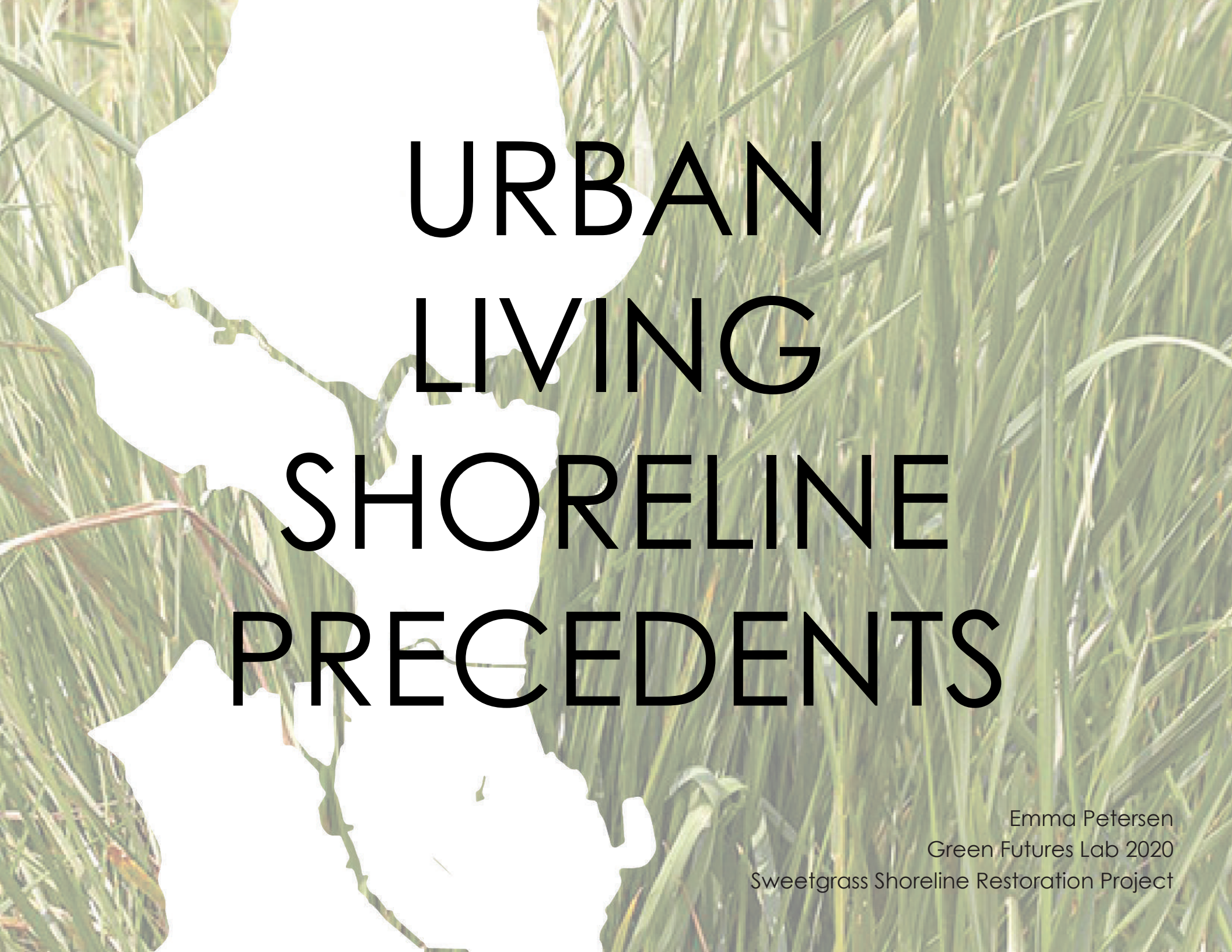


URBAN LIVING SHORELINE PRECEDENTS

Emma Petersen
Green Futures Lab 2020
Sweetgrass Shoreline Restoration Project

The purpose of the Sweetgrass Living Shoreline Restoration Project is to test new ways to retrofit existing armored urban shorelines with living shorelines that can improve water quality, increase salmon habitat, and restore cultural keystone species such as Ka'qsxW or sweetgrass (common three-square bulrush) in the Lake Washington Basin, Ship Canal and Central Puget Sound. This project will build on the planning and design groundwork established by the Sweetgrass Urban Shorelines Working Group, which is bringing together planners, scientists, regulators, designers, and community stakeholders to reimagine living shorelines that are connected to local communities.

