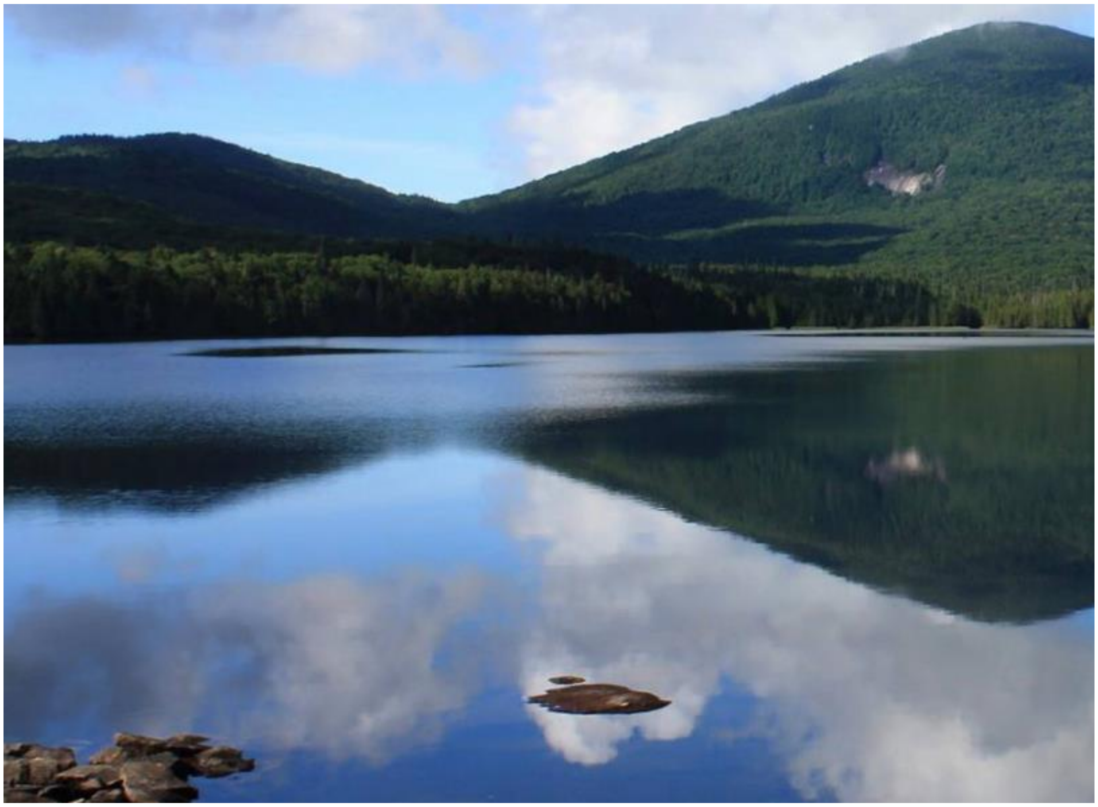
Vermont Department of Environmental Conservation

Watershed Management Division

Statewide Surface Water Management Strategy



Revised January, 2017

Chapter 1. Strategic Framework for Statewide Efforts to Guide Surface Water Management

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A. Introduction

Why a Watershed Management Division

A watershed is an area of land that drains downslope to its lowest point. Water moves through a watershed in a network of drainage pathways that generally converge in a stream or river system, perhaps leading to a lake or wetland. Watersheds can be large or small. Watershed boundaries follow the major ridge-line around the channels and meet at the bottom where the water flows out of the watershed. Rainfall and snowmelt run off the land surface, and water flows into and out of a watershed.

The interrelationship of land use impacts and the connectivity of watershed resources are the primary reason why surface water assessment, management, and restoration need to be conducted at a watershed scale. Since water moves downstream in a watershed, any activity that affects the water quality, quantity, or rate of movement at one location can change the characteristics of the watershed at locations downstream. All activities impacting watersheds must be managed simultaneously, with consideration of their cumulative impacts, to effectively manage the resource.

The best organizational design for a natural resources agency is one that closely parallels the resources it seeks to manage. Given the physical nature of watersheds, the consideration of land-based activities affecting watersheds, and the close alignment of the individual watershed elements (e.g., rivers, wetlands, and lakes), creating a corresponding management structure is the most predictable and comprehensive means of ensuring clear, efficient, and effective water resource management. The central goal driving the composition and design of the Division's organizational structure is to better leverage the concept of holistic watershed management.

1. The Vermont Surface Water Management Strategy

What is this Strategy?

The Watershed Management Division (Division) has prepared this Vermont Surface Water Management Strategy (Strategy) to describe the management of pollutants and stressors that affect the uses and values of Vermont's surface waters. The Strategy presents the Division's goals, objectives and approaches for the protection and management of Vermont's surface waters, and will help to guide the Department's future decision-making to ensure efficient, predictable, consistent and coordinated management actions. For the purposes of this Strategy, surface waters are defined as all rivers and streams, lakes, ponds and reservoirs, and wetlands. This Strategy fulfills provisions of 10 V.S.A. 1253d regarding preparation of a comprehensive statewide surface water management strategy, and effectively updates the "Continuous Planning Process" document of 2001, and the Clean Water Act §208 Areawide Plan of 1981, both required by the United States Environmental Protection Agency (USEPA).

Specifically, this Strategy:

1. Sets forth goals and objectives for managing Vermont's surface waters in light of the goals of the federal Clean Water Act, and Vermont's Clean Water Act and state surface water quality policy;

2. Describes pollutants and stressors that affect the uses and values of Vermont's surface waters, approaches to address stressors, and appendices describing regulations, funding and technical assistance programs.

3. Describes the Division's approach to protecting and improving surface waters by managing stressors rather than individual pollutants;

4. Presents the Division's Business Plan for implementing this Strategy.

5. Describes the Division's updated Ambient Surface Water Monitoring and Assessment Strategy that will work hand in hand with watershed management planning at the statewide and basin-specific level to identify and prioritize waters in need of protection, restoration and management; and

6. Implements a focused approach to tactical basin-level watershed management planning that provides the geographic specificity necessary to effectively implement this Strategy.

This Strategy draws upon over 35 years of watershed management planning experience, project implementation, and watershed restoration carried out by the Division and its partner agencies. The Strategy reflects experience gained and lessons learned by the Division in working with partner programs and watershed stakeholders. This Strategy will be widely accessible and continually updated on the Division's website.

What is different about this Strategy?

This Strategy does not focus on managing individual pollutants. Rather, the Strategy establishes an approach to managing the stressors that are responsible for the pollutants that affect water quality and uses of Vermont's surface waters. By moving the focus of this Strategy beyond individual pollutants, WSMD is emphasizing the importance of managing waters in a watershed context, by coordinating the management of stressors. As one example, a watershed-wide coordinated effort to reduce channel erosion, one of ten major stressors to surface water quality and uses, necessarily will mitigate the effects of phosphorus, nitrogen, sediment, and habitat alteration on surface waters in that basin.

What terminology is used in this Strategy?

The WSMD has established a set of ***goals and objectives*** for surface waters of Vermont. The goals define the Division's vision for surface waters of Vermont. The objectives, when met, will result in attainment of the goals. This Strategy discusses how 10 major ***stressors*** are managed by the Division's many surface water management programs, in support of the Strategy's objectives. A ***stressor*** is defined as a phenomenon with quantifiable deleterious effects on surface waters resulting from the delivery of ***pollutants*** (or the production of a pollutant within a waterbody) or an increased threat to public health and safety. Stressors result from certain activities on the landscape, although occasionally natural factors result in stressors being present. Managing stressors requires management of associated activities. When landscape activities are appropriately managed, stressors are reduced or eliminated, resulting in the objectives of this Strategy being achieved, and goals met.

This terminology can be demonstrated using a real-world example of a poor biological condition that is caused by unmanaged encroachment upon riparian areas of surface waters (see Figure 1 below). Improperly managed construction of homes, camps, and other infrastructure along riverbanks and lakeshores can result in riparian buffers being reduced or eliminated. As shrubs, trees, and other vegetation are lost, shallow nearshore areas of surface waters receive more sunlight, and water temperatures climb due to warming of the water and underlying lakeshore or streambed. Sediment and phosphorus is rapidly lost from the riparian zone during the construction phase, then more slowly thereafter due to increased imperviousness, and lack of vegetation to filter runoff. This pollutant cocktail (temperature, sediment, phosphorus) adversely affects biology. Put more simply, trout can't live in waters that are too warm, too silty, and overly phosphorus-enriched.

