Flood Resilience: Strategy

Resilience is the capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment. This section focuses specifically on resilience to flooding, including the capacity to plan for, respond to, and recover from floods.

The following strategies are proposed for building flood resilience in Lamoille County:

Communities are flood resilient when they are able to anticipate, prepare for, respond to, and recover from significant floods with minimum damage to social well-being, the economy, and the environment. In the last 50 years, severe storms have gotten more common in Vermont and across the Northeast. While the future is not fully predictable, current models of climate change suggest this trend will continue. We need to take careful steps to ensure that our communities are prepared for and resilient to increasingly frequent floods.

Development is concentrated in areas safe from flooding. Currently in Lamoille County, 6% of residential structures, 12% of commercial facilities and 12% of critical facilities are in the flood hazard areas. Locating new development outside of hazardous areas is one way to reduce future losses. Moving existing buildings, especially critical facilities, out of hazardous locations may be prudent in some cases. Communities need to examine their public and critical facilities to be sure they are accessible, safe and functional when needed.

Development in flood prone areas is protected from flooding damages and does not cause an adverse impact to downstream areas. For those buildings and other infrastructure that can't be moved, steps can be taken to help them experience less damage in the next flood. Some measures include elevating the bottom floor of the building, elevating utilities, changing a below-ground basement into an above-grade level crawl space, and providing vents for flood water to enter and leave the crawl space. Conversely, filling in a floodplain area will only exacerbate flooding downstream and should be avoided.

Floodplains and upland forested areas are protected. Protecting our intact floodplains and river corridors is the single most cost effective way to prevent future flood damage. When we protect these critical areas we give rivers more room to spill over their banks and release their energy when severe storms occur. Over time, rivers connected to their floodplains become rivers less prone to catastrophic flooding. Likewise, forested areas provide multiple watershed benefits including capacity to retain precipitation and moderate flows. Forests in the watershed and even individual trees can help temper peak flows from small storms and larger events. Forests, particularly on higher and steeper locations, provide self-renewing areas that retain and delay water and reduce sediment loading. Branches and trees in the stream channel slow waters, and trap sediment appropriate to an equilibrium condition. Protecting forested lands in the watershed is an important strategy to prevent damaging peak flows. If water is not intercepted, retained and delayed in forest cover then more water may come sooner and quicker - exacerbating flash-flooding and erosive impact.

Ditches and water control structures for transportation infrastructure such as roads and trails are adequately designed, constructed and maintained. Currently most road crossing structures are undersized leaving the transportation infrastructure ripe for injury, loss of emergency services and economic disruption. In the event of a disaster, the loss of services can be devastating and the unbudgeted costs for repairs can be formidable. On the other hand, a transportation network with appropriately sized and spaced culverts and ditches withstands flooding events. To establish and maintain a reliable transportation network requires an assessment of needs, prioritization of infrastructure upgrades, and budgeting for future upgrades. There are state and federal funding sources available to help Towns fund repairs and replacements to safe and resilient standards.

Local communities are well-prepared for flooding emergencies. Communities that are well-prepared greatly reduce the loss of life and property damage when a disaster occurs. Preparedness is a responsibility of

residents, business, and government and includes emergency personnel acquiring suitable equipment and conducting training and exercises, developing and updating local emergency operations plans, establishing evacuation procedures, and communications protocols for disasters. Even simple preparedness measures like having disaster supplies on hand, installing smoke detectors, and knowing basic first aid help to lessen the impact of a disaster.

POLICIES & ACTION ITEMS

Policy: *Discourage new development in flood hazard areas and river corridors.*

Action Items:

- LCPC shall identify flood hazard areas and river corridors, based on maps provided by the Secretary of Natural Resources pursuant to 10 V.S.A. § 1428(a) or maps recommended by the Secretary.
- LCPC encourages municipalities to adopt flood hazard regulations that prohibit new development in the flood hazard areas and river corridors and encourage mitigation of existing development within these areas.

Policy: *Protect areas that help to attenuate flooding, such as wetlands, floodplains, river corridors and upland forests*

Action Items:

- LCPC encourages the protection of wetlands, floodplains, river corridors, land adjacent to streams, wetlands, and upland forests, to reduce the risk of flood damage to infrastructure and improved property.
- Restoration of riparian buffers of at least 50 feet is strongly encouraged along all surface waters.
- Existing riparian vegetation should be protected through such tools as management zones and shoreline zoning.
- LCPC supports riparian corridor and upland forest education efforts.
- LCPC supports federal and state wetland protection rules.

Policy: *Rivers should have access to floodplains wherever possible to establish and maintain stability in order to minimize stream bank erosion and avoid conflicts with human infrastructure.*

Action Items:

- Mitigate floodplain encroachments wherever and whenever possible. Mitigation may include "compensatory storage," removal of infrastructure, floodplain reconnection/re-vegetation, and/or implementation of projects identified in a river corridor plan or local hazard mitigation plan.
- Complete the remaining geomorphic assessments as identified by LCPC and the Vermont Department of Environmental Conservation.
- Work with State partners, communities and community partners to further refine and revise the statewide river corridors map to better reflect actual on-the-ground conditions.
- Assist municipalities in implementing wetland, river corridor, and riparian buffer protections to preserve these resources.
- Work with municipalities, developers, and regional partners to encourage land use practices that use appropriate erosion control techniques.

- Stabilization of eroded stream banks is encouraged in accordance with appropriate professionally accepted standards.
- LCPC supports State stream alteration regulations.

Policy: *For the safety and protection of human resources and infrastructure, new construction within floodplains should be avoided and measures should be taken to protect existing structures within the floodplain.*

Action Items:

- Flood hazard mapping (Flood Insurance Rate Maps) should be updated.
- LCPC will provide technical assistance to communities wishing to explore or enroll in the National Flood Insurance Program (NFIP).
- LCPC supports flood mitigation projects such as flood proofing, property acquisitions, removal of floodplain encroachments, and the development of flood storage space to reduce damage to property in flood hazard areas.
- Compatible land use activities within floodplains, such as agriculture and recreation, are encouraged.
- LCPC encourages communities to adopt bylaw standards above and beyond the minimum National Flood Insurance Program (NFIP) and river corridor standards, so as to encourage existing buildings in hazardous locations to be made safer from flood damage and less costly to insure.
- LCPC encourages elevation of existing structures within the flood hazard areas at least 2 feet above the base flood elevation.
- LCPC will provide technical assistance to communities wishing to explore or enroll in the Community Rating System Program.
- In light of the high percentage of critical facilities located in the Special Flood Hazard Area (SFHA) or river corridor, LCPC encourages communities to either (a) relocate such facilities to less vulnerable areas or (b) elevate the lowest floor and attendant utilities to at least 2 feet above the base flood elevation.
- LCPC will assist municipalities in obtaining grant funding or other financing to relocate or flood proof critical facilities
- LCPC will assist municipalities in identifying suitable areas of development outside of flood hazard areas and river corridors.

Policy: *Ditches and water control structures for transportation infrastructure such as roads and trails should be adequately designed, constructed, and maintained.*

Action Items:

- LCPC encourages municipalities to adopt and implement design standards for bridges and culverts to accommodate a 50-year flood event.
- Ensure additional scrutiny for major transportation infrastructure investments near river confluences, as traditional hydrological modeling may not properly account for the complex water movements in these areas. LCPC will provide technical assistance related to resources for developing local standards, such as the Vermont Better Back Roads Handbook.
- LCPC encourages and provides technical assistance for municipalities to develop inventories, geomorphic assessments of stream-crossing structures, and capital plans.
- LCPC will pursue funding to conduct road erosion assessments in all Lamoille County Towns.

- Regular maintenance of existing bridges and culverts, such as clearing debris, is strongly encouraged to ensure they are operating at full capacity.
- Work with communities to identify infrastructure at risk for and/or known for flood damage and review these for possible mitigation strategies; pursue HMGP and/or water quality grant funding opportunities to further scope out and implement potential mitigation strategies.

Policy: *New development should have adequate stormwater treatment and control mechanisms*

Action Items:

- LCPC encourages the use of municipal stormwater ordinances to address projects under the threshold for state regulation; especially in conjunction with waste water management.
- Proposed development projects must conform to the Vermont Stormwater Management Handbook. LCPC strongly supports use of the voluntary stormwater management credits found in this manual.
- Encourage low-impact development techniques to minimize stormwater runoff impacts.
- Assist municipalities with the development of stormwater design guidelines for both new and existing development.
- Recognize and address impacts of stormwater runoff from both new and existing development.

