From Resistance to Resilience: Reinvigorating Wetland Ecology Along the Detroit River

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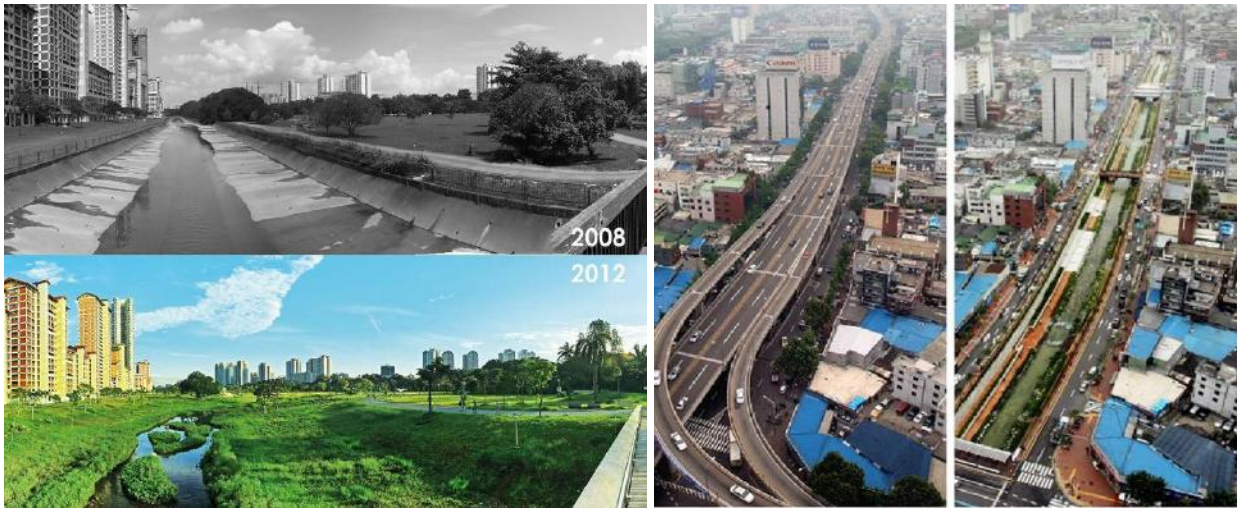

Figure 1: Examples of transforming ecologically defunct rivers into activated urban spaces that overlap ecology, economy, and recreation: Kallang River Bishan Park Singapore (Henning Larsen, 2010); the Cheonggyecheon Stream Seoul (SeoAhn Total Landscape, 2018).

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ABSTRACT: The architectural and engineering goals pursued in most cities along river edges, such as Detroit, during the 19th and 20th centuries, were justified for that time as they supported the rapid growth of those cities. Such goals aimed to provide flood safety, separate sewage, and support trade and transportation. However, the relationship shaped between the Detroit River and the urban form around it during that time presented a conflict between two systems: the natural and the built. Civic needs fueled by the industrial revolution and an economy for growth were favored over the natural system and the ecological services that it offered. Although not without merit, the design of these systems failed to incorporate the dynamic and spatial qualities of rivers, and urbanization during that time was basically "building on top of the environment" (Hajer et al. 2020). Such an approach created issues like the increase of an impermeable footprint that in turn increases polluted runoff that enters waterways, the complete loss of ecosystems and habitats due to extensive armoring of the river edge, and the erasure of wetlands, which constituted the first nature of the Detroit River prior to settlement. Nowadays, the vulnerability of those engineered systems is starting to show as they reach a tipping point where they are failing in front of natural forces due to climate change. These climatological shifts have made it necessary to foster a more ecologically sensitive and sustainable relationship with the Detroit River and to build resiliency along the edge through a framework of social-ecological resilience, where treating nature as a stakeholder and an ally is an inseparable part of thinking about cities, and where nature-based solutions, where the power and intelligence of nature are taken as a starting point for finding solutions. (Hajer et al. 2020)
To test this claim, this thesis proposes to reimagine the design of a mixed-use riverfront development present along the edge of the Detroit River, through a framework of social-ecological resilience and urban form resilience, that will be achieved by the tools of landscape ecology and spatial morphology.

KEYWORDS: Social-Ecological Resilience, Wetland Ecology, Resilient Urban Form, Ecological Water Management.

DEDICATION: I am dedicating this thesis to a beach once vibrant with people who longed for a dip in its crystal blue water. A beach that fostered fond memories of many generations. A beach I swam in every summer as a kid until it got plagued with untreated wastewater from a newly built CSO. I devote this thesis to my small coastal hometown along the southern Lebanese shoreline in hopes that this work may in some way contribute to a collective allegiance to the natural bodies of water we dwell around.

ACKNOWLEDGEMENTS: I would like to express my gratitude to the thesis committee. To Professor Scott Shall for his patience and faith in me. To Doctor Kim and Professor Orlowski for nurturing my thinking and guiding me through this process.

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Part 01: FIRST NATURE OF THE DETROIT RIVER

1.1. The Detroit River before settlement

Before the arrival of Europeans, native American tribes lived in the Detroit River for thousands of years, their relationship with the river was a survival relationship as they managed the landscape and cultivated crops that helped them sustain their living. When the French first settled along the edge of the River in 1701, they described the river and the landscape around it as a lush and vibrant one of diverse typologies such as forests, prairies, wetlands, and waterways, with dozens of varieties of fruits and nuts. (The All-Too-Common Reed 2016) Though it is imprecise what the landscape exactly looked like 300 years ago, regional historical accounts suggest that the landscape around the Detroit River was a wetland that was a haven for different species that dwelled within it and rendered it as a biodiverse refuse where ecology was naturally thriving. (The All-Too-Common Reed 2016) This testament alludes to the fact that the health of the ecology at that time was at its peak. However, that was mainly due to the fact that the low population back, and the subsequent lack of need for development did not present a conflict between the natural system and civic needs. Thus, the conditions presented a given set of circumstances where nothing impeded the ecology from prospering.

