

NORTH WOODS

**PROMOTING PHYTOREMEDIATION DESIGN TECHNIQUES AND PUBLIC
EDUCATIONAL OPPORTUNITIES FOR THE TWIN CITIES ARMY AMMUNITION PLANT
[ARDEN HILLS, MINNESOTA]**

NORTH WOODS

PROMOTING PHYTOREMEDIATION DESIGN TECHNIQUES AND PUBLIC EDUCATIONAL OPPORTUNITIES FOR THE TWIN CITIES ARMY AMMUNITION PLANT

A DESIGN THESIS SUBMITTED TO THE
DEPARTMENT OF ARCHITECTURE AND LANDSCAPE ARCHITECTURE
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BY
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Primary Thesis Advisor



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THESIS ARCHIVAL NOTE

The following thesis project, entitled ***NORTH WOODS***: PROMOTING PHYTOREMEDIATION DESIGN TECHNIQUES AND PUBLIC EDUCATIONAL OPPORTUNITIES FOR THE TWIN CITIES ARMY AMMUNITION PLANT, was composed over the course of the 2016-2017 academic school year. The Thesis Program, as contained here, was initiated and completed in the fall semester as a part of the LA 563: Programming and Thesis Preparation course. Supplemental material, including the Thesis Boards and the Thesis Presentation documents, were generated in the spring semester as a part of the LA 572: Design Thesis studio. Any inconsistencies between the different documents, in terms of research and design, should be disregarded per the evolution of the project across the two semesters.

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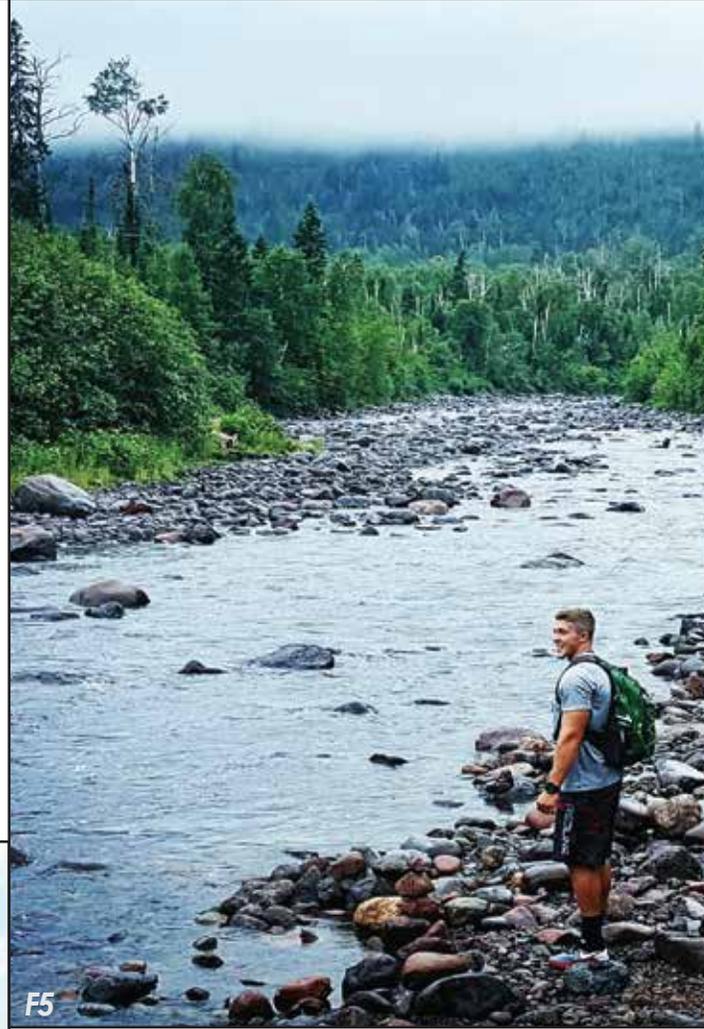
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As the human population increases and expands from growing urban environments, many pressures are imposed on the undeveloped natural wetlands. Traditional practices of land development produce high amounts of risk for the natural environment by creating large regions of impervious areas, hence devastating and destroying the hydrology, infiltration rates, and buffer zones of these specific ecosystems. The enormous amount of polluted runoff built environments produce is increasing erosion, vegetation disruption, and the introduction of toxic materials into wetlands, thus changing the water quality, the health, and hydrology of the site.



F5



F6

Growing up in the mid-west provided me with countless opportunities to explore the outdoors whether it be hunting in North Dakota all the way to hiking in Northern Minnesota with family and friends. Water has always been an interest of mine, the flow, the consistency, and sounds. If it wasn't for these life experiences, I would not have the love for nature like what I do today, from this is where I found my interest in design. Landscape Architecture provides me with a way to give back to the programs, organizations, and people that have given me the opportunity to explore and love what nature has created.



STATEMENT OF INTENT

The Thumb", located within the Twin Cities Army Ammunition Plant was the primary source of ammunition production in the United States during WWII. In 1983, this location was added to the National Priorities List as a Superfund site, this was because of the vast amount of use the land endured. Because of this, there are large amounts of acids, metals, pesticides, and more within the ground to this day. Incorporating a solution through landscape design will help reduce the amounts of pollution over time. Proposing a system of wetlands that will apply practices for both surface and sub-surface runoff thus



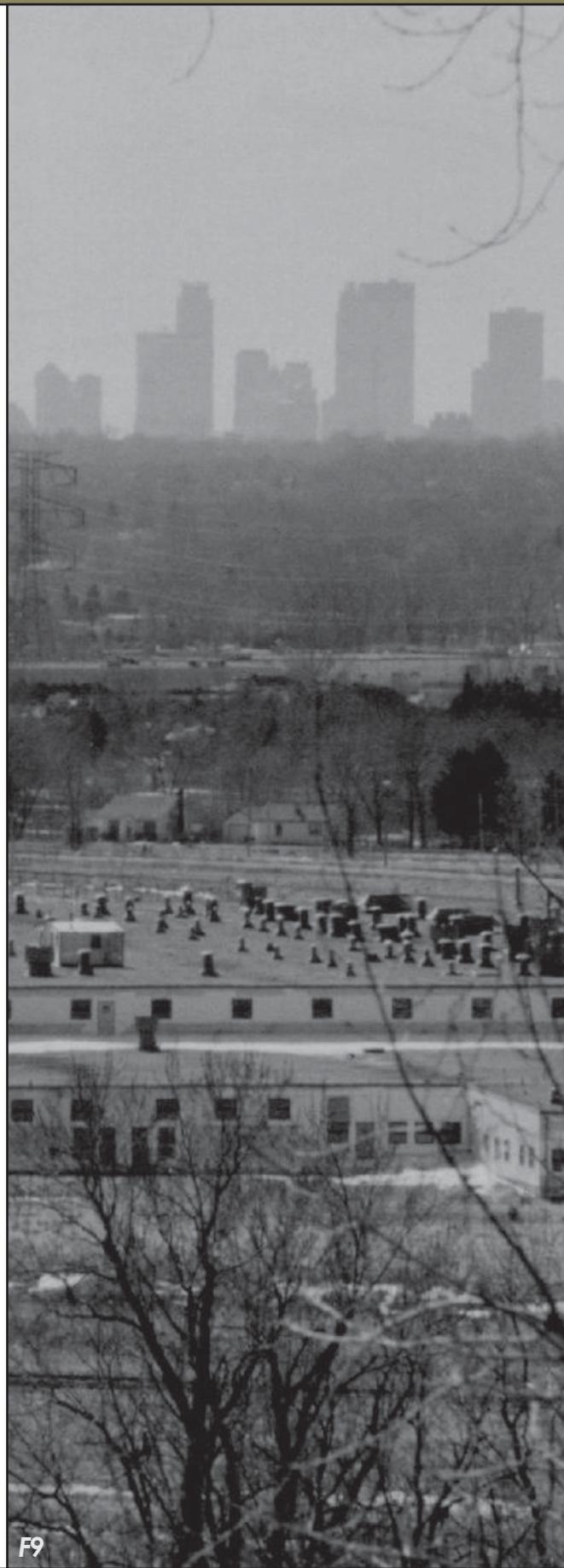
F8

INTRODUCTION

DEDICATION



The "Thumb" is a piece of the TCAAP (Twin Cities Army Ammunition plant) located in Arden Hills, MN. The entire TCAAP site itself is 2300 acres bounded by County Road 1 to the North, I-35W to the West, and U.S. Route 10 to the Southwest. This area was built as a part of the government-owned, contractor-operated (GOCO) war materials production program that was established by the Governmental War Department during WWII. The plant itself produced .30, .50, and .45 caliber ammunition until 1976 when it was put on standby, in 2002 more than 600 acres were declared "in excess" by the United States Army. Then in 2002, more than 600 acres were declared "In excess" by the United States Army, this allowed for Alliant Techsystems to continue manufacturing munitions there until as recently as 2005 when the U.S. closed all production due to pollution levels. This is where the idea of redevelopment was being brought to the table by a committee for the Minnesota Viking Football Team, they put in a bid for the land to be the new home field but failed due to pollution levels. Rice Creek is a located on the site and runs from north to southwest until finally reaching the Mississippi, this is the main feature of the site. Conservation of the area around this stream is crucial because of the pollutants being brought downstream through the watershed, by proposing sustainable techniques such as designing wetlands, the task of pollution removal can be easily obtained.





