Land of 10,000 Dying Lakes

Designing for Sustainable Water Management Through Wetland Conservation and Public Recreation

a design thesis by Zach Unruh

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Designing for Sustainable Water Management Through Wetland Conservation and Public Recreation

A Design Thesis Submitted to the Department of Architecture and Landscape Architecture of North Dakota State University

Completed by Zach Unruh

In partial fulfillment of the requirements for the degree of Master of Landscape Architecture

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Primary Thesis Advisor: Matthew Kirkwood
Date

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The Proposal

Thesis Abstract

In 2017, 169 harmful algal blooms were reported nation-wide. Existing in all water body types, saltwater or freshwater, this number is increasing every year, and Minnesota is no exception.

In the land of 10,000 lakes, 48 different locations have experienced a Harmful Algae Bloom at least once over the last decade. Growing not only in frequency, but also size, the presence of these Cyanobacteria blooms are killing aquatic species, lowering water quality, limiting recreational use, and in some cases producing toxins capable of killing humans and animals that come into contact with the water.

Due to global warming, the average temperature of our water bodies continue to rise. This, paired with excessive runoff that is polluted with fertilizers and chemicals, creates a perfect opportunity for these harmful blooms to flourish.

This study will focus on a strategy to mitigate the environmental damage caused by nutrient dense runoff through environmental planning. Using geospatial and hydraulic data for the drainage area, in conjunction with varying case studies and wetland research, the result will provide a plan for wetland restoration and future protection, with sustainable runoff management, in a public recreation setting. The final design will seamlessly combine project programming into a re-envisioned runoff management system.

Thesis Narrative

Premise for investigation

Cyanobacteria in Minnesota Lakes

The presence of blue-green algae is having a harmful effect on recreational uses and damaging the existing aquatic habitat. When these blooms occur, they can be deadly to humans, pets, and aquatic species. They can cause mass kill offs of lake species by blocking out sunlight and using up all available oxygen in the water. These blooms are a result of increased temperature in bodies of water paired with the abundance of phosphorus and nitrogen.

Suburbanization has sprawled and encircled lakes throughout the region. The top question is how can runoff be collected, stored, filtered and then safely released into water bodies, while systems remain naturalized and providing for healthy habitat and recreational use. As the average temperature of water bodies continue to rise, similar design interventions will continue to become increasingly common throughout the discipline of landscape architecture. Being unable to directly stop the warming of water bodies, it will be a necessity to design around other ways of protecting our water systems.

Context

The summer sun is shining down on the water. It is summer lake season, normally a season bustling with lake activity, but not today. Instead of watercraft and swimmers covering the surface of the lake, a large mass of green algae is spread throughout the water and onto the shore. There is a terrible stench coming from the water. A cyanobacteria Harmful Algal Bloom is in full effect.

This is becoming a more regular scene throughout Minnesota. When these blooms occur, public recreation is shut down due to the potential of harmful toxins that can kill humans, fish, birds, and pets. Even if the toxins created by the cyanobacteria are not present, these massive blooms can still drown out native aquatic species by restricting the amount of sunlight able to penetrate into the water, and by using up the available oxygen in the water.

As global temperatures rise, so does the temperature of our water bodies. Combined with the high levels of chemical ridden runoff, the quality of lakes, rivers, streams, and drinking water will only continue to deteriorate. Water recreation will become more and more limited, and HABs will become more and more prevalent.

Project typology

Environmental planning with ecological remediation, sustainable storm-water management. This typology was chosen for the following reasons:

1. Damaged wetland/aquatic habitats from polluted runoff

2. Restore natural environments

3. Ability to design for sustainable water management

The finished design will represent a drainage area with strategic remediation of areas most affected by runoff and naturalized habitat reconstruction, to provide for the ongoing existence of a healthy aquatic habitat and recreational use.

Case study projects were selected based on overlapping typologies. The selections cover a variety of site scales, user programming, and hard scape/soft scape design implementation.

The Site

Region: Midwest
City: Minneapolis
Site: Minneapolis Chain of Lakes - Lake of the Isles

Typology Research

Case study projects were selected based on overlapping typologies. Project characteristics used for selection are as follows:

1. Wetland Conservation

2. Runoff Treatment

3. User Programming

4. Location context

Selected Case Studies:

1. Gowanus Canal Sponge Park
   Brooklyn, NY

2. Nature Boardwalk at Lincoln Park Zoo
   Chicago, IL

3. Weishan Wetland Park
   Jining, Shandong Province, China

4. JEL Wetland Park
   Wilmington, N.C.

5. Qunli Stormwater Park
   Harbin Heilongjiang, China

6. Houtan Park
   Shanghai, China

Gowanus Canal Sponge Park

The Gowanus Canal Sponge park is an urban waterfront park system focusing on urban redevelopment, runoff control, and brownfield remediation. It is designed by DLANDstudio. Located along the Gowanus Canal in Brooklyn, this system is designed to handle runoff from the 1758 acre watershed area. It is contained within a once highly industrialized area, adding to the heavy pollution of the canal. The park itself is 11.4 acres, with 7.4 acres set aside for greenway/ open space design, and 3.5 acres for remediation design. The most distinguished characteristic of the park is the terraced, remedial wetland construction that is working to rebuild the habitat of the canal, which is impressive given the highly toxic current conditions – no use of the water at all is currently advised. This will provide for a revitalized canal while still allowing for pedestrian access and use of the area.

Program elements for the Sponge Park include:

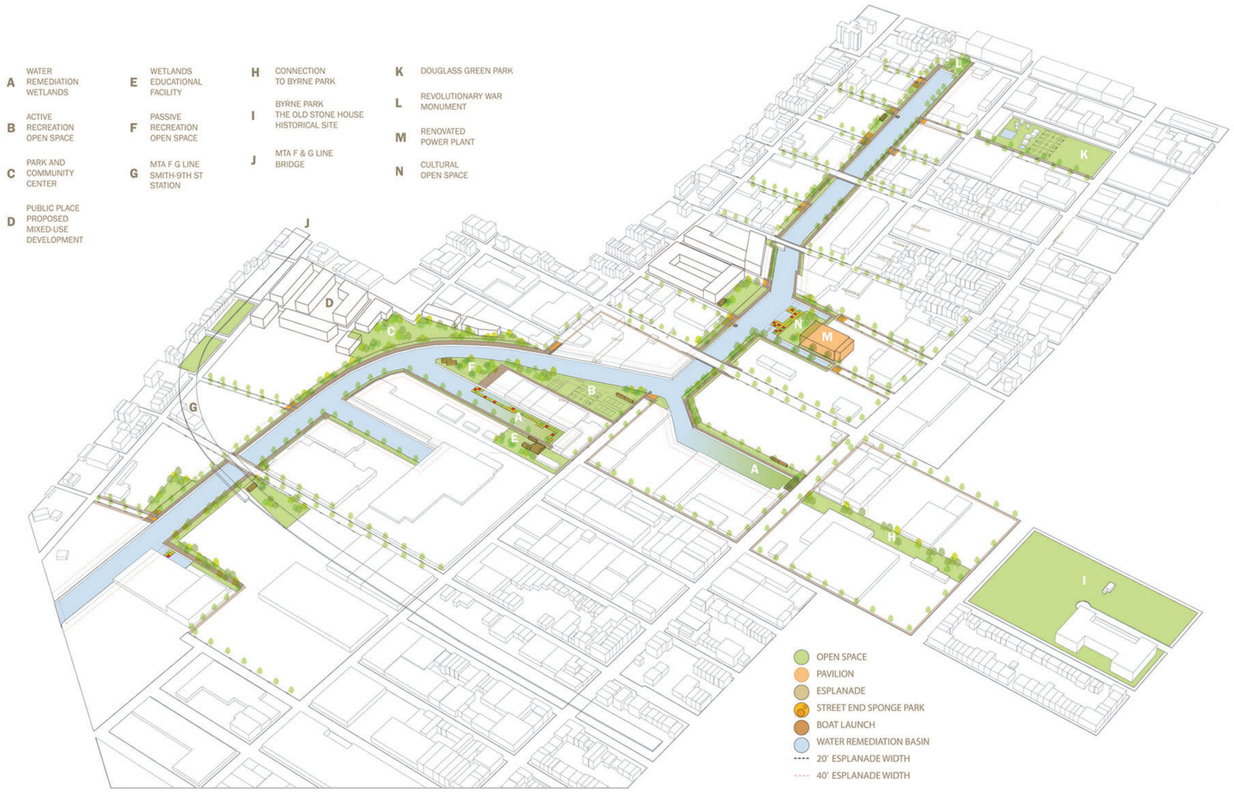
- Water remediation wetlands/basins
- Active recreation open space
- Park and community center
- Public place proposed mixed use development
- Wetlands educational facility
- Passive recreation open space
- Connections to existing parks/historical sites
- Cultural open space
- Renovated industrial buildings
- Pavilions
- Esplanades
- Boat launches

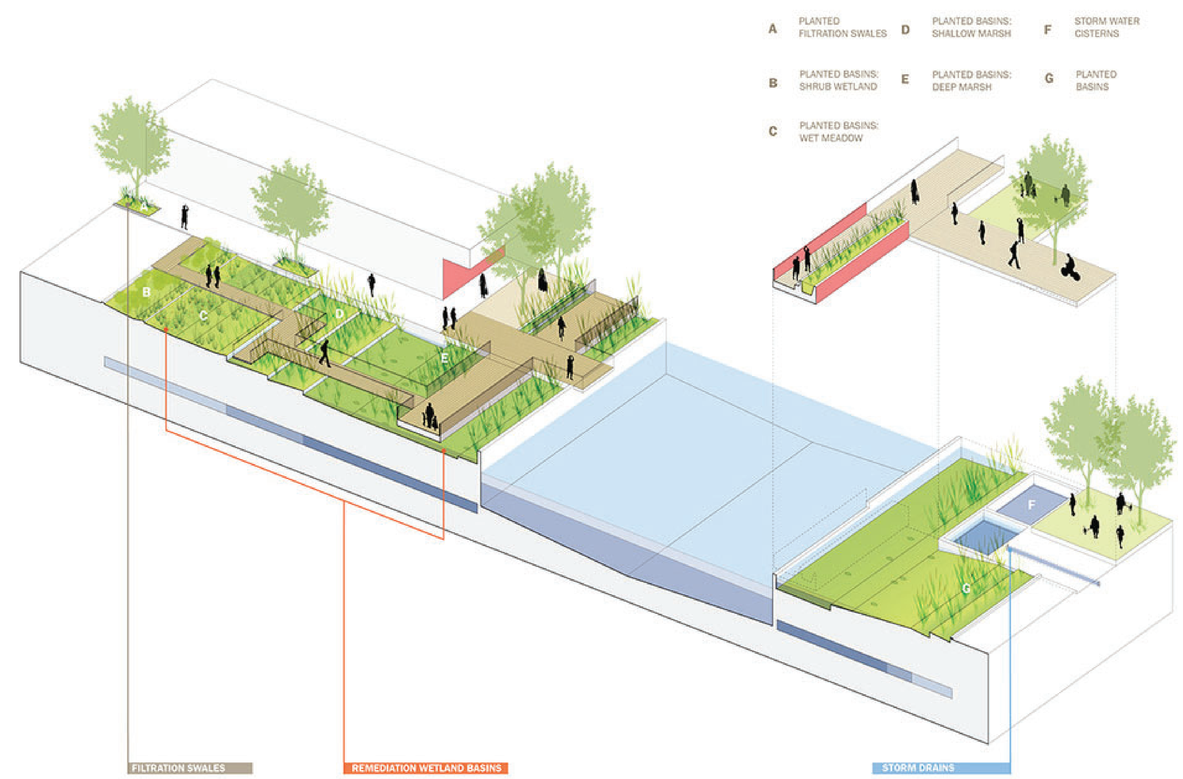
In terms of basic environmental remediation and storm water runoff control, this case is very similar to the other cases. What begins to set it apart is the incredibly high level of toxicity it is addressing in the Gowanus Canal and the level of polluted runoff it is collecting and filtering from the surrounding drainage basin of highly developed urban/industrial area.

In 2016 DLANDstudio created a pilot of the greater Sponge Park project. This pilot is capable of handling nearly 2,000,000 gallons of runoff yearly.

The Gowanus Canal Sponge Park is respondent to its given site (Gowanus Canal) environmentally, socially, and also culturally. Responding to the site environmentally is the basis of the entire project, which is to create a canal with a thriving habitat while simultaneously cleaning the water and collecting/filtering storm-water runoff. Socially, the plan provides for areas of public engagement with one another through active and passive recreational uses and pavilions/esplanades. In addition, it took public feedback on programming and then implemented the feedback into the final design. Culturally, it was designed to fit into its neighborhood in Brooklyn, and provides cultural open spaces.
(case study analysis)

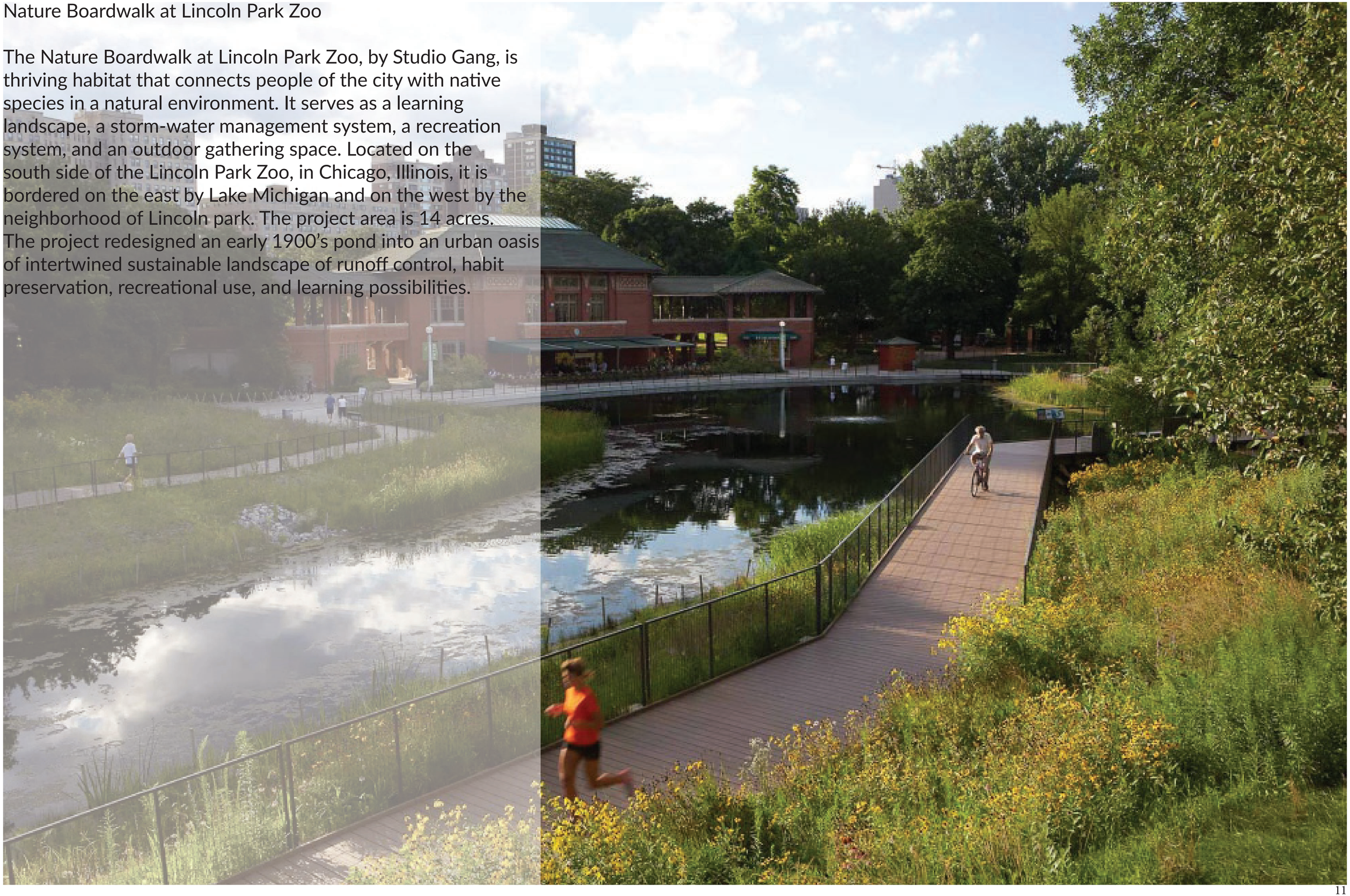
The Gowanus Canal Sponge Park provides an understanding that a naturalized storm-water runoff control system and brownfield rehabilitation in a modular design is possible even at this high of a level of toxicity and runoff, in an urban/industrial area. The Gowanus Canal site is much more polluted (and with different chemicals) than the Cedar Lake site chosen for this thesis, but regardless the overall method and ideas are congruent with one another.





