EMBRACE THE FLOOD

Introducing a Symbiotic Lifestyle:
Designing Resilient and Livable Landscapes in Winnipeg by Integrating Nature-Based Solutions into the Urban Water System

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Colophon

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Master Thesis 2022-2023

Territorial Land Acknowledgement

The City of Winnipeg and therefor the area I am creating a design proposal for, are located on original lands of Anishinaabeg, Cree Oji-Cree, Dakota and Dene peoples and are the homelands of the Métis Nation. I respect the Treaties that were made on these territories, I acknowledge the harms and mistakes of the past and dedicate myself to move forward in partnership with Indigenous communities in a spirit of reconciliation and collaboration.

Acknowledgements

This thesis report is the outcome of my Graduation Project in Urban Ecology Lab, and a reflection of this Master program in the track of Landscape Architecture at the Faculty of Architecture and the Built Environment at Delft University of Technology.

I would like to express my sincere gratitude to my first mentor, Nico Tillie, for his constant encouragement, support, and mentorship throughout the entire thesis. Your expertise in the field have been beneficial in shaping the direction and methodology of my research. And your belief in my abilities and words of motivation have given me a constant source of strength.

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Abstract

The city Winnipeg, built on the wet prairie, has been threatened by severe flooding for decades. The initial decision to build the city at the confluence of the Red and Assiniboine rivers led to the inevitable consequence of recurrent natural flooding. The floods prompted the provincial government to take a series of flood control structural measures to prevent the city property. However, the waterlogging crisis has still not subsided.

During the significant territorial transformations in the last two centuries, the rivers and creeks have been heavily dammed and channelized. The hasty attempt at city development resulted in immediate economic benefits, but at the expense of eliminating the land's ability to drain water through naturally occurring streams and coulees. Due to environmental impacts on a wider geographical scale, most notably climate change, both floods and droughts are hitting the extremes, which is escalating the challenge on flood management.

One of the main obstacles in this project is to solve the problem of threatening floodwaters and turn the negative impacts into the opportunities for a more sustainable lifestyle. Tracing back to last century, the indigenous peoples of the plains used to share a mutually beneficial living pattern with beavers and other species on the prairies. This coexistence approach towards humans, wildlife and nature deserves an opportunity to be brought back to Winnipeg. Through flood-mitigation measures based on natural processes, the urban hydrologic system is anticipated to move toward sustainable development and provide fairness and reliability to the living environment and urban ecosystems in response to challenges posed by habitat loss, climate change, and emerging conservation issues.

Keywords

Flood Resilience, Urban Water System, Nature-based Solution, Green-blue Infrastructure, Livable Cities, Urban Ecology, Beaver Recolonization

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Figure 1-1: Geographic location of Winnipeg and typical flood event
Source: City of Winnipeg, 1950

PART 1

General Research

1.1 Flood History

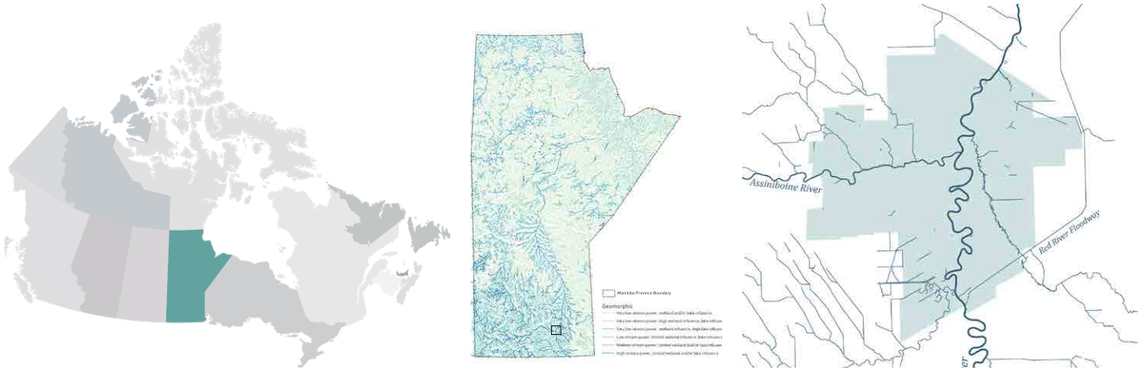


Figure 1-1: Location of the City of Winnipeg
Completed by Author

Historical background

Winnipeg, a city situated at the confluence of the Red and Assiniboine Rivers in the province of Manitoba, Canada, has a complex history intertwined with its natural context and the recurring issue of flooding.

The natural geography of Winnipeg is characterized by an extensive system of rivers, including the two primary water bodies, the Red and Assiniboine Rivers. These rivers have played a vital role in shaping the land and providing a source of sustenance for indigenous populations long before the arrival of European settlers. However, the same waterways that have brought life and vitality to the region have also presented significant challenges.

Back to the history, Winnipeg has experienced periodic flooding due to its geographical location and the flat topography of the surrounding area, known as the Red River Valley. The Red River, in particular, has a reputation for its volatile nature, prone to seasonal flooding as melting snow and heavy rainfall swell its banks. The resulting inundation of land has posed significant risks to the city's development and population.

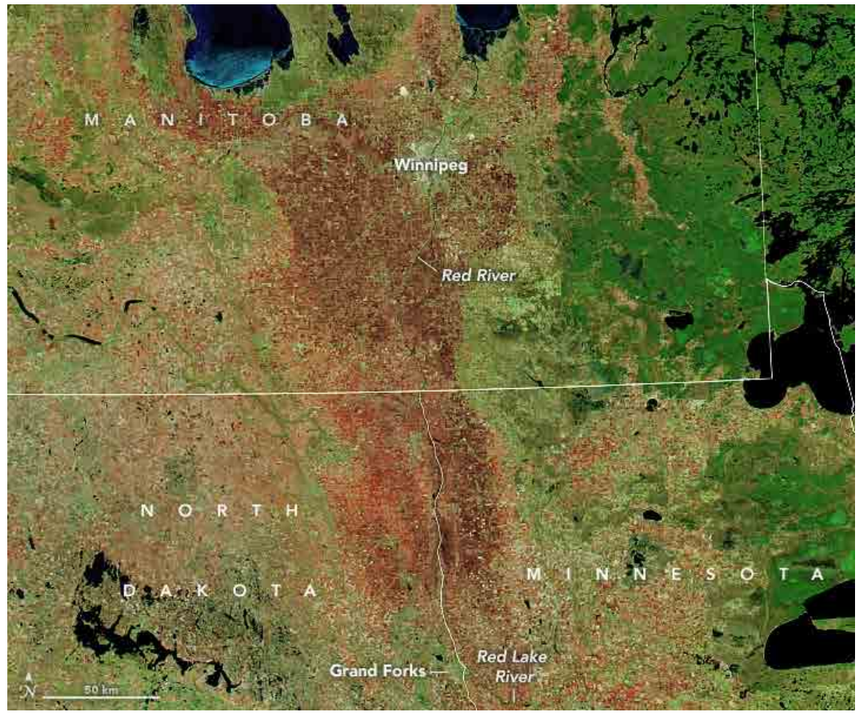


Figure 1-2: The false-color satellite images of Red River Valley on May 10 & 11, 2020
Source: https://earthobservatory.nasa.gov/images/149822/red-river-flooding-is-worst-in-a-decade

Types of flooding

In Winnipeg, two common types of flooding that pose significant challenges to the city are river flooding and overland/basement flooding.

a) River Flooding: River flooding occurs when the water levels in the Red and Assiniboine Rivers, which flow through the city, rise beyond their normal capacity. This type of flooding is typically caused by heavy rainfall, rapid snowmelt, or a combination of both. River flooding in Winnipeg can result in widespread inundation of low-lying areas near the rivers, including residential neighborhoods, parks, and agricultural lands. The city's geographical location at the confluence of these rivers makes it particularly susceptible to river flooding. To manage and mitigate river flooding, the city has implemented various flood control measures, such as the construction of dikes, diversion channels, and floodway systems, which help redirect and contain the excess water, protecting the city's infrastructure and residents.

b) Overland or Basement Flooding: Overland or basement flooding, also known as surface flooding, occurs when excess water accumulates on the ground surface or enters basements and lower levels of buildings. This type of flooding is often caused by intense rainfall events that overwhelm drainage systems, the inability of the ground to absorb the water due to soil saturation or urbanization, and inadequate stormwater management infrastructure. Overland or basement flooding can have significant impacts on homes, businesses, and public infrastructure, leading to property damage, disruption of services, and health and safety risks. To address this type of flooding, the city has been working on improving stormwater management systems, implementing measures such as the installation of larger culverts, upgrading sewer infrastructure, and promoting the use of permeable surfaces to enhance water infiltration and reduce surface runoff.

Both river flooding and overland/basement flooding present unique challenges to the city of Winnipeg. River flooding needs effective management of water levels and flow in the major rivers, while overland/basement flooding necessitates a more improved drainage system and urban planning strategies to mitigate the impacts of intense rainfall events.

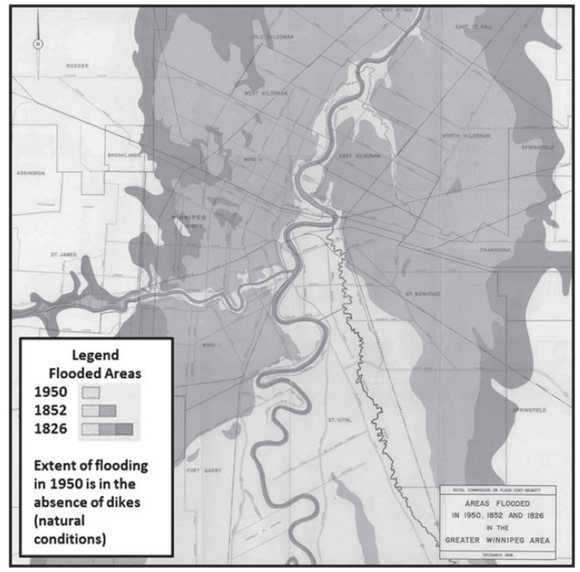


Figure 1-4: Extent of flooding in 1950s
Source: City of Winnipeg, 1950

Figure 1-3: Photos of the devastating flood that washed over Winnipeg
Source: City of Winnipeg, 1950

Mitigation efforts

The most famous project among all infrastructure built to address the floods was the construction of the Red River Floodway, also known as the 'Duff's Ditch'. This impressive engineering project, completed in 1968, is a 47-kilometer long diversion channel that reroutes excess water from the Red River during periods of high flow. The floodway has the capacity to divert water at a rate of 7,500 cubic meters per second, effectively reducing the flood risk for the city.

The construction of the floodway has significantly reduced the risk of river flooding and mitigated the potential damage. Although the tremendous engineering solution and its high cost were very controversial in the first place, it has at the end earned the name as a leader in flood control in Winnipeg.

Figure 1-5: Natural Spring Peak Discharges of Red River at James Avenue, Winnipeg
Completed by Auther
Data soutce: Manitoba Conservation and Water Stewardship

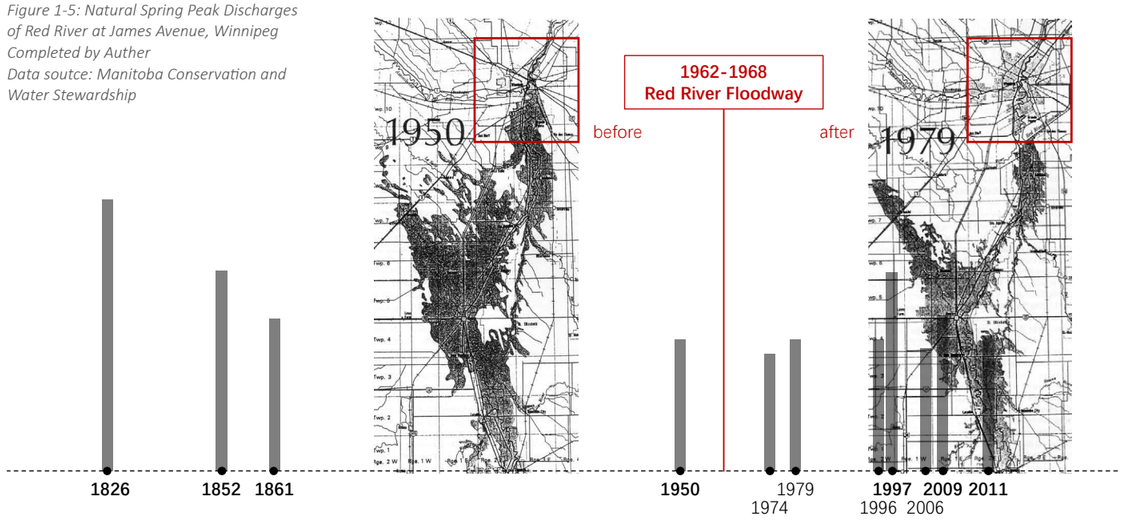
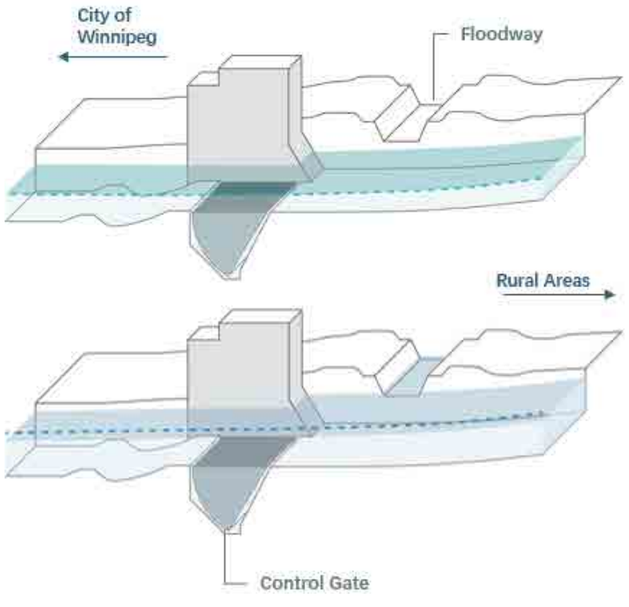
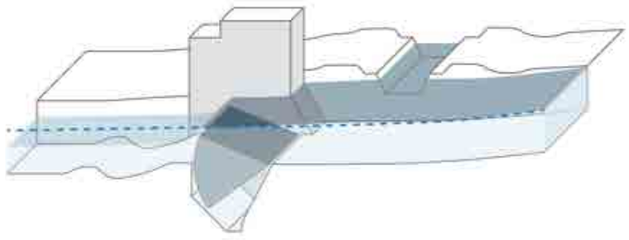


Illustration of inlet operation



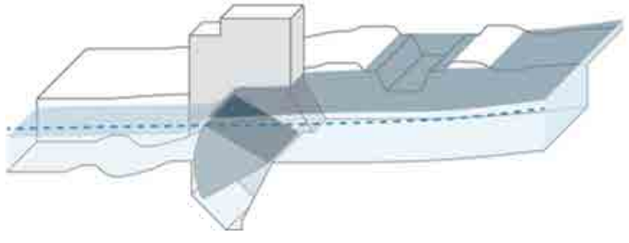
Natural water level in low flow conditions

Natural water level in high flow conditions



Normal Operations

The floodway gates are raised so that the water level south of the floodway channel inlet is restored to its natural level.



Major Flood Operation

The floodway is operated to keep water levels in Winnipeg below the primary dike system, raising water levels upstream of the floodway channel inlet above natural.

In addition to the Red River Floodway, the city has developed an extensive system of dikes and flood protection structures. Dikes, which are earthen embankments, are strategically built along the riverbanks to contain floodwaters and prevent them from overflowing into residential and commercial areas. These dikes act as a barrier, providing a line of defense against rising river levels. The city continuously monitors and maintains the dikes to ensure their effectiveness in protecting vulnerable areas during periods of high water.

Winnipeg has also invested in flood control infrastructure at the neighborhood level. Retention ponds and reservoirs are strategically constructed to capture and store excess water during heavy rainfall or rapid snowmelt, preventing it from overwhelming the drainage system and causing localized flooding. These retention ponds and reservoirs help regulate water levels, particularly in areas with limited natural drainage capacity.

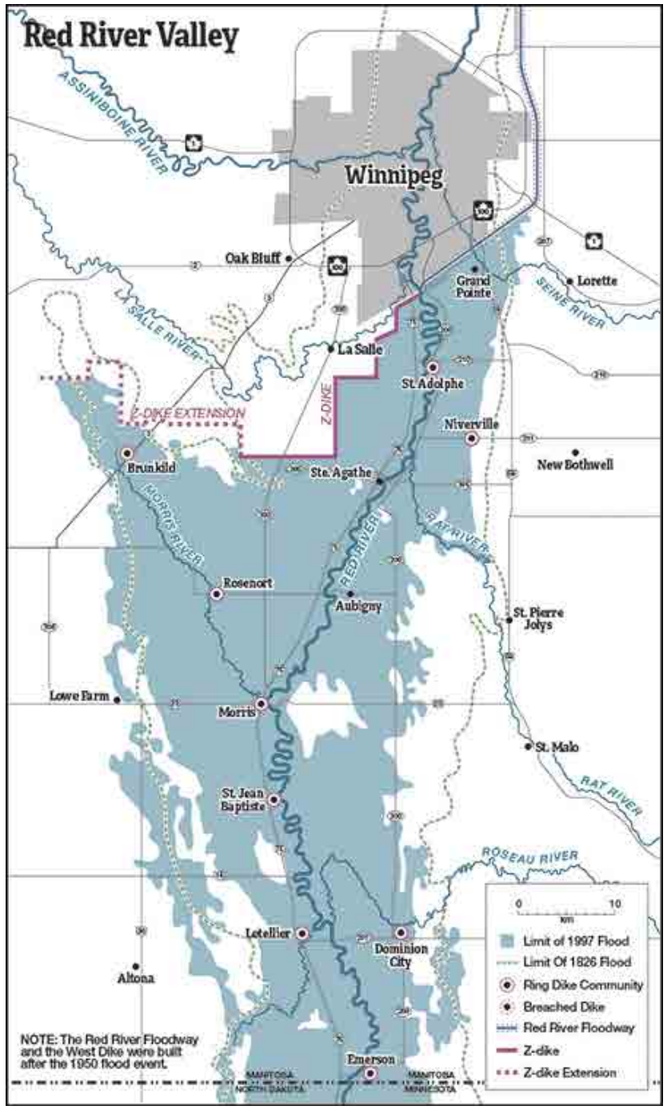


Figure 1-6: Illustration of inlet operation
Completed by Auther
Source: Manitoba Conservation and Water Stewardship

Despite these mitigation efforts, Winnipeg has faced several major flooding events throughout its history. Notable floods include the devastating flood of 1950, which caused widespread damage and displacement, as well as more recent floods in 1997 and 2009, which resulted in significant property damage and economic losses.

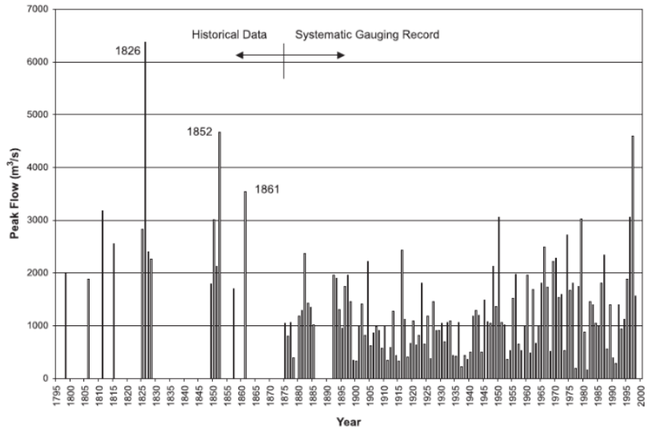


Figure 1-7: Illustration of inlet operation
Source: Burn, Donald. (2011). Flood frequency analysis for the Red River at Winnipeg. Canadian Journal of Civil Engineering. 28. 355-362. 10.1139/cjce-28-3-355.

1.2 Landscape Transition

Etymology

The name of the city, which takes its roots from the Western Cree language, specifically the words 'winipīhk', means muddy water. This metaphorical connection might be seen as a reflection of Winnipeg's historical struggles with flooding.

In this sense, the name 'Winnipeg' becomes more than a mere label for the city; it becomes a metaphorical representation of the challenges, resilience, and ongoing efforts to reconcile human development with the powerful forces of nature, particularly in relation to water.

Original landscape

The territory used to be part of the Manitoba prairie, which is a rich tapestry of diverse ecosystems that have flourished in the region for thousands of years. Stretching across vast expanses of land, this landscape showcases the natural beauty and ecological significance of the prairie environment.

The characteristic of the prairie ecosystem is embodied in its expansive grasslands, dotted with wetlands, woodlands and the meandering waterways that crisscrossed the region. The precipitation is higher than many other areas in the Prairies Ecozone. These higher levels of precipitation are what makes it possible for the species of the Tall Grass Prairie to survive here.

Wetlands are an integral part of the Manitoba prairie landscape, offering valuable habitats for diverse plant and animal species. Marshes, bogs and fens provide crucial breeding grounds for waterfowl, including ducks and geese, as well as habitat for amphibians, aquatic plants, and insects. These wetland areas also act as natural filters, helping to improve water quality and regulate water flow within the prairie ecosystem.

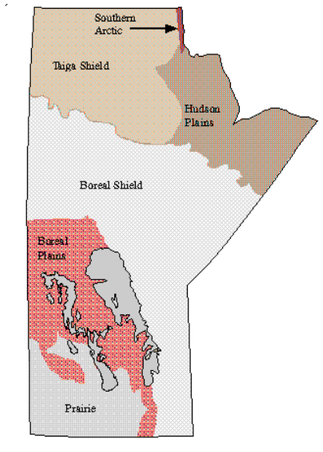


Figure 1-8: Manitoba Ecozones
Source: Manitoba Conservation

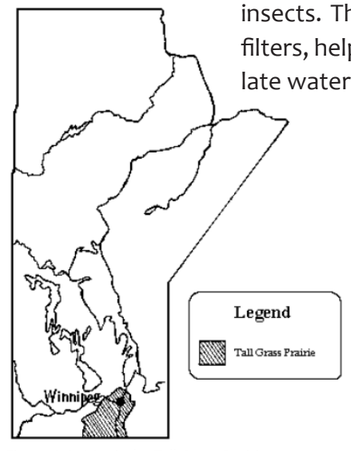


Figure 1-9: Manitoba Tall Grass Prairie
Source: Living Prairie Museum

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Indigenous cultural landscape

Prior to the arrival of European settlers, indigenous communities in the region, including the Anishinabe (Ojibway), Ininew (Cree), Oji-Cree, Dene, and Dakota, lived in harmony with the natural environment, shaping a vibrant and sustainable cultural landscape.

Indigenous peoples relied on a deep understanding of the land's ecosystems, seasons, and resources. Their cultural practices, traditions, and knowledge were intimately connected to the cycles of nature, and they lived in balance with the natural world. They utilized the land's resources for sustenance, shelter, clothing, and spiritual practices, while also recognizing the need for conservation and responsible stewardship.

The indigenous cultural landscape in Winnipeg was characterized by a nomadic or semi-nomadic lifestyle, with communities moving seasonally in search of food sources and following the patterns of wildlife migration. They established temporary camps, utilizing areas along rivers, lakes, and wetlands that provided abundant fish, waterfowl, and plant resources. These locations were not only practical for survival but also held spiritual and cultural significance, fostering a deep connection to the land.

With the arrival of European colonization, the indigenous cultural landscape in Winnipeg and throughout Canada experienced significant disruption and displacement. The imposition of colonial policies, land dispossession, forced assimilation, and the suppression of indigenous cultural practices severely impacted the traditional ways of life and the cultural landscape of indigenous communities.

The colonization process brought about the transformation of the landscape as settlers established permanent settlements, developed agricultural practices, and altered the natural environment to suit their needs. Indigenous peoples were often pushed to the margins of society, facing the loss of their traditional territories, cultural practices, and spiritual connections to the land.

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Modern landscape

As Winnipeg developed into a thriving urban center, the landscape experienced a gradual transformation. The expansion of urban areas led to the clearing of land, the infrastructure construction, and the establishment of residential and commercial zones. As a result, the natural landscape gave way to a more built-up environment, characterized by streets, buildings, and a grid pattern of urban planning.

The change in Winnipeg's landscape can be observed easily through the conversion from natural areas to urbanized areas. Wetlands and creeks, which were once abundant, have been drained or filled to make way for construction projects. Prairie grasslands, once stretching as far as the eye could see, have been replaced by residential neighborhoods and commercial districts. The gradual loss of these natural features has greatly impacted local biodiversity and ecosystem services including the manner of land drainage.

As the city experienced an influx of settlers, immigrants, and industries, it necessitated the expansion and modernization of its built environment.

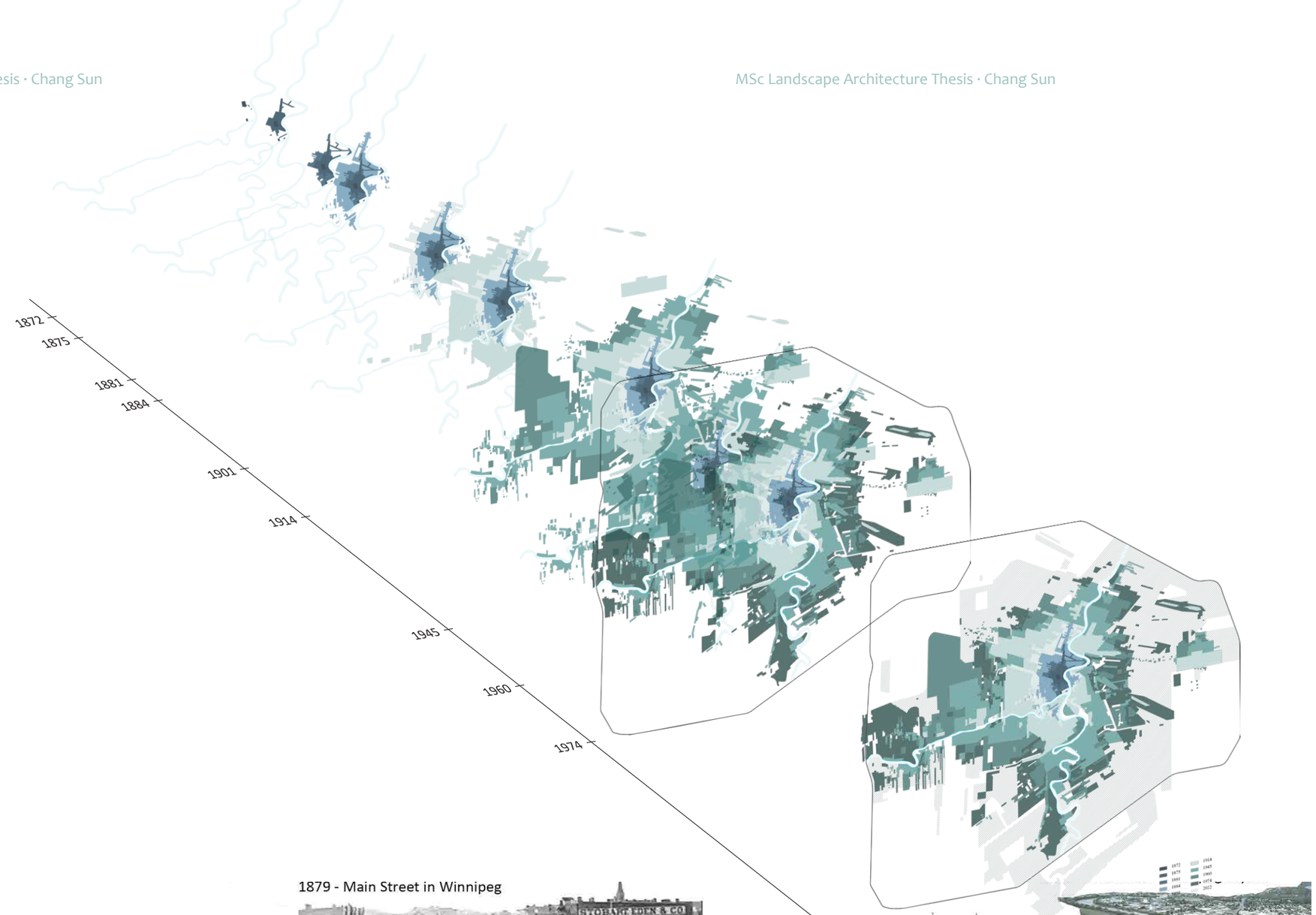

Figure 1-10: Modern Landscape Evolvement
Completed by Author

Figure 1-11: Prairie in Winter
Source: Scott Plumbe, Manitoba Museum

Figure 1-12: Prairie in Spring
Source: Scott Plumbe, Manitoba Museum

Figure 1-13: Prairie in Summer
Source: Scott Plumbe, Manitoba Museum

Figure 1-14: Prairie in Autumn
Source: Scott Plumbe, Manitoba Museum

1.3 Urban Flood Conflict

Water Hazards in the City

The water hazards in Winnipeg have caused significant property damages, including those affecting roads and basements. During periods of intense precipitation or rapid snowmelt, the water levels in the rivers can rise rapidly, leading to overflow and inundation of surrounding areas. This can result in damage to roadways, bridges, and other transportation infrastructure.

The basements are also very vulnerable to water damage during repetitive flooding events. This is not only causing distressing experiences and huge troubles to citizens' daily life, but at the same time requires costly repairment for house-owners and businesses.

Another consequence of flood is the water pollution. As water overflows to the ground, it is also collecting pollutants and impurities. In urban catchment areas, the lack of natural filtration and the presence of contaminants from human activities (e.g., pollutants from vehicles, industrial discharges, and stormwater runoff) can significantly degrade water quality. This becomes worse during periods of heavy rainfall or snowmelt, when the combined sewer overflows occur, the additional volume of water in combined sewers system contains not only land drainage, but also wastewater and debris, and the systems are designed to overflow and discharge the excess volumes directly into the river without getting treated by the sewage treatment plant.

Figure 1-15: Main Water Crisis in Winnipeg
Completed by Author

WINNIPEG

Weekend storm leaves hundreds of basements flooded in Winnipeg

Danton Unger
CTVNewsWinnipeg.ca
Editorial Producer
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Published April 26, 2022 3:32 a.m. CEST

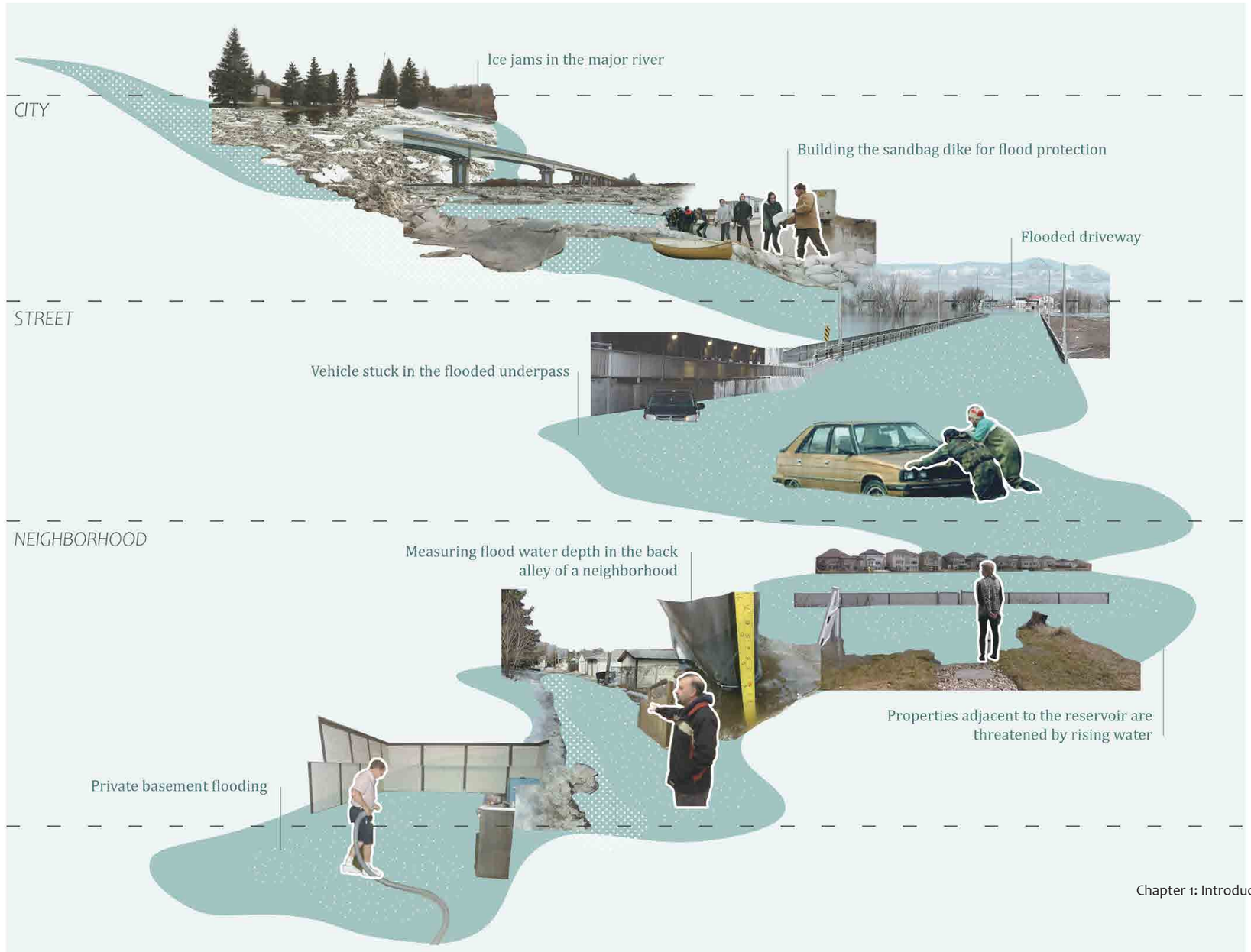
Winnipeg swings from historic drought last year to wettest year on record in 2022

Meteorologist confident extremes tied to climate change as 739 mm of precipitation recorded in Winnipeg

Bryce Hoye · CBC News · Posted: Oct 24, 2022 2:45 PM CT | Last Updated: October 24

City IDs over 100 properties at risk of spring flooding

By Sam Thompson · Global News
Posted March 29, 2019 11:33 am · Updated March 29, 2019 12:22 pm



2.1 Collision of Morphology

The form of the water channels often affect the impact of flooding. The collision between forms of natural drainage pattern and urbanization patterns in Winnipeg presents a fascinating contrast between the organic and the structured. This contrast is particularly evident when considering the curvilinear shape of natural waterways juxtaposed against the grid pattern commonly applied in the North American urban plannings.