Policy: *Ensure an efficient, coordinated regional response network exists during flooding emergencies.*

Action Items

- Assist LCPC staff, emergency responders, and municipal officials with proper training and equipment to respond to anticipated disasters.
- Provide support for Citizen Corps Programs that bring emergency responders and volunteers together.
- Continue to provide support and assistance to local and regional emergency response organizations, committees, and individuals for trainings, coordination, drills, and exercises.
- LCPC supports efforts by municipalities to provide emergency response services for all residents.
- Communities are encouraged to develop emergency response plans and provide education to households about emergency preparedness activities. Response plans should be shared with LCPC and with the Vermont Division of Emergency Management and Homeland Security.

Policy: *Reduce the loss of life and damage to property from flooding hazards.*

Action Items

- LCPC will continue to map and track critical facilities, mitigation priorities and vulnerable populations for use in local and regional emergency planning.
- Assist municipalities in adopting and updating all-hazard mitigation plans, emergency operations plans, flood hazard regulations, and other planning documents to strengthen emergency preparedness and community resiliency.
- Assist emergency responders with securing funding for preparedness equipment, such as advanced warning systems and USGS Stream Gages.
- Upgrades to local and regional public safety facilities and equipment are supported and encouraged.

- LCPC supports new residential and commercial developments that include development standards that incorporate disaster resistant designs, such as appropriate emergency response vehicle access, drainage systems, siting, proximity to existing water resources, and flood proofing measures.
- Critical local and regional emergency and governmental facilities should be built and located to be disaster resistant and able to continue to function during disasters.
- Work cooperatively with Emergency Management Directors and the Local Emergency Planning Committee to improve emergency planning.

Flood Resilience: Background and Inventory

Mountainous geography influenced the settlement and historical development patterns of our Vermont communities, so that many of our population centers and farms occupy valley floors where there is more gently sloping land with generally richer and less rocky soil. Many of the valley floors, whose gentle slopes, rich soils, and diverse ecological resources made them so attractive for development, are actually floodplains formed by the meandering movement of streams eroding and re-depositing soil and organic matter. Consequently, our valleys surrounded by steep hills flood often (at least yearly in some locales) and stream channels frequently change position.

Most Vermont watersheds have been altered by human activities including deforestation and farming, channelization, stream bank retaining walls, filling, and construction of roads, bridges, dams, and buildings. When development encroaches or stream channels are altered, conditions in the flood erosion hazard zones become more unstable, exacerbating dangers to downstream occupants and structures.

For more than 200 years we have incurred significant, recurrent, and ever-increasing expenses to control and stabilize our moving rivers, creating a cycle of ever increasing safety risks and maintenance costs. Therefore the most beneficial and least costly course over the long term lies in an approach that reduces flood and erosion hazards; minimizes the recurrent costs of trying to control our streams and repairing/replacing community infrastructure; and allows us to keep our valuable and irreplaceable soil resources while improving stream water quality and aquatic habitat. The goals of protecting our community and our natural resources are interdependent and mutually supportive.

What is Flood Resilience?

Resilience generally refers to "a capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment."[4] This section focuses specifically on resilience to flooding, including a community's capacity to plan for, respond to, and recover from floods.

Types of Flooding

There are generally two types of flooding, flooding caused by inundation and flooding caused by erosion. Inundation, or overbank flooding, occurs when a stream channel or waterbody receives a significant amount of rain or snow melt from its watershed, or when the stream channel is blocked by a debris or ice jam. The excess water spills out onto or inundates the floodplain. This type of flooding can occur slowly or in a short duration; flood waters can cover a small area or a large area.

While inundation-related flood loss is a significant component of flood disasters, the more common mode of damage is associated with fluvial erosion – the dynamic, and oftentimes catastrophic, physical adjustment of stream channel dimensions and location during storm events. These adjustments are often due to bed and bank erosion, debris and ice jams, or structural failure of or flow diversion by man-made structures.

4 National Research Council. *Adapting to the Impacts of Climate Change*. Washington, DC: The National Academies Press, 2010. http://www.nap.edu/openbook.php?record_id=12783.

Inundation (left) and erosion (right) flood hazards.

Causes of Flooding

Flooding in our region is caused by different weather related events, and the severity and duration of flooding is influenced not only by the event itself but also by the condition of the surrounding landscape. By far the most common type of weather event to occur in our region is a severe storm, which may include thunder, lightning, hail, high winds, and precipitation. Severe storms with particularly heavy precipitation have the ability to create flash flood conditions. However, over an extended period of time, severe storms may cause inundation flooding due to the cumulative effects of continuous rain, saturated soils and a high water table/high aquifer levels.

Both severe storms and hurricanes/tropical storms occur during the summer and into the fall months, but ice jams and the combination of melting snow and rain leave our region vulnerable to the impacts of flooding in the winter and early spring. Ice jams typically occur during the spring when river ice begins to break up and move downstream, but may occur during a thaw period in the winter months. Sheets of ice become hung up on a narrow portion of the stream or river, such as under a bridge, culvert or another obstruction, creating a "dam" and additional ice and water begin to back up behind the hung-up ice sheets. This creates inundation flooding immediately adjacent to the site of the "dam," and additional inundation flooding upstream.

Once the "dam" breaks free, flash flooding may occur downstream as well. Ice jams in our region typically cause minimal damage, but they can damage road infrastructure, and flood homes and businesses. The Lamoille mainstem and North Branch have experienced ice jams or are vulnerable to them. Finally, the combination of melting snow and rain, can lead to flooding in the region. The communities of Cambridge Village, Jeffersonville, and Johnson were particularly hard hit by this combination during the spring of 2011, in which inundation flooding resulted in costly damages to infrastructure located in the floodplain, as illustrated below (Figure 4-18).

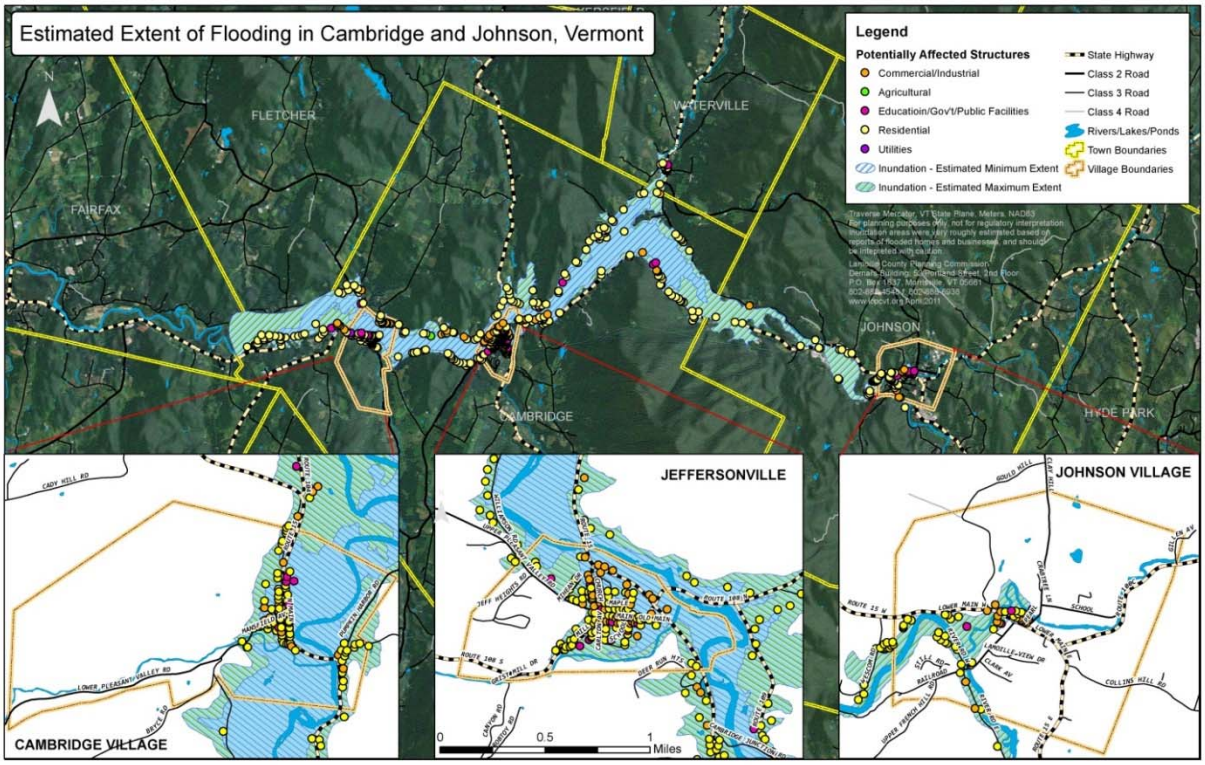


Figure 4-18. Approximate extent of 2011 Spring flooding in Cambridge Village, Jeffersonville and Johnson Village

Regional Impacts of Flooding

Flooding is a natural occurrence in a floodplain, the land adjoining a water body. If floodplain areas were left in their natural state, void of development, floods would cause significantly less damage. Flooding is worsened by land uses that create hard surfaces that lead to faster runoff, and past stream modifications that have straightened or dredged channels, creating channel instability. Furthermore, development in a floodplain can raise the floodwater height as the storage capacity of the floodplain is reduced.