Nature Boardwalk at Lincoln Park Zoo

The Nature Boardwalk at Lincoln Park Zoo, by Studio Gang, is thriving habitat that connects people of the city with native species in a natural environment. It serves as a learning landscape, a storm-water management system, a recreation system, and an outdoor gathering space. Located on the south side of the Lincoln Park Zoo, in Chicago, Illinois, it is bordered on the east by Lake Michigan and on the west by the neighborhood of Lincoln park. The project area is 14 acres. The project redesigned an early 1900's pond into an urban oasis of intertwined sustainable landscape of runoff control, habit preservation, recreational use, and learning possibilities.



Key programming elements include:

- Boardwalk
- Educational habitat zones
- Pavilion
- Existing Café Brauer

To create a sustainable landscape and thriving habitat, the project focused on three parts: wetland, hydrology, and the existing pond. On the shore of the pond, wetland plantings have replaced the original pond edge. Behind the wetlands, native prairie grasses are planted to create additional habitats. To tackle issues of hydrology, the pond was deepened and the removed fill was used to create a more successful drainage system within the watershed zone.
This project responds to its site environmentally, socially, and culturally. Environmentally, the project took an unsustainable pond over 100 years old and adapted it to modern necessities of runoff control and habitat preservation. Socially, this project provided a place for locals and tourists to gather for outdoor recreation and use of a living, learning landscape. Culturally, it ensured the continued use of a historical pond and the historical Café Brauer.

The main contribution this case makes to the Theoretical Premise is through its hydrology and the creation of a learning landscape.

Weishan Wetland Park

Weishan Wetland Park is an environmental planning, wetland conservation, water remediation, and tourism project in Weishan County, Jining, Shandong Province, China. Lead by AECOM, the entire project covers an area of approximately 9,900 acres, with roughly 5,000 acres of that coming from the wetland park itself. The distinguishing characteristics of the case would be its five landscape zones, optimized water resource management, wetland restoration with native planting, multiple wildlife habitats, low impact materials, car-free, enhanced plant diversity, and sustainable architecture.

The program elements include:

- main entrance/visitor center
- farmland and forest habitats
- constructed wetland zone
- natural wetland zone
- fish ponds
- Walking/biking paths
- Bird watching corridors
- Raised walking/viewing decks
- Swimming
- Water paths

As with the two previous case studies, this case shares a primary function of water treatment through natural means, to provide for the conservation of natural habitats. Promoting pedestrian use, both locals and tourism, is a major design factor in all cases. What sets this case apart from the previous two, is the scale. Not only in physical size, but in terms of entire water systems, financial cost, and flora and fauna involved.

Main Flow
Main Pipes
Water Body
Constructed Wetland
Xinxue River Constructed Wetland
Small-scale Constructed Wetland
Weishan Lake

A series of wetlands with different ecological functions is used to improve water quality and flow in each featured zone to maintain the pleasant environment.

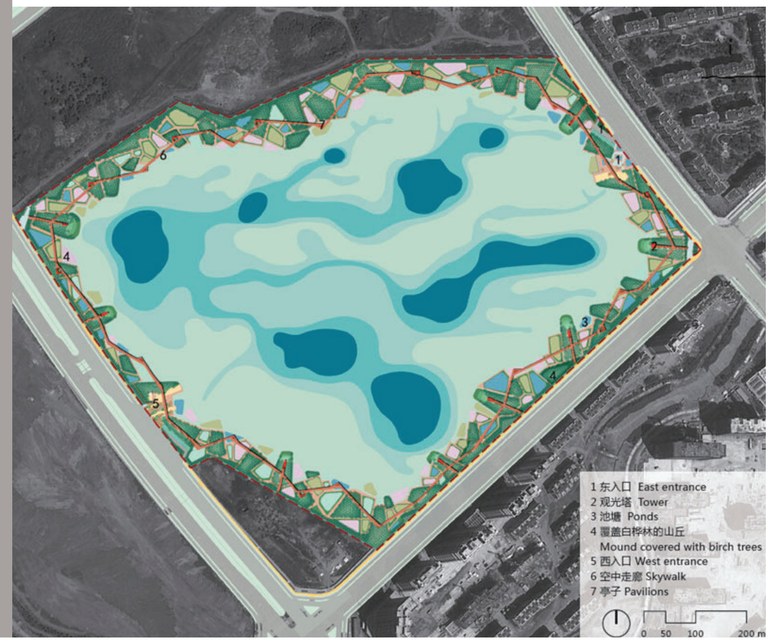
Qunli Stormwater Park

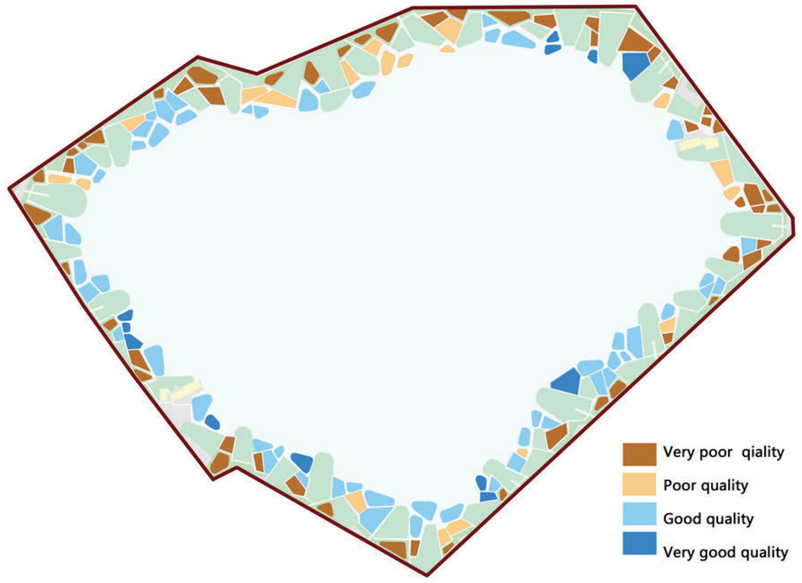
Qunli Stormwater Park is a stormwater management and wetland regeneration project located in the Qunli Neighborhood, Harbin Heilongjiang, China. The existing wetland had been cutoff from the nearby river from mixed-use urban development. Designed by Turenscape, the site is 84 acres. The wetland collects stormwater runoff from the adjacent neighborhoods, and then directs it through a series of basins designed for sedimentation and treatment. After runoff has traveled through the treatment zones it then reaches the main wetland area.

The public is able to engage with site via boardwalks and paths and viewing towers around the boundary of the site, while the center of the site is reserved specifically for the natural wetland zone.

The stormwater park treats an area of approximately 111 acres and is sized to hold a 1 year storm event. Due to seasonal changes, the site is constantly changing from fluctuations in water level and the native plants blooming cycles. The park provides ecosystem services of flood protection, stormwater treatment, and replenished groundwater supplies, while for humans providing natural open space in an urban environment

Programming elements:
- boardwalks
- ponds
- pavilions
- Skywalk
- upland mounds
- sedimentation basins
- viewing towers
- shallow and deep water pockets





JEL Wade Park

JEL Wade Park is a free water surface constructed wetland designed to treat stormwater runoff before releasing it back into the downstream system. Located in Wilmington, North Carolina the 11.5 acer site collects stormwater from the 289 acre surrounding suburban neighborhoods and is designed for up to a 100 year storm event.

The site collects stormwater in a first sedimentation basin, where the flow is then slowed by weirs and directed to meander through the treatment wetland for maximum treatment.

The site caters to public by providing bike routes, boardwalks, turf area, playgrounds, education areas, overlooks, and restrooms.

Program Elements:
- sedimentation basins
- weirs
- low-flow streams
- by-pass channel
- treatment wetland

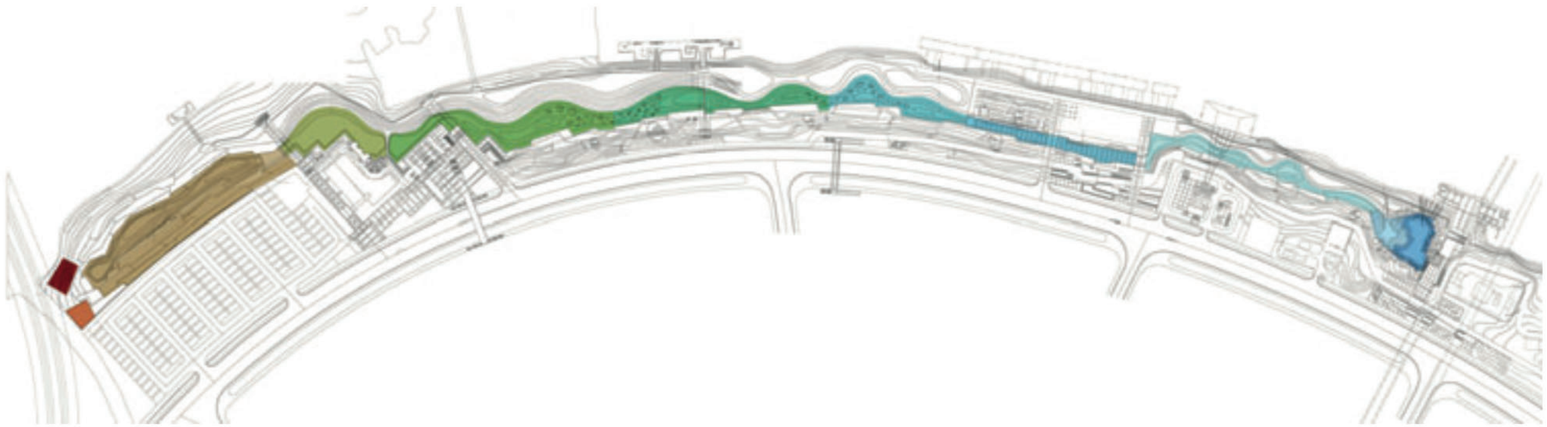
Houtan Park

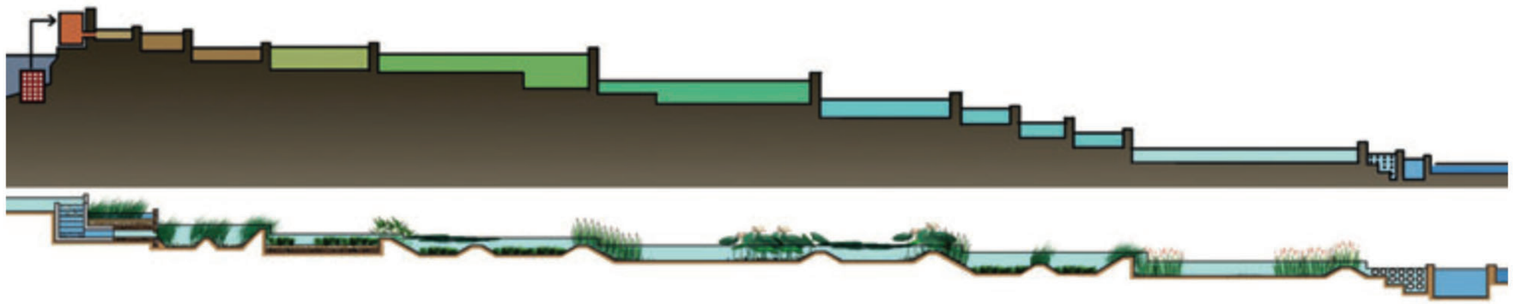
Houtan Park is a 34 acre site designed by Turenscape, located along the Huangpu River in Pudong, Shanghai, China. It is a riparian constructed wetland designed to treat some of the water flowing through the heavily polluted river.

The design uses a terraced system that slows flow and implements different water depths and plants to effectively treat the water as it moves through the system.

The public engages with the site through paths and boardwalks and art installations and pavilion areas.

Program Elements:
- Sedimentation basins
- water depth pockets
- flood wall
- flow control





Typology research summary

The presented case studies show that through sustainable design, we can create responsible landscapes that are preserving our natural world, while simultaneously providing a place for local culture to thrive.

While differing in scale, location, and focus, the case studies are all still closely intertwined with another and shed light towards how to properly solve the issues presented at Lake of the Isles.

Common Principles:

1. Sustainable runoff/storm-water management this is the key principle/ purpose for each case study project. As with the proposed thesis site, this will also be the main principle.

2. Multiple interventions used on each site
   Each site implements a combination of remediation techniques to solve filtration/contamination issues.

3. Healthy ecosystem = Healthy culture
   Culture and “people places” thrive through healthy environments

4. Stewardship through Education
   Each site promotes environmental stewardship by providing opportunities for education on how the remediation systems work.

5. Remediation + Conservation = Resiliency
   Protecting our wetland zones allows for them to flourish and in return provide resiliency for cities in terms of stormwater management and flood protection.

Common Programming

The case studies all share common programming elements that are necessary when designing successful stormwater management systems.

