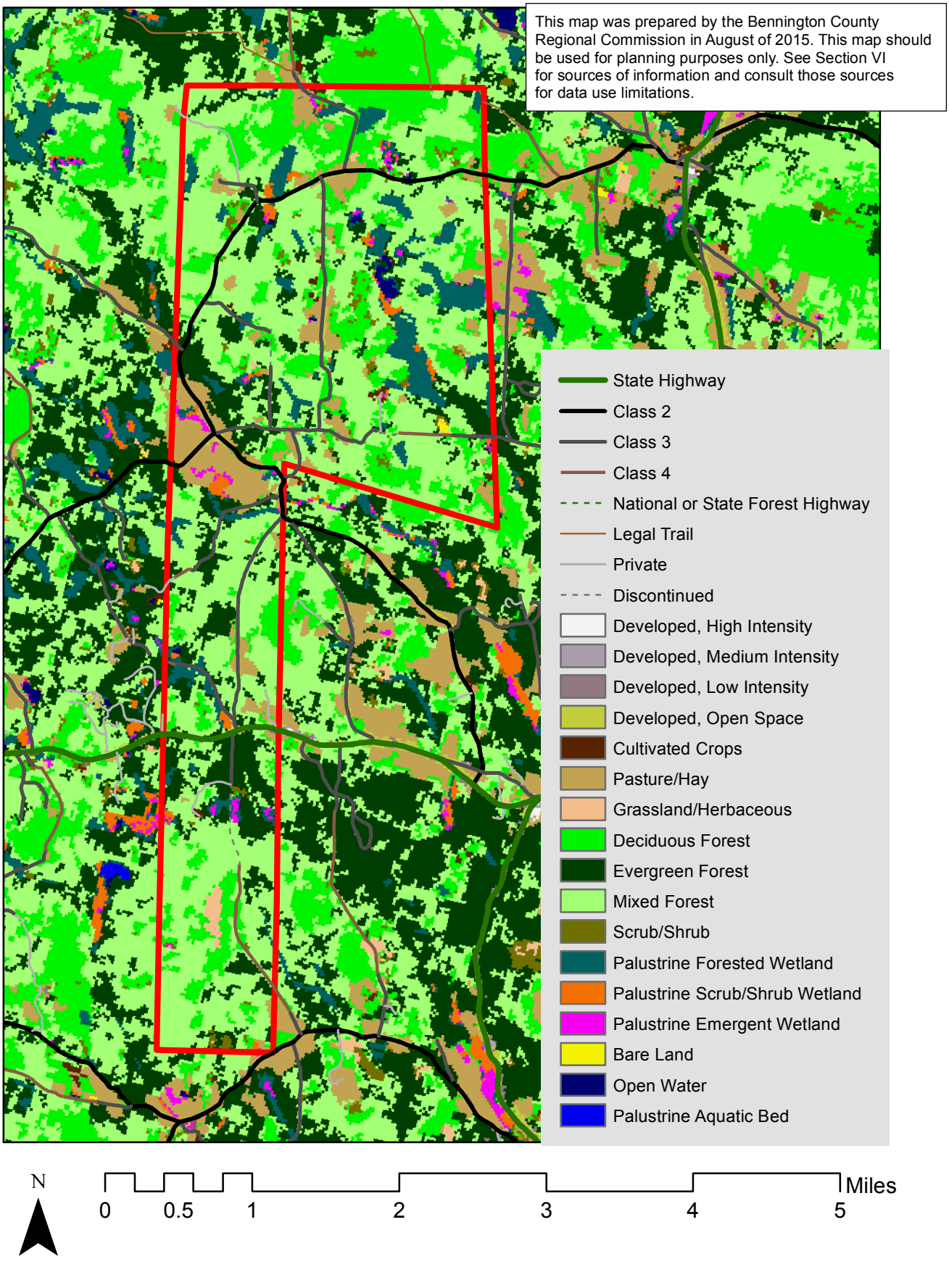
Stuart Hinson, NOAA regarding NCDC data, stuart.hinson@noaa.gov