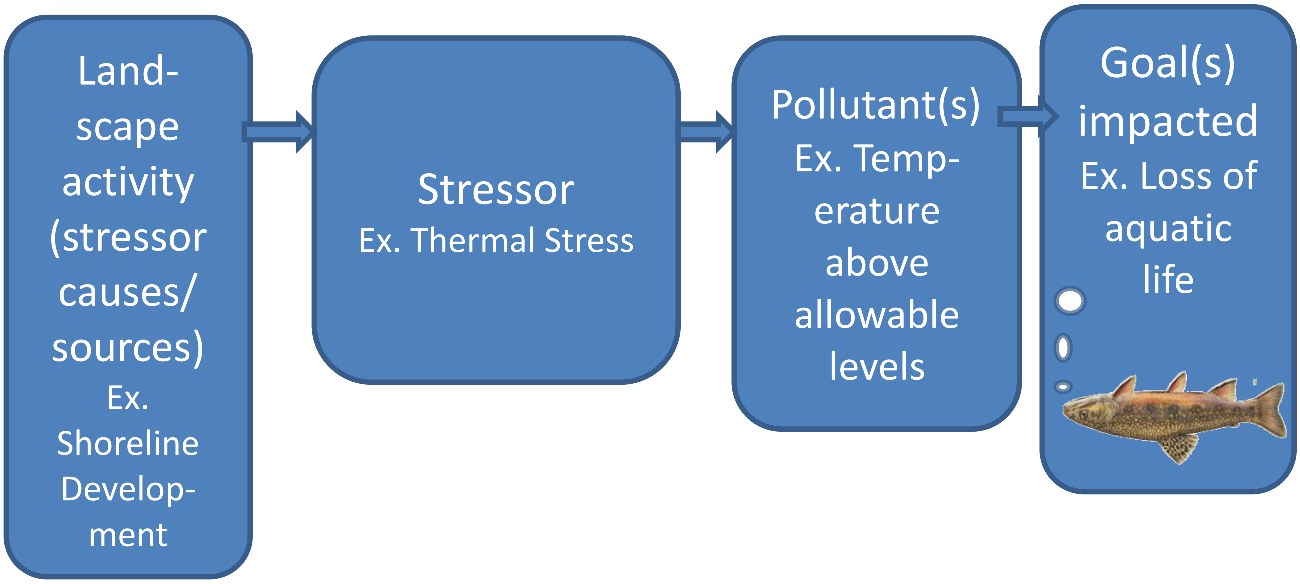


Figure 1. An example of the cascading effects of landscape-level activities that result in stressors, which produce pollutants.

How do I use this Strategy?

The user of this Strategy can access information pertaining to stressors, their causes and sources, and resultant pollutants, and readily observe the way these all interrelate. In addition, the Strategy, by means of several Appendices or standalone documents, provides a description of the monitoring and assessment, education and outreach, technical assistance, financial assistance, and regulatory programs carried out, supported by, or participated in by the Division. Using this Strategy as a starting point, the reader can access information and web-based resources for all of the Division's programs and actions in support of surface water protection and improvement. Section 11 of this Introduction presents a roadmap for each Chapter of the Strategy.

2. Surface Water Goals and Objectives

The federal Clean Water Act identifies biological, chemical, and physical integrity and recreational suitability as core goals of the Act, to be actively protected and restored by the U.S. Environmental Protection Agency, in partnership with States. These terms are commonly referred to by the colloquialism "fishable and swimmable." Vermont has incorporated these Federal Clean Water Act goals, along with the goals of the Vermont Clean Water Act (Act 64 of 2015) and other important state water quality policy (Acts 110 of 2012 and 138 of 2013) into this Strategy, In this Strategy, the Division has consolidated the Clean Water Act and state water quality policy goals into three broad goal statements pertaining to *integrity*, *use*, and *health and safety*. By supporting these goals and their associated objectives, the Division is implementing Federal and State law. Four specific objectives have been identified that, when met, should ensure the biological, chemical, and physical integrity, and public use and enjoyment of Vermont's water resources, and protect public health and safety.

The three primary goals of the Watershed Management Division are to manage Vermont's surface waters to:

- ***Protect, Maintain, Enhance and Restore the Biological, Chemical, and Physical Integrity of all Surface Waters***
- ***Support the Public Use and Enjoyment of Water Resources***
- ***Protect the Public Health and Safety***

Four objectives support these Goals:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution***

Objective B. ***Protect and Restore Aquatic and Riparian Habitat***

Objective C. ***Minimize Flood and Fluvial Erosion Hazards***

Objective D. ***Minimize Toxic and Pathogenic Pollution, and Chemicals of Emerging Concern***

3. About Biological, Physical, and Chemical Integrity

By managing stressors, the simultaneous goals of attaining biological, chemical, and physical integrity, public use and enjoyment, and public health and safety can be met. Goals pertaining to public use and enjoyment and health and safety are easy to understand. Consider these questions:

Can I swim and boat? Is the water aesthetically pleasing?
Can I eat the fish? During a flood, will my home be safe?

A "yes" answer to these questions implies attainment of public use and enjoyment, and public health and safety goals. The concept of ecological integrity captures the biological, chemical and physical integrity of a waterbody. The Division is required by Federal and State law to manage surface waters to support integrity, but what exactly is "integrity" in the context of surface waters?

Habitat for aquatic biota in and terrestrial biota adjacent to surface waters is directly a function of integrity. In essence, physical and chemical integrity inter-relate to support biological integrity. The inter-relationship of physical and chemical conditions defines the availability of habitat for biological communities. If physical and chemical integrity are compromised, biological integrity declines, because the habitat that supports biota is compromised. The following discussion is intended to provide a basin-wide understanding of physical, chemical, and biological integrity.

Biological Integrity

The condition (health) of the biological community is a reflection of the level of combined human-induced stresses acting upon it. Communities integrate the sum of stressors and associated pollutants, and exhibit, in a repeatable fashion, changing and measurable attributes with increasing stress. While it is possible to identify a particular stressor from such measurements, the specificity of the identified stressor is generally low. Aquatic communities that are most impaired suffer from an accumulation of multiple stressors.

The term "biological integrity" was introduced in the Federal Clean Water Act of 1972 as one part of a three-part objective of the Act: "to restore and maintain the chemical, physical and biological integrity of the nation's waters." The three forms of "integrity" were presented without being defined. The current operational definition of biological integrity offered by scientists is "the ability to support and maintain a balanced, integrated adaptive assemblage of organisms having species composition, diversity, and functional organization comparable to that of natural habitat of the region (Frey, 1977, per USEPA)." Section 1-01.B.10

of the Vermont Water Quality Standards defines biological integrity as the ability of an aquatic ecosystem to support and maintain, when consistent with reference conditions, a community of organisms that is not dominated by any particular species or functions (balanced), is fully functional (integrated), and is resilient to change or impact (adaptive), and which has the expected species composition, diversity, and functional organization.

Some would argue that implicit in the definition of biological integrity is the concept that the integrity exhibited by waters in the time of pre-European settlement is a standard by which waters may be evaluated. Under this interpretation, a waterbody with biota that closely resembles the pre-settlement condition is said to have the highest biological integrity. This approach does not fully accommodate society as a component of the natural world. Humans, like all other "social" animals, adapt their environment to benefit their own survival and reproduction. In so doing, the integrity of waters is affected. Vermont's water quality policy articulates the goal of managing towards a condition reflecting minimal changes from human alteration. Such waterbodies are in their current natural condition, and are known as reference waters[1]. Most commonly, then, evaluations of biological integrity use the reference of "nearly-natural" condition as a reasonable point from which to compare the current condition of any given waterbody. The farther the biological condition departs from the reference condition, the lower the biological integrity.

Scientists have identified various levels of departure from the reference condition that exist along a gradient of increasing aquatic community change resulting from human influenced stressors. Aquatic communities respond in a predictable fashion to increasing levels of stress. The Biocondition Gradient (Figure 2) is a framework developed by the USEPA that describes in narrative fashion how

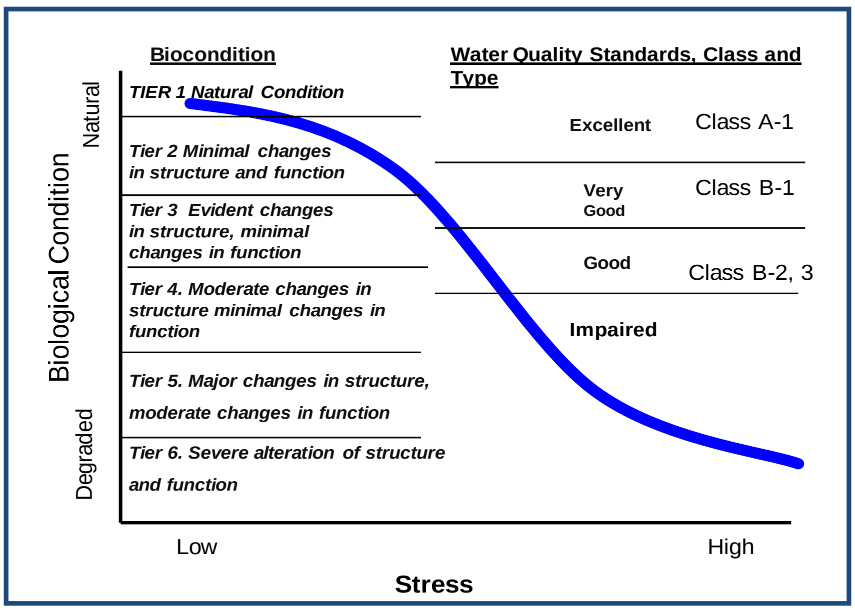


Figure 2. The Biocondition Gradient

[1] The Water Quality Standards define reference condition as *"the range of chemical, physical, and biological characteristics of waters minimally affected by human influences. In the context of an evaluation of biological indices, or where necessary to perform other evaluations of water quality, the reference condition establishes attainable chemical, physical, and biological conditions for specific water body types against which the condition of waters of similar water body type is evaluated."*

biological attributes of the community change with increasing stress. There are six tiers of condition ranging from natural condition to highly degraded, each represented by a narrative description of the community. This framework embodies how biological integrity is defined by the Vermont Water Quality Standards, and provides a clear way of communicating aquatic community condition to the public.