F10

Do to the large amounts of pollutants located on the TCAAP site (hydrocarbons, acids, pesticides, etc.), a sustainable system must be put into play in order for this area to be redeveloped again. Wetlands are water covered soil, either present or near the surface of the soil for varying periods amount of time during the year, including the growing season. The water saturation (hydrology) is largely dependent on the soil types, plant types, and animal types living within that represented ecology. Specific types of wetlands have different purposes when passing runoff through them. Also different plant types help absorb chemicals in the water either surface or sub-surface over time, this cleanses the water that is passing through before entering creek beds, rivers and lakes. The idea behind using different wetland systems is to help clean the surrounding “Thumb” (TCAAP) soils which contain the previously stated pollutants. By having plant species, surface and sub-surface water systems, and sustainable practices, the TCAAP soils will slowly come back to health. Implementing sustainable systems will help the natural ecosystem by removing harmful pollutants from previous years. By proposing a designed wetland system, the overall watershed with this region of the state will gradually become healthier downstream thus providing safer conditions for plants, animals and humans.



PROJECT TYPOLOGY



WETLAND ECOLOGY
CREEK MANAGEMENT
RUNOFF CONTROL



F14

HYDROLOGY AND PLANT TYPES

Author Dennis F. Whigham (biologist), explains the specifics of wetland ecology in his book **“Science of the Total Environment: Ecological Issues related to Wetland Preservation”** (May 1999). Whigham explains with his research that wetlands are only able to survive and thrive based on two items; hydrology and plant type. By this he means that the correct type of systems need to be in place in order for the wetlands to even be considered wetlands. Two main type of wetlands are tidal and non-tidal wetlands, the tidal wetlands are those near ocean currents and the non-tidal would be classified as those near lakes, rivers, pond, etc. The non-tidal wetlands will have standing water whether it be surface or sub-surface for an estimated time annually. The tidal wetlands will have standing water but only based on the size and duration of the ocean flow. From this, the classification of the “Thumb” and the proposed wetlands needed for this area are going to non-tidal, but will be broken down into separate sub-fittes based on the type of system being used. The watershed containing these wetlands will be affected by the hydrology levels, functionality, cleanliness of the working systems whether it be surface or sub-surface. This author was able to specify what plant types and water levels are sufficient for cleaning the passing runoff, but fails to define what a suitable design would look like.

F14



WATER QUALITY IMPROVEMENT

In Gerald A. Moshiri's "**Constructed Wetlands for Water Quality Improvement**" published in 1992, he looks at the issues pertaining to water quality within urban and rural areas. The areas that he was looking into were the zones around the constructed wetlands, these zones didn't have a filter systems or sustainable aspects that would clean the water before entering the constructed wetlands. The ideas Moshiri had involved adding buffer systems around the edges of the constructed wetlands, this would allow for the runoff coming into the site to be cleaned first. The research that Moshiri had done seemed to be a viable factor when trying to fix a water quality issue, he had different results based on where the test was done and what the variables were surrounding each of the locations. In the urban setting much of the runoff entering the site didn't have a chance to be cleaned because of the vast amounts of hardscapes and gutter systems the water had to pass over or through. The rural areas were the opposite because the passing runoff didn't have to travel through gutter systems, the water was able to pass through lawns and wooded zones where the quality was vastly improved before entering the constructed wetland zones. From these test Moshiri was able to analyze how the areas outside of the study zone can affect what the results are. This didn't end up becoming a design based plan, but by researching the human elements, including built and none build items, the proposed future site design of the "Thumb" will have increased water quality levels.

HUMAN INTERACTION

The research done by Allen P. Davis in "**Green Engineering Principles for Human Circulation**" (Sept. 2006) goes into detail on how we can eliminate the human carbon footprint on the environment. Davis describes the various ways we are destroying important pieces of nature whether it be in an urban setting such as a park or in a rural location like a national park. His research looked into why many individuals cross over section of grass along sidewalks, cut through tree groves, create new paths not designed for foot traffic, etc. Much of the results came back the same, the individuals are trying to save time or want to interact with the environment more than what is presented to them. At this point Davis came to many conclusions as to what possible actions could be put into place for adjusting these issues, incorporating more vegetation based design while setting the path to be the shortest distance possible while in urban setting. The results given did not go into detail about the best possible way to design around these issues though. These important findings help in the thought process and proposing a human circulation system (such as a boardwalk) that will let the public interact with the environment but not disturb the ecosystem will be the challenge.

POLLUTION CONTROL

In June of 2014 the Watershed Forestry Resource Guide published "**Watershed Protection and US Forest Services: Environmental Protection Practices**". This article explained the importance of keeping watersheds clean, not only through sustainable practices but also alongside with the addition of vegetation and trees. This is important because in order to have a healthy ecosystem it starts from the bottom up, and water is the foundation of life for all living things. Applying this to the knowledge of the soil condition on the TCAAP site will help in reducing the levels of toxins. The article did not go into detail pertaining the approximate or appropriate way to apply correct methods in cleaning the water but it did state that in order to protect the watershed the runoff that is passing through needs to be clean. This is important because if the toxins are being passed through the watershed (surface or sub-surface), they can be getting caught in downstream locations which in turn can just add additional issues in the long term. Applying knowledge pertaining planting locations, buffer systems, filtration systems, sedimentation ponds, etc., can help in the end design thus assisting the removal of pollution on and off the site.

Wetlands perform an array of ecological functions when it comes down to water purification and the water quality. As stated by the Department of Ecology – State of Washington, in a recent article “Water Purification through Wetlands” (June, 2015), wetlands protect water quality by trapping sediments and retaining excess nutrients and other pollutants such as heavy metals. Tying this back into the TCAAP site is an important feature because of the history of the site, the vast amount of hazardous materials that still sit within the soil. This would not be such a large issue if the TCAAP site was isolated from a surface water source such as Rice Creek, but since this stream moves through the site it has a higher potential to harm the environment. Adding specific types of wetlands to the TCAAP site would reduce the amount of pollution that would head downstream and through the watershed. By specifying where and what type of wetlands will go where on the site the reduced amount of pollutants will not harm drinking water supplies, swimming, fishing, or other water based activities.

Sediments, nutrients, and toxic chemicals enter wetlands primarily through off site runoff, a term used to describe the rain and storm water that travels over land surfaces on its way to larger bodies of water. In urban areas runoff may wash through streets and gutters, over buildings such as industrial, commercial, and residential, where it may pick up pollutants and carry them down the watershed.





In rural areas, the runoff may pick up sediments that have come from agriculture or forested lands which can also interrupt the water quality of a large body of water. This runoff may carry pesticides and fertilizers which have been applied to specific farmlands. Runoff waters often carry nutrients that can cause water quality problems in large bodies of water such as a lake. This has been known to create “algae blooms”, large green smelly smite that builds up in areas contaminated with too much nutrients. To combat this, wetland sedimentation ponds are an answer, this allows for nutrients and toxics to slowly move through the shallow body of water classified as a wetland thus helping the pollutants fall to the wetland floor. From this the plants will eventually uptake the pollutants, in turn getting rid of 94% of the pollutant, the plant will have the chemicals inside of it but gradually overtime the amount of toxins will decrease. Because of the large amounts and variety of toxins located on TCAAP, the application of wetlands will help reduce the overall levels of pollutants thus increasing the water quality for the entire watershed downstream.



PROJECT GOAL

KEEP 100% OF STORMWATER ONSITE TO BE TREATED BEFORE HEADING DOWNSTREAM IN WATERSHED



OBJECTIVES TO OBTAIN PROJECT GOAL

1. REDUCE RUNOFF THROUGH SITE DESIGN
2. REDUCE POLLUTANTS COMING INTO SITE
3. CAPTURE AND TREAT RUNOFF

REDUCE RUNOFF THROUGH SITE DESIGN

Using site planning and design techniques to reduce impervious cover will help to lower disturbed soils and storm water impacts not only on site but surrounding the site as well. As stated in Protection Center for Watershed's recent article, "**Approaches to Stormwater Management**" (August 2016), the less runoff that is coming into the site, the less chance of bringing in unwanted substances and pollutants. Designing systems using sustainable techniques will help when trying to keep the runoff from entering the site but also if needing to revert the water in a different direction before entering the site. The idea is to have any of the offsite runoff that does make it to the site, first come through the wetland section of the TCAAP, this will ensure that the water will have time to be cleaned and filtered before moving its way into the creek bed. This is important because of the previously stated issues that offsite runoff can have on specific areas. By having buffer systems and other water entry way systems on the edges of the site, this will ensure that the water entering the site will be cleaned, then become safer in all aspects.



REDUCE POLLUTANTS COMING INTO SITE

The next objective in order to achieve the final project goal will be to reduce pollutants coming into the site. This will be important because of the wide variety of pollutants created by humans and the environment each and every day. Much of the rainfall captures sediment and pollution while it runs through streets, gravel roads, fields, etc., this is why diverting the areas of higher pollution will be important. The areas of higher pollution will need to be identified first, then after this is done a combination of buffer systems, diversion systems, and/or pollution filtration systems can be placed along this zones. To ensure the safety of the site various practices must be put into the site design when dealing with the off site runoff that is going to make its way through the designed areas, as stated by Agency Wetland and Protection's recent article, **"WARPT: Wetlands-At-Risk Protection Tool"** (May 2015). The safety of the site is not only important for the people that will be visiting the site but also for the built and non-built environments that were designed there. Protecting all aspects of the site design is just as important as creating a sustainable design but the main concern is creating systems that will decrease high pollution levels and increase the water quality levels.

