

# Softening The Edge – The Land/Water Interface

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## **Abstract**

Appropriately selected deep-rooted native perennial wetland and prairie plant materials can be very useful for stabilization of riverbanks and shorelines. However, successful design of these systems is dependent not only on an understanding of plant materials, but also of other factors influencing the riverbank and shoreline environments. Live planting solutions are generally the weakest on the day of installation and get progressively stronger over time, whereas more traditional methods are strongest on the day of installation and get weaker over time. In addition to protection of the land/water interface, native plantings can provide aesthetically pleasing environments, enhance fish and wildlife habitat, and provide water quality benefits.

## **Introduction**

As we approach the 21<sup>st</sup> century, there is a growing interest in providing green shorelines and riverbanks in association with waterfront development. This approach is often in stark contrast to past efforts to armor the water's edge using techniques such as a rip rap, concrete walls, steel sheet piling, gabion baskets, and other methods. The successful design of a soft or green land/water interface is different from traditional landscape design in that it requires an understanding of many of the same factors necessary to construct more structural solutions. Shorelines and riverbanks are complex dynamic environments requiring a thorough understanding of the structure and function of multiple elements, and how those elements are interconnected. Simply put, the successful green shoreline or riverbank must be "engineered" to be as soft as possible.

Shorelines and riverbanks are influenced by a wide variety of factors operating at different scales and timeframes. To adequately predict the success or limitations proposed actions will have on a particular project site, the factors influencing and controlling the system need to be understood. Self-regulating mechanisms, such as feedback loops, link together different factors that at first may appear to be independent. To understand influencing factors, each must be examined individually and quantitatively; to understand the system, factors must be considered collectively and qualitatively.

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The primary factors influencing the ultimate success of green riverbank improvements are 1) hydrology, 2) hydraulics, 3) geotechnical considerations, 4) fluvial geomorphology, and 5) vegetation (including soils). All of these factors individually and collectively affect the stream power, soil erosion, habitat, and ultimately the degree to which a softer, non-structural solution will be successful in the riverine environment.

Shorelines of ponds, lakes, reservoirs, and other water bodies are different from riverine environments in that they are not influenced by flowing water, but are often subject to wave action generated both by wind and water craft. The factors influencing shorelines include 1) hydrology, 2) wave climate, 3) geotechnical considerations, and 4) vegetation.

## **Understanding the Factors**

The six factors affecting riverbank and shoreline environments identified above – hydrology, hydraulics, geotechnical considerations, fluvial geomorphology, wave dynamics, and vegetation – are intimately connected and overlapping. An analysis of these elements can initially seem overwhelming, but in reality is not. In many instances, some of the required data already exists. Most of the analyses are not new or unique. However, the qualitative assessment of the interactions between the factors may require the input of an experienced professional.

A brief overview of each of the six factors is presented next. After the discussion of each factor individually, the connectivity and potential interaction(s) between them will be discussed.

### ***Hydrology***

Hydrology is the science dealing with the properties, distribution, and circulation of water. All aspects of the hydrological cycle may play key roles in a shoreline or riverbank environment, especially the downstream phase driven by gravity. Precipitation, including both rain and snow melt, largely control flood stage and duration, along with of man-made controls such as dams. It is imperative to understand surface water runoff and ground water movement to successfully design vegetation-based solutions to riverbank and shoreline problems. The quantity of water and its related hydroperiod largely determine what vegetation can become established and persist in a riverbank or shoreline environment. In most instances, it is not possible to alter the hydrology of a specific site because hydrologic processes usually operate at the watershed level, extending far beyond the limits of a specific project site.

### ***Hydraulics***

Hydraulics is the branch of physics dealing with the mechanics of water. In riverine environments, we are concerned with the energy of moving water, specifically the work moving water can do. Sediment transport, including both erosion and deposition, can be dramatically influenced by channel boundary and floodplain conditions. A shear stress or tractive force analysis (Chow 1959, Newbury and Gaboury, 1993) is often necessary to understand anticipated forces. Velocity is not a good measure of force against channel boundaries when considering vegetation treatments, because vegetation often increases boundary roughness resulting in decreased velocities at the land/water interface.

Published laboratory and field data for vegetation resistance to shear stress is quite variable, ranging from 0.35 to 8.50 psf (Hoitsma and Payson 1998). The variation is most likely attributable to differences in types of vegetation, completeness of vegetation cover, and underlying soil properties. Shear strength of vegetation reinforcement is quite variable as the literature indicates, and must be carefully considered in any application. As previously stated, vegetation may also increase boundary roughness. This may result in decreased shear stresses against a channel boundary, increased sedimentation, and possibly burial of plantings.