The landscape of the past was mostly shaped by the forces of nature, with natural drainage patterns and the rich biodiversity of the surrounding ecosystems. Known for its abundant rivers, lakes, and streams that traverse the country, these waterways are shaped by the forces of nature over centuries. This process often creates meander in graceful curves, following the path of least resistance. They represent the organic flow of the land and provide a sense of tranquility and harmony with the environment.

In contrast, urbanization in Canadian cities is typically characterized by planned, structured development. Grid-like patterns dominate the layout, with streets intersecting at right angles, creating a systematic and efficient arrangement. This grid planning facilitates navigation, enables efficient land use, and simplifies infrastructure development.

When these contrasting elements converge, the result is a collision between nature's organic forms and urbanization's rigid patterns.

Observing the city texture of Winnipeg, it is indeed a palimpsest. The main waterways, the Red and Assiniboine rivers, as well as several continuous streams are treated as immutable features because they're relatively perennial. Then the collision took place in the intersection of two patterns, where the urban fabric is extended till the very last few tens of meters near the riverbank. Inversely, the intermittent streams and inconstant wetlands are completely drained and filled for urban construction plans. They can noow only be traced from historical maps back from the first settlement.

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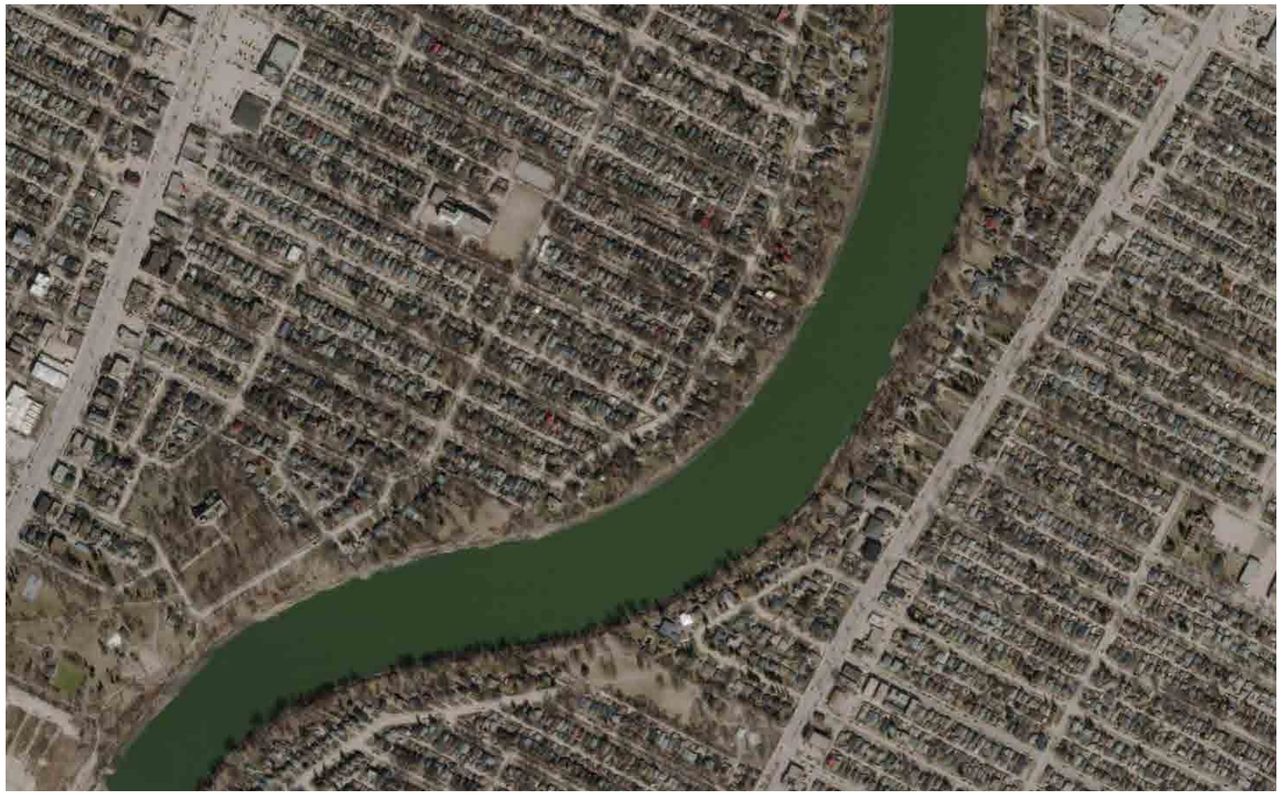

Figure 2-1: Residential areas on both sides of the Red River
Source: World Imagery Wayback, 09.2021

The morphology of nature and urban texture can indeed create a significant diversity, but arouse a sense of divergence and even tension in me. It can be brilliant to seek for the balance of nature and the built environment. More design interventions can be embraced to reintegrate nature into urban spaces to create a more sustainable and livable environment.

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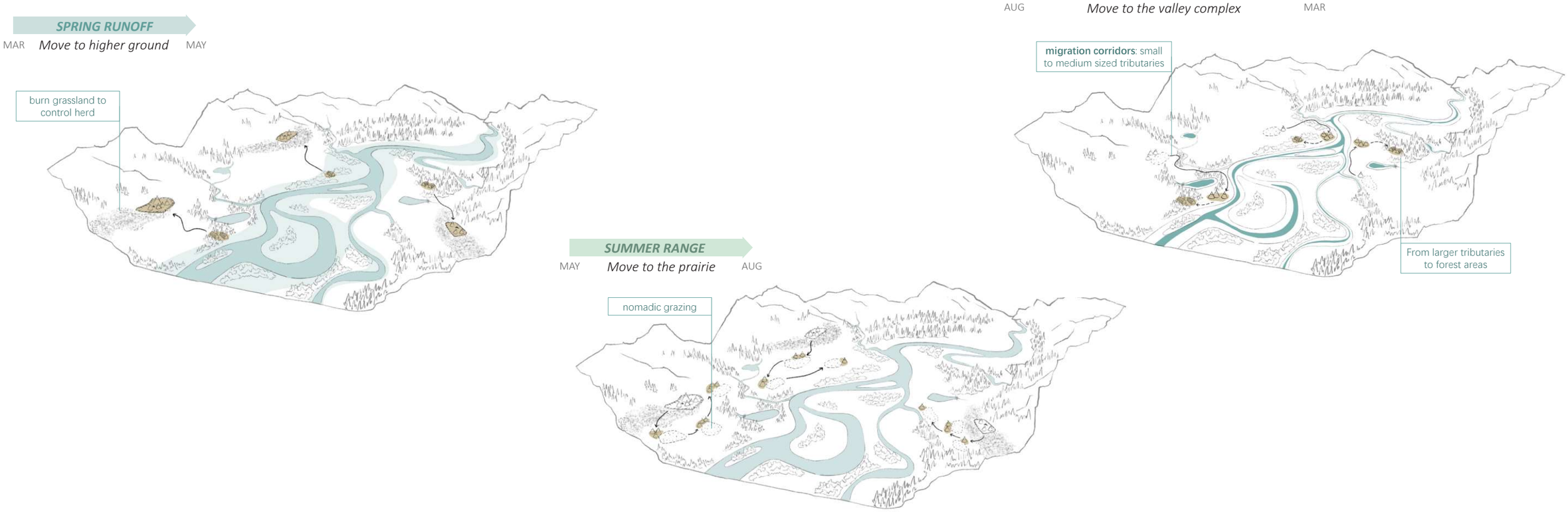
2.2 Indigenous Insight

Schematic diagram of migration pattern [in a seasonal cycle]



Migration cycle on the plains

The native landscape of the Manitoba prairie has evolved in harmony with the region's climate, geographical, and geological conditions. It has adapted to periodic floods, droughts, fires, and other natural disturbances, which have shaped the composition and structure of the ecosystem over time. Indigenous peoples have long recognized the importance of this landscape, utilizing its resources for food, shelter, and cultural practices.

Indigenous peoples in the Canadian prairies have long practiced a nomadic lifestyle, moving in reaction to the natural processes of the plain. Their migrations are deeply connected to the seasonal changes in water flow, which played a vital role in their survival and resource utilization.

The prairie region experiences significant fluctuations in water availability, with distinct wet and dry seasons. During the wetter periods, rivers and streams swelled with water from snowmelt and rainfall, creating abundant water sources across the plains. The fluctuation of water flow has such a variety in water body range that the communities had to move their settlements in order to prevent the invasion of floodwaters in floodplain areas.

As temperature rises and surface water evaporates in the summer, indigenous communities would strategically move back to the plain, establishing temporary settlements near rivers, lakes, and wetlands. These areas provided not only a reliable source of drinking water but also abundant fish, waterfowl, and other aquatic resources for sustenance.

Adaptation to drought

In times of drought, when water became scarce, indigenous tribes relied on their deep understanding of the landscape and the natural behaviors of animals, particularly beavers. Beavers are renowned for their ability to construct dams and create ponds, which retain water even during dry spells. Indigenous peoples possessed intricate knowledge of the locations of beaver ponds within their territories. These ponds became essential water sources during drought periods, providing a reliable supply for drinking and supporting the needs of both humans and wildlife.

The indigenous communities' intimate connection with the land and their knowledge of the seasonal water flow patterns allowed them to adapt their migration cycle to the changing environment. They understood the importance of sustainable resource management, so that ensured the long-term survival of the tribes by maintaining the delicate balance of the system.

Spirit of sharing

As a lifestyle, indigenous cultures developed a tradition of sharing resources and knowledge within and between tribes. Trade networks facilitated the exchange of goods, including food, tools, and medicinal plants, enhancing resilience and cooperation among different communities. This sharing of knowledge and resources enabled tribes to overcome the challenges posed by the variable water flows and sustain their way of life.

Today, many indigenous communities in the Canadian prairies continue to embrace and preserve their traditional ecological knowledge. Their deep understanding of the land, its seasonal water flows, and the coexistence of all living creatures offers valuable insights for modern conservation efforts and sustainable land management practices. By recognizing and respecting the wisdom of indigenous peoples, we can imagine a more harmonious relationship with the natural world in the continuation of urban development.

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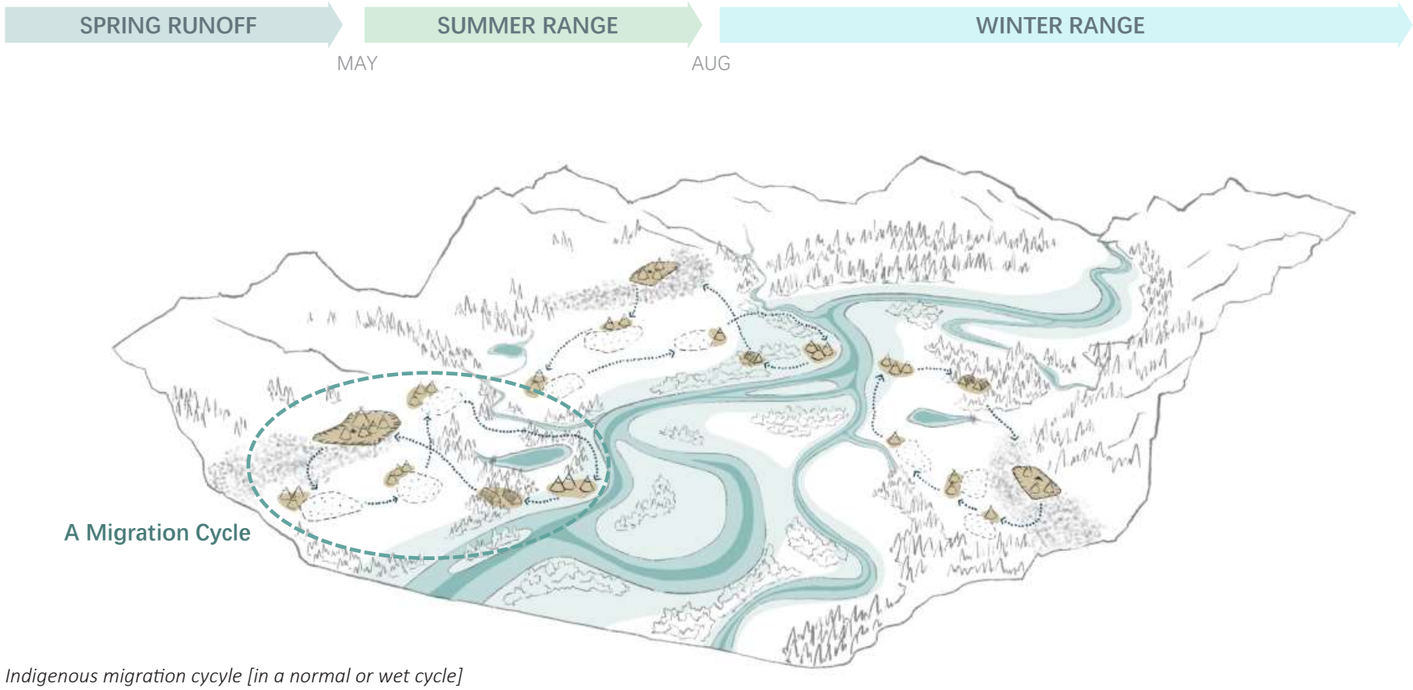
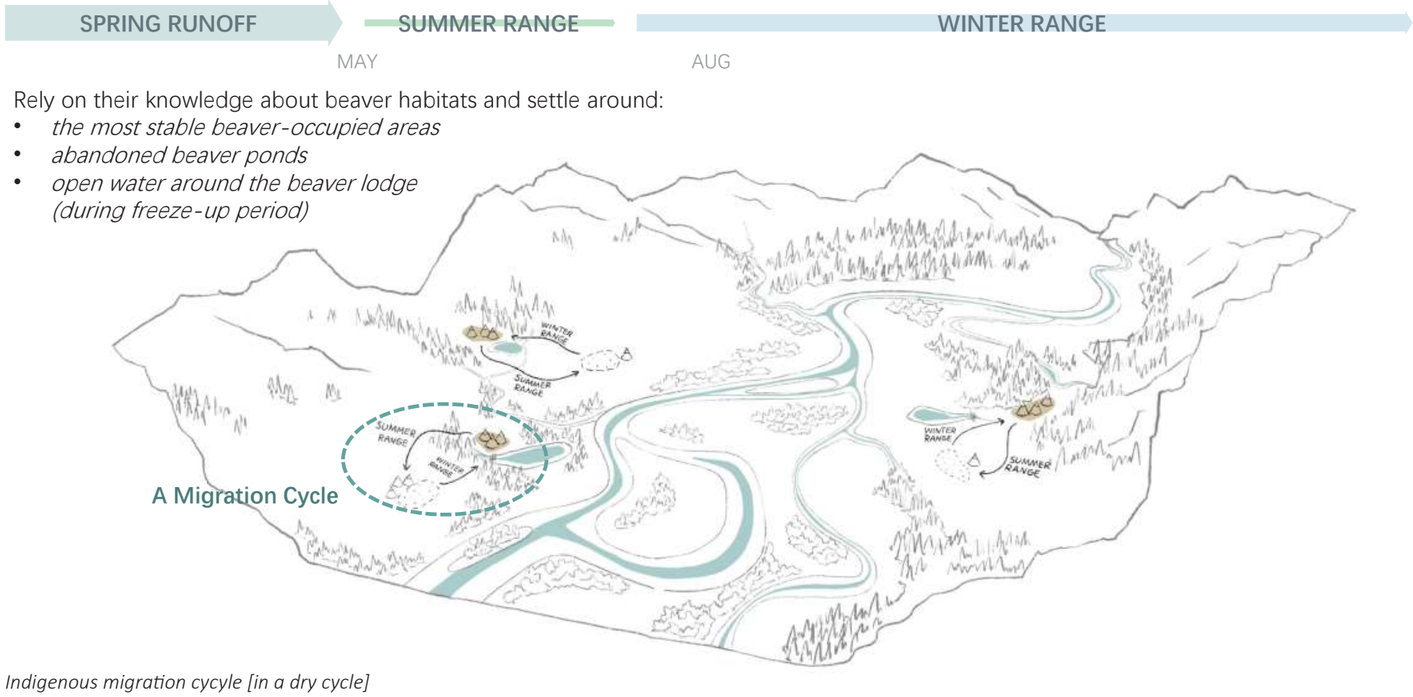


Indigenous migration cycyle [in a normal or wet cycle]



Indigenous migration cycyle [in a dry cycle]

3.1 Causes of Flood

Concluding the flood events in Winnipeg area, they can be attributed to various causes.

Geographical Base

Winnipeg is located at the confluence of the Red and Assiniboine Rivers, which makes it susceptible to flooding. The flat topography of the region, combined with the presence of these rivers, creates a natural basin that can collect and retain water during periods of heavy rainfall or snowmelt. At the same time, the high plasticity of clay soil exacerbates the drainage problem. Clay soil have the ability to absorb and hold large amounts of water, causing the soil to become even more waterlogged.

Increased Flood Controls

Over the years, flood control measures, such as the construction of dams, dikes, and diversion channels, have been implemented in Winnipeg to mitigate the impact of flooding. While these measures have been effective in reducing the severity of floods, they have also altered the natural flow patterns of water and can sometimes contribute to localized flooding if not properly maintained or adjusted to changing conditions.

Urbanization

The rapid urbanization of Winnipeg and the surrounding areas have significantly altered the natural hydrological processes. The replacement of natural landscapes with impervious surfaces, such as buildings, roads, and parking lots, reduces the ability of the land to absorb and retain water. As a result, more water becomes surface runoff, leading to increased volumes and faster flow of water during rainfall events.

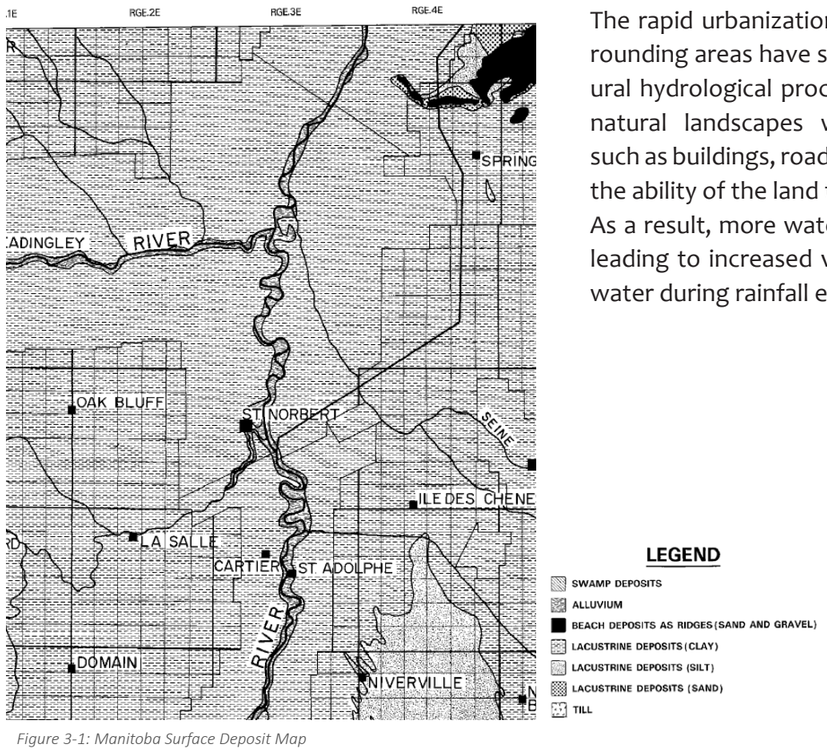


Figure 3-1: Manitoba Surface Deposit Map
Source: J.Little, Water Resources Branch, Manitoba, 1980

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Wet and Dry Cycle on the Prairie

The prairie region, including Winnipeg, experiences a natural cycle of wet and dry periods. During wet cycles, characterized by above-average precipitation, the capacity of rivers and waterways can be overwhelmed, leading to flooding. Conversely, during dry cycles, when precipitation is limited, water levels can drop, exacerbating the effects of drought and increasing the risk of wildfires.

Effect of Climate Change

Climate change is a significant factor contributing to increased flood risk in Winnipeg. Rising global temperatures have led to changes in precipitation patterns, including more intense rainfall events and rapid snowmelt. These changes can overwhelm drainage systems, increase river and waterway levels, and result in more frequent and severe flooding. Additionally, the warming climate can also lead to the melting of permafrost, which can further affect the water-holding capacity of the land and increase the risk of localized flooding.

It is important to note that these causes often interact with one another, intensifying the risk of flooding. For example, urbanization can compound the effects of increased rainfall by limiting natural water absorption and creating more impervious surfaces, while climate change can intensify precipitation patterns, further challenging flood control infrastructure.

Addressing the causes of flooding in Winnipeg requires a comprehensive approach that combines effective land and water management strategies, climate change mitigation measures, and community engagement. This includes sustainable urban planning, the preservation and restoration of natural water retention areas, improved stormwater management systems, and a focus on adapting to the changing climate. By addressing these causes and implementing appropriate mitigation measures, Winnipeg can reduce the impact of flooding and enhance its resilience to future flood events.

3.2 Hydrological System

Comparison of Catchment Systems

In natural catchment areas, the land is typically covered by vegetation, including trees, shrubs, and grasses. These natural landscapes have the ability to absorb rainfall and promote infiltration into the soil, allowing water to gradually seep into groundwater reservoirs or flow into nearby streams and rivers. Natural areas, such as wetlands and forests, often have the ability to store significant amounts of water.

The native landscapes also have the advantage of natural filtration mechanisms provided by vegetation and soil. As water infiltrates the ground, the pollutants and impurities are removed before it reaches groundwater or surface water bodies.

In contrast, urban catchment areas usually have impervious surfaces such as concrete, asphalt, and buildings. These surfaces hinder natural infiltration, leading to increased surface runoff and reduced water absorption into the ground.

While the nature allows natural processes to regulate water flow and maintain ecological balance, the city relies on a massive drainage system to get rid of the water. This includes the construction of combined and separate sewer systems to collect both land drainage (rainwater and snowmelt) and wastewater (sewage from homes and businesses) in the same pipe.

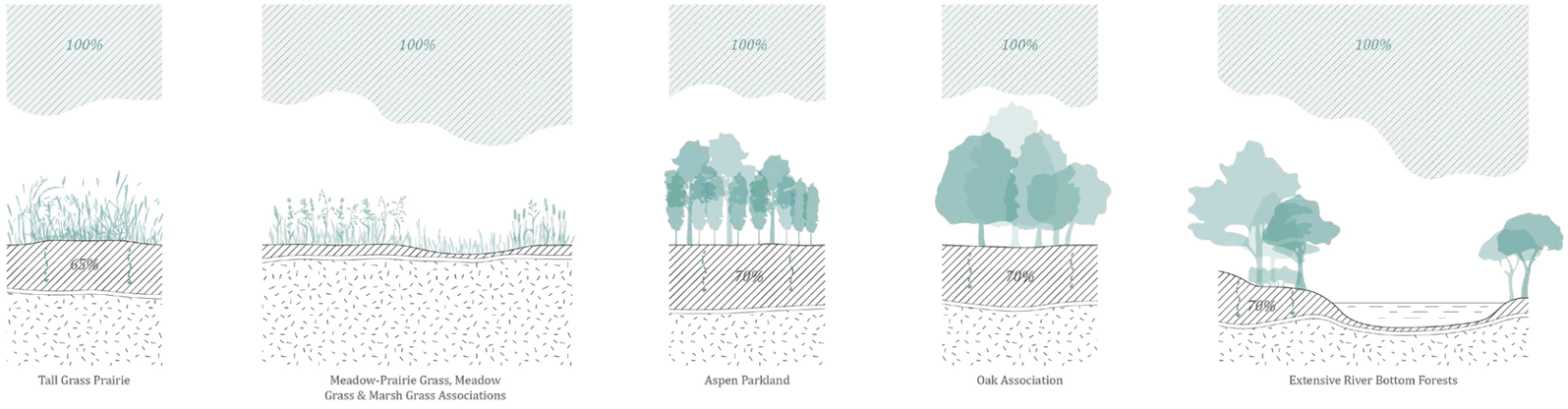
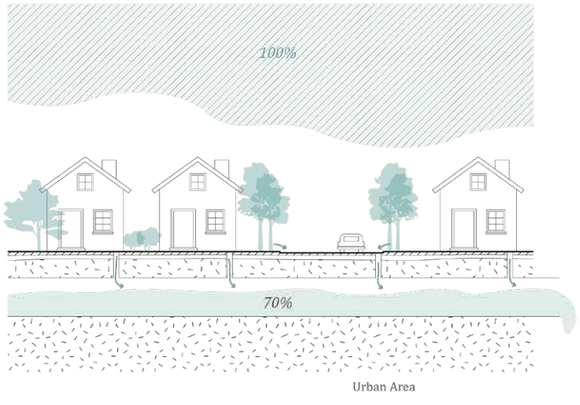


Figure 3-2: Interception value for the vegetatlon in the native landscape Adpted from Graham, Robert Michael W. The surface waters of Winnipeg: rivers, streams, ponds and wetlands 1874-1984: the cyclical history of urban land drainage



Wastewater
(sewage from homes and businesses)

+

Land drainage
(rainwater and snowmelt)

Combined sewer

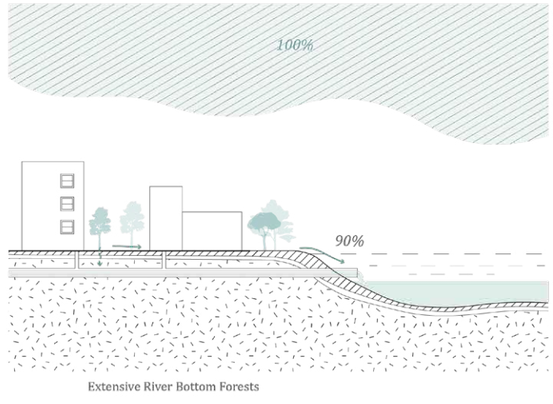


Figure 3-3: Precipitation runoff in the urban deainage system Completed by Auther

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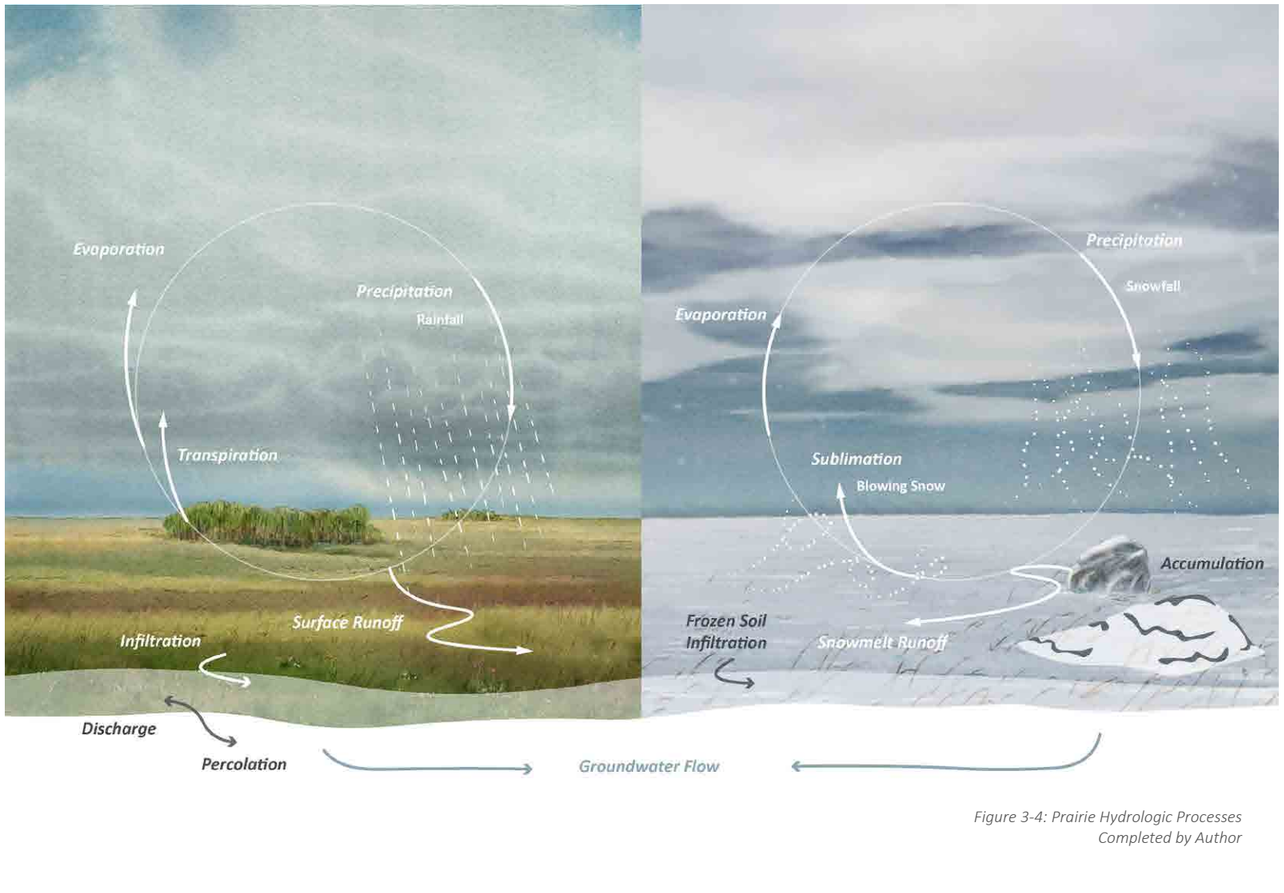

Figure 3-4: Prairie Hydrologic Processes
Completed by Author

Prairie Hydrological Cycle

The natural hydrological cycle is a continuous process through which water circulates on Earth, involving various stages such as evaporation, condensation, precipitation, and runoff. The hydrological cycle on the prairie, specifically in the Winnipeg region, is influenced by the unique characteristics of this vast grassland ecosystem.

On the prairie, the hydrological cycle is marked by distinct features that shape the movement and distribution of water. The flat topography of the prairie landscape allows for broad expanses where precipitation can accumulate and form temporary or permanent wetlands, ponds, and lakes. These water bodies serve as important reservoirs, providing habitats for various species of plants and wildlife.

Precipitation on the prairie is relatively modest related according to two types of precipitation, snowfall and rainfall. Snow is an important water resource on the Canadian Prairies. Approximately one third of annual precipitation occurs as snowfall, which produces 80% or more of annual local surface runoff. On the other hand, most rainfall occurs during the summer months. This means that the next process, runoff, tends to have the peak periods during spring snowmelt and summer heavy rains.

Due to the region's predominantly flat terrain and lacustrine deposits with low hydraulic conductivity, water tends to flow slowly across the land, often forming shallow, meandering channels. These waterways, known as ephemeral or intermittent streams, can carry water during wet periods and gradually dissipate during drier times. The runoff from precipitation helps recharge groundwater systems and maintains the moisture levels of the soil.

Urban Hydrological Cycle

The urban hydrological cycle in Winnipeg, Manitoba, plays a crucial role in the city's water management and the challenges it faces regarding droughts and floods. Understanding this cycle provides insights into how water moves within the urban environment and the impacts of urbanization on the water balance.

In Winnipeg, the urban hydrological cycle begins with precipitation, which can come in the form of rain or snowfall. Precipitation can occur throughout the year, but it is typically more abundant during spring and summer months. Once it falls onto the city, the water follows different pathways depending on various factors such as land use, infrastructure, and natural features.

One major aspect of the urban hydrological cycle is surface runoff. In urban areas with impervious surfaces like roads, parking lots, and buildings, precipitation cannot infiltrate into the ground effectively. Instead, it rapidly flows over these surfaces, collecting pollutants and sediments along the way. This runoff is directed towards storm drains, sewers, or nearby water bodies, where it can contribute to flooding events during heavy rainfalls.

Another aspect is infiltration, which refers to the process of water seeping into the ground. In areas with green spaces, parks, and vegetated areas, there is a greater potential for water to infiltrate the soil. However, due to extensive urban

development, the amount of available land for infiltration is reduced, leading to increased surface runoff and decreased groundwater recharge.

Additionally, the urban hydrological cycle involves the management of stormwater through engineered systems. In Winnipeg, stormwater is collected in a combined sewer system, where both sanitary sewage and stormwater runoff are conveyed in the same pipes. During normal conditions, the combined sewage flows to wastewater treatment plants for processing. However, during intense rainfall events, the system can become overwhelmed, resulting in combined sewer overflow (CSO) and the discharge of untreated or partially treated wastewater into rivers.

Drought and flood events are significant challenges associated with the urban hydrological cycle in Winnipeg. During droughts, when precipitation is scarce, water sources may become depleted, leading to water shortages for both residential and agricultural needs. In response, the city implements water conservation measures and promotes responsible water usage to mitigate the impacts of drought.

On the other hand, during periods of heavy rainfall or snowmelt, the city faces the risk of flooding. The combination of impervious surfaces, limited infiltration capacity, and intense precipitation can overwhelm drainage systems and cause localized flooding in low-lying areas. To address this, Winnipeg has implemented flood mitigation strategies, including the construction of flood protection infrastructure, such as dikes and retention ponds, and improved stormwater management practices.

