Context

Historically, the Toronto waterfront was a rich mosaic of aquatic and terrestrial habitats, including bluffs and beaches, cobble reefs, estuaries and bays with productive marshes, wooded shorelines and meadows (Whillans, 1999). Clear water streams and broad rivers meandered through densely forested watersheds to Lake Ontario. Diverse communities of fish and wildlife lived in these habitats which provided opportunities for shelter, food, spawning, nesting, over-wintering and migration.

Over the past 200 years, the pressures of colonization, port expansion, industry, transportation and recreation changed this waterfront almost beyond recognition. With these changes came serious environmental degradation, to the extent that in 1987, the Toronto waterfront was included on the International Joint Commission's list of 42 Areas of Concern for the Great Lakes (WRT, 2001).

In recent decades, however, considerable work has started the process of restoring natural habitats and improving water quality, with promising results as aquatic and terrestrial communities have begun to show signs of recovery (see the 2001 progress report on implementation of the Toronto and Region Remedial Action Plan (WRT, 2001)). At the same time, there has been renewed emphasis on increasing public access to the Lake, and ensuring that new development respects and enhances the special conditions and opportunities of the waterfront.

The desire to improve the waterfront has been included in recent City of Toronto plans and policies, its new Official Plan (2002) (City of Toronto, 2002), Natural Heritage Study (2001) (City of Toronto and TRCA, 2001), and Central Waterfront Part 2 Plan (2003) (City of Toronto, 2003 a). The Toronto Waterfront Revitalization Corporation was established by the three levels of government in 2001 to oversee development of the downtown waterfront. Current projects include naturalization and flood protection for the Lower Don River, Portlands Preparation Project, Front Street Extension, Union Station Subway Platform Expansion, development of a Public Space Framework, and preparation of precinct plans (TWRC, no date). The Toronto and Region Conservation Authority's Lake Ontario Waterfront program includes a variety of shoreline management and parks projects (TRCA, no date).

This Aquatic Habitat Restoration Strategy provides practical information to assist decision-makers, designers and regulatory agencies to ensure that implementation of **all** waterfront projects incorporates opportunities to improve aquatic habitats as an integral part of creating a more liveable waterfront for people as well as fish and wildlife.

Benefits

The Lake Ontario waterfront is a special place that helps to define Toronto's character and is valued and used in many ways. In recent decades, many waterfront areas have changed from industrial and transportation uses to a mix of residential, commercial, cultural and recreation uses. A clean and healthy waterfront provides a much more attractive setting in which to live, work and play and is becoming an increasingly important element of Toronto's quality of life.

For example, many recreation activities take place on, in or near the water, and are enhanced by opportunities to view wildlife, catch fish and enjoy the beauty of natural landscapes. Waterfront locations provide a wonderful venue for physical exercise and relaxation, benefiting human health and well-being. Tourists are attracted to vibrant waterfronts, and show a growing interest in experiencing nature. Implementating this Aquatic Habitat Restoration Strategy will foster these opportunities for both residents and visitors, while generating considerable social and economic benefits for the community.

The emphasis of this Strategy on ecological integrity, habitat diversity and native species encourages the development of diverse, self-sustaining communities of fish and wildlife. In turn, these are less expensive to manage over the long term than more formal, high maintenance landscapes, where human intervention is required on a regular basis.

Goals and Objectives

The geographic scope of the Toronto Waterfront Aquatic Habitat Restoration Strategy is the Lake Ontario waterfront from Etobicoke Creek to the Rouge River, extending up estuaries of rivers and creeks (ie to the upstream extent of lake effects). The overall goal of the Strategy is "to develop and achieve consensus on an aquatic habitat restoration strategy that will maximize the potential ecological integrity of the Toronto waterfront".

To achieve this goal, the Strategy has **four** primary objectives:

1. identify the potential for self-sustaining aquatic communities in open coast, sheltered embayments, coastal wetlands and estuaries;

2. identify limiting factors, evaluate opportunities and propose actions to protect and enhance nearshore habitats and restore ecological integrity;

3. develop sustainability indices to evaluate the success of the strategy, taking into account changes in land use and policy context; and

4. develop an implementation plan to restore aquatic habitats on the Toronto waterfront, including targets, actions, roles and responsibilities, public education, regular reporting and plan review.

Guiding Principles

The Strategy strives to create a more sustainable waterfront as part of the Living City. The Living City is the Toronto and Region Conservation Authority's vision for the protection and restoration of ecological health in the Toronto region. It is based on the recognition that in order to ensure a healthy environment for ourselves, future generations and the life around us, we must stop acting as if our actions have no consequences on the environment, instead, and develop new ways to live, work and play. The Living City vision encourages human communities to flourish as part of nature's beauty and diversity in shared habitats, where we learn from nature and mimic natural processes to achieve greater environmental health, social well-being and economic vitality.

Within this context of sustainability, the Strategy uses an ecosystem approach to increase ecological integrity, to provide suitable conditions for the maintenance of self-sustaining communities and to improve ecological connectivity. The Strategy emphasizes the use of conservation design based on native and naturalized species. The Strategy takes into account human uses of the shoreline and nearshore waters and was developed using a consultative, consensus-based approach involving stakeholders and the general public.

- **The ecosystem approach** is based on the understanding that "everything is connected to everything else" and focuses on relationships among air, land, water and living organisms, including humans and their activities. It takes a comprehensive view of the combined effects of all activities in an area over time, and seeks to achieve overall, long-term benefits while avoiding negative cumulative impacts.

- **Ecological integrity** is the ability of an ecosystem to maintain its organization and functions. Some factors that contribute to integrity are resilience to change, productivity, vigour, and species diversity.

- **Self-sustaining communities** are able to reproduce naturally, with minimal human intervention, to maintain healthy populations of plants and animals, including species at risk.

- **Native and naturalized species** are those species that are indigenous to the Toronto waterfront (eg lake trout) as well as those that have been introduced but have become an integral part of the ecosystem (eg Pacific salmon). Most non-native species (eg carp, goby) take advantage of degraded ecosystems, and their numbers and productivity should decline when ecosystem health improves.

- **Ecological connectivity** recognizes the physical and biological relationships among nearshore, watershed and lakewide ecosystems. Examples include shoreline processes, wetland functions, migration and over-wintering patterns, and spawning and feeding requirements.

- **Conservation design** is planning and designing for a variety of wildlife habitats and incorporates principles of natural succession to restore or create functional habitat.

- **Human use** is an integral part of the waterfront. Water and land-based human activities will be incorporated in the Habitat Restoration Strategy. Habitat improvements will be integrated into waterfront redevelopment initiatives wherever possible.

- **A consultative approach** is essential to ensure that the many interests of individuals, groups and agencies are met in seeking to improve aquatic habitats. Although there may be competing or conflicting objectives and approaches, this Strategy strives to achieve consensus and a clear direction for future actions.

The Strategy is intended to improve waterfront aquatic habitats for all species of native and naturalized species — fish, mammals, reptiles, amphibians, molluscs, invertebrates and plants. However it focuses on fish because they are excellent indicators of the overall health of the ecosystem. In addition, aquatic habitats that meet the varied requirements of diverse species of fish at different stages of their lifecycle also meet the needs of many other species.

Conclusions

Based on a thorough analysis of the physical processes, cultural influences and aquatic communities on the Toronto Waterfront, the Strategy concludes that most of the aquatic ecosystems suffer from poor ecological health, with a few locations, such as the Rouge River estuary and parts of Toronto Bay, exhibiting somewhat better conditions. Traditionally, urban planning, waterfront redevelopment, park development, stormwater management and shoreline management activities have not paid sufficient attention to the needs of aquatic communities. However, it is essential to recognize that aquatic ecosystems are integral to the environmental health of the waterfront, and must be given full consideration in planning, design and development processes.

This strategy provides a strong foundation including the biophysical attributes of the shoreline, an illustrated compendium of habitat restoration techniques and a habitat plan on a shoreline reach and site specific basis. It builds on and implements a number of key plans and policies, including the City of Toronto Official Plan, Central Waterfront Part 2 Plan and Natural Heritage Study; the Federal Policy for the Management of Fish Habitat; Lake Ontario Fish Community Objectives; and the Toronto Waterfront Revitalization Corporation's Development Plan and Public Space Framework

Recommendations

The Strategy is a blueprint for positive change, providing guiding principles and practical tools for implementing habitat projects across the Toronto Waterfront. The following recommendations for waterfront agencies and other landowners are intended to ensure that aquatic habitats are created and restored. The recommendations focus on endorsement of the Strategy, improving ecological health, and mechanisms for implementation.

(1) ENDORSEMENT

Waterfront revitalization provides opportunities for many agencies and private landowners to incorporate aquatic habitat restoration from the outset of a wide variety of projects, ranging from new building developments and environmental infrastructure to new or renovated parks and shoreline management. The Advisory Panel recommends that:

- Agencies with responsibilities for the waterfront (eg. Toronto and Region Conservation Authority, Toronto Waterfront Revitalization Corporation, City of Toronto, Toronto Port Authority, Fisheries and Oceans Canada, Ontario Ministry of Natural Resources) should formally endorse this Strategy as the guiding document for the creation and restoration of waterfront aquatic habitats.

- Endorsement recognizes the need to achieve significant increases in aquatic habitats and to restore self-sustaining aquatic communities. Agencies should use this Strategy as a planning tool to ensure that all future waterfront projects incorporate aquatic habitat improvements.

(2) MANAGEMENT TO IMPROVE THE ECOLOGICAL HEALTH OF OUR SHORELINE

In order to restore healthy, self-sustaining aquatic communities, it is necessary to create physical, chemical and biological conditions required for a balanced community of native and naturalized species. Most non-native species (eg. carp, goby) take advantage of degraded ecosystems, but their numbers and productivity will be reduced when ecosystem health improves. To achieve conditions required for centres of biological organization that will support self-sustaining aquatic communities, the Advisory Panel recommends that:

- Water and sediment quality should be improved as quickly as possible by implementing the City of Toronto's Wet Weather Flow Management Master Plan.

- Top predators (eg walleye, muskellunge) should be re-introduced where appropriate and carp should be excluded from key habitats that are favourable for their reproduction (eg coastal wetlands).

- Structural diversity should be increased across the waterfront, by implementing the habitat plan on a reach by reach basis. In most cases, there is sufficient scientific knowledge to proceed with implementation. In cases where there is less certainty, experimental management approaches should be applied, providing an opportunity to monitor, learn and adjust methods where necessary.

- Emphasis should be placed on opportunities associated with:
    - existing centres of biological organization where a relatively modest investment will create significant benefits,
    - places where development that is largely focussed on land, such as new waterfront parks and urban redevelopment, can easily incorporate major improvements to aquatic habitats, and
    - shoreline management projects such as erosion control and harbour maintenance.

(3) IMPLEMENTATION

The success of the Toronto Waterfront Aquatic Habitat Restoration Strategy will be measured by the extent of project implementation, reporting of improvements in aquatic habitats, the utilization of the Strategy by waterfront agencies and private landowners, and the acceptance of projects by the public. To ensure success, the Advisory Panel recommends that:

- The TRCA establish an inter-agency coordinating mechanism to:
    - ensure that aquatic habitat opportunities associated with existing centres of biological organization, park development and amenities, waterfront revitalization, shoreline management, lakefilling and erosion control projects are incorporated into ecological pre-planning, design, and implementation of projects.
    - ensure a high standard of scientific rigour, use of the best tools, techniques and appropriate design of experimental habitat management projects.
    - identify potential cumulative effects of projects, oversee monitoring programs, and develop sustainability indices to determine trends over time.
    - report regularly on the Strategy implementation, including progress reports on specific projects, aquatic community trends, and other measures, the first progress report to be provided by December 2004.

- A similar strategy should be developed for the TRCA's jurisdiction within the Durham waterfront.

Products

The Toronto Waterfront Aquatic Habitat Restoration Strategy includes a number of related products:

1. Synopsis of existing physical processes, cultural influences and aquatic communities.

2. Compendium of habitat restoration techniques.

3. Habitat plan that matches habitat restoration techniques with appropriate physical and biological conditions across the waterfront.

Process

The development of the Toronto Waterfront Aquatic Habitat Restoration Strategy was guided by an Advisory Panel and an Agency Stakeholder Committee (see Appendix A for membership). On May 15, a habitat restoration workshop brought together a diverse group of agency and community stakeholders for a preliminary discussion of approaches to restoring specific habitats. On June 10, a public forum was held to provide an opportunity for public review and input into the draft strategy.

For more information, you can read a summary of the May 15 Workshop and the June 10 Public Forum in the consultation section.

Related Iniatives

The Toronto Waterfront Aquatic Habitat Restoration Strategy builds on key strategic directions and plans for Lake Ontario and the Toronto Waterfront, especially the following:

Fish community objectives for Lake Ontario prepared by New York State and the Province of Ontario recognize the importance of nearshore fish communities and the aquatic environment upon which they depend (Stewart, et al, 1999). The objectives state that the nearshore fish community "will be composed of a diversity of self-sustaining native fishes" including walleye, yellow perch, smallmouth and largemouth bass, sunfish, and eels. The objectives encourage the expansion of the populations of these species into favourable habitats. It is also implicit that repairing nearshore environments would provide needed habitat for young forms of off-shore and deep water species, thus contributing to the objective for pelagic fish communities like lake trout, whitefish and their prey species of both fish and invertebrates. In this regard, the Toronto Waterfront Aquatic Habitat Restoration Strategy meets the requirement of sustaining existing populations of these species, and proposing places and methods to create more "favourable" habitats to assist in the expansion of ranges closer to former boundaries that existed before the mid-1800s.

Operation Doorstep Angling (Macnab and Hester, 1976), examined the fishery resource of the watersheds and waterfront within the jurisdiction of the Metro Toronto and Region Conservation Authority with a view towards improving and promoting angling.

In 1993, Ontario Ministry of Natural Resources published a more detailed document for Metro Toronto Waterfront Aquatic Habitat Rehabilitation (Struss, et al, 1993) under the auspices of the Metro Toronto Remedial Action Plan. The document identifies habitat goals, objectives and targets focusing on protection, enhancement and restoration. It also provides rehabilitation strategies, assessment criteria, monitoring activities, rehabilitation measures and site-specific recommendations for action. The Plan provided the basis for the habitat classification of open coast and sheltered areas. Many recommendations of the Plan have been implemented and are also reflected in the summary of shoreline regeneration projects in this Strategy in the section on Cultural Influences.

The Policy for the Management of Fish Habitat administered by Fisheries and Oceans Canada provides important direction for the Strategy (Fisheries and Oceans, Canada, 1986). The overall policy objective of the Policy is to achieve net gain of habitat for Canada's fisheries resources with specific goals for conservation, restoration and development of fish habitat.

In addition, the Toronto Waterfront Aquatic Habitat Restoration Strategy is being undertaken in parallel with a number of current, complementary initiatives and will be coordinated with them.

For example, the Toronto and Region Conservation Authority is developing a comprehensive Natural Heritage Program throughout its jurisdiction (City of Toronto and TRCA, 2001). This program has identified restoration areas and significant habitats in the bioregion. Within this framework, two integrated strategies are being developed for aquatic and terrestrial habitats on the Toronto Waterfront.

The Toronto Bay Initiative is a community group dedicated to promoting a clean, green, connected and accessible Toronto Bay. In 1998 the group published *A Living Place: opportunities for habitat regeneration in Toronto Bay* (Kidd, 1998) and has been working with the City of Toronto and TRCA to implement a number of habitat projects, including the Spadina Quay Wetland, the Peter Street Slip, and the Toronto Island Sand Dune Restoration project.

The City of Toronto recently developed a *Wet Weather Flow Management Master Plan* to improve water and sediment quality throughout the watersheds and waterfront (City of Toronto, 2003 b). Implementation of this plan will be an important contribution to the

Remedial Action Plan process to clean up the Toronto and Region Area of Concern. The result will be improved environmental conditions necessary for healthy aquatic habitats.

As noted above, the Toronto Waterfront Revitalization Corporation is responsible for implementation of waterfront improvements in the Central waterfront, as well as selected projects at Port Union (Scarborough) and Mimico (Etobicoke) (TWRC, no date). The City of Toronto is implementing a new parks plan for the Harbourfront area. All these projects provide opportunities to contribute to aquatic habitat restoration.

Physical Processes and Cultural Influences

Aquatic Habitats are Products of…

Aquatic habitats along the Toronto waterfront are the product of various combinations of physical conditions and processes. In essence, there are three major influences on the location, function, and attributes of shoreline habitats:

1. Nearshore Geology
2. Meteorological Conditions; and
3. Cultural Influences

Nearshore Geology – Post-glacial Shorelines

The modern shoreline of Lake Ontario is situated between two post-glacial abandoned shorelines. The landward abandoned shoreline originally marked the edge of the higher post-glacial Lake Iroquois, resulting in a stranded shoreline bluff and abundant beach material along the present day tablelands. The Lake Iroquois shoreline influences the morphology of modern streams and focusses the mid-reach recharge of ground water sources. However it has a minor effect on current aquatic habitats.

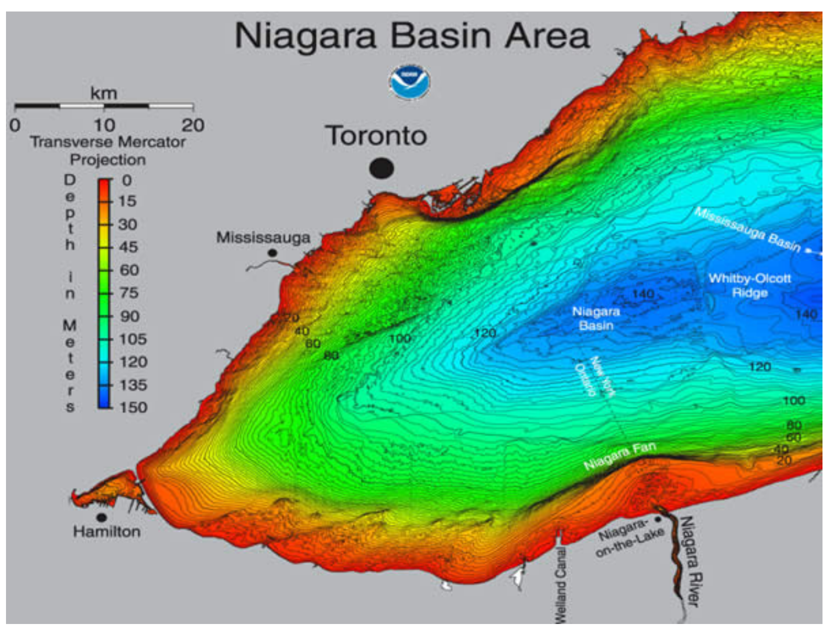
An off-shore abandoned shoreline created by the lower post-glacial Admiralty Lake has a much greater effect on today's shoreline. The former Admiralty Lake shoreline has left a variety of submerged features including a prominent off-shore bluff known as the Toronto Scarp that runs parallel to the Toronto Islands and Scarborough shoreline. Admiralty Lake was also the source of relict sand and gravel deposits still found in deep off-shore waters. The most significant surficial geological features that affect and determine current shoreline conditions are found between the abandoned Admiralty Lake shore and the modern shoreline. Most current and historic habitats were created in this inundated area. For example, historically, the dynamic movement of littoral material established the peninsula and lagoons of Toronto Bay. The bulk of this material was supplied from shoreline erosion of significant deposits of sands found in the Scarborough Bluffs and re-worked beach deposits made available during rising water levels. In addition, the Toronto Scarp at the shoreline of the former Admiralty Lake is an important area of congregation for salmonid fish.

Nearshore Geology – Western Lake Ontario Bathymetry

The bathymetry of western Lake Ontario displays a number of features that affect aquatic habitats. Lake Ontario is a deep, cold, oligotrophic (nutrient-poor) lake with relatively steep shorelines, particularly on the northern shore. Shale bedrock is apparent along the shorelines of Niagara Region, Halton Region, Mississauga and Etobicoke. A major depositional zone exists at the Hamilton lakehead. There is an underwater bluff, similar to the Scarborough Bluffs, off the Niagara Region shoreline.

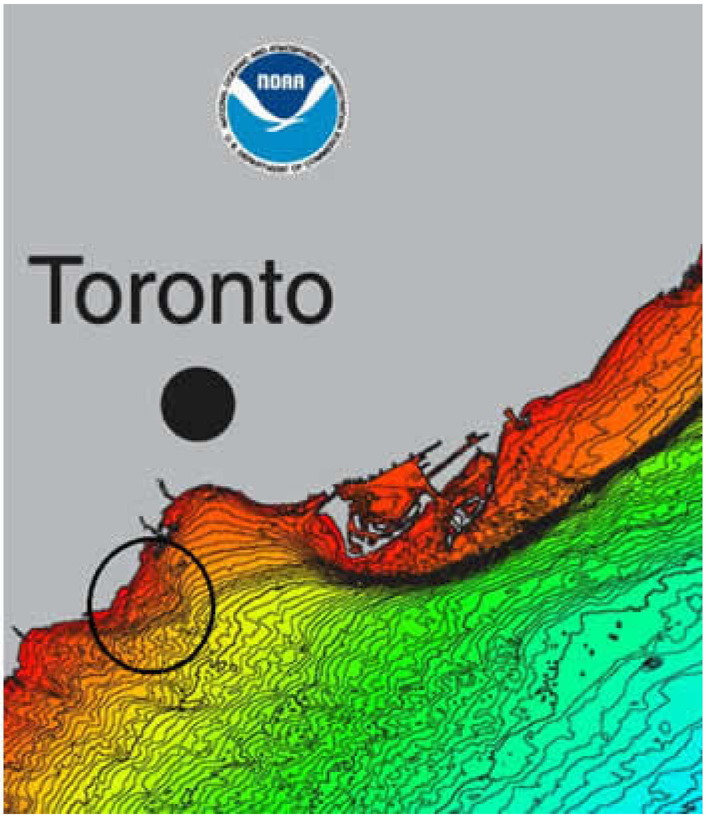
The geological complex of the Toronto shoreline has five zones:

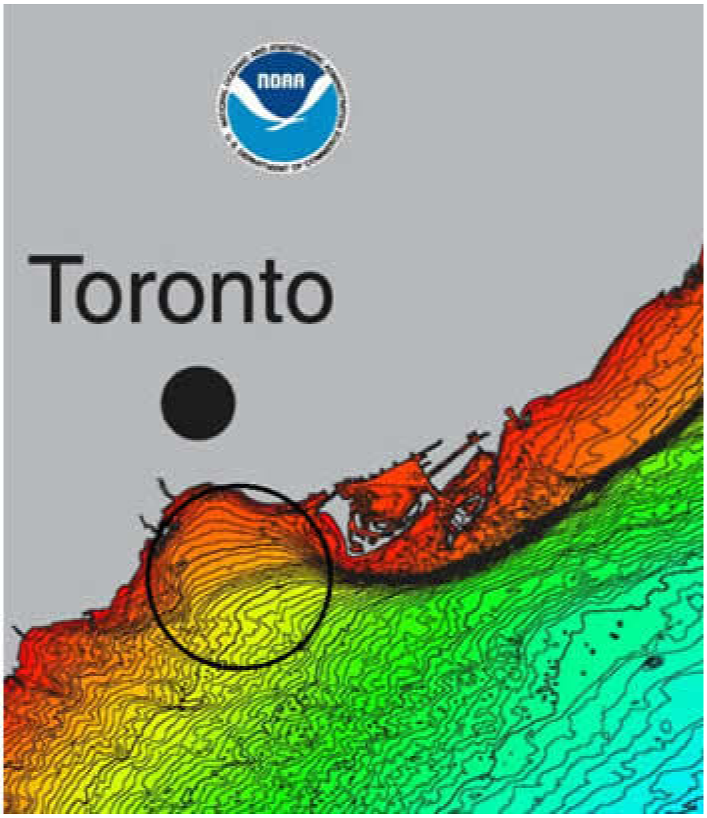
1. Etobicoke Shale Outcrop
2. Humber Bay Depositional Area
3. Toronto Scarp
4. Scarborough Sand Plains
5. Scarborough Boulder laden Till



1. Etobicoke Shale Outcrop

Along the western sector a thin till layer that originally covered the bedrock has been scoured by glacial action leaving a prominent area of bedrock substrate that extends from the mouth of Mimico Creek westward to Burlington. This bedrock forms a convex shoreline profile consisting predominantly of broken shale boulders on top of bedrock extending into deep water



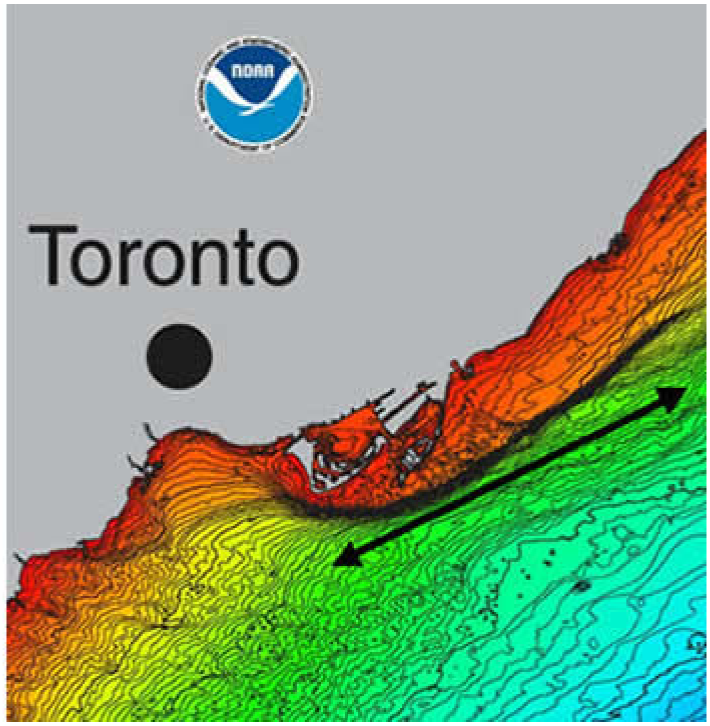


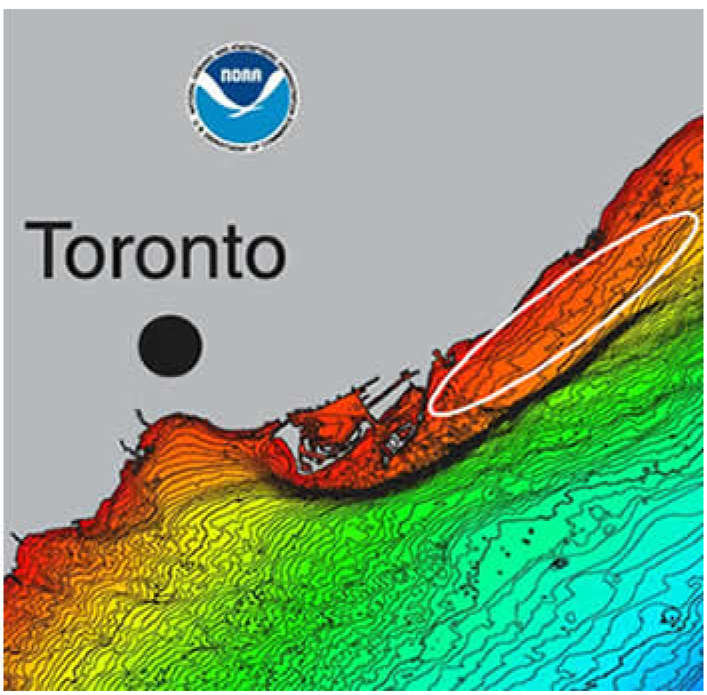
2. Humber Bay Depositional Area

From Humber Bay east to Ontario Place the substrates are dominated by fine material. Humber Bay and Toronto Bay are depositional areas containing recent silt deposits that predominantly come from the suspended sediment loads associated with the Humber and Don Rivers. The depositional area of Humber Bay is thought to be formed as a result of significant fluting in the underlying bedrock which produces the deep basin-like depression of the Bay.

3. Toronto Scarp

The Toronto Scarp represents the former shoreline of Admiralty Lake about 5km from the existing Lake Ontario shoreline. It is a prominent underwater bluff comprised of extensive sand deposits. The water depth increases abruptly at the edge of the shelf from about 20m to approximately 60m.

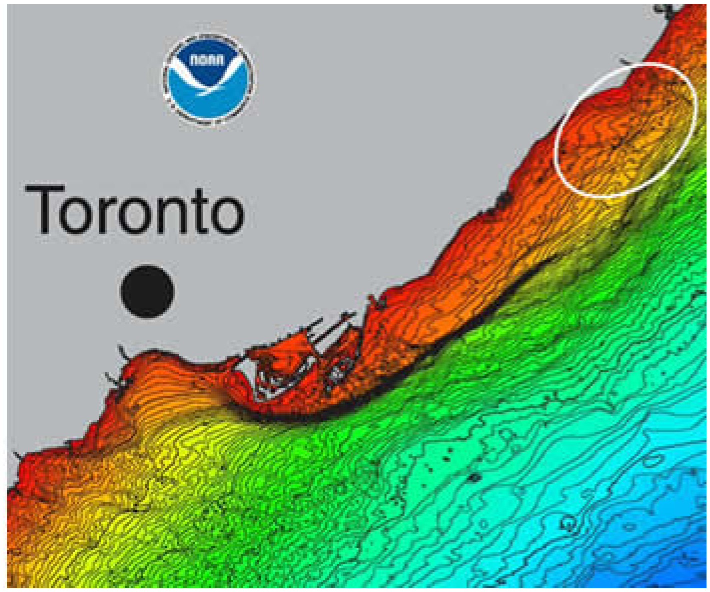




4. Scarborough Sand Plains

An extensive underwater sand plain occurs from the south shore of the Islands to the Toronto scarp and eastward to Bluffers Park. This very thick deposit of sand is most likely a glacial relict of flooded beaches and eroded material that originated from an interglacial river deposit of deltaic sands derived from the cathedral section of the Scarborough Bluffs. Within these sand substrates there are small pockets of gravels and cobbles, especially in the nearshore areas just west of Bluffers Park. This section of sand-dominated substrates displays a prominent concave shoreline profile.

5. Scarborough Boulder-laden Till



From the east side of Bluffers Park to the East Point area there is a transition zone from sand to cobble, gravels and boulders. This coarser material originated from the high boulder content of adjacent tills that were eroded from the shore and re-worked as a boulder pavement. The headland created at East Point is a direct result of the high boulder and cobble content of the till, creating an area resistant to erosion. The boulder pavement provides an excellent example of unconsolidated material forming a convex shoreline profile. The extensive quantity of nearshore gravels provides a degree of shoreline protection by attenuating waves and providing a dynamic equilibrium between erosion and accretion.

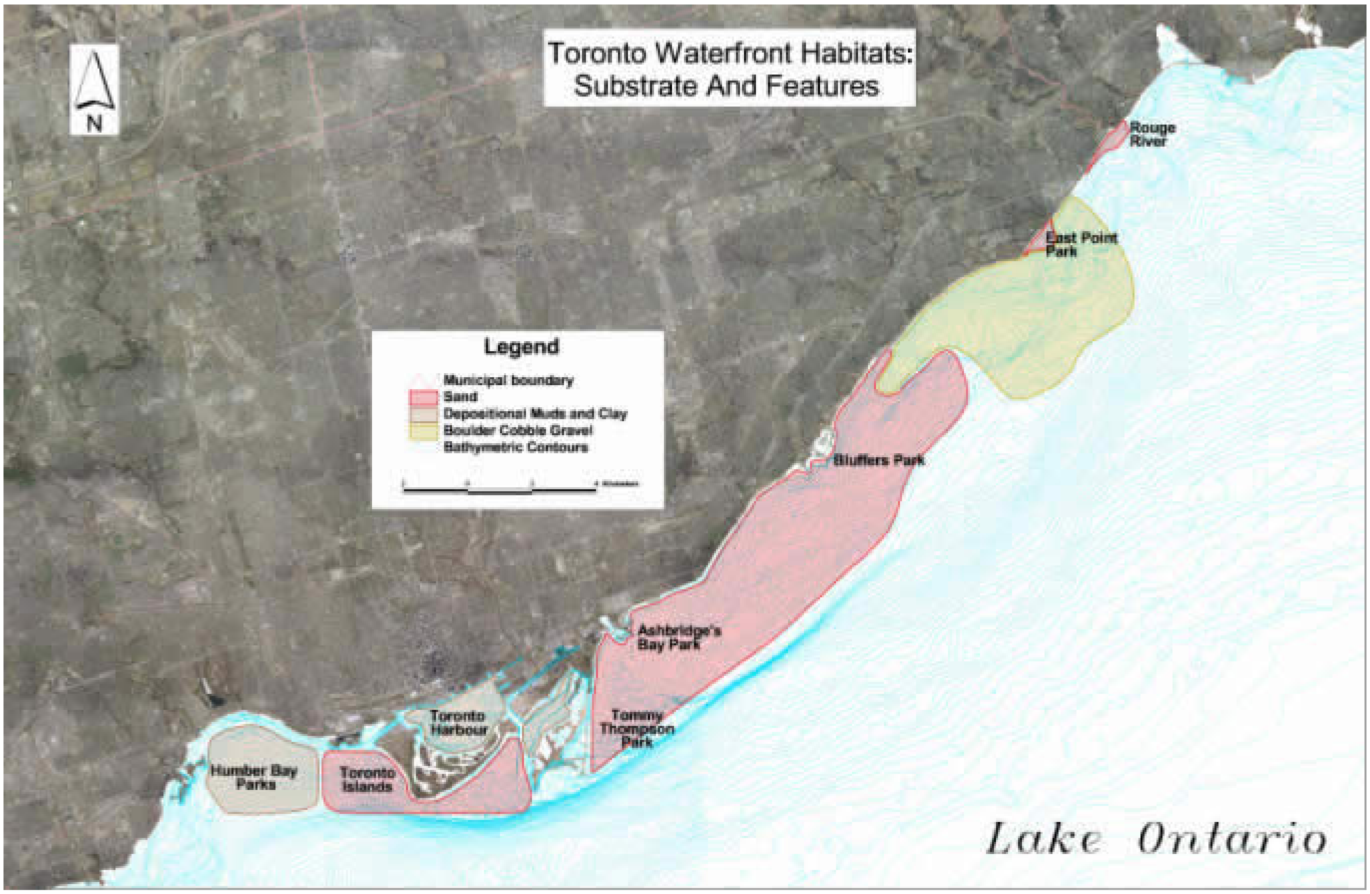
Nearshore Geology – Wave Zone Areas

Along the wave zone area bedload sediments from the major rivers have surcharged the shoreline with sand and helped to establish the barrier beaches associated with local coastal wetlands at the mouths of the Rouge and Highland Rivers.

The boulder-laden till also loaded the wave zone areas with a vast quantity of aggregates. Approximately 1 million cubic metres of stone were historically removed by stone-hooking for use in construction activities.