Floods can damage or destroy public and private property, disable utilities, make roads and bridges impassable, destroy crops and agricultural lands, cause disruption to emergency services, and result in fatalities. People may be stranded in their homes for a time without power or heat or they may be unable to reach their homes. Long-term collateral dangers include the outbreak of disease, loss of livestock, broken sewer lines or wash out of septic systems causing water supply pollution, downed power lines, loss of fuel storage tanks, fires, and release of hazardous materials.

Of all types of natural hazards experienced in Vermont, flooding has historically caused the greatest magnitude of damage suffered by private property and public infrastructure. According to the State of Vermont, from 1990 to 2014, over $8 million dollars has been spent to repair the publicly-owned infrastructure (FEMA Public Assistance) in Lamoille County due to damage that has occurred during Presidentially Declared Disasters (see Table 4-19 for full list). Since 2000, Vermont has had more than one federally-declared disaster per year. Since 1990, Lamoille County has had 17 federally-declared disasters due to severe storms and/or flooding.

Table 4-19. Federally declared flood related disasters in Lamoille County, 1990 – 2014

Date	Disaster Number	Description	Damage Costs
April 2014	4178	Severe Storms and Flooding	$350,000
July 2013	4140	Severe Storms and Flooding	$120,000
May 2013	4120	Severe Storms and Flooding	$200,000
May 2012	4066	Severe Storm, Tornado, and Flooding	$194,000
August 2011	4022	Tropical Storm Irene	$551,459
April 2011	1995	Severe Storms and Flooding	$1,124,558
August 2008	1790	Severe Storms and Flooding	$150,000
July 2008	1784	Severe Storm, Tornado, and Flooding	$300,000
April 2007	1698	Severe Storms and Flooding	$40,000
August 2004	1559	Severe Storms and Flooding	$40,000
June 2002	1428	Severe Storms and Flooding	Unknown
September 1999	1307	Tropical Storm Floyd	$187,930
June 1998	1228	Severe Storms and Flooding	$771,661
July 1997	1184	Severe Storms and Flooding	$1,606,517
January 1996	1101	Mid-winter Flooding	$35,555
August 1995	1063	Severe Storms and Flooding	1,870,692
June 1990	875	Severe Storms and Flooding	$658,555

Floods can have a potentially devastating impact on the regional economy. Tropical Storm Irene, arriving just prior to fall foliage season, caused road closures throughout Vermont and disrupted travel for many in-state residents and out-of-state tourists. For Lamoille County, which had minimal transportation impacts, even the perception of potential road damage hurt the region's economy.

Implications of Climate Change and Flooding

There is evidence of increasing frequency and severity of flooding. Whereas the 100-year flood, the standard basis for floodplain management, is by definition 1% likely to occur in any given year, evidence suggests that actual flooding hazards are significantly underestimated. For example, the 100-year event is now closer to a 20% likelihood in any year, and FEMA itself has estimated that the size of flood zones could increase by nearly 50% in the coming decades. Consequentially, the 500-year flood (by definition 0.2% likely to occur in any given year, but the chance of occurrence is actually much higher), may be a more appropriate level for floodplain management. Unfortunately given the age of flood hazard mapping in the county, many floodplains do not have the 500 year (0.2%) flood data delineated.

The greatest increases in severe floods are expected in the Northeast (and Pacific Northwest). This will potentially lead to increased damage from flooding in homes and along roadways; and will also tax the capacity of our wastewater treatment systems, thus impacting our drinking water supply. More frequent and intense rainfall events can also cause direct flooding damage to above-ground utility facilities and buried infrastructure. This, of course, has a financial cost to communities. A changing climate may bring about dramatic social, economic, and environmental change to the region. Accordingly, we should plan for ways to adapt to the changing climate and prevent or minimize the resulting hardships.

Assessing Risks and Vulnerabilities

The first step in becoming more flood resilient is to better understand the risks and vulnerabilities. Where are the areas prone to flooding and fluvial erosion? How many and what kinds of infrastructure are located in and near

these areas? Are there suitable areas located outside the floodplain that could be targeted for future development without fragmenting or encroaching upon the forested areas that are valuable for flood attenuation?

Mapped Flood Plains and River Corridors

Two complementary flood hazard mitigation programs are: (1) the National Flood Insurance Program (NFIP) promoted by FEMA to address inundation hazards, and (2) the river corridor program developed by the Vermont ANR River Management Program to address fluvial erosion hazards.

The National Flood Insurance Program (NFIP) is a voluntary program that provides access to flood insurance to participating communities. These communities adopt and administer land use regulations in flood hazard areas, so as to reduce property damage from inundation. Residents of participating communities are then able to purchase NFIP flood insurance to protect their buildings and possessions. Flood insurance rates are based on Flood Insurance Rate Maps (FIRMs), which delineate areas of the floodplain likely to be inundated during a flood. Inundation areas are divided into zones according to flood risk and include the Special Flood Hazard Area and the FEMA regulatory floodway.

NFIP maps have been created nation-wide, and may be based on assorted data sources, such as studies of historical river flows, rainfall, community knowledge, floodplain topographic surveys, and hydrologic and hydraulic data. There is some degree of variability in how much detail and accuracy is captured in a given location's map. This variability is related in part to the extent of supporting data available. For example, elevation data for rural areas may be unavailable; as a result, many Vermont streams have more "approximate" floodplain delineations than streams mapped in more populated, developed areas.

The NFIP maps focus on a *particular type of flood risk* to the low-lying lands next to the river channel. They show the areas that would be covered, or "inundated," by water as flood waters rise. Technically speaking, the Special Flood Hazard Area (or floodplain) includes the stream channel plus adjacent land inundated by river discharge during a "base flood". The base flood is sometimes referred to as the "100-year flood", which may give the false impression that a base flood can only occur once every 100 years. A more accurate way of describing the base flood is to say that in any given year, there is a 1% chance that a flood of this size will occur. Some Vermont rivers have experienced more than one "100-year flood" within a decade. For example, the upper Lamoille River and Wild Branch experienced flooding of that magnitude in both 1995 and 1997.

In order to enable property owners to be eligible for federal flood insurance though the NFIP, municipalities must adopt and enforce a floodplain management ordinance, often called "flood hazard bylaws," "flood hazard area regulations," or "flood hazard overlay districts" in Vermont. A community's flood hazard regulations must apply to at least the Special Flood Hazard Areas (SFHA) identified by FEMA. The regulations regulate new structures in the floodplain and place restrictions on other types of activities within the floodplain. They also specify land, area, and structural requirements to be adhered to within the SFHA. Paradoxically, using only the minimum required regulations can *increase* flood risk, as they allow filling in flood zones, potentially increasing velocities and/or flood elevations.

The Vermont ANR River Management Program has developed an additional program to supplement the NFIP called the river corridor program. The river corridor program maps a river corridor specially tailored to protect against the predominant form of flood damage in Vermont—fluvial erosion. Based on studies of each stream's

geomorphic (or physical) condition and inherent sensitivity to erosion, river corridor maps provide towns with a powerful flood hazard planning tool. Once the river corridor map is created, towns have the option to adopt a river corridor overlay district, limiting development in the river corridor

The river corridor is designed with the recognition that rivers are *not static*, and that flood damages in Vermont are often a result of fluvial erosion hazards. Considerable damage can occur when a flooding river dramatically enlarges or makes a catastrophic change in course, resulting in severe erosion of the river bed and banks. Typical and costly damage occurs when streams and rivers cannot flood and the power of the trapped water digs the channel deeper until the nearby roadbank fails, houses fall in, or culverts blow out.

A certain amount of erosion is natural in Vermont floods because of the region's relatively steep terrain and flashy, frequent storms. However, due to human encroachments and historical channel engineering (e.g., bank armoring, berming, and channel straightening), many Vermont rivers have become unstable and can no longer flood leading to increasing stream power and damage.

The river corridor zone includes both the channel and the adjacent land. The purpose of the zone is to identify the space a river needs to re-establish and maintain stable "equilibrium" conditions. In other words, if the river has access to floodplain and meander area within this corridor, the dangers of flood erosion can be reduced over time. The river corridor is delineated based on scientific, location-specific assessment of the fluvial geomorphic (or physical) condition of a river.


Aerial photo showing a river's natural meander pattern.