Biological Integrity of Wetlands and Lakes

Wetland areas are known for being biological hotspots. Around 80% of bird species nationally rely on wetland habitat for some or all of their life stages. Over fifty percent of rare, threatened or endangered plant species in Vermont occur in wetlands. There are over 45 wetland natural community types identified in Vermont by the VT Fish and Wildlife's Natural Heritage Inventory. This includes forested wetlands, peatlands such as bogs and fens, shrub-scrub wetlands, marshes, and emergent aquatic beds. Each type of wetland and each species present has unique characteristics which in turn affect how the wetland influences chemical and physical characteristics of adjacent surface waters. For instance, wetlands with higher biodiversity are better able to absorb excess nutrients than monotypic stands which senesce in the fall and flush nutrients back into the waters. Native woody vegetation in floodplains hold and retain sediment while floodwaters enter the floodplain and dissipate much of the force of floods. Floodplains without healthy vegetation experience higher erosion, and floodplains with dense, shallow-rooted invasive species such as Japanese knotweed also experience erosion and are diminished in their flood storage capacity. The accumulation of peat mosses (*Sphagnum* spp.) in many bogs, fens, and acidic forested wetlands can act like a giant sponge, creating a raised water table which acidifies the waters but vastly increases the wetlands' water holding capacity. If these wetlands experience disturbance the peat may decompose, greatly reducing the ability of the wetland to carry out this function.

Lakes too support a large biological community, both within the lake itself and on the land adjacent to the water. Wetlands often merge into lakes, blending the habitats of terrestrial and aquatic life. Many species of birds, mammals, fish, amphibians, reptiles and insects depend on the lake littoral zone and nearby shore for food and shelter. Healthy native plant communities in the littoral zone and along the shoreline also serve to protect the physical and chemical integrity of lakes. These communities help dampen wave energy and slow erosion. Natural shorelines prevent ice damage in winter and absorb nutrients from runoff. The physical and chemical integrity of lakes is supported by a healthy biological community. In turn, the biological community thrives when physical and chemical integrity is maintained.

Physical Integrity:

The physical integrity of surface waters may be measured differently for rivers, streams, lakes, and wetlands, but in all instances, physical integrity is defined by the interactions between riparian areas, floodplains, and the surface water. The physical integrity of surface waters can be affected by actions on the landscape that are directly adjacent to the waterbody, or at the farthest-most up-gradient point in a watershed. Habitat in surface waters is a function of physical integrity.

Physical Integrity of Streams:

Physical integrity in streams is defined by the degree of "equilibrium" exhibited by the stream. Equilibrium is the condition in which a stream and floodplain morphology is sustained over the long-term by the dynamic interaction of water flow, sediment transport, and woody debris movement from the watershed. If dynamic equilibrium of a stream system is achieved at the watershed scale, the streams exhibit minimal erosion, minimal loss of sediment from watersheds to the stream channels, and high diversity in aquatic and riparian habitat.

Physical integrity is highest when there exists an optimum balance between the shape of a stream in terms of its sinuosity, depth, and access to floodplains, and the water flow, sediment, and woody debris supplied by the watershed. The type of equilibrium exhibited by a given stream is a function of the valley width and slope, bedrock and surficial geology, soils, and vegetation. Collectively, the forces associated with water, sediment, and debris runoff determine the shape or morphology of the river and floodplain. High physical integrity, as evidenced by persistent channel shape, depth, and floodplain access is developed and maintained over time by the annual high flow events and the sediment produced by the watershed. It is these high flow events that produce the greatest amount of "work" on the channel and floodplain and transports the greatest volume of sediment over time. Put simply, there is a balance between the shape of the river, and the amount of water, sediment, and debris the river can carry. When there are changes to any of these components, the dynamic fluvial equilibrium is affected, and physical integrity declines.

Figure 3 illustrates how water volume, sediment volume, sediment particle size, and the slope of a river channel are naturally balanced. If the balance is tipped the channel responds by either aggrading (building up sediment on the channel bed) or degrading (scouring down the channel bed). A change in any one of these factors will cause adjustments of the other variables until the river system comes back into equilibrium. For example, rapid urbanization of a watershed has been shown to increase peak runoff such that a river channel receives a greater volume of water more frequently. The diagram illustrates that an increase in the river's water volume would tip the scale downward on the right. The river will respond by degrading until either the volume and/or size of sediment (along the channel boundaries) increases enough to bring the scale (river channel) back into balance.

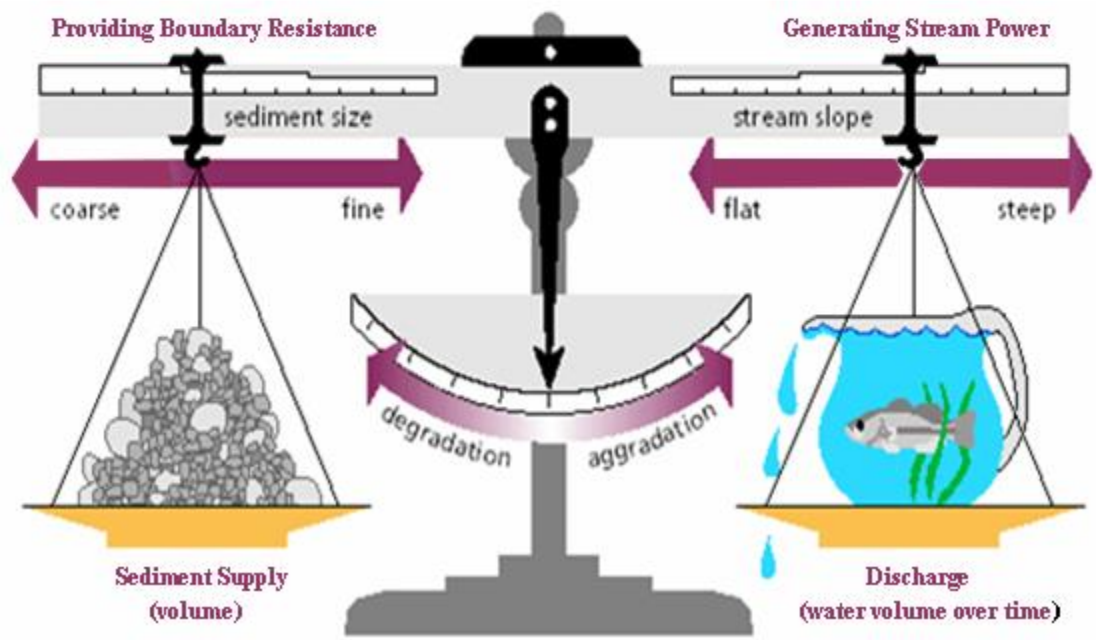


Figure 3. Balance of water supply and sediment supply (after Lane, 1955). Reproduced by permission of the American Society of Civil Engineers.

The actions people take on the landscape are constantly affecting physical integrity. Activities within or adjacent to riparian corridors that significantly alter the runoff patterns of water and/or sediment, will elicit a channel adjustment process. When these processes change the relationship of the river with its floodplain (by aggrading or degrading the channel bed), it becomes increasingly difficult to plan for, as well as expensive to maintain those land uses, and the risk of flooding damage increases considerably. Habitat quality is also degraded as a result of excessive scour of substrate cover, the fining or sedimentation of bed features (e.g., pools and riffles), and /or the vertical disconnection of aquatic with riparian habitats.