This document is meant to serve as a collection of urban living shoreline precedents to help inform site selection and design criteria for the Sweetgrass Shoreline Restoration Project. Precedents are split up into different shoreline edge conditions - Riprap, Breakwaters/Bridge Fenders, Sea Wall/Armored, Pier/Dock, and Soft Edges. This collection of precedents is meant to spark inspiration and serve as a jumping off point for further design research. Much of the language is taken directly from project websites, there are links included with every project to credit each source. This is a living document that can be updated as more precedents are found.

CONTENTS

SOFT EDGES


Riprap

Riprap describes a range of rocky material placed along shorelines, bridge foundations, steep slopes, and other shoreline structures to protect from scour and erosion. Rocks used range from 4 inches to over 2 feet. The size of the rock needed on a project depends on the steepness of the slope and how fast water is moving. Riprap is a very durable, natural-looking treatment. One drawback is the potential for the rocky material to not be easily traversable by animals; by filling the open spaces between the rocks with soil or smaller rocks helps to address the issue.

Riprap is used where a structure or shoreline is continuously exposed to rushing water:

- along a lake shoreline to limit eroision associated with wave action
- along the outer bank of a river bend, dissipating the force of the water against the bank.
- Near bridges along embankments and adjacent to supports in waterways.

SOURCE

Brewer Shoreline Protection

Chesapeake/Delaware Bays

Brewer Pond is a 22-acre tidal pond along the Severn River that is surrounded by 50 acres of riparian forest called Brewer Pond Natural Area. An important spawning site for fish, amphibians, and reptiles, the pond is also a breeding area for bald eagles, colonial waders and reclusive forest interior dweller birds.

Over the years, natural wave action, boat wakes, and tidal inundation caused the tidal marsh to erode, even after the construction of the stone revetment. In addition, the sediment source for the very existence of the tidal marsh feature extending into Brewer Pond may have been cut off or redirected after the 1995 construction of stone breakwaters immediately north of the project site.

Biohabitats

The team's design applied a hybrid living shoreline approach to provide shoreline protection through a combination of tidal marsh restoration, a marsh sill, and adjacent formed oyster reef structures to prevent further erosion and loss of tidal marsh habitat. The hybrid living shoreline will be constructed in a manner that avoids/minimizes impact to the existing SAV to the maximum extent possible. For example, construction access will be from the water using a shallow water barge or similar vessel and construction activities will coincide with tide elevations that will avoid/minimize impact to the SAV.

Click here to view the project page.

Round Bay Community Beach

Chesapeake Bay

Unique Features: breakwater present
Wave energy: Fetch of 2 mi to the SSW. Significant boat wake
Nearshore water: Some of area has exposed beach off the rock, other areas have gently sloping shallow water not exposed at normal low tide
Sediment: Less than 1" of sediment accreted.
Aspect and Shade: South facing. Full sun.
Existing plants: none
The community of Round Bay wanted to beautify and improve the riprap that was present along their community beach. With the help of the Chesapeake Bay Field Office of USFWS, they planted 600 marsh grasses along 300 feet of bare riprap shoreline. Planting was done by wedging the grass plugs (grown out in 3" coir pots) between the rocks. An existing breakwater likely helped the grasses establish and spread further along the riprap by mitigating 2 miles of fetch and significant boat wake. Community members were so pleased with the success of the planting that they have since planted more grasses on their beach. Landowners along the beach are especially satisfied with the aesthetic improvement upon the bare rock.
Click here to view the project page.

West Severna Park Marina

Chesapeake Bay

Wave energy: Max fetch of 0.3 miles to the SSW. Protected cove, no boat wake
Nearshore water: Bottom is not exposed at normal low tide
Sediment: Less than 1" of silty sediment accretion in rock.
Aspect and Shade: South facing. Full sun.
Existing plants: High tide bush, Hibiscus

Click here to view the project page.

