Remediating the Red

Development of Integrated Solutions for Flood Management and Erosion Control

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Master of Landscape Architecture

Department of Landscape Architecture
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Remediating the Red

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Abstract

The purpose of this practicum is about developing a resource for future riverfront development through the integration of ecological erosion control techniques, flood design strategies and insightful planning principles. With a new outlook on protection solutions and design opportunities for riverfront spaces, the Red River will return as the ecological spine of Winnipeg, ensuring the health and longevity of our future River City.

All photographs taken by the author unless otherwise noted

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Introduction

Living in a city that flood's every year, I have developed an interest in the degrading riverfront and the impact flooding and erosion have on the natural and urban environments. Overtime, Winnipeg has lost a significant portion of the riverbank to the rivers flow, destroying the natural function of the riparian forest as well as the opportunity to create public riverfront spaces. Approximately 50 feet of the bank has eroded away over the past 50 years. We are at the time where action must be taken to protect our riverbanks before our most important resource washes away the potential for waterfront connections and development for our city into the future.

In its natural state, the Red River was free to meander- shifting and altering the landscape. The development of cities like Winnipeg, do not allow for this natural shift to occur, resulting in the need for future development strategies to resist the river's natural forces. This practicum explores alternative erosion control solutions that combine conventional engineering strategies with vegetated techniques to create a restored, healthy riverfront with the potential for public connection to the water. Chapter 1 introduces the habitat and development currently in place along the Red River. A photo inventory conducted in the individual landscape topics is explored to identify erosion problems, solutions currently used as well as issues with connectivity from surrounding neighbourhoods to the riverfront. Chapter 2 describes the process and types of erosion, signs to look for in the landscape as well as a comparison between conventional and biotechnical engineering strategies for erosion control. Chapter 3 reviews the causes and effect flooding has on the landscape along with the current water regulations in place within Winnipeg. Chapter 4 introduces integrated riverfront design strategies and planning principles essential for creating long lasting public spaces along the Red. Case studies are reviewed based on their application of an integrated vocabulary of erosion control, flood resilient spaces and riverfront planning principles. Chapter 5 reviews the sites chosen from the photo inventory, analyzing current site programming, transportation connections, erosion problems, and site opportunities and constraints. Finally, Chapter 6 explores the development of a design intervention based on a series of iterations created from the research in the practicum.

The purpose of this practicum is to explore landscape design possibilities that integrate erosion control and flood management strategies along Winnipeg's riverfront. As we lose several meters of land to the river every year, I am interested in understanding what we as landscape architects can do to prevent this degradation. It is not just about finding an easy fix for stabilization, but more of an opportunity to bring the Red River back to the forefront; to show its importance to our city and that we want to protect it. Within my research, I seek to develop an understanding of sensitive riverfront design that improves bank stabilization and public gathering space.

1. Red River of the North

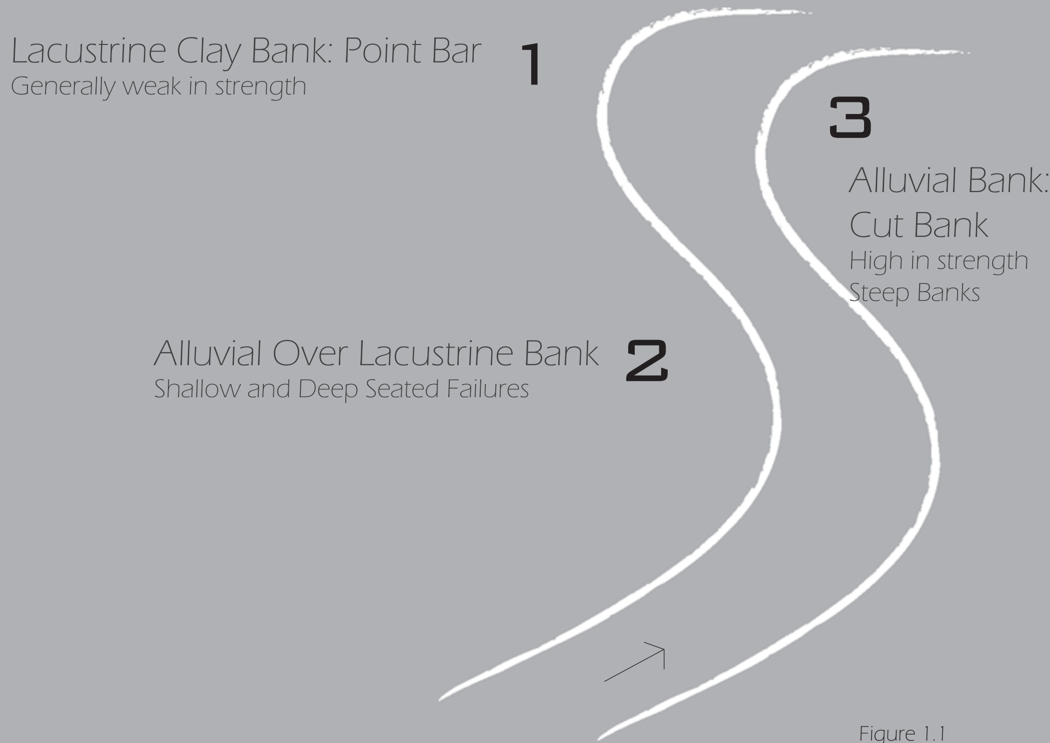


Figure 1.1

River Flow

River channels are formed by the water they carry, flowing in a curved pattern across the landscape. As a river flows, the landscape is carved into a series of meanders, each characterized by its gradient, geology and volume. The force of the water determines how each bend in the river is formed. The outside bank referred to as the ‘cut bank’, switches from side to side as the river curves through the land. The force of the water causes deposition within the river, removing sediments from the outside banks to the inside banks. The waters velocity is often slower at the inside bank, or ‘Point Bar’, allowing for the buildup of deposition materials. The velocity of the water is greater near the cut bank, making it more likely for it to erode. The fastest flowing and deepest part of the river is known as the Thalweg. As erosion scours the cut bank and deposition occurs at the point bar, the river channel moves towards the next cut bank, alternating the pattern of erosion and deposition. As rivers flow overtime, they tend to become more sinuous, the sharpness of each curve is determined by the flow of the river. (Living With A River)

The Red River of the North as it is now called is located within the Red River Valley that stretches from the United States into Canada. As the river flows northward, the gradient decreases from 0.08 meters per kilometer to 0.024 meters per kilometer. The Red River originates from the confluence of the Bois de Sioux and Otter Tail rivers between Minnesota and North Dakota. From there, the river flows north, forming the border of Minnesota and North Dakota, continuing through Winnipeg, Manitoba. Ultimately the Red River empties into Lake Winnipeg, then into Hudson Bay via the Nelson River. The meanders in the River are currently still actively migrating at a rate of 0.04 m/yr over past 1000 years. (Brooks)

The Red River is made of clay rich soils, formed when Lake Agassiz drained across the province 11,500 to 8000 years ago, creating deep channels in the clay material. Overtime, silt and sand were deposited and the clay material thickened resulting in a uniform settling of these materials to the ancient lake bottom. With the glaciers receding, erosion was inevitable. Post glacial erosion resulted in steep riverbanks that are susceptible to bank failure. (River Stability, 2012)

In Winnipeg, we have classified the banks into 3 main types: Lacustrine Clay, Alluvial over Lacustrine and Alluvial. Lacustrine Clay banks are found along the outside bend, generally weak in strength with failure controlled movements. (River Stability, 2012) The soil ground water and river hydraulic conditions affect the bank stability and are often found along large sections of the bank. Alluvial banks are found on the inside bends, exhibiting higher strengths and therefore a steeper gradient. These banks often require erosion control due to damage from river hydraulics, wave and ice action, precipitation and varying soil cover. Alluvial over Lacustrine banks are located in the transition zone between the inner and outer bends. These exhibit shallow and deep seated failures and have the potential for significant riverbank loss.

While erosion is a naturally occurring process that aids in the health of the river ecosystem, human activity plays a pivotal role in increasing the degradation of the river landscape. Activities such as boating, construction, industrial activity or fertilizer use near the water line are a few of the many actions that can cause harm to the water quality and physical damage to the riverbank. Structures such as houses or bridges are often built in close proximity to the riverbank where the soil is often weak and susceptible to bank failure. The weight of the structure can add pressure to the riverbank as well as the increased storm water runoff that comes from more urbanized areas. This creates accelerated slumping along the riverbank. If natural vegetation is removed from the bank, slumping will again be accelerated due to the loss of the root structure holding the bank together. Along the shores of the Red, the health of the vegetation and water quality impact fish habitats, native plant communities and human health (Granite Environmental).

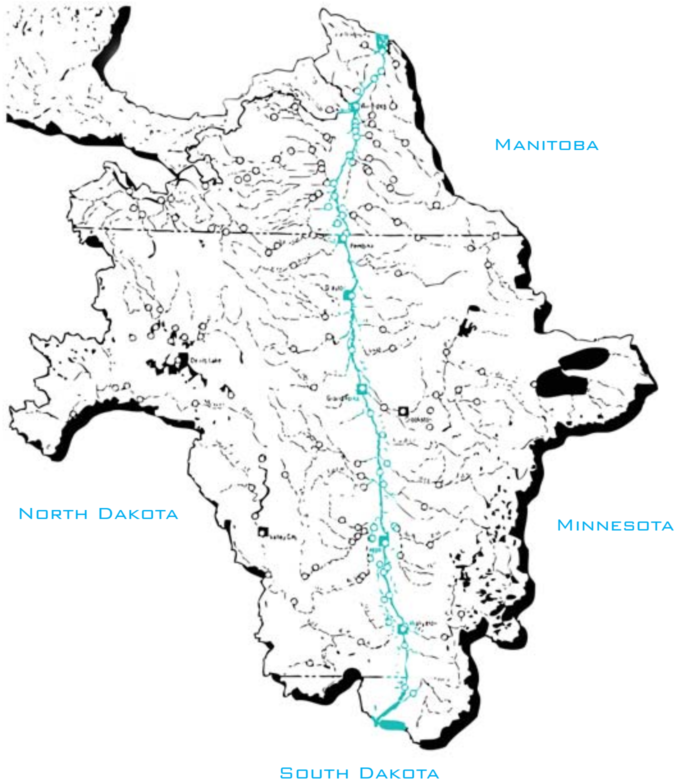


Figure 1.2

Diagram Adopted from: "Streamgages in the Red River of the North Basin in U.S. and Canada" USGS. http://nd.water.usgs.gov/floodinfo/red.html (accessed November 4, 2013).

River Lot System

Winnipeg's development from a trading post at the Forks, displays the significant influence the Red River has had on our City. The Metis were among the first settlers to the region, resulting from the marriage of French fur traders and aboriginal women from the Manitoba region. Before Manitoba became a province in 1870, the Hudson Bay Company was in control of the waterways and the land surrounding them since 1820. The river lot system established to divide property was designed after the French seigneurial system. The land was divided into long, narrow strips allowing every property to have access to the water, as it was the primary source of transportation and trade at the time. The lots were typically only 150-250 m in width, but up to 3 km in depth, stretching out into the landscape (Manitoba Metis Federation). According to Canadian Geographic, the river lot system was developed, "to give each family a share of fertile black river soil for crops such as wheat, oats, barley and vegetables, as well as space further back for some hay and pasture" (Canadian Geographic).

Once the region became a province of the Dominion of Canada, an attempt was made to impose an English lot system that saw square townships within the region. The attempt was not altogether successful. With an increasing number of people arriving in the Red River settlement –now the City of Winnipeg, new lots were measured along the same river lot formation. This resulted in Red River trails established parallel to the river; one closest to the river connecting the houses, another other developed along the two mile border and one at the four mile border. This resulted in the English system super imposed on the French seigneurial system, which can still be seen in the layout of many streets in modern day Winnipeg (Canadian Geographic).

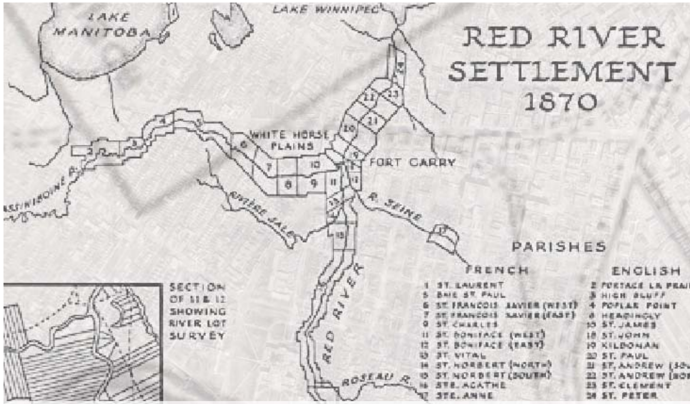


Figure 1.3: Red River Settlement System
Riverlots and scrip: elements of Metis aboriginal rights. Winnipeg: Manitoba Metis Federation, 1978. Print.

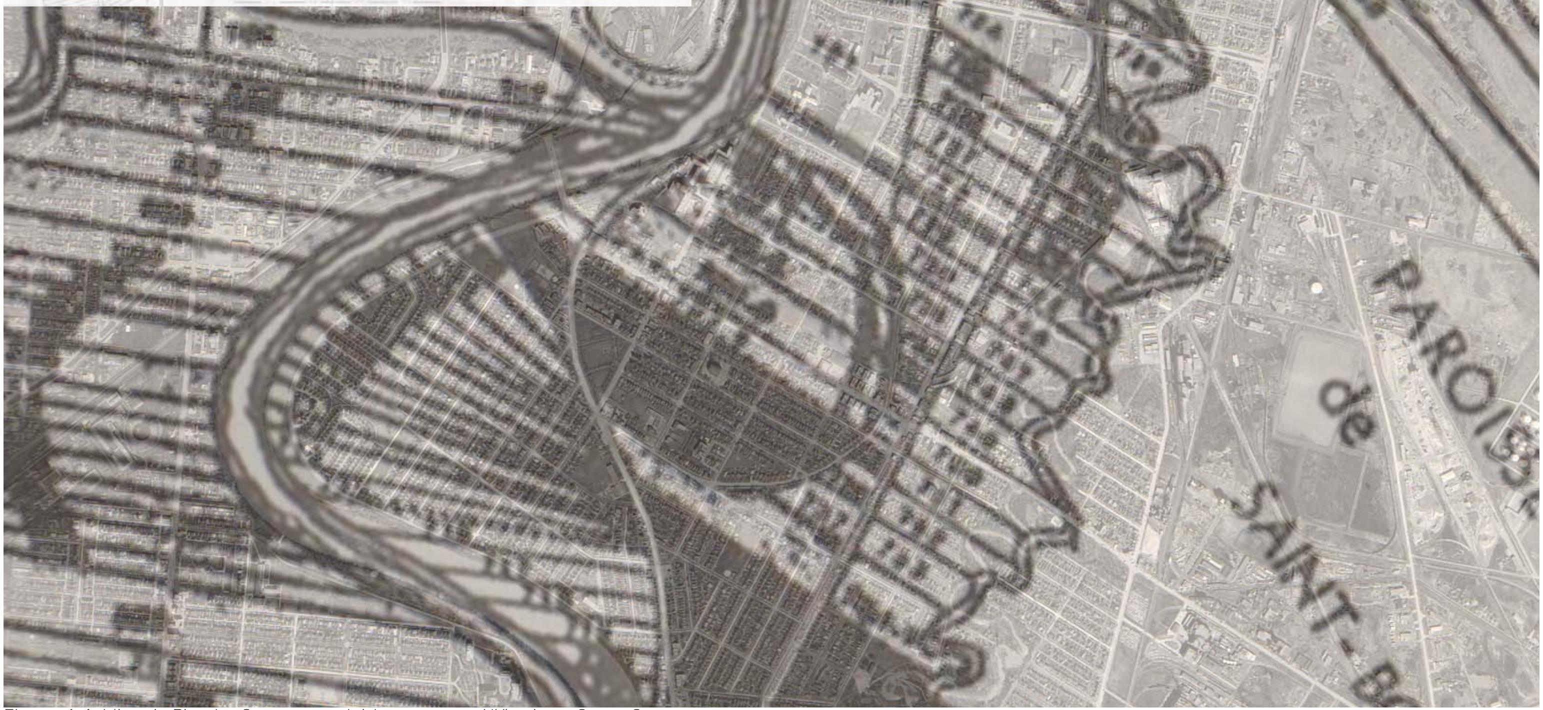


Figure 1.4: Historic Riverlot System overlaid on present Winnipeg Street System
"Canadian Wartime Experience." Canadian Wartime Experience. http://www.umanitoba.ca/canadian_wartime/grade6/module3/stboniface.shtml (accessed January 8, 2014).

Riparian Habitat

Riparian areas are transitional spaces where the river and the land meet. Riparian areas develop unique plant communities with combinations of trees, shrubs, forbes and grasses. This area provides an essential buffer between the river itself and upland uses, protecting the health of the river ecosystem. Riparian health can be determined by the ability of the habitat between river and upland to perform its ecological functions. Riparian vegetation is the most influential component in the performance of ecological functions such as providing aquatic habitat, moderating river water temperature as well as acting as a buffer space that filters sediment and stabilizes the riverbank. (Riparian Health)

Essential ecological functions affected by riparian vegetation include:

1. Increased riverbank stability enhancement and resiliency of the landscape
    - -Stability is the ability to persist and withstand stress; deep rooted vegetation such as Willows or Dogwood help stabilize the bank
    - -Resiliency is the ability to recover or bounce back from events such as flooding; Willow species have flexible branches, allowing them to recover after flooding
2. Protecting of Water Quality
    - -A healthy riparian area can quickly re-vegetate bare soil
3. Trap Sediment
    - -Increases stability and resilience
    - -Vegetation slows runoff and water flow, reducing the amount of sediment it can carry
    - -Sediments can reduce water quality for aquatic habitats
4. Filtering Runoff and Flood Water
    - -Riparian area filters and removes contaminants from runoff
    - -Improves water quality and enhances the abundance of vegetation for filtering and buffering

5. Reducing Impact of Flooding
- -Stores floodwater therefore reducing energy in the water for transporting sediment and causing erosion
- -Increases the extents of flooding

6. Build and Maintain Stream banks and Shorelines
- -Natural shorelines are always moving as erosion on the outside bend is balance with deposition on the inside bend
- -Riparian areas slow down the processes of erosion and deposition
- -Accumulated sediment along the banks enhance the soil nutrients

7. Recharging Groundwater
- -Vegetation traps snow in winter
- -Spring melt waters seep into the riparian area, maintaining soil moisture
- -Lush vegetation (ferns, shrubs & trees) growth need a lot of water- their root systems bring water up to the soils surface,

8. Maintaining Biodiversity
- -Rich soils support diverse vegetation growth
- -Canopy offers protection for low lying vegetation and animal habitat
- -Riparian areas are transitional and therefore can support a wider range of species that are either aquatic or terrestrial

Riparian Health. (n.d.). Ecological Functions. Manitoba Riparian Health. Retrieved September 14, 2013, from http://www.riparianhealth.ca/riparian-areas/ecological-functions/

Figure 1.5

Riverbottom Forest

The river bottom forest is the dominant riparian habitat found within the Red River Valley. Spring flood waters are essential for the growth and development of the forest as they deposit silt and sediment with nutrients needed for vegetation establishment. The root system of the forest stabilizes the river bank, aiding in the protection against erosion. The river bottom forest is identified by three main layers, the riverbank, flood plain and terrace. (Riverbottom Forest)

The riverbank layer, as it implies, is the area along the edge of a water channel. Debris and vegetation are found along this shoreline functioning to hold nutrients, filter pollutants, and provide habitat for fish. Examples of vegetation in the Red riverbank layer include: Cattails (Typha spp.), Sandbar Willow (Salix exigua), Peachleaf Willow (Salix amygdaloides), Cottonwood (Populus deltoids), cord grass (Spartina spp.) and sedges (Cyperaceae). Adjacent to the river bank, lays the relatively flat floodplain. Acting as a buffer for the riverbank, the flood plain stabilizes the bank and reduces flooding impacts. The plant community consists of a dense forest canopy of flood tolerant species that allow for flood water fluctuation in the spring and summer seasons. Common species include: American Elm (Ulmus americana), Cottonwood, Peach Leaf Willow, Manitoba Maple (Acer negundo), American basswood (Tilia americana), Green Ash (Fraxinus pennsylvanica), Dogwood (Cornus spp.), Ferns (Pteridophyta), Trilliums and other shade tolerant species. The terrace is the most upland layer of the river bottom forest. Being the furthest layer from the water, the terrace offers a drier habitat for managed trees and shrubs. Vegetation found along the higher portions of the flood plain, such as American Elm, Green Ash, Manitoba Maple, can be found along the terrace. Other common species include: Bur Oak (Quercus macrocarpa), Trembling Aspen (Populus tremuloides), Chokecherry (Prunus virginiana), Nannyberry (Viburnum lentago), and Canada plum (Prunus nigra).

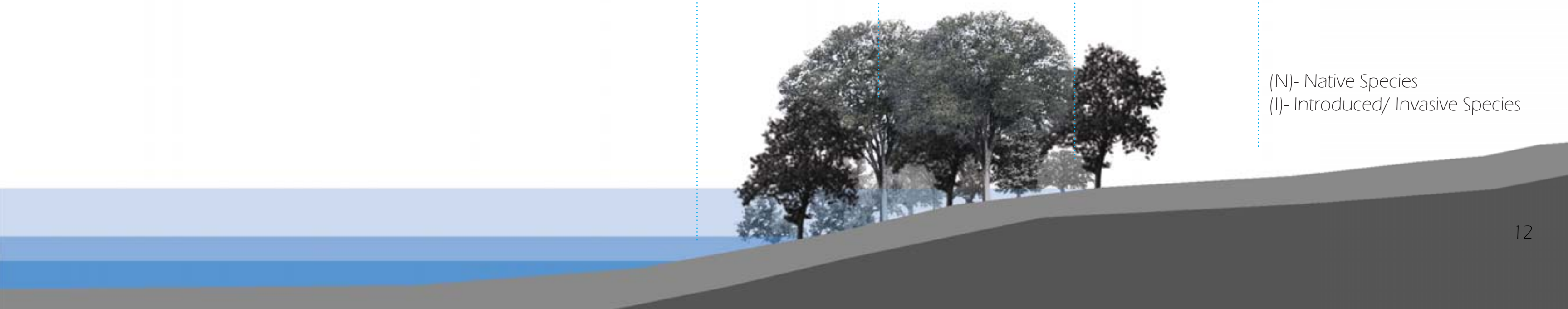
Historically, Cottonwood and Peach Leaved Willow were the most common trees along the Red River; reaching out from the lower banks (Marr Consulting). A native river bottom forest is composed of large trees with strong root systems, as well as a variety of shrubs and grasses within the understory. As water activity and flooding have increased over the years, the natural make up of the forest has changed, altering the number of native species found and increasing the number of introduced species. The damaged banks have been re- vegetating themselves overtime with fast growing invasive species such as curled dock (Rumex crispus), burdock (Arcticum spp.), sage (Artemisia spp.), Canada thistle (Cirsium arvense), sweet clover (Melilotus spp.), sow thistle (Sonchus spp.) and Siberian elm (Ulmus pumila). (Riverbottom Forest)

Figure 1.6: General Riverbottom Forest Section

Within the redevelopment of the riverbanks, the goal is to enhance the river bottom forest. By focusing on native planting solutions, the vegetation has the opportunity to flourish rather than allowing invasive species to take over. Preserving the natural integrity of the forest will help the overall function of the forest against riverbank erosion and flood damage overtime.

Riverbank	Flood Plain	Terrace
Cottonwood (N)	Manitoba Maple (N)	Bur Oak (N)
Sandbar Willow (N)	Great Ragweed (N)	Basswood (N)
Peach Leaf Willow (N)	Red Osier Dogwood (N)	False Indigo (N)
Silverweed (N)	Green Ash (N)	Indian Hemp (N)
Virginia Creeper (N)	American Elm (N)	Sage (N)
Smooth Brome (I)	Wood Nettle (N)	Aster (N)
Quack Grass (I)	Siberian Elm (I)	Burdock (I)
Sow Thistle (I)	Tufted Vetch (I)	Canada Thistle (I)
		Alfalfa (I)
		Sweet Clover (I)
		Dandelion (I)

(N)- Native Species
(I)- Introduced/ Invasive Species



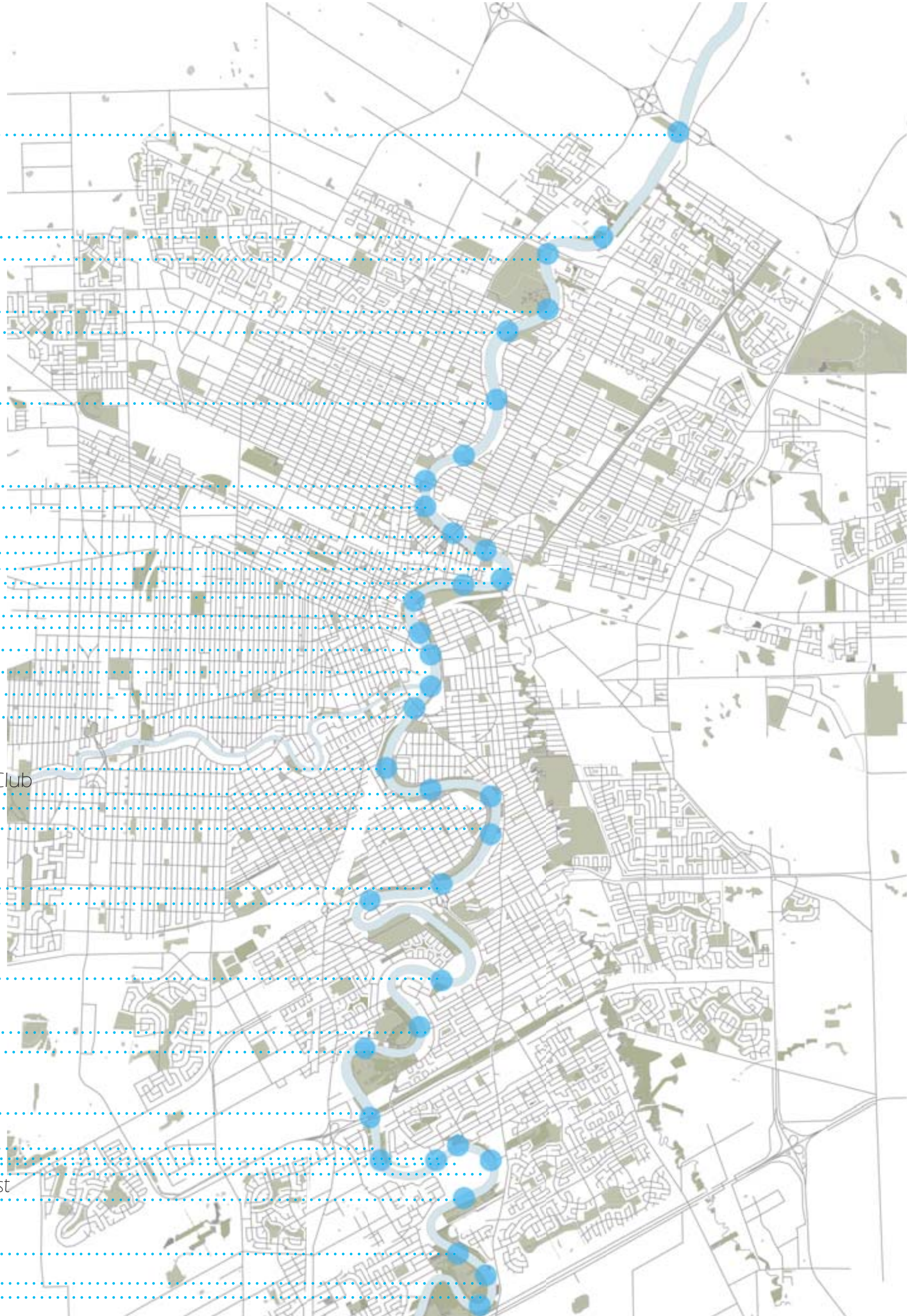
Public Access

A photo inventory was conducted to evaluate the current riverbank conditions of publicly accessible sites found along the Red River within Winnipeg. Thirty-eight sites were visited within this investigation, revealing a significant amount of erosion and damage to the riverbanks as well as a small list of erosion control practices implemented. The City does not currently offer a diverse range of erosion control methods, largely due to the high cost required to protect every city owned riverbank. Rip rap is currently the most common practice being used along the banks as it is considered the most cost effective solution and has been proven to prevent bank erosion and instability. Other practices implemented include crib walls, gabions, piles, retaining walls, vegetated terracing and erosion control blankets. While these techniques are effective in preventing erosion, most lack the potential to increase riparian vegetation health and habitat. Of the thirty-eight sites, five locations stood out based on neighbourhood character, current site uses, potential for riverfront connections and need for erosion and flood management practices. The following pages review Maple Grove Park, River Point West & Southwood Lands; St. Mary's at Guay Park; Lyndale & Churchill Drive and Alexander Docks & North Saint Boniface.

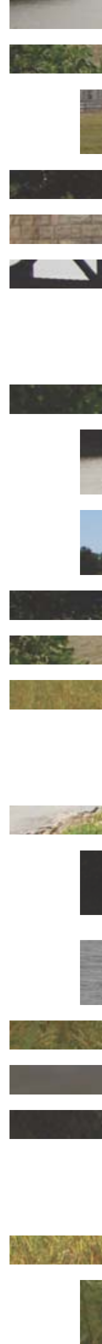
The inventory resulted in a general understanding of the Red River as an important, but often missed opportunity for Winnipeg. The riparian forest along the shores provides the city with a scenic resource that also provides the important function of maintaining the health of the river ecosystem. Living in a city that sees flooding every year, it is hard to look away from the damage that is caused along the banks of the Red. We have lost several square meters of public and private property to erosion and flood damage overtime, in turn destroying the natural function of the riparian forest. Approximately 0- 0.5 meters perpendicular to the waters edge is lost every year. While our rivers may not be the most clear, or the most breath taking water bodies, they are uniquely our own and should be protected (Neirinck, 55).

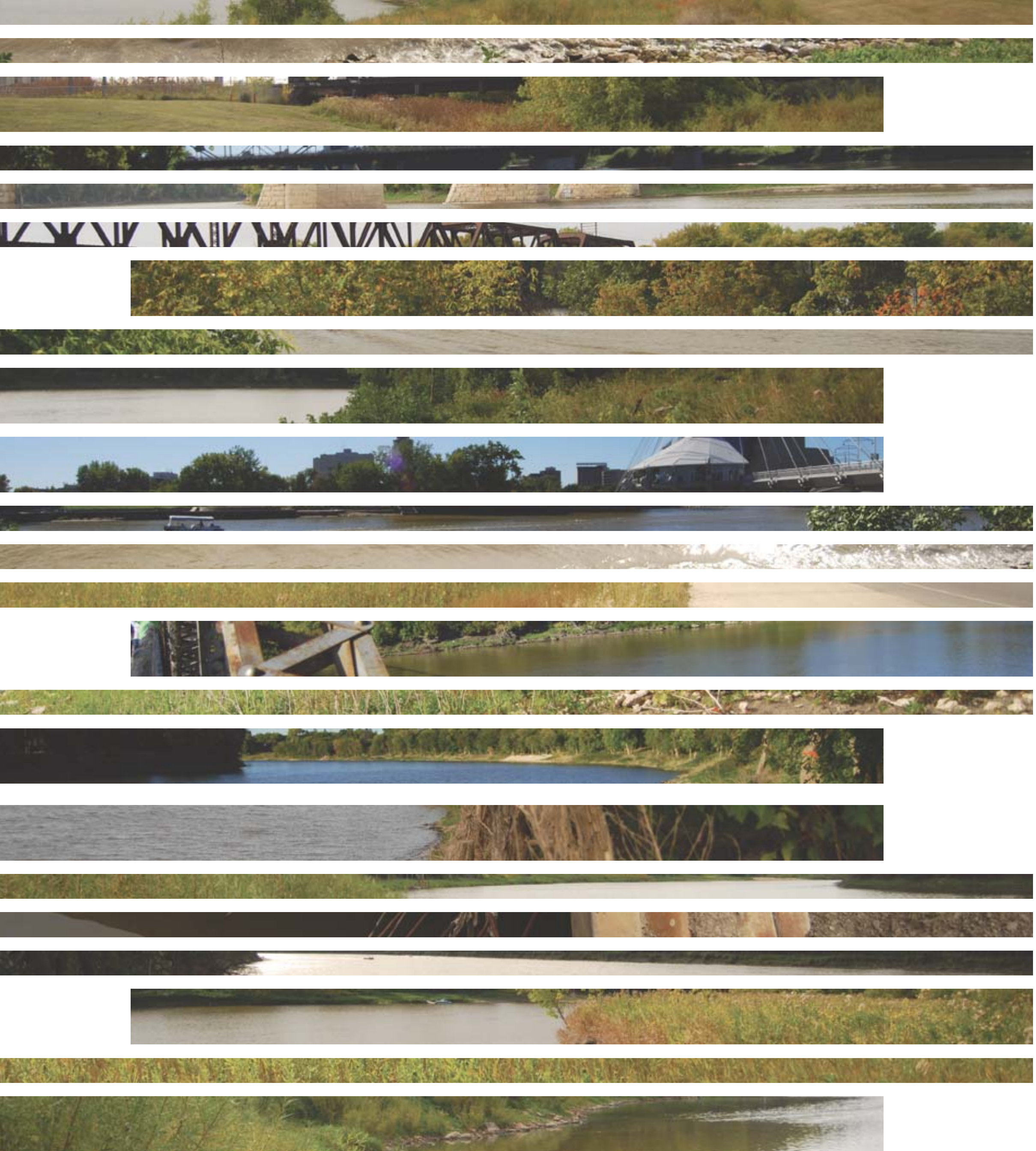
Figure 1.7: Forks Riverwalk >

Public Access Sites:



38: Henderson Hwy at Perimeter
37: Valhalla near Henderson
36: Chief Peguis Trail
35: Pumphouse- Kildonan at Hawthorne
34: Frasers Grove Park and Kildonan Park
33: Elmwood Park
32: Redwood Bridge
31: Elmwood Cemetery
30: Ernie O'Dowda Park
29: Nairn near Allan St.
28: Watt near Rail Bridge
27: Whittier Park
26: Alexander Docks
25: Tache at Messager
24: Parc Elzear Goulet
23: Provencher Bridge
22: Tache Promenade
21: Tache Water Dock
20: Forks Riverwalk
19: Norwood Bridge
18: Lyndale Dr and Churchill Drive Canoe Club
17: Churchill Dr.
16: St. Mary's Near Guay
15: St. Mary's Near Ellesmere
14: St. Vital Bridge
13: Bridge Drive In
12: Salme at Lotus
11: Moore at River Rd
10: St. Vital Park
9: Fort Garry Bridges
8: River Point Park
7: St. Amant and Community Garden
6: Minnetonka School/ River Road Park West
5: River Road Park East
4: Henteleff Park
3: Normand Park Bike Path
2: St. Mary's Rd at Perimeter
1:Maple Grove Park at Perimeter





<Figure 1.8

Site One: Maple Grove Park at Perimeter

Figure 1.9

Ground Cover:

Native & non-native grasses| Aspen/Oak parkland| sedges|dried and wet clay|rip rap: limestone rocks for toe protection

Figure 1.10

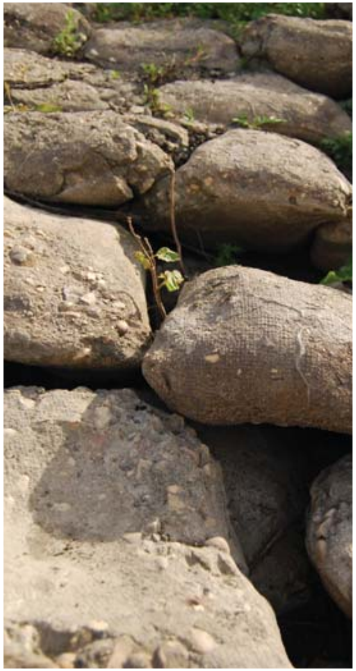


Figure 1.11

Programmatic Elements:

Figure 1.12

Notes:

- Alluvial bank- slumped in terraces
- Concrete sand bags to prevent bank movement
- Dominated by sedges and sand bar willow
- Across from Kings Park
- Recreational Fishing Spot
- Fallen, decomposing logs

Figure 1.13

Ground Cover:

Mown lawn along dike| American elm| Green ash|shrubs|Oak| Cottonwood| Aspen trees| dried, hard, cracked clay along flood plain

Figure 1.14

Figure 1.15

Programmatic Elements:

Figure 1.16

Notes:

• Forested area and dike are designated as park space, but feels like a private area due to the residential homes backing onto the forest, many of them with fenced off yards
• Only tree house seen so far in a publicly accessible area

Site Sixteen: St. Mary's Near Guay

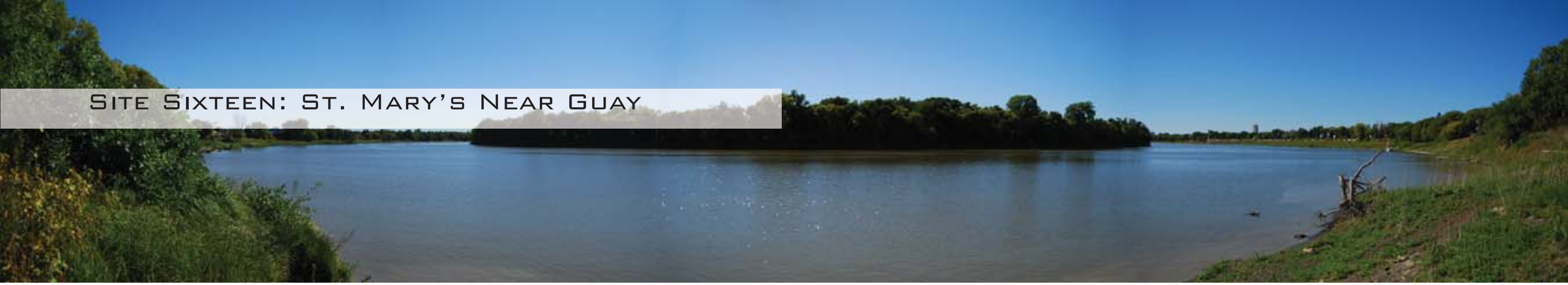


Figure 1.17

Ground Cover:

Flower beds with perennials|mown lawn within park|wind breaks| non- native grasses, shrubs, trees along the river bank| dried clay in flood plain| wet clay on shores| weeds surrounding river bank| Willows

Figure 1.18

Figure 1.19

Programmatic Elements:

Figure 1.20

Notes:

"In the 1870s, The regiment left its mark and instilled in the men of St. Vital a need to protect Manitoba life and Value. As proof, the Victoria Cross- Canada's highest award for military valour- was awarded to Guay avenue resident John Robert Osborn of the Winnipeg Grenadiers. Osborn threw himself on a grenade in the 1941 Battle of Hong Kong, saving the lives of over 30 Canadians" -Sign on Site

- Evidence of deep seated failure on site, upstream and downstream

Site Eighteen: Lyndale Dr and Churchill Drive Canoe Club

Figure 1.21

Ground Cover:

Mown lawn along Lyndale Park Dr| Cottonwood, Ash, Poplar, Basswood trees| native & non-native shrubs and grasses| timber piling used along Lyndale Drive| rock columns| steep bank near Hemlock Ave |slumped bank near Gauvin Ave| sedges

Figure 1.22

Figure 1.23

Programmatic Elements:

Figure 1.24

Notes:

- Canoe club along Churchill feels like a private property but has the opportunity to become more public to create a space to view the recreational river activities
- Rock column stabilization project along Lyndale drive within the past year and rip rap along the toe completed in 2000
- Previous timber piling has been done along Lyndale drive but the bank in front of the piling has begun to slump into the river
- Stairwell access along Lyndale down to slumped bank

Site Twenty Five: Tache at Messager

Figure 1.25

Ground Cover:

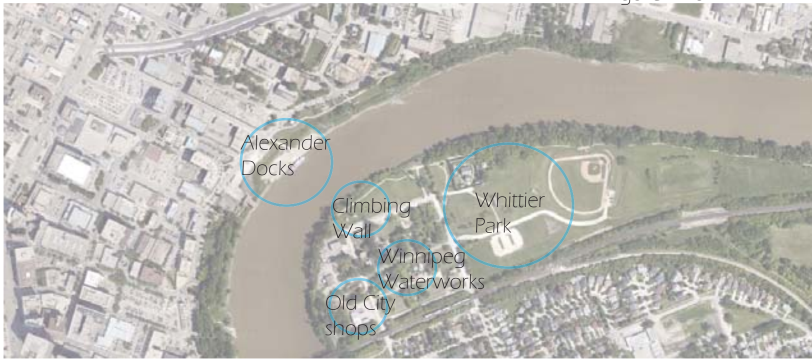
Exposed gravel and soil parking lot|dead end street| mown grass along parkway |exposed tree roots along the riverbank|wet and dry clay banks|old timber piles|concrete pieces broken|native & non native grasses, shrubs|Cottonwood, Ash, Basswood, Oak trees|Virginia creeper|Dogwood|sedges|steeply eroded due to flooding and fast moving waters|fallen trees along bank|pieces of iron along bank

Figure 1.26

Figure 1.27

Programmatic Elements:

Figure 1.28



Notes:

- Open park space offers opportunity for public riverfront access space and brings new life into the fairly small industrial area
- A climbing tower located nearby is utilized all year round is transformed into an ice wall in the winter months
- The bank is very eroded- needing to climb down to get to shoreline
- The site is interesting due to its remnants of timber piles and concrete pieces that could have possibly been another dock
- Across the River is Alexander Docks where the River Rouge Cruise Line is docked
- A secondary desire line pathway is located along the upper bank

Current Erosion Control Techniques

Table A: Current erosion control techniques currently implemented on each of the 38 sites from the Public Access Inventory conducted in Summer 2013. The most common techniques used are riprap for toe bank protection and vegetated terracing for habitat enhancement. Riprap is commonly used along the riverbanks in Winnipeg due to cost needed to implement erosion control practices as well as ease of access to limestone in Manitoba.