It must be recognized that streams that are in equilibrium still erode their banks, migrate over time across their valleys, and periodically experience small-scale lateral and/or vertical adjustments. Even with these changes, a stream will remain in equilibrium as long as the physical characteristics of the stream are consistent with the inputs of water, sediment, and organic debris at a given point in the watershed continuum (from highlands to lowlands). Climate change, geologic events, and major storms can change the shape of river channels. When this occurs, natural adjustments occur continually until dynamic equilibrium is reestablished. These adjustments, however, have been greatly altered during the past two centuries in Vermont by human-imposed changes to rivers from intensive watershed and riparian land uses. Nearly every Vermont watershed has streams that are "in adjustment" as a result of initial land clearing, the subsequent clearing of boulders, beavers, woody debris, and gravel from stream channels to move water and sluice logs from headwaters to village mill sites, and extensive ditching to drain wet soils to promote agriculture. The effects of these actions have been exacerbated by efforts to lock stream channels in place within floodplains to protect or expand infrastructure including transportation, agriculture, streamside homes, and impoundments. This is not to imply that high physical integrity of streams is exclusive of infrastructure. Rather, historical efforts to manage landscapes have resulted in many Vermont streams being in considerable disequilibrium. Act 110 (2010) substantiates the need to develop a balance between placement and management of infrastructure, and the

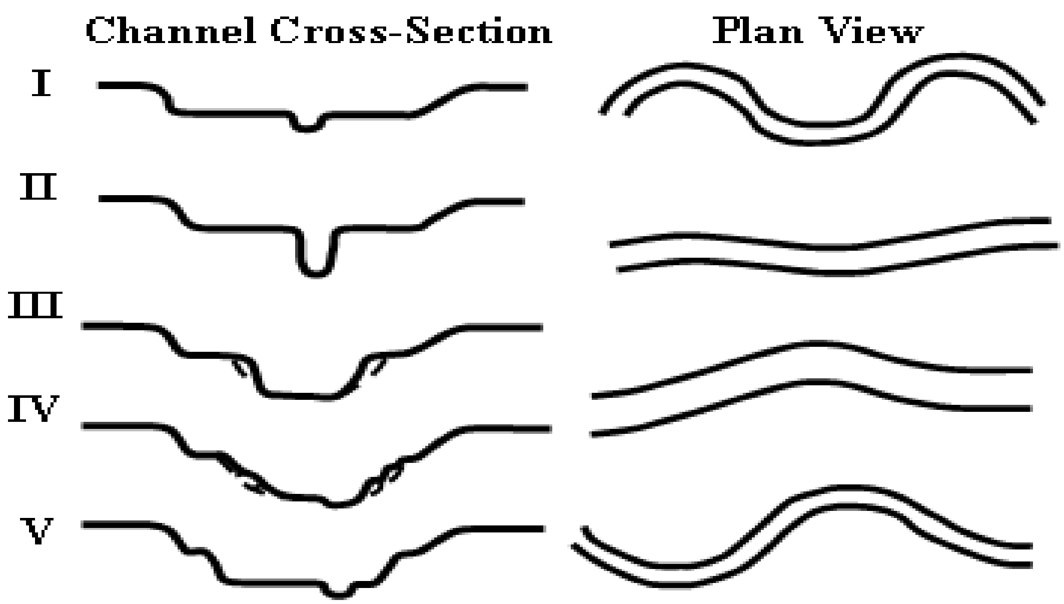


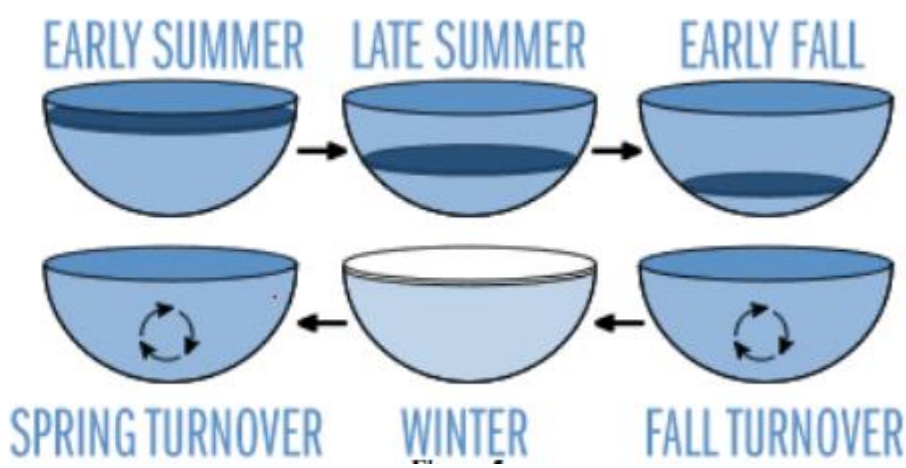
Figure 4. Channel Evolution Model showing a stable channel in Stage I, channel down-cutting or incision in Stage II, widening through Stages III and IV, and floodplain re-establishment at lower elevation in Stage V. Stages I and V represent equilibrium conditions. The Plan View shows the meander pattern of streams in the various stages of evolution.

physical integrity of streams. Stream access to floodplains may be the most important factor in maintaining equilibrium. Depending on the type of channel, the effects of disconnecting a channel from its floodplain vary. Channel evolution models help to explain a stream channel's response to losing its floodplain. Figure 4 shows how stream channels respond to deepening either due to excess water flow, or stream channel straightening. Channel evolution may also result in profound physical adjustments upstream and downstream from the site of alteration. To assess the physical integrity of streams, Vermont implements a three-phased approach to assessing stream geomorphic condition that permits scientists to assign streams to the stages of the channel evolution model, and to develop river corridor plans to manage streams towards equilibrium conditions.

The failure to understand, protect and preserve the access of rivers to their floodplains has directly resulted in conflicts between human investments and river system dynamics. Over the last century, many miles of Vermont's rivers have been subjected to channel management practices such as armoring, dredging, gravel mining and channelization, for the purpose of containing high flows in the channel and to protect human investments built in the historic floodplains. Following, and in support of the land drainage and damming practices started during the 19th century, structural controls and loss of floodplain access are largely responsible for loss of stream physical integrity in Vermont today.

Physical Integrity of Lakes and Wetlands

The natural physical integrity of lakes is highly variable. Lakes can be thought of as aquatic islands in a terrestrial landscape. Like islands, lakes are isolated but influenced by their surroundings. Lake shapes (morphology) vary, as do lake depths (bathymetry). Some lakes are fed primarily by groundwater, while others have enormous watersheds and are fed predominantly by runoff. Some lakes are located at high elevations that experience different weather than those at the same latitude located at sea level. As a result, lakes have different rates of water replenishment, different spatial and temporal patterns in temperature layering, and different ice cover durations. An integral part of the natural physical integrity of the open water of a lake is how it "mixes," or turns over. Monomictic lakes fully mix or 'turn over' once a year. Dimictic lakes turn over in spring and fall. Polymictic lakes, which are usually shallower, turn over multiple times a year. Meromictic lakes have stratified layers that do not fully mix (e.g. lakes with deep holes like Great Hosmer Pond). Most lakes in Vermont are either dimictic or polymictic. Managing lake



Graphic showing the progression of water temperature layering in lakes through the year. Image courtesy of USEPA. The cycle shown is for a "dimictic" lake.

water quality requires an understanding of these dynamics, which is obtained by water quality monitoring.

A key component protecting the natural physical integrity of the nearshore shallow area of a lake is the condition of the adjacent lakeshore. Natural lakeshores in Vermont are wetlands, forests, or forested wetlands. The physical characteristics of the littoral zone off a wetland are typified by soft or sandy sediments. The structure of wetland plants serves to dampen wave energy, allowing fine particles to settle out. Non-forested wetlands do not shade the littoral zone, so a diversity of submersed aquatic plants often thrive in the littoral zone adjacent to them. Plants provide physical structure and habitat and further dampen wave energy. Forested shores shade the littoral zone, and provide leaf litter as well as fine, medium and large woody structure. Many sediment types can be observed in the shallow water off a forested lakeshore in Vermont. Areas may have naturally fine sediments, but more commonly feature rocky or even boulder lake beds. This results in a three dimensional, physically complex, heterogeneous shallow water environment. Physical habitat heterogeneity increases species diversity because it provides a wide variety of niche environments. It is for this reason that the littoral zone is thought of as a lake's nursery grounds. The structural complexity of the nearshore environment provides cover and food not found in either the open water environment of a lake or the terrestrial environment of the lakeshore.

Complex healthy habitat in the shallow-water area of a Vermont lake. The mix of boulders, sands and silts, and aquatic plants provide cover for fish and other aquatic animals.

The transformation of lakeshores and wetlands from natural vegetation to lawns and sandy beaches, accompanied by development (e.g. residential homes) can compromise physical integrity. As lakeshores are converted from forests to lawn, impervious surface, and sand, enhanced runoff results in increased littoral embeddedness, increased temperature (due to loss of shading) and in most cases more abundant aquatic plant growth in the shallows. Physical integrity of littoral habitat is further simplified by the direct removal of woody structure from the shallows, which is also considered wetland, and interruption in the resupply of this critical habitat component. In some cases, development is associated with introduction of fill material which completely removes the functions of low-lying lakeshores and their associated wetlands.

This alteration of the nearshore and littoral habitat affects a variety of both terrestrial and aquatic wildlife and has been well described by scientists. Green frog, dragonfly and damselfly populations decline. The nesting success and diversity of fish species also declines, with sensitive native species being replaced by more disturbance tolerant species. Turtles lose basking sites and corridors to inland nest sites, and bird composition shifts from insect-eating to seed-eating species. Even white-tailed deer are affected, with reduction in winter browse along shorelines reducing winter carrying capacity. The removal of conifers along shores can also reduce shoreline mink activity. Ultimately, the cumulative effects of lakeshore development impact considerably on physical integrity and habitat, affecting many types of aquatic and terrestrial wildlife.

