Transfixed

Leveraging Local Ecology to Create a Thick Transportation Corridor in Minneapolis, Minnesota

Derek Holmer

A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Landscape Architecture

University of Washington
2018

Committee:
Nancy Rottle
Julie Johnson

Program Authorized to Offer Degree:
Landscape Architecture

University of Washington

Abstract

Transfixed: Leveraging Local Ecology to Create a Thick Transportation Corridor in Minneapolis, Minnesota

Derek Holmer

Chair of the Supervisory Committee:

Nancy Rottle

Landscape Architecture

As American cities begin to see the effects of climate change, many are turning to low-carbon transportation as one way to mitigate these challenges. This thesis seeks to explore how transportation can be a catalyst for more socially and ecologically robust cities. In particular, this project asks: how can transportation corridors be for more than just passing through? Taking inspiration from the synergies between streetcar development patterns and landscape ecology, this thesis proposes the solution as a series of thick transportation corridors designed to integrate multiple ecological and social functions.

This project develops a framework for analyzing and leveraging local ecology in order to design resiliency back into our urban habitats. This framework is then applied to the Midtown Corridor in Minneapolis, Minnesota, a Midwestern city built in a streetcar pattern plagued with severe implications from climate change. Three sites are identified with a series of detailed design concepts are proposed. These interventions, while site specific, are meant to highlight strategies that transcend scale and time in order to ensure the Midtown Transitway enhances the rich community through which it passes.

Transfixed strives to achieve urban corridors that connect people, animals, clean air and water while also grounding design and function in the unique conditions of each locale. Thick transportation corridors have the potential to nurture local and regional ecologic function, providing resilience in this uncertain age of climate change.

Transfixed

Leveraging Local Ecology to Create a Thick Transportation Corridor in Minneapolis, Minnesota

Derek Holmer

Image Source: Google Earth

Contents

Acknowledgments

I would like to express my sincerest gratitude to my committee members: Nancy Rottle and Julie Johnson. Your guiding voices and thoughtful critique helped me push this project beyond disciplinary bounds. Also, thank you to Elizabeth Umbanhower for your willingness to decipher my unintelligible banter into productive conversations.

I am grateful to a slew of professionals who all lent me their time and wisdom. Thank you to Sean Batty for showing me that Landscape Architects do belong in transportation and reminding me that cities are human habitat. Thank you to Steve Durrant for your powerful insights into the ecology and communities of Minneapolis and for holding me accountable to those. Thanks are also due to Michael Mechtenberg for sharing your experience leading the Midtown Transitway project and for your excitement about renewing interest in the corridor.

Finally, thank you to my cohort for being a source of constant inspiration and my family for your love and support from afar.

1. Introduction

Image Source: Google Earth

Over the last two centuries, transportation has been the major driving force shaping the form of cities in the United States and Canada. From walking, to streetcars, to automobiles, the size and spread of urban areas has responded to citizens' capacity to move from point A to B. Automobiles, in particular, inspired a revolution in transportation, one in which moving vehicles took priority over moving people. Freeways were used by urban-renewal-minded planners to clear blight while moving as many vehicles as possible. Only recently, cities are beginning to grapple with the problems this auto-centric transportation system have induced: ecological damage, social and economic inequity, segregation, gentrification, and displacement. Perhaps the most insidious effect is the amount of carbon this system emits, a major driver of the changing global climate. Increasingly, transportation is being leveraged as a solution to many of these problems. How can the system that caused these problems also pose solutions? How can transportation be a catalyst for more socially and ecologically robust cities?

Urban designer Patrick Condon advocates looking to the very system that formed the core of urban areas in America and Canada: streetcars. While he argues for a literal return to streetcar systems, his larger discussion of the benefits of the streetcar city as a pattern for urban development proposes an answer to this question. Essentially, the streetcar city is about a pattern of development—largely a gridded fabric with commercial corridors of higher density—as well as the processes that shaped this pattern—a network of high-capacity transit corridors. It is this process that serves as the blueprint for more sustainable urban design.[1]

Introduction

As the major organizing features of the urban fabric, these corridors must serve many functions—beyond simply moving people through them. In ecology, corridors serve a vital function in not only facilitating the mobility of species, but also as habitat, diversifying communities, and ensuring the connectivity of other patches in the matrix.[2] As human ecosystems, the concepts of landscape ecology apply to urban areas as well. A key element of the resiliency of an ecosystem is the presence of thick corridors that provide interior habitat as well as allow the migration of species. In a similar vein, cities on the brink of a changing climate should view transportation corridors as more than single right-of-ways with some development potential near stations. These corridors must become the backbone of a complex system: connecting dense and diverse patches spread equitably throughout the urban matrix. By hanging green infrastructure, alternative energy production, housing construction, services, and jobs on a series of thick transportation corridors, cities can actively mitigate and adapt to a changing climate, foster vibrant social communities while fighting economic injustice, and support local and global ecological functions.

Figure 1.1
Streetcar Corridor in Minneapolis

Critical Stance

In order to make transportation corridors that are for more than just passing through, this project proposes the concept of a thick corridor. These corridors foster social and ecological resiliency, enhancing the communities through which they pass by embracing local ecology: the patterns and processes that have shaped them and the performance of necessary functions along the corridor. Local ecology is characterized by a framework consisting of six systems: mobility, water, habitat, open space, metabolism, and culture/history. This framework is presented through a thorough analysis and resulting design concept in Minneapolis, Minnesota, a historic streetcar city faced with immense threats from climate change. Transfixed seeks to be radical in imagination and anticipatory in practice: a landscape architecture approach to transportation in the age of climate change.

Why Minneapolis?

A Streetcar City

Minneapolis is a city shaped by both its once-expansive streetcar network as well as regional and local ecological systems. The city's gridded form largely follows the north-south orientation of the streetcar lines shown in Figure 1.2. The grid only deviates from this pattern where landform or water dictates. In downtown, for example, the grid shifts twice to align with the Mississippi River. Well established streetcar corridors and nodes provide a strong basis for expanding the transportation system and injecting ecological corridors into the city.

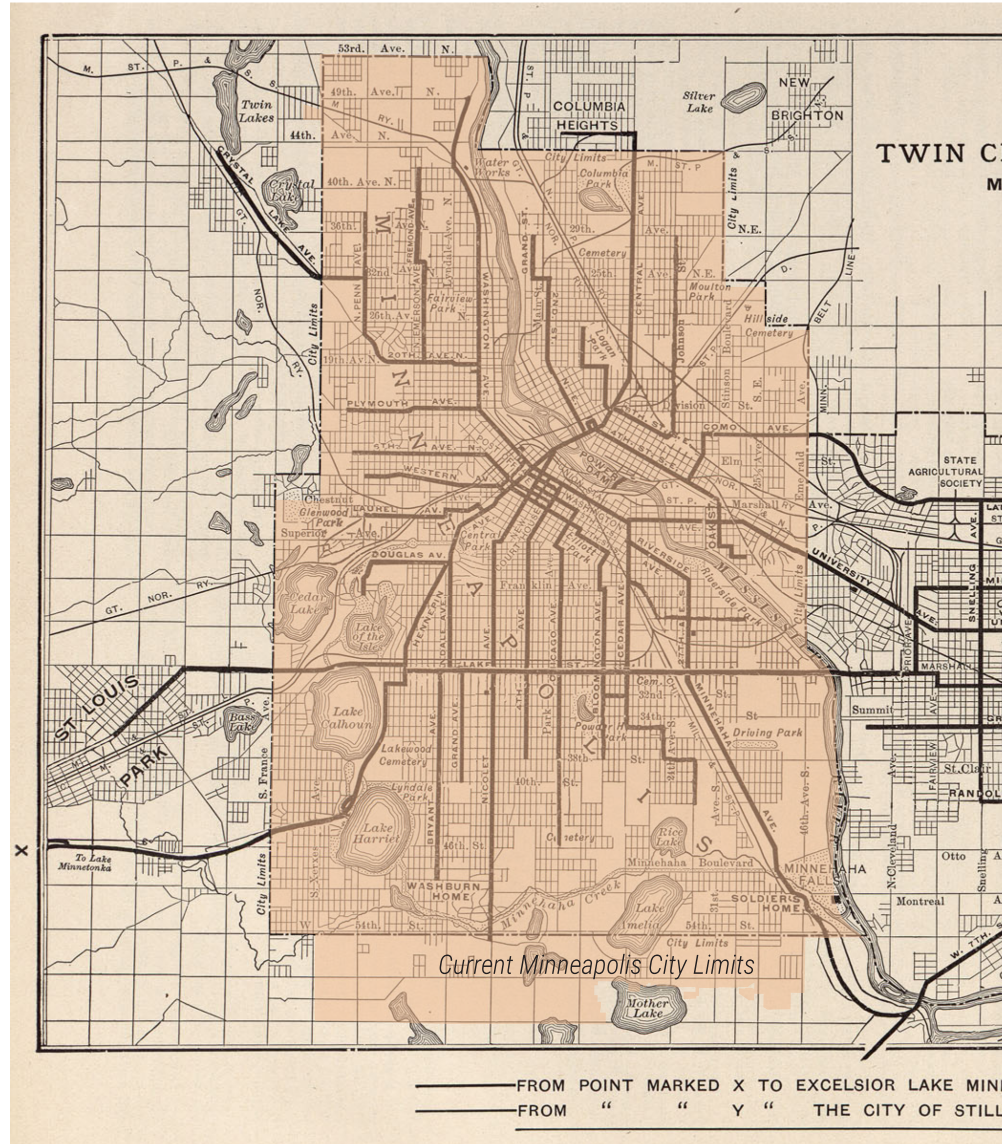


Figure 1.2

1913 Map of Twin Cities Rapid Transit Lines

The Grand Rounds

In 1884 renowned landscape architect H.W.S. Cleveland captured the value of the city's natural resources in his plan for a Minneapolis Park System.[3] While expanding development competed directly with the Park Board's aims, most of Cleveland's plan was implemented. The Minneapolis Park System is now recognized as the best urban park system in the country, winning the Trust for Public Land's annual Park Score for the last six years.[4] This established network of open space and habitat corridors provides opportunities for new intersecting connections.

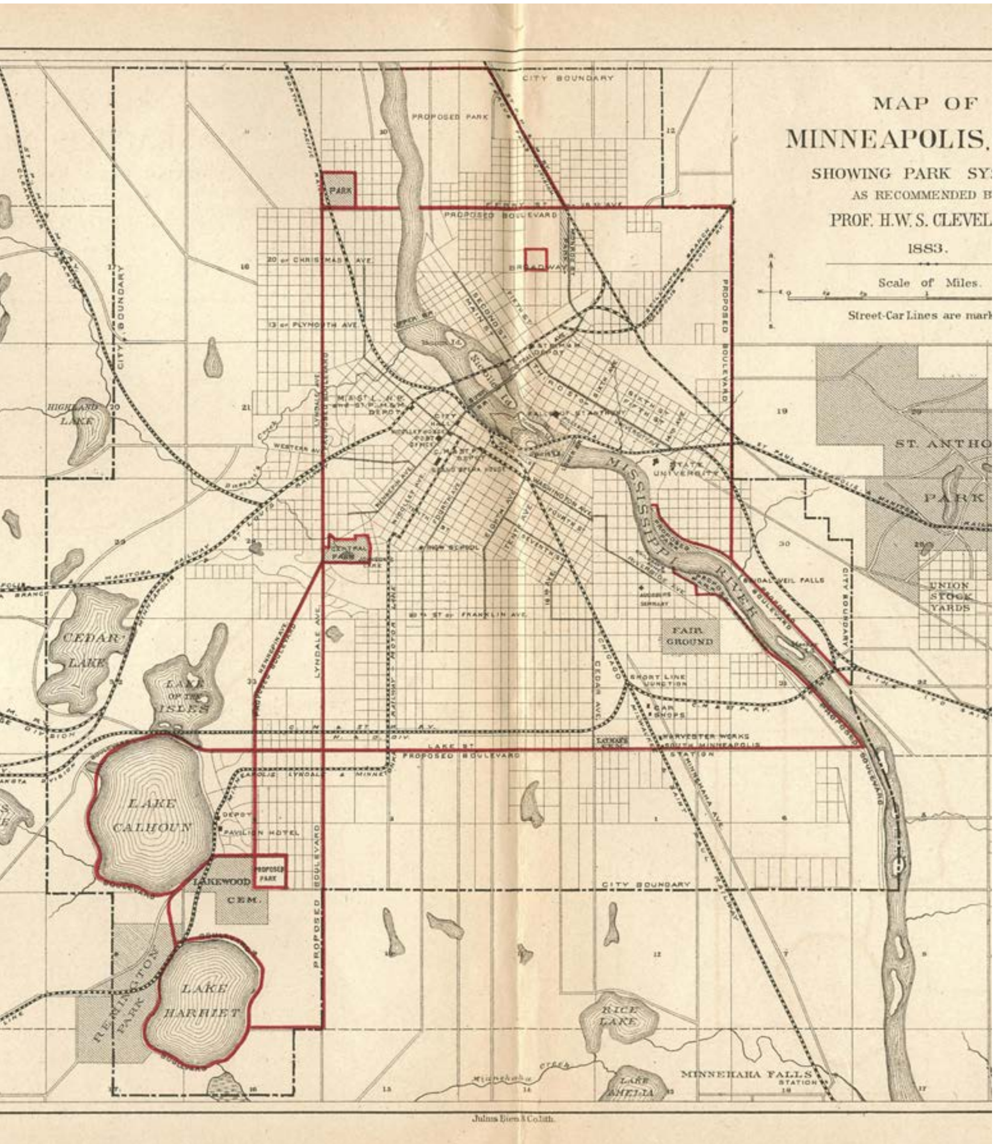


Figure 1.3

H.W.S. Cleveland's Proposal for a Minneapolis Park System

Figure 1.4

Parkway in Minneapolis

Built Before Cars

Minneapolis grew quickly in the latter half of the 19th century, annexing large plots of land into the city. However, by the 1920's, many outlying neighborhoods were forming their own cities. Minneapolis annexed its last neighborhood in 1927.[5] Hemmed in by its municipal neighbors, the city reached its current borders before the auto age, completing the urban form in the traditional streetcar pattern. Thus, if implemented, thick corridors could reach every neighborhood in the city without much alteration to the existing fabric.

Figure 1.5

Driveway-less Minneapolis

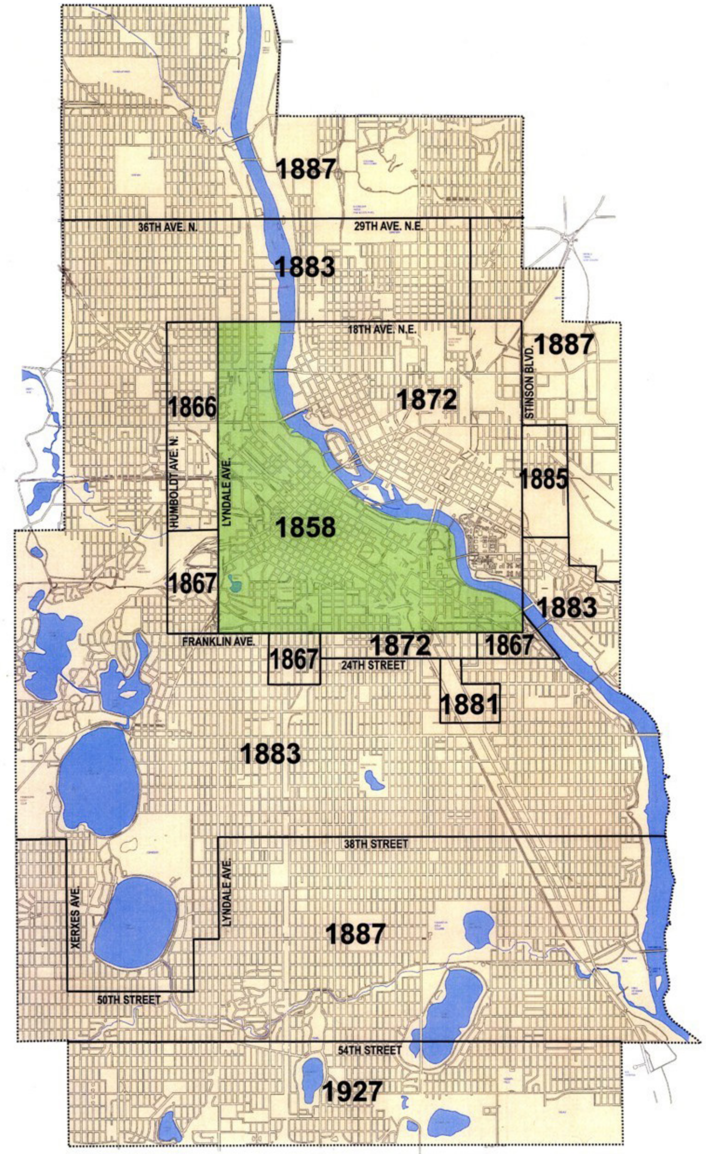


Figure 1.6

Minneapolis Annexation Map

Figure 1.7

April 2018 Blizzard in Downtown Minneapolis

Warmer, Wetter, Wilder

Minneapolis is expected to face major impacts from climate change. While safe from sea level rise, the city will be subjected to every other weather extreme.[6] Precipitation will come in larger amounts in smaller bursts while droughts will become more intense. The urban heat island effect will increase summer temperatures in the city to as much as 22 degrees Fahrenheit higher than that of the surrounding farm land.[7] Winters will also see an increase in snowfall events and cold blasts. Frankly, life will become uncomfortable, if not downright deadly, for residents of the city. The resiliency of Minneapolis will depend on creating a network of corridors for low-carbon transportation, stormwater, air circulation, energy production, cool refuge, wildlife habitat, and other functions.

Figure 1.8

Landslide Caused By Heavy Rains in Minneapolis

Regional Connectivity

At only 53.9 square miles and 422,331 people,[8] Minneapolis is a relatively small city in both size and population compared to the larger Minneapolis/St. Paul metropolitan region (nearly 3,000 square miles and 3.5 million people).[9] Along with the twin city of St. Paul, Minneapolis must coordinate planning with surrounding communities to achieve a cohesive region. A network of robust, thick corridors would ensure that ecological and transportation corridors do not end once they reach the dense urban fabric of the city. Rather, transportation, habitat, and other corridors would blend seamlessly into Minneapolis's grid.

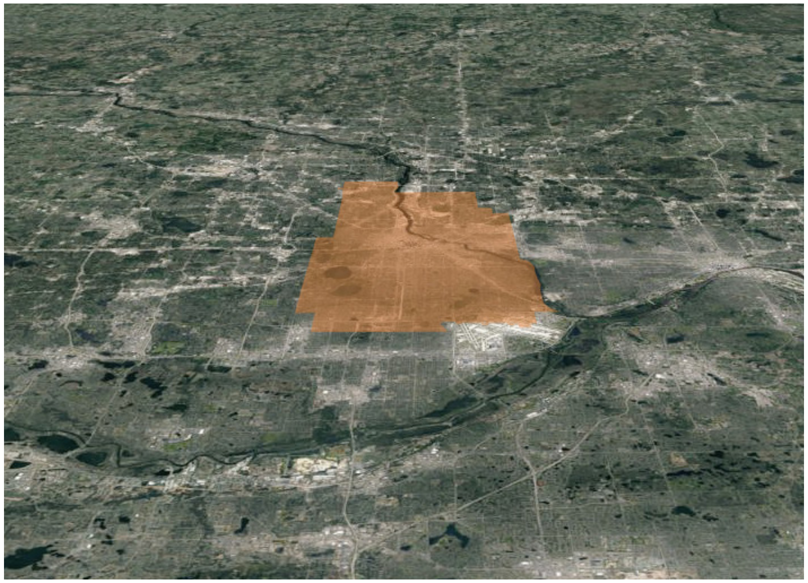


Figure 1.9

Minneapolis Metropolitan Context

Figure 1.10

Minneapolis Skyline Above the Mississippi River

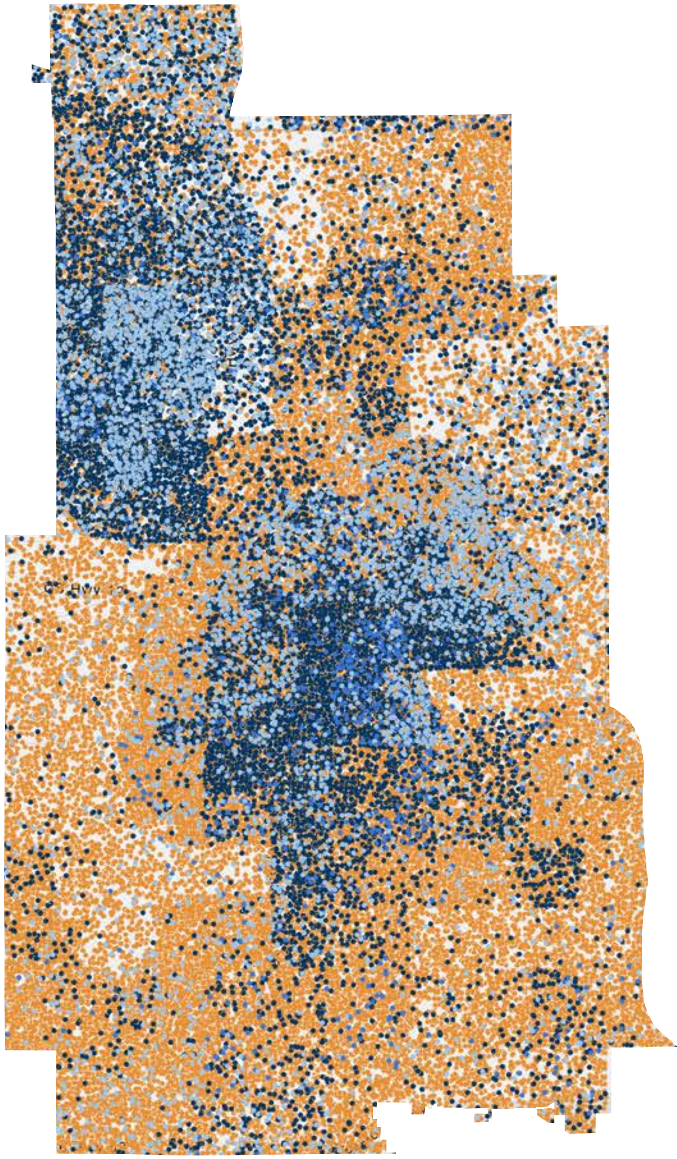


Figure 1.11

Racial Distribution of Minneapolis

A City Divided

Minneapolis is incredibly diverse for a Midwestern city. Large populations of Somali and Hispanic immigrants call the city home. The city's population is 60% white[10] while the state of Minnesota is 80% white.[11] However, this diversity is incredibly segregated, as Figure 1.11 shows. Despite a progressive reputation, Minneapolis residents face some of the highest racial disparities.[12] In addition, urban renewal and freeway construction destroyed the thriving communities of color in Minneapolis. By dispersing investment across a streetcar pattern, the distribution of development would reach all neighborhoods in a more equitable pattern. This strategy could also be a part of reconnecting Minneapolis across old transportation scars.

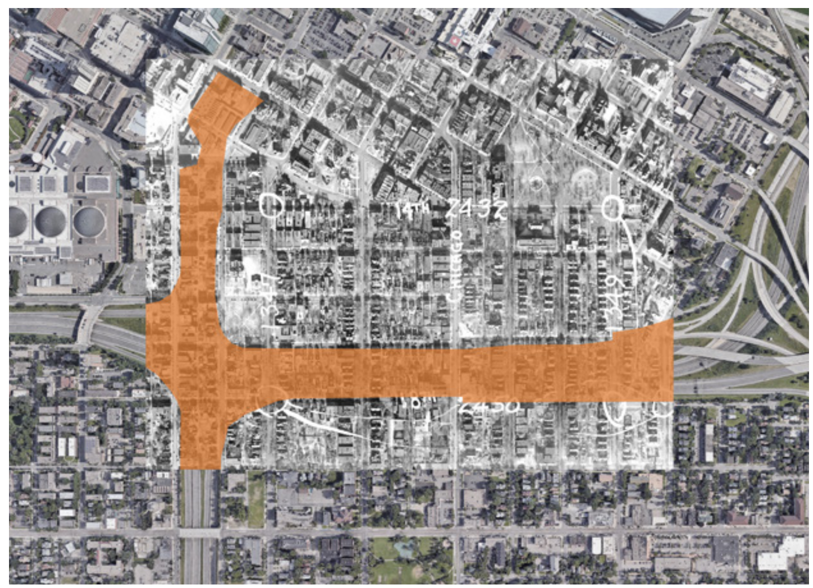


Figure 1.12

Thriving in 1938, Divided in 2018

Planning for the Future

Minneapolis is currently drafting a 2040 Comprehensive Plan, focusing on issues tied to climate change, social equity, ecology, and transportation. Two key pieces of this plan are the Land Use Plan and the Built Form Plan (Figure 1.14). Key transportation corridors have been mapped out in order to inform land use planning. This is then used to leverage the form of the city. Rather than simply zoning based on land use policy, the type of building, both in height and lot size, is specified based on transportation corridors.[13] These corridors largely follow the historic streetcar network. Recognizing this, Minneapolis has already begun the process of planning a 21st century streetcar city. Thus, it is the perfect candidate for thick corridors.

Figure 1.13

Minneapolis 2040 Built Form Plan (Transit 10)

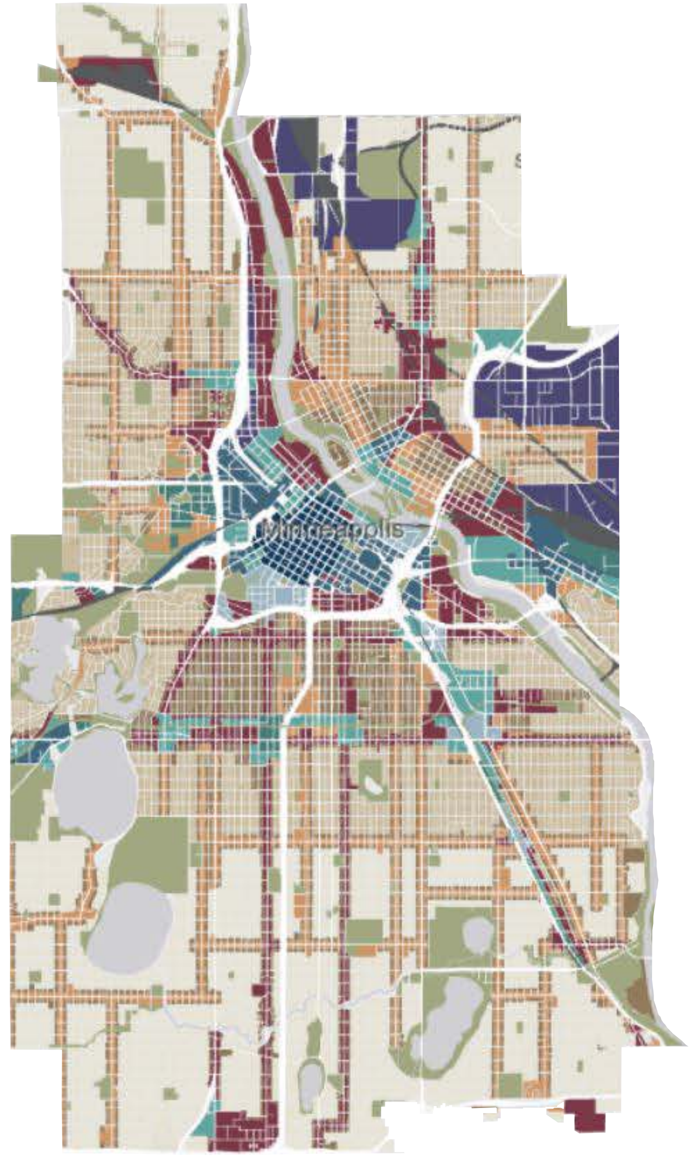


Figure 1.14

Minneapolis 2040 Built Form Map

Figures

1.1- **Streetcar Corridor in Minneapolis,** Source: "Mural on Kmart depicts fight to keep Nicollet open," *MPR blog*, https://blogs.mprnews.org/cities/2014/03/mural-on-kmart-depicts-fight-to-keep-nicollet-open/

1.2- **1913 Map of Twin Cities Rapid Transit Lines**, Source: University of Texas Libraries, https://legacy.lib.utexas.edu/maps/historical/txu-oclc-6445490-electric_railway-minneapolis-st_paul-1913.jpg

1.3- **H.W.S. Cleveland's Proposal for a Minneapolis Park System**, Source: MNopedia, Minnesota Historic Society.

1.4- **Parkway in Minneapolis,** Source: "Grand Round Scenic Byway," Minneapolis Park & Recreation Board, https://www.minneapolisparks.org/parks__destinations/trails__parkways/grand_rounds_scenic_byway_system/

1.5- **Driveway-less Minneapolis,** Source: Google Street View

1.6- **Minneapolis Annexation Map,** Source: Hennepin County Libraries, 2011, https://hclib.tumblr.com/post/5366939924/growth-of-minneapolis-here-is-a-map-we-worked-on

1.7- **April 2018 Blizzard in Downtown Minneapolis,** Photographed by Anthony Souffle for the *StarTribune,* 15 April 2018.

1.8- **Landslide Caused by Heavy Rains in Minneapolis,** Source: Jeffrey Thompson, MPR News, 2014, https://www.mprnews.org/story/2016/09/01/more-landslides-possible-twin-cities

1.9- **Minneapolis Metropolitan Context,** Source: Google Earth

1.10- **Minneapolis Skyline Above the Mississippi River,** Source: Mississippi Watershed Management Organization Homepage, https://www.mwmo.org/homepage/minneapolis-skyline/

1.11- **Racial Distribution of Minneapolis,** Source: US Census Bureau 2016 American Community Survey, 5-year estimates, visualization by Social Explorer.

1.12- **Thriving in 1938, Divided in 2018,** Source: Google Earth; University of Minnesota Historical Aerial Photographs Online, https://www.lib.umn.edu/apps/mhapo/

1.13- **Minneapolis 2040 Built Form Plan,** Source: Minneapolis Draft 2040 Comprehensive Plan, https://minneapolis2040.com/topics/land-use-built-form/

1.14- **Minneapolis 2040 Built Form Plan,** Source: Minneapolis Draft 2040 Comprehensive Plan, https://minneapolis2040.com/topics/land-use-built-form/

Notes

1. Patrick Condon, *Seven Rules for Sustainable Communities: Design Strategies for the Post-carbon World*, (Washington [DC]: Island Press, 2010).
2. Richard Forman and Michel Godron, *Landscape Ecology*, (New York: Wiley, 1986).
3. H.W.S. Cleveland, *Suggestions for a System of Parks and Parkways for the City of Minneapolis*, (Minneapolis: Johnson, Smith, and Harrison: 1883).
4. "Park Score," Trust for Public Land, accessed May 20, 2018, http://parkscore.tpl.org/rankings.php#sm.00004or20h8azfoysto1tpg7wnmur.
5. "Minneapolis: 150 Years of Growth," Hennepin County Library- Special Collections Tumblr (blog), 2011, https://hclib.tumblr.com/post/5366939924/growth-of-minneapolis-here-is-a-map-we-worked-on
6. Michele Berger, "The weather.com Climate Disruption Index," weather.com, 2015, http://stories.weather.com/disruptionindex.
7. Michael Rietmulder, "Minneapolis, St. Paul among cities worst hit by climate change," *City Pages*, July 13,2015, http://www.citypages.com/news/minneapolis-st-paul-will-be-among-worst-hit-by-climate-change-7472836.
8. "Quick Facts: Minneapolis city, Minnesota," United States Census Bureau, 2016, https://www.census.gov/quickfacts/fact/table/minneapoliscityminnesota/PST045216
9. "The Twin Cities Region," Metropolitan Council, accessed May 20, 2018, https://metrocouncil.org/About-Us/Who-We-Are/The-Twin-Cities-region.aspx.
10. USCB, "Quick Facts: Minneapolis."
11. "Quick Facts: Minnesota," United States Census Bureau, 2016, https://www.census.gov/quickfacts/MN.
12. Taylor Gee, "Something is Rotten in the State of Minnesota," Politico Magazine, 16 July 2016, https://www.politico.com/magazine/story/2016/07/minnesota-race-inequality-philando-castile-214053.
13. "Minneapolis 2040," City of Minneapolis, accessed April 02, 2018, https://minneapolis2040.com/. This plan is currently in draft form and remains open for community feedback until July 22, 2018.