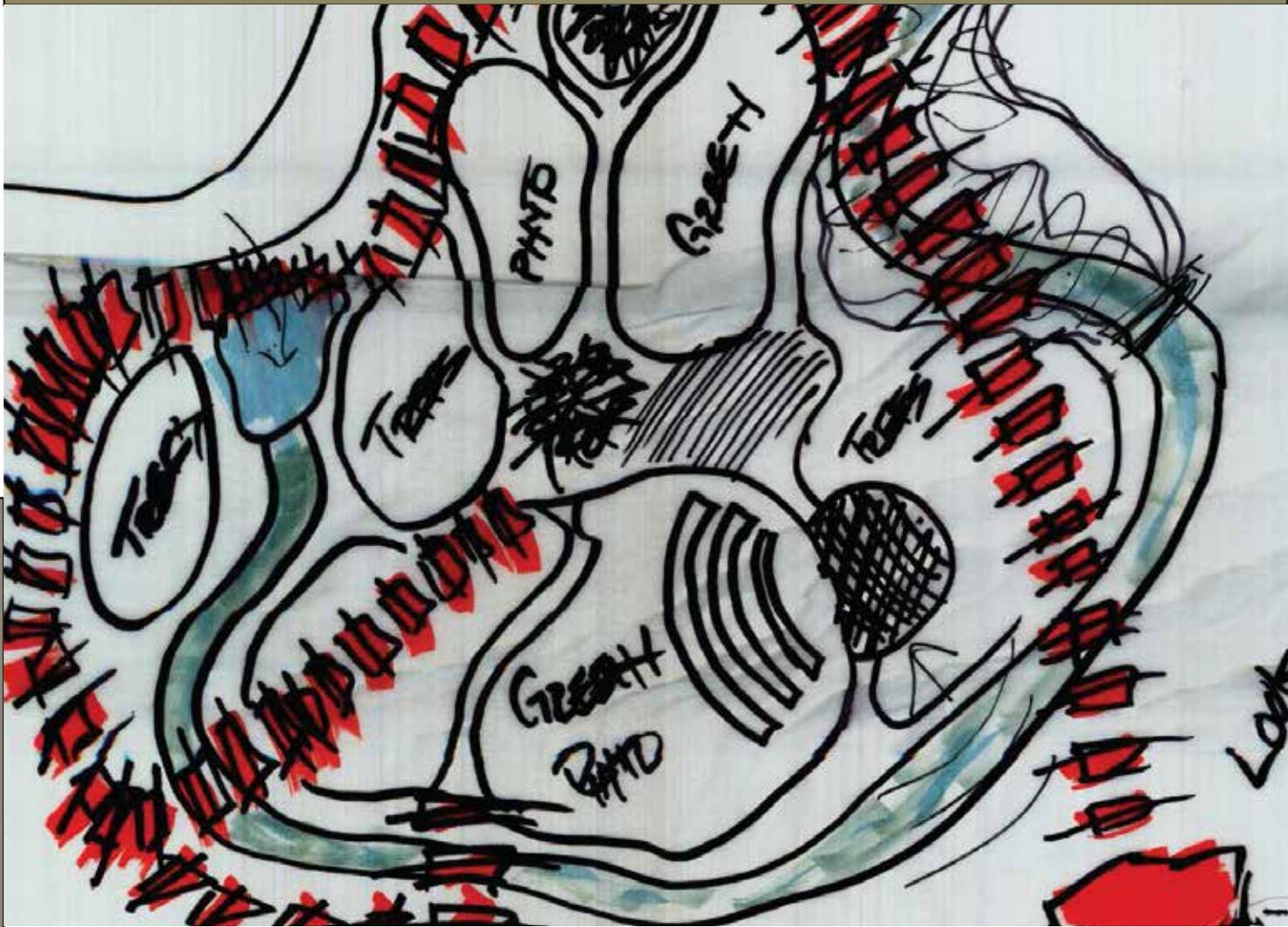
CAPTURE AND TREAT RUNOFF

After diverting the off site runoff either to a new location or if worst comes to worst, onto the site, it will need to be captured and treated before being able to leave. This will be made possible by setting up a wetland system, this system will be a human made constructed wetland system which its purpose will be to capture all rainfall (on site/off site) and ensure that the water is sustainability cleaned before entering the creek bed. In the Watershed Forestry Resource Guide's recent article, **"Watershed Protection and US Forest Services, Environmental Protection Practices"** (June 2014), they stated that to ensure that all water is cleaned properly, use of source control and pollution prevention practices reducing the exposure of pollutants through rainfall and runoff are demanded. Meaning that all water types entering the systems must pass through specific water types to ensure pollutants and chemicals either get taken up by plants as food or sediments to the bottom of the ponds. This objective will create higher water quality for all water types entering the site and in the long run for the downstream watershed.

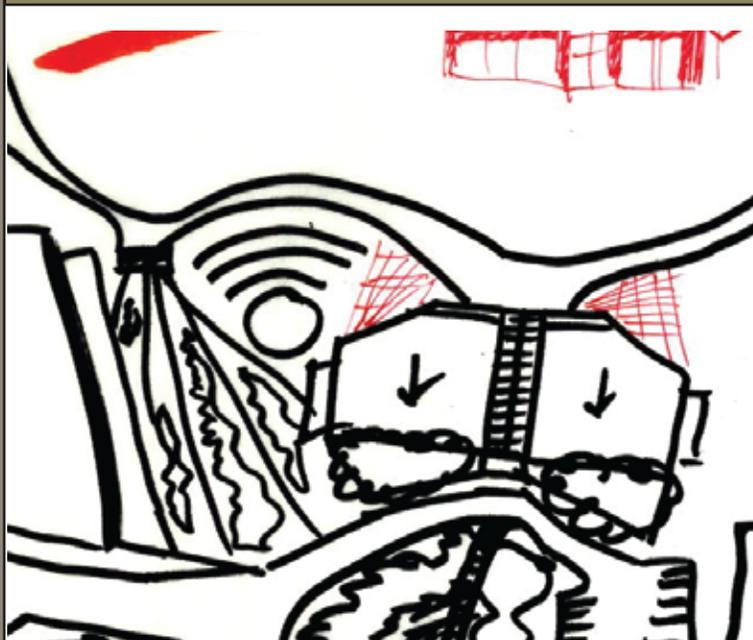
PROJECT GOAL

After applying all the previously stated objectives, the final goal of containing 100% of the storm water on site will be feasible. There are many good reasons why keeping all water on site until being cleaned and filtered downstream is a good thing. The first reason would deal with what the previous objectives are concerned about, if the water that is on the TCAAP site were to be moving its way to a different location downstream before being cleaned, then the pollutants would also move with them. Keeping the water on site is important not only for the TCAAP site itself but also for the existing other sites that could be affected if the runoff from the THUMB would make it to them. As stated by Environmental Services: City of Portland's recent website journal, **"Stormwater Discharge Problems and Solutions Areas"** (August, 2016), containing the vast majority of runoff is essential to providing the environment with the correct amounts of nutrients and avoiding the creation of higher pollution levels within the designed locations experienced by humans on a daily basis. Designing a park that will be aesthetically beautiful to look at and experience will be just as important as creating something that will have a positive function. Creating spaces that will allow for users to learn about the important of saving water, containing, and cleaning the water will help in promoting a healthier ecosystem not only with the TCAAP park but within possible future designs.





NUMBER OF TIMES VISITED OVER INDIVIDUALS LIFETIME



The vast majority of users will be from within a **1 – 15 mile** radius from the TCAAP location. This means that the site needs to be interesting but also needs to keep drawing local individuals back to the site. Creating spaces and features that are exciting, educational, and desirable will be needed especially if these local individuals want to experience the THUMB location more than once.

The second group of individuals will be outside a radius of **30+ Miles and/or out of state**. These individuals will be experiencing the site only for the first time, this means creating something memorable is important to keep visitors but also bring in new visitors from out of state each year.

PLAN FOR PROCEEDING:

To proceed with this project I will be using case studies, research information, and looking at what the users desire.

SITE VALUES:

Populated area
Rice Creek runs North To South
High number of Tree Clusters

PROGRAM ELEMENTS:

- Water Management
- Wetlands
- Tree Implementation
- Grass Implementation
- Trail System
- Learning Center
- Land Structures
- View Ports
- Water/Land Connection
- Plaza
- Parking
- Restoring Vegetation
- Signage
- Water Quality Control
- Runoff Control

DESIGN GOALS:

- Increase Hydrology
- Reduce Erosion along trail systems, roads, and buildings
- Create wanted spaces and edge conditions
- Educate visitors about importance of wetlands
- Conserve Rice Creek

CLIENT:

The City of Arden Hills and the National Priorities List Superfund Organization will be the main client for The THUMB, TCAAP site location in Arden Hills, Minnesota project. That means that this would be a government run operation. Arden Hills would be the ones using the conservation of Rice Creek and the surrounding wetlands for research and would allow the park to thrive while still allowing for visitors to explore and enjoy the location.

USERS:

The design for The THUMB, TCAAP, will have to take into consideration 3 specific user types.

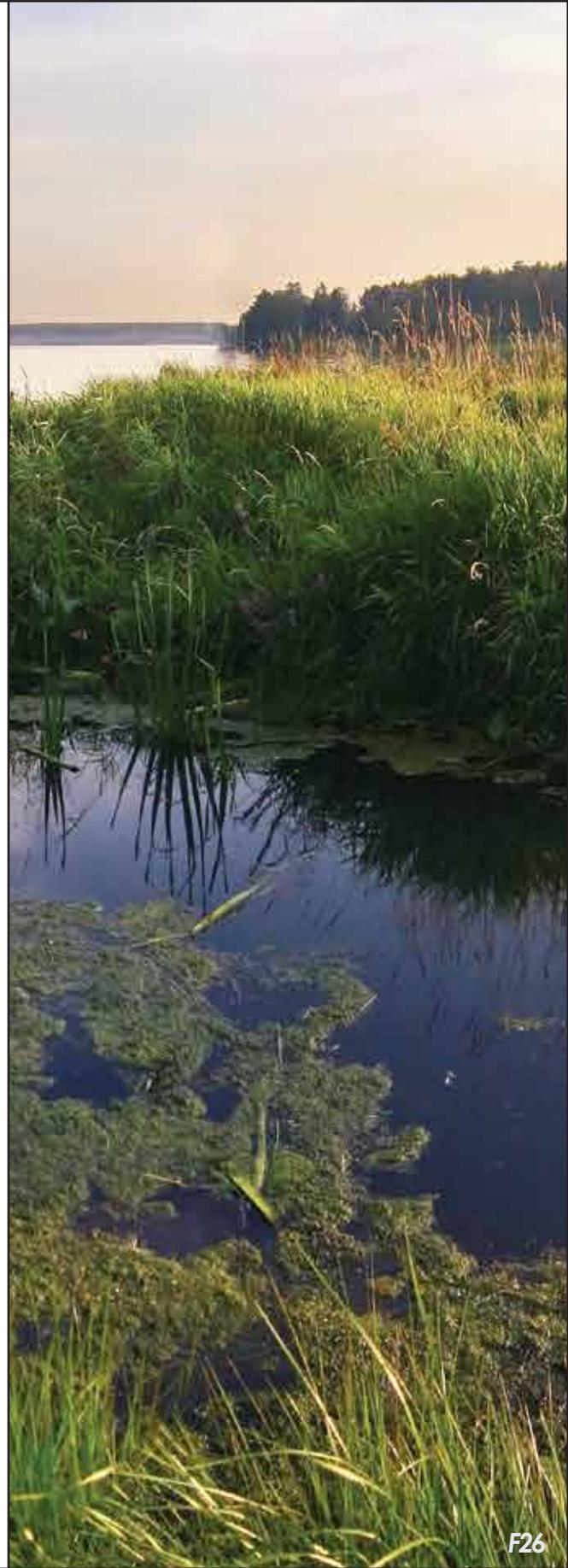
- 1. Residents of Arden Hills**
- 2. 30+ Mile Radius of Site Location**
- 3. Research based individuals**