Because the underlying methods of mapping differ significantly, it is not surprising the flood maps differ. In some situations, the river corridor is narrower than the FEMA floodplain, usually as a result of bedrock or elevated landforms that may not have been evaluated in the NFIP studies. In other areas, the river corridor may extend beyond the FEMA regulatory floodway or even the Special Flood Hazard Area boundaries. These locations are potentially hazardous, and under minimum NFIP guidelines alone, development and infrastructure in these areas may be susceptible to flood damage and/or may contribute to further instability and erosion hazard upstream or downstream. Moreover, on streams where FEMA has mapped "approximate" flood hazards (Zone A areas), river corridor maps provide communities with essential, more detailed flood risk data.

Mapping Vulnerable Locations

The maps below show the flood hazard areas and river corridors in Lamoille County and areas vulnerable to flooding. The flood hazard areas are derived from the most recent FEMA maps developed largely in the 1970s and 80s (with the exception of Wolcott and Stowe, both produced in 2006). The Vermont Department of

Environmental Conservation completed a statewide map of river corridors in 2014, the results of which are shown below. This map is available online at www.lcpcvt.org and the mapping data can also be viewed on the ANR Natural Resources Atlas. Another map below depicts transportation infrastructure within the FEMA designated Special Flood Hazard Area (SFHA) or within the ANR designated river corridors. In Lamoille County there are 59 miles of road within a SFHA or river corridor. Of this, 11 miles are classified as State Highway and 38 miles are classified as Class 1, 2 or 3 Town Highway. Town bridge and culvert inventories conducted since 2011 (not including Morristown and Stowe) indicate that 19 "critical culverts" (culverts less than 25% open or that have critical deficiencies) are within a SFHA or river corridor area.

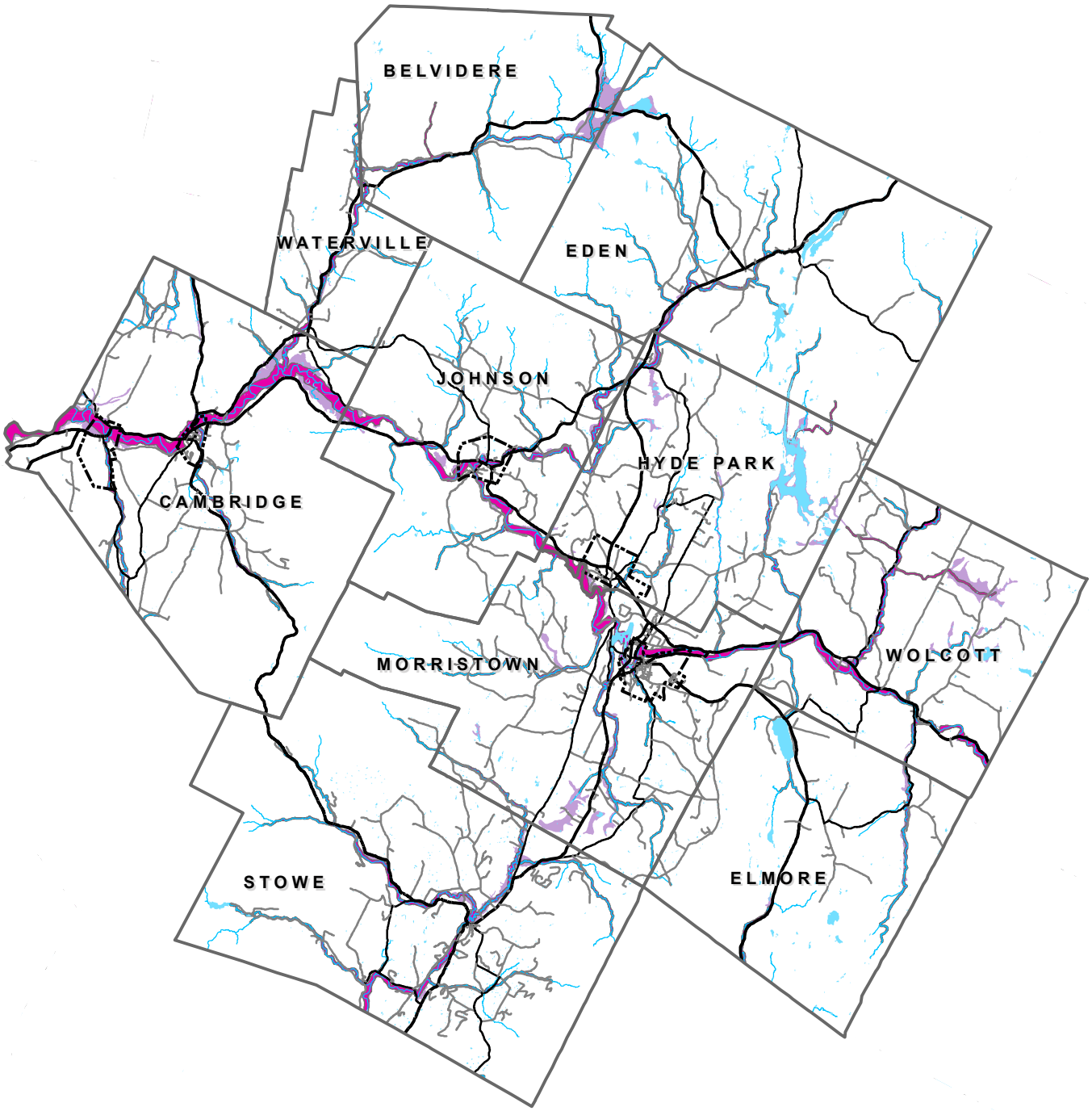
Where geomorphic assessments have been conducted, the 'percent of bankfull width' has been calculated for bridge spans and culvert diameters to indicate how compatible the structure is by design. A percent of bankfull width less than 100% contributes to the likelihood of sediment buildup, requiring maintenance and leading to a higher risk of failure. This data can be found in River Corridor Plans."

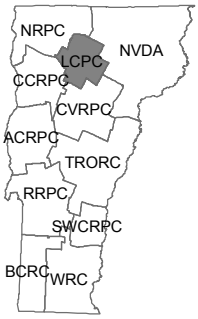
Structures at risk of damage from flood events are those structures that are within the FEMA designated Special Flood Hazard Area (SFHA) or within the ANR designated river corridors. The Structure Vulnerable to Flooding map below overlays the SFHA and river corridors with E911 structures. Structures were divided into the following categories:

Residential: Camp, mobile home, multi-family home, single family home, seasonal home, and other residential.
Commercial/Industrial: Industrial, commercial, commercial farm, commercial with residence, lodging, and other commercial.
Public/Critical Facilities: Cultural, educational, fire station, government, health clinic, house of worship, law enforcement, public gathering, and utility.
Other: Accessory building, abandoned, development site, gated without building, public telephone, other, unknown.

