What is Excessive Channel Erosion?

Channel erosion is a natural process that benefits stream and riparian ecosystems. Erosion in naturally stable streams (i.e., streams that are in equilibrium condition) is evenly distributed and therefore minimized along the stream channel. Erosion is also a dynamic process, where the movement, sorting, and distribution of sediment and organic material create a diversity of habitats. When streams are in disequilibrium, excessive erosion occurs in some channel locations, while excessive deposition occur at other locations up and down the length of the stream. Some habitats become scoured of beneficial woody debris and sediment, while others may become smothered. Where stream disequilibrium is prevalent in a watershed, nutrients (e.g. phosphorus) that are attached to eroded sediments are released in unnaturally large amounts.

When the slope or depth of flowing water increases, the power of the water to erode may increase beyond the resistance of the bed and bank materials, leading to excessive channel erosion. When excessive bed erosion is started (i.e., incision), the stream may go through a series of adjustments referred to as channel evolution, which causes systemic erosion over large temporal and spatial scales. From ANR field surveys, nearly three-quarters of Vermont streams (~2,100 assessed miles) have down-cut and lost some physical connection with their historic floodplains. Channel incision is pervasive, especially in the valley bottom streams. Deepened floods, contained in straighter, steeper channels, are resulting in a tremendous increase in stream power, channel adjustment and erosion (Kline and Cahoon, JAWRA, April 2010).

Stream Equilibrium Condition occurs when water flow, sediment and woody debris are transported in a watershed in such a manner that the stream maintains its dimension, pattern and profile without unnaturally aggrading or degrading at the river reach or valley segment scales. Benefits of managing streams toward equilibrium conditions include the reduction of flood damages, the naturalizing of hydrologic and sediment regimes, improved water quality through reduced sediment and nutrient loading and restoration of the structure and function of aquatic and riparian habitat.

Excess channel erosion can create critical gaps between habitats that are important in aquatic organism life cycles. Streambed, riparian and floodplain habitats become both vertically and laterally disconnected when streams down-cut and widen. Public property and private investments on floodplains and within river corridors are also threatened by flood and erosion hazards associated with rapid channel evolution and disequilibrium.

Pollutant: Fine sediment from eroded soils, when it accumulates on the bottom of a waterbody, results in sedimentation. The suspension of fine sediment in the water column causes turbidity which degrades habitat, e.g., reducing visibility for predators. Sedimentation smothers necessary rocky or riffle habitat for the invertebrates that provide an important source of food for fish. Some smaller species of fish also rely on the crevice space between rocks as a primary habitat. Sedimentation can cover spawning substrate and suffocate fish eggs by preventing water circulation and oxygenation. Additionally, the accumulation of sediment over spawning gravel may even deter fish from spawning at all. Fish species like walleye, trout and salmon rely on clean gravel for spawning.

The ANR Stream Geomorphic and Reach Habitat Assessment Protocols (2009), the River Corridor Planning Guide (2010), Standard River Management Principles and Practices (2015), and the Vermont Stormwater Manual (2016) provide in depth discussions on channel erosion science, erosion-related stress to aquatic ecosystems, and fluvial erosion hazards. These Guides and the referenced literature explain channel erosion in terms of the human activities that modify hydrology, sediment regimes, natural streambank integrity, channel geometry, and floodplain function.

How important is excessive channel erosion?

The effects of channel erosion are pervasive and consequential throughout the state. Where it occurs, unmitigated channel erosion causes long-term (>25 year recovery time) impacts that are very costly to repair. Numerous Vermont streams exhibit impaired biological communities due, in large part, to the erosion and subsequent habitat impacts caused by urbanization and altered hydrology. Stream geomorphic data show that two-thirds of assessed stream miles are in major vertical adjustment and experiencing excessive channel erosion due to disequilibrium. Cross-channel structures such as dams and culverts that contribute significantly to stream disequilibrium also impact habitat by obstructing aquatic organism passage. There are 1,200 dams and tens of thousands of undersized culverts in Vermont. Based on the Watershed Management Division's stressor evaluation, channel erosion is considered a highly-ranked stressor.