Table A>

Public Access Sites:	Current Erosion Control Techniques								
	None	Crib Retaining Wall	Gabions	Piles	Retaining Wall	Riprap (General)	Riprap (Toe)	Vegetated Terracing	Erosion Control Blankets
1							x		
2								x	
3							x		
4	x								
5	x								
6							x		
7	x								
8	x								
9						x	x		
10			x				x	x	x
11							x		
12	x								
13						x	x		x
14						x			
15				x	x			x	
16	x								
17	x								
18		x		x			x		
19	x								
20					x		x		
21					x		x	x	
22							x		
23							x	x	
24	x								
25									x
26	x								
27	x								
28							x	x	
29				x	x				
30								x	
31						x	x		
32							x		
33	x								
34	x								
35							x		
36							x		
37	x								
38							x		

2. Erosion Control

Landscape Erosion

Erosion is a naturally occurring process which consists of the removal of soil particles by water, wind and ice movement from the bed and channel and distributed through the flow of the river. The severity of erosion is dependent on material properties, bed load and shear stress such as velocity, viscosity and turbulence of the water. Types of erosion can be characterized based on differences in soil movement through water flow and fluctuation. (Gray, 1982)

The difference between erosion and instability is a result of the overall forces impacting the banks. Erosion is based mainly on water moving particles along the bank, only evident in the interface between water and soil. The impact of erosion is most evident in areas of significant flooding, resulting in a larger loss of sediment compared to the average water flow. The stability of the bank refers to the overall structure of the bank and its ability or inability to resist driving forces against the banks. Evidence of structural failure is often washed away from erosion along the banks, but can be visible through tension cracks and shifts in the ground. Movement from ice during the spring thaw, often scrapes away the face of the bank resulting in surface erosion and bank instability due to the shear force of the ice impacting the bank.

The most common types of erosion occurring along Winnipeg's Red River include, Toe Undercutting, Bank Scouring, Wave Erosion and Bank Sloughing. When in the field, there are five main signs to look for when identifying erosion problems along the riverbank, tilted trees, head scarp, failure terraces, tension cracks and slumping. The severity of the damage caused will mainly be determined after a structural analysis of the bank, however understanding what to look for when conducting an initial site analysis is useful for determining solutions necessary for bank restoration.

Figure 2.1: Normand Park looking North to the University of Manitoba >

Types of Degrading Mechanisms Along Riverbanks:

Figure 2.2

Figure 2.3

Figure 2.4

1. Toe Undercutting

A type of stream channel erosion that 'attacks' the toe of an underwater slope, leading to slumping or sliding of the bank. (Figure 2.2)

2. Flow Erosion

Tractive (pullingstress imposed by flowing water can cause the river bank to wear away. The force of the water plays an important factor in the level of degradation to the bank; the higher the velocity, the more degradation to the bank.

3. Bank Scour

The direct removal of bank materials by the action of flowing water and the sediment it carries. (Figure 2.3)

4. Piping

Bank erosion caused by ground water seepage. This process, also known as 'spring sapping', is described as, "the detachment and movement of soil particles at the point of emergence of a spring or seep in the ground." Piping results in ground level cavities or flow lines that are further widened by moving water.

Figure 2.5

Figure 2.6

5. Wave Erosion

Movement of bank material caused by current or wave action against the bank as a result of pumping action, pore-pressure and fluctuation (Figure 2.4)

6. Splash Erosion

The result of raindrop impact on unprotected soils; the larger the raindrops and the greater the slope, the farther down hill the soil particle will move and the greater the risk of erosion

7. Rill and Gully Erosion

Rill erosion is characterized by small, even tiny channels about a few inches deep that abrade and intertwine. Gully erosion is identified by large channels, up to 10 feet deep that are obviously damaging. (Figure 2.5)

8. Bank Sloughing

Slumping of saturated, cohesive banks incapable of free drainage during rapid draw down (Figure 2.6)

Figure 2.7

Figure 2.8

Figure 2.9

1. Tilted Trees

Trees that have moved and are often tilting towards the river are a sign of a weak bank structure. The ground cover is often bare and exposed roots are visible along the bank (Figure 2.7)

2. Head Scarp

The failure line at the top of a slumped bank (Figure 2.8)

3. Erosion & Failure Terraces

Weak bank structure and flowing water can cause the land to form terraces into the riverbanks (Figure 2.9)

Figure 2.10

Figure 2.11

Figure 2.12

4. Tension Cracks

Cracks in the ground, resulting from the toe of the bank pulling away from the top of the bank (Figure 2.10)

5. Slumping

The downward movement of a bank structure due to instability at the toe of the bank as a result of water movement undercutting the bank. The bank falls, commonly creating a concave form into the bank. (Figures 2.11& 2.12)

Gray, Donald H., and Robbin B. Sotir. Biotechnical and soil bioengineering slope stabilization: a practical guide for erosion control. New York: John Wiley & Sons, 1996.

Erosion control practices can be divided into conventional and ecological strategies, each with their own benefits. Ecological engineering and conventional engineering have several differences that should be noted. Conventional engineering practices are based on human controlled processes, occurring in human-created structures driven by human supplied energy. Ecological engineering is based on natural processes occurring in landscape design. The main difference between the two is how they interact with the natural environment. Ecological engineers practice in collaborate with nature rather than oppose natural forces. For example, wetland plants can be used instead of riprap to absorb shoreline wave energy to prevent erosion. (Barrett, 1999, pg 183)

Hard techniques are typically used due to their availability, ease of installation, existence of building standards, acceptance by specifiers and familiarity to contractors. They are designed with life spans and specifications in mind, creating an added security that it will perform its distinct purpose. Bioengineered solutions incorporate living matter into the equation adding some uncertainty as to if or when it will perform to its functions. Traditional engineered techniques such as retaining structures and revetment systems are often used to protect banks from failures and erosion. These techniques are used when it is not practical to re-grade the slope of the bank. Retaining walls, for instance are used to increase the slopes resistance to failure in addition to slope stabilization. Examples of retaining structures include: gabions, dry-laid stone wall, vertical timber wall, horizontal timber wall and 3D geosynthetic wall. Revetment systems are placed on slopes to armour and prevent scour and erosion. Revetments can assist in the prevention of mass movement of a slope and protect riverbanks from slump failure and undercutting. Examples of revetments include: rip rap, quarry stone and gabion mattresses (Gray, 1982).

Biotechnical engineering is a form of engineering that combines structural, biological and ecological concepts to construct living structures for erosion, sediment and flood control. Vegetation in the form of plant cuttings are used as construction materials to create and maintain stable sites in conjunction with other non living construction materials. The root systems from the vegetation provide bank stability and structural bank naturalization. Biotechnical engineering can also be referred to as Ecological Engineering or, “the design of human society with its natural environment for the benefit of both.” (Barrett, 1999, pg 182) Biotechnical engineering is meant to compliment the natural and manmade environments by creating a fast recovery of bank slope through reestablishment of native plant communities as well as a, stable riverbank that will outlast conventional structures alone.

There is a definite overlap between the two erosion control practices, with room for landscape architecture to become part of the conversation. Engineers have traditionally been the primary designers to build land and waterscape structures for engineering purposes such as storm water detention ponds, levees and dams. Solutions for erosion control in particular can range from using purely ecological engineering approaches or conventional engineering approaches. In most cases, a combination of the two will provide for the best outcome. In many cases, vegetation alone may not solve the erosion or stability at the site, requiring the need to implement hard techniques such as rip rap or retaining walls in order to ensure the best results. The idea of 'ecoengineering' is still emerging- making it difficult to find and create building standards due to plant establishment and implementation of techniques requiring a more site specific approach. With the integration of engineering with ecological experts and landscape architects, a new form of ecological riverbank design can form; creating new opportunities for erosion control and riverfront design.

Benefits to using Conventional Engineering Techniques:

1. Immediate protection against erosion and bank failure such as mass movement, scour, and slumping
2. Implemented Building Standards due to widespread use
3. Long Lasting
4. Can be easily constructed in small areas and steep riverbanks
5. Protection against flood waters
6. Opportunities for riverside walkways

Benefits of Using Ecological Engineering Methods:

1. Protection against surface erosion
2. An increase of slope stability by root reinforcement and drainage of the soil
3. Regulation of temperature close to the surface, promoting growth of vegetation
4. Improvement of habitat
5. Reduction of construction and maintenance costs

Review of Ecological Approaches

A selection of ecological solutions have been chosen and broken down into their applications for erosion control, including suitability for type of erosion, ability to provide immediate protection and natural enhancement of the riverbank. With the application in mind, an appropriate solution can be chosen for each site.

Images of erosion control practices pg 35-44

Figure 1.13: Sheet Piling & Gabions. Lester Beach, Manitoba

Table B: Applications of Engineering Techniques- Chart Adapted from Biotechnical and Soil bioengineering slope stabilization: a practical guide for erosion control

Applications of Engineering Techniques	Riprap	Gabion Walls	Live Fascine	Willow Spiling	Brush Layering	Branch Packing	Coconut Fiber Roll	Joint Planting	Live Crib Wall	Live Stakes
Effective above and below OHW	×	×					×			
Adds Tensile Strength from Branches			×	×	×	×		×		×
Deflects Strong Currents	×	×	×	×						×
Facilitates High Drainage on Site	×	×	×							
Filter Barrier to prevent erosion	×	×	×	×	×	×	×		×	×
Moulds to existing contours	×						×			
Immediate Protection	×	×							×	
Minimum Site Disturbance			×	×		×	×	×		
Maintains Natural Bank Appearance			×	×	×	×	×			×
Protects against Shallow slides	×	×	×	×		×	×	×	×	×
Reduces Surface Erosion	×	×	×		×		×		×	
Reduces Toe Erosion	×	×	×	×			×	×	×	×
Reduces Water velocity hitting bank			×							
Roots Stabilize bank			×	×	×	×		×	×	×
Protects during Fluctuating Water Levels	×	×								
Traps Sediment	×	×	×	×	×	×	×	×	×	
Effective in Limited Space	×	×	×	×			×	×	×	×

1 Rip Rap:

Rip rap is one of the most commonly used revetment systems along riverbanks to protect against scour and erosion. This erosion control technique consists of carefully placed or piled layers of stone and boulders along a streambed. If scouring occurs and vegetation establishes, riprap can settle and conform to the riverbank contours overtime. To install riprap, a filter blanket is often placed along the river bank first in order to prevent fine particles from the bank to wash out through the stones. The blanket must be chosen to suit the soil particles of the particular riverbank as well as the stones being used for the rip rap system. (If piping or sediment removal is not a concern, then the filter blanket may be excluded from the process). When installing, care must be taken to ensure that the filter blanket remains intact and parallel to the riverbank surface. The rip rap should extend up the bank enough to protect against scour by ice, running water and wave action. In order to protect against ice damage on the bank, two layers of riprap can be used- the bottom layer will protect against wave action while the top layer will protect against ice damage.

Figure 2.14

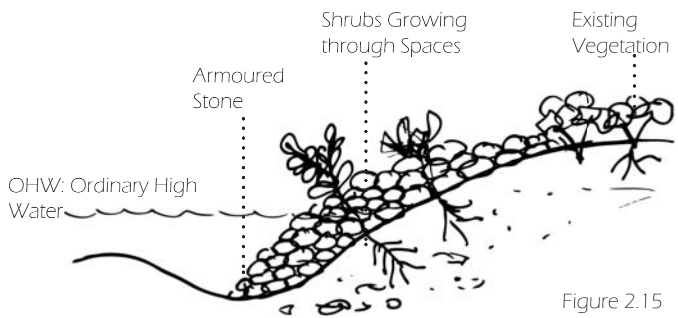


Figure 2.15

2 Gabion Walls:

Gabion walls are a gravity wall, erosion control system that utilize wire baskets filled with stone or rock to stabilize riverbanks and prevent further erosion. The wire baskets are often rectangular containers manufactured from twisted hexagonal mesh made with galvanized steel wire. A basic gabion wall sits 3 feet high within one tier. A second tier can be added on top of the first tier and set back at varying distances, depending on the project. Higher tiered walls require a greater width at the base or the use of counterforts to brace the wall and prevent overturning failure. Gabions function to prevent bank failure due to the shear strength of the rock fill for internal stability and their weight to resist the external, lateral earth forces (Gray, 1982).

Figure 2.16

Cesterzoo Gabions. June 2, 2007. Courtesy of Anthony Appleyard. Retrieved on Feb. 2, 2014 from http://commons.wikimedia.org/wiki/File:Aa_cesterzoo_gabions.jpg.

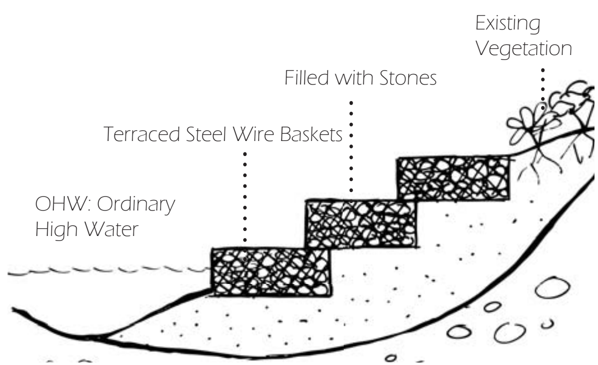


Figure 2.17

Diagrams adapted from 'Soil Bioengineering Guide'

3 Live Fascine:

Live Fascines, also known as wattling or live siltation are a low tech, easy to install form of erosion control. Using a biotechnical approach, live fascines consist of bound cylindrical bundles of stems or branches from an easy rooting material. The bundles are tied together with twine and laid in shallow contour trenches along the contours of the slope face and staked into position before backfilled. The trenches are often dug by hand, causing minimal site disturbance and decreasing the need for heavy machinery in the construction process. Trenches should be dug above the ordinary high water mark or bankfull level except on very small drainage area sites. The stakes holding the bundles in place act as anchors to prevent the slope from potential debris slides and failures. Live fascines are used to trap and hold soil along the riverbank by reducing the slope length to a series of shorter slopes through the creation of dam like structures. This protects the slopes from shallow slides and offers immediate protection from surface erosion. (Sotir, 1996)

Figure 2.18
Robbin Sotir 2001. Live Siltation. © Used with permission by Robbin Sotir. Retrieved on Jan. 8, 2014 from http://www.sotir.com/publications/use_riprap.html

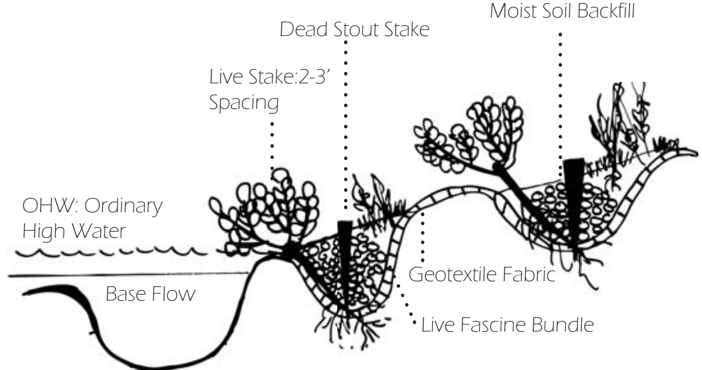


Figure 2.19

4 Willow Spiling:

Willow spiling is a form of bioengineering used to stabilize eroding banks. The technique uses living willow branches woven together to create live, flexible structures that resist water flow and enable the bank and vegetation to regenerate to stabilize and prevent further erosion. Live willow rods are woven together between live stakes set into the contours of the eroding bank in a systematic order. The space behind the wall will be backfilled with soil, giving the willows a place to establish their fast growing root system. This erosion control technique is best used in a riverbank area where there is flowing water. While this system is easily implemented on steep/ vertical banks, it cannot be used as a retaining structure. (Sotir, 1996)

Figure 2.20
Spiling Pics 005. May 11, 2013. Courtesy of KWynn 42. Retrieved on Feb. 2, 2014 from http://commons.wikimedia.org/wiki/File:Spiling_pics_005.jpg. .

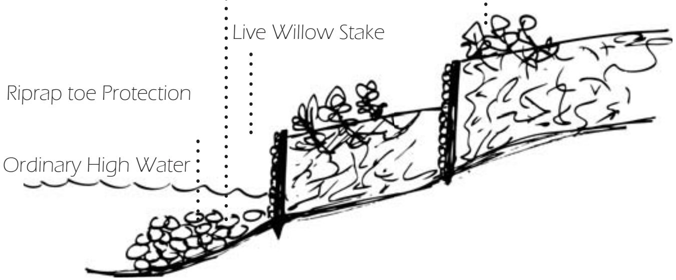


Figure 2.21

Diagrams adapted from 'Soil Bioengineering Guide'

5 Brush Layering:

Brushlayering is an erosion control technique that uses live cut branches placed between layers of soil, following the contour of either an existing or filled riverbank. The branches are placed more or less perpendicular to the slope face within dug out trenches along riverbanks in a crisscross or overlapping pattern, allowing the branches to protrude out of the bank. This creates a barrier for sediment to filter through and slow down the velocity of any surface runoff. The branches extend into the bank, serving as tensile earth reinforcement to provide shallow stability of slopes and to prevent bank failure such as overturning. Brush layering can be installed with natural geofabrics in order to provide additional reinforcement on the bank. The best time to implement brush layering is in conjunction with the construction of a filled slope operation. Brush layering is an effective erosion control method against shallow sliding or mass wasting in addition to riverbank erosion protection. (Sotir, 1996)

Figure 2.22
Templin Channel. September 6, 2006. Courtesy of Sebastian Wallroth. Retrieved on Feb. 4, 2014 from http://en.wikipedia.org/wiki/File:Templin_channel.jpg

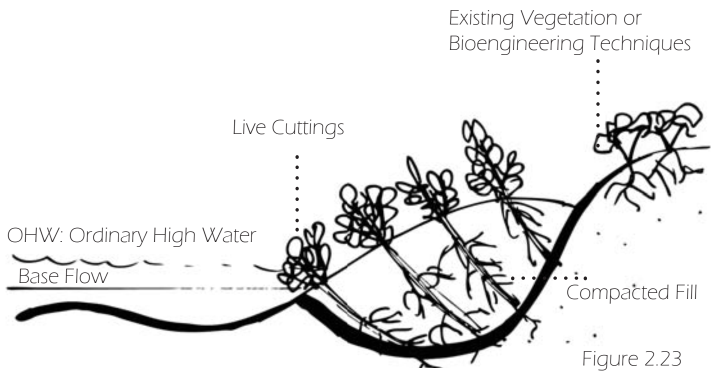


Figure 2.23

6 Branch Packing:

This technique consists of alternating layers of live branches and compacted backfill. The branches trap the sediment, refilling slumps along river banks while roots spread throughout the backfill and into the surrounding earth to create a unified mass. This form of erosion control slows runoff and reduces surface erosion and scour as plant tops begin to grow. Branch packing enhances the riverbank conditions for the colonization and rapid growth of native vegetation. (Sotir, 1996)

Figure 2.24
Completed Stream Bank. March 12, 2004. Courtesy of Sound Native Plants. Retrieved on Feb. 4, 2014 from http://www.flickr.com/photos/soundnativeplants/2647774552/sizes/o/

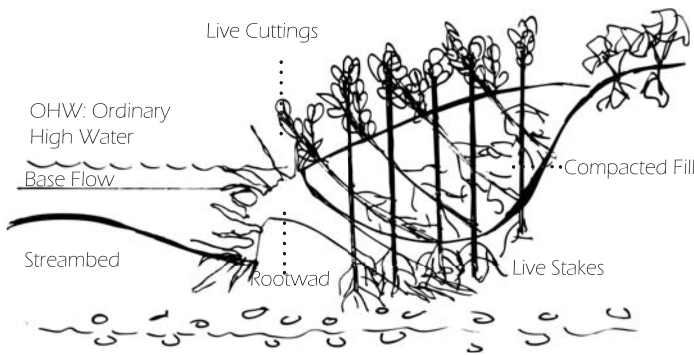


Figure 2.25

Diagrams adapted from 'Soil Bioengineering Guide'

7 Coconut Fiber Roll:

A cylindrical structure composed of coconut husk fibres bound together with twine also woven by coconut fibers. This structure is installed at the toe of the slope, generally at the ordinary high water mark or bankfull level. It is used to protect the toe of the bank and define the river's edge by moulding to the existing curvature of the riverbank. This technique is useful for protecting slopes from shallow sliding or undermining as it traps sediment within and behind the roll. It is estimated to last approximately 6-10 years before decomposing into the riverbank.

Figure 2.26

© Erosion Control. June 28, 2007. Courtesy of Wisconsin Department of Natural Resources. Retrieved on Feb. 2, 2014 from http://www.flickr.com/photos/widnr/6589946413/sizes/l/.

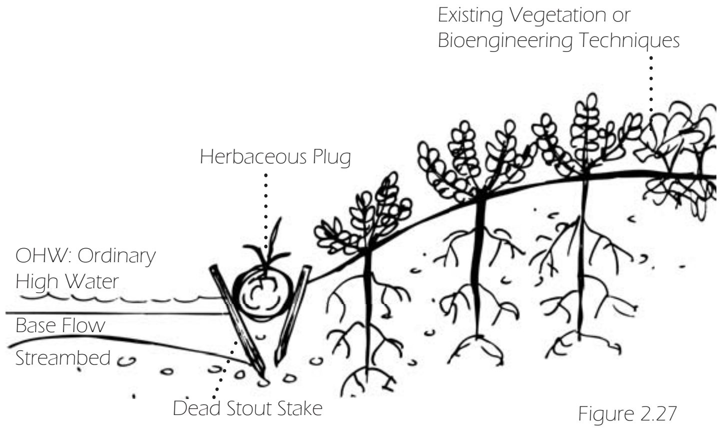


Figure 2.27

8 Joint Planting:

Joint planting is essentially a natural "disguise" for rip rap. It involves staking live cuttings into joints or open spaces between existing rocks or when rock is being placed on a slope face. The plant roots help to hold the soil together underneath the rocks. Much of the time, this technique does not take off in its first year. It requires significant maintenance in the form of irrigation in order to improve survival rates. Overtime, the vegetation creates a living root mat in the soil base beneath the rock face. The root systems bind and reinforce the soil and prevent washout of fine particles between and below the rocks. This technique is useful as it provides immediate protection and is effective in reducing erosion on actively eroding banks as well as dissipates some of the energy during a flood season. (Sotir, 1996)

Figure 2.28
Image Copyright © Melissa Neirinck

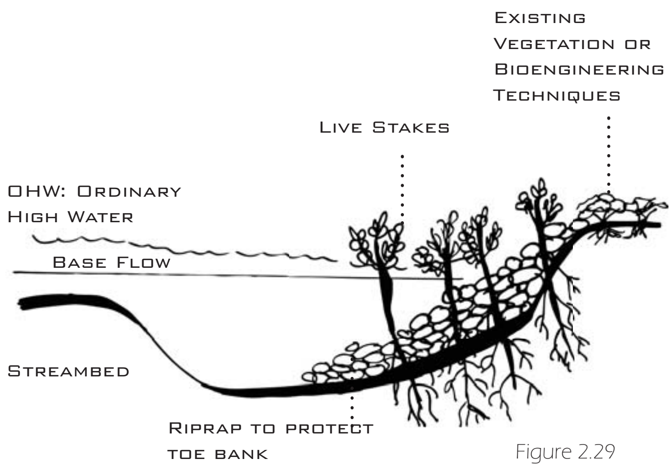


Figure 2.29

Diagrams adapted from 'Soil Bioengineering Guide'

9 LIVE CRIB WALL:

Crib walls are boxlike interlocking arrangement of untreated log or timber members used to rebuild a nearly vertical eroded riverbank. The structure is then filled with rock at the bottom and soil beginning at the ordinary high water mark or bankfull level. Layers of branch cuttings are laid inside the crib structure and extend into the slope. Overtime, the branch cuttings root and become established, eventually taking over the structural functions of the wood members. This technique is appropriate at the base of a slope where a low wall may be required to stabilize the toe of the slope and to reduce steepness of the bank. It is best used where space is limited and requires a more vertical structure. This technique is most effective on outside bends of rivers where strong currents are present. (Sotir, 1996)

Figure 2.30

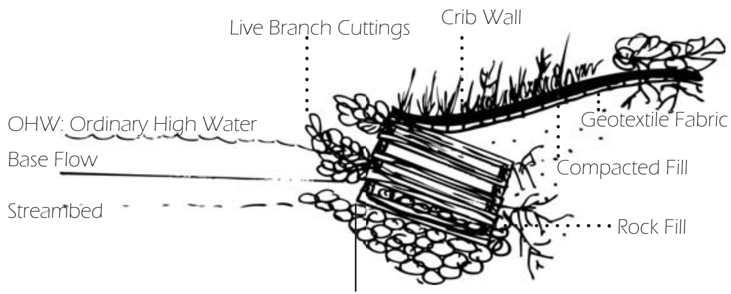


Figure 2.31

10 Live Stakes:

This technique utilizes live cuttings to create a living root mat that stabilizes the river bank, reinforcing soil particles by binding them together and soaking up excess soil moisture. Live cuttings are staked into the ground between coconut fiber logs within a wet zone along the bank where precipitation is likely to pool and keep the soil moist during the growing seasons. This technique is low tech and easy to install, providing an excellent option for sites that are uncomplicated, construction time is limited and an inexpensive method is needed. This method is used to enhance conditions for natural colonization of vegetation from surrounding plant communities and produce stream side habitat longevity. (Sotir, 1996)

Figure 2.32
© Side View (Live Stakes). October 21, 2013. Courtesy of Luke McGuff. Retrieved on Feb. 2, 2014 from http://www.flickr.com/photos/holyoutlaw/10409737753/sizes/l/.

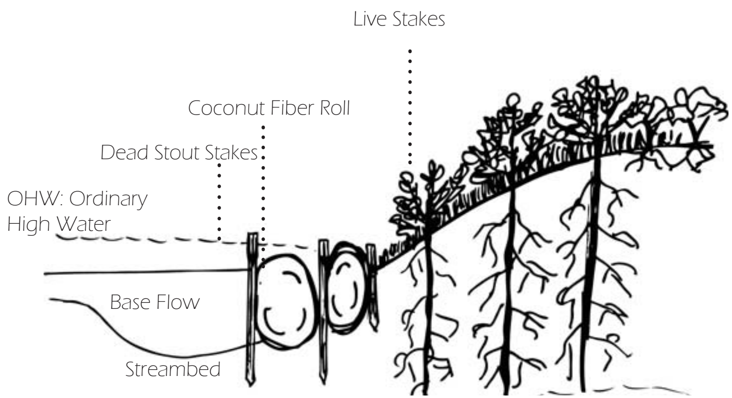


Figure 2.33

Figure 2.39 lists a series of vegetation suitable for bioengineering techniques based on habitat value, form of plant, root type, rooting ability from cuttings, as well as tolerance to deposition, flooding, drought and salt. Vegetation highlighted in blue are species best suited for native riparian habitat enhancement in Manitoba, often found growing within the floodplain or riverbank layer of the riparian forest. Examples include Cottonwood, Western Snowberry, Manitoba Maple, Red-Osier Dogwood and Peachleaf Willow as shown in Figures 2.34- 2.38.


Figure 2.34: Cottonwood


Figure 2.35: Western Snowberry


Figure 2.36: Manitoba Maple


Figure 2.37: Red-Osier Dogwood


Figure 2.38: Sand Bar Willow

Name	Habitat Value	Size/Form	Root Type	Rooting Ability From Cuttings	Deposition Tolerance	Flood Tolerance	Drought Tolerance	Salt Tolerance
Acer Negundo: Manitoba Maple	Excellent	Small Tree	Moderately Deep Spreading	Poor to Fair	High	High	High	Medium
Red Alder	Excellent	Large Tree	Shallow Spreading	Poor	High	Medium	Low	Low
Paper Birch	Good	Tree	Fibrous Shallow	Poor	Medium	Medium	Medium	Medium
Silky Dogwood	Very Good	Small Shrub	Shallow Fibrous	Very Good	Low	Medium	Medium	Low
Gray Dogwood	Very Good	Medium to Small Shrub	Shallow	Good	Medium	Medium	High	Low
Red Osier Dogwood	Very Good	Medium to Small Shrub	Shallow	Very Good	Low	High	Medium	Low
Hawthorn	Good	Small Dense Tree	Tap Root	Fair to Good	Medium	Low	High	Low
Silverberry	Poor	Medium Shrub	Shallow	Fair to Good	High	Low	High	Medium
Arrow leaf Cottonwood	Good	Tree	Shallow	Good	Medium	Medium	High	Medium
Eastern Cottonwood	Good	Large Tree	Shallow	Very Good	Medium	High	Medium	Low
Quaking Aspen	Good	Large Tree	Shallow	Fair	Medium	Low	Medium	Medium
Red Raspberry	Very Good	Small Shrub	Fibrous	Good	Medium	Low	Medium	Low
Coyote Willow	Good	Medium Shrub	Shallow Suckering	Good	High	High	Medium	Low
Sandbar Willow	Good	Large Shrub	Shallow to Deep	Fair to Good	High	High	Low	High
Peachleaf Willow	Good	Very Large Shrub	Shallow to Deep	Very Good	High	High	Low	High
Prairie Willow	Good	Medium Shrub	Fibrous	Very Good	Medium	Medium	High	Low
Shining Willow	Good	Medium to Large Shrub	Fibrous	Very Good				
Black Willow	Good	Large Shrub to Small Tree	Shallow to Deep	Excellent				
Douglas Spirea	Fair	Dense Shrub	Fibrous Suckering	Good	Medium	Medium	Medium	Low
Scarlet Elder	Very Good	Medium Shrub	Deep Laterals	Fair to Good				
Snowberry	Good	Small Shrub	Shallow Fibrous	Good	Low	Low	High	High
Nannyberry Viburnum	Good	Large Shrub	Shallow	Fair-Good	Medium	Low	Medium	Low

Table C >

Adapted From Biotechnical and Soil Bioengineering Slope Stabilization

3. Flooding in the Landscape

Winnipeg Flooding & Water Regulation

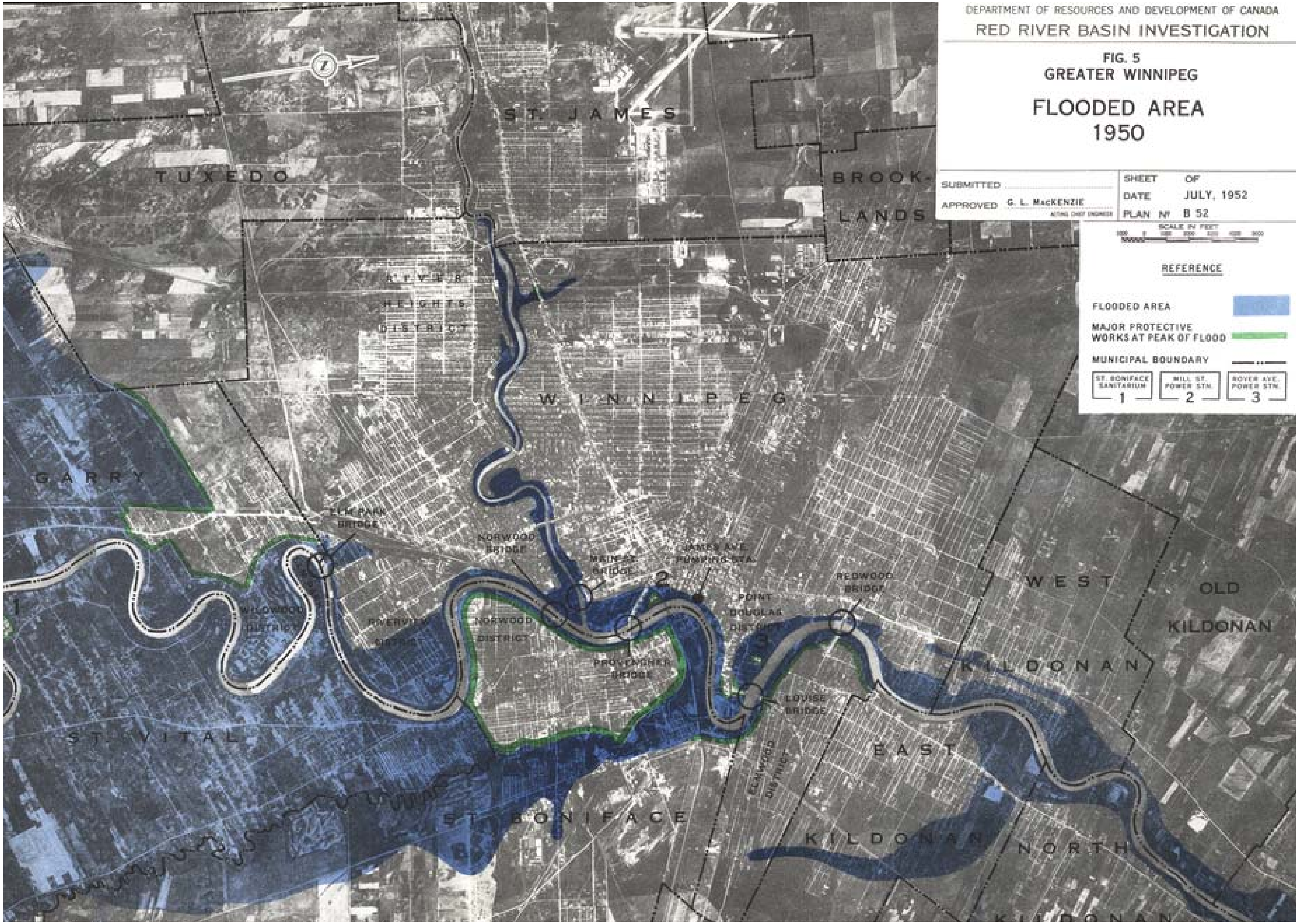
Winnipeg experiences meters in water fluctuation every year as the flood waters come from spring thaw and ice jamming. The Red River water level is regulated to stay around 223.7 m during the summer and is allowed to drop to an unregulated winter level of approximately 221.7 m. (River Levels). Keeping a stable water level is useful for travel along the Red River between Winnipeg and Lake Winnipeg. This route is not used as often as it used to be during times of trade, before the development of the major highways in Manitoba. The M.S River Rouge however, does still maintain travel along this route as it travels from Winnipeg through the St. Andrew's Lock and Dam and on to Lower Fort Garry a few times throughout the season. The River Rouge is then stored in Selkirk for the winter months before returning to Winnipeg for the cruise season once much of the flood waters have receded.

Fluctuating water levels are a part of the natural cycle, unfortunately flooding has negative effects on people, buildings, recreational space and riverbank infrastructure. In Manitoba, flooding can be characterized into four main events: minor, moderate, major and record flooding.