Managing the urban hydrological cycle in Winnipeg requires a comprehensive approach that balances the need for water supply, flood protection, and environmental sustainability. The city continues to explore innovative solutions, such as the incorporation of green infrastructure, rainwater harvesting, and low-impact development techniques, to enhance the resilience of its urban water systems and mitigate the impacts of both droughts and floods.

The urban hydrological cycle in Winnipeg plays an important role in the city's water management and the challenges it faces regarding droughts and floods. Managing the urban hydrological cycle in Winnipeg requires a comprehensive approach that balances the need for water supply, flood protection, and environmental sustainability.

3.3 Growing Population

The growing population in Winnipeg presents significant challenges when it comes to solving the flood problem, particularly in the context of land use and social needs. As the city's population increases, there is a greater demand for housing, infrastructure, and economic development, which often results in increased urbanization and changes in land use patterns. However, these changes can exacerbate the risk of flooding and pose challenges for flood management strategies.

The task of solving the flood problem becomes more complex as land use conflicts with the need to manage water and mitigate flood risks. The growing needs for new residential and commercial spaces lead to the occupation of more vulnerable areas. This puts both the existing and new developments at higher risk of flooding during intense rainfall events or when river levels rise.

Balancing the demands for urban development with the necessity to protect floodplains and natural waterways requires careful planning and implementation of appropriate land use policies. This involves identifying and preserving areas with high flood risk for open spaces, green-blue infrastructure, or other forms of non-residential development that can tolerate periodic flooding.

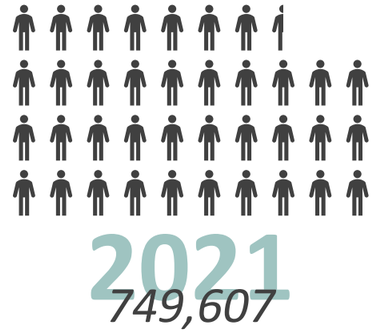

Figure 3-5: Population Growth in Winnipeg
Data source: Winnipeg Population Estimates and Projections, June 2022

3.4 Problem Statement

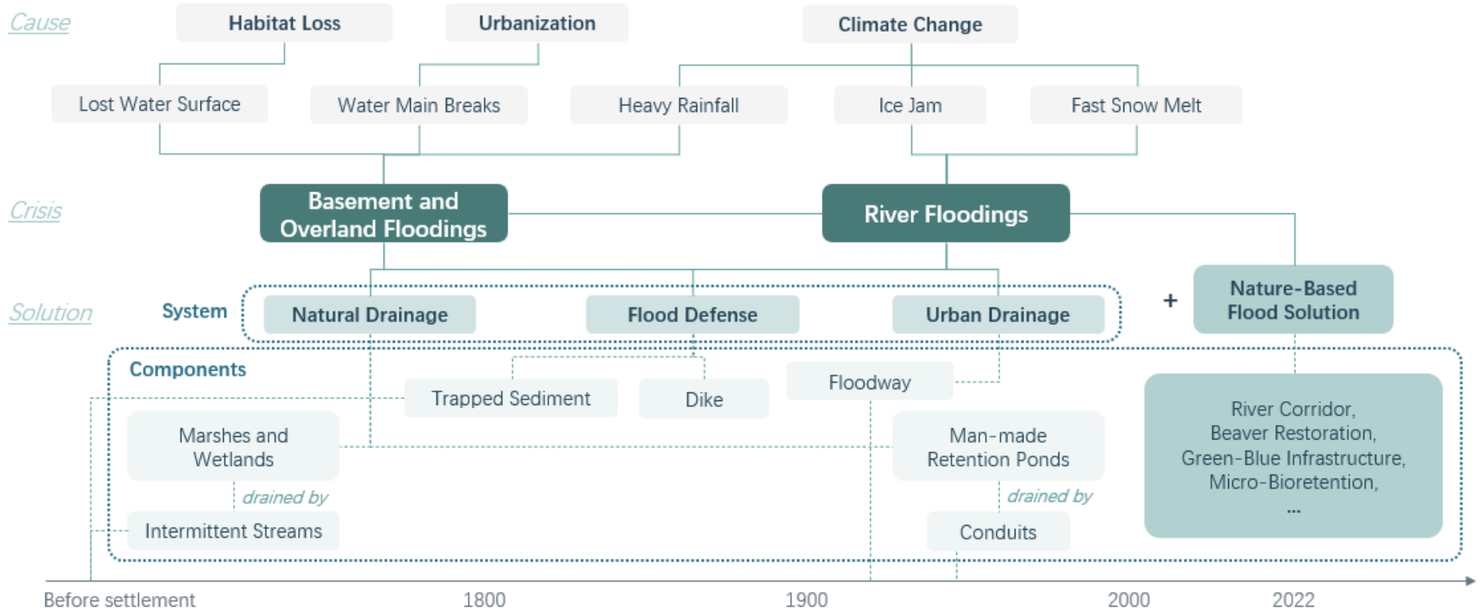

Figure 3-6: Conclusion of the flood crisis in Winnipeg

The urban expansion in Winnipeg is facing the challenge of threatening water issues, including flooding and water scarcity. To ensure sustainable development and mitigate the negative impacts on the environment, there is a need to establish a comprehensive and resilient urban hydrologic system that promotes collaboration between humans and wildlife, transforming these water-related challenges into opportunities for additional value.

The traditional approach of flood control and water management solely through engineered solutions is no longer sufficient. There is a need to shift towards a more holistic and sustainable approach that considers the dynamic interaction between humans and wildlife, taking the natural processes and ecosystems into the system to regulate water flow and storage.

The current urban development patterns, characterized by increased impervious surfaces and altered hydrological flows, have resulted in frequent and severe flooding events. These flood risks are further compounded by the changing climatic conditions and the limited availability of suitable land for expansion. Conversely, the growing population's increasing demand for housing, infrastructure, and economic development is putting pressure on the existing land, pushing development into unplanned areas.

In addition, lessons can be learned from the indigenous communities, whose traditional knowledge and connection with the land can provide valuable insights for managing water resources and creating a landscape that evolves in harmony with both human and wildlife needs.

The successful resolution of these challenges will require a multidisciplinary approach, involving urban planners, engineers, ecologists, policymakers, and community members. By developing a sustainable urban hydrologic system that transforms the negative impacts of threatening water issues into additional values, Winnipeg can achieve a resilient and thriving urban expansion, where human and wildlife communities coexist and contribute to the evolving landscape.

4.1 Research Question

How to design **a resilient spatial framework** for Winnipeg in response to the flood challenge and integrate nature-based principles to achieve **long-term coexistence between man and wildlife** in a cohesive urban design?

Sub Questions

*1. How can we increase **stormwater storage** through ecological rehabilitation based on the current fragmented open space structure?*

*2. How to incorporate Winnipeg's **urban hydrologic system and ecosystem** into the solution response to threatening floods?*

*3. In what way can we use **beaver ecology** as a cost-effective strategy to secure and stabilize water flows in the urban system?*

*4. Can the deep connection of **human settlements and local ecosystem** in the indigenous insight be revitalized in the urban dwelling environment?*

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4.2 Design Objective

Three levels of design objectives are expected to be reached in this project:

System Level

To implement specific restoration strategies on various components of the urban hydrologic system, such as major waterways, tributaries, and water surfaces. This includes measures like restoring natural flow patterns, preventing erosion, and reducing stormwater runoff through the use of green infrastructure techniques. By mimicking natural hydrological processes, water management can be optimized, reducing the risk of flooding and enhancing water quality.

In the system level, a crucial aspect of the design is to build a green-blue network. This network can integrate green spaces and blue infrastructure in the urban fabric, creating a cohesive and interconnected system that enhances the urban hydrological cycle and promotes ecological resilience.

Habitat Level

To enhance the volume of water storage through ecological rehabilitation. This can involve restoring wetlands, creating retention ponds, and incorporating natural drainage systems that allow for water infiltration and storage. These measures increase the capacity to retain water during rainfall events, mitigating flooding and replenishing groundwater resources. Additionally, the creation of ecological corridors and green spaces can provide habitats for native flora and fauna, supporting biodiversity and improving the overall ecological health of the urban environment.

The design can focus on incorporating sustainable measures in neighborhoods, implementing nature-based solutions like green roofs, rain gardens, and bioretention swales.

Species Level

To introduce beavers as a positive addition to the urban ecosystem. Empowering beavers in appropriate locations within the urban environment can provide a range of benefits, including improved water storage, increased biodiversity, and enhanced ecosystem resilience. This requires careful consideration of ecological dynamics, coexistence with human activities, and long-term management plans to ensure a balanced and sustainable coexistence between beavers and urban communities.

The design aims to explore and enhance positive interactions among a diversity of species and inhabitant groups. This involves creating spaces that support biodiversity and provide opportunities for people to engage with nature.

5.1 Theoretical Framework

Five-step approach

Sven Stremke

This approach proposes a five-step methodological framework for spatial planners and landscape architects to work at the regional scale. It helps adapt the design and planning of sustainable landscapes to to a changing environment, and advances long-term thinking in regional planning and design.

It's necessary to consider the integration of three modes of change into the design process:

a) change due to current, projected trends,
b) change due to critical uncertainties,
c) intended change.

The five steps from the methodological framework are led by a set of questions and composed into a sequence, which should be passed through twice.

Step 1: analysing present conditions: how does the present region function and how can it be evaluated in comparison with other regions?

Step 2: mapping near-future developments: how will the region change in the near-future?

Step 3: illustrating possible far futures: what kind of possible long-term developments (at which location) are expected in the study region?

Step 4: composing integrated visions: how can we turn a possible future into a desired future?

Step 5: identifying spatial interventions: which possible intervention should be implemented?

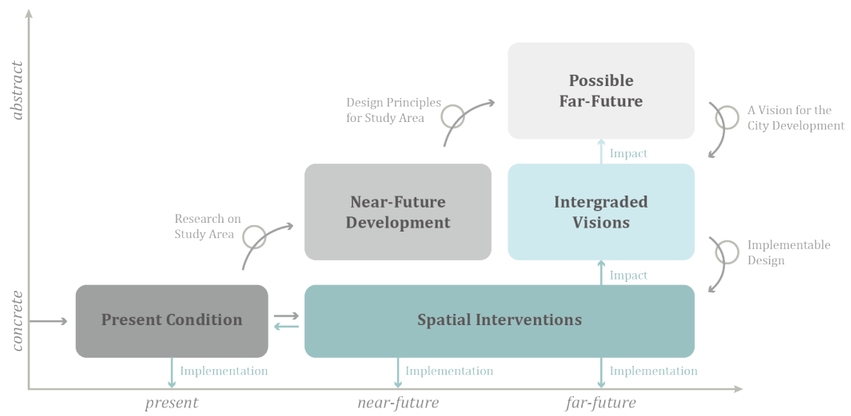

Figure 5-1: Methodological framework of the five-step approach for integrated visions
Adapted from Sven Stremke, 2010

ECOPOLIS

Sybrand Tjallingii

The general principle of this theory is to view the city as a dynamic and complex ecosystem, not just a metaphor. The social, economic, and cultural aspects of the city are influenced by the rules of abiotic and biotic nature. There are three main themes in the ECOPOLIS Strategy Framework:

The Responsible City: Urban areas must take responsibility for environmental issues caused by input and output flows. Strategies should be developed to regulate these flows and ensure the quality of the surrounding environment.

The Living City: Ecological rules within the city must be considered to create a healthy habitat for both people and nature. Utilizing local ecological potential can contribute to the city's identity and environmental diversity.

The Participating City: People's involvement in the management of their environment is crucial. Strategies should be developed to increase public participation and address urban problems through different lifestyles and types of businesses.

These themes highlight the importance of responsibility, adherence to ecological rules, and public engagement in achieving ecologically sustainable urban development.

The theory also suggested to use a set of 'guiding models' for chains, areas and organization to help develop dynamic urban systems.

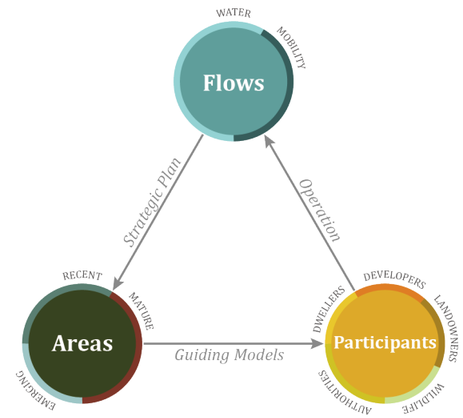

Figure 5-2: Framework for the three guiding models
Concluded and drawn by author

Swarm Planning
Rob Roggema

The theory points out a growing need for approaches that incorporate dynamic environments, embrace change, and recognize the role of key actors outside of government in shaping spatial order.

Swarm Planning proposes two planning strategies in two different levels. At the system level, early interventions are necessary to initiate self-organizing processes and anticipate wicked problems. At the component level, landscape elements are attributed with qualities to enable emergent behavior and self-organization.

Swarm Planning theory enhances the beneficial aspects of swarm behavior in improving overall resilience and mitigating the negative impact of uncertainties, complexity, and change.

Patch-Corridor-Matrix Theory
Richard T. T. Forman

As the foundational theory of landscape ecology, Patch-Corridor-Matrix Model highlights the importance of considering both the structural and functional aspects of landscapes. It recognizes that landscapes consist of various elements, including patch, corridor and matrix.

Patches, as discrete habitat areas, function in supporting biodiversity and ecological processes. Matrixes, the surrounding elements, provide context and influence the movement and interactions of organisms within and between patches. Corridors serve as vital linkages, facilitating the movement of species and genetic flow, thus promoting resilience and enhancing landscape connectivity.

This theory emphasizes the interconnectedness and interdependence of these landscape elements. It recognizes that a balanced landscape, characterized by a mosaic of patches embedded within a suitable matrix and connected by corridors, promotes ecological health, species conservation, and ecosystem functionality.

5.2 Research Methodology

This project applies the 'Research by Design' methodology in the following steps:
Introduction: Provide an overview of the study, introducing and defining the topic of the study.

Fascination: Describe the aspect that sparked the researcher's interest or curiosity, highlighting the motivation behind the study.

Problem Statement: Clearly state the problem or issue that the research aims to address, identifying the gap or knowledge deficit in the existing condition.

Research Question: Formulate a specific research question that guides the investigation and serves as a focal point for the study.

Design Objective: Define the objective or goal of the research, specifying what the study aims to achieve or contribute to the field.

Data Collection & Analysis: Gather relevant resources and intergrate the collected data to instrumental conclusions.

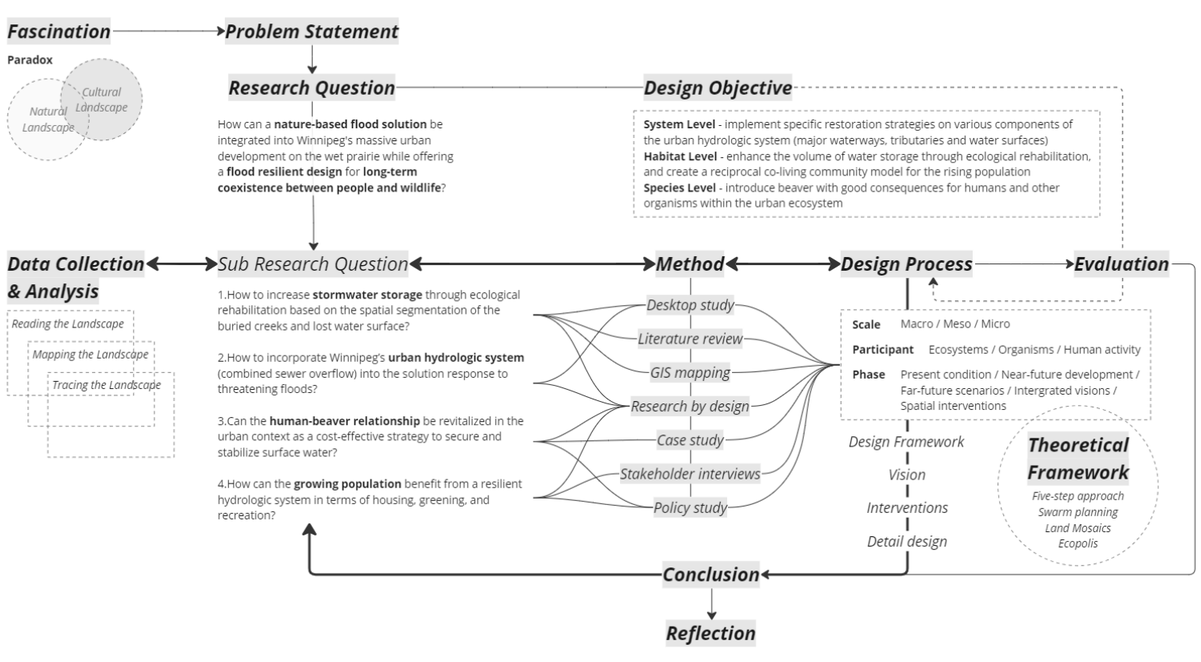

Figure 5-3: Research Methodology
Completed by Author

Methods: Provide a series of research methods or approaches used to answer the research question, including literature study, mapping, case study and mixed methods.

Design Process: Outline the step-by-step process undertaken to develop and refine the research design or intervention. This section can include a variety of scales, participents and phases.

Conclusion: Summarize the outcomes of the study, highlighting their implications and contributions to the field.

This section may also address any limitations or areas for future research.

Reflection: Engage in critical reflection on the research process and address limitations in the project. Discuss the researcher's own insights, challenges, and lessons learned throughout the study.

In the methodology, it should be emphasized that the processes between data collection and analysis to methods, design process, and conclusion are not a linear progress but rather a continuous iterative cycle. This means that these stages of the research and design may involve back-and-forth iterations, adjustments, and refinements based on the emerging paradox and insights.

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5.4 Time Planning

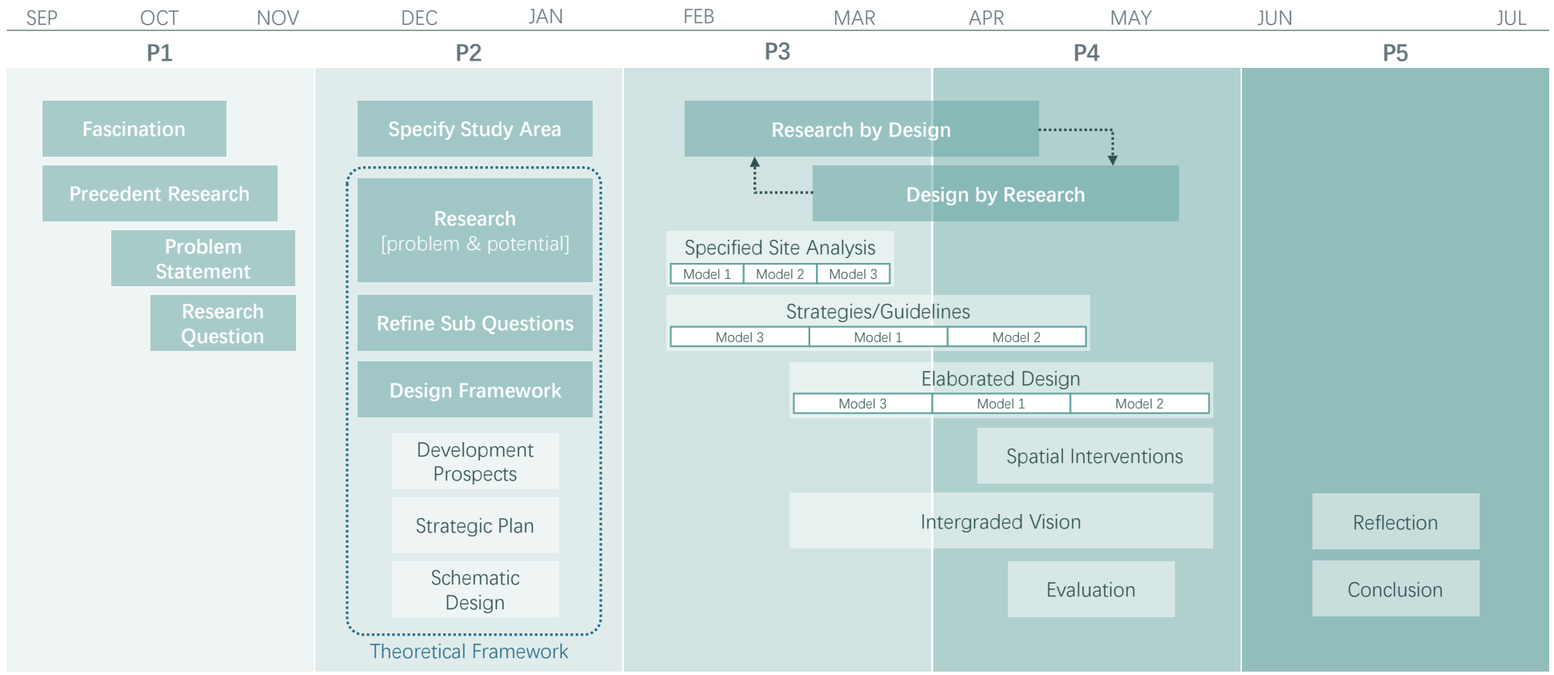


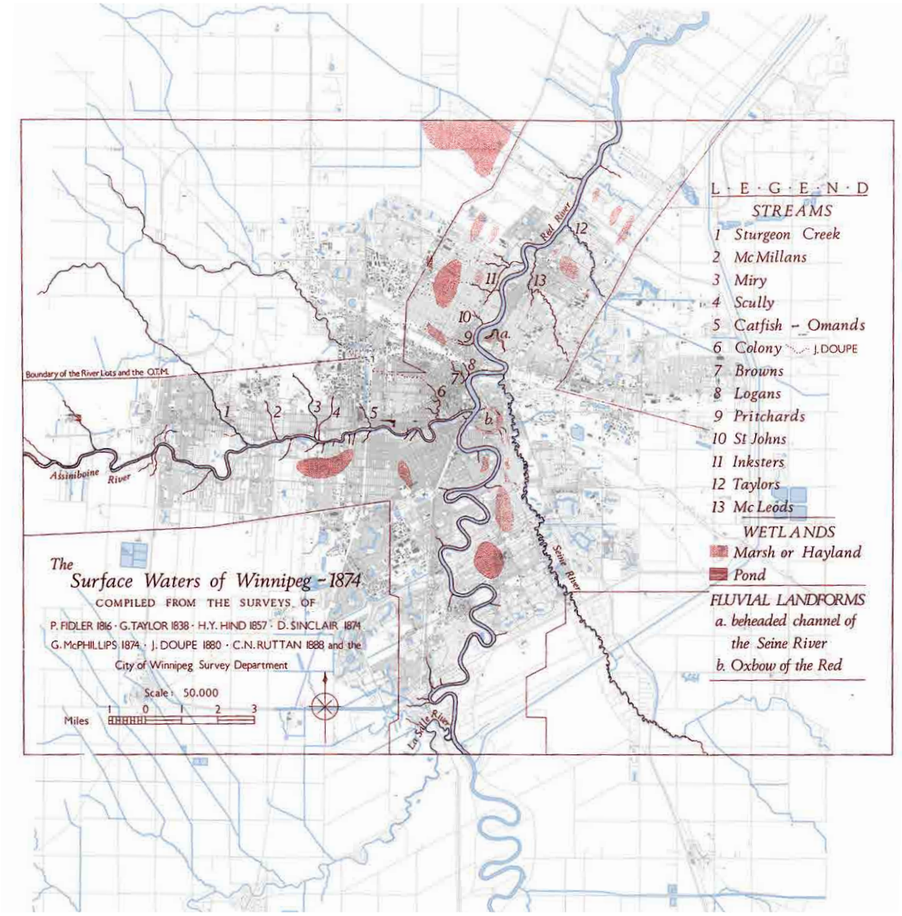
Figure 5-4: Time Planning
Completed by Author

PART 2

Design Research

6.1 Historical Water Features

The overall layout of Winnipeg's urban water system has undergone significant changes. Meandering natural creeks have been replaced by canals and sewer systems that feed directly into the river. The disappeared creeks are concentrated to the northwest of the Fork. On the west bank north of the Red River, more than a dozen creeks have been completely filled, including some large wetlands and marshes. The urban structure of built environment has hardly been adapted or conceded to the riparian space or buffer area in any form.



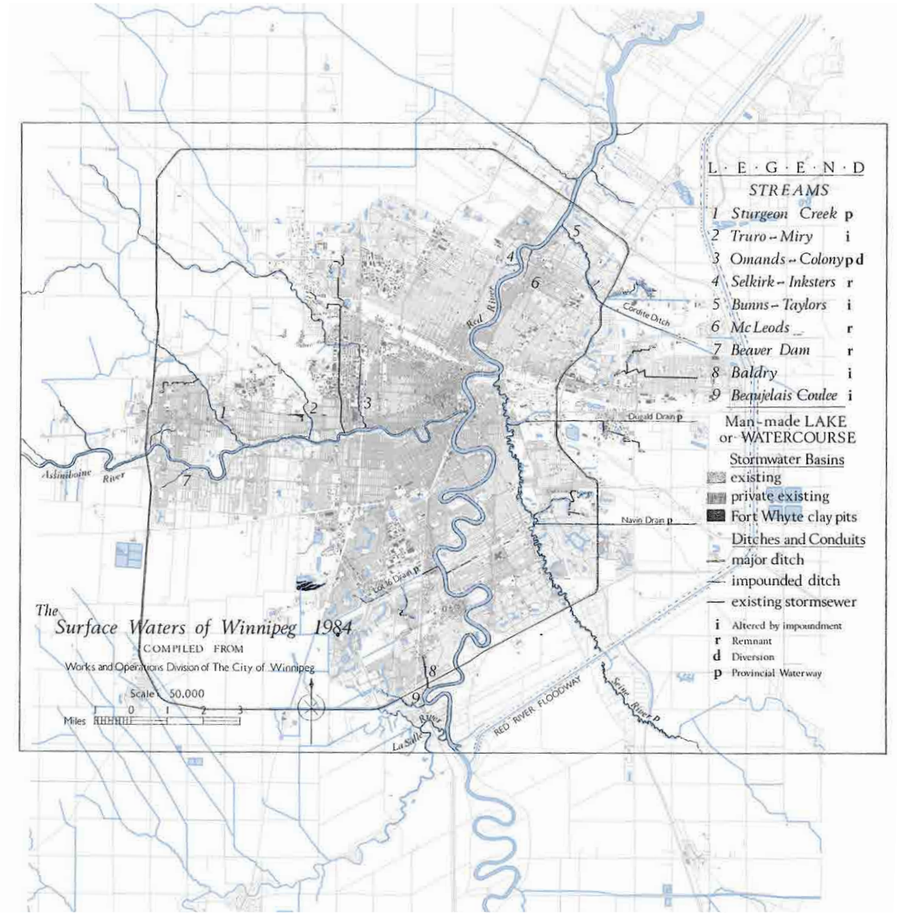


Figure 6-1: Comparing the present water system with the ones of 1874 and 1984 in Winnipeg
Map source: Graham, Robert Michael W. The surface waters of Winnipeg: rivers, streams, ponds and wetlands 1874-1984: the cyclical history of urban land drainage
Mapping made by Author

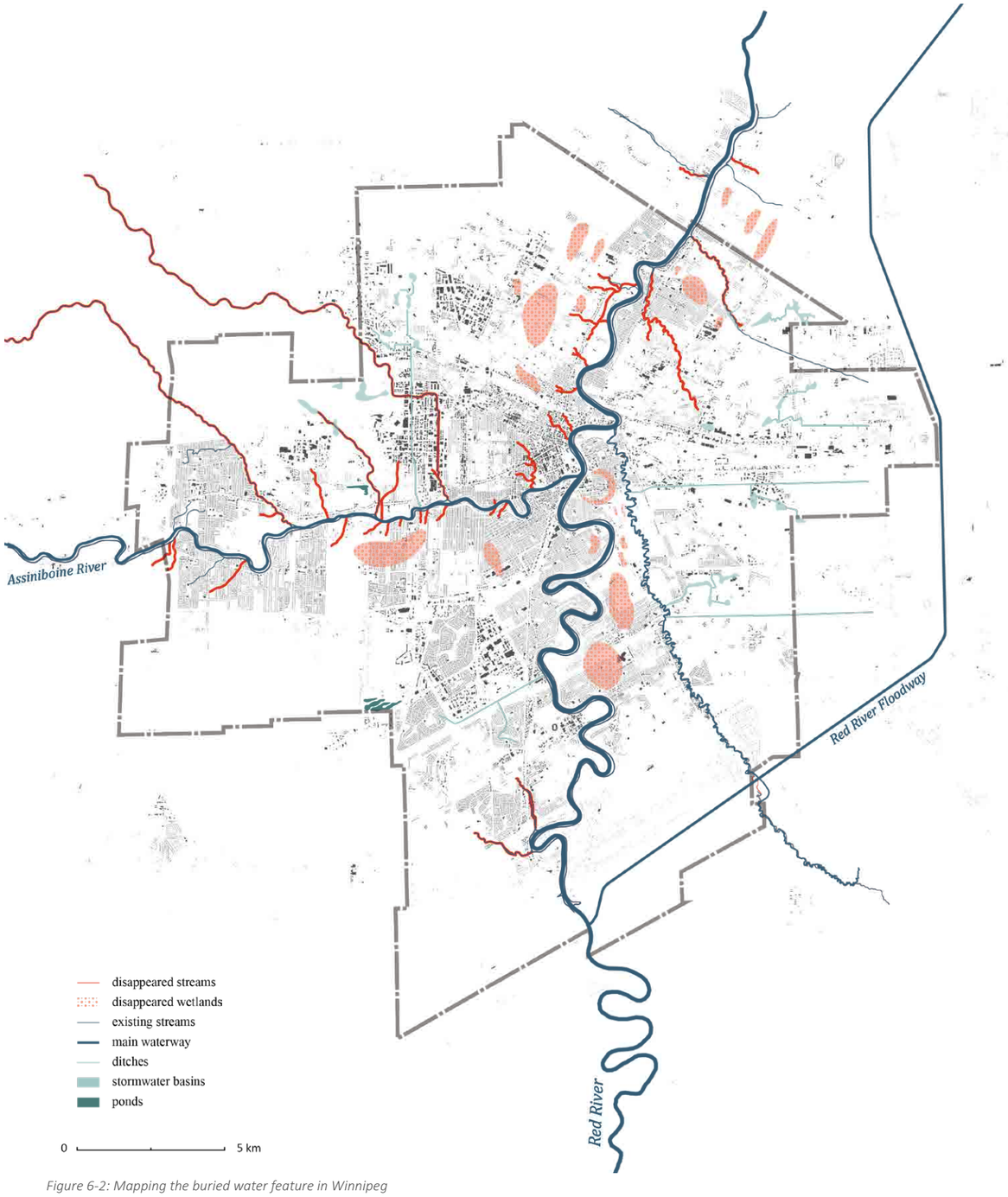


Figure 6-2: Mapping the buried water feature in Winnipeg
Completed by Author

Figure 6-3: A model representing water conditions
Models and photos made by Author

Flow State of Water

In this model, the persistent artery with the corrugated appearance shows that water flows in a high rate and discharge, while the dashed curves represent the intermittent tributaries, which have mostly disappeared. Compared to the mainstream, water-logged areas hold less power in terms of water transfer, but have great potential for water storage. Therefore the marshes and wetlands are displayed through peeled surfaces, as a relatively static state of the water.

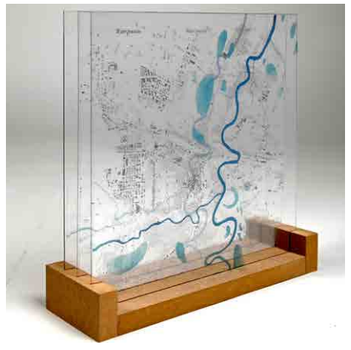


Figure 6-4: A model representing water surface change
Models and photos made by Author

Relocation of Water Surface

During the significant technical and territorial transformations in the last two centuries, the rivers and creeks have been heavily dammed and channelized. The hasty attempt at city development resulted in immediate economic benefits, but at the expense of eliminating the land's ability to drain water through naturally occurring streams and coulees. The different distributions of faint blue areas nicely demonstrate the relocation of surface water over time.

6.2 Open Space Allocation

The present green space pattern, instead, is redeveloped by the city targeted to be public spaces, parks, and sports fields in the new grid plan. These areas provide residents and visitors with opportunities to engage with nature, but ironically in a way of reestablishment. The fragmented distribution of urban parks and open spaces indicates that there're limited green corridors that promote pedestrian and cycling access or contribute to ecological connectivity.

Another important feature is that many pocket parks in residential areas serve a single function, primarily sports activities. This results in a park that can only accommodate a single plant community, in the form of manicured lawns.