What objectives are achieved by controlling excessive channel erosion

Addressing excessive channel erosion promotes several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution*** **–** Nutrients and organic matter associated with eroded sediments are a major source of impairment to Lake Champlain, Lake Memphremagog, and other Vermont lakes. Published North American studies include results that a major proportion of the suspended sediment load may be attributable to excessive bank erosion. Vermont ANR and the LCBP have worked with the USDA Agricultural Research Station to conduct similar sediment loading calculations for the Missisquoi River watershed to better understand the contribution of channel erosion to the nutrient loading of Lake Champlain. Agency efforts to reduce excessive erosion, by promoting practices that mimic natural hydrology and by protecting and restoring channel and floodplain features that store sediments and nutrients, will help minimize anthropogenic nutrient and organic pollution.

Objective B. ***Protect and Restore Aquatic and Riparian Habitat*** – Cover, feeding, and reproductive habitats of aquatic organisms are dependent on flows, hydrologic cycles, and the quantity, size, sorting and distribution of sediments and woody debris. By managing streams and rivers toward equilibrium conditions, complex physical habitats, supporting a diverse assemblage of aquatic and riparian species, may be restored. Human-placed constraints on rivers and their corridors leads to the loss of flood-attenuating features such as floodplains and riparian wetlands. This, in combination with increased runoff from widespread ditching and impervious cover, is causing excessive scour and enlargement of Vermont stream and river channels. This erosion of aquatic and riparian habitat features, and the loss of both lateral and longitudinal habitat connectivity, may be reduced where the Agency works to remove constraints, protect attenuation assets, and manage stormwater.

Objective C. ***Minimize Flood and Fluvial Erosion Hazards*** **–** The Vermont geomorphic assessment data cited above, concerning loss of floodplain function and the extent of stream adjustment and channel evolution, confirm the conclusion of the 1999 Act 137 report to the General Assembly that fluvial erosion is the primary cause of flood hazards in the State. On average, the annual expenditures associated with flood recovery in Vermont are near $14 million (not including recovery costs from T.S. Irene in 2011). These costs may be reduced if the State is successful in working with towns and landowners to

implement an avoidance approach that protects river corridors and floodplains in combination with hazard mitigation activities that restore equilibrium conditions.

What are the causes and sources of excessive channel erosion

The WSMD has identified four specific anthropogenic causes of channel erosion in Vermont's watersheds, and a suite of sources.

1. **Alteration of hydrologic regimes (flow characteristics).**
   The hydrologic regime may be defined as the timing, volume, frequency, and duration of flow events throughout the year and over time. Hydrologic regimes may be influenced by climate, soils, geology, groundwater, land cover, connectivity of the stream, riparian, and floodplain network, and valley and stream morphology. When flow characteristics have been significantly changed, stream channels will respond by undergoing a series of channel adjustments. Where hydrologic modifications are persistent, the impacted stream will adjust morphologically (e.g., enlarging when stormwater flows are consistently higher) and often result in significant changes in sediment loading and channel adjustments in downstream reaches. When land is drained more quickly and flood peaks are consistently higher, the depth, slope, and power to erode are higher. Activities that may be a source of hydrologic regime alteration when conducted without stormwater best management practices, include:
   a. Urban or Developed Lands (increased runoff)
      i. Stormwater runoff when farm and forest lands are developed
      ii. Transportation infrastructure
   b. Agricultural Lands
      i. Wetland Loss (dredge and fill)
      ii. Pastureland (incr. runoff & pollutants)
      iii. Cropland (incr. runoff & pollutants)
   c. Forest Land Management
   d. Climate Change

2. **Alteration of sediment regimes**

The sediment regime may be defined as the quantity, size, transport, sorting, and distribution of sediments. The sediment regime may be influenced by the proximity of sediment sources, the hydrologic regime, and valley, floodplain and stream morphology. There is an important distinction between "wash load" and "bed load" sediments. During high flows, when sediment transport typically takes place, small sediments become suspended in the water column. These are wash load materials which are easily transported and typically deposit under the lowest velocity conditions, e.g., on floodplains and the inside of meander bends at the recession of a flood. When these features are missing or disconnected from the active channel, wash load materials may stay in transport until the low velocity conditions are encountered, such as in a downstream lake. These alterations are significant to water quality and habitat, as the unequal distribution of fine sediment has a profound effect on aquatic plant and animal life. Fine-grained wash load materials typically have the highest concentrations of organic material and nutrients.