The wetlands that offer benefits to surface water quality support a unique spectrum of ecosystem types that vary in hydrology, vegetation, and position on the landscape. The physical integrity of a wetland varies between these types. Wetlands that act as headwaters on sloping hillsides or high-elevation basins are an important transition between groundwater and surface waters, both through recharge of groundwater and discharge to surface water. Other types of wetlands comprise floodplains or backwaters along streams that feed into lakes and ponds. The wetlands that line the shores of lakes and ponds are the transitional zone between upland and deep water habitat, and are inherently sensitive to hydrological changes. Surface flow through many wetlands is largely undefined by channels, is seasonal in nature, and is critical in helping slow flood waters before entering more clearly defined river systems. Furthermore, unlike the lakes and ponds themselves, wetlands are sometimes completely lost in the face of extreme impacts. Fill, dredging, the alteration of hydrologic inputs and outputs, sedimentation, changes in water chemistry and the removal of vegetation from the wetlands can alter the physical integrity of a wetland or even lead to the complete loss of wetland functions and values. Such activities need not occur within the wetland to effect physical integrity and therefore activities within the adjacent upland need to be evaluated for change as well. For instance, diversion of streams that feed a wetland or installation of extensive impervious surfaces in the watershed of a wetland can cause severe impacts to the wetland.

Lakes and Eutrophication

Natural eutrophication of lakes refers to the aging of lakes in geological time, a gradual accumulation of sediment from a watershed that occurs over hundreds or thousands of years. As a lake ages and accumulates sediment naturally, biological and chemical characteristics also change (see Figure 5). Through this process, lakes naturally progress from the oligotrophic stage (deep clear water, few nutrients, few aquatic plants, high dissolved oxygen, sandy or rocky bottoms), through the eutrophic stage (high nutrients, extensive plant beds and algae, low dissolved oxygen, accumulated bottom sediments) to eventually become wetlands.

Human activities on the land have increased the movement of sediment and nutrients from the land to our lakes, a process known as 'cultural eutrophication'. As a result, lakes are aging much more rapidly and reaching the eutrophic stage much sooner (e.g. decades) than would occur in the absence of these activities. Lake management seeks to slow the cultural eutrophication process through the management of stressors while respecting the natural progress of lakes to wetlands.

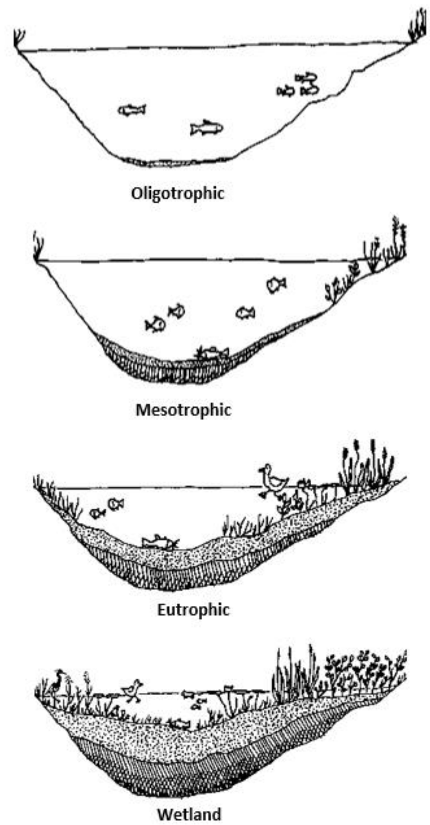


Figure 5. The stages of lake eutrophication.

Drawings by Susan Warren

Chemical Integrity

Compared to biological and physical integrity, chemical integrity is relatively simple to understand. The chemistry of water is an intrinsic component of habitat. When a chemical pollutant affects aquatic biota, it is because that chemical is affecting the organism's physiology owing to the contamination of the habitat. Thus, reducing pollutants in waters by managing stressors necessarily improves and restores habitat.

The chemical makeup of waters varies widely in Vermont. Some waterbodies are naturally enriched in phosphorus (e.g. Danby Pond, in Danby), or very low in phosphorus (Crystal Lake, Barton). Entire watersheds may be predisposed to acidification due to their geologic makeup (Lye Brook, Manchester), while other waters will never be at risk of acidification (Shelburne Pond or Lake Champlain). The chemical gradients that exist in natural waters are wide, and natural communities are adapted to these waters. However, when stressors affect the chemical integrity of waterbodies resulting in chemical levels outside of the expected natural range, biological integrity is likely to suffer.

The use of water management technologies (e.g. pesticides, alum, aeration) has successfully been used in Vermont and elsewhere to restore the chemical integrity of waterbodies. However, in some cases, these restoration approaches can also compromise the integrity of a waterbody. This depends on the capacity of the waterbody to sustain a balanced and resilient biological system with the full suite of ecological processes expected for the waterbody type. When these elements or processes are manipulated, the biological system of a waterbody can become unbalanced, which may result in a phenomenon called a “stable-state shift” (e.g. a lake with a plant-dominated stable state can shift to an algae-dominated stable state). These shifts can be difficult to reverse.

Wetland water chemistry is dependent on the water sources (surface or groundwater) and the bedrock and surficial deposits the source water flows through. Calcium is one of the more important minerals affecting plant composition in wetlands. Some of the most unique wetland types are on the opposite ends of the nutrient scale. Rich Fens are peatlands which are found where waters have surfaced from calcium-rich bedrock. They are high in minerals and pH, are typically very small, and are biological hot-spots. Conversely, true bogs such as Dwarf Shrub Bogs are peatlands which have a raised water table, primarily receive water from precipitation, are subsequently low in nutrients and high in water acidity, and have their own specialized plant community assemblages. A sudden change in nutrients due to alteration of the landscape of either of these wetland types would allow for invasive species intrusion, a loss in biodiversity and a loss in nutrient assimilation by native vegetation. In the case of bogs, increase in pH and nutrient level can also cause the peat layer in the wetland to quickly decompose, strongly compromising wetland function.

4. Protecting and Improving Surface Waters by Managing Stressors

In developing this Strategy, the Division engaged in an intensive evaluation process aimed at identifying areas of program duplication and program "gaps", as a way to ensure program efficiency in meeting the goals and objectives identified in the Strategy. A key element of this approach is the recognition that individual pollutants (often more than one) can be simultaneously mitigated by managing surface water stressors. These stressors are of interest not only to the Division, but also to Federal, State, and local agencies and organizations with in interest in surface water management. The Division has identified a list of 10 major stressors with unique causes and sources, and sometimes overlapping effects, which result in the surface water impacts documented in Vermont. By identifying stressors and approaches to their management, the Strategy sets the stage for the WSMD's approach to multi-agency planning and implementation that will meet the WSMD goals.

What are the 10 Major Stressors?

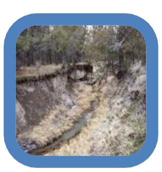
The ten major stressors are presented here in alphabetical order. The importance of each stressor has been evaluated in light of its extensiveness, intensity, duration, and urgency, and also in terms of the programs available to address the stressor. This information is described in detail in Chapter 2.

Acidity:

Acidification of Vermont's lakes and streams is a major problem caused primarily by the atmospheric deposition of acidic nitrogen and sulfur compounds (e.g., acid rain). Acidification can also result from runoff of active or abandoned mines. Acidification is widespread in the higher-elevations of Vermont, resulting in considerable impacts to lake and stream biology. Successful management of acidity meets Objectives A, B, and D of this Strategy.

The icon at left shows high-elevation forests that have been killed off due to acidification.

Channel Erosion:



Excessive channel erosion occurs throughout Vermont and is brought about by human activities that alter runoff patterns and channel morphology and lead to stream disequilibrium. Channels and floodplains that have the capacity to store sediment and associated nutrients are now transporting these materials. Excessive channel erosion adversely affects stream habitat, and higher loads of nutrients and sediments have become pollutants in downstream receiving waters such as inland lakes and Lake Champlain. Successful management of channel erosion achieves Objectives A, B, and C of this Strategy.

The icon at left shows a highly incised river channel and exemplifies channel erosion.

Flow Alteration:

Altering the natural flow regime of rivers and streams (i.e., impounding or dewatering) or the natural fluctuations of lake levels affects the extent and quality of aquatic, riparian and wetland habitats, water temperature, dissolved oxygen and other aspects of water chemistry, including concentrations of toxins in aquatic organisms. Flow alteration is an inevitable consequence of water withdrawals and hydroelectric power generation, so these activities must be properly managed to avoid impacting aquatic biota and recreational uses. Successful management of flows and water levels meets Objectives A, B, C, and D of this Strategy.

The icon at left shows an aerial view of the spillway at the Harriman Reservoir Dam, in Whitingham, Vermont.

Encroachment:

The placement of public or private infrastructure upon lakeshores, wetlands and river corridors results in the loss of riparian zone buffers, increasing sunlight penetration of shallows, and reducing habitat quantity and quality. Encroachments along river corridors can also create or perpetuate stream disequilibrium, both immediately adjacent to the structure, and in areas far upstream or downstream. Encroachments are pervasive along Vermont lakes and streams. In wetlands, fill, alteration of vegetation, and changes to hydrology result in a loss of the functions and values. Lakes with poor lakeshore habitat from overdevelopment can be three times more likely to have poor ecological integrity. Management of encroachments meets Objectives A, B, and C of this Strategy.

The icon at left shows an example of streambank and floodplain encroachment.