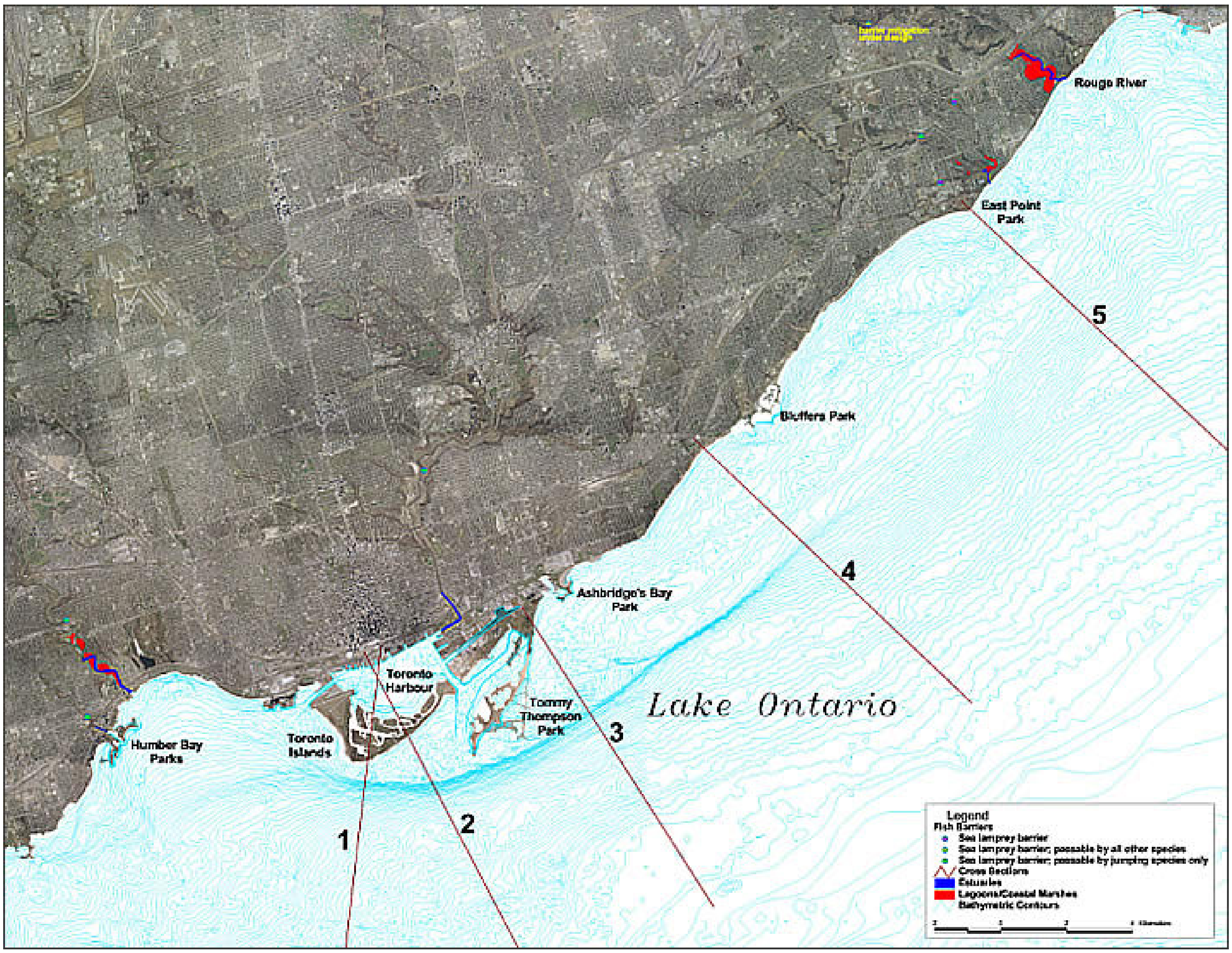
Nearshore Geology – Toronto Waterfront Habitats: Substrates and Features

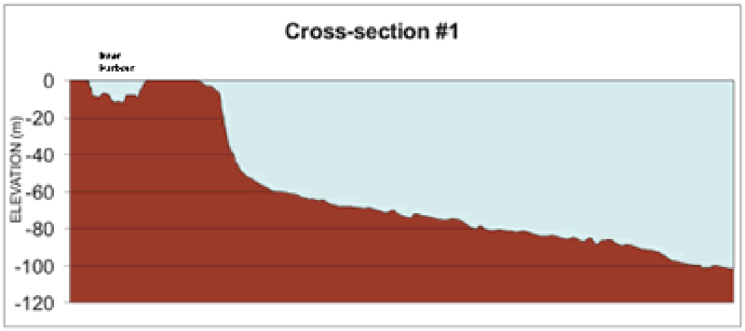
In summary, shown below are the major substrates along the Toronto waterfront: shale bedrock, sand, muds and clay, and boulder, cobble and gravel.



Nearshore Geology – Shoreline Profiles

The shoreline profiles vary considerably along the waterfront, as shown in the cross sections 1 through 5, below. For example, in the vicinity of the Toronto islands (section 1 and section 2) the Toronto Scarp appears as a precipitous drop that varies from 15 - 60 metres to the deep lake, with the relatively shallow waters of Toronto Bay being sheltered by the islands. In section 3, there is a gradual slope into the Lake from the base of the Leslie Street Spit, followed by a deep bluff formed by the Toronto Scarp. In section 4, the effects of the Toronto Scarp have almost disappeared, and in section 5 there is the gradually sloping convex shoreline of the Scarborough boulder till.




Cross-section #1
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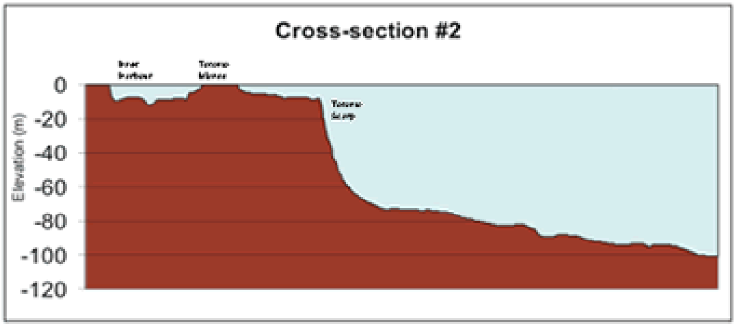
-100
-120
ELEVATION (m)


Cross-section #2
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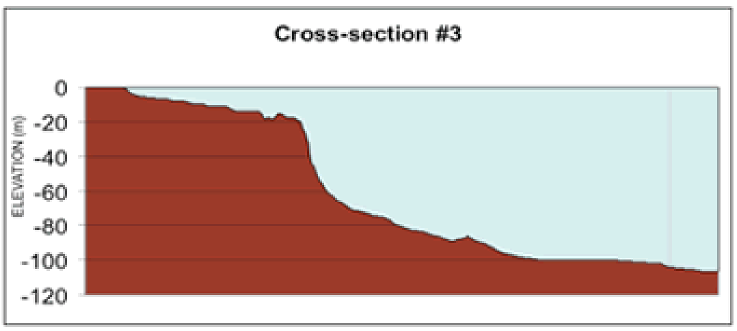
Elevation (m)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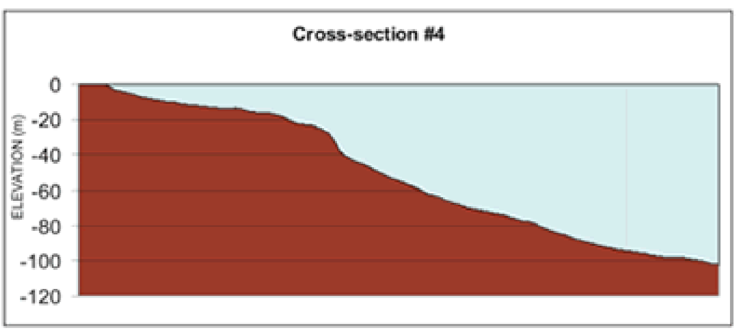
ELEVATION (m)


Cross-section #4
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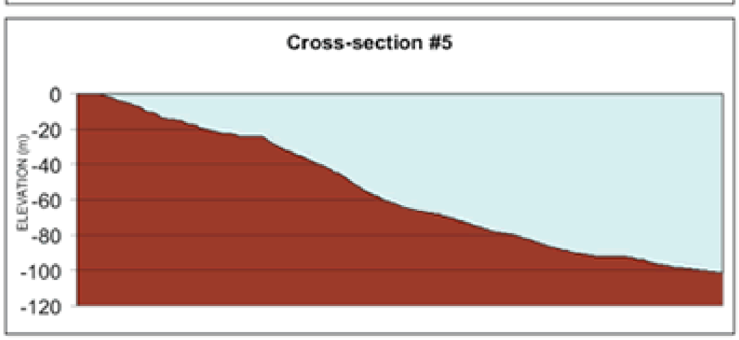
ELEVATION (m)


Cross-section #5
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-100
-120
ELEVATION (m)

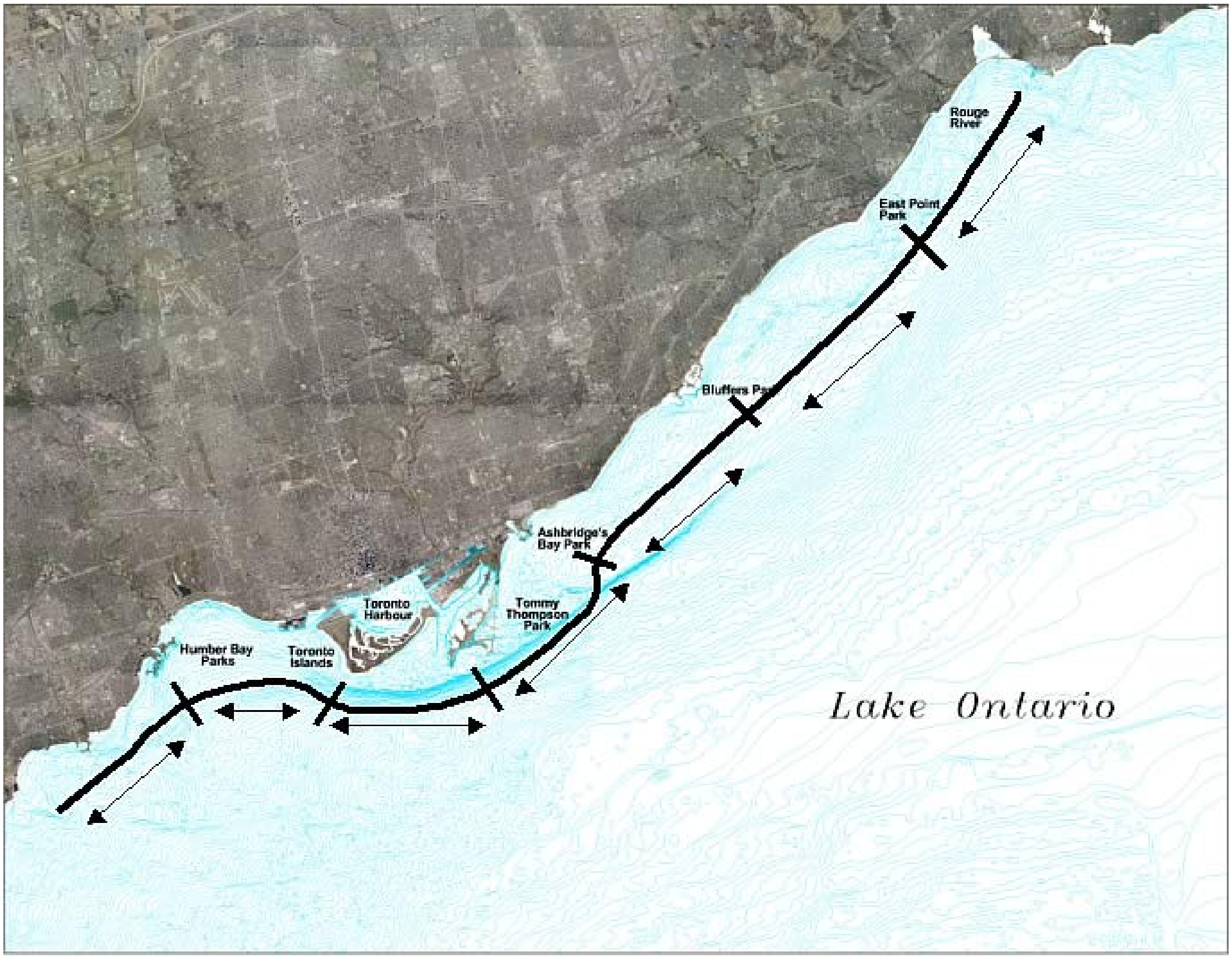
Meteorological Conditions – Winds and Waves

Meteorological conditions — wind, nearshore wave climate, regional climatic conditions, solar heating, and thermal characteristics — have considerable influence on shoreline conditions and aquatic habitats.

Winds and Waves
Winds, in combination with length-of-fetch, determine wave conditions across the Toronto waterfront. A high percentage of lake currents and most nearshore waves are induced by wind conditions. Winds are responsible for the lake-wide circulation patterns that create the west-to-east ambient currents throughout the Toronto Waterfront. Although prevailing winds are generally from the west, the much longer eastern fetches produce more wave energy. In the eastern sector of the Toronto Waterfront, the predominant eastern wave energy is partially balanced by wave energy from the southwest. In contrast, in the western sector, the southwest waves provide less energy because of the much shorter fetches to the southwest.

Meteorological Conditions – Littoral Transport

The energy in breaking waves is the driving force that moves sediment and other materials along the shore. This littoral transport is the main mechanism that established the Toronto Islands. Littoral transport also sorted and piled a variety of aggregates in the wave zone and moved historic and recent deltaic sediments to create beaches. Sediment eroded from the north shore of Lake Ontario was transported into the Toronto Islands because the net wave energy is directed westward. Changes in net wave energy directions, which can be caused by shoreline features, define the boundaries of littoral cells.

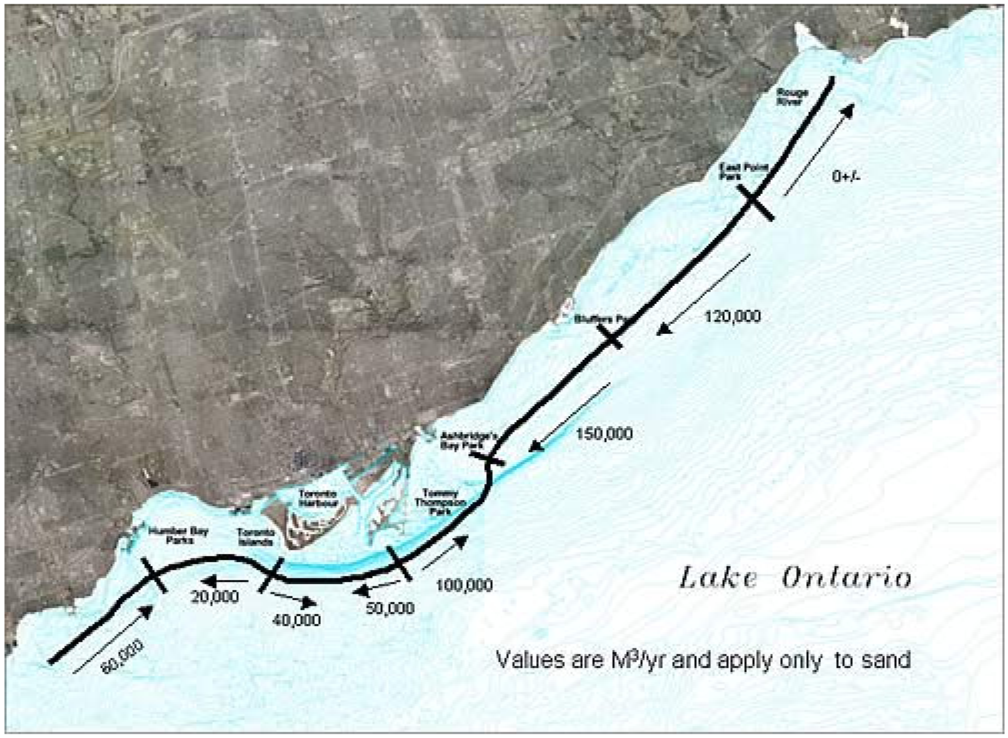


Littoral cells are sections of the shoreline defined so that no input or outflow of sediments take place across their boundaries — see image above. They are important shoreline features because actions taken on the shoreline can have consequences anywhere within their littoral cell but seldom affect the shoreline in other cells.

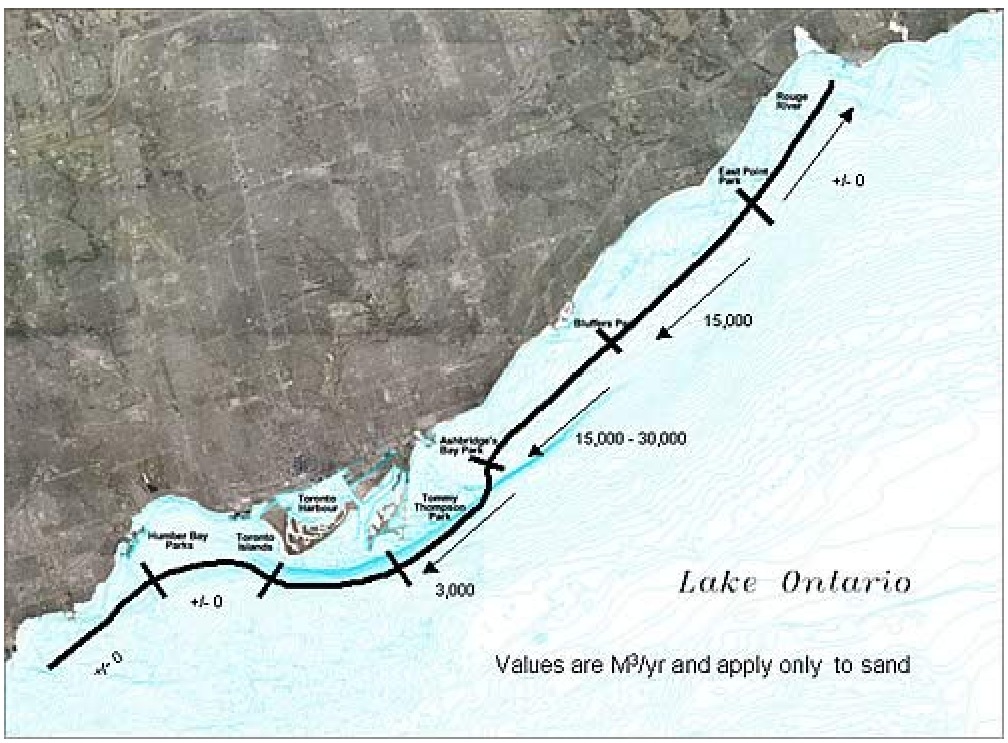
Along the Toronto waterfront the potential for material to be moved along the shoreline is limited by sediment supply (see Potential and Actual Sediment Transport maps).

The volume of littoral drift produced through erosion of the shoreline is less than could actually be carried by the available wave energy. For example, between Bluffers Park and East Point the available wave energy could transport 120,000 cubic metres of sand per year but now only 15,000 cubic metres per year, on average, is produced through erosion.
Historically, about 45,000 cubic metres were produced annually, before significant artificial armouring of the shoreline began in the 1970s. In contrast, stonehooking between 1850 and 1910 increased sand supply through higher shoreline erosion by removing the stones that naturally armoured the lakebed.

Potential Sediment Transport Map



Actual Sediment Transport Map

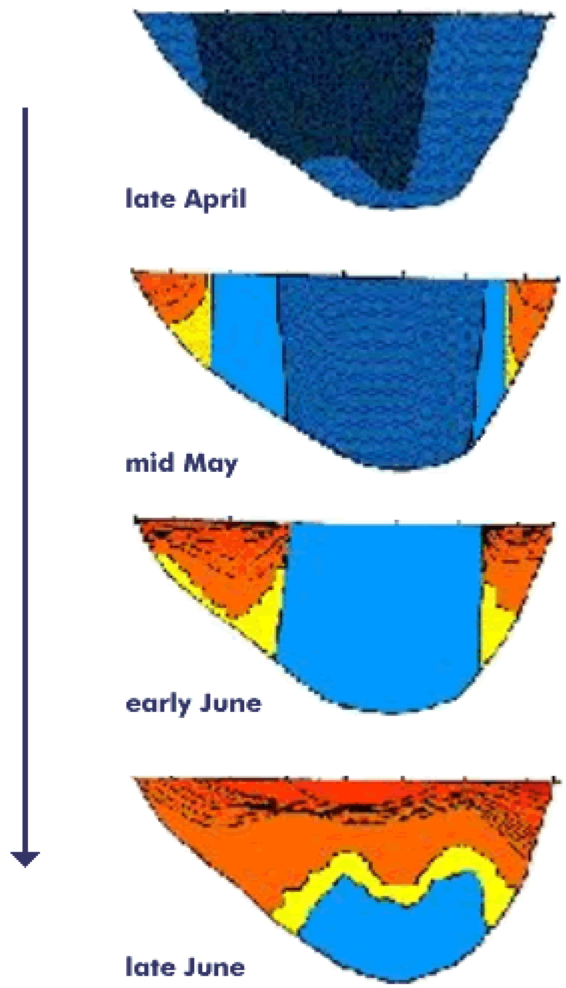


Meteorological Conditions – Thermal Conditions

Daily and seasonal weather conditions, especially solar heating, play a critical role in the ecology of Lake Ontario. The lake waters stratify according to temperature in the summer and winter. The amount and intensity of solar heating defines the scope and extent of this thermal stratification and the subsequent aquatic habitat conditions. Two additional temperature-induced conditions that dramatically affect nearshore habitats are the formation of a thermal bar and hypolimnetic upwellings.

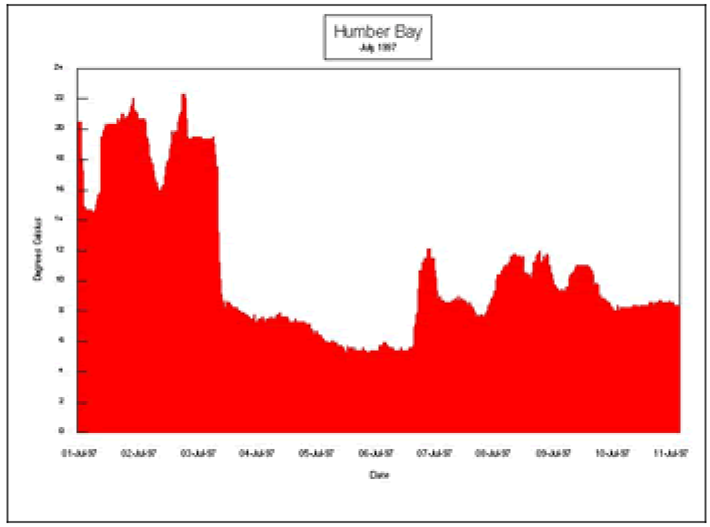
Early in the spring the nearshore waters of the lake warm and form a band of warm water held in place by a thermal bar consisting of colder, denser off-shore water (water is at its maximum density at 4 degrees Celsius; represented by the light blue band on the mid-May diagram).

Thermal Bar Spring Progression
Ontario Mid-lake Temperature Sections
(from the Rochester Institute of Technology)



The warmer water (shown in yellow and red) builds in depth and concentrates warm water discharges from rivers, creeks and storm drains within the nearshore area. Thermal bars typically last until mid June, and surcharge the nearshore area with warm, nutrient-rich water. The early season influx of nutrients has a profound effect on aquatic life by promoting primary production and accelerating the establishment of warm, eutrophic conditions along the shoreline of the oligotrophic Lake Ontario. The thermal bar dissipates into full stratification in the early summer and under the appropriate wind conditions is vulnerable to hypolimnetic upwellings of deep cold lake water.

Meteorological Conditions – Hypolimnetic Upwelling



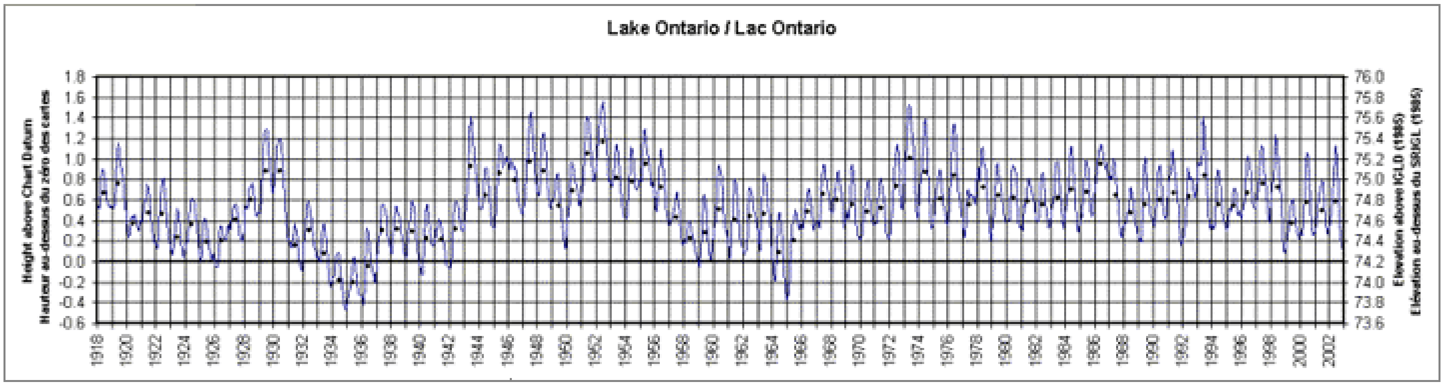
Prevailing north-west winds and the location of the Toronto waterfront on the north-west coast of Lake Ontario make this area vulnerable to the displacement of relatively warm surface water by cold hypolimnetic upwellings. Dramatic temperature changes occur quickly during an upwelling event and can be lethal to fish. Upwellings have the opposite effect of the thermal bar in that they can reduce productivity, limit the growth and survival of aquatic organisms, and disperse offshore the warmer water associated with river discharges and point sources. Alewife, a non-native species in Lake Ontario, has not adapted to hypolimnetic upwellings and is prone to massive die-off each spring because of the dramatic change in water temperatures.

Meteorological Conditions – Water Levels

As the last in the chain of Great Lakes, the amount of water flowing into Lake Ontario, and hence the water levels, are greatly influenced by precipitation and evaporation throughout the Great Lakes Basin. Water level fluctuations, both seasonally and from year to year, are a normal occurrence in the Great Lakes. Over the decades, historical records show that Great Lakes water levels tend to follow an irregular cyclical pattern, as shown below. The pattern of annual fluctuations has been dampened since lake-wide regulation of water levels was introduced in the Great Lakes in 1958.

Fluctuating water levels play an important role in the development and maintenance of diverse shoreline ecosystems. They affect currents, wave action, turbidity, pH, temperature and nutrients. Wetland plants and animals are generally adapted to these changes and in many cases depend on them for certain functions (such as germination of seeds from sediments exposed by low water levels).

The Great Lakes system experienced extremely high water levels in the 1870s, early 1950s, early 1970s, mid-1980s and mid-1990s. Extremely low water levels were experienced in the late 1920s, mid-1930s, mid-1960s, and in the late 1990s. The recent decline in water levels is due mostly to evaporation during the warmer-than-usual temperatures of the past three years, a series of mild winters, and below-average snowpack in the Lake Superior basin. Net water supplies to Lake Ontario in 2003 will likely be significantly lower than the long-term average.

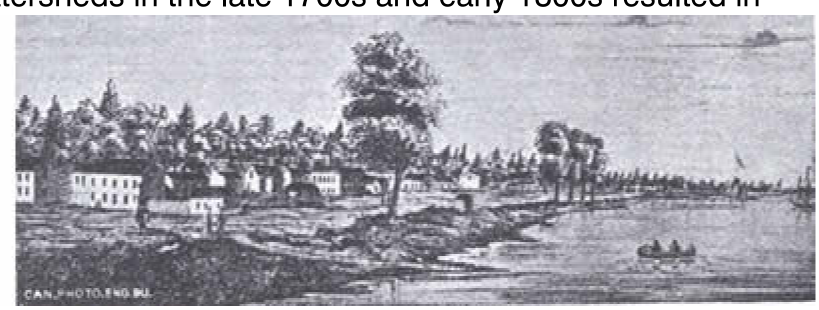


Cultural Influences

Prior to settlement of the Toronto area, the shoreline was very different from the one we know today. Rivers and creeks supplied clear, cool water and provided habitats for river-spawning fish such as salmon. Nutrient-rich estuaries supported wetlands teeming with wildlife. Sandy spits provided protection from winds and wave action. Sheltered stretches of shoreline were lined with lush stands of emergent vegetation. Much of the nearshore was covered with sand, gravel and stone (Whillans, 1999).

Cultural Influences – Forest Clearing

Colonization of the Toronto watersheds in the late 1700s and early 1800s resulted in profound changes to physical conditions in the rivers and creeks, which in turn affected waterfront habitats, fish and wildlife (EMCWTF, 2002). These changes began with extensive clearing of the dense forest cover that originally blanketed the uplands. As the forest trees and understory plants were removed, and land contours altered by grading, water and sediment runoff to the creeks and rivers increased, resulting in increased flooding and bank erosion downstream. Estuaries and rivermouth wetlands were choked by excessive inputs of sediments.

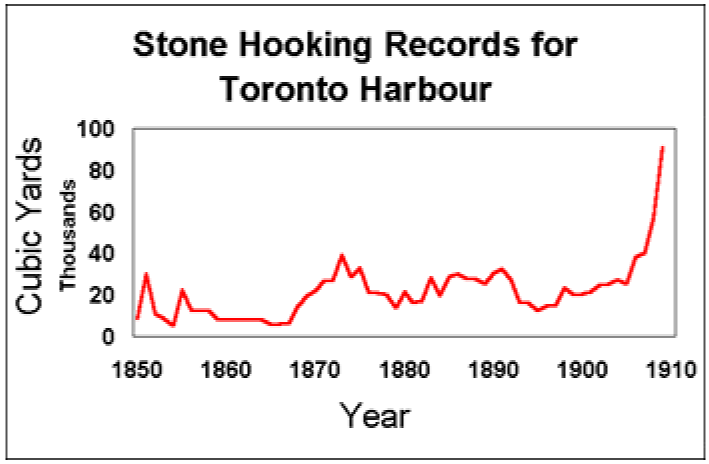


Cultural Influences – Sawmills and Gristmills

Numerous sawmills and gristmills were built along the banks of the creeks and rivers. They discharged their wastes directly into the watercourses, resulting in water pollution and siltation of fish spawning grounds. The millponds increased water temperatures, trapped sediments and altered flow regimes. The dams created barriers to fish moving upstream. The native salmon populations that were once plentiful in this area declined rapidly, with the last recorded catch in Toronto Bay occurring in 1874 (Whillans, 1999).

Cultural Influences – Stonehooking

From 1850-1910, stonehooking — the removal of aggregate materials from the lake bottom for use in construction — was a major force in changing physical conditions and shoreline processes. During this time period, 1 million cubic metres of materials were removed from Toronto Harbour alone — enough to cover the entire waterfront from Etobicoke Creek to the Rouge River with a layer 1 metre thick and extending 25 metres offshore. As a consequence, large amounts of valuable aquatic habitat disappeared, and the shoreline was exposed to accelerated erosion from waves and currents.



Some areas, for example Northumberland County, still have an abundant supply of stone material, an important component of the physical structure of the shoreline. The movement of stone material along the shoreline forms bays, points and bars, which are critical elements of aquatic habitats. (See photos.)

Cultural Influences – Shoreline Alterations

Other early shoreline alterations included weed removal, filling of wetlands and small streams, hardening of the shoreline, and channelization of watercourses. Starting in the 1790s, aquatic plants were removed from Toronto Bay because they impeded navigation. A map of Toronto Bay in 1813 shows early shoreline modifications in the form of docks, jetties and filling of small creeks.

Alterations to Toronto Bay, 1813

By 1913, further alterations included navigable channels such as the Western and Eastern Gaps and the Keating Cut. Ashbridge's Bay at the mouth of the Don River became severely polluted by wastes from the growing Town of York, the Gooderham and Worts Distillery, and associated cattle byres.

Alterations to Toronto Bay, 1913

Cultural Influences – Toronto and Region Area of Concern

By 1987, environmental conditions were so badly impaired that the Toronto waterfront was included on the International Joint Commission's list of 42 Areas of Concern around the Great Lakes requiring remedial action. The impairments noted for Toronto's waterfront were:

- Restrictions on fish and wildlife consumption
- Degradation of benthos
- Restrictions on dredging
- Eutrophication and undesirable algae
- Beach closures
- Degradation of aesthetics
- Degradation of fish and wildlife populations
- Loss of fish and wildlife habitat

Factors contributing to these problems are combined sewer overflows, contaminated stormwater, loss of habitats, and degradation of natural landscapes. In the past 25 years, eutrophication has been reduced, sediment quality has improved, and habitat availability and diversity have been increased, but Toronto remains on the list of Areas of Concern.

Cultural Influences – Wet Weather Flow Management Master Plan

The City of Toronto's 2002 Wet Weather Flow Management Master Plan (WWFMMP) provides important direction for ongoing improvements. The plan proposes a program totalling $1 billion over the next 25 years, including public education, municipal operations, shoreline management, stream restoration, and control measures at the end-of-pipe, during conveyance, and at the source. The shoreline management proposals include structures at the waterfront, near the mouths of Etobicoke Creek and the Humber River, to deflect ongoing inputs of pollutants away from waterfront beaches. These are proposed because the WWFMMP is limited to the City of Toronto, and there will be continued contributions of bacteria, nutrients and sediments into the watercourses from the "905" municipalities north of the City of Toronto.

Over the next 25 years, implementation of the WWFMMP will improve waterfront aquatic habitats by reducing inputs of nutrients, sediments and chemical pollutants to the watercourses and Lake Ontario. It will also improve habitat conditions in the rivers and creeks, with benefits to aquatic species that migrate upstream from the lake.

Cultural Influences – Invasive Species

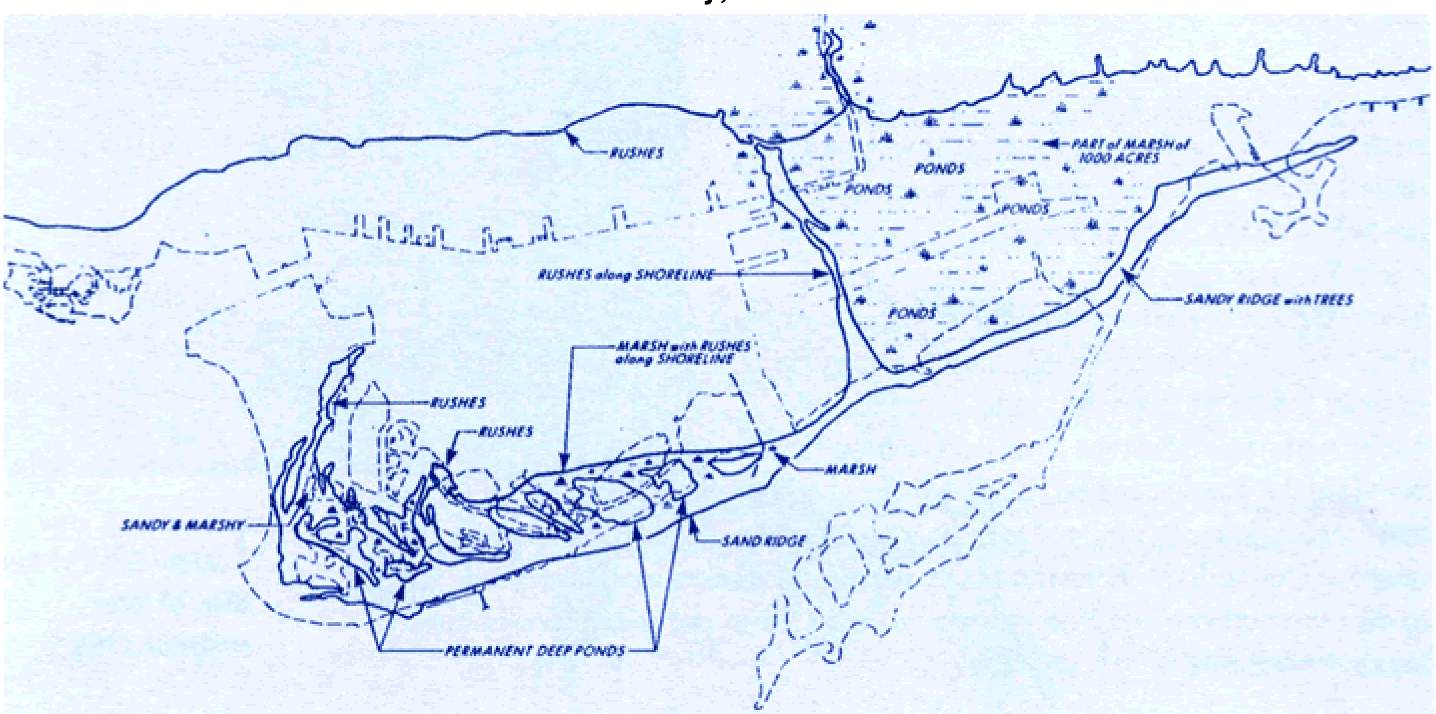
Invasive species have also been responsible for major alterations in aquatic communities. Since the 1800s, more than 140 exotic aquatic organisms of all types — including plants, fish, algae and mollusks — have become established in the Great Lakes. One of the most dramatic recent invasions has been the zebra mussel which colonizes rocky substrates and other hard surfaces. Zebra mussels are highly efficient filter feeders, removing substantial amounts of phytoplankton and zooplankton from the food chain. They have also caused significant improvements in water clarity, which in turn is increasing the diversity and productivity of aquatic plants in the nearshore zone.

Cultural Influences – Lakefilling

During the industrial period from 1900-1960, extensive lakefilling transformed the 826 hectare Ashbridge's Bay wetland complex, most of the central waterfront south of Front Street, portions of the Toronto Islands including the airport, the Leslie Street Spit, Ontario Place and the Western Beaches, as seen below.