Bed load is comprised of larger sediments, which move and roll along the bed of the stream during floods. Coarser-grained materials stay resting on a streambed until flows of sufficient depth, slope, and velocity produce the power necessary to pick them up and move them. Bed load materials will continue to move (bounce) down the channel until they encounter conditions of lower stream power. The fact that it takes greater energy or stream power to move different sized sediment particles results in the differential sorting and transport of bed materials. This creates a beneficial sequence of bed features (e.g., pools and riffles). When these patterns are disrupted, there are direct impacts to aquatic habitat. The lack of sorting

and equal distribution may result in vertical instability, channel evolution processes, and a host of undesirable erosion hazard and water quality impacts. Activities that may be a source of sediment regime alteration include:

a. Instream structures that impede sediment supply
    i. Dams and Diversions
    ii. Bridges and culverts
    iii. Stream bank armoring
b. Channel incision that leads to increases in sediment supply
    i. Erosion of legacy sediments
    ii. Mass wasting and landslides

3. Alteration of channel and floodplain morphology

Direct alteration of channels and floodplains can change stream hydraulic geometry, and thereby change stream processes that affect the way sediments are transported, sorted, and distributed. Vermont ANR Phase 1 and Phase 2 stream geomorphic assessments, the River Corridor Planning Guide (2010), and Standard River Management Principles and Practices (2015) are used to examine alteration stressors, their effect on sediment regimes, and subsequent stream processes. The table below sorts alteration stressor causes and sources into categories; those that affect stream power and those that affect resistance to stream power, as afforded by the channel boundary conditions. These categories are further subdivided into components of the hydraulic geometry, i.e., stream power into modifiers of slope and depth; and boundary resistance into those stressors affecting the streambed and stream banks. Finally, stressors are sorted as to whether they increase or decrease stream power and/or increase or decrease boundary conditions. By categorizing alteration activities, it becomes easier to see how they may lead to channel adjustment and the excessive erosion associated with disequilibrium. Activities that may alter channel and floodplain morphology include:

a. Floodplain and river corridor encroachment
b. Channel straightening, constriction, dredging, armoring, damming, or berming

4. Alterations that increase streambank erodibility

The resistance of the channel boundary materials to the shear stress and stream power exerted determines, in large part, whether streambanks will erode. Boundary resistance is a function of the type and density of riparian vegetation and the size and cohesion of inorganic bank materials (e.g., clay, sand, gravels, and cobbles). The root networks of woody vegetation bind stream bank soils and sediment adding to the bank's resistance to erosion. Herbaceous plants in lower gradient, meadow streams serve the same function. The table below categorizes those activities that increase or decrease the resistance of bed and bank materials. Decreasing resistance may lead directly to excessive erosion. Artificially increasing resistance works for a period of time (i.e., when other components of the system are in equilibrium), but will either fail or transfer stream power to the downstream reach. Activities that may increase streambank erodibility include:

a. Livestock trampling
b. Removal of riparian vegetation
c. Stream bank armoring (transferring erosive power downstream)

Recovery operations from major flood disasters as a predominate source of channel erosion

Tropical Storm Irene underlined a fact that had been previously borne out by nearly a decade of stream geomorphic assessments in Vermont, that major floods have resulted in major channel works that heretofore have led to increased channel erosion in the ensuing decades. Many of the major river systems that were dredged and straightened after the 1973 flood were the rivers that experienced the most severe damage during Irene. All four causes of excessive erosion described above have historically been accentuated during post-flood recovery operations.