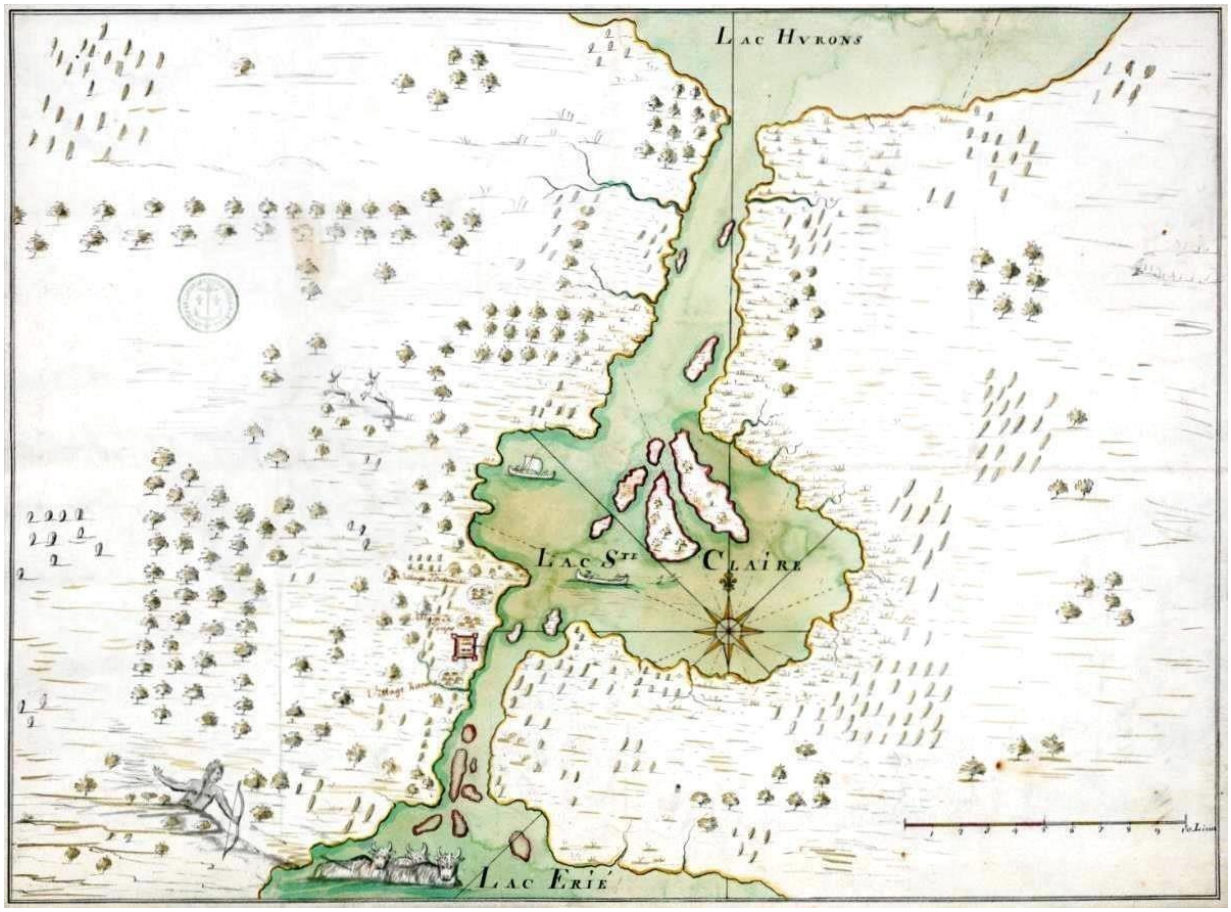

Figure 2: The first French settlers' 1700s map of the Detroit River showed the vibrant and productive landscape they spoke of. The map shows how the landscape along the edge of the river was unaltered at that time. (The All-Too-Common Reed 2016)

Unfortunately, the loss of wetlands along the edge of the Detroit River has been extraordinary. Wetlands used to line up both edges of the river and spread about 2 miles inland. From the 1800s till now, over 90% of those wetlands have been lost in southeast Michigan due to anthropogenic practices and human development. The loss is even more drastic when focusing on the Detroit River where both the U.S. Geological Society and U.S. Fish and Wildlife Service estimate that 3% of coastal wetlands along the Detroit River remain from the pre-industrial time. (Bloch 2021)

1.2. Wetland Ecology and the great ecological services they offer

Should we be concerned about the disappearance of wetlands and the muddy, murky marshes that usually line up the edge of rivers and lakes? The answer should be an unequivocal yes, as wetlands offer effective solutions to many of the problems our cities are experiencing today, such as flooding and water pollution, among others. The deterioration of wetlands has left the Detroit River defenseless against non-point source pollutants such as urban and agricultural runoff. Excessive pollutants, sediment, and nutrients from runoff keep infiltrating the river as there are no means for them to be intercepted and captured as the river lost its natural defense mechanism that was present in the ecology of wetlands. This further exacerbates the ecologically defunct state of the river as pollutants keep pouring in with no means of river regeneration due to the excessive armoring and channeling of the river that deprives it from its natural mechanisms.

Not only are wetlands powerful and effective water filtration agents through the abundant and numerous deep-rooted

vegetation they harbor, but they also provide a range of ecological services and functions.
They help improve water quality, including that of drinking water, by intercepting surface runoff and removing or retaining inorganic nutrients, processing organic wastes, and reducing suspended sediments before they reach open water. For example, as the runoff water passes through wetlands, they retain or process excess nitrogen and phosphorus, decompose organic pollutants, and traps suspended sediments that would otherwise clog waterways. (US EPA Watershed Academy Web 2021) Protection against shoreline erosion and dampening potentially destructive waves are also major benefits of wetlands provided by the thick coverage of plants present in a wetland. They also provide food and habitat for different wildlife species and organisms that are often endangered. Such species are an integral part of keeping a healthy and sustainable ecosystem. Wetlands also allow for sediment recharge, which helps sustain a productive and regenerative river bed. In addition to that, they also help replenish groundwater. The diverse ecosystem also provides unique recreational spaces.

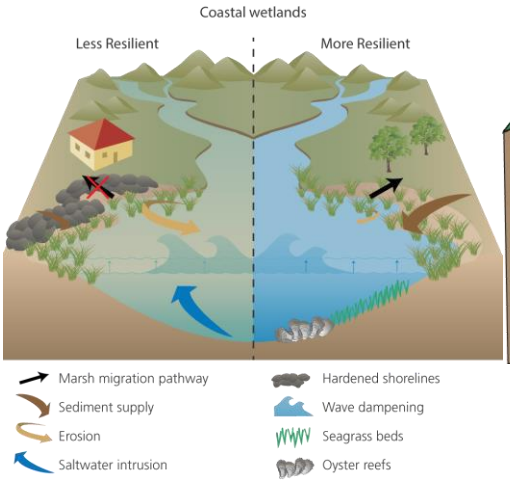

Figure 4: A breakdown of some of the ecological benefits wetlands offer and the issues that arise they disappear (Fries 2014)

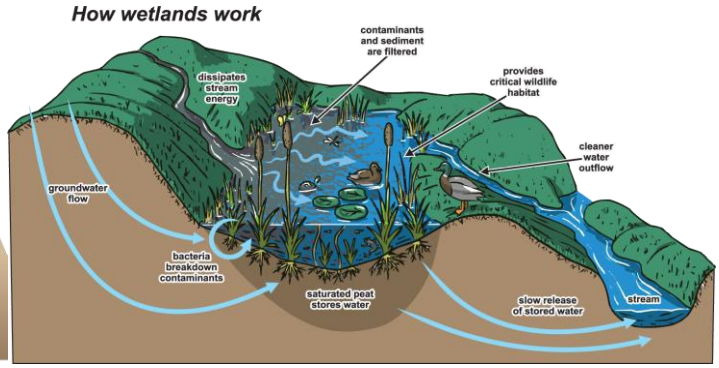

Figure 5: Wetlands function through the complex web of species and organisms they foster (The Environmental Services Office in when Kanabec County 2020

Research and studies support the importance of wetlands and reinforce their role as strong natural agents that provide solutions to many of the problems our urban systems currently face. According to the United States Environmental Protection Agency, functioning wetlands help significantly cut down on costs required to sustain the urban environment. A 1990 study showed that the "Congaree Bottomland Hardwood Swamp in South Carolina removes a number of pollutants that would be equivalent to that removed annually by a $5 million wastewater treatment plant." There are other studies that prove the same point. A 2,500-acre wetland in Georgia "saves $1 million in water pollution abatement costs annually." According to another study carried by the US EPA. Wetlands also reduce environmental problems, "such as algal blooms, dead zones, and fish kills, that are generally associated with excess nutrient loadings." (US EPA Watershed Academy Web 2021) However, wetlands do not have an unlimited capacity in buffering all pollutants before reaching the body of the river. An excessive amount of pollutants such as nutrient and sediment that is carried by encroached runoff can degrade wetlands and thus the ecological benefits that ecosystem provides. With legislative action taking care of point-source pollutants such as industrial dumping, non-point source pollutants like urban and agricultural runoff remain a considerable threat to the wetlands that remain and to restoration efforts.

That stated, it becomes important to acknowledge that reinvigorating wetlands, on its own, won't lead to the disappearance of all the environmental challenges we currently face in relation to water. Thus, to achieve resiliency, a framework should be comprehensive and combine powers of social change, political legislation, and innovative sustainable technologies together to achieve a symbiotic relationship between the urban and the natural system. When it comes to an architectural intervention, this thesis will explore how riverfront development can aid in the mitigation of urban runoff by eliminating it and dealing with it on site, rather than further increasing encroached runoff by adding more to the impermeable footprint near the edge of the river.

Part 02: SECOND NATURE OF THE DETROIT RIVER

2.1. Development of the landscape along the Detroit River

As mentioned above, over 90% of wetlands have been lost along the edge of the Detroit River since the 1800s. To understand how this came to be, it should be understood how waterfront development evolved along the edge of the Detroit River into what it is today, and what factors influenced this evolution.