1. Minor flooding occurs when water reaches a height at which some property along the edge of the water might be damaged or at risk. In order to qualify as minor flooding, there must be some potential danger to the public.
2. Moderate flooding includes flooding of low lying roads and structures. At this stage, it might be necessary to move some people and their belongings to higher ground.
3. At the major flooding stage, the water causes extensive flooding of the surrounding areas and roadways. At this stage, there will be significant property damage and a large number of evacuations of both people and belongings.
4. Record flooding occurs when the water rises to a point equal to or higher than any previous measurement. At this stage, large areas and roadways are under water, and there is major damage to property. There is widespread evacuation of people and property

The main causes of flooding in Manitoba are the result of natural events that have occurred due to climatic changes as the river flows northward as well as the form the land has taken overtime. The four main causes of flooding along the Red River include: spring thaw, ice jams, the affects of the Glacial Lake Plain and the decrease in gradient downstream. (Manitoba Infrastructure and Technology)

Figure 3.1: Winnipeg Flood 1950>



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© Greater Winnipeg Flooded Area 1950. February 5, 2008. Courtesy of Manitoba Historical Maps. Retrieved on Feb. 2, 2014 from http://www.flickr.com/photos/manitobamaps/2304469813/sizes/l/.

Figure 3.2
© 2009 Red River Flood at Selkirk. April 13, 2009. Courtesy of J. Hazard. Retrieved on Feb. 2, 2014 from http://commons.wikimedia.org/wiki/File:2009_Red_River_flood_at_Selkirk4.JPG.

Figure 3.3
© 2009 Red River Flood. April 17, 2009. Courtesy of J Hazard. Retrieved on Mar 2, 2014 from http://commons.wikimedia.org/wiki/File:2009_Red_River_flood_at_Winnipeg12.JPG.

1. Spring Thaw

Spring thaw is the result of several scenarios. The first exists when southern end of the Red River thaws first, sending the melt waters northward within the basin. Other factors include local runoff, as well as a rise in the Assiniboine River water levels flowing in towards the Red. In a worst case scenario the thawed rivers will flood consecutively from the south to the north in the Red and east to west in the Assiniboine. As the river flows, the southern water begins to join with the fresh melt in the northern region. If the northern region has not yet thawed, the river is not given the opportunity to properly drain into Lake Winnipeg creating the potential for high levels of flooding. (Figure 3.2)

2. Ice Jams

Ice Jams can be caused by local or sheet ice, broken by structural barriers in the river such as bridges and piers. In addition ice from the south, travels north creating a high concentration of ice breaks within an area, creating the potential for rapidly decreasing water flow or damming the water all together- flooding the immediate region.

3. Glacial Lake Plain

The Glacial Lake Agassiz basin was one the flattest expanses of land in the world. With the retreat of the ice, the Red River has carved a shallow, meandering valley across the landscape. Due to its flat nature, flood waters have the potential to spread across the land.

4. Decrease in Gradient Downstream:

The river gradient decreases from 0.08 meters per kilometer to 0.024 meters per kilometer near Drayton-Pembina. This creates the potential for flood waters to pool near Drayton, all the way to Lake Winnipeg due to the lack of slope, becoming a shallow lake. (Schwert, Donald)

5. Summer Flooding Related to Rain Events

Excessive amounts of rainfall during the spring often cause a back up drains within the city, contributing to overall flood events

Flooding can cause loss or destruction of property with the potential of displacing people from their homes in extreme scenarios. Riverside public realms are often damaged from the deposition of unwanted debris, sediment and ice movement as the water begins to thaw. Flood water scours the bank causing vegetation to be removed, subjecting soil to erosion from the fast flowing waters. As the flood waters retreat, riverbanks once held up by the strength of the water are removed leaving the soft, clay banks weakened due to excessive pore water pressures and therefore subject to further erosion from water flow and wave movement from watercrafts. (Living with a River)

Figure 3.4:
© Red River Valley Overland Flooding. April 30, 2009. Courtesy of Jordan Morningstar. Retrieved on Feb. 2, 2014 from http://www.flickr.com/photos/morningstarphoto/3533745788/.

Figure 3.5
© Legislature. June 28, 2009. Courtesy of Loozrboy. Retrieved on Feb. 2, 2014 from http://www.flickr.com/photos/loozrboy/3678244719/

Figure 3.6
© 2005 Winnipeg Flood. July 26, 2006. Courtesy of Northwest. Retrieved on Feb. 2, 2014 from http://en.wikipedia.org/wiki/File:2005_Winnipeg_Flood.JPG.

Figure 3.7

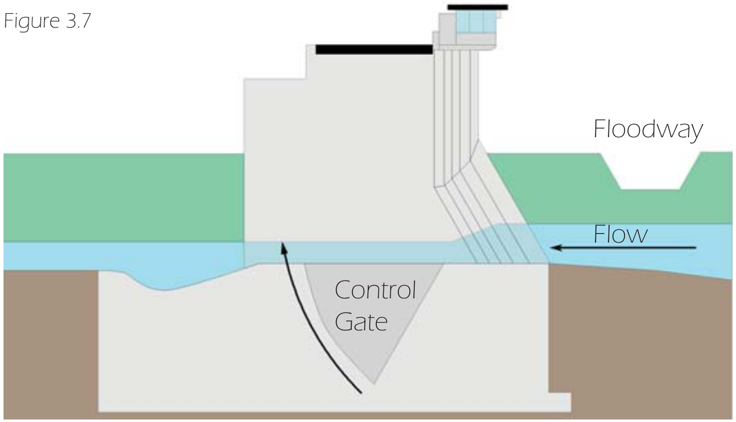
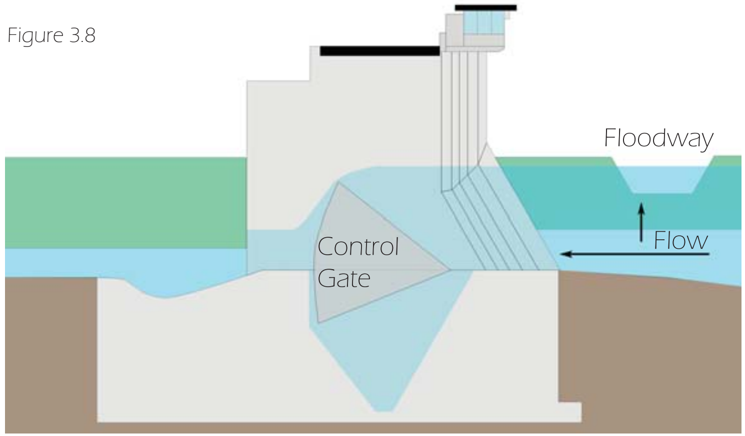


Figure 3.8



Diagrams adapted from Government of MB

The Red River Floodway was originally built between 1962 and 1968 as an artificial flood waterway control system that diverts high waters from the Red River around the city, meeting up with the Red again near Lockport (Figures 3.7 & 3.8). It was designed in response to the 1950 flood that enveloped much of the City of Winnipeg, causing 100, 000 people to evacuate their homes. After a state of emergency was called, the Canadian Army was brought in to help protect residents and properties. The flood waters remained at a high level for over 50 days, resulting in the destruction of $125 million in damages (Equivalent to about $1 Billion according to today's standards). The original design could carry up to 90 000 cfs (cubic feet per second), providing a 1 in 90 year level of flood protection. The idea for the floodway stemmed from Premier Duff Roblin, who believed that the development of a flood protection system was necessary for the longevity and protection of Winnipeg. (Floodway Authority)

An expansion of the floodway was proposed after the flood of '97, to protect Winnipeg against a 1 in 700 year flood. With the expansion, the capacity went from 90 000 cfs to 140 000 cfs. As the Red River begins to rise it spills over the floodway channel entrance and flows down the channel around the east side of Winnipeg. During this process, the river follows two routes, one through the city and one through the floodway. The government of Manitoba describes the operation of the floodway as:

"When the floodway gates are raised, the water level south of the floodway inlet is restored to its natural level which, in turn, allows more water to spill into the floodway. As the Red River flows continue to increase, the level south of the inlet drops below natural again and the gates are raised further. This process continues as long as the flow in the Red River continues to increase. During the majority of floods, the floodway is operated to ensure that the water level south of the city is maintained at the natural level - that is the level that would occur if the flood control works did not exist." (Red River Floodway)

Figure 3.9
© Lockport Dam on Red River. February 6, 2010. Courtesy of Shanoor Habib Munmun. Retrieved on Feb. 2, 2014 from http://commons.wikimedia.org/wiki/File:Lockport_Dam_on_Red_River_Manitoba_Canada_(2).JPG

The Lockport dam, also known as the St. Andrews Lock and Dam was originally built to aid navigation over Lister Rapids for trade by steamboats along the Red River in the early 1900s. The bridge and locks artificially raises the water, submerging the rapids and regulating water levels within the City of Winnipeg. (Figure 3.9)

The design of the dam is a caméré design, consisting of a fixed concrete/ stonework structure with a steel truss bridge. The lock is 200 feet long, 45 feet wide with 9 feet over the sill and a lift of 21 feet. The lock was completed in 1910, with the bridge completed in 1913. The lock and dam changed trade and river traffic significantly. It increased Winnipeg's ability to serve as a supply hub for Northern Manitoba as well as increasing river traffic through Winnipeg on to Lake Winnipeg. (APEGM)

Summer Flooding & Regulation

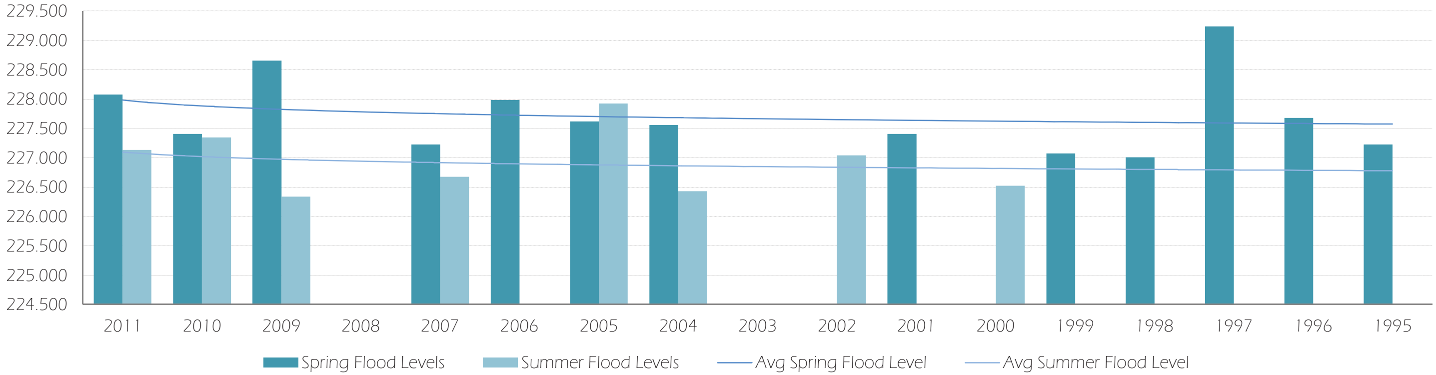


Figure 3.10

Summer flooding has impacted the Red River since around the year 2000. As a result, vegetation along the riverfront has steadily decreased in diversity. Plants are most often still dormant from the winter during spring floods and therefore more tolerant to being submerged. During summer floods, plants are becoming active, many of which can only tolerate a couple of days of flooding during the growing season. The clay-rich soils along the banks of the Red do not help vegetation growth, as they retain soil moisture longer than sandy soils.

" Symptoms of plants under excessive water stress include yellowing or browning of leaves, leaf curling and pointing downward, leaf wilting, reduced new leaf size, early fall color, defoliation, branch dieback and in extreme cases, gradual plant decline and death over the next couple of years." (Agriculture Natural Resources)

Successional Development

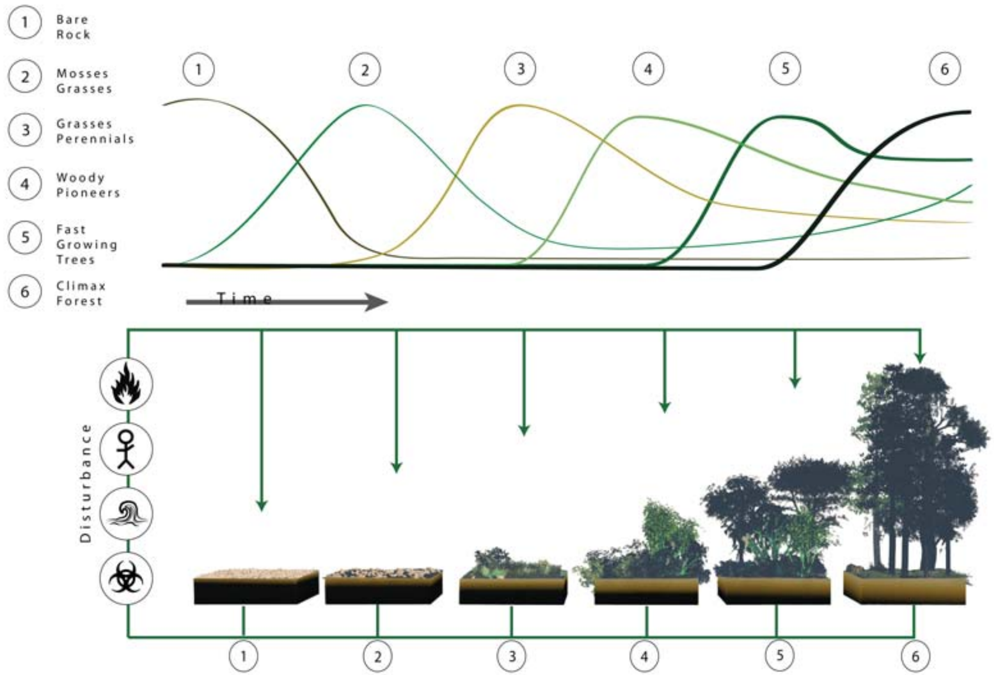


Figure 3.11

© Forest Succession Depicted Overtime. February 7, 2011. Courtesy of Lucas Frey. Retrieved on Feb. 2, 2014 from http://en.wikipedia.org/wiki/File:Forest_succession_depicted_over_time.png

When planting for erosion control, use plants that will root and establish quickly as well as plants that are slow growing. The long lived plants will protect the site long term while the fast sprouting plants are suitable for more immediate protection.

Summer flooding has prevented the lower bank from becoming vegetated, contributing to further erosion of the bank and degradation of the health of the riparian forest. To re-establish this vegetation, it will be important to take into consideration the time of year the vegetation is planted, water regulation levels as well as using primary and secondary succession species to grow along the bank. Figure 3.11 shows the successional growth of vegetation.

Primary succession occurs in newly formed patches of bare earth, such as the river bed. Secondary succession occurs in patches that formerly grew vegetation but has been scoured away like the lower river bank. The goal within the new site development will be to take advantage of the erosion and deposition to change and adjust the river bank into an enhanced riparian zone.

4. Riverfront Design Strategies

Riverfront Design Strategies

Review of the book 'River. Space Design', resulted in a list of design strategies suitable for Winnipeg's flooded landscape. In the book, 96 design strategies were outlined for flood events in rivers wide and narrow, naturalized and urban. 25 strategies were adopted as integrated design solutions for Winnipeg as they were suitable for a river as wide as the Red and could be easily integrated with ecological erosion control solutions. A table was developed with a list of the potential applications for the chosen landscape design strategies along riverfronts, including shoreline access during low and high waters, bank reinforcement and flood protection.

Diagrams on pages 60-72 have been adapted from River Space Design (Prominski, 2012)

Table D: Applications of Landscape Deign Strategies >

Landscape Design Strategies	Viewing	Shoreline Access (Low)	Shoreline Access (OHW)	Bank Reinforcement	Flood Protection	Changing River Currents	Adapting/ Temporary Protection	Tolerating Flood Water
Branches					X			
Mounds					X			
Building on Piles					X			
Escape Routes					X			
Cableways	X							x
Flood Plain Paths		X						X
Flood Plain Parks		X						x
Floating Structures			x				X	
Marinas	X		x				X	
Large Single Rocks		X				X		
Laid Stone Gyrones		X		X		X		
Piled Stone Gyrones		X		X		X		
Riverbed Sills						X		
Extending Flow Length						X		
Inner Bend Beaches	X	X			X	X		
Bay Beaches		X			x	X		
Living revetment				X				
Stone Revetment		x		X				
Building over Existing Reinforcement	X	X	X					
Terraces							X	
Riverbank Steps		X	X					
Parallel Riverbank Access	X		X	x				
Perpendicular Riverbank Access			X	X				
Balconies	X							
Tolerating								X
Boulders and Stepping Stones		x	x			x		
Submergible Paths		x						X

1. Branches:

Branches are a form of flood protection that can be made by excavating the river channel adjacent to the flood plain to divide the discharge of flood waters. This creates an expanded space for the river to flow during high water events. With this type of earthwork the volume of flood water is distributed across a wider channel, easing the pressure of the riparian forest to absorb the rivers flow.


Figure 4.1: Ohta River Diversion Channel

2. Buildings on Piles:

Building structures on piles is an effective method for preventing flood damage during high water events. The piles, built to the regional high water line will protect new buildings built near the water's edge allowing waters to flood beneath. A current disadvantage to this type of building is not being accessible during high flood waters unless an escape route is built out to a nearby dike system (see below). In addition this type of construction can cause build up of sediment and debris, creating an added pressure to the structure of the building. Using strong, durable and easily cleaned materials for construction are vital for this flood tolerant structure.

Figure 4.2: F9 Flood Proof House

3. Escape Routes:

Access systems are built between buildings above the high water level mark to allow for movement in and out during flood events. Buildings are then connected to a dike system by a constructed bridge or boardwalk. This form of flood protection keeps users safe without disrupting connections to high ground areas.

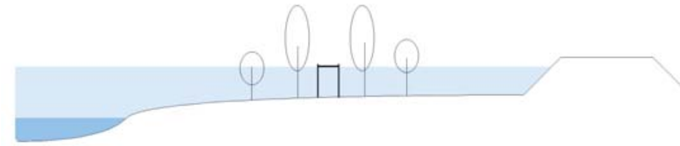
Figure 4.3: Parc de La Villette, Paris, France

4. Cableways:

Constructing a cableway or gondola system across a river creates a unique and attractive option for crossing the floodplain and river during high water events. This can be constructed as a mechanically operated gondola across larger river systems or as a hand operated mechanism, powered by individual users across smaller river systems. This option for flood protection maintains connections across rivers while providing excellent views of the river habitat.

Figure 4.4: Gondola across the River Thames, London, England

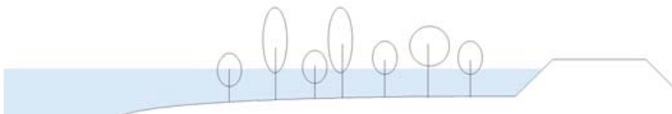
5. Flood Plain Pathways



Building within the flood plain is often discouraged in most cities as flood waters can damage construction and leave behind sediment and debris. Pathways within the flood plain can be created using a low dike system as a path or building a boardwalk above the normal high water level. This technique adds interest to the natural flood plain as it marks the fluctuating water levels by pathway visibility. Cleaning the path after the flood season is often necessary for removing sediment and debris for access during normal to low water seasons.

Figure 4.5: Watertown, Nordhorn

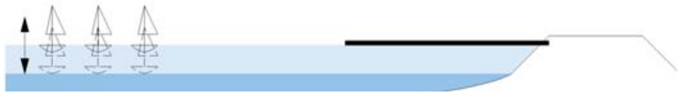
6. Flood Plain Parks



Parks can be designed as flood and ice resistant spaces when located within the designated floodplain. Plants and furniture must be flood resistant, durable and designed to be submersible for several days. Willows, poplars or dogwoods are good examples of flood tolerant species in Manitoba. Heavy stone or plastic composite benches are also durable options for seating features in a flood plain park as ice can cause damage during the spring thaw. Good drainage systems will be required on site to allow for quick drainage and site use following high water events.

Figure 4.6: Garrison Humphrey;s Complex, South Korea

7. Marinas



Floating jetties are made to extend from the shoreline, allowing for fluctuating water levels during low and high water. Marinas promote public use of the riverfront through recreational boating and opportunity for restaurants and cafes. Access during flood levels can be made to roads through dike systems if necessary, although recreational water activities are often restricted during high water events.

Figure 4.7: North Vancouver, BC

8. Large Single Rocks

Placing single rocks along the shore of a wide river or along the middle of narrow rivers act to deflect the current, reducing wave impact to the riverbank. Contact with the water is encouraged by creating visual interest to the shoreline. Varying the size of the rocks will allow for low water flow variation and sediment build up, allowing riparian habitats to develop along the shore. Local stones should be placed with sufficient size and weight according to the river system to resist the current.

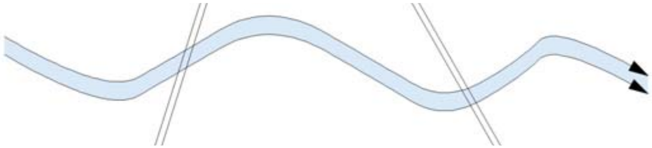
Figure 4.8: Gauley River, West Virginia

9. Laid Stone Groynes:

Groynes and wing dikes are perpendicular structures to the river bank used to build up sediment on one side and reduce erosion on the other. These structures change the flow of the current and water temperature along the banks, increasing the opportunity for habitat along river shorelines. Groynes/ wing dikes work to prevent ice jamming and lateral erosion along riverbanks. Groynes can be made from large stones placed by hand, piled by machine or constructed from bioengineered pieces of land.

Figure 4.9: Nuevo Vallarta, Mexico

10. Riverbed Sills



Sills made of large stones placed at an angle to river deflect the current. This secures the riverbed and prevents the river flow from cutting deeper into the channel. If the sills are constructed at varying heights, the river bed will be altered from deep areas to shallow area changing the flow of the current.

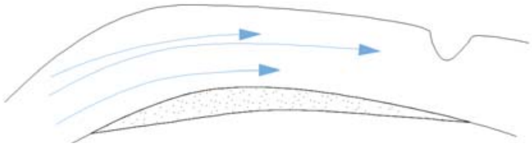
Figure 4.10: River Carron

11. Extending the Flow Length

The river channel is graded with varying cuts into the banks, altering the flow of the current. The cuts deflect the current, changing the erosion and deposition of the cut bank and point bar. This technique is useful for transforming small river systems into a more varied watercourse with areas of deposition for future riparian vegetation growth.

Figure 4.11: River Torrens, Adelaide, Austrailia

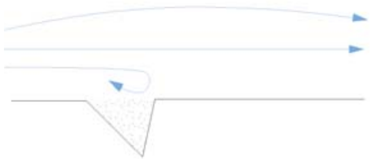
12. Inner Bend Beaches



Beaches have the potential to form naturally along rivers, often in calm zones along the inner bend. The current carries sediment from the cut out bank and deposits along the point bar, creating a beach-like condition. If desired along small river systems, beaches can be created using current deflecting structures such as stone groynes along the edge of the channel.

Figure 4.12: Xiajiang River Beaches

13. Sand and Gravel beaches in Bays



Beaches can also be formed in calm areas within widened bays along river banks. As the river flows into the calm zones, it deposits sediment- creating the potential for gathering spaces along the shoreline. The upstream portion of the bay area must be protected against further erosion if a beach space is desired. If not protected, the river will follow its natural course, widening and straightening the water channel.

Figure 4.13: Upper Tukituki River, New Zealand

14. Living Revetment

Living Revetment is another term for Bioengineering Techniques. Living plants secure the riverbank and protect against erosion and bank scour. In addition to protecting the bank, living revetments create diverse riverside habitats.

Figure 4.14: Willow Spiling

15. Stone Revetment

Made from piled or hand placed stone, this type of revetment is another form of rip rap. Stones may be locally chosen and placed with small or large gaps to allow for plants to grow through, creating an ecological niche. If choosing to create an accessible space for pedestrians, stones that are smooth and uniformly distributed can be used. If stones are piled by machine, riverbanks become inaccessible spaces with fewer spaces for vegetation to grow.

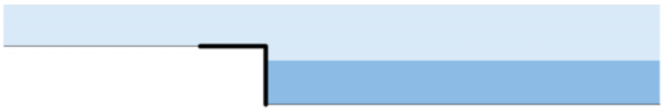
Figure 4.15: Elmwood Cemetary Winnipeg, MB

16. Terraced Stone Revetment

Erosion can be prevented along riverbanks using large placed stones stepping down towards the water. The primary function of a terraced stone revetment is bank reinforcement by preventing lateral forces from impacting the bank. A secondary function is the creation of places to gather as well as direct access down to the water along steep riverbanks.

Figure 4.16: Puerta Vallarta Waterfront, Mexico

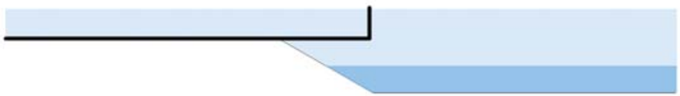
17. Masonry Riverbank Revetment



Using a masonry revetment creates a vertical wall into the river, reinforcing the bank. This technique can be used along a steep bank edge, allowing opportunity for direct access into the water and pathways alongside the shore. This solution offers little ecological advantages to the riparian habitat, but can be a sensible choice for use along riverside parkways. Using flood resistant materials for pathway development along the revetment will be necessary as high waters can flow over the masonry revetment.

Figure 4.17: Saginaw River, Bay City

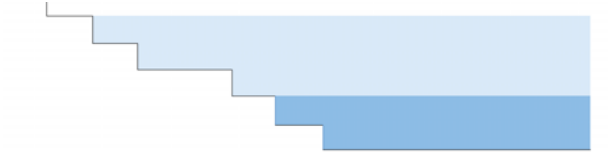
18. Building over existing reinforcement



In areas where erosion control and bank stabilization techniques are already in place, it is possible to build walkways out and over to create better access to the river. This creates spaces for viewing the water and places for people to linger.

Figure 4.18: St. Mary's Rd at Elllesmere Ave, Winnipeg, MB

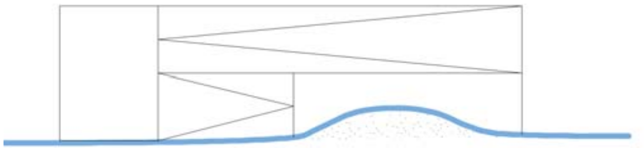
19. Terraces:



Terraces are a solution for flood management that creates a linear expansion of the riverbank. This approach is best suited for areas where there is a wide buffer space between building development and the river's edge as it acts as a transition space, creating opportunity for low and high water gathering spaces. In addition, terraces add a visual function of a water level marker.

Figure 4.19: Ollantaytambo, Peru

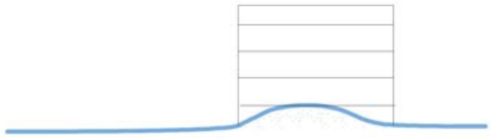
20. River access parallel to Bank



Parallel access to the water can be constructed using a switch-back ramp system. This is an access solution that can be used in smaller riverbank spaces, creating an interesting transition space with changing views of the riverside.

Figure 4.20: Tache Water Docks, Winnipeg, MB

21. River Access Perpendicular to Bank



Perpendicular access to the water is created by constructing openings to the river at right angles to the bank. The angle of the opening to the bank will alter the length of access to the waterfront as well as the type of views out onto the water. Perpendicular access can be made through use of boardwalk spaces or piers jutting out onto the water as well as through altered topography, shaping the land with mounds and cuts along the riverbank.

Figure 4.21: North Vancouver Pier

22. Balconies

Balconies can be designed as a retaining wall, preventing further erosion of the bank while inviting people to gather out over the water. This flood solution should be built above the high water mark, allowing for visual connections to the water during both high and low water seasons. Balconies create the opportunity to view the river from a new perspective, reaching out into the middle of the river.

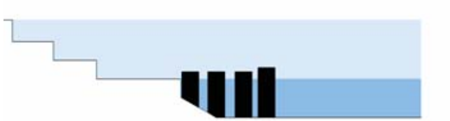
Figure 4.22: North Vancouver Waterfront Balcony

23. Underwater Steps

Underwater steps are a form of flood management that tolerate fluctuating flood levels. Easy access in and out of the water all year round can be created by constructing the lowest step or platform to be below the low water mark. The steps create a visual water level marker, acting as a historic indicator of high water events, much like the steps leading down to the Assiniboine River at the Forks in Winnipeg.

Figure 4.23: Council House Steps

24. Boulders and Stepping stones



Boulders and stepping stones out in the water create potential for direct contact with the water. If stones are selected at varying heights and sizes, public experience of the waterfront can be enhanced through an alternative access strategy. Boulders break up the surface of the water, making fluctuations in water level more apparent as well as creating visual interest through the altered current flow.

Figure 4.24: Stepping stones on the River Mole

25. Submergible Paths

Creating spaces adjacent to waterways for people to walk along have become very desirable, especially in river cities. Pathways designed and constructed with hardy, flood resistant materials create a viable option for gathering spaces to be located directly beside the water. Drainage and cleaning of the pathways will be needed, subject to regular flood events throughout the seasons.

Figure 4.25: Forks Riverwalk Winnipeg, MB

Chapter Image References: Photos taken by author unless noted below

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Principles of Ecological Riverfront Design:

Figure 4.26

The final component to the riverfront vocabulary are the Principles of Ecological Riverfront Design. These principles serve as the foundation for how to approach design along rivers, particularly in an urban centre such as Winnipeg. The combination of principles in riverfront design will help ensure ecological longevity within a city.

1. Demonstrate characteristics of the city's unique relationship to the river in the riverfront design

Winnipeg began at the junction of the Red and Assiniboine Rivers. Overtime, we have relied on this resource for trade, navigation, hydro electric power as well as a basic necessity to live. The levels of the Red River have been regulated since the early 1900s. The Lockport Dam, officially known as the St. Andrew's Caméré Curtain Dam, was built between 1901 and 1910. The Lock was originally built to allow for navigation of steamboats through the region that was previously too shallow to allow for movement of freight and passenger services. (APEGM)

2. Know the river ecosystem and plan for a scale larger than the riverfront

The Red River is buffered by the river bottom forest. This highly vegetated habitat plays an important role in maintaining the river's health through the filtration of pollutants and sediments as well as protecting the river from further erosion and degradation. The Red River stretches from the junction of the Bois de Sioux and Otter Tail rivers near the South Dakota border running between Minnesota and North Dakota, then up through Winnipeg, Manitoba and onto Lake Winnipeg. The watershed is relatively flat, creating a higher opportunity for high water levels to flow out into the landscape. The watershed experiences flooding on a yearly basis, caused from spring thaw, ice jams, the flat glacial plain, and a decrease in slope downstream. This constant phenomenon creates an interesting opportunity to explore landscape design strategies for mitigating flood waters as well as erosion control techniques to protect the banks along the entire watershed.

Figure 4.27

3. Minimize Floodplain Development

The Red River Floodway is designed as an artificial waterway that diverts high flood waters from the Red River around the east side of the city, meeting up with river near Lockport. Its purpose is to regulate the water levels within Winnipeg, thus decreasing the size of the floodplain that is affected by high waters. Development such as trails and parks should be designed to minimize their affect on floodplain functions: minimize impervious surfaces, development should not cause or add to normal flooding scenarios

4. Provide for public access, connections and recreational spaces

Winnipeg's riverfront has the potential to be a dynamic, publicly accessible space by people of all walks of life. It should not only be accessible by well off citizens who have bought or inherited riverfront property or those that can afford a boat, canoe or membership to a club. It is a source of beauty and character that acts as the backbone to our entire city and should be available to all. The Forks National Historic Site is a great example of providing direct access to the water's edge, linking the downtown to the water through the river walk system. In addition to a trail system, The Forks provides a multitude of commercial spaces such as restaurants, shops and offices. This multi use space embodies the character of the type of trade that the city once had. It is a place for meeting and viewing. This character should be replicated all along the river by creating spaces that connect the neighbourhoods to the river both physically and visually.

5. Celebrate the River's Environmental and Cultural History

The river holds a strong character for the City of Winnipeg through gathering and trade. Our connection to the outside world began with the longboat, then the steamboat, granting us the opportunity to obtain goods from beyond our immediate context, offering us a glimpse of what lay beyond the Canadian Prairies. Water levels have been controlled through the development of both the Lockport Dam and the Floodway, influencing the river bottom forest ecosystem. This habitat is an important component to both the environmental and cultural history within Winnipeg. Through the development of interpretive trails and way finding systems, we can establish an educational component to the riverfront to teach the public about the ecological and cultural importance of the river.

Principles Adopted from: Otto, Betsy, Kathleen McCormick, and Michael Leccese. Ecological riverfront design: restoring rivers, connecting communities. Chicago: American Planning Association, 2004.

Case Studies

A series of case studies have been chosen and reviewed based on the idea of creating an integrated vocabulary for riverfront design: Erosion Control, Flood Resilient Spaces, and Application of Riverfront Planning Principles. Through analyzing these projects, my thoughts towards approaching the future site design have shifted towards creating a balance between strategic site planning and the impact the overall design can have on its environment. The following projects take into account the function of the space as well as how people will move and engage with the landscape. In many of the projects, the design is subtle. Through simple interventions the sites are transformed into functional spaces through flood management strategies, erosion control techniques as well as places for human interaction.

Project Name: Rhone: Berges du Rhone, 2004-2007

Figure 4.28

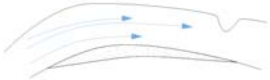
Figure 4.29

Figure 4.30

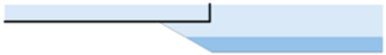
Figure 4.31

A. Erosion Control:

Inner Bend Beach



Building over Existing Reinforcement



B. Flood Design:

Intermediate levels

Terraces

Riverbank Steps

Submergible Path

Balconies

Description:

The Rhone riverfront was previously cut off from the City of Lyon by a busy roadway with cars parked along the wharf, right next to the water. The river experiences violent but short floods throughout the year. The redesign focused on creating new, accessible open space that could survive flooding while strengthening the presence of the nature of the river within the city. The design began with reducing the amount of roadway space allowed next to the river and moving parking into an underground parkade, creating open park space at ground level.

In the former wharf spaces, a new flood resistant promenade was built, featuring playgrounds, sports fields, restaurants and a new path network. Due to the risk of flooding, the promenade was designed to withstand flood waters including submergible furniture, plantings and pathways. The lower pier is located just above the mean water level. The design focuses on creating a differing sequence of riverside views. As you move along the river towards the town centre, the promenade space transitions from more natural riverfront to more urban- altering the design strategies used.

The front of the promenade along the northern edge remains almost natural, with shallow beaches and small islands forming within the river. Being located near the slip- off slope (where deposition occurs), the river has decreased its velocity in this section of the riverfront. At the end of this area, the islands formed morph into “ribbons of meadows planted with ornamental grasses.” (Prominski, 2012, pg 160)

Reflection:

This project takes into consideration how to design for flooding, even if it only comes in short bursts. For Winnipeg, flood waters often remain high for a few months out of the year. This means we must take into account flood damage to any riverfront development located within the floodplain such as the Riverwalk at the Forks. This area was built at a specific level so that it would not be damaged by the ice break and retreat. While this is a good start, the materials used are not easily cleaned and end up costing the city thousands of dollars every year to make usable. The idea of utilizing naturally forming beaches and islands by promenades for visual interest to the riverfront could be an interesting possibility to explore for Winnipeg’s waterfront in Saint Boniface. The area already has sandy soils and beach like vegetation. If it were to be cleared of debris and emphasized through the development of a public pier, the space could become a way to bring people out onto the river during low waters.

Figures 4.28-4.31: Prominski, Martin. River, space, design: planning strategies, methods and projects for urban rivers. Basel: Birkhauser, 2012. Print. © Used with permission for Educational Purposes by Martin Prominski

Project Name: Seine: Park Corbiere, 1996

Figure 4.32

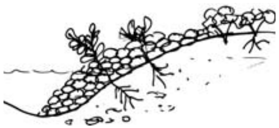
Figure 4.33

Figure 4.34

Figure 4.35

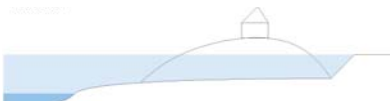
A. Erosion Control:

Rip Rap with Vegetation

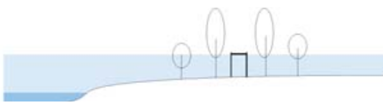


B. Flood Design:

Mounds



Flood Plain Paths



Description:

Le Pecq, France is a small town about 20km outside of Paris. The Corbiere flood park was designed to accommodate temporary changes in water levels. Topography in the park was designed to retain large amounts of water, protecting other areas from flooding. The back section of the park features an elevated avenue surrounded by low-lying areas with pipes directing the flow and drainage of surface water. The entrance to the park has been designed with an elevated terrace, allowing visitor access during both high and low water levels. The site features vegetated expanses with willows, dogwood, ash and maples along with a children's playground and large sandy area near the riverfront to bring recreational opportunities near the water. (Prominski, 2012, pg 222)

Reflection:

The project does not allow for direct access to the river itself. The steep sloped bank creates a clear divide between the Seine River and Corbiere Park. This is a missed opportunity to create a dynamic riverfront space that explores bank protection and integrated landscape design. Winnipeg is in need of an integrated solution for flood management and landscape design. This project offers an interesting approach to dealing with flood waters by, re-grading the site to accommodate the same level of flood waters on site in new ways. This approach could be used as a way to create a flood event space, to celebrate the fluctuation between low and high water seasons

Figures 4.32- 4.35: Prominski, Martin. River, space, design: planning strategies, methods and projects for urban rivers. Basel: Birkhauser, 2012. Print. © Used with permission for Educational Purposes by Martin Prominski

Project Name: Wiese, Revitalisation, 1999-2000

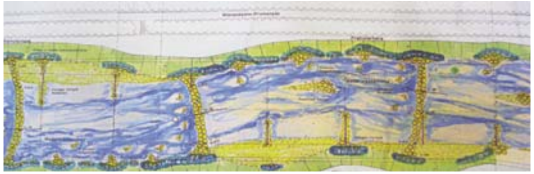


Figure 4.37

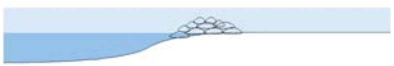
Figure 4.36

Figure 4.38

Figure 4.39

A. Erosion Control:

Laid Stone Groyne



extending the Flow Length

Large Single Stones

B. Flood Design:

Riverbed Sills

Beaches in Bays

Description:

Overtime, the Wiese River has straightened out losing its natural habitat to stone and concrete edges. The purpose of this project was to recreate a natural, dynamic river space. The scope of the project was to enhance the ecological components of the river as well as create improved access and connections. The redesign enhances the river through the implementation of individual rocks placed within the riverbed and stone groynes that change the flow of the river to move from side to side as a way to reintroduce a curving condition into the river flow.