		Sediment Transport Increases	Sediment Transport Decreases
	Stream power as a function of:	**Stressors that lead to an Increase in Power**	**Stressors that lead to an Decrease in Power**
Stream Power	**Slope**	• Channel straightening and armoring, • River corridor encroachments, • Localized reduction of sediment supply below grade controls or channel constrictions	• Upstream of dams, weirs, • Upstream of channel/floodplain constrictions, such as bridges and culverts
	Depth	• Dredging and Berming, • Localized flow increases below stormwater and other outfalls, • Within, adjacent and downstream of channel constrictions	• Gravel mining, bar scalping, • Localized increases of sediment supply occurring at confluences and backwater areas
Boundary Conditions	**Resistance to power by the:**	**Stressors that lead to a Decrease in Resistance**	**Stressors that lead to an Increase in Resistance**
	Channel Bed	Snagging, dredging, and windrowing	Grade controls and bed armoring
	Stream Bank and Riparian	Removal of bank and riparian vegetation (influences sediment supply more directly than transport processes)	Bank armoring (influences sediment supply more directly than transport processes)

Monitoring and assessment activities addressing channel erosion

Monitoring and Assessment Activities

Existing monitoring and assessment activities that focus on the causes and effect of excessive channel erosion are listed below. Full descriptions of the programs that carry out these activities may be found in the State Monitoring and Assessment Strategy and in Appendix D. (the toolbox)

Stream Geomorphic Assessments
Bridge and Culvert Assessments
Dam Inventories
River Corridor Planning
Floodplain and River Corridor Mapping
Stormwater Modeling
Stormwater Mapping
Basin Assessment and TMDL Planning
Biological Monitoring
Wetland Inventories
Land Use Imagery
River & Stream Gauging
Climate Monitoring

Key Monitoring and Assessment Strategies to Address Excessive Channel Erosion

- Conduct stream geomorphic and reach habitat assessments and complete river corridor plans in stream and river watersheds and for small lake tributaries to support technical assistance, regulatory, and funding programs and track progress in achieving the State's surface water goals and objectives.

- Conduct integrated biological monitoring and physical assessment programs, with data and scale-appropriate interpretations, made accessible through tailored reporting from a web-based system. Achievement of this strategy will help:
    1. place streams on the physical/biological condition gradient;
    2. analyze the full suite of channel erosion causes and sources;
    3. identify and prioritize management activities;
    4. conduct alternatives analysis for designing and regulating management actions;
    5. evaluate the effectiveness of management actions; and
    6. conduct trend analyses for the development of channel erosion BMPs.

- Conduct monitoring and assessment programs to establish a robust (empirical) connection between the designated surface waters use (VWQS) and the maintenance of equilibrium conditions. This strategy will enable more uniform and consistent application of the antidegradation policy when regulating activities that may lead to excessive channel erosion.

- Conduct watershed hydrologic modeling to monitor the cumulative effects of impervious cover and other land use conversions. Include increases in runoff as predicted by regional climate change models.

- Maintain GIS-based data on the extent and condition of public lands and conservation easements along Vermont waterways as a part of Vermont's green infrastructure with the highest restoration potential in river corridors and shorelands.

Technical assistance activities addressing channel erosion

Technical Assistance Programs

Existing programs that provide technical assistance in various aspects of managing the causes and sources of excessive channel erosion are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

River Management Program
River Corridor and Floodplain Program
Basin Planning Program
Flow Protection Program
VTrans Environmental Services
Better Roads Program
FWD Fisheries Division
Natural Resource Conservation Districts
Natural Resource Conservation Service
UVM Extension
Partners for Fish &Wildlife (USFWS)
VT Dam Task Group
Green Infrastructure Program
Stormwater Program
Forest Watershed Program

Key Technical Assistance Strategies to Address Excessive Channel Erosion

- Develop and maintain the capacity to technically assist landowners, municipalities, land developers, agencies, and organizations in the:
    1. design and execution of data collection and analytical methods, necessary to understand channel erosion causes and sources at the appropriate temporal and spatial scales;
    2. analysis of alternatives consistent with Standard River Management Principles and Practices to design protection, management, and restoration projects, based on both a-priori and project-related river assessment and planning; and
    3. implementation of projects and management activities that avoid or resolve specific causes and sources of excessive channel erosion.

