River Corridor Protection and Management

FACT SHEET

Vermont Agency of Natural Resources

Overview

Vermont towns, like many others in America, were, for the most part, established and developed along rivers and waterways. Before roads and electricity, the benefits of a river as a source of transport and power far outweighed the risks of flooding for most settlements.

As towns and communities have grown, so have the costs of flood damage.

The past century has been one of great change for Vermont's waterways. Early in the century many watersheds were cleared of forests, river systems have been straightened and channelized and sediment and erosion have become an increasing problem.

Works, large and small, have been carried out to allow for roads, railways and bridges, and to repair flood damage.

Balance

Experience and science tell us that a stable, balanced river - that is, one that is just wide enough, deep enough and long enough to move the right amount of water and gravel, generally will not erode its banks and change course, even in flood situations. However, if a river becomes 'unbalanced', then it will change course, slope, depth, or width, - or all four - until it becomes balanced again.

An important way to keep rivers from becoming unbalanced or to allow them to re-establish balance is to protect their 'riparian corridors', - the river channel, the banks on either side and the areas close to the river that carry excess water during storms and heavy rain.

Tyler Branch in Enosburg

Flood Damage

Degraded riparian corridors increase the risk of damage from flooding to our communities – and it's an expensive risk. From 1995 through 1998 alone flash flooding damage in Vermont approached $60,000,000.

Much of this damage occurred where rivers have been separated from their flood plains by some kind of development, or where rivers have been adjusting their length, depth or width because activities in the river or on the banks have caused a river to become unbalanced and destabilized.

The dollar cost of such damage may well be equaled by other economic losses including diminished recreation opportunities, impaired ecological functions, and long-term channel instability.

Partnership

Because rivers and waterways don't follow state and town boundaries the approach to fixing problems needs to cross political boundaries.

The solution requires a community, local, regional, State and Federal partnership that can work in natural watersheds to protect riparian corridors, across political boundaries.

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- Protecting river corridors
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Fundamental Principles of River Systems:

Until recently, river management has largely focused on water and how to contain or withstand its flow. Throughout North America river scientists and managers are now bringing the principle of river "stability" into the management of river corridors.

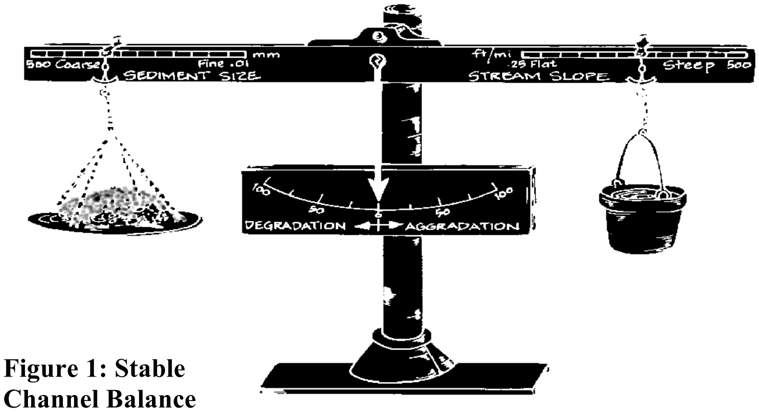


Figure 1: Stable Channel Balance

This has meant understanding that human activity near rivers must not only withstand the forces of running water but must avoid changing the <u>movement of sediment</u> in the river in order to remain secure.

Stream or river channels are a reflection of what goes into them (water, ice, sediment and woody debris) and the valley type within which the stream is located. The shape of a river channel including its dimension (the width &depth), its pattern (or plan form), and its profile (or slope) is developed and maintained over time by the action of water, sediment and debris that drains from the surrounding area. This 'channel forming flow' is approximated by the average annual high water event, which, by virtue of its frequency, does the greatest amount of "work" on the channel and flood plain and transports the greatest volume of sediment over time.

Stable rivers are recognizable by their ability to carry water, sediment and debris, even during high water, without changes occurring in the depth, width or length of the channel.

Figure 1 (Lane, 1955) illustrates a stable channel balance and indicates the relationship between the watershed inputs of water, sediment size and volume, channel slope and the physical response of the channel either by aggradation (building up of sediment) or degradation (scouring down). A change in any one of these parameters will cause adjustments of the other variables or a physical response of the stream channel until the system is brought back into balance.