"Old bank reinforcement was removed, but the new course is also designed so that it will stay within its banks. The groynes direct the current away from the riverbanks while half-buried tree trunks and large rocks secure vulnerable areas. During flooding, water is able to flow straight over these flat structures, and thus the redesign has not impaired the flood management." (Prominski, 2012, pg 251)

With the introduction of stone gyrones, the water has begun to stir up sediment, causing areas of deposition to create small beaches along the river. This change in river structure has improved access to the water as well as enhancing the overall river habitat for the area.

Reflection:

The Wiese River revitalization project may not be completely applicable to the Red River due to the overall size of the river. The Wiese River is relatively narrow at 30m wide compared to the Red River at about 150m wide. Using techniques such as stone gyrones and rocks placed within the river could add another dynamic layer to the Red River currentc during low water seasons and potentially divert the flow away from the banks, helping with erosion control techniques.

Figures 4.36-4.39: Prominski, Martin. River, space, design: planning strategies, methods and projects for urban rivers. Basel: Birkhauser, 2012. Print. © Used with permission for Educational Purposes by Martin Prominski

Project Name: Neckar: Green Ring, 2005


Figure 4.40


Figure 4.41


Figure 4.42

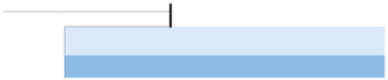
A. Erosion Control:

extending the Flow Length

Large Single Stones

B. Flood Design:

Balconies



Beaches in Bays

Description:

Ladenburg is located near the junction of the Neckar and Rhine rivers. The idea behind the project was to create a "Green" connection between Ladenburg and the Neckar River, improving the stream habitat and flood protection along the way. Once completed, the Green Ring surrounds the town reaching 3.5km in length. The project focused on creating public event spaces that were flood tolerant. Pathways were constructed into the higher elevated dike system, offering new views of the river. The dike then steps down to the water with broad terracing grass steps offering places to sit and relax. The pathway along the dike guides users to a new pier and balcony overlooking the river below. Within the scope of the project, the riverbank vegetation was cleared to make room for low seating walls and a public beach area at the shore.

To the south of Ladenburg, two streams, the Kandelbach and the Loosgraben have been revitalized to help mitigate flood waters that would back up onto the Neckar River. This was done by opening up the streams and making the banks relatively flat to create better sight lines and easy crossing. Stepping stones were placed in several spots along the streams to allow for crossing. The network of paths in the park space are influenced by flooding, with the footpath being made of broad steeping stones that can just be seen when water levels are high. (Prominski, 2012, pg 242)

Reflection:

This project is similar to the design of the Forks Riverwalk in Winnipeg, using the idea of creating flood tolerant pathways and event spaces for a fluctuating water system. Balconies and stepping stones offer places for people to connect both physically and visually to the water, encouraging a greater sense of gathering along the waterfront. The areas adjacent to the river have the potential to increase riparian habitat through ecological engineering strategies such as brush layering or live stakes placed along the lower bank. This would enhance the natural appearance of the bank and improve the stream habitat and flood protection.

Figures 4.40- 4.42: Prominski, Martin. River, space, design: planning strategies, methods and projects for urban rivers. Basel: Birkhauser, 2012. Print. © Used with permission for Educational Purposes by Martin Prominski

Project Name: Wupper: Mungsten Bridge Park, 2006

Figure 4.43

Figure 4.44

Figure 4.45

A. Erosion Control:

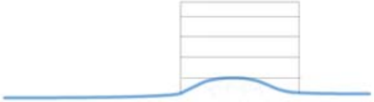
Large Single Stones

B. Flood Design:

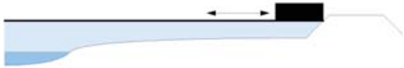
Balconies

Beaches in Bays

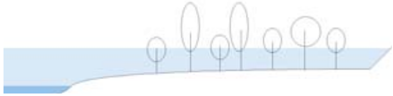
Perpendicular Access



Cableways



Flood Plain Parks



Description:

The Wupper River flows through a canyon where the Mungsten Bridge crosses at 107m above the ground. The reasoning for this had to do with a car park on one side rather than the river itself. This created a disconnection between the people and the river. In 2006, this touristy area was renewed with a park space located beside the Wupper River and Mungsten Bridge.
The waterfront was designed to create a dynamic space that used several design strategies to stabilize the banks and celebrate the flood waters within the park. In River Space Design the project is described as follows:

> "The first step was to shift the bank away from the shore so that its design could be varied without reducing the present cross section. A clod-like (soil mounds) topography was created with spaces that relate to the river. Very shallow bay-like shores alternate with steep slopes high above the water that have been stabilised with stones."

The site offers varying levels for the river to be viewed and accessed, creating a perpendicular access system along the banks. This design influences how high waters are received by the park, allowing waters to flow into the park in narrow strips. The edges of these strips were vegetated with native shrubs to stabilize the banks. The alternating steep banks were reinforced with open jointed boulders, allowing vegetation to grow through the spaces, creating additional reinforcement. (Prominski, 2012, pg 230)

Figures 4.43- 4.45: Prominski, Martin. River, space, design: planning strategies, methods and projects for urban rivers. Basel: Birkhauser, 2012. Print. © Used with permission for Educational Purposes by Martin Prominski

Project Name: River First (Winning Entry from Minneapolis Riverfront Competition)


Figure 4.46

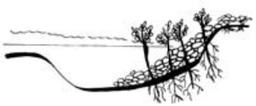

Figure 4.47


Figure 4.48

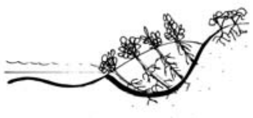
A. Erosion Control:

Remediated Vegetated Banks (Technique Not Specified)- Potential Possibilities:

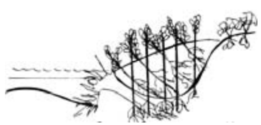
Joint Planting



Brush layering



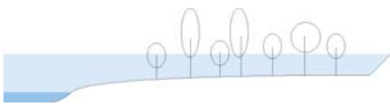
Branch Packing



B. Flood Design:

Stormwater Remediation, Sculpted Landforms

Flood Plain Parks



Submergible Path

Description:

RIVERFIRST is the winning entry from the Minneapolis Riverfront Competition that took place in 2010. This conceptual design is based on the remediation of the storm water management system through biofiltration landscapes that filter the pollutants from runoff before returning to the river. The Winners, TLS/KVA focus on four main principles in the design: Water, Health, Mobility and Green Economy. The design of the riverfront takes into account the natural dynamics of a river, “Where water carves and erodes, subtractive design principles are used to create water remediation ravines and terrace overlooks. Where the river deposits new material, accretive principles of design are used to mold and shape land berms for the new park.”

The topography on site is sculpted to connect Farview Park on the north side with the river through a multitude of pedestrian and bike trails that rise above existing barge terminals creating connection during high and low waters. The remainder of the site looks to create public gathering through a public swim/skate and kayak launching facility along with sustainable housing and an Arts Center at Scherer Park. The landscape at Scherer Park enhances the natural dynamic of the river through the production of, “sand bars and shallow pools that shift according to winter melts, patterns of sediment deposition and river flows.” (Priority Projects- as noted below)

Reflection:

This project stands out because it takes into consideration flood water and erosion along the riverfront into the design of the landscape. It uses the processes of erosion such as water carving the landscape and depositing sediment into the design of the riverfront as a way to celebrate the natural processes. This reflection of the natural environment can be utilized within the design of riverfront spaces in Winnipeg as a way to educate the public on the processes of the river and create spaces for gathering and viewing with minimal intervention.

Figures 4.46-4.48“Priority Projects.” RiverFirst RSS. http://riverfirst.com/projects/priority-projects/ (accessed January 9, 2014). © Images used with Permission by Janette Law

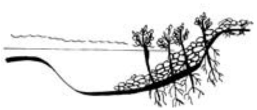
Project Name: Chicago Botanical Garden

Figure 4.49

Figure 4.50

A. Erosion Control:

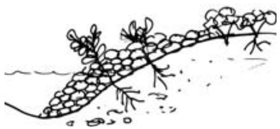
Joint Planting



Brush layering

Coconut Fibre Roll

Rip Rap with Vegetation



Stone Revetment

Figure 4.49: © Chicago Botanic Garden. October 31, 2010. Courtesy of Janet and Phil. Retrieved on Feb. 4, 2014 from http://www.flickr.com/photos/dharma_for_one/5144792272/sizes/l/

Figure 4.50: © Chicago Botanic Garden 14. November 10, 2013. Courtesy of Janet and Phil. Retrieved on Feb. 4, 2014 from http://www.flickr.com/photos/dharma_for_one/12231531096/sizes/l/

Description:

The Chicago botanic garden and the U.S. Army Corps of Engineers developed a shoreline erosion control and habitat enhancement project in 1999 to protect and enhance the North Lake within the botanic garden. This project transformed both the ecological and aesthetic components of the park, using multiple bioengineering solutions to protect and enhance the degrading shoreline. The goal of the project was to improve the shoreline by protecting against erosion, reducing nonpoint source pollution and create wetland habitats to improve the overall health and character of the lake. The extent of the degradation of the shoreline ranged from 1-3 feet in eroded banks down to the water's edge with the majority being exposed soils that are more susceptible to further erosion. The North Lake Project integrated 6 erosion control solutions with 4 being bio-engineering techniques to create stable banks that encourage water tolerant plants to flourish and anchor the shoreline soils. The following treatments were used:

1. Clay Soil Shelf with emergent and aquatic plants. Benthic mesh was laid along a cut out shelf on the shoreline from the normal waterline, then planted with emergent and floating vegetation. The roots of the vegetation provide soil stability and help to retain and filter sediments along the shoreline.

2. Underwater stone berm with emergent and aquatic plants- An underwater 'shelf' was creating using stones, then covered with clay soil, then planted with emergent and floating vegetation. This technique functions the same as the clay soil shelf, using the vegetation to filter runoff and stabilize the bank. An added advantage is the stone protects the toe of the bank from slip failure.

3. Submerged Sheet Piling with emergent and aquatic plants. A shallow water planting zone is creating by digging a shelf by the shoreline and using sheet piling under the water to stabilize the shelf in place rather than using stone. This technique was used primarily in areas where steep banks were eroded and needed extra stabilization.

4. Exposed sheet piling- Traditional sheet piling was used in areas of the lake where cutting shelves into the banks would create areas of low water and provide inadequate water circulation, thus contributing to the degrading health of the lake. Sheet piling is a good choice for severely eroding banks, but does not contribute to improving the aquatic habitat of the shoreline and deflects wave action to other areas of the lake.

5. Interplanted boulders with small stones interspersed. This technique used existing boulders on site, redistributing them along the shoreline to provide added stability. They were then filled with smaller stones, leaving gaps for emergent vegetation to grow in between. This technique adds visual texture along the shore, allowing water to move between the boulders, creating areas for fish habitat and white noise from the water movement.

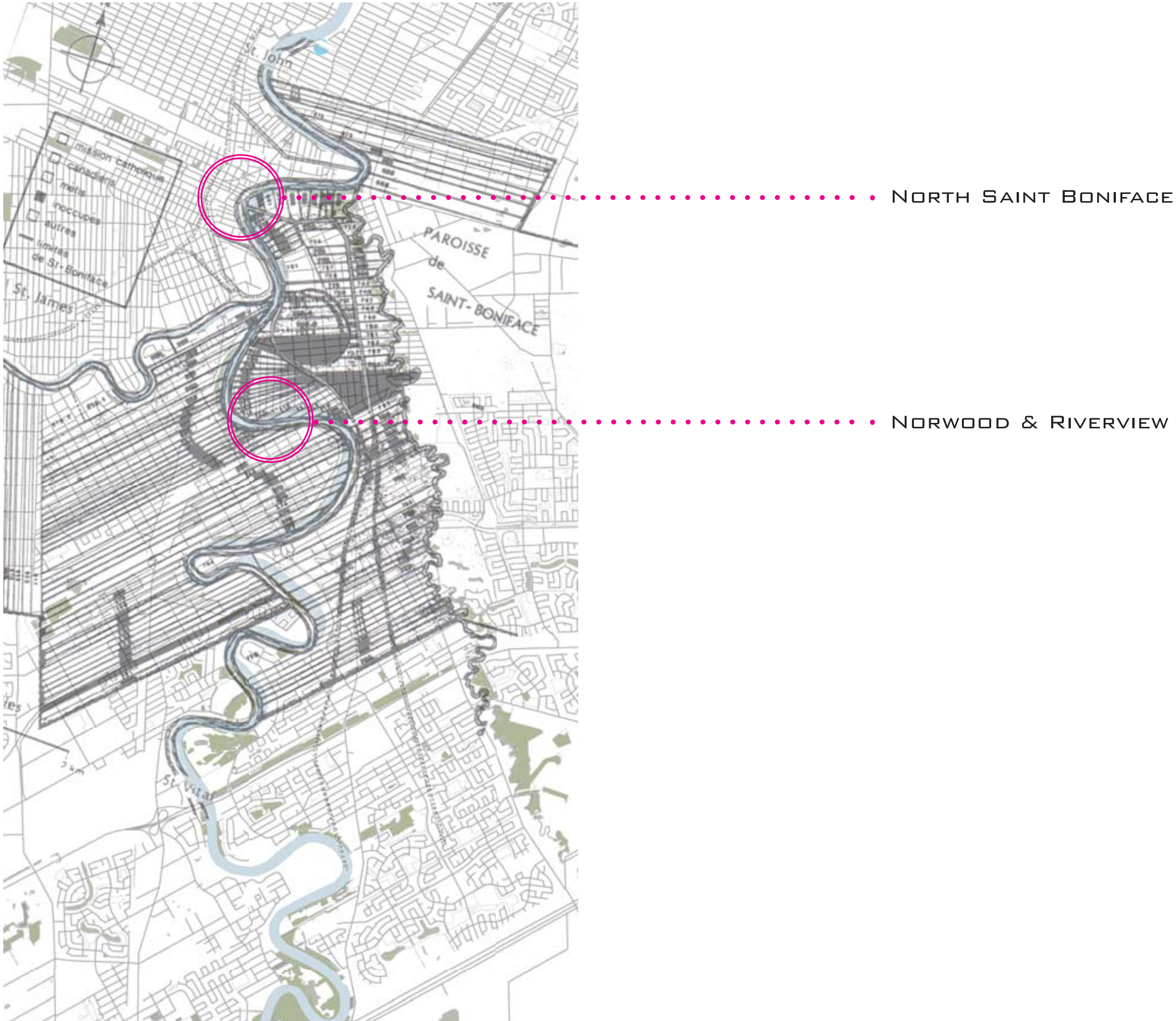
6. Coir roll- rolls of coconut husk fiber were placed along the shoreline about 2 feet out. The coconut mesh is staked into the ground with live cuttings. The coir roll will degrade naturally overtime, giving the live cuttings enough time to establish roots and add stabilization and filtration to the shoreline. (Chicago Botanic Garden)

5. Integrated Solutions:

Site Selection | Analysis | Design Possibilities

The banks of the Red River within the city limits are shifting away, degrading the health of the river through rapid surface runoff and eroded shorelines. The natural river system wants to meander through the landscape, changing the edge condition along its banks. With the development of Winnipeg, the riverbanks have become more susceptible to the stresses caused by urban environments such as building development and recreational activities. A manageable riverbank is needed through flood management and erosion control strategies in order to protect land adjacent to the river from shifting into the water. The city is currently lacking in publicly accessible spaces that celebrate the core of our city's identity. A successful riverfront design celebrates the city's cultural history, creates physical and visual connections for the community and ensures the health and longevity of the river ecosystem.

The two sites chosen from the photo inventory include Norwood & Riverview and North Saint Boniface. The two sites have been chosen due to their differing neighbourhood qualities, one is more urban, sitting along the edge of the Saint Boniface, and the other is along a well established suburb. The areas chosen feature both the concave and the convex bends in the river and they offer differences with regards to the bank stability, erosion problems and opportunities for development.


St. John
mission catholique
canadiens
métis
inoccupés
autres
limites de St-Boniface
St. James
PAROISSE de SAINT-BONIFACE
St. Vital
North Saint Boniface
Norwood & Riverview
Figure 5.1

History of the Sites:

Figure 5.2

Norwood and Riverview:

The Norwood West neighbourhood is located north East of the Red River not far from Winnipeg's Downtown. It was originally a part of the City of St. Boniface, before becoming a part of Winnipeg on January 1, 1972. The neighbourhood is largely residential, with mostly single family dwellings. Many of the homes were built between the two World Wars, with the majority being built from 1946-1970. Across the River to the south, the Riverview neighbourhood was originally part of the Old City of Winnipeg before amalgamation. Riverview is also a mainly residential neighbourhood, growing slowly over time with housing being built from 1900-1950. Most of the oldest homes built before World War One are located along Morley Avenue and the newer homes were built in the southern portion of the neighbourhood. Commercial and mixed use buildings are found along Osborne Street, providing few amenities to the immediate neighbourhood. (City of Winnipeg-History of Norwood West)

Within the north-east area of Riverview, the Redboine Boating Club and Manitoba Canoe and Kayak centre are located along the Red River. Both facilities require memberships/ fees to use the dock space for boats and canoes. The Redboine Club is only accessible to members, having the area fenced off to the public. The area appears to be rundown from the outside and offers the potential to create a local boating hub for the public. The Manitoba Canoe Centre is publicly accessible, open from the road with a gravel pathway running through the area along the Red. It has the potential to become a more welcoming space, by creating a greater presence from the road as well as from across the river along Lyndale Drive.

Figure 5.3

North Saint Boniface:

North Saint Boniface lies to the east of the Red River, north of Provencher Boulevard. The adjoining sites are largely single and multi family homes. In recent years, this area has been booming with new condo developments creating a node of residential activity with the potential for commercial and recreational development along the Red River. With the development of Esplanade Riel and the new Human Rights Museum, this Francophone neighbourhood has the opportunity to bring its Francophone cultural identity to the forefront and connect with the surrounding neighbourhoods along a new public riverfront space.

Historical Site Development:

The Red River has been a source of transportation, food and water for power since Winnipeg began settlement. The area surrounding Whittier Park and Lagimodiere-Gaboury Park is historically associated as the birthplace of St. Boniface and the catalyst for Francophone and Metis settlement and culture in much of Western Canada. Jean Baptiste Lagimodiere and Marie-Anne Gaboury are known as the founding couple of St. Boniface. In 1817, Lagimodiere received a land grant from Lord Selkirk east of the Seine River as well as about 100 acres west of the Seine- the area now known as North Saint Boniface. The areas developed along the Red River followed the river lot system, laid out as long narrow strips of land. (Canadian Geographic)

Figure 5.4

Figure 5.5

Site Exploration

Lyndale Drive:

The surrounding neighbourhood consists mainly of single family dwellings, and is only accessible to the rest of the city off of St. Mary's Road. With this limited access, the area almost feels like a gated community. Along the riverfront, a single gravel pathway guides active and passive users along the upper shoreline within an open lawn space.

The riverbank along Lyndale drive transitions from a sloped vegetated bank to the east, to a steep, cut out bank with limited vegetation and bare soil forming a cliff along the western bend of the river. As the flood waters go down, the structural integrity of the bend decreases, causing the bank to fall right into the river. The eastern end of the bank features a small forested area with riprap protecting the toe of the bank. This area offers an excellent animal habitat and area for exploration. A stabilization project, drilling rock columns into the ground was completed in Fall 2013 along a retaining wall experiencing bank failure. Adjacent to the concrete retaining wall is an old timber pile wall that is maintaining the current grade of the sidewalk and road next to the slumped vegetated bank. This area has experimented with a few erosion control techniques along the slumped, straight lengths of the river, but has neglected to address the extreme erosion along the inner bend. With above ground hydro lines, and bank failure potential, building development along the river is limited but holds the potential to create a destination point within the community and visually connect to the marina and canoe club across the river.

Churchill Drive:

Churchill drive is located in the Riverview neighbourhood, off the east side of Osborne, south of the new rapid transit terminal. The area of particular interest is along the northern length of Churchill drive across from Churchill High School on Hay Street. This area features the Redboine Boating Club and the Manitoba Canoe and Kayak centre. The site is highly vegetated with native sedges and shrubs along the shoreline with aspen and maple trees along the upper banks. A public pathway runs through the forested area and into the canoe club domain. While the area is public space, it feels like a private area that is lacking a stronger connection to the surrounding community. The Redboine Boating Club is a private membership only space that is fenced off to the public. With the area looking run down, it didn't look like an inviting club where many would want to invest their money.

The river bank appears relatively stable as it is on the straight and outer bend of the river where the water flows more rapidly. Due to the high recreational water activity, wave action along this portion of the river especially is causing an undercut to the soft clay banks. The area has the potential to explore bioengineering techniques to prevent further erosion and filter runoff of the bank as well as the opportunity to create an educational component that will connect the site to Churchill High school, Riverview Elementary and the greater community.

Current Site Uses: Norwood and Riverview

The main access into the site along Lyndale Drive is from St. Mary's Road, creating a neighbourhood peninsula just outside of downtown. Along Churchill Drive, the main access to neighbouring communities is from South Osborne Street, connecting into the area by streets such as Brandon Avenue. An active and recreational pathway is located along the South-west side of the river, connecting Churchill Drive to the Rapid Transit Station. On Lyndale drive, a single meandering gravel pathway guides pedestrians and cyclists along the upper bank of the river (Figures 5.6-5.15).

Figure 5.6


Figure 5.7


Figure 5.8


Figure 5.9


Figure 5.10

Circulation:

Figure 5.11


Figure 5.12


Figure 5.13


Figure 5.14


Figure 5.15

Evidence of Erosion

Figure 5.16

Figure 5.17

Figure 5.18

Figure 5.19

Figure 5.20

Figure 5.21

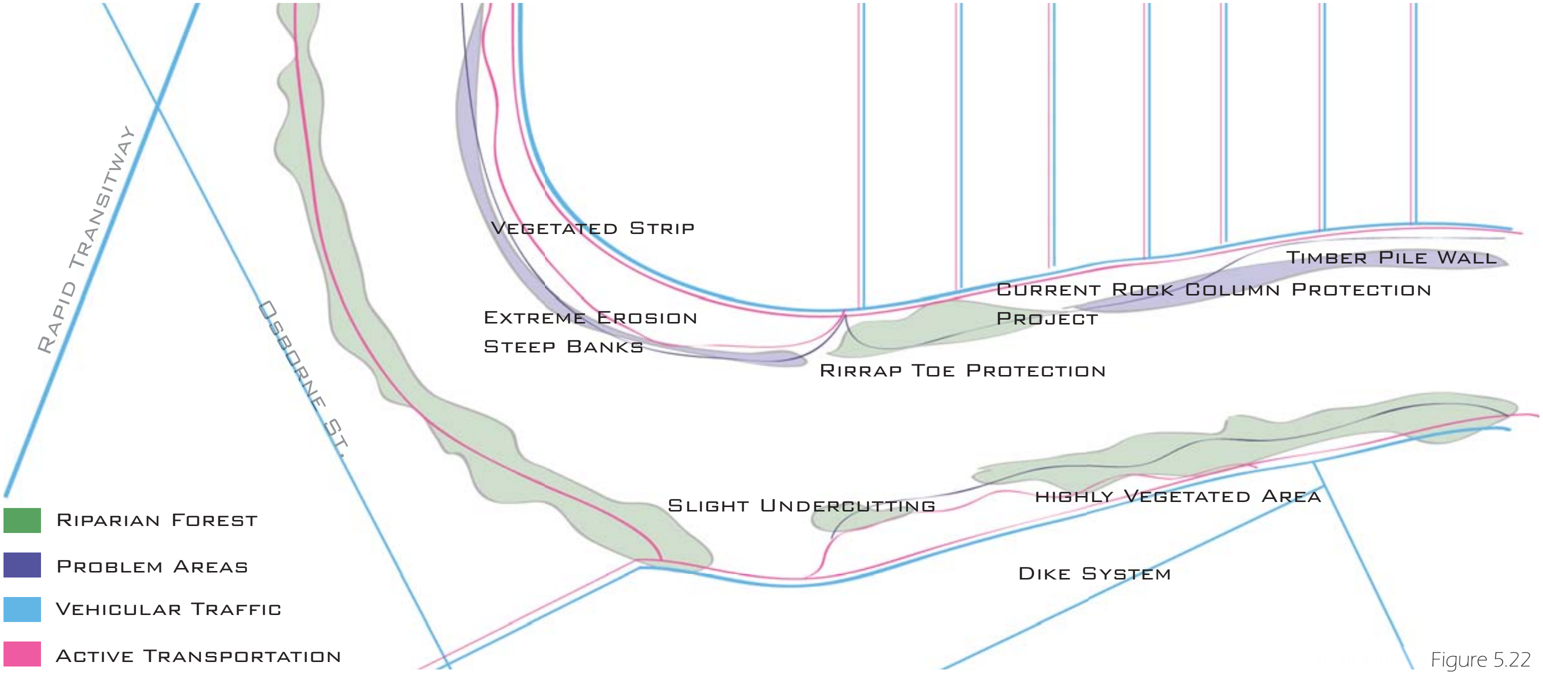


Figure 5.22

Vegetation:


Figure 5.23


Figure 5.24


Figure 5.25


Figure 5.26


Figure 5.27


Figure 5.28

Lyndale drive features a slumped vegetated bank with native shrubs and grasses at the east end, transitioning into a small section of riparian forest, then to the steep bank with shrubs and grasses at the west end. Churchill drive features a highly vegetated bank, with native shrubs and sedges along the riverbank level and aspen and maple trees along the upper flood plain and terrace.

Riparian Zone: Lyndale Drive

Terrace	Flood Plain	Riverbank
Burdock	Manitoba Maple	Quack Grass
Canada Thistle	Dogwood	Smooth Brome
Sweet Clover	American Elm	Curled Dock
	SIberian Elm	Sandbar Willow
	Wild Rhubarb	Cottonwood

Riparian Zone: Churchill Drive

Riverbank	Flood Plain	Terrace
Quack Grass	Manitoba Maple	Burdock
Smooth Brome	Dogwood	Canada Thistle
Curled Dock	Green Ash	Kentucky Blue Grass
Reed Canary Grass	American Elm	Sage
Sandbar Willow	SIberian Elm	Aster
Cottonwood	Peach Leaf Willow	

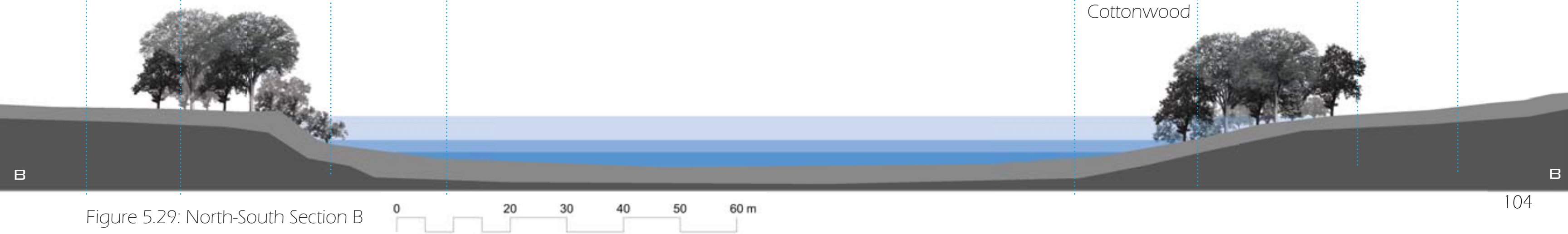


Figure 5.29: North-South Section B

Current Site Advantages

Using the process of erosion and deposition as a starting point, the site has the potential to create public access down to the water all year round through riverbank steps and parallel access strategies. Visual connections will be made by lookout points from the retained steep banks. In places of the private boating club, a public marina will bring opportunity for riverside shops, drawing people from the neighbourhood down to the water. The area has the potential to become an educational destination connecting the river to the nearby schools and the greater community. Figures 5.30- 5.35 show the site as it currently exists with natural bank vegetation, recreation opportunities and educational facilities.


Figure 5.30


Figure 5.31


Figure 5.32


Figure 5.33


Figure 5.34


Figure 5.35

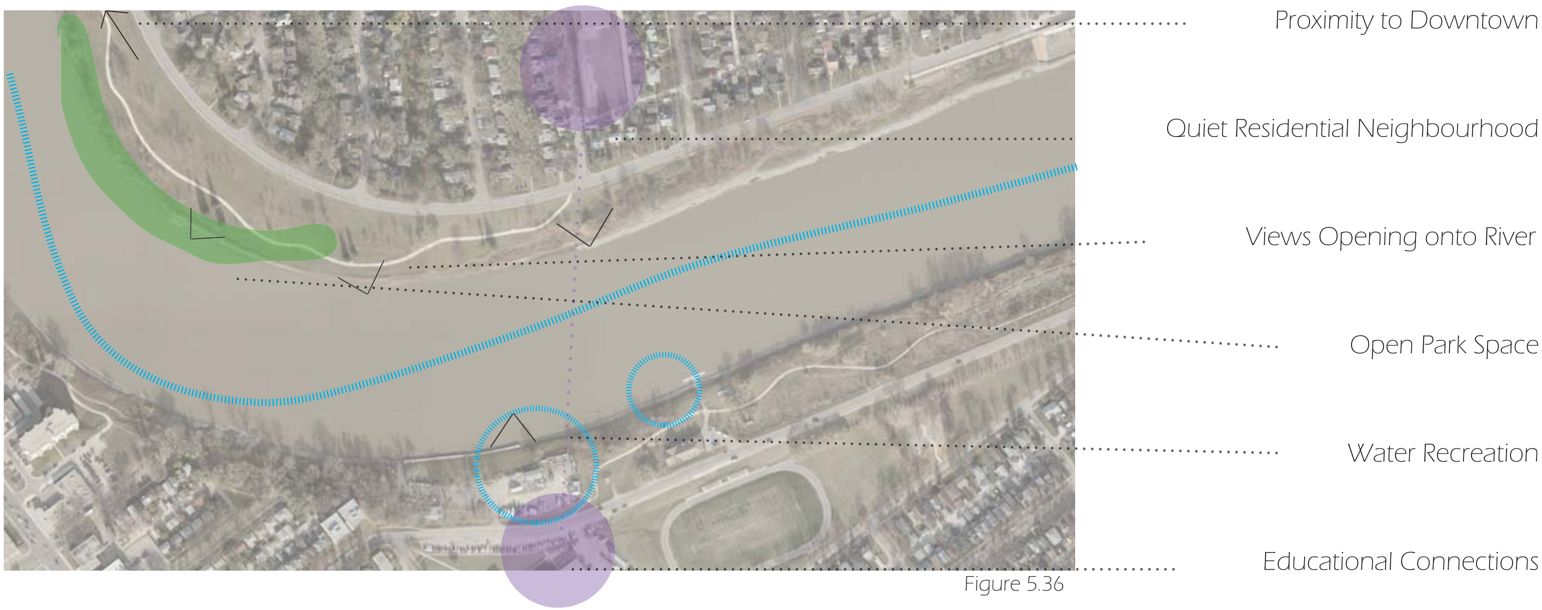


Figure 5.36

Current Site Disadvantages

The site is currently lacking in an overall neighbourhood character as well as a disconnection between the public and water recreation. There is no direct access to the Riverfront along Lyndale drive and an undetermined public-private connection along Churchill near the canoe club. The site does not feature any significant visual connections across the river or current winter connections along the shoreline.


Figure 5.37


Figure 5.38


Figure 5.39


Figure 5.40


Figure 5.41


Figure 5.42

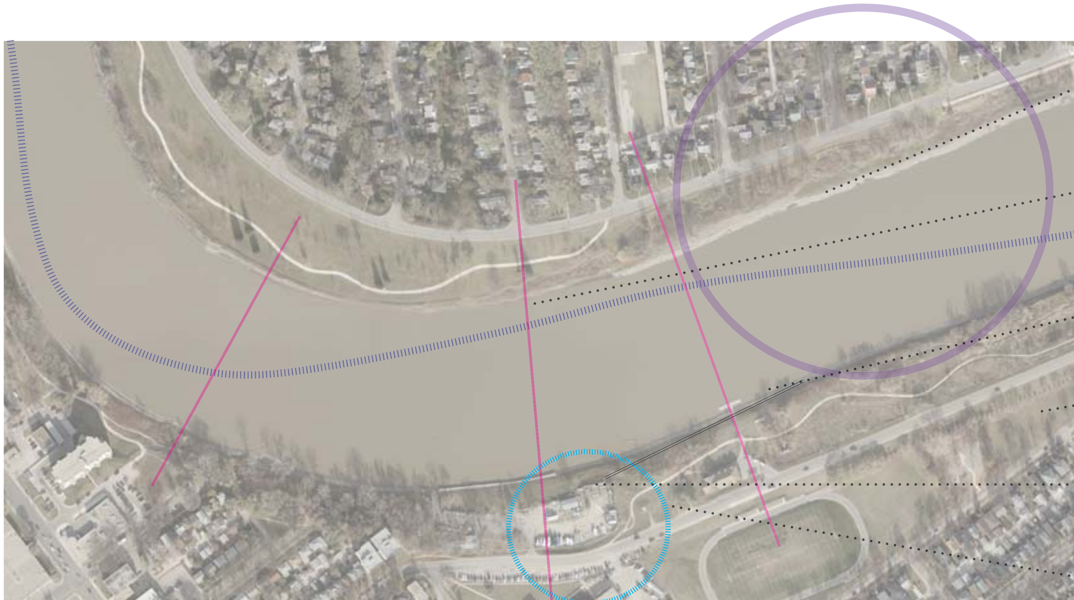


Figure 5.43

Fluvial Processes

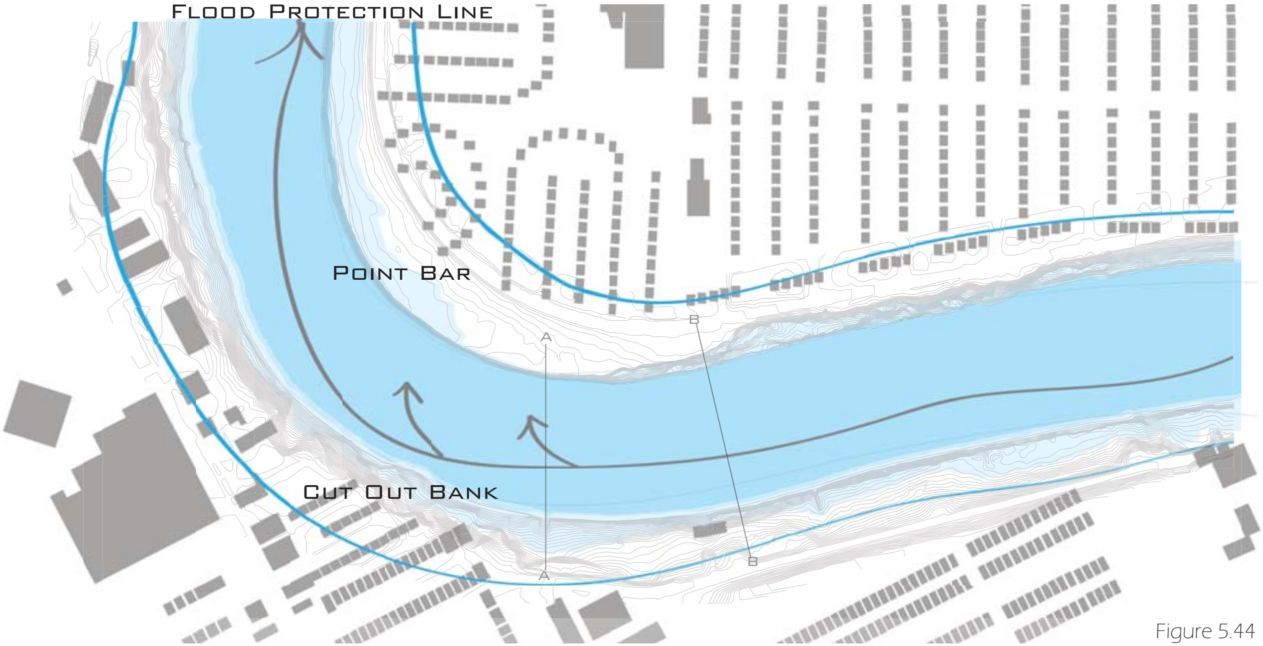
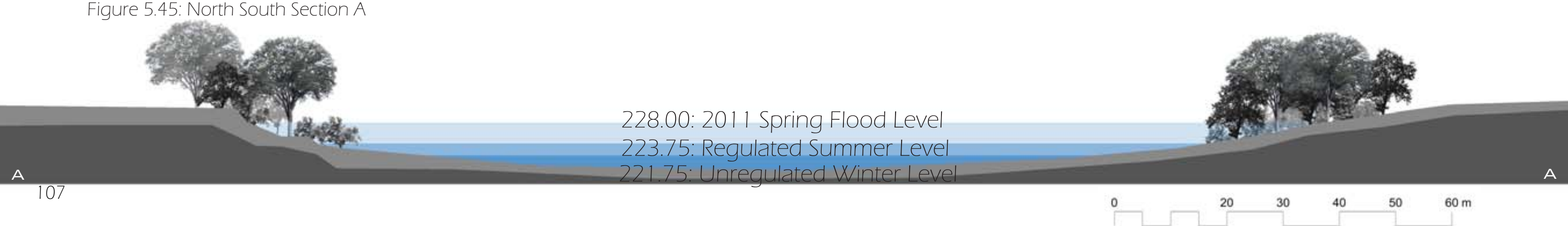


Figure 5.44

The thalweg moves towards the outside bend of the river in a fast, cylindrical motion, scouring the cut out bank along Churchill Drive, causing slumped vegetated banks and a deepened riverbed. As the current flows to the inner bend it slows down leading to the deposit of sediment along the point bar. The steep bank along the west end of Lyndale Drive is caused from the rapid draw down of flood waters, high flood waters, as well as ice damage breaking off pieces of the bank.