1. Free-flow surface wetland

2. Sedimentation basins

3. Water depth pockets

4. Low-flow/flat slope

5. Education opportunities

6. Public recreation

7.Phytoremediation

Major Project Elements

Watershed Analysis
A study of the surrounding neighborhoods' runoff flow. This will show where water from the region is first entering the lakes. Using this, a plan can be made for where the key remediation areas should be.

Existing Ponds, Swales, and Filtration Locations
Locating what interventions have already been implemented will be necessary in order to redesign and implement into the larger system.

Existing Wetlands
Locating the existing wetland areas and assessing how damaged they may be. This will create a starting point of where to locate implemented remediation.

Bio-remediation Through Native Selections
Using native plants that succeed in nitrogen and phosphorous removal and aid in creating a self-sufficient native wetland will be a major project element.

Continuation of Lake Season
Minnesota summers at the lake are a staple of the local culture. Ensuring this can continue by supporting recreational use and conservation of the lakes is a major project element.

Wetland Conservation
The basis of the entire project. Restoring and protecting what we have now - for future use, self-sufficiency, and resiliency.

Identity
It will be necessary to stay true to the current identity of the lake while expanding upon it while allowing it stand out from the surrounding lakes

Public Engagement
Allowing the site to not only be for treatment, but to allow for passive recreation and education to maximize engagement with the site.

User Description

The project will be designed for the surrounding neighborhood users and outside users, and employees.

Individual Requirements
The design must support use by children, elderly, and meet ADA standards. People with children, elderly, outside visitors, and users who bring their own watercraft will need specific considerations when placing parking distances. Neighborhood users would need limited parking, as they predominately access the lake through the trail system.

Peak usage
The peak usage for the site is the summer time. Quite popular during lake season, Cedar Lake is approximated to receive 173,000 visitors during the summer months alone.

Main User Profile
The site design is targeted as the main users being those who come to the site for kayaking and those who are wishing to use the trail system through biking, running, and walking

Project Emphasis

1. Development of modular systems
   Creating a replicable solution is an important part of this thesis. By developing a solution that is modular and replicable will allow the system to be easily implemented throughout the chain of lakes, with only minor changes like vegetation or materials varying.

2. Integration of treatment and programming
   Rather than restoring wetlands and then placing programming in left over space, I plan to find solutions to intertwine the two with one another, creating seamless transitions from conservation to programming, and spaces that feel like they belong.

3. Analysis of hydraulic data
   This is crucial to create a successful project. This step of using GIS data, will be the main determiner of intervention location and sizing.

4. Conservation of wetland areas
   The driving force/main idea behind this thesis project is wetland conservation and how to protect these habitats for generations to come.

5. Naturalized intervention
   Creating a treatment system that looks at home in a natural wetland setting while still reaching treatment goals.

Goals of the Thesis Project

1. Academic – To produce a thesis project reflective of the research and work of a graduate level student.

2. Professional – To contribute to the discipline of landscape architecture as a whole by providing a high level project that can provide new ideas.

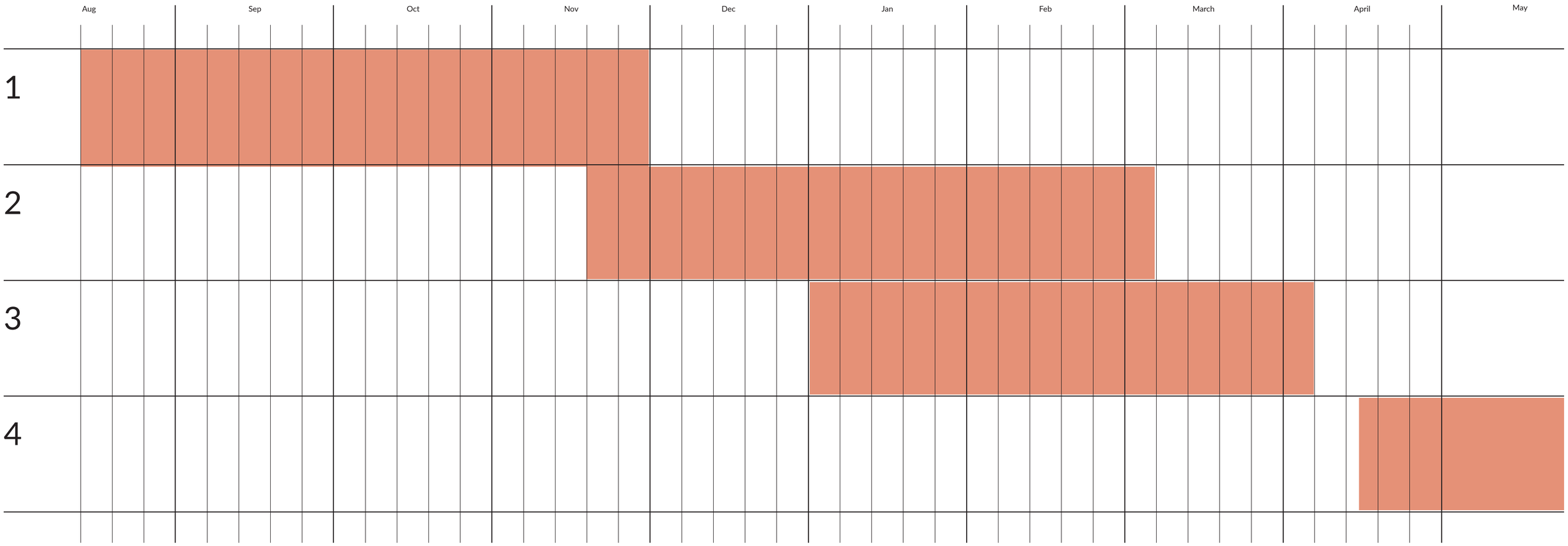
3. Personal – Complete a project reflective of my personal interests in environmental stewardship.

4. Promote environmental stewardship.

5. Present a final project that displays a high level of skill in design and analytical software.

6. Continue to draw attention to our damaged wetlands.

Project Schedule



KEY DATES: April 30th Presentation

1. Proposal
   Topic/typology selection, research, site selection

2. Program
   Programming elements for the selected site and research typology

3. Design
   Combination of proposal/typology research and the programmatic needs

4. Presentation
   Culmination of the project

Plan for Proceeding

Definition of the Research Direction
Proceeding, the project will follow the laid out schedule and dates, while working with my thesis advisor to continue making additions and improvements to the proposal and general research direction.

The next phase of programming coincides with the design phase. The design phase will consist of:

Programming/analysis
Concepts and design development
Digital modeling
Design completion

Design Methodology
My project implements a mixed method of quantitative and qualitative data analysis. They will both be analyzed and presented through graphic and digital means. The thesis project will rely more on the research and study of the quantitative data aspects of the site, as compared to the qualitative. Although, the qualitative will become more important as the project moves through the design development stages.

Documentation of Design Process

Compilation
All of the design process will be documented each step of the way, through digital files as well as hand drawn documents. They will then be compiled into the thesis book as well as presentation boards as a means of presentation for crucial design process information.

Preservation
The design process will be preserved through the compilation process of collection for presentation purposes and will continue to live through computer based files.

Presentation
The project will be presented through physical modeling, large board layouts, and digital images, all aiding the oral presentation.

Research

Theoretical Premise Research

Research has utilized the methodologies of:

1. historical research
2. quantitative/qualitative research
3. case study/combined strategies

Fusing these main methodologies. the main topics of interest which are being studied, can be grouped into the following categories:

1. Constructed Wetlands
2. Phytoremediation
3. Human-Nature Interaction/Other

These three categories are used to direct the following literature review. Presented in each category is the primary literally source of information for the topic. Literature sources that are utilized do blend a bit between categories, but are studied for the main purpose of the category they are placed in and analyzed with each other.

Literature Review
Constructed Wetlands

Constructed Wetlands and Sustainable Development
by Gary Austin and Kongjian Yu

Overview
Austin and Yu cover the functions and performance of constructed wetlands and the positive effects they create for the environment and people. It provides a look at the different types of constructed wetlands and how to design, plan, and monitor them.

“Sustainable development must include water quantity and quality as indicators applied to both human and ecosystem health”, says Yu. As this thesis continues to move forward, this is a primary factor to its success. This helps to set up necessary metrics that the site design must meet in order to be considered a successful project. Key introductory information is presented in the opening chapters: constructed wetland sizing in regards to its setting, water resource planning, water quality, condition of existing wetlands and streams, and types of constructed wetlands.

The book continues to discuss the roles constructed wetlands play in ecosystem and human health, the pollutants they are capable of cleaning from water, and how they are capable of creating high quality water that can be used for ecosystem restoration. In later chapters, more in-depth and deeper understanding of the landscape planning, technical information, landscape design, and ecological systems involved in constructed wetlands.

Literature Review
Constructed Wetlands

Review/Information Gained
This book was extremely helpful in providing a high level of understanding the entirety of constructed wetlands. It supplied numerous case studies which aided in the design process. It provided the information necessary to understand how to create a successful constructed wetland for stormwater management and treatment and how it would be effective in my thesis design.

Summary/relation to my thesis
Austin and Yu’s Constructed Wetlands and Sustainable Development is an invaluable source of high quality information for this thesis, and will allow for an easy transition from research into the design phase of the thesis project.

Literature Review
Phytoremediation

Phyto: Principles and Resources for Site Remediation and Landscape Design
by Kate Kenned and Nial Kirkwood

Overview
"PHYTO presents the concepts of phytoremediation and phytotechnology in one comprehensive guide, illustrating when plants can be considered for the uptake, removal or mitigation of on-site pollutants. Current scientific case studies are covered, highlighting the advantages and limitations of plant-based cleanup. Typical contaminant groups found in the built environment are explained, and plant lists for mitigation of specific contaminants are included where applicable.

This is the first book to address the benefits of phytotechnologies from a design point of view, taking complex scientific terms and translating the research into an easy-to-understand reference book for those involved in creating planting solutions. Typically, phytotechnology planting techniques are currently employed post-site contamination to help clean-up already contaminated soil by taking advantage of the positive effects that plants can have upon harmful toxins and chemicals. This book presents a new concept to create projective planting designs with preventative phytotechnology abilities, 'phytobuffering' where future pollution may be expected for particular site programs.

Filled with tables, photographs and detailed drawings, Kennen and Kirkwood guide the reader through the process of selecting plants for their aesthetic and environmental qualities, combined with their contaminant-removal benefits."

Literature Review
Phytoremediation

Review/Information Gained
This book was very helpful in first identifying the types of design typologies in which plants can be used to effectively treat stormwater. Next, it provided an understanding of which and how to use these typologies to best address my thesis problem. Finally it provided an understanding of plants and their mechanisms for removing pollutants from the water and soil and which of these plants are best in use for removal of nitrogen and phosphorous.

Summary/relation to my thesis
Kenned and Kirkwood's "Phyto" provided necessary information of phytoremediation, which is a major part of my thesis design.

Project Justification

Cultural/Social Justification
The project is important in its social/cultural context because these lakes are a crucial part of the summer lake season, which is a huge part of the Midwest culture. It would be ensuring the continuation of use for years to come.

Ecological Justification
The environmental impacts of my project would be restored wetlands, protection of existing habitats, cleaner water, and the cessation of harmful algal blooms in the lakes.

Personal Justification
This project is important to me because i am a strong believer in environmental stewardship and taking care of/protecting our natural lands for future use. Growing up in the Midwest, I have personal experience with the summer lake season and how important our bodies of water are for our regional culture. This project is imperative for me. I do believe that it is important and worth doing over other contemplated projects. I believe it could be left for someone else. I am personally interested and invested in solving it myself. It is a project and typology that i care very much about. I believe i can solve it, and it will therefore serve as an excellent cap to my studies at NDSU.

Site Justification
The project site is justified because it experienced harmful algal blooms this past year. It is surrounded by residential neighborhoods of which the runoff can be controlled, the shorelines allow for wetland resurrection and recreational use.

Academic/Professional Justification
This project is important to me at this stage of academic development because i have had the opportunity to work on other similar and very different projects and realize that i am interested in this specific typology.

I have also increased my knowledge of what is happening with our natural landscapes and can pair that with a greater understanding of how to research and design for a solution. My knowledge base is being helped by the intensive research into pollutants in runoff, how to manage/filter the pollutants, and how to design for a resilient, self-sufficient wetland habitat. Currently, this project is greatly expanding on my research skills. In the spring, it will advance my graphic and design skills as a landscape architect. Professionally, the topic of wetland conservation and problems with Harmful Algae Blooms are becoming an increasingly present topic. It is by collecting solutions from previous projects in the profession and building upon them, that this project will be successful and then be able to present solutions that can be used by the profession as a whole. I believe this project contributes to the advancement of the profession by providing a source to turn to for future needs of wetland conservation and runoff treatment. By developing a replicable, modular system, this project can provide an excellent base to continue to be built upon.

Historical, Social, and Cultural Context

With global warming being a top topic in today's world and changes and laws being implemented worldwide for cleaner, more sustainable energy, environmental stewardship is a top social "trend" within our society today. This project directly fits into this. Long overdue, this projects is one of many that is taking a deeper look into how we are polluting the lands we love, and what we must do to change to protect our natural resources going forwards.

This project is far from the first to tackle the issues of soil or water contamination from human use. Since the first commercial use of bio remediation in the U.S. in 1972, bio remediation and phytoremediation has become increasingly more common and practical for cleaning of water and soils.

Since 1883, Lake of the Isles has been set aside for public use. This ties the lake in deeply with local culture. It attracts approximately 5.5 million users every year. It provides an escape from the city, providing a natural area with picturesque views that users love. Although there is no boating on the lake, it provides passive recreation and kayaking. Lake season in Minnesota is a key social and cultural aspect. In the winter it provides for ice hockey, cross country skiing, and biking/walking trails on the ice surface.

Performance Criteria

1. Space Allocation

Performance Measure: Area of necessary wetland space vs. run-off producing space vs. other space. Additionally, design to have no “extra” “wasted” “unnecessary” space. Every space should be designed for a very specific purpose.

Performance Measure Source: Through heavy site analysis and site development concepts.

Performance Analysis: 3D Modeling of the site to analyze and better understand the ideal spatial planning for the site. Hydrology analysis and simulation through GIS and tr55 to understand how much space must be dedicated to design interventions before separate programming can be placed.

Performance Judgment: By whether or not the site has been designed to include enough wetland/ run-off treatment space to lower water pollutants to acceptable level, or else it must be redesigned. Also, if there is any un-programmed space that is left over to serve no specific function.

2. Energy Consumption

Performance Measure: Energy required for site maintenance - for example turf grass maintenance, wetland maintenance

Performance Measure Source: By analyzing the needs for maintenance of all flora chosen for the design.

Performance Analysis: Analysis of native species necessary in creating a native habitat that is fully self-sufficient and does not need external care/ maintenance. Turf grass (and other high energy consuming materials) should be kept to a minimum or not used at all; only used if/when the programming directly requires it.