Ken Yelsey, ANR regarding gpm requirements for private wells, ken.yelsey@state.vt.us

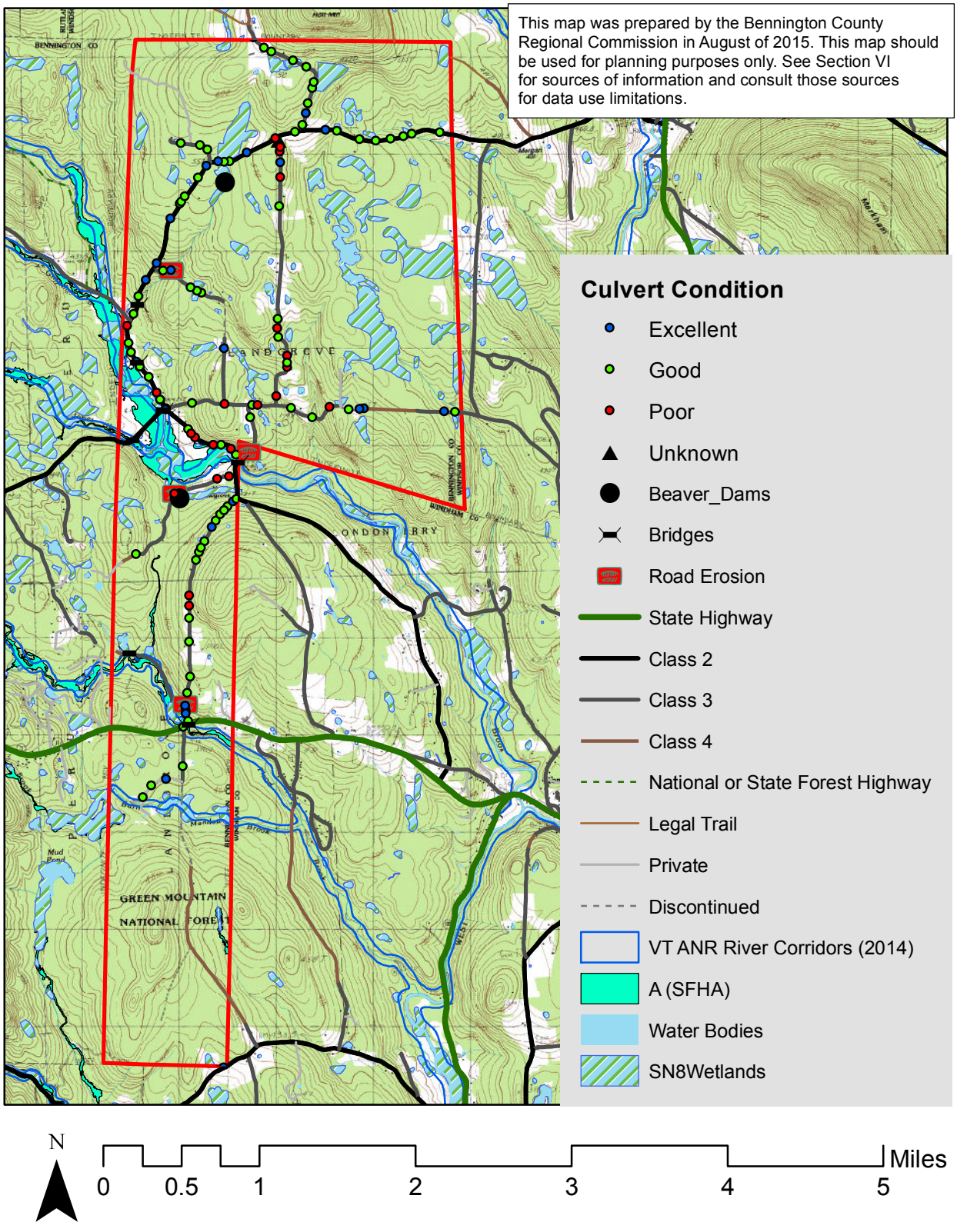