Eau Claire Phoenix Park

Eau Claire, WI

The Riverfront Terrace design included a new concrete road with parallel and diagonal parking and a tabletop pedestrian feature. The project included design for reconstruction of a section of North Barstow Street. Shoreline design on the Chippewa and Eau Claire Rivers included regrading existing riprap areas, adding new riprap for stabilization, and designing toe stabilization features for the fishing wall on the Eau Claire River. In coordination with the landscape architect, Ayres proposed native prairie seed mix over topsoil to cover the riprap on the upper portions of the riverbanks.

Click here to view the project page.

Breakwaters/ Bridge Fenders

Breakwaters are artifical offshore structures protecting a harbour, anchorage or marina basin from water waves. Breakwaters intercept longshore currents and tend to prevent beach erosion. Over the long term, however, the processes of erosion and sedimentation cannot be effectively overcome by interfering with currents and the supply of sediment.

SOURCE

Bridge Fenders are protective structures built around bridges to protect them against collisions from boats and other maritime vehicles and objects. In many cases, these protection systems reduce vessel impact loads until they reach nondestructive levels. In other scenarios, physical protection systems may act to redirect vessels when they come too close to bridge piers. However, bridge fenders can interfere with marine habitat.

SOURCE

Long Wharf
Connecticut

With its commercial, educational, industrial, port, and recreational facilities, the Long Wharf district of New Haven, CT is an important regional hub. Its location along New Haven Harbor and directly off of Long Island Sound, however, makes it susceptible to flood damage from extreme weather events. Most recently, the area suffered flooding and structural damage following Hurricane Irene and Superstorm Sandy.

As a key member of a team led by GZA, Biohabitats worked with the City of New Haven to enhance the resiliency and safety of Long Wharf in the face of future storms and sea level rise while also potentially improving the local ecology.

Biohabitats developed design strategies for a flood protection system for the City's vulnerable resources. The first day of field work coincided with record cold temperatures, but that didn't hamper progress or enthusiasm for a project that combines both human and ecological protection. Biohabitats' primary focus was on progressing concepts related to coastal resiliency, including designs for offshore oyster reef breakwaters, living shorelines, and an expanded coastal ecosystem including sandy beach, tidal wetland, and dune habitats.

Click here to view the project page.

Buras Boat Harbor
Louisiana

Decades of marsh erosion and subsidence along the levees near Joshua's Marina in Buras, Louisiana, have compromised the integrity of these levees, which protect the coastal community of Buras against storm surge. This project was designed to protect this important infrastructure. Funding for the project was provided by the U.S. Fish & Wildlife Service's Coastal Impact Assistance Program (CIAP) and Plaquemines Parish Government.

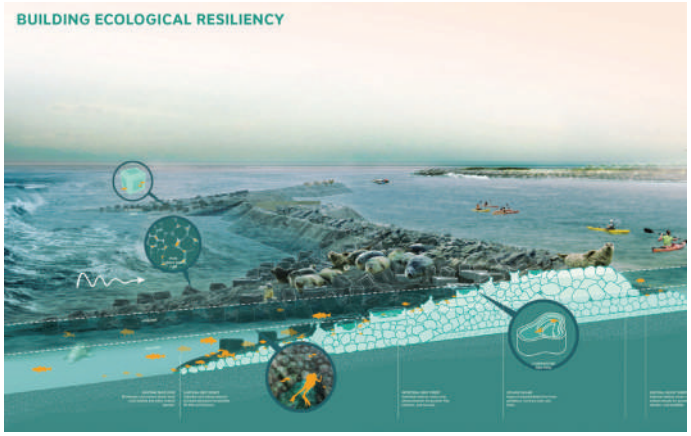
Martin Ecosystems was subcontracted to install 660 feet of Vegetated EcoShield ® on the south berm in July 2014. Within a week of project completion, a storm came through the area causing damage to the remaining unprotected 4000 feet of earthen berm. High winds caused waves to erode the berm five feet in some places. Martin Ecosystems was again subcontracted to install EcoShield™ on the remaining 4000 feet of unprotected berm. Construction of this phase was completed on September 11, 2014.