Special Flood Hazard Areas and River Corridors

Lamoille County





State Highway or Class 1 Town Highway

Class 2 Town Highway

Class 3 Town Highway

Lake/Pond

Stream

River Corridor

Special Flood Hazard Area

0 2.5 5 Miles

N

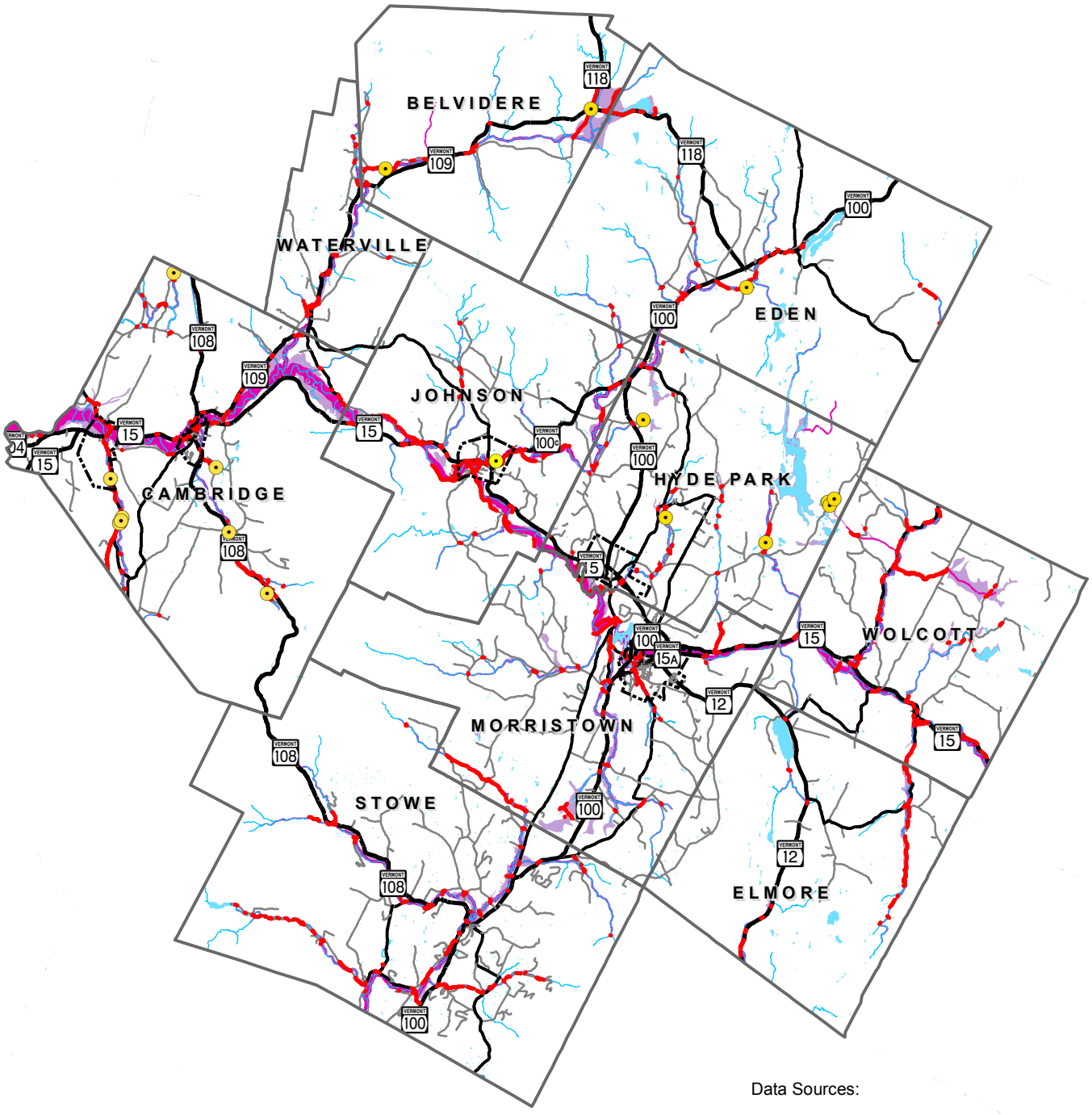
Data Sources:

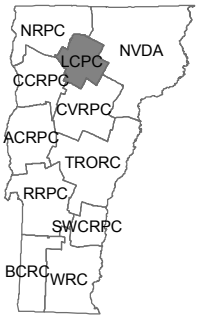
Flood Hazard Areas: Digitized from FEMA Flood Insurance Rate Maps. DEC, Water Quality Division, 1983; Wolcott and Stowe Digital Flood Insurance Rate Map (DFIRM), FEMA, 2006. Floodplains for planning purposes only.
River Corridors: VT ANR River Management, 2015.

Created 7/30/2015 by LCPC. Map is for planning purposes only, not for regulatory interpretation.

Transportation Infrastructure Vulnerable to Flooding

Lamoille County





- Critical Culverts in SFHA or River Corridor
- Roads in SFHA or River Corridor
- State Highway or Class 1 Town Highway
- Class 2 Town Highway
- Class 3 Town Highway
- Lake/Pond
- Stream
- River Corridor
- Special Flood Hazard Area

0 2.5 5 Miles

N

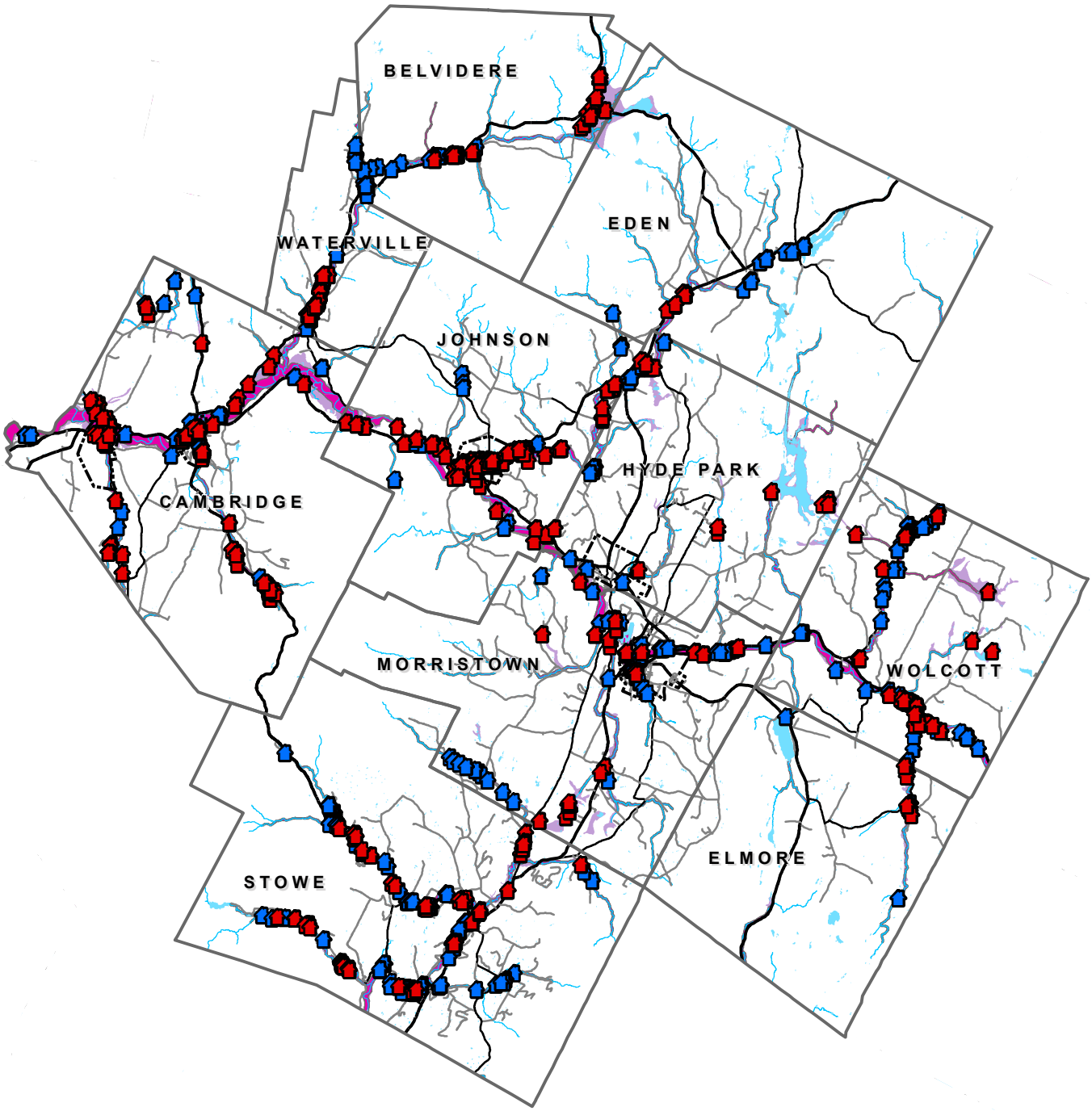
Data Sources:

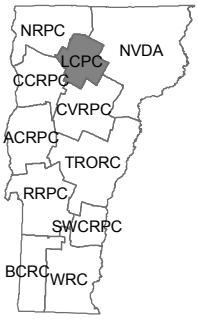
Flood Hazard Areas: Digitized from FEMA Flood Insurance Rate Maps. DEC, Water Quality Division, 1983; Wolcott and Stowe Digital Flood Insurance Rate Map (DFIRM), FEMA, 2006. Floodplains for planning purposes only.
River Corridors: VT ANR River Management, 2015.
Roads in River Corridor or Special Flood Hazard Area: Based on intersecting E911 roads data with mapped floodplains and river corridors.
Critical Culverts in River Corridor or Special Flood Hazard Area: Based on intersecting critical culverts with mapped floodplains and river corridors. Culverts rated as "critical' or "urgent" in inventories conducted by LCPC since 2011. Stowe and Morristown are excluded due to the age of their structure inventories.

Created 7/30/15 by LCPC. Map is for planning purposes only, not for regulatory interpretation.

Structures Vulnerable to Flooding

Lamoille County





- Structures in SFHA
- Structures in River Corridor
- Lake/Pond
- Stream
- River Corridor
- Special Flood Hazard Area

0 2.5 5 Miles

N

Data Sources:

Flood Hazard Areas: Digitized from FEMA Flood Insurance Rate Maps. DEC, Water Quality Division, 1983; Wolcott and Stowe Digital Flood Insurance Rate Map (DFIRM), FEMA, 2006. Floodplains for planning purposes only.
River Corridor/Fluvial Erosion Hazard Areas: VT ANR, 2015.
Structures: E911 data, 2014.