In the 1970s, the Metro Toronto and Region Conservation Authority began to develop a series of lakefill parks along the waterfront (Colonel Sam Smith, Humber Bay, Ashbridge's Bay, and Bluffers Parks) to provide recreation opportunities for a rapidly increasing urban population.

Industrial Period Alterations to the Toronto Bay, 1900 to 1960



Cultural Influences – Dredging Activities

The Toronto Port Authority regularly dredges the Keating Channel, Inner Harbour, East Gap, Western Channel, Coatsworth Cut and Ashbridges Bay.

Each year, 35,000 to 40,000 cubic metres of sediment settle into the Keating Channel. The material comes from run-off and erosion upstream in the Don River. Dredging is undertaken in the channel for flood protection and maintenance of navigable water. The channel is dredged to a depth of 5.8 metres below chart datum and the dredged material is transported by tug and barge to the Toronto Port Authority's Confined Disposal Facility (CDF) within the Leslie Street Endikement. The project is subject to ongoing environmental monitoring by the Port and Conservation Authorities. The dredging operation is jointly funded by the City of Toronto, the Toronto and Region Conservation Authority (TRCA) and the Toronto Port Authority.

Although the majority of sediment from the Don watershed is captured in the Keating Channel, aerial photographs show a plume of sediment moving into the Inner Harbour.

When needed, small quantities of material are dredged at berths to maintain required depth. Approximately 3,000 cubic metres are dredged every three to five years. Similar to the Keating Channel dredgate, the material is transported to the Toronto Port Authority's CDF.

The East Gap is part of the main shipping channel into Toronto Harbour. Prior to the construction of the Leslie Street Spit, regular dredging of the Gap was required to maintain the navigation depth of 8.2 metres below chart datum. Some sediment continues to intrude into the Gap from western littoral drift and erosion off the Centre Islands. The quantity of this sediment is in the order of 3,500 cubic metres per year. The Toronto Port Authority is currently undertaking a five-year program to remove approximately 60,000 cubic metres of material from the Gap. This material is clean sand suitable for open water disposal in accordance with MOE guidelines. The Port Authority has worked with TRCA to use the clean material in Embayment "A" of Tommy Thompson Park to improve aquatic habitat conditions and develop an emergent wetland area.

Similar to the East Gap, erosion of the shoreline of the Toronto Islands results in transportation of material into the Western Channel and restricts navigation. Preliminary work is assessing possible alternatives for the disposal of the dredged material. An environmental assessment will be undertaken, and dredging will probably start within the next two years. The current design depth of the channel is 8.2 metres below chart datum, but may be reduced as a result of the environmental assessment.

Maintenance dredging is required in the Coatsworth Cut channel in Ashbridge's Bay every two or three years. The design depth of the channel is 1.8 metres below chart datum. The Toronto Port Authority has permitted this dredge material to be transported and disposed in the Toronto Port Authority's CDF.

Cultural Influences – Shoreline Regeneration Initiatives

Modifications of the shoreline changed dramatically with the implementation of the 1967 Waterfront Plan developed by Metro Toronto. Lakefilling activities were directed away from creating port and industrial lands and focused on creating regional waterfront recreational parks. The parks provide waterfront access, local greenspace, boating facilities, and — most important to this strategy — aquatic habitats. Following is a summary of the key projects.

Sam Smith Waterfront Park incorporates many successful habitat creation projects, including wetlands, coastal meadows, shoals and reefs.

Humber Bay Park is the site of a range of intensive habitat restoration works, including a Ministry of Natural Resources habitat project that used woody debris in a sheltered embayment. Test scale wetlands were established in the estuary of Mimico Creek in 1995, and additional wetlands were created in association with the pedestrian bridge over the Creek. The estuary now provides an excellent opportunity to recreate a coastal wetland estuary complex. As part of the development of the Humber Bay Shores area, habitat islands, beaches and shoals have been strategically built along the east side of Humber Bay Park, including one of the largest wetland creation projects to date.

The Toronto Bay area was the focus of a study by the Toronto Bay Initiative (A Living Place: opportunities for habitat regeneration in Toronto Bay) that outlines many habitat opportunities (Kidd, 1998). The wetland project and pike spawning habitat at Spadina Quay is an excellent example of created habitats within the harbour and is a useful design template for larger initiatives. The restoration of the lower Don River and the wetland at the mouth of the Don River is one of the largest proposed restoration schemes for the Toronto Waterfront.

Within the *Toronto Islands* at the trout pond, a large wetland complex was enhanced and reconnected to the lagoons. This lacustrine marsh provides critical habitat functions for the fish and wildlife community of the islands. Works undertaken in the mid 1990s on the islands focussed on repairing vertical seawalls with a variety of shoals and riparian improvements. Of particular interest is the wetland shoreline that was created at the Queens City Yacht Club that provides vegetated shorelines and improved public access.

The potential for *Tommy Thompson Park* to act as an aquatic habitat centre for the waterfront is based on the habitat restoration opportunities in the 160 hectares of lagoons and bays associated with the park. The Cell One wetland capping project is the single largest wetland gain to date on the waterfront. Additional wetland creation projects in the Park include Triangle Pond, Embayment A, and Embayment C.

Ashbridge's Bay and Bluffer's Parks are the location of two shoal and reef features within a boat basin on Toronto waterfront. Both parks have potential for additional habitats works.

East of Ashbridge's Bay, the open coast shoreline is characterized by groynes and headland features. Overall these structures function well as aquatic habitat with the best example being the recent headland structure west of the RC Harris Water Filtration Plant. East of Bluffer's Park, the Sylvan Avenue project is an example of integrating aquatic habitats into the form and function of an erosion control project. The Port Union Road shoreline improvement project is another example of the integration of aquatic habitats into a shoreline management structure.

Aquatic Communities

The principal biological components of aquatic communities considered in this report on the Toronto waterfront were:

1. Phytoplankton and Zooplankton
2. Algae
3. Invertebrates
4. Aquatic and Riparian Vegetation
5. Fish
6. Reptiles and Amphibians
7. Birds
8. Mammals

Phytoplankton and Zooplankton

Phytoplankton and zooplankton provide significant food sources for many life stages of aquatic organisms. With less eutrophication due to reduced nutrient inputs, plankton productivity has returned to more normal levels in recent years. The degradation of phytoplankton and zooplankton is listed as a potentially impaired use in the Toronto and Region Area of Concern.

- image from SOLEC 2000

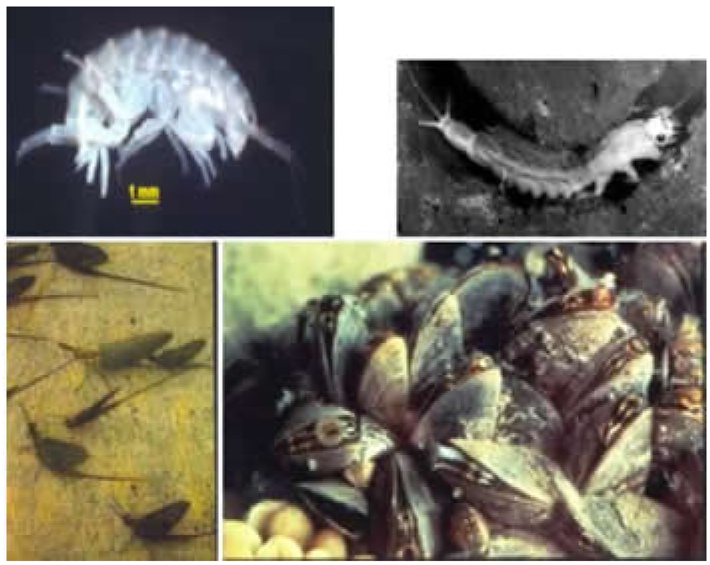
Algae

Suitable conditions for the growth of attached algae include the availability of hard substrates (such as Etobicoke shale), high levels of phosphorus, and the nearshore thermal bar that forms in spring and early summer. Increased water clarity also boosts algae growth in deeper water.

Attached algae form important habitat for benthic invertebrates which in turn are a food source for larger invertebrates, fish, migratory shorebirds and aquatic mammals. However, when algae become detached from their substrate, wash up on the shoreline and decay, they create foul odours that become a nuisance to waterfront residents, particularly in the Etobicoke portion of the Toronto waterfront.

The taste and odour problems in the Toronto water supply are due to free-floating algae that increase rapidly during warm weather, particularly in waters with a high organic content. The cause of the taste and odour impairments is geosmin, a naturally occurring chemical that is created during the metabolism of algae as they decay. This problem should be reduced as water quality improves. In the meantime, Toronto water treatment plants have now installed activated carbon feed systems to control this problem.

Invertebrates



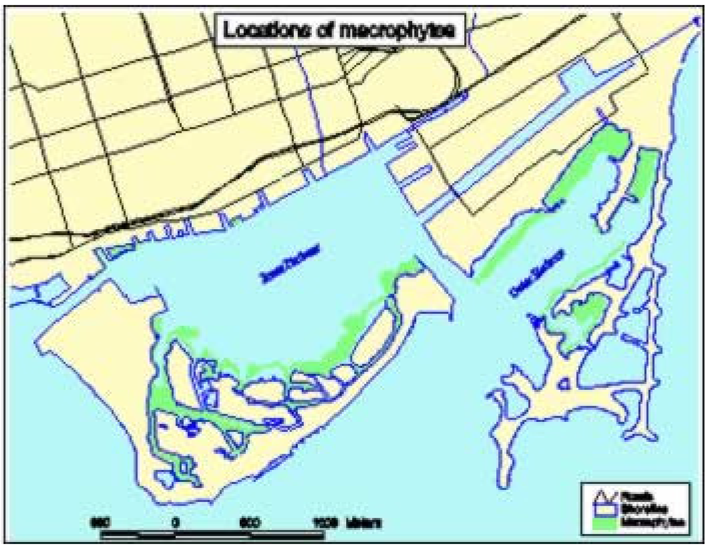
Invertebrates in aquatic habitats include a wide range, from tiny plankton to large insects, mollusks, crayfish and snails. Many of them have two life stages: a larval aquatic one, and an adult one that may be aquatic, aerial or terrestrial. Many larvae and some adults are benthic, or bottom-dwellers, feeding on decaying plant material and bacteria.

The benthic invertebrate communities in depositional areas such as Toronto Bay and the Lower Don River are dominated by pollution-tolerant species such as worms. In other areas, away from the influence of the Don River, the densities of pollution-tolerant species are considerably lower. The implementation of the City of Toronto Wet Weather Flow Management Master Plan which will reduce the loadings of organic-rich sediments from combined sewer overflows and storm sewers is expected to increase the diversity of benthic invertebrates in the Toronto Bay area.

In contrast, areas with hard, rocky substrates and/or plentiful aquatic macrophytes support more diverse and self-sustaining communities of benthic invertebrates which in turn support communities of fish, amphibians, reptiles, birds and mammals.

Recent bioassays show that, in many places, sediment quality is now good enough to support sensitive species like *Hexagenia* (mayflies). The limiting factors for invertebrates include quantity, quality and location of substrates, particularly in depositional areas. For example, *Hexagenia* larvae create burrows in silty sand, but these are easily collapsed in areas with high silt loadings.

One of the best-known invertebrates associated with aquatic communities is the mosquito. There are several different species of mosquito that occur in the Toronto area. West Nile Virus is primarily transmitted by species of mosquito that breed in sheltered, stagnant water in urban areas. The mosquito species found in natural ecosystems such as wetlands and estuaries tend not to be the ones that carry the virus. In addition, complex wetland ecosystems include predatory fish, birds, frogs and insects that help control mosquito populations. For more information on transmission of West Nile Virus, visit www.trca.on.ca.



Aquatic and Riparian Vegetation – Submerged Rooted Aquatic Plants

Submerged, rooted aquatic plants create good habitat conditions for fish and other aquatic organisms. Plants slow currents, hold substrate, fix carbon dioxide, produce oxygen, support invertebrates and provide shelter for fish and wildlife. A study undertaken by TRCA in summer 2002 demonstrated a significant improvement in the extent and diversity of submerged vegetation in the Toronto Bay area since 1995 (TRCA, 1995).

Wild celery vallisineria spp

The image above shows the extent of Macrophyte beds in Toronto Bay and Outer Harbour in Summer 2002.

This trend is also apparent in other areas of the waterfront, particularly in the sheltered embayments. The native plant, water celery (Vallisneria sp), is a good indicator of improved conditions providing excellent aquatic habitat. Vallisneria is becoming a principal component of the plant community in water front embayments.

Aquatic and Riparian Vegetation – Emergent Vegetation

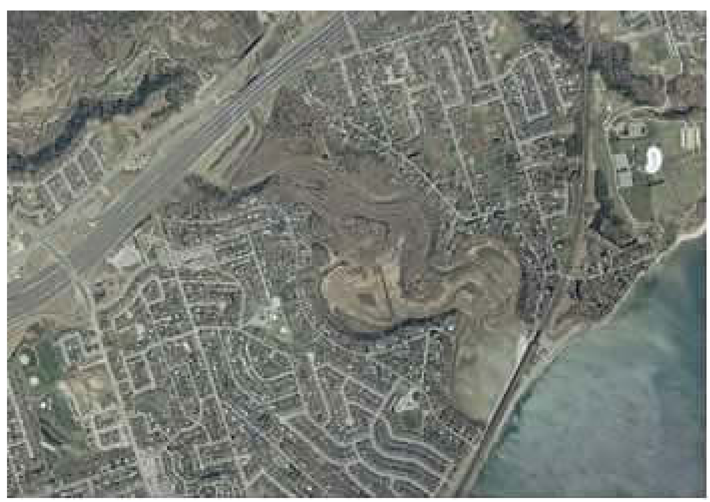
Emergent vegetation grows near the shore in shallow zones, particularly in the estuaries, sheltered embayments, and the north shore of the Toronto Islands and its lagoons. Areas of deep water with steep, hard-edged dock walls support very little emergent vegetation.

Rouge Marsh and Estuary 1958

Carp limit the growth of emergent and submerged vegetation in many barren areas of the waterfront by uprooting or consuming plants; as well, carp indirectly restrict plant growth by stirring up bottom substrates during feeding, which increases turbidity and reduces the light available for photosynthesis. Other limiting factors, particularly in estuaries and areas near storm water outfalls, are organic pollution, high densities of suspended solids and excessive sedimentation.

Emergent vegetation is also vulnerable to persistent high water levels and to major flooding episodes, such as Hurricane Hazel. In healthy aquatic ecosystems, the vegetation is resilient and regenerates after such natural events, but recovery may be severely impeded in systems that are degraded by such factors as poor water quality, sedimentation and carp.

For example, comparisons of the Rouge Estuary Marsh in 1954 and 1999 (see aerial photographs of Rouge Estuary in 1954 and 1999) illustrate a dramatic loss of emergent vegetation, probably due to a combination of disturbance by carp, high water levels and watershed impacts.



Rouge Marsh and Estuary 1999

TTP Embayment A

In contrast, excellent results have come from wetland creation projects on the waterfront. For example, the constructin of an embayment in Tommy Thompson Park mimics a backwater lagoon, and is developing excellent stands of submerged and emergent vegetation. See plan and photograph of TTP embayment A below.

Aquatic and Riparian Vegetation – Riparian Vegetation

Riparian vegetation occurs at the interface of the land and water. It can be lowland (seasonally/permanently flooded) or upland (on drier ground). See photographs of riparian vegetation.

Lowland Riparian

Upland Riparian

Riparian vegetation has numerous ecological functions. Riparian vegetation filters pollutants, nutrients and sediments from incoming water; detain flows; provides organic material to watercourses; moderates water temperatures by providing shade; and reduces bank erosion. Many forms of wildlife such as frogs, turtles, mink, muskrat, coyote, herons and colonial birds inhabit the riparian zone. As well, pike spawn in flooded lowland riparian areas.

Fish – Waterfront Fish Communities – Overview

The Toronto and Region Conservation Authority has been monitoring waterfront fish communities since 1982. Electrofishing is the principal method, supplemented by seine and index netting.

Over the past two decades, the monitoring results program have indicated gradual improvements in fish communities, as measured by the proportions of native and introduced species, the age structure of populations, and the ratio of predators to forage species. For example, there are downward trends in some introduced species, such as alewife and carp, and increases in many native species including northern pike and forage species like common, spottail and emerald shiners and bluntnose minnow.

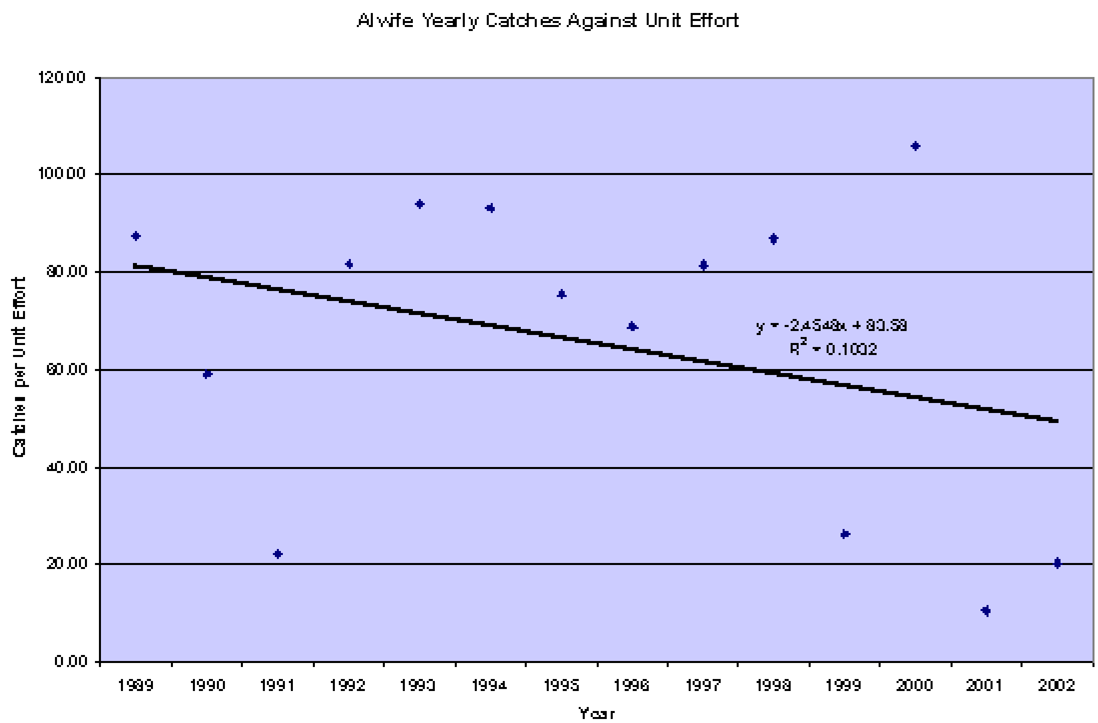
Table A: Toronto Waterfront fish communities by biomass and abundance sampled during July from 1998-2002

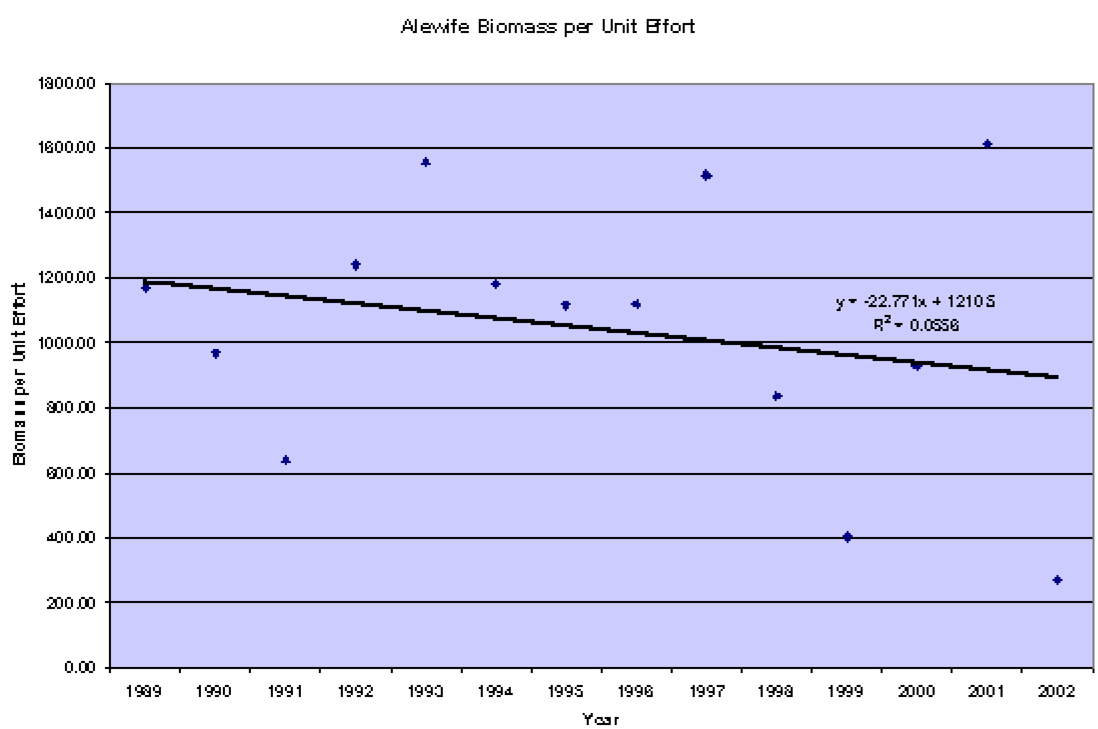
95% of catch by abundance		95% of catch by biomass	
Alewife	45%	White Sucker	38.7%
White Sucker	16.4%	Common Carp	38.2%
Pumpkinseed	10%	Gizzard Shad	4.5%
Spottail Shiner	5.2%	Northern Pike	4.3%
Emerald Shiner	4.5%	Freshwater Drum	2.8%
Rock Bass	2.4%	Alewife	2.5%
Rainbow Smelt	2.1%	Brown Bullhead	1.6%
Yellow Perch	1.8%	Yellow Perch	1.3%
Common Shiner	1.7%	Rock Bass	1.3%
Gizzard Shad	1.6%		
Common Carp	1.6%		
Bluntnose Minnow	1.3%		
Brown Bullhead	1.2%		

The high numbers of alewife reflect the eutrophic conditions that have existed over the last few decades. White sucker and carp dominate the biomass. White sucker are a good forage food for predator species, but it would be beneficial to shift the population to greater numbers of smaller fish.

Fish – Waterfront Fish Communities – Alewife

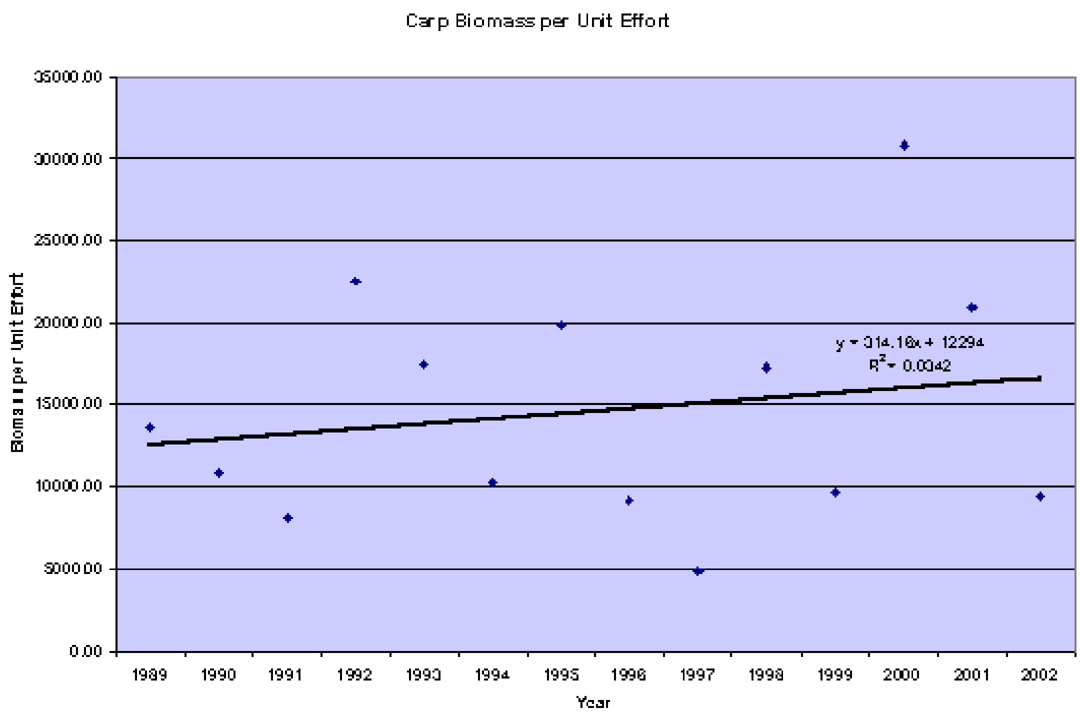
Trends indicate a gradual decline in abundance and biomass of alewife from 1989-2002, probably due to recent reductions in nutrient loadings to the Lake.

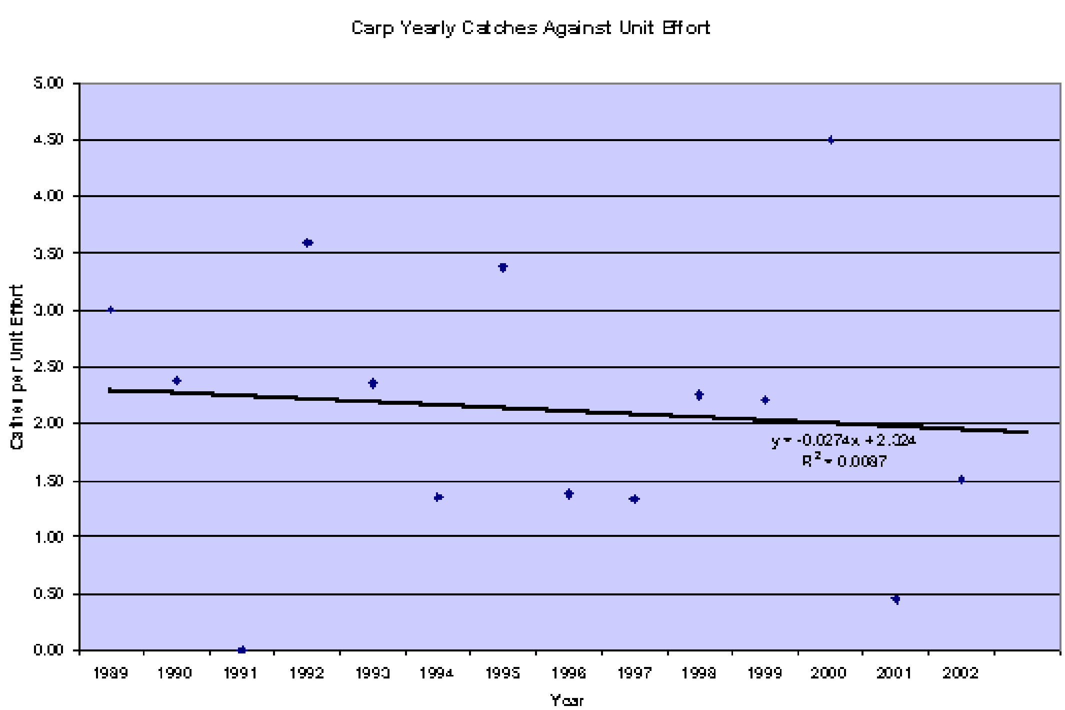




Fish – Waterfront Fish Communities – Carp

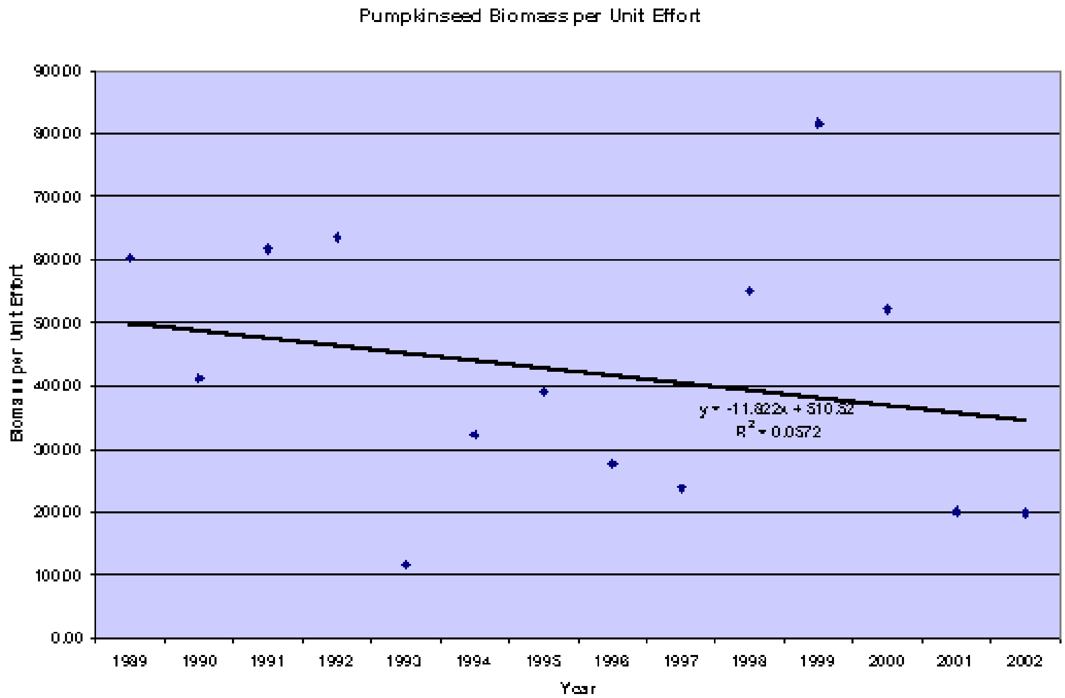
The abundance of carp is declining slowly, but biomass is increasing, reflecting smaller numbers of larger, older fish and a probably decrease in spawning success. It would be beneficial for the restructuring of fish communities to encourage this trend and reduce the carp population overall.

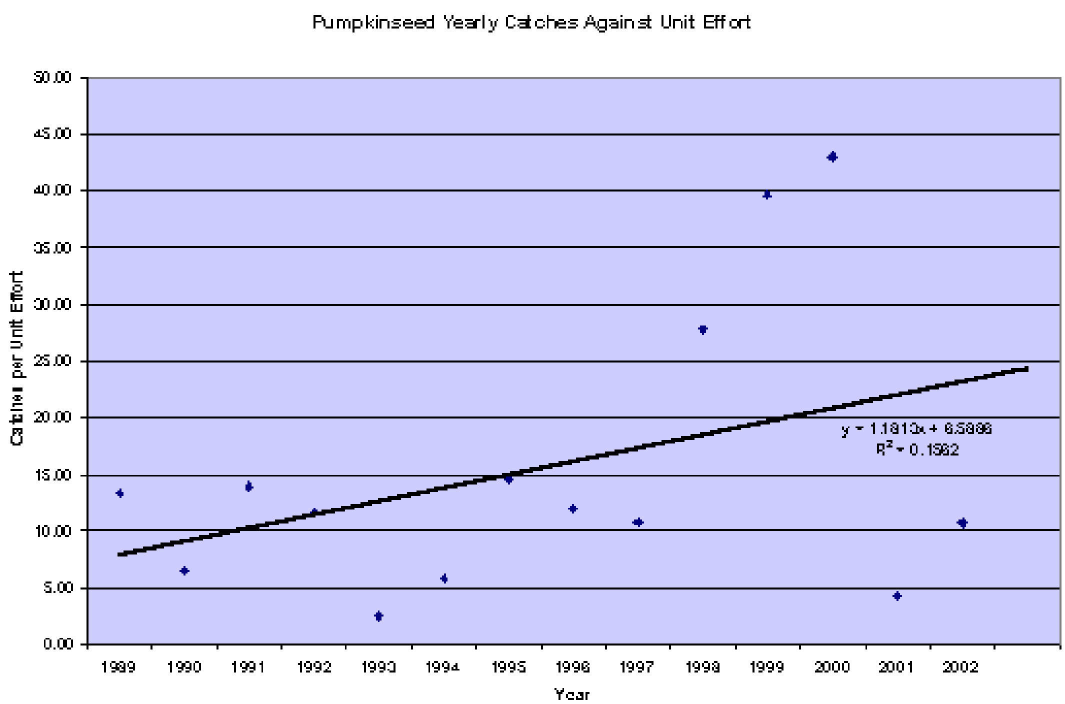




Fish – Waterfront Fish Communities – Pumpkinseed

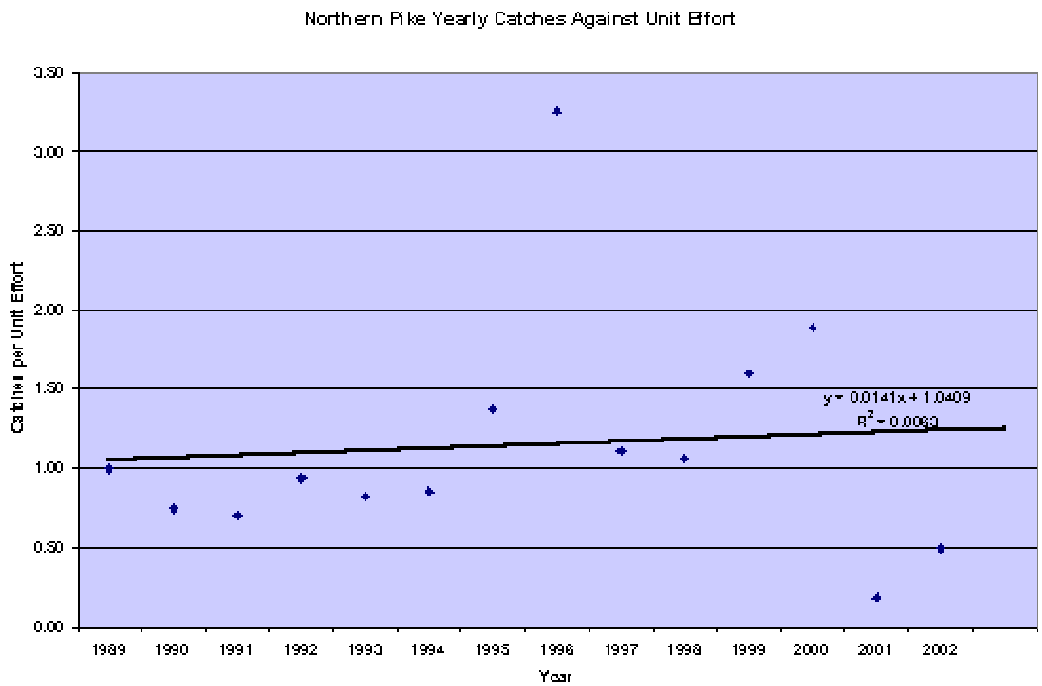
The abundance of pumpkinseed is increasing, while biomass has decreased, reflecting a trend toward a larger number of smaller fish. Small pumpkinseed are important forage for large predators, both fish and birds.