Performance Judgment: By studying each individual space as it is designed and exploring multiple possibilities in design and material in order to keep maintenance needs at a minimum.

3. Environmental Performance

Performance Measure: Duration it takes run-off to leave its origin site and enter either lake vs. how long it will after the design interventions are placed. Also, the number of locations where run-off enters the site.

Performance Measure Source: tr55 data on the existing site and surrounding neighborhoods. Also, GIS study of topography and drainage patterns to find where runoff is entering the site.

Performance Analysis: Analysis of both the tr55 and GIS data to compare the current conditions with multiple design concepts.

Performance Judgment: the number for appropriate time needed for runoff to run through the design components for proper filtration and control will be determined and the final design must meet or exceed that. For location of runoff entrance, all locations must be accounted for. They should be combined as appropriate to limit the possibility of runoff entering the site untreated. All entrance locations must have a treatment system in place.

4. Behavioral Performance

Performance Measure: Duration it takes run-off to leave its origin site and enter either lake vs. how long it will after the design interventions are placed. Also, the number of locations where run-off enters the site.

Performance Measure Source: tr55 data on the existing site and surrounding neighborhoods. Also, GIS study of topography and drainage patterns to find where runoff is entering the site.

Performance Analysis: Analysis of both the tr55 and GIS data to compare the current conditions with multiple design concepts.

Performance Judgment: the number for appropriate time needed for runoff to run through the design components for proper filtration and control will be determined and the final design must meet or exceed that. For location of runoff entrance, all locations must be accounted for. They should be combined as appropriate to limit the possibility of runoff entering the site untreated. All entrance locations must have a treatment system in place.

Site Ecological Research

Research into the site ecologic zones for plant matter provided the following information. This information on plant species will be used in the planting design for the site, specifically in the treatment wetland.

MRn93 – Northern Bulrush-Spikerush Marsh
Emergent marsh communities, typically dominated by bulrushes or spike rushes. Present mainly along lakeshores and stream borders.

Vegetation Structure & Composition
Floating-leaved and submergent aquatic plant cover is variable, frequently with water smartweed (Polygonum amphibium var. Stipulaceum) and duckweed (Lemna spp.) and infrequently with greater duckweed (Spirodela polyrhiza) and pondweed (Potamogeton spp).

Graminoid cover is variable, often consisting of dense, clonal, single-species patches interspersed with areas of open water. Community most often is dominated by bulrushes, including soft stem bulrush (Scirpus validus) and river bulrush (S. Fluviatilis), or by red-stalked spikerush (Eleocharis palustris), with lesser amounts of rice cut grass (Leersia oryzoides).

Forb cover is variable. Typical species include broad-leaved arrowhead (Sagittaria latifolia) and bur reeds (Sparganium spp.)

Shrubs are absent.

Site Ecological Research

MRn83 – Northern Mixed Cattail Marsh
Emergent marsh communities, typically dominated by cattails. Present on floating mats along shorelines in lakes, ponds, and river backwaters or rooted in mineral soil in shallow wetland basins.

Vegetation Structure & Composition

Floating-leaved and submergent aquatic plant cover is sparse, with species such as duckweed and greater duckweed frequent and common bladderwort and common coontail occasionally present. Seasonally prolific, floating clones of the liverworts may be present, becoming stranded during watertable drawdown.

Graminoid cover is variable, with lake sedge and bristly sedge commonly present

Forb cover is strongly dominated by cattails, usually with >50% cover. Other common forbs include emergent species such as broad-leaved arrowhead, marsh skullcap, small or three-cleft bedstraw, and bur marigold and beggarticks.

Shrubs are absent or very sparse

Site Ecological Research

WMn82 - Northern Wet Meadow/Carr
Open wetlands dominated by dense cover of broad-leaved graminoids or tall shrubs. Present on mineral to sapric peat soils in basins and along streams.

Vegetation Structure & Composition

Moss cover most often is <5% but can range to >75%. Brown mosses are usually dominant, but Sphagnum can be dominant on some stie.

Graminoid layer consists of dense stands of mostly broad-leaved graminoids, including bluejoint, lake sedge, tussock sedge, and beaked sedge.

Forb cover is variable, with tufted loosestrife, marsh bellflower, marsh skullcap, and great water dock common, and small or three cleft bedstraw, bulb-bearing water hemlock, northern bugleweed, linear-leaved, marsh, or downy willow-herb, water smart weed, and northern marsh fern occasional.

Shrub cover is variable. Tall shrubs such as willows, red-osier dogwood, and speckled alder can be dense, along with meadowsweet. Paper birch, black ash, red maple, American elm, and tamarack saplings are occasionally present and if so, have low cover (<25%).

Site Ecological Research

WMs83 – Southern Seepage Meadow/Carr
Open wetlands dominated by a dense cover of hummock-forming broad-leaved sedges or tall shrubs. Present in areas of groundwater seepage along streams and drainage ways, on sloping terraces, and at basses of slopes

Vegetation Structure & Composition

Moss cover is typically absent, although brown mosses may be present.

Graminoid cover is interrupted to continuous (50-100%); typically dominated by tussock sedge or aquatic sedge with bluejoint, lake sedge, prairie sedge, woolly sedge, and fowl manna grass common. Hairy-fruited sedge is dominant on some sites.

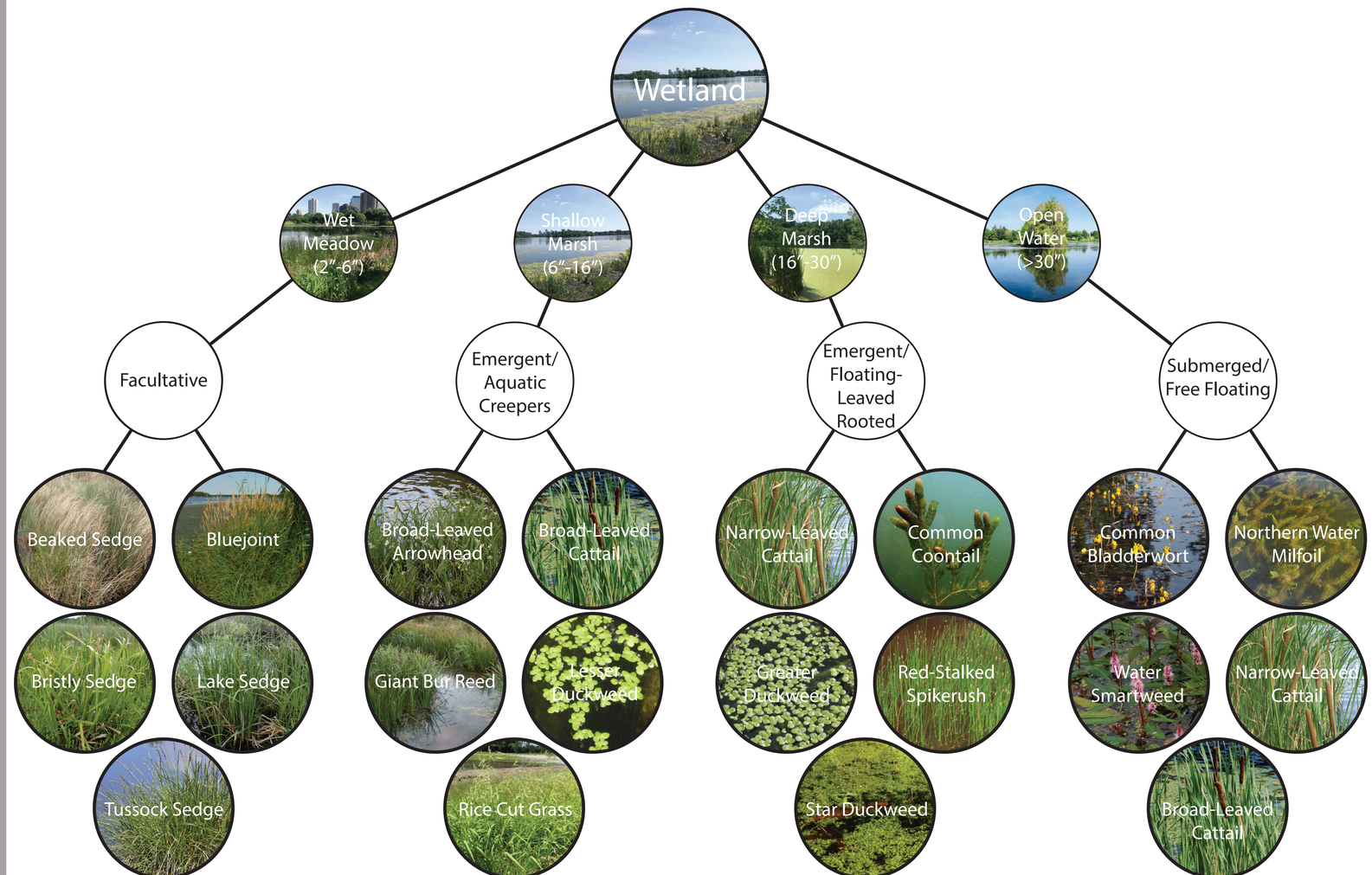
Forb cover is variable (5-75%); common species include spotted joe pye weed, great water dock, common boneset, marsh bellflower, red-stemmed aster, swamp milkweed, northern and cut-leaved bugleweeds, common marsh marigold, giant sunflower, and tough-me-nots.

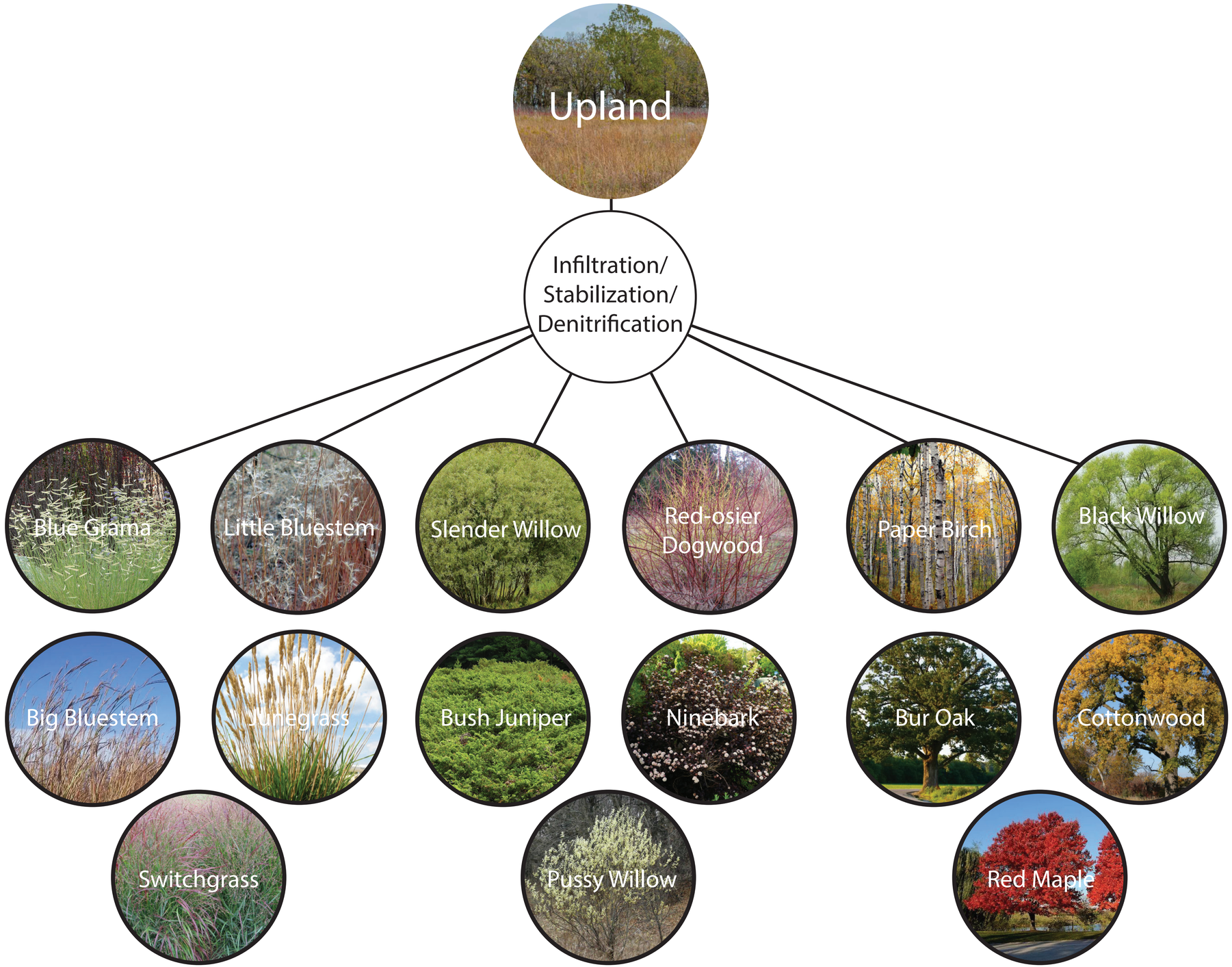
Shrub cover is variable. Tall shrubs, if present, include red-osier dogwood, pussy willow, slender willow, and Bebb's willow.

Ecosystem Zones

Based on site location in Minnesota, it falls into the previous ecosystem zones. The plant species of each of these zones was then compared with one another to find the overlapping species that would best thrive in the site location. This provides a plant palette that uses exclusively native wetland species, and a vibrant wetland ecosystem. Five species were selected per category of water depth.

For upland plants, the same process was used to narrow the palette down to five grasses, five shrubs, and five trees for use.




Upland
Infiltration/
Stabilization/
Denitrification
Blue Grama
Little Bluestem
Slender Willow
Red-osier
Dogwood
Paper Birch
Black Willow
Big Bluestem
Junegrass
Bush Juniper
Ninebark
Bur Oak
Cottonwood
Switchgrass
Pussy Willow
Red Maple

Research Summary

Phytotechnology

Remediation Techniques
-Phytovolatization
-Phytometabolism
-Phytoextraction
-Phytohydraulics
-Phytostabalization
-Rhizofiltration

Phytotypologies
-Stormwater Filter
-Surface-flow Constructed Wetlands
-Subsurface Gravel Wetland
-Floating Wetland
- Multi-Mechanism Buffer

Plant Selection
1. Species targeting inorganic Nitrogen & Phosphorus

2. Diversity but massed species planting

3. High growth rates, evapotranspiration rates, biomass

4. Low maintenance effort/cost

Research Summary

Constructed Wetlands

Wetland Typologies
-Free Water Surface Constructed Wetlands
- Horizontal Subsurface Flow Treatment Wetlands
-Vertical Subsurface Flow Constructed Wetlands
-Hybrid Constructed Wetlands

Planting Zones
-Upland Terrestrial
-Wet Meadow
-Shallow Marsh
-Deep Marsh
-Open Water

Programming
-Flow Control
-Sedimentation Basins
-Planting Zones
-Depth Pockets

Saving Minneapolis's Chain of Lakes Through Replicable Wetland Design

a design thesis by Zach Unruh
Advisor - Professor Matthew Kirkwood

Site Selection

Cedar Lake, Lake of the Isles, Brownie Lake and Lake Nokomis all experienced HABs this previous summer. Throughout the state the blooms are becoming more prevalent, but this specific site selection allows for combined conservation of wetlands with the design for high recreational use.