Human land use, especially within riparian corridors, that significantly alters the runoff patterns of water **and** sediment will trigger a channel adjustment process. When these processes change the relationship of the river with its flood plain (by aggrading or degrading) it becomes increasingly difficult to plan and very expensive to maintain those land uses.

Flood Plain Access and Channel Evolution:

Cutting a river off from its flood plain by raising bank heights, armoring, or deepening a channel will cause a river to attempt to regain its balance through physical change.

The result of containing greater flows in the channel, or to prevent access to the floodplain, is to increase the stream's power that must be resisted by the channel boundary materials; i.e., the rocks, soil, vegetation or man-made structures that make up the bed and banks of the river. The following set of diagrams show channel evolution as predicted by the model published by Shumm (1984) and illustrate:

a) channel response to loss of flood plain;
b) typical Vermont flood plain development scenarios; and
c) the inadequacies of the existing National Flood Insurance Program (NFIP) floodway delineations in the prediction of the erosion hazards associated with floods and unstable channels.

These diagrams only illustrate channel response at one cross section. There are equally profound physical adjustments that occur upstream and downstream from the site of alteration as bed degradation (head cuts) migrate up through the system and aggradation in the form of sedimentation occurs downstream.

It is important to recognize the temporal aspect of channel response to change. Fluvial systems are energized by episodic events. Channel adjustment in response to management practices or encroachments may begin immediately but may also persist for decades depending on the sensitivity and morphology of the affected stream, the magnitude of alteration, and the frequency of high flow events. The first three stages might occur within a few months to a few years. The last three might not reach completion for decades.

Channel Evolution and Flood Hazard Identification

1880 Stable channel with fully accessible flood plain at discharges at and above the average annual high flow. Plan form is sinuous; supportive of energy dissipating bed features (riffles, runs, pools) essential to channel stability. Channel slope (vertical drop in relation to length) generates flow velocities and stream power in balance with the resistance of stream bed and bank materials.

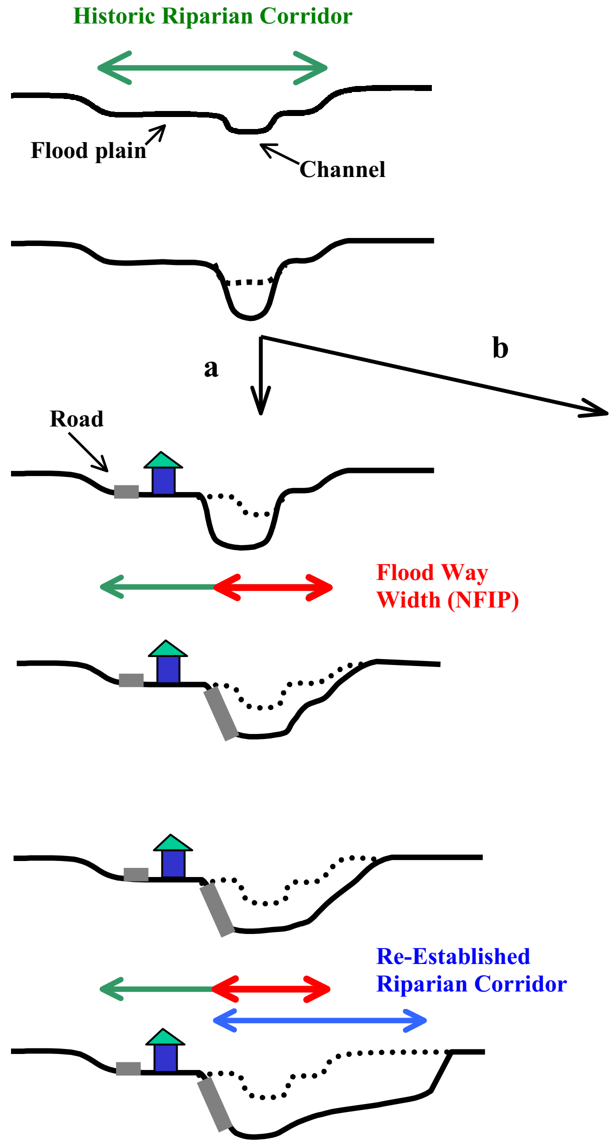
1930 Channel is dredged, deepened and straightened after the 1927 flood damaged agricultural land in the adjacent flood plain. Channel has now lost access to its flood plain. Discharges well in excess of the annual high flow are now contained in the channel. Channel slope is increased with commensurate increase in velocity and power to erode the stream bed and banks (boundary materials).