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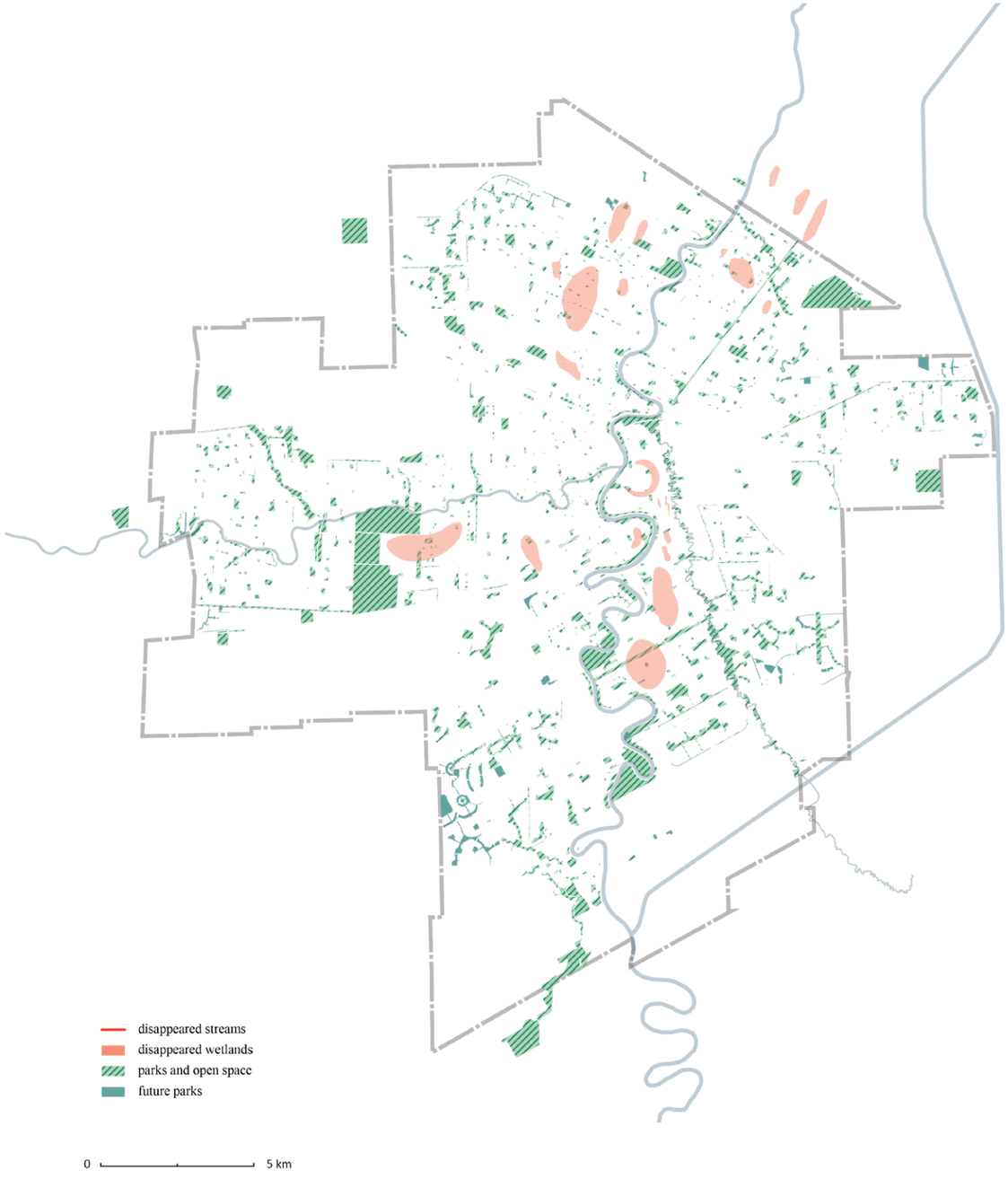

Figure 6-5: Mapping the public green space and potential for water storage in Winnipeg
Completed by Author

6.3 Flood Risk

Based on the open data of changes in floodplain regimes over Canada due to climate change, the flood water depth information is presented in the time period of 2020 to 2060 for 100-yr return period.

Although this set of data can only be used as a spatial reference, it cannot accurately simulate the complex conditions under the influence of snowmelt, rainstorm and urban drainage system. We are still recognize the flooding issues in the northwest part of the city, and foresee a significant damage from medium to large flooding events.

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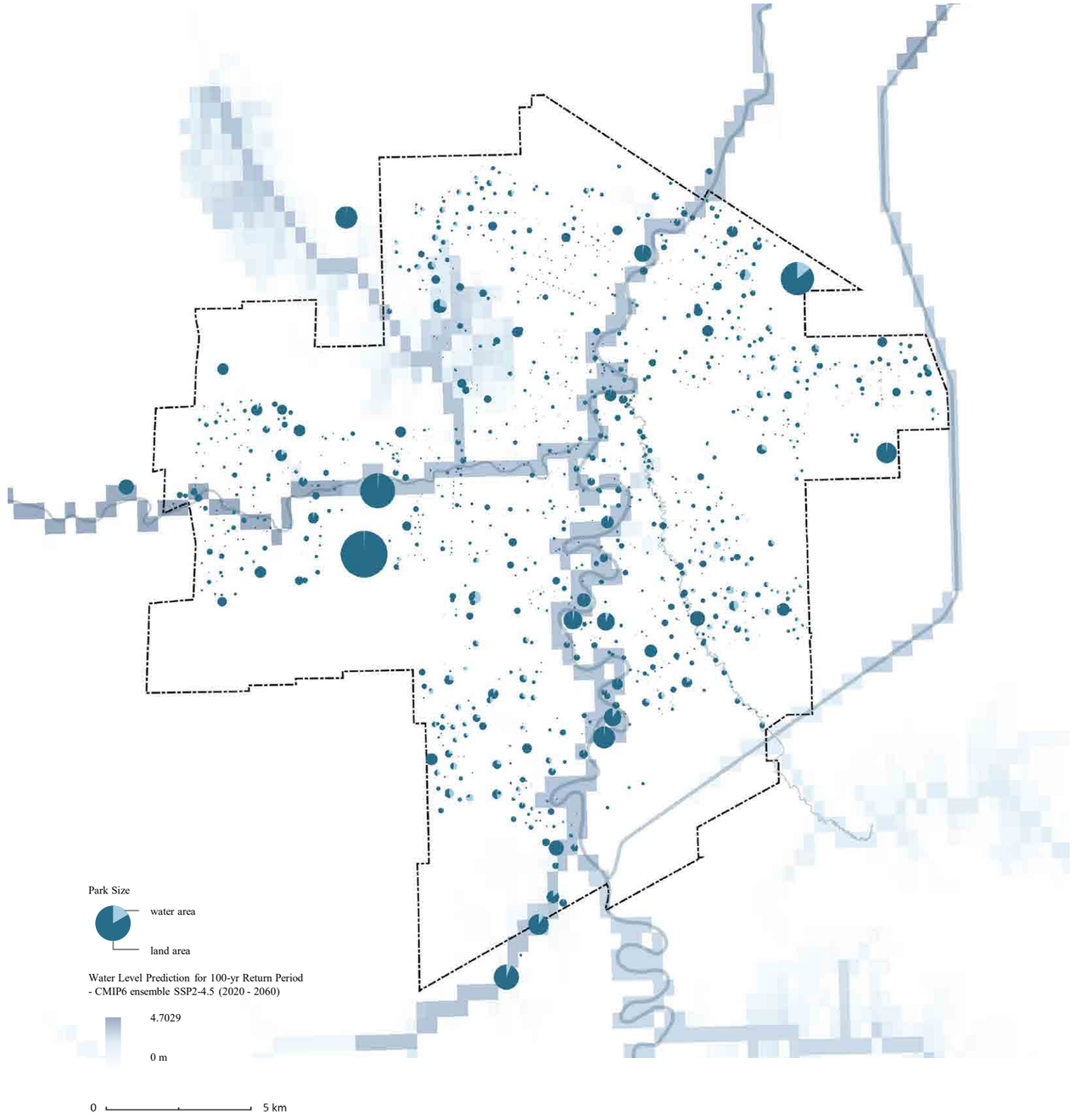


Figure 6-6: Mapping the flood risk area in Winnipeg
Completed by Author

6.4 Rethinking Beavers

In Canada, beavers hold a significant place in the country's history, culture, and natural heritage. They are often considered a national symbol and are protected under Canadian law. Now more Canadian cities recognize the ecological importance of beavers and embrace their presence in urban areas.

Beavers bring great benefits to local ecosystems in building and maintaining ecosystems, particularly in aquatic habitats. Their ability to construct dams and lodges not only help maintain surface water and improve water quality, but also create attractive habitat for other wildlife and enhance a whole ecosystem.

While a certain number of beavers live in urban environments, dilemmas and challenges present in infrastructure interference, tree damage and public perception. Reintroducing beavers requires deep understanding in the role of beavers in ecosystems and thoughtful management approaches to keep a balance between human needs and the ecological benefits of these remarkable animals.

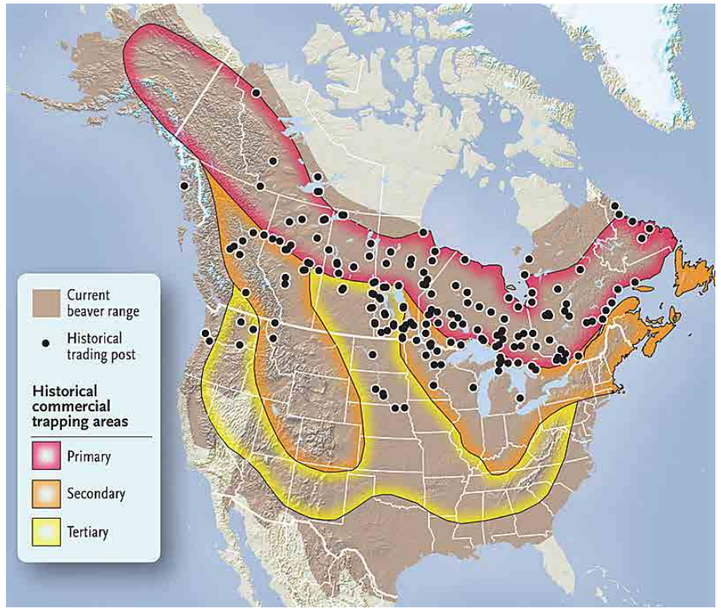


Figure 6-7: Current beaver range and historical commercial trapping areas
Source: Chris Brackley, Historical Atlas of Canada, Wild Furbearer Management and Conservation in North America)

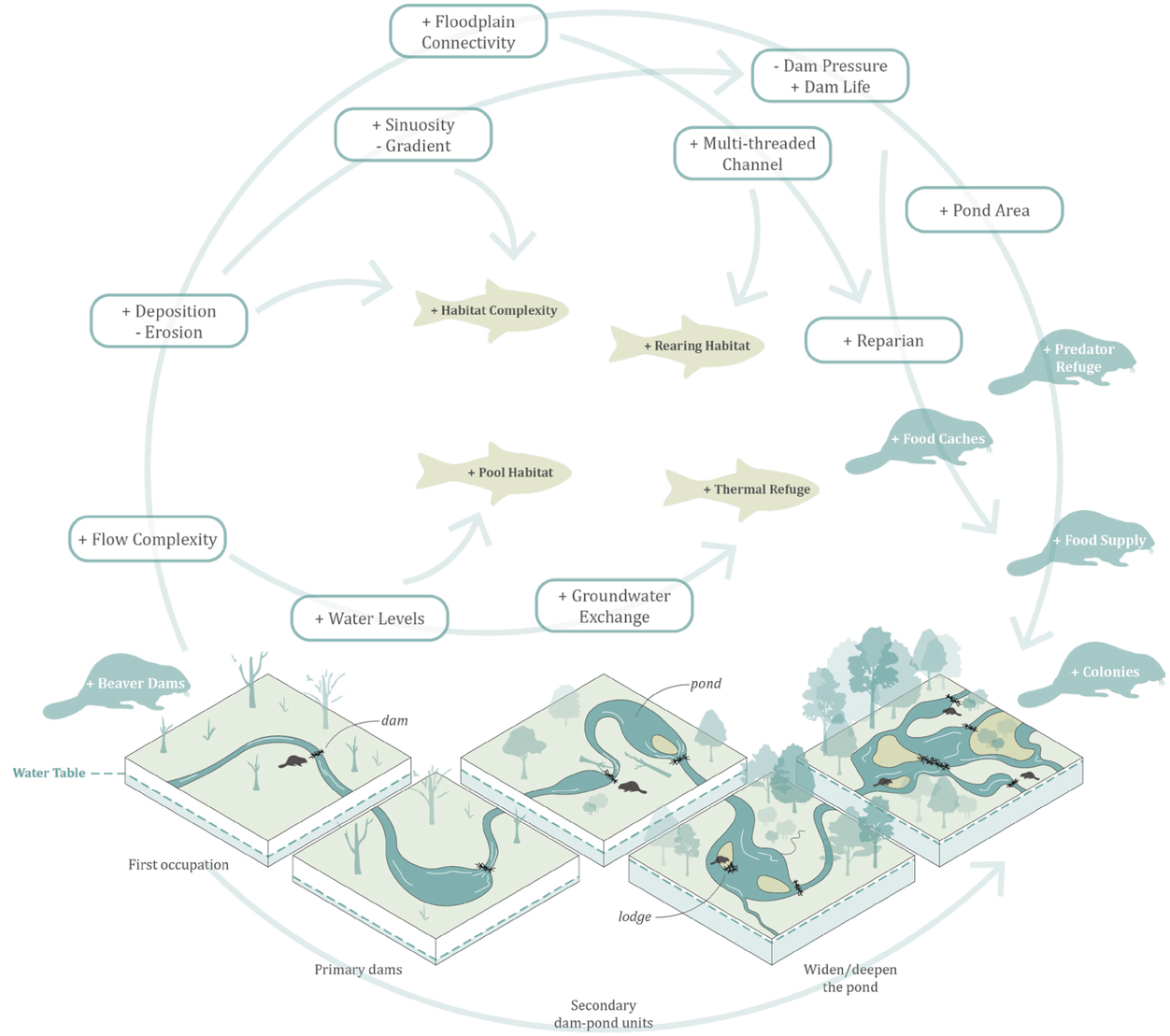


Figure 6-8: The forming process and ecological influence of a beaver pond complex
Completed by Author

6.5 Population Flow

Winnipeg exhibits diverse population characteristics that contribute to its vibrant and multicultural identity. The city is home to a steadily growing population with a mix of ethnicities, cultures, and languages. Indigenous communities and a growing population of immigrant communities have contributed to the city's cultural diversity and enriching its social landscape.

While the city offers a mix of economic opportunities, there are pockets of socio-economic disparities, with some communities facing challenges such as poverty, unemployment, and inequality. This spacially related to the communities with more indigenous residents.

Seen the diverse needs and aspirations of Winnipeg's population, there are potentials to engage these communities into the proper step of the design planning for promoting social cohesion for the city's residents and creating a more equitable and sustainable city.

Population Identifying Reporting North American Origins in Winnipeg

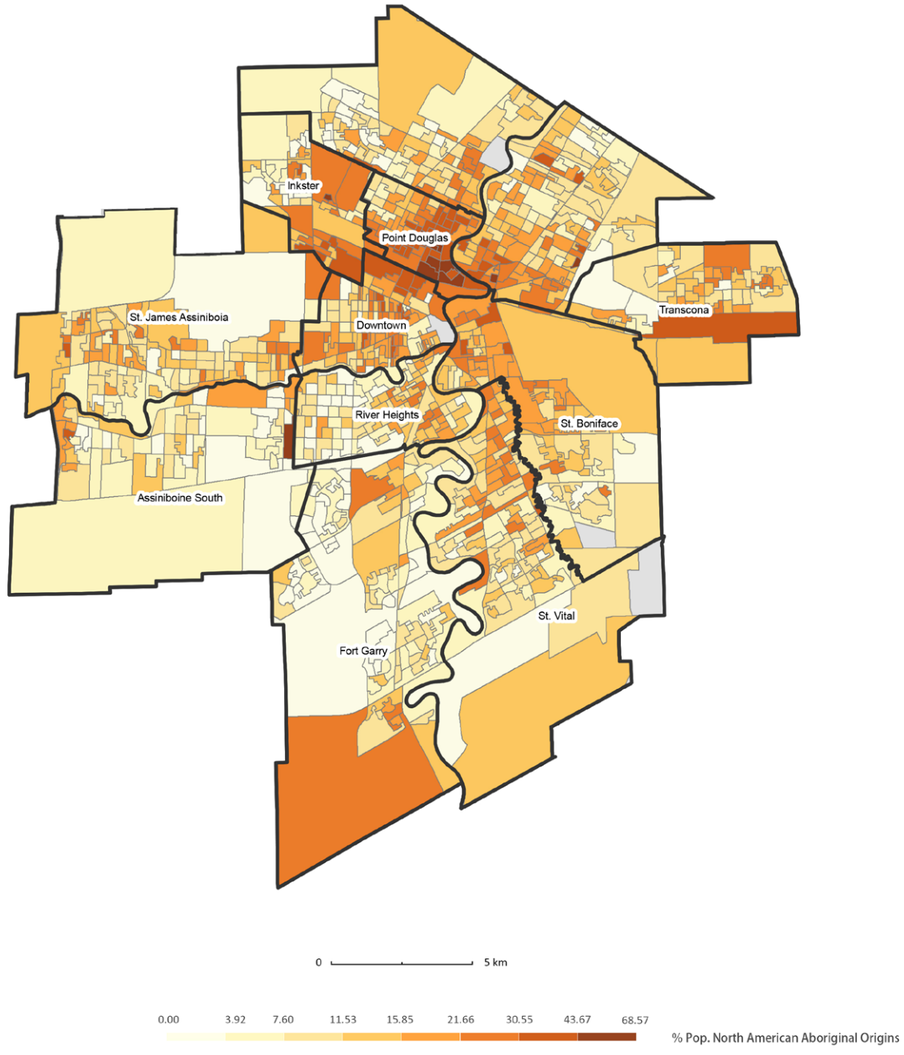


Figure 6-9: Population Identifying Reporting North American Origins in Winnipeg
Source: Manitoba Collaborative Data Portal

Population Identifying as a Recent Immigrant in Winnipeg

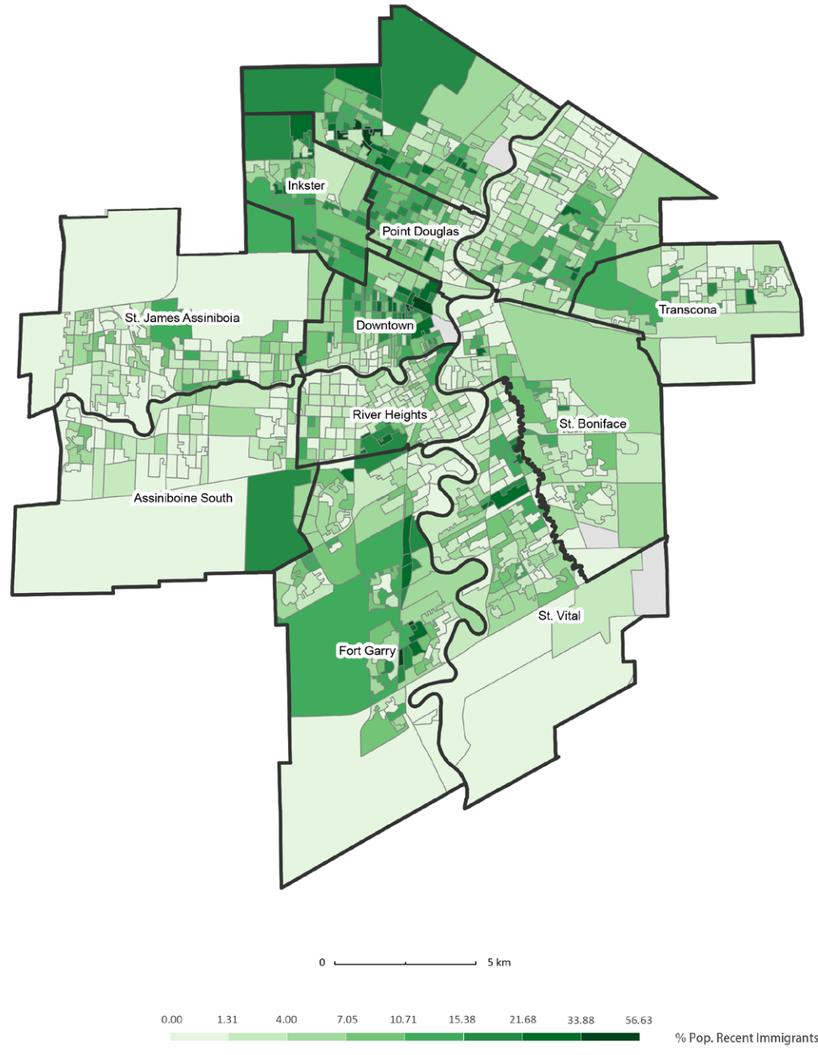


Figure 6-10: Population Identifying as a Recent Immigrant in Winnipeg
Source: Manitoba Collaborative Data Portal

6.6 Community Study

Age of construction

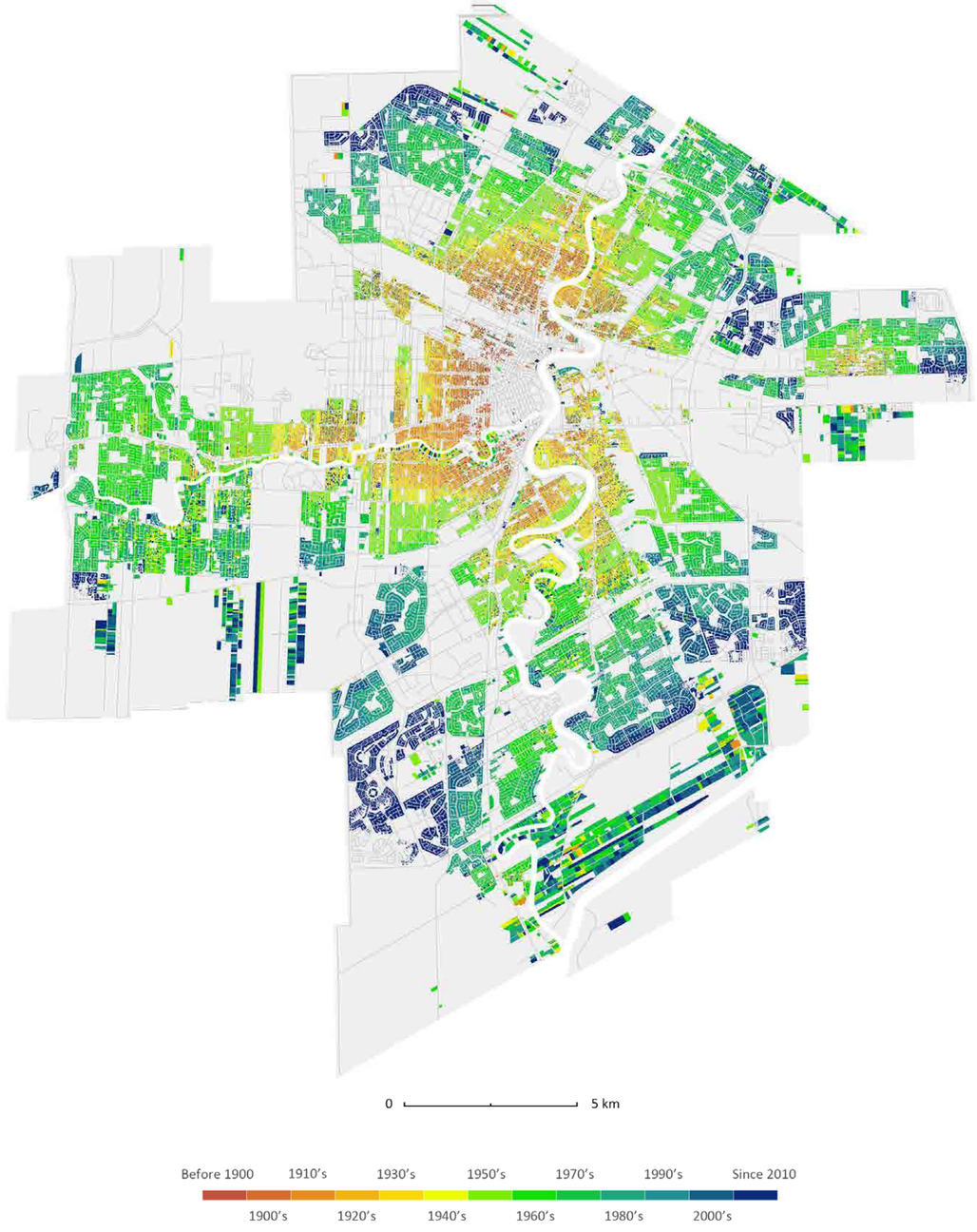


Figure 6-11: Construction Age of the Residential Area
Source: https://www.reddit.com/r/Winnipeg/

Housing Type

Figure 6-12: Type of housing in the Residential Area
Completed by Author

6.6 Community Study

Community Type

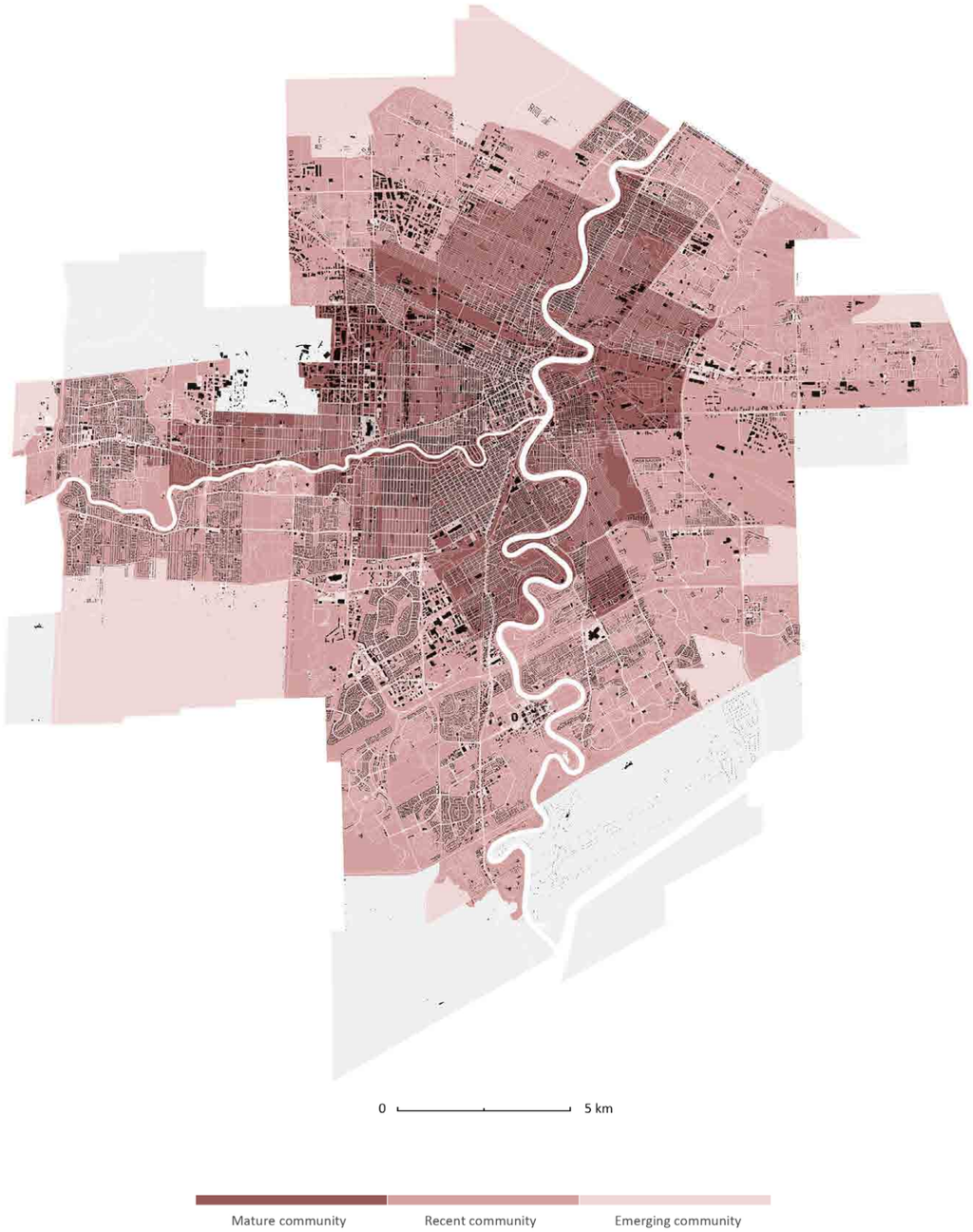


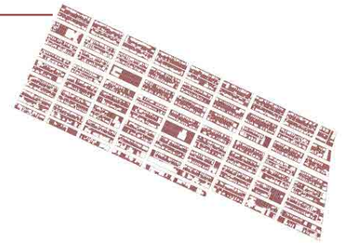
Figure 6-13: Community Type
Completed by Author

Dwelling Density

Mature Community *William Whyte (1900)*

Population: 6,295
Dwellings: 2,160
Area: 1,161,579 m²

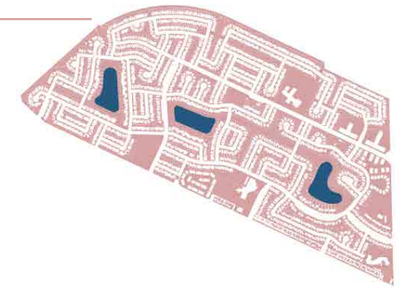
7.5 du/ac
2.9 p/du



Recent Community *Amber Trails (2000)*

Population: 8,533
Dwellings: 2,170
Area: 1,993,120 m²

4.4 du/ac
3.9 p/du



Emerging Community *West Kildonan Industrial (constructing)*

Population: 0
(growth in 10 years: 4,550)
Dwellings: 0
Area: 2,231,843 m²

approx. **3.5 p/du**
New dwelling units in 10 years: **1300**

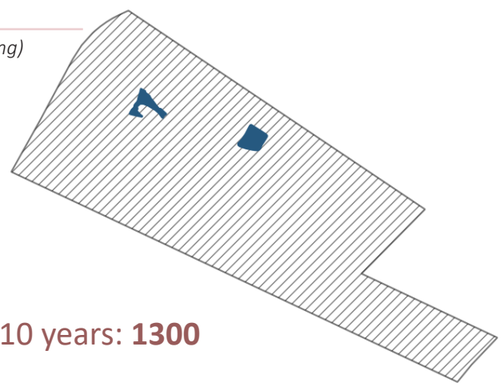


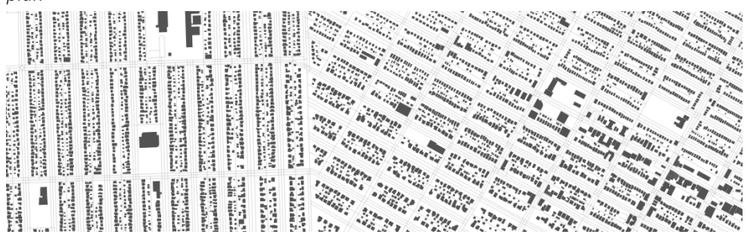
Figure 6-14: Three Typical Neighborhoods from Three Community Types
Completed by Author

Community Characteristic

Mature Community

- Grid pattern of roads
- Primarily north-south, east-west orientation of streets with back lanes
- Older housing stock
- A variety of housing types and lot sizes
- Largely planned prior to the 1950s

plan



perspective

streew view

Recent Community

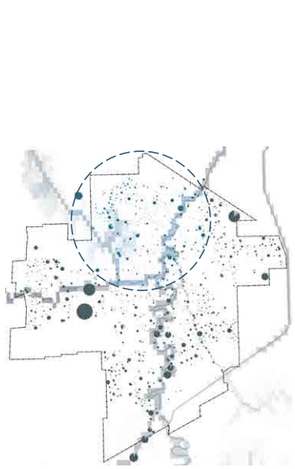
- Dispersed, low to medium-density development patterns
- Curvilinear local road pattern with many cul-de-sacs
- Typically planned after 1950

Emerging Community

- Curvilinear road pattern with cul-de-sacs
- Planned communities that are still under development
- Primarily single-family residential with some multifamily and retail

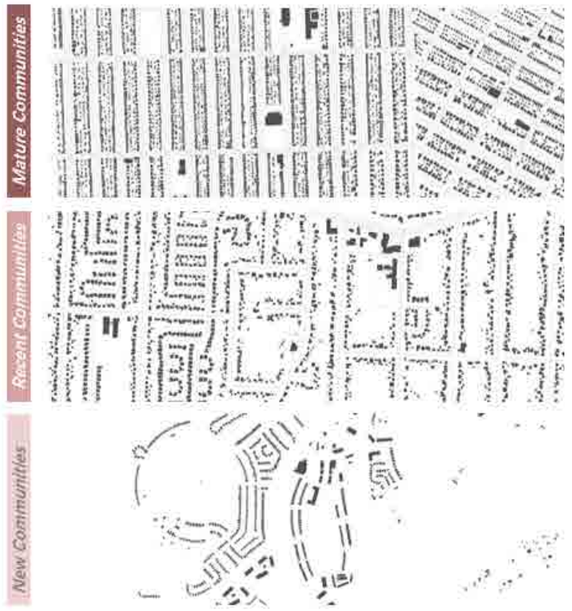
Figure 6-15: Characteristic Analysis of Three Community Types
Data source: open street map; Image source: Google Streetview
Completed by Author

6.7 Area of Focus



Urban area with poor resilience

Buried creeks and wetlands



The intergrated design process select the North-west region of the Fork as an ideal study area for investigating urban expansion, flood dynamics, and the impacts of development on the natural environment, as outlined below:

Burial of Natural Creeks: The analysis reveals that during urban expansion, the natural creeks in the region were buried. This suggests that the North-west area of the Fork was subject to significant urban development, resulting in the alteration and covering of the original watercourse. Therefore, the study area is situated in the North-west region due to the presence of buried natural creeks.

High Flood Risks: Another reason for selecting the North-west region as the study area is the high flood risks associated with this area. The analysis indicates that this area of the Fork is particularly susceptible to flooding. It might be due to factors such as differences in terrain, impermeable clay soil and inadequate drainage infrastructure. Given the high flood risks in this region, it becomes crucial to study and understand the dynamics of flooding in the area.

Transition from the old to the new area: The North-west region of the Fork has undergone a significant transformation over time. It is mentioned that this area has evolved from the oldest neighborhood into a massive developing area. This suggests that the North-west region has experienced substantial urbanization and development activities, making it an interesting location for study. Understanding the changes and development patterns in this area can provide insights into urban growth, land-use changes, and associated environmental implications.