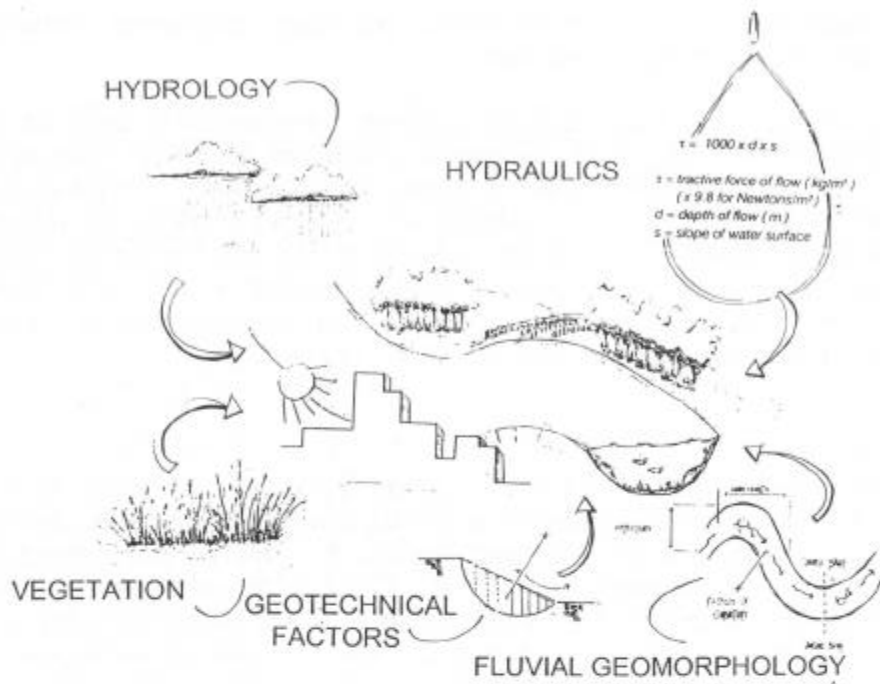


Figure 1. Primary factors influencing riverbank environments.

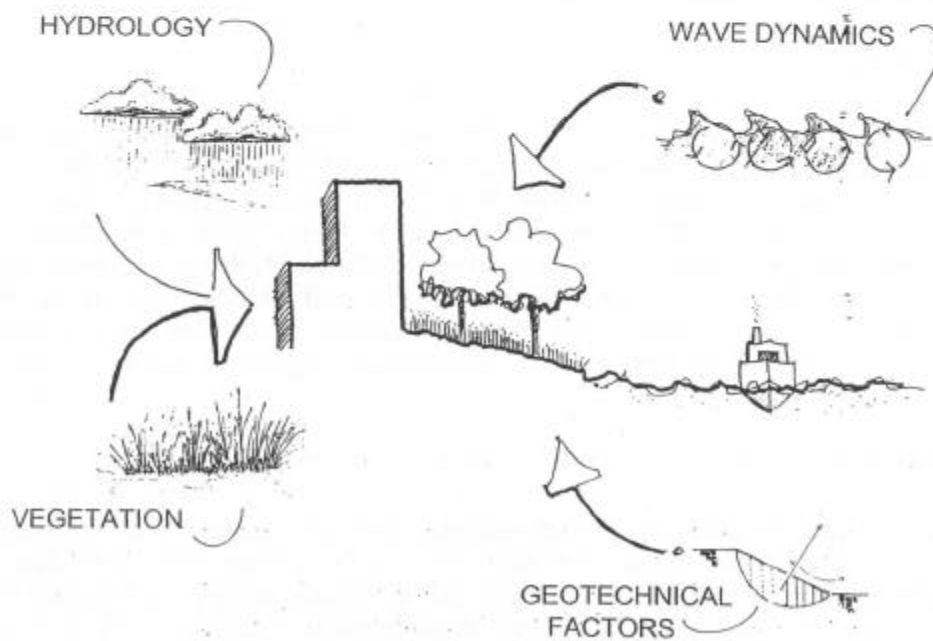


Figure 2. Primary factors influencing shoreline environments.

## ***Wave Dynamics***

Shorelines of ponds, lakes, and other impoundments are not subjected to the same forces of flowing water that riverbanks are. However, they are often affected by the forces of waves generated by wind and watercraft. Waves are described by measurements of height, wavelength, and period. The size of wind-generated waves depends on wind speed, fetch (the over-water distance across which the wind blows), water depth, and bottom conditions (in shallows). Much of the power expended in propelling watercraft is transferred into waves.

Wave action can damage shorelines through direct hydraulic action (wave energy is roughly proportional to the square of wave height). Wave run-up, the distance wave travel up a shoreline, affects the success of any planting. Wave breaks, either rip rap or organic geotextile material, may be necessary to establish vegetation in a shoreline environment subject to wave action. Once established, vegetation is able to withstand and often dissipate wave energy.