Map 1. Town of Landgrove



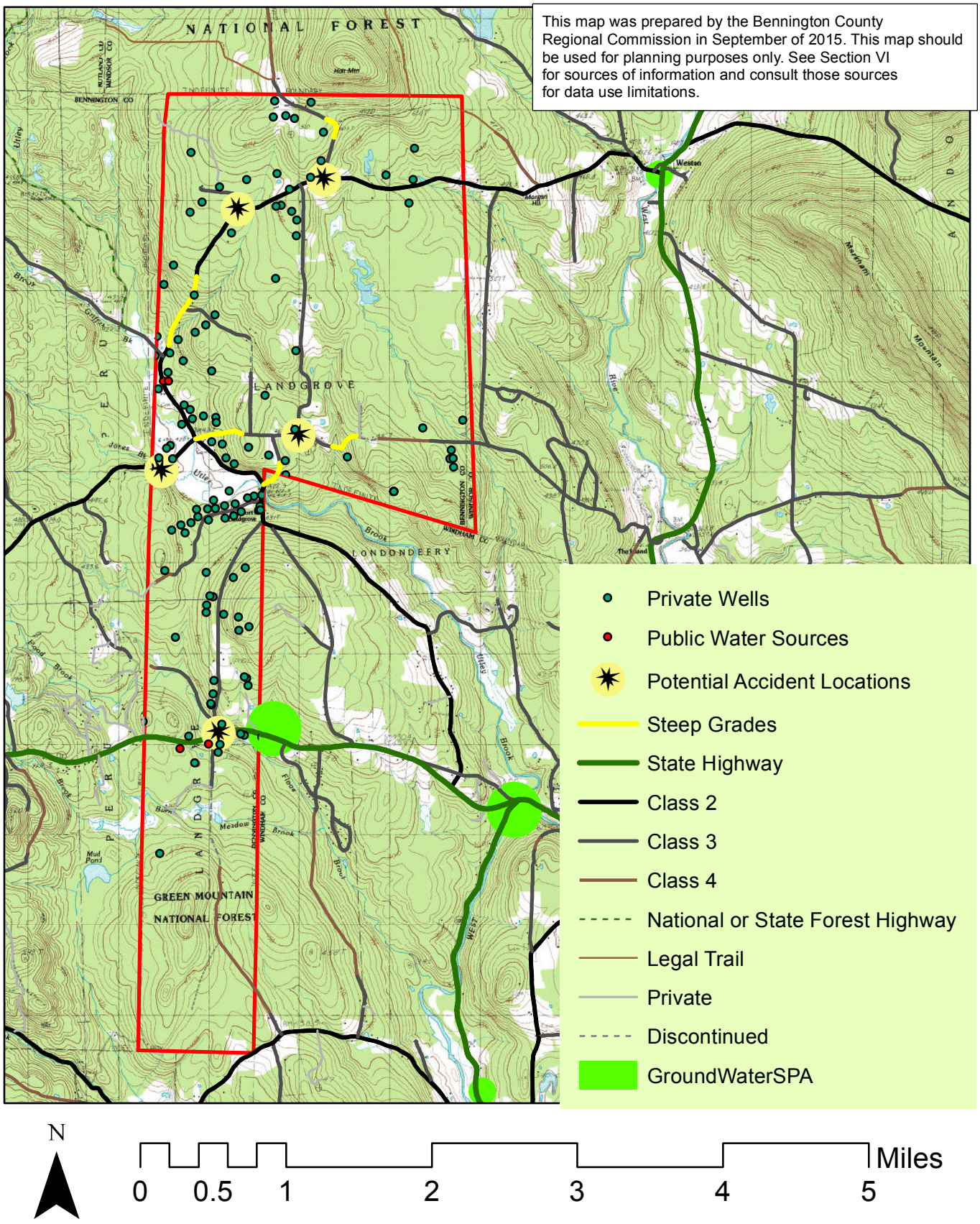
Map 2. Town of Landgrove Land Cover