Figure 5.45: North South Section A



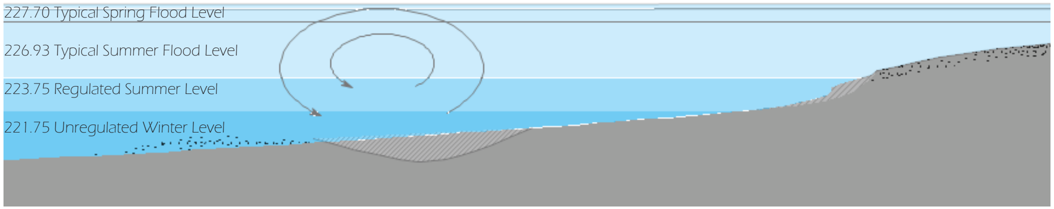


Figure 5.46: Thalweg Current

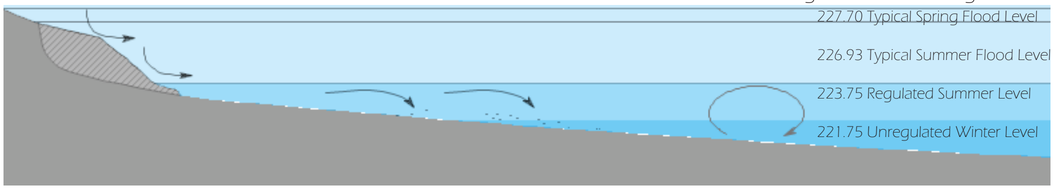


Figure 5.47: Sediment Movement

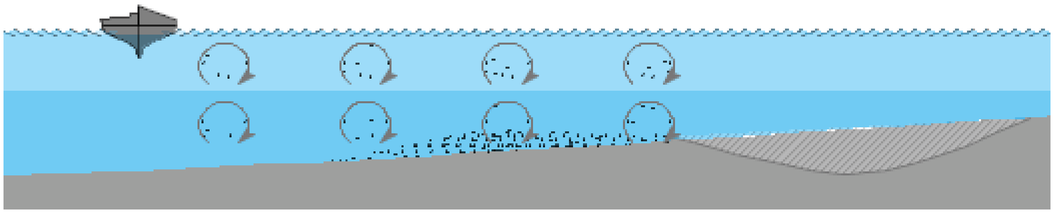


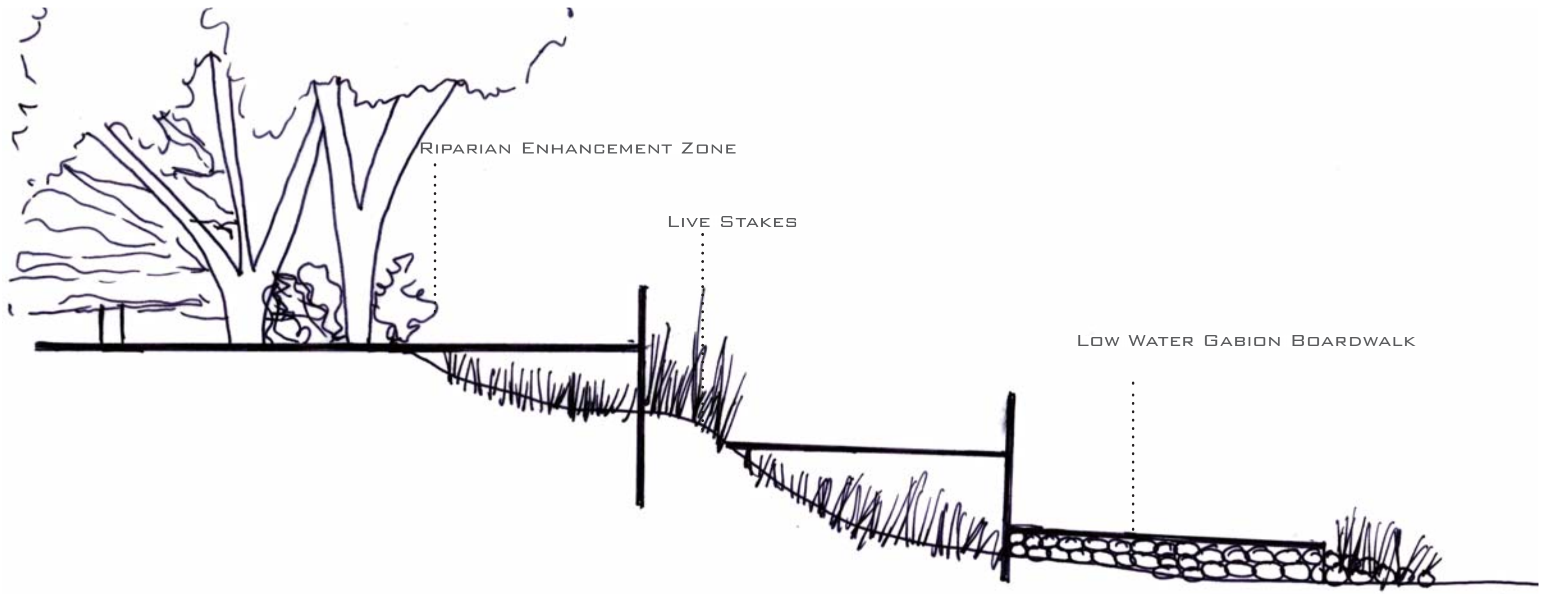
Figure 5.48: Boat Wake Action

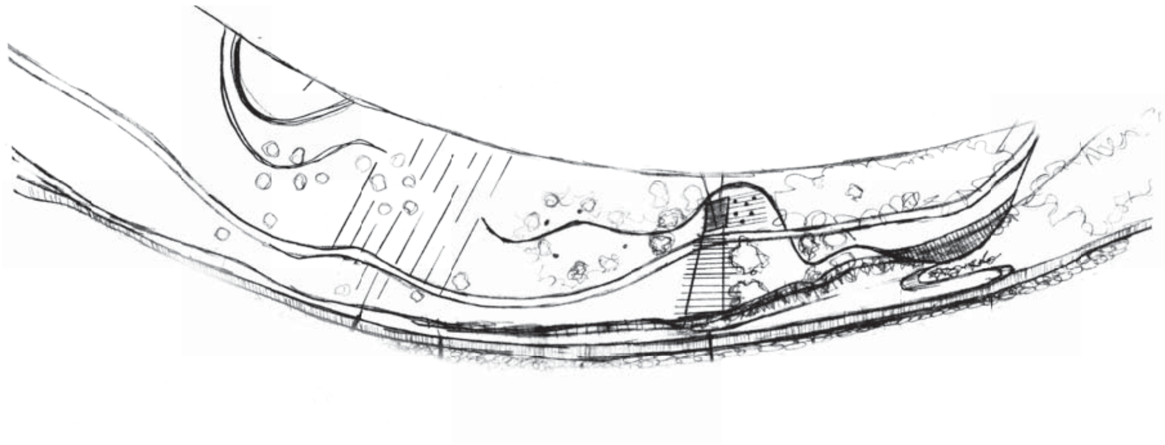
During high water events the thalweg grows larger, exerting more force as it meanders through the river. With strong currents, the bed of the river grows weak, causing pools to be carved out of the bottom with the sediment deposited downstream. When the discharge is low, the current flows at a slower rate allowing the once carved out pools to be filled, creating a level profile. (Living with a River,4)

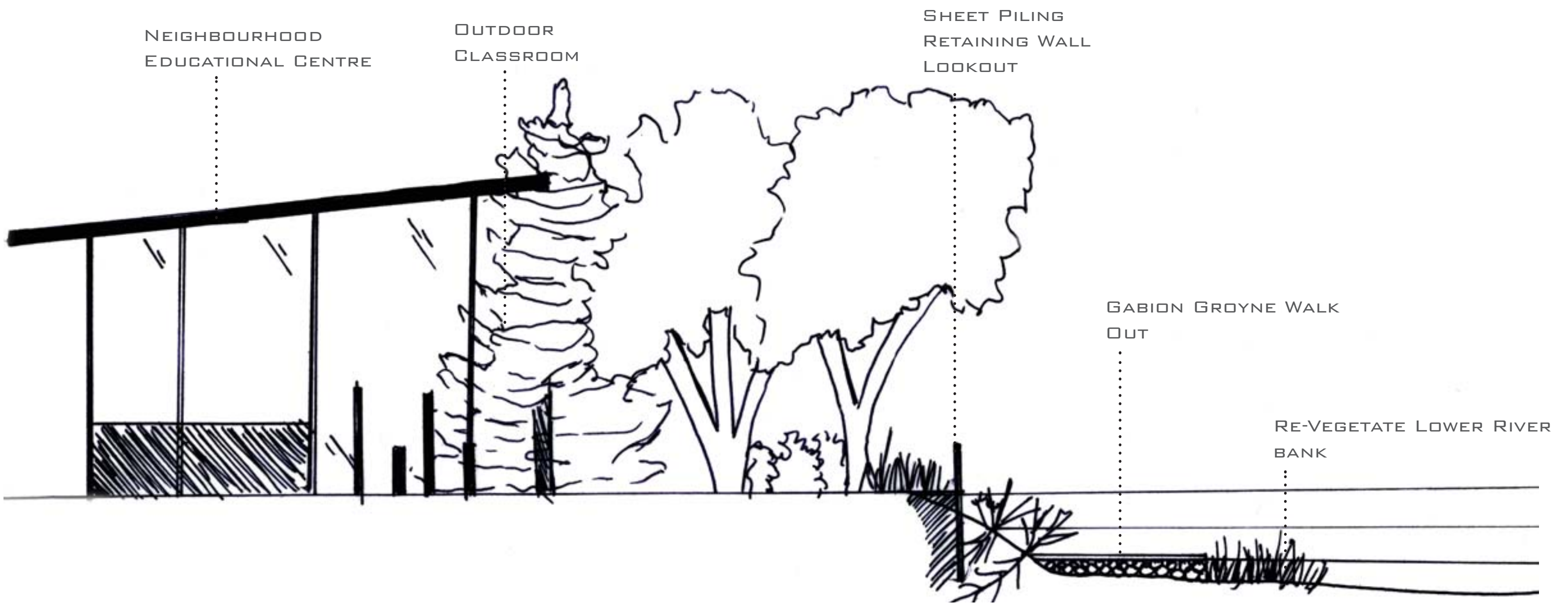
The river channel is shaped by the continuous pattern of erosion and deposition. As the water levels fluctuate the entire profile of the river banks are put under stress from the moving current, allowing sediment to erode away at varying levels. In addition to the current, the river particularly around Norwood and Riverview are subject to boat wake action. Although this is a low speed area for boats, the wake causes a significant amount of damage. As a boat moves at a faster rate, the wake exhibits a more frequent pattern at a lower height. When a boat is moving at a slow rate, the wake created is less frequent, but at a higher height. In addition to wake patterns, the movement of boats through the area causes a cylindrical movement of particles downwards, creating a shift in the river bed through eroded pools and deposited sediment piles.

Initial Design Concepts

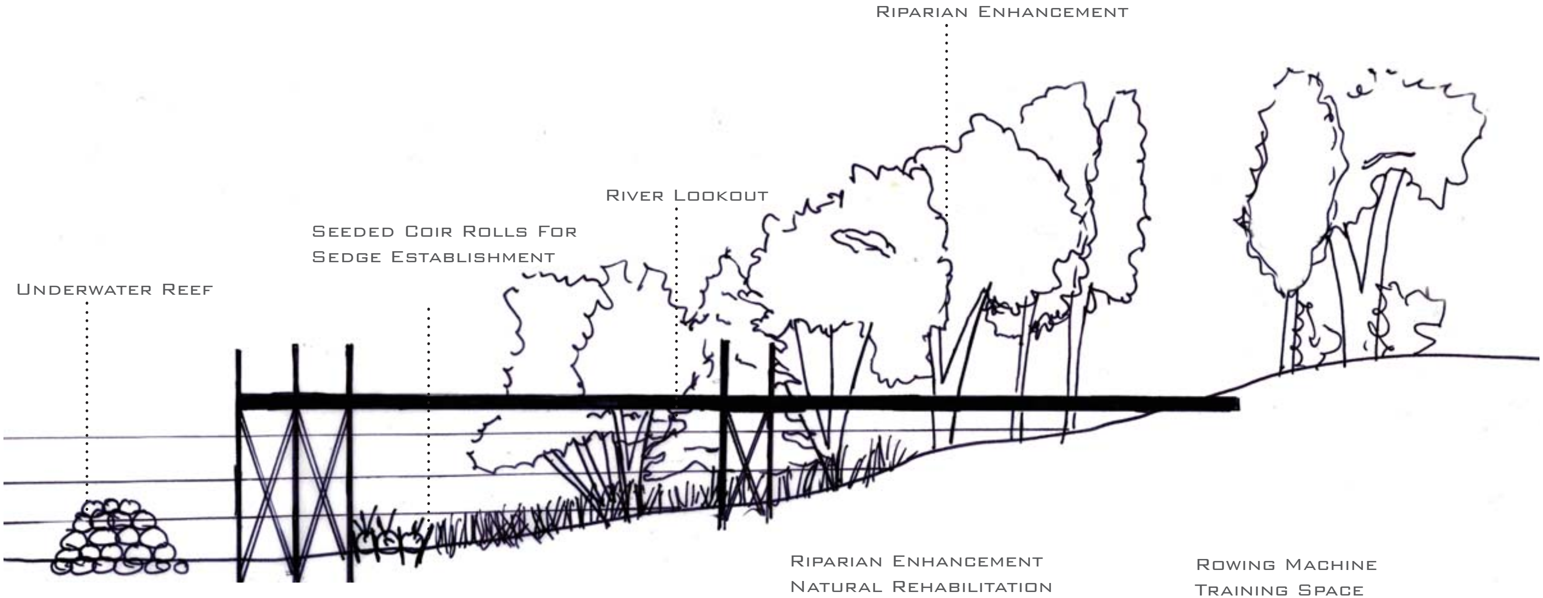
The initial design ideas for Norwood and Riverview range from creating a hard edge to the bank with a sheet piling retention wall for preserving the initial integrity of the neighbourhood with more natural solutions for erosion control. Sketching through different iterations led to the conclusion to maintain the original character of each space, while enhancing the site for community gathering and riverbank protection. Each design is meant to work with the erosion control techniques on the site rather than behave as separate pieces. The major challenge in the design was finding a balance between focusing entirely on the structure of the bank versus the overall site design. Through simple elements, the sites can be transformed from secluded spaces to areas of community activity.

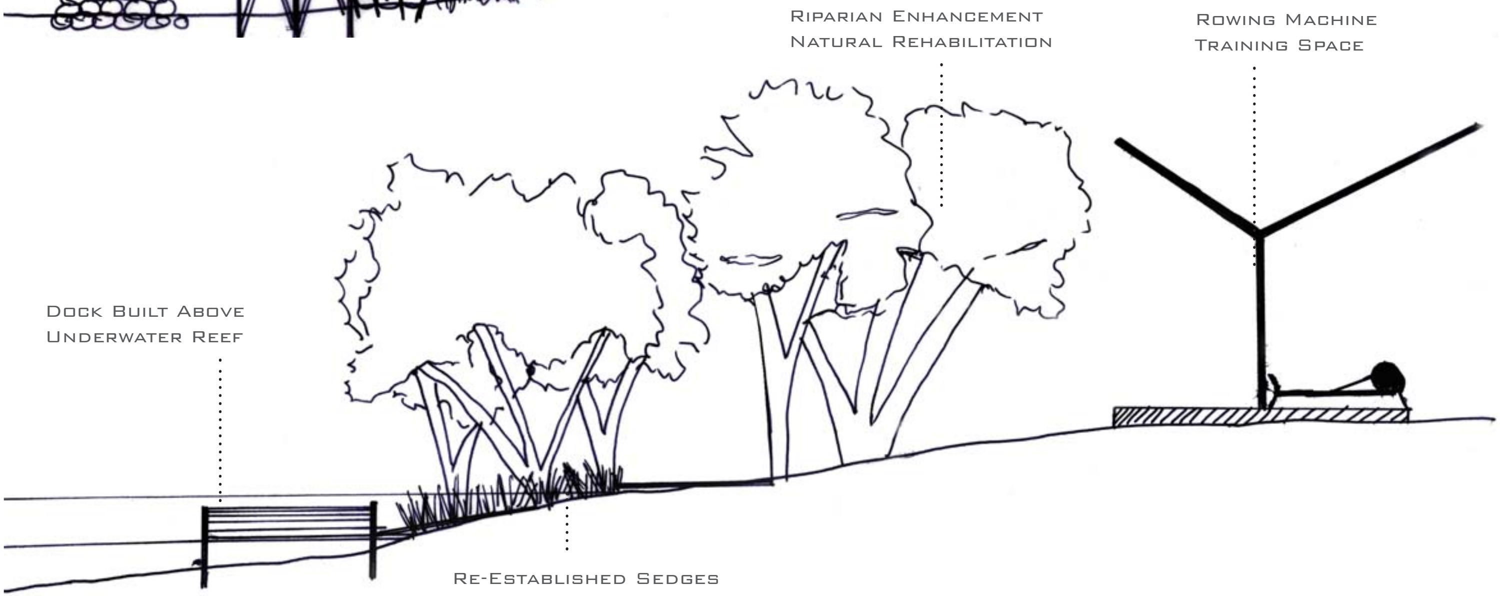


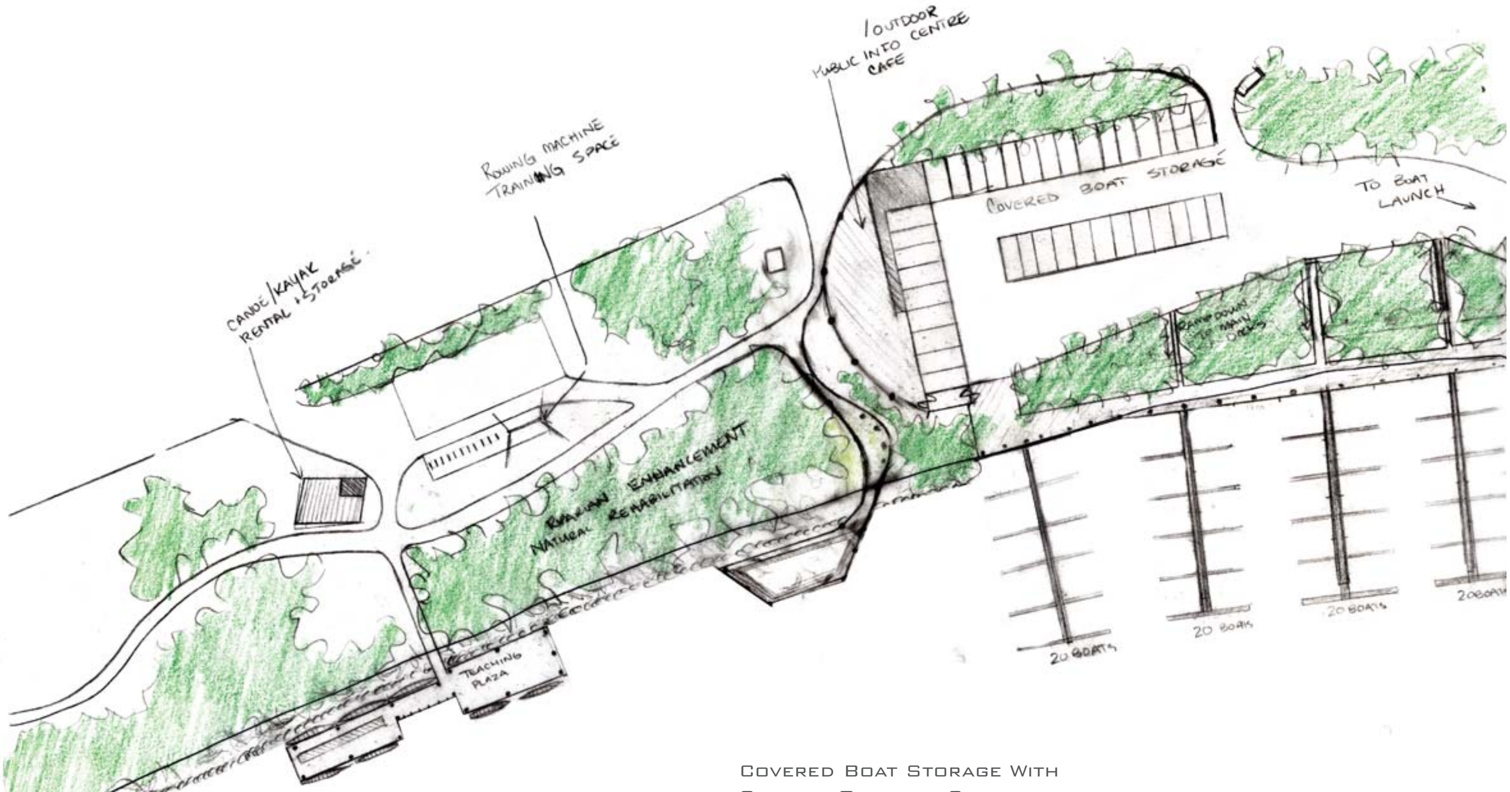




Neighbourhood Educational Centre
Outdoor Classroom
Sheet Piling Retaining Wall Lookout
Gabion Groyne Walk Out
Re-Vegetate Lower River bank


Riparian Enhancement
River Lookout
Seeded Coir Rolls For
Sedge Establishment
Underwater Reef


Riparian Enhancement
Natural Rehabilitation
Rowing Machine
Training Space
Dock Built Above
Underwater Reef
Re-Established Sedges



Covered Boat Storage With
Cafe on Opposite Side

New Boat Dock
Configuration

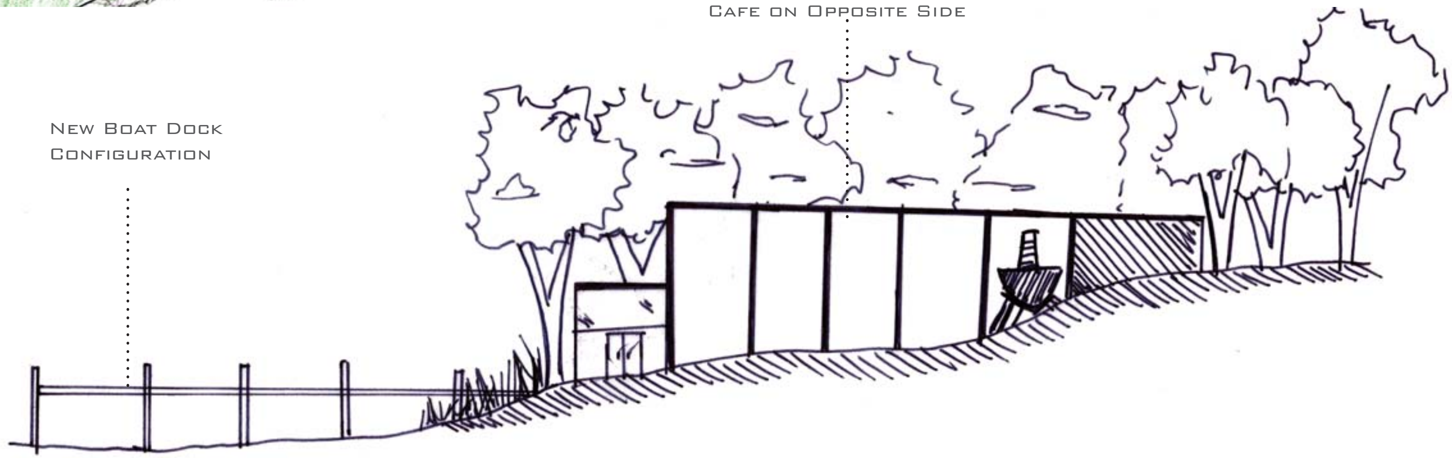


Figure 5.49

Figure 5.50

North Saint Boniface:

The site is located at the northern edge of St. Boniface, adjacent to Whittier Park and the re-created Fort Gibraltar. The surrounding neighbourhood appears to be going through some changes in development, with many condo buildings being built along Tache Ave, north of Provencher Blvd. The area immediately surrounding the site appears industrial, featuring the City of Winnipeg Waterworks building and aqueduct surge tank as well as old City Park Services buildings. The park area is small and open, bordered by the river bottom forest located along the river. A desired trail system is marked out along the upper shore line, leading into the St. Boniface Parkway. Whittier Park is home to the popular Festival du Voyageur that celebrates the areas Francophone and Metis culture. The area has the potential to continue this cultural celebration in the form of public art and character for longer periods than its short one week season.

The bank has been severely eroded from the fast moving flood waters of the Red and the rapid draw down of water levels that has devastated the structural integrity of the bank overtime. The lower shoreline is accessible through a stepped down bank, requiring a bit of adventurous climbing. Once next to the water, remnants of old docking grounds appear in the form of timber piles and steel pieces washed up on shore including an anchored chain. When next to the water, an amazing view of the Exchange District presents itself. The River Rouge parked at Alexander Docks adjacent to the old pump house and new boutique hotel offer an excellent opportunity to connect the two neighbourhoods visually across the river. Along the bank, the ground cover is a mixture of sandy clay soil and native shrubs and grasses. Mature trees line the bank, offering a natural filter for river sediments as well as offering habitat for small mammals and birds. Unfortunately, the bank has been cut out by the river, exposing most of the tree roots, degrading the health of the forest. Exploring the site in its autumn transition phase was rather exciting to see the flora change in appearance in a few short weeks. This creates an interesting visual and functional opportunity to create a space that can be used all year round.

Alexander Docks:

Located within Winnipeg's historical Exchange District, Alexander Docks is the current home of the River Rouge cruise ship. The River Rouge offers a unique opportunity to explore our city and travel along what started settlement and trade many years ago. The dock itself has been deteriorating in recent years. The wooden boards have been damaged from water and excessive use, causing softened areas to break on the deck and the need for much of it to be replaced. Winnipeg is lacking in public riverfront access for pedestrians, cyclists, boaters, canoeing and many other recreational services. Keeping the integrity of the dock space, this area has the potential to become an extension of the Forks and become a dominant commercial, recreational area within the city. With new development along Waterfront Drive the area is trying to re- create itself as a multi-use district. The neighbourhood needs more than expensive condos and a boutique hotel to holds its own and attract people of Winnipeg out into this area.

The dock space has the opportunity to connect into the landscape design of the new hotel as well as the trail system currently implemented along Stephen Juba Park. Additionally, the Exchange near the Waterfront has many cultural and entertainment spaces such as the Manitoba Theatre Centre, Centennial Concert Hall, Manitoba Museum, and Union Sound Hall among many other restaurants and nightlife venues. The riverfront could become an event space that celebrates the strong entertainment culture Winnipeg prides itself in.

Current Site Uses: North Saint Boniface

Being located at a dead end, Tache Avenue at Rue Messager is mainly accessible via private vehicle from Provencher Blvd., with public transit available down part of Tache Ave. Active and recreational trails are found along the river, connecting to the St. Boniface Parkway and onto Whittier Park. Across the river, the site is accessible mainly through private vehicle use as well along Waterfront Drive. Recreational trails are located throughout Stephen Juba Park, connecting Alexander Docks to the Goldeye's Stadium and further down, to The Forks National Historic Site.

Current Site Uses: North Saint Boniface

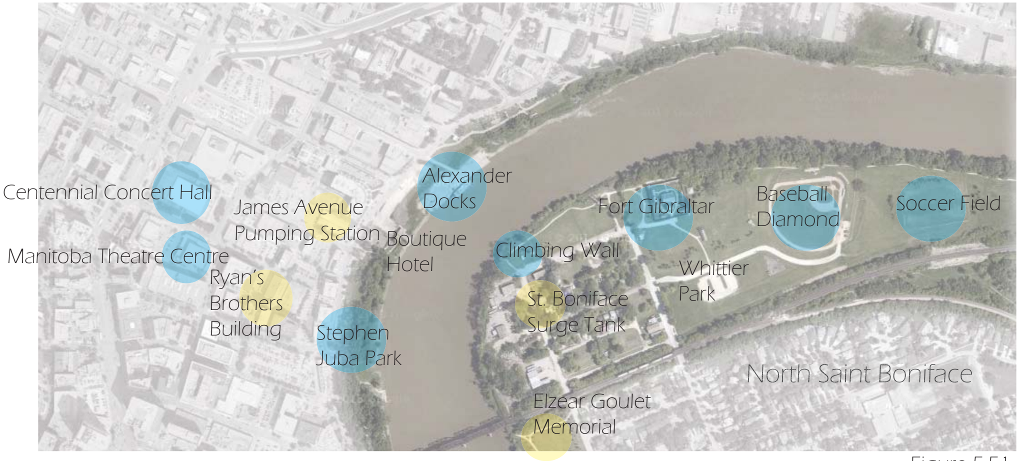


Figure 5.51


Figure 5.52


Figure 5.53


Figure 5.54


Figure 5.55

Circulation:

Figure 5.56


Figure 5.57


Figure 5.58


Figure 5.59


Figure 5.60

Evidence of Erosion

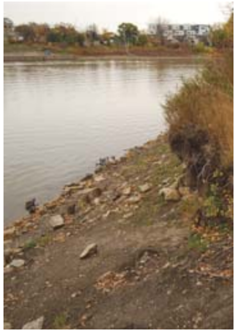


Figure 5.61

Figure 5.62

Figure 5.63

Figure 5.64

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Figure 5.66

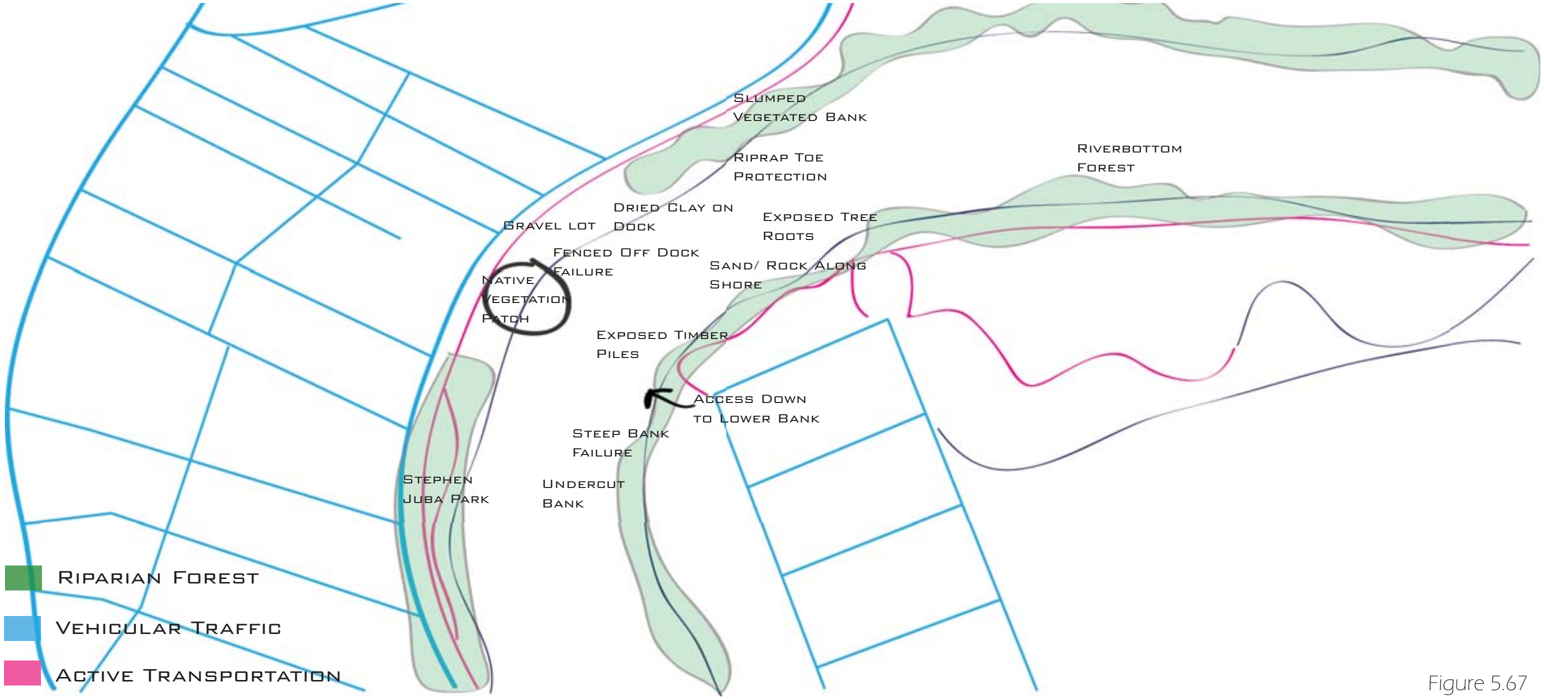


Figure 5.67

Vegetation:


Figure 5.68


Figure 5.69


Figure 5.70


Figure 5.71


Figure 5.72


Figure 5.73

Along the bank, the ground cover is a mixture of sandy clay soil and native shrubs and grasses. Mature trees line the bank, offering a natural filter for river sediments as well as offering habitat for small mammals and birds. Unfortunately, the bank has been cut out by the river, exposing most of the tree roots, degrading the health of the forest.

Riparian Zone: Alexander Docks

Terrace

- Burdock
- Canada Thistle
- Sweet Clover
- Sage
- Choke Cherry

Flood Plain

- Manitoba Maple
- Dogwood
- American Elm
- Green Ash
- Wild Rhubarb

Riverbank

- Ragweed
- Smooth Brome
- Curled Dock
- Sandbar Willow
- Cottonwood

Riparian Zone: Saint Boniface

Riverbank

- Quack Grass
- Smooth Brome
- Curled Dock
- Cottonwood

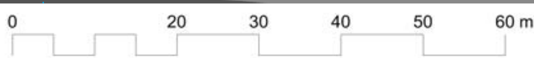
Flood Plain

- Manitoba Maple
- Dogwood
- Green Ash
- American Elm
- SIberian Elm
- Peach Leaf Willow

Terrace

- Burdock
- Canada Thistle
- Sage
- Aster
- Prairie Clover
- Wild Rye

Figure 5.74: East West Section B



Flooding and Water Movement

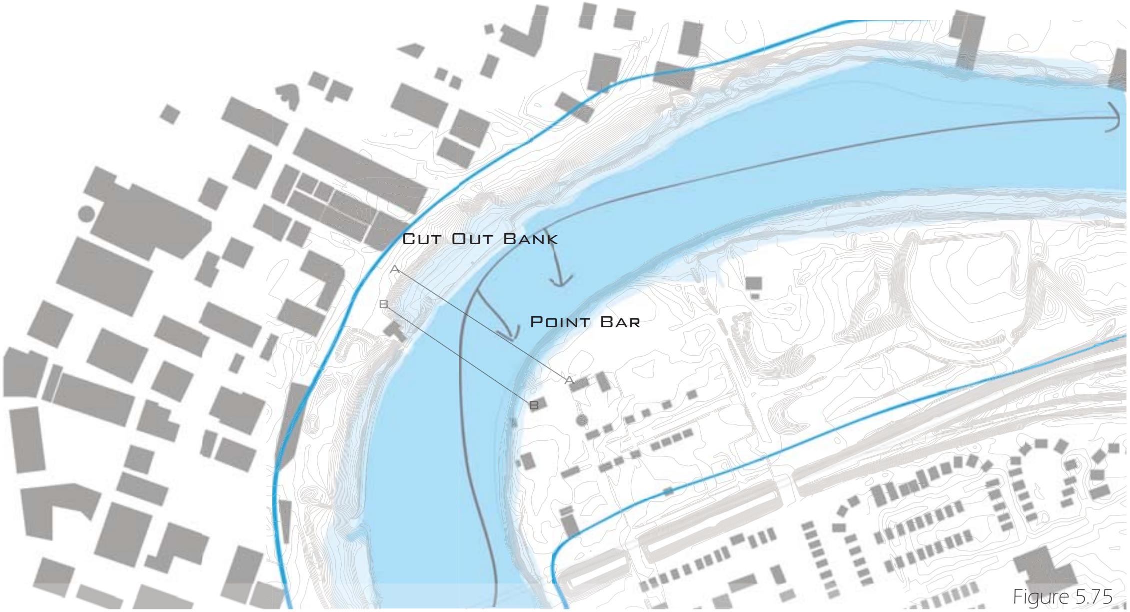


Figure 5.75

The north flowing river scours the cut out bank along Alexander docks and South Point Douglas, causing slumped vegetated banks. As the river flows around the bend, sediment builds up along the toe of the inner point bar bend, depositing beach like sands on the lower water shoreline at Tache and Messager. Flood Waters have severely damaged Alexander Docks overtime, creating the need for regular maintenance of a new dock using flood tolerant materials.

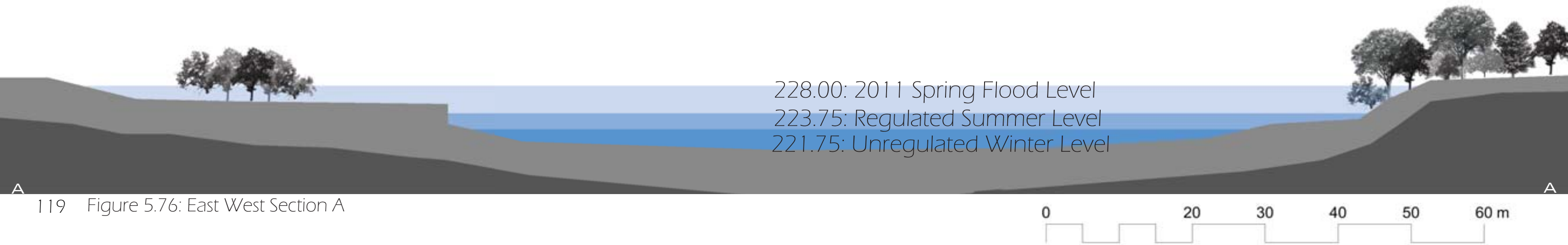


 Figure 5.76: East West Section A

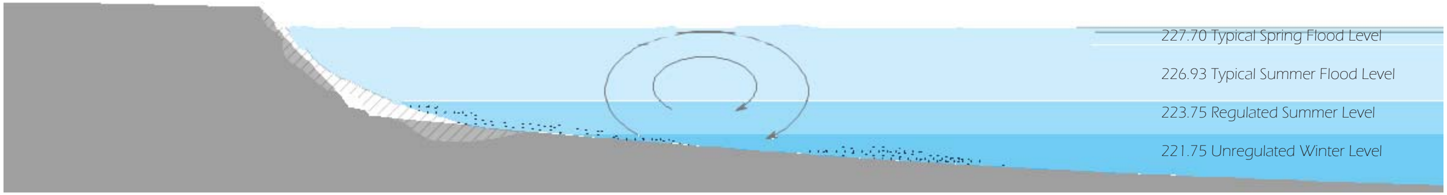


Figure 5.77: Thalweg Movement

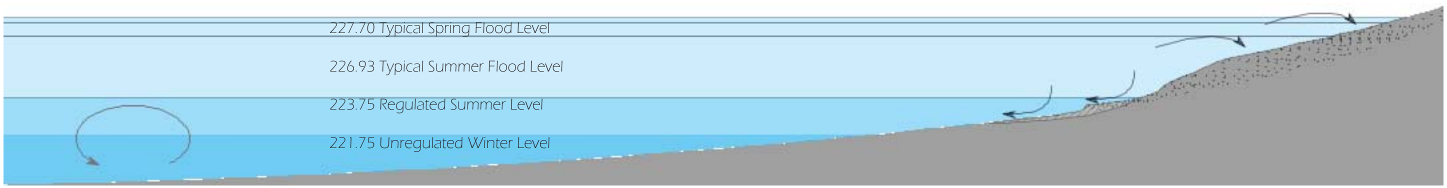


Figure 5.78: Sediment Movement

As the thalweg meanders through the river, the force of the current pushes sediment from the outer edges towards the inner edges. This process is magnified during high water events, as the thalweg is larger and stronger compared to normal levels. As mentioned before, as the water levels move up and down, the clay banks are weakened, causing an increased amount of erosion during the flooding season. The force of the thalweg causes debris to flow in a similar pattern, leading to bank scour and damaging built structures such as Alexander Docks across from North Saint Boniface. As the current moves away from the docks, debris is directed towards the Saint Boniface site. By implementing ecological erosion control techniques along the river, the thalweg current could be slowed down, and sediments could be filtered before reaching the river.