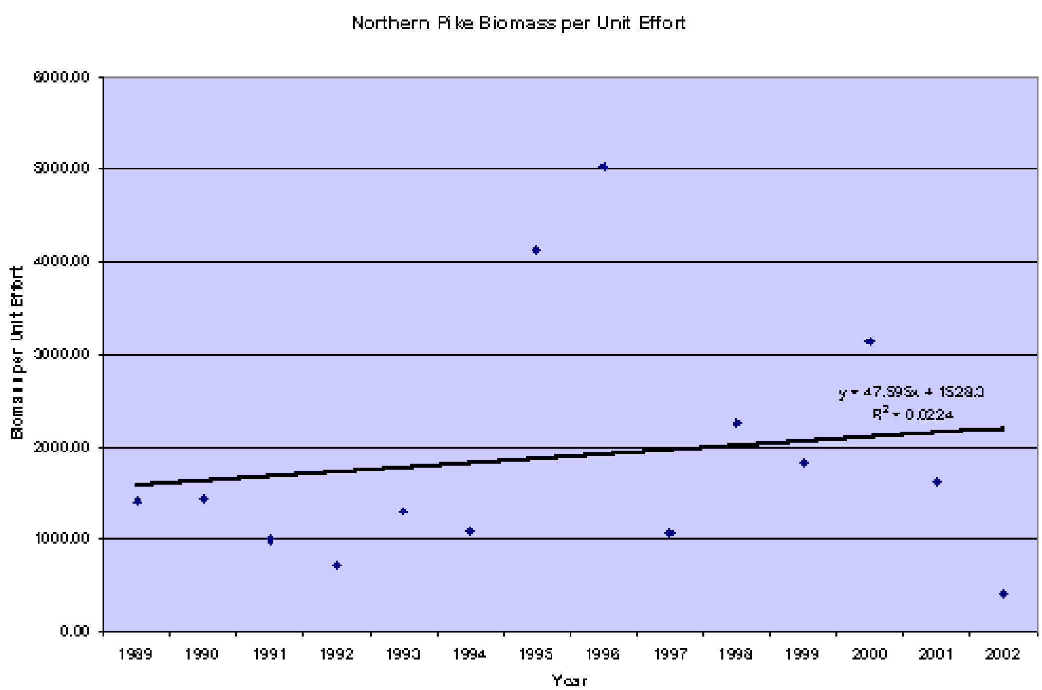




Fish – Waterfront Fish Communities – Northern Pike

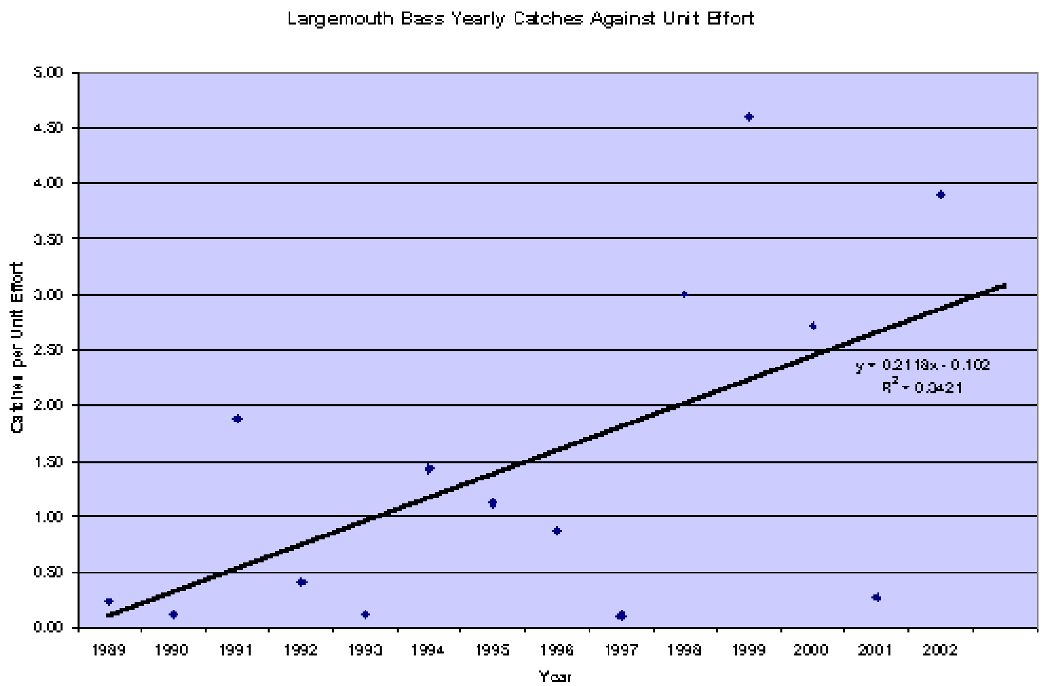
The abundance and biomass of northern pike have been increasing gradually, likely because of increased submerged vegetation and habitat restoration projects. However the age structure of the population is weighted towards large, more mature individuals. It would be desirable to shift this structure to a greater variety of sizes and ages.

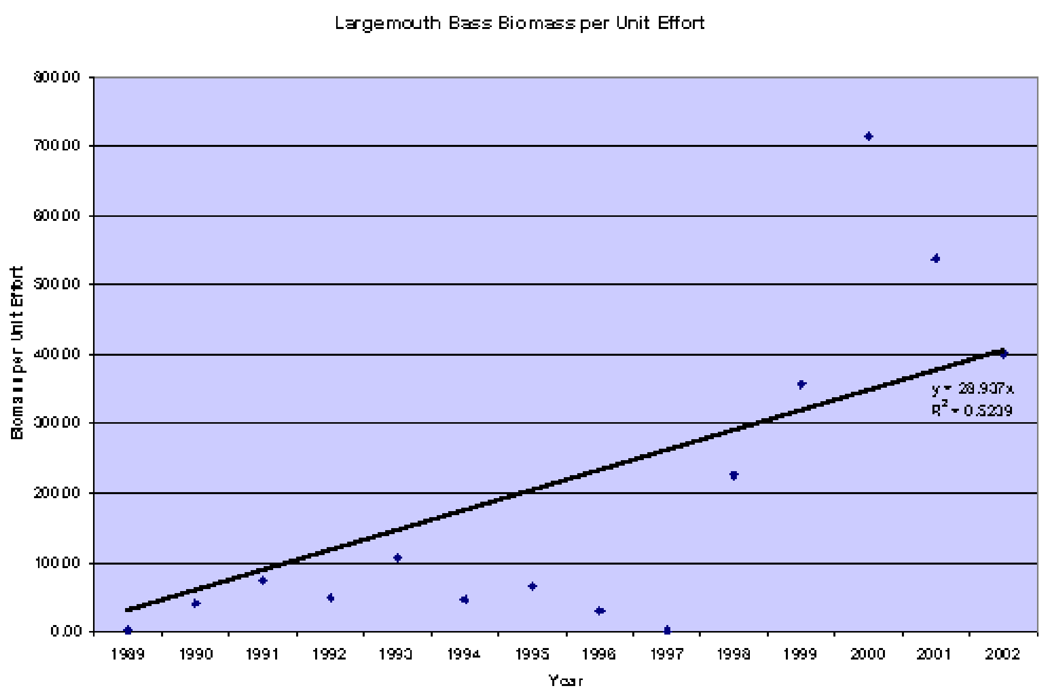




Fish – Waterfront Fish Communities – Largemouth Bass

Largemouth bass has significantly increased in both abundance and biomass, probably because of increasing amounts of emergent vegetation along the waterfront which provides shelter and sources of food for juvenile fish.





Fish – Waterfront Fish Communities – Monitoring Program

The monitoring program also provides information about the fish that are commonly found during summer months in the four major habitat types on the Toronto waterfront. Coastal wetlands, estuaries and sheltered embayments have similar assemblages of fish species whereas the open coast has a different community.

2001 Toronto Pike Telemetry Study
2002 Toronto Fish Community/Habitat Study

November 2000 pike locations

These four habitat types, along with tributary streams, contain biophysical features that are essential for self-organization, and provide special locales where the highest percentages of reproduction and predation occur. These locales are considered to be centres of ecological organization, in contrast to the open lake.

Whenever centres of organization are degraded or obliterated, more ecological damage occurs than just the loss of function at a specific site. Without adequate and sufficient habitat for reproduction, species and aquatic communities suffer because the transfer of genetic information is thwarted. When feeding sites are detrimentally affected, large species do not grow and mature, so that energy transfers are reduced to recycling in large populations of very small, short-lived animals usually associated with open water. The overall effect is a decrease in the self-regulatory capacity of the biotic systems, an effect that is ecologically and spatially manifested well beyond the location of the actual centre of ecological organization.

It is also important to recognize that many species of fish use different habitats depending on the season and/or weather conditions. For example; estuaries are used by coldwater species (such as rainbow and brown trout, white sucker and Atlantic salmon) when they move from the cold waters of the open lake to migrate upstream for spawning. As well, thermal corridors of warmer water provide suitable conditions for many fish to migrate along the open coast between the estuaries, wetlands and sheltered embayments.

The following sections provide information about fish communities in the four waterfront habitat types: estuaries, coastal wetlands, sheltered embayments and open coast.

Fish – Waterfront Fish Communities by Habitat Type – 1a) Estuaries

Estuaries are the lower reaches of streams that are influenced by lake levels (eg the Rouge River from Lake Ontario to Highway 401). Estuary habitats are essential to the function of the entire waterfront. Healthy estuaries are very productive because they hold nutrients from the watersheds and provide stable thermal conditions. Backwater lagoons in estuaries are principal areas of production and provide a variety of habitats, including spawning. Estuaries also represent a physical connection between the lake and watershed for species that need both open waters and riverine habitats.

Don River

Humber River

Highland Creek

Fish – Waterfront Fish Communities by Habitat Type – 1b) Estuaries

The environmental quality of the estuaries along the Toronto waterfront varies. Longer estuaries, such as the Rouge River and Highland Creek, still have functional estuarine habitats, albeit degraded. Mimico Creek estuary has benefited from restoration projects in recent years and is showing some signs of recovery. Etobicoke Creek estuary has been considerably shortened and degraded, with little bottom structure or vegetation. The Don River estuary is the most severely altered, with very limited aquatic habitat.

- Estuary – Area influenced by lake levels
- Estuary/Wetland Relationship
    - A conduit of nutrients
    - Backwater lagoons
    - River discharge
    - Essential habitat

Estuary – An area influenced by lake levels.

The river provides a conduit of nutrients, stable thermal conditions and connection between the lake and the watershed.

Backwater lagoons are principal areas of biological production and provide a variety of essential habitats

River discharge areas are commonly very productive littoral.

The wetland estuary complex is essential habitat for the entire waterfront

Fish – Waterfront Fish Communities by Habitat Type – 1c) Estuaries

Although the estuarine fish communities are dominated by alewife and white sucker, shiners (spottail and emerald) and other minnows provide an important forage base in healthier estuaries. Northern pike, freshwater drum and smallmouth bass make up a high biomass in Toronto estuaries, despite the predominance of carp and white sucker.

Table B: Toronto Estuary fish communities by biomass and abundance sampled during July from 1998-2002

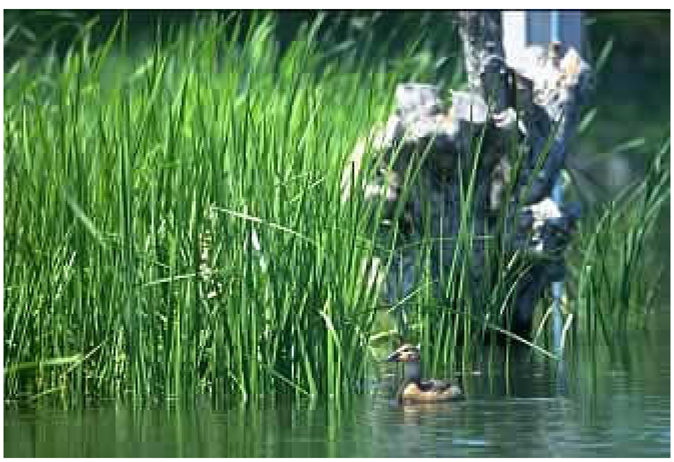
95% of catch by abundance		95% of catch by biomass	
Alewife	44.8%	Common Carp	66%
White Sucker	14.1%	White Sucker	17.2%
Spottail Shiner	8%	Northern Pike	2.7%
Emerald Shiner	6.1%	Freshwater Drum	2.6%
Brown Bullhead	3.4%	Smallmouth Bass	2.5%
Common Shiner	3.2%	Alewife	2.5%
Pumpkinseed	3.1%	Brown Bullhead	2.3%
Common Carp	2.9%		
Gizzard Shad	2.8%		
Smallmouth Bass	2.5%		
Rainbow Smelt	2.1%		
Bluntnose Minnow	2%		
Yellow Perch	1.1%		

Fish – Waterfront Fish Communities by Habitat Type – 2) Coastal Wetlands

Coastal wetlands occur in many estuaries (notable exceptions are Etobicoke Creek and the Don River both of which have been channelized) and in sheltered embayments such as Tommy Thompson Park lagoons, the Inner Harbour and most lakefill parks.

Rouge River **Triangle Pond-Tommy Thompson Park**

Mimico Creek



At present, approximately 51% of the coastal wetland fish community is comprised of alewife and emerald shiner (an important forage species). Carp and white sucker represent nearly 62% of the biomass. Largemouth bass represent only 1.6% of the abundance and 2.3% of the biomass, but show trends towards increases in both. Two keystone species are northern pike and bowfin, indicators of improving environmental quality.

Table C: Toronto Coastal Wetlands fish communities by biomass and abundance sampled during July from 1998-2002

95% of catch by abundance		95% of catch by biomass	
Alewife	28.6%	Common Carp	35.0%
Emerald Shiner	22.4%	White Sucker	26.9%
Pumpkinseed	8.7%	Gizzard Shad	10.9%
White Sucker	5.7%	Northern Pike	8.1%
Common Shiner	5.7%	Brown Bullhead	4.5%
Gizzard Shad	5.1%	Bowfin	4.5%
Spottail Shiner	4.4%	Largemouth Bass	2.3%
Brown Bullhead	4.2%	Alewife	1.9%
Bluntnose Minnow	3.3%	Freshwater Drum	1.4%
Rainbow Smelt	2.5%		
Largemouth Bass	1.6%		
Yellow Perch	1.6%		
Common Carp	1.4%		

Fish – Waterfront Fish Communities by Habitat Type – 3a) Sheltered Embayments

Sheltered embayments in harbour areas, the Toronto Islands and lakefill parks provide thermal refuges as well as a variety of shoreline conditions and configurations with significant areas of aquatic vegetation. Water currents between sheltered embayments and open waters of the lake attract and hold forage fish, providing a concentrated area for feeding by predators.

Bluffer's Park

Spadina Quay - Toronto Inner Harbour

Embayment B Wetland - Tommy Thompson Park

Fish – Waterfront Fish Communities by Habitat Type – 3b) Sheltered Embayments

Sheltered embayments are critical habitats because they privide the following conditions:

- Thermal Habitat
- Significant areas of aquatic vegetation
- Variety of shoreline conditions and configuration
- Important centers of biological organization

Tommy Thompson Park – *image* »

In the sheltered embayments, alewife is nearly 45% of the abundance, with fairly high numbers of white sucker and pumpkinseed. 74% of the biomass is white suckers and carp. There is a good forage component. The relatively small number of large carp suggests that there is little ongoing reproduction. The presence of largemouth bass is a reflection of abundant submerged aquatic plants. The sporadic occurrences of walleye are a good indicator of appropriate conditions for cool water fish including high primary productivity for the young to feed.

Table D: Toronto Sheltered Embayments fish communities by biomass and abundance sampled during July from 1998-2002

95% of catch by abundance		95% of catch by biomass	
Alewife	44.7%	White Sucker	43.7%
White Sucker	16.1%	Common Carp	30.6%
Pumpkinseed	11.4%	Northern Pike	5.5%
Spottail Shiner	5.3%	Gizzard Shad	4.5%
Emerald Shiner	3.7%	Alewife	2.7%
Rock Bass	3.2%	Freshwater Drum	2.5%
Yellow Perch	2.4%	Brown Bullhead	1.9%
Bluntnose Minnow	1.9%	Rock Bass	1.5%
Rainbow Smelt	1.8%	Yellow Perch	1.5%
Gizzard Shad	1.5%	Pumpkinseed	1.3%
Brown Bullhead	1.4%		
Common Carp	1.3%		
Largemouth Bass	1.2%		

Fish – Waterfront Fish Communities by Habitat Type – 4a) Open Coast

Open coast habitats occur across most of the Toronto waterfront. In sharp contrast to sheltered embayments, coastal wetlands and estuaries, the open coast has much colder water, and is exposed to extensive wind and wave action, resulting in a relatively hostile environment for littoral vegetation and animals. Hypolimnetic upwellings of cold sub-surface waters are common, resulting in temperature fluctuations of as much as 12 Celsius degrees and reduced survival of warmwater fish in these areas.

Port Union Shoreline

Western Beaches

Sylvan Ave/South Marine Drive

Open coast habitats with bedrock or cobble/boulder substrates and convex profiles are particularly suited to coldwater fish, since species such as lake trout and lake whitefish often rely on these substrates with nearby steep drop-offs for reproduction. Headlands, where the greatest aggregations of boulders occur, provide high quality coldwater spawning habitats. Open coast habitats associated with concave profiles (eg Scarborough Bluffs) and shifting lakebeds associated with dynamic beaches are suited to species which broadcast their eggs in water, such as lake herring, emerald shiner, alewife and smelt. These fish provide an important forage base for other species, including most sport fish. Many fish, for example, salmon species, also use open coast habitats as corridors during seasonal movements.

Fish – Waterfront Fish Communities by Habitat Type – 4b) Open Coast

Open coast habitats were classified into four types:

1. River discharge areas/barrier beaches
2. Headland/groyne beaches
3. Unprotected shorelines
4. Walls and revetments

Most open coast habitats along the Toronto waterfront have been degraded by human interventions. In recent years, the design of shoreline management works has evolved to incorporate more ecological functions. The open coast has a high abundance of alewife (about 62% of the catch). American eel, salmon and trout are found in cooler waters of the open coast. The occurrence of carp in the open coast will be reduced if measures can be successfully taken to reduce their reproduction in the wetlands and embayments. Nearshore benthos can be improved by modifying the substrate, for example by replacing some of the 1 million cu metres of rocky materials removed historically from the Toronto shoreline. Another important factor in the open coast is the general lack of debris such as large timbers and woody materials from the upstream watersheds. However, the Highland and Rouge estuaries still have many logs that have washed down the rivers and are now embedded in the shoreline.

Table E: Toronto Open Coast fish communities by biomass and abundance sampled during July from 1998-2002

95% of catch by abundance		95% of catch by biomass	
Alewife	61.7%	White Sucker	45.7%
White Sucker	13%	Common Carp	28.9%
Emerald Shiner	8.7%	Alewife	7.3%
Spottail Shiner	5.2%	Brown Trout	6%
Rainbow Smelt	3.5%	Smallmouth Bass	2.1%
Threespine Stickleback	1.1%	Freshwater Drum	1.6%
Smallmouth Bass	0.9%	American Eel	1.5%
Pumpkinseed	0.6%	Lake Trout	1.5%
Common Carp	0.6%	Rainbow Trout	0.9%

Reptiles and Amphibians

Reptiles and amphibians (herptiles) are some of the most environmentally sensitive species associated with aquatic and terrestrial near-shore habitats. Herptiles depend on healthy, functional wetland and shoreline habitats found in estuaries, coastal marshes, and vegetated sheltered embayments. Unfortunately, there is very little historical data on reptiles and amphibians on the Toronto waterfront, so that their long term population trends are poorly understood.

Recently, scientists, naturalists, and other wildlife watchers have become more concerned about these habitat-dependent herptile species. This concern has generated amphibian and reptile monitoring programs designed to document changes in these populations, and correlate them with environmental conditions. For example, the TRCA has been participating in the Marsh Monitoring Program (MMP), which was established by Bird Studies Canada and Environment Canada in 1994, and includes a variety of sites across the Toronto waterfront. This program showed that herptile abundance and diversity are very low across the Toronto waterfront, likely attributable to the physical and biological degradation of waterfront habitats. Populations are primarily restricted to significant estuary habitats and the remnant coastal marshes.

Eight species of amphibians commonly found in Lake Ontario include: northern leopard frog, wood frog, green frog, bullfrog, chorus frog, spring peeper, grey tree frog, and american toad.

The Toronto Waterfront currently supports only three of the eight common species including northern leopard frog, green frog, and american toad. Two other species, chorus frog, and grey tree frog have been listed as probable occurences, but have not been confirmed.

Monitoring has also shown that these populations have great resilience and quickly respond to improvements in their habitat. The restoration of aquatic habitats, particularly productive emergent marsh habitats, can result in great improvements in coastal herptile communities. The TRCA and other organizations have had great success in improving herptile communities when restoration projects incorporate critical habitat features such as basking/sunning logs, rock piles, hibernacula, isolated ponds, protected nesting sites, deep water over-wintering sites, and vegetated corridors.

Birds

Shorelines and associated aquatic habitats are important for bird communities which have been the subject of considerable study in along the Toronto waterfront. Self-sustaining, diverse, aquatic communities are not only necessary for bird species that live and reproduce on the waterfront year-round, but are also critical for other birds that forage and migrate through waterfront areas.

Shorelines of large waterbodies like Lake Ontario are biological centres of organization which support high diversities of bird species, act as fall-out and staging areas during migration, and provide corridors which facilitate regional movement of species.

The dependence of avian communities on aquatic habitats can be generally categorized into the following groups:

- Dependent on wetland habitat for all stages of lifecycle eg. Virginia rail
- Migrational stopover and staging species eg. Canada warbler
- Seasonally-dependent (eg over-wintering) species eg. Common loon
- Colonial waterbirds eg. Caspian tern

The value of diverse aquatic habitats to bird life on the Toronto waterfront is probably best described through the example of Tommy Thompson Park. Tommy Thompson Park (TTP), a created environment, also known as the Leslie Street Spit, has been designated as an Important Bird Area (IBA) of global significance by Birdlife International. The designation is based on a variety of criteria including:

- Occurrence of breeding populations of colonial waterbirds
- Value of the area for migratory waterfowl
- Value of the area for both migratory and resident songbirds
- Value of the area for migratory owl and raptor species

The existence and persistence of the avian communities associated with TTP result from a complex of natural and created habitats that exist within the park. In addition, the biological value of these habitats is greatly increased by their location or proximity to the north shoreline of Lake Ontario.

There is no definitive count of the number of avian species which use the Toronto Waterfront, although local naturalist groups, agencies and bird professionals suggest a number of just over 300 species. That is higher than other well known natural areas on the north shore of Lake Ontario, such as Second Marsh (288), and just below other IBAs such as Presquille Point (320).

Mammals

One indicator of good ecological health is a well balanced, self-sustaining mammal population. The distribution of mammal species can vary greatly and are usually regulated by several environmental factors. The factors can be grouped into four major categories: weather/ climate, food, other animals and disease, habitat. (Dobbyn,1994). The complex of aquatic, wetland and terrestrial habitats currently found along the waterfront should attract a wide range of mammal species. However, currently waterfront sites support relatively low numbers of mammal species in comparison with less urban sites. Smaller, less mobile species such as the rodents are more likely to remain isolated in small pockets of habitats and are physically unable to disperse do to development barriers, roads, houses etc. The lack of connecting corridors between habitat blocks is one major factor. Larger more mobile species such as coyote and raccoons move more freely through developed areas and use all types of natural blocks, parks, brown fields and habitat nodes for foraging and habitation. Habitat quality is impacted by invasive species, chemical contamination and urban population influences. Waterfront aquatic and near-shore terrestrial habitats could, through enhancement, provide areas for resident wildlife while connecting corridors between isolated habitats located along the waterfront and those running north south along watershed green space.

Mammals commonly found on the Toronto waterfront include several species of bat, red fox, eastern cottontail, groundhog, eastern grey squirrel, meadow vole, raccoon, opossum, mink, weasel species, striped skunk, red squirrel, eastern chipmunk, shrews, mole, white footed mouse and muskrat. Less common are beaver, coyote and white-tailed deer. (Dobbyn, 1994)

Small mammals perform a notable role in wetland, nearshore and terrestrial ecosystems and are considered keystones to these systems while serving as a food source to larger mammals (eg coyote) and predatory birds (eg owls and hawks).

The relatively small size of most waterfront habitat areas limits their value to large mammals such as deer. The small blocks are most likely used to provide migration routes, temporary cover, and occasional forage.

Beavers living in urbanized areas can disrupt parks and naturalized areas by girdling, cutting or felling trees onto pathways and roads. Dams built by beavers may cause flooding, alter watercourses and have a potential negative effect on fish habitat. They can also damage or kill newly planted trees. Both the beaver and coyote take advantage of large isolated blocks of natural areas such as Tommy Thompson Park; these areas need to be managed to strike a balance between natural predator and prey to keep the population of these species at a desirable level.

Habitat Compendium

Introduction

This compendium of habitat restoration techniques provides illustrative and detailed information about construction materials and techniques needed to improve aquatic habitats and to address key aquatic and fish management objectives for each waterfront habitat type, used in the Strategy.

Habitat Targets

Targets were developed for each habitat type, based on biological and physical factors that currently limit the potential for healthy aquatic communities.

TARGETS	Open Coast	Sheltered Embayments	Coastal Wetlands	Estuaries
Improve emergent vegetation		✓	✓	
Improve submergent vegetation			✓	
Increase high quality riparian vegetation	✓	✓	✓	✓
Reduce carp biomass			✓	
Increase areas of primary production		✓	✓	✓
Increase essentail habitats for top-order Piscivores		✓	✓	✓
Increase essential habitats for cool and cold water species	✓			✓
Improve forage	✓	✓	✓	✓
Add structural elements to improve near shore habitats	✓	✓		✓

Compendium of Restoration Techniques

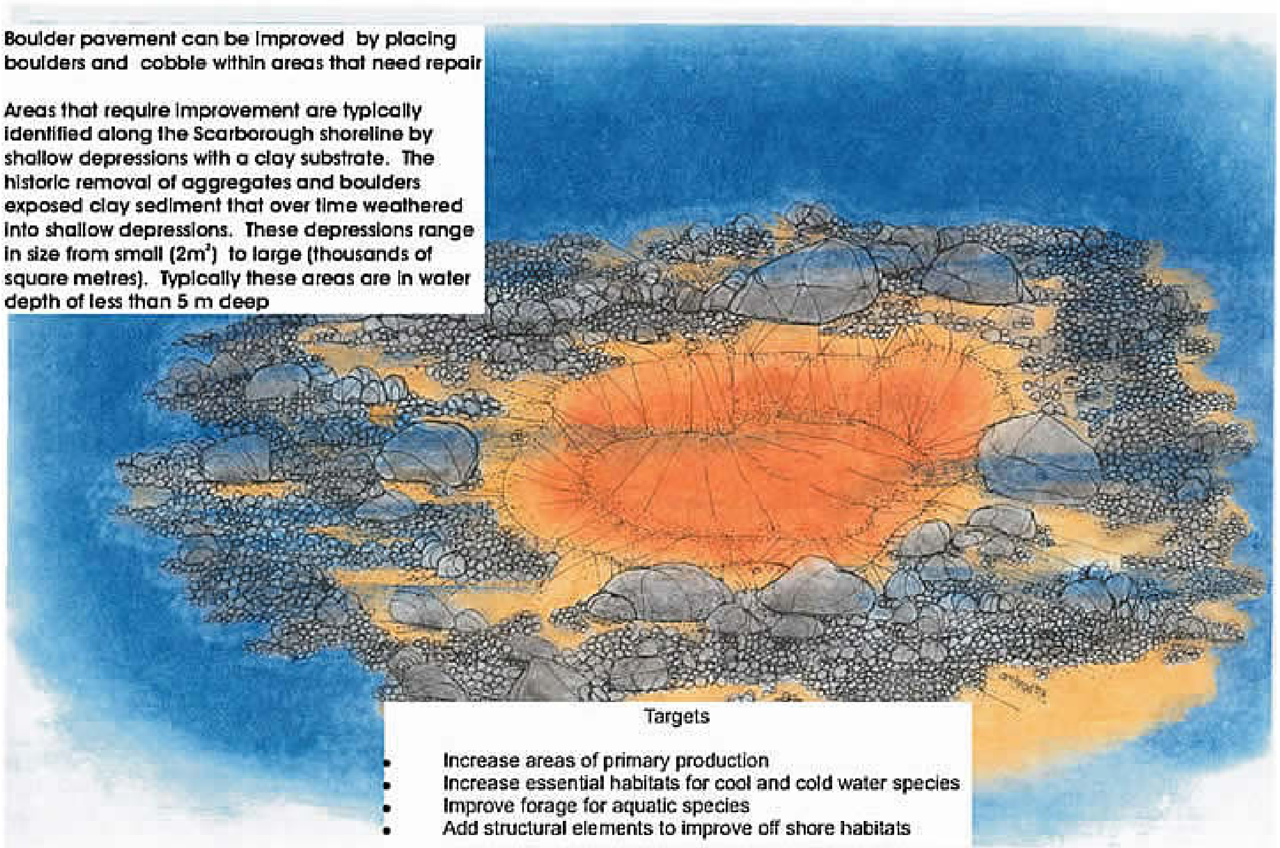
Habitat restoration techniques were developed with these targets in mind. Some are more suited to a specific habitat type whereas others can be more broadly applied to one or more habitat types, as shown in the table below.

Habitat Type	Restoration Technique	Purpose
Open Coast	• Boulder Pavement • Repaired Boulder Pavement	Substrate diversity and structural elements
	• Surcharged Revetment	Substrate diversity and structural elements
	• Surcharged Groyne	Substrate diversity and structural elements
	• Underwater Reef	Underwater structural habitat
Sheltered Embayments	• Shoreline Vegetation Zones	Critical design consideration for shoreline vegetation
	• Wetland Shoreline Profile and Lake Ontario Water Levels	Critical design elevation for aquatic and riparian vegetation communities
	• Log Piles	Underwater structural habitat
	• Underwater Reef	Underwater structural habitat
	• Anchored Logs	Underwater structural habitat
	• Deep Weed Wall	Underwater terracing creates primary and secondary drop offs
	• Shoreline Shoal	Shoreline diversity
	• Modified Growth Submerged Aquatic Vegetation	Technique to ameliorate excessive nearshore submerged aquatic plants
	• Aquatic Vegetation	Fluted substrates to improve function of aquatic vegetation
	• Complex Shoreline Profile Improvements	Use of material (dredge spoils or fill) to improve the function of the shoreline profile
	• Inner Harbour Quay Treatments	Amelioration of vertical seawalls
	• Reptile Habitat	Key and essential habitats for turtles
	• Log Tangles	Structural habitat elements
	• Constructed Islands	Shoreline diversity and structural habitat elements
	• Lowland Riparian Woods	Add structural elements to improve near shore habitats
Coastal Wetlands	• Shoreline Vegetation Zones	Critical design consideration for shoreline vegetation
	• Reptile Habitat	Key and essential habitats for turtles
	• Log Tangles	Structural habitat elements
	• Wetland Berms	Critical design consideration for wetland improvements
Estuaries	• Low Estuary Hooks	Structural habitat and in-stream cover
	• High Estuary Hooks	Structural habitat and in-stream cover with riparian habitats

RESTORATION TECHNIQUE: **Typical Offshore Boulder Pavement Repair Area**
HABITAT TYPE : **Open Coast**

Boulder pavement can be improved by placing boulders and cobble within areas that need repair

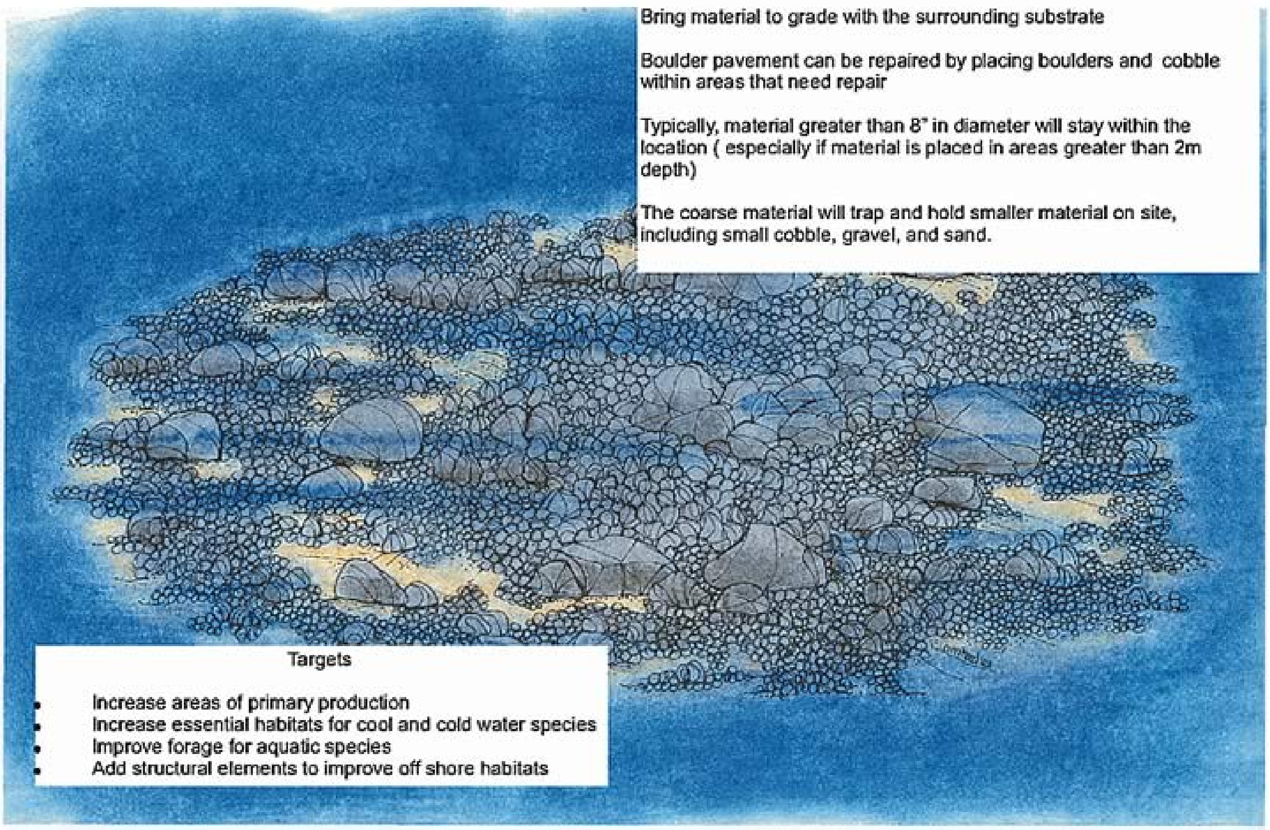
Areas that require improvement are typically identified along the Scarborough shoreline by shallow depressions with a clay substrate. The historic removal of aggregates and boulders exposed clay sediment that over time weathered into shallow depressions. These depressions range in size from small ($2m^2$) to large (thousands of square metres). Typically these areas are in water depth of less than 5 m deep



Targets

- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic species
- Add structural elements to improve off shore habitats

RESTORATION TECHNIQUE: Offshore Boulder Pavement Repair
HABITAT TYPE : Open Coast



Fill in depleted offshore areas of the boulder pavement.

Bring material to grade with the surrounding substrate

Boulder pavement can be repaired by placing boulders and cobble within areas that need repair

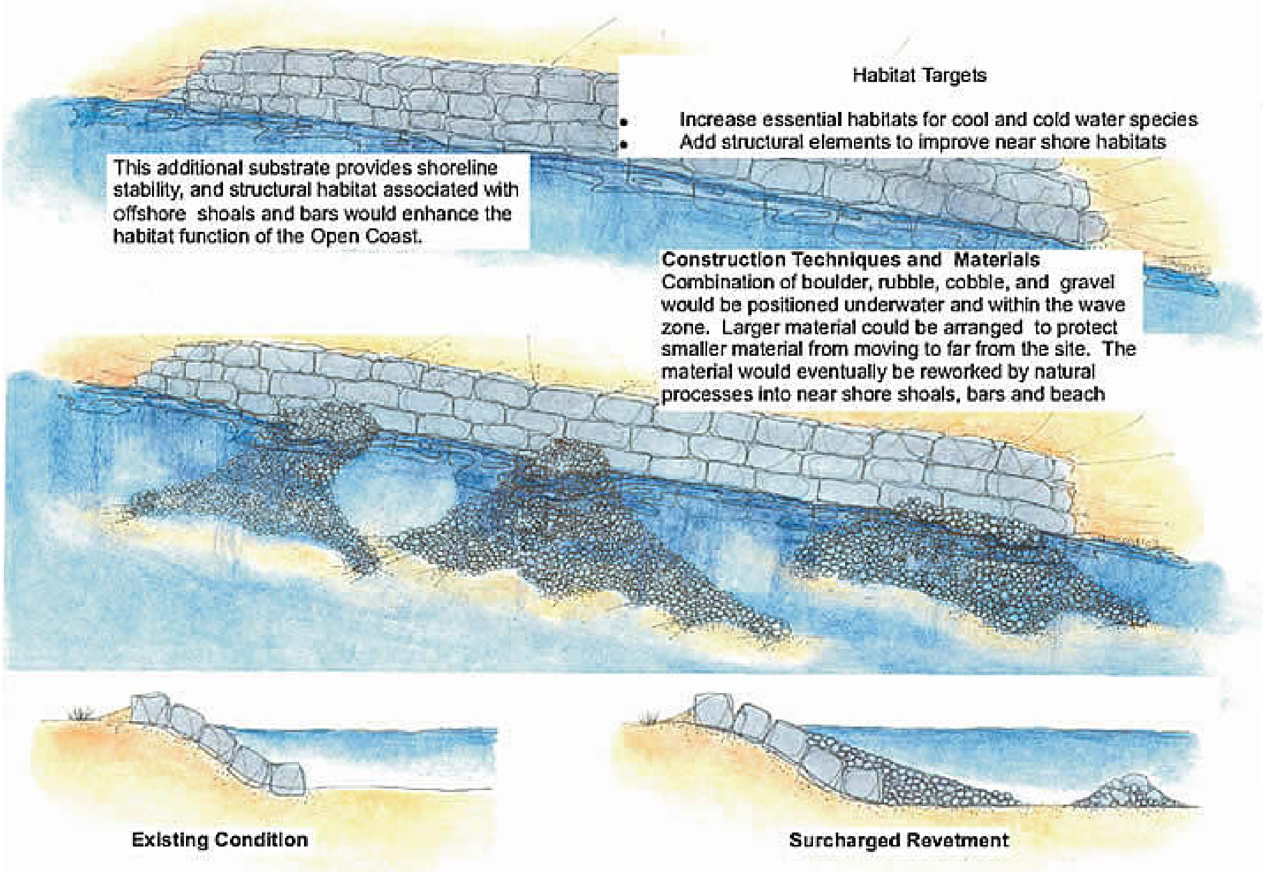
Typically, material greater than 8" in diameter will stay within the location (especially if material is placed in areas greater than 2m depth)

The coarse material will trap and hold smaller material on site, including small cobble, gravel, and sand.