2. Framework

Image Source: Google Earth

The analysis and design presented in the following sections is grounded in a body of literature ranging from urban design to landscape ecology, systems thinking to green infrastructure. This literature both supports the overall concept of thick corridors as well as the framework for analyzing the local ecology to ensure that designs fit the context. This informs the title of this project: Transfixed. "Trans" refers to the ability to move: the connecting of two points, from regional to local scales. This is the thick corridor and the transportation infrastructure. "Fixed" means these corridors are grounded, both within the local context but also within larger systems. Here, each thick corridor becomes unique, addressing specific systems in place, providing habitat for the communities through which they pass.

After this brief theoretical grounding and an introduction to the local ecological framework, the Orange Line, a light rail corridor in Portland, Oregon, is examined as a case study. This project, envisioned as a 'zipper' to unite communities, is examined as a transportation corridor beginning to embrace a thick profile through ecological and community interventions.

Theoretical Grounding- Thick Corridors

Urban and Ecological Patterns

People have been thinking about the patterns of cities since they began congregating in permanent settlements. But it was not until 1867 that the term (and professional discipline) of urbanism was codified by Ildefons Cerda, the engineer behind the massive expansion of Barcelona into the city we know today.[1] He took a scientific approach to the layout of the Eixample district, precisely calculating the amount of air and light needed by residents and translating that into street widths and a gridded pattern for equitable access. Across the Global West, other urbanists were taking other approaches to the pattern of cities. Architects approached the city as a piece of art, exemplified through the City Beautiful Movement and designers like Camillo Sitte[2] and Daniel Burnham. As the 20th century advanced, urbanism took the form of urban renewal as led by engineers. Cities, again, became a machine. By building enough freeways and clearing large tracts of land, the machine could work efficiently. In response, planners took to examining the pattern of urban form. Kevin Lynch developed a framework for creating a mental map of urban form through paths, edges, districts, nodes, and landmarks.[3] Perhaps the most famous work of this era was Jane Jacob's *The Death and Life of Great American Cities*. Suddenly, the discipline of urbanism recognized that great cities were more than a plan to beautify (pattern), but were an evolution of construction and creativity (process).

These approaches have been followed by a rise in similar research among ecologists. Richard Forman and others began coding the pattern of ecological formation and quality. Forman's research focuses on both the patterns of the landscape as well as the processes shaping them. His study of landscape ecology breaks landscapes down into five basic pieces: matrix, patch, corridor, edge, and boundary.[4] There is a close parallel between Forman's landscape elements and Lynch's urban elements, tearing down the false wall between nature and cities. Rather, we can structure and understand our cities through the same set of elements as the natural world. The city truly is the human habitat, an ecosystem organized in a similar way to the surrounding landscape.

These synergies shape the way this project defines ecology. Borrowing from Fritjof Capra's writings on ecological literacy and systems thinking, this project defines ecology in terms of relationships, connectedness, and context.[5] Ecology is the network of systems, both natural and man-made, that form the community of focus. These networks exist in nested scales and include blocks, neighborhoods, cities, and entire regions. Still they are unique to each location, hence the term local ecology. Capra refers to this as a shift away from objective knowledge toward a paradigm of contextual knowledge.[6] The key to understanding cities through such an ecological lens is systems thinking.

Systems Thinking & Resiliency

Traditionally, engineered systems are designed for efficiency and growth. A growing economy is desirable. The Earth's human population is on a massive growth spike, but living systems operate differently: they are nonlinear and rooted in patterns of relationships.[7] They are diverse, they cycle, they are interdependent, and are open systems. This systems-network approach must infiltrate the way designers think about cities. Instead of a series of fixed objects existing in space, cities are an ecosystem, a complex network of living systems. Engineering these systems to maximize efficiency creates a network that is fracture critical. In a fracture critical network, one failure can bring down the entire network. Designer Thomas Fisher explains this concept through the example of the Interstate 35W bridge in Minneapolis.[8] In August of 2008, a single gusset plate failed, bringing the entire bridge crashing into the Mississippi River. Without redundancy in the design, one failure brought down the entire system. The same type of network is required to provide resiliency to protect our urban ecosystems.

According to systems thinking, we should no longer engineer systems individually in order to maximize efficiency. External pressures, such as increasing precipitation or heat, can push these systems beyond their thresholds. Thresholds are the limits beyond which, systems behave differently.[9] In nature, for example, this explains how a slight change in climate can shift a landscape from a forest ecosystem to a prairie. In an urban setting, this explains how political and maintenance decisions can strangle New York's subway system.[10] Systems thinking provides the blueprint for resilient networks when this paradigm shifts. Redundancy, decentralization, and fail-safes must be designed to allow for flexibility when conditions change unexpectedly. This is especially true of urban areas facing increasing risks from climate change.

Bringing It All Together

This project is not the first to propose bringing ecological resiliency into urbanism. Landscape architects first reached into the urbanism foray with a movement called Landscape Urbanism (LU). Founded by Charles Waldheim and widely publicized through such landscape projects as Field Operations Fresh Kills Landfill Competition, the Highline, and Downsview Park Competitions, landscape urbanism focused on the cityscape as a process, similar to landscape formation.[11] While many essays were written as part of this movement, the results were mostly large parks, ecological preserves, and competition entries. While these projects did have an impact, this was largely confined to the landscape architecture profession.

Ecological urbanism (EU) was sparked as a contemporary movement to LU, critiquing the narrow focus and academic atmosphere of that movement. EU advocated a more holistic approach to urbanism, where all aspects of ecology, including social and cultural, were included in projects. Mohsen Mostafavi advocated for EU as a method through which designers should speculate about the future context through aesthetic explorations. He writes, "In this context, it is now up to us to develop the aesthetic means—the projects—that propose alternative, inspiring, and ductile sensibilities for our ethico-political interactions with the environment. These projects will also provide the stage for messiness, the unpredictability, and the instability of the urban, and in turn, for more just as well as more pleasurable futures. This is both the challenge and promise of ecological urbanism."[12]

This thesis proposes thick transportation corridors based on a streetcar pattern as the aesthetic means for the future of American and Canadian central cities. This next section develops the framework for adapting corridors to each locale: local ecology.

Framework- Local Ecology

A local ecology approach borrows thinking from the above sources to create a simple, overarching framework designers can use to analyze and design within existing ecosystems. This framework consists of the scales and layout of systems (pattern), how these patterns have changed and continue to change (process), as well as how to capture the services of these systems for both social and ecological communities (performance). These systems are categorized according to identified systems of green infrastructure: mobility, water, habitat, open space, and metabolism,[13] with an added system to include the culture and history of communities.

Pattern, Process, and Performance

Pattern is the arrangement of urban and ecological elements in a given landscape. The dominant habitat is the matrix, while areas of contrasting habitat are patches. Linear habitats that contrast the matrix and often connect patches are corridors,[14] which are the focus of this project. However, understanding the patches which the corridors connect, as well as the matrix through which they pass are of vital importance to their success. This is true at the neighborhood scale as well as the regional scale.

Process is the acknowledgment that these patterns change. Dynamism is the natural state, despite efforts to keep built environments static. Sean Batty, a Landscape Architect at TriMet, refers to this process as urban succession,[15] a play on ecological succession. Like pattern, these processes exist at a nest of temporal scales, reaching as far back as the formation of bedrock, and as far forward as we dare to speculate.

Performance refers to the services these patterns and processes provide the ecosystem. Derived from the concept of ecosystem services, in this framework there is equal importance placed on the performance for all species. Landscape architecture is beginning to acknowledge the importance of protecting and enhancing ecosystem services for species other than humans.[16] In this framework, transportation corridors must also serve as habitat corridors, water corridors, and community corridors.

Systems

The first five systems of the framework come from the concept of green infrastructure put forward by Nancy Rottle of the University of Washington's Green Futures Lab: mobility, water, habitat, open space, and metabolism. A sixth system, culture/history, attempts to capture the intangible relationships between communities and their ecosystems as well as how these relationships have changed over time.

- Mobility is the circulatory system.[17] This includes infrastructure meant to move people as well as migratory patterns of species that move to/from/through the corridor/city/region seasonally.
- Water is the hydrologic system. This includes water as a resource as well as the health of aquatic ecosystems.[18] This system is highly dependent on climate and topography.

- Habitat is the biological system. This system supports a region's biodiversity[19] and is a major concern in urbanized areas.
- Open Space is the social system. This system consists of the spaces that create community as well as the public realm assets that bring value to that community.[20]
- Metabolism is the energy cycle. This consists of the energy cycle of an ecosystem, both alternative energy production for electric power as well as the food production system.[21]
- The final system, culture/history, is about the social capital, the relationship among humans, and the connection to the landscape. This can be a complex system, especially in urban environments where waves of immigration have occurred in the same neighborhood.

Together, this framework for thick corridors designed to fit the local ecology becomes flexible enough to apply in any urban center and requires insights specific enough to elicit deep analysis and understanding of the established ecosystems.

Figure 2.1

Orange Line Overview

Agency	TriMet - Oregon Metro
Location	Portland - Milwaukee, OR
Mode	Light Rail
Length	7.3 miles
Stations	10 new
Cost	$1.49 billion
Opening	September 2015
Planning	Corridor lead was a landscape architect
Ridership	12,140 daily

Case Study

Orange Line Corridor

This framework is expanded on the Portland region's fifth light rail line, the Orange Line. This 7.3 mile line is TriMet's first rail project to southern Portland and Milwaukee, a suburb with its own compact urban center. Sean Batty, ASLA, who led the project, sought to leverage this massive investment for the benefit of the ecosystems along the corridor.[22] He found opportunities to synergize the construction and operation of this light rail line with ecological systems and processes in need. The resulting corridor, featured in a 2016 article of *Landscape Architecture Magazine*, is about much more than just passing through a south Portland rail yard.[23]

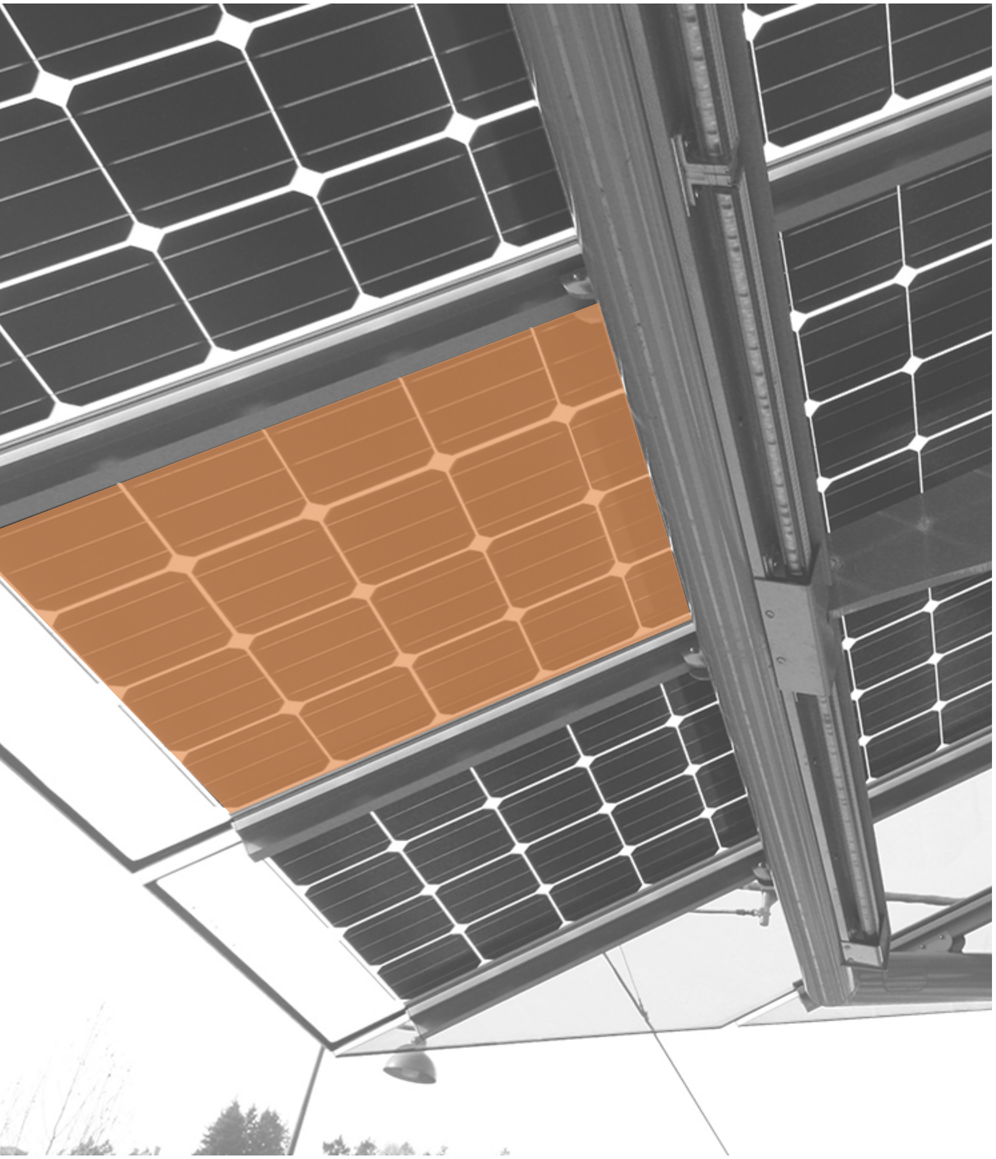


Figure 2.2
Solar Panel Station Canopy

The most visible impact of this project is the Tilikum Crossing, a new bridge carrying pedestrians, bikes, light rail, buses, and streetcar across the Willamette River (Figure 2.3). This piece of infrastructure makes connections far beyond the Orange Line, including streetcar and bike loops. The name and art accompanying the bridge honor the legacy and continued culture of the Chinook people in Oregon. Along the shores of the Willamette River, the project invested in near-shore, shallow aquatic habitat restoration. This urban portion of the line also includes the first American application of eco-track at the Lincoln Street/SW 3rd Avenue Station (Figure 2.4). One universal feature is the photovoltaic panels integrated into the glass canopies at each station (Figure 2.2). Altogether, there are 28 solar installations along the Orange Line. Other metabolism features include superconductors that capture energy of braking trains for use keeping voltage across the system stable.[24]

Outside the urban center, interventions focus on improving habitat for the king species of the Northwest, salmon. Crystal Spring Creek received extensive renovation (Figure 2.5). The project, working with several stakeholders, replaced undersized culverts with larger, open-bottomed culverts to free the creek passing through in addition to opening historic salmon habitat. In Westmoreland Park, a new channel was dug, wetland plants reintroduced, and large woody debris placed along the new stream channel. Where the line crosses Johnson Creek, the station and park-and-ride were pushed south to allow for a slice of riparian restoration along the creek. In addition to thinning the canopy to reveal the waterway, a boardwalk and interpretive signage was introduced to give another use to the public space

Figure 2.3

Tilikum Crossing: Bridge of the People

Figure 2.4

Eco-Track

Figure 2.5
Crystal Springs Creek Channel Restoration

Figure 2.6
Johnson Creek Riparian Restoration

(Figure 2.6).

The line passes through downtown Milwaukee, crossing the established grid at an unusual angle. This presented the opportunity to adjust streets, narrowing lanes, pedestrianizing blocks (Figure 2.7), and softening the hardscape with green stormwater infrastructure. As a historic urban center, the community outreach and support from the Milwaukee community was vital to the project. Here, Batty stressed the importance of designing a corridor of the community, not simply through. Similar to the question posed in this thesis, the Orange Line had to be a transportation corridor for more than just passing through.

While an excellent case study, this project exists largely outside the urban focus of this framework. The importance of thick transportation corridors outside the urban center cannot be understated. However, this thesis seeks solutions for designing transportation corridors through dense urban areas. In the Orange Line's case, only three stations are located in this environment. Thus, when selecting a corridor in Minneapolis, one passing through established communities is preferred. In this context, the traditional method for engineering a transportation corridor can be challenged.

Figure 2.7

Pedestrian Circulation in Downtown Milwaukee

Figures

2.1- **Orange Line Overview,** Source: Map by author; Imagery from Google Earth; Data from Oregon Metro, City of Portland, USGS
2.2- **Solar Panel Station Canopy,** Source: Photograph and edits by author
2.3- **Tilikum Crossing: Bridge of the People,** Source: Photograph and edits by author
2.4- **Eco-Track, Source:** Photograph and edits by author
2.5- **Crystal Springs Creek Channel Restoration,** Source: Photograph and edits by author
2.6- **Johnson Creek Riparian Restoration,** Source: Photograph and edits by author
2.7- **Pedestrian Circulation in Downtown Milwaukee,** Source: Photograph and edits by author

Notes

1. Marta Bausells, "Story of cities #13: Barcelona's unloved planner invents science of 'urbanisation,'" *The Guardian*, April 1, 2016, https://www.theguardian.com/cities/2016/apr/01/story-cities-13-eixample-barcelona-ildefons-cerda-planner-urbanisation.
2. Camillo Sitte, *City Planning According to Artistic Principles*, trans. George Collins and Christiane Craseman Collins (New York: Random House, Inc, 1965).
3. Kevin Lynch, *The Image of the City* (Cambridge, Mass: MIT Press, 1960).
4. Richard Forman and Michel Godron, *Landscape Ecology*, (New York: Wiley, 1986).
5. Fritjof Capra, preface to *Ecological Literacy: Educating Our Children for a Sustainable World*, eds. Michael Stone & Zenobia Barlow (San Francisco: Sierra Club Books, 2005), 20.
6. Ibid., 21.
7. Ibid., 20.
8. Thomas Fisher, "Designing Systems to Avoid Failure," filmed September 2013 at TEDxUMN, Minneapolis, MN, video, https://www.youtube.com/watch?v=0SO--f6EWs4.
9. Brian Walker and David Salt, *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*, (Washington: Island Press, 2006), 53.
10. Brian Rosenthal, Emma Fitzsimmons, and Michael LaForgia, "How Politics and Bad Decisions Starved New York's Subways," *New York Times*, November 18, 2017, https://www.nytimes.com/2017/11/18/nyregion/new-york-subway-system-failure-delays.html.
11. Charles Waldheim, *Landscape as urbanism: A general theory*, (Princeton, NJ: Princeton University Press, 2016).
12. Mohsen Mostafavi, "Why Ecological Urbanism? Why now?" in *Ecological Urbanism*, eds. Mohsen Mostafavi & Gareth Doherty (Zurich: Lars Muller Publishers, 2010) 50.
13. Nancy Rottle, "Urban Green Infrastructure for Climate Benefit: Global to Local," *Nordic Journal of Architectural Research*, Issue 2 (2013), 43-66.
14. Richard Forman, *Land Mosaics: The Ecology of Landscapes and Regions*, (Cambridge; New York: Cambridge University Press, 1995) 6.
15. Sean Batty, Landscape Architect at TriMet, in discussion with the author, January 2018.
16. Sarah Primeau, "Designing Constructed Ecosystems for a Resilient Future," in *The New Landscape Declaration: A Call to Action for the Twenty-First Century,* Landscape Architecture Foundation, (Los Angeles: Rare Bird Books, 2016) 151-154.
17. Rottle, "Urban Green Infrastructure," 48
18. Ibid., 47.
19. Ibid., 47.
20. Ibid., 47.
21. Ibid., 48.
22. Batty, January 2018. Most anecdotal information in this section comes from a conversation while riding the Orange Line with Sean.
23. Betsy Anderson, "All Along the Line," Landscape Architecture Magazine, May 2016, 92.
24. JLA Public Involvement, "Portland-Milwaukee Light Rail Transit Project Sustainability Overview Report," TriMet, March 2015, https://trimet.org/orangeline/pdf/sustainability-report.pdf.

3. Context/Analysis

Image Source: Google Earth

Figure 3.1

Midtown Transitway Overview

Agency	Metro Transit- Metropolitan Council
Location	Minneapolis, MN
Mode	Rail & Enhanced Bus Service
Length	4.4 miles rail | 8.6 miles bus
Stations	9 rail | 20 bus
Cost	$250 million
Opening	On-Hold
Planning	Planned through locally preferred alternative
Ridership	32,000 projected per day 14,600 per day in 2012

The Corridor

Midtown Transitway

In Minneapolis, there is a transportation corridor already through early planning stages. In 2012, Metro Transit set out to begin the planning of the Midtown Transitway. This corridor runs perpendicular to the dominant grid of Minneapolis: an east-west corridor running about a mile south of downtown. This project is meant to connect two high capacity transportation corridors: the existing Blue Line via the Midtown Station (eastern end) and the future Southwest Green Line extension via the Lake Street Station (western end). The locally preferred alternative is rail service in the Midtown Greenway (between each station) and enhanced bus service on Lake Street (from Uptown Transit Station across the Mississippi into St. Paul). While the project is currently on hold, this thesis assumes this project is being built as planned, with a focus on enhancing the ecological and social systems through which the corridor passes.[1]

Figure 3.2 [top] and 3.3 [bottom]

Current Bus Stop [top], aBRT Station Configuration [bottom]

A Streetcar Corridor

This corridor is selected due to its history as a streetcar corridor. Thus, it can be the beginning for Minneapolis's reimagined streetcar pattern of thick transportation corridors. Where the streetcars once ran, enhanced bus service will prioritize more localized mobility for community members while enhancing the public realm at bus stations, like the Metro renderings in Figure 3.3. One block north, the sunken Greenway will be leveraged for rail transportation, with a light rail guideway and stations sharing the narrow space with the legendary Midtown Greenway shared-use trail. Figure 3.4 shows two renderings by Metro showing proposals for standard ballast track (left track in Figure 3.5) and a turf track (right track in Figure 3.5). This project is based on the existing engineering while proposing a new design concept for the corridor, based on the local ecology analysis that follows.

Figure 3.4

Current Greenway at Bloomington Ave

Figure 3.5

Light Rail Station Configuration at Bloomington Ave


Northern Forest | Mixed Wood Shield
Eastern Temperate Forest | Mixed Wood Plains
Minneapolis/St. Paul
Quad Cities
Great Plains | Temperate Prairie
St. Louis
Mississippi River
Memphis
Mississippi Flyway
New Orleans

East of the Mississippi Meets West

Minneapolis sits where the forests east of the Mississippi River meet the prairies to the west. The first major urban center along this vital waterway, the city hosts millions of seasonal birds which follow the river's path between Canada and the tropics.[2]

Eco-Regions

The three main eco-regions that make up Minnesota include the Northern Forests, Eastern Temperate Forests, and the Temperate Prairies of the Great Plains.[3] Specifically, Minnesota supports three forest biomes: Deciduous Woodland, Coniferous Woodland, and Aspen Parklands. Minnesota's fourth biome is Prairie Grassland.[4] Within each are many variations based on slope, precipitation, soil type and other factors. This unique combination of biomes results in combinations of grassland and woodland regions in certain places.