When the French first settled in Detroit, they had a close relationship with the Detroit River. This close relation is manifested by the creation of the ribbon farms that allowed their owners access to water, which was a vital resource for human survival and a tool that helped with agriculture and wildlife survival. This symbiotic relationship did not last long after the arrival of settlers, as they have set the pace for the first paradigm shift that changed the relationship between man and the river. Detroit became a center of commerce and trade well before the industrial revolution. During the fur trade era in the 1700s, settlers hunted beavers from the Detroit River and exported around 50,000

skins annually until beavers were near extinction. This marked the beginning of the change in the landscape of the edge of the river. (Hartig 2015)

Detroit's role as a major trade and commerce hub continued to grow, leading to industrial development, and the City became an embarkation point for the lands farther west, thus attracting more human traffic. The advantage of water and rail transportation made Detroit a strategic location for industry. Detroit went through another paradigm shift when it became one of the most prominent ship-building ports in the U.S.A yards and ship-building factories started to line up the edge of the river as the pressing demand for transportation of both people and goods continued to grow. (Hartig 2015) Shortly after came Detroit's industrial revolution. A major paradigm shift that drastically changed the landscape of the Detroit River, where industrial facilities and urban development that aided Detroit's role as a pioneer of the automobile industry lined up the edge of the river. (Hartig 2015) The factories, mills, metalworkers, and railways that supported the heart of America's auto production spread out across the region. This industrialization took a toll on the land and the many Detroit-area wetlands. Factories, roads, and houses damaged habitat and fragmented the landscape. The edge of the river was almost entirely hardened in order to deepen the basin of the river for navigation, and so the riparian edge and the first nature of the river was replaced by a hardened stretch of impervious surfaces. (The All-Too-Common Reed 2016)

2.2. Detroit's Industrial Revolution and its impact on the river

From the early 1900s to the mid-1900s, Detroit embarked on a journey to become the United States automobile capital. The Detroit River played a major role in allowing Detroit to reach this level of prosperity. The use of the waterfront during that time was heavily industrial and served functions such as shipping, manufacturing, and associated land-based transportation and storage facilities. The Detroit River waterfront served these functions very well and became a site where the success of the industrial revolution manifested and where a great amount of wealth was made (Hartig 2015). However, during that time, the river became a dumping ground for industrial waste and toxic pollutants that were being constantly discharged into the river from factories along its edge. The act of dumping was often overlooked by authorities as the influence of industry on the growth of the city was profound enough for them to justify the negative impacts. Factories continued the act of unregulated dumping until the Detroit River became the most polluted river in the U.S. during the 1950s.

Figure 7: One of at least 12 times the Cuyahoga River in Cleveland caught on fire in 1952. Similar to other rivers across the U.S. such as the Detroit River, Cuyahoga was a dumping ground for industrial waste and toxins that were being discharged into rivers unchecked, and that up to this day still suffer the bitter consequences of the industrial revolution. This incident inspired the passage of the Clean Water Act, the most prominent law regarding water quality in U.S. fresh water. (Graham 2022)

In order to support Detroit's blooming industry and growing population, the Detroit River had to be altered in ways that aimed to provide flood safety, separate sewage, and facilitate trade and transportation, which were all justified during that time. However, the design of this infrastructure failed to incorporate the dynamic and spatial qualities of rivers. Such systems created issues like the increase of an impermeable footprint, that in turn increases polluted runoff that enters our waterways, the complete loss of ecosystems and habitats due to extensive armoring of the river edge, and the erasure of wetlands, the first nature of the Detroit River. Of those measures, resistive sea armoring was one of the detrimental engineered systems that affected the ecology of the river, as such measures erased the existing ecology and replaced it with a hard edge that aimed to resist natural forces. The river edge was armored in order to deepen the basin of the river and allow for navigation, and also to protect against flooding. This measure came with negative effect on ecology, which are illustrated in figure 8.

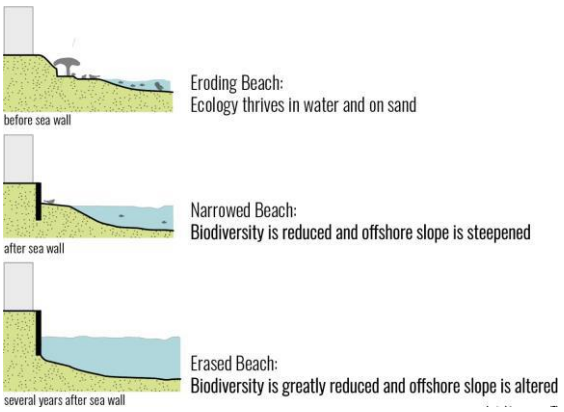

Figure 8: The impositional impact of sea armoring on ecology and biodiversity. Image by author.

This period of time marked the peak of the dissonance between the Detroit River and Detroit Residents. At that time, the river was only regarded as a working one that's sole function is to support commerce, trade, and technological progress. According to Marie McCormick, an executive director of the Friends of the Rouge, "Some people characterized the situation as peak pollution and environmental indifferences. The cost of doing business for 100 years." (Nissen 2019) This is how the industrial revolution shaped environmental ethics and the relationship people had with

the Detroit River. Civic needs and an economy for growth heavily fueled the favoritism of civic needs over natural systems and the ecological services that they offered. The symbiotic relationship that was once present when Native Americans dwelled along the waterfront of the River, and when first settlers first arrived, has been lost to accommodate for the growth of our cities and their economy, as that generated great wealth for many people.

2.3. The Anthropocene and its impact on environmental ethics

The Anthropocene marked the beginning of a geological era where human activities started to have a profound and mostly detrimental impact on the environment and its ecosystems. a "Great Acceleration" of population growth, reliance on fossil fuels, industrialization, and the emergence of technological advancement characterized this geological era. The landscape was being reshaped, where at least half a trillion tons of concrete, plastic, and other chemicals were becoming widely disseminated on land and in the sea. The global biosphere was also shifting, where species were at threat of extinction while others became invasive and shifted ecologies. (Waters & Zalasiewicz 2017). The beginning of the Anthropocene coincided with Detroit's industrial rise where the city was the center of the automobile industry and was rapidly growing at a very high rate.

The Anthropocene was characterized by the shift from a symbiotic relationship between nature and the few people dwelling on it into an imbalanced relationship where the perception of nature changed and was molded by new advances in urbanization, technology, and industry. Wilderness and the newly constructed perception of nature promoted this idea that raw nature is the antithesis of civilization. (Adhya & Plowright 2017). The Anthropocene promoted the idea that the natural system and the urban one could not exist in one space. The urban system was regarded as the beacon of civilization, modernity, and invention, whereas the raw natural system was regarded as a primitive entity that has no place or function in the urban environment. The Anthropocene promoted ego-centric environmental ethics where all non-human constituents, including natural bodies of water, are viewed as means to a human end and commodities for human gratification and needs.

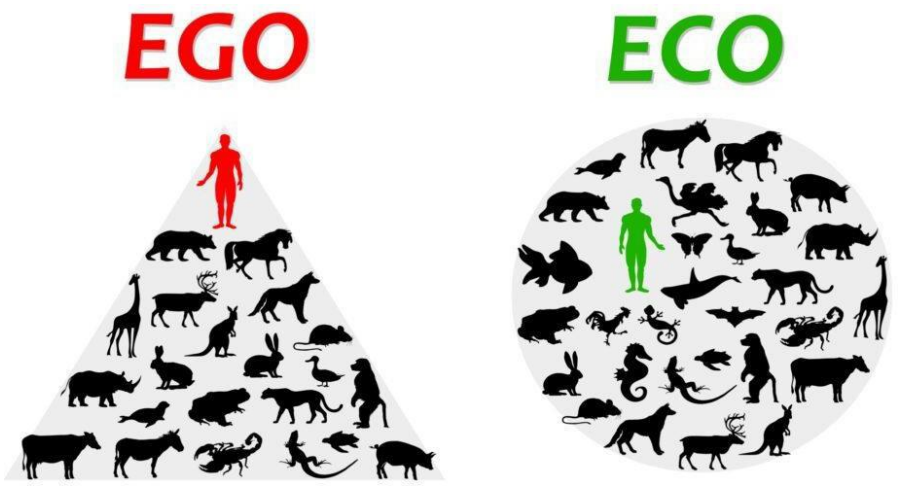

Figure 6:

Eco-centric environmental ethics, the opposite of ego-centric, require humans to view nature and non-human constituents as stakeholders and allies, focusing on the well-being of the whole, and the elimination of anthropogenic threats that could prevent the sustainability of our ecosystems.
Source: (Darach Social Croft 2020)

2.4. Post-Industry and the Detroit River

After the 1950s, the industrial waterfront started to decline as transportation modes changed and switched from river transport to the bulk cargo mode of transportation. Also, many manufacturing operations started to relocate away from the riverfront. The decline was also fueled by the shift of the local economy from an industrial-dominated economy to a service industry. This decline happened across the entire city where Detroit, at large, suffered from a decline in population and industry. The decline kept aggravating until Detroit became the largest city in the U.S. to file for bankruptcy. This decline left its impact on the waterfront where many underutilized and vacant lots lined up the edge of the river. Not only that, but brownfields were also a legacy left by the industrial revolution of Detroit. Many of them are still present along the edge of the river today, and they pose an obsolete stretch of land that poses a threat to the quality of the water as contaminants and toxic waste could seep into the water. Such sites often sit without intervention for a long period of time, as the complexity of the state of contamination and pollution requires careful and costly measures. This legacy of post-industry did not help in alleviating the weakened dynamic interaction between the river and the city, as with industry leaving the city, it left the river edge with numerous vacant buildings, and underdeveloped lots along its edge. The impact of industry was also still profound as the river remains highly contaminated to this day with no means to regenerate itself as it lost its natural defense mechanism, which is wetlands.