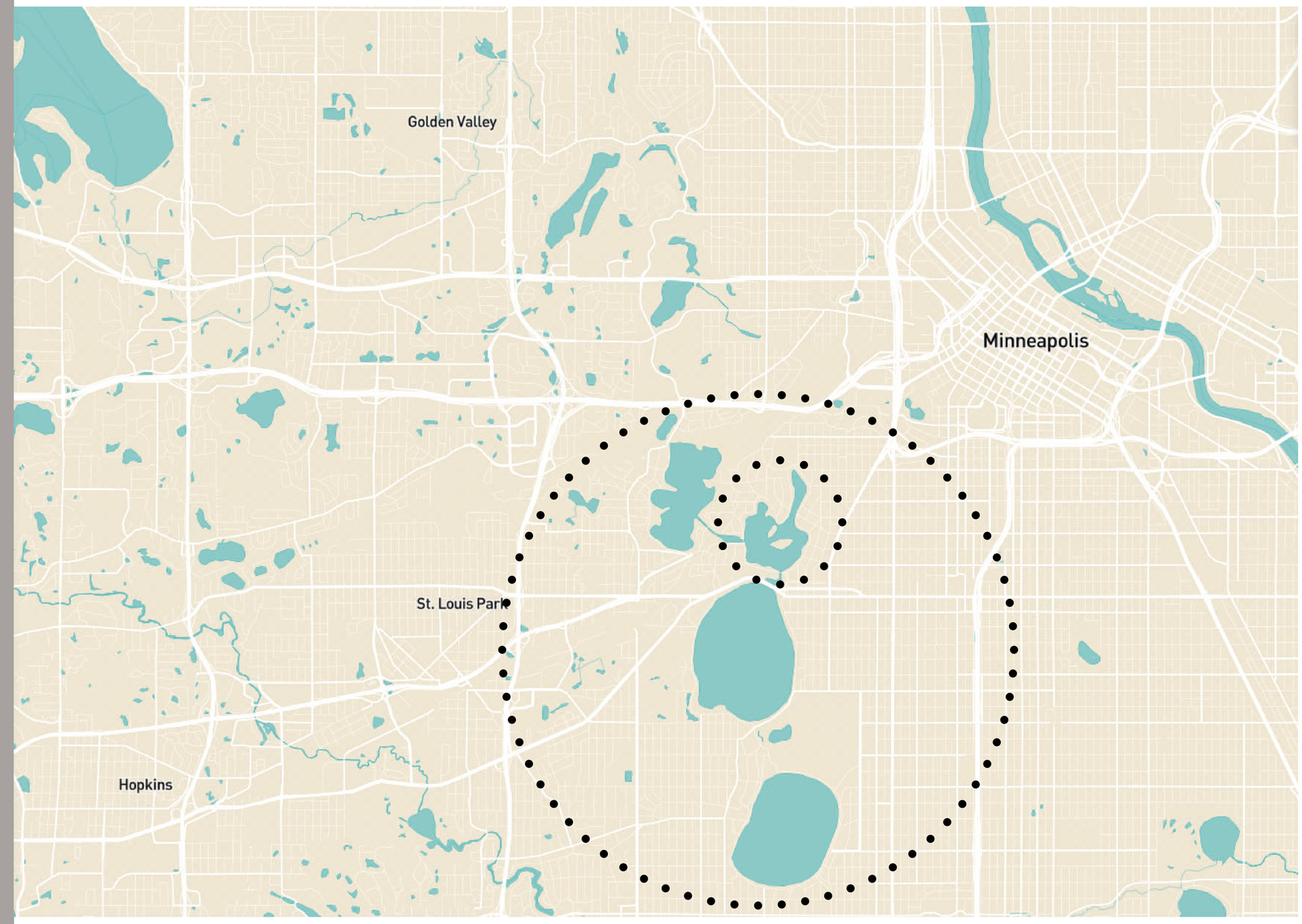
1. Stormwater Treatment Potential
Due to their location and being surrounded by heavy residential surroundings, this provides an opportunity to control the runoff coming from surrounding neighborhoods.

2. Constructed Wetland Potential
Lake of the Isles specifically has more naturalized shorelines and wetland areas, which would allow for wetland rehabilitation.

3. Programming Potential
Lake of the Isles is revered for its natural feel which would pair well with the goals of the thesis. It currently has an identity of passive recreation and kayaking, fitting well with the thesis.

The Site

Region: Midwest
City: Minneapolis
Site: Minneapolis Chain of Lakes - Lake of the Isles

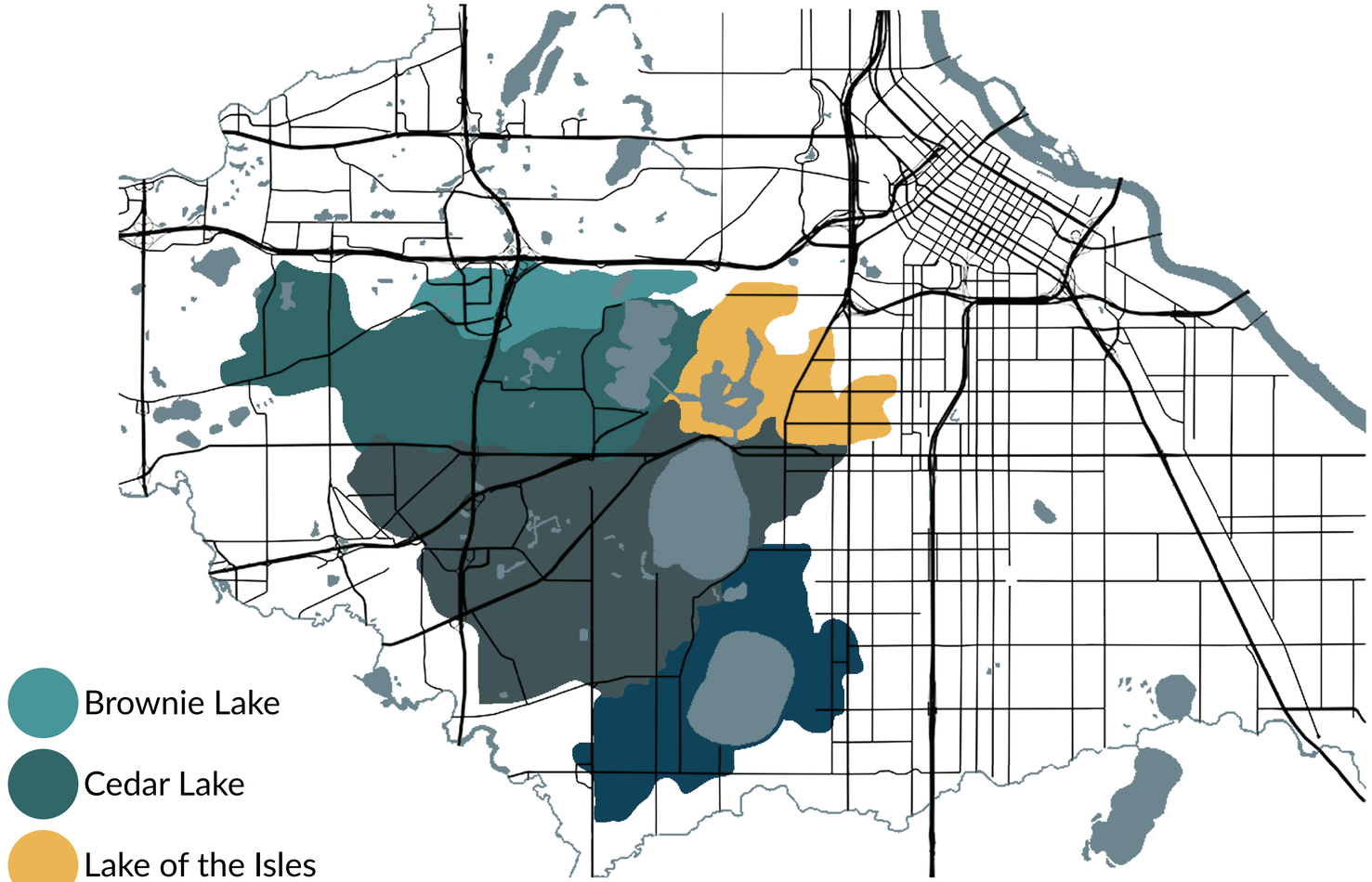


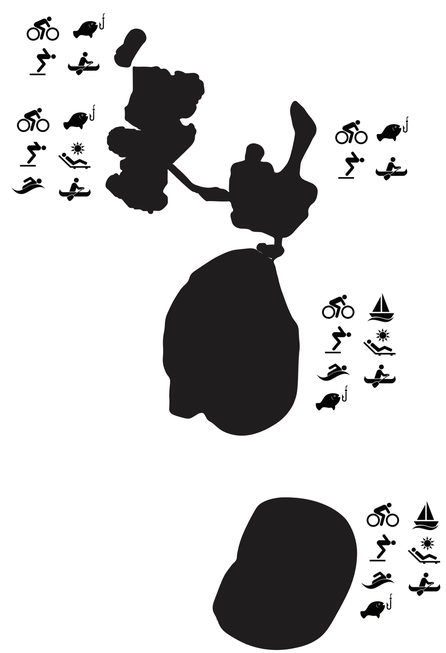
Chain of Lakes Analysis

Water Shed
- Brownie Lake - 369 acres
- Cedar Lake - 1956 acres
- Lake Harriet - 1139 acres
- Lake of the Isles - 739 acres
- Lake Calhoun - 2992 acres

Existing Programming
- Grand Rounds Scenic Byway
- Kayaking
- Canoing
- Fishing
- Swimming
- Cross country skiing
- Sailing
- Beaches

Based on the previous site selection parameters, and a study of water shed size and existing lake programming and identity, Lake of the Isles comes as the best choice for this thesis.





Application of Results

Site Selection was based off of the following parameters:

1. Level of pollutant entrance
   - City outflow points
   - Topography flow

2. Depth of water
   - Shallow for design
   - Deep pockets

3. Opportunity for upland design
   - Slope
   - Dry areas
   - Existing programming

The potential sites were then numbered according to their suitability for the design process, with 1 being the most suitable and 3 being less suitable.

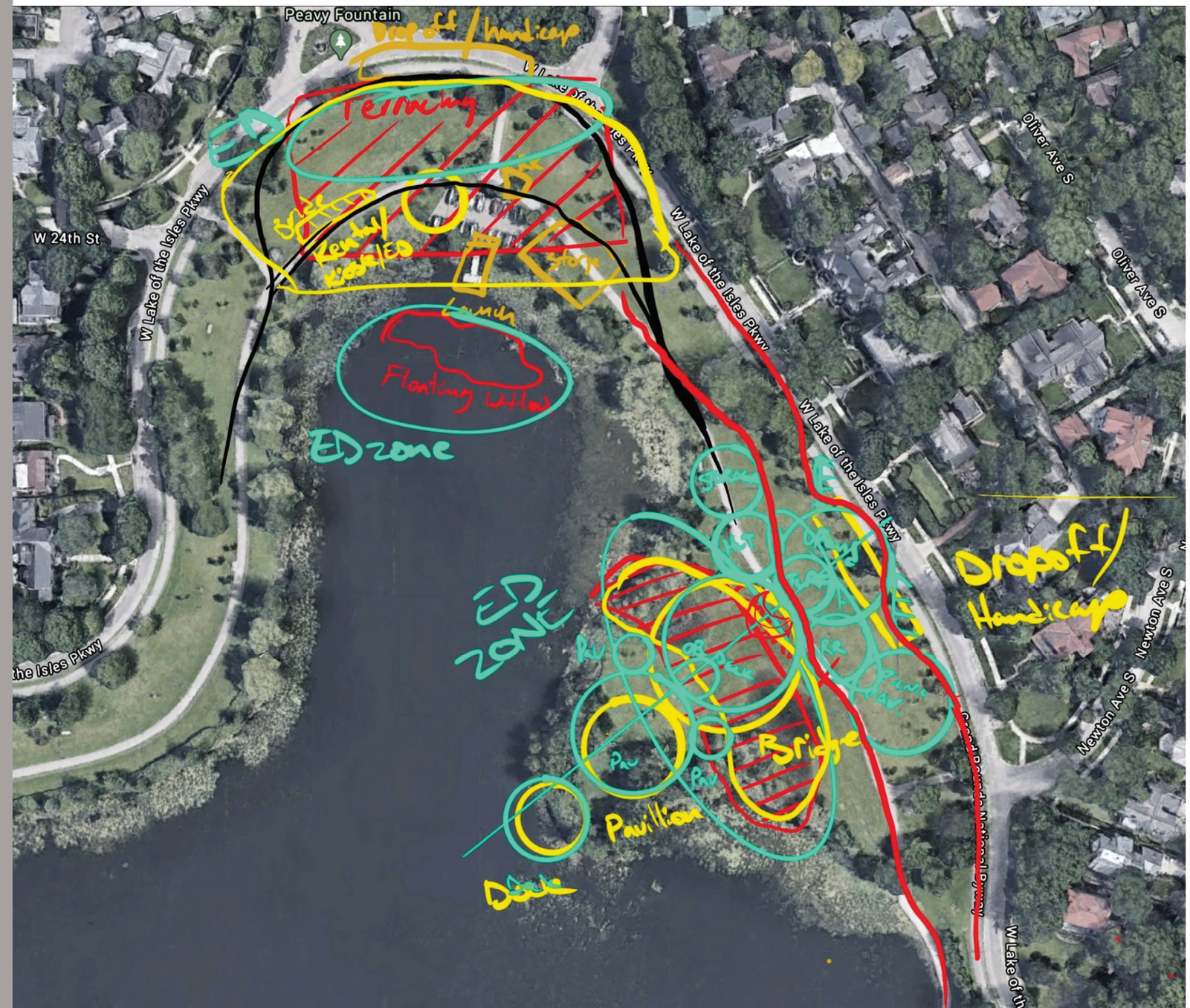
Plan Rough Draft

Design Concept

The idea behind the design is to create a natural surface flow treatment wetland and passive recreation while staying true to the image of Lake of the Isles as a picturesque, native ecosystem. The design takes advantage of the water it treats by creating scenery that changes as the water levels fluctuate and creates seasonal interest with blooming, fall colors, and prevalent native grasses that provide year round appeal.