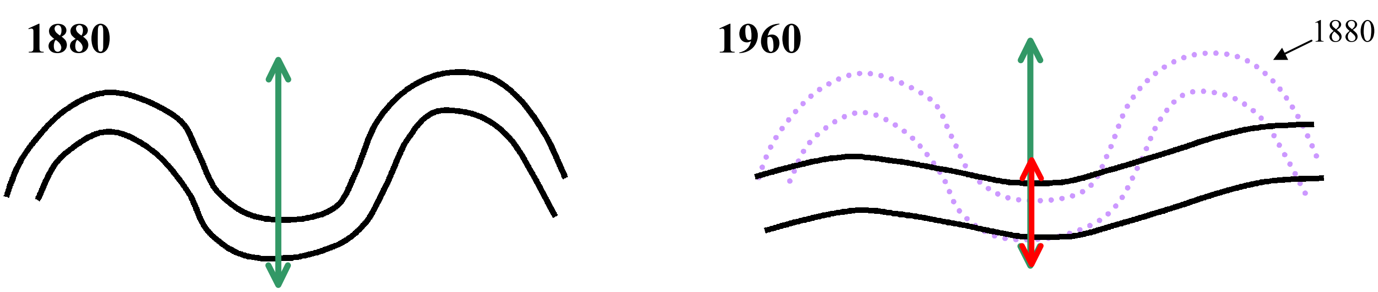
1960a A road is upgraded and relocated into the river corridor encroaching within the historic flood plain. Agricultural land use is converted to residential. Channel is widening and migrating laterally in response to the post-1927 flood recovery works (channelization) through bank erosion caused by the increased stream power. The system is attempting to regain balance between its power and boundary materials by flattening its slope through increased sinuosity.

1980a As erosion and lateral migration of the channel threaten residential development and highway infrastructure, the channel bank is armored to prevent or repair damage to human investments. NFIP floodway limits are delineated without consideration of the channel undergoing an active adjustment process.

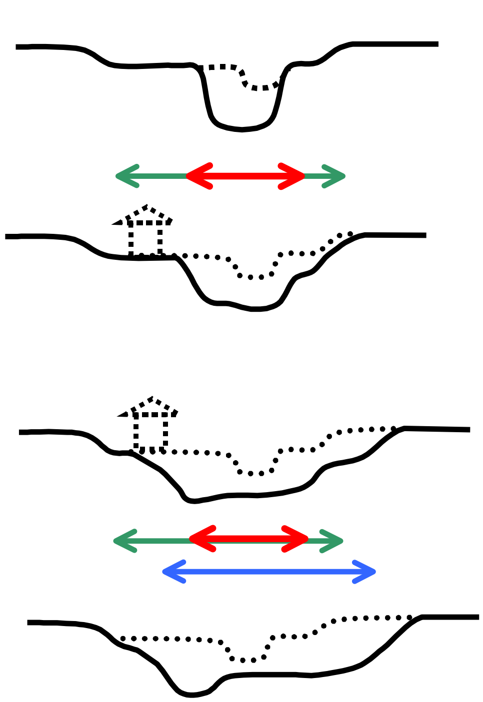
1990a Channel dimension and plan form adjustment process continues but on adjacent property across the river and upstream and downstream of the armored bank. Bank armoring is repaired due to outflanking and/or undermining.

2020a Channel adjustment process is complete. However, future adjustments in plan form may continue to threaten the residential and highway infrastructure encroachments within the historic riparian corridor.





Previously channelized reach of the West Branch in Stowe, VT. Historic flood plain is on right at top of bank. Channel is now widening and forming a new flood plain at a lower elevation.