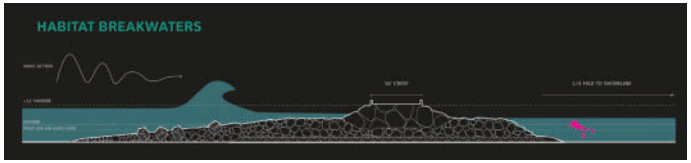
Click here to view the project page.

Living Breakwaters

Staten Island, NY

SCAPE





The Living Breakwaters concept design was developed by the SCAPE team for the U.S. Department of Housing and Urban Development's Rebuild by Design (RBD) Initiative, and was one of six winning proposals in this global competition. SCAPE's layered approach overlays coastal resiliency infrastructure with habitat enhancement techniques and environmental stewardship models, linking in-water protective interventions to on-shore resiliency and community engagement.

Proposed for the South Shore of Staten Island, Living Breakwaters employs a necklace of breakwaters to buffer neighborhoods from wave damage and erosion while providing a more biodiverse habitat for juvenile fish, oysters, and other organisms. This living infrastructure is paired with social resiliency frameworks in adjacent neighborhoods on-shore to help increase awareness of risk, empower citizens, and engage local schools in waterfront education. The proposal was awarded to New York State and is currently being implemented by the Governor's Office of Storm Recovery with $60 million of CDBG-DR funding allocated for this project, currently in the schematic design process. Read more about the schematic design process here.

Click here to view the project page.

Sea Wall/ Armored

A seawall is constructed at a coast or shoreline, at the foot of possible cliffs or dunes. A seawall is typically a sloping concrete structure; it can be smooth, stepped-face or curved-faced. A seawall can also be built as a rubble-mound structure, as a block seawall, steel or wooden structure.

The nearly vertical seawall, which was mainly used in the past, had the unfortuante function of reflecting some of the wave energy, whereby the erosion was aggravated, resulting in accelerated disappearance of the beach. However, all kinds of seawalls involve beach degredation as they are used at locations where the coast is exposed to erotsion. The seawall will fix the location of the coastline, but will not arrest the ongoing eroision in the coastal profile. On the contrary, it will to a varying degree, accelerate the erosion.

SOURCE

World's Largest Floating Riverbank

Rennes, France

658m2 of floating ecosystem surface, divided over four riverbank sections, make up the largest floating riverbank ever created.

268 Biomatrix floating islands modules were used, including 26 High Buoyancy Planters for small trees and shrubs.

6200 native marginal aquatic plants were planted on the islands, they are expected to mature within their first growing season.

Streamlined deflectors, internal structural bracing and dynamic anchoring were incorporated in the system to accommodate the challenging site conditions. Peak water flow velocity exceeds 2 m/s and water levels can fluctuate up to 2.5 meters.

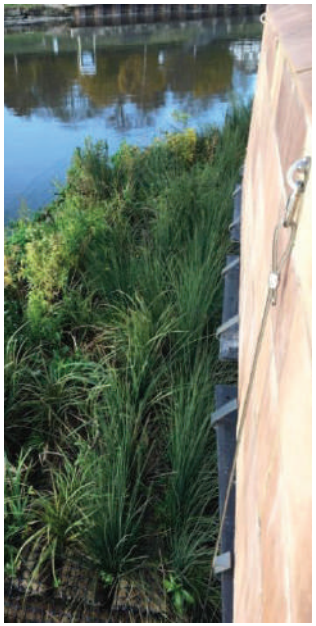
Service walkways run along the entire length of the riverbank sections for the Gardner's to access the garden.

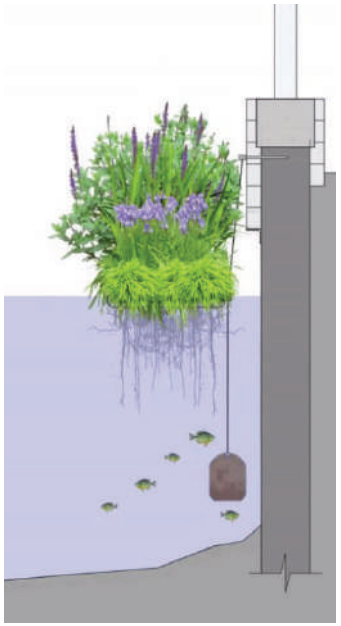
Installation continued over one month and a major flood occurred halfway through the installation, with the ecosystems withstanding the high flow rates without difficulty.