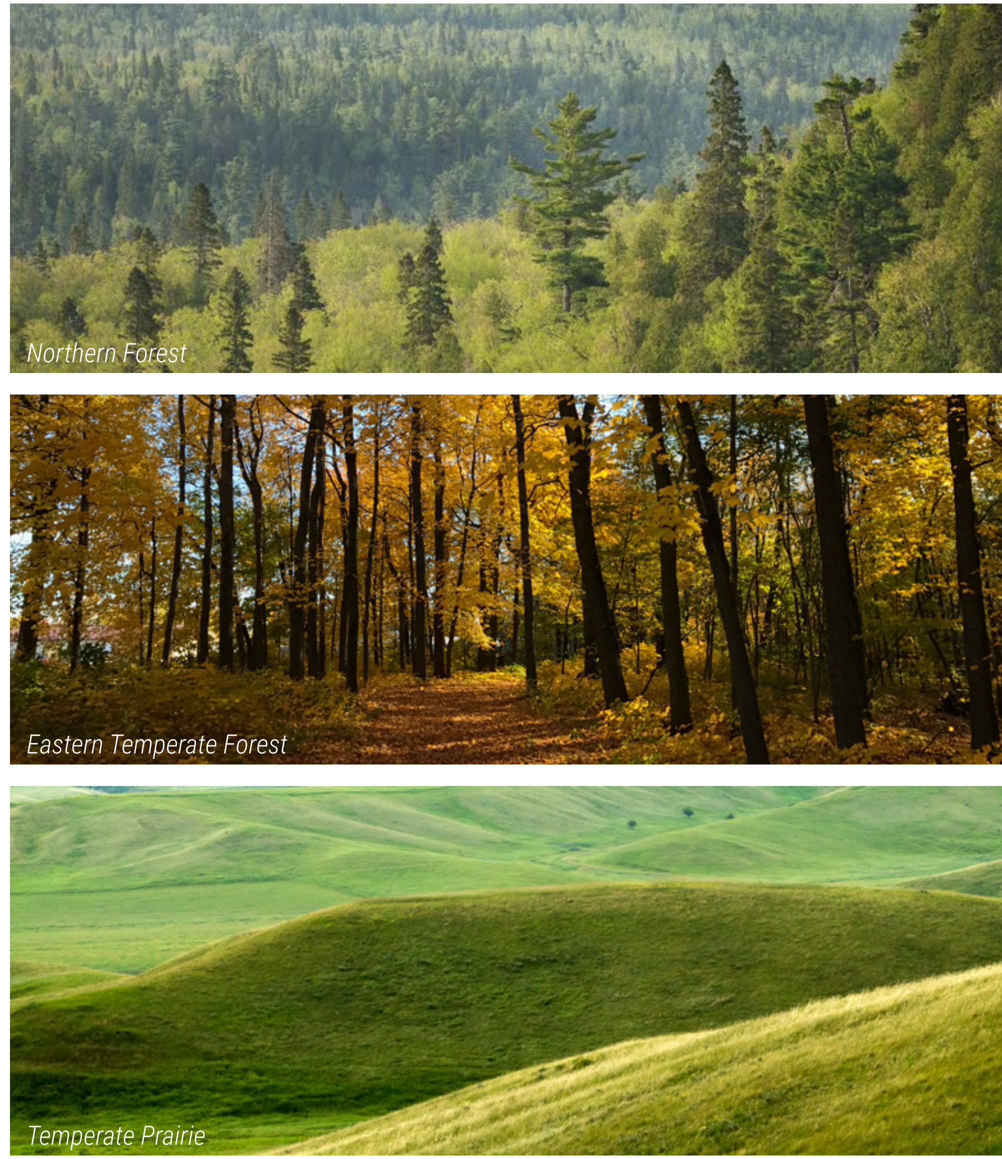


Figure 3.6 [opposite]
Continental Context

Figure 3.7
Minnesota Eco-Regions

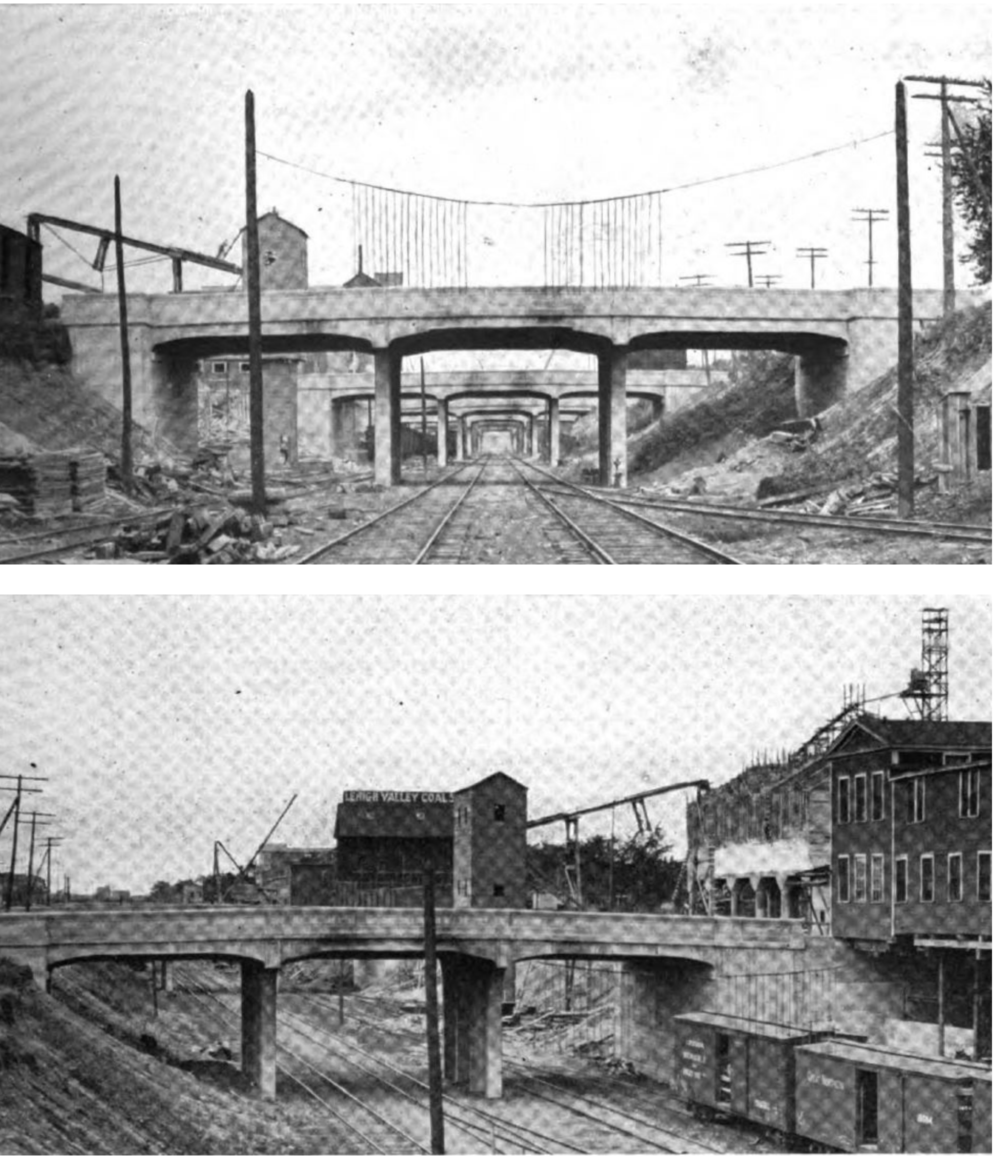


Figure 3.8
Midtown Minneapolis Railroads

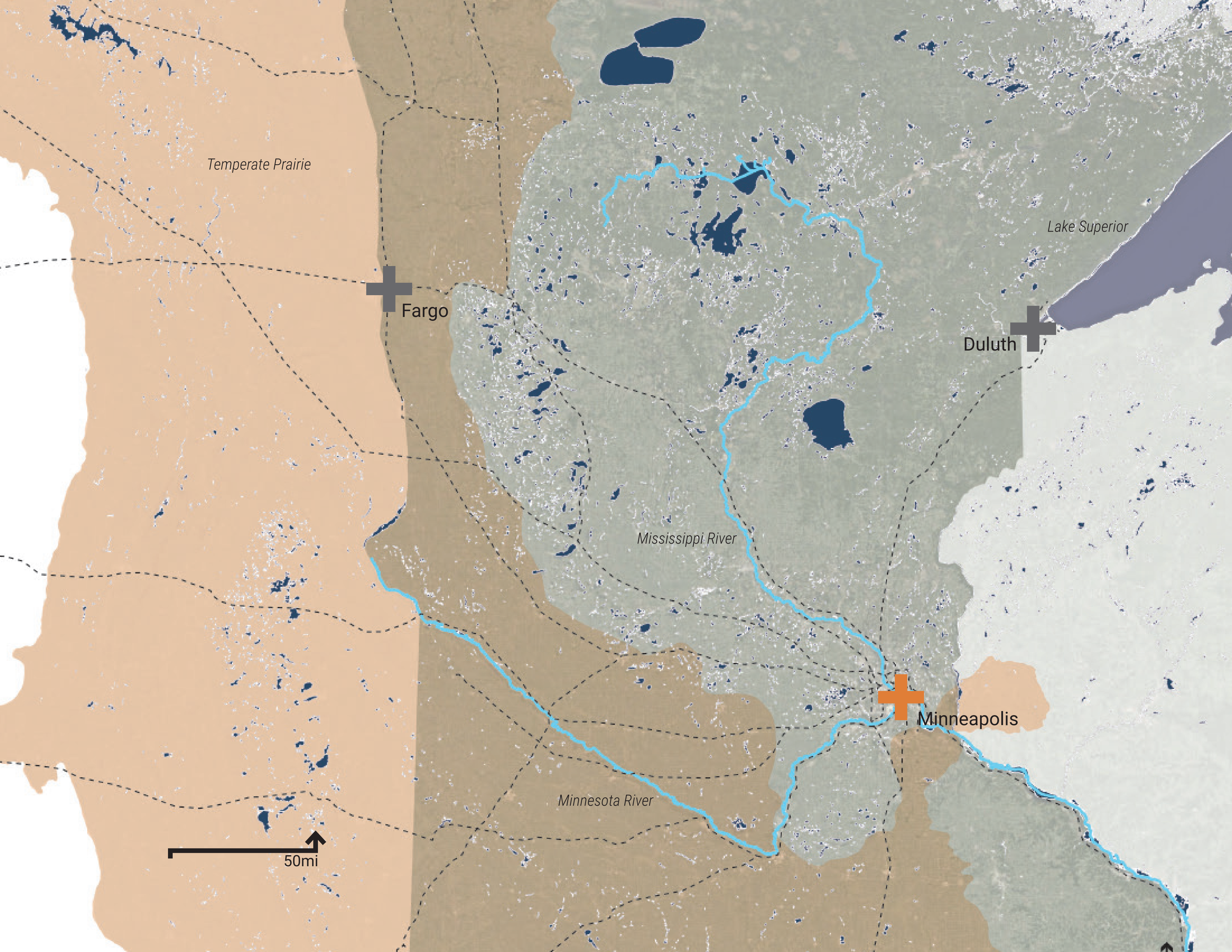
Railroads Meet the River

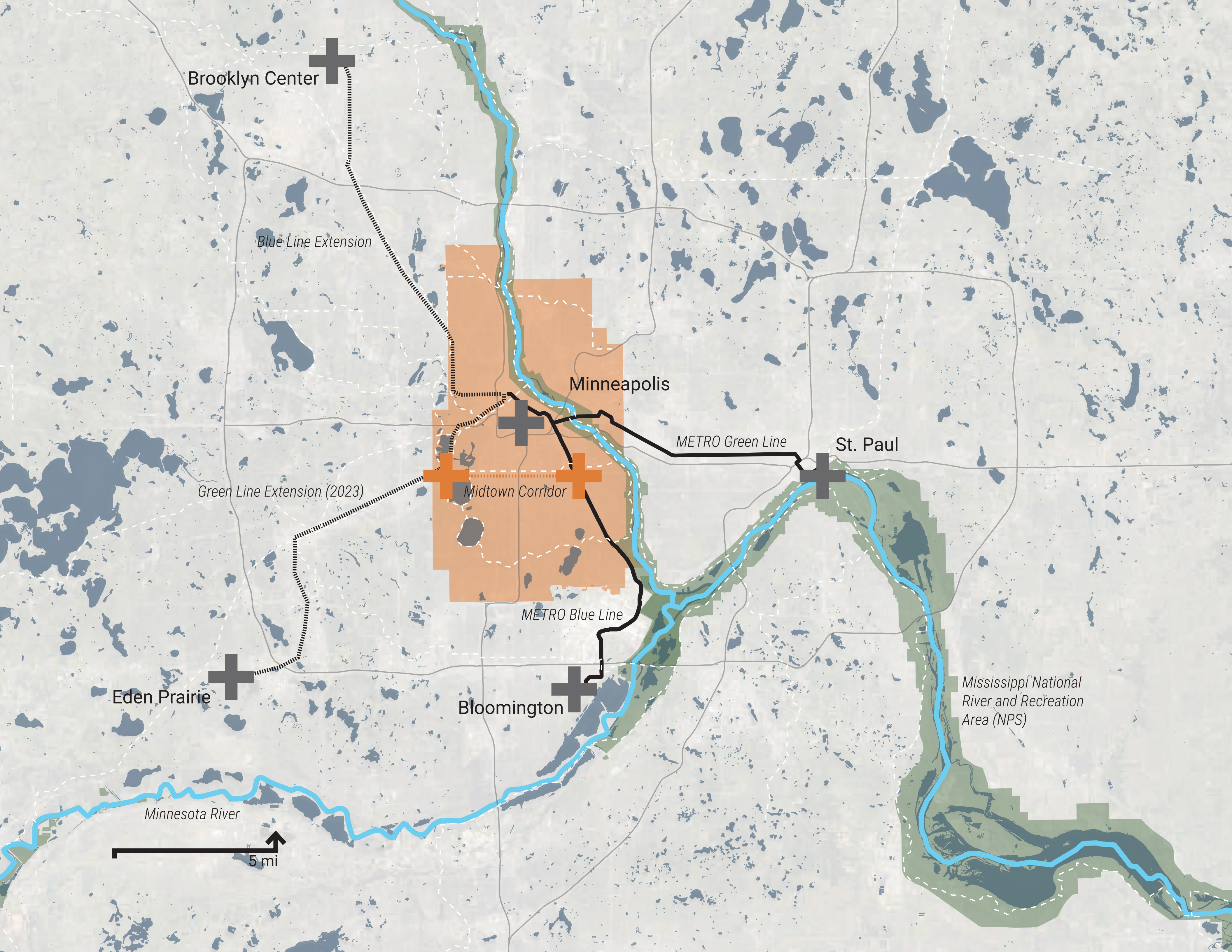
Just beyond the head of navigation, Minneapolis harnessed the power of the Mississippi. The city became the major destination for railroads carrying grain from the west and later flour to the east.

A Railroad Town

Minneapolis was crisscrossed by railroads transporting grain from the Dakotas and western Minnesota into the city's many mills. Most of these companies were either bought by the Class 1 companies or folded together. Today, the only railroads serving Minneapolis are Burlington Northern-Santa Fe, Union Pacific, Canadian Pacific, and the Twin Cities Western. The Greenway was purchased from the Soo Line railroad, which was purchased by Canadian Pacific. Other light rail lines and shared-use trails follow railroad right-of-way throughout the Minneapolis-St. Paul region.[5]

Figure 3.9 [opposite]
Regional Context


Temperate Prairie
Fargo
Lake Superior
Duluth
Mississippi River
Minneapolis
Minnesota River
50mi


Brooklyn Center
Blue Line Extension
Minneapolis
METRO Green Line
St. Paul
Green Line Extension (2023)
Midtown Corridor
METRO Blue Line
Eden Prairie
Bloomington
Mississippi National
River and Recreation
Area (NPS)
Minnesota River
5 mi

Flowing Water Meets Still Water

The Minneapolis/St. Paul region is a mosaic of moving and still water. The mighty Mississippi, St Croix, and Minnesota Rivers have carved through the land providing energy and mobility. Abundant prairie pothole lakes have provided places of repose and habitat while regulating water quality. The built pattern of the region largely follows the hydrological system.

Figure 3.10 [opposite]

Metropolitan Context

Figure 3.11

Rivers and Lakes of the Twin Cities

Figure 3.12
Grand Rounds at Bde Maka Ska

Urban Grid Meets Shorelines

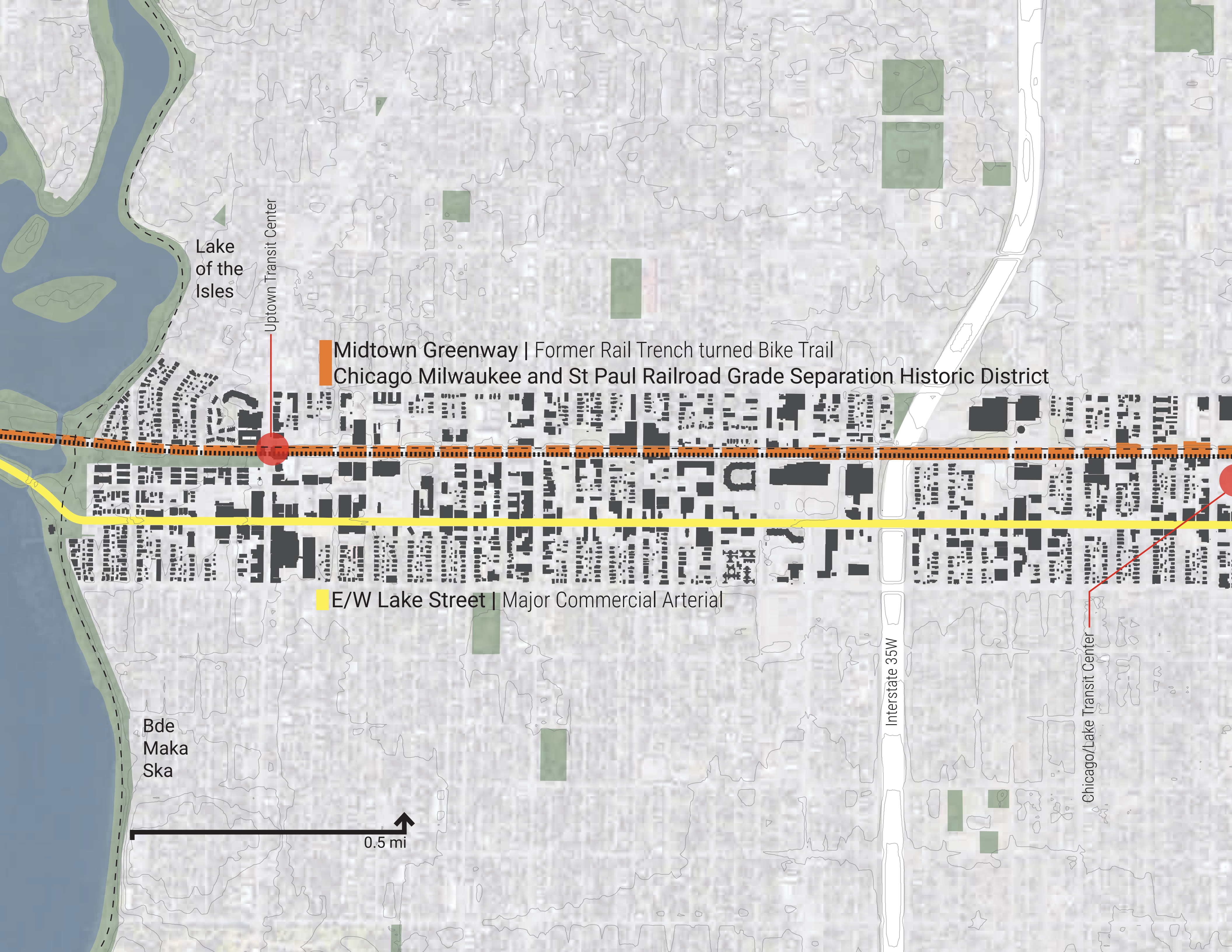
Water guides the urban form of Minneapolis. Like most late 19th and early 20th century American cities, the blocks take a gridded form, particularly laid out in a north-south orientation. This grid is punctured by a system of parkways that takes their form from the bodies of water ringing the city. The Midtown Corridor is a mid-point connecting the Chain of Lakes in the west to the Mississippi River in the east.

Grand Rounds

Speaking of Minneapolis' park system, one piece is of national importance. The Grand Rounds Scenic Byway, a 52 mile network of interconnected parkways, bridges, and bike paths, is recognized by the Federal Highway Administration as the longest continuous system of public urban parkways.[6] The Grand Rounds' importance stretches beyond the parkway. The entire byway is connected with pedestrian and bike trails, providing a safe, separated route for bicyclists to circle the city of Minneapolis (shown as a red dashed line on Figure 3.13). The Midtown Greenway is a vital connection within this system, providing a link through the middle of the ring. As a part of Cleveland's original park system for Minneapolis, this corridor has the potential to be the next leg of the Grand Rounds park system.

Figure 3.13
Urban Context


Blue Line Extension
Mississippi River
Downtown
Midtown Corridor
Green Line Extension (2023)
Lake Street Station
METRO Blue Line
Midtown Station
Chain of Lakes
Grand Rounds


Lake
of the
Isles
Uptown Transit Center
Midtown Greenway | Former Rail Trench turned Bike Trail
Chicago Milwaukee and St Paul Railroad Grade Separation Historic District
E/W Lake Street | Major Commercial Arterial
Interstate 35W
Chicago/Lake Transit Center
Bde
Maka
Ska
0.5 mi

Rails Meet Rubber

This cross-town corridor consists of two major spines: the Midtown Greenway and Lake Street. The Greenway is a former railroad trench while Lake Street was built as a streetcar corridor. Today, the Greenway is a major bike trail and Lake Street is a major vehicular and bus thoroughfare. The reintroduction of rail will complete the multi-modal character of the corridor.

Figure 3.14

Midtown Corridor

9,000-7,000 ya
Paleo-Indians first to inhabit Minnesota. The Dakota (Sioux) and Ojibwe (Chippewa) arrive later.

1680
Father Hennepin, Accault, and Auguelle explore upper Mississippi and are captured by Dakota. Hennepin names St. Anthony falls.

1682
Robert de LaSalle claims entire Mississippi River basin for France

1803
Louisiana Purchase brings area into the United States

American Settlement

- 1819 Fort Snelling constructed, opening area to settlement
- 1830 Heyata Otunwe, Dakota village and mission founded on shores of Bde Maka Ska
- 1839 St Paul first inhabited by squatters evicted from St Anthony Falls
- 1848 St Anthony founded on east side of St Anthony Falls
- 1851 Treaties remove Dakota to western Minnesota
- 1852 Minneapolis established on west side of St Anthony Falls
- 1854 First bridge across the entire Mississippi River built at Hennepin Avenue
- 1872 Minneapolis annexes St Anthony, bringing the east bank into the city limits

American Settlement

Welsh & Greek Immigration

1879-1881
Chicago, Milwaukee, and St Paul Railroad (CM&StP) build the Benton Cutoff line to haul grain from fields of western Minnesota to the flour mills of Minneapolis along 29th Street beyond city limits.

1883
Minneapolis annexes land between Franklin Avenue/24th Street and 38th Street (including Midtown Corridor)

1906
Selby-Lake Streetcar service opens, connecting Lake Street to St Paul

1896
Nicollet Park, home of the Minneapolis Millers baseball team, built near Lake and Nicollet

1883
Horace Cleveland includes Lake Street as a proposed boulevard in his 'Suggestions for a System of Parks and Parkways for the City of Minneapolis

450,000,000 ya
A sea covers Minnesota. The beach sand forms a soft layer of Saint Peters Sandstone while coral and other dead sea creatures form a fractured hard layer of Platteville Limestone above.

40,000-12,000 ya
Glaciers scrape away rock newer than Platteville Limestone, deposit present topsoil.

20,000 ya
St Anthony Falls forms near present day downtown St. Paul, migrating 10 miles upstream over the next 20,000 years

Swedish Immigration

1910 Minneapolis requires CM&StP to depress Benton Cutoff line below street level

CM&StP challenge city all the way to the Supreme Court, but loses

1912-16 Grade separation constructed from Cedar Ave to Hennepin Ave

1927 Sears, Roebuck, & Co. build their mail-order warehouse and a retail store at Elliot and Lake Street with access to the CM&StP.

1954 Twin Cities Rapid Transit ends streetcar service

White Flight

1964-7 Interstate 35W built through corridor, erasing a block of Midtown between Stevens and 2nd Avenue

The freeway, built with only two directional access, begun a progressive downturn along the Lake Street corridor which saw many local shops close, car dealerships leave, and empty lots crumble.

Hispanic Immigration

1992 Hennepin County Regional Rail Authority purchases the Midtown Greenway from the Soo Line Railroad Company

1994 Sears closes retail store on Lake Street

Midtown Greenway

- **2000** Phase 1 opens: Hennepin to Portland Ave
- **2001** Freight rail traffic abandoned in trench
- **2004** Phase 2 opens: Portland Ave to Hiawatha
- **2005** Trench placed on the National Historic Registry as the Chicago, Milwaukee, and St. Paul Grade Separation District
- **2006** First Midtown Corridor transit study
- **2013** Midtown Greenway named best new bicycle trail in America by USA Today
- **2013** Final Metro Transit study recommends lightrail/street car in the greenway and aBRT on Lake Street (B Line)

2005 Midtown Exchange opens with global market, affordable housing, offices, and a county service center

2018 Minneapolis Park Board and the Minnesota DNR restores Bde Maka Ska to its Dakota name

Figure 3.15

Midtown Timeline

Midtown Timelines

The Midtown Corridor, like the rest of Minneapolis, contains a rich tapestry of history. Figure 3.15 on the previous page shows how Midtown's narratives are intertwined. In an effort to simplify, three separate threads have been pulled from the whole in order to give a more detailed look at certain processes that shaped the Midtown Corridors. These are mobility, water, and people. Their stories follow.

Mobility Timeline

While there are stories of Dakota trails crisscrossing the Minneapolis landscape, the mobility timeline begins in earnest when the Chicago, Milwaukee, and St .Paul Railroad built their Benton Cutoff line beginning construction in 1879 and finishing in 1881. The line, which followed 29th Street, was well beyond residential development when constructed.[7] However, in 1883, the city annexed the land between 24th Street and 38th Street (including the Midtown Corridor)[8] and development quickly built-up beyond the rail line.[9] Over the next decade, conflicts between the railroad and residents grew. In 1910, the city demanded the railroad sink the Benton Cutoff below grade. The CM&StP used litigation to resist until the Supreme Court ruled in favor of the city and, in 1912, construction of the grade separation began.[10] Completed in 1916, the project included a double-track main line, sidings to serve industries, as well as bridges at every block, ensuring a continuous street grid from the western city limit to Cedar Avenue.

Simultaneously, Lake Street was developing into a major transportation corridor. In 1906, Twin Cities Rapid Transit (TCRT) began service on the Selby-Lake Street streetcar line, connecting Midtown to downtown St. Paul across the Mississippi River.[11] For 20 years, streetcars ruled Lake Street until the rise of the automobile. The streetcar made a final run in 1954.[12]

The next major piece of the mobility timeline contributed significantly to the decline of the corridor in the latter half of the 20th century. In 1963, the first houses along the Midtown Corridor were cleared, preparing a block wide swath for construction of Interstate 35W. Six years later, the freeway opened to traffic, separating the once thriving Lake Street corridor into two distinct halves. The western half was still majority white while the east became increasingly minority (African American and Hispanic populations increased). In addition, only two ramps were built for Lake Street (a northbound exit ramp and a southbound entrance ramp) further cutting off access from the Midtown Corridor.[13]

The Midtown Corridor struggled through the final decades of the 20th century. During this time, the corridor has been served by local buses provided through the regional transit commissions (the precursor to Metro Transit). As industries along the Benton Cutoff closed and the need for freight traffic waned, Hennepin County purchased the trench in 1992 from the Soo Line Railroad in preparation for future rail transit.[14] While freight service continued in the eastern portion, the western portion of the trench was developed into a shared bike-pedestrian trail. Phase One, from the western city limits to Portland Avenue, opened in August of 2000. Once the final freight customer closed, Phase Two was constructed, opening to Hiawatha Avenue in 2004.[15] The next year, the Chicago, Milwaukee, and St. Paul Grade

Separation Historic District was placed on the National Register of Historic Places.[16] This designation coincided with early planning processes for transit in the Greenway.[17] The current Midtown Transitway Plan was released by Metro Transit in 2013 and is currently in waiting for funding and political will to continue.

Water/Geology Timeline

Water and geology are inextricably connected in the Midtown Corridor and the larger region. Geology is the canvas upon which water has carved an intricate topography of ridges and valleys. 500 million years ago, Minnesota straddled the equator and was the floor of a vast, shallow sea.[18] Over the next 50 million years or so, the sandy sea bottom became compressed into a vast layer of sandstone, specifically the St. Peter Sandstone formation. Above this layer is the Platteville Limestone formation, formed by the remains of microscopic creatures deposited on the sea floor.

In the Twin Cities region, all rocks younger than 450 million years old were then scraped away in the latest ice age. Approximately 11,000-12,000 years ago, the most recent glaciers retreated into Canada, leaving the Platteville formation as the newest layer of rocks below top soil. As these glaciers melted, lakes and rivers formed, carving the valleys now containing the Minnesota and Mississippi Rivers. This meltwater, upon reaching modern day St. Paul, found the perfect geological conditions for carving a wide valley. Upon entering this valley, the water formed a waterfall 1.5 miles wide with a vertical drop of 150-200'. This is the ancestor of St. Anthony Falls in downtown Minneapolis. The layering of the soft St. Peter Sandstone under the hard but fractured Platteville Limestone created a situation in which the falling water would erode away the sandstone, undercutting the limestone above. Eventually, this limestone shelf fell, moving the waterfall backwards. Over 12,000 years, the waterfall has migrated 12 miles upriver, now held permanently in place by a 1960s concrete apron. The retreat of St. Anthony Falls formed other waterfalls along the Mississippi River, including the well-known Minnehaha Falls.

The same process created the many lakes that puncture the landscape throughout the region. Bedrock valleys carved by meltwater provided low points for water to collect. In many instances, the bedrock prevented water from infiltrating, creating a permanent lake. In other areas, the low points are filled seasonally, depending on snowmelt and rainfall. This is typical of a prairie pothole ecosystem.[19] While the Midtown corridor lacks much topographic interest, the western edge includes the Chain of Lakes—a series of glacial bedrock lakes, just south is Powderhorn Lake—a pothole wetland, and at the eastern edge is the Mississippi River Gorge.

During the modern era, human activity has considerably impacted the hydrology of the region. Ground water pumps have lowered lake levels. Industry and runoff have polluted the Mississippi River while agricultural runoff has severely impacted the Minnesota River. Perhaps the largest effect of human activity has been the use of road salt in winter, an issue in many cold climates. Chloride can have disastrous effects on aquatic habitat and ground water: chloride pollutes well drawn drinking water; is toxic to many fish, aquatic bugs, and amphibians; kills native wetland plants often allowing invasion by exotic species; and can even affect the structure of the soil column, reducing water retention capacity, increasing erosion, and increasing the alkalinity. The major unknown piece of the water timeline moving forward is the long term effects of salt and chloride pollution.[20] Current stormwater best management practices (BMPs) are largely ineffective at filtering salt out of water due to the chemical properties of salt once dissolved.[21]

Cultural Timeline

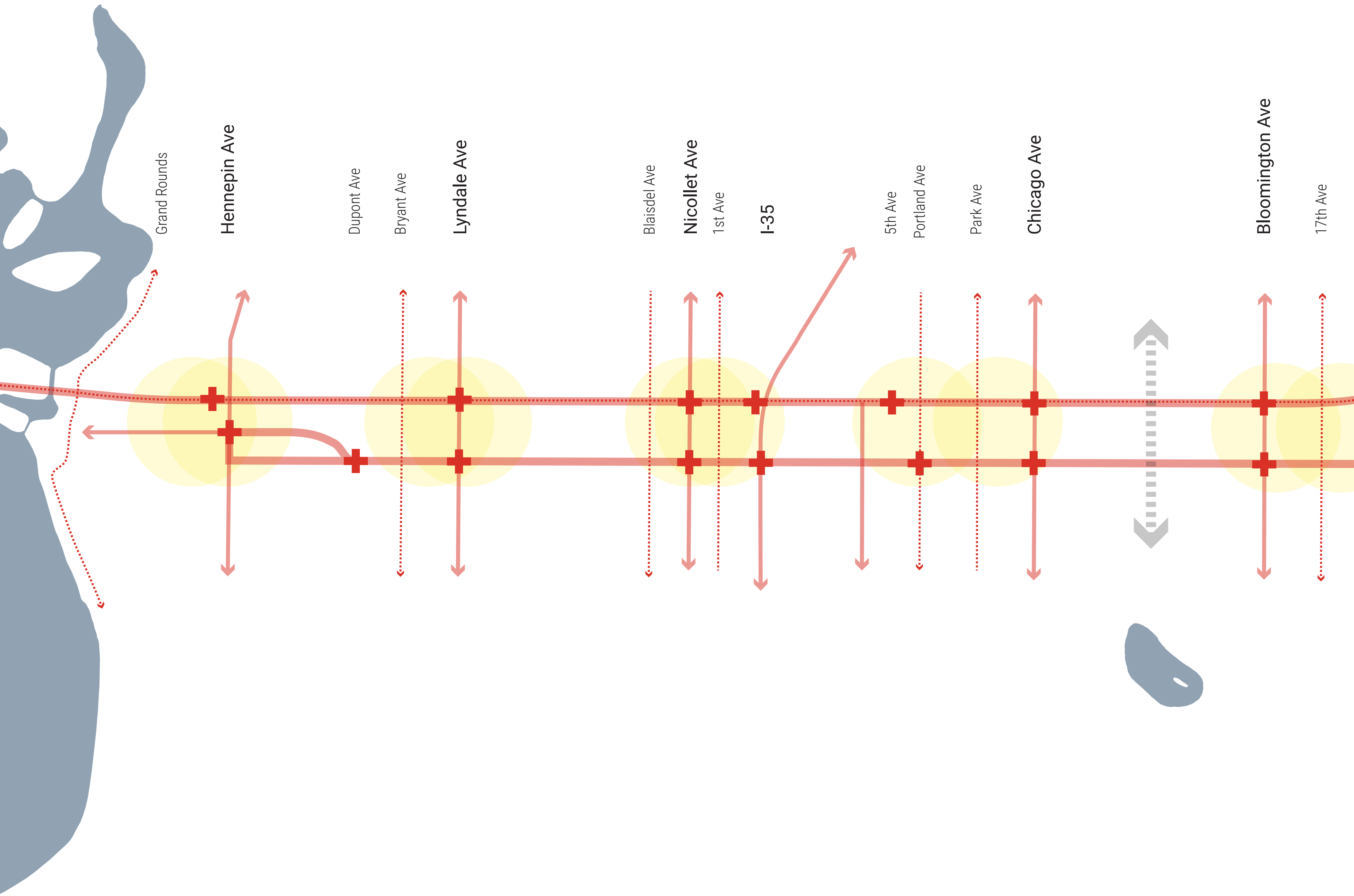
Any project must begin from a place of acknowledgment for the cultures that existed before modern record-keeping. While it is easy to begin site analysis with the first European explorers or the first white settlers, people have lived on the land that is now Minneapolis for over 14,000 years.[22] These first inhabitants were Paleoindians, beginning with the Clovis peoples. By the time the first European explorers entered the area, people had lived in Minnesota well over 13,000 years. In the 17th century, the dominant nation was the Dakota people. From 1669 through the early 1700s a series of explorers, including friars and traders, traversed Minnesota, interacting with the Dakota people. Both the Louisiana Purchase of 1803 as well as American victory in the War of 1812 brought all of Minnesota into American possession. In 1819, Fort Snelling was built as the first [American] structure in the area.[23] What followed was a series of treaties between the American government and the Dakota nation, ceding most of their land to the government while not establishing any permanent reservations. After decades of mistreatment and broken promises, frustration among the Dakota erupted into the US-Dakota War of 1862. As a result of this war, the US backed out of all promises made to the Dakota nation and exiled them from Minnesota. These wounds are still being healed today.[24]

While the government and settlers were stealing Dakota land and banishing them from the territory, the urbanization of Minneapolis began. St. Anthony, on the east side of St. Anthony Falls, was founded in the 1840s with Minneapolis following suit in 1854. These cities were founded on the power of the falls to drive lumber milling first, then flour milling once the forests of Minnesota had been depleted of old growth timber. In 1872, Minneapolis annexed St. Anthony, uniting both sides of the river.[25] As industry grew, the cities attracted waves of immigrants with the promise of a new life among the prairies. By the 1890s, Minneapolis was the primary American destination of Scandinavian immigrants, with Swedish, Norwegian, and Danish communities all settling along the Midtown corridor. Other immigrants arriving at the turn of the century included both Greek and Welsh immigrants. These communities shaped the culture of the corridor through their institutions, especially schools and churches, many of which exists today.[26]

The next major shift in the Midtown Corridor accompanied the construction of 35W, bisecting the corridor between the lower income east and the higher income western portion. Similar to many urban centers, the corridor underwent white flight in the late 20th century. With the sudden exodus of many of the white residents and business owners, the corridor struggled into the 1990s when a large influx of Mexican immigrants began settling along East Lake Street. Since 1990, the Mexican population has grown over 500% with over 300 Latino owned businesses in the area.[27] Many of these now residents immigrated from the Mexican state of Morelos, with both Minneapolis and the Morelos capital city of Cuernavaca agreeing to become sister cities in 2003.[28] Another major immigrant community that contributes to the diversity of the corridor is the Somali community, also beginning in the 1990s. While Somali immigration has not been centered in the Midtown Corridor, East African culture contributes to the breadth of businesses and residents of the corridor.[29]

The cultural diversity as well as the entrepreneurial spirit of the residents is captured in the Midtown Exchange, a revitalization project in the shuttered Sears and Roebuck Warehouse and Distribution Center at East Lake Street and Chicago Avenue South; including affordable housing, condominiums, offices, and a county service center. The cultural heart of the project is the Midtown Global Market. This internationally-themed public market[30] includes stalls from every culture along the corridor as well as in Minneapolis. It provides new immigrants and entrepreneurs the opportunity to introduce Minnesotans to their culture, whether it is through food, crafts, baked goods, or art. Here, one can experience the diversity of the corridor under one roof. It is this cultural history that makes Midtown Minneapolis such a rich social tapestry but also why this corridor is in such a need for investment.

A deeper look into the data of the corridor paints a less-than-rosy picture of the economic and social condition of the corridor, especially east of I-35W. For example, Lake Street touches both Minneapolis' wealthiest census tract and the second-poorest with median incomes (2016) of $116,872 and $18,799. These neighborhoods are located within a mile-and-a-half of each other. The communities east of 35W (especially north of Lake Street) have a far more diverse population, with several census tracts containing a no clear majority racial group. In addition, between 35W and Hiawatha Avenue, those who identify as Hispanic ranges from 20-50%, the highest range in all of Minneapolis.[31] Thus, the most diverse portion of the corridor is also the most economically disadvantaged, with the corridor severely segregated by I-35W. A thick corridor must acknowledge this and strive to bring economic health back to the community while celebrating the diversity of the communities through which it passes.