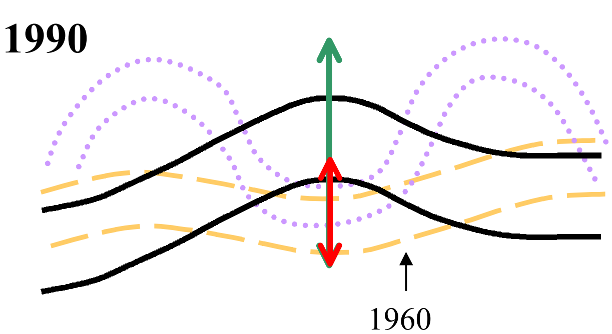


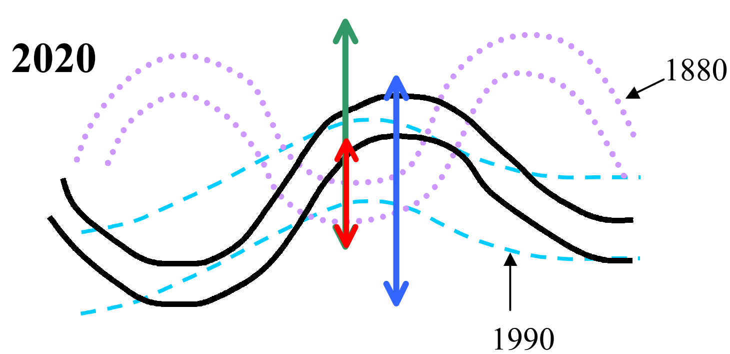
1960b Channel is widening and migrating laterally in response to the post-1927 flood recovery works (channelization) through bank erosion caused by the increased stream power. The system is attempting to regain balance between its power and boundary materials by flattening its slope through increased sinuosity.

1980b Channel continues eroding and migrating laterally. NFIP floodway limits are delineated without consideration of the channel undergoing an active adjustment process. Conversion of former flood plain, outside NFIP floodway, to residential use is proposed.

1990b Channel dimension and plan form adjustment process continues as the river builds a new flood plain at a lower elevation within the active channel. Approved building site is now within the active river channel. No change in mapped NFIP floodway delineation.

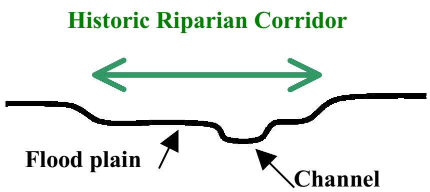
2020b Channel adjustment process is complete. Channel dimensions and relationship with flood plain are as they existed prior to channelization but at a lower elevation. Stable plan form (sinuosity) is restored but in a different location. Stable channel slope is achieved. Stream power is in balance with resistance of channel boundary materials and sediment transport needs.



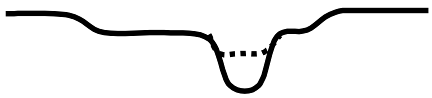


Review of Channel Evolution and Flood Hazard Identification

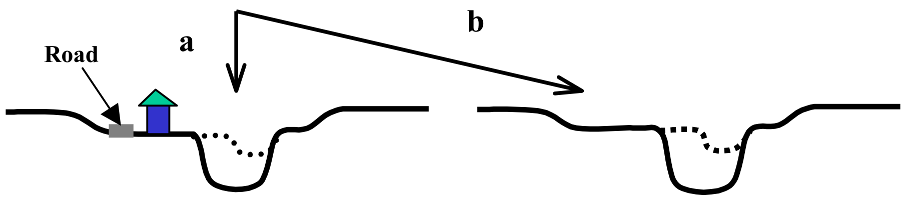
1880 Stable channel with fully accessible flood plain at discharges at and above the average annual high flow.



1930 Channel is dredged, deepened and straightened after the 1927 flood damaged agricultural land in the adjacent flood plain.

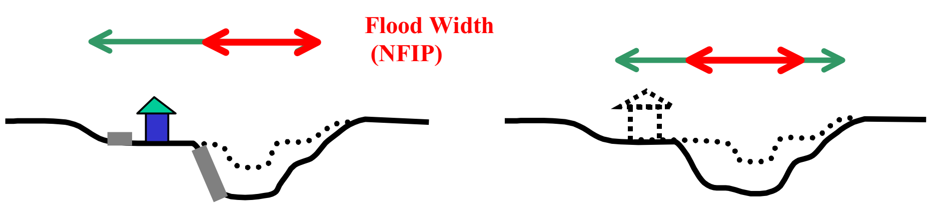


1960a The road is upgraded and relocated into the river corridor encroaching within the historic flood plain.



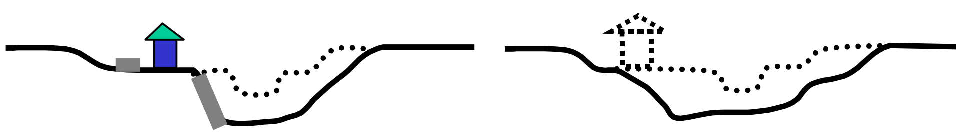
1960b Channel is widening and migrating laterally in response to the post-1927 flood recovery works (channelization) through bank erosion caused by the increased stream power.

1980a As erosion and lateral migration of the channel threaten residential development and highway infrastructure, the channel bank is armored to prevent or repair damage to human investments.