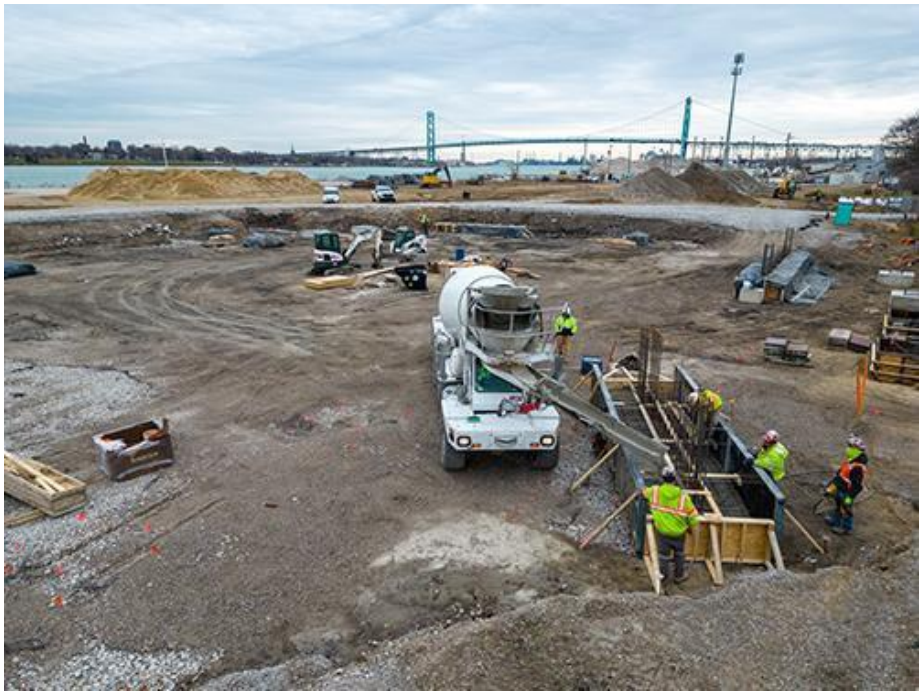

Figure 9: The former Uniroyal site along the waterfront, which is a brownfield, sat idle for nearly 40 years before any work got underway. Only parts of the site are being revitalized as others remain contaminated. Before any work could have been done, a 7 feet wide seawall had to be erected to prevent contaminants from leaching into the river. Such armoring procedures, though justified, are very impositional on ecology as once erected they are everpresent. (Detroit Riverfront Conservancy 2022)

2.5. Climate change and the failure of resistance-based architecture and engineering

With climate change becoming more severe by the day, engineered water management systems aimed at flood protection such as sea armoring and CSOs are increasing the potential risk of flooding, as such measures resist water rather than working with it and giving it room to move. As the impermeable urban footprint grew larger and extended closer and closer to the river edge, and as cities continued to build in flood plains, measures had to be taken to ensure there is resistance to flooding. Rivers were straightened, diverted, armored, and deepened. River edges were heavily hardened and armored, as this is considered as the most prominent strategy to keep water away. Armoring deepens the river bed over time, creating more room for water to be held in the body of the river. However, these measures, which are detrimental to the ecology and first nature of the river, failed to consider the uncertainties stemming from human-induced climate change which has been exacerbating since the beginning of the Anthropocene. Nowadays, these engineered systems are reaching a tipping point and flooding is becoming a more pressing issue, which creates an urgency that requires turning to different approaches that are resilient rather than resistive, and look back to nature for finding solutions.

Figures 10 & 11: How many once-in-100-years floods must Detroit go through every decade? Recent images showing the extent of recent floodings in different neighborhoods in Detroit - Right: Jefferson Chalmers (Rahal et al. 2021) - Left: River Rouge (Northey 202)

2.6. The Detroit River waterfront currently

The abundant ecological and social benefits that the first nature of the Detroit river could have provided has been diminished since settlers turned Detroit into a commerce and trade center. The focus on growth fueled by industrial advancement did not leave capacity for a symbiotic relationship between the natural system and the built form. The contesting, vast impermeable urban footprint, as well as the brownfields and vacant lots lining up the edge of the Detroit River, are depriving the City of ecological, social, psychological, and structural benefits that the first nature of the river could offer.

When the Clean Water Act was passed in 1972, the condition of the Detroit River waterfront began to slowly improve. Dumping of industrial waste and pollutants became more regulated, and clean-up efforts were exerted to some extent. However, the act failed to address any reparational needs and placed the burden of cleaning up the river on local communities rather than the establishments that caused this pollution. Yet, some aspects of Detroit's River revival journey are remarkable, and there is evidence that the ecology is gaining its health back. This is documented through different evidence of recovery, mainly through the return of different native species that were once endangered, like the Detroit River otter, and the improvement of water quality, even though the river is still considered well polluted from all the industrial dumping that once occurred. This thesis will explore one of the endless potential scenarios a riverfront development can be sensitive to the ecology of the river, contrary to the majority of the current riverfront development.

Some examples of sustainable redevelopment are worth highlighting. One good example is the transformation of the Chrysler Manufacturing Facility in Trenton, about 20 miles south of Detroit, into the Refuge Gateway Park and visitor center. The center is LEED certified and the project serves as a hub for raising environmental awareness, as well as showcasing a model of sustainability that aims to teach visitors how to live sustainably. The site operated as a manufacturing facility for Chrysler for 44 years, before it was abandoned in 1990. Then, the state and Chrysler had a legal battle over the extent of Chrysler's responsibility in cleaning up the site from pollutants. Chrysler put some effort into cleaning up the site. However, over 15 acres of the site were designated as restricted zones due to subsurface pollution as Chrysler buried some of the pollutants on site. The site sat idle for another decade before being acquired by Wayne County for development. A master plan was completed to ensure the site would be a model of sustainable redevelopment that supports public use. The sustainable redevelopment was completed in 2012 and it included the clean-up of capped and contaminated restricted zones, the creation of blue infrastructure using the tools of landscape ecology to slow and treat runoff on-site, the restoration of coastal wetlands and marshes which helped local species thrive, and the construction of low impact developments such as a LEED certified visitors center, trails for recreation, roads for connectivity, and other amenities that allow the public to experience the unique and vibrant ecology.

Figure 12: Aerial view of the Chrysler Manufacturing Facility in 1967. Source: (City of Trenton) and Refuge Gateway Master Plan. Source: (Hamilton Anderson Associates)

When it comes to the urban riverfront along the edge of the city, a considerable portion of the land is either abandoned buildings, underutilized street parking lots, material storage piles, or cement silos that prohibit access to the Detroit River (Hartig 2015). Revenue returns rendered the industrial use of riverfront properties as the best kind of use. However, now that Detroit is in its post-industry era, many of these properties are now obsolete and undervalued. Detroiters can now shift the perception of the city as a Rust Belt city, into one that is a pioneer of sustainable redevelopment.

Some developments are already demonstrating the potential of the river as a space of ecological remediation and an engine for sustainable development. Of these developments, the most prominent is the renovation of the GM RenCen and having the main entrance of the building facing the riverfront, as well as the construction of an atrium that aimed to lay the foundation for investments that sought to create a riverfront greenway. (Hartig 2015) Other developments included the launch of greenway initiatives by multiple community foundations, as well as the development of different sustainable riverfront typologies. Some of those projects include the creation of green and blue infrastructure in parks along the river that capture and decontaminate runoff from near roads and impervious surfaces. As well as the rehabilitation of certain parks with the consideration of nonhuman habitats in mind, along with the establishment of different LEED-certified pavilions in different parks along the Detroit River.