Grand Rounds
Hennepin Ave
Dupont Ave
Bryant Ave
Lyndale Ave
Blaisdel Ave
Nicollet Ave
1st Ave
I-35
5th Ave
Portland Ave
Park Ave
Chicago Ave
Bloomington Ave
17th Ave

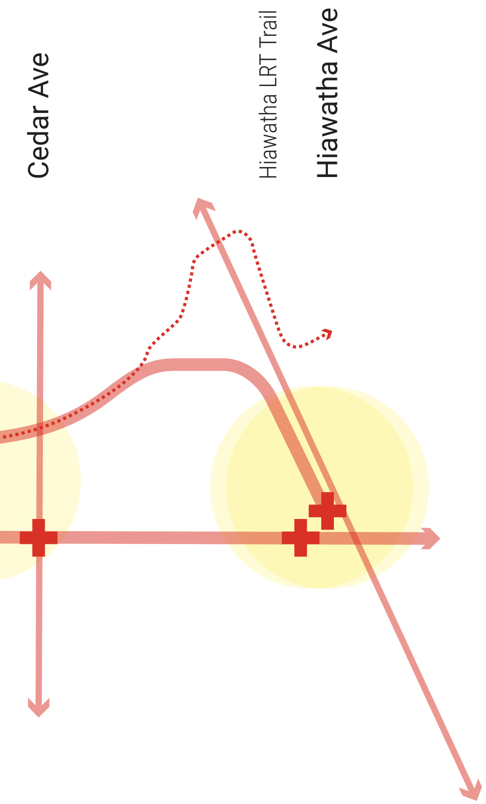


Figure 3.16
Mobility Analysis

Midtown Local Ecology

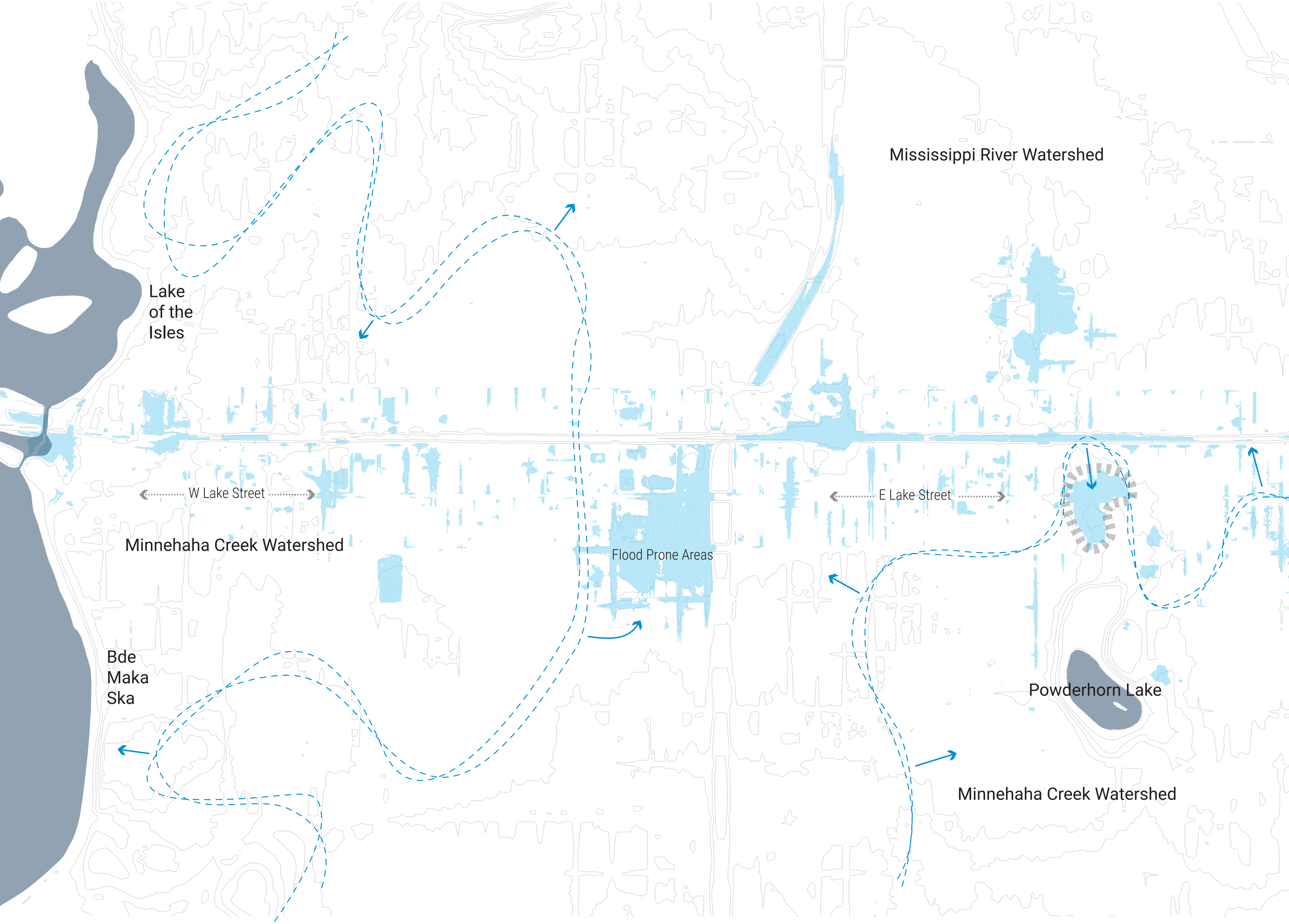
With the analysis complete, two systems seem to be driving the ecology of the Midtown Corridor: mobility and water.

Mobility

The Midtown Corridor is structured through the intersection of transit corridors. This is a relic of the streetcar development pattern but is being reinforced by future transit projects. In addition to these major nodes, several north-south bike connections provide another grain of mobility through the corridor. The largest gap in this mobility network is between Chicago Avenue and Bloomington.

Climate Challenges

As temperature extremes plague Minneapolis, mobility infrastructure must be resilient and multifunctional. A future transportation system will work with ecological function, eliminate emissions while producing energy, and encourage active mobility such as walking and biking.



Mississippi River Watershed
Lake
of the
Isles
W Lake Street
E Lake Street
Minnehaha Creek Watershed
Flood Prone Areas
Bde
Maka
Ska
Powderhorn Lake
Minnehaha Creek Watershed

Figure 3.17
Water Analysis

Water

While the Midtown Corridor is generally flat, the underlying hydrology is anything but simple. The divide between the Mississippi and Minnehaha Creek Watersheds snakes across the corridor. Minneapolis soils are generally well draining, but the abundance of impervious surfaces coupled with slight depressions in the street grid produce flood prone areas, scattered across the corridor similar to prairie pothole lakes. In particular, where 12th Avenue S and Lake Street meet, one of these urban pothole wetlands coincides with the low point along the grid.

In this flat context, the topographic change of the Greenway becomes an even greater feature of the corridor. It is an anomaly in the landscape, one which presents the opportunity to put gravity to work for controlling stormwater and flooding.

Climate Challenges

The major challenges facing the local hydrologic system stem from increased runoff. Flooding will become more frequent while recieving waters will be at a higher risk of pollutants. A resilient system of stormwater management as well as runoff filtration is necessary to protect Minnesota's 10,000 lakes from phosphorus and the Mississippi River from increased sediment load.

Herbacious Dominated Habitat
Honey Bee Permits
Tree/Shrub Dominated Habitat

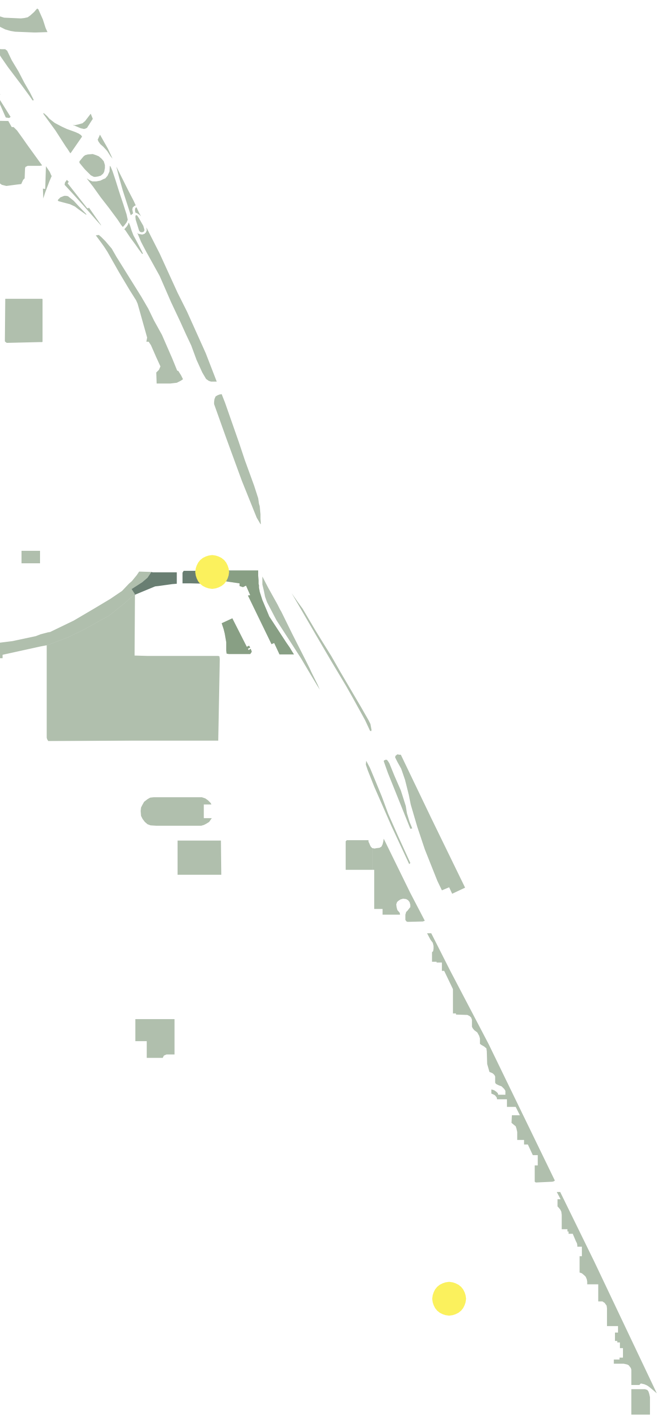


Figure 3.18
Habitat Analysis

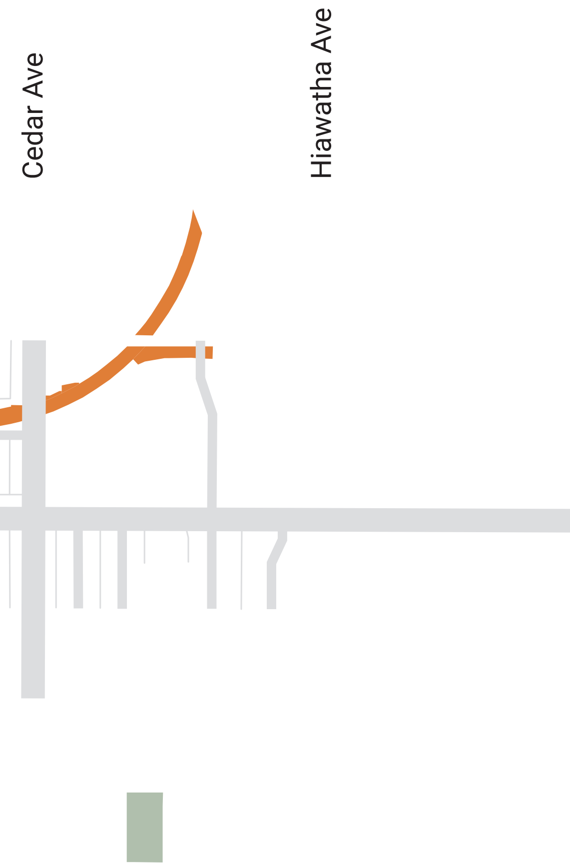
Habitat

The Midtown Corridor passes through a portion of Minneapolis that is heavily developed. Most the corridor is less than 25% vegetated.[32] However, the Greenway is a habitat connector between the Chain of Lakes and the Mississippi River to the east. In addition, Minneapolis provides permits to residents who host honey bee colonies on their property.[33] Thus, the Midtown Corridor has a great potential to become a habitat corridor, connecting patches separated by development as well as serving pollinators isolated in these residential neighborhoods.

Climate Challenge

Changing climate and increasing urbanization has decimated habitats for many local species. As a result, there is an increasing clash between human and natural habitat. Rather than fight this, the Midtown Corridor must embrace this, reintroducing the variety of habitat that once made this area so diverse. Wetlands, prairie, a wooded gorge filled with limestone cliffs, and riparian habitat must all be reintroduced into Midtown to reflect this historic matrix.


Hennepin Ave
Lyndale Ave
Whittier Park
Nicollet Ave
Chicago Ave
Stewart Park
Bloomington Ave
The Mall
Bryant Park
Powderhorn Park



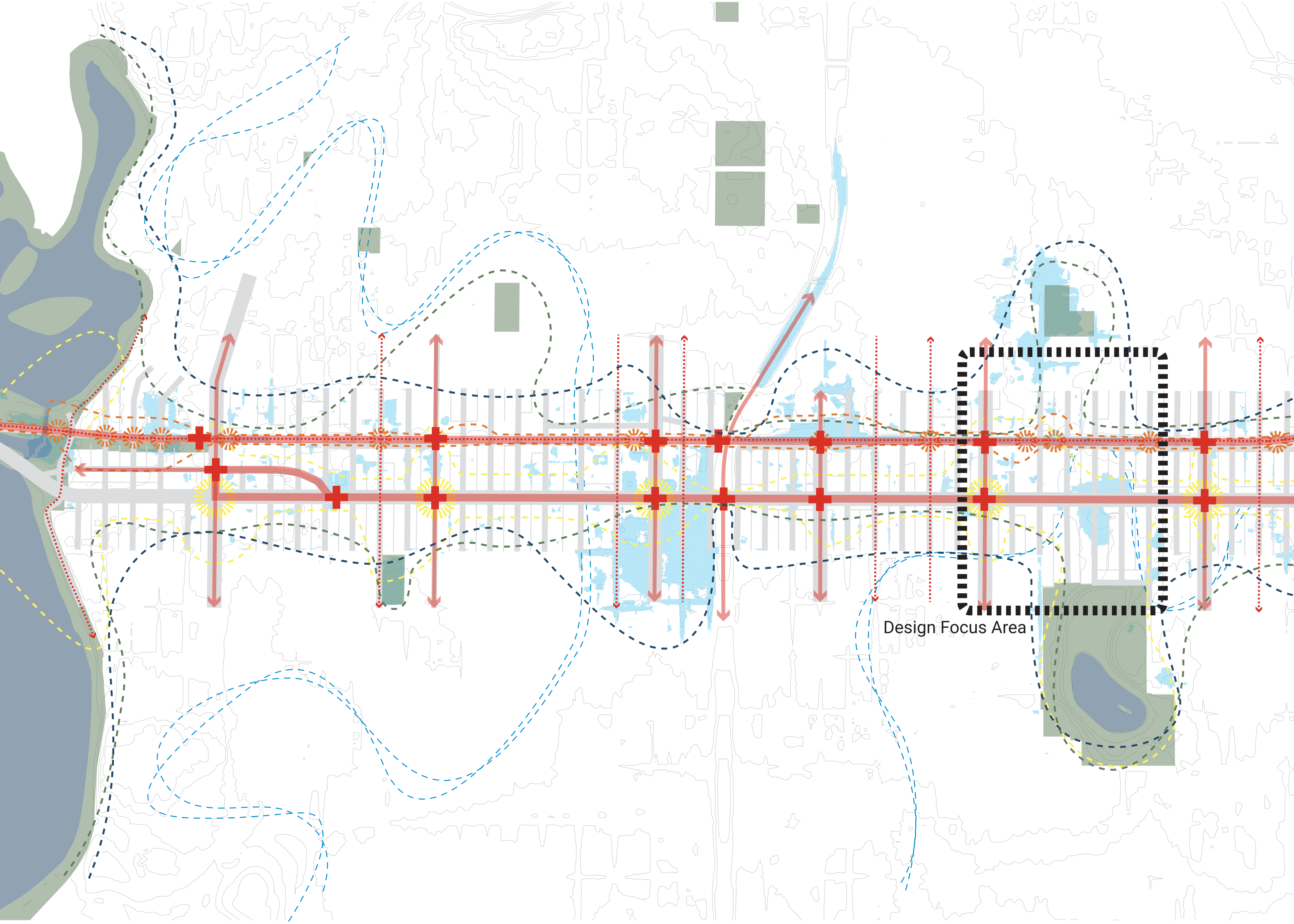
Public Realm

Private development will invariably follow, or even precede, such a large infrastructure project. However, the goal of this project is to leverage the public realm for the benefit of the Midtown community. Thus, public land has been mapped, with the orange line representing the Greenway (which is technically a series of parcels, not a right-of-way). This is the canvas upon which conceptual design will be proposed. There are several parks just beyond the corridor proper, including the 67 acre Powderhorn Park. Leveraging north-south streets to connect these to Lake Street and the Greenway thickens the corridor.

Climate Challenges

The public realm will bear the brunt of climate change. In addition to providing efficient mobility, the public realm of the Midtown Corridor will have to detain and filter stormwater, connect habitat, move fresh air, and provide gathering spaces as Minneapolis densifies.

Figure 3.19
Public Realm Analysis


Design Focus Area

A Thick Midtown Corridor

Overlaying these systems, this map shows the thickness of the Midtown Corridor. Clearly, the 200 feet H.W.S. Cleveland proposed for the Lake Street Parkway was not nearly enough to capture the rich ecosystems that make up this corridor. In order to allow for a more detailed design exploration, one area in particular was selected. This area, highlighted in Figure 3.20, contains the full range of conditions spanning the corridor, including both a commercial node and an interstitial zone along Lake Street and a portion of the Greenway with saturated soils. These conditions are explored through conceptual design interventions in the next section.

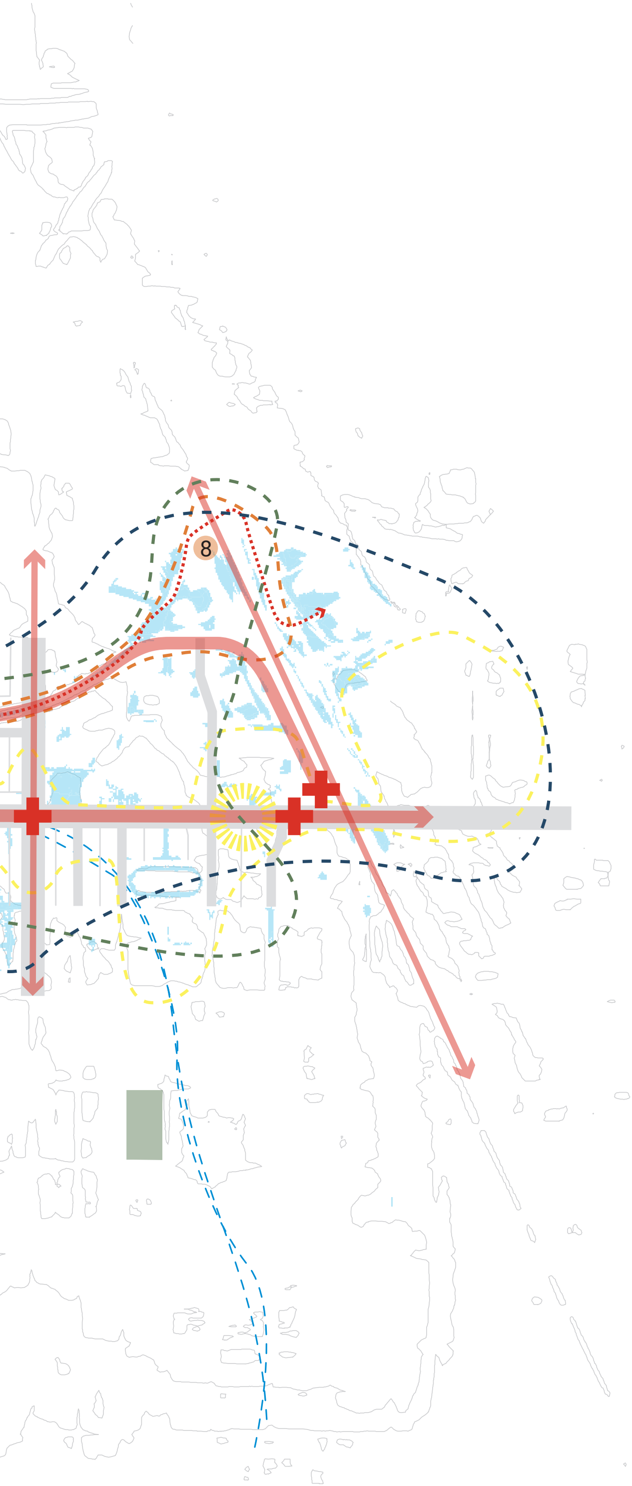


Figure 3.20

Thick Corridor

Figures

Notes

1. “Midtown Corridor Alternatives Analysis,” Metro Transit, accessed January 21, 2018, https://www.metrotransit.org/midtown-corridor. This webpage includes a library of project documents and plans as well as the final report. All research for the existing project comes from this archive.
2. "Mississippi Flyway," National Audubon Society, accessed June 1, 2018, https://www.audubon.org/mississippi-flyway
3. “Ecoregions of North America,” United States Environmental Protection Agency, accessed February 12, 2018, https://www.epa.gov/eco-research/ecoregions-north-america.
4. “Minnesota’s Biomes,” Minnesota Department of Natural Resources, accessed February 12, 2018, https://www.dnr.state.mn.us/biomes/index.html.
5. “Twin Cities Area Freight Railroad Map,” Minnesota Department of Transportation, September 2015, https://www.dot.state.mn.us/ofrw/maps/MetroRailMap.pdf
6. “Grand Rounds Scenic Byway,” Federal highway Administration, accessed March 2, 2018, https://www.fhwa.dot.gov/byways/byways/2243.
7. TKDA and Hess Roise, “Midtown Corridor Historic Bridge Study,” City of Minneapolis Public Works Department, 2007, http://midtowngreenway.org/files/mgc/ckfinder/files/MidtownCorridorHistoricBridgeStudy5-30-07.pdf, 19.
8. “Minneapolis: 150 Years of Growth,” Hennepin County Library- Special Collections Tumblr (blog), 2011, https://hclib.tumblr.com/post/5366939924/growth-of-minneapolis-here-is-a-map-we-worked-on.
9. TKDA, “Historic Bridge Study”, 19.
10. Ibid., 20.
11. Linda Cameron, “For thirty years, electric streetcars ruled Twin Cities streets.” *MinnPost*, March 08, 2016, https://www.minnpost.com/mnopedia/2016/03/thirty-years-electric-streetcars-ruled-twin-cities-streets.
12. Ibid.
13. Patricia Cavanaugh, “Politics and Freeways: Building the Twin Cities Interstate System,” University of Minnesota, October 2006, https://conservancy.umn.edu/bitstream/handle/11299/2082/Freeways.pdf.
14. TKDA, “Historic Bridge Study”, 23.
15. “Midtown Greenway,” Minneapolis Public Works, last updated January 30, 2012, http://www.minneapolismn.gov/bicycles/midtown-greenway.
16. TKDA, “Historic Bridge Study”, 7.
17. From here on, the CM&StP Grade Separation Historic District will be called the Midtown Greenway or simply the Greenway.
18. Jim Miller, “A Geology Tour of the Twin Cities,” University of Minnesota-Duluth, July 28, 2016. http://www.d.umn.edu/~mille066/Outreach/Geology%20Tour%20of%20the%20Twin%20Cities-guidebook.pdf. All facts in this section are sourced from this article unless otherwise noted.
19. Darrel Drake, Brenda Tozer, and Geoffrey Stillwell, “Prairie Pothole Wetlands and Region,” Emporia State University, 2012, http://academic.emporia.edu/aberjame/student/drake2/ppr.html.
20. “Chloride (salts),” Minnesota Pollution Control Agency, accessed February 20, 2018, https://www.pca.state.mn.us/water/chloride-salts.
21. “Cold climate impact on runoff management,” from the Minnesota Storm Manual, Minnesota Pollution Control Agency, accessed February 20, 2018, https://stormwater.pca.state.mn.us/index.php/Cold_climate_impact_on_runoff_management.
22. “Prehistoric Period,” Minnesota Department of Administration- State Archaeologist, accessed May 15, 2018, https://mn.gov/admin/archaeologist/the-public/mn-archaeology/prehistoric-period/.
23. “Contact Period,” Minnesota Department of Administration – State Archaeologist, accessed May 15, 2018, https://mn.gov/admin/archaeologist/the-public/mn-archaeology/contact-period/.
24. “Post-Contact Period,” Minnesota Department of Administration – State Archaeologist, accessed May 15, 2018, https://mn.gov/admin/archaeologist/the-public/mn-

archaeology/post-contact-period/.
25. Annette Atkins, “St. Paul, Minneapolis, and Minnesota’s Urban Origins,” *MNopedia,* August 11, 2011, http://www.mnopedia.org/st-paul-minneapolis-and-minnesotas-urban-origins.
26. “Midtown: A Place to Call Home,” Museum in the Streets, Lake Street Council, accessed April 4, 2018, http://visitlakestreet.com/images/website/museumtinthestreets-midtown-tour.pdf.
27. “Latino Community,” City of Minneapolis Neighborhood and Community Relations, last updated June 5, 2017, http://www.ci.minneapolis.mn.us/ncr/outreach/WCMS1P-143470.
28. Ggrinager, “Zapata statue finds a home on East Lake Street in Minneapolis,” *Twin Cities Daily Planet*, July 28, 2012, https://www.tcdailyplanet.net/zapatas-statue-finds-home-east-lake-street/.
29. Ibrahim Hirsi, “The complicated reality behind the story of the Somali community’s success in Minnesota,” *MinnPost*, August 14, 2017, https://www.minnpost.com/politics-policy/2017/08/complicated-reality-behind-story-somali-communitys-success-minnesota.
30. Midtown Global Market Homepage, accessed May 15, 2018, https://midtownglobalmarket.org/.
31. All data from the U.S. Census Bureau’s 2016 American Community Survey (ACS), 5-year estimates.
32. “Minnesota Land Cover Classification System: User Manual,” Minnesota Department of Natural Resources, 2004, https://files.dnr.state.mn.us/assistance/nrplanning/community/mlccs/mlccs_manual_v5_4.pdf.
33. “Homegrown Minneapolis,” City of Minneapolis, last updated December 14, 2017, http://www.minneapolismn.gov/sustainability/homegrown/WCMS1P-133195.

4. Design

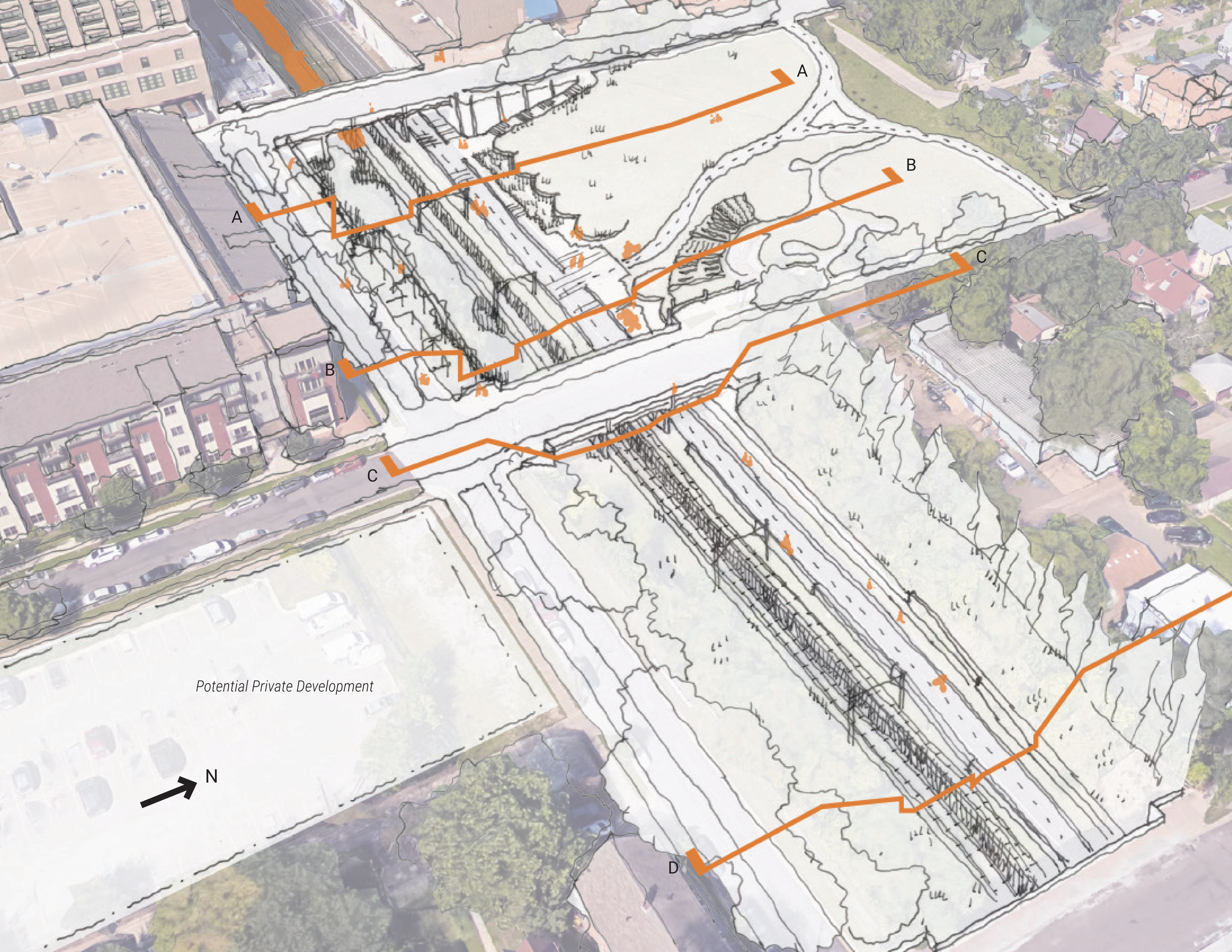
Image Source: Google Earth

Midtown Focus Area

Using a smaller focus area along the eastern portion of the Midtown Corridor, I grounded the framework presented in Chapter 2 through a series of conceptual design interventions. Translating the idea of a thick corridor these interventions reimagine the intersection of urban fabric and infrastructure with the mobility and water systems so vital to Minneapolis. One site is within the Greenway itself, seeking solutions to saturated soils and flood risk with rail and trail infrastructure. The second site is the intersection of Chicago Ave and Lake Street, where stormwater strategies soften a hard commercial node and transit infrastructure contributes to community public space. The final site is between two nodes, where the opportunity to collect water and provide active transport find synergies on a quiet residential street. These conceptual designs are site specific, but represent approaches that apply to the wider corridor. Individually they are moments within the corridor but together, they form the thick Midtown Corridor. As the age-old adage goes, "the [thick urban corridor] is greater than the sum of its [individual interventions]."[1]

Figure 4.1
Midtown Focus Area, Looking North


Downtown Minneapolis
CEPRO/Greenway Site
Chicago Avenue & Lake Street
12th Avenue & Lake Street
Powderhorn Park
N


A
A
B
B
C
C
D
Potential Private Development
N

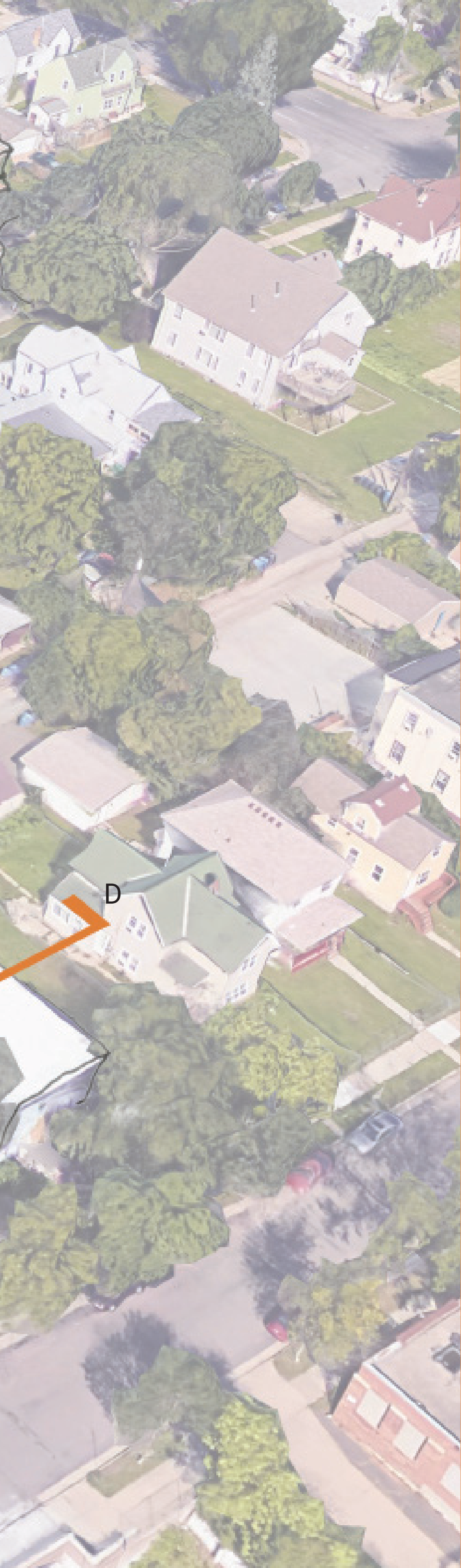


Figure 4.2

CEPRO Site - Greenway, Looking Northwest

CEPRO/Greenway Site

This site is unique in that it was home to the longest functioning industrial facility along the Greenway, the Stewart – CEPRO grain elevator. Tearing down this relic provided one of the few open spaces along the entirety of the Greenway. This open space reduces the slope of the grade change, providing a gradual, accessible connection into the Greenway. One block east, the Greenway narrows. This site is an ideal testing ground for design concepts within the Greenway due to all typical Greenway conditions occurring in short space. Thus, strategies for the entire length can be tested in the span of two blocks. The light rail infrastructure in the Greenway is dimensioned based on Metro Transit standard engineering documents.