Created 3/10/2015 by LCPC. Map is for planning purposes only, not for regulatory interpretation.

In Lamoille County 736 of 12,453 structures (not including "other" as defined above) are within the SFHA or the river corridor. As shown in Figure 4-20 at right, although residential homes comprise 89% of E911 structures, only 5% are in the flood hazard areas. Contrasting this, 12% of critical facilities, comprising only 2.6% of the total structures, are in the flood hazard areas. Likewise, 12% of commercial facilities lie within the flood hazard areas. Notably, much of the flood related damage to public infrastructure in the Lamoille region has historically not occurred within the identified 100-year flood zone, but within the river corridors due to the persistent impacts of fluvial erosion.

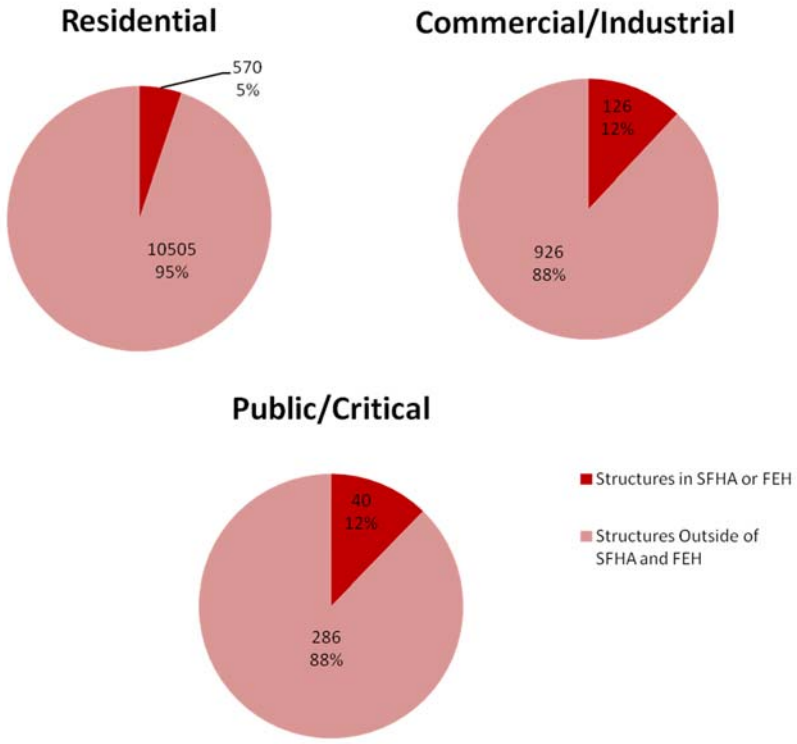


Figure 4-20. Number and percentage of structures within flood hazard areas.

National Flood Insurance Program

Since 1978, there have been 101 NFIP policy claims amounting to $ 1,057,976 in Lamoille County. There are 143 NFIP policies in effect. Towns in Lamoille County not participating in the NFIP are Eden and Waterville. Neither town participates due to a lack of perceived threat from flooding. LCPC will continue to support NFIP compliance in each of its local jurisdictions by working with municipalities on the review and update of floodplain management ordinances, as well as bylaws, floodplain identification, and mapping.

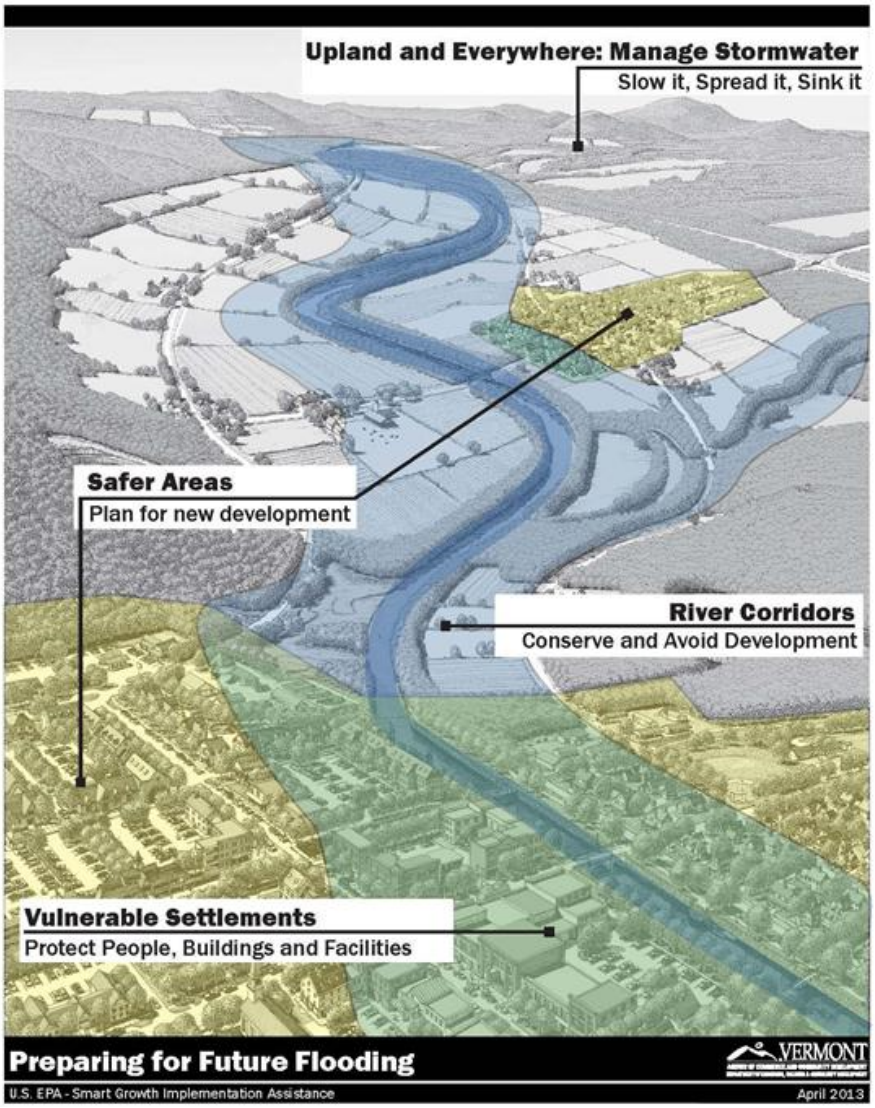
The NFIP was instituted in 1968 to make flood insurance available in those communities agreeing to regulate future floodplain development. As a participant in the NFIP, a community must adopt regulations that: 1) require any new residential construction within the 100 year floodplain to have the lowest floor, including the basement, elevated above the 100 year flood elevation; 2) allow non-residential structures to be elevated or dry flood proofed (the flood proofing must be certified by a registered professional engineer or architect); and 3) require anchoring of manufactured homes in flood prone areas. The community must also maintain a record of all lowest floor elevations or the elevations to which buildings in flood hazard areas have been flood proofed. In return for adopting floodplain management regulations, the federal government makes flood insurance available to the citizens of the community. In 1973, the NFIP was amended to mandate the purchase of flood insurance as a condition of any federally regulated, supervised or insured loan on any construction or building within the 100-year floodplain.

Communities with a large number of structures already in the flood hazard zone may benefit from participation in the FEMA Community Rating System (CRS) program. The CRS program provides a discount on premiums to flood insurance policy holders in towns that choose to participate. Participating towns accrue rating points by exceeding the minimum NFIP requirements, for example, by prohibiting the development of new structures within the SFHA and the river corridor, or through public outreach efforts, storm water maintenance, and other actions.

Becoming More Flood Resilient[5]

There are many steps that communities can take to reduce the risks of flooding, and the loss, disruption, and repetitive costs that may occur. Many towns are already taking these steps. Specific local land use policy options to improve flood resilience are organized into four categories, representing different geographic areas in a community:

- River Corridors: Conserve land and discourage development in particularly vulnerable areas along river corridors such as flood plains and wetlands.
- Vulnerable Settlements: Where development already exists in vulnerable areas, protect people, buildings, and facilities to reduce future flooding risk.
- Safer Areas: Plan for and encourage new development in areas that are less vulnerable to future floods.
- The Whole Watershed: Implement enhanced stormwater management techniques to slow, spread, and infiltrate floodwater.



Four categories of approaches to enhance resilience to future floods. Credit: VT ACCD

The policy options in these categories offer multiple and interrelated benefits. For example, directing development out of flood plains not only keeps people and property safe, it also protects the ability of flood plains to hold and slow down flood water before it reaches downstream settlements.