The final design presents a functionable treatment wetland with the aesthetics that are appreciated of Lake of the Isles.

Locating the primary entrance from city outflow and topography runoff led to the terraced treatment wetland being placed at the north end of the site, while the main programming zone needed to be located in the south east corner, due to larger land area and flat topography. The treatment zone is crossed by a pedestrian boardwalk and includes meditative spaces and lookouts. Combined with the programming area is a demonstration wetland with pedestrian boardwalk bridge over the top, leading to more programming in the form of a large pavillion and meditative spaces.



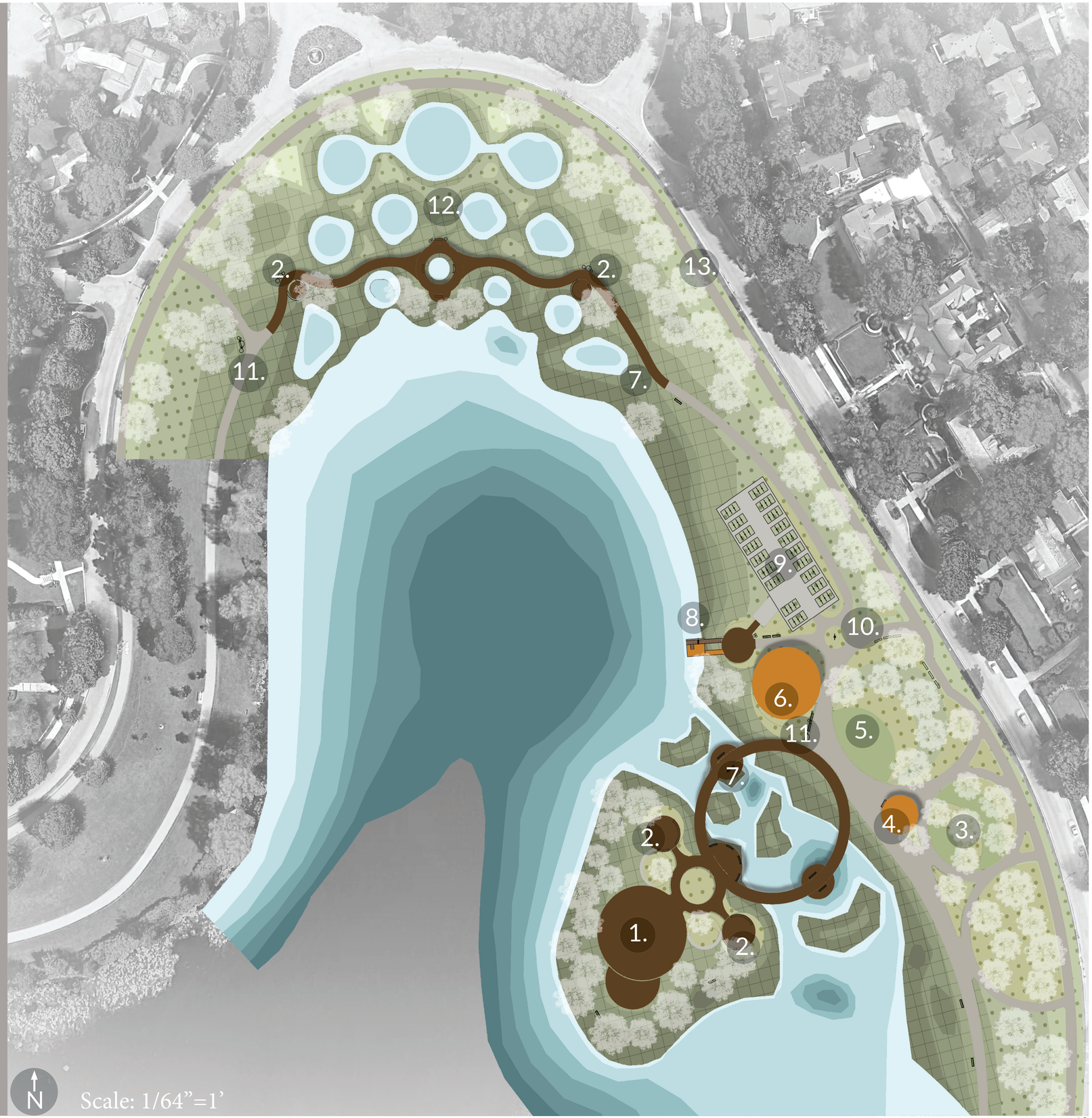
N

Site Plan

1. Pavilion
2. Reflection Decks
3. Picnic Grove
4. Restrooms
5. Turf Lawn
6. Visitor Center/ Kayak Rental
7. Wetland Boardwalk
8. Handicap Accessible Kayak Launch
9. Kayak Storage
10. Entrance Signage/ Bicycle Rack
11. Information Kiosk
12. Treatment Wetland
13. Grand Rounds Scenic Byway

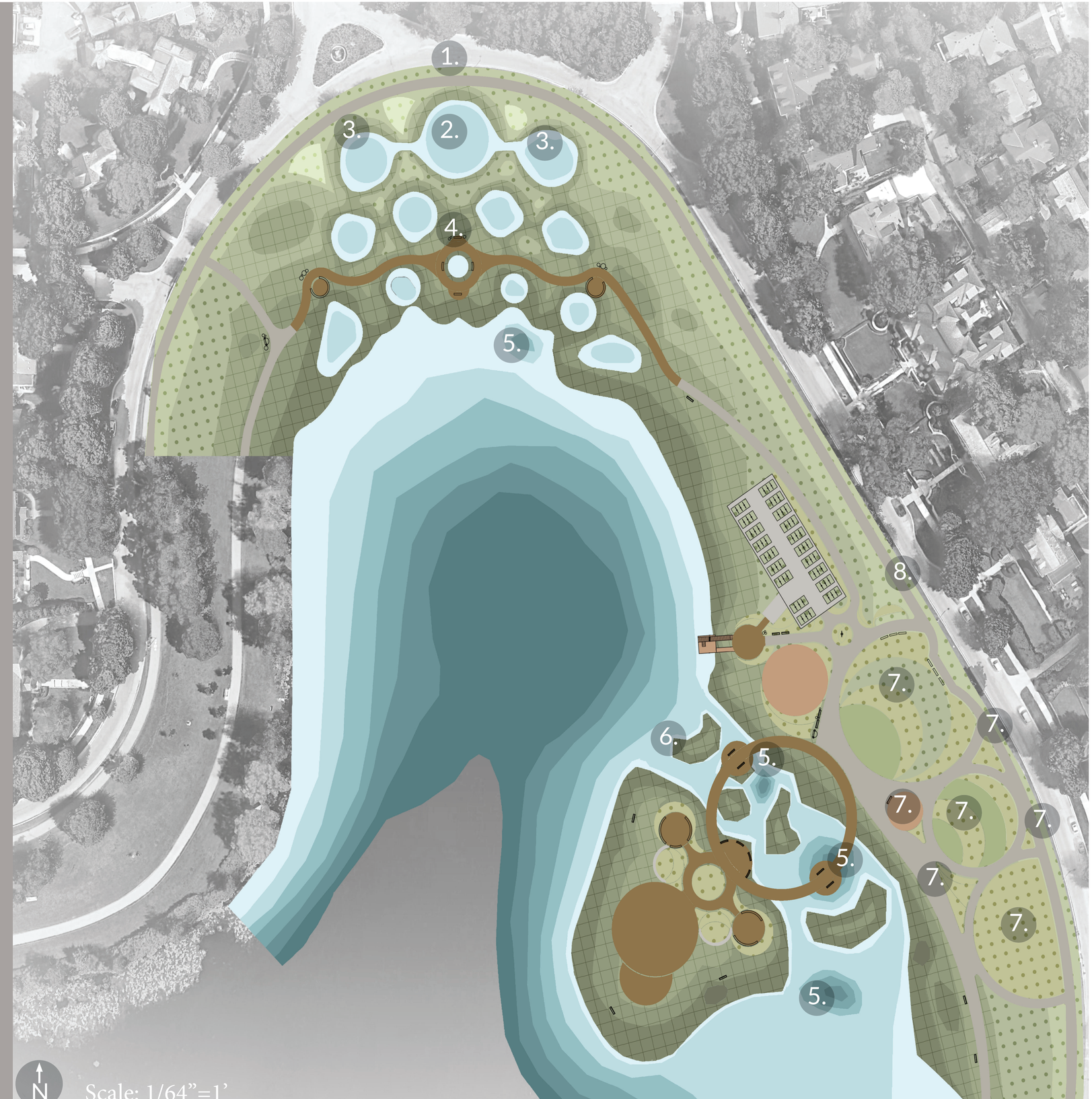
Wetland Planting

Upland Planting

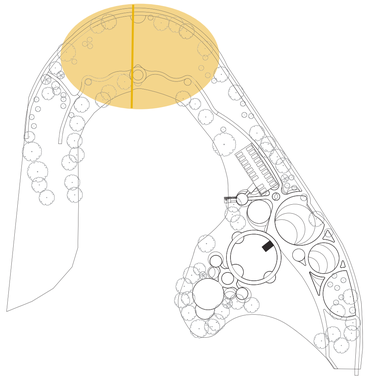


Site Plan Treatment Mechanisms

1. Primary Surface Flow Treatment Wetland
2. Primary Sedimentation Basin
3. Secondary Sedimentation Basins
4. Treatment Pockets
5. Depth Pockets
6. Secondary Surface Flow Treatment Wetland
7. Multi-Mechanism Buffers
8. Stormwater Filter