- Consistent with Act 110 (2010), further develop a River Corridor and Floodplain Protection Program and maintain the capacity to technically assist all municipalities and agencies, with land use authority and responsibility for public infrastructure, in the:
    1. development of plans, policies, procedures, and regulation that are consistent with the State surface water goals and objectives;
    2. implementation of strategies to avoid conflicts between human investments, wetland and floodplain function, and the dynamic equilibrium of streams; and
    3. implementation of stormwater regulations which require sustainable site planning and the use of Low Impact Development (LID) and Green Infrastructure (GI) techniques.

- Develop and maintain the capacity of conservation organizations to protect river corridors and shorelands and coordinate with the State's Conservation Reserve Enhancement Program (CREP).

- Assist VTrans and municipalities in the use of Standard River Management Principles and Practices (2015) in the design and implementation of non-emergency stream alterations, as well as emergency protective measures during post-flood recovery operations.

Regulatory activities addressing channel erosion

Regulatory Programs

Existing programs that regulate activities causing excessive channel erosion are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

Stream Alteration Permit
Section 404 Permits
Section 401 Water Quality Certifications
Wetland Permits
Act 250 / 248 Permits
Required Agricultural Practices
Accepted (Forest) Management Practices
Municipal Zoning
Flood Hazard Area and River Corridor Permits
Stormwater Operational Permit
Stormwater Construction Permits
Stormwater MS4 Program
Stormwater MSGP
Stormwater RDA
Stormwater Offset Program
Stormwater Impaired Waters Program
Road and Bridge Standards
Dam Orders

Key Regulatory Strategies to Address Excessive Channel Erosion

- Develop and maintain the regulatory and enforcement capacity to exercise the State's stream alteration jurisdiction on all perennial streams in both non-emergency and emergency situations. Careful management of small tributary streams is important to the Division's goal in reducing pollutant loads to Vermont lakes. Regulatory oversight of crossing structures and alterations in small stream is critical to sediment regimes and habitat connectivity in river systems and the mitigation of fluvial erosion hazards.

- Continue to implement the State's stormwater regulatory programs. The State's stormwater program is the primary mechanism for regulating discharges from developed land. Regulatory oversight of new development is necessary to ensure that stormwater discharges do not contribute to stream channel instability.

- Ensure that regulatory programs have full access to stormwater mapping/modeling and river corridor planning to enhance the rendering of decisions based on empirical data and interpretation of stream equilibrium at the reach and valley segment scales.

- Have in place a set of meaningful incentives for municipalities to adopt plans and bylaws which protect floodplains, river corridors, buffers and natural hydrology.

- Ensure that rules and regulations promulgated by other authorities are consistent with those of the Division to meet the goals and objectives of the State Surface Water Management Strategy. With respect to managing the four primary causes of excessive channel erosion, this means ensuring that other rules and regulations do not contain inconsistencies with stream equilibrium policy.

- Work with Agency of Agriculture to improve and enforce farm regulations with specific attention to preclusion of streambank stabilization or ditch and tile practices that may lead to disequilibrium.

- Develop and implement a set of water quality-based design standards and best management practices for road maintenance and drainage and link state transportation funding for municipalities to adherence to the standards.

- Work with VTrans to revise the town road and bridge standards to incorporate a suite of practical and cost-effective best management practices for the construction, maintenance, and repair of all existing and future state and town highways. These best management practices should address activities which have a potential for causing pollutants to enter waters of the state, including stormwater runoff and direct discharges to state waters.

- Develop robust design standards and best management practices for surface runoff management focused on infiltration, evaporation/transpiration, and capture and re-use.

- Work with VLCT, RPCs, VTrans Districts, and Emergency Management to assist municipalities in the reporting and implementation of post-flood Emergency Protective Measures in compliance with the standards established in the Stream Alteration Rule.