River Corridors

Communities that wish to reduce future flood risk can consider conserving land and discouraging development in particularly vulnerable areas, such as flood plains along river corridors. Conserving land in river corridors, especially land that is in a natural, vegetated state, can reduce flood risk by absorbing and making room for water during floods. Moreover, discouraging development in these areas can reduce the risk that homes, businesses, and critical infrastructure will be damaged by floods. Some strategies for conserving land and discouraging development in flood-prone areas include:

5 The information contained in this section was obtained and modified from the EPA authored report entitled **Planning for Flood Recovery and Long-Term Resilience in Vermont: Smart Growth Approaches for Disaster-Resilient Communities**.

1. **Acquire or protect land in flood-prone locations,** through such means as conservation or river corridor easements, property buyouts, Transfer of Development (TDR) programs, and restoration of riparian buffers. Numerous riparian buffer projects have been implemented within Lamoille County. Several Lamoille County communities including Jeffersonville, Wolcott, and Stowe have purchased river conservation easements in the floodplain or river corridor, and those easements are managed as recreational green spaces. Stowe has developed a TDR program. Under a TDR program, sensitive or vulnerable lands, such as flood plains or land in a river corridor, are zoned to restrict development and designated as a "sending area." Communities then designate "receiving areas" where they wish to see additional development. Those "receiving areas" are zoned to allow additional density.

2. **Encourage agricultural and other landowners to implement pre-disaster mitigation measures.** Agricultural land in flood plains may be subject to erosion during floods, impacting farmers' ability to continue agricultural activities on their property. However, with planning and implementation of pre-disaster mitigation measures, agricultural land can be protected and can provide flood storage capacity during heavy rains, reducing flood-related damage and associated losses to both the farm and the community. Where farmers have access to upland fields they can have fall-back crops during flood years. Also, river corridor easements are available to help farmers manage fields in a way that is compatible with dynamic channel adjustments.

Agricultural landowners could also implement specific flood mitigation measures, such as storing hay bales in areas less likely to be flooded, since these bales can be carried into the river during floods, clogging culverts and bridges, which can create a dam downstream and inadvertently contribute to increased flooding along the riverbanks. Farmers and forestland managers can also install ponds or swales to capture stormwater and plant vegetation that can tolerate occasional inundation. Utilizing such techniques can help reduce damage from flooding and can also help recharge aquifers.

3. **Implement flood plain development limits that exceed FEMA requirements.** Paradoxically, using only the minimum required regulations can *increase* flood risk, as they allow filling in flood zones, potentially increasing velocities and/or flood elevations. The experiences of communities across the country demonstrate that simply adopting the NFIP minimum standards does not guarantee avoidance of flood damage and losses. The Community Rating System (CRS) is a part of the NFIP. The CRS reduces flood insurance premiums to reflect what a community does above and beyond the NFIP's minimum standards for floodplain management. The objective of the CRS is to reward communities for what they are doing, as well as to provide an incentive for new flood protection activities. The reduction in flood insurance premium rates is provided according to a community's CRS classification.

There are 10 CRS classification levels for communities. All NFIP communities start at Class 10 and begin to receive reduced premium rates at Class 9. Each time a community goes to a lower class, premiums for properties in the special flood hazard area are reduced by 5%. The maximum benefits under the program are at Class 1 with a 45% reduction. Only a handful of communities in Vermont are CRS communities.

To earn CRS credit involves such actions as preserving open space in the floodplain; enforcing higher standards for safer new development; maintaining drainage systems; and informing people about flood hazards, flood insurance, and how to reduce flood damage.

4. **Protect River Corridors and Floodplain Functions.** Development in river corridors can cause erosion and changes to the river channel. To further protect vulnerable land and avoid exacerbating downstream flooding, communities can adopt hazard area bylaws to protect river corridors and floodplain functions. Stowe has incorporated river corridor protection regulations in its development codes, and other Lamoille County communities are considering adoption of river corridor protection area overlay districts. If communities choose to allow limited development in river corridor areas, they could require protecting alternative river corridor/floodplain areas to balance the loss of area for channel adjustments caused by that development and thereby offset impacts on existing structures and public safety. However, this strategy might not reduce flooding risk as effectively as limiting development and redevelopment in these areas altogether.

5. **Adopt agricultural or open space zoning.** Agricultural or open space zoning is another technique available to communities that wish to protect land to allow flood water to spread and soak in the soil. This type of land use policy can limit or prohibit development in agricultural or other natural areas by limiting the number of residential units allowed on a parcel. Increasing the agricultural or open space zoning to require a minimum lot size of 20 acres or more might more effectively preserve agricultural and open space uses and manage flood water.

Vulnerable Settlements

Many historic downtowns and village centers are located along rivers in vulnerable areas and in flood plains, which often contributes to their attractive character and to the town's or region's economy. These centers represent significant investments in infrastructure over generations, and many communities choose to repair and rebuild these areas after floods because of their economic, cultural, and social importance. If communities choose to rebuild in areas that are particularly susceptible to future flooding, they can take some steps to reduce the damage that might occur in future floods, although they cannot eliminate these risks entirely.

1. **Adopt conservation or cluster subdivision ordinances.** Some communities are adopting conservation or cluster subdivision ordinances that encourage or require new development to protect tracts of intact open space (including sensitive natural areas like river and stream corridors) while clustering development into a smaller section of the parcel. These types of ordinances might help conserve land that is important for retaining flood water.

2. **Encourage natural protection methods.** Conventional, engineered approaches to protect development in flood and erosion prone areas such as armoring riverbanks with rock riprap and channelizing rivers, while necessary in some cases, should be discouraged or at least combined with non-structural techniques, such as planting trees and vegetation along riverbanks. One of the challenges of conventional, structural engineered approaches to flood resilience is their cost. Armoring riverbanks and rebuilding and elevating structures can be very expensive. Engineered approaches can also cause future unintended flood damage upstream and down. Riprap tends to increase the speed of water flow and can cause erosion downstream in some areas while contributing to siltation in other areas. As streams and rivers come into a fluvial geomorphic equilibrium slope, the need for engineered barriers will be reduced and vegetated streambanks should provide adequate resistance to the lower stream power and rates of erosion.

3. **Upgrade regulations to protect vulnerable structures.** Many communities control flood plain development through special flood plain or flood hazard area zoning overlay districts with associated development standards. Many of these standards require the lowest floor of any structure in these districts to be elevated at least 1 foot

above the base flood elevation. Base flood elevation is the elevation to which flood water is expected to rise during a 100-year flood (a flood that has a 1% chance of being equaled or exceeded in any given year). Communities should consider increasing this requirement to a minimum of 2 or more feet above the base flood elevation to provide an extra margin of safety, although as noted above, this may not be sufficient in some places subject to fluvial erosion processes. Alternatively, towns could consider prohibiting development in the floodway or flood plain entirely to reduce risk further.

4. **Address nonconforming uses.** Many areas of Lamoille County were developed before implementation of the National Flood Insurance Program. As a result, some communities have development that does not comply with current flood damage prevention requirements. Often these homes and businesses fail to comply with zoning-related requirements such as setbacks, off-street parking, or design-related provisions. Because modifications to these older structures would trigger the requirement for full compliance with all development standards, which can be cost-prohibitive, these nonconformities continue unchanged through the years. To address these problems, some communities are implementing nonconforming use regulations that recognize partial compliance with development standards and incorporate incentives for property owners to redevelop and/or reconstruct nonconforming structures using more hazard-resilient techniques, such as building elevation or flood-proofing of heating, ventilation, and air conditioning (HVAC) equipment. Incentives for redeveloping nonconforming structures, when coupled with requirements for greater hazard resilience, can help development in flood-prone areas better withstand future floods. The home or business owner can increase the value of their property without incurring the expenditure of full code compliance, while the community benefits from a structure that is less likely to sustain serious damage during a future flood.

5. **Create new flood storage capacity through redevelopment.** When redevelopment opportunities arise in vulnerable areas next to rivers, communities can require developers to design projects to include additional flood storage capacity. New flood storage capacity could mean creating parks and other open spaces in flood-prone locations, replacing a vertical wall along a river bank with a more gradual slope to create more room in the river channel for rising water, creating a shallow depression in a lawn that can accommodate inundation, or designing buildings to enable the first floor or basement to flood (and then be readily repaired when the waters recede). Localities can encourage developers to create flood capacity in new development by providing density bonuses or reduced stormwater fees in exchange for creating flood capacity improvements on site and/or adding zoning overlays that indicate where new development must include additional flood capacity features.