Wetland Planting Zones



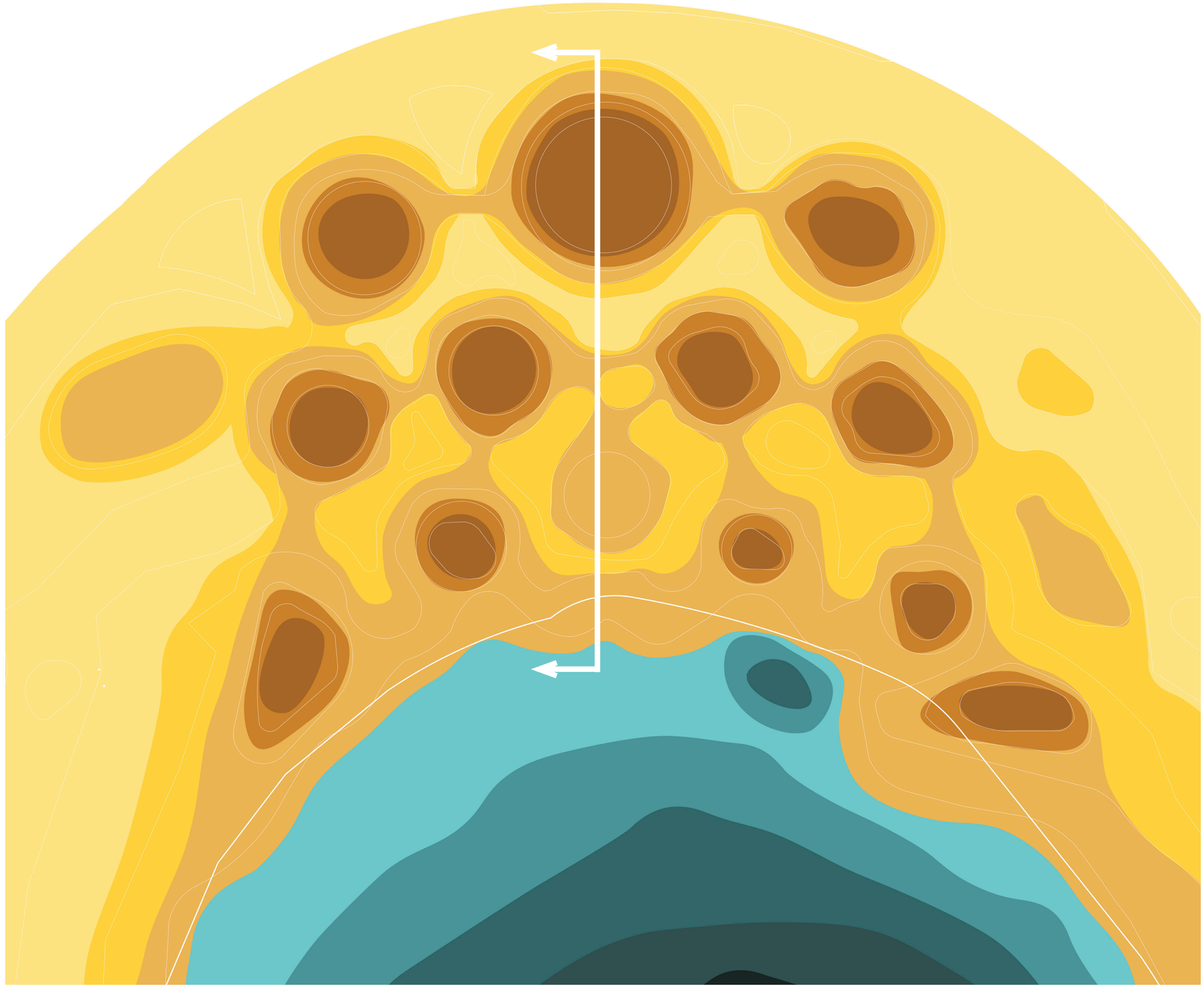
Submerged/Free Floating

Emergent/ Floating-leaved Rooted Plants

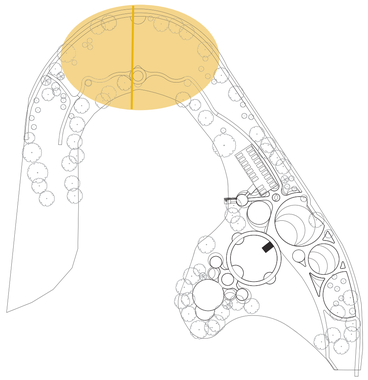
Emergent/ Aquatic Creepers

Facultative

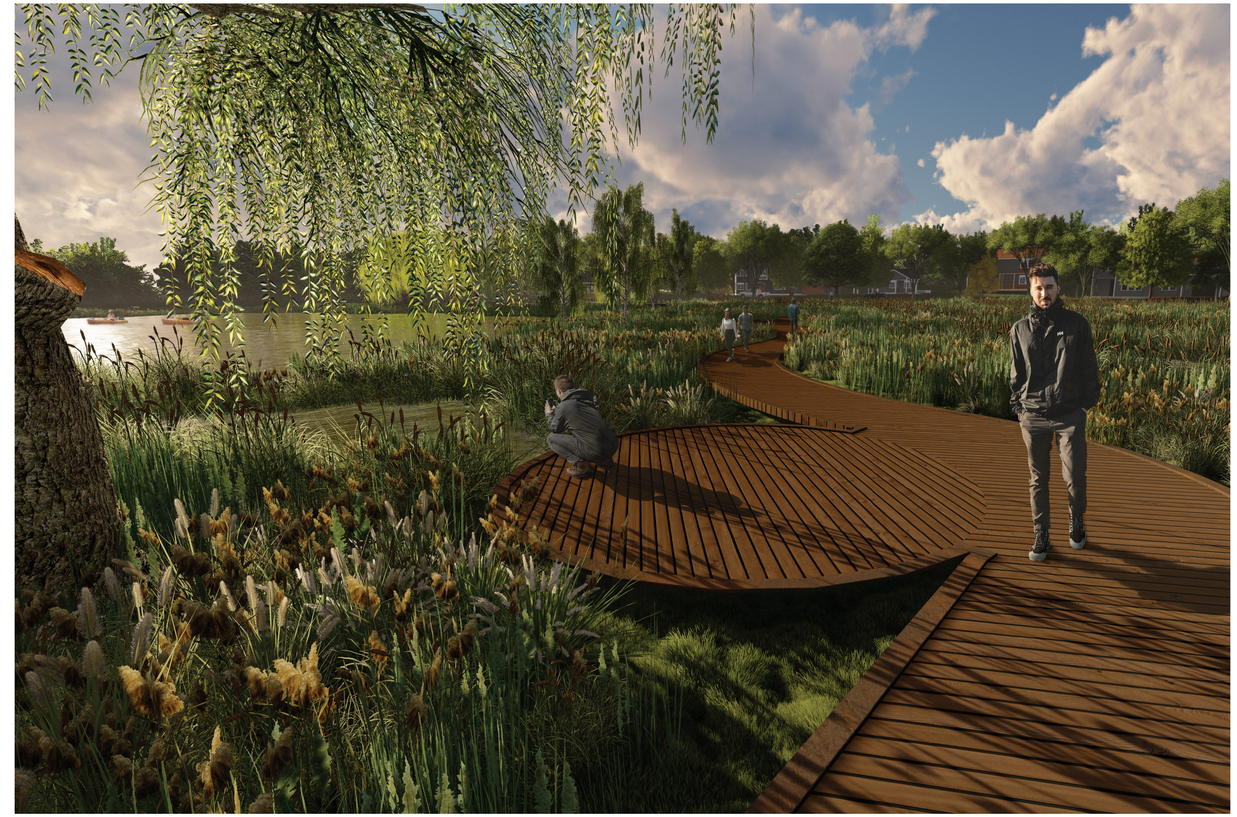
Upland



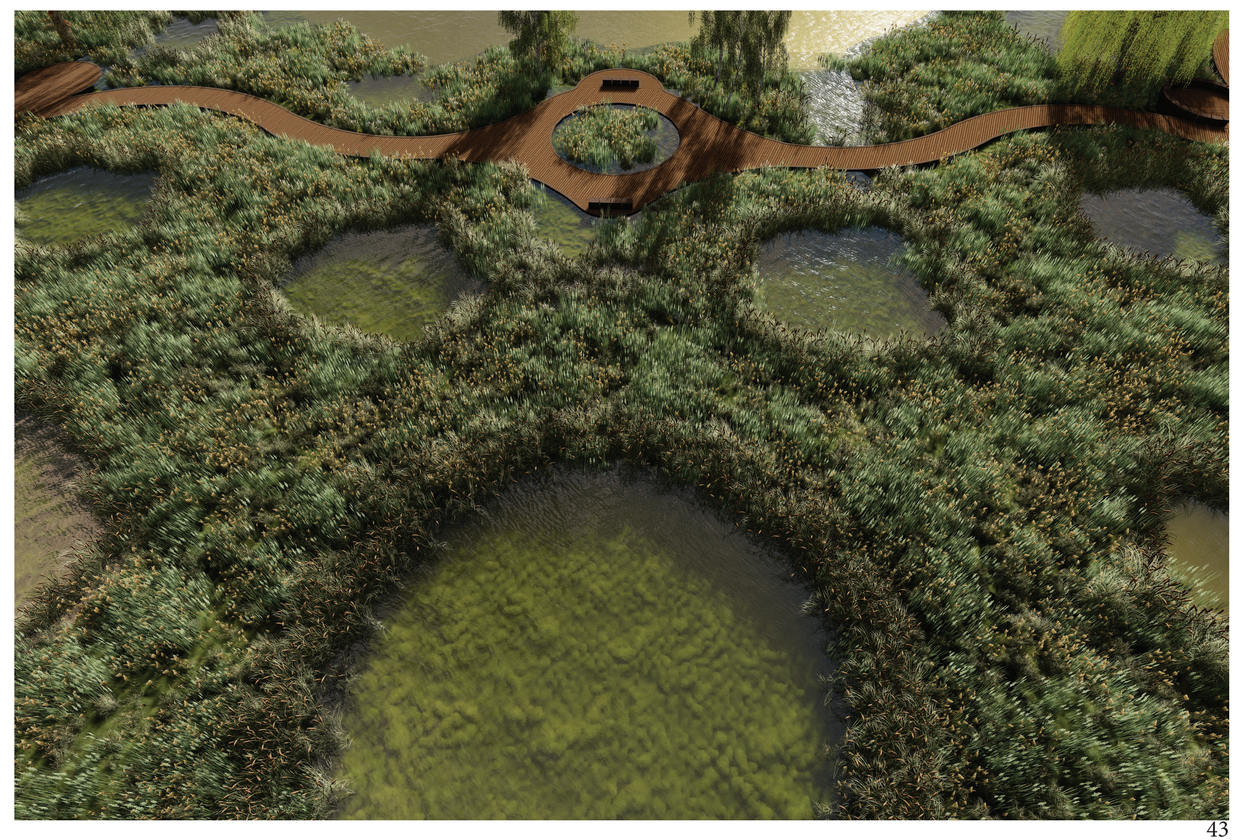
Wetland Views



1. Boardwalk View



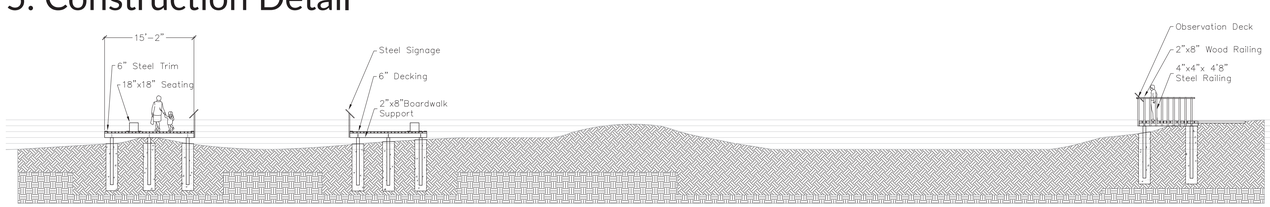
2. Wetland Aerial



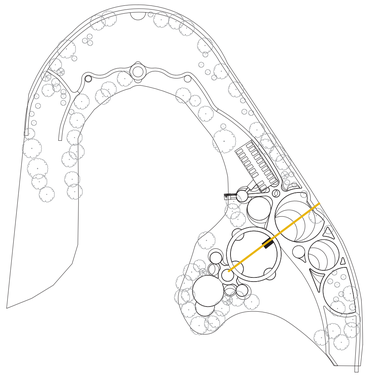
3. Existing Conditions

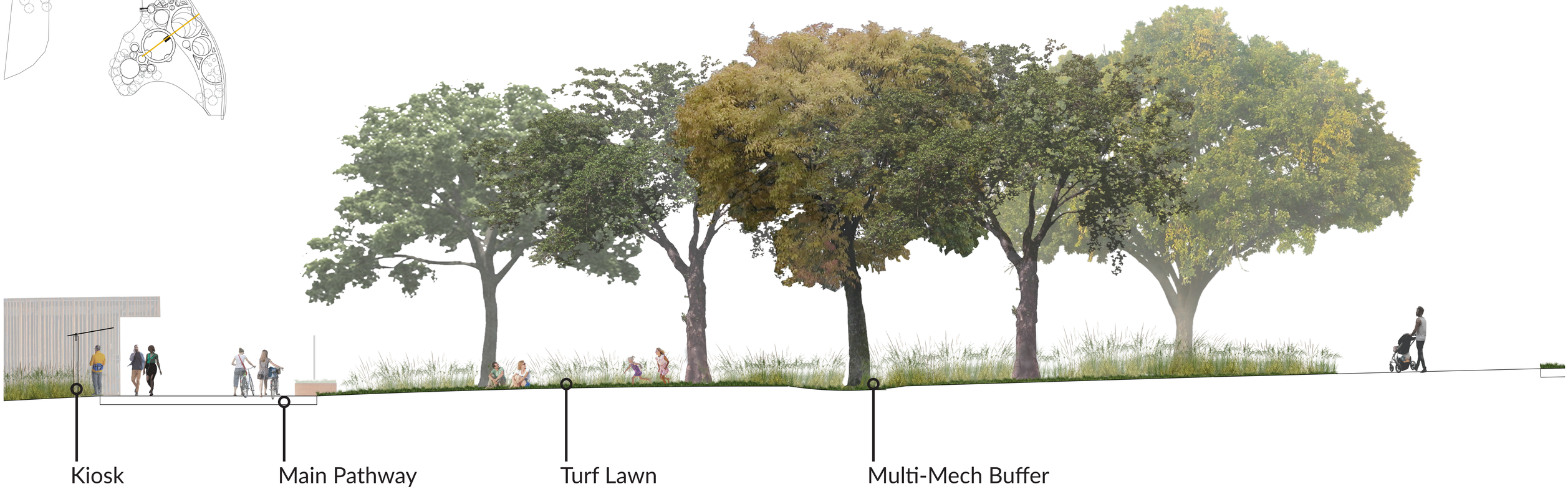
4. Proposed Conditions

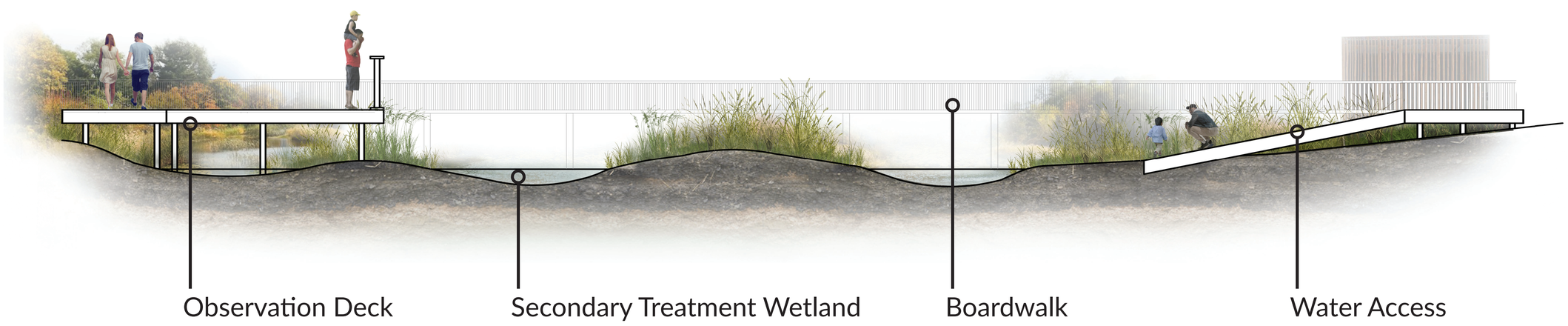
5. Construction Detail



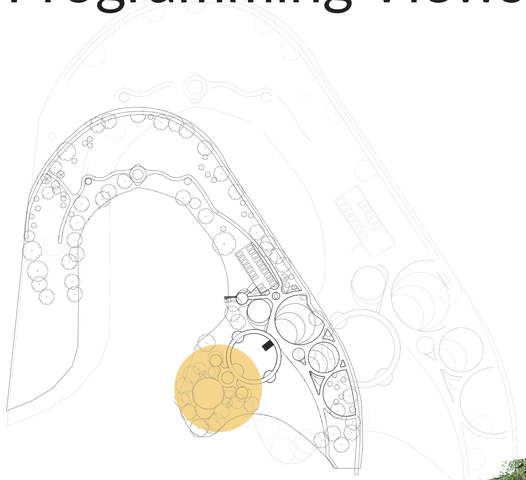
Programming Views

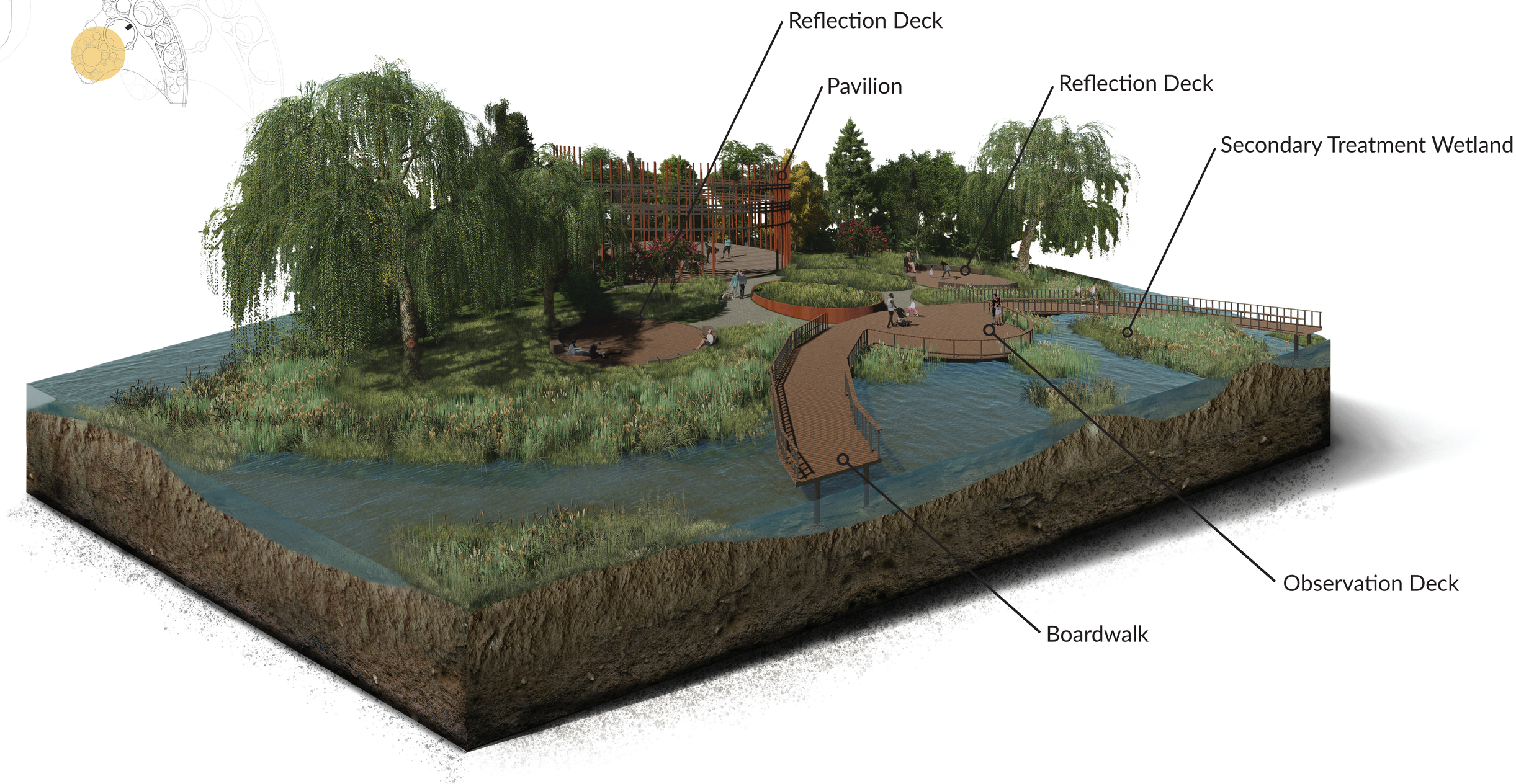






Programming Views



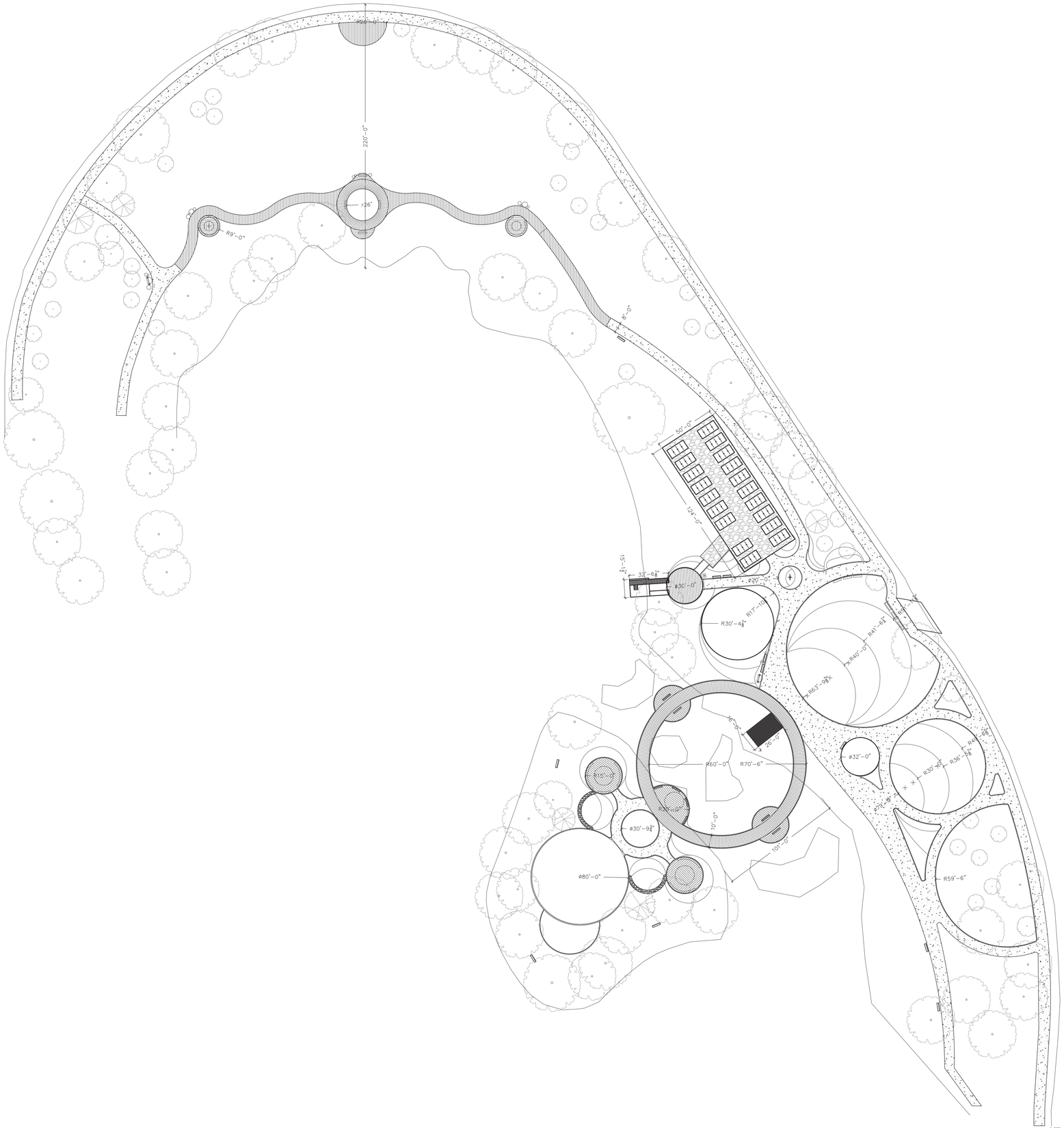


Topography and Bathymetry Plan

Scale: 1\64”=1’

Layout Plan

Scale: 1\64”=1’

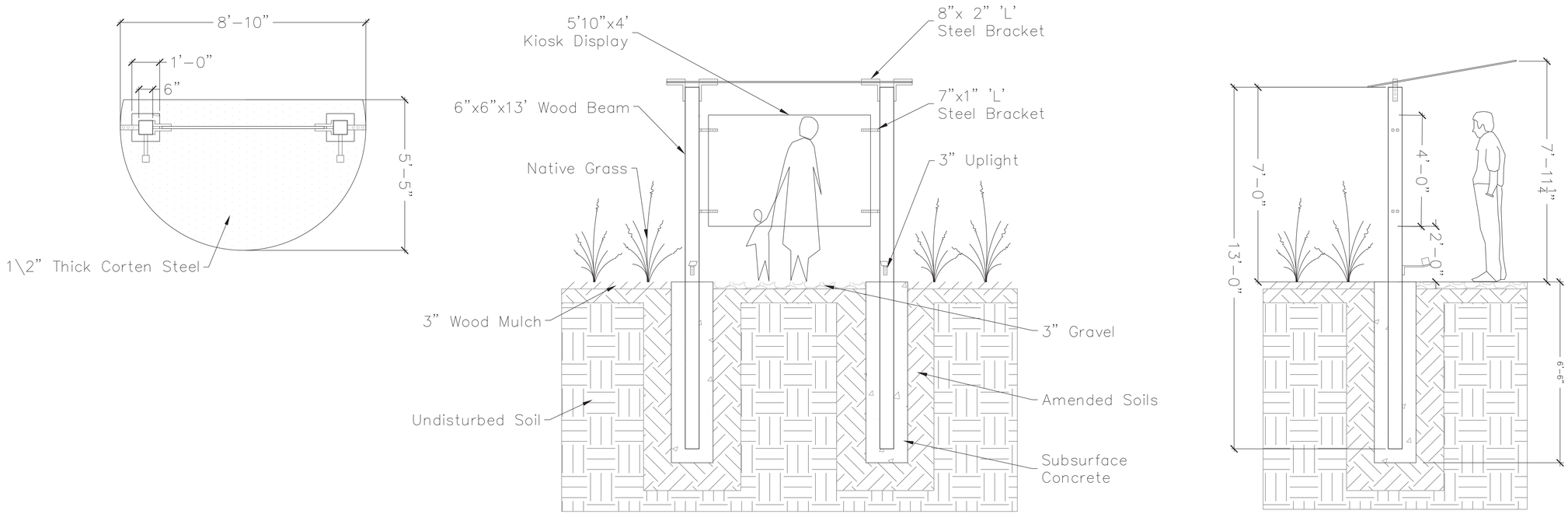


Planting Plan

Scale: 1\64”=1’

Kiosk Construction Detail

Scale: 1\2”=1’



Conclusion

-2 acre wetland for 40 acre watershed
-Site design reflective of existing image
-57% wetland increase
-8% impervious increase
- 53% turf decrease
-15 locations of treatment wetland potential

Performance analysis

1. Space allocation
   The site was designed to handle stormwater from a 100 year event. All space was utilized and programmed to its best extent.

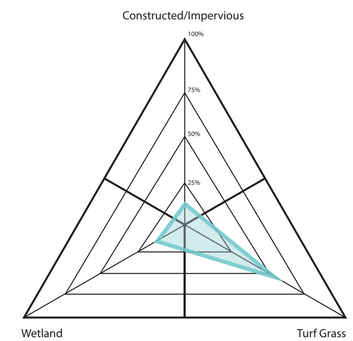
2. Energy Consumption
   Site utilizes native species which require minimum maintenance and significantly lowered the area of turf grass.

3. Environmental Performance
   Treatment wetland is sized correctly and designed properly to effectively treat stormwater before it enters the lake. The native wetland area is restored able to thrive.