A key regulatory strategy for addressing the adverse effects of channel erosion was established in 2013 with adoption of the Stream Alteration Rule with the following **Performance Standards** for non-emergency activities:

> **Equilibrium Standard** - An activity shall not change the physical integrity of the stream in a manner that causes it to depart from, further depart from, or impedes the attainment of the channel width, depth, meander pattern, and slope associated with the stream processes and the equilibrium conditions of a given reach of stream.
>
> The equilibrium standard is met when it can be shown that, following the stream alteration, the water flow, sediment, and woody debris produced by the watershed will be transported by the stream channel in such a manner that the stream maintains its dimension, general pattern, and slope with no unnatural aggrading (raising) or degrading (lowering) of the channel bed elevation along the longitudinal stream bed profile.
>
> **Connectivity Standard-** An activity shall not change physical stream forms or alter local channel hydraulics, natural streambank stability, or floodplain connectivity in a manner such that changes in the erosion or deposition of instream materials results in localized, abrupt changes to or disconnects within the horizontal alignment of streambanks or vertical profile of the stream bed.
>
> A person shall not change the course, current, or cross-section of a watercourse so as to create a physical obstruction or velocity barrier to the movement of aquatic organisms or change the vertical stream bed profile in a manner that impedes the movement of aquatic organisms.
>
> A person shall not establish, construct, or maintain a berm in a flood hazard area or river corridor unless authorized as an emergency protective measure.

Implementation funding activities addressing channel erosion

Funding Programs

Existing funding programs that support projects to address the causes and sources of excessive channel erosion are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

CWA 319 Grants
Clean Water Initiative Program
Flood Hazard Mitigation
Lake Champlain Basin Program
Connecticut River Mitigation & Enhancement Funds
Conservation License Plate Grants
USDA Farm Bill Programs
CREP
Better Roads Program
Stormwater Utilities
Use Value Appraisal Program
Agricultural Buffer Program
SEP

Key Funding Strategies to Address Excessive Channel Erosion

- Seek to incorporate grant selection criteria in all relevant funding programs that projects be supported by stormwater and river corridor plans, such that funding decisions are based on empirical data and interpretation of stream equilibrium at the reach and valley segment scales.

- Consistent with Act 110, have in place a set of meaningful incentives in relevant State funding programs for municipalities to adopt plans and bylaws which protect floodplains, river corridors and buffers.

- Develop and maintain a stable and comprehensive funding program which the assessment, planning, and design phases necessary to identify projects consistent with the goals and objectives of the State Surface Water Management Plan.

- Develop and maintain a stable funding program to conserve floodplains, river corridors, shorelands, and wetlands. Limiting encroachment into riparian areas where critical attenuation processes are occurring is one on the primary tools for limiting a host of activities (sources) which lead to excessive channel erosion.

- Better align Federal and State funding programs and priorities. For example FEMA/COE funding programs need to be revised to better fit with size and objectives of VT programs.

In addition to these strategies, the Division has developed the following guidance to assist in the disbursement of discretionary funds in support of streambank stabilization projects:

Streambank stabilization projects proposed as emergency or next-flood protective measures that will not meet the Stream Equilibrium and Connectivity Performance Standards of the Stream Alteration Rule, may cause or contribute to erosion and aquatic habitat impacts. While such projects may be authorized to protect public safety and threats to improved property the State will hold the use of discretionary water quality and conservation grant funds to the higher performance standards set in the Rule . Consistent with the Guidance outlined below, publicly funded projects should align with the Division's surface water goals and objectives and should <u>not</u> alter or fix channel geometry in a manner that would cause a departure, further departure, or impede the attainment of equilibrium conditions.

Guidance

Prior to any Division determination that financial assistance will be made available to a landowner, municipality, or other entity for streambank stabilization, the Watershed Management Division and its staff, in concurrence with the Rivers Program, will review proposed projects and ensure consistency with the following guidance.