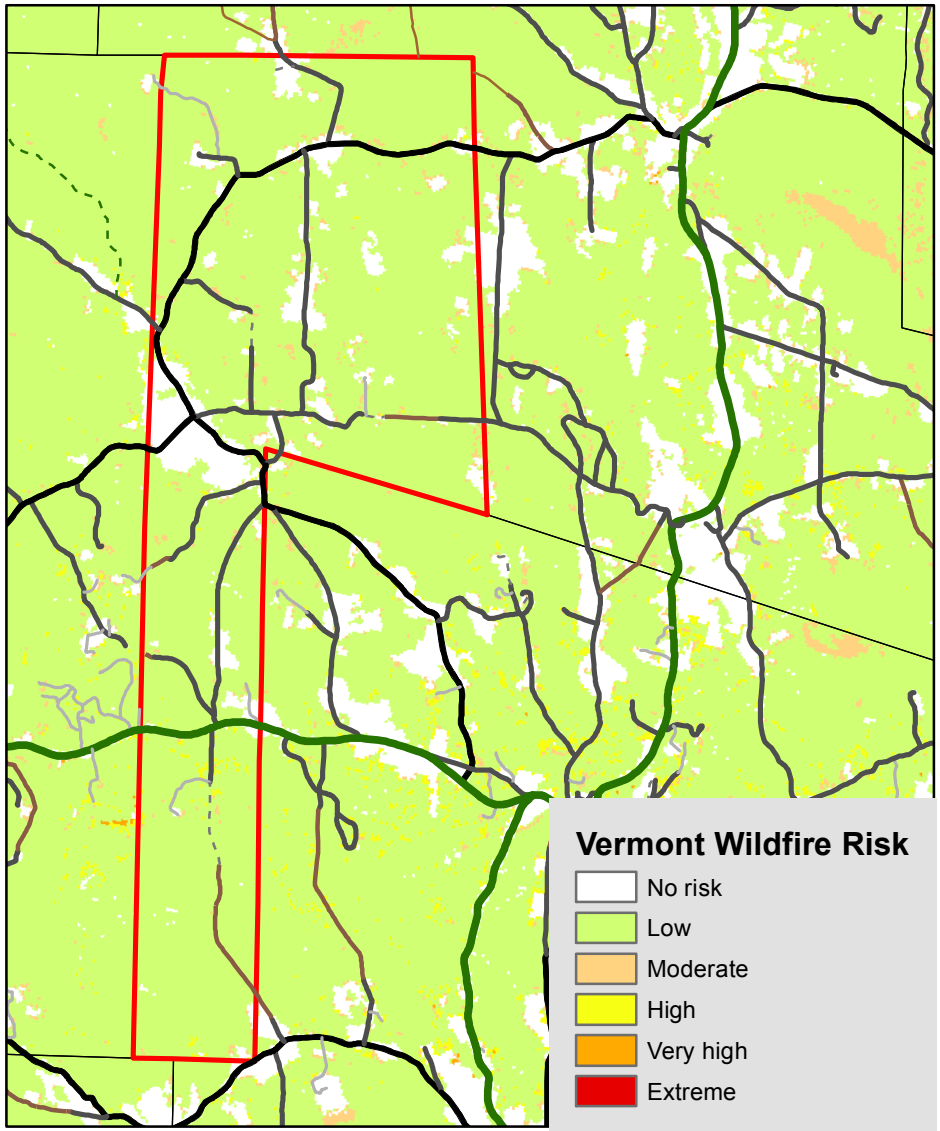
Map 3. Town of Landgrove
Special Flood Hazard Zones and River Corridors