Current Site Advantages

The area has the potential to create a cultural celebration extended from the spirit of Festival du Voyageur in the form of public art and site character. At the shoreline, an amazing view of the Exchange District presents itself as is. Through the creation of a publicly accessible space along the river, the public will be invited to experience our unique industrial Winnipeg skyline. The River Rouge parked at Alexander Docks adjacent to the old pump house and new boutique hotel offer an excellent opportunity to connect the neighbourhoods visually across the river as well as creating an extension of the Forks River Walk along the shoreline. With the exchange becoming an entertainment district with spaces such as Manitoba Theatre Centre, Centennial Concert Hall and Union Sound Hall, the riverfront could become a dynamic event space that celebrates the strong entertainment culture Winnipeg prides itself in.


Figure 5.79


Figure 5.80


Figure 5.81


Figure 5.82


Figure 5.83


Figure 5.84

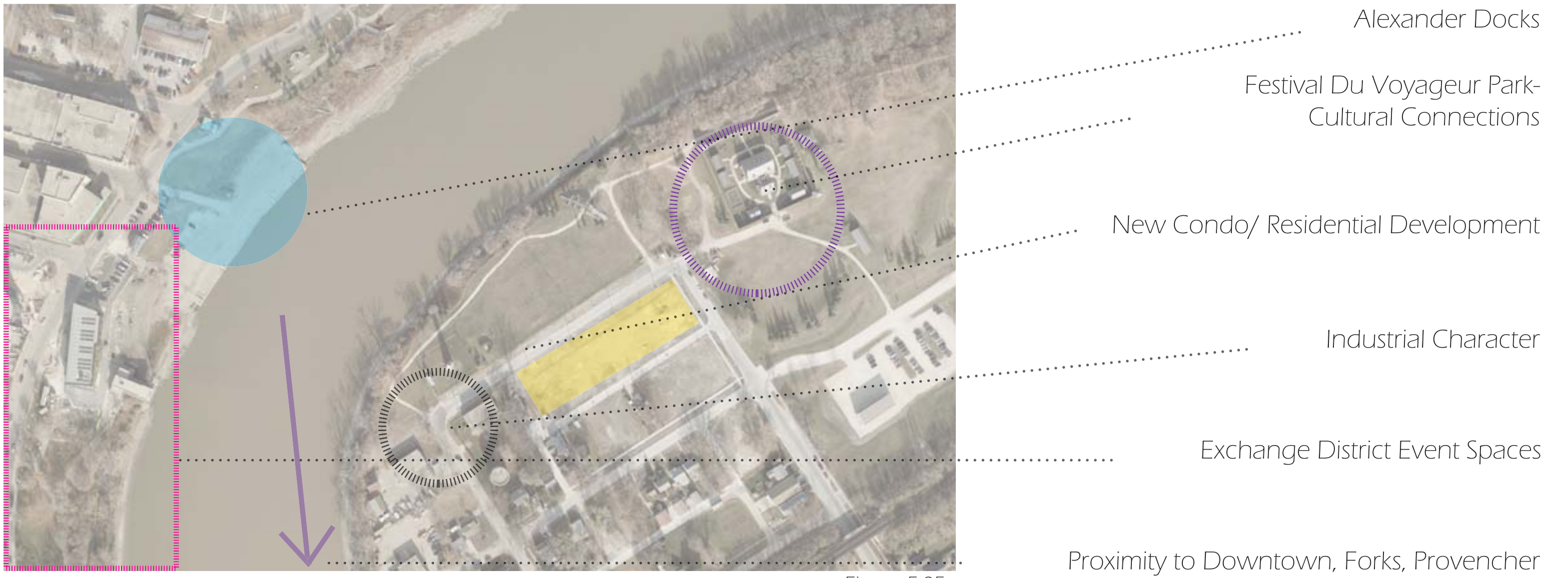


Figure 5.85

Current Site Disadvantages

Currently the site does not act as a significant draw for people to the area, with the exception of Festival du Voyageur for one week in February. In Saint Boniface, the site lies on a dead end street without any amenities or space for people to gather year round. There are a lack of amenities such as a café or corner shop within the immediate vicinity, potentially hindering the appeal for people moving into the new condo developments. The closest amenities are located along Provencher Blvd., while not too far on a map, are still a fair distance for walking in the cold winter months 6 month out of the year. The rock climbing tower along Rue Messager has the potential to be the start of a recreational hub, although it is currently very solitary and could use some further enhancement to appeal to the general public. Currently the sites on both sides of the river have a significant lack of winter connection to the river as well as lack of access to water recreation in the summer.


Figure 5.86


Figure 5.87


Figure 5.88


Figure 5.89


Figure 5.90


Figure 5.91

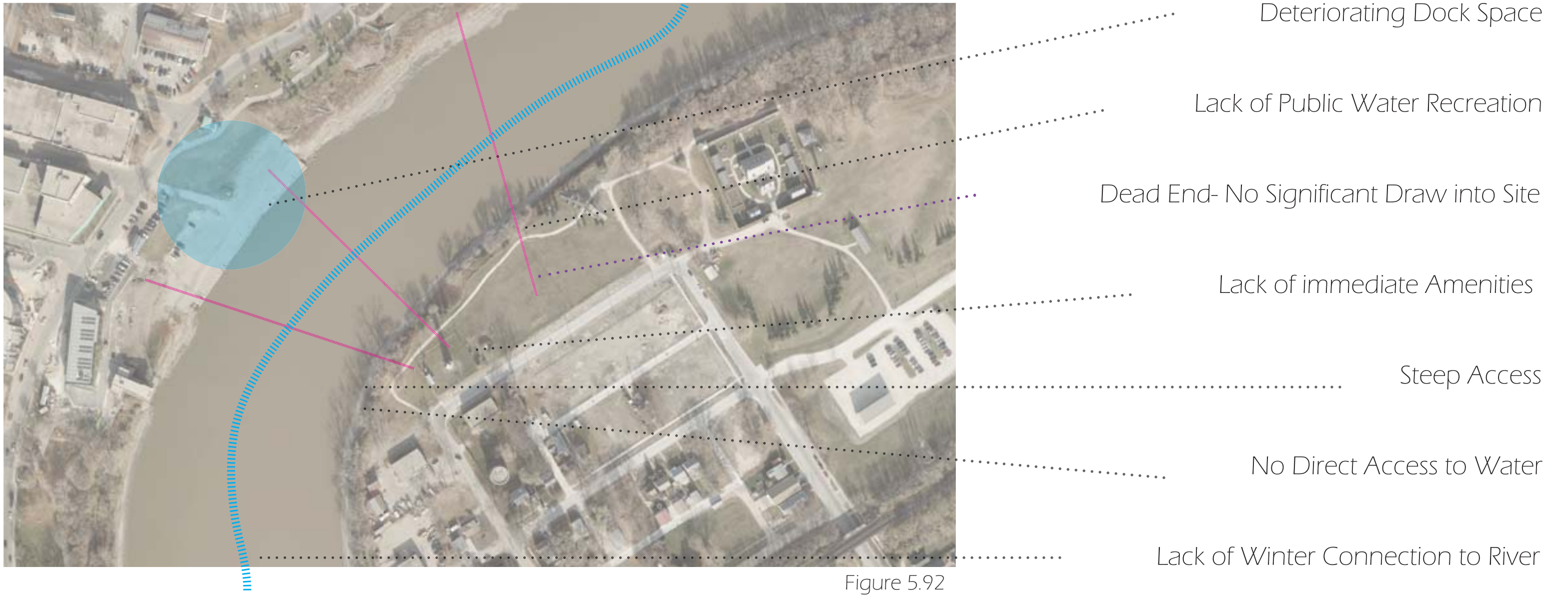
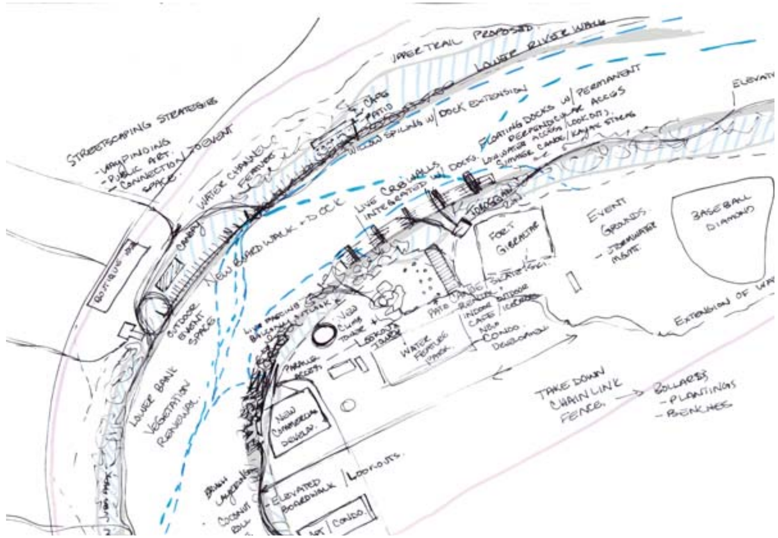
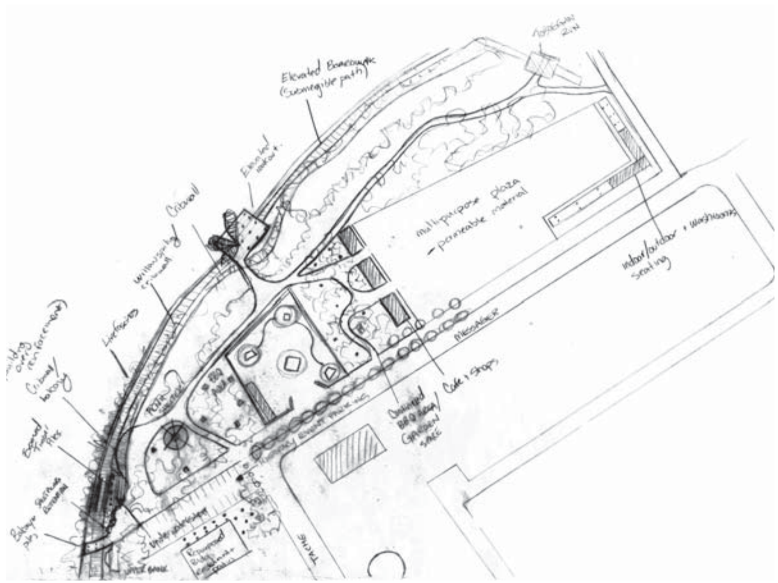


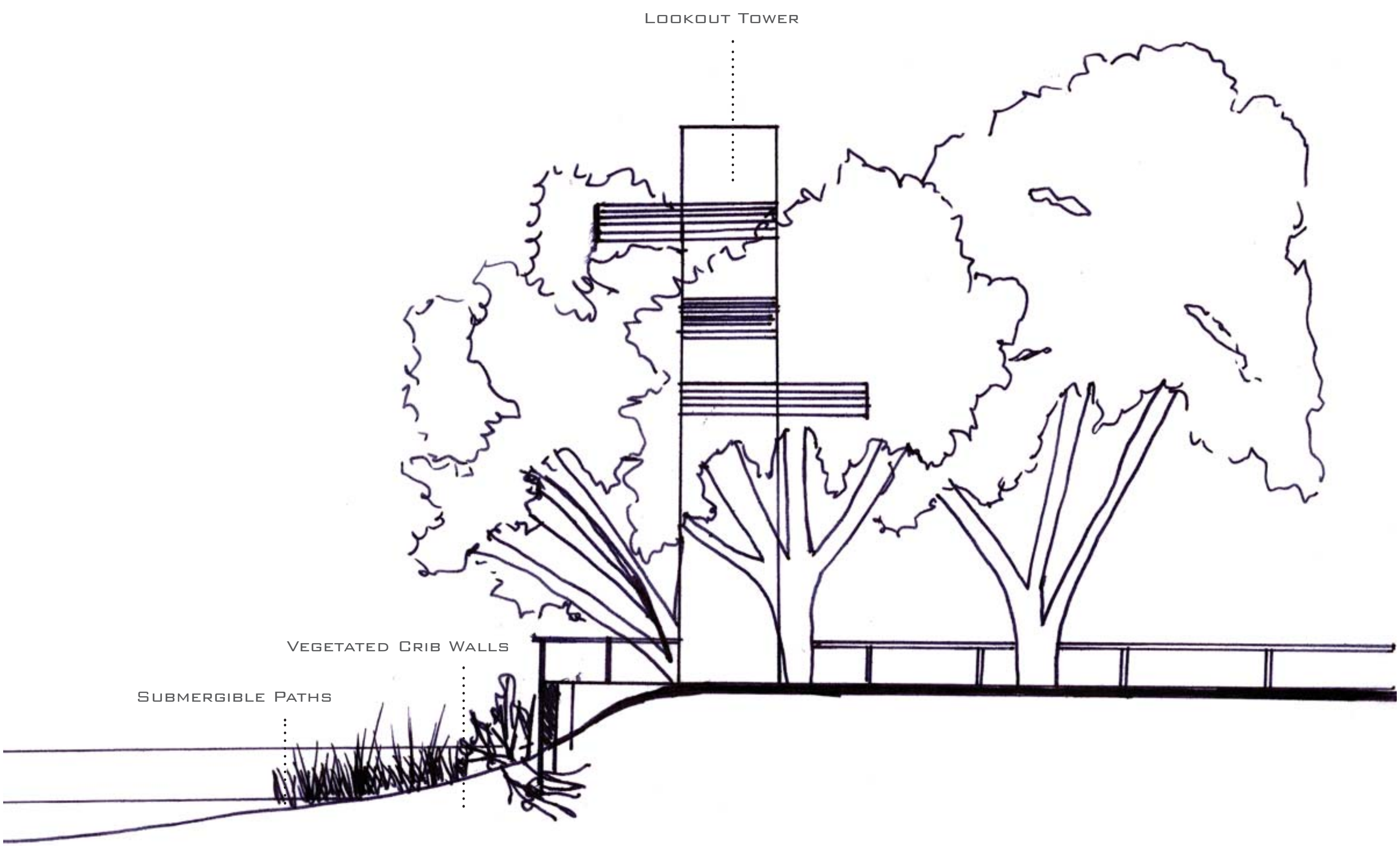
Figure 5.92

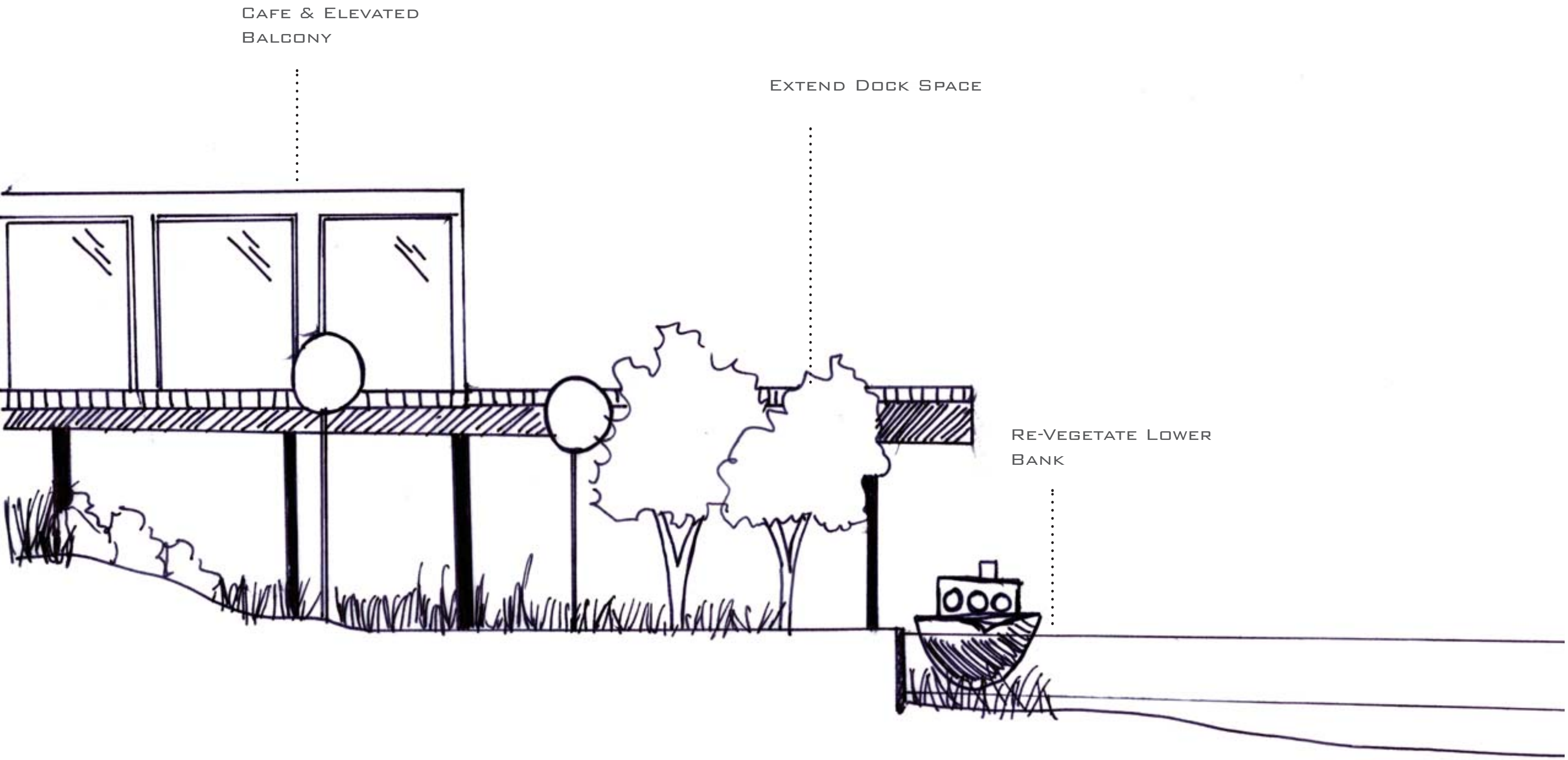
Initial Design Concepts

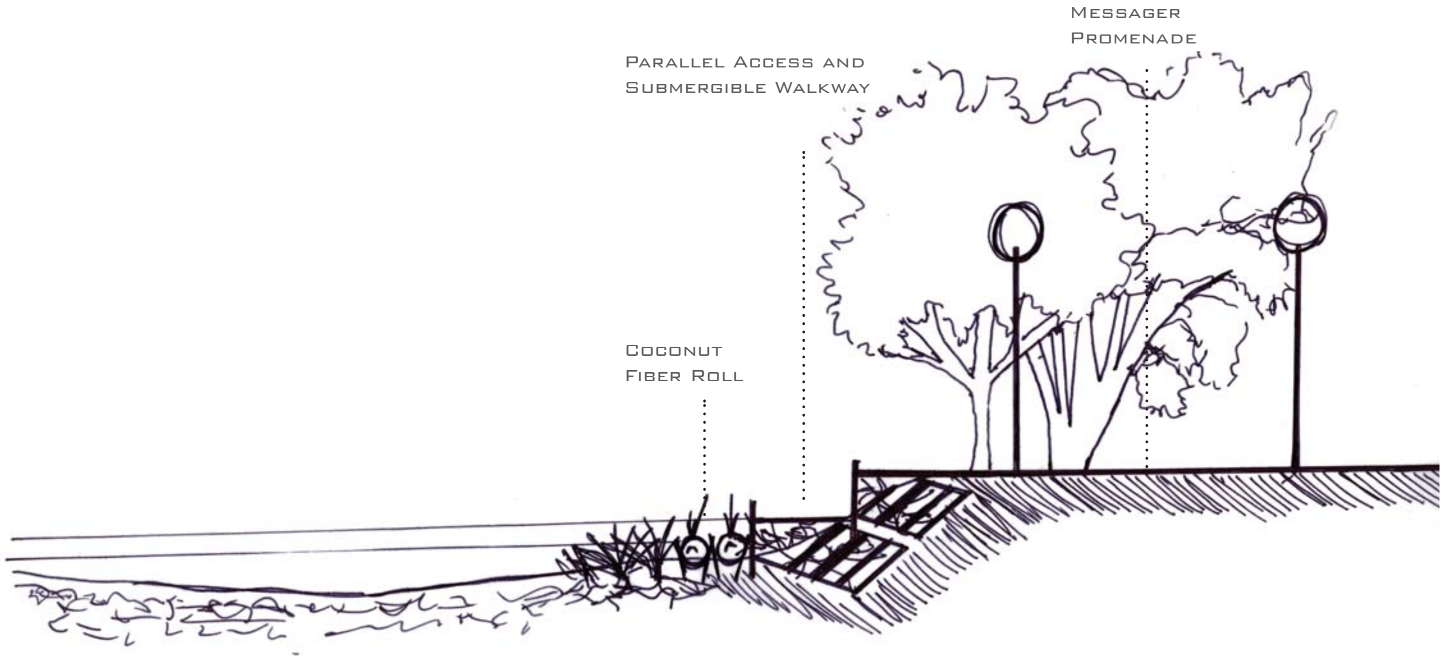


The initial design ideas for North Saint Boniface stem from dealing with the processes of erosion in the landscape. Areas of extreme erosion lead to the desire for spaces to extend out over the river or above the forest canopy from a lookout tower. The current character from the historic Fort Gibraltar, Festival Du Voyaguer and Waterworks pumphouse inspire the materials and design elements throughout the site in the form of a sheet piling retention wall and multipurpose plaza for events.




Lookout Tower
Vegetated Crib Walls
Submergible Paths


Cafe & Elevated Balcony
Extend Dock Space
Re-Vegetate Lower Bank


Messager
Promenade
Parallel Access and
Submergible Walkway
Coconut
Fiber Roll

6. Design Intervention:

Developing Case Studies

"Go to the Waterfront" is a document represents Winnipeg's twenty year waterfront vision developed by the Forks North Portage Group in conjunction with the City of Winnipeg. The vision was developed as an extension of the City's "Our Winnipeg" document that describes a sustainable twenty-five year vision. The two visions complement one another to create a positive outlook and hope for the future development of Winnipeg. The Waterfront document sets the stage for future development along the Red and the Assiniboine, stating the following:

"Riverfront lands are valued as essential to the urban fabric, a prime example being The Forks, the city's "meeting place"... How we see our city of the future and guide its development along the rivers can be transformative for Winnipeg. Beyond The Forks and downtown, and radiating from the water's edge, is a tapestry of adjacent urban neighbourhoods stretching over 40 kilometres of riverfront lands. These riverfront precincts are the primary focus of a 20 year vision to build and celebrate Winnipeg's identity as a river city." (City of Winnipeg- Go to the Waterfront, 2012 Pg 5)

The main goals of the vision include:

1. Promoting opportunity for social engagement
2. Manage Green Corridors along streets and river
3. Expand Ecological Networks and linkages
4. Ensure Public Access to our Riverbanks

The overall vision sees seven main themes emerging from future riverfront development:

1. "Awaken our Neighbourhoods" through active use and enjoyment of our rivers
2. "Celebrate our Friendships with event spaces and cultural/ community connections
3. "Explore the Riverfront" by engaging water flux, shoreline access and information signs
4. "Engage the Elements" all year round with the continuation of the Warming Huts competition and waterfront access
5. "Sustain our Ecosystem" by reducing greenhouse gasses, managing riverbank erosion and providing active transportation throughout the city
6. "Inspire waterfront Living" with the development of homes, businesses and amenities within infill lots downtown
7. "Transform our City"

Go to the Waterfront, 2012 Pg 11

20 year vision for Norwood & Riverview:

The vision for this suburban neighbourhood sees the development of a riverbank pathway along Churchill through raised boardwalks and bank stabilization techniques. Public access will be enhanced through canoe/kayak storage lockers, rentals and riverside restaurant spaces. Lyndale drive will be redeveloped with vehicle and pedestrian lookouts, revegetation of the banks as well as barbeque pits for gathering along the upperbank. Winter crossing trails in the form of ice bridges will be created across the river, enhancing the overall neighbourhood connection between Norwood and Riverview.

20 year vision for Exchange District and North Saint Boniface:

The vision for the Voyageur neighbourhood enhances cultural connections with permanent facilities along a new 'Voyageur Trail', promoting festivities all year round. Summer and winter access will be created along the bank in the form of dock spaces with canoe/kayak storage lockers. Opportunities for small vendors will enhance the overall connection to the riverfront while providing a destination point for the neighbourhood. Whittier Park will develop a one way park drive, a cross country ski course, and picnic/ barbeque areas as well the potential for urban camping as a strategy to create a notable public waterfront park space in Saint Boniface.

A pedestrian connection will be made across the river towards Stephen Juba Park and Alexander Docks through an active transportation bridge alongside the CN railline. A waterfront plaza with seating and commercial kiosk opportunities will enhance the public gathering space for the Alexander Docks and Paddlewheel services. The site will act as the gateway into the East Exchange, offering opportunities for entertainment events.

While still in its draft phase, the Waterfront document focuses on the need for connection to the river year round, but is lacking in the development of structural or ecological integrity of the river itself. The research put forth in this practicum has the potential to be a complimentary document for the City's Riverfront Vision, working hand in hand with future planning strategies and ecological principles.

City of Winnipeg. "Go to the Waterfront." The Forks. http://www.theforks.com/uploads/ck/files/Publications/GoWaterfront_2014.pdf (accessed November 8, 2013).

Designing a Case Study

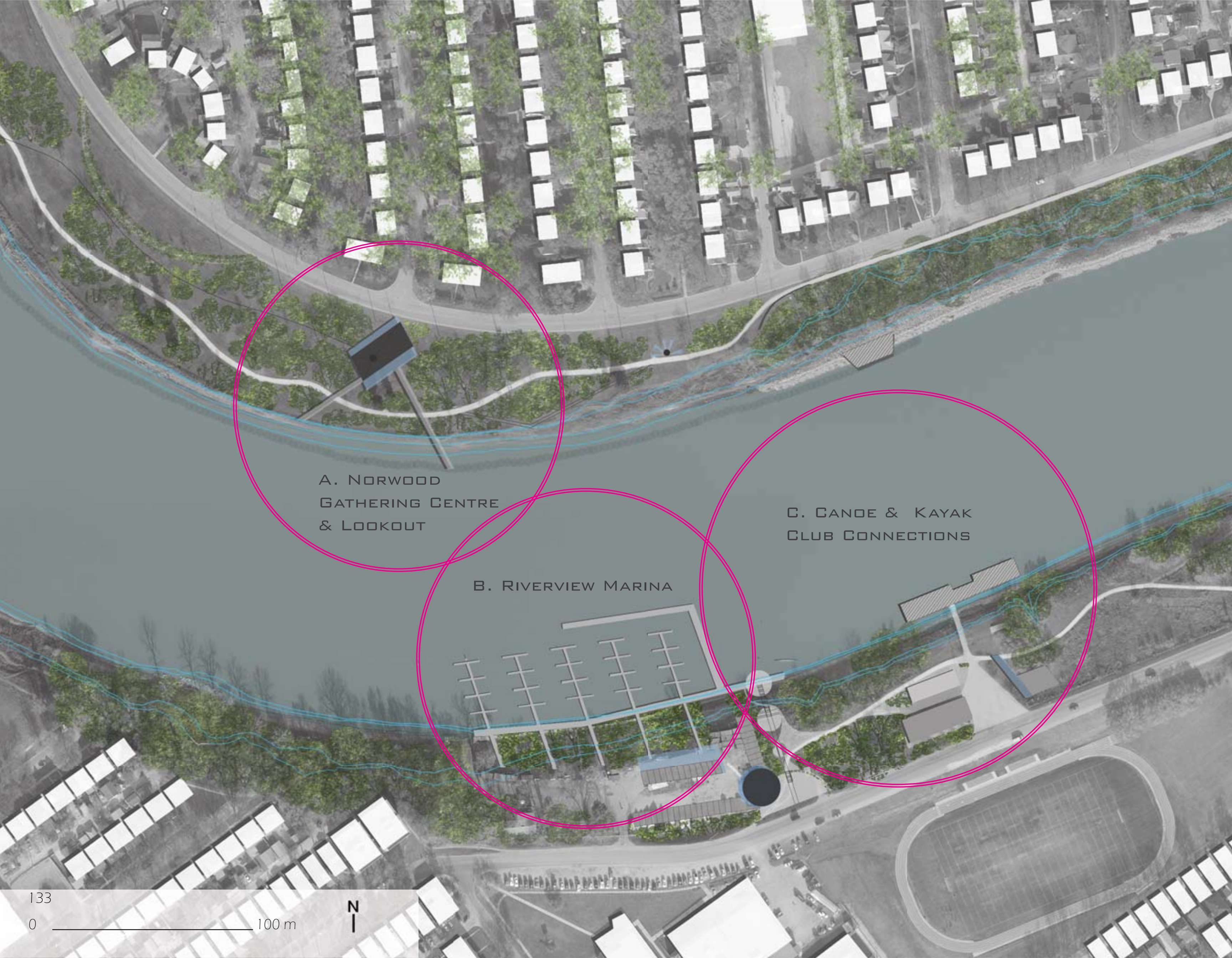
Designing the riverfront, while at first may appear like a straight forward task, raises many concerns and issues for understanding multiple components in solidarity as well as in balanced unity. Developing a case study that marries the most important components to riverfront design is an essential task to ensure the potential for successful and ecologically sensitive designs along our urban water bodies. The previous sections described the three main driving mechanisms for riverfront design: erosion control techniques, flood design strategies and riverside planning principles. With the combination of the three, a new riverfront vocabulary is created. This section of the book describes how the new riverfront vocabulary is put into action, creating integrated landscape design solutions.

Three case studies along the Red River in Winnipeg were formed in response to the riverfront vocabulary research: Norwood, Riverview and North Saint Boniface. The designs on each site adopt the proposed concepts brought forward by the City's twenty year vision plan while adding much needed consideration for the structural integrity and enhancement of the riverfront through erosion control and flood management. Three main concepts are considered in the design of each site: Riparian Habitat Improvement, Shoreline sensitivity and Social Enhancement.

The riparian habitat holds the ecological integrity of the site. It is the source of nutrients, natural flood control and is home to many organisms. Rehabilitating and sustaining the riparian habitat is an important part in the design process that will help create spaces celebrating the natural function of the river within an urban realm. Each site design protects and enhances the existing riparian forest through the establishment of preservation zones and future establishment areas. Succession is taken into consideration when planning the new forested areas in order to maintain and enhance biodiversity along the riverfront.

Development along the shorelines of a river requires attention to sensitive design. Protecting the shoreline through ecological techniques will further enhance the riparian habitat once implemented. The techniques chosen on each site require an initial disturbance to the natural shoreline in order to install erosion control structures or live stakes along the banks. It is not feasible to completely protect the bank without first disturbing the existing shoreline to a small degree in most cases. Each site will be examined for the techniques chosen and how they will impact the shoreline. Spring and summer flooding are considered in the designs of the mid-lower banks, taking into account the velocity change in the river current during low and high water events. Hardy, deep rooting shrubs such as Sandbar Willow were chosen to be planted along the mid-high banks as the root systems will establish, creating a protective root mat for the weak, clay soils. The lower shorelines will be largely planted with sedges as they are resilient in nature, being able to withstand fast currents and large amounts of deposition. Through ecological techniques chosen for erosion control, the designs ensure the longevity of the riverfront for the future of the city.

Being a river city, social enhancement along the river corridor is essential for bringing communities together. It provides opportunity for playful gatherings and alternative ways of movement throughout the city. With the integration of urban culture, the riverfront can become a place that celebrates our unique mix of arts, entertainment, sports and cultural amenities. The designs at each site reflect the character of the surrounding neighbourhood while responding to the social and ecological needs at that location.


A. Norwood
Gathering Centre
& Lookout
B. Riverview Marina
C. Canoe & Kayak
Club Connections
0
100 m
N

Norwood & Riverview Case Studies

When designing a riverfront space, it is important to take into consideration both sides of the river as well as up and downstream as they are all connected both physically and visually. The design of the site reflects the existing neighbourhood character and takes into consideration the current form developed from erosion and deposition overtime. The 20 year vision for Norwood and Riverview includes an extension of the Forks Riverwalk system and added connections from the roadway to the shoreline. In this proposal, the vision is further developed with the idea of creating a destination point for the Norwood neighbourhood to encourage community gathering. This is accomplished by establishing a gathering centre, bike shop and picnic shelter at the west end of the site. Where the bank has been carved into a steep gradient, a lookout space emerges from the centre, through the enhanced riparian forest, extending 10 meters from the shoreline out over the water. This space offers a new opportunity to get out over the water to appreciate the structure of the bank and the nature of river. To the west a one way street is proposed for leisurely weekend drivers to view the river. Spaces between the trees have been created to ensure a direct view of the river is made from the proposed roadway. Moving towards the east, the forest has been enhanced through succession planting zones featuring an assortment of Maple, Basswood, Willow and Dogwood species. Fire pits and picnic tables are scattered throughout the forest, offering spaces for visitors to rest and relax. Secondary trails meander through the forest off the main path, creating opportunity for natural exploration and cross country skiing, At the eastern end of the site a durable ramp system leads down into the floodplain to a fishing dock for summer recreation. During the winter months, this dock serves as an access point to the extended river trail and Riverview neighbourhood.

On the south side of the river, the Manitoba Canoe & Kayak Club is opened up towards Churchill Drive. A canoe and kayak rental building is situated opposite the existing storage facility, creating additional water recreation opportunities for the neighbourhood. The dock has been re-configured to allow for technique training to commence on the dock itself as well as for the dragon boats to be parked along its edges. Should vandalism be an issue a retracting gate could be installed at the toe of the bank. Towards the west, a public entrance is created to unite the new Riverview Marina and Manitoba Canoe and Kayak club. At the entrance a round glass building is offset from the main path to allow a clear view down constructed terraces towards the river. The building features a cafe and information desk, allowing interested patrons to the Marina or Canoe club to make inquiries. Durable concrete terraces lead users down into the floodplain. During high water events, the terraces are slowly covered, creating a visual marker for flood levels and allowing multiple opportunities for shoreline engagement as the water fluctuates throughout the seasons. As the flood waters retreat, a lower fishing dock atop gabions can be found at the bank toe. At the western edge of the site, the existing boat club is transformed into a more structured marina. The entrance building has a private entrance for marina members in order to maintain security for the marina itself. Within the area, secured boat lockers are installed above the average spring flood level to ensure boats and supplies remain dry throughout the year. An emergency access road is proposed at the east end of the marina, furthest away from the boat dock. This road extends out on to a durable bulkhead crossing the thalweg as a space for police and ambulance water traffic to dock during emergency events. The design of the site creates an overall sense of community while promoting water recreation for the Riverview neighbourhood as well as the City of Winnipeg. Throughout this chapter, the designs on each site will be examined in detail for how they incorporate erosion control techniques, flood management strategies and overall design principles.

<Figure 6.0: Norwood & Riverview Site Map

Figure 6.1: Visual Connections

Figure 6.2: Design Concept

The design of the site was largely informed by the visual and physical connections between the existing elements and possible concepts (Figure 6.1). By creating a web of views and nodes between important landmarks, gathering spaces and potential riverbank protection sites, the conceptual design emerges, complimenting the existing sites

Thalweg Movement

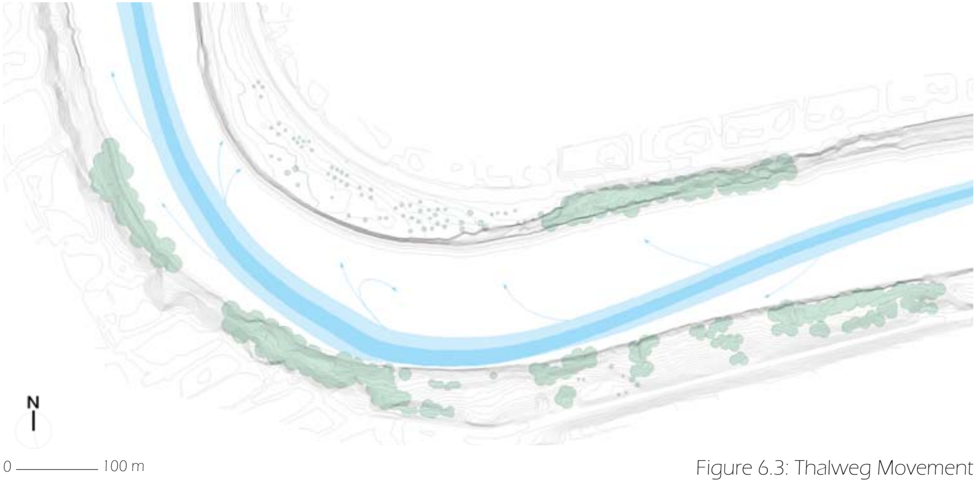


Figure 6.3: Thalweg Movement

The thalweg current moves from the inner to outer bends of the river, carrying sediments and debris to deposit and erode the bank as it travels. As the water levels fluctuate, the size and velocity of the thalweg also fluctuate. The flow pattern of the water is important since the current boat club is in the direct path of the thalweg, creating the high potential for destruction. The design of the new marina takes this pattern into account with the design of a durable bulkhead, discussed later in the chapter.

Developing Erosion Control Solutions

The Norwood site along Lyndale drive features 2 distinct zones along the bank in terms of its state of erosion. Upstream, the bank is extremely eroded with steep banks and degrading vegetation along the lower to mid banks. Downstream, the bank transitions into a softer gradient showing signs of slumping and hardier vegetation growth with signs of rip rap constructed at the toe of the bank.

The following diagrams show a series of iterations, working through different possibilities for erosion control techniques two different zones. Each iteration uses biotechnical strategies for protecting the riverbank. In every option, vegetation is established on the site to offer ecological improvement through habitat shelter, improved bank stability with root structure formation as well as regulating the temperature of the river close to the shore, promoting the growth of additional vegetation. Each scenario is broken down into the techniques suggested, as well as the benefits and drawbacks of each solution.