Part 03: REINVIGORATING THE FIRST NATURE THROUGH SOCIAL-ECOLOGICAL RESILIENCE

3.1. Why ecological resilience? Why now?

Water is our world's most precious resource, according to several reports by the United Nations. These reports also mention that we are entering a new era where water as a resource is becoming unstable. In addition to that, the world's population continues to grow. This growth is accompanied by a migration of people from rural to urban areas. Research anticipates that around 80% of the world's population will live in urban areas by 2050. This number of people will require the building of infrastructure that can support the civic needs of such people. An increased population and bigger cities tend to encourage the unsustainable exploitation of our limited natural resources. To avoid such a fate as cities continue to grow over the next few decades, riverfront development must be more respectful of the ecology of the river and treat it as a stakeholder in the design process. This also requires a framework where the built environment fosters a symbiotic relationship between the river and the dwellers, so that the resiliency of the urban form is supported by forces of social change.

In addition to that, humans are constantly being reminded of the climate change-induced challenges we are facing with the environment. When it comes to water in particular, there is evidence from around the world that we are entering a new situation where water as a vital resource is becoming unstable. The U.S. west coast experienced historic drought levels and unprecedented rainfall levels all within the span of two years. Other parts of the world are experiencing the same issues where rivers are swiftly drying up and at the same time other parts of the world experience unprecedented rainfall levels and flooding. Here in the Great Lakes region, people are lucky enough that the extent of instability of water resources is under control. Though many bodies of water are still suffering from consequences stemming from anthropogenic practices, our water resources are abundant and somewhat stable.

If anything, the events from around the world should serve as a wake-up call for us to change the way we manage this vital and precious resource that is water. Water security will drive people to move from less stable regions to more stable ones. Some even make the claim that future wars will be fought over water. Developing an ecologically sensitive and sustainable riverfront could potentially mean that the water quality of the river is safe enough for certain types of consumption. However, for this to happen, change needs to happen across the entire length of the river, and not just within a few developments.

Sustainability is a popular discourse among architects and planners. However, when it comes to sustainability as a movement, it is often becoming "an alternative lifestyle of renunciation, stripped much of pleasure." (Mostavi 2010) Another concern with sustainability is the scale that only focuses on the architectural object and fails to foster a conversation around the larger infrastructure that supports our cities. (Mostavi 2010) As cities become bigger and the pressure on resources increases, architectural approaches will need to reconsider the larger scale and complex relations that affect how our built environment interfaces with nature.

In order to speculate on the role of the architect and how it can support legislative action, the thesis will focus on the building scale, and the relationship between the site and the built form in order to develop a scenario where riverfront can still be present along the river, without further contributing to its demise by increasing the impermeable footprint and encroached runoff from the site. The goal is to create a prototype of urban development at the building scale where the building and the site as a whole unify to make the ecological restoration and the symbiotic relationship possible.

3.2. Sociological use as a second dimension of ecological resilience

The conjoining of ecology, sociological usage, and urbanism is the structuring principle of the proposed framework. In order to respond to the overarching challenges stemming from anthropogenic practices and a legacy of industrialism, a framework of social-ecological and urban form resilience is proposed. The reason behind choosing a framework of social and ecological resilience is that if left to their own devices, policies that aim to be sustainable might become a technology-focused and technocratic response that creates little social support and change on the way. (Hajer 2020)

If cities continue to be built the same way they were in the 20th century by developers, the imbalance between the urban form built in response to civic needs and natural systems will continue to grow, causing further challenges that will need to be addressed. We should not continue to build unsustainable low-density cities using more concrete,

steel, and asphalt. Such trends can be altered by changing the way people think of the built environment. Using the scale of the building as our lens, buildings should be conceived as more than tectonic objects deployed with technocratic sustainability technologies. Once a socially induced paradigm shift in how we think of buildings is established, we could start to see a new form of cityscape emerging, which a profound emphasis on ecological green, blue, and grey infrastructure, water management and retention, social interaction, and ecological well-being. All that is achieved through using the building as an agent that creates a symbiotic relationship between the built form on one hand and the natural systems and ecology on the other.

A major principle behind this approach is that buildings do not stand alone, but they are functionally and socially interconnected with other buildings and landscapes, that are nested in a wider, more integrated urban network. To arrive at this reimagination, social resilience is an important agent that can be deployed to catalyze this needed change in how we construct our urban environment. Another principle is that while the argument for a more resilient urban fabric is as necessary as ever, it must not be forgotten that it is also important to curate places that are pleasant to live in and places that bring out the best in people. Then, the sociological use as a second dimension of ecological resilience becomes crucial in realizing this framework.

3.3. Unpacking terminology and dissecting the applicability of the framework to the Detroit River

To successfully create a sense of urgency to rethink how we build cities and interface with nature and ecology, and catalyze that with the powers of social change and social resilience, it is necessary to unpack terminology and make it as accessible and understandable as possible for people with no architectural or ecological background to understand.

Social-ecological resilience, which is the framework deployed in response to the current state of the urban environment along the Detroit River is defined not just according to how long it takes for the system to bounce back after a shock, but also by how much disturbance it can take and remain within critical thresholds. Social-Ecological resilience focuses on “the ability of a complex socio-ecological system to change, adapt, and, crucially, transform in response to stresses and strains” (Aalto et al. 2018)

Given that this thesis is using the building scale as a lens to reimagine how we construct our urban environment, urban form resilience is another dimension that needs to be added to the framework.
Urban form resilience, which is the intended main characteristic of the proposed typologies is defined by dense and diverse inclusivity of building types founded using low-impact development. A resilient urban fabric accommodates functional and flexible multipurpose green, blue, and green infrastructure spaces. (Davoudi et al. 2012)

Spatial Morphology and Landscape Ecology are the design tools that enable the implementation of social-ecological resilience and urban form resilience. Spatial morphology “combines the qualitative study of individual urban forms, such as streets, squares, and buildings typical for urban morphology... and the quantitative approach of spatial analysis that rather look at cities as spatial systems” (Davis et al. 2013)

Landscape Ecology is the study of “the interaction between spatial patterns and the ecological process, it combines the spatial approach of geography with the functional approach of ecology. (Ahern, J. 2013) When used as a tool to design our urban spaces, it can yield a symbiotic relationship that allows the urban to exist without being impositional on the natural environment.

Part 04: DESIGN INVESTIGATION PARAMETERS AND EVALUATION OF SUCCESS

To reiterate the issue at hand and the subsequent position, the rapid industrialization and growth of Detroit made it necessary to favor civic needs over the intrinsic natural processes embedded in the ecology of the Detroit River, which resulted in a highly polluted, ecologically defunct river. To build a more resilient relationship with the river edge and undo part of the harm done, it is imperative to reintegrate the first nature of the Detroit River in the built form, especially riverfront development, so that both can exist symbiotically, through a framework of social-ecological and urban form resilience, that is achieved by the tools of landscape ecology and spatial morphology.

To investigate the claim raised by this thesis, a mixed-use development will be reimagined from an ecologically sensitive lens. The development will seek to respect the innate natural processes of the river ecology by working to reintegrate them into the built form and the site. In exchange of the development having what the river offers from an appeal to dwellers, the mixed-use development shall create a symbiotic relationship between the building, site, and river, so that both the urban nature and the river ecology can exist within the same medium, symbiotically. The development will also promote a strengthened connection between communities and the river.

4.1. Analyzing earth cover and developing frameworks from precedent analysis

Prior to beginning the serial design investigation, it should be understood that the earth cover and the relationship between the urban system and the landscape is unique and varies across the entire length of the river. There are moments where underdeveloped site can be quickly turned into ecological havens or given back to nature in efforts of restoring ecology. There are other areas where the soil is contaminated, making urban development complicated yielding multiple subsequent negative impacts if development was to occur on site. There are also areas where the urban footprint is so dense, making ecologically sensitive development extremely difficult to achieve. Figure 14 shows how earth cover is mostly impervious near the Detroit River. Turf grass and bare soil earth cover, though better for ecology and the natural water cycle than impervious surface, do not offer many ecological benefits and have a low absorbance coefficient compared to wetlands, due to the difference in the root structure of the plants in each.