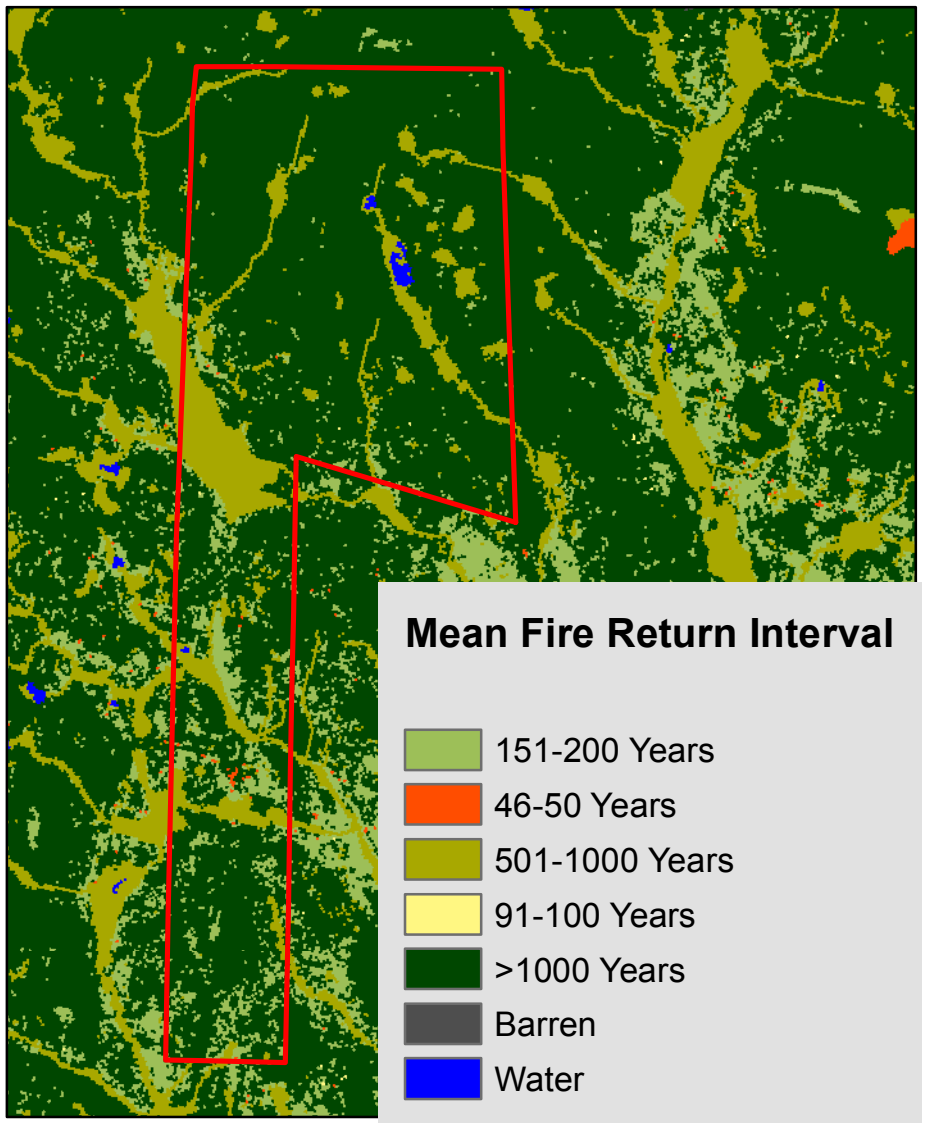


Map 4. Landgrove Water Resources, Potential Accident Locations and Road Hazards



Map 5. Town of Landgrove Wildland Fire Potential





N

0 0.5 1 2 3 4 5 Miles

This map was prepared by the Bennington County Regional Commission in May of 2015. This map should be used for planning purposes only. See Section VI for sources of information and consult those sources for data use limitations.