Invasive Species:

Invasive species such as Eurasian watermilfoil, Japanese knotweed, purple loosestrife, water chestnut, zebra mussels and spiny waterflea cause severe impacts to aquatic habitat. These species readily out-compete native plants, algae, and animals, ruin recreational opportunities, and alter entire ecosystem functions. Invasive species are at risk of spreading throughout Vermont surface waters, especially lakes, and are transported from one waterbody to the next by boats or following road ditches. Successful control of invasive species meets Objective B of this Strategy.

The icon at left shows a dense infestation of Eurasian watermilfoil.

Land Erosion:

Erosion of sediments off land surfaces delivers both sediment and nutrients to surface waters. These sediments can readily alter the dynamic equilibrium of naturally functioning stream channels, resulting in stream instability and delivery of sediments and nutrients to downstream waters. Land erosion occurs in all landscape types (urban areas, dirt roads, and improperly managed forest and farms). Successful control of land erosion meets Objectives A, B, and C of this Strategy.

The icon at left shows an example of rill erosion.

Nutrient Loading:

Direct discharge or runoff of nutrients also occurs independently of channel or land-based erosion. Wastewater treatment facilities, septic systems, and fertilizer usage in residential areas and agricultural settings deliver nutrients directly to waters. Nutrients like phosphorus and nitrogen are beneficial in naturally-occurring low levels, but excess nutrient loading results in eutrophication of lakes and streams, and increases the likelihood of toxic algae growth. Successful control of excessive nutrient loss meets Objectives A, B, and D of this Strategy.

The icon at left shows the chemical symbols for nitrogen and phosphorus.

Pathogens:

Pathogenic organisms may occasionally be present in Vermont's surface waters. When swimmers are exposed to pathogens in excessive levels, they may become ill, typically with gastrointestinal distress. Pathogenic organisms are the result of fecal contamination from several sources: poorly maintained septic systems, unmanaged agricultural runoff, pet waste, and natural sources. Vermont employs a readily-measured indicator organism called *E. coli* to assess the potential presence of pathogens from warm-blooded animals. Monitoring and controlling pathogens meets Objective A of this Strategy.

The icon at left shows coliform bacteria that are fluoresced under a microscope.

Toxic Substances:

Several categories of toxic contaminants may be present in Vermont's surface waters. Mercury contamination of lake fishes is widespread, reflecting that mercury is an atmospheric contaminant. Hazardous waste sites can result in localized contamination of PCB's, heavy metals, and other toxic compounds. Toxic cyanobacteria are becoming more frequently

observed in certain lakes and ponds. Of particular concern are "new generation" compounds such as endocrine-mimicking compounds, pharmaceutical degradates, and personal care products. These compounds come from the products society uses as part of daily living. They occur at very low concentrations, have poorly understood but consequential impacts to aquatic life, and are a direct manifestation of people as an integral part of Vermont's watersheds. Successful management of toxic substances meets Objectives A, B, and D of this Strategy.

The icon at left shows the chemical configuration of a poly-aromated hydrocarbon known as benzo-a-pyrene.

Thermal Stress:

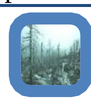
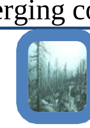
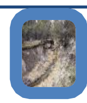
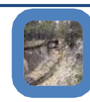
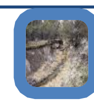
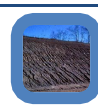
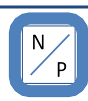
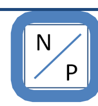
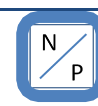
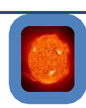
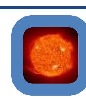
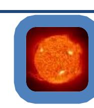
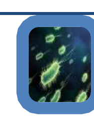
Excess warming occurs as a result of riparian buffer removal, the impoundment of water, loss of headwaters wetlands, cooling water discharge, and climate change. Excessive warming of surface waters impacts aquatic species that are intolerant of warm temperature. Further, excess warming can turn an otherwise cool babbling brook into bathwater; an undesirable effect on a hot day. Successful management of thermal stress meets Objectives A, B, and C of this Strategy.

The icon at left shows abnormally high sunspot activity.

Integrating Stressors, Objectives, and Goals

In the preceding sections, the basis for this Strategy was described in terms of a conceptual framework (Figure 1), goals that reflect federal and state law and Vermont's surface water quality policy, objectives that support those goals, and surface water stressors as a unifying theme for surface water management. The ways in which each stressor relates to the goals and objectives are shown graphically in Table 1 below. This table shows at a glance those stressors that must be managed to support the goals and objectives of this Strategy.

Table 1-1. Relationship of Goals, Objectives, and Stressors described by WSMD's Vermont Surface Water Management Strategy.

Strategy Goals	Biological, Chemical, Physical Integrity Public Use and Enjoyment Public Health and Safety	Biological, Chemical, Physical Integrity Public Use and Enjoyment --------	----------- Public Use and Enjoyment Public Health and Safety	Biological, Chemical, Physical Integrity Public Use and Enjoyment Public Health and Safety
Objectives→ ***Stressors*** ↓	A. Minimize anthropogenic nutrient and organic pollution	B. Protect and restore aquatic and riparian habitat	C. Minimize and flood and alluvial erosion hazards	D. Minimize toxic, pathogenic pollution and chemicals of emerging concern
Acidity				
Channel Erosion				
Flow Alteration				
Encroachment				
Land Erosion				
Nutrient Loading				
Toxic Substances				
Thermal Stress				
Invasive Species				
Pathogens				

Using the Stressor Approach to Evaluate Program Effectiveness

In Chapter Two of this Strategy, ten stressor-specific summaries are provided that further describe the stressors, their associated pollutants, their unique causes and sources, and the State, Federal, Municipal, and non-profit programs in place to manage the stressors. Each stressor-specific subchapter describes the WSMD's programs and approaches for working with partner organizations to address the stressors through activities in five specific areas:

- ***Monitoring and Assessment*** activities to document locations of stressor impacts and identify areas to protect or remediate.
- ***Technical Support*** programs to assist individuals and organizations with the development of projects to address the stressor.
- ***Funding*** programs that provide cost-share assistance or complete funding for projects.
- ***Rules and Regulations*** that address the stressor, including permitting programs.
- ***Education and Outreach*** activities that confer understanding to the general public on the importance of the stressor.

The WSMD is has evaluated gaps in its ability to directly or indirectly protect and improve surface waters through the management of these stressors. By evaluating the extensiveness, intensity, urgency, and duration of 10 major stressors and their component causes, the WSMD evaluated stressor importance. The WSMD has also examined existing monitoring and assessment, education and outreach, technical assistance, financial assistance, and regulatory permitting programs pertinent to each stressor, to identifying gaps and areas of overlap in its ability to address the stressor areas. Chapter Three of this Strategy describes the results of this overall program evaluation and gap analysis, and identifies opportunities for greater program integration, enhanced internal and external coordination and other steps that would better promote the protection of Vermont's surface waters.

5. A Comprehensive Ambient Surface Water Monitoring and Assessment Program

Elements of the Surface Water Monitoring and Assessment Strategy

Monitoring Strategy
Monitoring Goals and Objectives
Monitoring Project Design
Core and Supplemental Indicators
Quality Assurance
Data Management
Data Analysis and Assessment
Reporting
Programmatic Evaluation
General Support and Infrastructure

In parallel with the development of this Strategy, the WSMD has also recently completed a wholesale revision to its existing strategy for guiding surface water monitoring and assessment. This new 2015 Vermont Surface Water Monitoring Strategy has two primary purposes, to describe the who, what, where, when and why of monitoring Vermont's waters, and to coordinate with partners at all levels. Effective monitoring is integral to watershed management and planning at the statewide and basin-specific level, and to identify and prioritize waters in need of protection, restoration or management. Regulatory programs need monitoring data to more fully assess the impact of individual permit decisions, and monitoring results directly support the use of Vermont's Assessment and Listing Methodology to identify stressed, altered, and impaired waterbodies. The Monitoring Strategy is organized into 10 elements as recommended by the USEPA (see sidebar).

The Monitoring Strategy's goals and associated objectives are:

1) ***Predict and monitor the condition of Vermont's surface water resources to:***
   - identify emerging problems before they become widespread or irreversible;
   - provide information essential to protecting, maintaining and/or restoring the integrity and use of these resources;
   - achieve comprehensive monitoring coverage of all Vermont waters;
   - identify water quality conditions, impairments, causes, and sources; and,
   - evaluate the success of current policies and programs.

2) ***Communicate, collaborate and coordinate with organizations, agencies, and the general public to:***
   - increase public knowledge of and involvement in aquatic and wetland resource monitoring and assessment (and hence water resource management);
   - promote efficient and effective monitoring and assessment programs; and
   - collect useful data to supplement state monitoring and assessment programs.

On a biennial basis, the Division uses the data generated by the monitoring and assessment program to produce a statewide assessment of the conditions of Vermont's surface waters. This assessment, known as the Integrated Report on the Water Quality Integrated Assessment Report, is prepared in satisfaction of §305(b) of the Federal Clean Water Act.

For the purposes of identifying and tracking important water quality problems where the Vermont Water Quality Standards (VTWQS) are not met, VTDEC has developed the Vermont Priority Waters List. This list is composed of several parts, each identifying a group of waters with unique water quality concerns that are either impaired or altered: Impairment means that the surface water in question no longer supports one or more of the designated uses protected by the Water Quality Standards. Pursuant to the Federal Clean Water Act, impaired waters are those that are legally determined to be polluted, and that Act requires that most impaired surface waters be subject to a watershed specific pollution control plan known as a Total Maximum Daily Load (TMDL).