The Visitors of the park would be the people who benefit most from the project. It will allow them to come and visit, interact and learn from Rice Creek and the surrounding wetlands while still keeping the ecosystem healthy as time goes by so that they can come and visit the wetlands again. all of this will be designed with the idea of erosion and compaction control to ensure overuse does not happen. The site would benefit from the design protecting and conserving it from further pollution, while lowering the disturbance of humans within and on the landscape.



THE IMPORTANCE

This project is personally important because of not only the location of the site being close to my home town of Elk River, Minnesota, but because of my connection with the outdoors. Anything that is going to help create a healthier and safer environment close to my hometown is personally not a bad thing. I grew up appreciating nature, this was because of the countless hunting trips with family members across the upper mid-west of the country. I learned how to care for the environment through my father, he taught me the importance of having undeveloped spaces like wetlands, lakes, rivers, and forest. The thing that hits closest to home with this project is the wetland portion and why the implementation of it will be important in the long term. After taking countless trips out west into North Dakota for waterfowl hunting, the love of wide open spaces and the importance of wetlands became even more and more relevant over the years. Without the vast amounts of wetlands and fields in the state of North Dakota, much of the waterfowl population would not be there. This would be a huge economical change for the state because of the vast amount of hunters that travel to that state year after year. This is why designing a park where visitors can experience and learn what actually makes up a wetland and the importance behind it in the first place, personally means a lot.



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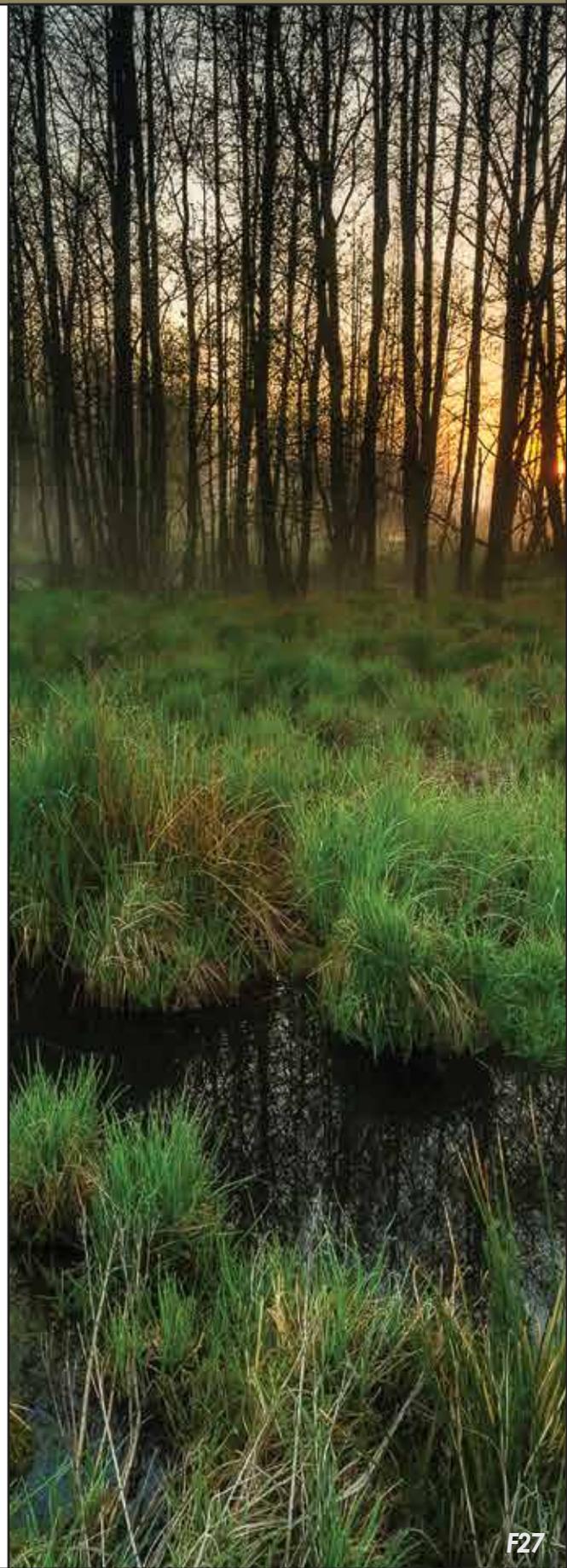


As stated by Nancy A. Minich in *“The Role of Landscape Architects and Wetlands”*, the broad educational background, employment history, and experience of a landscape architect brings together elements of design and engineering, which is connecting the traditional ways of design such as architecture, engineering, and natural sciences. The landscape architects design typically involves the actual design but also the management practices of that specific area as well. Wetland creation, enhancement, and restoration projects convey important design and aesthetic components to agencies and to the users (public). Understanding the science behind wetlands as well as adding an aesthetic application to the construction and design of stormwater management systems becomes even more important when dealing with projects location in highly dense populations such as urban areas. This is because many people have bad views or ideas of what a wetland should look like and traditional wetlands are not to their specific liking, this is why adding an aesthetic application to the wetlands will make it important for the design. Because the need for wetland is increasing, the public’s view has become more and more relevant when it comes to design. This is also where landscape architects can bridge the gap between design and functionality, the landscape architect can show graphic models (3D, Poster, Maps) that will get the design idea across easier.



THE REASON

Designing a park setting where pollution levels are the highest in the state of Minnesota can cause issue regarding the soil types and what toxins are inside them. Wetlands provide economic, social, and cultural benefits as well which can bring communities together. Wetlands are also helpful when reducing impacts from storm damage and flooding, they maintain good water quality, recharge the groundwater levels, store large amount of carbon, and help stabilize climatic conditions while controlling pests. The agriculture, forestry and tourism providing by wetlands creates popular locations for recreational activities such as birdwatching and hiking. Wetlands improve water quality by trapping sediments, filtering out pollutants and absorbing nutrients that would otherwise result in poor water quality for downstream users. They may also be linked to groundwater resources. These areas also reduce the risk of flooding by slowing down the movement of floodwaters along rivers and releasing water over time. River systems with intact wetlands in their headwaters have more consistent flows than rivers where the catchment and its wetlands have been largely cleared. When it comes to science and education Wetlands provide important locations for scientific research and play an important role in educating people about biodiversity and natural processes in NSW, OEH and educational institutions conduct research into the ecological response of river flows, flooding and environmental watering of wetlands.



F27



“My approach to this site will take a qualitative and quantitative view. Observing vast amounts of data and displaying it through tables, images, galleries, and graphic portrayals of what is found. Research will focus on the environment and how the ecological impacts of wetlands can help increase water quality but decrease pollution levels of The THUMB, TCAAP site while looking into how artificial disruptions can change it. Looking at the demographics of users and the amount of individuals projected to use the site can help narrow down the specific recreational activities that would be needed and most enjoyed by the user while causing the least amount of impact to the wetland ecosystem. Collection of data is subject to Professions knowledge, Scientific articles, GIS mapping, and Surveys. This research approach and style will be answering these important research issues and questions.”

RESEARCH IDEAS

ECOLOGY:

1. What kinds of pollution are located on site?
2. How can design decrease pollution levels?
3. What wetland type is the correct solution?
4. What systems works best for surface water?
5. What systems works best for sub-surface water?
6. What vegetation types will perform the best in wetlands?

DESIGN:

1. How should a visitor be able to experience the site?
2. What activities should be offered on site?
3. What type of path system is correct for not disturbing ecosystem?
4. How should visitor be able to interact with site?
5. What is proper size for Learning Center?



RESEARCH METHODOLOGY

Through analyzing case studies based on the topic of wetland conservation and reproduction of plant life, the correct data samples will draw me in the right direct of where the TCAAP project should head. The reasoning behind using this method is because the much of the research is done for me, this way I can apply knowledge already known in the specific field of study. Along with analyzing qualitative and quantitative data sets relevant to the wetland types and pollution types located on site. These data sets will help me gather information needed to find out the correct calculations regarding the right amount of wetland to combat the size of the pollution. Through these different research methodologies, the plan is to isolate specific site issues and hazards thus from the results one is able to come up with multiple ways to design around the issues and resolving them.

DESIGN METHODOLOGY

As stated in the previous section above, the methodologies used for research will cover much of the same areas as the design portion. The reasoning behind this is because the research that will be done will to find specific issues and their solutions, after finding these specific issues and coming up with solutions, whether it be one or multiple, they can be tested through design methodologies. This stage is where the actual site will come alive, the methods used in this portion will help figure out what needs to go where and how everything comes together. By using analysis drawings over the site, one can figure out the circulation patterns that would be needed to move people over the wetlands and creek. Generating 3D models will help in showing others what the issues were and how they are being fixed, this offers different ideas and views of people to be brought to the table, offering various new solutions if needed.