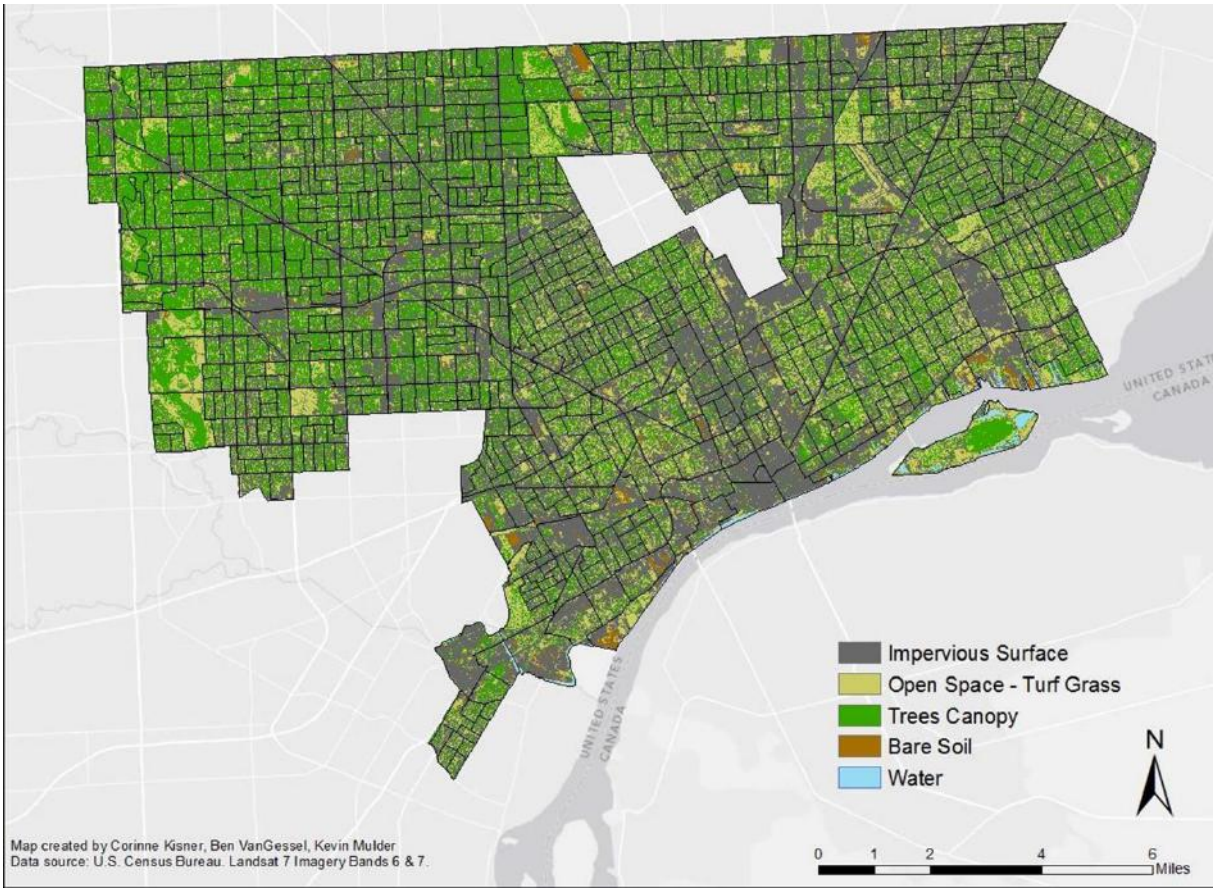

Figure 13: A vast impervious footprint near the river further exacerbates pollution caused by urban runoff, which calls for design interventions that address this problem. (Detroit Environmental Agenda, 2020)

To come to a holistic approach that comprehends different approaches of how the building and the site can work together to eliminate all stormwater and surface runoff, speculations were developed that took into consideration the range of landscape conditions along the edge of the Detroit River. Those different landscape conditions require design interventions that are unique to the issues that arise within each plot. The speculations were based on a series of precedent analysis that not only helps in developing an informed speculation, but also aid in the process of developing the design investigation. Through the analysis of different design intentions and strategies, different plans of action were developed to respond to the different conditions present along the river.

Starting by the most complex landscape condition such as brownfields, to underdeveloped, turf covered lots that constitute a great opportunity for ecological development, different strategies can be extracted from the precedent analysis to inform the speculation and intervention.

Figure 13: The Great Wall of WA, Luigi Rosselli, Australia

Figure 14: The Loop Village, MAaP2 Architects, China

The precedents shown in figures 13 and 14 blend the built form with the landscape for two main reasons. The first one is that the building becomes an extension of the surrounding landscape and ecology, thus avoiding disruption to that ecology. The second reason, which is observed in the Loop Village precedent, is that such an approach allows the natural water cycle to continue to take place, thus reducing surface runoff from the site.

Figure 15: Cuisinart Center, TSOI KOBUS, RI

Figure 16: Watersquare Benthemplein, DE Urbanisten, Rotterdam

The precedent shown in figure 15 is built in a flood plain, and thus elevated off the ground in order to not disrupt the ecology. The rest of the ground floor is designated as a sacrificial floor that is designed to fail fast and fail cheap in cases of severe rain. The precedent highlighted in figure 16 sums up a series of precedents that celebrate water management and turn it into a visible and exciting experience that is centered around public spaces. Elevating stormwater management and turning it into a visible experience brings awareness to the issue of preserving and conserving water.

4.2. Contextualizing the design investigation

After further understanding the landscape condition along the river and developing strategies from precedent analysis, the lessons learned are distilled into one integrated design investigation. The site of the investigation is situated west of E Jefferson avenue just north of the bridge that leads to Belle Isle. The area is characterized by a disconnect created by E Jefferson between the land east of it and the communities that live west of it. The development east of Jefferson are mostly private residential and commercial developments which require a very significant parking footprint. There are also quite a few underdeveloped lots that are turf covered. Typically, in this area, zoning is flexible and allows for a range of typologies, opening the room for semi-private developments such as residential towers and private commercial developments.

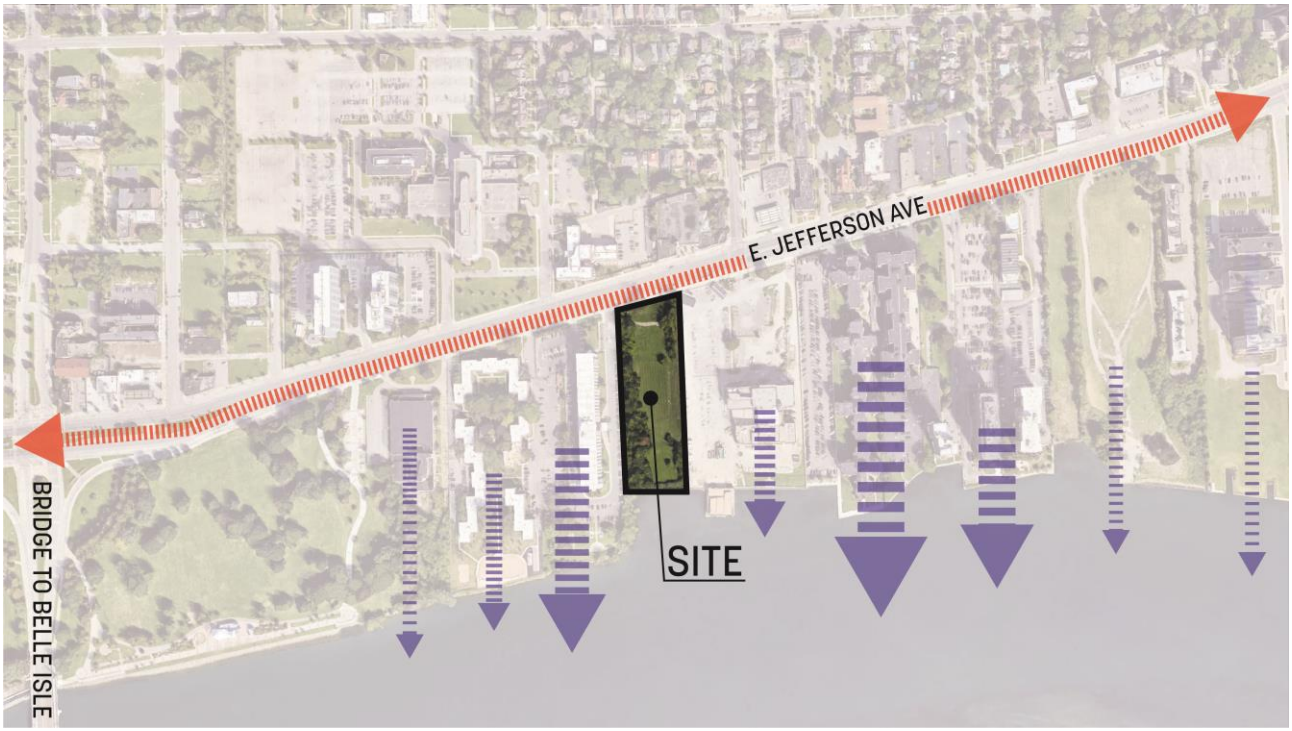

Figure 17: The site of the investigation, east of Jefferson Ave. is shown to be surrounded by a vast impermeable footprint and underdeveloped lots