6. Total Maximum Daily Loads and other Pollution Control Plans

A TMDL is a legally binding document that identifies the surface water designated use that is impaired, the pollutant that causes the impairment, and the total maximum discharge of that pollutant that may be allowed to enter the waterbody in question and still maintain the designated use. TMDLs are unique to each waterbody. The general process by which they are developed can be summarized as follows:

- Problem Identification: the pollutant for which the TMDL is developed must be identified. Examples might include sediment that impacts habitat for aquatic organisms, nutrients that cause excessive algal growth, or bacteria that creates an unsafe environment for swimming.
- Identification of Target Values: this element establishes water quality goals for the TMDL. Target values may be stated explicitly in the Water Quality Standards or they may need to be interpreted.
- Source Assessment: all significant sources of the pollutant in question must be identified in the watershed. This often requires additional water quality monitoring.
- Linkage Between Targets and Sources: this element of the process establishes how much pollutant loading can occur while still meeting the Water Quality Standards. This step can vary in complexity from simple calculations to development of complex watershed models.
- Allocations: once the maximum pollutant loading is established, the needed reductions must be divided among the various sources. This is done for both point sources and nonpoint sources.
- Public Participation: stakeholder involvement is critical for the successful outcome of any TMDL. Draft TMDLs are released for public comment prior to their completion.
- EPA Approval: EPA approval is needed for all TMDLs as required by the Federal Clean Water Act. The New England regional office of EPA (Region 1), located in Boston, Massachusetts is responsible for TMDL approval.
- Follow-up Monitoring: additional monitoring may be needed to ensure the TMDL, once implemented, is effective in restoring the waters.

This surface water management strategy incorporates all TMDLs developed to date by the State of Vermont, and also the Lake Champlain Phosphorus TMDL that was promulgated by USEPA in 2016, following rescission of the 2002 Vermont Lake Champlain Phosphorus TMDL.

Lakes

- Lake Champlain Phosphorus TMDLs
  - (incorporated pursuant to USEPA's June 17 cover letter transmitting this TMDL to the State of Vermont)
- Lake Carmi TMDL - Franklin - phosphorus

- Ticklenaked Pond TMDL - Ryegate – phosphorus
- Lake Memphremagog Phosphorus TMDL – *forthcoming in 2017*.
- Moon Brook Thermal TMDL – *forthcoming in 2017*.

Rivers and Streams

- Winooski River - Cabot - pathogens
- Black River - Ludlow - phosphorus
- Tributary #1, Ball Mountain Brook - Stratton - sediment
- Styles Brook - Stratton - sediment
- Potash Brook - South Burlington - stormwater
- Bartlett Brook - South Burlington- stormwater
- Centennial Brook - South Burlington & Burlington - stormwater
- Englesby Brook - Burlington - stormwater
- Morehouse Brook - Winooski & Colchester - stormwater
- Allen Brook - Williston & Colchester - stormwater
- Indian Brook - Essex & Colchester - stormwater
- Munroe Brook - Shelburne - stormwater
- Sunderland Brook - Colchester – stormwater
- Moon Brook – Rutland - stormwater
- Rugg Brook – St. Albans – stormwater
- Stevens Brook – St. Albans – stormwater

TMDLs for Acidified waterbodies due to acid rain

- 2012 TMDL (2 acid impaired waterbodies)
- 2004 TMDL (7 acid impaired waterbodies)
- 2003 TMDL (30 acid impaired waterbodies)

Statewide/multiple waterbodies

- Statewide TMDL for Bacteria-Impaired Waters
- Vermont, 5 other New England states & New York state - mercury (note: concerns 31 Vermont waters)

In certain instances, TMDL's are not the most effective regulatory mechanism to address a water quality impairment. Pursuant to 40 C.F.R. §130.7(b), the State may use a Water Quality Remediation Plan (WQRP) in lieu of a TMDL for an impaired water when the State determines that the pollution control requirements of the WQRP are stringent enough to meet State Water Quality Standards within a reasonable period of time, and the regulatory authority exists to compel development *and* implementation of a WQRP. WQRP's are used most commonly in the case of impairments that result from the actions of a single landowner or business operator, and where that landowner or business operator controls all of the pollution sources in question. Several Vermont development areas are subject to WQRPs.

7. About the Vermont Clean Water Act (Act 64 of 2015)

The Vermont Clean Water Act (VCWA, or the Act) was signed into law by Governor Peter Shumlin on June 16, 2015. The Act represents a major step forward in Vermont's ability to reduce sediment and nutrient (phosphorus and nitrogen) pollution across the State. There are many areas in which the Act requires new or augmented efforts to control runoff. The roles and responsibilities of the State and the community in implementing these efforts is described in the following.

Agricultural Runoff

The State's Role:

- Promulgate new Required Agricultural Practices by the end of 2016.
- Train and certify businesses that apply manure to fields to minimize runoff in nearby waterways;
- Provide training for farmers and establish an annual certification for small farmers on how to comply with State standards by July, 2017;
- Increase farm inspections and technical assistance to ensure compliance with state agricultural water quality rules;
- Work with federal partners to increase support and funding to help farmers undertake water quality improvements on farms;
- Target support and funding to farms in the northern and southern segments of Lake Champlain Basin, where phosphorus pollution from agricultural sources are particularly significant;
- Evaluate and employ technical, regulatory and educational options for tile drain management. A report to the legislature on tile drains and recommendations for additional Required Agricultural Practices to address tile drainage is due Jan. 15, 2017.

The Farmers' Role:

- Provide a minimum of 25-foot buffers along streams and 10-foot buffers along field and road ditches;
- Eliminate gullies that are eroding valuable agricultural land;
- Develop nutrient management plans and implement actions to keep manure, fertilizer and topsoil from running into waterways;
- Install fences to keep livestock out of streams and rivers where needed.

Stormwater from Developed Lands

The State's Role:

- Update the standards contained in the Vermont Stormwater Manual during 2016;
- Provide municipalities support in identifying, prioritizing and initiating stormwater control needs;
- Help municipalities, developers and property owners reduce stormwater runoff from unregulated impervious surfaces by employing practical and cost-effective best practices including *green stormwater infrastructure* — actions that mimic or employ natural processes to capture, reuse or filter stormwater and minimize the cost of collecting, transporting and treating stormwater runoff.
- Release the general permit for existing development by 2018 and a schedule to require retrofits in the Champlain Basin no later than Oct. 2023, and in the rest of the State no later than Oct. 2028.

Municipalities' and Developers' Role:

- Control stormwater discharges at existing developments with 3 or more acres of impervious surface that were never permitted or not compliant with the 2002 Vermont Stormwater Manual − the rulebook for new development projects that require a state stormwater permit;
- Develop and go forward with more municipality-wide stormwater runoff control plans in communities that are discharging a significant amount of untreated stormwater into rivers and other waterways.

Stormwater from Roads

The State's Role:

- Develop and promulgate a Municipal Roads General Permit program by December, 2017
- Develop, in consultation with VTrans, and promulgate a General Permit to reduce erosion and stormwater discharges generated from state-managed highways and related infrastructure;
- Support municipalities in conducting road inventories that identify and prioritize critical areas in need of erosion and sediment control;

- Increase support and funding for municipalities in implementing practices that improve the resilience of local roads to flooding while minimizing erosion and stormwater runoff discharging into streams.

Municipalities' Role:

- Reduce erosion and stormwater discharges being generated from municipal roads;
- Apply for permit coverage by July 1, 2021.
- Implement necessary practices by 2026.

River Corridors and Floodplains

The State's Role:

- Provide support to cities and towns, including financial incentives, to aid adoption of enhanced floodplain and river corridor protection standards and enhance flooding resilience;
- Establish a "Flood Ready" website to promote municipal flood resiliency planning and actions;
- Provide education and training to municipalities on stream and river management practices as well as support prior to and during flood emergencies.

Municipalities' Role:

- Comply with the National Flood Insurance Program;
- Qualify for incentives to adopt floodplain and river corridor protection standards that enhance flood resilience and insure that actions of property owners do not heighten the risk of flood damages to other property owners;
- Increase floodplain and river corridor protection and restoration projects.

Wetlands Management

The State's Role:

- Expand support and financial assistance to landowners in wetland restoration and protection; Partner with federal and state agencies, local partners and landowners to identify and undertake wetland restoration projects;
- Increase inspections to achieve greater wetland permit compliance;
- Target critical wetlands for State Class I wetlands protection for flood resilience and phosphorus reduction.

- Collect data about wetlands to establish baselines of wetland condition throughout the state, monitor changes over time, and evaluate success of restoration and protection projects.