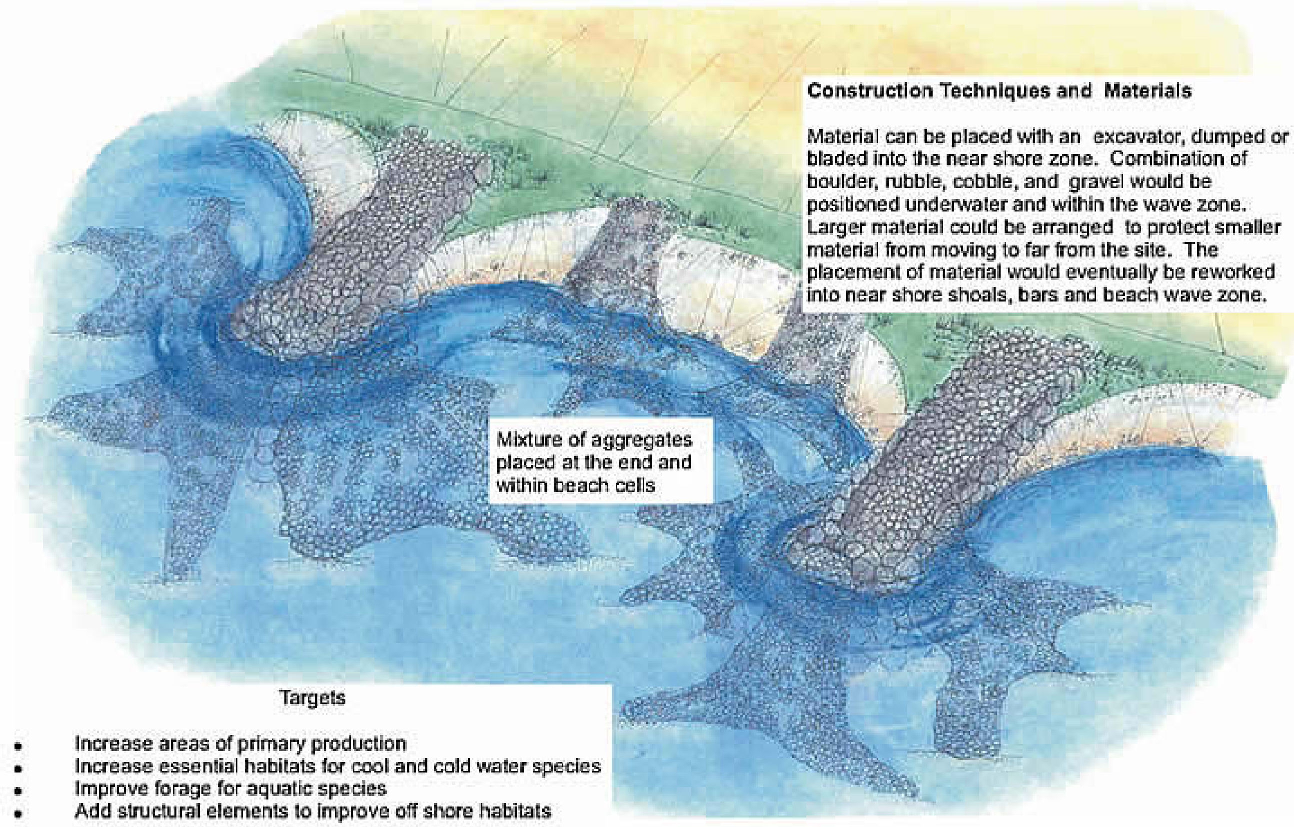
Targets

- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic species
- Add structural elements to improve off shore habitats

RESTORATION TECHNIQUE: Surcharged Open Coast Revetment
HABITAT TYPE : Open Coast



RESTORATION TECHNIQUE: Surcharged Open Coast Groyne
HABITAT TYPE : Open Coast



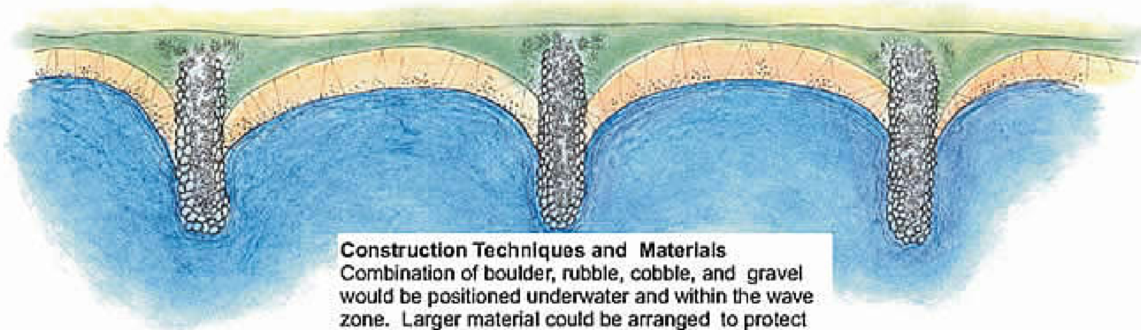
Construction Techniques and Materials

Material can be placed with an excavator, dumped or bladed into the near shore zone. Combination of boulder, rubble, cobble, and gravel would be positioned underwater and within the wave zone. Larger material could be arranged to protect smaller material from moving to far from the site. The placement of material would eventually be reworked into near shore shoals, bars and beach wave zone.

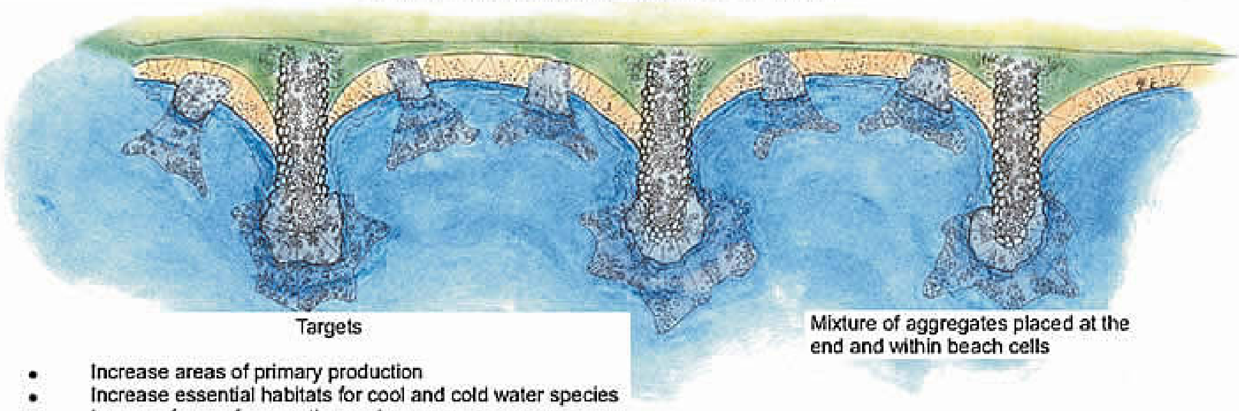
Targets

- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic species
- Add structural elements to improve off shore habitats

RESTORATION TECHNIQUE: Surcharged Open Coast Groyne
HABITAT TYPE : Open Coast



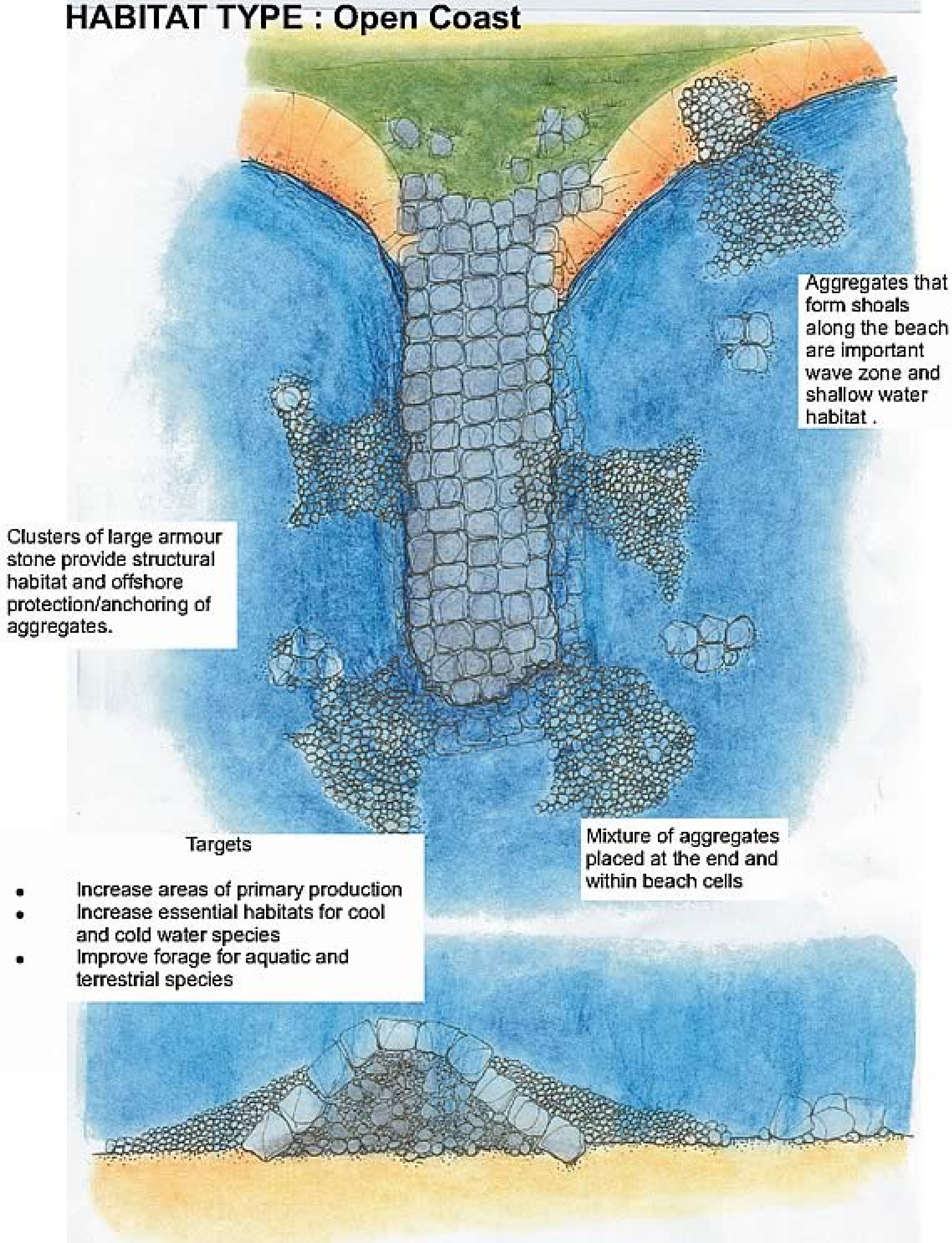
Construction Techniques and Materials
Combination of boulder, rubble, cobble, and gravel would be positioned underwater and within the wave zone. Larger material could be arranged to protect smaller material from moving to far from the site. The placement of material would eventually be reworked into near shore shoals, bars and beach wave zone.



Targets

- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic species
- Add structural elements to improve off shore habitats

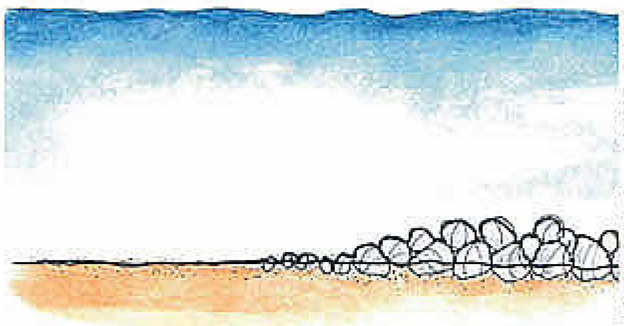
RESTORATION TECHNIQUE: Surcharged Groynes
HABITAT TYPE : Open Coast



Targets

- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species

RESTORATION TECHNIQUE: Underwater Reefs
HABITAT TYPE : Sheltered Embayments / Open Coast



GOOD

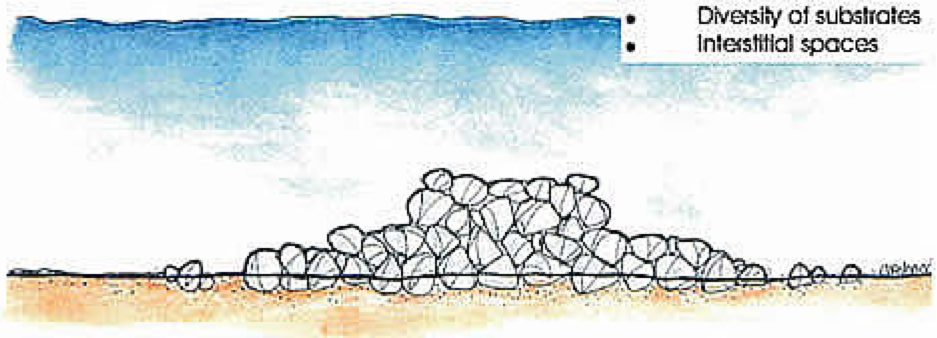
Construction Techniques and Materials

Use a variety of material to create underwater reefs

Quarried stone and aggregates, concrete, brick rubble and other inert building materials

Reefs are deployed to create:

- Vertical relief to bottom topography
- Irregular outline
- Diversity of substrates
- Interstitial spaces



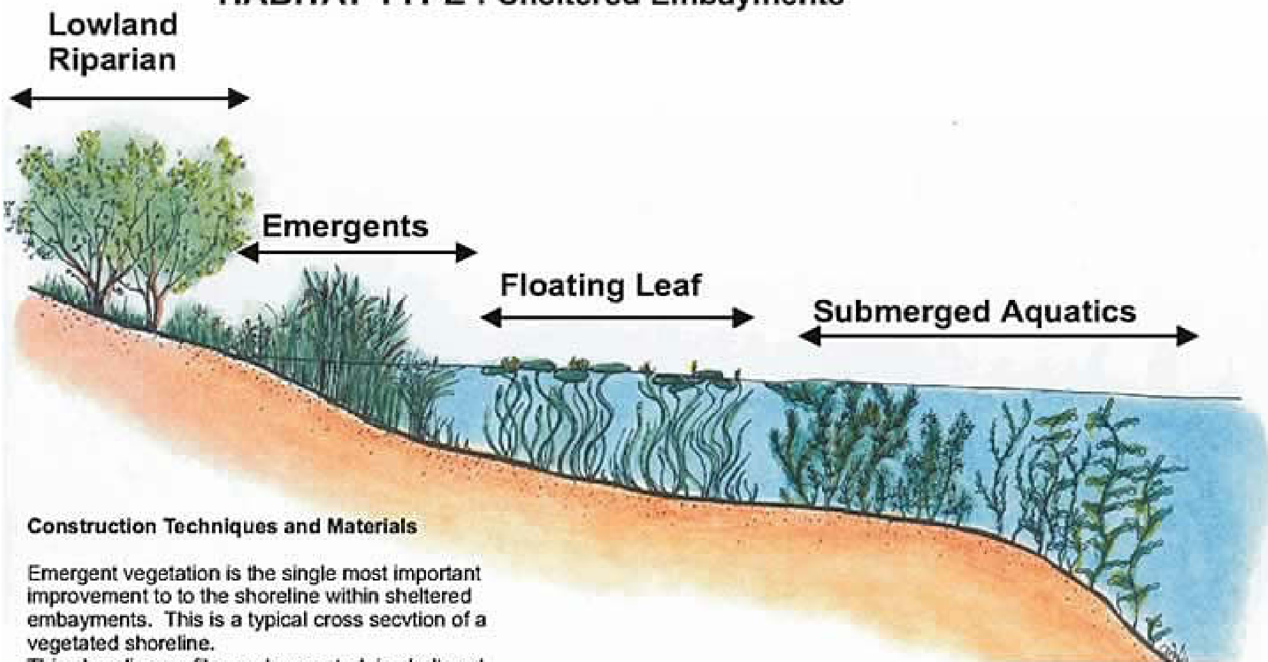
BETTER

BEST

Targets

- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic species
- Add structural elements to improve off shore habitats

RESTORATION TECHNIQUE: Vegetation Zones
HABITAT TYPE : Sheltered Embayments



Construction Techniques and Materials

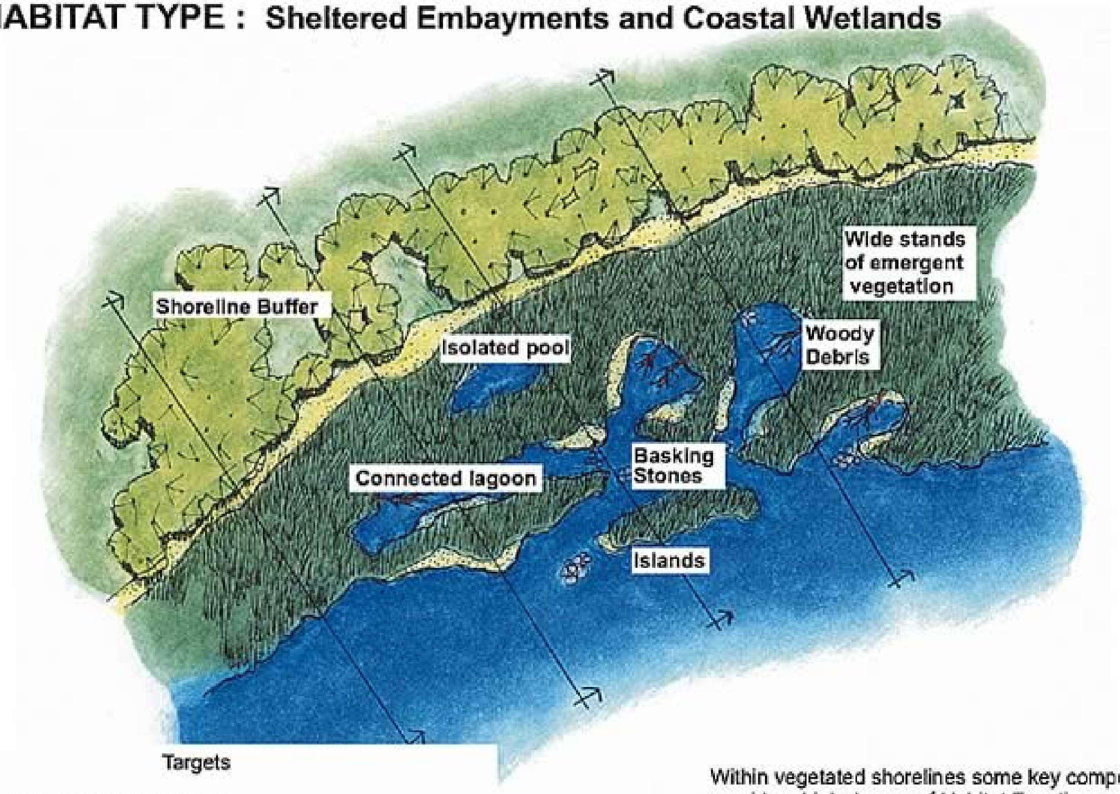
Emergent vegetation is the single most important improvement to to the shoreline within sheltered embayments. This is a typical cross secvtion of a vegetated shoreline.
This shoreline profile can be created in sheltered embayments when:

- The location fetch is low
- Waves are attenuated
- Proper substrates are in place
- Elevations are graded to the specific water levels and corresponding water levels.
- Construction can focus on creating substrate elevations favourable to various wetland

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Reduce carp biomass
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Vegetated Shorelines Components
HABITAT TYPE : Sheltered Embayments and Coastal Wetlands



Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Reduce carp biomass
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

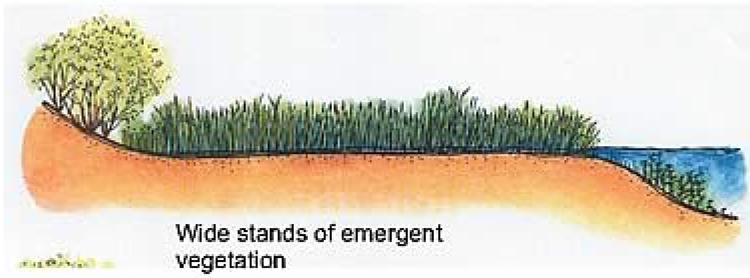
Within vegetated shorelines some key components provide a high degree of Habitat Function:

- Broad stands of emergent vegetation
- Lagoons
- Isolated openings
- Islands and backshore areas

RESTORATION TECHNIQUE: Contour Modification Vegetated Shoreline Cross Sections

HABITAT TYPE : Sheltered Embayments and Coastal Wetlands

A



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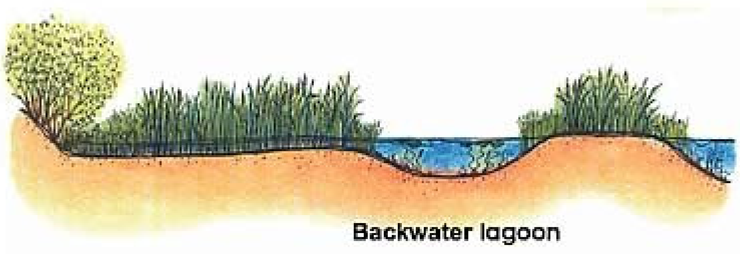

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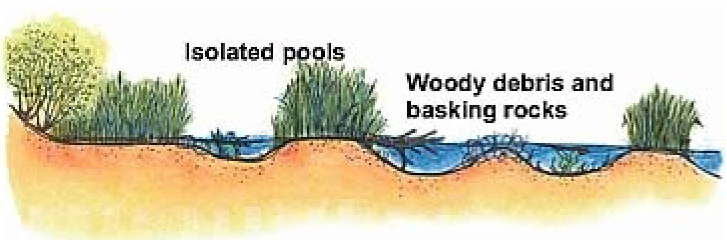

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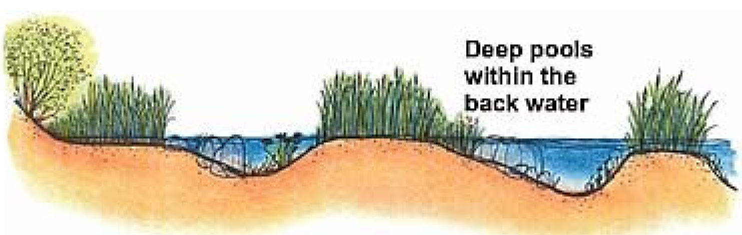
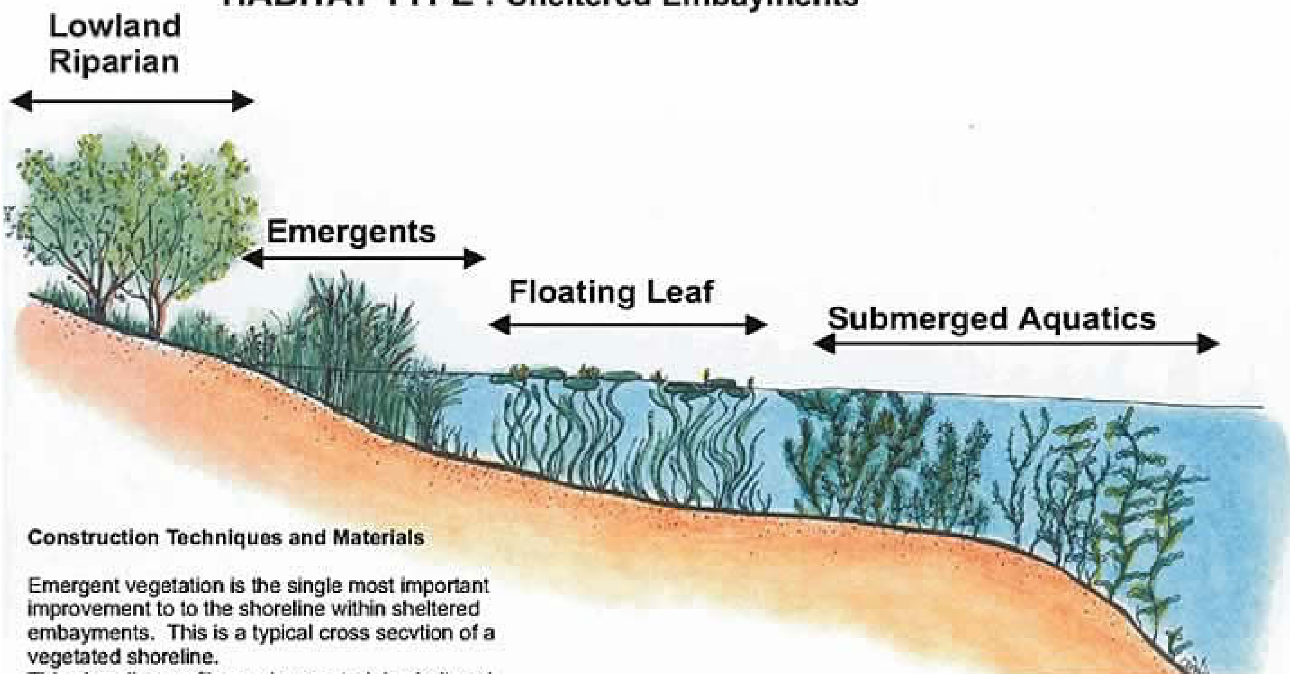


Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Vegetation Zones
HABITAT TYPE : Sheltered Embayments



Construction Techniques and Materials

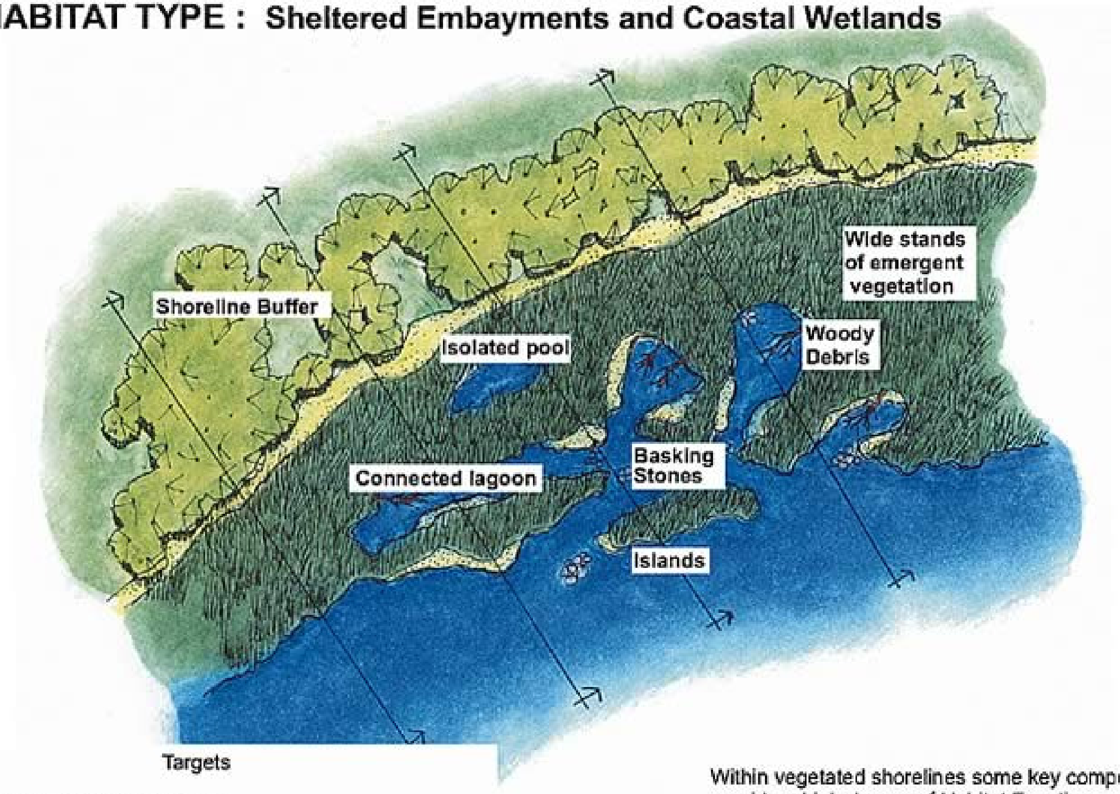
Emergent vegetation is the single most important improvement to to the shoreline within sheltered embayments. This is a typical cross secvtion of a vegetated shoreline.
This shoreline profile can be created in sheltered embayments when:

- The location fetch is low
- Waves are attenuated
- Proper substrates are in place
- Elevations are graded to the specific water levels and corresponding water levels.
- Construction can focus on creating substrate elevations favourable to various wetland

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Reduce carp biomass
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Vegetated Shorelines Components
HABITAT TYPE : Sheltered Embayments and Coastal Wetlands



Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Reduce carp biomass
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

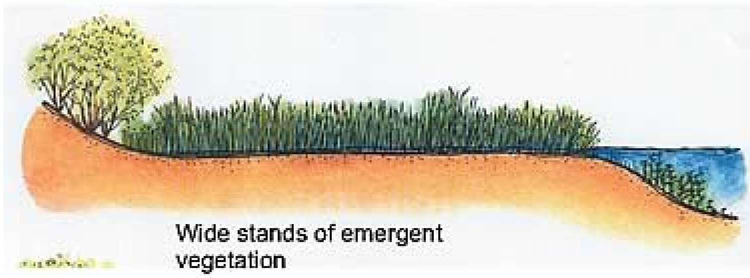
Within vegetated shorelines some key components provide a high degree of Habitat Function:

- Broad stands of emergent vegetation
- Lagoons
- Isolated openings
- Islands and backshore areas

RESTORATION TECHNIQUE: **Contour Modification Vegetated Shoreline Cross Sections**

HABITAT TYPE : **Sheltered Embayments and Coastal Wetlands**

A



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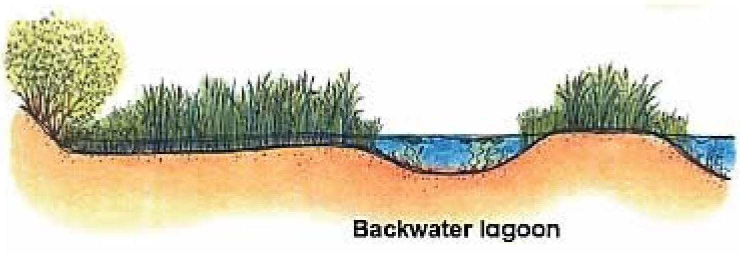

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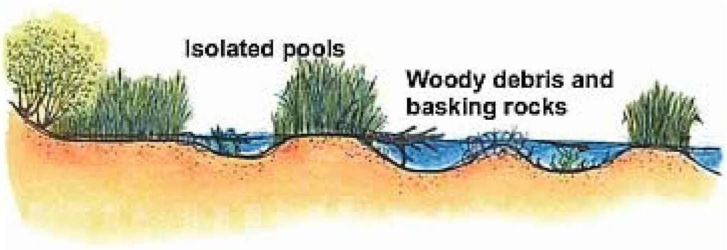

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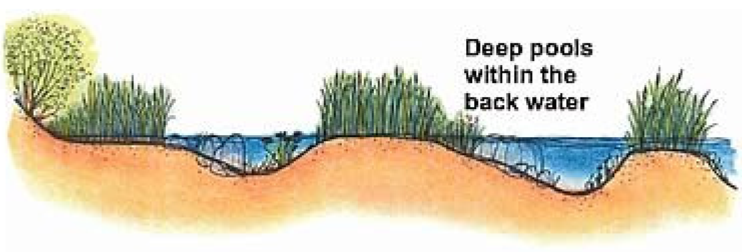

Targets

- Improve emergent vegetation
- Improve submergent vegetation
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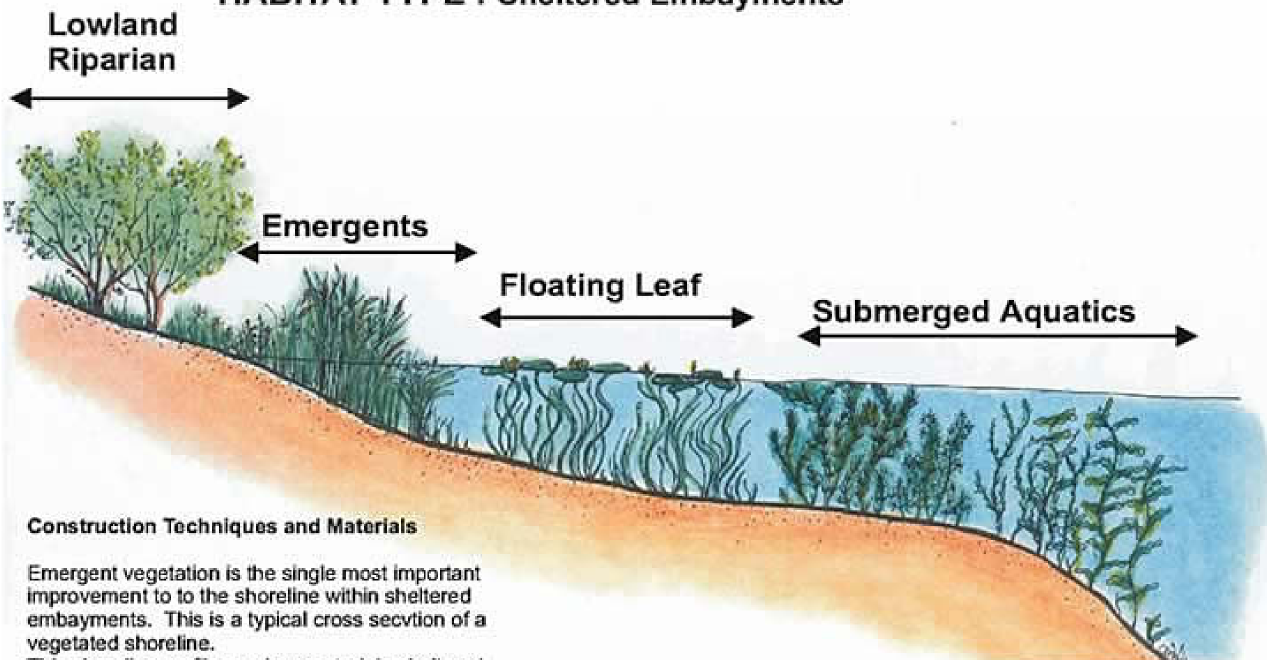
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Vegetation Zones
HABITAT TYPE : Sheltered Embayments



Construction Techniques and Materials

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This shoreline profile can be created in sheltered embayments when:

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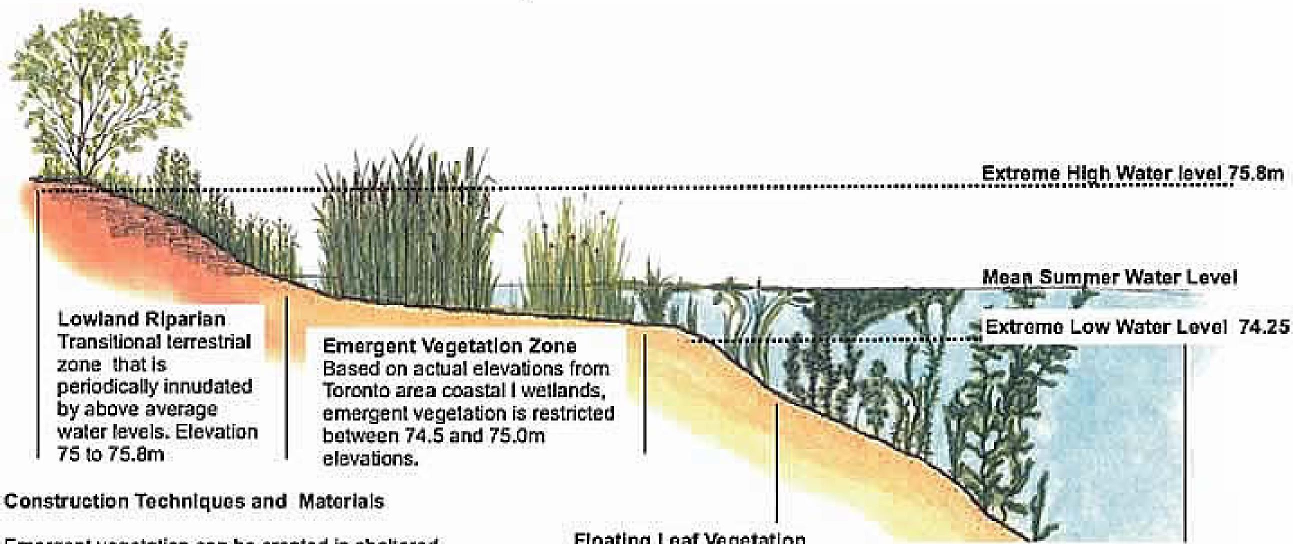
- Proper substrates are in place
- Elevations are graded to the specific water levels and corresponding water levels.
- Construction can focus on creating substrate elevations favourable to various wetland

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Reduce carp biomass
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Wetland Shoreline Profile and Water Levels
HABITAT TYPE: Sheltered Embayments



Construction Techniques and Materials

Emergent vegetation can be created in sheltered embayments when the fetch is low and efforts are made to attenuate waves. Construction can focus on creating substrate elevations favourable to various wetland vegetation types. Substrates types are less critical than elevations and plants establish well on clean fill and or sand.