4.3. Controls and variables

the proposed design is a mixed-use high rise that reevaluates the relationship of riverfront development to the river through the ecological management of stormwater runoff and by strengthening the connection to the river by reimagining the structure of the relationship between the urban and the natural system. In order to efficiently and effectively investigate the claim, a set of controls are set in place. The first controls are the site conditions of the chosen lot. This control offers scale and social context constraints. Importantly, it also offers a set of ecological integration constraints that depend on how the site is oriented as well as how the surrounding context might affect some biological conditions such as daylight and wind.

Another control is the chosen typology and its program, which is a mixed-use development. Such control offers a scale and massing constraint, as well as different programmatic needs that require different adaptations in terms of social-ecological integration with the edge of the river. They also require water management systems of different scales and capacities. In addition to this, a mixed-use tower is chosen as the typology given that it will guarantee public access to the site, contrary to the surrounding developments that are semi-private residential or commercial only.

Zoning and code requirements are another set of controls that are to be followed. Such controls will inform the design process through mandating that the civic needs are met, yet ecological sensitivity is still guaranteed. Some of the zoning requirements that lead to immediate harmful impacts on the ecology of the river include the amount of surface parking required for some of the buildings erected along the edge of the river. The impervious footprint of these parking lots is one of the main contributors of encroached runoff that makes its way to the river. This is to be addressed through the design investigation.

Figure 18: An aerial view of two waterfront residential towers shows how much surface parking is required for such buildings. The surface parking footprint is almost three times that of the building. Though surface parking is convenient and offers an organized way of parking, it leads to greater amounts of contaminated runoff making its way into the river.

The primary independent variable is the kind of ecological and sustainable blue and green landscape or engineering based infrastructure implemented at each intervention, based on the constraints offered by the controls.
The main metric of success will measure how the integrated blue and green infrastructure will contribute to the health of the river and its ecology. Metrics of success will be measured both quantitatively and qualitatively. Quantitative measurement includes the calculation of the volume of the runoff that the building and site are capable of offsetting. Qualitative measurement will evaluate how the serial investigation creates different moments within the project that celebrate the management of urban runoff and turn it into a visible and exciting experience. Qualitative measurement will also evaluate how the designed site and building will strengthen the connection of surrounding communities to the river.

4.4. Serial Design Investigation

To start the serial investigation, the controls are first laid out. The building shall occupy no more than 20 percent of the total allowable buildable area. This control determines the tower typology.
The serial investigation then explores different landscape-based strategies that aim to create a productive landscape that aids in restoring the ecology of the river and supports a healthy and sustainable relationship between riverfront development and the river.
The first and most pressing issue that the serial investigation will address is the square footage of parking required to support a mixed-use development. per zoning regulations, the amount of surface parking required to support a building of this type is almost three times the footprint of the building. And such a footprint would generate a very high volume of encroached runoff that would need to end up in the sewer system or might even make it to the river. In order to deal with this and still provide necessary infrastructure to the development, surface parking needs to be retrofitted into an ecologically sensitive space. Rather than simply being critical of the code requirements or suggesting underground parking, both which lack sensibility as findings of design investigation, surface parking can be covered with a landscape cover. This will help significantly reduce the amount of encroached runoff from the site, as well as creating public amenities in the area that strengthen people's connection to the river.

Figure 18: Retrofitting the vast impervious footprint within the immediate context of the site will yield multiple green spaces, reduce impervious surfaces, and subsequently reduce urban runoff.

Further strategic implementation of landscape-based green and blue infrastructure will help intercept urban runoff from the site and its surrounding context. Engineered systems can help channel this runoff into collection tanks for recycling and reuse within the building, or for decontamination before reaching the city's sewer system. This strategy deals with one end of the site. To address the river end of the site, the factor that is being worked against is the rigid sea armoring that is detrimental to ecology. Though not without merit, traditional concrete or steel sea armoring completely erases the riparian edge and erases the complex ecology that that environment houses. Effective wetland restoration cannot take place if the rigidness of sea armoring is not broken down. To address this issue, the design intent is to take a rigid sea wall, break it into sections, then stretch those sections horizontally in a way that allows for the restoration of wetlands between the pulled fragments of sea armoring. The strategy will require developers to sacrifice some of the footprint of the site of ecological restoration, as more space along the site is given back for the river to reclaim it.

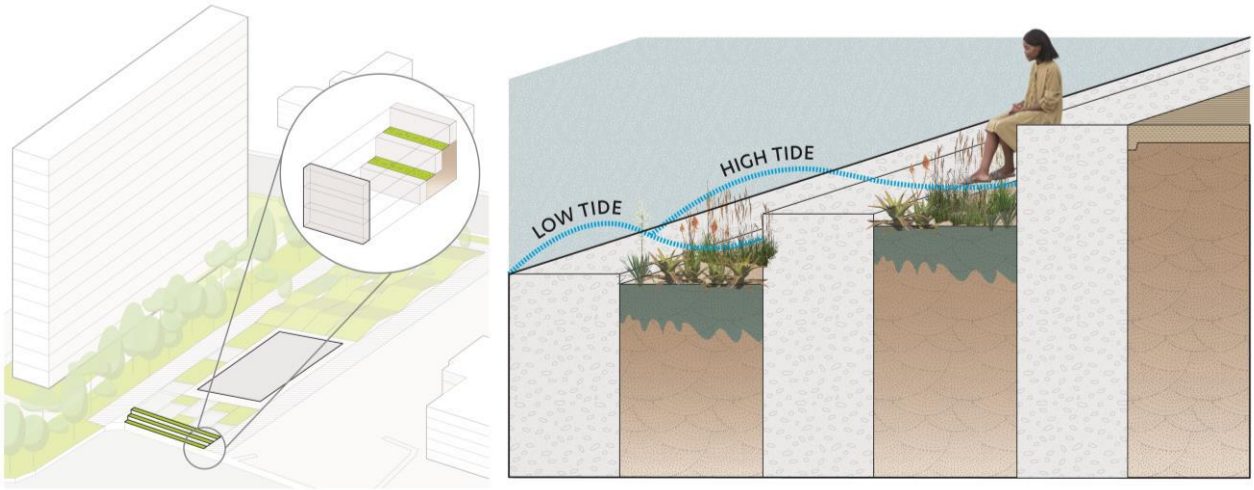

Figure 19: Breaking down the rigidness of the sea wall into horizontal sections yields an armoring prototype that offers the same protection a traditional sea wall does while aiding in ecological restoration.

As far as addressing the mixed-use tower, after establishing a public program within the site which will increase access to the riverfront for the communities that live west of Jefferson Ave., different morphological approaches can be applied to the tower to further integrate it with the landscape, and to turn it into a machine that reduces urban runoff and turns stormwater management into a visible, educational, and exciting process. The thesis only explores a few of the multiple approaches that can be applied. One of the approaches that the design investigation explores is taking a wetland and vertically integrating that within a building. The strategy will inform spatial morphology as the vegetation will require adequate daylight. Carving out at particular locations and integrating different sets of vegetation within those carved out pockets creates an ecosystem within the built form where the runoff collected from the landscape-based strategies on site can be pumped for decontamination. The process happens by first collecting runoff, then pumping into one set of vegetation, then into another set, then into decontaminated water collection tanks. Although there might be a considerable cost and energy footprint for pumping water up within the tower, that can be offset by creating a local circular economy where runoff is collected, recycled, then reused. The ecological pockets can also yield other benefits such as providing passive ecological service like daylight control, and heat and humidity regulation.