Click here to view the project page.

Alleviation Wall

Northwich, UK





Waterfront cities and towns worldwide are upgrading their flood defences. Interventions often involve the construction of flood-walls. While these walls provide the necessary protection, the downside is that the waterfront becomes increasingly hard-edged, resulting in a loss of amenity value and biodiversity. The result of this is that we become increasingly walled off and disconnected from the water environment. In the scenic town of Northwich, UK, a sheet pile flood defence wall was required in the centre, and there were concerns at the planning stage regarding the aesthetic and ecological impacts of this wall.

A floating riverbank was constructed from Biomatrix 4D floating ecosystem modules that were custom designed to match the curvature of the wall. This floating ecosystem softens the steel-clad wall, providing habitat and a natural waterscape aesthetic. Stone cladding and glass panels were also utilised. The project demonstrates a robust and innovative solution to allow the essential work of flood alleviation schemes to proceed, while actually enhancing the waterscape's ecological potential and natural beauty.

Click here to view the project page.

From Stone Basin to Urban Habitat

Rochdale Canal, Manchester, UK

Bridgewater Basin is a disused branch of the Rochdale Canal in central Manchester, situated outside Manchester's premium international concert hall. It was devoid of healthy aquatic life and completely surrounded by vertical hard stone and concrete edging. The frequent fluctuations of waterlevels and the concrete edges made traditional sloped edge planting impossible in this urban location, limiting the basin's water quality, aesthetics and natural waterscape appeal.

Click here to view the project page.

The Wild Mile

Chicago, IL

In 2011, the Chicago River was listed as one of America's most endangered rivers. With water pollution being addressed through various interventions over the years, the water quality has been gradually improving. However, most of the river banks have hard edges, providing virtually no opportunity for realising green riverbanks and riparian edge ecosystems. Also aquatic wildlife and vegetation was largely absent. Community group Urban Rivers has taken it as a mission to bring the river back to life, by creating floating habitats and teaching the community about their urban waterways.

Click here to view the project page.

Lake Restoration

Bogart Hole Park, UK

Boggart Hole Clough lake was lined with concrete and brick, lacked planting and opportunities for wildlife. The water quality was lacking due to the absence of circulation and aquatic life. In 2014, poor water quality and anaerobic conditions led to a serious outbraeak of avian botulism, resulting in many casualties.

Biomatrix Water was commissioned to design and install a floating ecosystem to revitalise and transform the stagnant, ecologically low in quality water body. Several floating islands were implemented on the north and south side as well as the edges of the lake. The islands incorporated hanging sub-surface biofilter columns to create an artificial reef-like habitat for microorganisms, fish and other aquatic life. Also a fountain aerator was installed in the central area of the floating spiralled garden. Breaking up the large open water surface had the additional benefit of being less attractive to Canadian Geese and thereby attracting more native ducks and coots.

Click here to view the project page.

Concrete Wall Ecosystem

River Brent, UK

Biomatrix Water Land & Water Services, and Terraqua Environmental Solutions, were commissioned by the Canal & River Trust to provide river bank protection and new habitat, in order to restore a vertical concrete edged section of the River Brent. The project team was tasked with creating new riparian habitat without obstructing flow or navigability of the waterway.

A Floating Edge Ecosystem was designed that stretched along 124 meters of riverbank, with a natural curvature to allow water and any flotsam to flow past smoothly, without obstructing the water flow. The floating riverbank was engineered with anchoring posts, which allow the system to move up & down with the changing water levels. The floating nature of the system, and the ability for water to flow smoothly underneath were important features for the approval of the Environmental Agency (EA) in the floodprone location.

Installation took just 3 days, in collaboration with Land & Water Services and Terraqua Environmental Solutions. Sections fit together using a locking stainless steel quick connect system, which can be adjusted to match up to the curvature of the embankment.

Click here to view the project page.

Floating vegetation quay-wall

Groningen, Netherlands

For the “Floating Vegetation Quay-wall” in Groningen, Donker Groen BV commissioned us to place Aqua-Flora® Floatlands .