MIDTOWN

Figure 4.3 [left]

Existing Greenway with Standing Water, Looking West

Figure 4.4 [above]

CEPRO Site Access to Greenway, Looking South

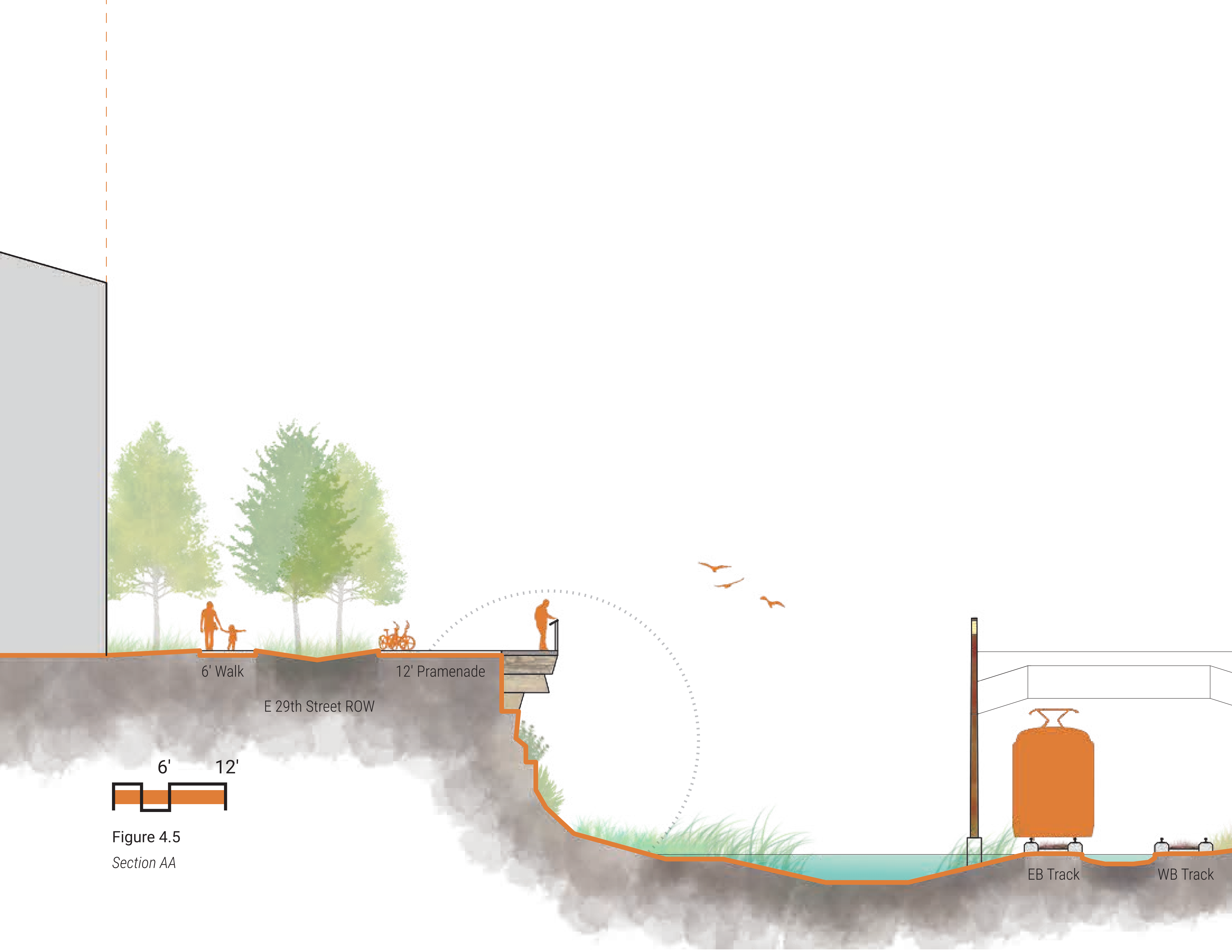
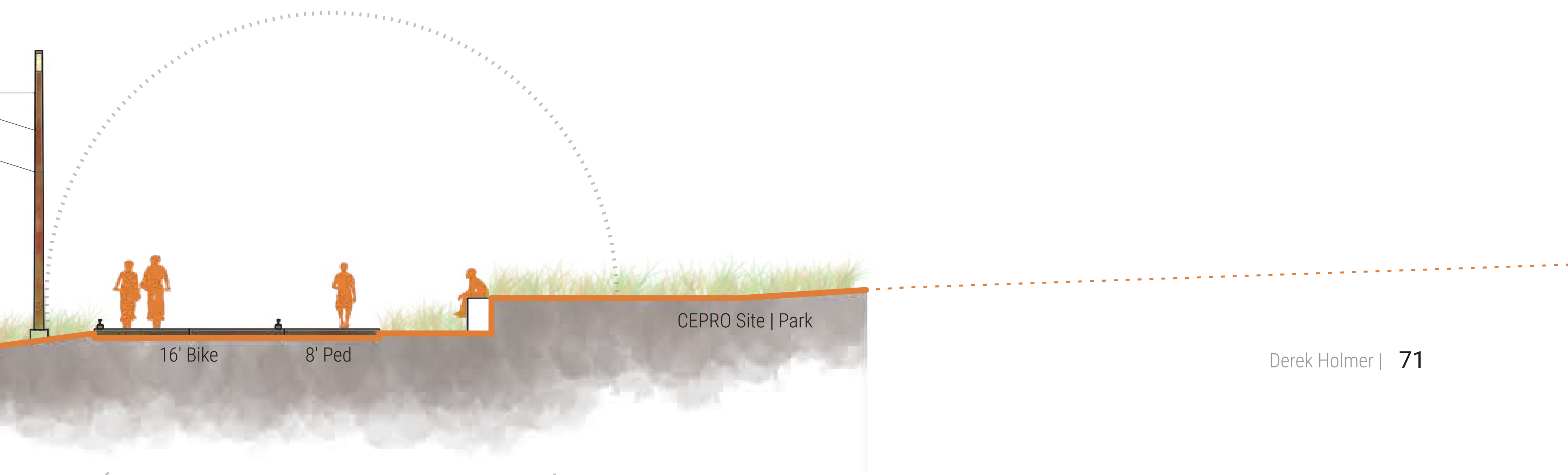


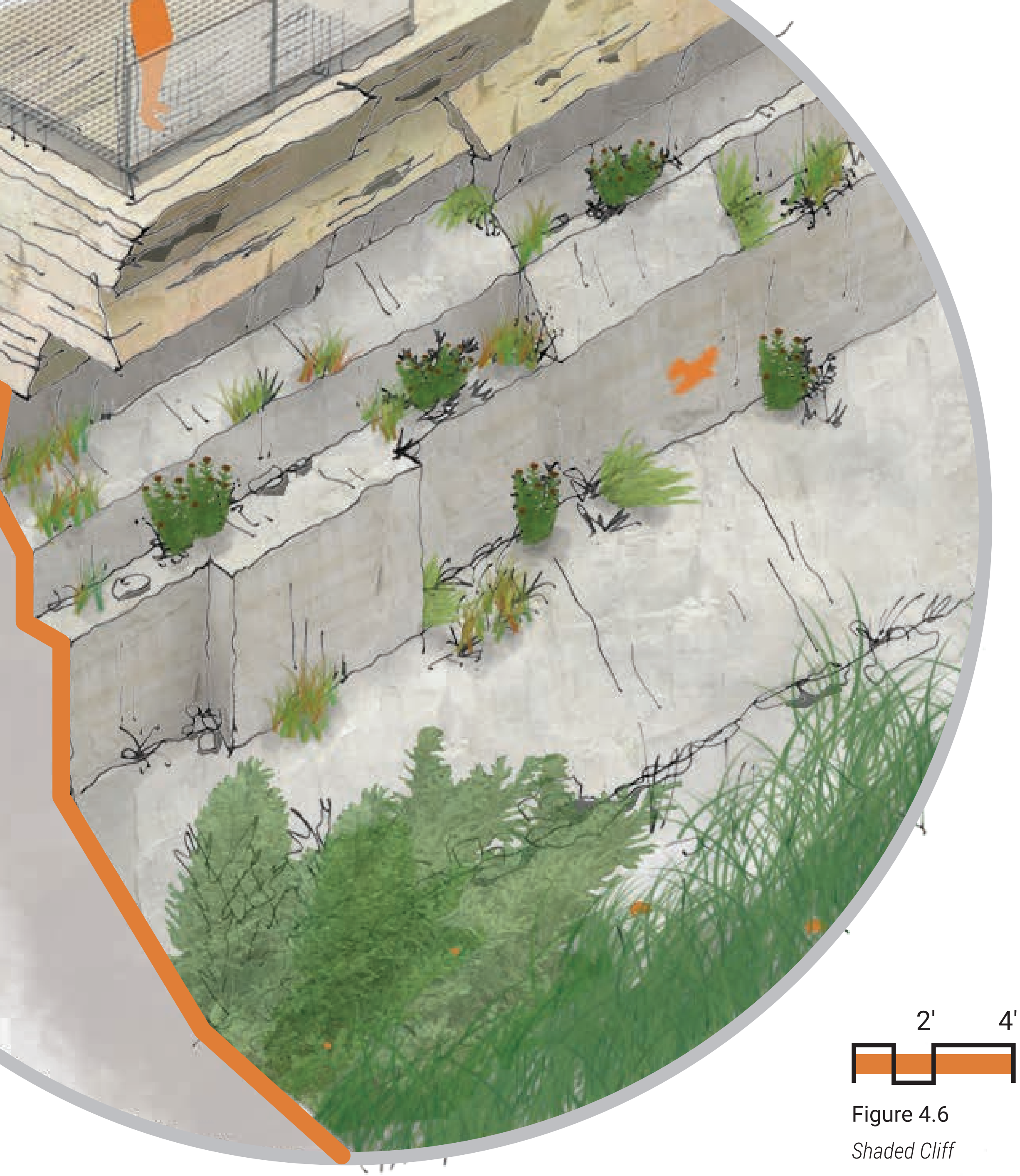
Figure 4.5

Section AA

CEPRO West | Greenway Wetlands

This section represents the low point along the length of the Greenway at an elevation of approximately 841’. The soil here is saturated as evident by the standing water pictured in Figure 4.3. With climate change, this accidental wetland will be saturated year round. It is expanded, taking advantage of this feature to collect, filter, and infiltrate stormwater from the streets above and higher points along the Greenway. Both the light rail tracks and the 20’ grade change provides an inaccessible space where the wetland can function without interruption. An existing retaining wall (north of the trail) echoes the shape of the grain silos previously occupying the site. Other opportunities exist to recall this industrial heritage through materiality and vegetation.





Ecological Echoes

Cliff Dwellers

This inaccessible north-facing cliff offers habitat for several specialized species, many threatened by the changing climate in Minnesota, including Maidenhair Spleenwort (*Aplenium trichomanes ssp. trichomanes*),[2] Michx (*Draba arabusans var. superiorensis*),[3] (Torr. & Gray) Britt (*Sullivantia renifolia*),[4] Leedy's Roseroot (*Rhodiola integrifolia ssp. leedyi*),[5] Wolf's Bluegrass (*Poa wolfii*),[6] and Bluff Vertigo Snail (*Vertigo meramecensis*).[7] While not endangered, Canadian Yew (*Taxus Canadensis*)[8] provides a good transition between the cliff habitat and the wetlands below.

Figure 4.6

Shaded Cliff

Industrial Echoes

Grain Meadow

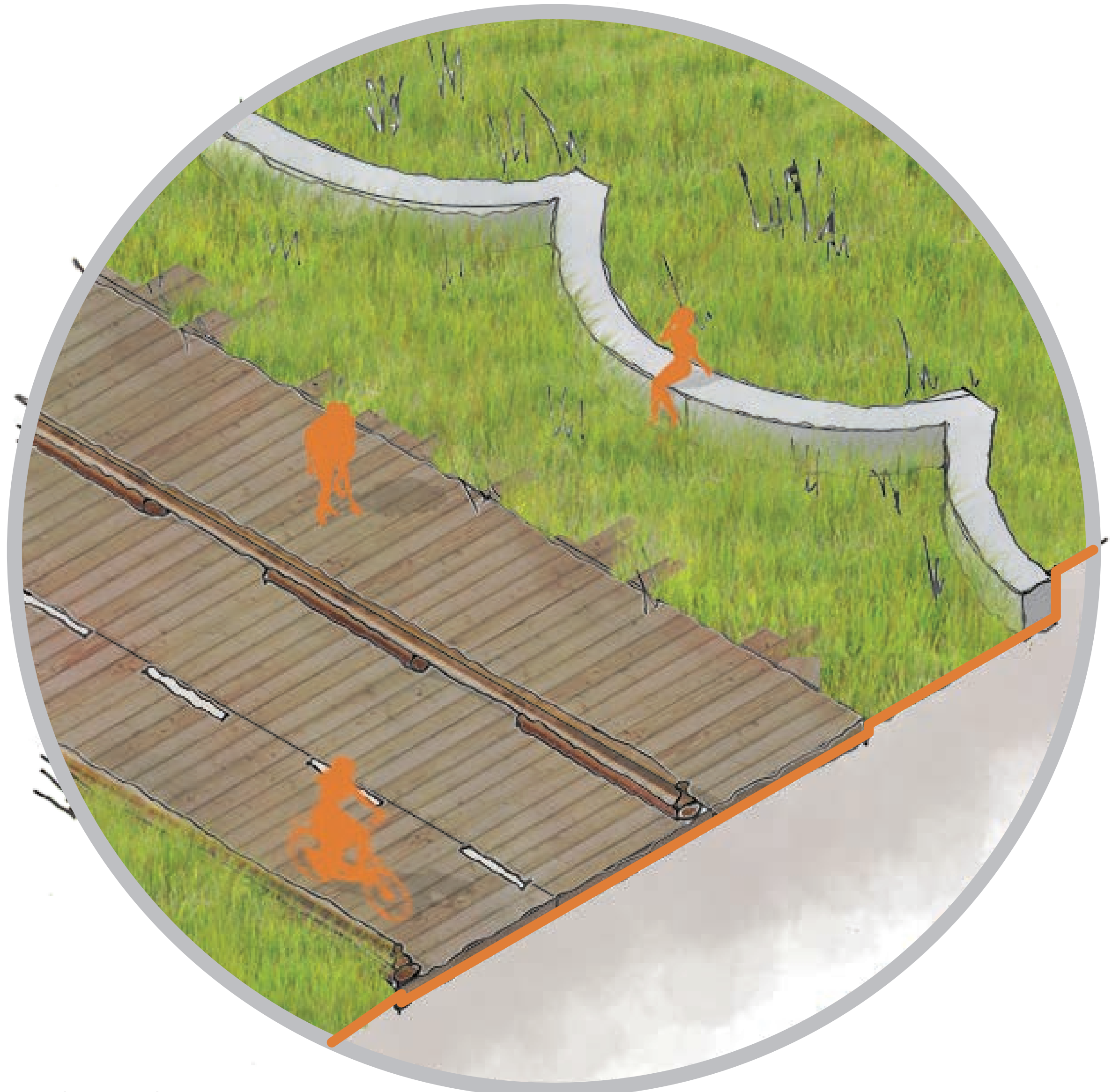
Tall grasses and grain cover portions of the open space, echoing the grain which the Chicago, Milwaukee, & St. Paul Railroad shipped through the corridor.

Existing Retaining Wall

The wall's form recalls the grain silos that stood on the site until their demolition in 2004.[9]

Boardwalk Mixing Zone

A boardwalk base and rusted rail curb form the materiality of the shared-use trail in mixing zones. This serves to both slow bike traffic at intersections and key nodes but also recalls history of the railroad trench. This treatment of shared-use trails is used in other locations in Minneapolis.



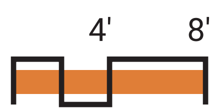


Figure 4.7

Boardwalk Mixing Zone

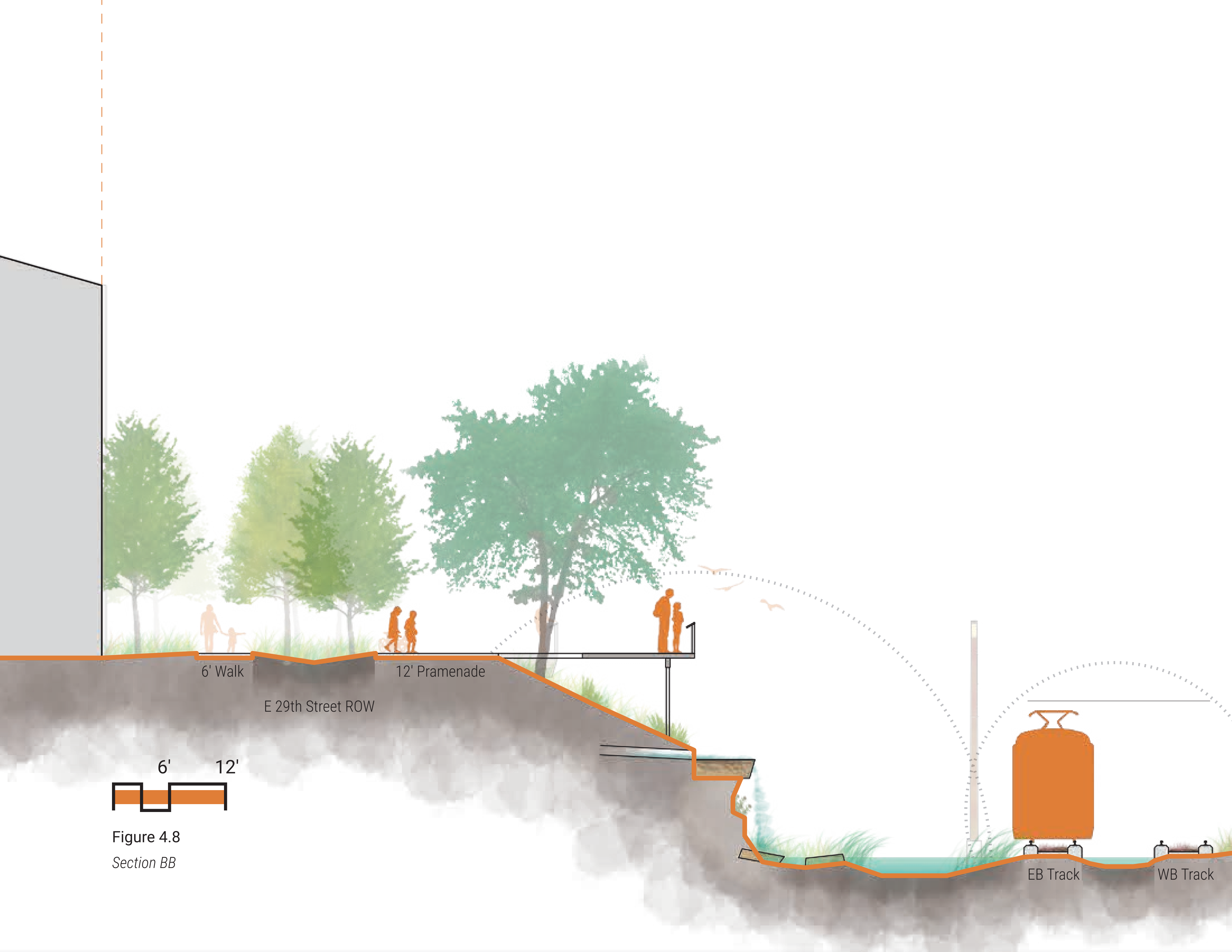


Figure 4.8

Section BB

CEPRO East | Greenway Wetlands

Here the retaining wall/cliff has reduced in height in order to daylight a stormwater outfall, celebrating the process that forms area waterfalls. Above the Greenway, E 29th Street (40’ ROW) is transformed into a pedestrian promenade with a narrow sidewalk nearer the affordable housing complex and a wider promenade along the overlook structure. This structure allows a visual connection between the city level and the Greenway level, with interpretive signage highlighting the areas industrial and ecological history as well as lessons learned from the design process.

Geologic Echoes

Stormwater Waterfall

Stormwater (and meltwater) falls over a designed waterfall that mimics the underlying geology which formed such falls as St. Anthony and Minnehaha Falls. Limestone (Platteville) overhangs a cliff of sandstone (St. Peters) with limestone splash-pads below mimicking collapsed shelves. Salt-tolerating plants surround the outfall to ensure any salt left in meltwater does not affect the wetland.

Figure 4.9
Stormwater Waterfall

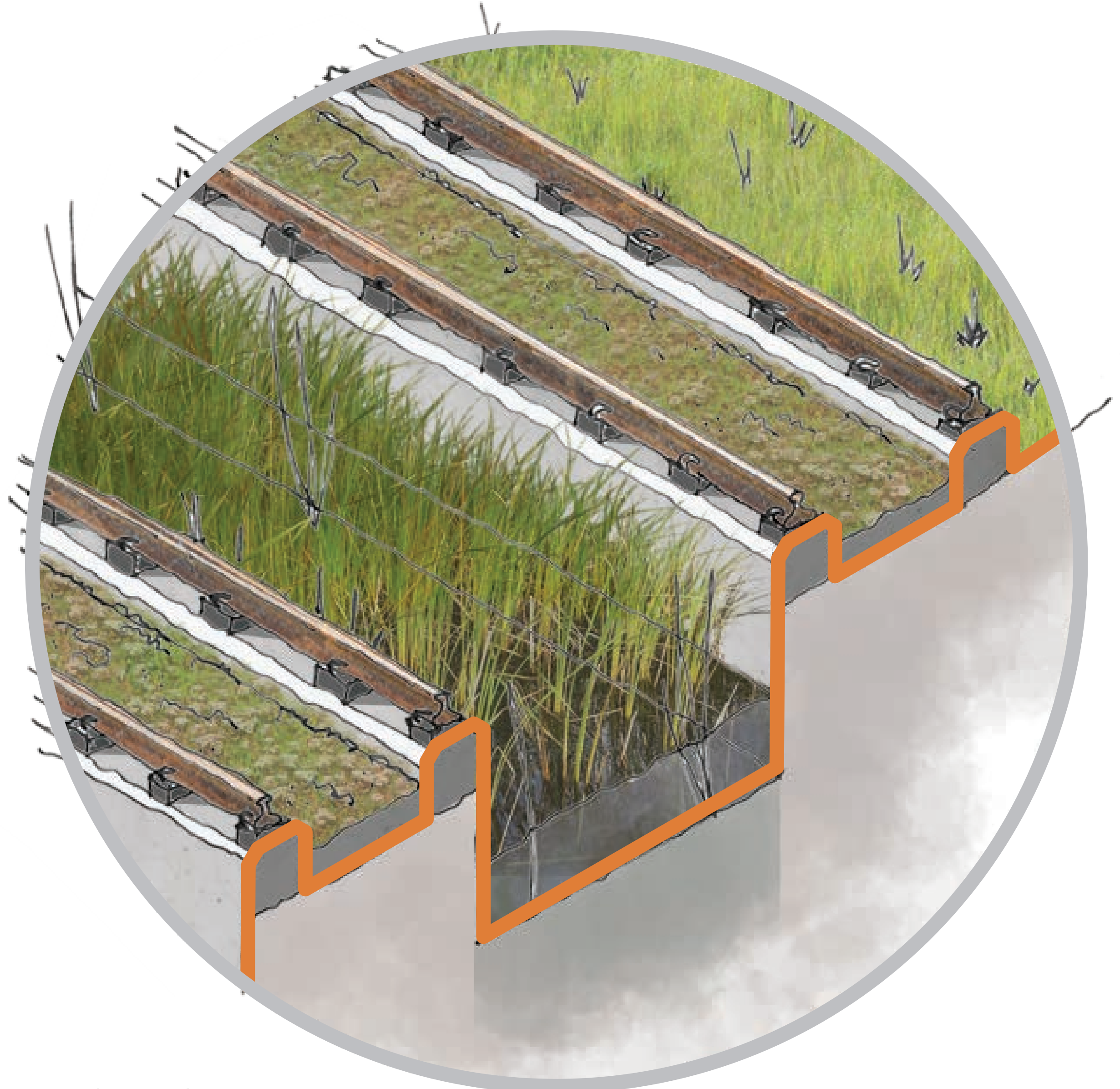
Greener Infrastructure

Eco=Guideway

A mat of drought tolerant sedum provides a carpet of green between the rails where ballast (gravel) would typically lay.

Stormwater Conveyance

The space between tracks conveys increased stormwater runoff along the corridor to a series of infiltration wetlands.



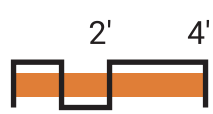


Figure 4.10

Eco-Guideway

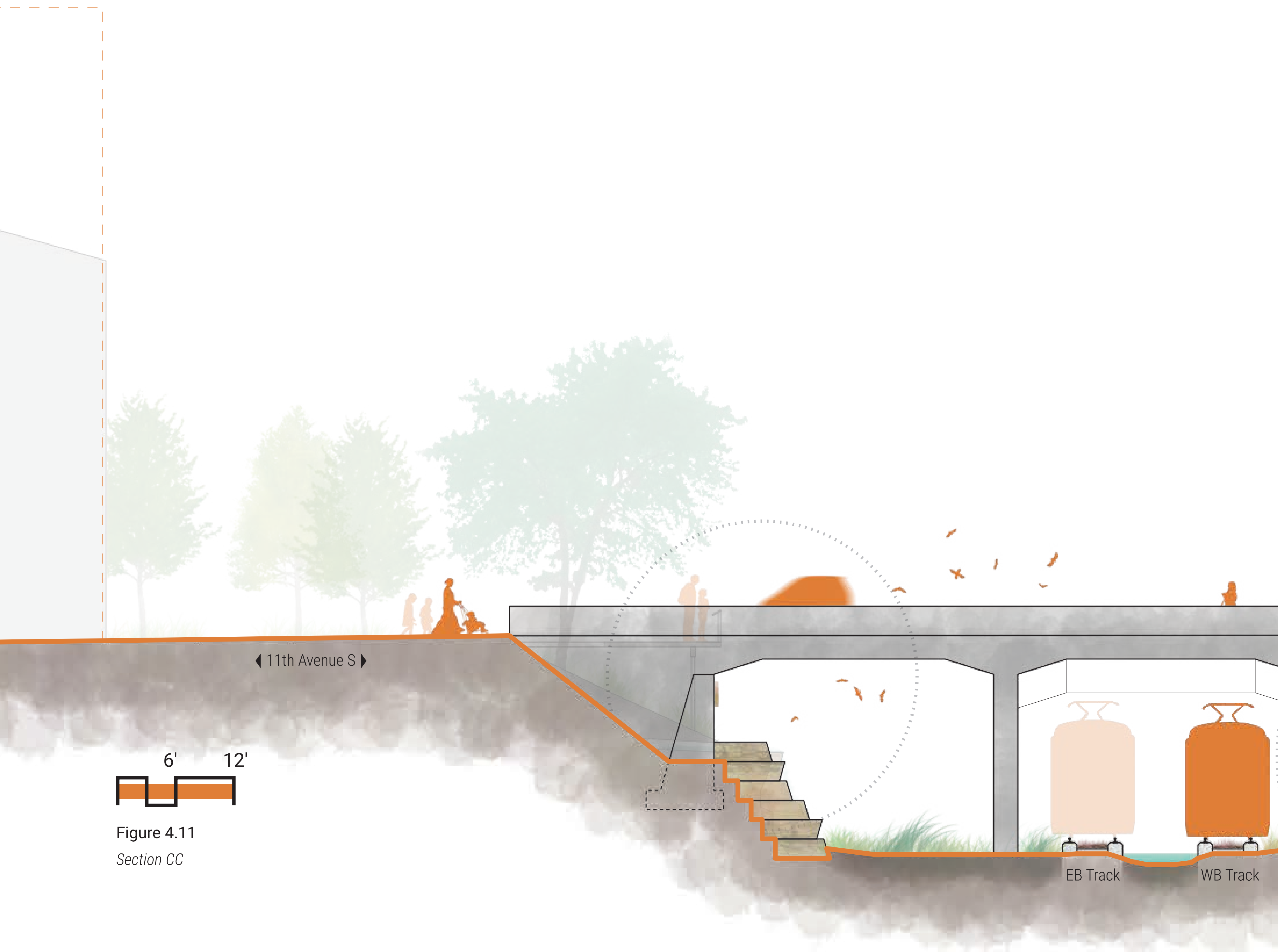
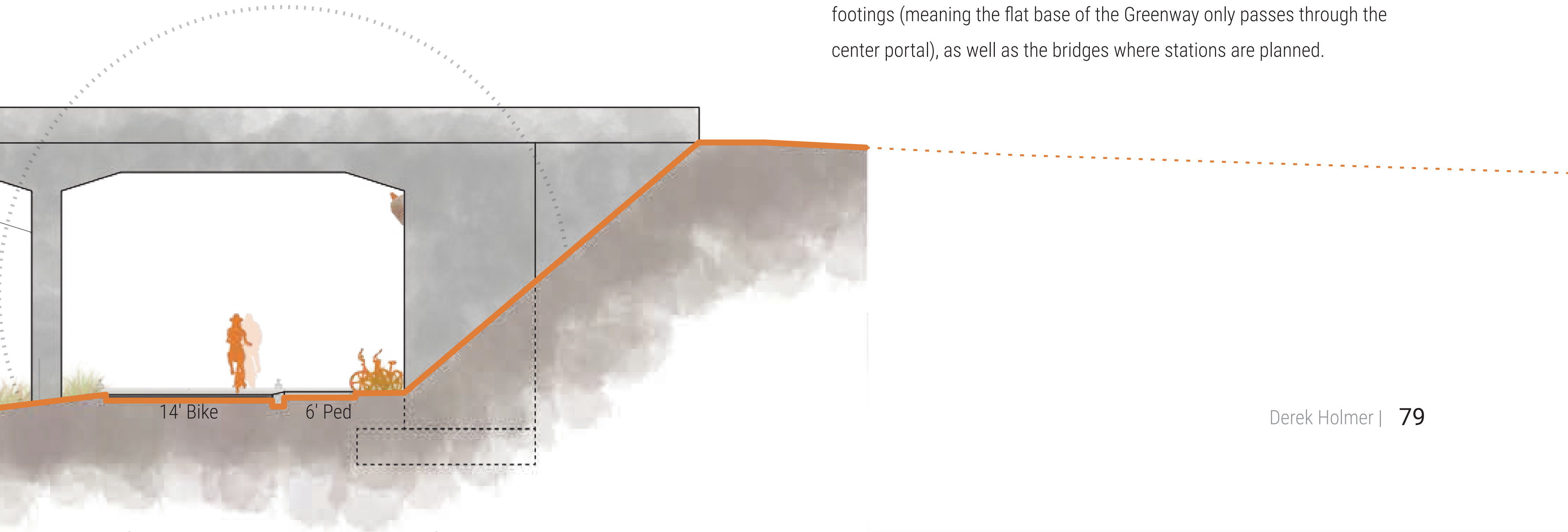


Figure 4.11

Section CC

11th Avenue S Bridge

The limiting spatial factors along the Greenway are the bridges. As a contributing element to the Chicago, Milwaukee, & St. Paul Railroad Grade Separation Historic District,[10] these bridges constrict the space available for both light rail infrastructure and the shared-use trail. Hennepin County (which owns the bridges) and the city (who maintains the streets on the bridges) are exploring options for how to repair the 100+ year old structures;[11] many of them have deteriorated to the brink of condemnation. However, this thesis assumes the bridges will remain and looks to how the transitway can be designed through the tri-portal bridges. One technical change required is the addition of pier protection. The piers must be filled with a concrete wall up to 12' to protect the bridge in case of a derailment.[12] Otherwise, this bridge section represents one of several typical bridge cross sections. Other cross sections differ due to the widths of the portals, the height of the bridge footings (meaning the flat base of the Greenway only passes through the center portal), as well as the bridges where stations are planned.



Bridge Habitat

Cliff Swallow Nests

Space under the bridge provides opportunity for Cliff Swallow nests. The sunny sides of the bridges also present opportunity for bat boxes, helping the bat population devastated by White Nose Disease as well as controlling mosquito populations.