Lake and Pond Management

The State's Role:

- Provide support and technical assistance for the protection and restoration of lakes and ponds;
- Partner with federal, state, and local partners to identify and implement protection and restoration projects;
- Monitor waterbody and shoreland condition to inform protection, management and restoration activities;
- Identify high quality waters for increased protection through reclassification, shoreland best management practices and/or nutrient reduction

The role of Municipalities and Local Residents

- Learn about best management practices to promote shoreland health, reduce nutrients and protect water quality
- Control erosion and reduce storm water run-off utilizing best management practices and by creating increased opportunity for infiltration
- Identify high quality waters for increased protection

Forest Lands Management

The State's Role:

- Enhance measures to protect water quality during timber harvesting operations by July, 2016;
- Provide technical assistance to forest landowners participating in NRCS cost-share programs;
- Develop and promote "climate-smart" forest adaptation strategies through the Working Lands Enterprise Initiative to support environmentally sound logging technologies.

Loggers' and Landowners' Role:

- Be encouraged to use low-impact timber harvesting technologies, such as portable skidder bridges, to reduce polluted runoff risks on timber harvesting operations;
- Control erosion on logging roads and at stream crossings by participating in cost-share programs offered by the USDA Natural Resources Conservation Service;

- Improve watershed health by restoring river, floodplain and lake-side forested buffers, supporting forest conservation, expanding developed land forest cover and reducing invasive tree pests.

The Act also established a Clean Water Fund that will serve as a repository for Federal, State, and Private funds that are dedicated to support implementation of water quality improvement projects. While the fund is supported for the first three years using Vermont's property Transfer Tax, the Act compels the State Treasurer to complete a report on the total need and financing options to implement VCWA, the Lake Champlain TMDL, and other pollution control plans (see Section 7, below). That report will be provided to the Vermont General Assembly in January, 2017.

8. The Lake Champlain Phase I TMDL Implementation Plan

While all EPA-approved TMDLs are required to be accompanied by an implementation plan, the implementation plan of the Lake Champlain TMDL merits summary here as the provisions of the Plan largely apply state-wide, and are foundational to the Division's efforts to manage surface waters over the next two decades. The Lake Champlain Phase I Implementation Plan was developed by the Vermont Agency of Natural Resources (ANR) and the Vermont Agency of Agriculture, Food, and Markets (AAFM) from 2015 to 2016. These agencies worked diligently to develop the types of policy commitments requested by USEPA to provide, or reduce the need for, reasonable assurances in the then forthcoming new Lake Champlain Phosphorus TMDL. The final form of the VCWA as passed was in-fact informed by initial drafts of the Phase I Plan, itself informed by the draft Lake Champlain TMDLs. The final October 2016 final Phase 1 Plan reflects EPA's final Lake Champlain Phosphorus TMDLs. The policy commitments described in the Phase I plan address all major sources of phosphorus to the lake, including the following:

- Wastewater treatment facility discharges;
- Untreated/unmanaged runoff from existing developed lands;
- Discharges from farmsteads and agricultural production areas;
- Poorly managed cropland;
- Unmanaged or poorly managed pasture;
- River and stream channel modifications;
- Floodplain, river corridor and lakeshore encroachments;
- Stormwater runoff from developed lands and construction sites;
- Road construction and maintenance;
- Forests and forestry management practices;
- Wetland alteration and loss;
- Legacy effects of historic phosphorus loading; and
- Additional phosphorus contributions anticipated due to climate change.

The commitments presented in the Phase 1 Plan include new and enhanced regulation, funding and financial incentives, and technical assistance, and build on work already done by the State over the past 10 years to reduce phosphorus contributions to the lake. They will require new and increased efforts from nearly every sector of society, including state government, municipalities, farmers, developers, businesses and homeowners. The Division is employing a twenty-year implementation schedule to allow for communities to plan and stage the necessary improvements to roads, stormwater and wastewater infrastructure into long-term capital funding plans as a means of keeping costs and funding burdens down.

9. Tactical Basin Planning

The Federal Clean Water Act requires the development of a watershed planning approach, while VCWA requires the development of fifteen basin-specific watershed management plans[2]. Chapters Two and Three of this Strategy provide a statewide perspective on Vermont's approach and toolkit for watershed management, Chapter Four describes a tactical basin planning approach that maximizes geographic specificity and coordinates multi-program implementation to a common set of stressors. Tactical basin plans are the vehicle by which the WSMD will implement the actions laid out in the Strategy, by providing coordination of the many water quality protection and improvement programs in Vermont. In addition to the Agency of Agriculture, Food and Markets, Vermont's Regional Planning Commissions and Natural Resources Conservation Districts are statutory partners to the planning process. Sister agencies in State and Federal Government are also core partners. Since the initial implementation of the tactical basin planning process in 2010, tactical basin plans have been completed for all of Vermont's fifteen basins, and they have been re-issued every five years, as required by statute.

The tactical planning process is predicated on a monitoring and assessment cycle that provides refreshed data and information to guide prioritized implementation efforts. The Vermont Integrated Watershed Information System provides online access to all water quality and biological monitoring data compiled by the Division in a series of simple graphical reports. Monitoring and assessment data stored within this system provides the Starting point for geographic targeting strategies for protection or intervention. Through this system, the WSMD attributes individual surface water testing locations to categories of quality categories such as "High Quality Waters," and "Altered or Impaired Waters." Recent improvements to the tactical planning process include the technical capacity to conduct fine-scale phosphorus runoff modeling, and other geographically-based watershed targeting analyses, using tools such as the Keurig Green Mountain Coffee Roasters-supported Clean Water Roadmap.

In addition to water quality testing and modeling, there are five specific assessment processes that are integrated when producing a tactical basin plan. The priorities identified by each assessment are integrated into priorities for implementation. Each assessment process also yields critical on-the-ground information on the types of stressors at play. In sum, the assessment processes used in developing tactical basin plans include:

- Water Quality Monitoring;

[2] 40 CFR §130.6, 10 VSA §1253, and the VT Water Quality Standards

- Water Quality Modeling and the Clean Water Roadmap;
- Stream Geomorphic Assessment;
- Assessment and Monitoring of Wetlands;
- Stormwater Master Planning;
- Better Roads Capital and Road Erosion Inventories;
- Stormwater Mapping and Illicit Detection Discharge and Elimination (IDDE);
- Natural Resources Conservation Service high-resolution agricultural plans

The integration of these assessment processes in each tactical basin results in a five-chapter document. Chapter One presents a summary of the plan, including statements of the documented geographic areas and sector-specific areas for protection, practice installation, and restoration. Chapter Two presents a summary of all assessment information for that basin. Chapter Three presents detailed modeling results, and provides a breakdown of TMDL allocations where appropriate. Chapter Four presents opportunities for protection of very high-quality rivers, lakes, and wetlands using reclassification or other designation processes. Finally, Chapter Five of the tactical basin plan provides a summarized implementation table of actions necessary to protect, maintain, enhance, and restore surface waters in the basin.

10. Implementation Priorities and Tracking

As described above and by the Lake Champlain Phase I Implementation Plan, each tactical basin plan Implementation Table is housed within the Division-supported Watershed Projects database, This database includes a project grading system, addressing project readiness and prioritization factors, including estimates of environmental benefits, to assist Basin Planners and the Division's planning partners in prioritizing projects for implementation and funding. Implementation Tables will also address actions to be taken as a result of regulation, including compliance with RAPs, as well as various stormwater permit programs. As TMDL actions listed in Implementation Tables are implemented, the same DEC project database where Implementation Tables are housed will be used to track progress by the Division, on behalf of sister agencies and partner organizations.

The Division prioritizes management and remediation of pollution sources upstream of rivers, streams, lakes, ponds and wetlands prior to addressing in-water pollution. For example, it would be an unwise use of public resources to repair a failing streambank, when the cause of that failure is an upstream constriction in that stream. Addressing the constriction is a better use of resources. Full protection and restoration of surface waters can only be accomplished when upstream and upland stressors are reduced to levels which support biological, physical and chemical integrity in receiving waters. Under this policy, in-lake management approaches in most cases are utilized only when sufficient progress has been made on land immediately adjacent to the resource or deeper in the watershed. Ideally monitoring data should indicate that impacted waters are in the recovery phase. A good example of this practice was the implementation of an in-lake recovery treatment in Ticklenaked Pond, which was funded only after the watershed-level phosphorus sources were addressed.

11. Roadmap to this Surface Water Management Strategy

This strategy is comprised of four primary chapters, a standalone Monitoring and Assessment Program description, and several Appendices. Chapter One of the Surface Water Management Strategy is this document. Remaining chapters and appendices are as follows.

Chapter 2 - Managing Water Quality by Managing Stressors - Introduction

The 10 Major Stressors that result in pollution to surface waters are:

- Acidity
- Channel Erosion
- Flow Alteration
- Encroachment
- Invasive Species
- Land Erosion
- Nutrient Loading
- Pathogens
- Toxic Substances
- Thermal Stress

Chapter 3 - The Watershed Management Division Strategic Operations Plan for 2017-2019

Chapter 4 - Tactical Basin Planning: Managing Waters along a Gradient of Condition

Chapter 5 - Water Quality Monitoring Program

Appendix A: Vermont Regulations Pertaining To Surface Water management

Appendix B: Surface water pollutants that are found in Vermont surface waters

Appendix C: Landscape Activities that produce the stressors responsible for polluting our waters.

Appendix D: Programs that Protect and Restore Waters of Vermont