Norwood Site 1A: Gabion Terraces with Brush Layering


Figure 6.4

Norwood Site 1B: Crib Wall Lookout with Vegetated Rip Rap Toe Protection


Figure 6.5

Norwood Site 1C: Brush Layering, Live Fascine, Coconut Fibre Roll Toe Protection


Figure 6.6

Benefits:

Gabions resists lateral earth pressures, improving overall bank stability

Vegetation slows water velocity along the lower bank and filters sediment from runoff

Brush layering vegetation cuttings add tensile strength and stability through developing root structures

Creates an opportunity for terraced spaces during flood events

Drawbacks:

Gabions on their own do not provide ecological or habitat improvement

Often criticized for being unnatural in appearance

Requires Cut/ Fill

Vegetation acts as a filter barrier and softens the structured look as they grow overtime

Riprap at the lower bank protects against shallow slides, reduces toe erosion and traps sediment from eroding

Crib wall reduces surface erosion and creates micro habitat improvement for small organisms

Requires a significant amount of cut and fill to the existing bank

The crib itself will degrade overtime, decreasing its effectiveness

Improved tensile strength from branches along the bank

Fascines deflect strong currents/ wave action and reduce toe erosion

Minimum site disturbance during construction

Coconut Rolls filter and trap sediments during low and high water

Coconut rolls will not withstand high velocity waters during flooding

No opportunity for direct public access

Norwood Site 1D: Sheet Piling Retention Wall, Coconut Fibre Roll, Gabion Groyne

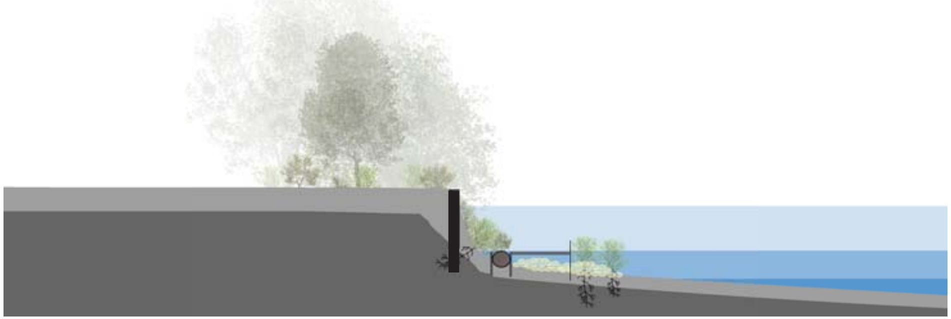


Figure 6.7

Norwood Site 2A: Switch Back Ramp System, Branch Packing, Joint Planting

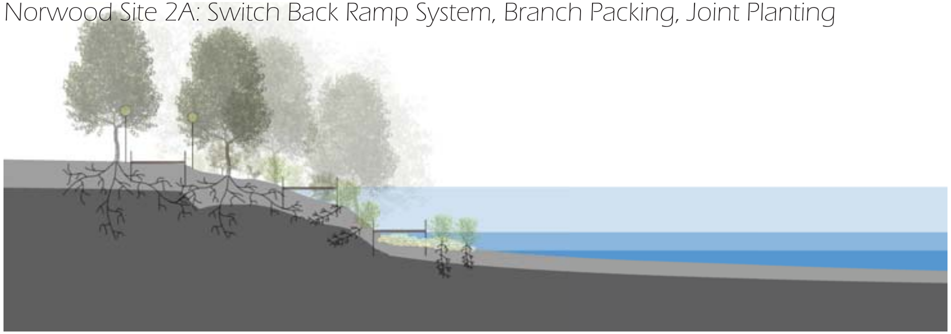


Figure 6.8

Norwood Site 2B: Vegetated Gabion Terraces, Coconut Fibre Roll

Figure 6.9

Benefits:

Sheet piling retains soil from upper bank

Coconut roll will allow for the re-vegetation of the lower bank

Gabion groyne will deflect waves from hitting the bank at a perpendicular angle, causing less erosion along the shoreline

Provides public access during low water seasons

Drawbacks:

Groynes can affect the overall current movement in the river, causing more destruction downstream and across the river.

Sheet piling creates a harsh edge along the bank, creating the need for further safety factors such as railings

Branches add tensile strength and filter barrier

Protects against shallow slides

Ramp system allows for universal access to the water line all year round

Creates a visual marker for flood levels

Blocked access during high water events

Does not enhance riparian habitat

Opportunity for re-vegetating the lower bank while protecting against toe erosion

Gabions provide immediate protection and can be made from existing rip rap

Sediment is trapped within wire mesh and coconut fibres, encouraging further vegetation establishment along the lower bank

Unnatural appearance until vegetation establishes

Coconut fibre roll will not withstand fast currents during flood seasons

Erosion Control & Flood Management Solutions

< Figure 6.10

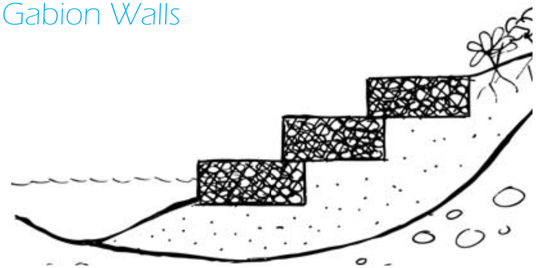
This map shows the selected erosion control and flood management solutions for the overall site design. Selections were made based on research regarding technique benefits, site needs and integration with design principles.

Diagrams on the right correspond to the numbers and letters located on the concept map.

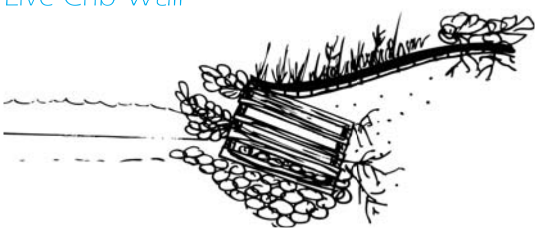
1 Coconut Fiber Roll:

2 Live Stakes:

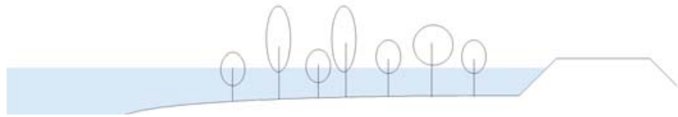
3 Gabion Walls



4 Live Crib Wall

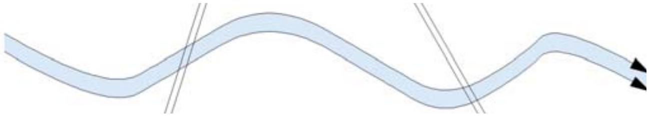


A Flood Plain Parks



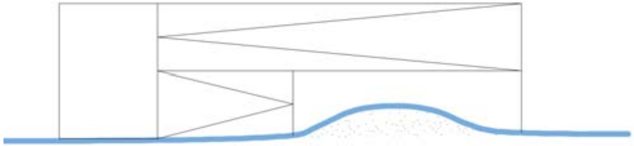
B Marinas

C Riverbed Sills: Parallel



D Balconies

E River access parallel to Bank



F Submergible Paths

A. Norwood Gathering Centre & Lookout

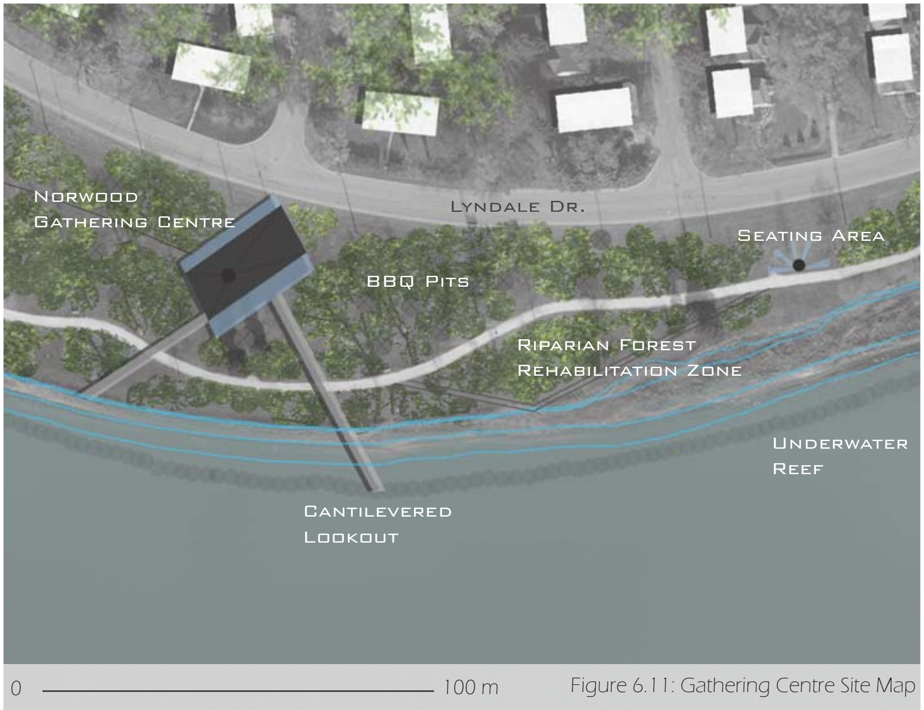


Figure 6.11: Gathering Centre Site Map

The Norwood Gathering Centre will be the new destination for the neighbourhood acting as a catalyst for further development of trails and fire pits throughout the forest. The form of the building creates a sense of permeability leading through the forest towards the river. Insulated glass panels skirt the outside, sliding open during the summer months to enlarge the picnic space. The centre leads users out into the forest, emerging to a wooden walkway reaching out over the riverbank.

From the marina across the river, the lookout creates a visual connection for water recreation activities such as boating or dragon boat festivities.

Figure 6.12: Riverview Marina overlooking Gathering Centre

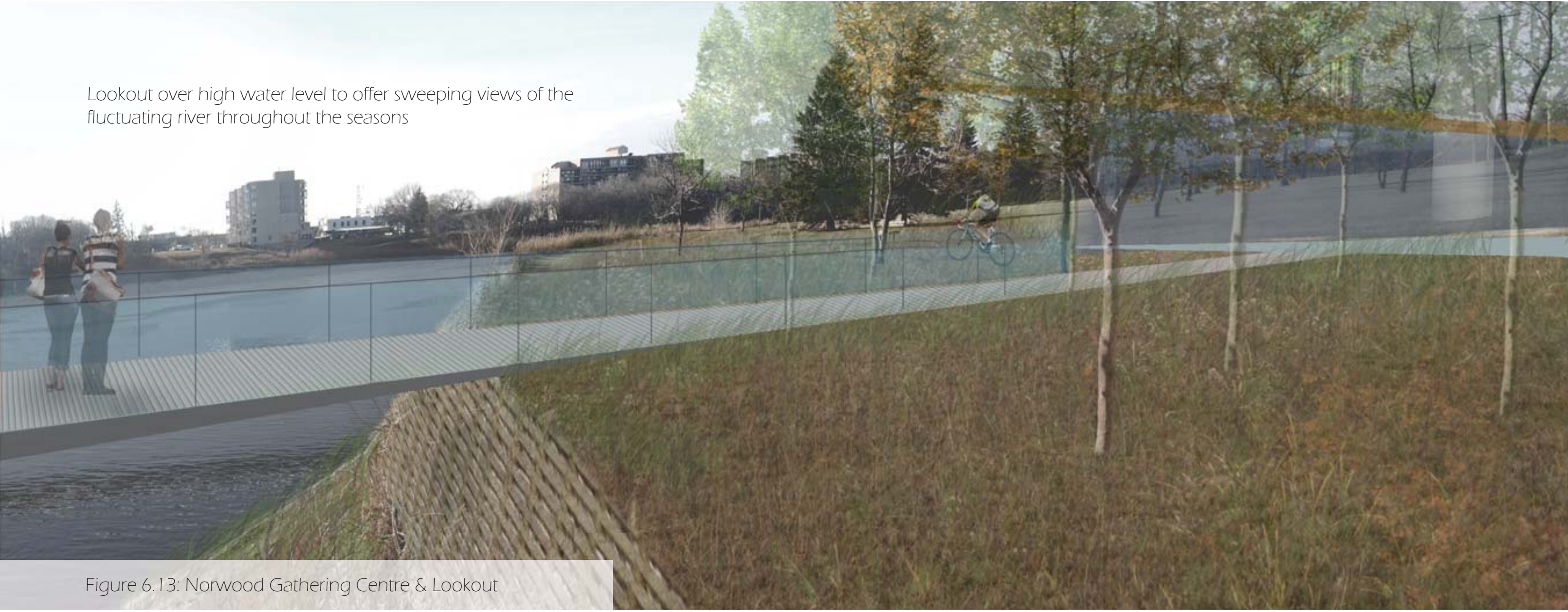


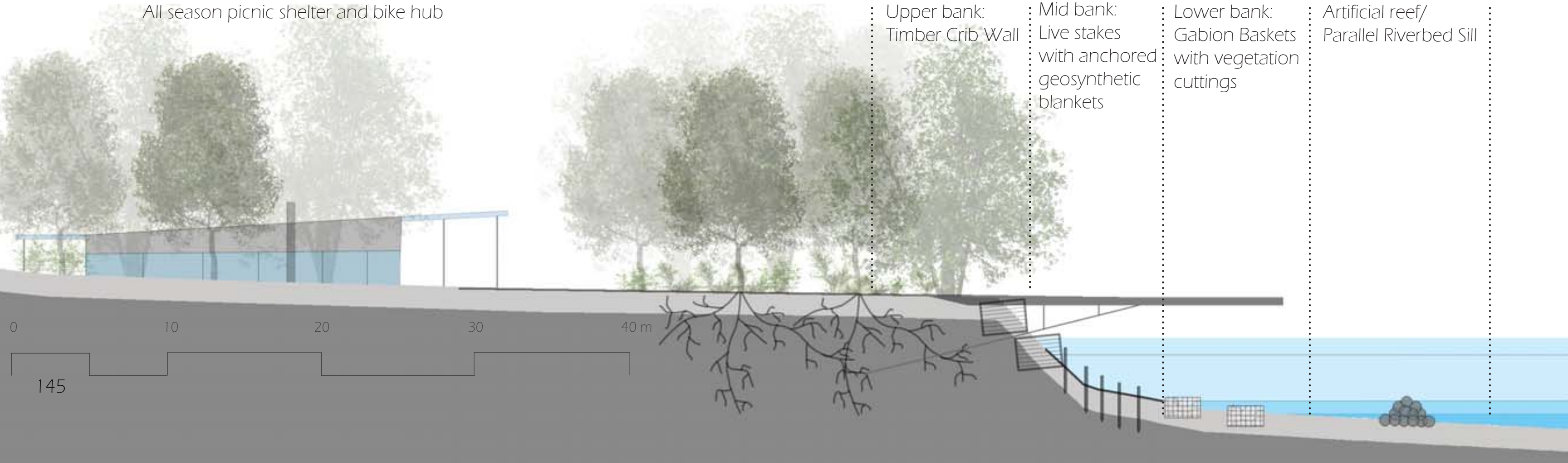
Figure 6.13: Norwood Gathering Centre & Lookout


Cottonwood


Hawthorn


Sandbar Willow

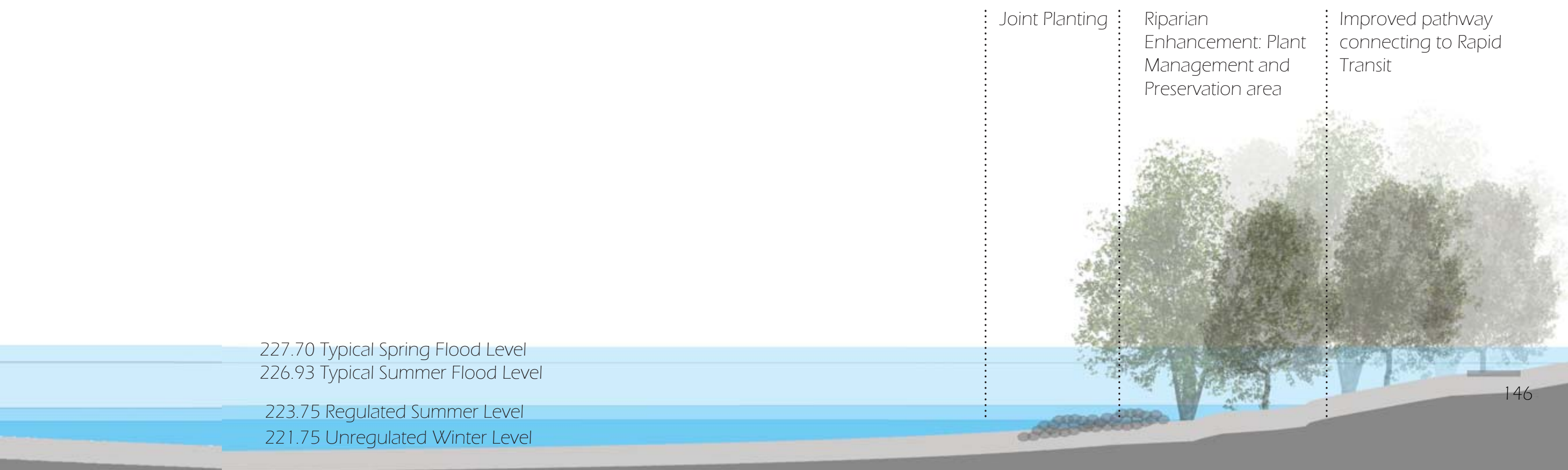

Cord Grass



The Norwood riverbank is divided into three zones for erosion protection. With the water levels fluctuating between 221.75 m in the winter to 227.70 during spring floods, the bank requires different solutions dependant on the level the water rests throughout the year. An artificial reef or parallel riverbed sill is constructed 15 m out from the shoreline to minimize wave action against the lower bank at Lyndale Drive. Gabion baskets along with sedges are installed at the lower bank along as toe protection to prevent significant scouring to the bank during flood seasons. Moving up the bank, Live peach leaf willow and red osier dogwood stakes are installed through an anchored geosynthetic blanket to prevent sediment removal from hydraulic drawback- where water current hits the bank, taking sediments with it as it retreats. The upper bank is reconstructed with treated timber crib walls, working together with Sandbar Willow, Eastern Cottonwood and Hawthorn to reduce surface erosion and create micro habitat improvement for small organisms. As the timber degrades overtime, the vegetation will establish with deep, fibrous root systems, working to protect the bank from scouring and high velocity flood waters.

Across the river along Churchill drive, the bank is currently experiencing slumping and a lack of lower bank vegetation due to summer floods preventing re-establishment. During the late spring before the summer flood takes place, the lower bank will be reconstructed using a joint planting technique. This involves piling a locally sourced stone such as limestone or granite along the shoreline with sedge and cord grass seed as well as willow cuttings staked through the open spaces. This technique provides a much needed protective barrier against toe erosion and prevents the bank from slumping into the river. The upper bank will be designated as a riparian enhancement and preservation zone requiring a monitoring period of 3 years to ensure vegetation survival. An assessment of initial forest health will be required, with further seeding and planting to increase biodiversity commencing following the assessment. Within the forest, an existing pathway will be improved with durable composite material to become a more significant route for the active transportation network within the city.

Figure 6.14



B. Riverview Marina

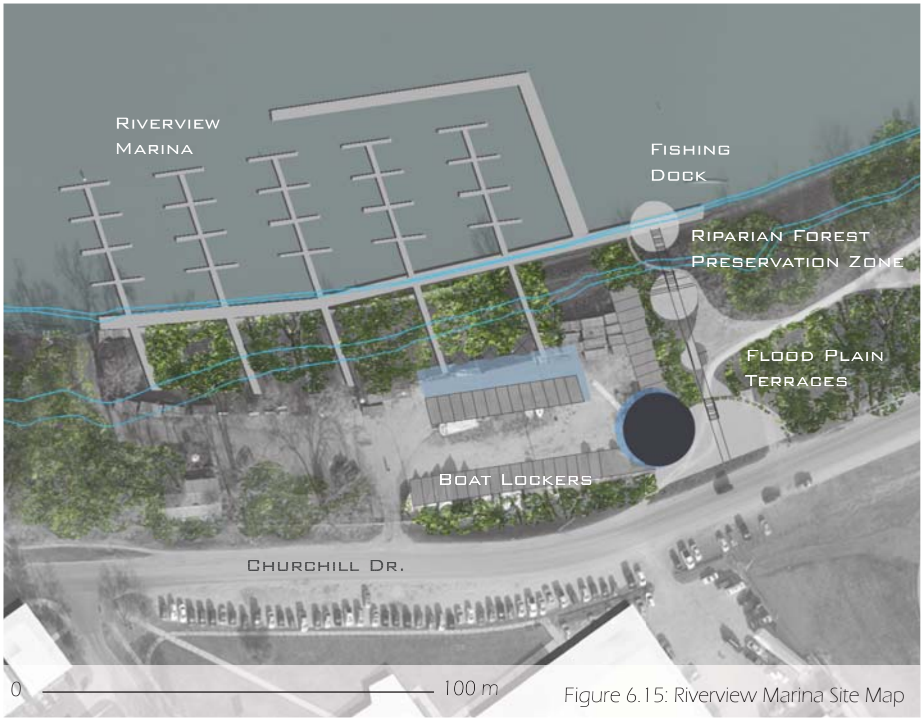


Figure 6.15: Riverview Marina Site Map

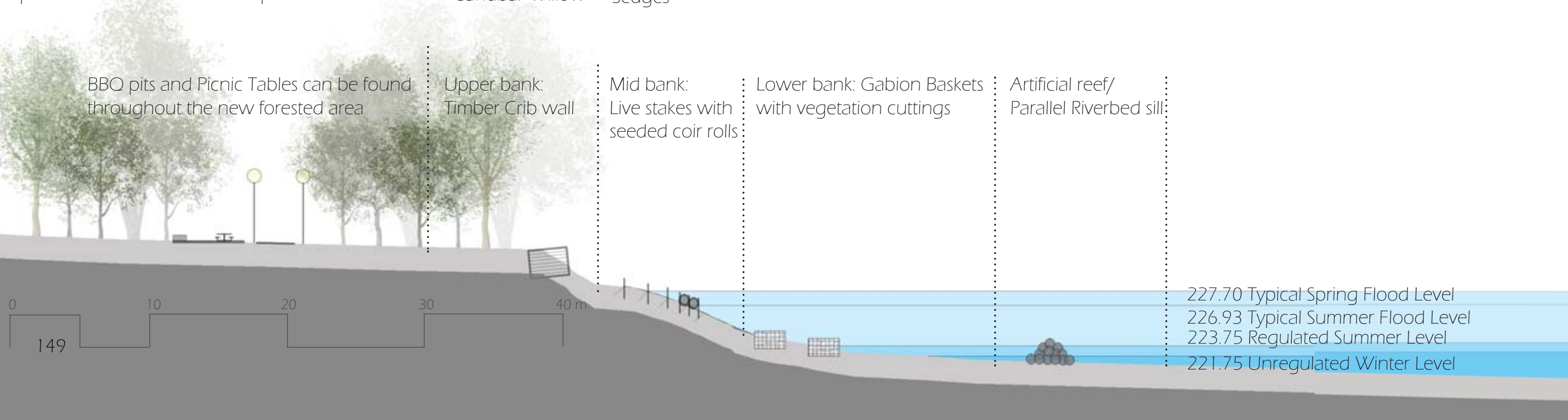
The Riverview Marina is located at the west end of Churchill Drive in the Riverview neighbourhood. The site has been upgraded from a deteriorating boating club into a vibrant marina space with room for 80 boats to be stored during the average summer water level season. An emergency access bulkhead crosses the debris flow line to prevent damage to the marina boats and to allow easy access for ambulance and police boats.

Entry into the site can be made through a public building featuring a cafe/ restaurant space with private access through the back of the building into the marina space.

Terracing steps create a formal entrance into the site, connecting the Marina and the Manitoba Canoe & Kayak club to the river. Three plazas are located along the terracing steps, offering spaces for visitors to stop and view the river during fluctuating flood seasons.

Figure 6.16: View to Marina From Lyndale Drive

Paper Birch | Manitoba Maple | Cottonwood | Sandbar Willow | Sedges

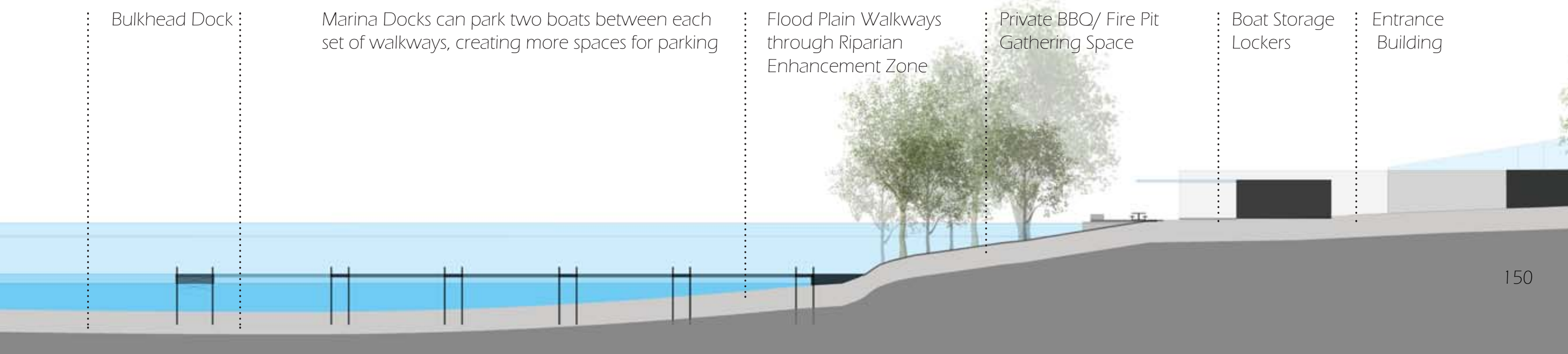


Towards the east along Lyndale Drive, the bank transitions from a steep profile to terrace-like steps. The reef continues down the lower shoreline to prevent wave damage from boats travelling in and out of the marina on the opposite bank. Gabions extend along the toe of the bank to prevent scouring and encourage vegetation such as Cord Grass to re-establish during low water seasons while remaining protected from uprooting and damage from the river flow. Seeded coconut fibre (coir) rolls are introduced along the mid bank with live sandbar willow cuttings staking them in place. The coir rolls are an effective technique for molding to the existing bank without significant disturbance to existing vegetation. Installation of the coir rolls need to take place after the spring flood retreats to ensure the establishment of vegetation.

The Marina along Churchill Drive will be re-constructed with a formal entrance for public inquiry and member access into the area. Drive-in boat lockers are installed on site to store the majority of boats and supplies all year round. A picnic/ fire pit area for marina members sits above the average spring flood level to ensure use throughout the year. The patio space is constructed as a balcony out over the high flood water level to allow vegetation to grow along the upper shoreline. Walkways made of durable wood composite material extend down to the shore within the riparian succession planting zones. Areas will be designated for sedge and shrub establishment closer to the normal summer water level and Manitoba Maple, Paper Birch and Eastern Cottonwood trees within the upper flood plain. The vegetation chosen on site are based on root type, habitat value and flood tolerance as outlined in Chapter 2: Figure 2.39.

Marina docks extend out perpendicular from the shore with temporary walkways floating at the average summer level. The docks fluctuate along removable steel tubes that reach down into the clay riverbed, creating a stable walking surface out on the water. A durable bulkhead dock made from heavy timber with steel plates crosses the thalweg, to prevent debris from hitting the boats in the marina after flood waters retreat. The bulkhead doubles as an emergency access point for ambulance and police traffic for ease of access from the river out towards Osborne Street and into downtown.

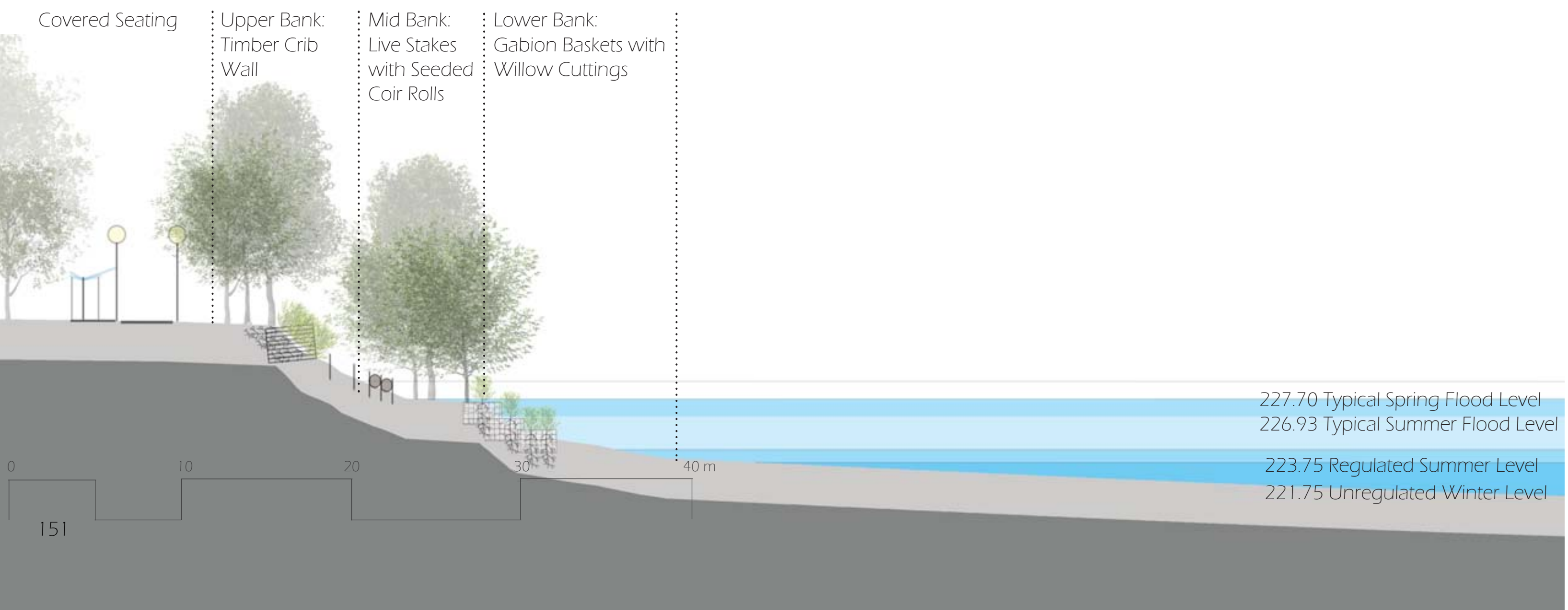
Figure 6.17



Along the main pathway on the Norwood site, a covered seating area is set back from the shoreline looking towards the Riverview fishing dock. The roof of the seating area points users in the direction of interesting features found on the site such as the Canoe and Dragon Boat docks directly across the river, the Riverview Marina as well as the Norwood Gathering centre and lookout. Simple lighting fixtures will run along the main active transportation route, encouraging use of the space all year round. Erosion control techniques are continued down the bank, using a timber crib wall along the upper bank, live stakes with sedge seeded coir rolls along the mid bank and gabion baskets along the toe.

Directly across the river, the Riverview fishing dock is built out over gabion baskets at the foot of the terraces. The dock connects to the main boardwalk into the marina, separated by a retracting gateway into the private sector. Sedges are planted along the toe of the bank, creating a woven root system, holding the weak clay banks in place during high water seasons. Sedges are resilient in nature, allowing opportunity for re-growth after the flooding season. Moving up the bank, trees line the main pathway guiding visitors up from the shoreline towards the entrance, distinguishing between public recreation spaces and private access into the marina. At the top of the terraces, an info/ cafe space is open to the public, providing a space for marina and canoe club inquiry. The building is offset from the main path to allow for direct views to the river while creating a formal entrance into the water recreation spaces.

Figure 6.18




Paper Birch


Manitoba Maple


Cottonwood


Sandbar Willow


Sedges


Figure 6.19

Figure 6.20

C. Canoe & Kayak Club Connections

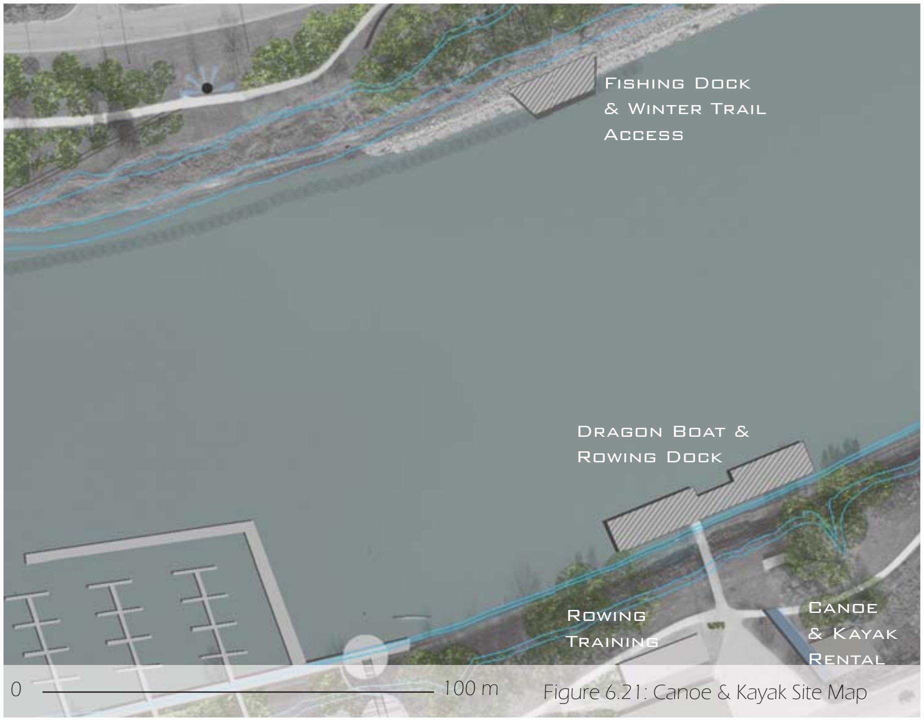


Figure 6.21: Canoe & Kayak Site Map

The entrance to the Manitoba Canoe and Kayak centre is re-configured to open up towards Churchill Drive, encouraging public access to and from the site. A canoe & kayak rental building is situated opposite the existing storage facility to promote water recreation for Churchill High school programs as well as the larger neighbourhood. A rowing machine training plaza is located just north of the storage facility for use by rowers during the off season and summer camps.

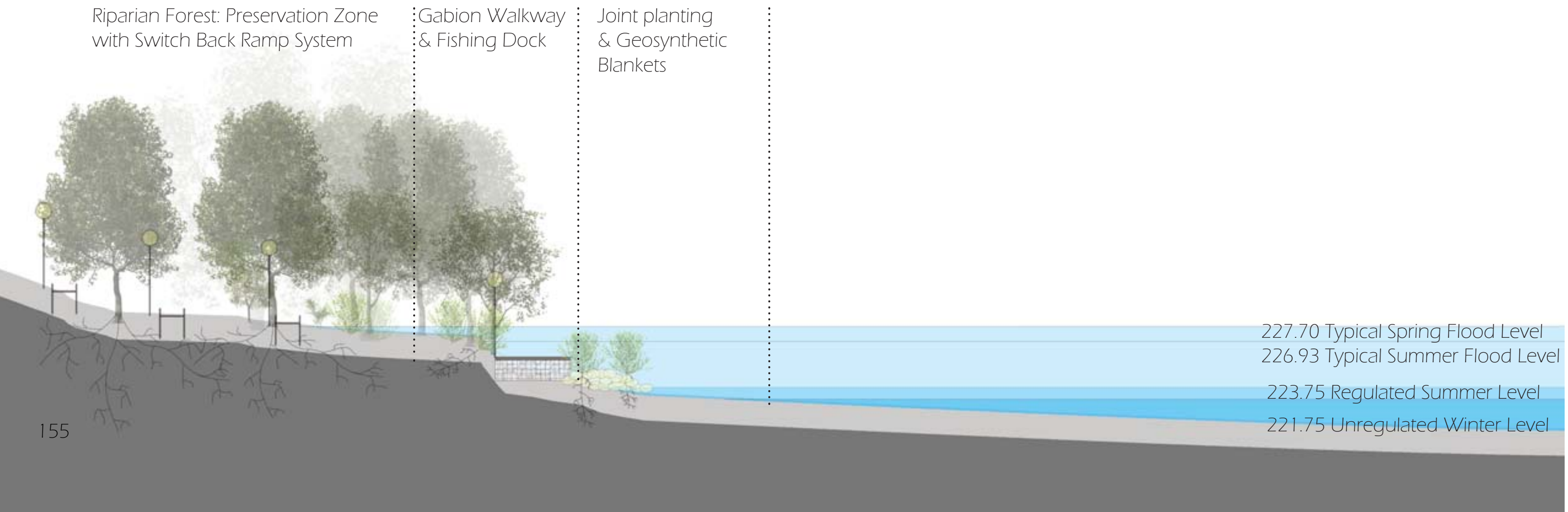
A new dock is located at the edge of the water to allow for dragon boats to be parked during the summer months. The dock is designed with a technique training space for rowing or dragon boat clubs to gather and teach.

Figure 6.22: View to Marina from Canoe Dock

At the eastern end of the Norwood site, the riparian forest is designated as a preservation zone, only allowing access through a carefully placed switch back ramp system. The ramp will guide users into the flood plain towards another recreational fishing dock. During the winter months, this ramp can be used as an access point for the extended river trail welcoming the opportunity for additional warming huts. A gabion walkway will be built out along the lower bank, providing access to the waterline, and allowing vegetation to establish through the wire baskets. Joint planting along with geosynthetic blankets will be used along the toe of the bank to prevent bank scour and hydraulic drawback from wave action.

An improved floating dragon boat and kayak space is designated at the summer water level, held in place by steel tubes allowing for increased dock stability. Sedge seeded coir rolls, live sandbar willow, peachleaf willow and red osier dogwood stakes and geosynthetic blankets will be used to improve lower bank vegetation. By re-vegetating the lower bank, the effects of erosion and deposition will be minimized, improving the overall health of the riverbank and riparian forest.