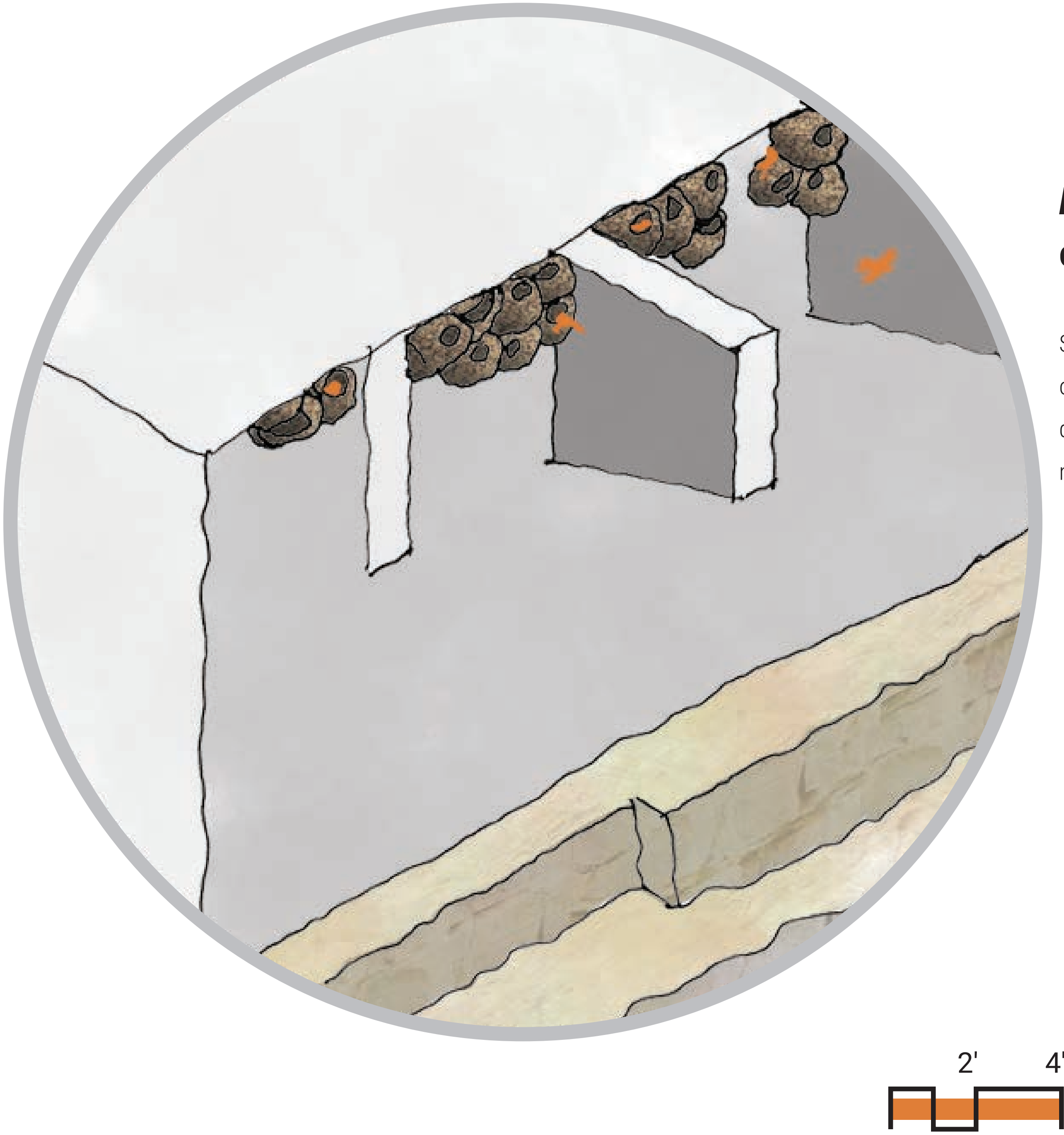


Figure 4.12

Cliff Swallow Nests

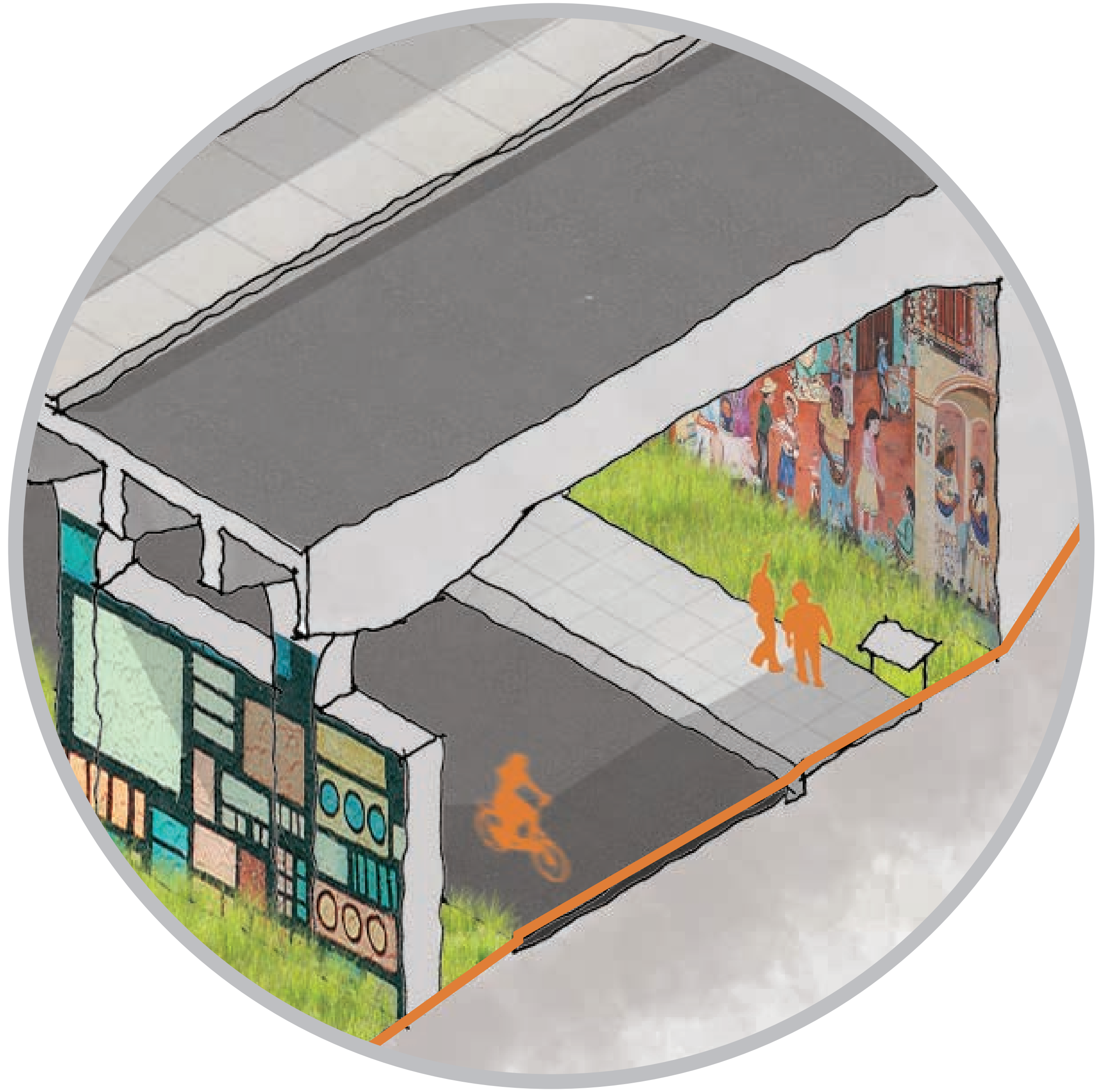
Public Art Portal

Museum in the Street

The shared-use trail portal provides space for curated community murals and museum in the street plaques, continuing the successful series along Lake Street one block south.[13]

Pier Protection Murals

Twelve feet of pier protection infill is required to reinforce the structure against a collision. This surface provides opportunity for regular murals and art viewed from a passing train.



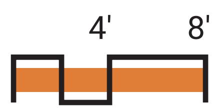


Figure 4.13

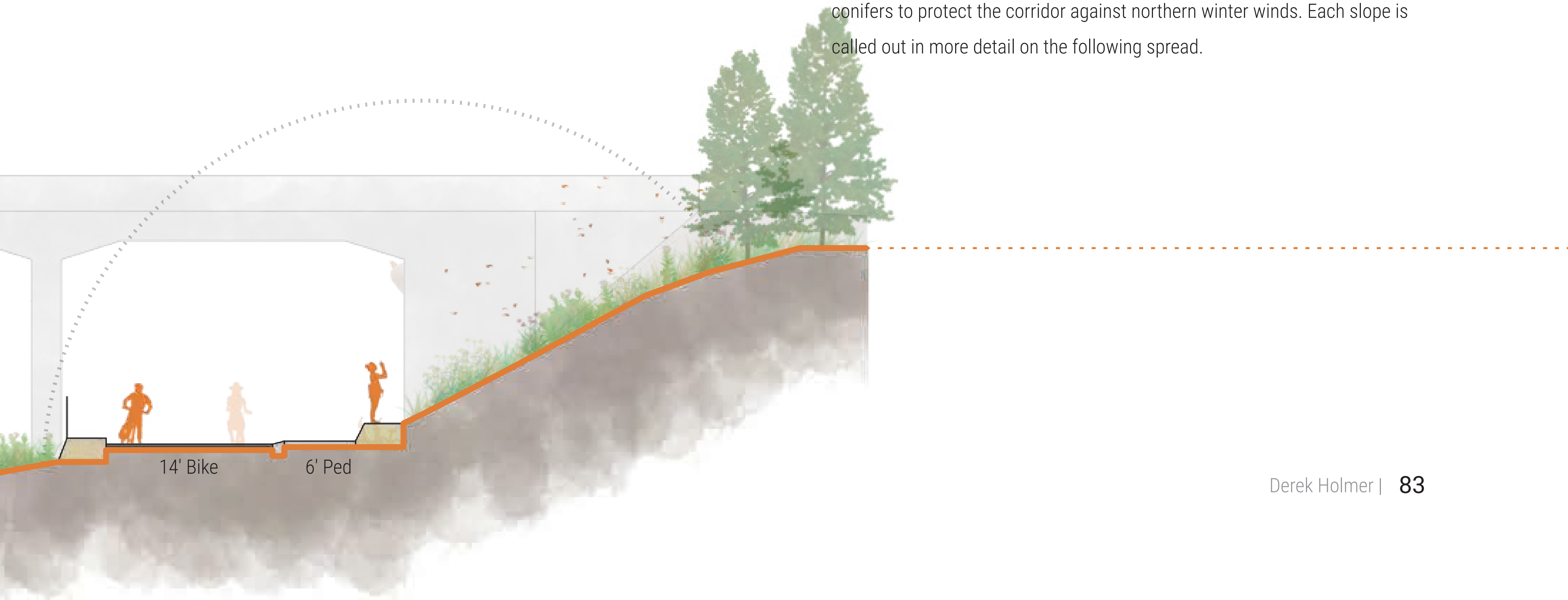
Public Art Portal

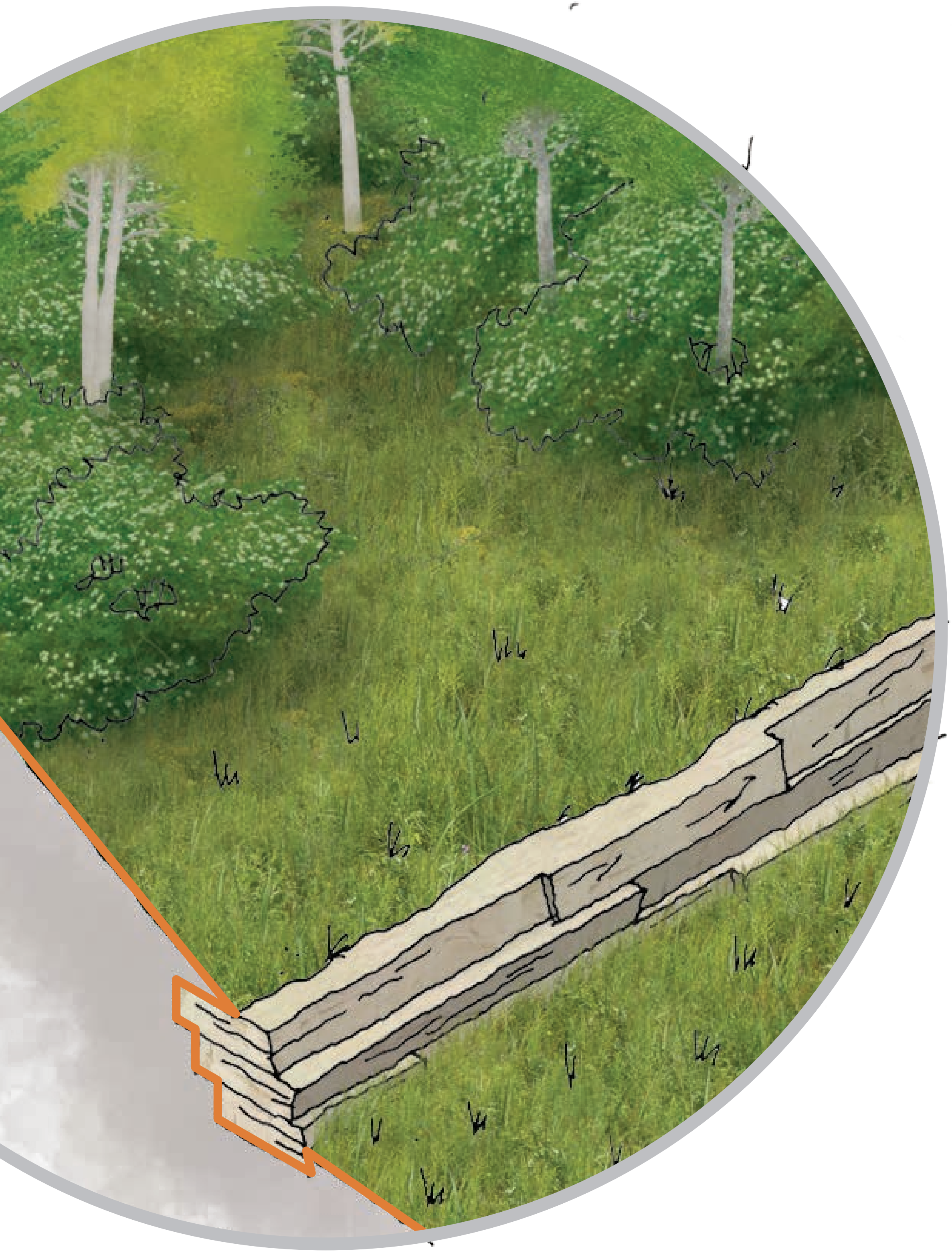
Figure 4.14

Section DD

Typical Greenway Section

This section represents the typical layout of the Greenway blocks. The typical ROW is 125-150', with an extra 40' on blocks where 29th Street parallels the Greenway. The rail passes through either the center or southern portal (depending on the slopes) while the shared-use trail passes through the northern portal. Limestone retaining walls of varying height allow space and separation between the light rail guideway and the shared-use trail. Due to the varying conditions along either slope, stormwater conveyance is limited to the space between tracks allowing a consistent bioswale along the corridor. Vegetation contrasts between the south and north slopes. The southern slope consists of thicker, deciduous vegetation that allows winter sun to reach the trail. The northern slope is planted as a prairie topped with conifers to protect the corridor against northern winter winds. Each slope is called out in more detail on the following spread.





Southern Greenway Slope

Upland Forest Groves

The shaded southern slope consists of deciduous upland forests found throughout Minnesota. In this instance, an Aspen grove consists of a canopy of Quaking Aspen (*Populus tremuloides*) and Paper Birch (*Betula papyrifera*) while an understory of Red Twig Dogwood (*Cornus sericea*) provides spring flowers and winter color. Other deciduous upland forests in Minnesota include Hardwood and Oak forests.[14]

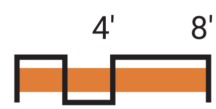


Figure 4.15

Aspen Grove

Northern Greenway Slope

Wildflower Meadow

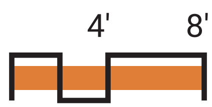
The sunnier and drier north slope is covered in wildflowers and dry prairie grasses that provide a variety of colors and texture throughout the growing season. These include Narrow-Leafed Purple Coneflower (*Echinacea angustigolia*), Black-Eyed Susan (Rudbeckia hirta var. pulcherrima), and Silky Aster (*Symphyotrichum sericeum*).[15]

Shared-Use Trail

Outside of mixing zones, the trail is a 14’ asphalt bike path and a 6’ pedestrian path separated by a 3” mountable curb. All drainage is provided through openings in the limestone curb into wetlands along the Greenway.

Pollinator Corridor

Including pollinator friendly plants, such as the Common and Swamp varieties of Milkweed (*Asclepias syriaca & A. incarnata*), in the prairies along the Greenway ensures a continuous pathway to draw butterflies, bees, and other pollinators along the corridor.[16]



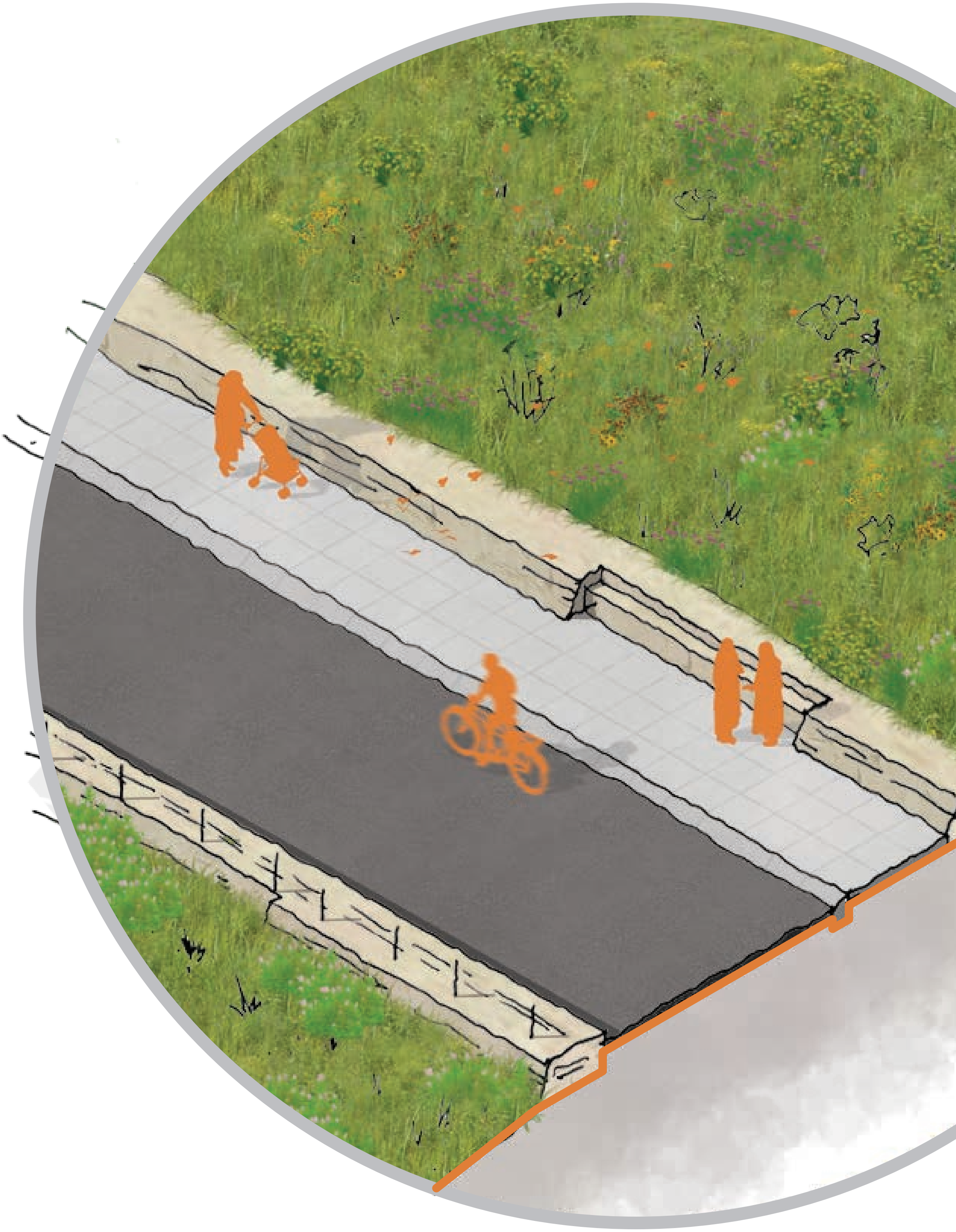
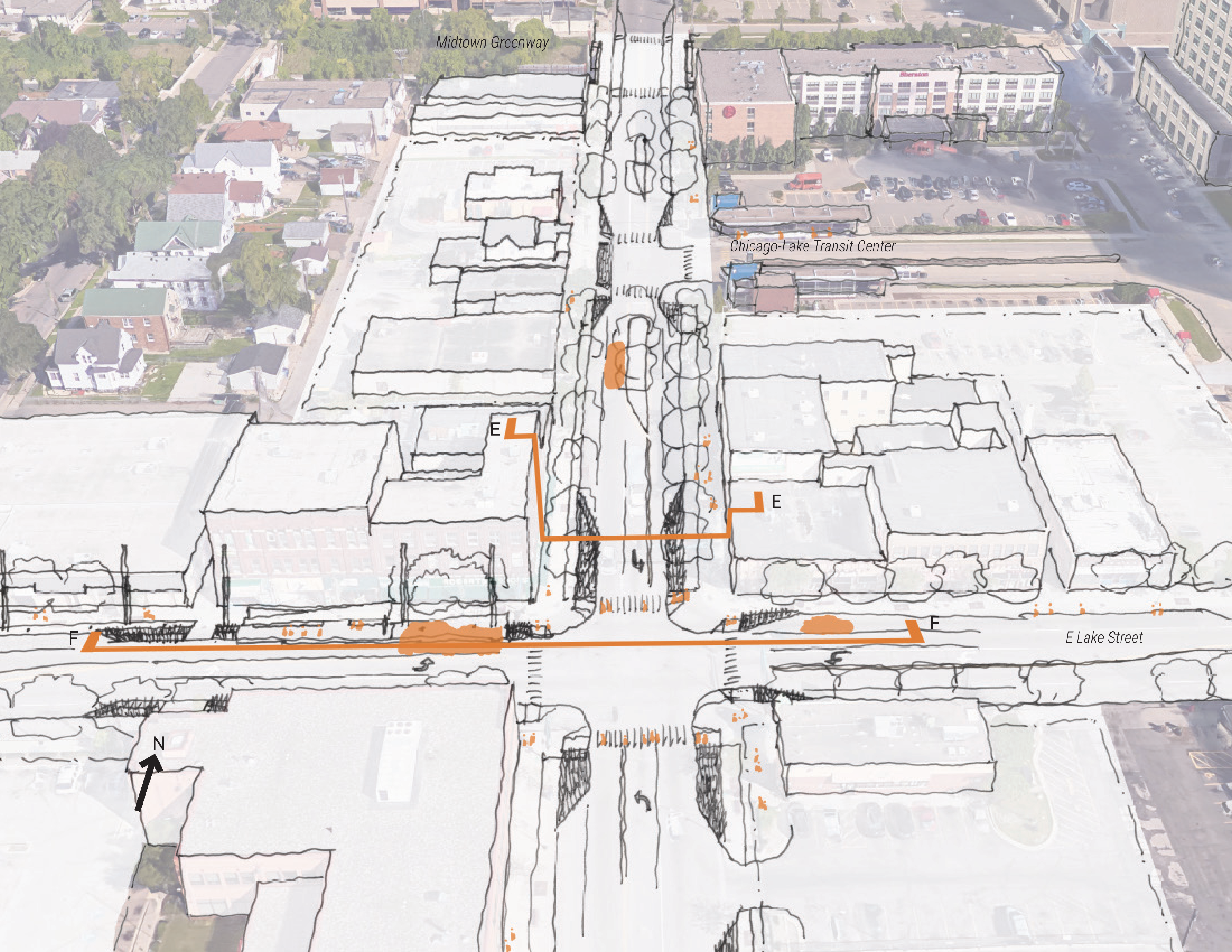


Figure 4.16

Shared-Use Trail and Prairie


Midtown Greenway
Chicago-Lake Transit Center
E
E
F
F
E Lake Street
N

Chicago Avenue & Lake Street

This major commercial node represents one of the most urban nodes along the Midtown Corridor. As a major commercial arterial, Lake Street forms nodes where it intersects all major north-south corridors. Many of these intersections must accommodate high numbers of pedestrians, transit vehicles, private vehicles, and—in some locations—bicycles. The intersection of Chicago Avenue South and East Lake Street provides the opportunity to leverage public space for all these users as well as enhancing the ecological function of the street. Along the entire corridor, an intersections such as this will see a drastic increase in the urban heat island affect during summers.

Figure 4.17

Chicago Avenue South and East Lake Street, Look North

Chicago Av S
FOR SALE
FOR SALE
PHONE REPAIR SPECIALISTS
Galaxy

Figure 4.18 [left]

Intersection of Chicago Avenue and Lake Street

Figure 4.19 [above]

Chicago Avenue north of Lake Street, Looking North

**As a testament to the concept of urban succession, the buildings shown at the corner of Chicago and Lake burned down during the final week of this project. These brick buildings were the final original structures at this intersection. The future of this node will very much depend on what is built on this lot.*

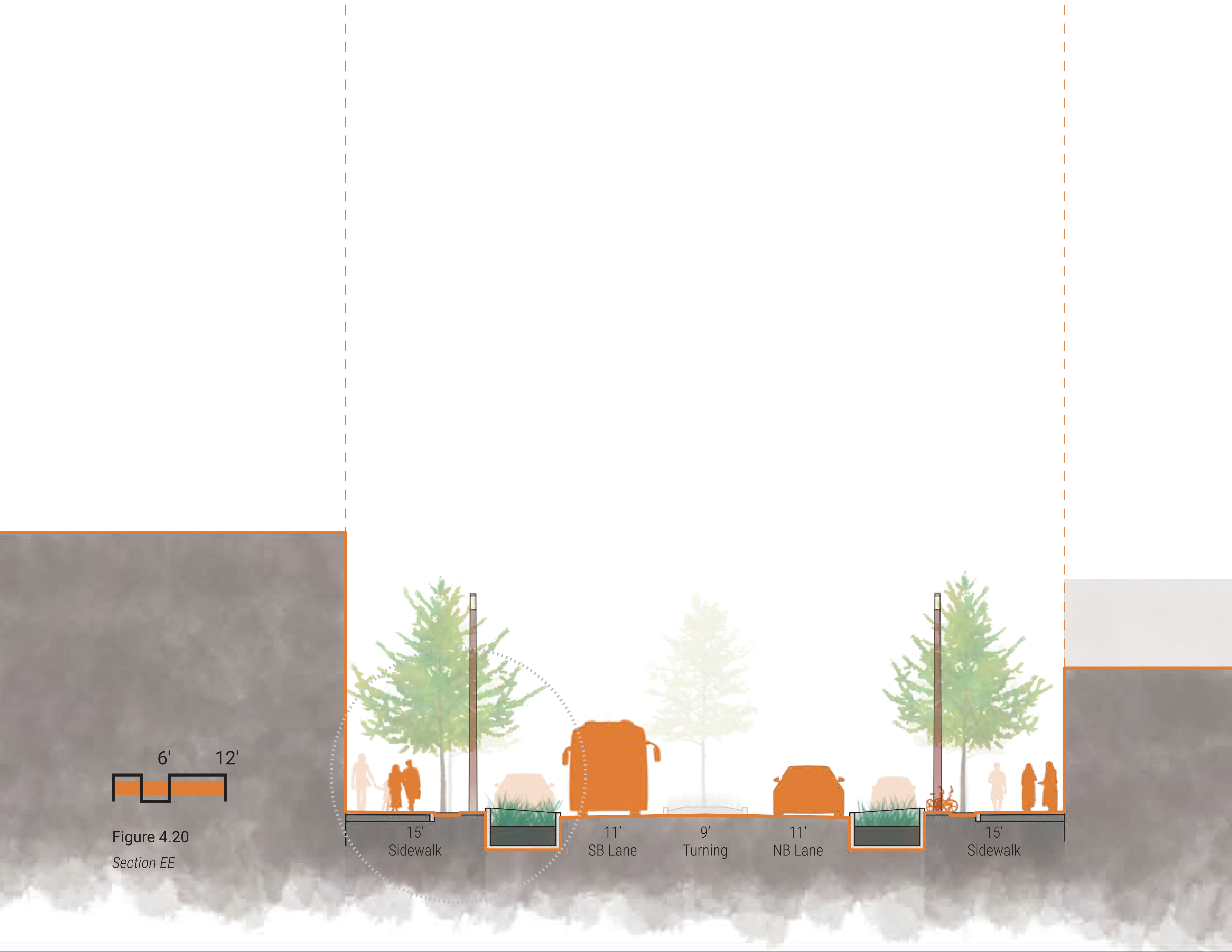
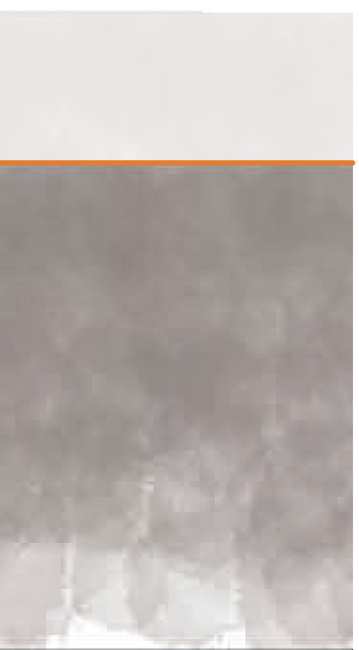


Figure 4.20

Section EE

Chicago Avenue Cross-Section

Chicago Avenue is a typical minor arterial in Minneapolis. Traffic counts are below 10,000 ADT[17] and the street functions with a 3-lane configuration. The street carries one of the region's busiest bus routes (Metro Transit Route 5) and is planned for an arterial Bus Rapid Transit (aBRT) upgrade with the D-Line.[18] In the Midtown Corridor, Chicago Avenue S has a ROW of 77'. Two 11' traffic lanes and a 9' turning lane make the width of the street 31'. Two 8' parking lanes become stormwater cells at intersections and crosswalks, with the remaining space (15' on either side) devoted to a wide sidewalk. The built environment of Chicago Avenue is currently inconsistent, including street frontage of 1-2 stories and other spaces with drive-throughs and parking lots fronting the street. The Minneapolis 2040 Comprehensive Plan calls for this area to be zoned for development up to 10 stories on small to medium-sized lots.[19]



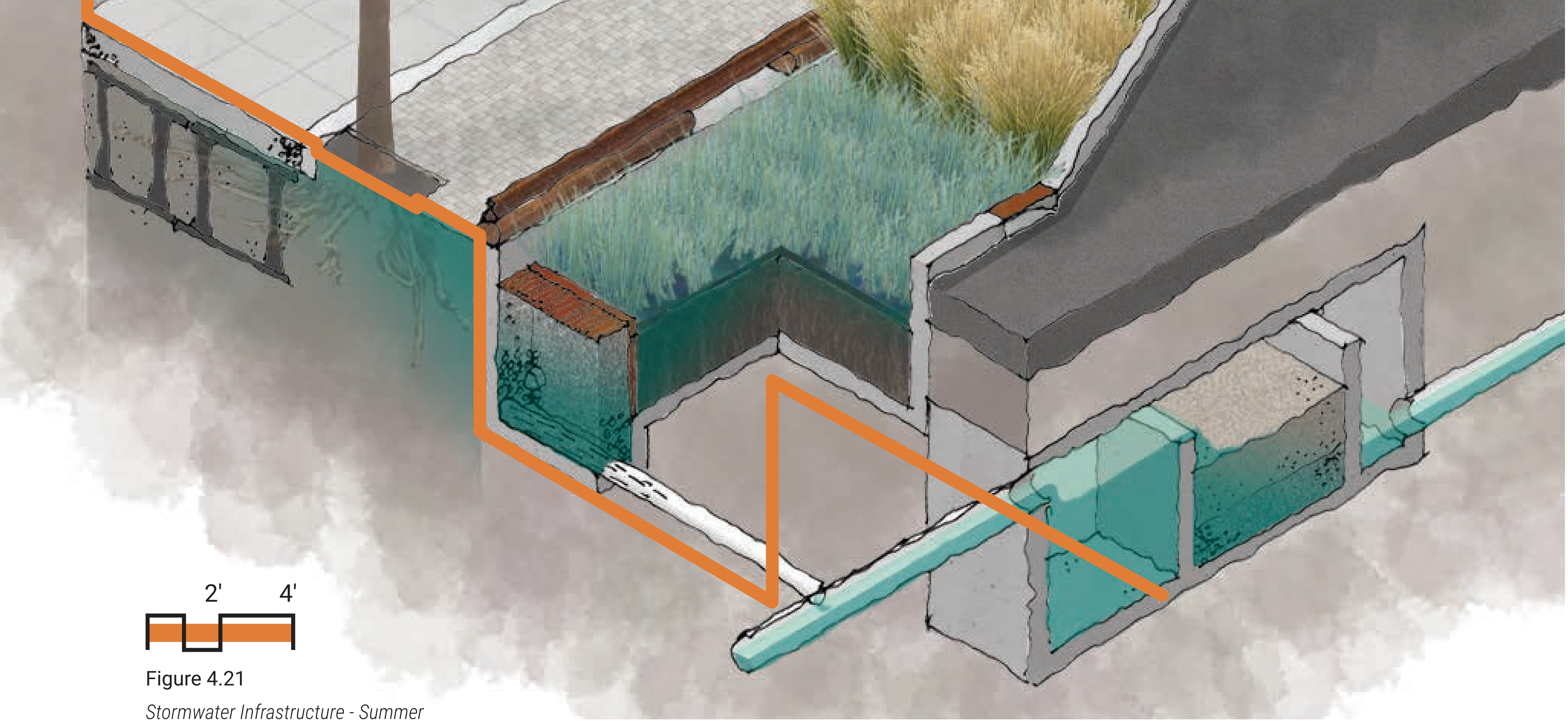


Figure 4.21
Stormwater Infrastructure - Summer

Stormwater Infrastructure

Summer Storm Runoff

Summer runoff is not polluted by salt. Thus, stormwater best management practices (BMPs) can be used to treat and infiltrate this water.[20] Runoff from the road and sidewalk enters the biofiltration cell through curb cuts. Grasses and biofiltration soils filter the water as it infiltrates into an underdrain. This underdrain carries the water into an underground system collecting the runoff from all biofiltration cells along the street. This water enters a sand filter where it is further treated through increasingly small aggregate. From here, the treated water runs toward the Greenway where it daylights into the stormwater waterfall highlighted in section BB. Once in the Greenway, the water is allowed to infiltrate. This helps reduce peak runoff flows into receiving water bodies and also filters out pollutants from major roads.