1. The Division will not promote or make available the use of discretionary public funds, granted for the purposes of water quality and natural resource conservation, for projects involving hard armoring or other structural treatments used to stabilize streambanks in a manner inconsistent with stream equilibrium conditions, except as provided for below. The Division's message to landowners and municipalities should be clear—water quality grants are not available for the sole purpose of property protection.

2. The Division may support the use of discretionary public funds for limited bank stabilization for the following types of projects:

    a. Hard armoring or the use of other structural treatments to stabilize streambanks, in a manner that is inconsistent with equilibrium conditions, but are part of a larger project, and:

        i. Where equilibrium is achievable in the overall stream reach; public assistance with bank stabilization serves as an incentive for a formal agreement to limit channel management and encroachment on the larger stream reach and other reaches with legal mechanisms that protect the stream or river corridor; or,

        ii. Where equilibrium is not achievable in the overall reach, due to the extent of existing encroachment, and public assistance with bank stabilization serves as an incentive for flood plain and wetland restoration, formal corridor protection in other reaches, and/or other project element(s) which result in net benefit to water quality, in a manner consistent with the goals and objectives of the Division's Surface Water Management Strategy.

    b. Hard armoring or the use of other structural treatments to stabilize eroding streambanks on vertically stable channels, which have the dimensions, pattern, and profile associated with its equilibrium condition. The Division and its staff may support stabilization of equilibrium streambanks, using discretionary water quality and conservation funds, with techniques including:

        i. Armoring only to the bankfull elevation, with the use of rock rip-rap or other structural treatments, but only where arresting the lateral erosion will provide other public riparian benefits[1], and only to the longitudinal extent necessary to protect developed property that would otherwise be threatened by the bank erosion in a next-flood; and/or,

        ii. Bioengineering and bank revegetation using native tree and shrub species where developed property is not threatened in a next-flood.

[1] **Example**: In the case of a laterally unstable stream, in equilibrium condition, the limited use of rock rip rap may be used to arrest the lateral movement of the stream toward a road and thereby preserve a forested riparian buffer at least 50' wide. Where the eroding bank is already up against the road, rock armoring the bank should be the responsibility of the road owner and not be supported by the Division with discretionary water quality grants (unless as provided for above).

Information and education activities addressing channel erosion

Information and Education Programs

Existing programs that inform and educate the general public about the causes and effect of excessive channel erosion are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

River Management Program
River Coriodr and Floodplain Protection Program
Basin Planning Program
Rivers and Roads Program
Lake Champlain Basin Program
Chittenden County Regional Stormwater Education Program
Vermont League of Cities and Towns, Municipal Assistance Program
Natural Resource Conservation Districts
River and Lake Groups
Forestry AMP Program

Key Information and Education Strategies to Address Excessive Channel Erosion

- Create a multi-media educational program, including printed material, photo libraries, videos, power point presentations, field demonstrations, and river flumes, which may be readily applied by Division staff at public forums as opportunities arise.

- Enhance the use of river flumes and train regional staff inside and outside the Agency to make use of them. This has been a highly successful I&E effort to explain stream instability to the public.

- Develop and maintain information & education materials on the causes and effects of both natural and excessive channel erosion pertinent to both lay and technical audiences. Publish a lay-person Guide to Stream Processes to explain the causes and sources of excessive channel erosion and the TA, regulatory, and funding programs available to address this stressor.

- Increase the number of Tier 2 and Tier 3 Rivers and Roads workshops offered.

- Develop and maintain a set of outreach materials and reports that explain the Division programs addressing excessive channel erosion. Where possible, these materials should contain case studies that will make the Division's work more real to the lay public.

- Develop and maintain the State Surface Water Management Strategy as an interactive, web-based site where people can get information about how the State is dealing with stressors such as channel erosion, but also provide input on the policies and programs developed to address them.

- Develop and maintain an education program focused on local governing bodies and the importance of the local ordinance in achieving public surface water goals.

- Inform the general public about the impacts associated with impervious cover and the cumulative impacts of seemingly small hydrologic alterations.

- Promote the use of GI practices through trainings, workshops, social media, and the internet.