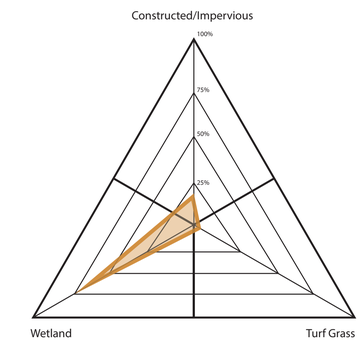
4. Behavioral Performance
   Provides opportunities for recreation and education and social engagement.

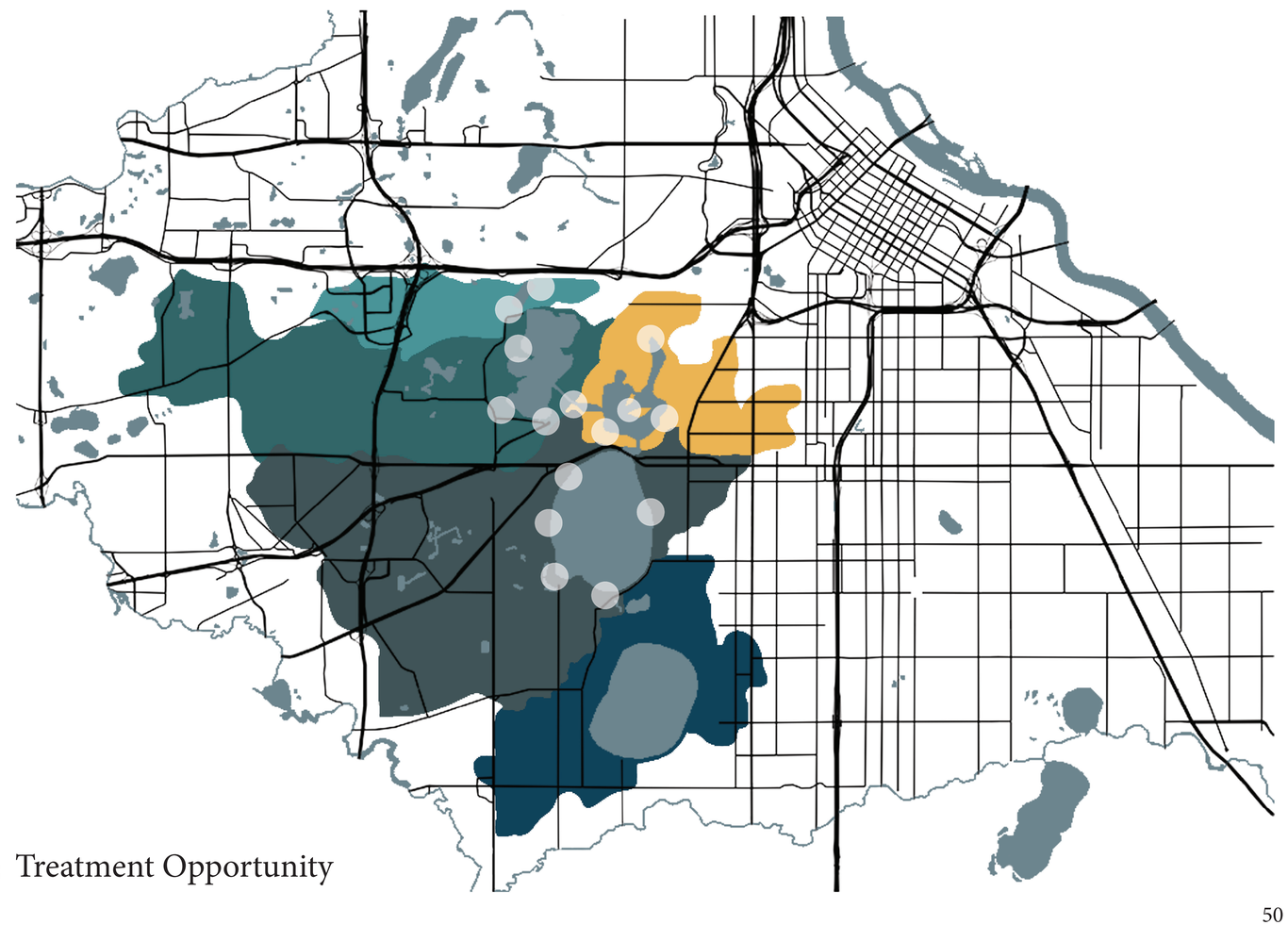
The final step of the thesis after designing a replicable wetland was to locate locations where the constructed wetland could be implemented throughout the Chain of Lakes. The following map depicts these locations.

Site 1
Pre Design



Site 1
Post Design





Appendix

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Minnesota GIS Data. https://metrocouncil.maps.arcgis.com/apps/webappviewer/index.html?appid=b514eebad49b44f3851639ef9a9a2a01

National Academy Press. (1993). "In situ bio remediation: when does it work?"

Important Resources

Design Tools
ArcGIS
Google Earth
AutoCAD
Lumion
Photoshop
Illustrator
InDesign
3D Printer
Laser Cutter

Case Studies Sources
asla.org
aecom.com
studiogang.com
dlandstudio.com

Site Resources
openstreetmap.org
mapbox.com
minneapolisparks.org
noaa.gov
epa.gov
cdc.gov
extension.umn.edu
health.state.mn.us

Studio experience

Second year
Fall 2017
Kathleen Pepple
Tea House; Moorhead, MN
City Farm; Fargo, ND

Spring 2018
Dominic Fischer
Downtown Fargo Plaza; Fargo,ND
Viking Ship Park; Fargo, ND

Third year
Fall 2018
Jay Kost
Mid America Steel; Fargo, ND
342 Broadway; Fargo, ND

Spring 2019
Anna Maria Visilia
International Design Competition; Zagreb, Croatia
Olive Tree Park; Amfissa, Greece

Fourth year
Fall 2019
Dominic Fischer
Lower East Side; Manhattan, NY
Moorhead Center Mall, Moorhead MN

Spring 2020
Jay Kost
Estes Park Downtown Masterplan; Estes Park, CO

Fifth Year
Fall 2020
Matthew Kirkwood
North Country Trail; Eastern ND
FM Diversion; Fargo, ND

The Author

Zachary Unruh
[redacted]