For this project a total of 69m2 of Aqua-Flora® Floatlands were placed, consisting of a floating body on which our Aqua-Flora® mats were installed. The anchoring consists of 3m-long wooden stakes with a synthetic head which are placed 2m c.t.c and at the corners.

Click here to view the project page.


Pier/Dock

Overwater structures, such as piers and docks, have been proven to pose potential mortality and fitnmess risks to marine animals and ecosystems. Mechanisms of impact are characterized as changes in light, wave energy, and substrate regimes. Modification of these regimes by the construction of, presence of, and operations around overwater structures have been found to produce significantly different distributions of invertebrates, fishes, and plants in under-dock environments than in adjacent non-shaded vegetated habitats.

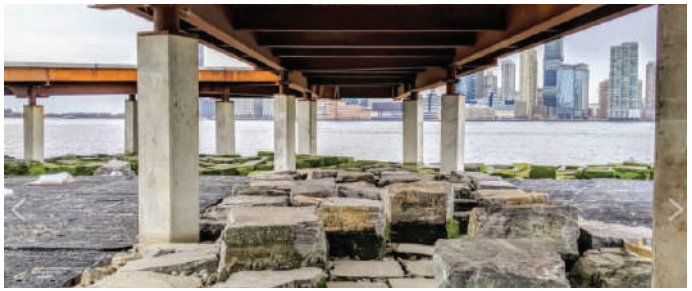
Effects of light limitation (shading) from overwater structures on migratory organisms such as juvenile salmon have been characterized as 1) behavioral barriers that can deflect or delay migration; 2) reduced prey resource production and availability; and 3) altered predetor-prey relationships associated with high intensity night lighting alterations to the nighttime ambient light regime.

Empirical findings indicate that the cumulative impacts of overwater structures can have significant impacts on ambient wave energy patterns and substrate types.

SOURCE

Pier 26
NYC

OLIN



In addition to a multi-use recreation field, spacious lawn, boardwalks and seating areas, Pier 26 features an innovative, engineered Tide Deck. Located at the western edge of the pier, the Tide Deck is a cultivated rocky salt marsh created to provide an immersive and educational river ecology experience. The elevated cantilevered walkway above the Tide Deck provides spectacular city and river views. At certain times, the Tide Deck is accessible for guided tours by Park staff. Learn more about the Tide Deck.

Click here to view the project page

Biohut

oppla

The Biohut is an artificial fish nursery meant to equip port infrastructures such as docks, pontoons or dikes. By providing food and shelter to the young fish, it restores the ecological nursery function that was lost when natural shallow coastal water were turned into urban environment. The Biohut reproduces the nursery function by a two-cages system: the inside cage is filled with empty oyster shells where a great variety of algae and tiny crustaceans will attach, providing food to the small fish, while the two empty cages around provide protection as their mesh size only allow the small fish to enter, keeping their predators outside.

Click here to view the product.

Floating Wetlands 1.0

Duwamish River, Seattle

In 2018 – 2019, a team of UW students and professionals from the Green Futures Lab and Port of Seattle constructed four floating wetland "Biobarges" which were then deployed in April 2019 and evaluated in two different sites in the Duwamish River. A team of students supported by a Technical Advisory Committee developed and tested methods for measuring fish use, water quality, plant growth and invertebrate production on the Biobarges in a "proof of concept" year, monitoring spring quarter until July 2019.

Click here to learn more.

Floating Wetlands 2.0

Duwamish River, Seattle

For the Floating Wetlands 2020 research, the Biobarges have been renovated with additional "biofilter" prototypes to vegetate and soften the outside edges. UW students in a Floating Wetlands Workshop have assisted with this construction, gaining hands-on learning about floating wetland systems. We are again monitoring for: juvenile salmon and other fish use; improvements to water quality measures related to salmon needs; and durability, functionality and growth of the floating wetland "biofilters." UW students are working together with staff and community scientists to regularly collect data, which will be analyzed, interpreted and presented in a final report.
Click here to learn more.