PART 3

Design Exploration

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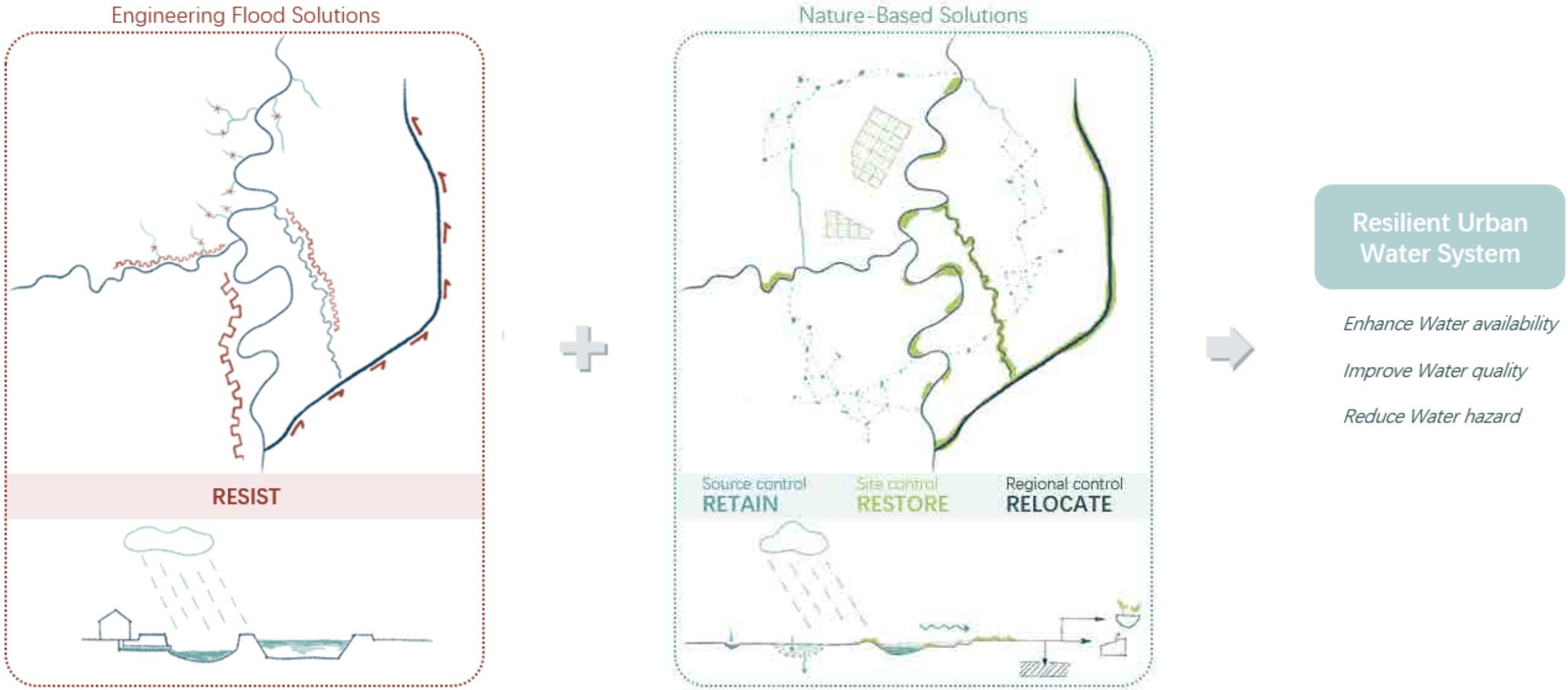
7.1 General Concept



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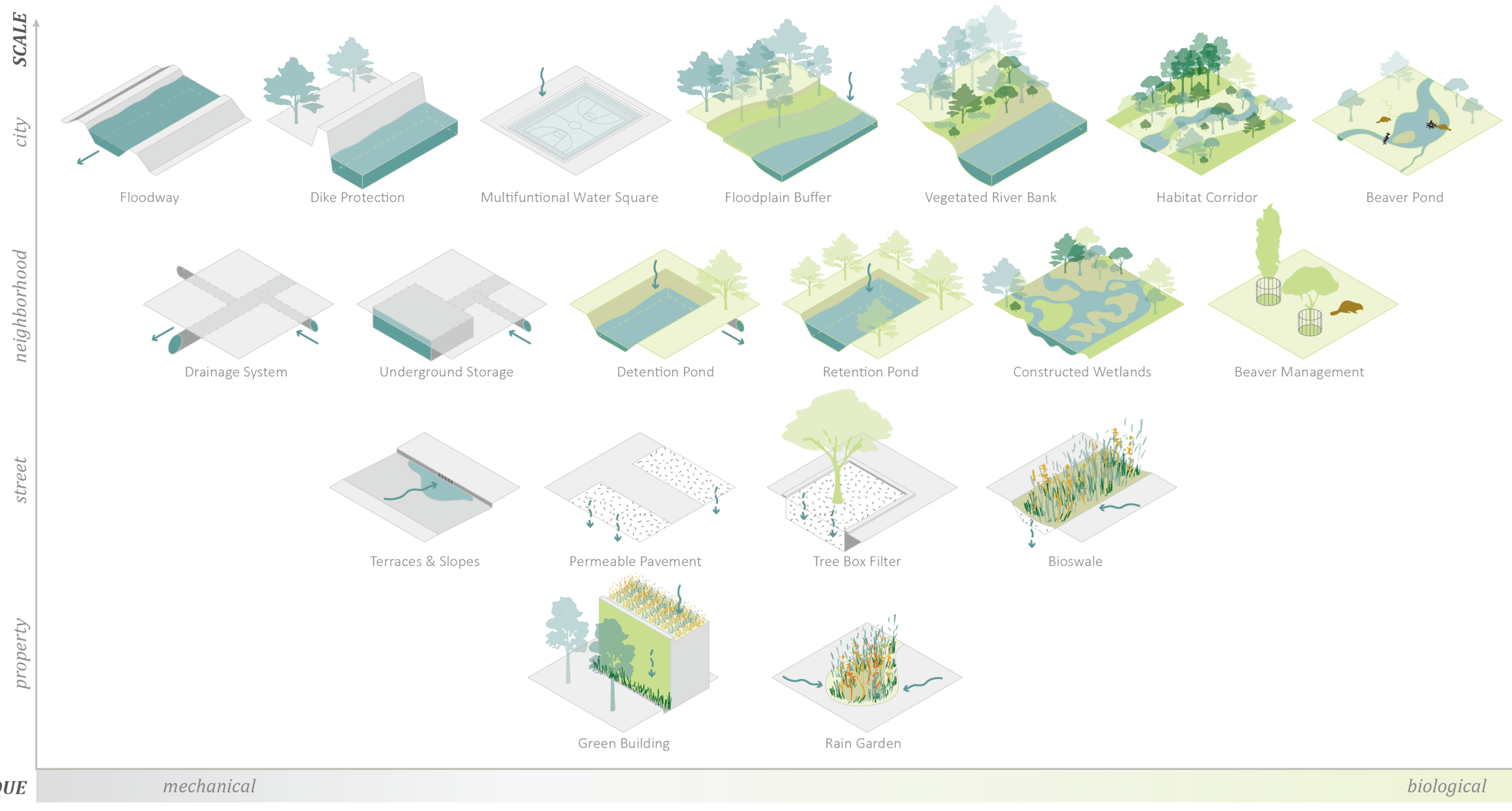
7.2 Urban Flood Resilience Toolbox



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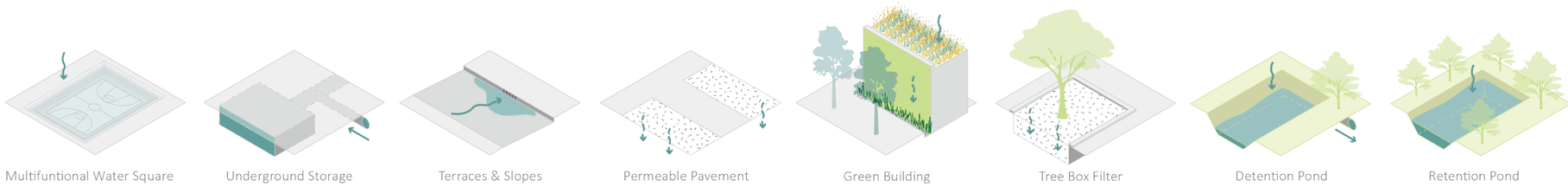
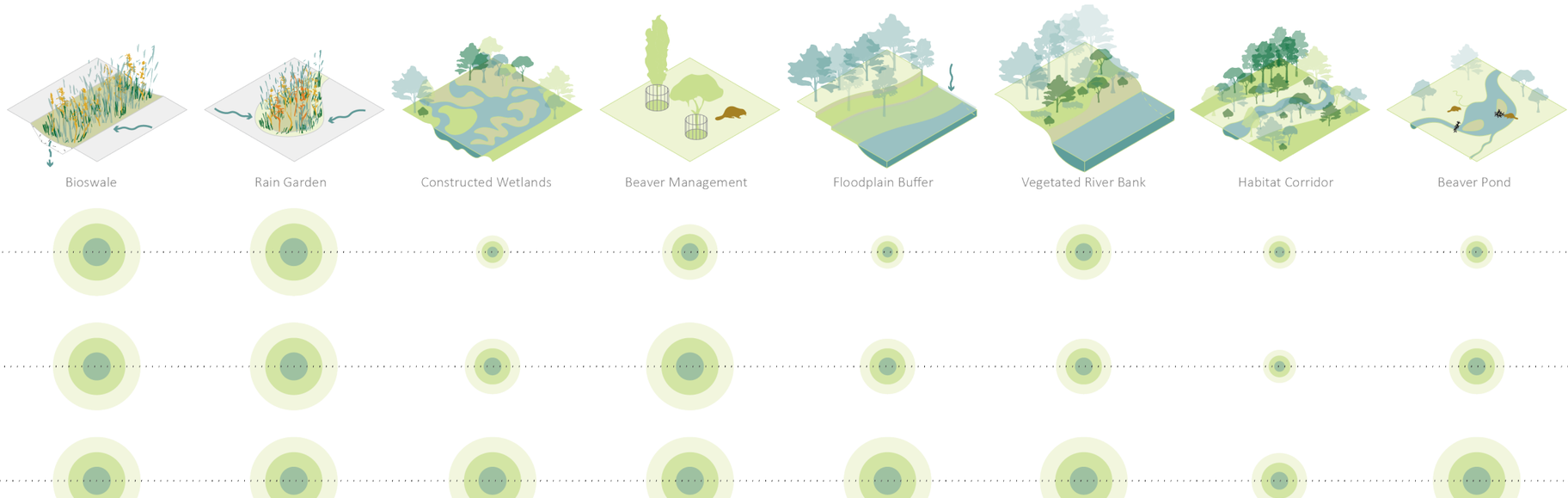
Toolbox Feasibility Assessment

Recommended Practical Not advised





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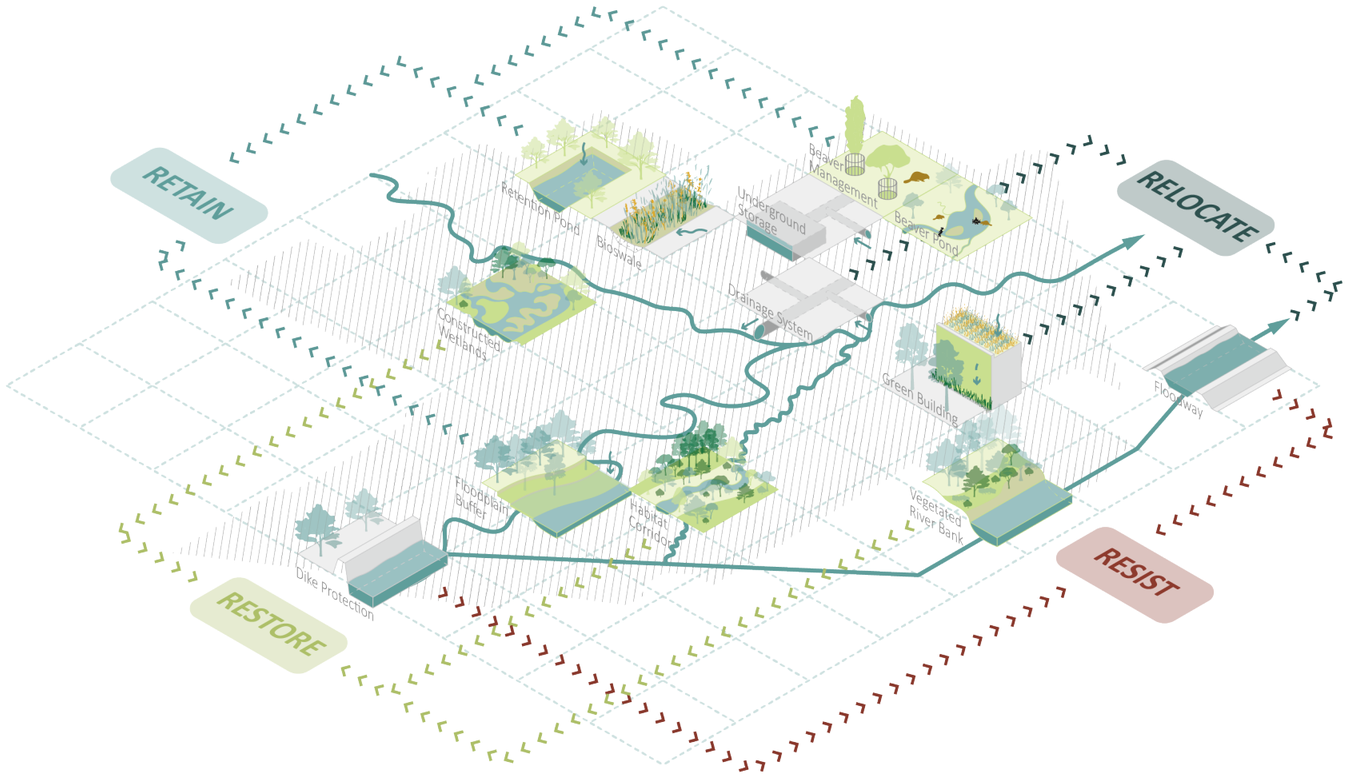
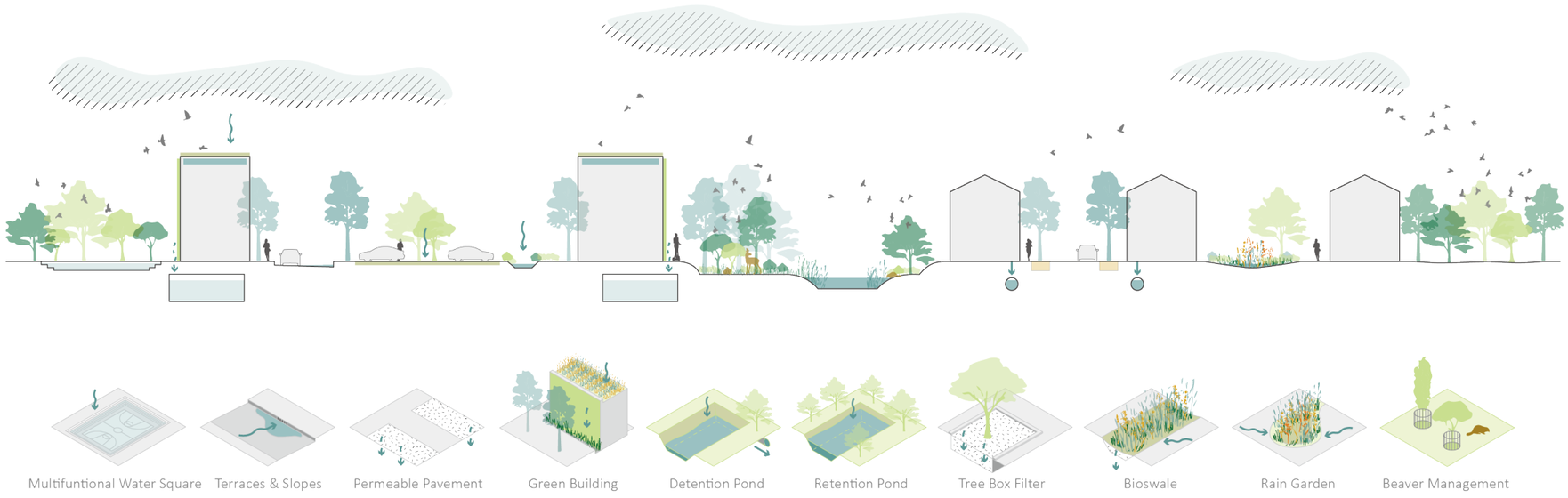
7.3 Urban Flood Resilience Scheme

At the city level



At the neighborhood level



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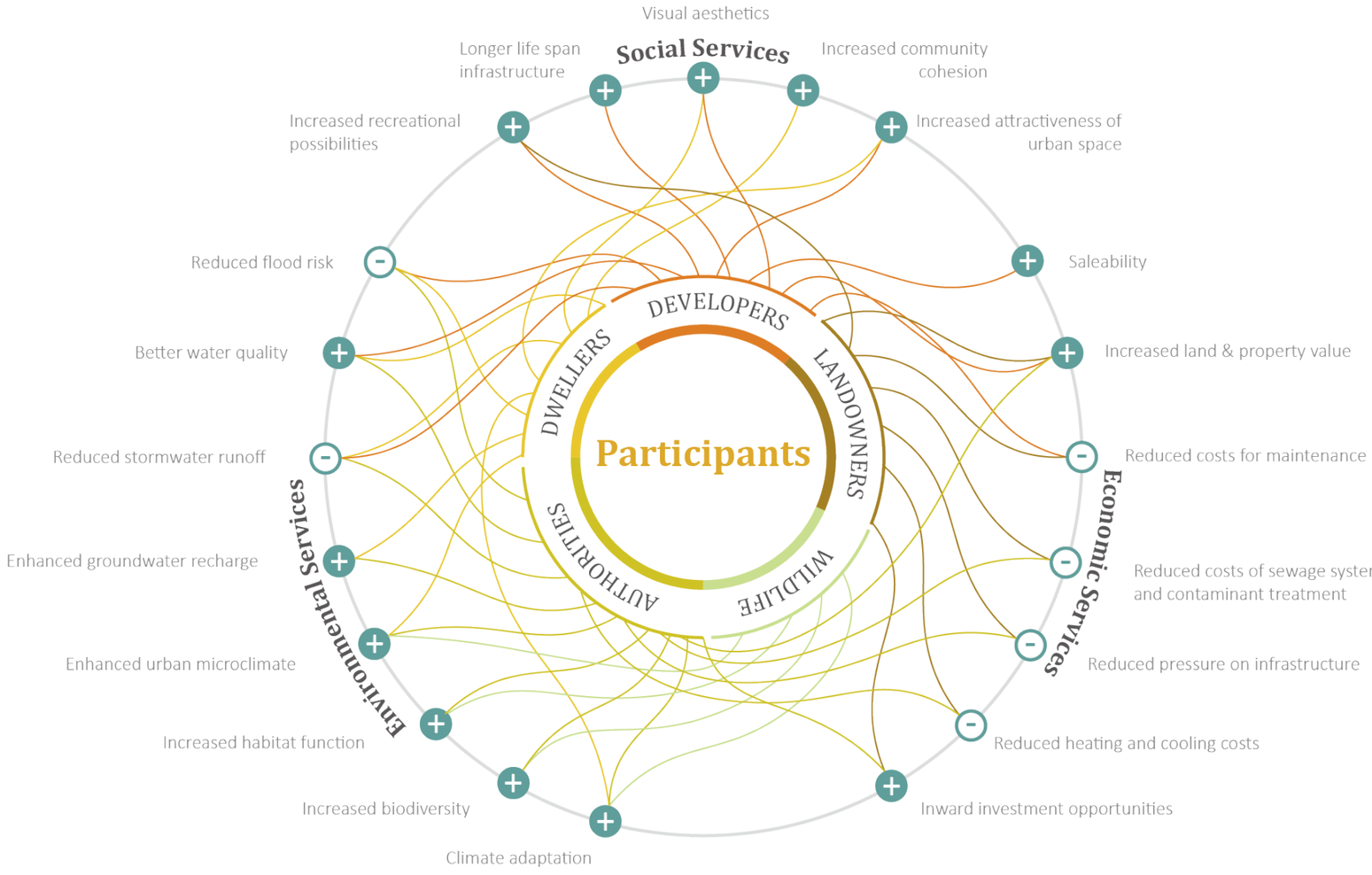
7.4 Participants



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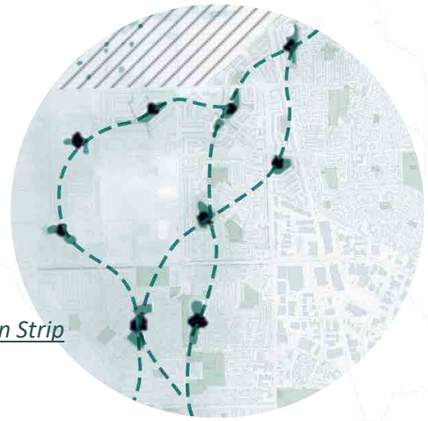
7.5 Strategic Plan

2050 Prospect

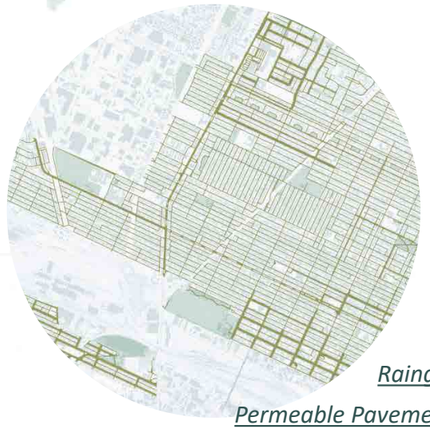


Bioswale

Retention Pond

Bioretention Strip

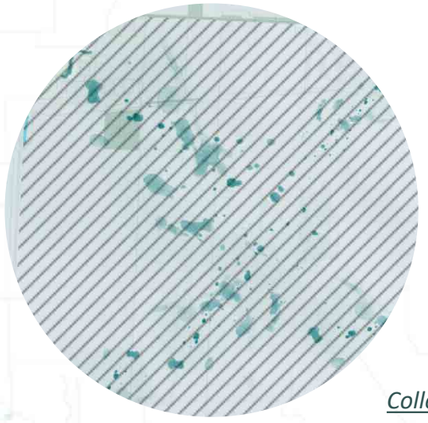
Key Design Area



Raingarden

Permeable Pavement

Underground Storage



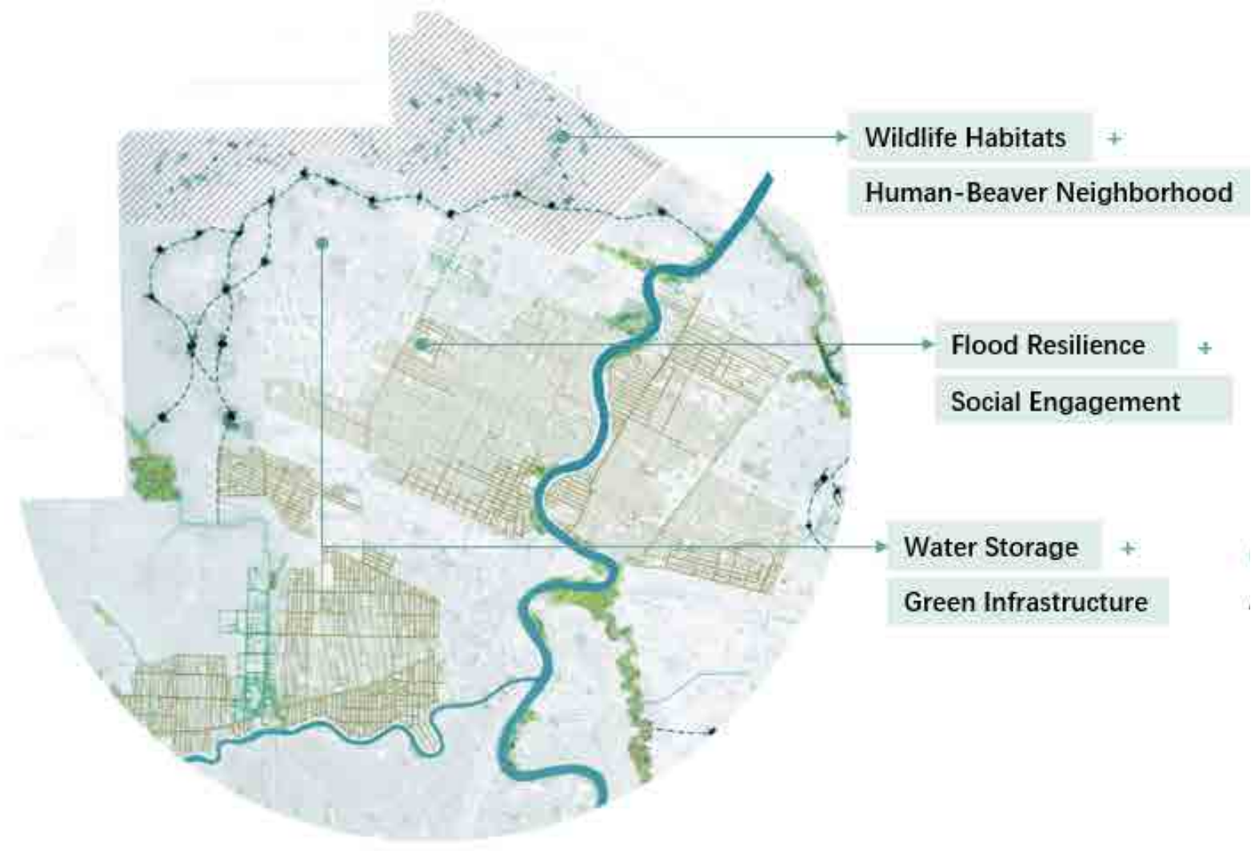
Collective Green Roof

Symbiotic Riparian Neighborhood

Riparian Buffer Zone

Riparian Habitat Corridor

7.6 Area of Focus



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Street Regeneration Guideline

A Design Intervention in the Mature Communities

This model explores the potential in the typical grid road networks. By focusing on the spatial features of streets, we can utilize them as water storage solutions, enhance walkability, and promote sustainability. This comprehensive resource offers practical recommendations and case studies to transform streets into vibrant, resilient, and multi-functional spaces. With innovative stormwater management, pedestrian-friendly design, and environmental sustainability measures, more vibrant urban environments are created to face urban challenges.

Naturalized Marginal Zone

A Design Intervention in the Recent Communities

This model focuses on enhancing the functionality and resilience of traditional stormwater retention ponds by incorporating naturalized design principles. By reimagining the marginal zones surrounding the ponds and newly constructed bioswales, a more ecologically diverse and aesthetically pleasing environment will be created that improves the retention pond's performance in the wet and dry cycles.

Symbiotic Neighborhood Model

A Design Intervention in the Emerging Communities

This model is a visionary approach that integrates ecological corridors and circular community design. It aims at achieving a harmonious coexistence between wildlife and residents within a water-resilient neighborhood. By embracing a more sustainable water system and restoring natural habitats, this model offers a transformative vision for sustainable urban living. Through an imitation of beaver pond complex systems and integration of indigenous cultural image, it opens up new possibilities of creating vibrant communities where humans and wildlife thrive in harmony while promoting ecological resilience and sustainable practices.

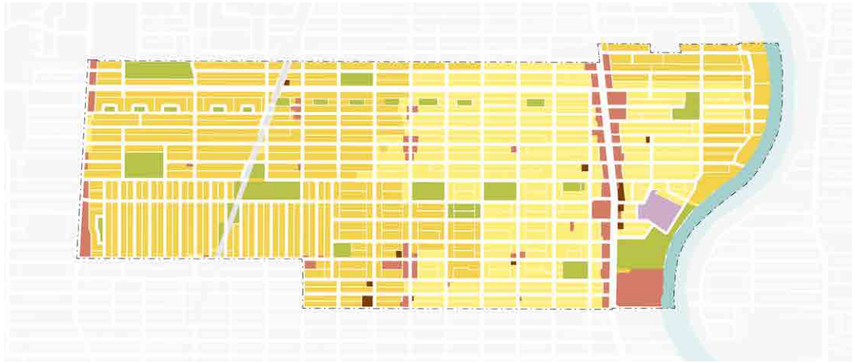
Model 1

Street Regeneration Guideline

A Design Intervention in the Mature Community

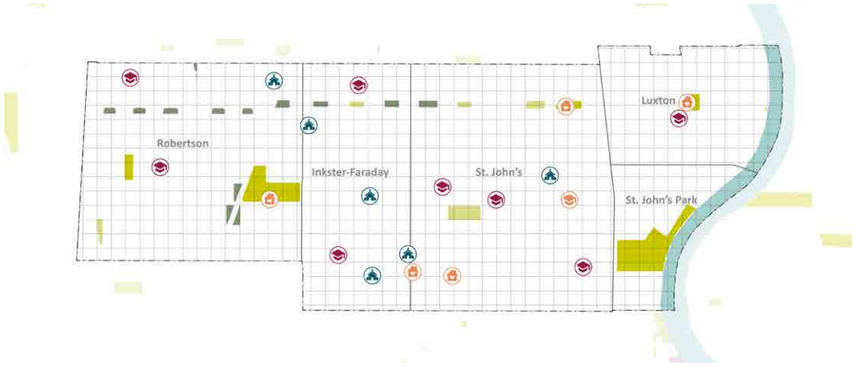
Land Use

- Residential Single-Family
- Residential Two-Family
- Residential Multi-Family
- Commercial
- Park and Recreation
- Rural Residential



Community Area Services

- Park and Recreation
- Rural Residential



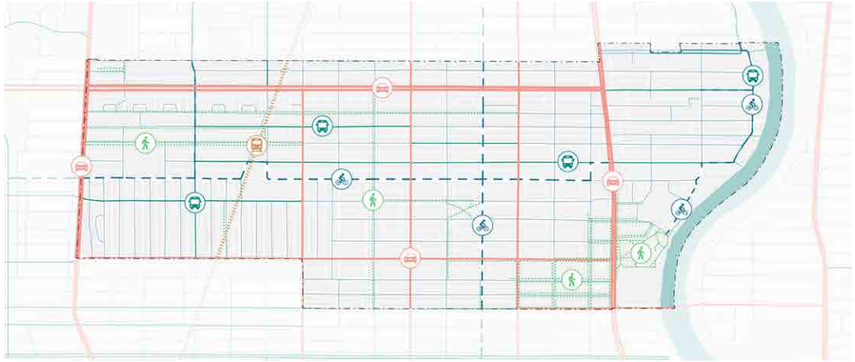
Traffic Volume on Major Streets

Average Weekday Daily Traffic 24H

9000 15000 20000 30000 50000

Transportation Priority

- Main Street
- Neighborhood Greenway
- Bicycle Lane
- Collector Street
- Residential Street
- Sidewalk
- Railway Line



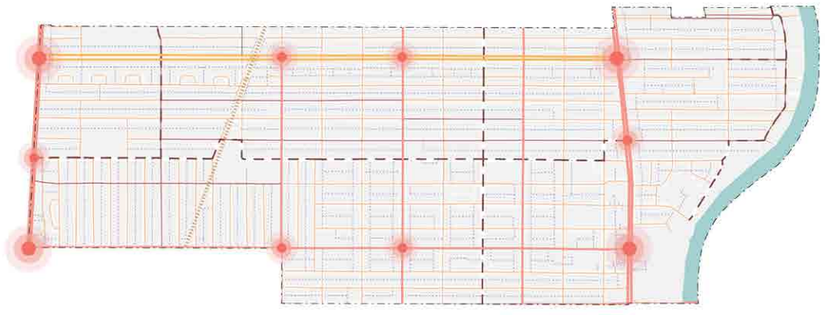
0 0.5 1 km

Context Analysis

The block cluster in question contains a collection of residential and commercial buildings, arranged in a typical grid road network configuration. However, what distinguishes this block is its notable demographic characteristics, a lower average income level and a higher percentage of residents of Indigenous origin. Recognizing the unique needs and challenges of this community, efforts have been made to identify available spaces and introduce innovative strategies to enhance the functionality and aesthetics of the street infrastructure.