## ***Fluvial Geomorphology***

Fluvial geomorphology is the science and study of landforms created by moving water. Relationships between discharge and channel form have been established, and are referred to as hydraulic geometry (Knighton 1984, Leopold 1994). Geomorphic design criteria should be included whenever possible during grading of channels or floodplains. Sensitively- and appropriately-designed channel geometry has been shown to increase channel stability, both vertical and lateral, and reduce the probability of channel avulsion (Skidmore and Boyd 1998). Stable landforms in the riverine environment also increase the probability of successful vegetation establishment and long-term sustainability.

## ***Geotechnical Considerations***

Vegetation can be very effective in reducing erosion caused by direct hydraulic action (scour) and shallow slump failures (less than 24-36" deep). However, riverbank and shoreline slopes subject to deeper-seated slump failures may never be stable, no matter what vegetation is established. Rapid draw-down of flood waters can result in heavy, saturated soils that are structurally weakened by increased soil pore water pressures. Therefore, geotechnical evaluation of slope stability, including existing and proposed conditions, is often desirable to ensure that proposed slope configurations will be stable and able to support vegetation.

## ***Vegetation***

Proposed vegetation must be able to withstand the range of conditions at the project site. Conditions in riverbank and shoreline environments can range from saturated soil and flooding in spring to dry, parched conditions later in the growing season. The stage and duration of flooding must be understood so that appropriate native perennial wetland and prairie vegetation can become established and flourish. Often several planting zones are incorporated into plans that accommodate moisture gradients.

Any existing vegetation must be evaluated as to its contribution to riverbank or shoreline stability. Areas that often appear "green", with woody tree and shrub vegetation, have limited to no ground-plane vegetation. It is the herbaceous ground-story vegetation that provides most of the soil stabilizing benefits of native perennial wetland and prairie plantings. The deep rooted grasses, forbs, and sedges of prairies and wetlands bind soils together and provide cover to minimize soil entrainment and transport. Weedy opportunistic trees and shrubs such as buckthorn (*Rhamnus* spp.), honeysuckle

(*Lonicera* spp.), boxelder (*Acer negundo*), and silver maple (*Acer saccharinum*) may need to be trimmed, thinned, and/or removed to allow enough sunlight to reach the ground to allow desirable herbaceous ground-plane vegetation to become established and flourish.

Soils must also be evaluated with respect to their ability to support plant life. The varying hydrologic settings of riverbank and shoreline environments (repeated flooding and drying) can destroy soil structure, especially when salt (chlorides) are present in the floodwaters. The result is often a cemented soil surface extending 6-12" below grade. The soil is so hard when it dries that seeds are not able to germinate, or plant roots cannot penetrate the layer.

Flood waters can also bring with them an abundance of nutrients, thereby enriching soils. This eutrophication of the riverbank and shoreline environment results in a robust nitrogen loving weed community. Plants such as reed canary grass (*Phalaris arundinacea*), stinging nettle (*Urtica dioica*), and purple loosestrife (*Lythrum salicaria*), dominate in these conditions and often are so vigorous as to exclude other more desirable species. Entire plant communities and diverse ecosystems have been converted to low quality systems lacking biological diversity through this discrete process.

### **Connectivity**

As each factor was presented and discussed above, interactions and connectivity with other factors becomes clearer. For example, one cannot talk about hydraulics without an understanding of hydrology. Likewise, fluvial geomorphology is directly related to hydrology and hydraulics. The successful establishment of native perennial wetland and prairie vegetation is intimately linked to all other factors discussed above. Hydrology limits what plants will grow and where; hydraulics affect and are affected by vegetation; wave dynamics can impact establishment of vegetation, while established vegetation can dissipate the force of waves.

### **Conclusion**

Green shorelines and riverbanks can provide multiple benefits in proposed projects. In addition to protecting the land/water interface, plantings of native herbaceous perennial prairie and wetland vegetation can provide aesthetically pleasing environments, enhance fish and wildlife habitat, and provide water quality benefits. Live plantings are typically weakest on the day of installation and get progressively stronger with time, whereas more traditional structural shoreline and riverbank treatments are strongest on the day of installation and get weaker over time.

The successful design and implementation of a soft or green land/water interface is not as simple as knowing what plant species to select. A variety of other factors affect the ultimate success of any riverbank or shoreline improvement project. Acknowledging these factors and understanding their affect on the riverbank or shoreline environment to the greatest extent possible will greatly increase the probability of project success. Nonstructural, green shorelines and riverbanks are complex design problems, but can be attractive, sustainable, diverse environments utilizing the approach described herein.

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