Soft Edges

Soft edges are shoreline conditions that have not been hardened by some of the previously listed conditions. Soft edges are more natural and can protect shorelines from the impacts of waves, tidal fluctuations, and surges while creating habitat for local marine flora and fauna.

Nature-friendly banks Thijssevaart

Delft, Netherlands

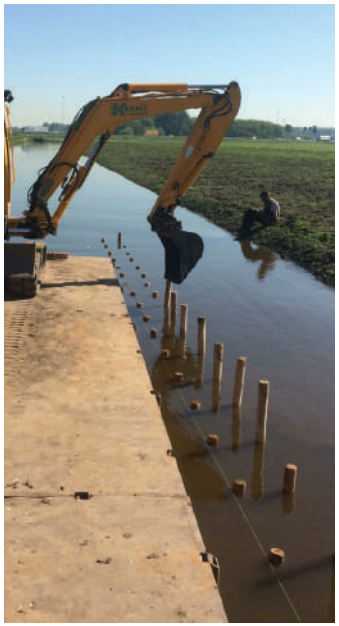
For the “Nature-friendly banks Thijssevaart” project in Delft, Aannemingsmaatschappij Van Gelder B.V. commissioned us to place Aqua-Flora® mats.

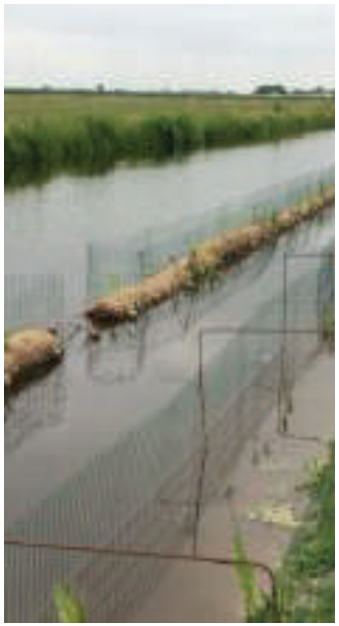
For this project a total of 200m2 of Aqua-Flora® mats (5x1m) were placed. We also supplied a number of seed blends for wet and dry banks.

Click here to view the project page.

Aalkeet-Buitenpolder watercourse

Vlaardingen, Netherlands





For the “Broadening of the Aalkeet-Buitenpolder watercourse” project, GKB Realisatie bv commissioned us to make nature-friendly banks using Aqua-Flora® rolls.

For this project a total of 167 Aqua-Flora® rolls (3×0.3m) were placed. The rolls were clamped between two rows of 1m long ø8cm stakes. Bundles of brushwood were used to fill the water depth. Apart from that, 3,000 Aqua-Flora® plants (4x4x8cm) were placed in the wetland zone behind the roll, towards the slope.

We also placed an anti-waterbird construction, both near the rolls and the plants. In addition, a two-year maintenance contract was concluded.

Species of plants used in this project;
Marsh-marigold (Caltha palustris)
Bulrush (Scirpus lacustris)
Purple loosestrife (Lythrum salicaria)
Flowering rush (Butomus umbellatus)

Click here to view the project page.

Rietland N509 Oosthuizerbrug

Oosthuizen, Netherlands

For the "Rietland N509" project in Oosthuizen, Gebr. Beentjes GWW BV commissioned us to place Aqua-Flora® Floatlands and a number of Aqua-Flora® mats.

For this project a total of 20m2 of Aqua-Flora® Floatlands were placed. The Floatlands were anchored to the stakes placed by the building contractor. In addition, 4 mats (5x1m) were placed.

Click here to view the project page.