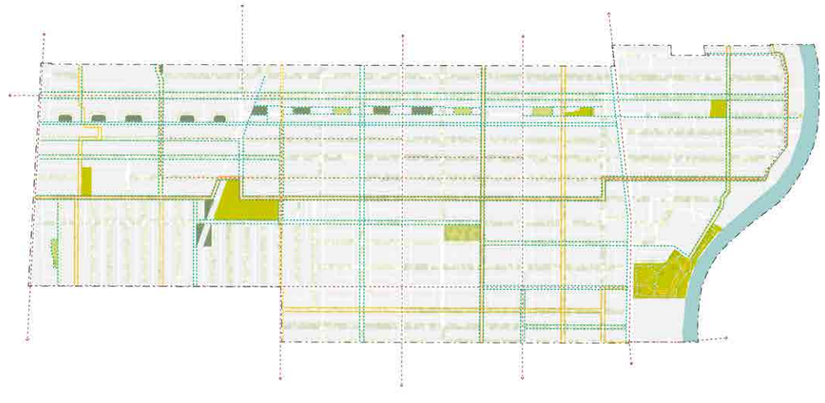
Traffic Hot Spot Area

- Major Regional Road
- Collector Street
- Neighborhood Greenway
- Boulevard
- Residential Street
- Back Lane
- Railway Line
- Hot Spot Crossing



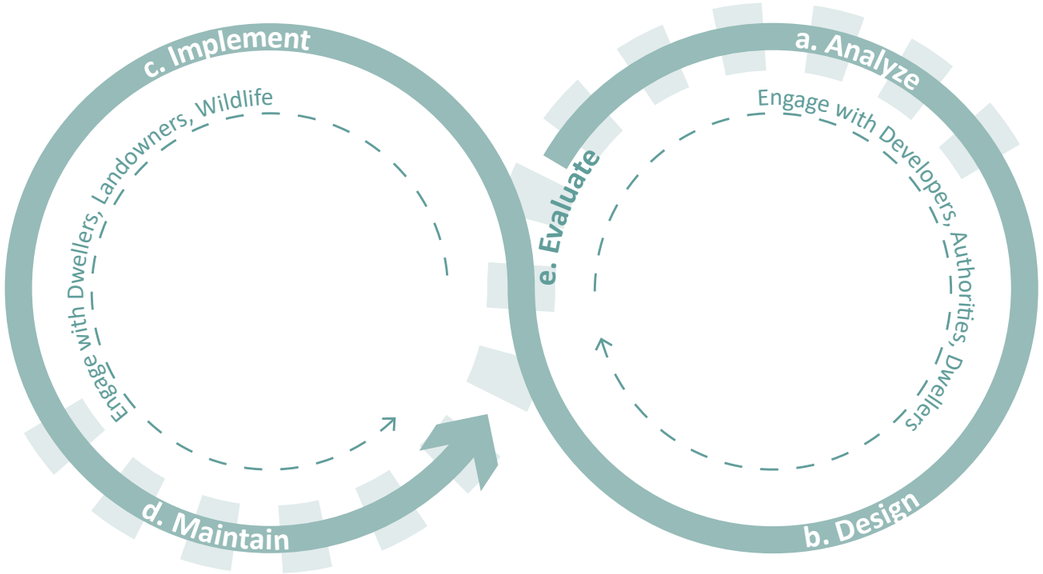
Green Space Allotment

- Cycle Lane
- Buffered Cycle Track
- Sidewalk
- Walkway
- Transit Routes



0 0.5 1 km

Design Guide Principles



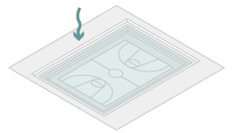
DETENTION:
Collect and hold runoff in temporary storage facilities or vegetated systems before slowly releasing the water into the downstream system.

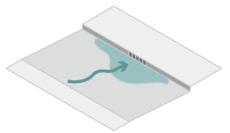
RETENTION:
Capture and hold stormwater on-site to reduce runoff to sewer systems. Water is then evaporated or transpired.

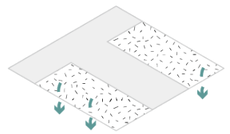
(BIO)FILTRATION:
Remove particulate matter and other pollutants by filtering stormwater runoff through porous media such as sand, soil, or other filter.

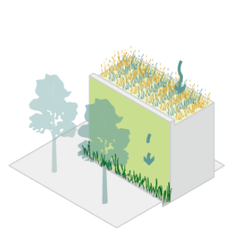
INFILTRATION:
Absorb stormwater through the ground surface and into the soil.

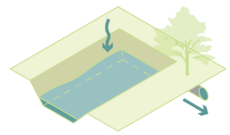
Potential Toolboxes

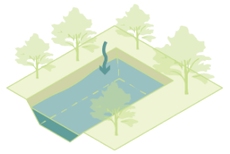

Multifuntional Water Square

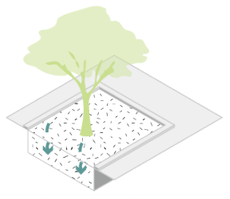

Terraces & Slopes

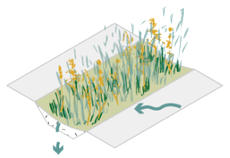

Permeable Pavement

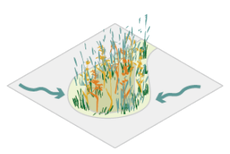

Green Building


Detention Pond


Retention Pond


Tree Box Filter


Bioswale


Rain Garden

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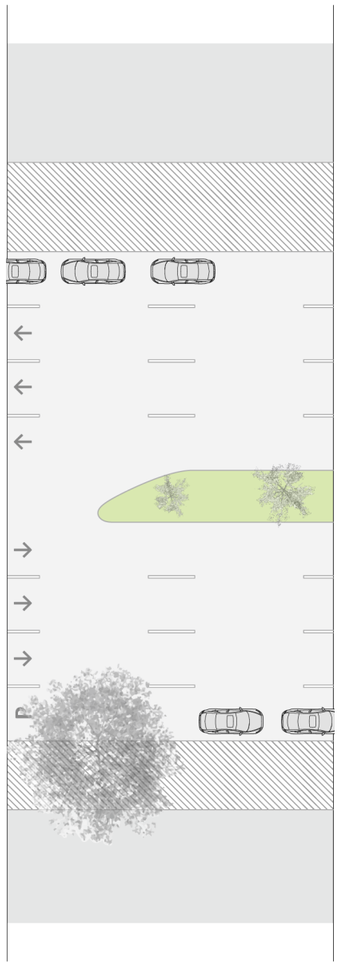
Street Typology

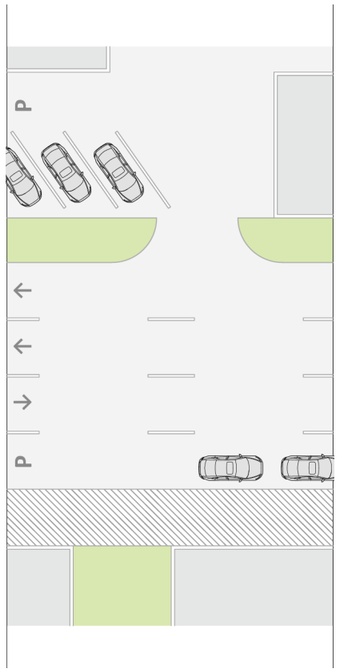
Current Status Analysis

Main Street



Traffic Volume	●●●●
Traffic Speed	●●●●
Green Space	●○○○
Street Tree Density	●○○○

Collector Street



Traffic Volume	●●○○
Traffic Speed	●●○○
Green Space	●●○○
Street Tree Density	●●●○

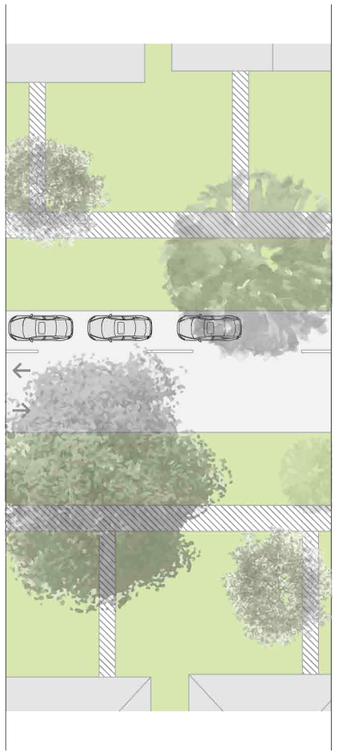
Boulevard

Traffic Volume	●●●○
Traffic Speed	●●●○
Green Space	●●●○
Street Tree Density	●●●●

Neighborhood Greenway

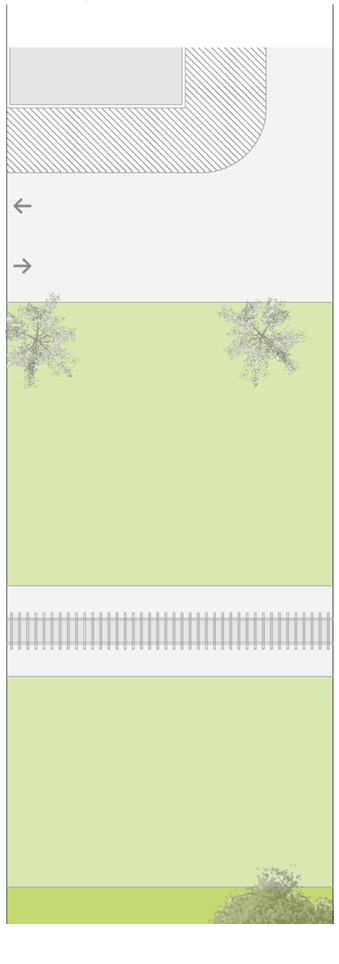
Traffic Volume	●●○○
Traffic Speed	●○○○
Green Space	●●●○
Street Tree Density	●●○○

Residential Street



Traffic Volume	●○○○
Traffic Speed	●○○○
Green Space	●●○○
Street Tree Density	●●●○

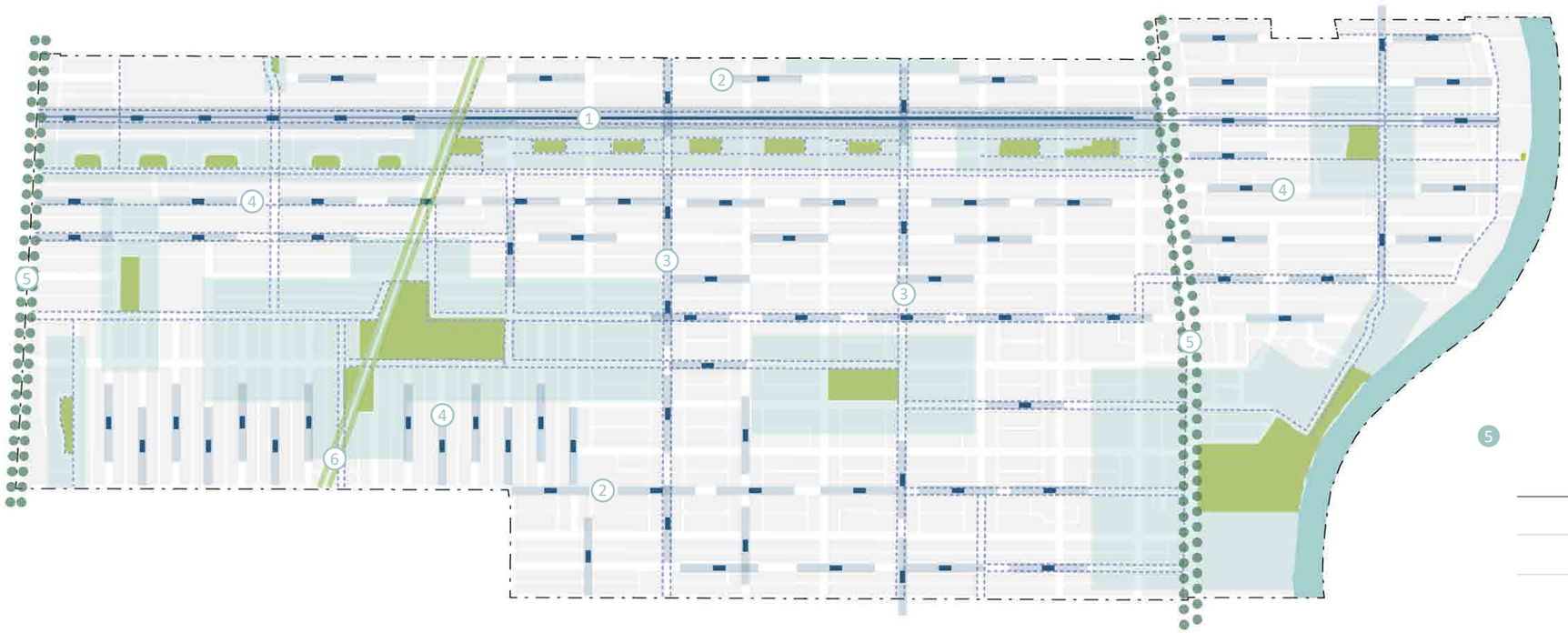
Railway Line



Traffic Volume	●○○○
Traffic Speed	●●●●
Green Space	●●●●
Street Tree Density	○○○○

Implementation

The primary objective is to increase the water storage capacity within the street area. The new toolboxes are implemented into different street types, which achieve multiple purposes. The street network surves as a new green-blue infrastructure network that can effectively capture and retain rainwater, mitigating issues related to stormwater runoff and flooding. This not only contributes to the overall resilience and sustainability of the neighborhood but also fosters a greener and more environmentally conscious urban landscape.



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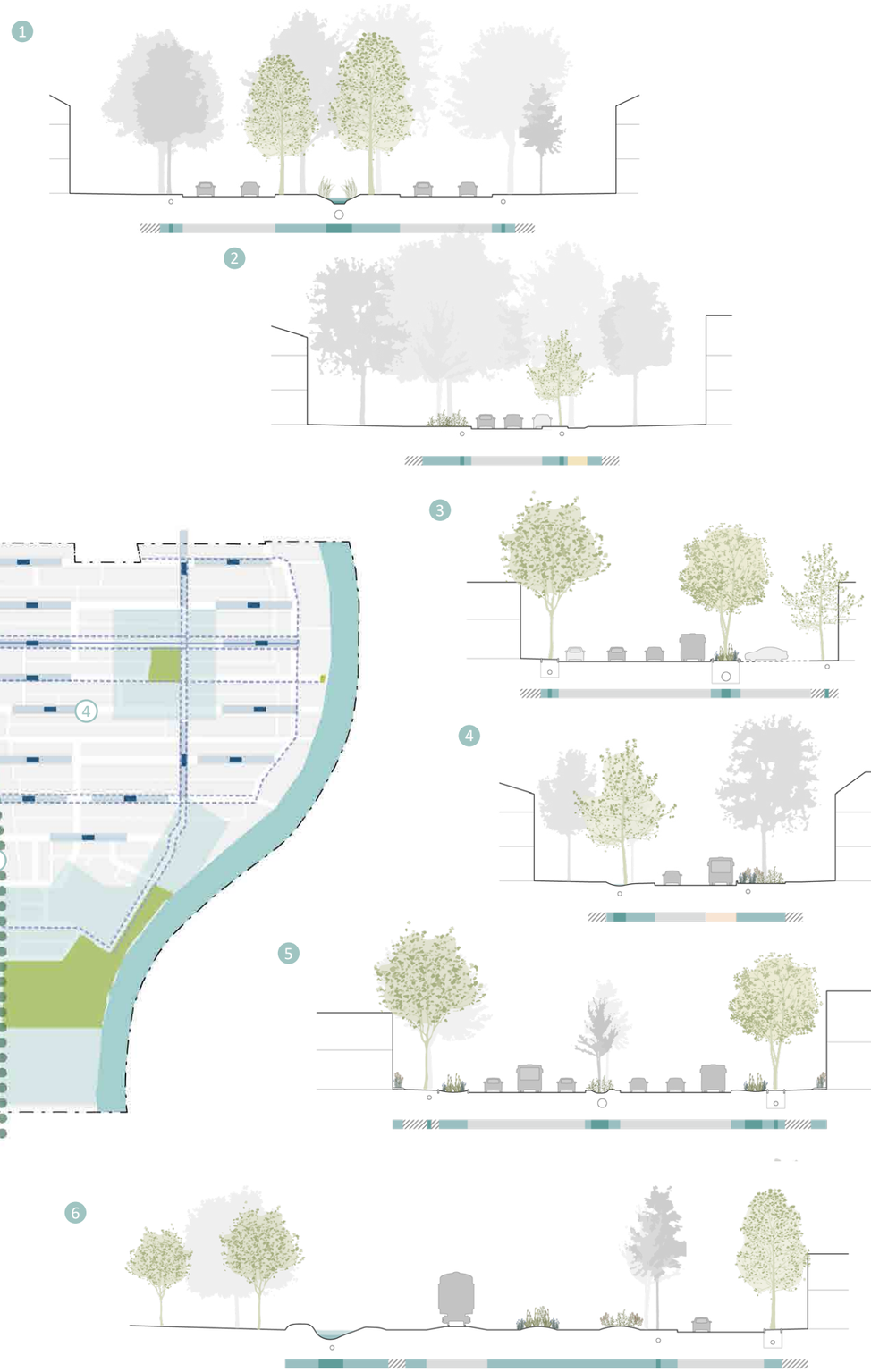
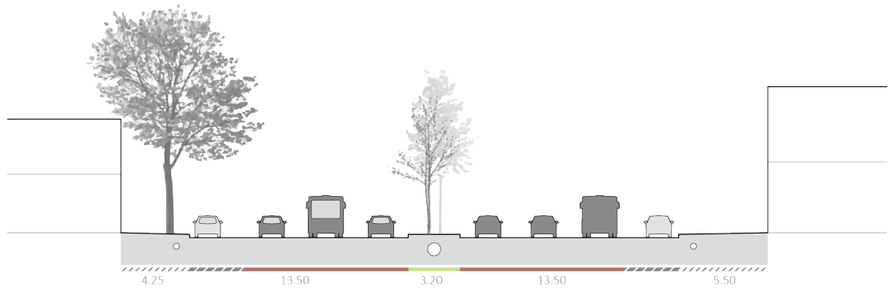


Street Regeneration Design

Main Street

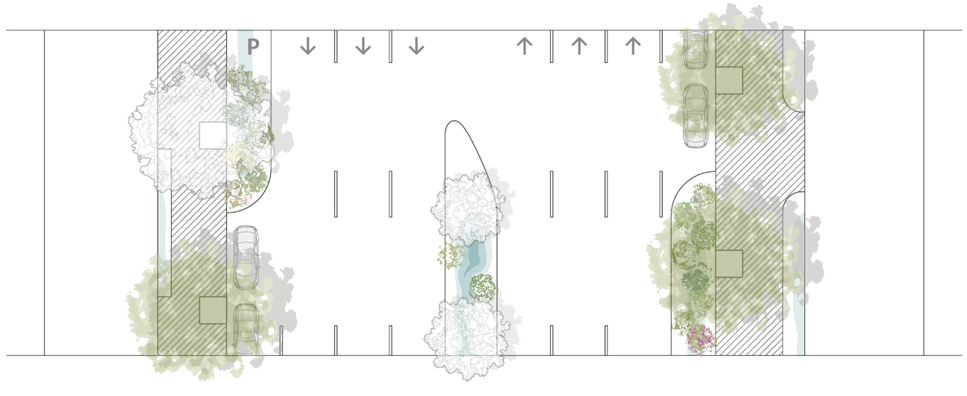
walkway
driveway
parking area
temporary parking
public green space

Existing condition



Proposed implementation

walkway
grey infrastructure
blue infrastructure
water channel
bus transit line

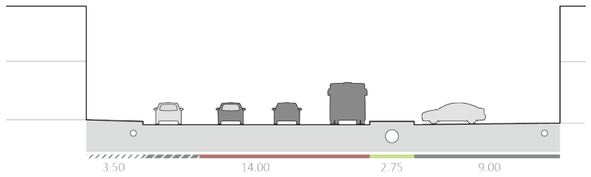


Applicable Toolbox

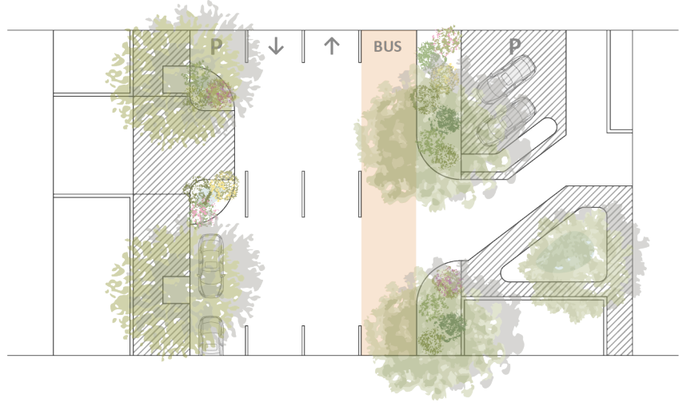
· *Bioretention Waterway*
· *Rain Garden*
· *Tree Trench*

Collector Street

Existing condition



Proposed implementation



Applicable Toolbox

· *Bioretention Planter*
· *Tree Trench*

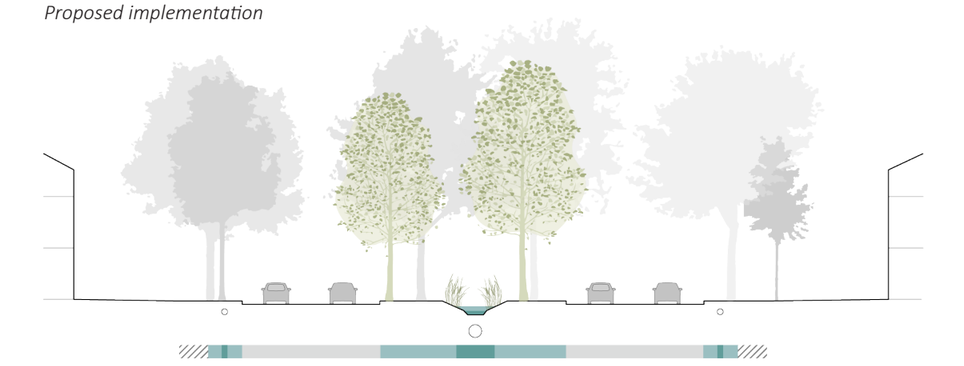
Boulevard

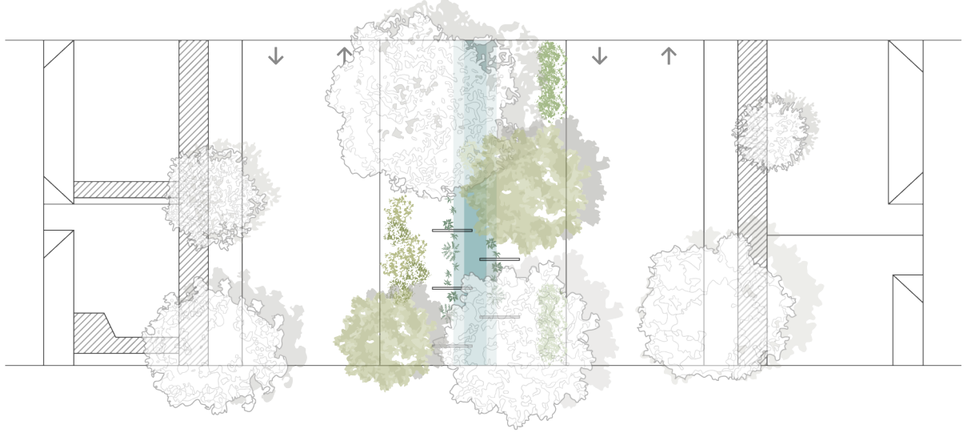
walkway
driveway
public green space
private yard

Existing condition

Proposed implementation

walkway
grey infrastructure
blue infrastructure
water channel
bus transit line





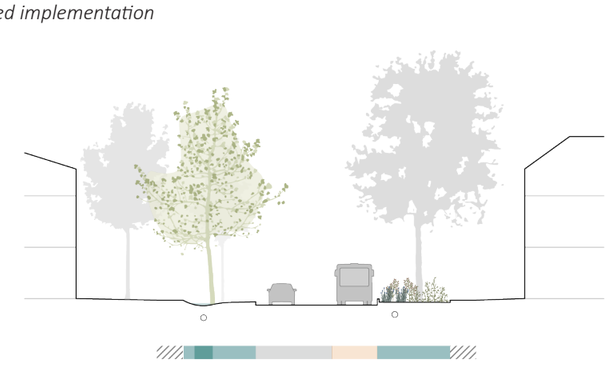
Applicable Toolbox

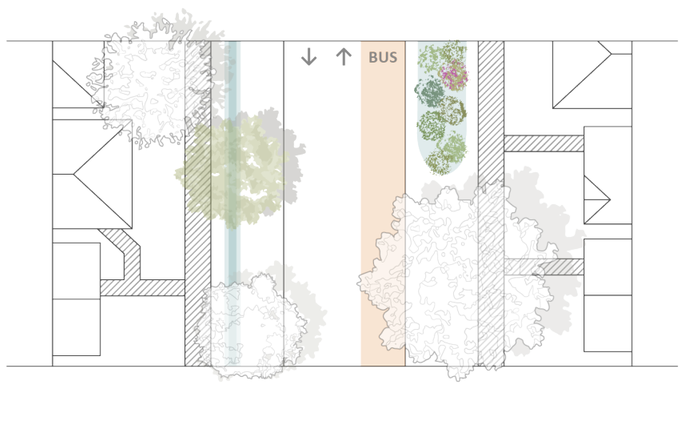
· *Bioretention Waterway*
· *Rain Garden*

Neighborhood Greenway

Existing condition

Proposed implementation





Applicable Toolbox

· *Bioretention Planter*
· *Bioswale*
· *Rain Garden*

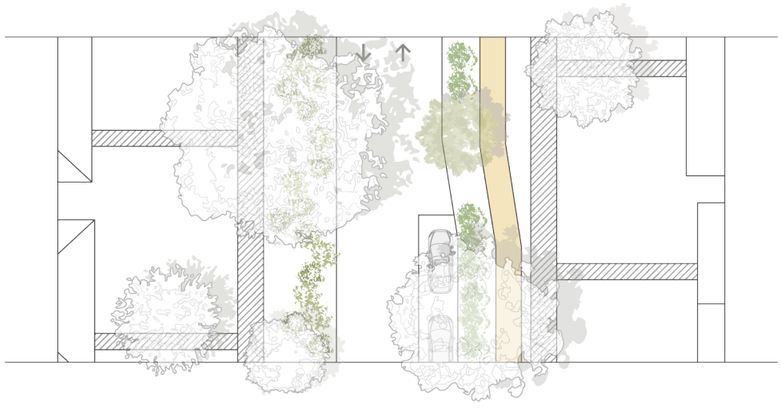
Residential Street

Existing condition

- walkway
- driveway
- temporary parking
- railway line
- public green space
- private yard

Proposed implementation

- walkway
- grey infrastructure
- blue infrastructure
- water channel
- bikeway



Applicable Toolbox

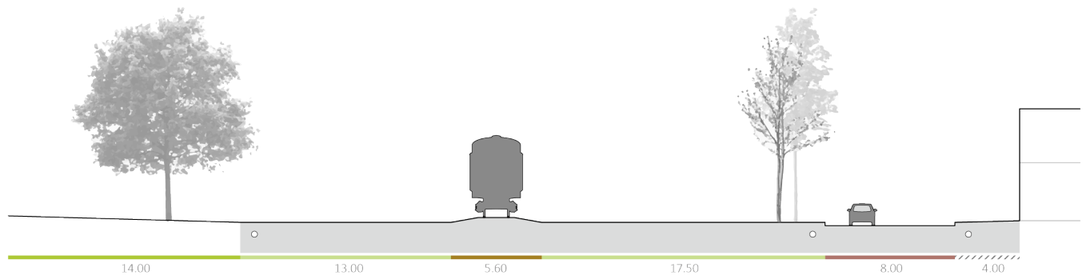
- *Bioswale*
- *Tree Trench*
- *Rain Garden*

Railway Line

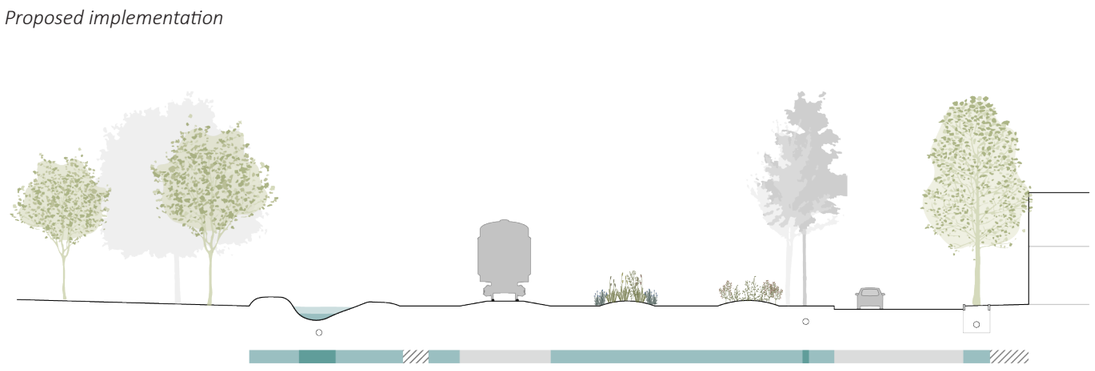
Applicable Toolbox

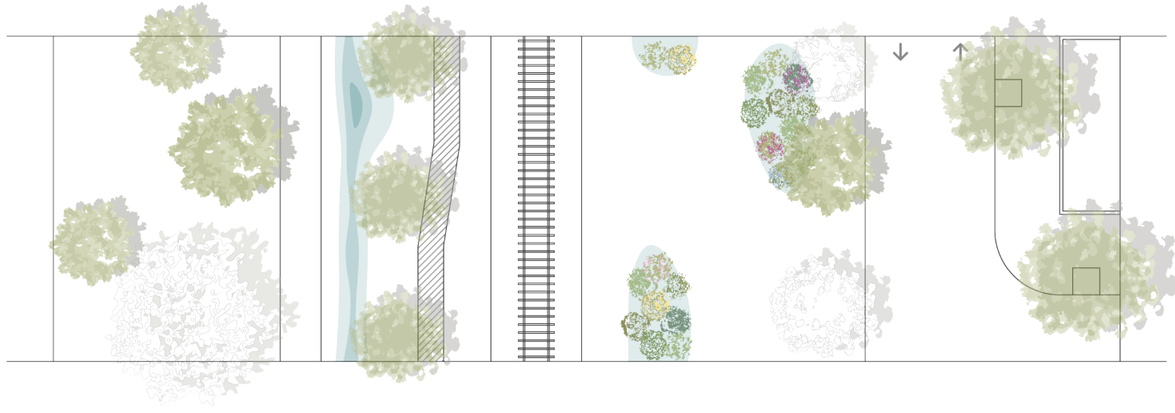
- *Bioretention Waterway*
- *Rain Garden*

Existing condition



Proposed implementation





Model 2

Naturalized Marginal Zone

A Design Intervention in the Recent Community

Present Status

Context Analysis

The primary objective is to increase the water storage capacity within the street area. The new toolboxes are implemented into different street types, which achieve multiple purposes. The street network surves as a new green-blue infrastructure network that can effectively capture and retain rainwater, mitigating issues related to stormwater runoff and flooding. This not only contributes to the overall resilience and sustainability of the neighborhood but also fosters a greener and more environmentally conscious urban landscape.