Targets

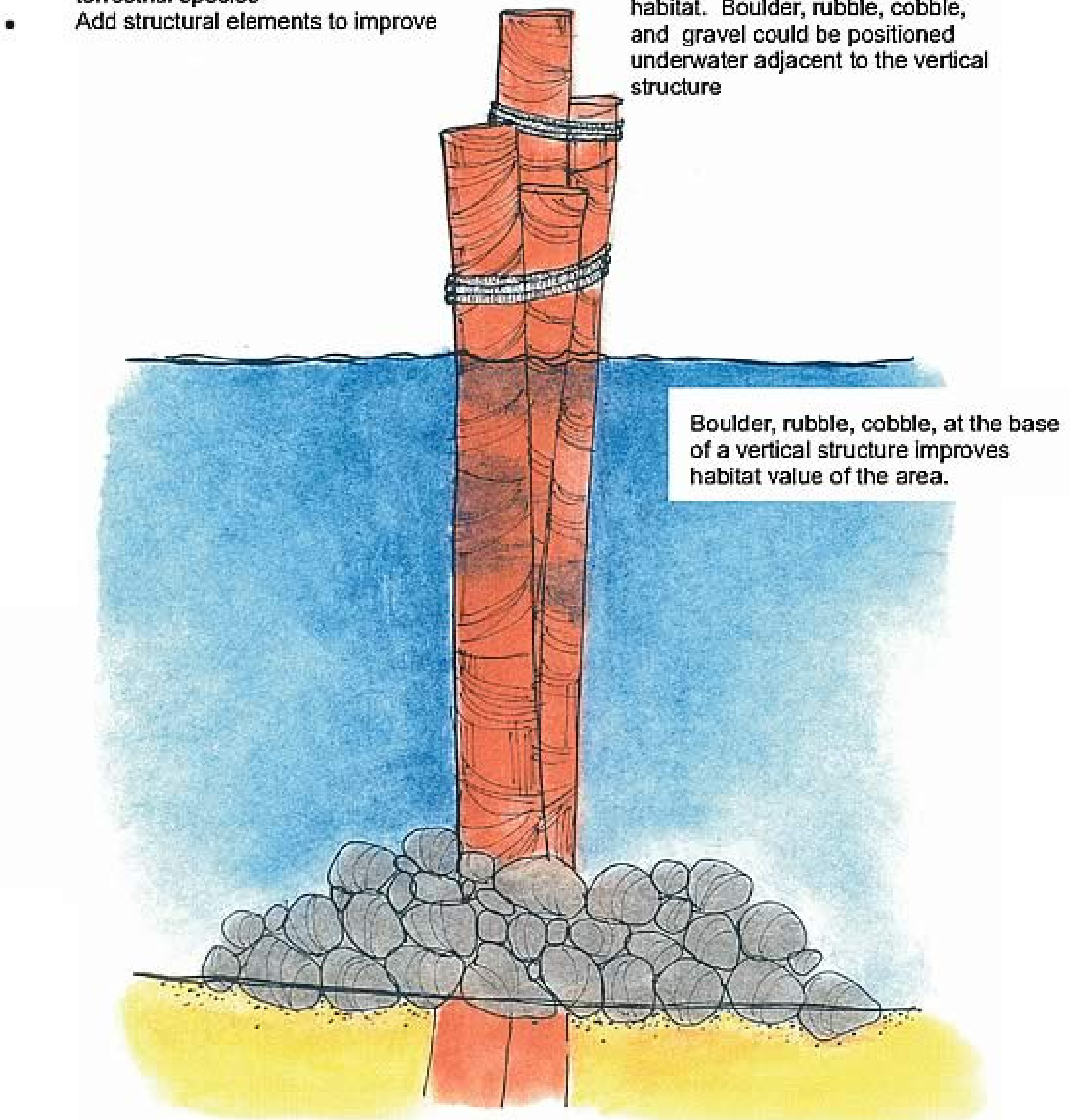
- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Log piles
HABITAT TYPE : Sheltered Embayments

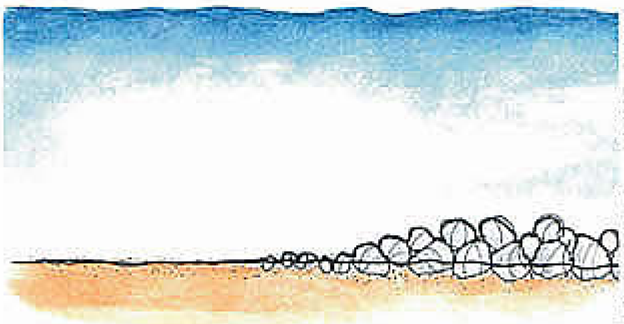
Targets

- Improve forage for aquatic and terrestrial species
- Add structural elements to improve

Construction Techniques and Materials
Any structural pile, caisson, or footing can be improved for aquatic habitat. Boulder, rubble, cobble, and gravel could be positioned underwater adjacent to the vertical structure



RESTORATION TECHNIQUE: Underwater Reefs
HABITAT TYPE : Sheltered Embayments / Open Coast



GOOD

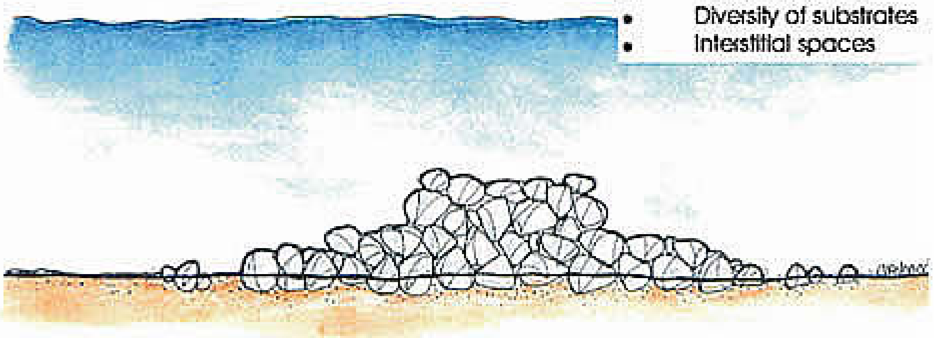
Construction Techniques and Materials

Use a variety of material to create underwater reefs

Quarried stone and aggregates, concrete, brick rubble and other inert building materials

Reefs are deployed to create:

- Vertical relief to bottom topography
- Irregular outline
- Diversity of substrates
- Interstitial spaces

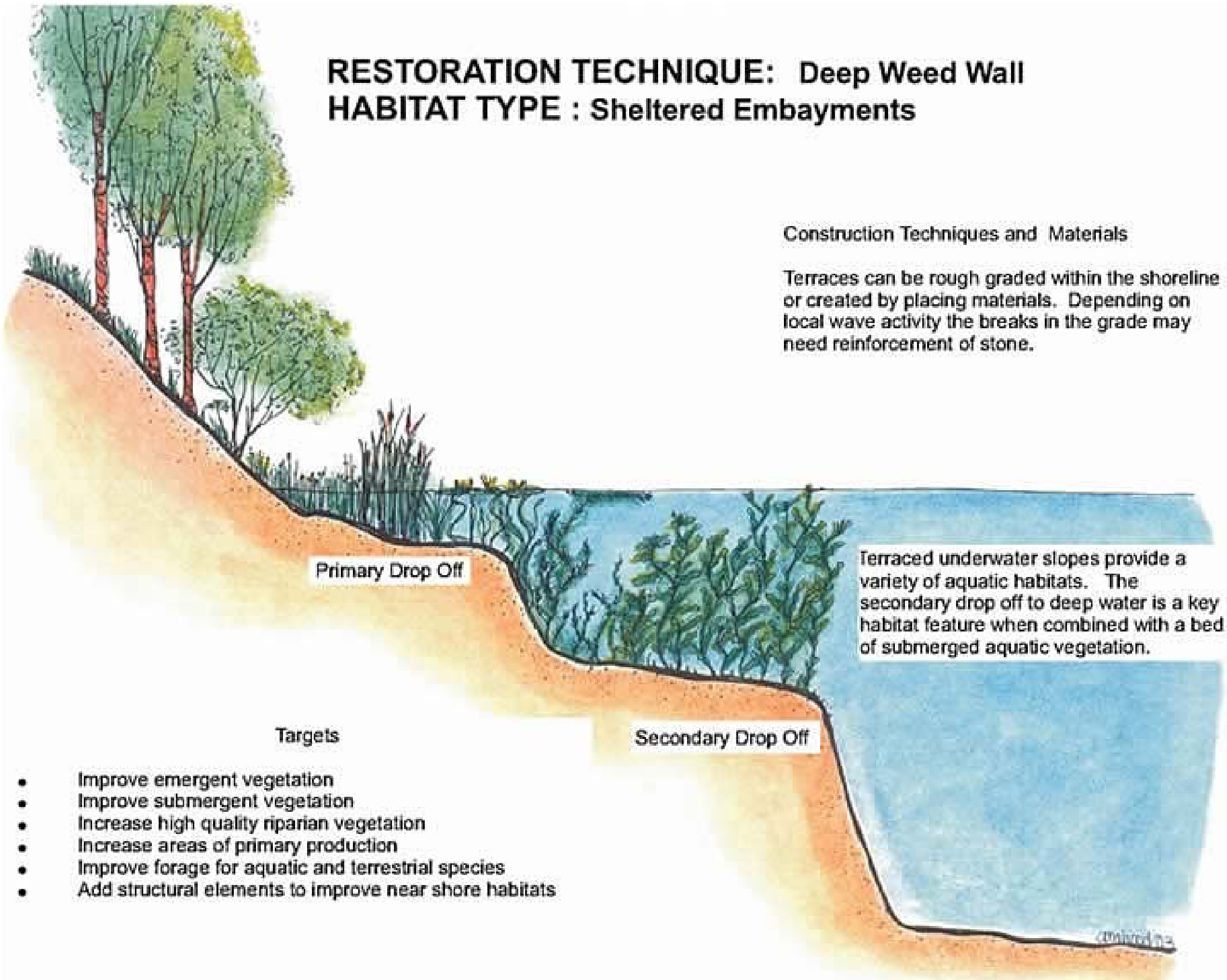


BETTER

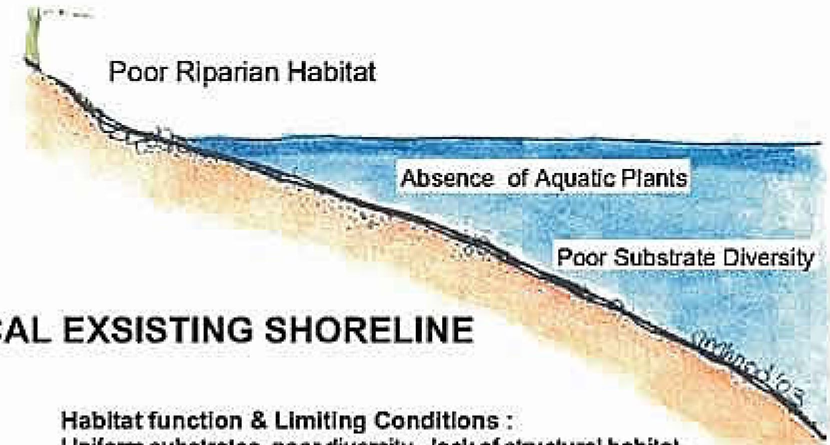
BEST

Targets

- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic species
- Add structural elements to improve off shore habitats

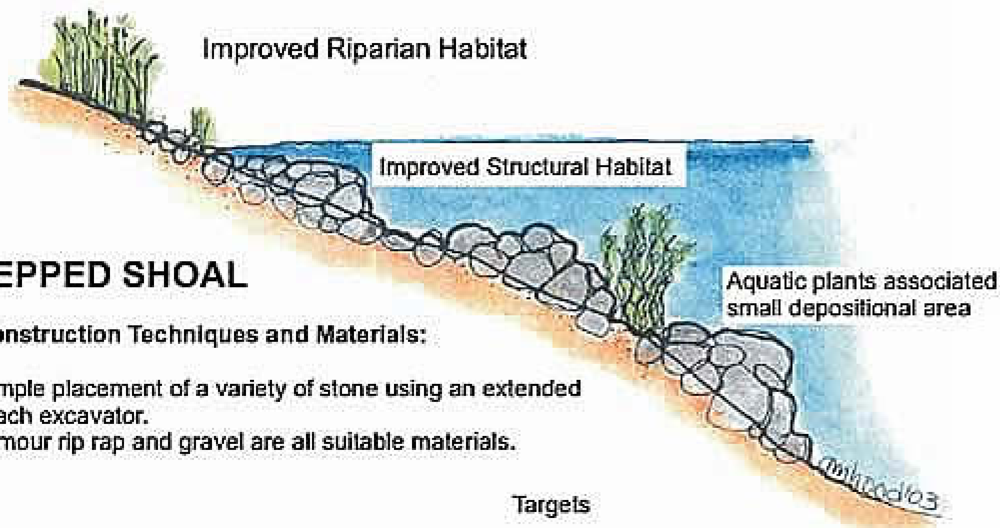

RESTORATION TECHNIQUE: Deep Weed Wall
HABITAT TYPE : Sheltered Embayments
Construction Techniques and Materials
Terraces can be rough graded within the shoreline or created by placing materials. Depending on local wave activity the breaks in the grade may need reinforcement of stone.
Primary Drop Off
Terraced underwater slopes provide a variety of aquatic habitats. The secondary drop off to deep water is a key habitat feature when combined with a bed of submerged aquatic vegetation.
Targets
• Improve emergent vegetation
• Improve submergent vegetation
• Increase high quality riparian vegetation
• Increase areas of primary production
• Improve forage for aquatic and terrestrial species
• Add structural elements to improve near shore habitats
Secondary Drop Off

RESTORATION TECHNIQUE: Shoreline Shoal Sections
HABITAT TYPE : Sheltered Embayments



TYPICAL EXSISTING SHORELINE

Habitat function & Limiting Conditions :
Uniform substrates, poor diversity, lack of structural habitat, favours opportunistic species like mature carp and sucker, overall poor productivity



STEPPED SHOAL

Construction Techniques and Materials:

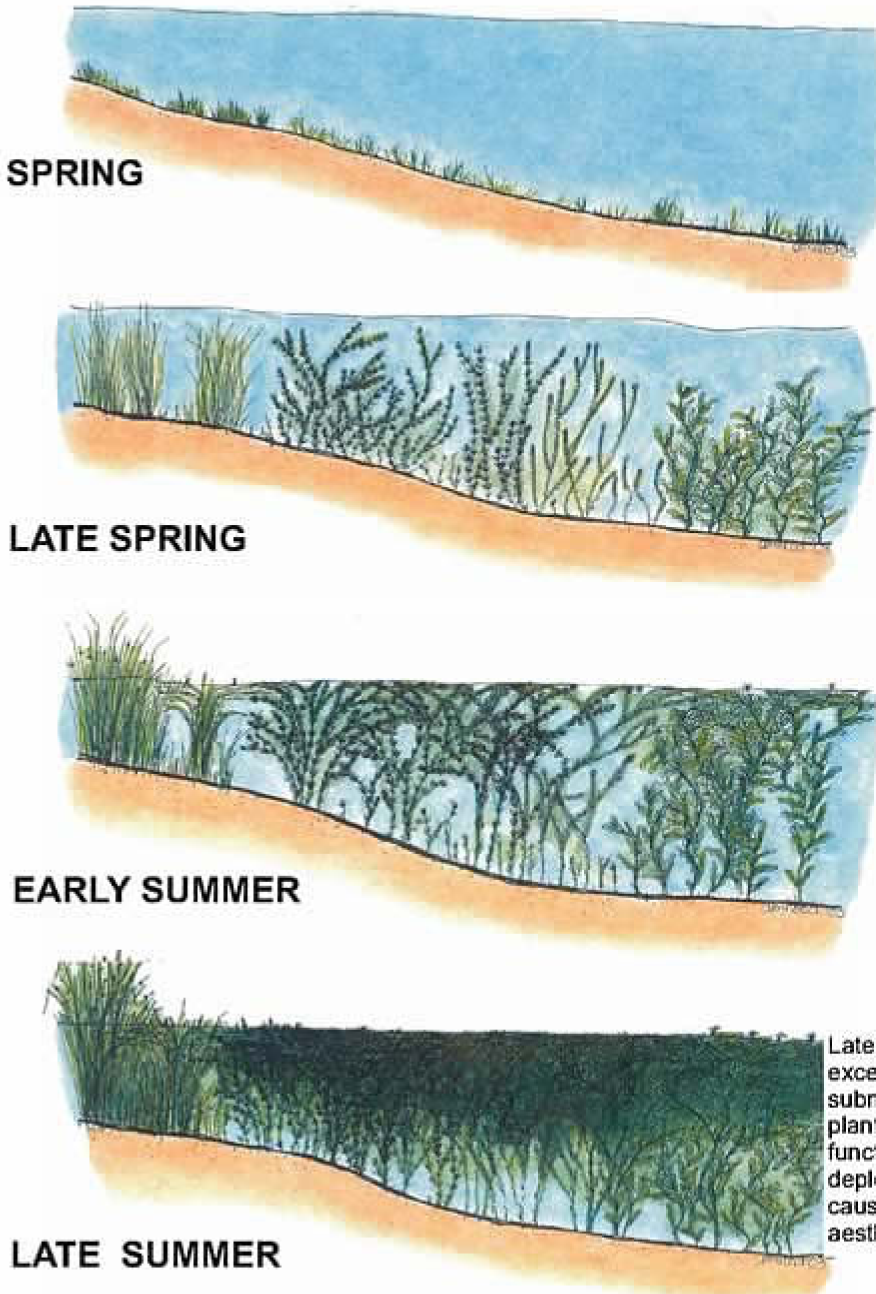
Simple placement of a variety of stone using an extended reach excavator.
Armour rip rap and gravel are all suitable materials.

Targets

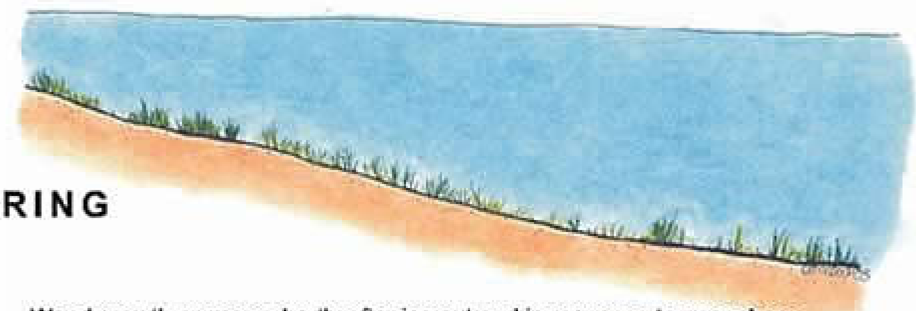
- Improve emergent vegetation
- Improve submergent vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Seasonal Growth of Submerged Aquatic Vegetation

HABITAT TYPE : Sheltered Embayments



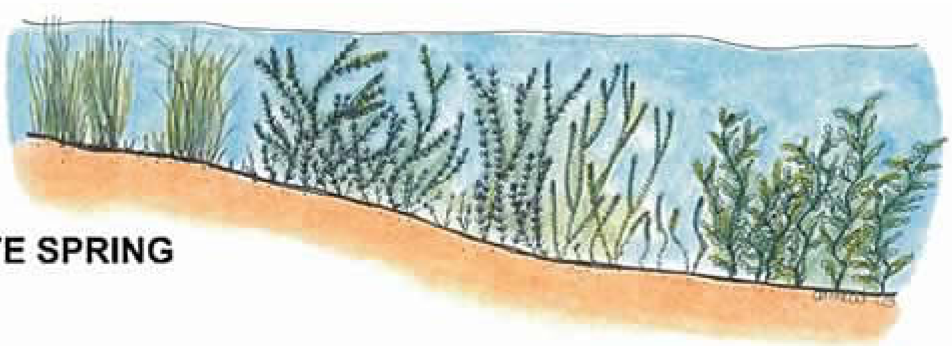
RESTORATION TECHNIQUE: Seasonal Growth of Submerged Aquatic Vegetation
HABITAT TYPE : Sheltered Embayments



SPRING

Weed growth appears shortly after ice out and in response to near shore nutrients, temperature, and increased photo period.

Early growth is important for primary production



LATE SPRING

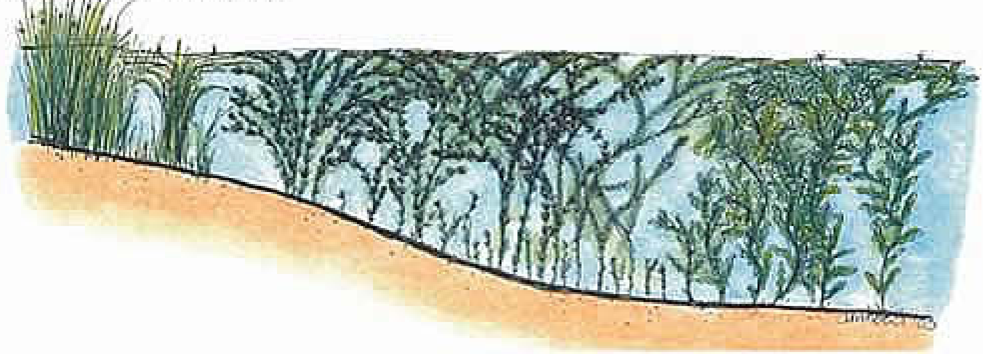
Submerged aquatic vegetation occupies ½ to 3/4 of the water column Critically important as juvenile habitat, adult cover, forage and primary production.

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Seasonal Growth of Submerged Aquatic Vegetation
HABITAT TYPE : Sheltered Embayments

EARLY SUMMER



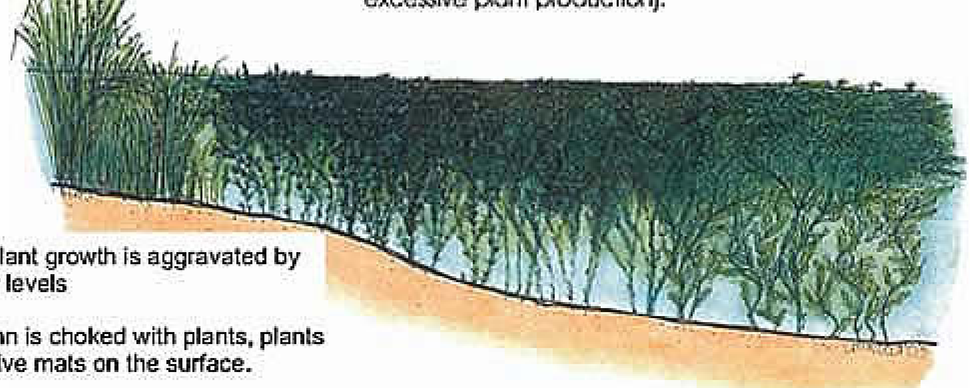
Submerged aquatic plants occupy the entire water column.

Optimum condition until plant density and biomass has not fully crowded areas within the aquatic system.

Optimum areas for cover, structural habitat value is at its peak.

Condition is limited by depth (shallow areas are prone to excessive plant production).

LATE SUMMER



Excessive plant growth is aggravated by falling water levels

Water column is choked with plants, plants form extensive mats on the surface.

Poor interstitial spaces provide low value from a cover perspective

Oxygen depletion is a localized problem

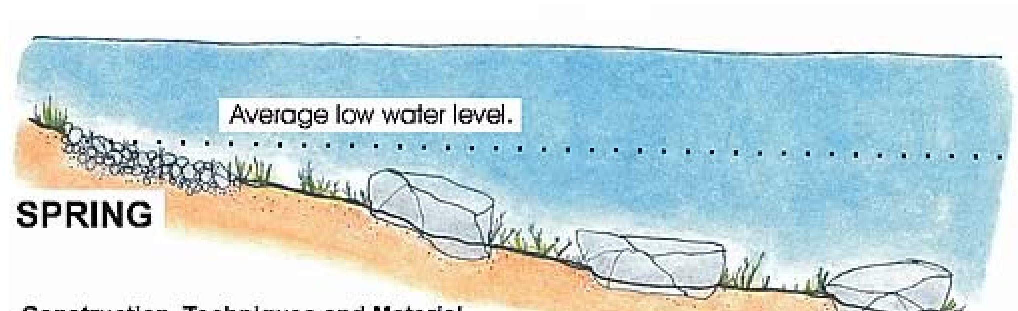
Condition is aggravated in shallow water zones

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: **Modified Growth of Submerged Aquatic Vegetation**

HABITAT TYPE : **Sheltered Embayments**



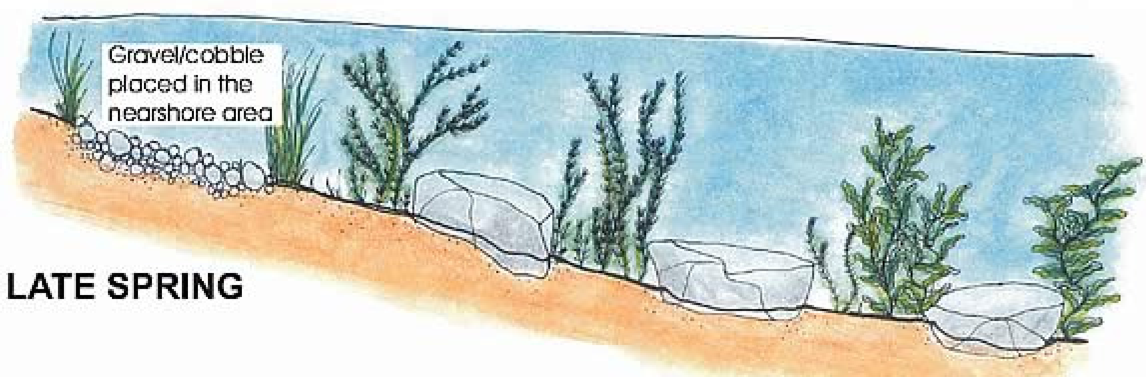
Construction Techniques and Material

Placement of aggregates and large flat rocks limit the extent of rooted aquatic vegetation

Material could also function as early season cover or spawning substrate

Large flat stones placed from shore or from a boat provide optimum coverage without impact to navigation

Gravels could be placed in areas that are exposed in low water (typically December) to enhance self cleansing

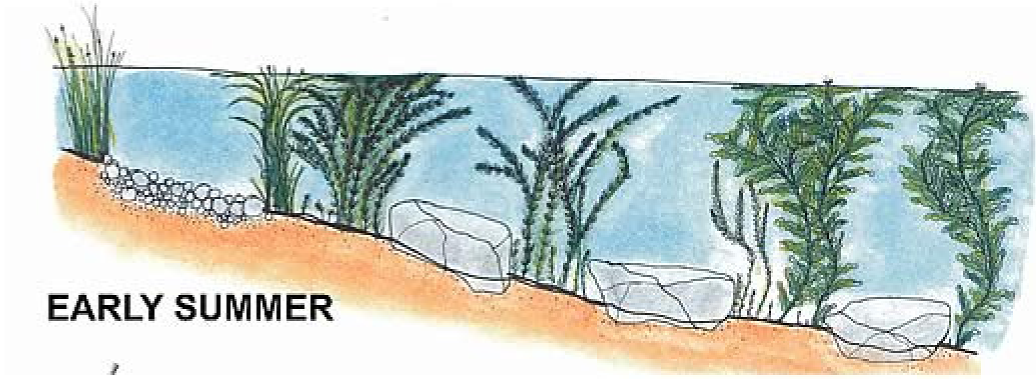


As the growing season progresses material provides areas free of submerged plants

Also provides areas within the water column that are free of vegetation which in turn dramatically increases edge habitat

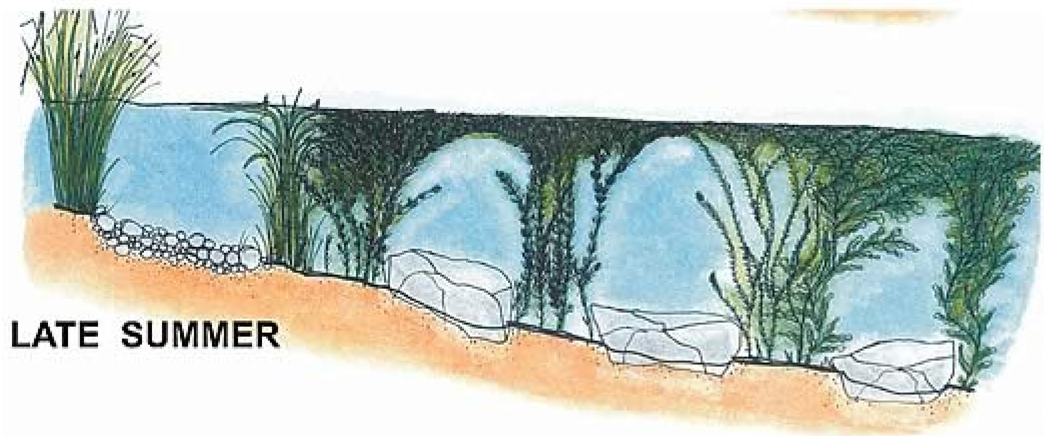
RESTORATION TECHNIQUE: Modified Growth of Submerged Aquatic Vegetation

HABITAT TYPE : Sheltered Embayments



Habitat Function and Limiting Factor

Growth of aquatic plants and the development of an edge and voids within the aquatic plants coincides with the most productive aquatic season.



Targets

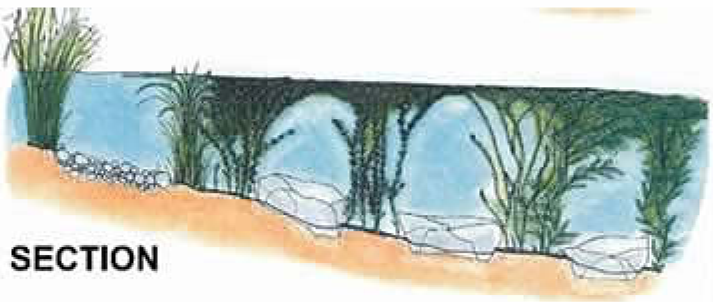
- Improve emergent vegetation
- Improve submergent vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Modified Growth of Submerged Aquatic Vegetation
HABITAT TYPE : Sheltered Embayments

Construction Techniques and Materials

Improved aquatic plant beds by limiting the late summer growth and altering uniform areas with strategic placement of stone and aggregates. Create areas of 50% open water and 50% aquatic plants ("Hemi" beds). Create edge pockets, internal voids and pathways from deep water to shallow nearshore areas.

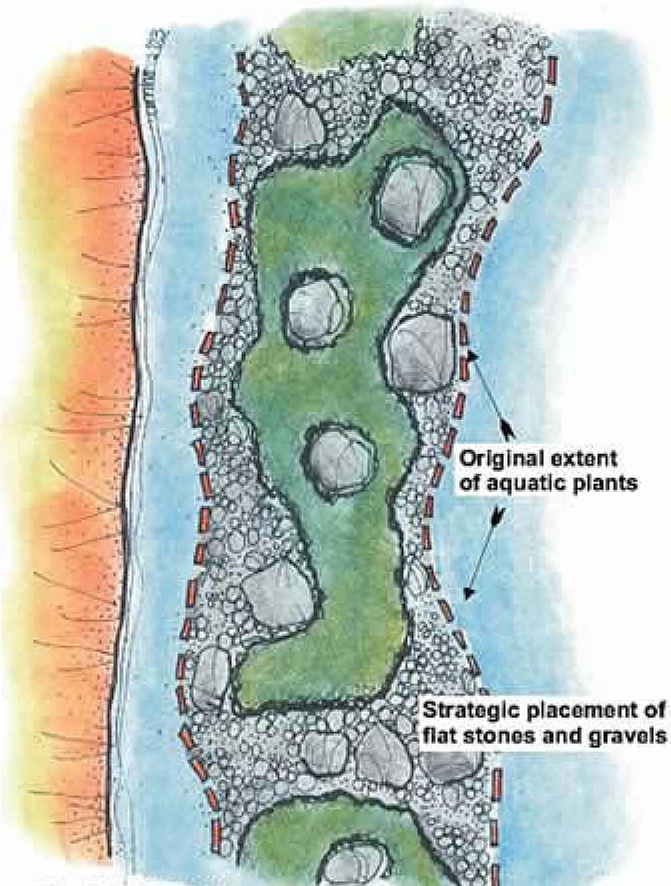
Use to improve problems associated with the aesthetic of eutrophic lagoons



SECTION

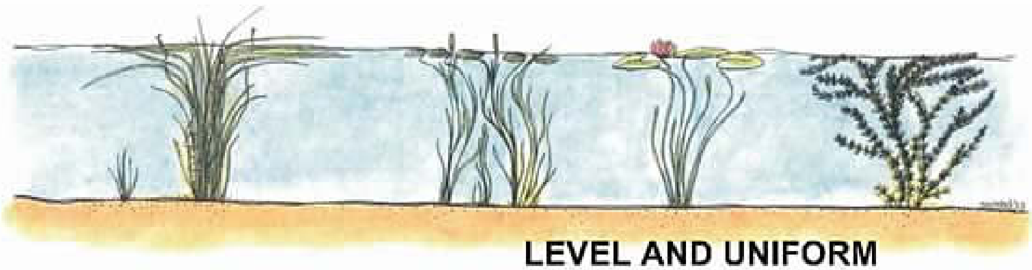
Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats



PLAN VIEW

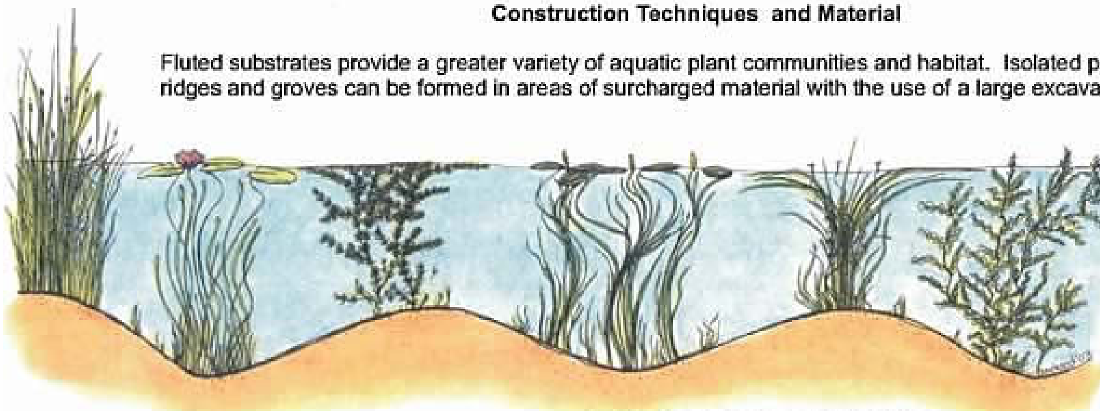
RESTORATION TECHNIQUE: Aquatic Vegetation
HABITAT TYPE : Sheltered Embayments



LEVEL AND UNIFORM

Construction Techniques and Material

Fluted substrates provide a greater variety of aquatic plant communities and habitat. Isolated pockets, ridges and groves can be formed in areas of surcharged material with the use of a large excavator .