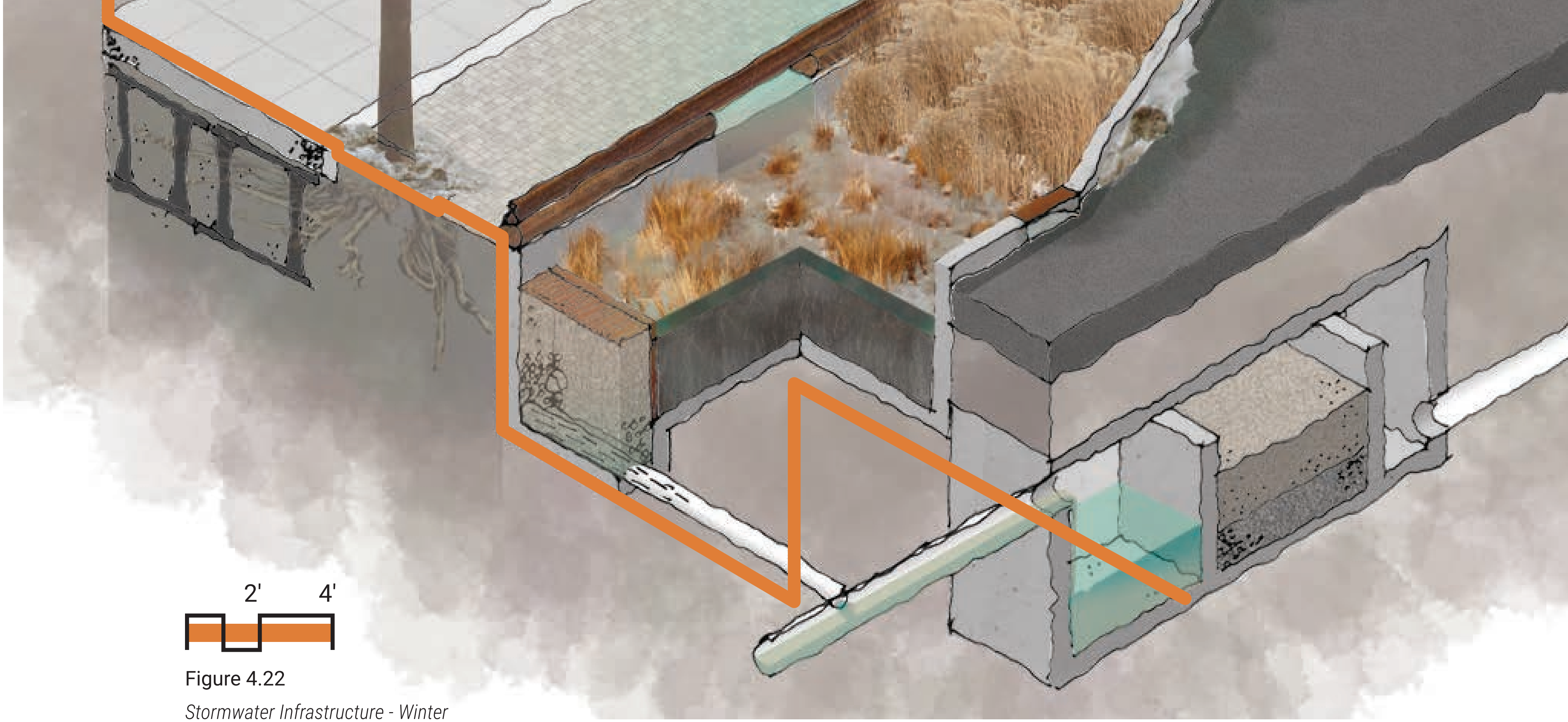


Figure 4.22

Stormwater Infrastructure - Winter

Winter Snowmelt

On arterial streets, snowmelt is heavily polluted with salt. This chloride pollution greatly affects groundwater and soil structure, thus cannot be infiltrated until after treatment. However, BMPs are ineffective in winter due to frozen soil conditions, dormant grasses, and dead organic matter.[21] Thus, the stormwater cell contains a final weir over which polluted runoff can overflow into aggregate to begin the filtration process. This water is then transported via underdrain into the same system under the street. The first chamber of the sand filter serves as a massive reservoir, holding the hyper-polluted first flush. Here, the chloride will be diluted by a second flush of fresher runoff before entering the aggregate and ultimately into the Greenway wetland system. Salt tolerant grasses nearest the outfall provide a final filtration before the meltwater is allowed to infiltrate.

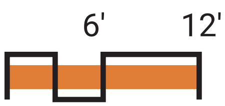
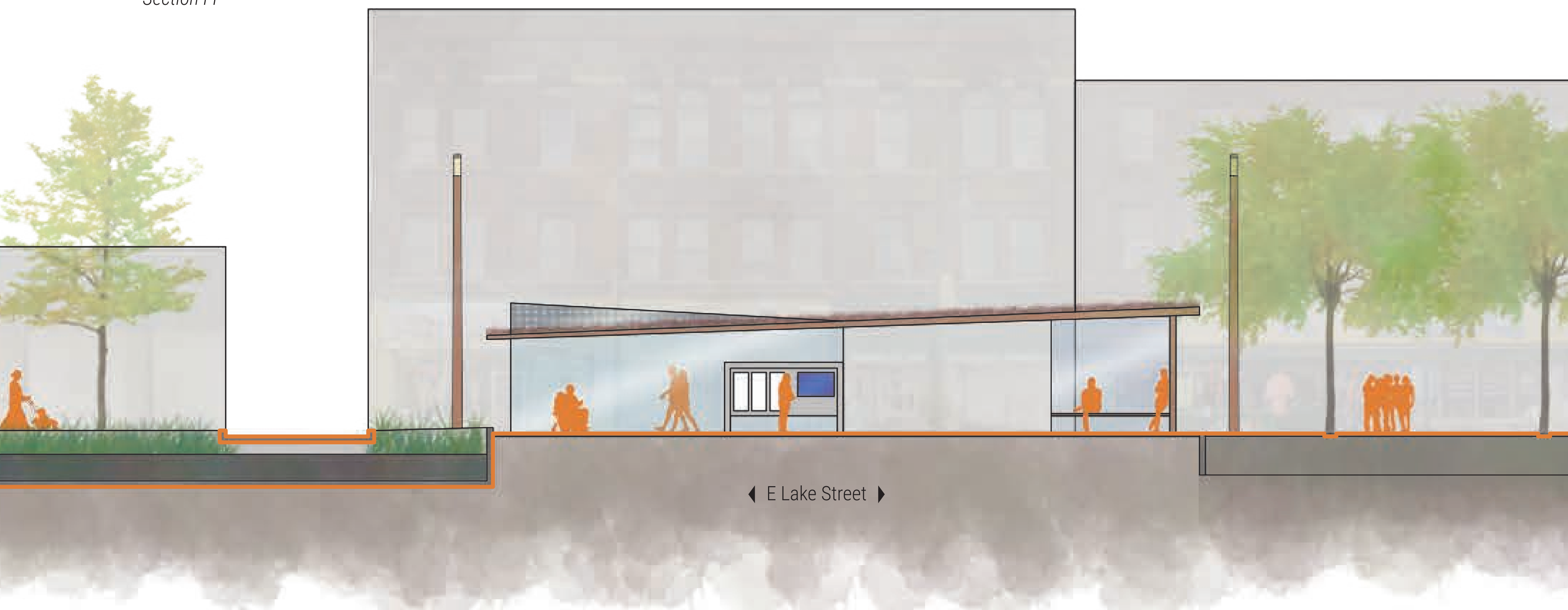


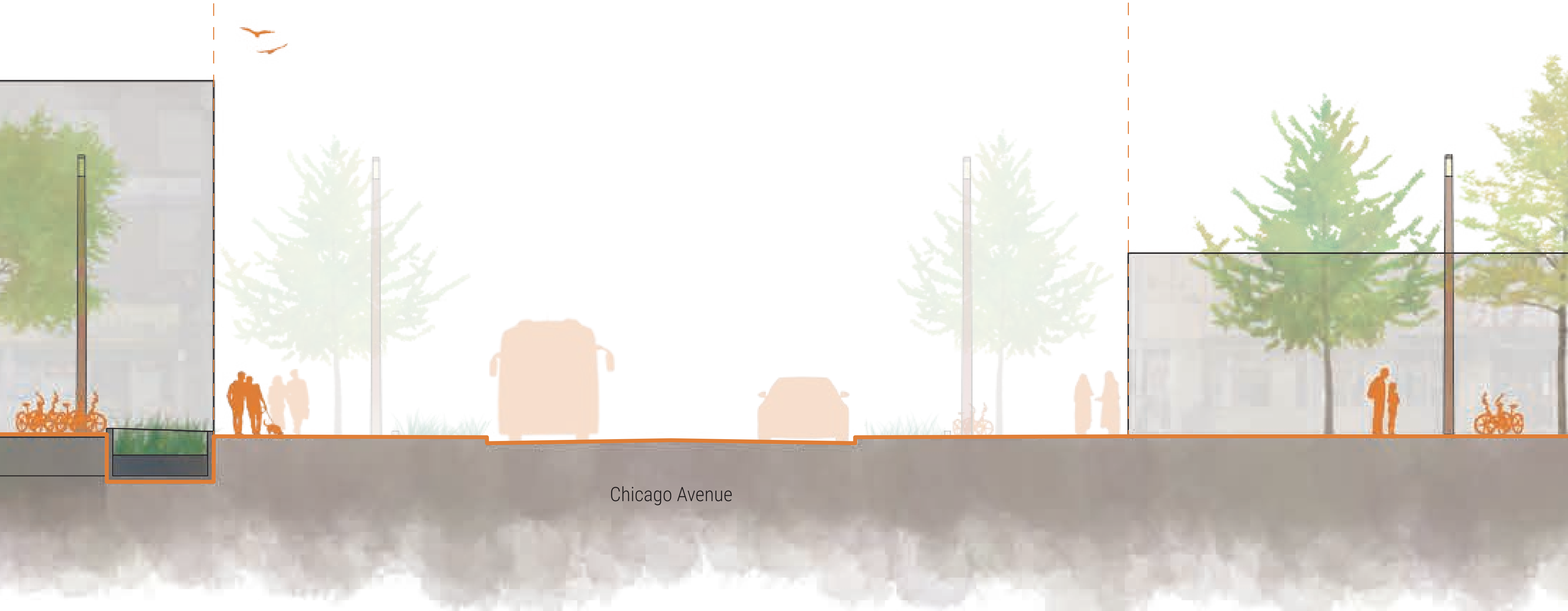
Figure 4.23

Section FF



Chicago Ave & Lake Street Station

Where Chicago meets Lake is a major node. Two aBRT lines, a light rail station one block north, a former streetcar node, the Midtown Exchange, and the many cultures of Midtown converge at this point. Public space is at a premium and the current 9-10’ sidewalks are insufficient. The hardscape also prevents any stormwater treatment and presents a hardened edge to the community. By increasing the amount of public space along the sidewalk, there are opportunities to soften the landscape, recalling the ecological processes that are occurring just one block north along the Greenway.



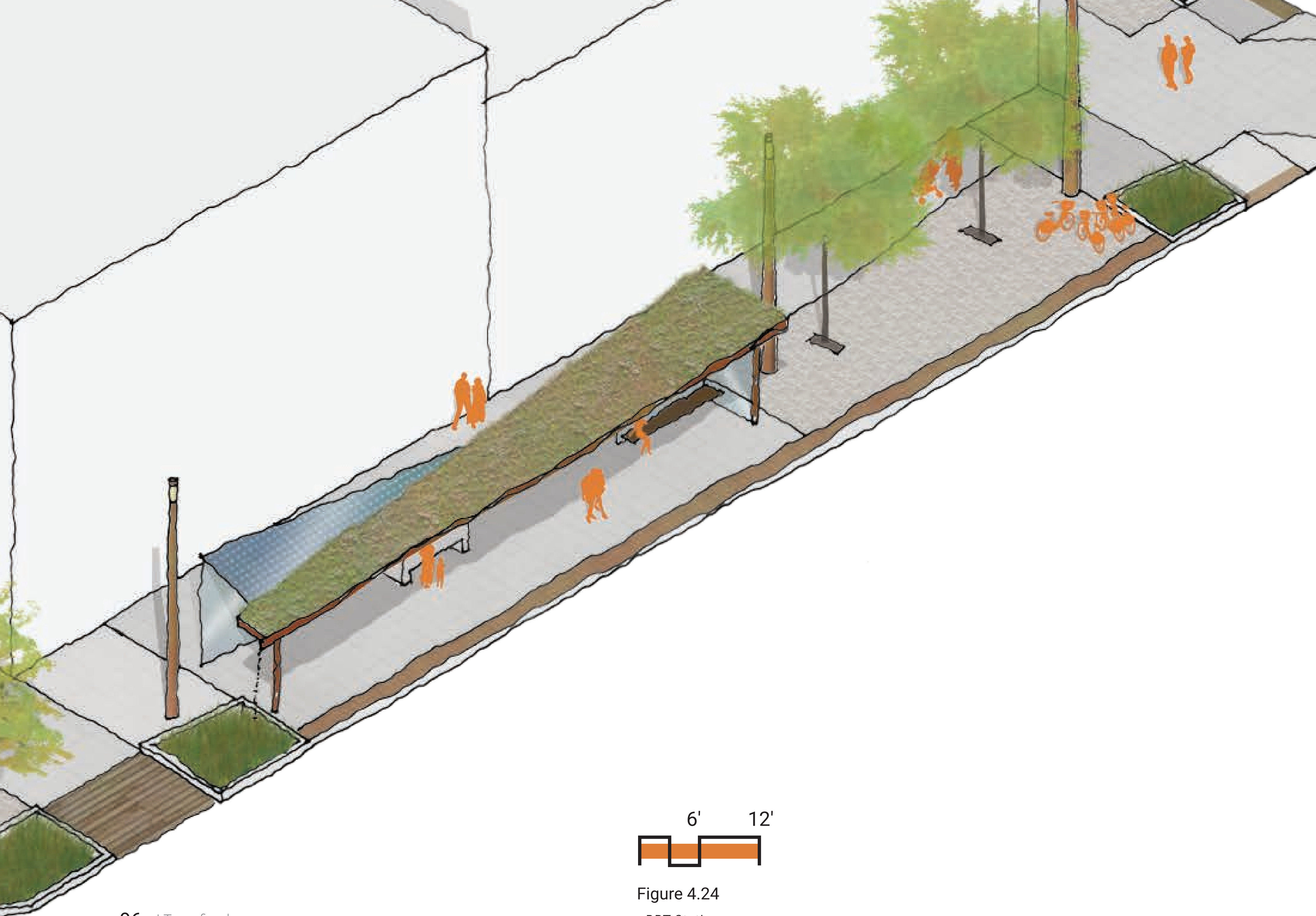


Figure 4.24

aBRT Station

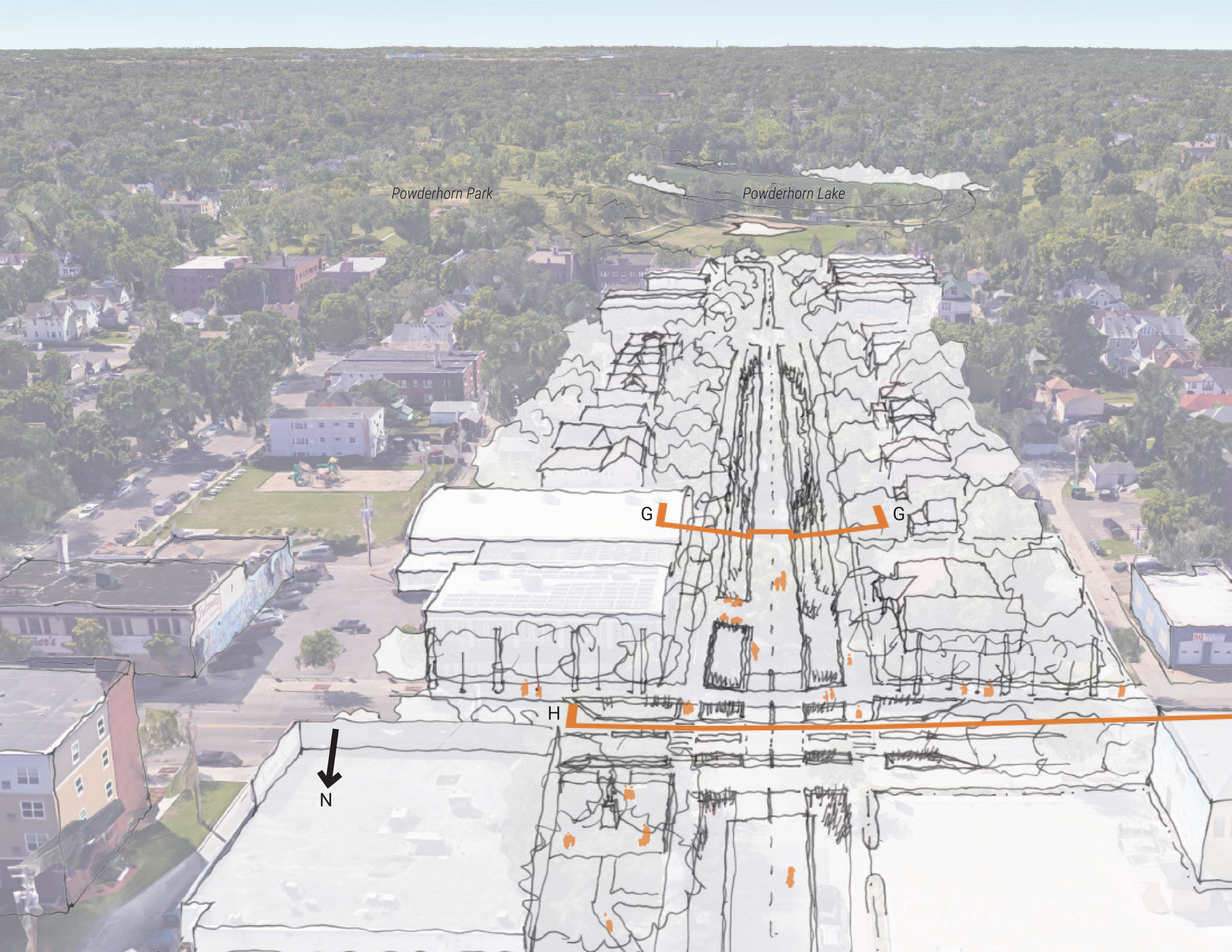
Bus Rapid Transit Station

Salt Tolerant Trees

Street trees along Chicago Avenue and Lake Street are tolerant of salt spray and other urban stresses. They are also among those listed on stormwater BMPs in cold weather climates.[22] These include Thornless Honey Locust (*Gleditsia triacanthos* var. *inermis*) and Ginkgo (*Ginkgo biloba*) trees.

Bus Station

Each bus station presents an opportunity for placemaking along the corridor. Photovoltaic panels embedded in glass and a green roof adorn the shelter, ensuring they are net-zero and distinguishing them from other corridors. The shade provided by the canopy provide a cool respite from the increased summer temperatures.



Powderhorn Park
Powderhorn Lake
G
G
H
N

Figure 4.25

12th Avenue South and East Lake Street, Looking South

12th Avenue & Lake Street

In addition to arterial bike lanes, Minneapolis is crisscrossed by a series of low-stress bicycle boulevards. These low-traffic, residential streets allow a safer ride for bicyclists to cross the city. 12th Avenue South in Midtown is reimagined as a bike boulevard (referred to here as a bikeway) with special attention paid to where this low-stress bike route crosses the relatively stressful Lake Street. The route is envisioned as connecting both bicyclists, pedestrians, and stormwater to Powderhorn Park, three blocks south of Lake Street.


HENNEPIN • POWDERHORN • PARTNERS
1201 E. Lake Street
FOR LEASE
12th Ave S

Figure 4.26 [left]

12th Avenue at Lake Street, Looking South

Figure 4.27 [above]

Powderhorn Park from 12th Avenue, Looking South

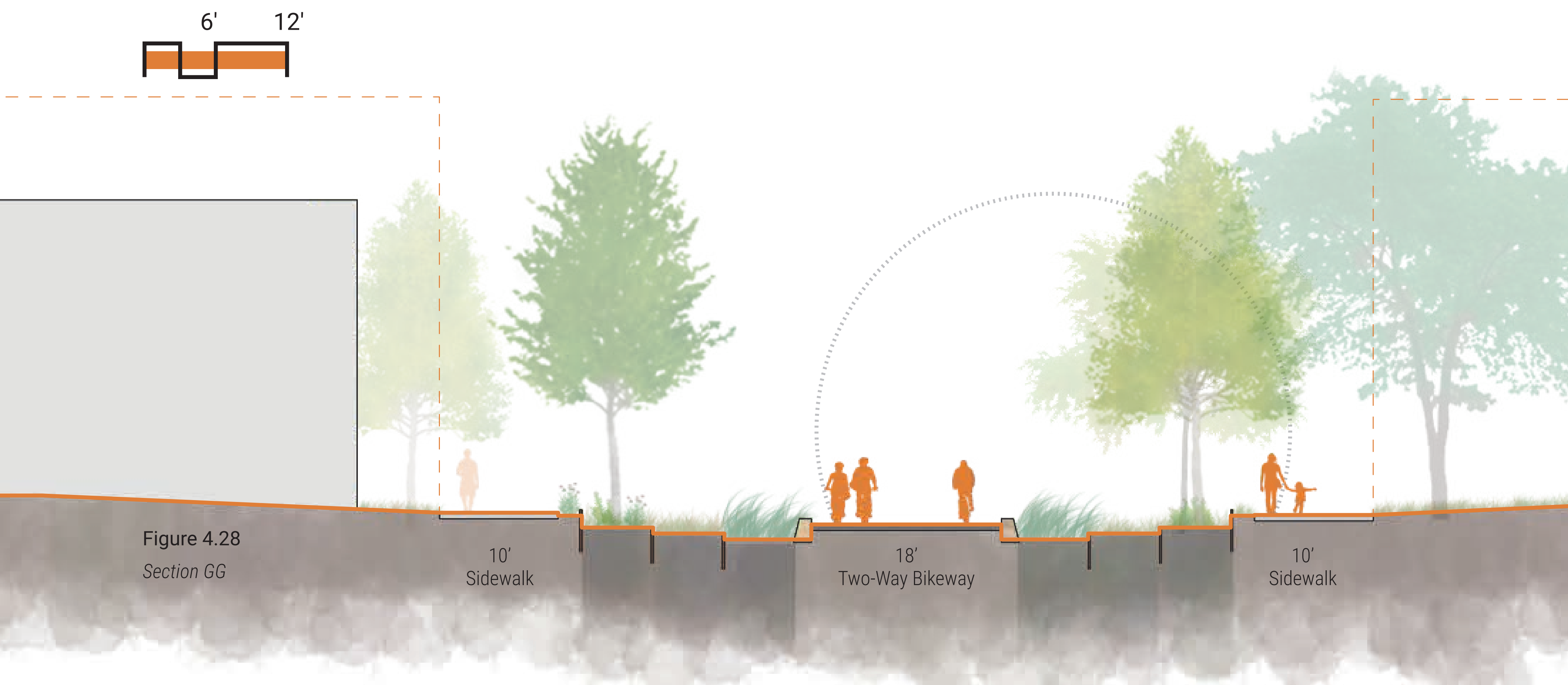


Figure 4.28

Section GG

12th Avenue Bikeway

This stretch of the Midtown Corridor is lacking in north-south bike facilities. Between the Park and Portland Avenue Protected Lanes and the 17th Avenue Bike Boulevard there are 12 blocks, 3/4 of a mile without a safe, dedicated bicycle facility. As a residential street that connects to Powderhorn Park in the south and extends north beyond the Greenway, 12th Avenue is designed as a dedicated bikeway. This street also passes a low spot in the corridor, where flooding risks are higher due to topography and increased extreme precipitation events. In mapping the flood risk, this area mimics a prairie pothole lake, but created by the urban street grid. Strategies of filtration and infiltration are translated from pothole lakes into the urban setting. Synergies are reinforced between a low-stress bike facility and a softening of the urban landscape to act as a pothole wetland system.

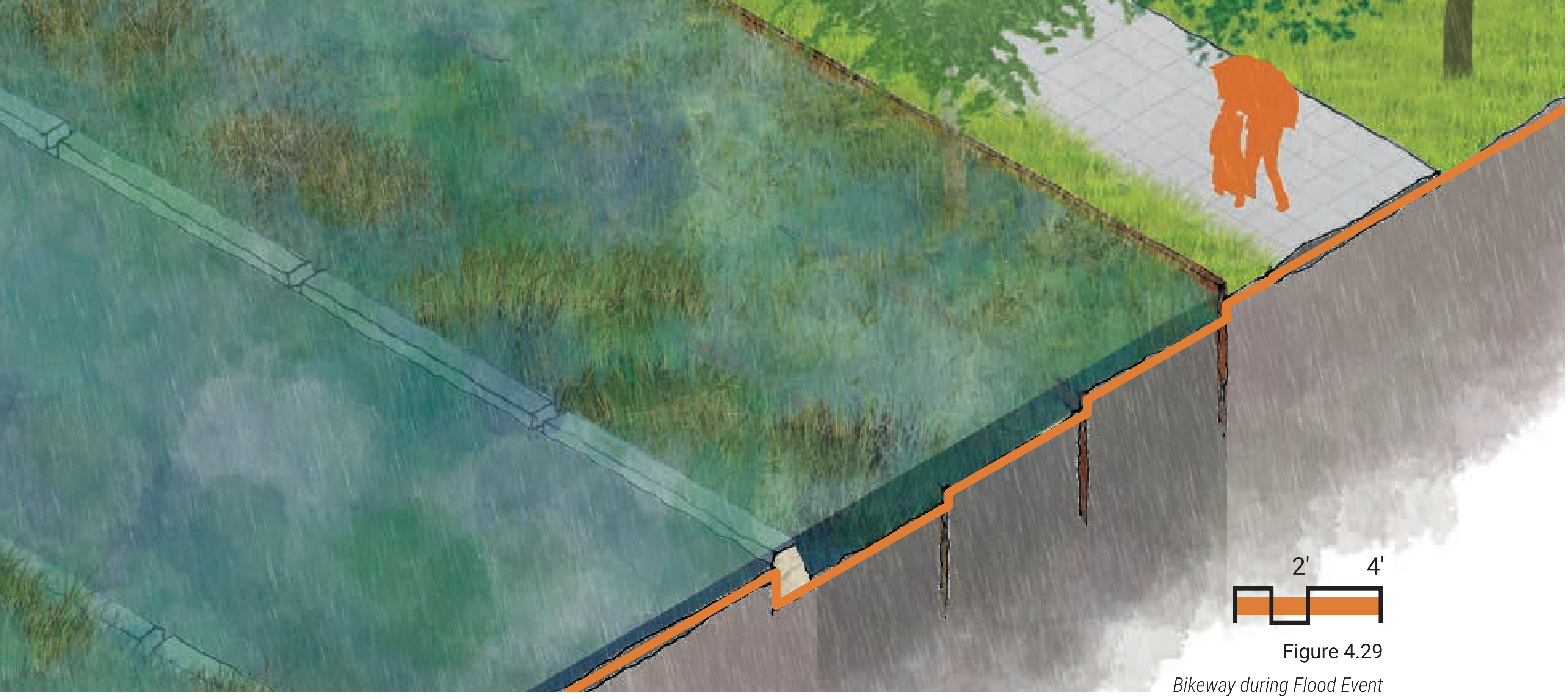


Figure 4.29
Bikeway during Flood Event

Bikeway Wetland

Extreme Flood Event

Similar to a prairie pothole, 12th Avenue is a low point in an otherwise flat corridor. This bikeway takes design cues from a prairie wetland system in which different levels of plant communities develop based on the number of days each level is inundated. In extreme storm events, the bikeway takes runoff from Lake Street, absorbing or transporting flood waters to Powderhorn Park. The entire bikeway can flood, protecting neighboring properties and pedestrian paths.