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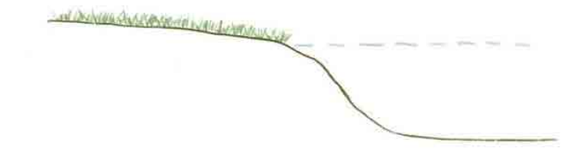
Source: Google Streetview

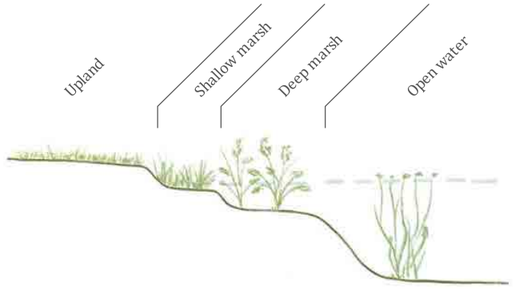
Strategy

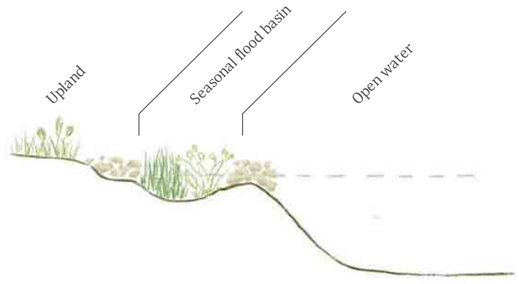
Present situation of the retention pond edge

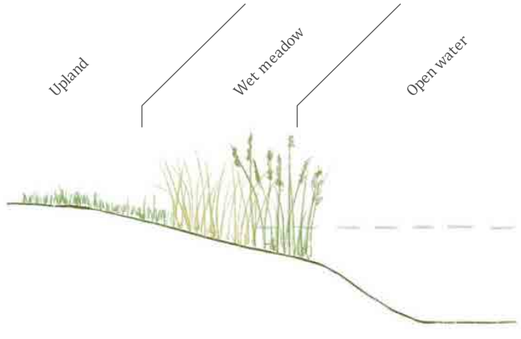


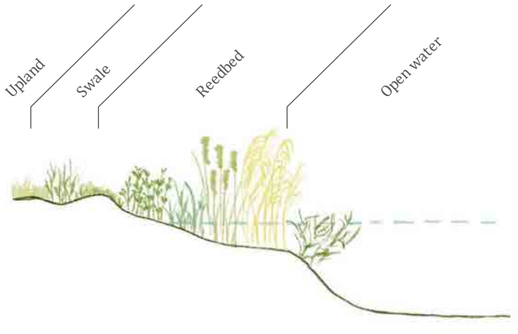
- *Poor water quality*
- *Homogeneous vegetation*
- *Excess algae/submersed plant growth*
- *Invasive species*
- *Excess of grazing geese*
- *Intensive upland management of grassed areas*

Design alternatives of naturalized pond edge









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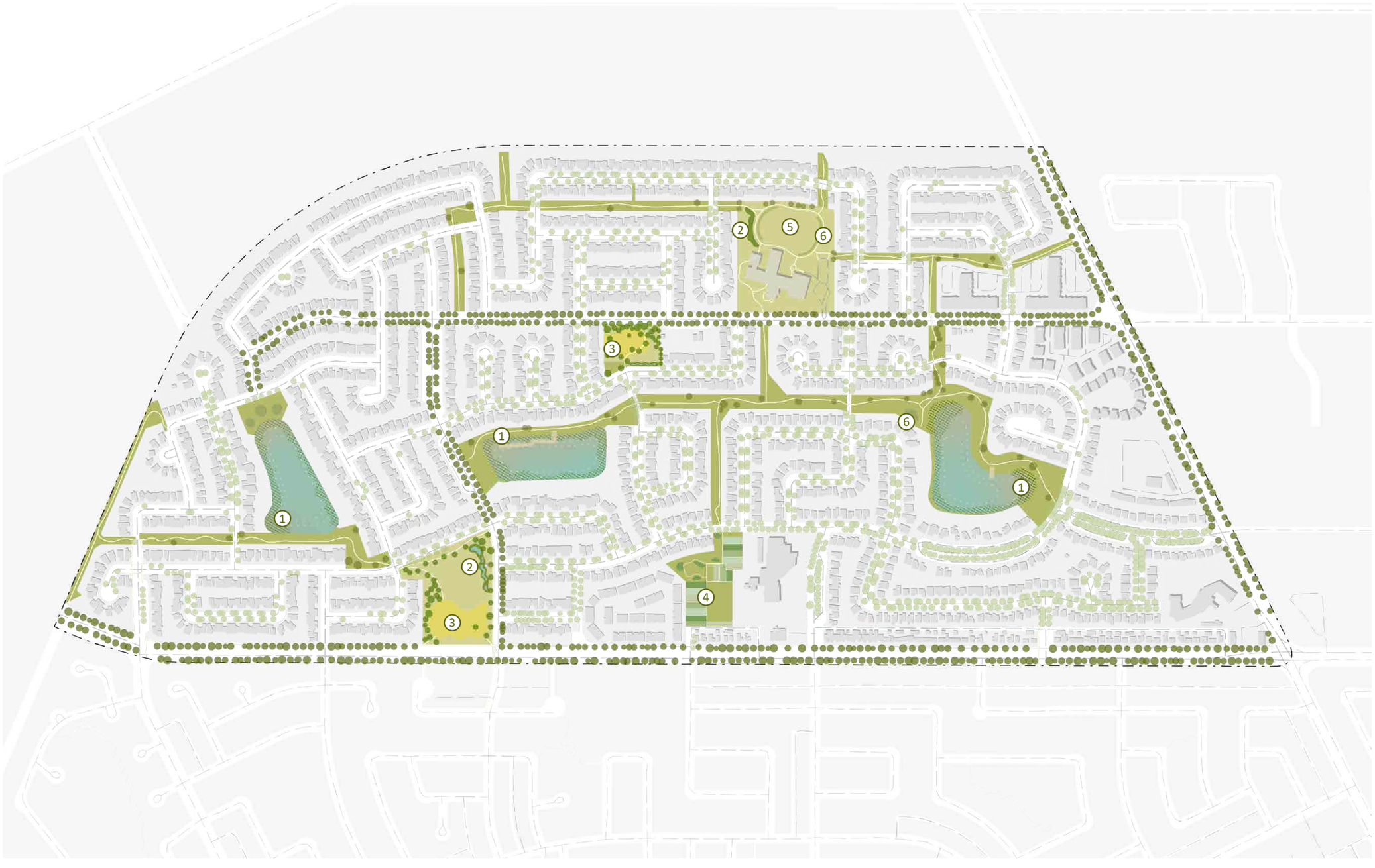
Landscape Improvement Plan



1. Naturalized Pond Margin
2. Bioswale
3. Wet Meadow
4. Urban Farms
5. Multi-used Green Space
6. Terrain Reconstruction

Model 3

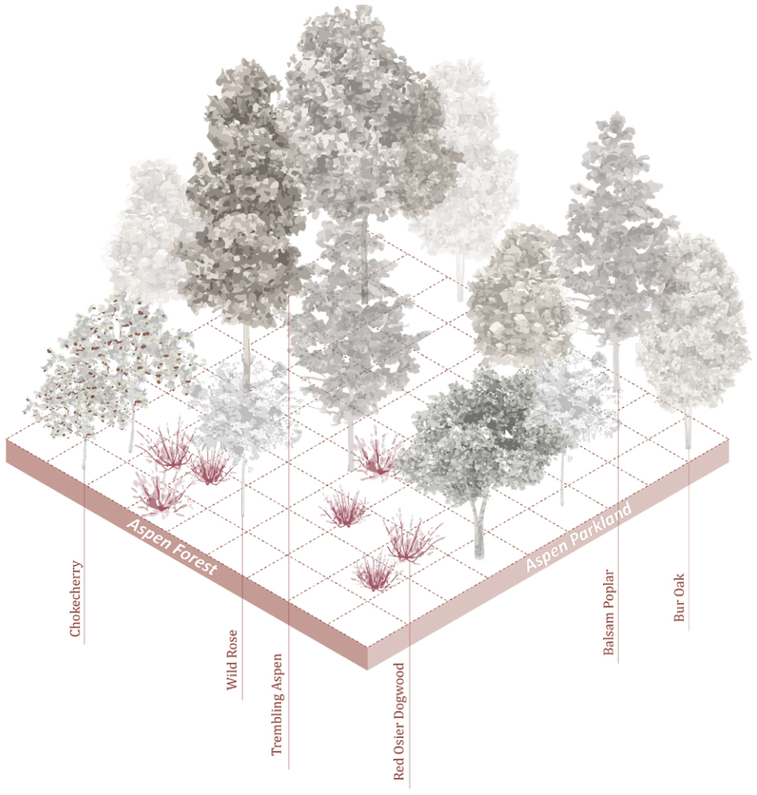
Symbiotic Neighborhood Model

A Design Intervention in the Emerging Community

Natural Habitat Types

Aspen Forest

Aspen forest is the most common natural habitat in Winnipeg and the surrounding area, dominated by stands of trembling aspen and grassland openings. Native prairie plants can still be found in undisturbed grasslands, while low-lying areas support wet meadow species and small wetlands. Aspen parkland refers to aspen forest mixed with native prairie openings. The forest also includes bur oak and balsam poplar trees, along with Manitoba maple and green ash. The open canopy allows sunlight to reach the understorey, fostering the growth of various shrubs, grasses, and wildflowers. Wildlife, including white-tailed deer, red squirrels, chipmunks, rabbits, and numerous bird species, find refuge in the aspen forest.



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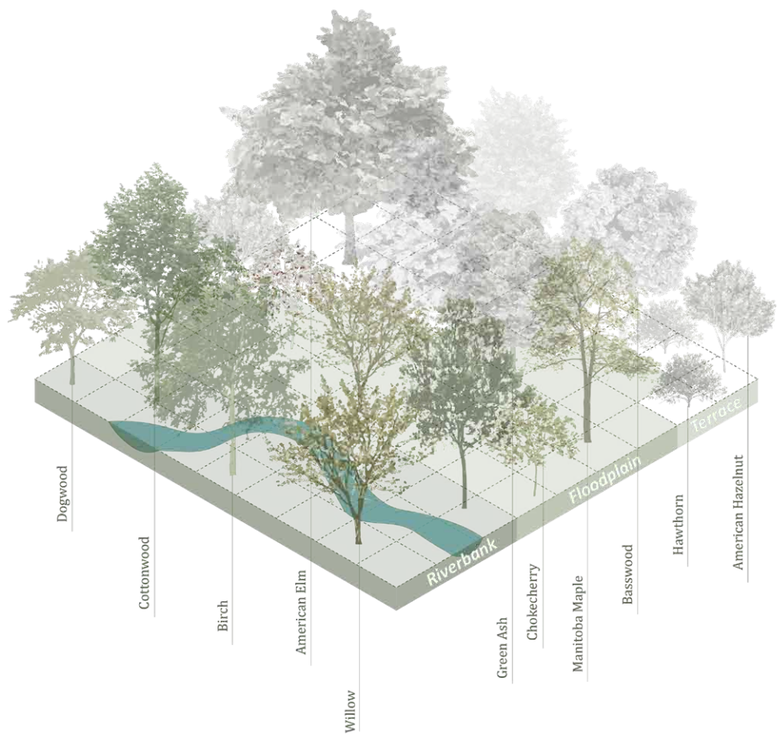
Riverbottom Forest

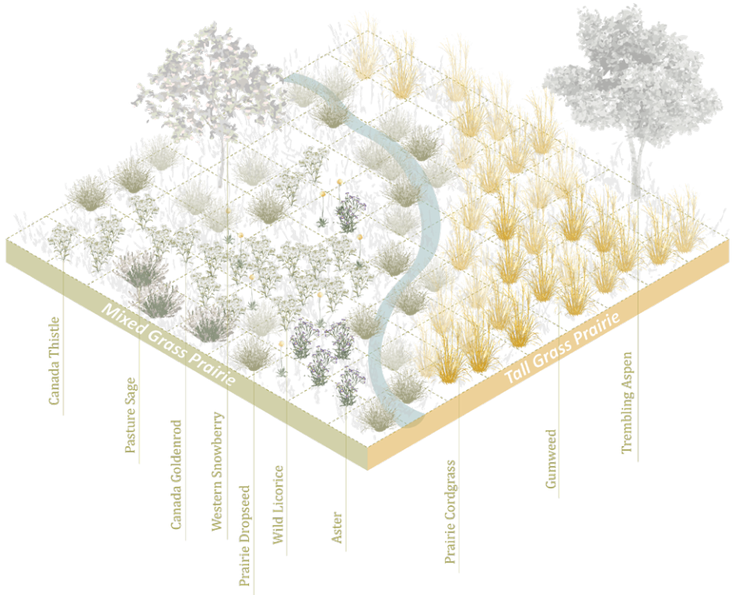
Riverbottom forests are found alongside rivers and streams, relying on spring floods to bring nutrient-rich silt that nourishes the soil. These forests play a crucial role in stabilizing riverbanks and reducing erosion through their root systems. They boast high biodiversity, housing a wide range of plant species. As a result, riverbottom forests serve as attractive habitats for diverse wildlife, offering abundant food, shelter, and proximity to water.

Riverbottom forests can generally be divided into three sections: the channel shelf or riverbank, the floodplain, and the terrace.



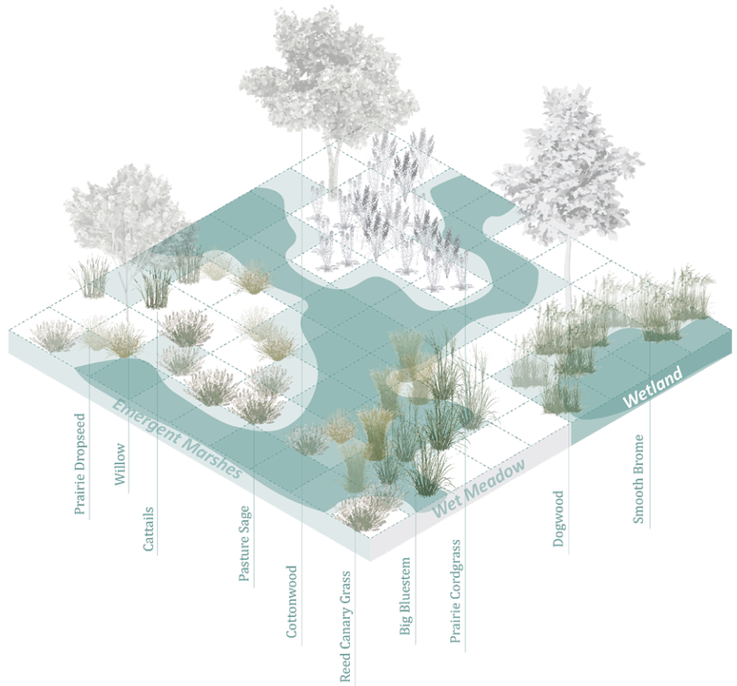
Tall-grass Prairie

Native prairie is a diverse ecosystem in Manitoba, dominated by a mixture of perennial grasses, wildflowers, and shrubs. Tall-grass and mixed-grass prairies are the two main types found in the region. The Red River Valley once showcased a thriving tall-grass prairie with towering grasses exceeding two meters in height. However, due to human impact, this ecosystem is now highly endangered, with less than 1% of the native tall-grass prairie remaining. The prairie undergoes continuous transformations throughout the seasons, from the emergence of crocuses in spring to the golden sway of grasses in autumn.



Wetland

Wetlands are water-filled depressions on land that can vary in size, depth, and plant coverage. Prairie wetlands rely on snow, rain, and groundwater as water sources. Wetlands can contain a lot of different zones, each with varying habitat conditions based on water levels. Wet meadows have wet soils but no open water, supporting plants that require moisture but not prolonged flooding. The emergent marsh zone occurs in shallow water around the edges of marshes and potholes.



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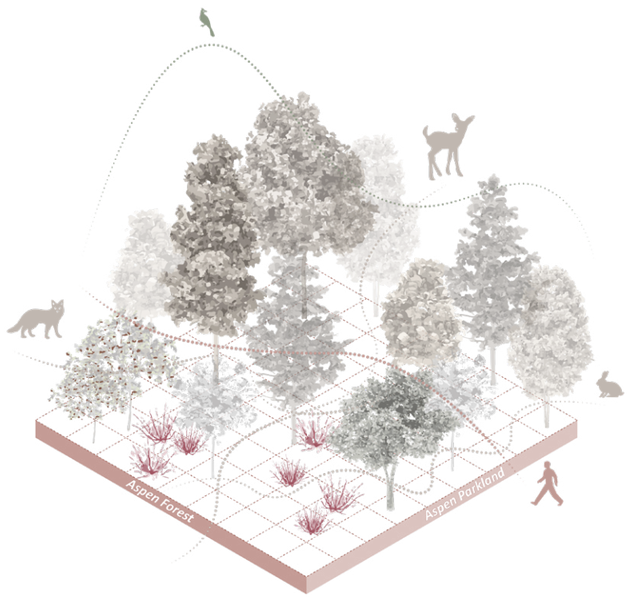
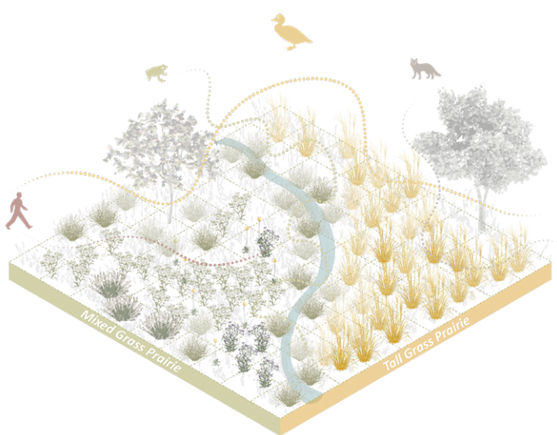
Attraction of different zones to different species

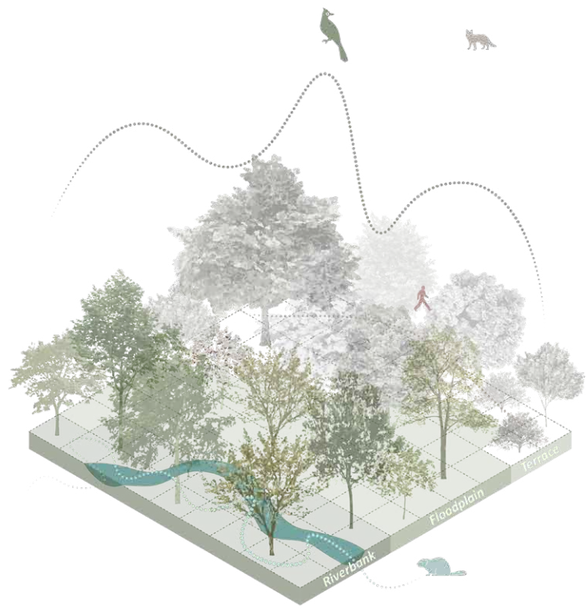
Aspen Forest



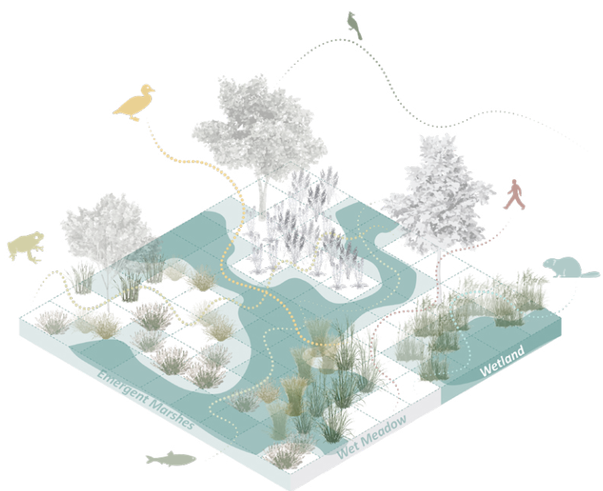
Prairie

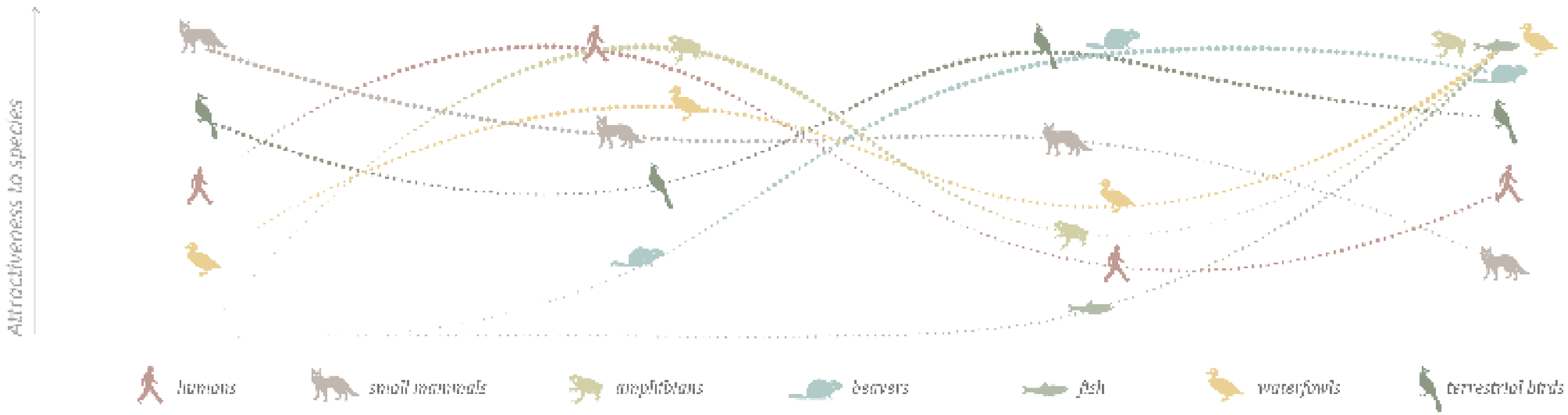


Riverbottom Forest



Wetlands





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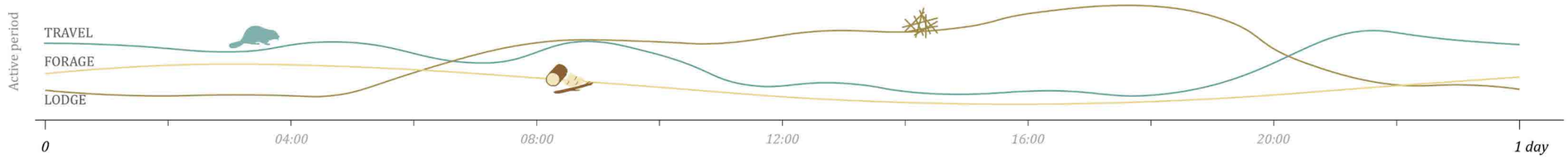
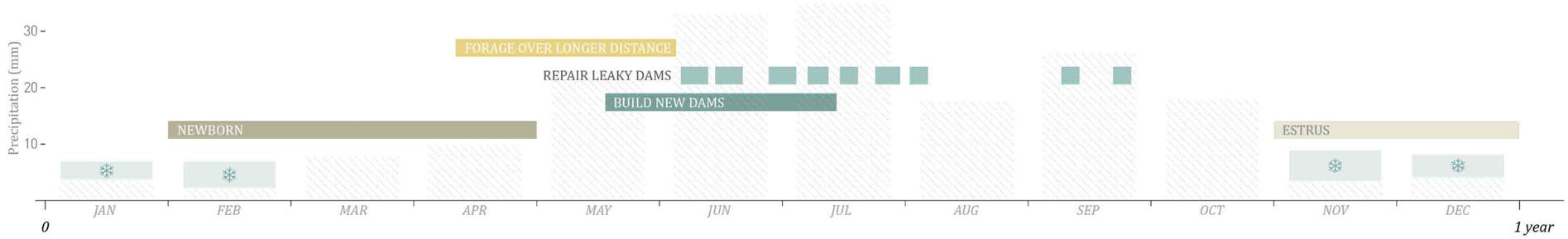
Nature Processes in Different Time Spans

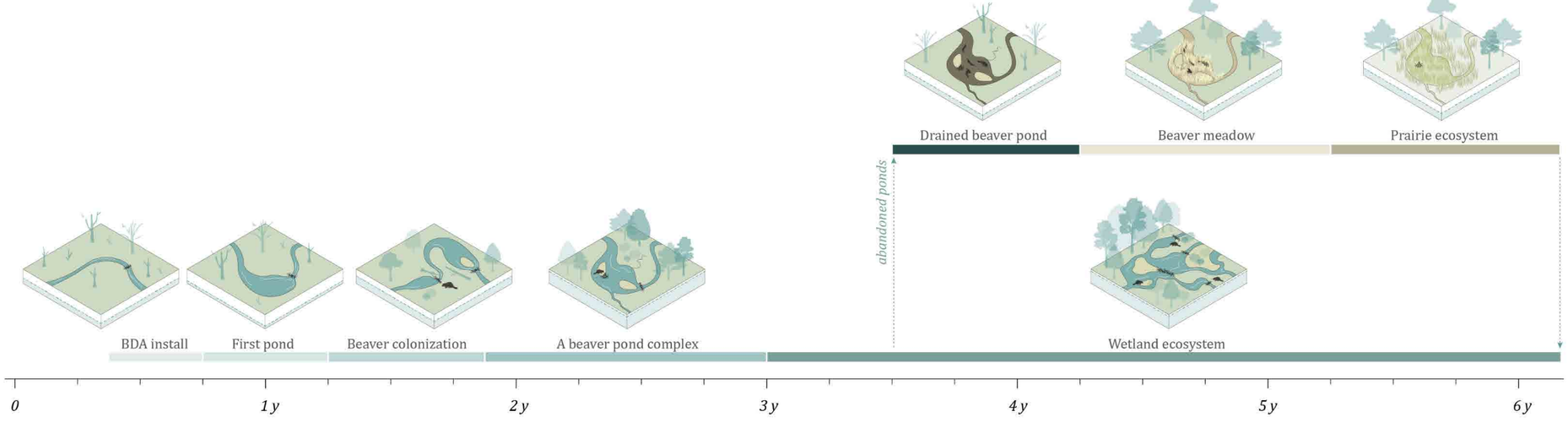
Beaver behavior
[in 1 day]



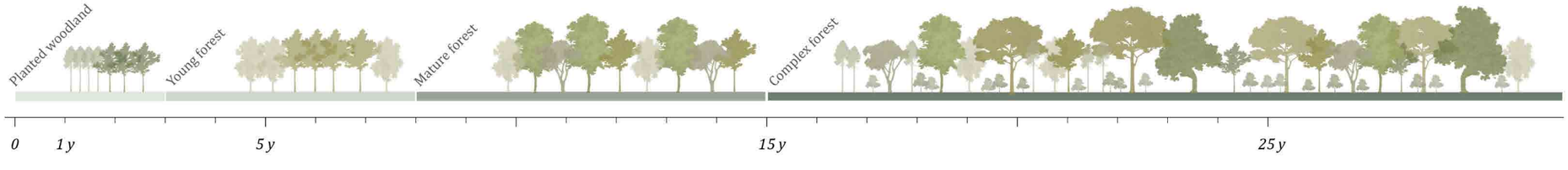
Beaver Life Cycle
[in a year]



Beaver Ponds Evolution Stages
[in 3 to 5 years]



Natural Succession Stages
[in 25 years]



Sequence of Landscape Transformation

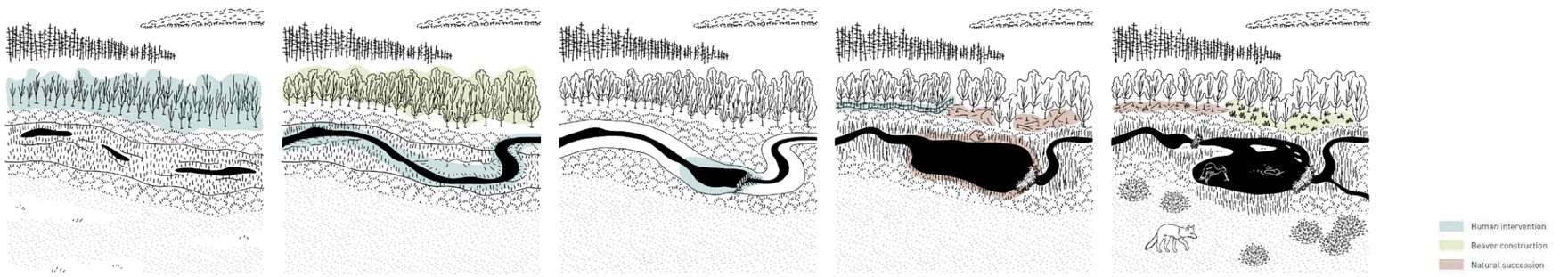
Habitat Creation

Connect Water Body

Install Beaver Dam Analog

Beaver Introduction

A Beaver Pond Complex

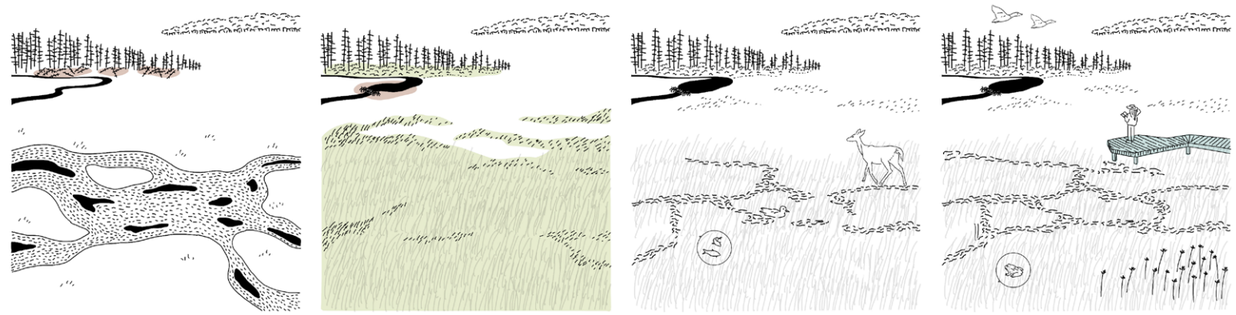


If beavers abandon their ponds

A New Prairie Grows

Small Mammals Inhabit

Low Impact Recreation Facilities

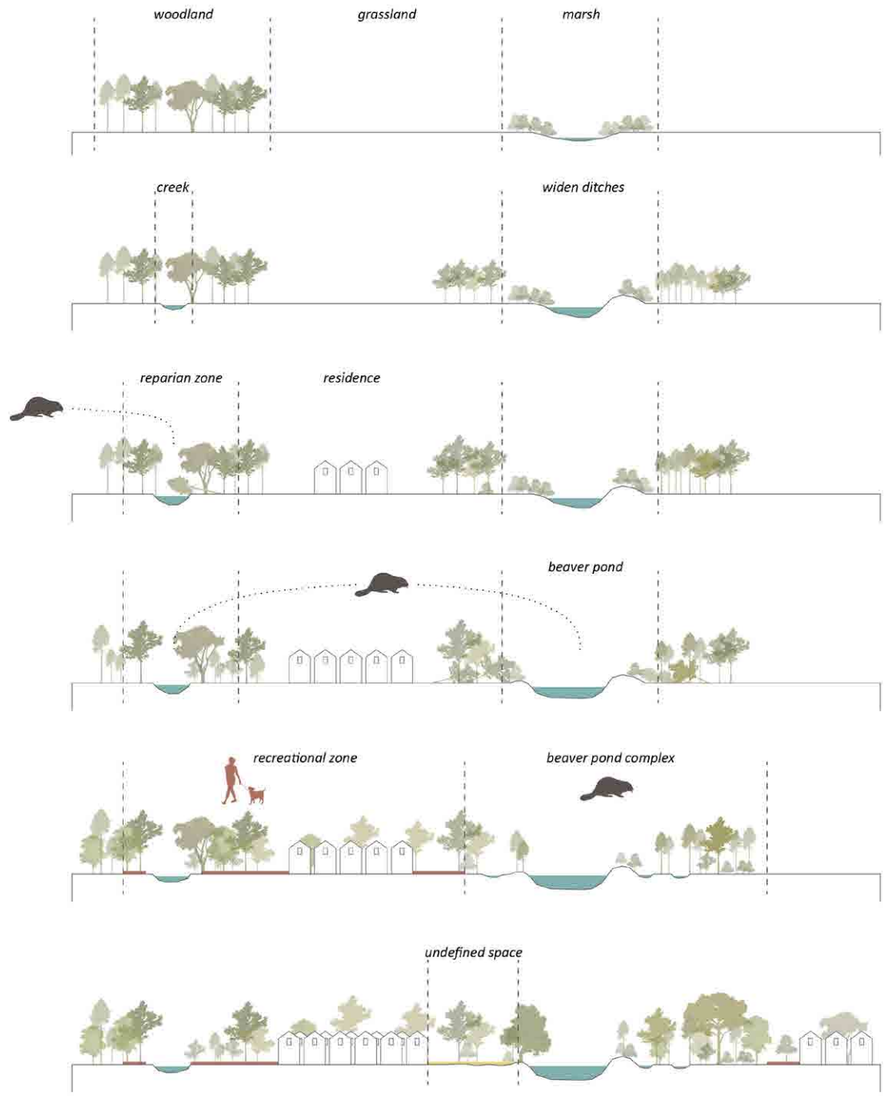


Operation Scheme

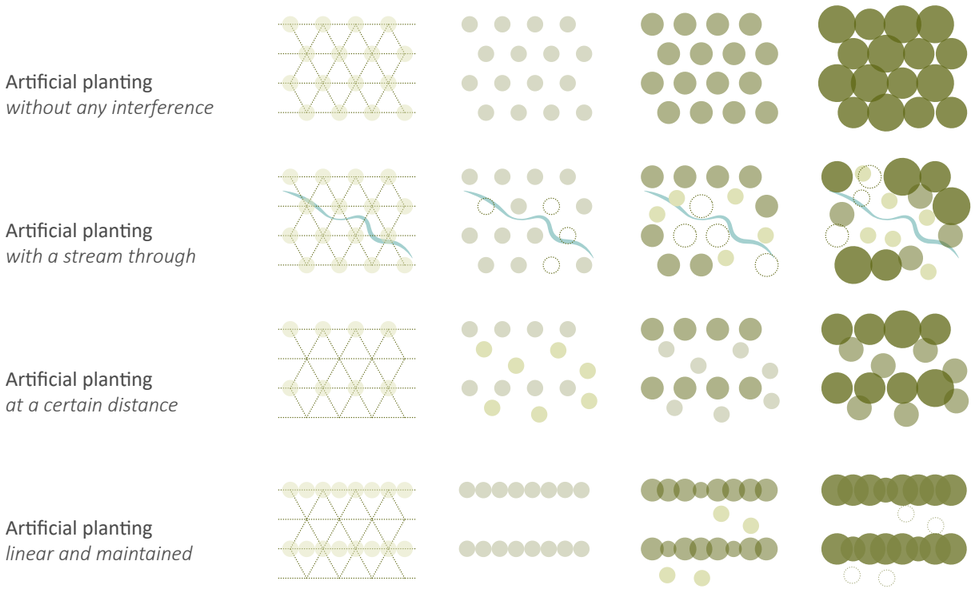
The first phase of the site's transformation is to dig a new stream through the existing woodland. With a plentiful source of food and building materials, a relatively simple beaver habitat is formed. A few years later, beavers began to maintain the riparian zone. Along with the expansion, the new wetland habitat is being reasted-ready for an expanding beaver population. Due to the irregular abandonment of the beaver pond, the meadow landscape can be reappeared and through appropriate management and design, it frees up new spaces for recreational activities.