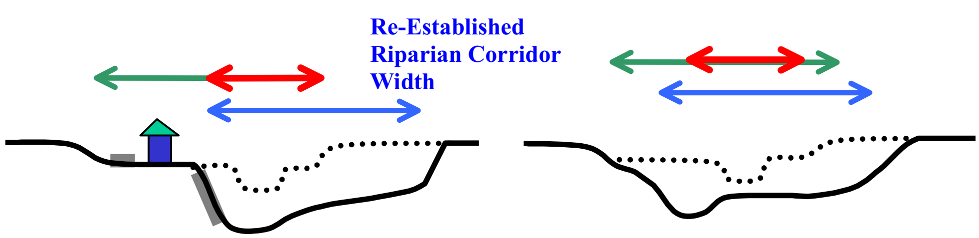
1980b Channel continues eroding and migrating laterally. NFIP floodway limits are delineated without consideration of the channel undergoing an active adjustment process.

1990a Channel dimension and plan form adjustment process continues but on adjacent property across the river and upstream and downstream of the armored bank.

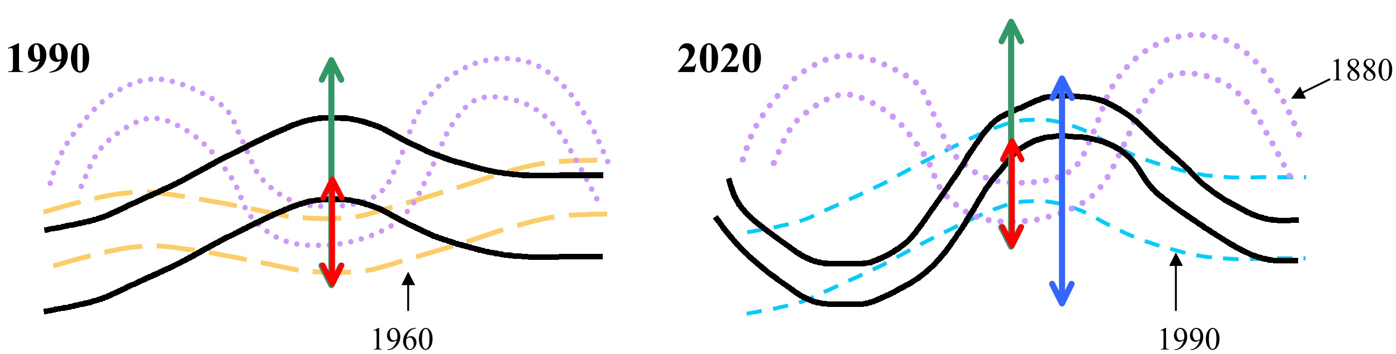


1990b Channel dimension and plan form adjustment process continues as the river builds a new flood plain at a lower elevation within the active channel.

2020a Channel adjustment process is complete.



2020b Channel adjustment process is complete. Channel dimensions and relationship with flood plain are as they existed prior to channelization but at a lower elevation.



Erosion Hazards:

Much flood damage in Vermont is associated with stream channel instability as opposed to inundation related losses. To an extent this reflects Vermont's natural geography and its human landscape consisting of steep, relatively narrow valleys with agricultural land uses, highway infrastructure, private residences and commercial properties located in close proximity to stream channels.

Mad River in Waitsfield, VT

River channels that are undergoing an adjustment process as a result of historic channel management activities or flood plain encroachments oftentimes respond catastrophically during large storm events. Stable, balanced channels, on the other hand, can handle major floods and may experience insignificant changes to dimensions, pattern and profile.

Historically, landowners and local government have relied on the standards and the flood hazard boundary maps provided by the Federal Emergency Management Agency (FEMA) though the National Flood Insurance Program (NFIP) to determine areas within riparian corridors susceptible to flood damage. The maps are also used to delineate the allowable (floodway) limits of riparian corridor encroachments and human land use investments. However, the NFIP maps address only inundation issues by applying a water surface elevation based standard.

For this reason the NFIP maps are often inadequate as an indicator of flood hazards. The "no encroachment" limits defined by the NFIP floodway do not necessarily provide for the riparian corridor width necessary for the channel to maintain a stable balance with its watershed inputs.

The NFIP standards do not recognize unstable channels which may be undergoing a physical adjustment process. The stream bed may be eroding or it may be actively aggrading due to erosion occurring upstream. The NFIP standards often allow for significant encroachment within floodplain areas and riparian corridors that may prevent the stream from ever re-establishing its stability.