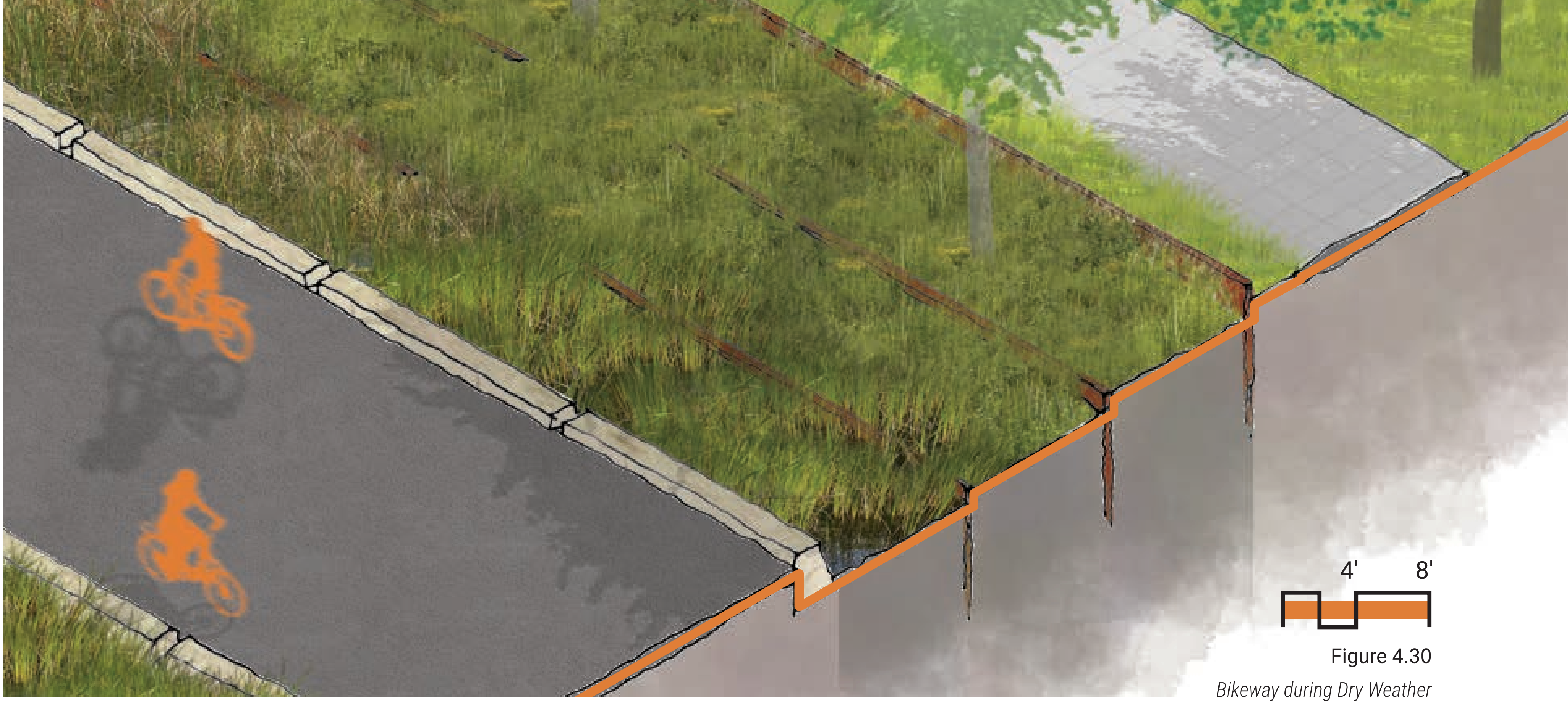


Figure 4.30

Bikeway during Dry Weather

Dry Day

Represented in this design are plant communities typically in wetlands of Minnesota and Wisconsin. The lowest level represents the shallow marsh typically inundated up to 6”. Next is the wet meadow, where the soil is typically wet, but inundation only occurs with heavy precipitation. Finally is the seasonally saturated basin, where inundation occurs only seasonally during the spring snowmelt or the most extreme flood event.[23] Because side streets receive far less salt in winter, this fresh water can be infiltrated on site.

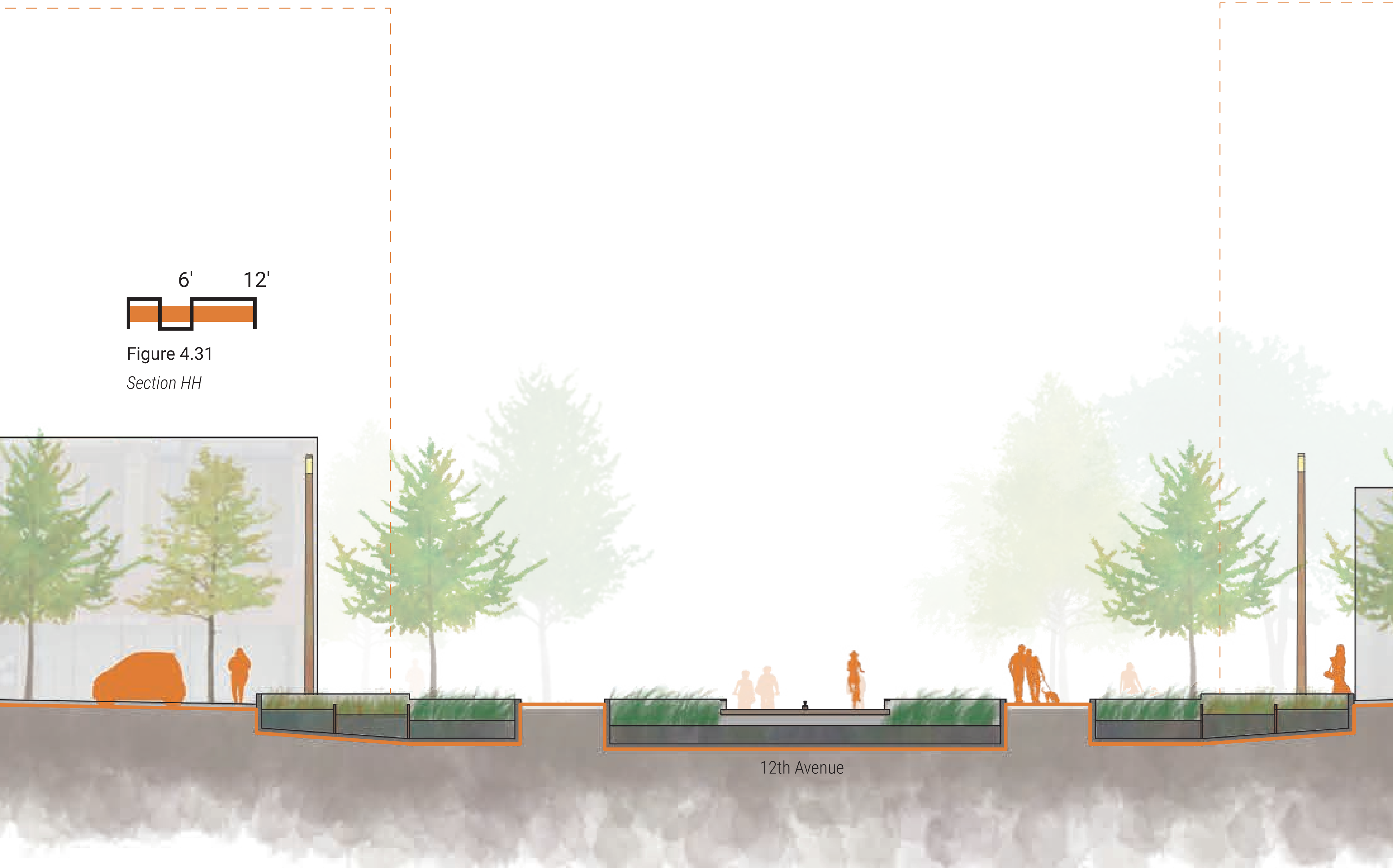
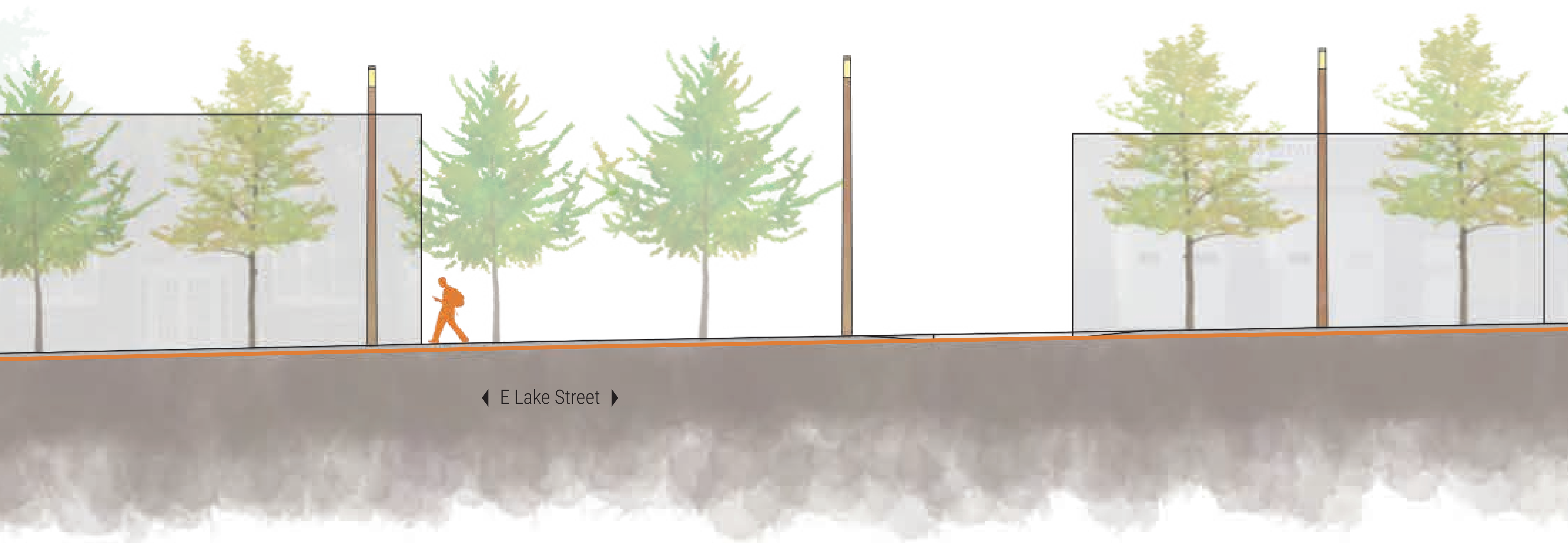


Figure 4.31

Section HH

12th Avenue & Lake Street

Special attention is paid to where the 12th Avenue Bikeway crosses Lake Street. Stormwater cells reduce the length of the crossing and boardwalks with rail curbs provide space for bikes to cross the stormwater cells while preventing vehicles from turning onto 12th Avenue S. Wide sidewalks anticipate the change in zoning of 2-6 stories as laid out in the Minneapolis 2040 Comprehensive Plan.



12th Avenue Bikeway

Placemaking

The material pallet ties this intersection together with the corridor; but the application of the materiality distinguishes the bikeway from the Greenway and commercial nodes. The green infrastructure is softer than that along Chicago Avenue but more urban than in the Greenway. Between the three sites, these typologies of green infrastructure help distinguish each site while creating a sense of place along the corridor.

Stormwater Capacity

The grading of the stormwater cells and the bike lane ensure that heavy rains can flow off of Lake Street, along the bike lane, across the sidewalk, and into the wide wetland infiltration cells shown in Figures 4.29-30. This will prevent Lake Street from flooding, protecting the vital transportation corridor from the adverse effects increase precipitation events.

Figure 4.32

12th Avenue Bikeway at Lake Street

Figures

Notes

1. This quote is commonly attributes to Aristotle. Insertions by the author.
2. "Asplenium trichomanes ssp. trichomanes," Minnesota Department of Natural Resources, accessed April 9, 2018, https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=PPASP021K2.
3. "Draba arabisans," MNDNR, accessed April 9, 2018, https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=PDBRA11070.
4. "Sullivantia sullivantii," MNDNR, accessed April 9, 2018, https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=PDSAX0X050.
5. "Leedy's Roseroot," US Fish & Wildlife Service, last updated March 12, 2018, https://www.fws.gov/midwest/endangered/plants/leedys/leedysro.html.
6. "Poa wolfii," MNDNR, accessed April 9, 2018, https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=PMPOA4Z2M0
7. "Vertigo meramecensism," MNDNR, accessed April 9, 2018, https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=IMGAS20190.
8. " Taxus Canadensis," Minnesota Wildflowers, accessed April 9, 2018, https://www.minnesotawildflowers.info/shrub/canada-yew.
9. "Demolition of the Stewart – CEPRO grain elevators," Phillips Neighborhood Network, March 2004, http://www.pnn.org/slideshows/cepro_elevator/main.htm.
10. TKDA, "Midtown Corridor Historic Bridges", 9.
11. Ibid.
12. Michael Mechtenberg, Transportation Planner at Metro Transit, in discussion with the author, March 2018.
13. "Museum in the Streets," Lake Street Council, https://www.lakestreetcouncil.org/programs/museum-in-the-streets.
14. "Tomorrow's Habitat for the Wild and Rare: An Action Plan for Minnesota Wildlife," MNDNR, 2005, https://files.dnr.state.mn.us/assistance/nrplanning/bigpicture/cwcs/tomorrows_habitat.pdf.
15. "Wildflowers of Minnesota's Northern Prairies," MNDNR, 2014, http://files.dnr.state.mn.us/natural_resources/prairies/wildflowers.pdf.
16. "Asclepia syriaca," Minnesota Wildflowers, accessed April 9, 2018, https://www.minnesotawildflowers.info/flower/common-milkweed.
17. "Transportation Data Management System," Minneapolis Public Works Department, accessed January 20, 2018, http://minneapolis.ms2soft.com/tcds/tsearch.asp?loc=Minneapolis&mod=.
18. "D-Line (Chicago-Fremont rapid bus)," Metro Transit, accessed April 12, 2018, https://www.metrotransit.org/d-line-project.
19. "Minneapolis 2040 Land Use and Built Form," City of Minneapolis Draft 2040 Comprehensive Plan, accessed April 9, 2018, https://minneapolis2040.com/topics/land-use-built-form/.
20. "Cold climate impact on runoff management," from the Minnesota Storm Manual, Minnesota Pollution Control Agency, last modified February 19, 2016, https://stormwater.pca.state.mn.us/index.php/Cold_climate_impact_on_runoff_management.
21. Ibid.
22. "Tree species list- tolerance to stresses," from the Minnesota Storm Manual, Minnesota Pollution Control Agency, last modified February 19, 2016, https://stormwater.pca.state.mn.us/index.php?title=Tree_species_list_-_tolerance_to_stresses.
23. Steve Eggers and Donald Reed, "Wetland Plants and Plant Communities of Minnesota and Wisconsin," U.S. Army Corps of Engineers, July 2015, https://usace.contentdm.oclc.org/digital/collection/p266001coll1/id/2801/, 23.

5. Reflection


Image Source: Google Earth

Framework Summary

Borrowing ecological concepts to create a framework for understanding and designing within an urban context shows incredible promise. With many of the challenges faced by cities today coming from the natural environment, mitigating them must come from a system of infrastructure inspired by ecological systems. Both pieces of the local ecology framework capture the incredible synergy between ecosystems and the built environment. Patterns, processes, and performance draw inspiration from decades of research on ecological systems and centuries of urban theory. The systems—mobility, water, habitat, open space, and metabolism—speak to the synergy between natural and engineered infrastructure. This framework also attempted to capture the social relationships among communities by looking beyond green infrastructure to a sixth system—culture/history. As a more abstract piece of the framework, this system never fully developed. Thus, the final framework as presented in Figure 5.1 slightly adjusts local ecology based on reflections of this project.

Here, the five green infrastructure systems form a matrix with pattern, process, and performance. This basic format allows for a simple, bias-free beginning to analysis of a particular region. History and culture have been stretched across all five systems. For example, mobility includes social mobility as well as the movement of species. This allows for an adaptable and transferable framework responsive to both unique ecological and cultural conditions. As Figure 5.2 reveals, the framework then morphs to reveal these particular conditions. In Minneapolis, the mobility and water systems rise to

Local Ecology
Framework

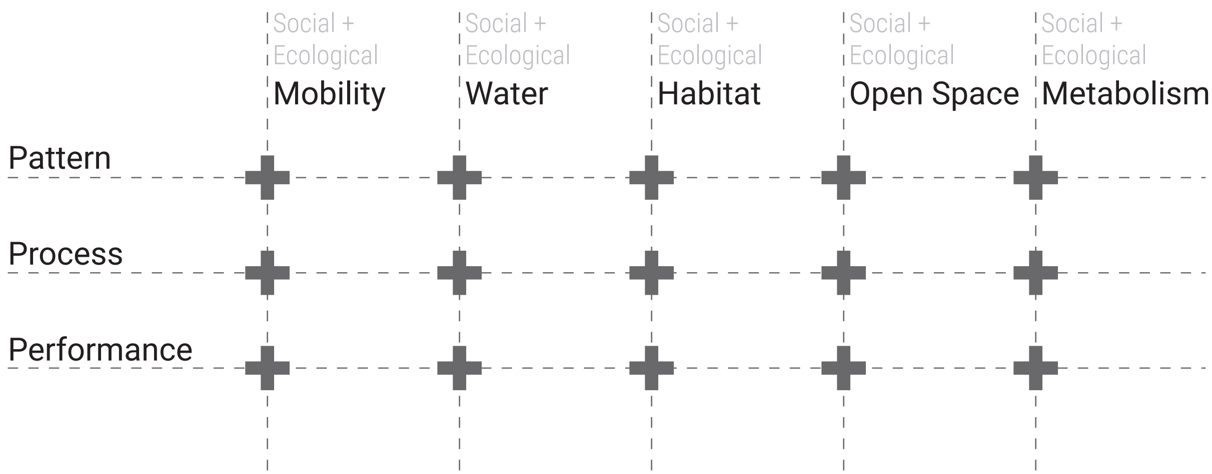


Figure 5.1
Local Ecology Framework

the top. All other systems are dependent on these in their pattern, process, and performance. Similarly, in other cities, one or two systems will drive the others, providing the scaffold upon which thick corridors should be designed. This allows for the design of a network of transfixed corridors allowing regional connectivity while reflecting fine grain places.

The major strength in this framework is the leverage it provides landscape architecture in approaching urban issues. Traditionally, the urban scale has been the realm of engineers, planners, and architects. However, local ecology provides landscape architects the knowledge to work at the range of scales necessary in these projects—from advocating for a particular neighborhood to designing a multi-county transportation and habitat corridor.

A Thick Midtown Corridor

As applied in Minneapolis, the framework excels at capturing the unique hydrologic and geologic conditions that produce specific ecologic functions.

Local Ecology
Midtown Corridor

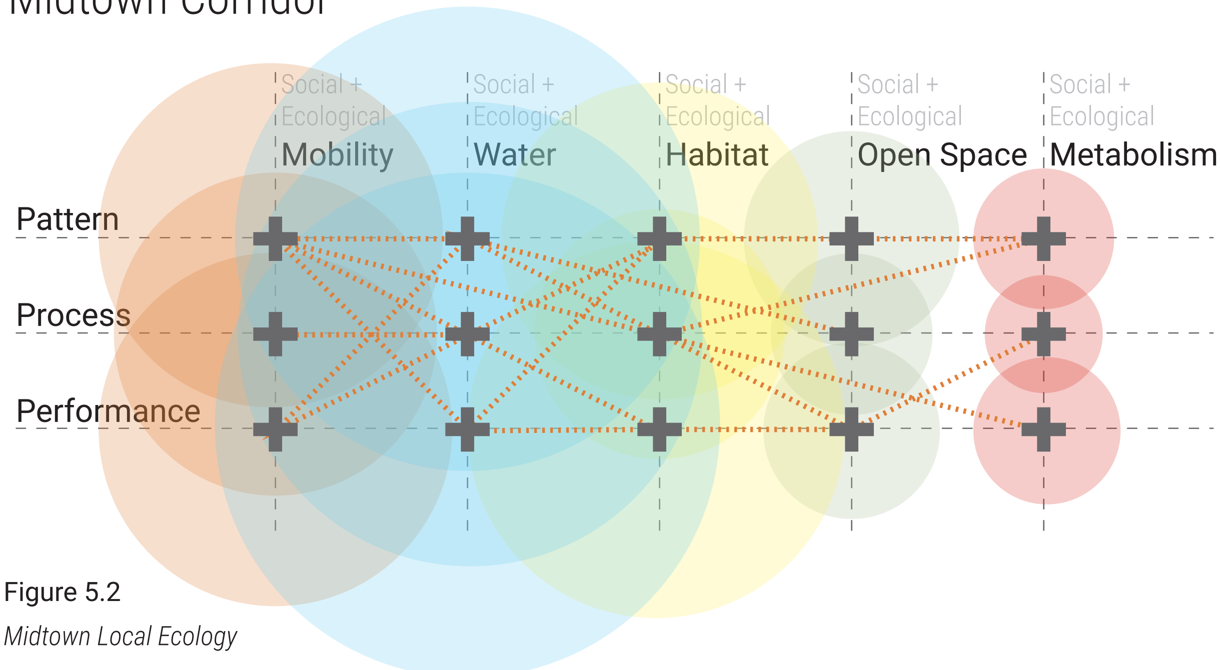


Figure 5.2

Midtown Local Ecology

For example, the patterns of prairie pothole wetlands provide a template for collecting and infiltrating runoff within the urban grid. The process of eroding sandstone from under a limestone shelf provides the template for daylighting stormwater outfalls. Prairie plants allow performance as a pollinator habitat corridor. However, as noted above, this project fails to capture the diverse social ecosystem of the corridor. One cause for this is the challenge inherent in a time-limited academic thesis. Both the short deadline and the limited labor render community engagement, especially for a distant site, difficult. In addition, I was mindful to avoid imposing cultural biases through design. This resulted in design interventions with only a superficial level of social engagement. However, with the changes noted above, this framework would embed cultural and historical connotations into each system.

The design process revealed the adaptability and transferability of the framework. By keeping it broad and inspired by basic ecological and urbanist theory, this framework could lend itself to designing thick corridors in a diverse variety of cities. The water system will look different in Seattle than in Phoenix, but still must be analyzed through pattern, process, and performance regardless of climate. Mobility may be light rail, streetcar, bus rapid transit, or even bike and pedestrian infrastructure. By understanding each particular location through an analysis of pattern, process, and performance at multiple scales, design strategies can be proposed that ensure all future transportation corridors in American and Canadian cities enhance the ecosystems through which they pass.

Conclusion

While Streetcar Cities are not new, the resurrection of this concept responds to 21st-century ecological and social challenges. In Minneapolis, these challenges include the threat of climate change, population growth, as well as social and economic inequity. In essence, many of our human and natural habitats are degrading at a rapid rate. The Streetcar City proposes an approach to reversing this decline through a focus on the pattern and distribution of development, transportation, ecology, and public space in an urban area. Put in the terms of landscape ecology, transportation corridors must become the backbone of urban habitat, connecting dense, diverse patches spread equitably throughout the matrix. However, instead of a whole-scale reintroduction of a 20th century streetcar network, a more malleable and resilient strategy is needed, one that results in solutions as unique as each city, each ecosystem, each corridor.

Transfixed proposes an answer to this challenge, one designers can leverage when navigating the world of engineering and planning. As shown in the Midtown Corridor, not all systems rise equally. In the Minneapolis context, mobility and water systems become the scaffold upon which the other systems hang. Design interventions are structured by these systems. The rail, bus, and bicycle infrastructure overlap the water system to produce synergies and resiliencies. Leveraging these synergies for habitat, open space, metabolism, and historic interpretation provides a glimpse into what a thick Midtown Corridor might look like.

While the cultural aspect of the corridor is underdeveloped in these conceptual design interventions, the adjusted framework provides the tools for planners and designers to better analyze and design thick corridors while serving as the foundation for engaging diverse communities. The Midtown Corridor is only a single strand in the network; if other transportation projects are designed in this way, Minneapolis and other American cities can become human habitats with transportation systems fixed in local ecosystems, where moving from A to B means recognizing and celebrating the communities through which we move, leaving us transfixed.

Figures

5.1- Local Ecology Framework, Graphic by author.
5.2- Midtown Local Ecology, Graphic by author.

Bibliography

References

Anderson, Betsey. "All Along the Line." *Landscape Architecture Magazine*. May 2016.

Atkins, Annette "St. Paul, Minneapolis, and Minnesota's Urban Origins." *MNopedia*. August 11, 2011. http://www.mnopedia.org/st-paul-minneapolis-and-minnesotas-urban-origins.

Bausells, Marta. "Story of cities #13: Barcelona's unloved planner invents science of 'urbanisation.'" *The Guardian*. April 1, 2016. https://www.theguardian.com/cities/2016/apr/01/story-cities-13-eixample-barcelona-ildefons-cerda-planner-urbanisation.

Berger, Michele. "The weather.com Climate Disruption Index." weather.com. Accessed May 20, 2018. http://stories.weather.com/disruptionindex.

Cameron, Linda. "For thirty years, electric streetcars ruled Twin Cities streets." *MinnPost*, March 8, 2016. https://www.minnpost.com/mnopedia/2016/03/thirty-years-electric-streetcars-ruled-twin-cities-streets.

Capra, Fritjof. preface to *Ecological Literacy: Educating Our Children for a Sustainable World.* Edited by Michael Stone and Zenobia Barlow, San Francisco: Sierra Club Books, 2005.

Cavanaugh, Patricia. "Politics and Freeways: Building the Twin Cities Interstate System," University of Minnesota. October 2006. https://conservancy.umn.edu/bitstream/handle/11299/2082/Freeways.pdf.

Chayka, Katy. "Minnesota Wildflowers." MinnesotaWildflower.info. Accessed March 1, 2018. https://www.minnesotawildflowers.info/.

City of Minneapolis Neighborhood and Community Relations . "Latino Community." Modified June 5, 2017. http://www.ci.minneapolis.mn.us/ncr/outreach/WCMS1P-143470.

City of Minneapolis Public Works Department. "Midtown Greenway." Modified January 3, 2012. http://www.minneapolismn.gov/bicycles/midtown-greenway.

City of Minneapolis Public Works Department. "Transportation Data Management System," Accessed January 20, 2018. http://minneapolis.ms2soft.com/tcds/tsearch.asp?loc=Minneapolis&mod=.

City of Minneapolis. "Minneapolis 2040 Draft Comprehensive Plan." Accessed April 9, 2018, https://minneapolis2040.com/topics/land-use-built-form/.

City of Minneapolis. "Minneapolis 2040." Accessed January 20, 2018. https://minneapolis2040.com/.

Cleveland, H.W.S. *Suggestions for a System of Parks and Parkways for the City of Minneapolis*. Minneapolis: Johnson, Smith, and Harrison: 1883.

Condon, Patrick. *Seven Rules for Sustainable Communities: Design Strategies for the Post-carbon World.* Washington [DC]: Island Press, 2010.

Drake, Darrel, Brenda Tozer and Geoffrey Stillwell. "Prairie Pothole Wetlands and Region." Emporia State University. 2012. http://academic.emporia.edu/aberjame/student/drake2/ppr.html.

Eggers, Steve and Donald Reed. "Wetland Plants and Plant Communities of Minnesota and Wisconsin." U.S. Army Corps of Engineers. July 2015. https://usace.contentdm.oclc.org/digital/collection/p266001coll1/id/2801/.

Federal Highway Administration. "Grand Rounds Scenic Byway." Accessed January 20, 2018. https://www.fhwa.dot.gov/byways/byways/2243.

Fisher, Thomas. "Designing Systems to Avoid Failure." Filmed September 2013 at TEDxUMN, Minneapolis, MN. Video.

Forman, Richard, and Michel Godron. *Landscape Ecology.* New York: Wiley, 1986.

Forman, Richard. *Land Mosaics: The Ecology of Landscapes and Regions.* Cambridge; New York: Cambridge University Press, 1995.

Gee, Taylor. "Something is Rotten in the State of Minnesota." *Politico Magazine.* July 16 2016. https://www.politico.com/magazine/story/2016/07/minnesota-race-inequality-philando-castile-214053.

Ggrinager. "Zapata statue finds a home on East Lake Street in Minneapolis." *Twin Cities Daily Planet.* July 28, 2012. https://www.tcdailyplanet.net/zapatas-statue-finds-home-east-lake-street/.

Hirsi, Ibrahim. “The complicated reality behind the story of the Somali community’s success in Minnesota.” *MinnPost*. August 14, 2017. https://www.minnpost.com/politics-policy/2017/08/complicated-reality-behind-story-somali-communitys-success-minnesota.

JLA Public Involvement. “Portland-Milwaukee Light Rail Transit Project Sustainability Overview Report.” TriMet. March 2015. https://trimet.org/orangeline/pdf/sustainability-report.pdf.

Lake Street Council. “Museum in the Streets.” Accessed May 10, 2018. https://www.lakestreetcouncil.org/programs/museum-in-the-streets

Lynch, Kevin. *The Image of the City.* Cambridge, Mass: MIT Press, 1960.

Metro Transit. “D-Line (Chicago-Fremont rapid bus).” Metropolitan Council. Accessed April 12, 2018, https://www.metrotransit.org/d-line-project.

Metro Transit. “Midtown Corridor Alternatives Analysis.” Metropolitan Council. Accessed January 20, 2018. https://www.metrotransit.org/midtown-corridor.

Miller, Jim. “A Geology Tour of the Twin Cities,.” University of Minnesota- Duluth. July 28, 2016. http://www.d.umn.edu/~mille066/Outreach/Geology%20Tour%20of%20the%20Twin%20Cities-guidebook.pdf.

Minnesota Department of Administration. “MN Archaeology.” Accessed May 20, 2018. https://mn.gov/admin/archaeologist/the-public/mn-archaeology/

Minnesota Department of Natural Resources. “Minnesota’s Biomes.” Accessed January 20, 2018. https://www.dnr.state.mn.us/biomes/index.html.

Minnesota Department of Natural Resources. “Rare Species Guide.” Accessed March 1, 2018. https://www.dnr.state.mn.us/rsg/index.html.

Minnesota Department of Natural Resources. “Tomorrow’s Habitat for the Wild and Rare: An Action Plan for Minnesota Wildlife.” 2005. https://files.dnr.state.mn.us/assistance/nrplanning/bigpicture/cwcs/tomorrows_habitat.pdf.

Minnesota Department of Natural Resources. “Wildflowers of Minnesota’s Northern Prairies.” 2014. http://files.dnr.state.mn.us/natural_resources/prairies/wildflowers.pdf.

Minnesota Department of Transportation . “Twin Cities Area Freight Railroad Map.” September 2015. https://www.dot.state.mn.us/ofrw/maps/MetroRailMap.pdf.

Minnesota Pollution Control Agency. “Minnesota Stormwater Manual.” Modified May 31, 2018. https://stormwater.pca.state.mn.us/index.php?title=Main_Page.

Mostafavi, Mohsen. “Why Ecological Urbanism? Why now?” In *Ecological Urbanism*. Edited by Mohsen Mostafavi and Gareth Doherty, 1-50. Zurich: Lars Muller Publishers, 2010.

Primeau, Sarah. “Designing Constructed Ecosystems for a Resilient Future.” In *The New Landscape Declaration: A Call to Action for the Twenty-First Century*, edited by the Landscape Architecture Foundation, 151-154. Los Angeles: Rare Bird Books, 2016.

Rietmulder, Michael. “Minneapolis, St. Paul among cities worst hit by climate change.” *City Pages* , July 13, 2015. http://www.citypages.com/news/minneapolis-st-paul-will-be-among-worst-hit-by-climate-change-7472836.

Rosenthal, Brian, Emma Fitzsimmons, and Michael LaForgia. “How Politics and Bad Decisions Starved New York’s Subways.” *New York Times*. November 18, 2017. https://www.nytimes.com/2017/11/18/nyregion/new-york-subway-system-failure-delays.html.

Rottle, Nancy. “Urban Green Infrastructure for Climate Benefit: Global to Local.” *Nordic Journal of Architectural Research*, Issue 2 (2013): 43-66.

Sitte, Camillo. *City Planning According to Artistic Principles*, Translated by George Collins and Christiane Craseman Collins. New York: Random House, Inc, 1965.

TKDA and Hess Roise. “Midtown Corridor Historic Bridge Study.” City of Minneapolis Public Works Department. 2007. http://midtowngreenway.org/files/mgc/ckfinder/files/MidtownCorridorHistoricBridgeStudy5-30-07.pdf.

Trust for Public Land. “Park Score.” Accessed May 20, 2018. http://parkscore.tpl.org/rankings.php#sm.00004or20h8azfoysto1tpg7wnmur.

United States Census Bureau. “Quick Facts: Minneapolis city, Minnesota,” 2016. https://www.census.gov/quickfacts/fact/table/minneapoliscityminnesota/PST045216.

Bibliography

United States Census Bureau. "Quick Facts: Minnesota." 2016, https://www.census.gov/quickfacts/MN.
United States Environmental Protection Agency. "Ecoregions of North America." Accessed January 20, 2018. https://www.epa.gov/eco-research/ecoregions-north-america.
United States Fish & Wildlife Service. "Leedy's Roseroot." Modified March 12, 2018. https://www.fws.gov/midwest/endangered/plants/leedys/leedysro.html.
Waldheim, Charles. *Landscape as urbanism: A general theory.* Princeton, NJ: Princeton University Press, 2016.
Walker, Brian and David Salt. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World.* Washington: Island Press, 2006.