6. **Develop a local flood model** – Given the age of many of the NFIP maps in the county, changes in the watersheds, and climate change considerations, communities may look to develop updated flood models to determine current and future risks. This type of model allows for better planning of current and future development needs while identifying opportunities for mitigation measures to reduce or eliminate flood risks. Also, an interactive, visual model is a very effective way to engage the local community. Jeffersonville incorporated watershed modeling into their current Hazard Mitigation Plan, and is taking recommended actions to reduce flood risk and improve flood resiliency.

7. **Help people connect with the river.** Opportunities to see and engage with the river could increase residents' consciousness of the river's presence and motivate them to engage in planning for future flooding and river protection. In vulnerable settlements, communities can consider creating parks, outdoor dining and vending, river-based recreation like fishing and kayaking, and other activities that can withstand flooding and bring people closer to the river during normal flows. Implementing these approaches can also provide important economic

development opportunities for communities. Wolcott's School Street Park and Wild Branch Park, Morrisville's Oxbow Park, and Stowe's Mayo Farm are some examples of communities' efforts to highlight rivers as scenic and recreational assets while preserving the resource of the surrounding floodplain.

8. Relocate structures to less vulnerable areas. As certain structures are flooded time and again, some communities and property owners might determine that it would be preferable to relocate them or rebuild them in safer areas. When the community decides to relocate structures through extensive and thorough community outreach, local governments can make the process easier for those who choose to relocate by creating a coordinated package of relocation services and resources for residents, including financial and logistical assistance with relocation. Through the relocation process, local governments can also move critical facilities such as town halls, fire and safety facilities, and drinking water facilities to less vulnerable locations, if possible. Some communities have created funding mechanisms, such as sales tax or stormwater utility fees, to buy properties that are susceptible to future floods. In addition to local funding, there might be opportunities to leverage federal assistance, such as FEMA's Pre-Disaster Mitigation Grant program, Hazard Mitigation Grant Program, or Flood Mitigation Assistance Program; and HUD's Community Development Block Grant program.

Safer Areas

Communities seeking to enhance their resilience to future floods can identify areas within or near centers that are less vulnerable to flooding, where growth can occur more safely in the future. By encouraging development in these safer growth areas, communities can accommodate new growth while reducing flooding risk. After communities have identified *where* they can more safely grow in the future, they can then also shape *how* development is built in those locations by using the smart growth principles. Several approaches and policies can help communities' direct growth into safer locations.

1. Identify locations suitable for development and redevelopment that are safer from flooding. Communities that are interested in targeting growth in *safer* locations would need to ensure that their desired growth areas are also located in areas that can more safely accommodate growth. They can then identify these safer growth areas in the land use plan or comprehensive plan. To identify where growth can occur more safely in the future, communities will need information about where flooding has occurred in the past and, to the extent possible, projections for future flooding that take climate change into account. The Vermont Agency of Natural Resources Flood Ready website has mapping resources that can be used for this purpose. The identification of safer areas for development needs to allow for the protection of natural areas like wetlands and upland forested areas, as these areas provide valuable flood attenuation and storage capacity, wildlife habitat, recreational and scenic value, and resources for forestry and forest products. Therefore, suitable safer areas for development should ideally be located within or in close proximity to downtowns and village centers.

2. Steer public policy and investments to support development in safer locations. Once communities have identified locations that are safer for development, they can adopt and implement policies and make public investments that will encourage development in those safer locations. Localities can update their zoning and subdivision regulations to remove barriers to development in safer areas. Localities can also direct public investments in new infrastructure, facilities, and schools into safer locations, which might help attract additional

private investment in these areas. By prioritizing capital investments such as sewer, water, and streetscape improvements in safer areas, communities can provide incentives for development to locate there.

The Whole Watershed

Communities can also implement policies to more effectively manage stormwater throughout the entire watershed. Adopting these policies can help slow stormwater, spread it out over a larger area, and allow it to infiltrate into the ground rather than running off into nearby streams and rivers.

1. **Explore watershed-wide stormwater management.** Flood damage mitigation measures, such as constructing levees or armoring banks, that are implemented in one jurisdiction in a watershed can have unintended consequences for other communities in that watershed by speeding the flow of floodwaters downstream. Recognizing this, some communities are joining together to take a regional, watershed-wide approach to stormwater management. To do this, communities can develop educational programs and stormwater master plans for their watersheds and use hydrologic data and watershed modeling to understand more clearly what actions to take to absorb and slow down stormwater across the watershed to reduce flooding risk.

The State of Vermont Department of Conservation recently completed a stormwater infrastructure mapping project for five Lamoille County towns. The primary goal of the project was to enhance the towns' capacities to develop stormwater management plans, while a secondary goal was to establish potential locations for Best Management Practice (BMP) stormwater retrofit sites. Final reports and data of the mapping project were provided to each municipality and are also available at: http://www.watershedmanagement.vt.gov/erp/htm/SW_IDDE_program.htm.

Some communities create stormwater utilities to address stormwater management across a wider geographic area. A stormwater utility is an entity established to generate and administer a dedicated source of funding for stormwater pollution prevention activities. Generally, users pay a fee to the utility based on land use and their contribution of runoff to the stormwater system. Stormwater utilities can oversee stormwater management regulation and can help prioritize, coordinate, and finance critical pre-disaster mitigation efforts such as streambank restoration projects.

2. **Better manage stormwater from roads, driveways, and parking lots.** Roads, driveways, and parking lots made of impervious surfaces do not allow stormwater to infiltrate back into the ground and can increase stormwater runoff volumes, especially during heavy rains. In addition, the runoff collects the debris, oils, and pollutants from these paved surfaces and carries them into surface waters. Communities could consider implementing policies that can reduce the effect that roads, driveways, and parking lots have on exacerbating flooding and degrading water quality. They could encourage the use of pervious material in new driveways and parking lots, and in new roads where feasible. In addition to green infrastructure practices (see paragraph below) such as pervious pavement and roadside swales that allow stormwater to infiltrate into the ground, communities could also require that culverts, which are often too small to adequately drain stormwater from large storms, be upgraded to protect roads from damage during flooding.

Communities can require techniques to slow the flow of water by spreading it into vegetated areas and infiltrating it in areas with pervious soils. Communities can also provide information about stormwater management techniques that private landowners could use for their driveways. Such techniques not only reduce flooding risk but can also improve water quality. LCPC recently conducted a stormwater analysis for the Town of

Elmore. The analysis provided valuable information about the effect of impervious surfaces on stormwater runoff, and influenced the Town's decision not to increase the allowable lot coverage in the Lake Elmore Shoreland District.

3. Adopt local stormwater management regulations that allow the use of green infrastructure techniques. Green infrastructure, also known as Low Impact Development (LID), is an approach that uses vegetation and soil to manage rainwater where it falls. It can help retain and/or reuse stormwater near where it is generated and can be less costly and less environmentally damaging than conventional stormwater treatment, particularly when it is designed into development from the start. Some examples of green infrastructure include directing runoff into rain gardens or bioswales, where it can be absorbed; using pervious concrete for parking lots and driveways; using rain barrels to collect and reuse rain water; and constructing green (vegetated) roofs that can absorb stormwater. In Vermont, state stormwater permits are required only for developments with more than 1 acre of impervious surface and sites that disturb more than 1 acre through the stormwater program. Most developments in Lamoille County's rural jurisdictions fall beneath this threshold. Communities that want to improve stormwater management can consider requiring new developments to prepare stormwater management plans that use best management practices including green infrastructure. More information on green infrastructure practices can be found at http://www.vtwaterquality.org/stormwater/htm/sw_green_infrastructure.htm.

4. Adopt tree protection measures. Large trees can absorb significant amounts of rain and can reduce stormwater velocity. To protect trees, communities could start by preserving existing, undeveloped forested areas. Communities could also require that larger trees, such as those that are more than 8 inches in diameter, be preserved on a development site as much as possible. Or, if those trees must be removed, a community could require that they be replaced at a minimum one-to-one basis on site or mitigated through payment into a municipal tree protection fund.

5. Adopt steep slope development regulations. Development on steep slopes can cause erosion and can increase stormwater volumes. Some communities recognize that development on steep slopes can affect stormwater volume and erosion and are adopting standards that discourage or prohibit development on very steep slopes. Several communities require conditional use review for any development on slopes greater than 15%, and prohibit development on slopes greater than 25%.

6. Adopt riparian and wetland buffer requirements. Stream and wetland buffer standards require development setbacks from rivers and other water bodies. These buffers can allow stormwater to infiltrate into the soil, reducing flood flows downstream in more developed areas of the community and reducing erosion by stabilizing river banks. Buffers can also remove some pollutants that would otherwise run off into local rivers. Studies show that in more rural areas, a buffer of 100 feet can significantly reduce stormwater runoff and improve water quality.