Stage 1 + 2
Restoration

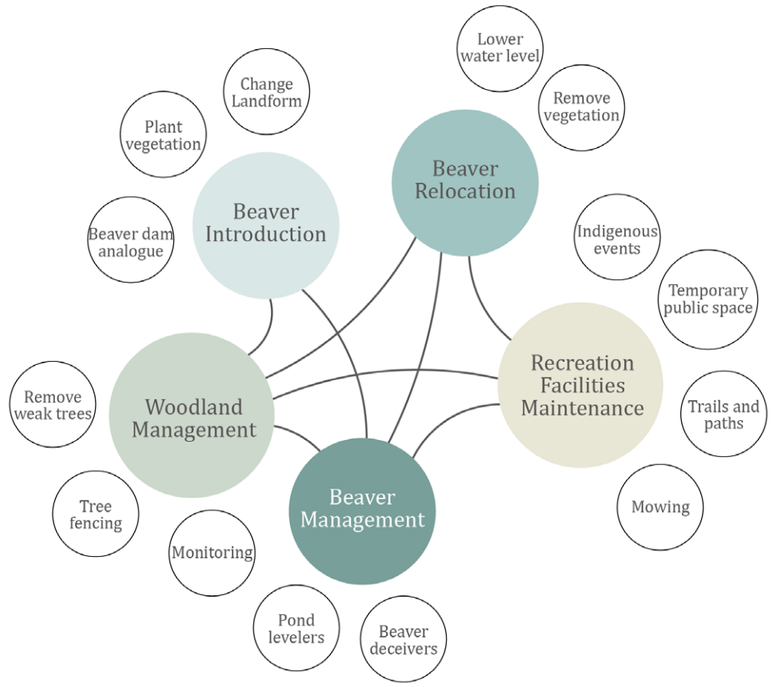
Stage 3 + 4
Naturalization



Planting Scheme



Differentiated Management Design

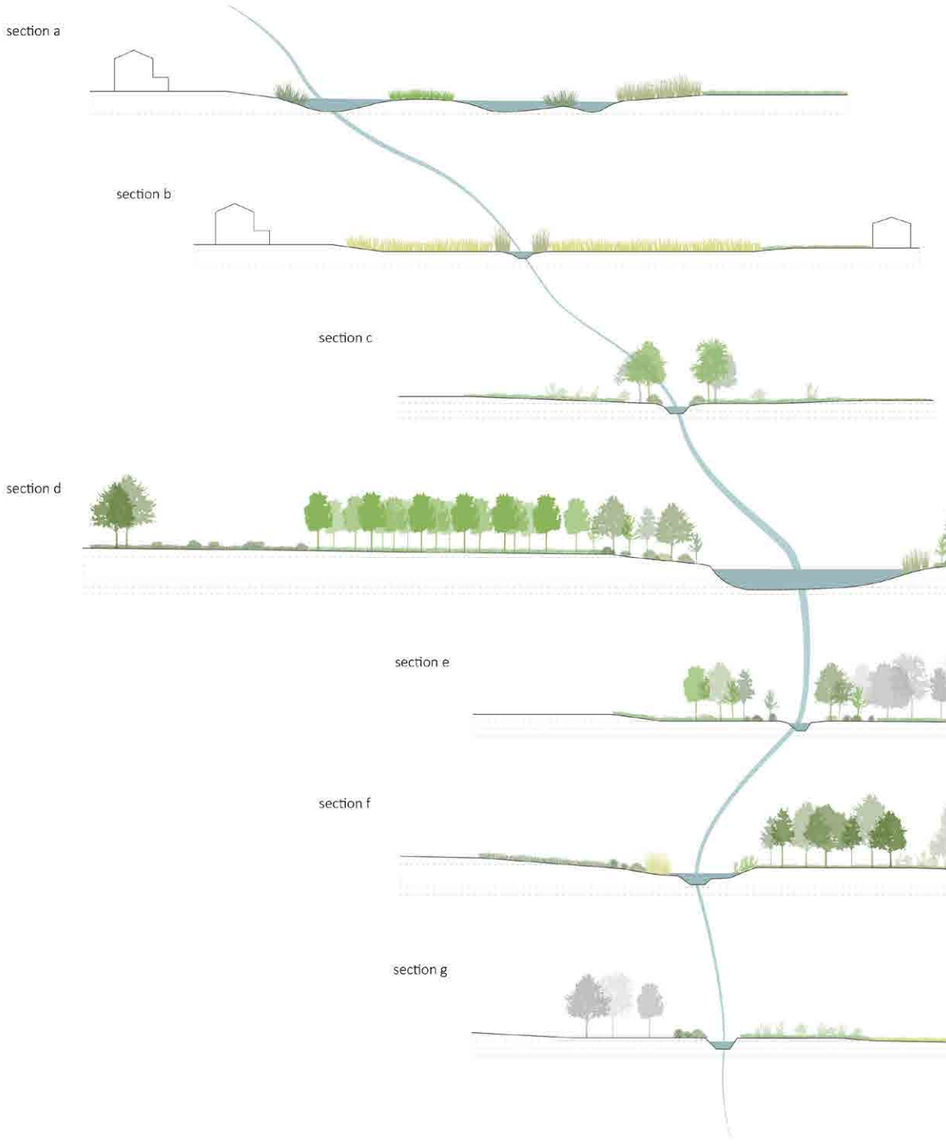


The construction of an artificial natural environment involves a comprehensive set of management schemes aimed at creating and maintaining a habitat that mimics a natural ecosystem. These schemes encompass various stages, ranging from the initial introduction of key species, such as beavers, to ongoing management practices, including relocation efforts when necessary. Additionally, the process entails continuous monitoring of woodland areas and the diligent upkeep of recreational facilities to ensure a harmonious balance between environmental preservation and human enjoyment.

One crucial aspect of constructing an artificial natural environment is the introduction of beavers. The management of beaver populations involves carefully considering their impact on the ecosystem and employing techniques like habitat manipulation, population control, or relocation, if necessary, to maintain a sustainable balance.

Furthermore, effective management of an artificial natural environment requires consistent monitoring of woodland areas. This involves regular assessments of the health and diversity of plant and animal species, tracking changes in ecological dynamics, and identifying potential threats or disturbances. By closely observing the environment, managers can implement appropriate interventions to mitigate any negative impacts and promote the well-being of the ecosystem.

Diversed Riparian Environments



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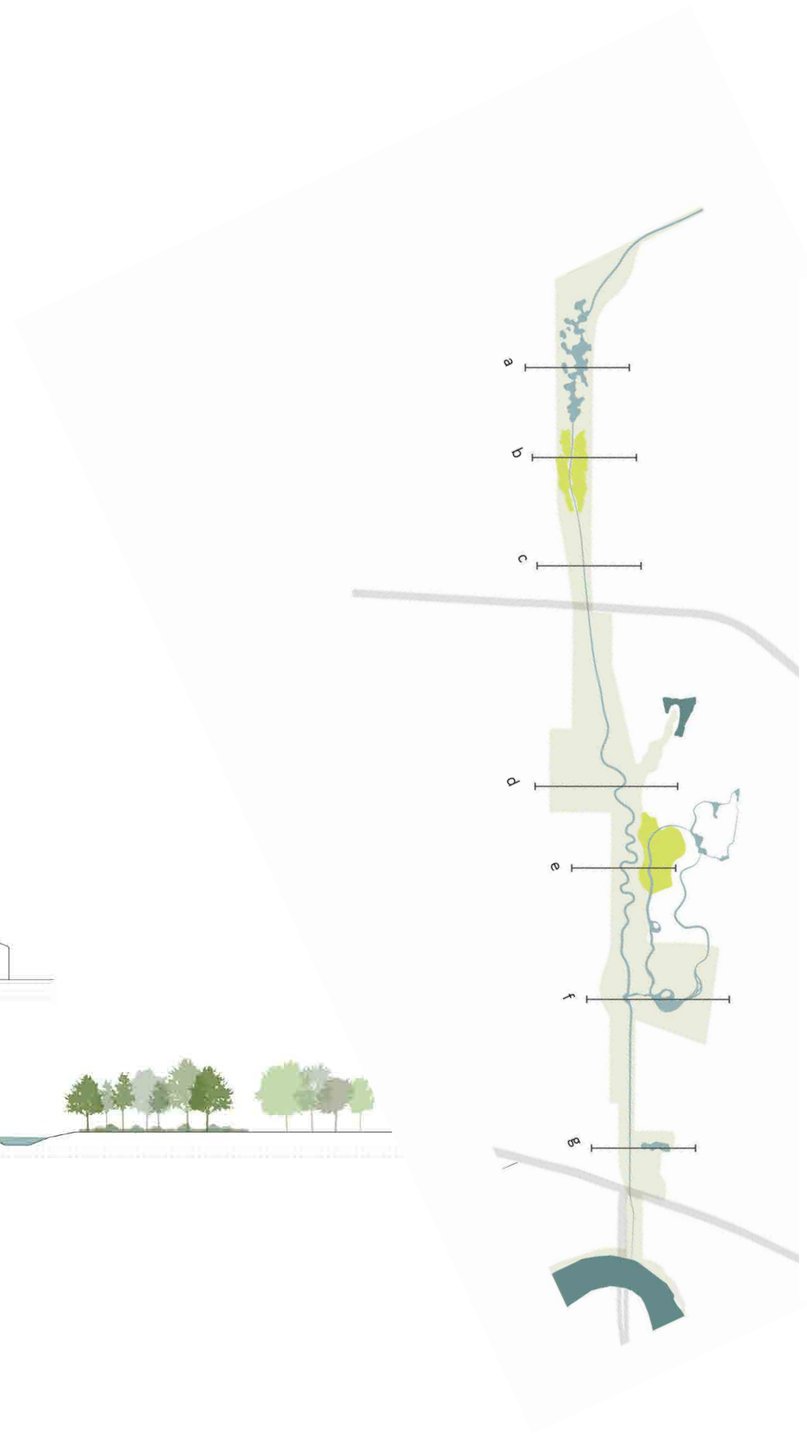

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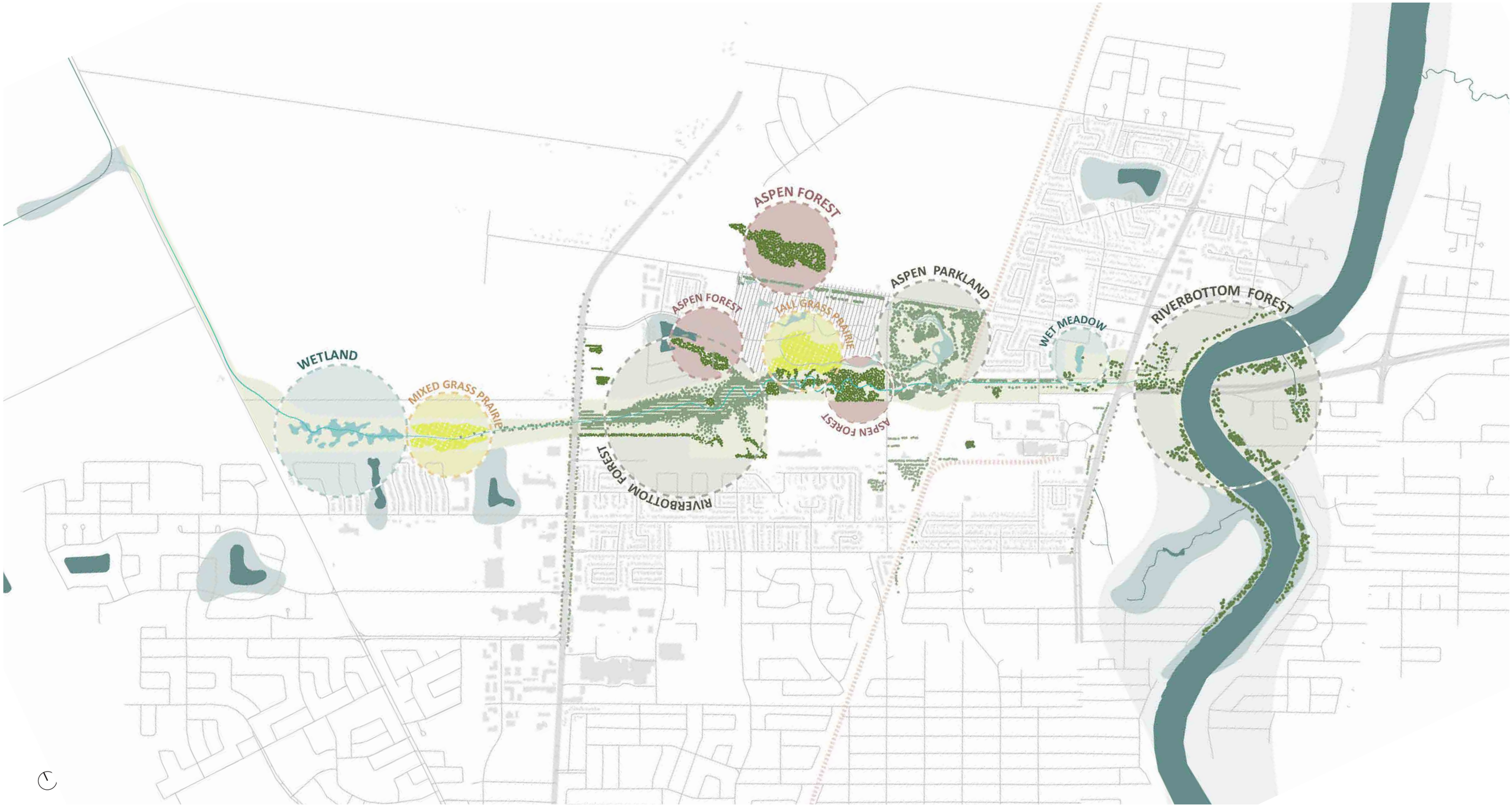
Habitat Corridor



Masterplan

1. Beaver Pond Complex
2. Artificial Planting Forest
3. Wetlands Park
4. Detention Basin
5. Retention Area
6. Floodable Zone
7. Tallgrass Prairie
8. Single Family Community
9. Elderly Community
10. Indigenous Student Community
11. Newcomers Community

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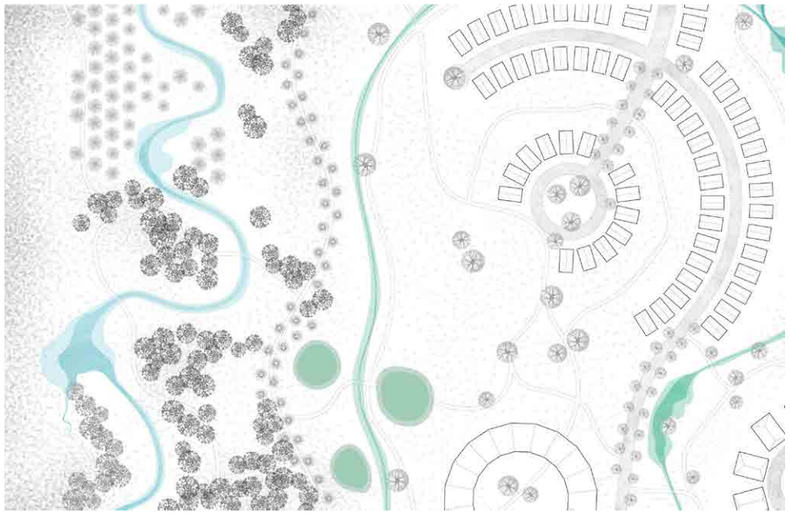
Zoom-in Area

This area focuses on the interaction between residents and wildlife. The design separates the beaver behavior space and People's Daily activity space in the riverbank zone and manages different areas through planting and maintenance methods.

Riparian Zone | *Transitional Zone* | *Residential Zone*

Vegetation plan

Under storm conditions



Scenario

Resilient Water Management in the Neighborhood

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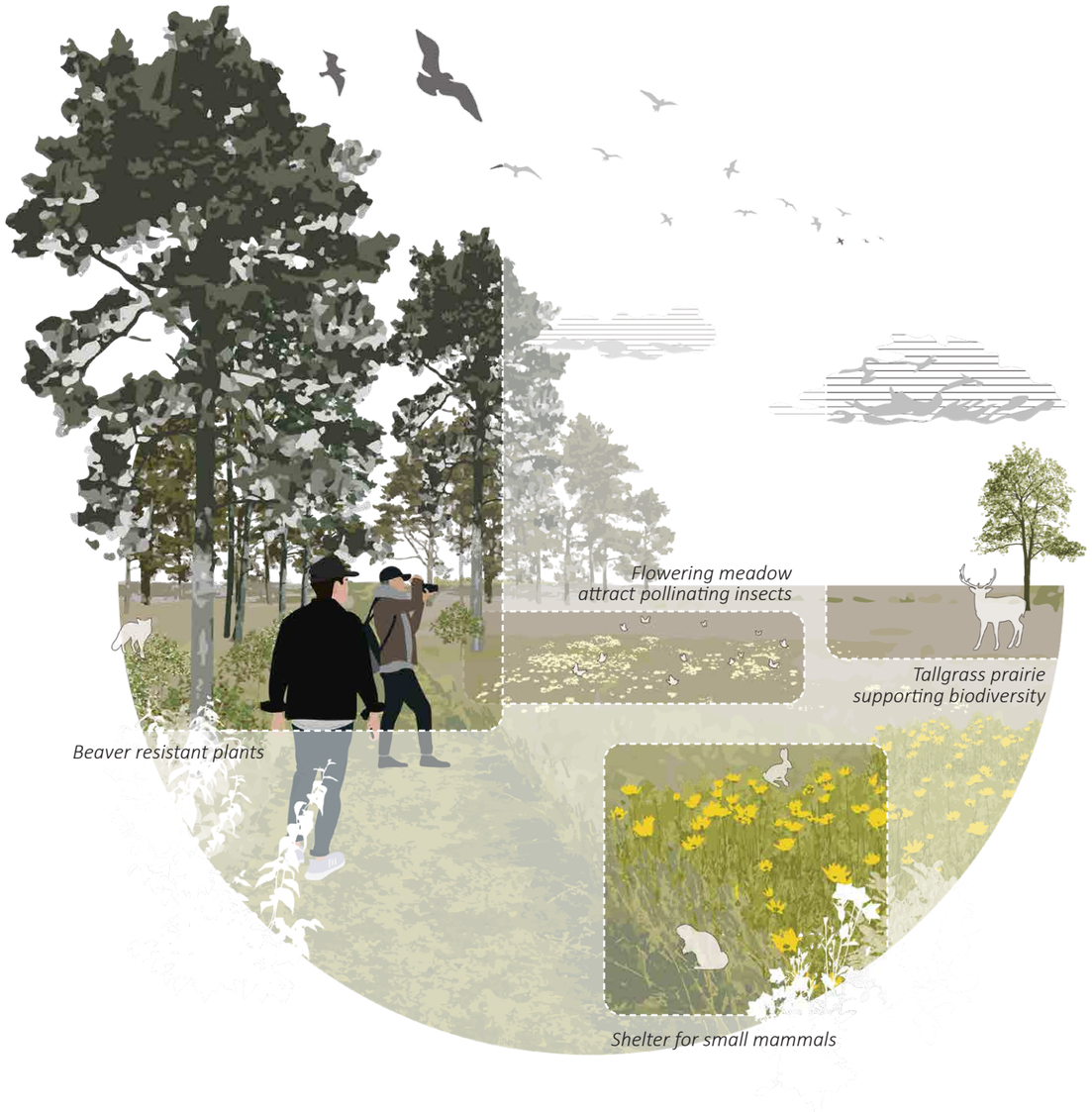
Scenario

Habitat Maintenance in the Buffer Zone



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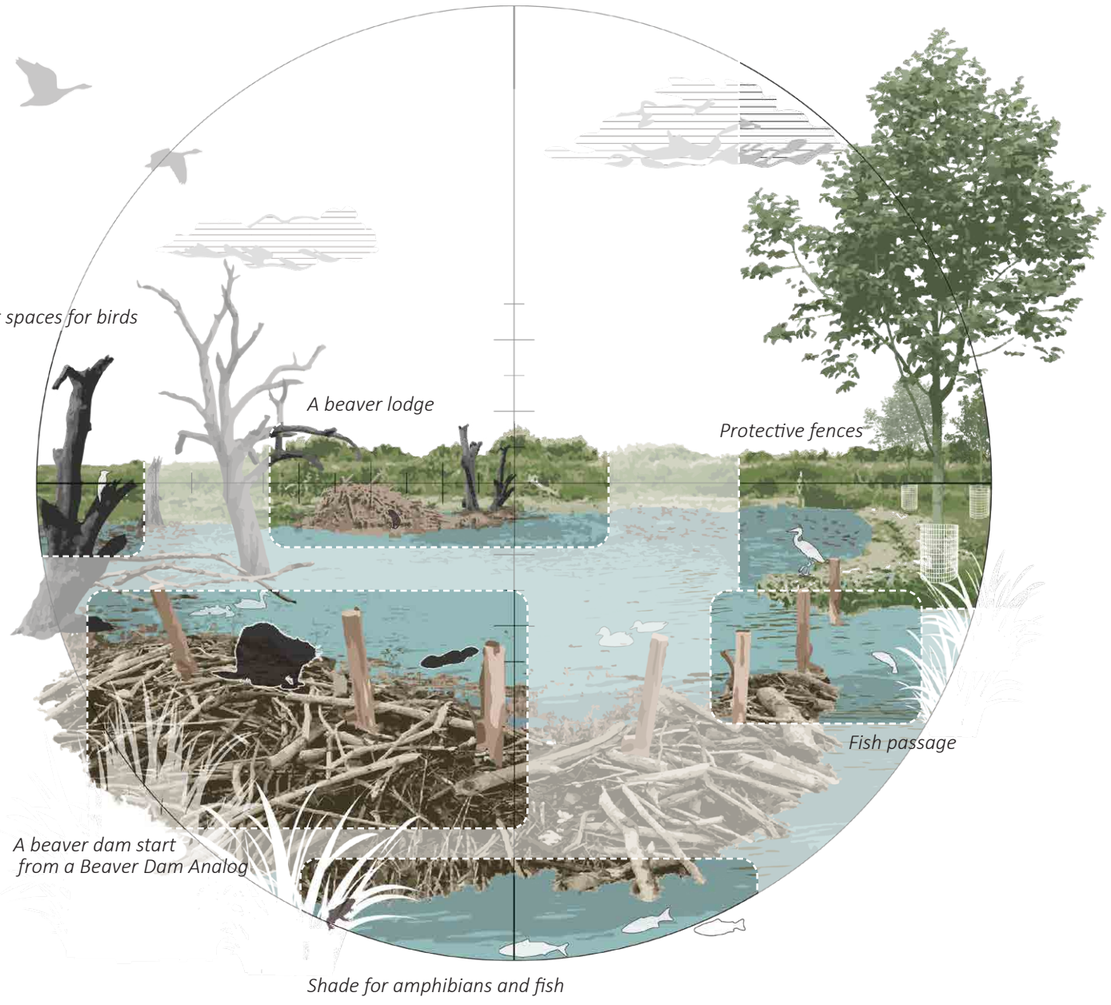
Scenario

Beaver Pond System and Evolvement



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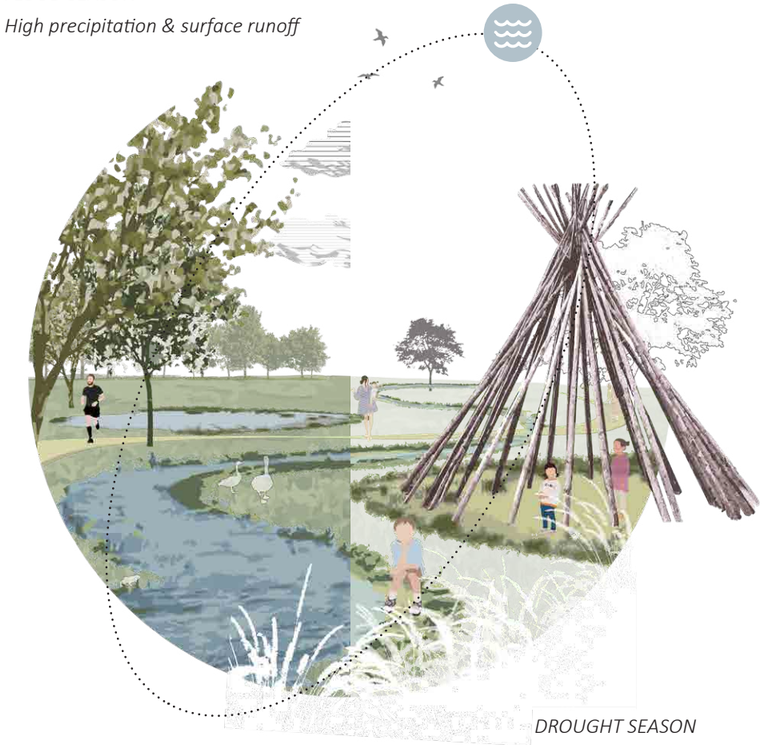
Scenario

A Dynamic Landscape

FLOOD SEASON

High precipitation & surface runoff



DROUGHT SEASON

High temperature and evaporation

NATURAL STATE

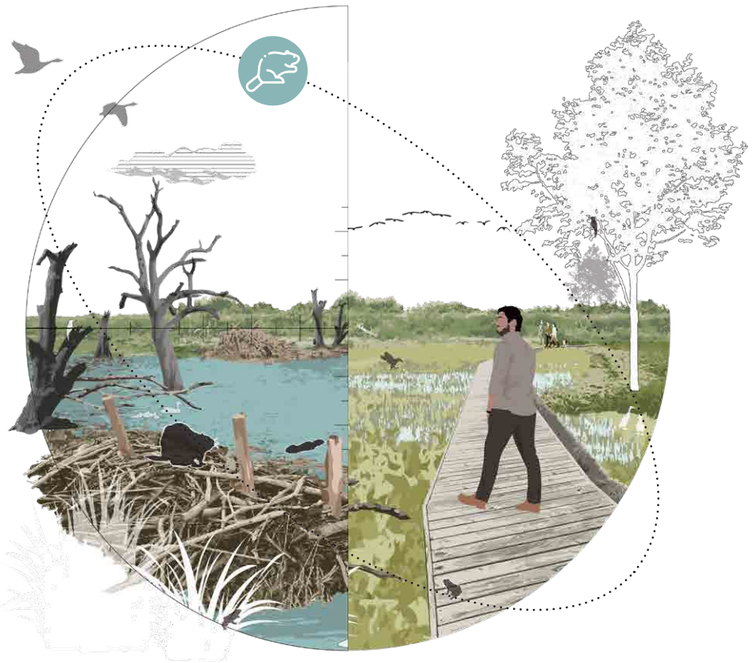
A mix of species and habitat

WITH MAINTENANCE

Managing and directing natural succession

BEFORE

Beaver colonization



AFTER

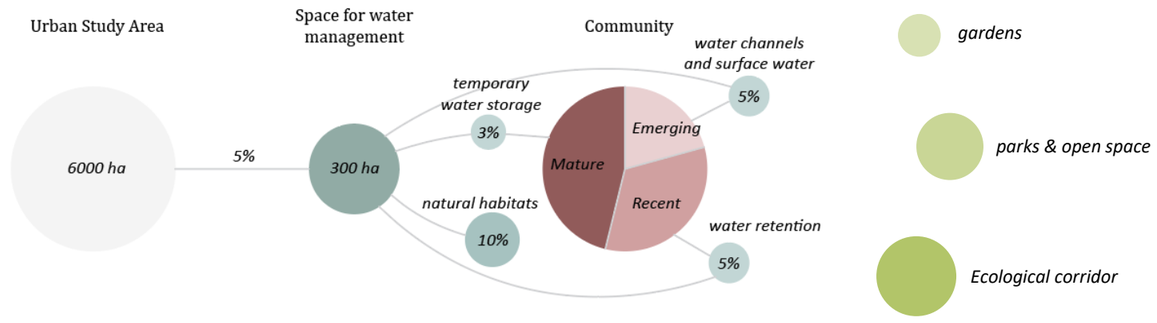
Beaver abandonment

Integration Stages

The project's primary objective is to establish a spatial framework that is capable of withstanding future changes and challenges. This framework is designed to be adaptable and flexible, catering to different types of communities. The overarching vision is to create a sustainable and resilient environment that can effectively respond to evolving needs and trends over the next 25 years.

The three guiding models will serve as basis for future community development and renewal so that each community receives a customized approach that aligns with its specific needs and aspirations. By utilizing these models, communities can make informed decisions about water management infrastructure and environmental management.

While the spatial framework provides the overarching vision and direction, the implementation of the project involves more specific and targeted actions. This is where the toolboxes come into play. The toolboxes anf their application scenario consist of practical and actionable strategies, techniques, and methodologies that can be applied in a mature and adaptable way. These tools help communities translate the guiding models into tangible actions on the ground.



PART 4

Reflection

9.1 Conclusion

Nature-Based Solutions: Insights and a Future-Proof Framework

The project embraced nature-based solutions as means to address urban flood challenges posed by various factors. By building a green-blue network, valuable insights were revealed on how to live in a more flood resilient urban environment. The project went beyond offering individual solutions and aimed to establish a future-proof framework. This framework provides a toolbox of strategies and showcases their feasibility under diverse conditions, serving as a foundation for a long-term sustainable urban development.

Modified Hydrological Cycle: Adapting to Real Environments

The project dives into different possibilities of urban spaces based on an understanding of the urban hydrological system. This involved adapting existing street typologies, water feature edges, residential house layouts, and green spaces to create a coherent and functional design. The project's focus on aligning with the context of real environments ensured practicality and relevance in its implementation.

Symbiotic Neighborhood Model: Blending Indigenous Culture and Living with Nature

Based on the prevailing urban residential pattern in Winnipeg, the project explored the concept of a circular water neighborhood. Drawing inspiration from indigenous practices, the project emphasized communal lifestyle and the integration of natural processes. Aiming at a symbiotic relationship with nature, the project creates a community that not only thrives with the lowest cost in rainwater management but also embraces the interdependent relationships with the surrounding environment.

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Role of Beavers: Mimicking Beaver Ecosystems in Urban Environments

While replicating a purely natural beaver habitat was not feasible in intensive urban environments, the project adopted an innovative approach by mimicking beaver ecosystems within feasible zones. It focused on incorporating essential elements that would attract and support beaver populations. By creating a beaver-friendly environment with suitable vegetation, water features, and appropriate shelter, the project aimed to achieve benefits comparable to those of naturally formed beaver ecosystems. Through ongoing beaver management, the project demonstrated the potential to realize the positive impacts associated with beavers, such as water regulation, habitat creation, and biodiversity support within urban settings.

Adaptable Schemes: Embracing Unpredictability for Changing Landscapes and Flood Resilience

Recognizing the dynamic nature of landscapes and the need for flood resilience, the project presented adaptable schemes for different layers and spatial scales. Understanding the unpredictable nature of landscapes, the project emphasized managing landscape changes rather than attempting to control them. By integrating this scheme into the overall framework, it showcased the feasibility of an integrated approach that accommodates natural processes while addressing human needs. This approach allowed for the development of strategies that respond to changing conditions and enhance the overall resilience of the built environment.

In conclusion, this project successfully explored the intricate relationship between natural processes and urbanization, drawing inspiration from indigenous wisdom and incorporating nature-based solutions. By embracing these principles, the project contributed a feasible solution for urbanization to coexist harmoniously with natural processes, ultimately contributing to sustainable and flood-resilient communities.

9.2 Implication

The thesis topic, centered around water issues in cities, presented a multifaceted and complex landscape architecture challenge. As the research goes deeper, it became apparent that to solve this problem required interdisciplinary collaboration and a comprehensive understanding of various perspectives. However, the unique contribution of the design process lies in its ability to integrate ambitious visions with practical, contextually compatible spatial solutions. The experiment on creating beaver-friendly environments within urban landscapes is a bold idea to replicate the functions and benefits of beaver ecosystems on urban.

In the process of research and design, I went through an approach from divergence to convergence at each stage, which is an entangled but necessary experience. I also explored the space design and management within both spatial and temporal scales. It is important to note the consideration of landscape management as a process, especially when it involves natural changes. Although several management schemes have been presented in this project, I still recognize the limitation of an unpracticed design.

Another contribution to my personal and professional growth is seeing the significant influence of social and cultural backgrounds on landscape design. Having my educational background in China and first year of master's degree study in the Netherlands, this project site with North America cultural background has revealed great differences with my prior practices. Despite not being able to visit the site due to some reasons, extensive research was conducted to understand the cultural significance of landscapes in the Canadian context. This challenge provided me an opportunity to compare various cases from North America, Europe, and Asia, expanding my understanding of the advantages and disadvantages of designs influenced by different social and cultural contexts.

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Reflecting on my master programme in landscape architecture, I am grateful for the opportunity to study in the field of Urban Ecology. The accomplishment of this project will equip me with a deeper understanding of landscape architecture's potential in creating sustainable and resilient urban environments. Moving forward, I am inspired to continue exploring innovative design solutions that integrate nature's principles into delicate design and link between urban environments and their ecosystems.

9.3 Scope and Relevance

Scope and relevance

Social Relevance

The project follows the trace of the sensitive hydrology phenomenon and calls for the necessity and urgency of natural watercourses preservation in cities, which contributes to a more sustainable city life. From the cultural perspective, the benefits of coexisting with wildlife can be a response to the indigenous views of the plains and beavers. Instead of replicating the way of life of the ancestors of the prairie, the project rethinks of a new vision that contemporary lifestyles, along with other natural organisms, can be integrated into urban ecosystems.

The project opens up a view on the beneficial interaction between ecosystems, animals, and human activity, improving sustainability in terms of maximizing cost effectiveness, promoting biophilia behavior of urban residents, and avoiding risks to city infrastructures from beavers and other animals while sharing. Moreover, it arouses the awareness of citizens to better live with the flood and rethink differently about land use in urban planning.

Bringing Winnipeg's urban hydrology system into the response to threatening floods also provide additional advantages for the city: reduced construction costs, increased property values, basement flooding elimination, recreational amenity, increased aesthetic values, potential for notable species habitat, and pollution load prevention for the receiving stream by the natural-based flood solution.

By structuring a more resilient hydrologic system with different stakeholders, they learn to collaborate to satisfy the requirements for housing, greening and recreation with a more sustainable approach.

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Professional and Scientific Relevance

Through research by design approach, the project would provide a comprehensive model for regenerating the potential for more adaptable hydrologic cycle. The strategic plan in response to two main flooding types in Winnipeg, overland flooding and river flooding, pursues a sustainable development approach on water availability, quality and safety for a better quality of life in urban environments.

In a larger scale, the disappearing water surface (creeks and marshes) under the influence of urban expansion has aroused hydrologic crisis that spreads across the metropolitan areas in North America. This graduation work aims at providing a solution to cure the losing water surface under the pressure of the rapid urban expansion.

Landscape planning and design is a vehicle for human understanding of ecosystems, a catalyst for the mutually beneficial development of humans and nature. It is also fundamental in this project to look for a different identity and provide a more livable social structure through landscape design, which counts on a combination of spatial strategies and social studies. The symbiotic urban development plan in Winnipeg's Northwest region may willingly show an aspect on working with different disciplines (architecture, engineering, ecology…) to achieve the public welfare.

By addressing water issues through a landscape architecture lens, we can advocate for sustainable urban design approaches that consider ecological and cultural contexts. This research demonstrates the potential to create beaver-like ecosystems within feasible urban zones, providing substantial ecological benefits. However, challenges such as managing beaver populations and balancing ecological and ethical considerations require further exploration and collaboration with experts and naturalists. This thesis serves as a stepping stone for future research and the development of innovative design approaches in urban landscapes.

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