ASK:

Identify the problem, the constraints, and how others have approached it. At this stage a system will be put into place regarding data sets, meta-data, GIS, etc., collection of information (even more than 1st semester, 5th yr). Start analysis of region, state, county, city, site, over amplify the data until a vision starts to emerge.

IMAGINE:

Find some solutions, brainstorm ideas, choose the best fit for the site and the issues at hand. Create schematic diagrams, models, sketches regarding site design and trying to combat the issues will solutions. Layer specific sketch ideas to see what fits where, what sits best, if ideas should be added or taken out of site or even moved.

PLAN:

Draw diagrams with solutions, make a list with the possible solutions and materials needed for solving issues. Start with a scale for design, see where all the parts of the project are going to site and how they interact will each other. Move things as needed until positive of solution. Identify the major items on site and what they are for, the movement of projected people, the location of wetlands, trails, trees, grasses and how everything is connected.

CREATE:

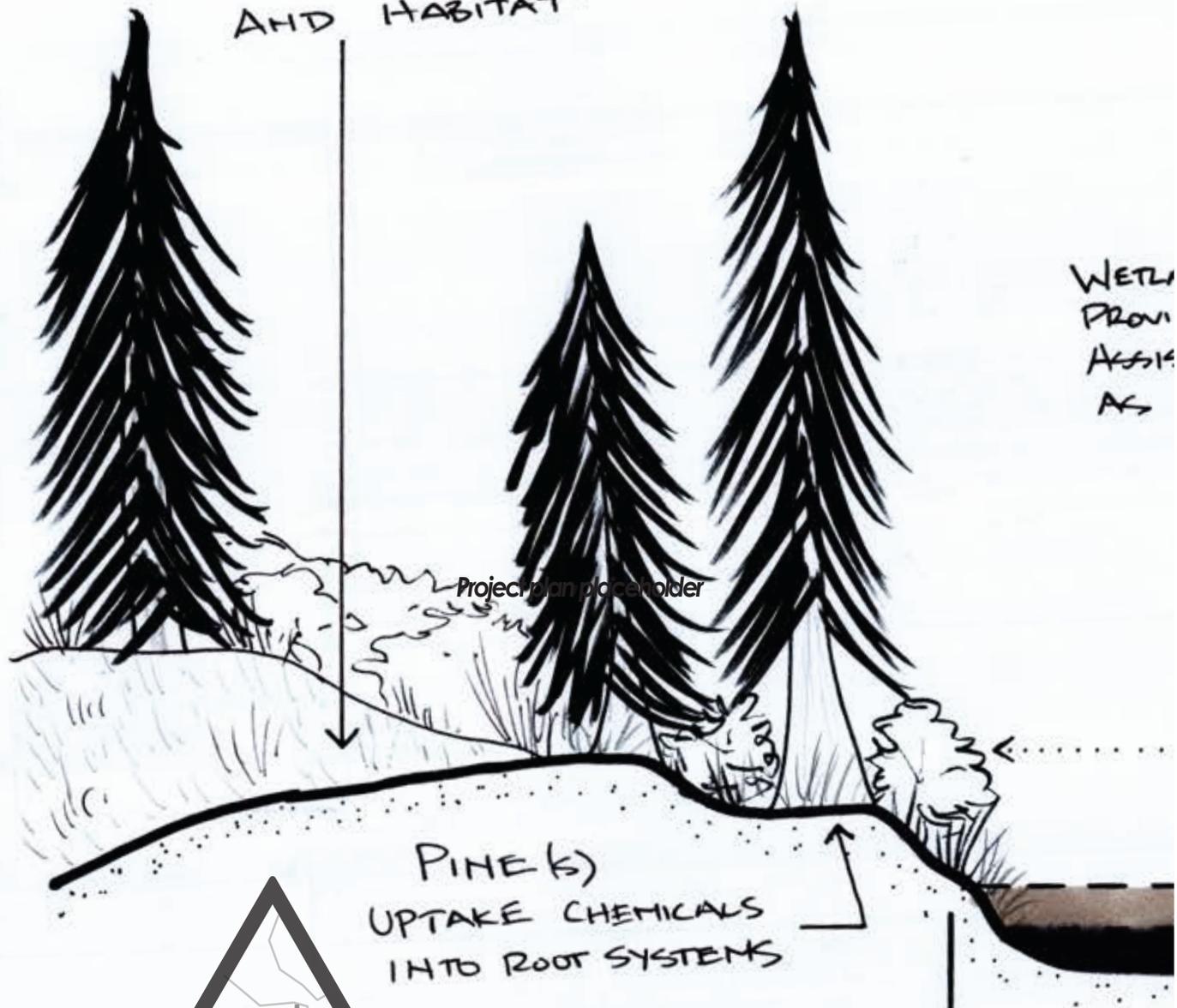
Follow the plan and start actually creating the design, test out the placement. Start line work with programs such as AutoCAD, then move into 3D modeling software, and eventually into the rendering stages to see what everything is going to look like. This is where if you need to move something it doesn't hurt to change it. Identify what the issue were and how they were solved even if they were not correct or what was designed.

IMPROVE:

What works? What doesn't? What could work better? Modify the design to make it better and then test it out again. This is the final stage of figuring out the issues at hand. Find the best ways know possible to create the solution.



CREATED LAND FORM
FOR HIGH-FLOW
CONTAINMENT
AND HABITAT



WETLAND
PROVIDES
ASSISTANCE

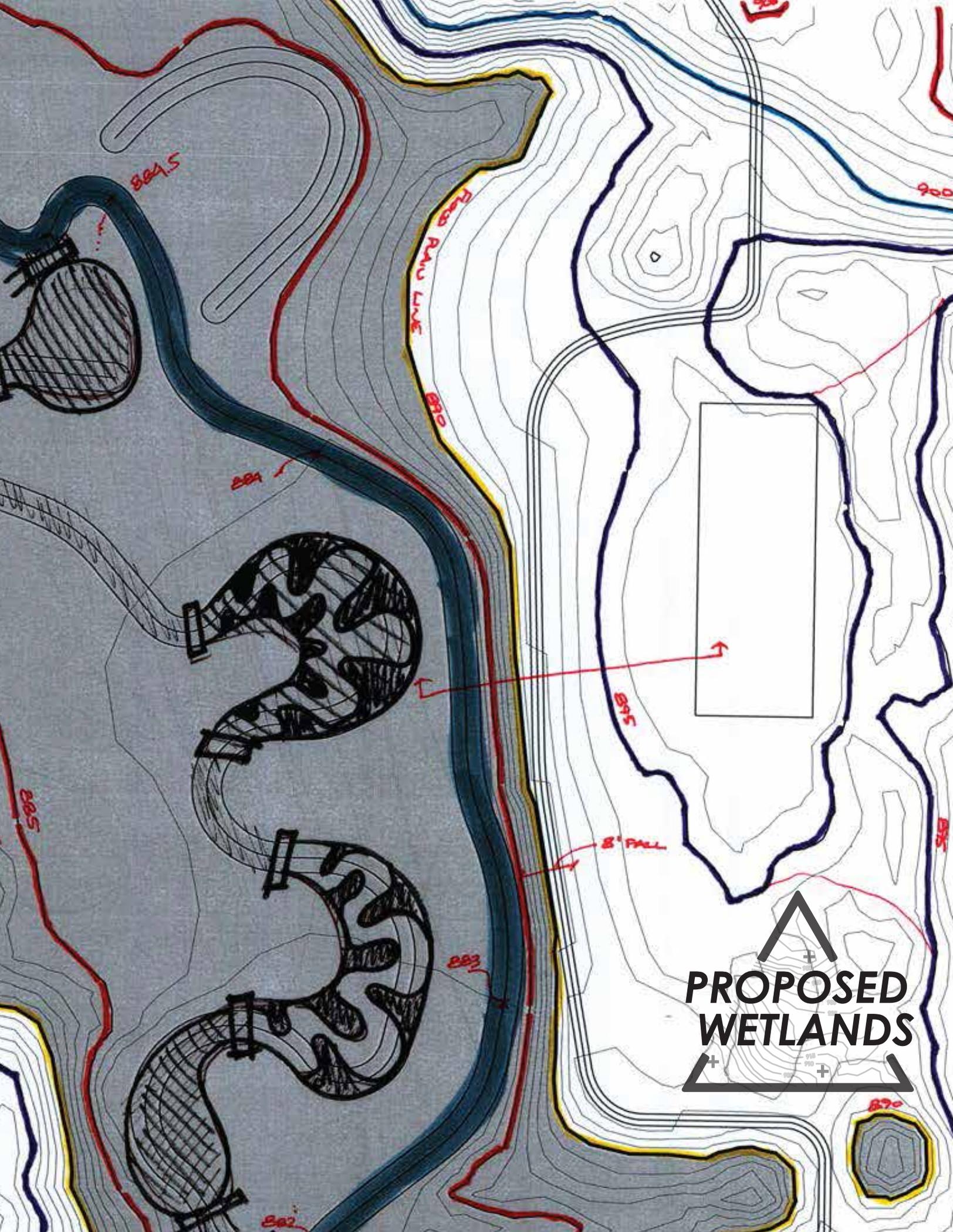
PINE(S)
UPTAKE CHEMICALS
INTO ROOT SYSTEMS