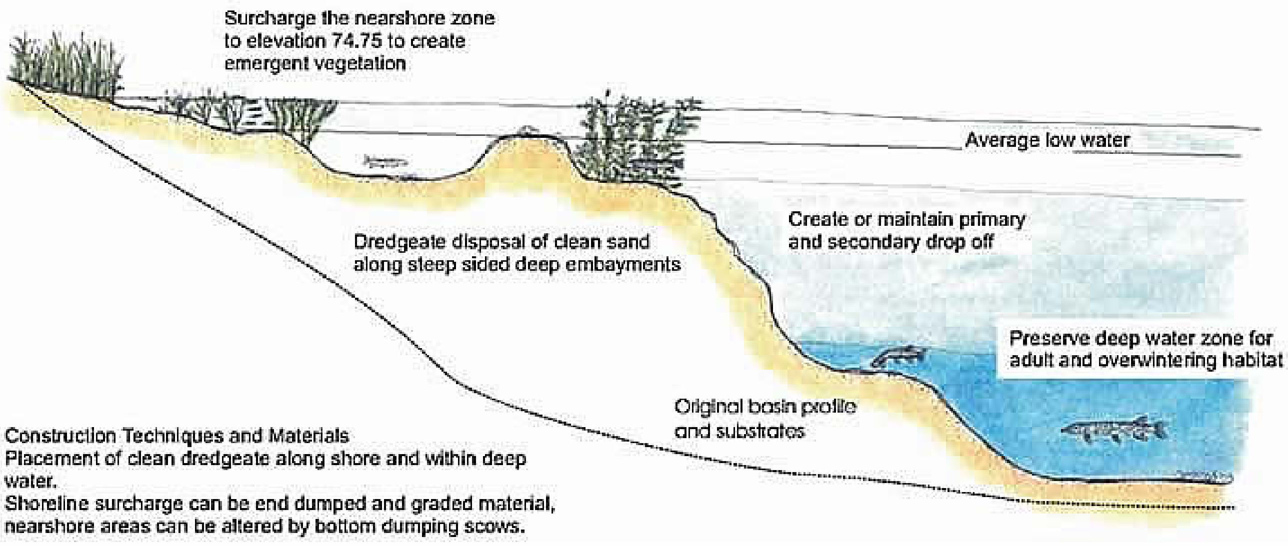


FLUTED SUBSTRATES

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species

RESTORATION TECHNIQUE: Shoreline Profile
HABITAT TYPE : Sheltered Embayments



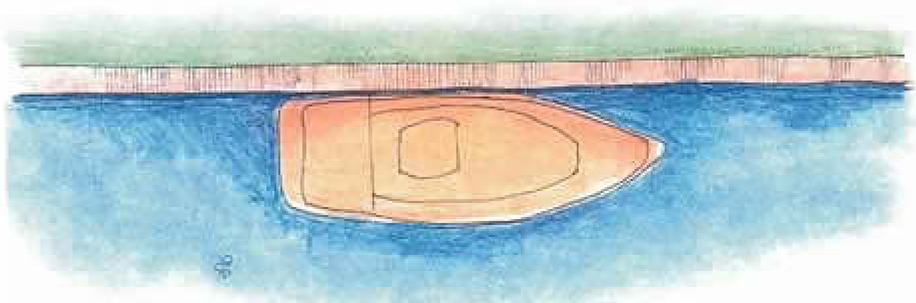
Construction Techniques and Materials
Placement of clean dredgeate along shore and within deep water.
Shoreline surcharge can be end dumped and graded material, nearshore areas can be altered by bottom dumping scows.

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

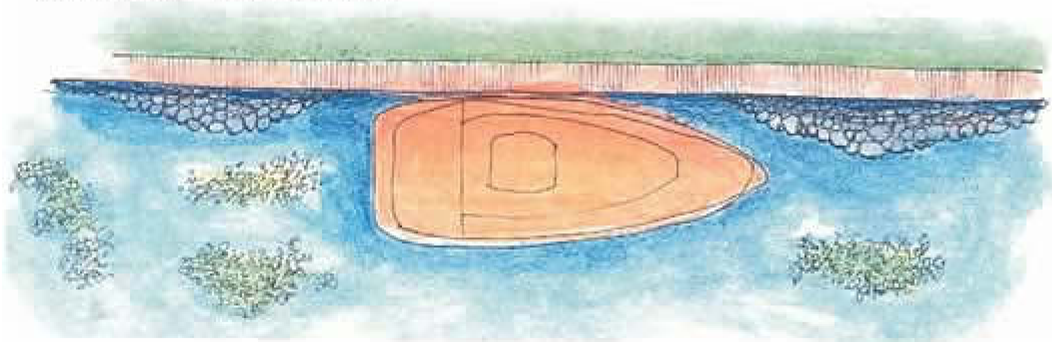
RESTORATION TECHNIQUE: Inner Habour Treatment
HABITAT TYPE: Sheltered Embayments Vertical Seawalls

Existing Conditions



Existing conditions have poor structural habitat, habitat function improves with colonization of aquatic plants

Improved Conditions

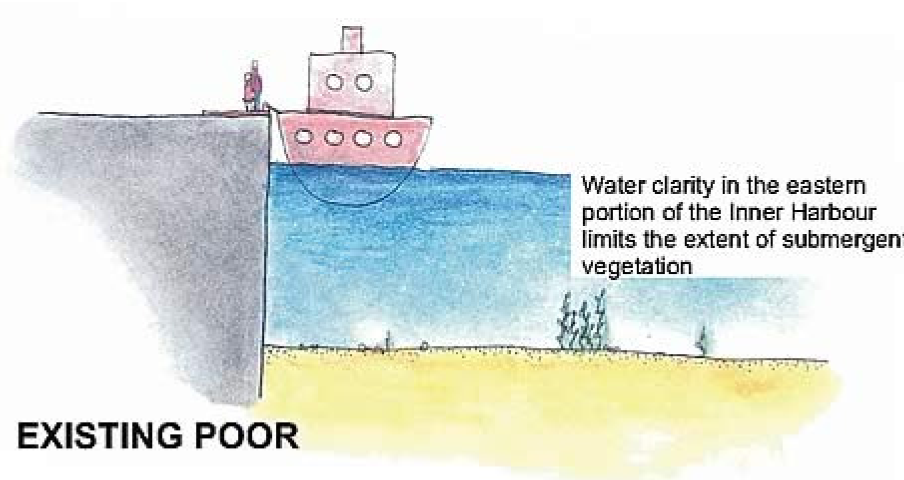


Simple Improvements include placement of material at the toe of the slope.

Targets

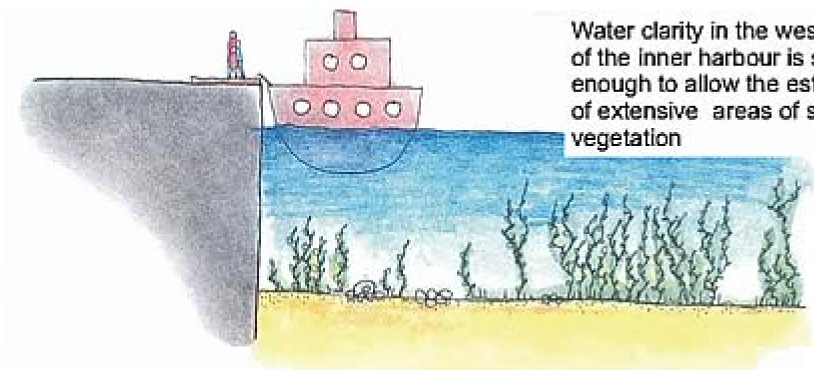
- Improve submergent vegetation
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Inner Harbour Treatment
HABITAT TYPE : Sheltered Embayments Vertical Seawalls



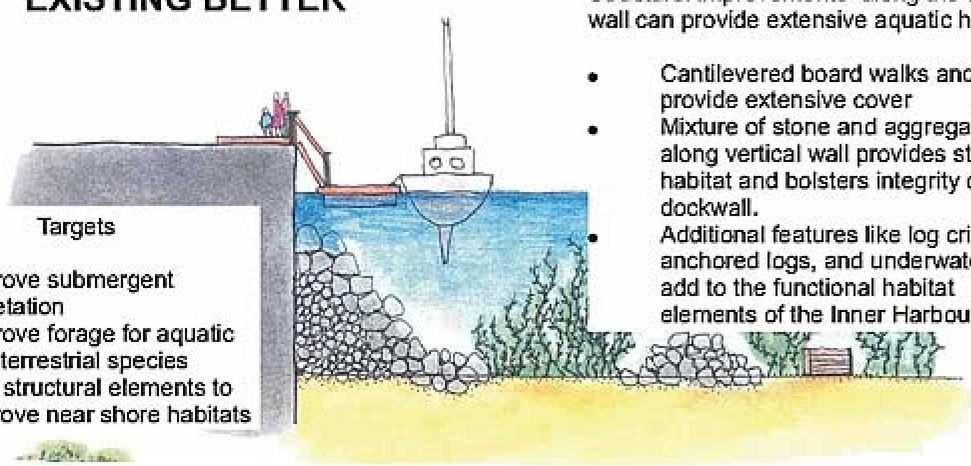
Water clarity in the eastern portion of the Inner Harbour limits the extent of submergent vegetation

EXISTING POOR



Water clarity in the western sector of the inner harbour is sufficient enough to allow the establishment of extensive areas of submergent vegetation

EXISTING BETTER



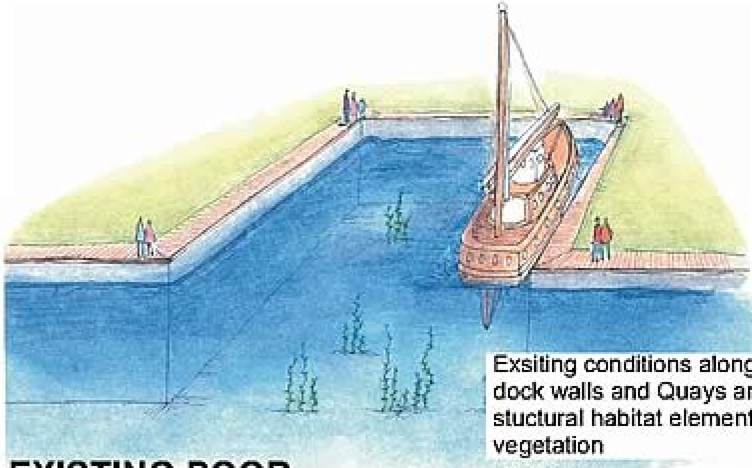
Structural improvements along the dock wall can provide extensive aquatic habitat.

- Cantilevered board walks and docks provide extensive cover
- Mixture of stone and aggregates along vertical wall provides structural habitat and bolsters integrity of the dockwall.
- Additional features like log cribs, anchored logs, and underwater cribs add to the functional habitat elements of the Inner Harbour

Targets

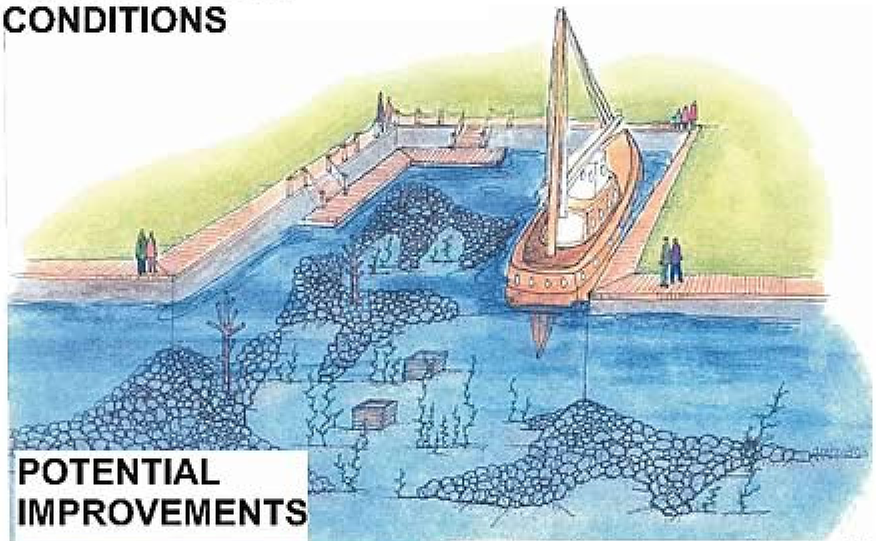
- Improve submergent vegetation
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Harbour Quay Treatment
HABITAT TYPE : Sheltered Embayment Vertical Seawalls



Exsiting conditions along the Inner Harbour dock walls and Quays are often void of stuctural habitat elements or aquatic vegetation

EXISTING POOR CONDITIONS



POTENTIAL IMPROVEMENTS

The strategic deployment of structural habitat including:

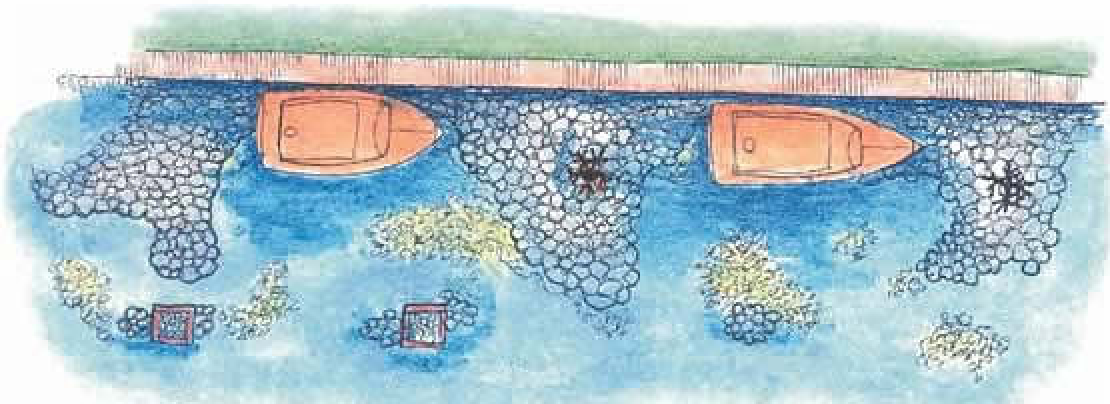
- Log Cribs
- Anchored Logs
- Floating docks and boardwalks
- And rock gravel shoals and reefs

The combination of deep water, the protection of a sheltered Quay, and the addition of structural elements would greatly improve the functional habitat within the Harbour.

Targets

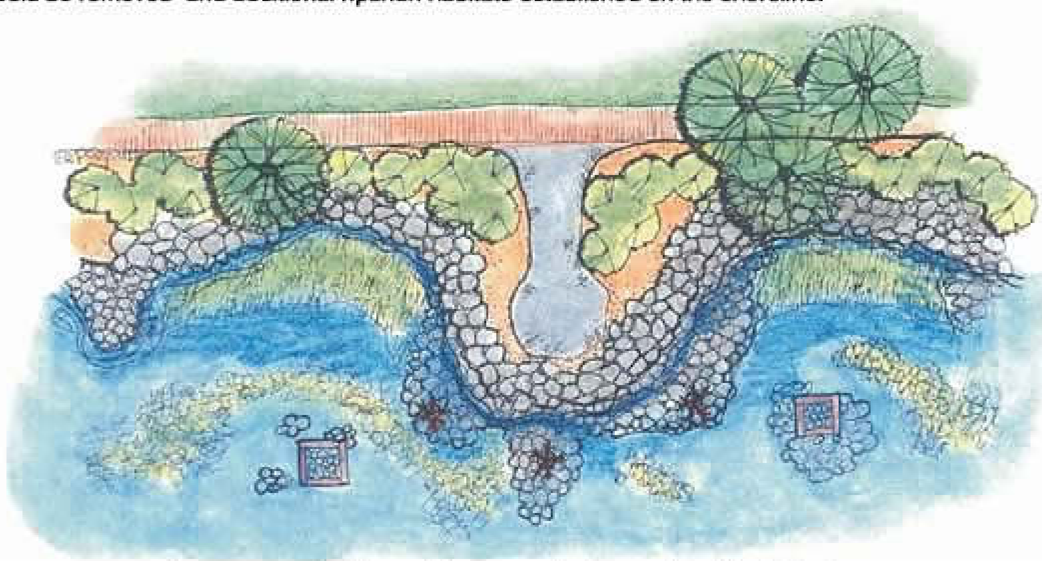
- Improve submergent vegetation
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Inner Harbour Treatment
HABITAT TYPE : Sheltered Embayments : Vertical Seawalls



Existing Seawalls with Improved Aquatic Habitat

Vertical Seawall can be improved by additional structural habitat along the existing seawall or the seawall could be removed and additional riparian habitats established on the shoreline.

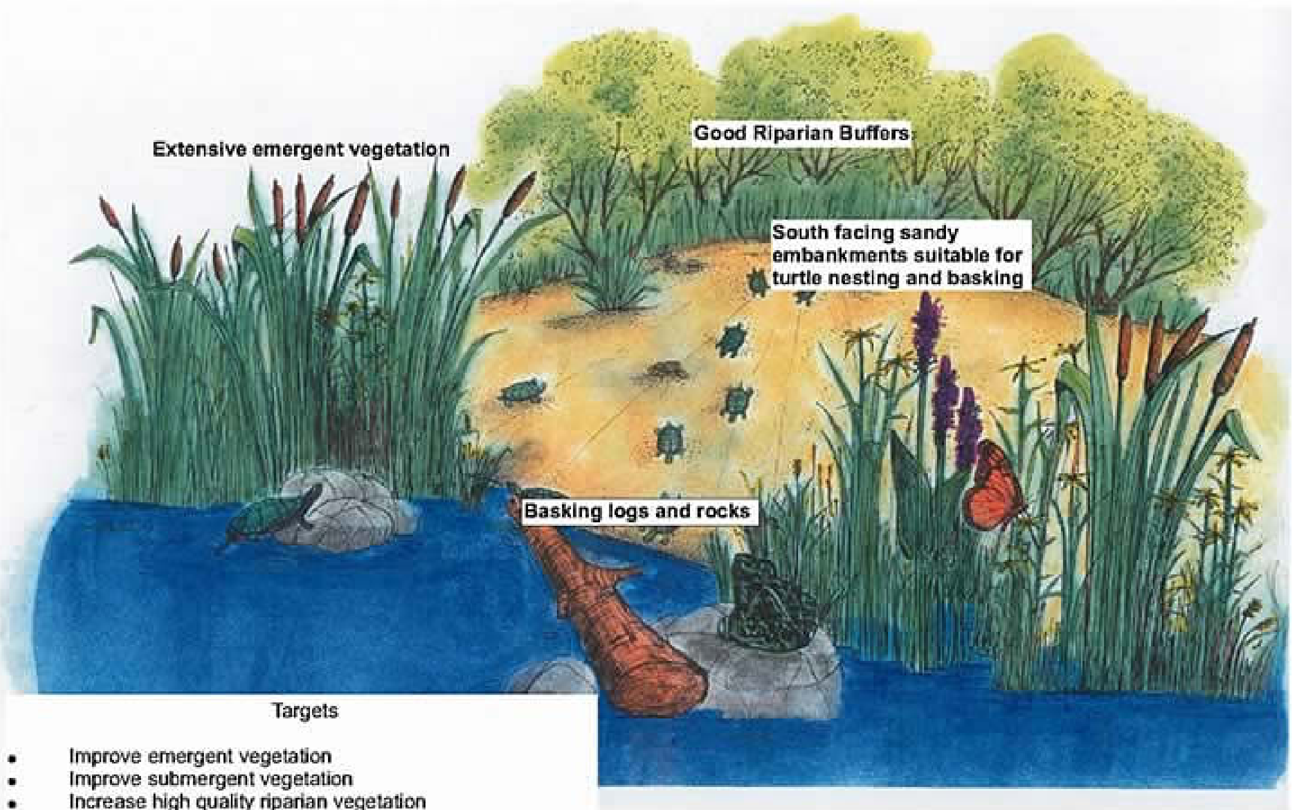


Improved Riparian and Aquatic Habitat

Targets

- Improve submergent vegetation
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

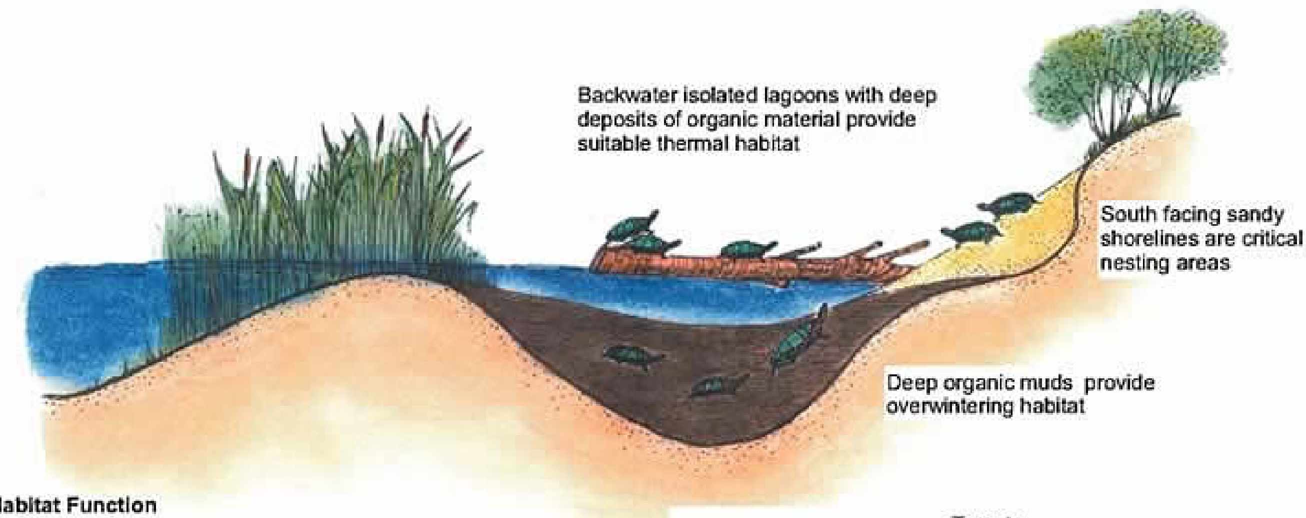
RESTORATION TECHNIQUE: Reptile/Amphibian Habitat
HABITAT TYPE: Sheltered Embayments and Coastal Wetlands



Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Reptile Habitat
HABITAT TYPE : Sheltered Embayments and Coastal Wetlands



Habitat Function

Turtle habitat is improved by a number of key factors:

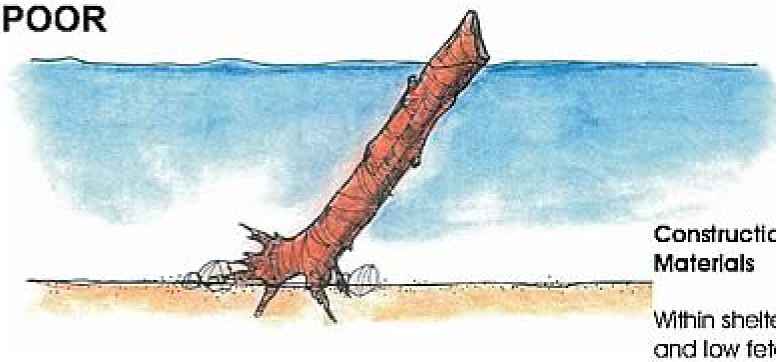
- Basking areas (rocks and logs) in back water lagoons
- Thermally isolated backwater areas that are protected from the cold lake water.
- South facing shoreline exposures and areas of sandy shoreline suitable for nesting
- Deep deposits of organic material that are suitable for overwintering

Targets

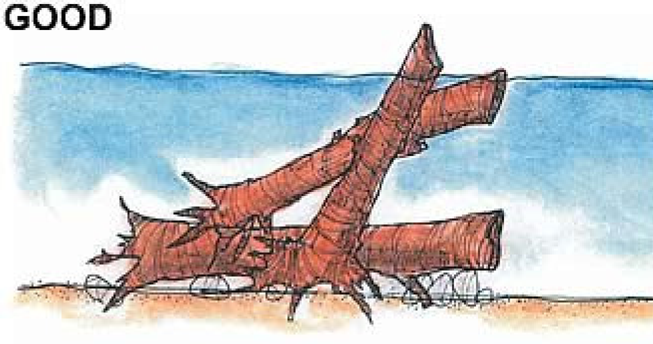
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Log Tangles
HABITAT TYPE : Sheltered Embayments / Coastal Wetlands

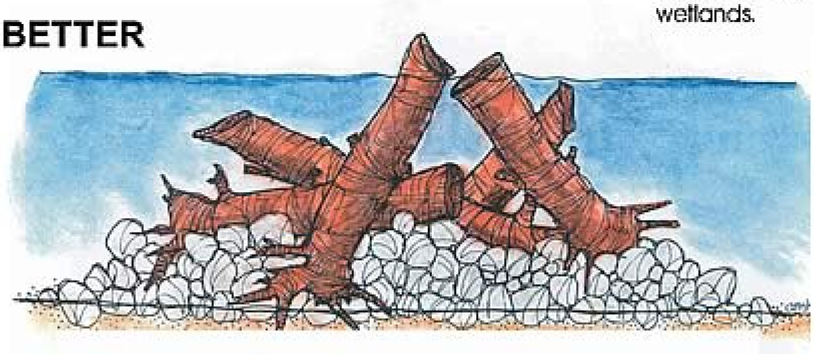
POOR



GOOD



BETTER



Construction Techniques and Materials

Within sheltered embayments and low fetch areas deploy a combination of logs and substrates to provide structural habitat.

Anchor logs by piling rocks on top of root wads or driving logs to resistance within soft sediments

Combination of vertical deployment of single or multiple logs and rock reefs provide habitat function. Single or multiple logs would function in backwater lagoons within coastal wetlands.

Targets

- Increase essential habitats for cool and cold water species
- Improve forage for aquatic species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Constructed Islands
HABITAT TYPE : Sheltered Embaymnets

Targets

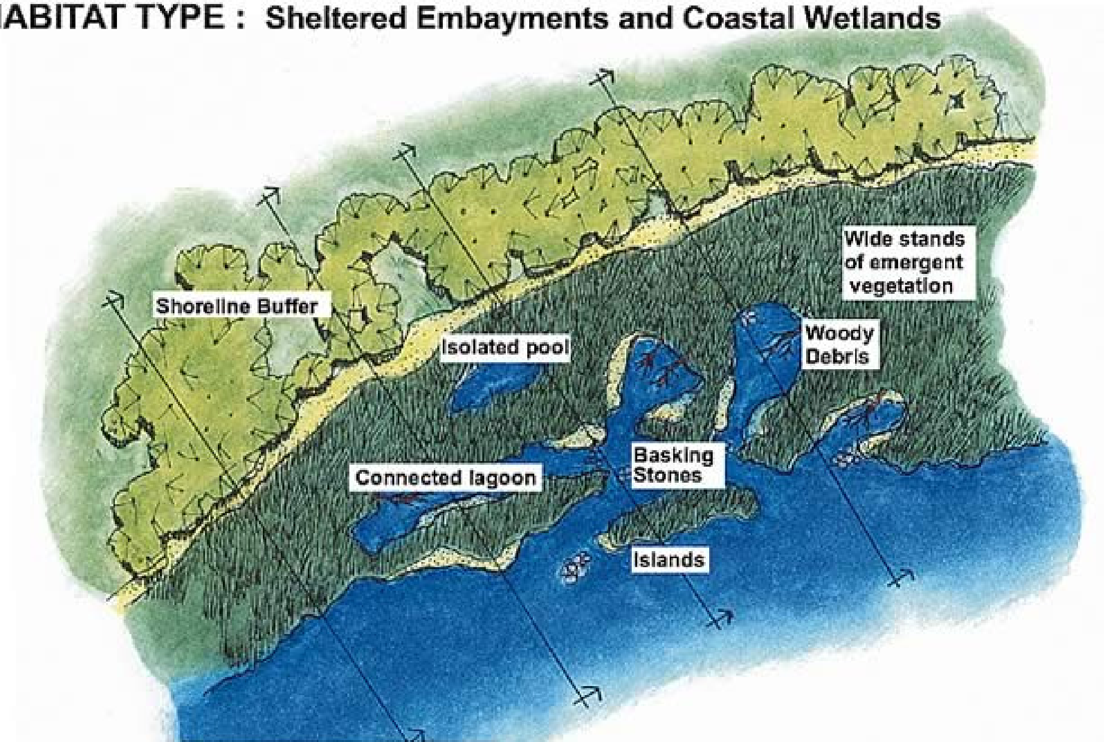
- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Lowland Riparian Woods
HABITAT TYPE : Sheltered Embayments

Targets

- Increase high quality riparian vegetation
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Vegetated Shorelines Components
HABITAT TYPE : Sheltered Embayments and Coastal Wetlands



Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Reduce carp biomass
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

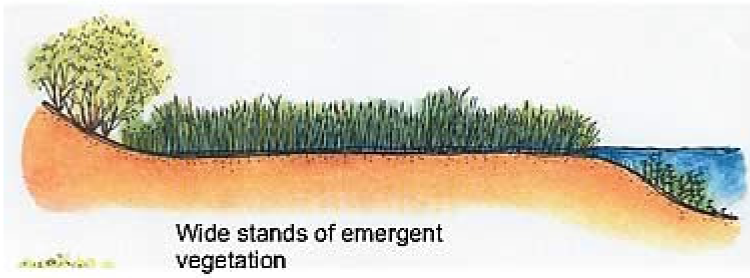
Within vegetated shorelines some key components provide a high degree of Habitat Function:

- Broad stands of emergent vegetation
- Lagoons
- Isolated openings
- Islands and backshore areas

RESTORATION TECHNIQUE: Contour Modification Vegetated Shoreline Cross Sections

HABITAT TYPE : Sheltered Embayments and Coastal Wetlands

A



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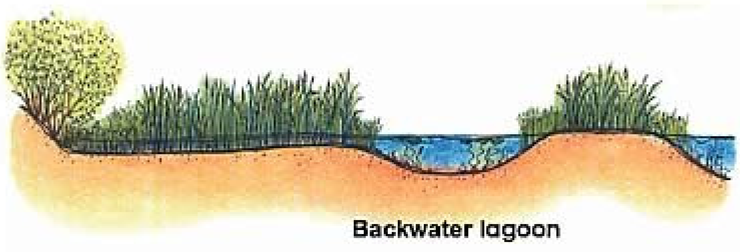

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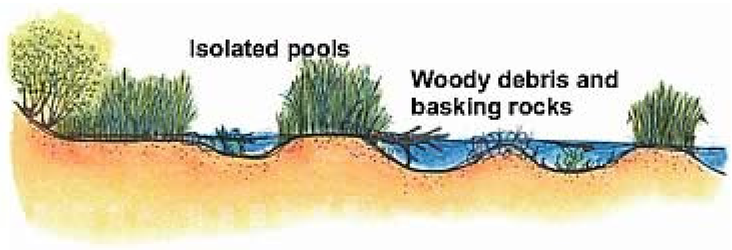

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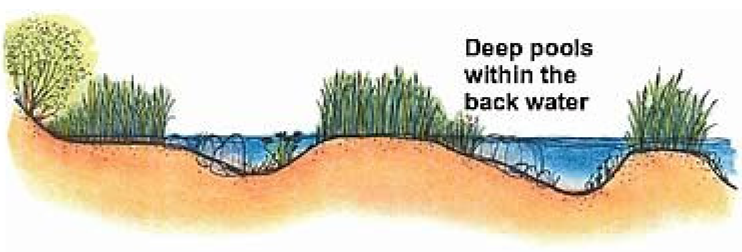


Targets

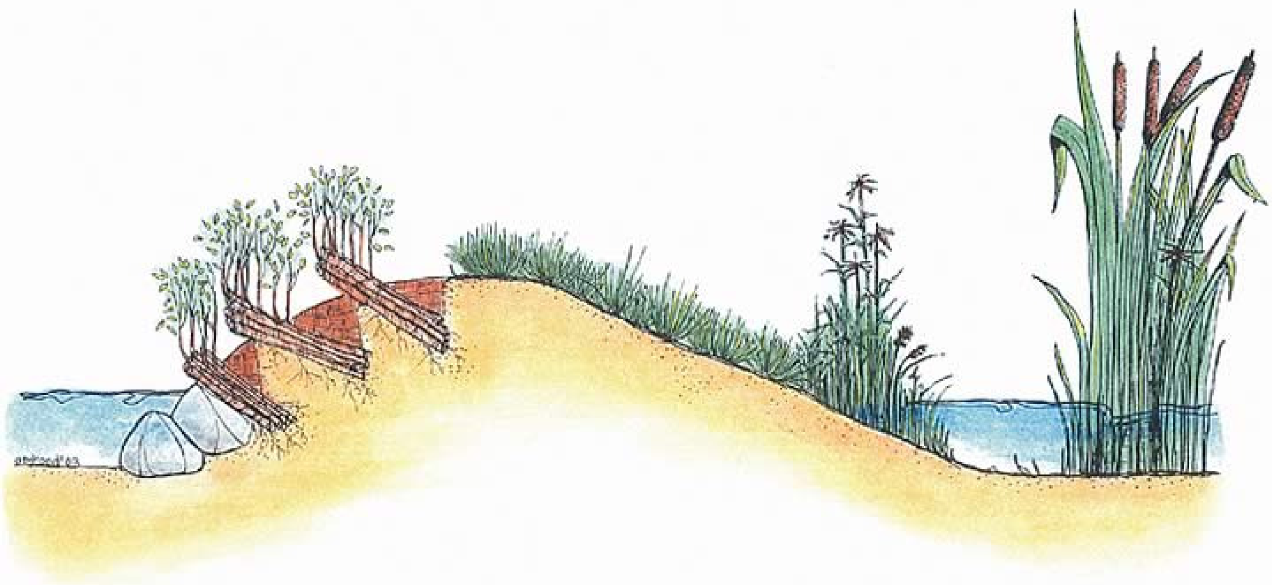
- Improve emergent vegetation
- Improve submergent vegetation
- Increase areas of primary production
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Bio engineered berms
HABITAT TYPE : Coastal Wetlands

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

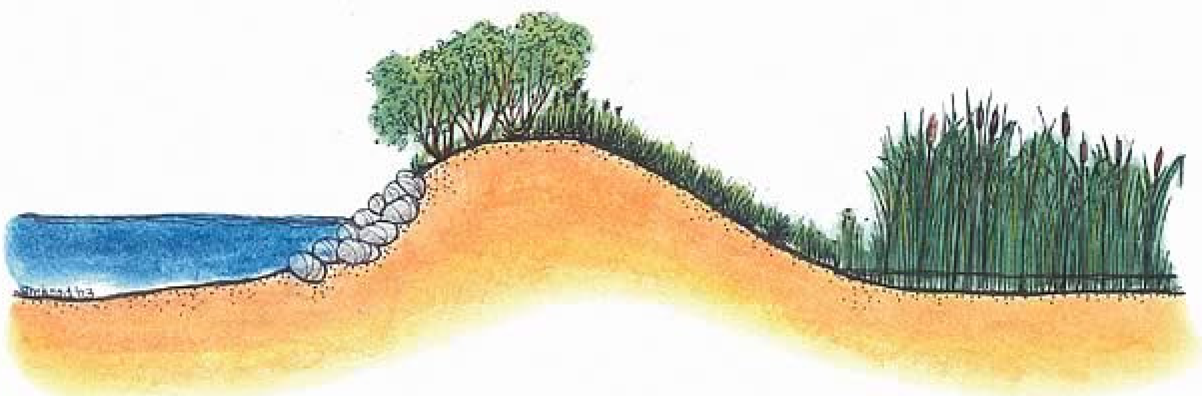
Construction Techniques and Materials
Berms placed with a combination of boulder, rubble, cobble, and gravel would be positioned underwater and within the wave zone. Larger material could be arranged to protect smaller material from moving to far from the site. The placement of material would eventually be reworked into near shore shoals, bars and beach wave zone.