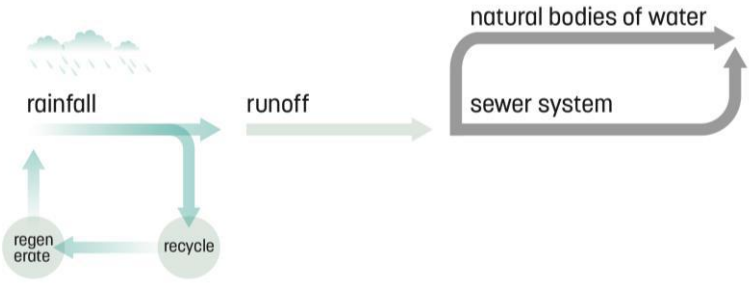

Figure 19: Offsetting cost and energy associated with pumping runoff that is collected on site up a building can be achieved by creating a local circular economy.

Other strategies that are explored within the serial investigation look at how green roofs can be more than a technical element incorporated within a building by creating a web of cascading roofscapes that support different functions and programs in order to generate social support and celebrate water management in ways that are visible. Furthermore, living units are adjusted in a way that will yield a larger square footage of green spaces. This is achieved by a series of push and pull where terraces and green spaces are created along one side of the building. This is another strategy that not only aims to capture more runoff, but to also create exciting spaces that people would be eager to dwell within.

Part 05: CONCLUSION

Even though the design investigation revealed that the proposed building and site managed to eliminate urban runoff from the site entirely, social-ecological resilience along the Detroit River cannot be achieved through a single design intervention. To mend the relationship with the river and undo years of harm, design needs to be supported by legislative action and social change. It should not be left to the designer or developer to decide whether a relationship of social-ecological resilience will be sought out or not. Code should mandate that through laying down a set of policies that ensure the river is treated as a stakeholder in the design process. The serial investigation revealed some hints of what could become policies that the city can adopt to make sure that riverfront development is sustainable and respects the ecology of the river. Of those policies, the most prominent one would be establishing a minimum distance from the river edge that cannot be developed into an impervious surface but instead should be landscaped in a sense that supports ecological restoration.

Figure 20: A rendering of the envisioned non-armored, ecological river edge condition

Appendix A: Literature Review

Ecological Urbanism
Mostafavi, Mohsen, ed. Ecological Urbanism. 1st ed. Baden, Switzerland: Lars Muller, 2010.

The publication makes the assertion that an ecological approach is required as an organizing framework and principle for new cities. The book also addresses the use of this framework as a remedial device for our urban systems that are often disconnected from the environmental systems and the ecology. The disciplinary approach is very fluid in scale and discipline, as there are no clear list of steps that constitute the framework of ecological urbanism. The approaches discussed in the book are contextually driven. Though many of them share similar aspects and deploy similar strategies and approaches, it is made clear that ecological urbanism is not a set of technocratic sustainability technologies, but it is rather a movement rooted in the understanding of the ecology and the history of the place.

Neighborhoods for the Future
Hajer, Maarten et al. Neighborhoods for the Future: A Plea for a Social and Ecological Urbanism. Amsterdam, Netherlands: Valiz, 2022.

This publication builds upon the principles and ideas discussed in *Ecological Urbanism.* The publications makes the assertion that an effective ecological framework should be coupled with face of sociological use. The publication focuses on neighborhoods as agents of catalyzing social change that they argue is an integral part of achieving ecological resilience.

Appendix B: Precedent Analysis

After recognizing the importance of wetlands and their benefit, precedents that incorporate those wetlands in the urban environment are analyzed in terms of how those wetland parks create a productive relationship between the natural processes embedded in wetlands while still respecting the needs of the urban form, by overlapping three stakeholders: ecology, recreation, and economy. However, it should be noted that this thesis is focusing on the building scale and the investigation will discover whether some or all aspects present in the analyzed precedents can be implemented at the building scale, so that our buildings can function as a network of resilient infrastructure.

Precedent 01: Wild Mile, Chicago / SOM / 2021 / Under Construction

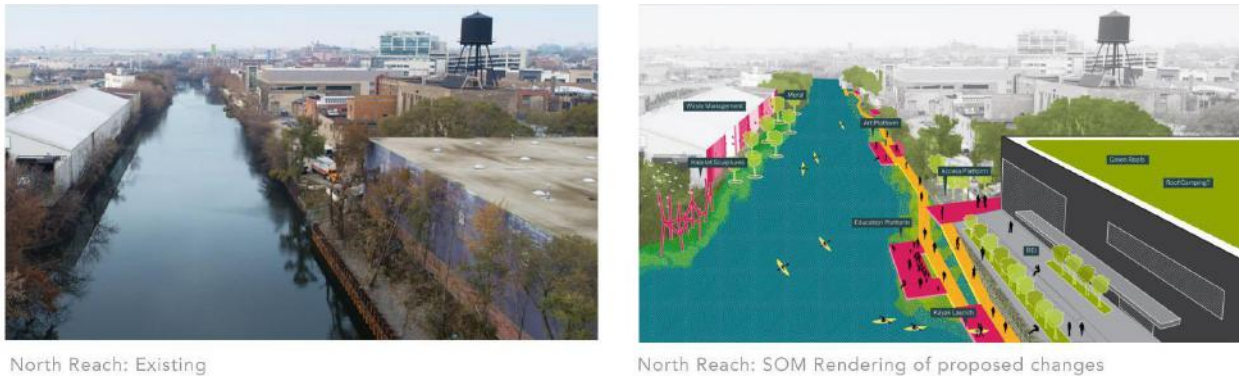

Figure B.1: The Wild Mile by SOM in Chicago is an ecological restoration project that utilizes cheap methods with a quick turnaround on investment to revitalize a stretch of the river..
The Wild Mile, in Chicago by SOM transforms an old industrial river corridor into an eco-park, by creating new environments for habitat, education, and recreation. The project helps generate cleaner water and supports a more vibrant ecosystem. One thing about this project is that the armored river edge was kept the same in most locations, and it was softened and ecologically restored through the construction of floating wetlands and ecosystems by the use of salvaged materials like wood, which were built using the help of community involvement.

A further source studied in support of this precedent is a research paper that analyzed the incorporation of wetlands with combined sewage outflow in some European countries, and in that paper, scientific data backed up the effectiveness of wetlands to reduce the number and density of pollutants in wastewater, when the wetlands are strategically incorporated in particular locations along the path of wastewater. The paper presented a breakdown of the density of pollutants as they were discharged from the water management facility in comparison to that of the water after it made its way through the constructed wetland. (Rizza, A. et al. 2020)

Figure B.2: The park was built on a brownfield where contaminants were treated on site. Part of the restoration included reintegrating a 2 mile wide wetland along the entire length of the new park.

Another precedent that was studied is the Shanghai Houton Park in China which is constructed on a brownfield. The project aims to create a new water environment based on low-maintenance and high-performance landscapes. The project includes a considerably sized wetland along the entire 2-mile edge of the park. And it includes different environments, as well as functions that also overlap three functions: ecology, recreation, and economy which are created through the tool of landscape ecology.
Also, the contaminated soil from the brownfield was treated on-site. And what was done is that the designers would dedicate certain lots in the park that people can't circulate through, and they would plant them with phytoremediation plants, thus safely treating the soil on site while minimizing people's contact with it. And this is something that I reference in one of my interventions.

Figure B.3: The proposal implements large scale tools of landscape ecology to radically transform the basin into a more resilient one.

A proposal by the Dutch firm DE URBANISTEN for the Raritan River in New Jersey was also studied. The architects propose the use of large-scale green infrastructure that simultaneously protects from flooding risk and connects people to the river, by developing a comprehensive framework that integrates different systems such as ecology, transportation, and development, as that will yield greater benefit for natural ecology as well as economic

development. One of the strategies noticed in this precedent as well as in many projects that fall under the movement of Dutch Urbanism, is that the river is given room to grow instead of it being capped and channeled, and this approach yields multiple benefits such as minimizing the risk of flooding, as well as being more sensitive to the ecology of the river and it's natural environment.

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