PROPOSED WETLANDS



WETLAND





884.5

Rapid Run Line
880

884

865

875

5' FALL

883

PROPOSED WETLANDS

870

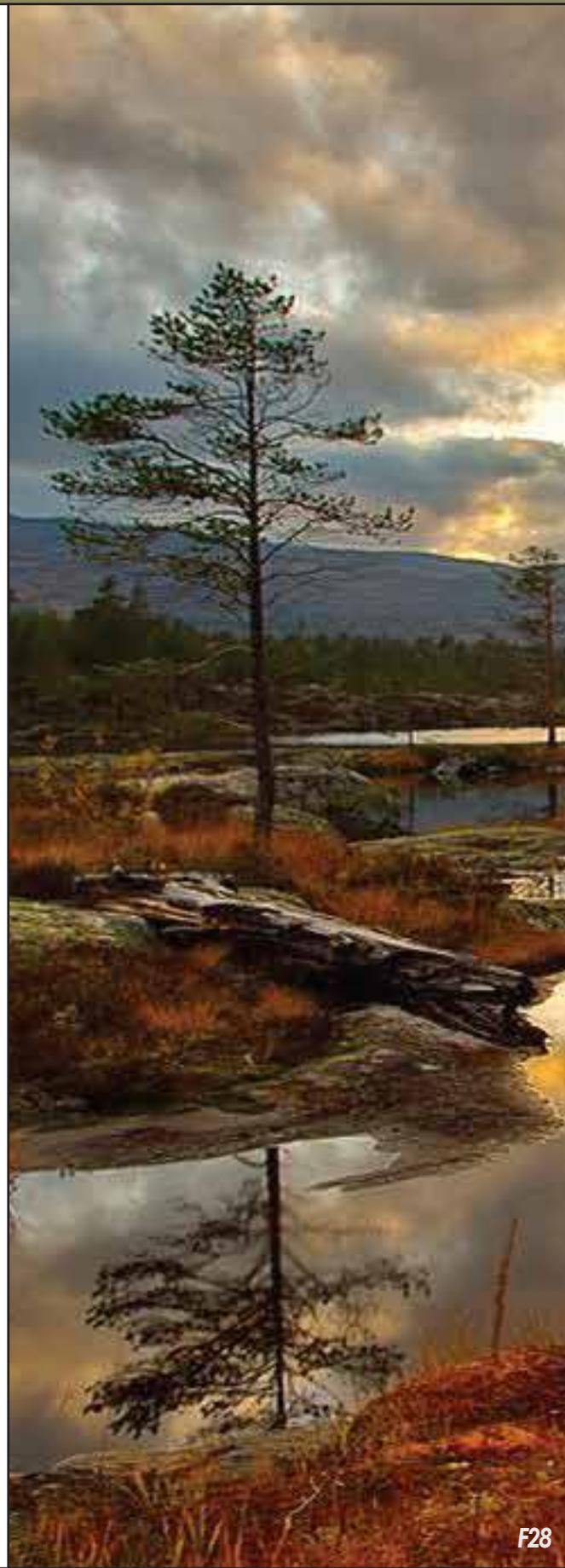
882

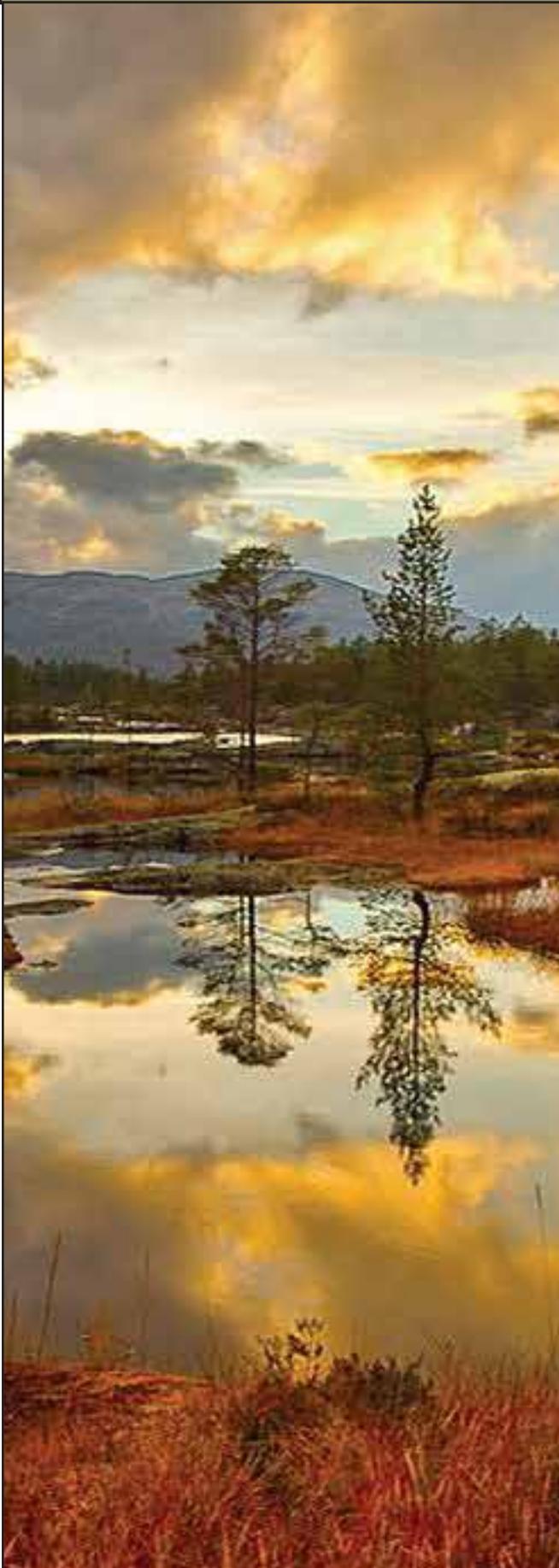
900

As the human population increases and expands from growing urban environments, many pressures are imposed on the undeveloped natural wetlands. Traditional practices of land development produce high amounts of risk for the natural environment by creating large regions of impervious areas, hence devastating and destroying the hydrology, infiltration rates, and buffer zones of these specific ecosystems. The enormous amount of polluted runoff built environments produce is increasing erosion, vegetation disruption, and the introduction of toxic materials into wetlands, thus changing the water quality, the health, and hydrology of the site. However, with proper attention to developmental methodology, techniques, and practices, environmental impacts on disrupted undeveloped wetlands can be minimized or completely reduced.

INTRODUCTION

More than 50% of the nation's original wetland areas have been lost and while the rate of wetland loss has declined, we continue to lose most types of wetlands (Whigham, 1999). Water management is important not only in day-to-day lives involving humans, but it affects everything inside of our environment as well, such as wetlands. Vast amounts of water are needed to maintain not only the built environments which we live in but to maintain the ecosystems around what we have created also (Davis, 2005).





This brings me to wetland development and what I am striving to accomplish, for this project I am going to be primarily focusing on storm water management within an area which has large amounts of wetland zones.

OBJECTIVES AND FINAL GOAL

I have three objectives I will need to accomplish for the overall goal to be completed, and the end goal is to provide a park for the public which will show how wetland ecosystems function while constructing a series of spaces that are visually pleasing.

Site Design Objectives:

1. Reduce runoff through design
2. Reduce pollutants carried by runoff
3. Capture and treat runoff

Objective #1: Using site planning and design techniques to reduce impervious cover, this will help lower disturbed soils and storm water impacts on site and surrounding (Protection, 2015). Objective #2: Use of source control and pollution prevention practices reducing the exposure of pollutants through rainfall and runoff (Watershed Forestry, 2014). Objective #3: Design stormwater practices collecting and treating the stormwater that is generated after applying the first two steps (Stormwater Capture, 2014). This is accomplished through the use of small-scale, distributed practices close to the source of runoff (rain gardens, pervious parking) combined with conventional practices (ponds and filters), (Center for Watershed, 2015).

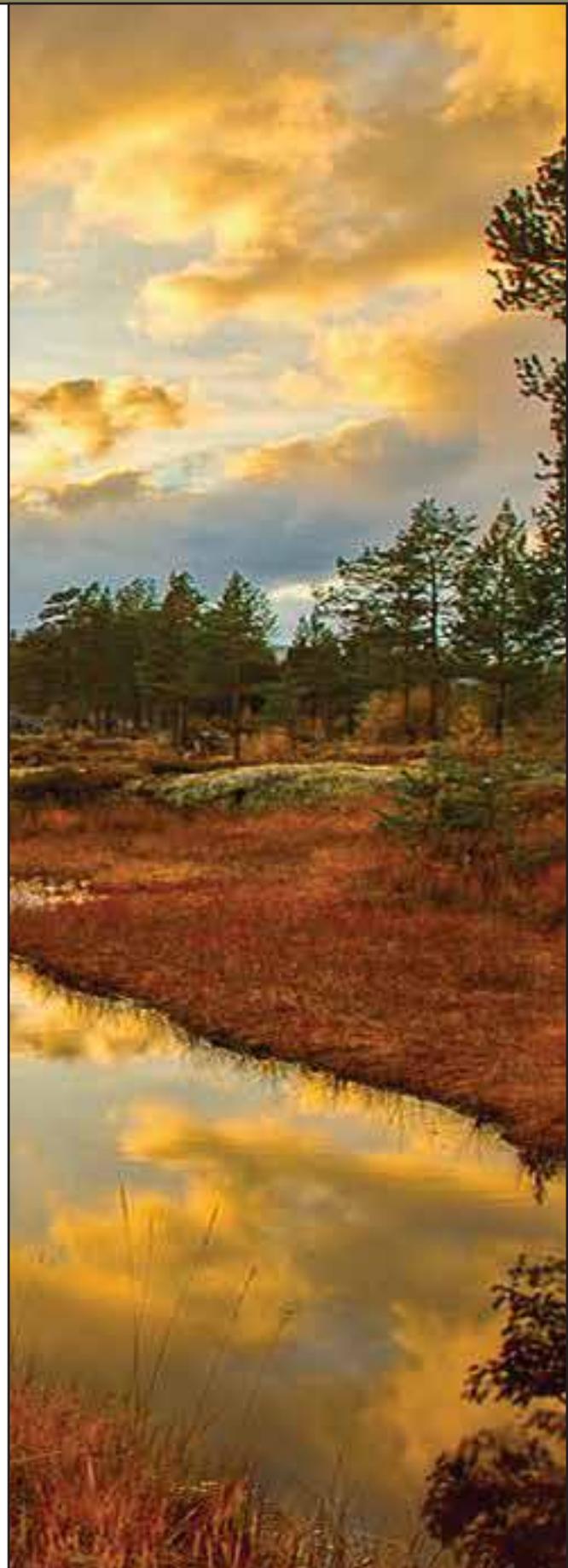


From these objectives the public will be able to venture through the wetlands without harming or disrupting the natural setting. This means I will be using sustainable practices and techniques pertaining to the design, and development of these particular zones through achieving the previously stated objectives, but also Low-Impact Development (LID), Environmental Site Design (ESD), and Storm water Treatment.