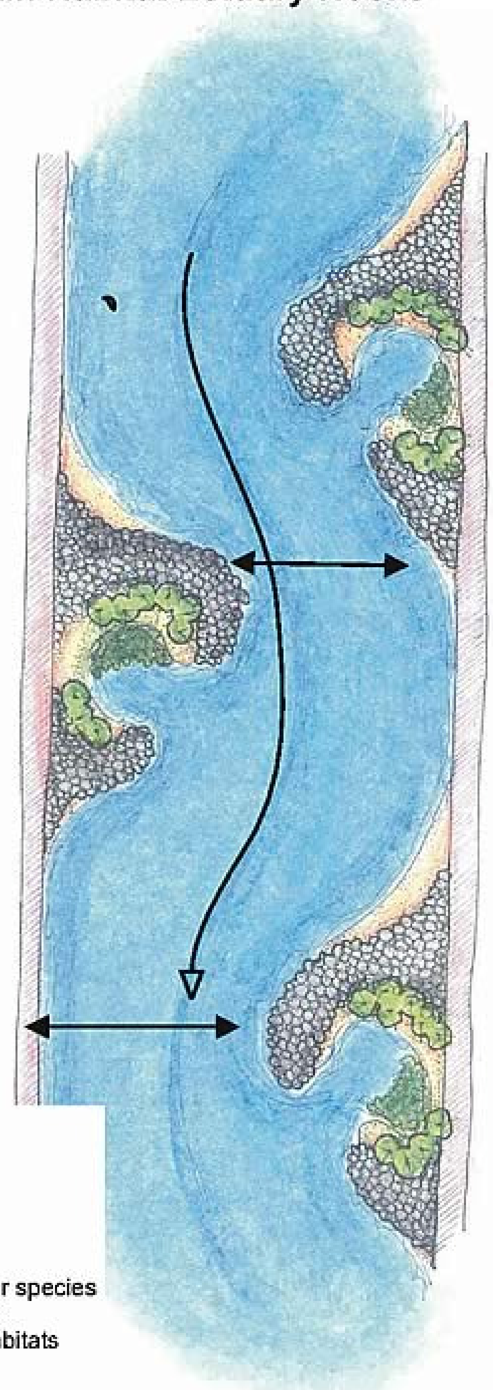
RESTORATION TECHNIQUE: Constructed Islands
HABITAT TYPE : Sheltered Embaymnets

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats



RESTORATION TECHNIQUE: Stream Habitat Estuary Hooks
HABITAT TYPE : Estuary



Construction Techniques and Materials

Adjacent to vertical walls or high banks place a variety of stone in a hook fashion to:

- Deflect and concentrate flows
- Entrain bedload sediments
- Encourage establishment of emergent vegetation
- Provide small eddy pools for habitat and primary production.

High profile design has material that is above baseflow water levels, low profile design remains underwater at all times.

Size can be major and constrict channel width and morphology. In contrast, the size can be reduced and limited to shoreline modifications that provide localized influences to the river and habitat features

Habitat Function and Limiting Factors

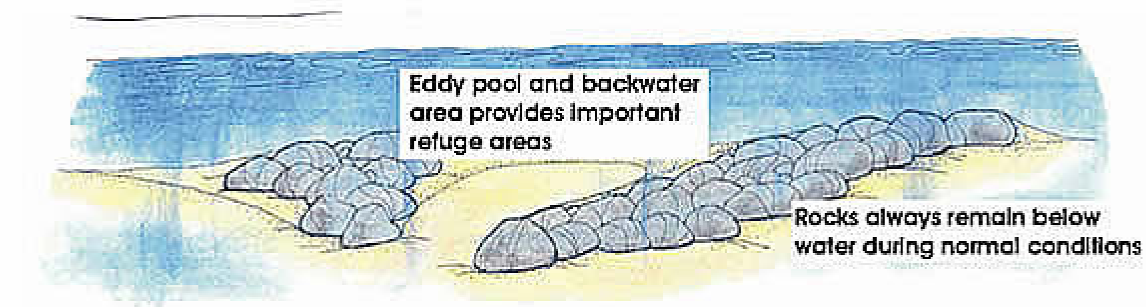
Provides staging areas for fish passage while concentrates flows, directs bedload sediments and improving currents. Eddy pool and deposional areas can be highly productive and encourage the growth of emergent vegetation.

Must be designed with hydrological analysis to determine the suite of habitat conditions under various flows.

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Stream Habitat Estuary Hook (Low Profile)
HABITAT TYPE : Estuary



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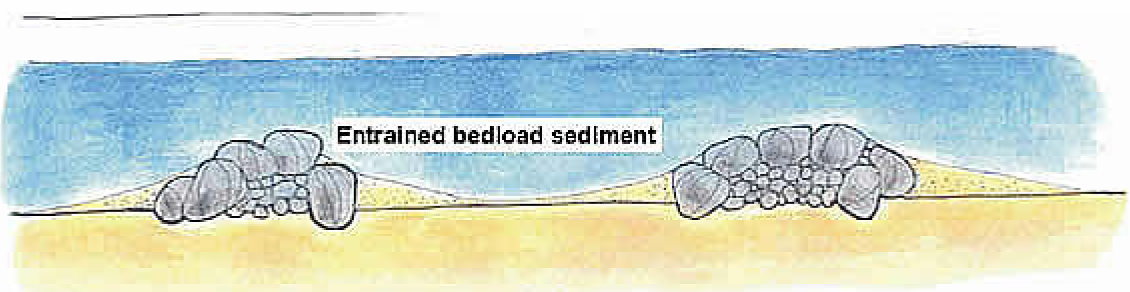


SECTION

Habitat Function and Limiting Factors

Urban estuaries (Etobicoke Creek, Lower Humber River and the lower Don River)are commonly channelized sections of these watercourses. They lack structural habitat and significant features. Estuary hooks in various configurations(high, low, large, small) can provide a the following conditions:

- Improved flows and channel morphology
- Staging areas for migratory and resident fish
- Juvenile habitat and areas of enhanced primary production
- Local pockets of lowland riparian and emergent vegetation

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Stream Habitat Estuary Hooks
HABITAT TYPE : Estuary

Construction Techniques and Materials

Adjacent to vertical walls or high banks place a variety of stone in a hook fashion to:

- Deflect and concentrate flows
- Entrain bedload sediments
- Provide small eddy pools for holding fish

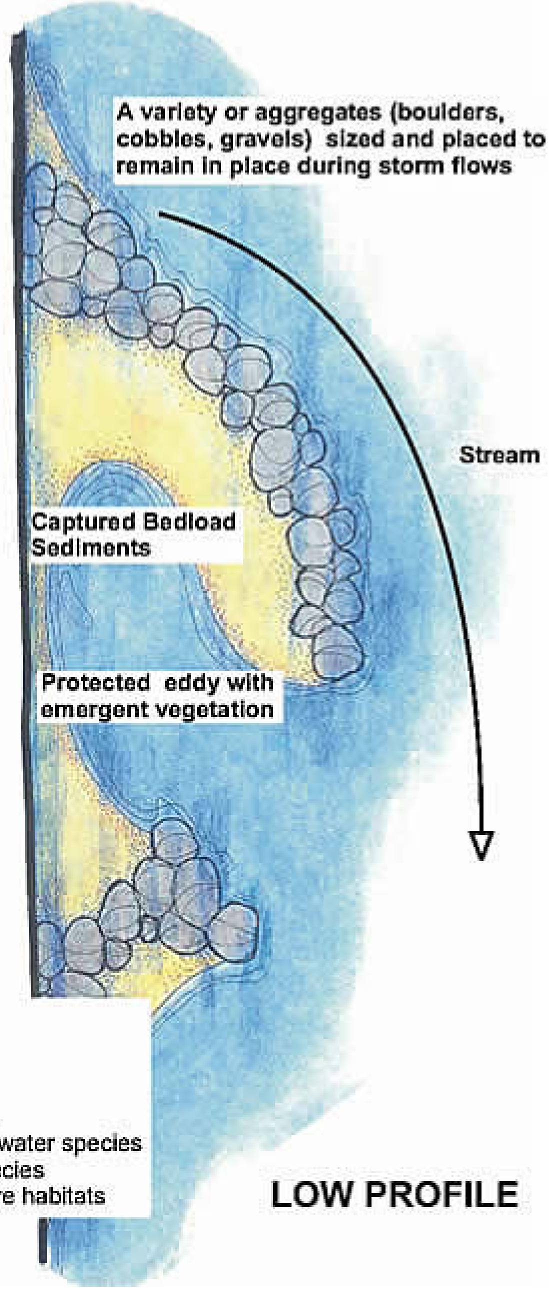
Low profile design has material that is below baseflow water levels.

Provides bottom structure and relief from flows

Habitat Function and Limiting Factors

Provides staging areas for fish passage
Entrains bedload sediments
Eddy pool and deposional areas can be important refuge area for fish

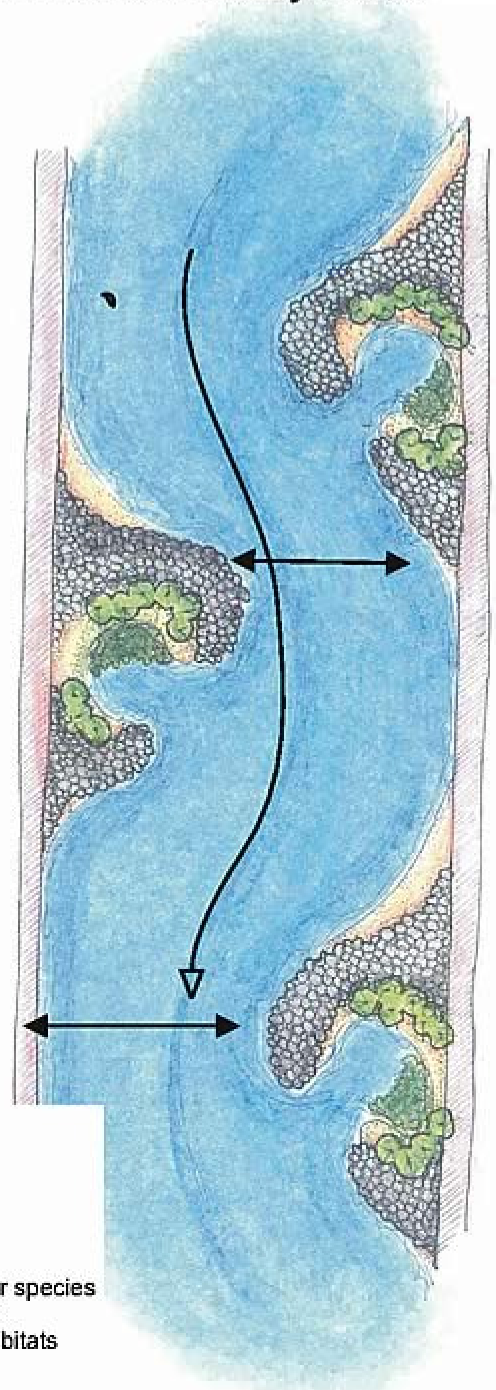
Must be designed with hydrological analysis to determine suite of habitat conditions under various flows



Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Stream Habitat Estuary Hooks
HABITAT TYPE : Estuary



Construction Techniques and Materials

Adjacent to vertical walls or high banks place a variety of stone in a hook fashion to:

- Deflect and concentrate flows
- Entrain bedload sediments
- Encourage establishment of emergent vegetation
- Provide small eddy pools for habitat and primary production.

High profile design has material that is above baseflow water levels, low profile design remains underwater at all times.

Size can be major and constrict channel width and morphology. In contrast, the size can be reduced and limited to shoreline modifications that provide localized influences to the river and habitat features

Habitat Function and Limiting Factors

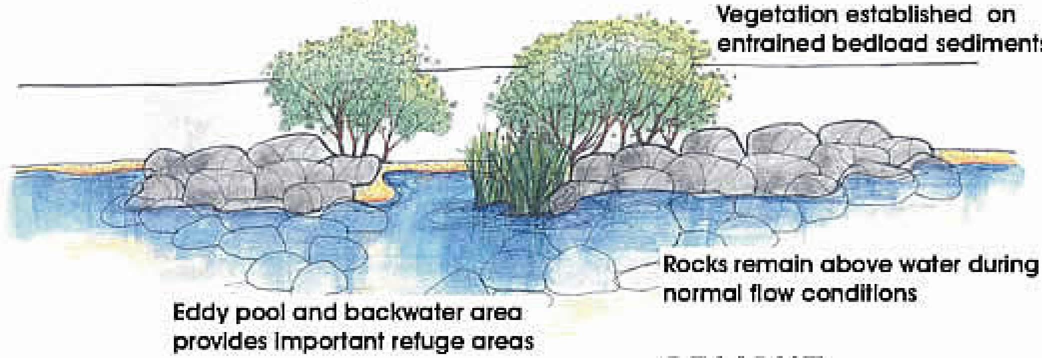
Provides staging areas for fish passage while concentrates flows, directs bedload sediments and improving currents. Eddy pool and deposional areas can be highly productive and encourage the growth of emergent vegetation.

Must be designed with hydrological analysis to determine the suite of habitat conditions under various flows.

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase high quality riparian vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Stream Habitat Estuary Hooks (High Profile)
HABITAT TYPE : Estuary



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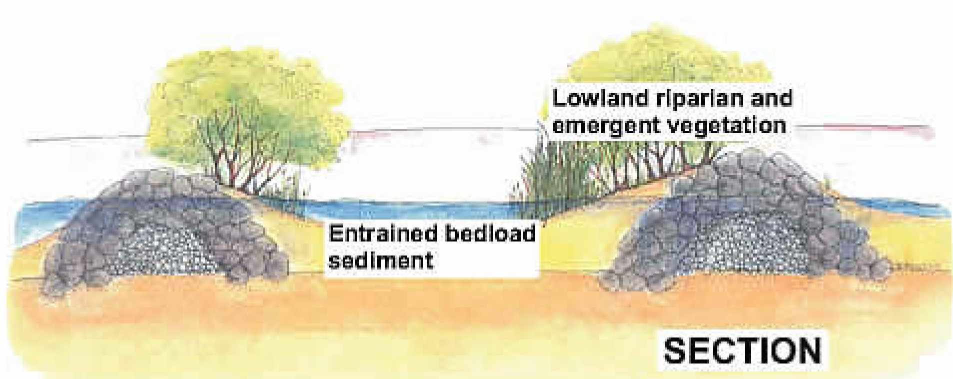

Habitat Function

Urban estuaries (Etobicoke Creek, Lower Humber River and the lower Don River)are commonly channelized sections of these watercourses. They lack structural habitat and significant features. Estuary hooks in various configurations(high, low, large, small) can provide a the following conditions:

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- Juvenile habitat and areas of enhanced primary production

Targets

- Improve emergent vegetation
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- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

RESTORATION TECHNIQUE: Stream Habitat Estuary Hooks
HABITAT TYPE : Estuary

Construction Techniques and Materials

Adjacent to vertical walls or high banks place a variety of stone in a hook fashion to:

- Deflect and concentrate flows
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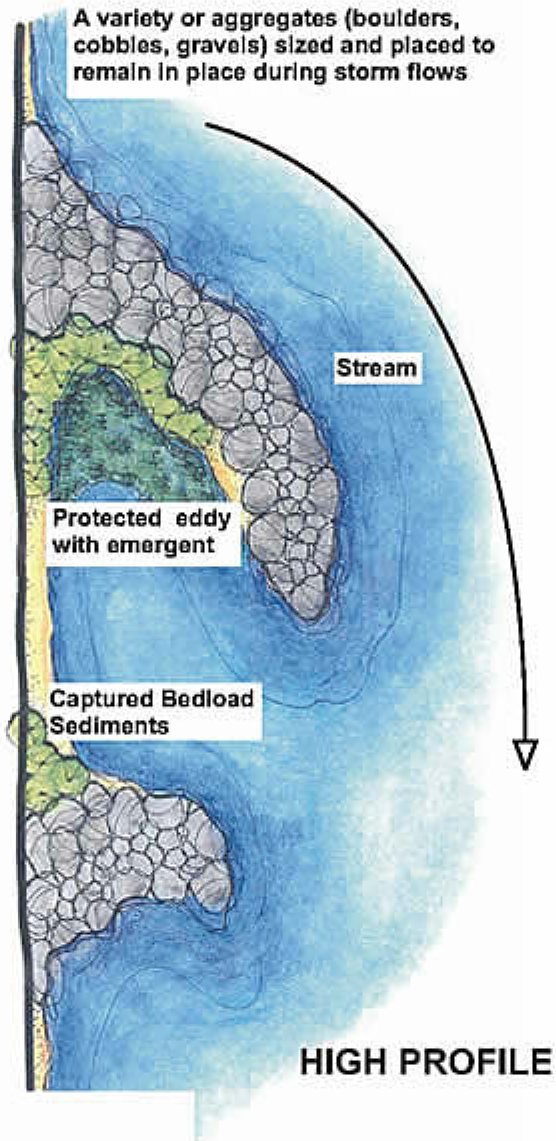

Targets

- Improve emergent vegetation
- Improve submergent vegetation
- Increase areas of primary production
- Increase essential habitats for cool and cold water species
- Improve forage for aquatic and terrestrial species
- Add structural elements to improve near shore habitats

Habitat Plan

Introduction

The Habitat Plan is a blueprint for siting and applying specific habitat restoration techniques in various waterfront locations. It can be used to guide shoreline landuse planning and habitat restoration at various scales for shoreline reaches, different habitat types and specific sites. The Plan will be useful for locating compensatory habitat, designing restoration works and assessing proposed projects.

All proposals are based on thorough local knowledge including physical conditions, fish community characteristics, construction access, and other specific considerations. They are also designed to be compatible with existing and potential future uses of the lands and water.

The restorations are clustered and deployed to fulfil the objectives and the targets of the overall strategy. For example, coastal wetland techniques focus on reducing the biomass of common carp and the techniques for sheltered embayments are applied along the shoreline to increase the amount and diversity of aquatic vegetation communities.

The Strategy also addresses potential cumulative effects of restoration work, achieves fish management objectives for the waterfront, and provides a basis for developing quantifiable measures of the success of habitat enhancements.

Toronto Waterfront Maps

For detailed information about a site, please select from the three waterfront maps below. Then, select a site map (shaded in yellow).

WEST WATERFRONT MAP

CENTRAL WATERFRONT MAP

EAST WATERFRONT MAP

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Glossary

Backshore – the part of the shoreline that is usually dry, above the average water level, and bounded inland by the limit of storm run-up.

Bathymetry – the science of measuring water depth to understand the topography of the lake floor.

Benthic – on the bottom of a body of water.

Benthos – organisms that live on the bottom of a body of water.

Breakwater – a barrier built out into the lake to protect the shoreline from the force of waves.

Centre of biological organization – a habitat or area with biophysical features that are essential for self-organization and provide for high levels of reproduction and predation.

Conservation design – planning and designing for a variety of wildlife habitats and incorporating principles of natural succession to restore or create functional habitat.

Delta – an area of sediment deposited at the mouth of a river, typically where it diverges into several outlets.

Ecological connectivity – the physical and biological relationships among nearshore, watershed and lakewide ecosystems. Examples include shoreline processes, wetland functions, migration and over-wintering patterns, and spawning and feeding requirements.

Ecological Integrity – the ability of an ecosystem to maintain its organization and functions. Some of the factors that contribute to integrity are resilience to change, productivity, vigour and species diversity.

Ecosystem – a dynamic complex of plants, animals and micro-organisms and their physical environment interacting as a functional unit.

Ecosystem approach – a wholistic approach to planning and managing natural resources that recognizes the interdependence of land, water, air and living things, including people.

Embayment – a natural or constructed area of sheltered water.

Emergents – aquatic plants that have roots below the surface of the water and leaves above it.

Estuary – the lower reach of a river or stream that is influenced by lake levels.

Eutrophic – high in nutrients.

Eutrophication – a process whereby high levels of nutrients in a water body results in excessive growth of organic matter, especially algae. This reduces the dissolved oxygen content of the water and can cause the loss of other organisms. Eutrophication can be a natural process or it can be accelerated by an increase of nutrient loading to a water body by human activity.

Fetch – line of continuous open water from point to point.

Groyne – a low wall or barrier built out into the lake to reduce erosion and littoral drift.

Hypolimnetic upwelling – the upwelling of cold water from a deep layer in a thermally stratified water body.

Lacustrine – pertaining to a lake.

Littoral – pertaining to or along the shore.

Littoral cells – sections of the shoreline defined so that no input or outflow of sediment takes place across their boundaries.

Littoral transport – the movement of materials in the water along the shoreline.

Macrophytes – Multi-celled aquatic plants, usually with well-defined roots, stem and leaves.

Native species – species that are indigenous to Toronto ecosystems (eg lake trout).

Naturalized species – species that are not native to Toronto ecosystems but have become an integral part of the ecosystem (eg Pacific salmon).

Nearshore – zone that extends lake-ward from the average water level, where wave action and currents directly influence the shoreline.

No net loss – a working principle by which the Department of Fisheries and Oceans strives to balance unavoidable habitat losses with habitat replacement on a project-by-project basis so that further reductions to Canada's fisheries resources due to habitat loss or damage may be prevented.

Oligotrophic – low in nutrients.

Onshore – the part of the shore that is land-ward of the limit of storm run-up.

Pelagic fish – open coast fish adapted to cold water temperatures, wave exposure and/or a free roaming (eg salmon and trout).

Phytoplankton – plant plankton.

Plankton – very small, drifting organisms that occur in water bodies.

Primary production – Production by organisms that use light energy to construct their organic constituents from inorganic compounds, such as phytoplankton, periphyton and aquatic macrophytes. When these are eaten by other organisms, radiant and chemical energy is passed on to higher system levels.

Riparian – bordering a lake or watercourse.

Thermal bar – a column of relatively cold, dense, off-shore water that holds a band of warm water in the nearshore zone in early spring.

Turbidity – the degree of cloudiness of water due to suspended silt or organic matter.

Salmonid – fish of the salmon and trout group.

Self-sustaining communities – communities of plants and animals that are able to reproduce naturally, with minimal human intervention, to maintain healthy populations of plants and animals, including species at risk.

Spit – a peninsula or extension of land from the shoreline that is almost surrounded by water.

Stonehooking was the removal of aggregate materials from the lake bottom for use in construction. Most stonehooking along the Toronto waterfront occurred from approximately 1850-1910.

Storm run-up – the water that reaches inland during a storm, higher than the average water level, as a result of wind and wave action.

Submergents – aquatic plants that grow below the water surface.

Warmwater fishery – a fish community adapted to sheltered habitats and cool or warm water, including pike, bass, walleye, bullhead, carp, sucker and minnows.

Zooplankton – animal plankton.

Advisory Panel Stakeholder Workshop
Summary Meeting Notes

When: May 15, 2003
Where: Black Creek Pioneer Village

Overview of Aquatic Habitat Restoration Strategy Process

Doug Dodge provided an overview of the process that is being used to develop the strategy (showed a powerpoint presentation on CD and the draft strategy document that was provided to meeting participants). He noted that the redevelopment of the Toronto waterfront represents an untapped opportunity to restore some of the ecological integrity of aquatic habitats that has been lost over the past two centuries. The strategy will establish a framework for changes that will lead to a more self-sustaining aquatic ecosystem while recognizing human uses of the waterfront.

Doug invited participants to provide comments on the draft document and powerpoint presentations at any time (to Gord MacPherson at gmacpherson@trca.on.ca, phone 416-661-6600 ext. 5246 or fax 416-667-6277).

Physical Processes, Aquatic Communities and Habitat Restoration Techniques

Gord presented the foundations of the strategy represented by physical processes and the existing aquatic communities on the waterfront. He also introduced participants to a draft compendium of techniques that can be used to restore aquatic habitats.

Questions and discussion included the following points:

Question: have you noticed an increase in dabbling and diving ducks in response to the increases in Vallisneria and other submerged vegetation?
Answer: yes — both resident and migratory birds are increasing in numbers and diversity. For example, canvas-backed ducks have nested recently in Cell 1 in Tommy Thompson Park.

Question: the amount of material removed from the shoreline by stone-hooking is incredible! Where do you expect that we can obtain enough material to put back on the waterfront?
Answer: there are several potential sources, including waste materials from quarries, constructions wastes including brick and concrete rubble, and rocks removed from green-field construction sites.

Question: can you predict the appropriate water levels for establishing emergent vegetation?
Answer: we survey existing wetlands to determine the preferred elevations for specific

species and then grade the new shoreline to those elevations. But we still need to develop better understanding of the effects of high and low water levels.

Question: what techniques have you used to create a wetland on a contaminated site in Cell 1 in Tommy Thompson Park?
Answer: we placed 0.5 metre of clean fill over the contaminated sediment. We have tested this method on the 2 hectare Triangle Pond that was built in the early 1970s in Tommy Thompson Park. The sediments were heavily contaminated including lead above the severe effect level. We have done bore-hole testing that confirms that the contaminants are contained below the cap.

Question: do you know the rooting depth of the vegetation?
Answer: mostly 10-15 cm.

Question: there's a lot of work to do to add habitat function to the hard shorewalls around the harbour. How successful has the Harbour Square Park project been?
Answer: it's working well, attracting a variety of birds and fish.

Question: how do you plan to test performance of future restoration projects? You are really undertaking field experiments. Will you have control sites? Are you focusing on quantitative performance standards or qualitative directions?
Answer: we are working with University of Waterloo and DFO to develop performance measures and methods.
Comment: Ken Minns is working on an index of biotic integrity that will measure the performance of re-created shorelines based on 12 metrics in three categories — productivity, diversity and trophic status. It is being used in Hamilton Harbour and we are finding it to be both useful and reproducible.

Break-out Discussions

Participants divided into six groups. Each group discussed two case studies in one of the three habitat types: open coast, sheltered embayments, and estuaries/wetlands. They were asked to be creative and "think outside the box". As a result, some of the suggestions do not reflect factors such as regulatory requirements and land or waterlot ownership.

The groups discussed the following case studies:

- Open Coast – Group A (Port Union & Fishleigh); Group B (Port Union & Fishleigh)
- Sheltered Embayments – Group A (Ashbridges Bay & Outer Harbour); Group B (Ashbridges Bay & Outer Harbour)
- Estuaries/Wetlands – Group A (Lower Don River & Humber River); Group B (Lower Don River & Mimico Creek)

The detailed notes from each group are below.

Plenary Reports and Discussion

Recurring Themes

- Specific objectives and themes should be developed for each case study, including aquatic habitat, terrestrial links, physical processes, water/sediment quality, and human uses.
- Restoration projects should be designed to allow for the ability to manage specific sub-areas (eg for carp control) and avoid re-creating existing problems.
- General acceptance of the proposed habitat restoration techniques.
- New habitat opportunities should be sought as well as retrofit opportunities.
- Recognize that this is an experimental management approach, providing opportunities to "learn-by-doing". Criteria should be developed to monitor success and to enable changes in management if necessary to respond to the results.
- Consider the long-term, big picture.

Constraints
Frequently-mentioned constraints included:

- Contaminants from outfalls (eg at Ashbridges Bay)
- Contaminated sediments (eg mouth of Don River)
- Ongoing sediment deposition and dredging requirements in mouth of Don River
- Transportation and land use constraints at mouth of Don River
- Flood control requirements at mouth of Don River
- Ice movement and scouring in estuaries
- Uncertainty about proposed energy generation projects and their potential impacts
- Dynamic conditions of the open coast

Design Concepts for Wetlands/Estuaries and Embayments
Some recurring ideas included:

- Small islands in the Outer Harbour
- Off-line ponds
- Modify existing water depths to encourage emergent vegetation
- Soften shorelines
- Increase sheltered waters
- Improve circulation
- Braided river in estuaries

- and estuary hooks
- Off-shore shoals
- Carp barriers
- Goose control

Design Concepts for Open Coast
An over-arching theme was to recognize the natural coldwater fishery and dynamic conditions of the open coast. It was suggested that modest shoreline enhancements could be made including:

- Surcharge with rocky materials
- Underwater reefs and shoals
- Repair boulder pavement
- Shoreline hooks
- Soften shorelines
- Woody debris on cobble beaches
- Incorporate habitat opportunities into shoreline erosion protection approaches

"Big Picture" Ideas
Discussion about the "big picture" re-affirmed the guiding principles of the aquatic habitat restoration strategy, with participants suggesting:

- We can make an analogy with human habitats in that we are trying to create a framework for diversity of aquatic life.
- Recognize and incorporate navigation requirements.
- Understand coastal processes including overall sediment transport (from watersheds as well as along-shore), ongoing erosion and shoreline replenishment.
- Avoid moving a problem (eg carp) from one area to another).
- Recognize that "valued ecosystem components" (eg desired fish species) vary from one stakeholder to another.
- Don't improve one valued ecosystem component at the expense of another.
- Define the problem and be specific about objectives for specific species of fish.
- Remove upstream barriers.
- Connect to terrestrial habitats.
- Recognize uncertainties for example invading species.
- Waterfront redevelopment process is iterative and will provide ongoing opportunities to ensure that projects incorporate aquatic habitat.
- Other case studies could include the proposed "deflector arms" at the mouths of the Humber River and Etobicoke Creek; recreational boating and international competition opportunities.
- Imagine 2050 — what will the waterfront look like then?

- Creating a more self-sustaining ecosystem will make it more capable of adapting to changing circumstances.
- Strategy should be both reactive (restore existing places) and proactive (set priorities for new work)
- Focus on building landscapes, not only on requirements of specific species.

Next Steps

Doug Dodge summarized the next steps, including:

- Participants will receive a summary of the workshop.
- Participants will be invited to a Public Forum planned for June 10th, 2003.
- The strategy will be presented to the TRCA Board in September.

Public Forum
Summary Meeting Notes

When: June 10, 2003
Where: Radisson Plaza Hotel Admiral, 249 Queen's Quay West

Attendance

Approximately 33 members of the public, agency stakeholder committee and advisory panel attended the public forum.

Open House

Displays included drawings from the compendium of habitat restoration techniques and ortho-photos of the waterfront showing proposed restoration projects and objectives. From 5:30 - 7:00pm, participants viewed the displays and discussed them with members of the advisory panel and agency stakeholder committee.

Welcome

Councillor Irene Jones welcomed participants to the workshop. She noted that the success of the City's and the Toronto Waterfront Revitalization Corporation's plans for the Central Waterfront, Port Union and Mimico Linear Park will rely in part on the integration of the Aquatic Habitat Strategy. She also stressed the importance of implementing the City of Toronto's Wet Weather Flow Plan to improve water quality and help achieve the full potential of the waterfront.

Overview of Aquatic Habitat Restoration Strategy Process

Doug Dodge provided an overview of the process that is being used to develop the strategy. He noted that the redevelopment of the Toronto waterfront represents an untapped opportunity to restore some of the ecological integrity of aquatic habitats that has been lost over the past two centuries. The strategy will establish a framework for changes that will lead to a more self-sustaining aquatic ecosystem while recognizing human uses of the waterfront.

Doug invited participants to provide comments on the proposed strategy by filling out the feedback form provided at the forum or by contacting Gord MacPherson at gmacpherson@trca.on.ca, phone 416-661-6600 ext. 5246 or fax 416-667-6277.

Presentation of Draft Aquatic Habitat Restoration Strategy

Gord MacPherson presented information about the physical processes and cultural influences that shape aquatic habitats on Toronto's waterfront. He noted that there are four primary waterfront habitats - estuaries, wetlands, sheltered embayments and open coast. For each habitat type, Gord described the existing aquatic communities, targets for improvement and examples of habitat restoration techniques.

Group Discussions

Participants divided into groups based on sections of the waterfront. They were asked to address five questions:

1. How do you use the waterfront?
2. Do you have comments on the strategy objectives and guiding principles?
3. What is your opinion of the proposals for aquatic habitats?
4. Are there any issues that should be addressed?
5. What are your suggestions for addressing these issues?

Plenary Reports and Individual Comments

A representative of each discussion group reported on their key ideas and recommendations. In addition, nine individuals provided detailed comments on individual feedback forms or separate letters. In summary, the major points were:

How do you use the waterfront?
Participants use the waterfront for birding, natural history, boating, cycling, canoeing, picnicking, walking, running, roller blading. Some participants are owners of private waterfront lands.

Do you have comments on the strategy objectives and guiding principles?
Seems like good science!

What is your opinion of the proposals for aquatic habitats?
One group summarized their views as follows: "The proposal is very well thought out by experienced authorities who have studied and worked on the waterfront development for a long time!"

Participants generally liked the proposals and were keen to see them implemented. There were some comments that the proposals do not go far enough, and lack a "big vision". People also felt that there were lots of good ideas being proposed, and we should just get on and try them.

There was discussion not only about the aquatic habitats, but also about the relationships with adjacent land uses, especially parks and trails.

Specific suggestions included:

- Create a Don greenway corridor with a minimum width of 300 metres. One group suggested that the greenway should include a river connection from the

Don River Mouth to the Ship Channel. Another group recommended beginning with a lake inlet from the Outer Harbour to the Ship Channel, with the opportunity to extend it to the Don River when the water and sediment quality in the river have been improved.

- Reconsider need for massive flood protection at Don River Mouth and instead create a green matrix in the Portlands including rain gardens.
- Create a true lacustrine marsh at the mouth of the Don River. Make it as large as possible and remove the Keating Channel. Focus on restoring ecological functions, with less emphasis on human uses. Ensure that the Lower Don EA gives full consideration to legitimate alternatives.
- Prepare a single master plan for the Don Narrows, Don Greenway and Lake Ontario Park, integrating terrestrial and aquatic habitats.
- Include ecological improvements to the Ship Channel — in the water and along the terrestrial edge of the channel. Connect it to Lake Ontario Park.
- Create a vegetated buffer zone along Commissioner's Street.
- Create a series of islands at the western edge of the Outer Harbour (from eastern point of the East Gap to Peninsula C on Tommy Thompson Park) to create more protected water and improve shoreline and aquatic habitats. This would also provide better conditions for many of the boating recreational activities, with the possible exception of board-sailing.
- Include a "pocket wetland" like Spadina Quay in Harbour Quay.
- Continue naturalization of parklands (eg Marie Curtis Park)

Are there any issues that should be addressed and what are your suggestions for addressing them?
Specific suggestions and questions included:

- Plan habitat improvements on a littoral cell or shoreline segment basis and include more emphasis on the biophysical rationale.
- Improve pedestrian, cycling and transit access to the waterfront, across the rivers and across the Gardiner and other major roads.
- Re-align roadways away from the Don Marsh and include transit improvements.
- Acknowledge the fact that there is a mix of public and private lands on the waterfront and respect private uses.

- Consult with specific user groups and landowners using surveys, signage and local public meetings.

- The relationship with adjacent land uses is important. There should be design guidelines that specify vegetated walks and roofs, use of native plant materials and lot level stormwater control.

- Address the perceived tension between formal recreation parks and naturalized areas by demonstrating ways to incorporate natural habitats into recreation parks.

- How much funding is required and where will it come from?

- When will the proposals be implemented?

- Education of the general public and local landowners is essential to gain their buy-in and support. People need more knowledge about existing water quality conditions, what measures are being taken to improve them, and the benefits of improving aquatic habitats. Provide an interpretive center and website. Highlight the human benefits (tourism, recreation, health, aesthetics) of the aquatic habitat restoration strategy in any public/media materials.

- Shoreline erosion is a problem in some areas - incorporate erosion protection into the aquatic habitat proposals.

- Are you addressing the needs of coldwater offshore species?

- Develop strategies to address nuisance species of plants, Canada Geese, carp and zebra mussels. Lobby for research funds from Federal/Provincial governments.

- Address concerns about Cladophora algae.

- Take decreasing water levels into account when designing projects.

- Clean up garbage and litter (eg at Amos Waites Park). They are unsightly and give people the impression that the water is highly polluted.

- Projects should address not only the opportunities to improve habitats, but also other factors such as the needs to improve navigation, safety, water quality, public access, and deteriorating infrastructure (eg dockwalls and breakwalls).

- What will be the impacts of warmwater inputs from the generating plant in the Portlands?

- Incorporate protection and interpretation of cultural heritage.

- Provide tax or other financial incentives for private landowners to help implement the restoration strategy.

Next Steps

Doug Dodge thanked everyone for participating and noted that comments from the public forum will be incorporated into the strategy. The draft aquatic habitat restoration strategy will be available for review in August, and participants will be notified when it is posted on the TRCA website for review. Anyone without internet access will receive a paper copy of the document. The final strategy will be presented to the TRCA Board in September.