Burgemeester Oudlaan

Rotterdam, Netherlands

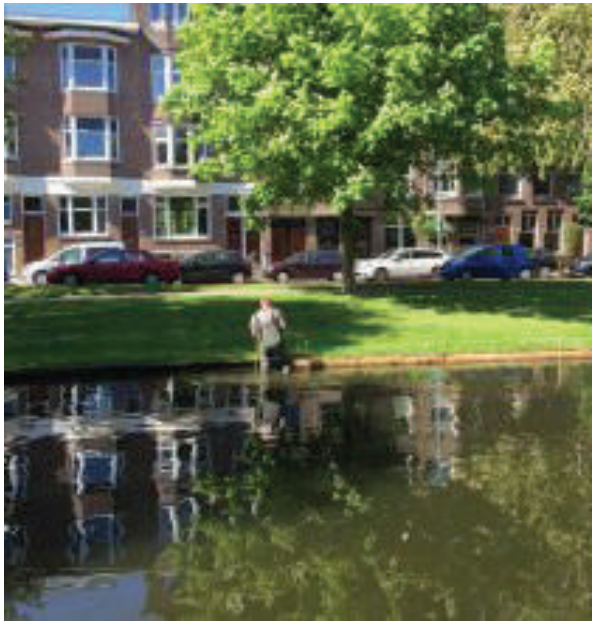
The Municipality of Rotterdam commissioned us to place Aqua-Flora® mats on Burgemeester Oudlaan, in Rotterdam.

For this project a total of 30m2 of Aqua-Flora® mats (5x1m) were placed.

Click here to view the project page.

Aqua-Flora® mats

Bergsingel, Netherlands



For the project on Bergsingel, the Municipality of Rotterdam commissioned us to place nature-friendly banks using Aqua-Flora® rolls.

For this project a total of 76 Aqua-Flora® rolls (3×0.3m) were placed. The rolls were hung in steel brackets, in which a board was placed to prevent the roll from sagging. We also placed an anti-waterbird construction, considering the number of resident waterbirds.

Click here to view the project page.

Dijckerwaal Aqua-Flora® mats

's Gravenzande, Netherlands

Weverling Groenprojecten b.v. commissioned us to place Aqua-Flora® mats on Dijckerwaal in 's Gravenzande.

For this project a total of 100 Aqua-Flora® mats (5x1m) were placed.

Click here to view the project page.

Nature-friendly banks Cor Druifplein

Medemblik, Netherlands

The Municipality of Medemblik commissioned us to place Aqua-Flora® mats on Cor Druifplein. We were also asked to supply and place Aqua-Flora® plants.

For this project a total of 17 Aqua-Flora® mats (5x1m) were placed. In addition, we supplied and placed 400 individual plants sized 6x6x12cm.

We used the following species:
Water mannagrass (Glyceria fluitans)
Great water dock (Rumex hydrolapathum)
Arrowhead (Sagittaria sagittifolia)

Click here to view the project page.

Aqua-Flora® mats

Honselersdijk, Netherlands

Jac. van Zeijl & Zonen commissioned us to place Aqua-Flora® mats in Honselersdijk.

For this project a total of 290 Aqua-Flora® mats (5x1m) were placed.

Click here to view the project page.

Casembrootlaan Aqua-Flora® mats

Poeldijk, Netherlands

Delfland Water Authority commissioned us to place Aqua-Flora® mats and floating-leave vegetation on Casembrootlaan in Poeldijk.

For this project a total of 56 Aqua-Flora® mats (5x1m) were placed. In addition, we supplied and placed 90 pieces of floating-leave vegetation (2L pots), including protective baskets.

Click here to view the project page.

Nature-Friendly Banks Overdie

Alkmaar, Netherlands

For "Nature-friendly banks Overdie" in Alkmaar, Schot Infra B.V. commissioned us to place Aqua-Flora® mats.

A total of 83 Aqua-Flora® mats (5x1m) were placed for this project. When accepting this commission a one-year maintenance contract was also concluded.

Click here to view the project page.

Walkartpark Banks
Zeist, Netherlands

De Enk Groen & Golf BV commissioned us to place Aqua-Flora® rolls in "Walkartpark" in Zeist.

A total of 16 Aqua-Flora® rolls (3×0.3m) were placed for this project. Considering the water depth we chose to hang the rolls in 66 stainless steel brackets.
The building contractor already knew that there were many waterbirds there, so we also placed an anti-waterbird construction along the full length.

Click here to view the project page.

Bolnes Pond
Ridderkerk, Netherlands

For "Bolnes Pond" in Ridderkerk, W. van den Heuvel & Zn BV commissioned us to place Aqua-Flora® materials.

For this project a total of 16 Aqua-Flora® mats (5x1m) and 17 Aqua-Flora® rolls (3×0.3m) were placed.

Click here to view the project page.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