LOW-IMPACT DEVELOPMENT

The first management technique I will be focusing on is Low-Impact Development. This is a storm water practice which goes through the approach to manage runoff using a series of small control devices (Wood, 1995). The goal is to copy much of what the site has already to offer, meaning when the water infiltrates the zone it will be filtered throughout the site, 100% of the water stored on site, then either evaporated or drained to various locations in the site itself.

“The idea behind this is to mimic what the natural hydrology of the site is already doing to make sure not to ruin or disrupt what is already there” (Agency Wetland, 2014 pg. 3). LID does this differently than most large scale built environments with large pipes and systems, Low-Impact means small-scale landscape design practices that are centered on preserving the natural drainage and landscape features (Moshiri, 1993).





The preservation of the pre-development hydrology of a site is the overall goal of LID. Alongside with typical stormwater design, the LID approach advocates for more careful site design in the planning phases. The purpose of the site design is to preserve as much of the site in an undisturbed condition, and where disturbance is necessary, reduce the impact to the soils, vegetation, and aquatic systems on the site (Wood, 95). Porous pavements have been extremely effective in infiltrating stormwater runoff. Concerns have been raised about groundwater contamination, but research has shown that this is not a problem in most settings. Green roofs have been found to retain a large percentage of rainfall (63% on average) in a variety of climates (Whigham, 1995).

GREEN INFRASTRUCTURE

The next storm water practice that I will be using in my design will be Green Infrastructure. Green Infrastructure is based around all nature systems which capture, cleanse, and reduce the amounts of runoff through applications of plants, soils and microbes on site (Davis, 2005). In the big picture, if we look at it on a regional level we can see that green infrastructure is something that was natural at first. This consists of the networks of natural areas (forest, floodplains, and wetlands) that already help improve the water quality without having a built component to them. These natural systems also provide recreational opportunities, help air quality, and wildlife habitat growth as well.



Green infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits (Protection Center, 2016). While single-purpose gray stormwater infrastructure—conventional piped drainage and water treatment systems—is designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits.

On a site scale the Green Infrastructure system consists of specific management practices which tend to be smaller and more focused on interconnected natural areas that are designed to maintain the hydrology of the site (Moshiri, 1993). The reason we can apply this to small-scale sites is so we can improve the natural hydrology in areas to where infiltrating precipitation might fail. Stormwater runoff is a cause of water pollution in urban areas. When rain falls on our roofs, streets, and parking lots in cities and their suburbs, the water cannot soak into the ground as it should. Stormwater drains through gutters, storm sewers, and other engineered collection systems and is discharged into nearby water bodies (Agency Wetland, 2015).

ENVIRONMENTAL SITE DESIGN

The third management practice I will be using is termed Environmental Site





Design (ESD), also referred to as Better Site Design (BSD). ESD is much like the previous two systems except that this technique is trying to mimic the entire stormwater flow path throughout the site from a combination of applications and design principles to design the location. The objective is to replicate water quality while also mimicking the natural maintenance systems of the site. ESD practices are considered one of the earlier parts of the design process because thinking about how to design a location while not completely changing what is there can be hard especially when we need to consider the stormwater infrastructure of a wetland. Examples of ESD/ BSD are preserving natural areas, minimizing land disturbance and how to properly treat the stormwater (Wood, 1995).

STORM WATER TREATMENT

Following the previously stated practices, I will also be applying three sub-categories of SWM (Storm Water Management). These additional technologies and methods will make the entire design easier when it comes to controlling the amount and quality of runoff. The first sub-category is SWT (Storm Water Treatment), much like it sounds the application of this practice is to make sure that any water that can and will be entering the wetland area will be clean runoff (Moshiri, 1993). This also applies to wetland areas that are not main zones but have all city runoff lead to as well, meaning either must be cleaned before entering or displaced elsewhere.



This system helps to not only preserve and conserve the existing wetlands but also helps with the other water based areas which happen to be downstream of the location. As a part of preserving all types of water based locations this system's goal is to promote effective practices to ensure that the land surrounding the wetland will also be preserved, whether through construction restrictions or pipe drain regulations (Watershed Forestry, 2014).

AQUATIC BUFFERS

As a part of the previously stated water management practice (Storm Water Treatment), Aquatic Buffers, the second sub-category of SWM, plays a role in keeping out the unwanted and uncleaned runoff from the desired site. By adding a wetland buffer to various outskirts of the site the designer can create a linked combination of wetland areas thus making one wholesome wetland habitat. By adding plant species and nature systems to the edges of the site or by creating sectioned off areas of access, wetlands will be undisturbed and remain natural (Whigham, 1999). Now these buffers will not protect the wetlands from nearby communities but will add another layer of filtration for runoff when entering the wetlands. By creating a border, habitat will remain unbothered, ecotone species will continue to grow and natural hydrology of the site will remain stable (Moshiri, 1993).





EROSION CONTROL

The final sub-category method I will be applying will be Erosion Control practices. This management system goes with the previous section about Aquatic Buffers, by adding these buffer type systems to the edges and site lines we will be able to control the amount of soil movement and erosion that storm water could potentially bring upon a location. Minimize open area by phasing or sequencing construction and preserving existing vegetation where possible. Erosion control plans can be permanent or even non-permanent depending on the needs of the site and the amount of runoff that is coming into the site from surrounding watersheds.

Erosion and Sediment Control Basics:

- o Divert storm water away from disturbed or exposed areas when possible.
- o Install BMPs to control erosion and sediment and manage storm water.
- o Inspect the site regularly and properly maintain BMPs, especially after rainstorms.
- o Revise the plan as site conditions change during construction and improve the plans if BMPs are not effectively controlling erosion and sediment.
- o Keep the construction site clean by putting trash in trash cans, keeping storage bins covered, and preventing or removing excess sediment on roads and other impervious surfaces (Agency Wetland, 2015).

Erosion Control practices will be used throughout the design process but primarily after the construction is finished, meaning there will be more frequent site inspections to make sure every aspect is up to code. By adding Erosion Control practices to site development the overall goal of maintaining and preserving the edge conditions, storm water quality will remain a constant and the site will not have issues pertaining to pollution through runoff.

CONCLUSION

Through analyzing a specific selection of Storm Water Management techniques, methods, and practices, a general vision of site design can be put into place for the planning of the undeveloped wetland location picked for this thesis site in Arden Hills, Minnesota. Through implementing the previously stated objectives, LID (Low-Impact Design), Green Infrastructure, ESD (Environmental Site Design), SWT (Storm Water Treatment) and its sub-categories, these will present themselves as the primary design aspects for increasing water quality. After using the intended criteria site, the public will be able to venture over and through the existing wetlands without harming the existing hydrology of the site. I will be applying a series of steps and layers to the site design to ensure that the end goal is that of both functionality and also aesthetic beauty. Surrounding edge conditions and topography will be taken into consideration in order to direct any runoff away or around the site location. Overall, by controlling all the aspects within the site, this will ensure that 100% of the stormwater will stay on site, thus containing all possible variables for pollution.



F30



ANNOTATED BIBLIOGRAPHY

Agency Wetland and Protection. WARPT: Wetlands-At-Risk Protection Tool. 6 May 2015

The author describes the different amounts of runoff pollutants that can be carried through a site from outside sources. As it flows over the land surface, stormwater picks up potential pollutants that may include sediment, nutrients (from lawn fertilizers), bacteria (from animal and human waste), pesticides (from lawn and garden chemicals), metals (from rooftops and roadways), and petroleum by-products (from leaking vehicles).

Davis, Allen P. "Green Engineering Principles Promote LID." Low-Impact Development of Wetlands (2005): 344.

Davis focuses on the concept of LID (low-impact development), going into further detail about the environmental concerns with land development but mostly focusing on the water and pollutant balances. The author explains the importance of having the natural land surrounding the built environments, going into detail about the consequences of urbanization and the deforestation of large habitat areas. Vegetation, hydrology, parking lots are just some of the many concerns that the author talks about when dealing with how to properly create a built environment.

Moshiri, Gerald A. "Constructed Wetlands for Water Quality Improvement." Moshiri, Gerald A. Constructed Wetlands for Water Quality Improvement. London: Lewis Publishers, 1993. 633.

The author of this article goes into detail about what the characteristics of a constructed wetland are. He explains how the hydrology of a site changes not only over time but season to season depending on the amount of water accumulated on and directed into a specific site. The main statement that Moshiri is trying to say is the majority of hydrology change is dependent on the types of plant material which is inside and surrounding the wetlands, this is because these plants act as the main filters for water passing through. These plants are also important because they regulate the amount and speed that outside sources of water enter the wetland sites.

Protection Center for Watershed. Approaches to Stormwater Management. 28 August 2016.

This article breaks down the various methods and systems that a designer can implement into their plan in order to promote higher water quality on and through the site. For example one section talks about how adding the correct types of plants and trees to a design will not only help with which way the runoff will flow through a site but it will perform the main goal and clean the water. This uses sources from the USDA Forest Services, Center for Urban Forest Research, and Pacific Northwest Research which talk about different methods and typologies that can be implemented into the design.