Table 1 compares values for floodway widths as delineated under the NFIP with the riparian corridor widths (belt width) necessary to accommodate and maintain channel stability. Data was obtained from representative valley locations unconstrained by human encroachments, FEMA Flood Insurance Studies, and hydraulic geometry relations published for Vermont rivers (DEC, 2000) and for North American rivers (Williams, 1986).

The NFIP flood widths for the Otter Creek and Third Branch are consistent with their belt width and river corridor needs. For other rivers, such as the Mad and Middle Branch, NFIP delineations grossly underestimate the belt width and riparian corridor that is necessary for these rivers to achieve and maintain stability.

Table 1

	Drainage area (sq. mi.)	Bankfull channel width (W_{bkf})	Predicted belt width $3.7 (W_{bkf})^{1.12}$	Measured belt width (ft.)	NFIP floodway width (ft.)
Otter Creek	87	95	607	500	840
Third Branch White River	108	100	642	550	550
Mad River	57	75	466	500	100
Middle Branch Williams R.	33	60	363	400	100

Physical (Geomorphic) Stream Stability Assessment:

Physical assessments performed at a watershed level can provide scientifically sound indicators of river channel condition, stage of adjustment process and sensitivity to change. Geomorphic assessment can help answer the following questions:

- What are the physical processes and features that characterize riparian corridors?
- How have human activities influenced these processes and features over time?
- Which of these physical processes and features are more sensitive to change and how are they likely to change in the future?
- Which of these processes and features present high erosion and flood hazard risks to human investments?

The results of watershed level assessments enable knowledgeable decisions to guide the protection, management, and restoration of stable riparian corridors. Geomorphic assessments will be essential for erosion hazards mapping to support flood hazard prevention, mitigation and recovery activities. The assessments will be useful in guiding land use, development and infrastructure planning and design. They can play an important role in the protection or restoration of the economic, aesthetic and ecological values of riparian corridors. Through understanding of the relationships between watershed processes and human investments, we are able to make wise riparian corridor management decisions.

Pilot watershed assessment projects have been initiated by the VT ANR in cooperation with local organizations in selected Vermont watersheds.

A Stream Geomorphic Assessment Handbook will be available for public distribution in 2002. The handbook will provide standard protocols for stream and riparian corridor stability assessments.

Hazard Mapping:

Information produced by a geomorphic assessment can be used to develop an erosion hazards map that will more comprehensively define high-risk areas for development. It will delineate the areas of a riparian corridor that should be protected from encroachments thereby preserving channel stability.

An erosion hazards methodology is presently being developed by the Vermont Geological Survey and the VT ANR River Management Program and should be available to the public sometime in 2002. The mapping will also include a slope stability hazards layer to help identify areas susceptible to mass soil failures on upland slopes.

Riparian Corridor Protection:

A stream stability assessment is an essential component of the on-going basin planning efforts by VT ANR in partnership with local governments, landowners, watershed associations and regional planning commissions. Watershed plans, hazard mapping and stream stability assessments will support adoption and implementation of riparian corridor protection plans thereby accounting for erosion hazards and maintaining stability of the fluvial system. The most effective method of implementation may be through establishment of a Riparian Corridor Overlay District under the municipal zoning by-laws.

A more direct, but less effective option would be to adopt standard set-backs from streams. The selection of the set-back dimension may be guided by the VT ANR Buffer Procedure.

Draft Rules being considered by the VT Agency of Administration, governing distribution of the Emergency Relief and Assistance Fund to municipalities following disaster events, provide incentives to communities for the adoption and implementation of riparian corridor protection ordinances.

VT ANR has begun advising District Environmental Commissions to consider erosion hazards and stream stability when reviewing Act 250 applications for projects located within riparian corridors and flood plains.

VT ANR has begun utilizing data obtained from stream stability assessments in its technical assistance to landowners, municipalities and governmental agencies and in its review of stream alteration proposals.

Sources of Additional Information:

Options for State Flood Control Policies and a Flood Control Program; VT DEC, 1999.

Unstable Rivers; Using a Geomorphic Watershed Based Approach to River Restoration; (video) VT DEC, 2000.

When Rivers Become Unstable; How Streambank Woodlands can Help Protect Land; (video) VT DEC, 2000.

VT Regional Hydraulic Geometry Curves; VT DEC, 2000.

VT DEC Water Quality Division Web Site; www.vtwaterquality.org

The Streamside Sentinel; VTDEC, 2001

Buffer Procedure; VT ANR, 1996