Figure 6.23




Paper Birch


Manitoba Maple


Cottonwood


Sandbar Willow


Sedges

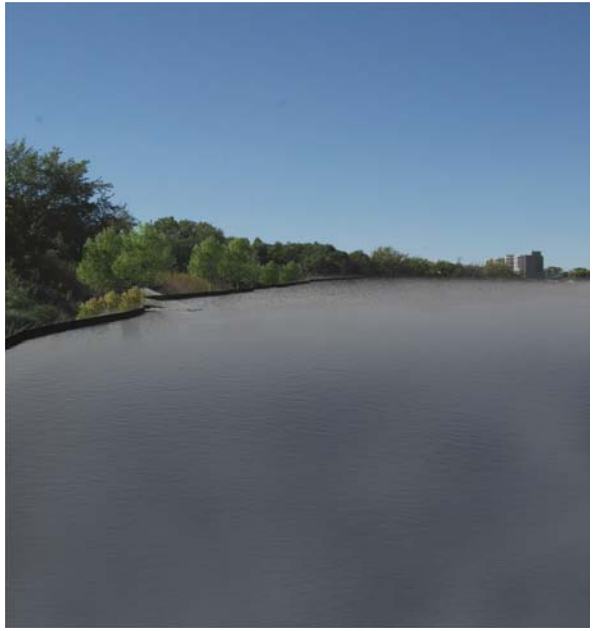
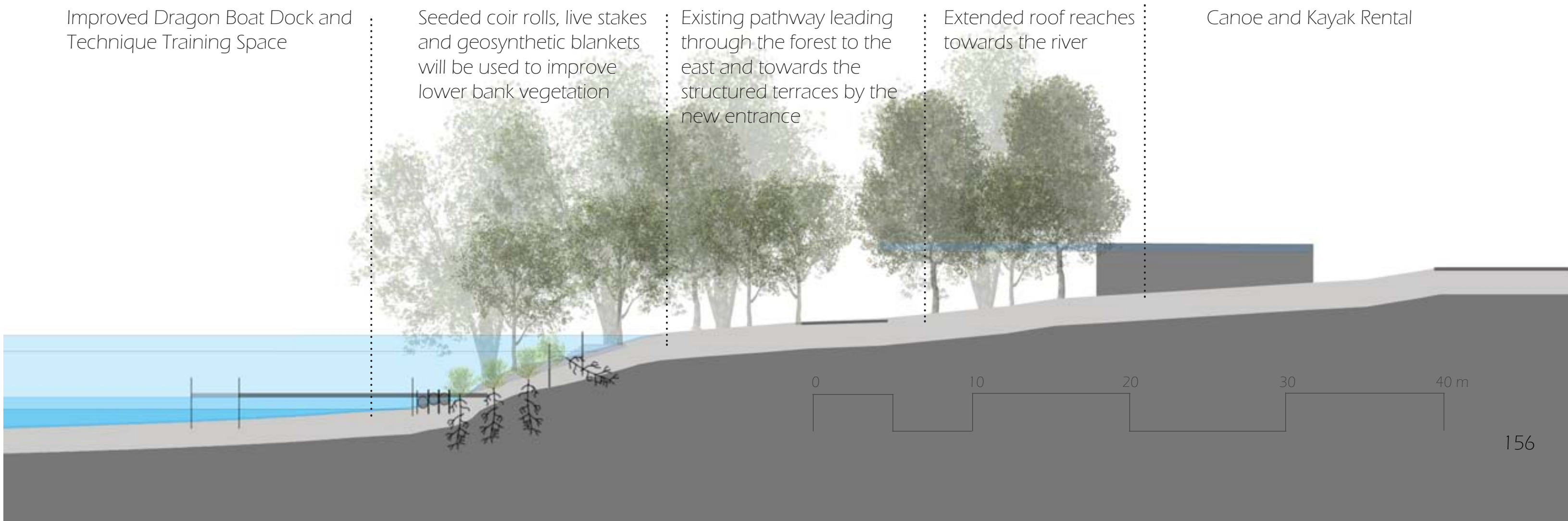


Figure 6.24

Figure 6.25




C. BMX Entrance Grounds
B. Adventure Park: Climbing Towers
A. Fort Gibraltar Promenade lookout
N
0
100 m

North Saint Boniface Case Study

The transformation of North Saint Boniface from a quiet, industrial neighbourhood into a destination for adventure seekers is proposed as a result of site exploration and examination after initial analysis. In addition to the current climbing tower, Fort Gibraltar and Festival Du Voyaguer opportunities, the site has been adopted for use by the Winnipeg mountain biking and BMX community. This continual use of the forest for jumps and tricks, severely compacts the weak clay soil further degrading the health of the riparian zone and decreases the opportunity for lower bank re-vegetation and stability. The proposed design takes into consideration the extreme sports community as well as ecological sensitivity to re-structuring the riverbank and preserving the riparian forest.

Using the idea of an adventure park, the site is transformed into zones of activity for Climbing, Mountain Biking and Water Recreation as well as pockets for rest and relaxation. Tache Avenue leads people into the site from Provencher Boulevard. At the terminating end a new 20 meter tall lookout tower is situated as a focal point for the site. The lookout tower doubles as a rock climbing wall during the summer months and an ice tower in the winter. The tower serves as the main feature of the climbing zone, with additional towers situated around it to promote further use by the climbing community and encourage the public to engage in physical activity. Along Rue Messager, a formal promenade lined with Manitoba Maple trees is constructed, connecting the historical Fort Gibraltar across the site to the waterfront. This connection is made to link the Fort and Festival grounds to the river and the extend Forks Riverwalk as well as a visual link to Alexander Docks in the Exchange District. The end of the promenade features a plaza at the upper bank with a curved ramp system down to the lower dock plaza. Creating two spaces for viewing the river at this location was important for encouraging visitor interaction with the river during fluctuating water levels. It plays off the idea of how the site was formed by the river to have a steep gradient that kept the majority of the users at a distance to the water. By creating a system to bring people down to the waterline, a new opportunity is developed for further interaction and use of the waterfront. The lower plaza connects to a canoe dock and fishing dock towards the east end of the site through a durable riverside walkway that becomes submerged during the flood seasons. This walkway system offers visitors direct access to the river during summer months, encouraging viewing of canoeing, boating and the River Rouge Cruise Line that sits across the way at Alexander Docks.

Along the Fort Gibraltar Promenade a designated entrance to the site is situated directly in the middle. This entrance designates the 3 zones for climbing, mountain biking and water recreation, featuring a set of three buildings that hold supplies for each activity. The west side of the entrance features the climbing zone, previously described. To the north-west, a pathway leading to a terraced canoe dock guides users down to the water's edge. Finally to the east, BMX grounds are designated by dirt piles with a narrow path cutting through the site. The dirt piles can be altered by the users of the space using designated equipment stored by a club on site. Jumps and hills can be molded for thrill seekers as a means to alleviate some of the stress currently put on the floodplain in the forest. During the winter months, the site can be transformed into snow piles for tobogganing or snowboarding as well as additional parking space as needed for Festival du Voyageur.

The goal of the design is to create a sense of community gathering and a means to promote outdoor recreation alongside waterfront development. The following section will look at the design in closer detail to examine how it addresses erosion and flood control as well as design principles in regards to the relationship between the river and neighbourhood.

< Figure 6.26: Saint Boniface Site Map

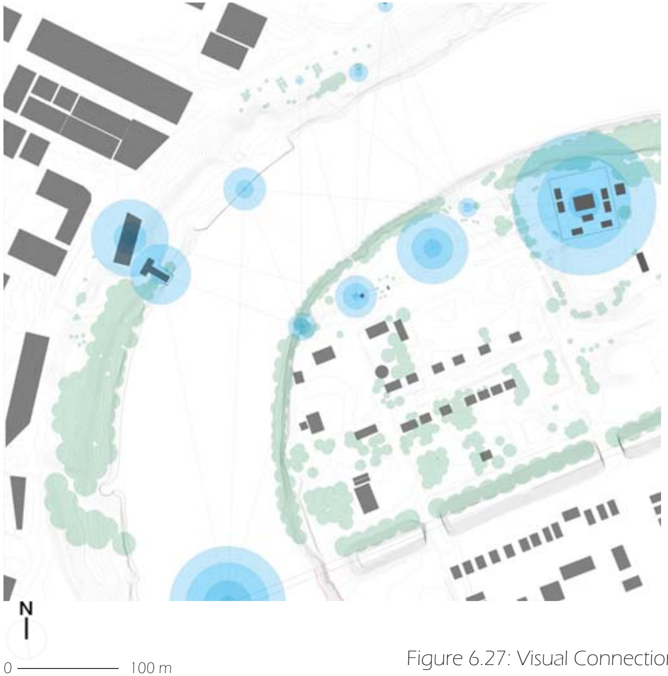


Figure 6.27: Visual Connections

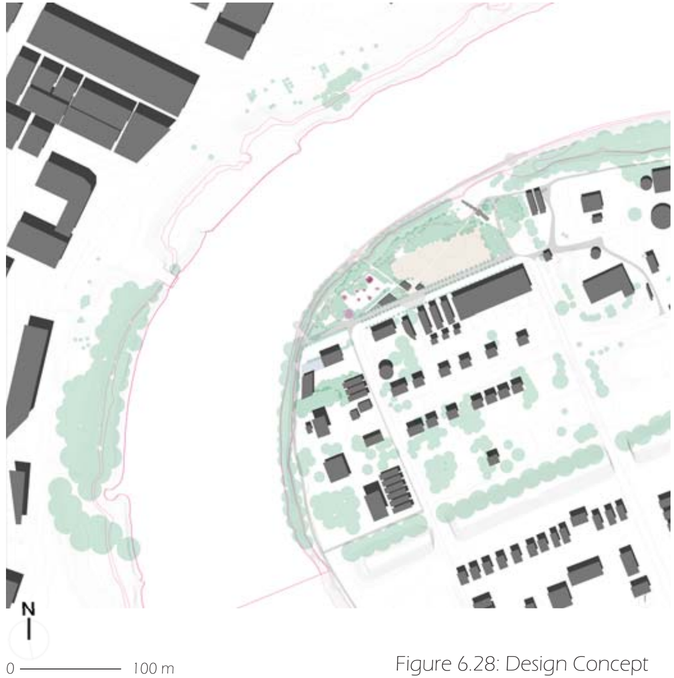


Figure 6.28: Design Concept

The layout of design elements proposed in North Saint Boniface were chosen as a result of a network of nodes and lines depicting views across the river towards Alexander Docks and Waterfront Drive.

Thalweg Movement

Figure 6.29: Thalweg Movement

Developing Erosion Control Solutions

The riverbanks along North Saint Boniface are severely degraded with steep edges and little vegetation along the lower shoreline. The techniques used in this case study offer more opportunity for hard erosion control techniques to be used in conjunction with the ecological solutions as the area is historically industrial allowing the techniques to compliment the character of the neighbourhood rather than remain a purely natural looking riverbank.

The following diagrams show a series of iterations, working through different possibilities for erosion control techniques along the west and east end of the North Saint Boniface waterfront. Each iteration uses biotechnical strategies for protecting the riverbank. In every option, vegetation is established at the lower and upper banks to offer ecological improvement to the riparian forest, improved bank stability with root structure formation as well as opportunity for the re-growth of vegetation at the lower bank. Each scenario is broken down into the techniques suggested, as well as the benefits and drawbacks of each solution.

Tache Site 1A: Sheet Piling Retention Wall, Elevated boardwalk, Live Fascines

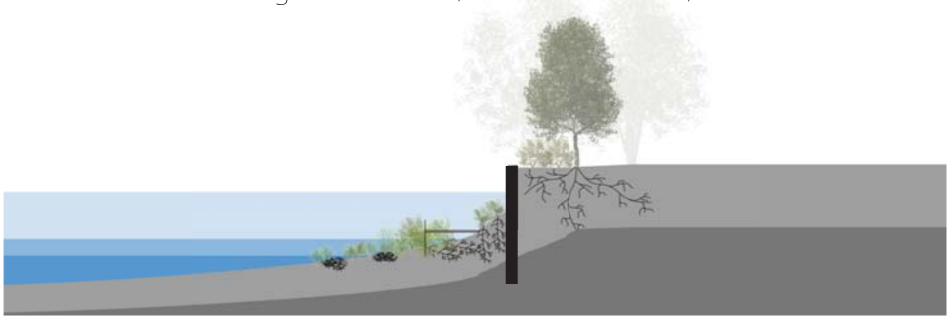


Figure 6.30

Tache Site 1B: Crib Wall, Boardwalk, Brush Layering, Live Stakes

Figure 6.31

Tache Site 1C: Terraced Crib Walls with Elevated Boardwalk

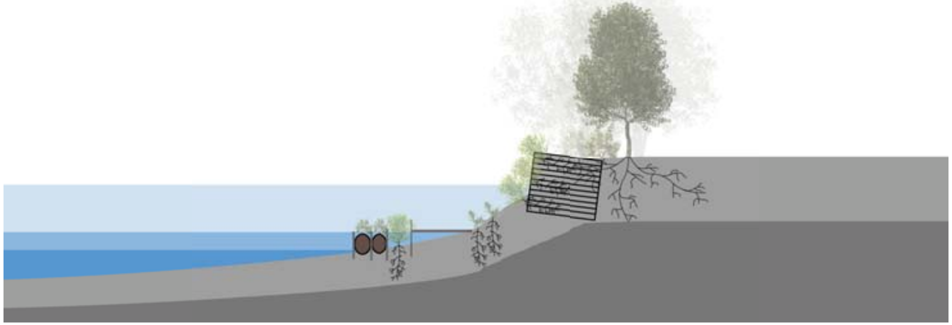
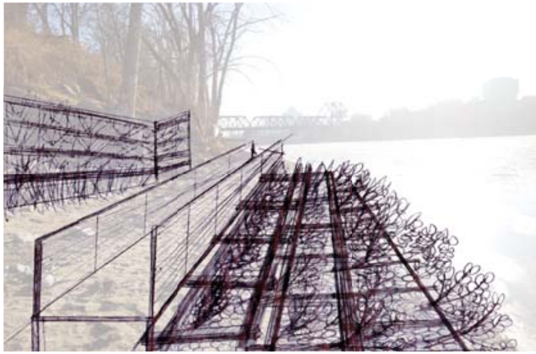


Figure 6.32



Benefits:

Sheet Piling prevents further erosion of the steep banks, protecting further damage to exposed roots and offering opportunity for vegetation health renewal

Sheet piling adds to the industrial character of the site

Live fascines, facilitate lower bank re-vegetation, toe protection, natural bank appearance, deflects strong currents

Creates a connection to the Forks river walk and visual connection across to Alexander Docks

Drawbacks:

Vegetation beneath walkway may not fully establish due to lack of direct sunlight

Direct access only during low water seasons

Provides a natural lower bank once vegetation establishes through seeded coir roll

Coir roll and stakes trap sediment along the shoreline, encouraging further plant establishment

Crib wall provides immediate protection while vegetation establishes overtime for further stabilization

Crib wall prevents further surface erosion, traps runoff sediment, and will reduce water velocity hitting the bank during high water events

Coir rolls are weak in preventing erosion during high water events as well as against wave action

No direct access to water

Provide immediate protection to the bank

Added tensile strength and bank stability from vegetation

Layered cribs, increase the structural integrity of the bank and filter sediment

Effective in reducing toe erosion and protecting against shallow slides

Effective in a limited space along the bank

Highly structured in appearance initially, softening overtime as the vegetation establishes

Requires cut and fill to the bank, increasing the possibility for degradation during construction of lower bank

Tache Site 2A; Crib wall, Brush Layering, Live Fascines

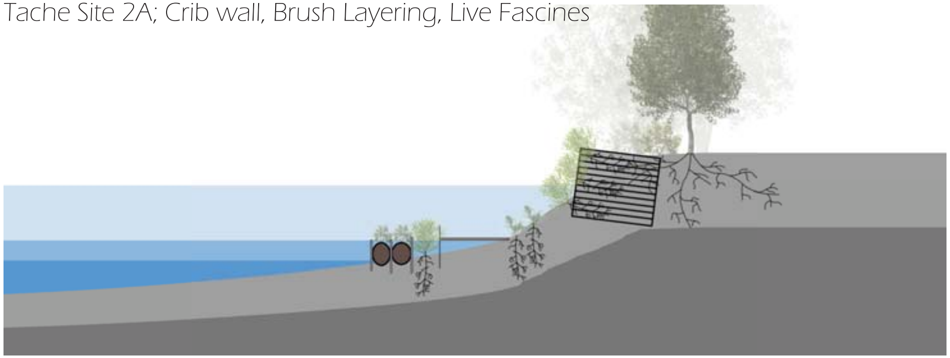


Figure 6.33

Tache Site 2B: Riverbank steps, Brush Layering, Branch Packing

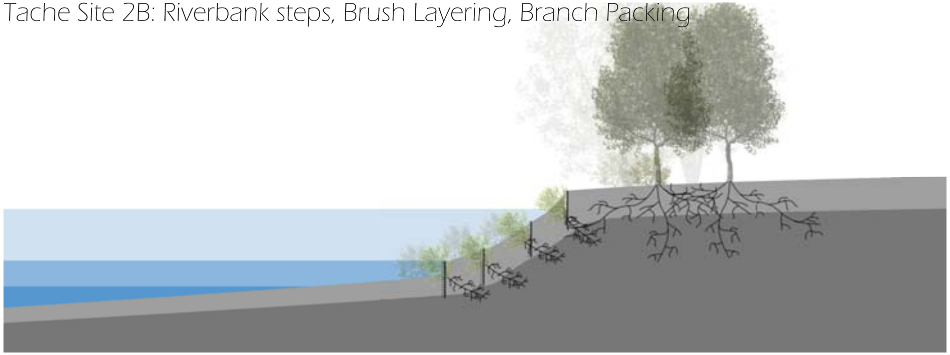


Figure 6.34

Tache Site 2C; Willow Spiling with backfill, Brush Layering

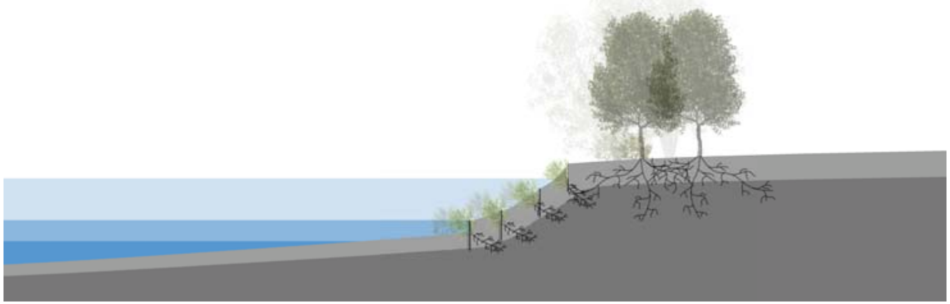


Figure 6.35

Benefits:

Fascines provide toe protection and reduce velocity of current hitting the bank

Crib wall immediately protects the upper bank while the vegetation grows overtime to create an added stability for the bank

Allows existing vegetation at the top of the bank the potential for renewal as the exposed roots are covered with fill and protected from further erosion and ice damage

The lower bank will maintain a natural bank appearance and increase the biodiversity

Drawbacks:

Will require maintenance over the first 3-5 years to ensure plant establishment

Requires cut and fill to the bank, increasing the possibility for degradation during construction of lower bank

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Benefits:

Riverbank steps provide easy perpendicular access to the water line

The elevated walkway allows for lower bank re-vegetation

Branches add tensile strength to the bank

Roots protect against shallow slides beneath the steps

Vegetation traps sediment beneath steps, creating an added stability and opportunity for vegetation growth

Drawbacks:

Vegetation beneath walkway may not fully establish due to lack of direct sunlight

Requires significant restructuring of the bank

Benefits:

Spiling provides immediate protection due to tensile strength and quick establishment of vegetation

If multiple species of branch cuttings are used for the brush layering, the bank will maintain a fairly natural appearance once the willows have established from the fences

Minimum site disturbance will occur during implementation

Provides protection against toe erosion and shallow bank sliding

Drawbacks:

Roots have the potential to compete with exiting root structures along the upper bank

No public access to shoreline

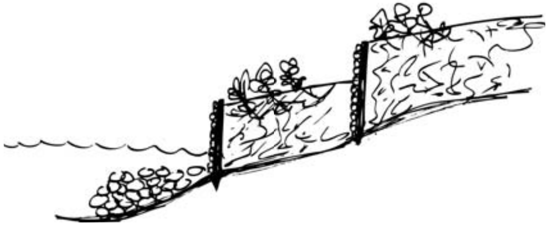
Erosion Control and Flood Management Solutions

< Figure 6.36

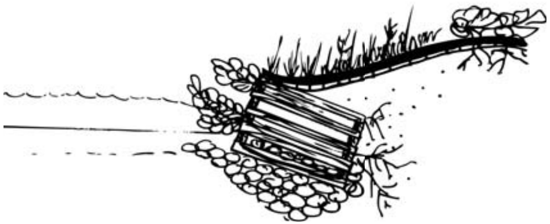
This map shows the selected erosion control and flood management solutions for the overall site design. Selections were made based on research regarding technique benefits, site needs and integration with design principles.

Diagrams on the right correspond to the numbers and letters located on the concept map.

1 Willow Spiling

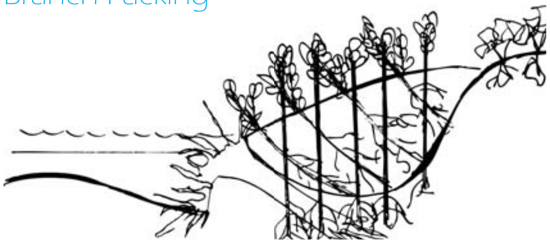


2 Live Crib Wall

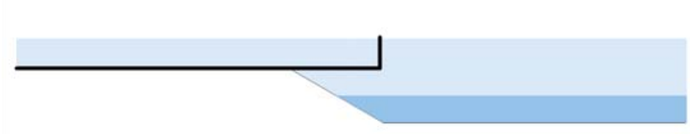


3 Coconut Fiber Roll:

4 Branch Packing

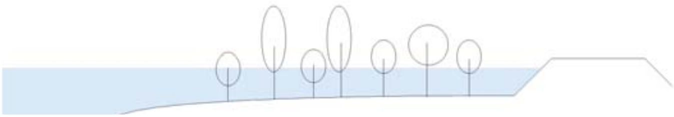


A Building over Reinforcement



B Submergible Paths

C Flood Plain Parks



D Marinas/ Floatable Structures

A. Fort Gibraltar Promenade Lookout

< Figure 6.37: Promenade Site Map

At the junction of Tache Avenue and Rue Messager, Fort Gibraltar Promenade connects across the site to an upper and lower bank plaza space overlooking Alexander Docks. The upper plaza balcony extends out over the steep bank reinforced with corten steel sheet piling, adding to the industrial character of the neighbourhood. The lower plaza is a submergible surface made of wood composite decking encouraging direct access to the shoreline during low to normal water levels.

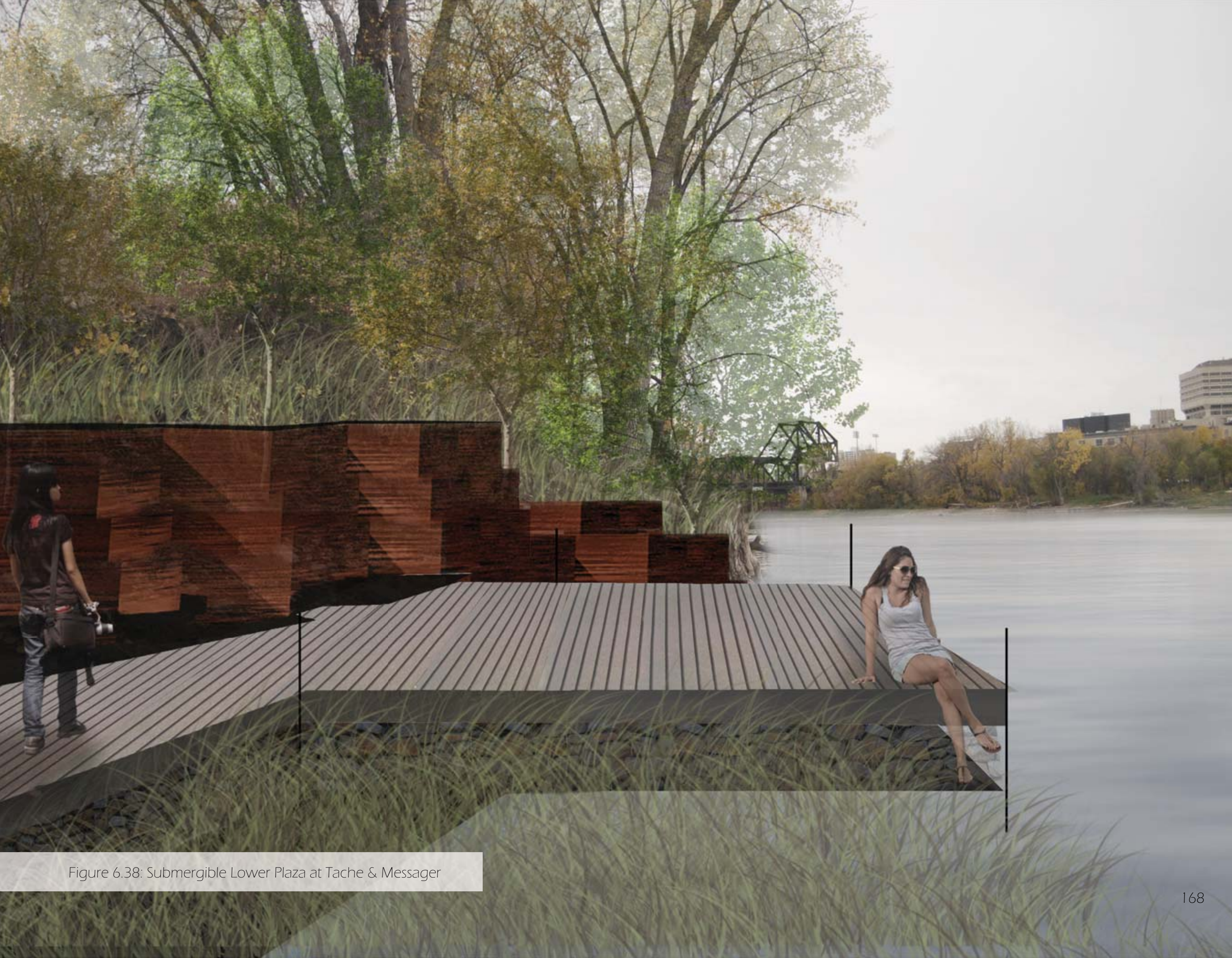
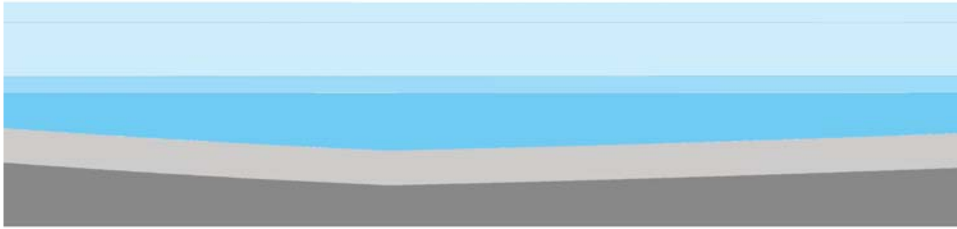


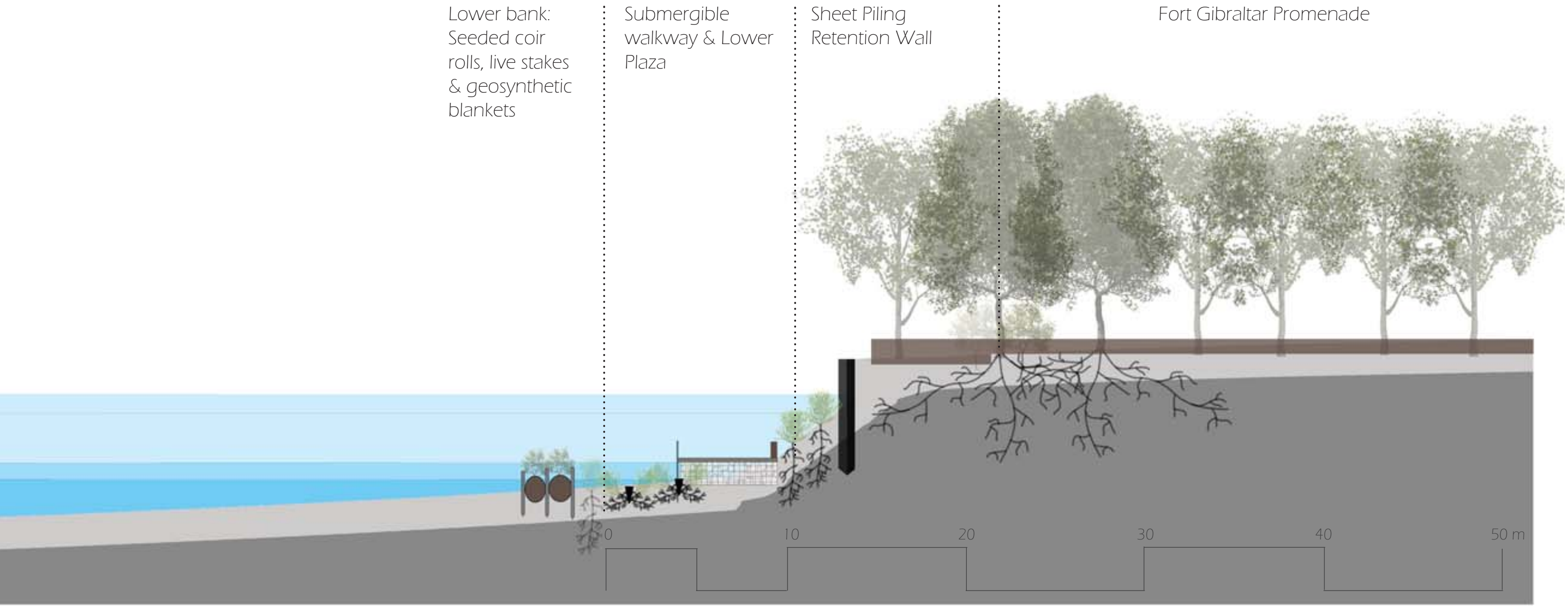
Figure 6.38: Submergible Lower Plaza at Tache & Messager

The Fort Gibraltar promenade lined with Maple Trees leads down Rue Messager towards the waterfront terminating in a high ground lookout plaza. The maple trees offer a bright, vibrant hue to the landscape, changing into shades of red, yellow and orange during the fall season. During high water events the lower plaza is submerged while the upper bank remains accessible. Corten Steel sheet piling will be installed adjacent to the already steep banks, providing a much needed protective barrier, extending the industrial character from the neighbourhood out onto the waterfront. Along the mid-bank, a submergible walkway is constructed on top of gabion baskets with a durable wood composite material below the spring flooding and ice off levels to ensure the longevity of the structure. The lower bank is constructed with seeded coir rolls for cord grass and sedge establishment, live sandbar willow and red osier dogwood stakes for deep, fibrous roots and flood tolerance as well as geosynthetic blankets as means of reducing sediment removal from the bank and slowing down the rivers current velocity and encouraging the re-growth of the lower shore vegetation.

Figure 6.39 >



American Elm Sandbar Willow Red-Osier Dogwood Cord Grass Sedges



B. Adventure Park: Climbing Towers

< Figure 6.39: Adventure Park Site Map

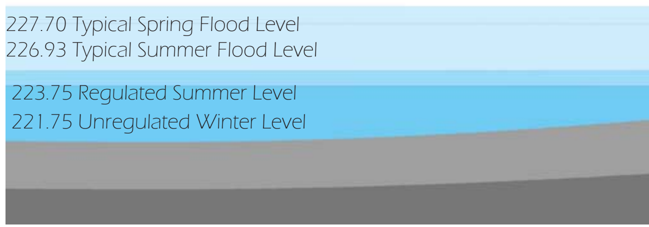
The new adventure park is developed as an extension to the existing climbing tower, promoting extreme sports within Winnipeg. From across the river, the climbing zone can be seen as a focal point for the North Saint Boniface neighbourhood. A storage facility for safety equipment is located along Rue Messager at the entrance to the adventure park. Beside the climbing park, a pathway extends from the entrance down towards a canoe dock, encouraging further water recreation.

Figure 6.40: View to Adventure Park from Alexander Docks

A climbing park is created as an extension to the current climbing tower. Additional structures create more opportunity for outdoor involvement of rock climbing while offering viewing across the river towards Alexander Docks and Waterfont Drive. The tower at the terminating end of Tache Avenue will feature a lookout tower for the general public, creating a focal point for the neighbourhood, visible down Tache Ave and across the river. Live fascines from peach leaf willows and treated timber crib walls are used along the upper bank to stabilize the degrading surface and add a softened texture to the structured bank overtime. Fort Gibraltar promenade frames the space, lining Rue Messager with maple trees, guiding users from the main entrance down a pathway connecting to a floating canoe dock. The dock extends out over the bank as a submergible path connecting to the lower plaza near Tache Ave and Rue Messager. At the lower shoreline, branch packing techniques will be used during the early spring and fall over a series of 3 years to ensure the development of the Sandbar Willow and Cord Grass overtime.

Figure 6.41: View to Adventure Park from Alexander Docks Flooded

Figure 6.42




American Elm
Manitoba Maple
Sandbar Willow
Sedges
Cord Grass


Lower Bank: Branch Packing
Floating Canoe Dock With Aluminum Supports
Treated Timber Crib Walls & Live Fascines
Adventure Park: Climbing Zone
Equipment Storage Facility
Fort Gibraltar Promenade
0
10
20
30
40
50 m

C. BMX Entrance Grounds

< Figure 6.43: BMX Entrance Site Map

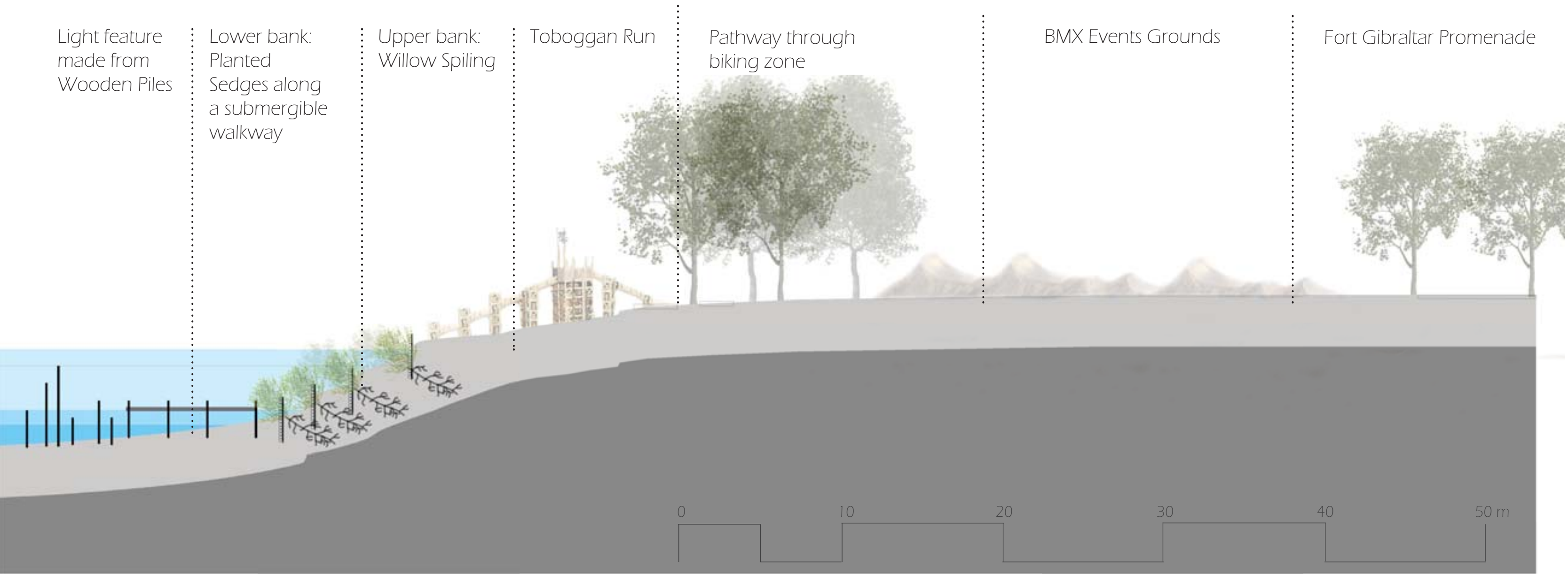
The BMX and mountain biking community have emerged in the North Saint Boniface area over the past several years. To the east of the adventure park entrance, a BMX zone has been designated as an area for dirt piles to be used for jumps and tricks. An equipment locker and bike storage facility is located at the main entrance for patrons to take part in the activities.

Figure 6.44: View from Toboggan Run onto BMX Grounds

Dirt piles and equipment will be stored at the park entrance allowing adventure seekers the opportunity to mold and create their ideal BMX grounds. By creating a designated space for mountain biking and tricks, the pressure put on the riparian forest from current activities will be diminished. A public pathway crosses through the BMX grounds leading towards the extended forest and existing toboggan run. Willow spiling techniques will be implemented along the upper bank near the toboggan run for additional reinforcement and enhanced biodiversity. A submergible walkway with aluminum supports is featured at the edge of the water, connecting to the canoe dock and the promenade lookout at the west end of the site. Sedges will be planted along the lower shoreline during low water seasons to encourage the re-growth and biodiversity of the banks existing habitat. Out on the water, a wooden pile light feature will be situated offshore from the toboggan run, adding to the historical nature of the site while creating a water level marker for yearly flood events.

Figure 6.45 >

American Elm | Manitoba Maple | Sandbar Willow | Sandbar Willow | Sedges



Conclusion

The design and protection of Winnipeg's riverfront requires a combination of strategies that work together as a balanced system. Through the development of three riverfront case studies, the driving mechanisms in riverfront design are brought together to ensure the potential for successful and ecologically sensitive designs along our urban water bodies. The integration of ecological erosion control practices, flood management solutions and riverfront design principles have formed a new vocabulary that is essential for the future riverfront development in Winnipeg as well as similar river cities. The strategies brought forward challenge current practices and the role landscape architecture can play in the structural development and well being of our river systems. The field of ecological erosion control, while not new, is still emerging, opening up opportunities for site specific experimentation at varying scales of development. The dynamic nature of the river means that no two sites are identical. The problems of erosion and flooding can be addressed through the development of the integrated vocabulary, but must take into account the individual make up of each site. The ecological and urban characteristics must be taken into account to ensure the success of potential riverfront design. I have learned there is no one solution to riverbank protection and design, but a collaboration of many. The work put forward in this practicum has the potential to change the way we think about riverbank erosion and the possibilities it brings to future landscape design. It is my hope and intention that the research in this project continues to be pushed beyond the practicum boundaries and become a body of knowledge shared with the City of Winnipeg as a future resource for riverfront development.

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