Stormwater Capture Potential. "Urban and Suburban systems". June 2014. IB: 14-05-G

This article applies to objective three. After having some of the driest years on the century, California turns to different water conservation practices pertaining to design. Capturing and using the stormwater that falls (if any) is key to having a sustainable community but also design. Drought, coupled with over-allocation of existing water sources, is affecting the cities, farms, businesses, etc., across the state. Lack of precipitation has shown critical need to try and find new ways to save and conserve the amounts of water used daily. The long term effects of climate change are now becoming relevant, finding new ways to design and conserve water are at an all-time high.

Watershed Forestry Resource Guide. "Watershed Protection and US Forest Services". Environmental Protection Practices 341.2-2. 25 June 2014

This article applies to the second objective, reduce pollutants carried by runoff. The watershed brings in large amounts of water when it is the correct season. The best way to try and kept a certain area clean through water management is to redirect the water around the site if possible. If this isn't an option then this article with help in developing a plan for site design which will include the exterior features of a site, entryway for runoff, where it will be leaving the site, etc.



Whigham, Dennis F. "Ecological issues related to wetland preservation." *Science of The Total Environment* 240.1-3 (1999): 40.

The author references many different sources in regard to wetland restoration and conservation. Going into further detail about specified regions and types of wetlands, this is important because of what is surrounding the site. The specific ecosystems which surround a wetland will influence the hydrology, habitat type and resistance of the wetland. The amount of runoff that follows through exterior items then into the site can play a huge role on what and how the water can be cleaned. The author breaks down the proper ways to avoid creating bad flow patterns and alleys to where the water may get caught up thus creating places to be polluted easier.

Wood, Andrew. "Constructed wetlands in water pollution control." *Water Science and Technology* 32.3 (1995): 29.

Wood writes about the constructed wetland systems that are used for treatment of wastewaters, pollution control and for enhancement of the environment. This application has become very popular because of the vast amounts of wetland water quality issues. These applications and techniques start off with the specified edge conditions then transition into the middle or center of the hydrology systems. The focus of these systems is to regulate and control the amounts of water pollution coming into the site and maintaining the highest level of quality within the existing hydrology.

The specifications of this sections deals with the analysis of what the image for my TCAAP site is going to look like and much of the research and design functions already created. The following designed sites are case studies that look into the importance of wetland design, these sites are located on different types of wetlands ranging from shallow to deep water and also salt to fresh water. The main function of all of these are to clean and treat runoff which flows into their individual sites through channels, creeks, rivers, forest, flooding, and even ground water. These sites all compose different methods of containing, treating, and passing cleaned water through their site locations, all incorporate surface and sub-surface treatment types and techniques. After analyzing the specifics for each of the following sites an image of what design will work for the TCAAP site will be put into place, evaluated and then designed.



Dense amounts of native fresh-water vegetation (Deep Water)

F31



Large open-water areas without design

F32



GREEN CAY WETLANDS, PALM BEACH, FLORIDA

F33

Conclusion:

The Green Cay Wetlands project is located within the Everglades in the south, usually with deep water ranging from 8' - 12'. The design for this location is meant to see wide spaces, this is possible from boardwalks and elevated buildings which are sitting over the water. This differs from what is projected for the TCAAP site in Arden Hills, MN, the design will be dealing with a shallow creek and shallow water levels (2' - 4') compared to Green Cay. The connections on this site are linear because of the design of the boardwalk system, TCAAP site design will be the opposite from this. Green Cay has large open spaces which cover vast amounts of acres and have little vegetative height, the TCAAP design will be smaller, enclosed spaces from tall native trees and constructed wetlands. Much of the Green Cay site is natural wetlands because of the Everglades being the main feature in this section of the county, the TCAAP site is located next to a large highway and residential neighborhood. Because the TCAAP site is contoured to a flat grade the depth of the constructed wetlands will be shallow.





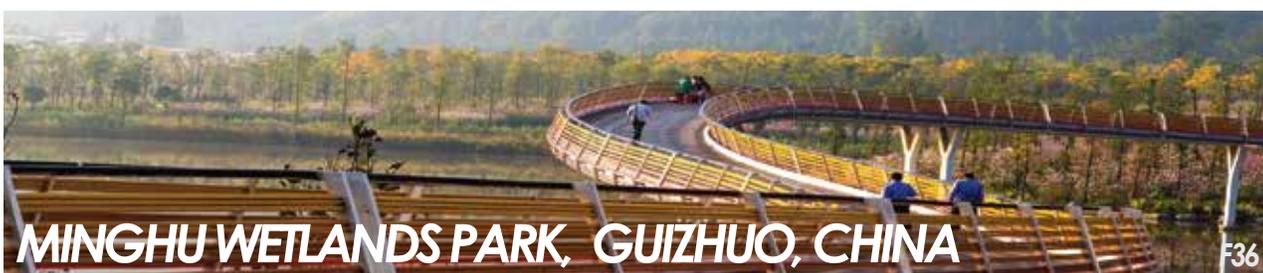
Dense amounts of native fresh-water vegetation (Shallow Water)

F34



Large open-water areas without design but able to experience with bridge

F35



MINGHU WETLANDS PARK, GUIZHUO, CHINA

F36

Conclusion:

The Minghu Wetland Park is located within the mountains of China, sitting at the base are the fresh-water marshes and wetlands. This is another large scale project with vast amounts of water and vegetation. The depth of the water here is also deep (12' - 18') compared to the TCAAP site (2' - 4'). This wetland covers multiple acres, most of it are large amounts of water thus the main feature running across the site is a bridge system. This design is closer to what is projected for the TCAAP site, Minghu has a bridge system that breaks off and weaves in different directions to ensure the viewer can see the entire site. This is more like what is proposed for the TCAAP site, the main way to view the site will be a series of paths and elevated systems which carve they way through the wetlands. Minghu is still elevated at a higher scale than what the TCAAP site will have though, the projected height for path systems will be about 1 foot above the normal water levels. This will ensure that the visitor will be able to experience the water and vegetation at a closer level but also allow for there to be smaller enclosed zones.





Moderate amounts of vegetation grouped together next to water-ways

F34



Large shallow water-ways marked with moderate vegetation islands

F35



LINCOLN PARK WETLAND, NEW JERSEY, U.S.

F36

Conclusion:

Lincoln Park Wetland in NJ, USA is a reclamation project placed along a river system within the marshes of the bank-side. This project is not designed in a way for the visitor to actually experience the park, this park is reclamation based thus meaning the land is being preserved and reused. This is a shallow marshland with moderate to tall vegetation isolated in large bodies of water. Lincoln Park is designed in a natural setting, this is like the projected idea for TCAAP. The TCAAP park will have a natural wetland system combined with constructed wetland systems, having both of these systems will allow for smaller viewing zones and tighter spaces. Having tighter, shallower spaces means more vegetation and ecological designed systems can be put into the park even with a smaller scale. Designing with a smaller scale will ensure that the quality of the wetlands will be healthier but also means the public will be able to see closer to the ecology and nature systems happening. Creating a series of channels and ponds will help this design come together because of the various possibilities of potential spaces.



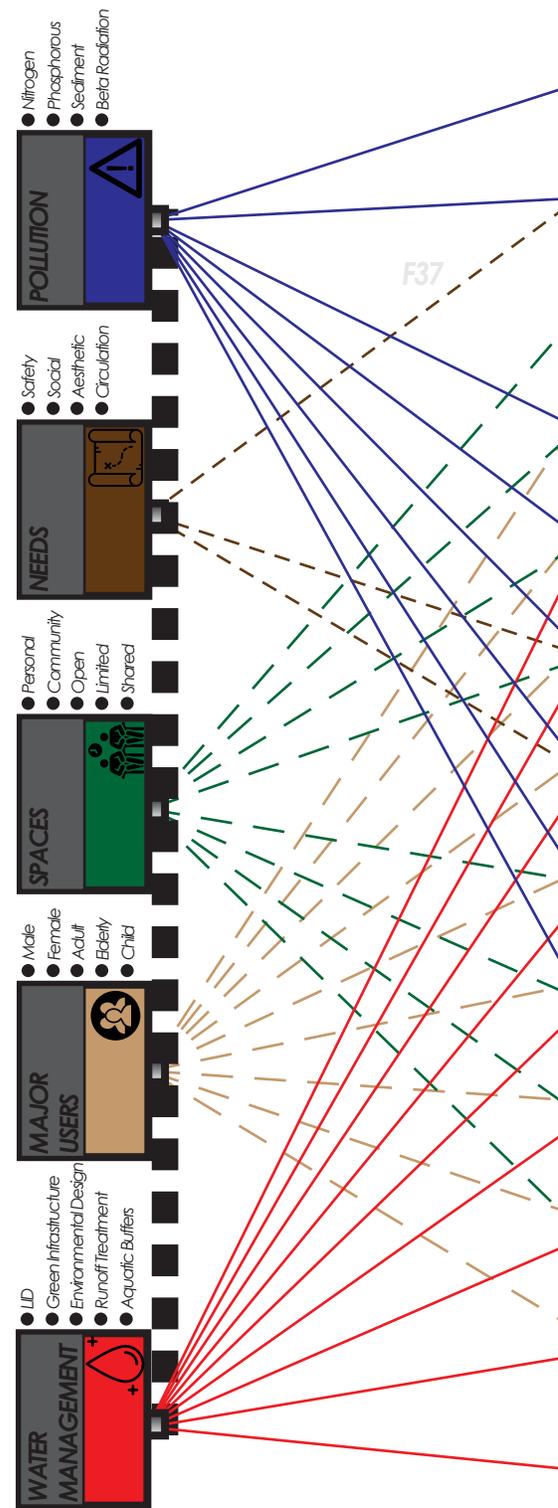


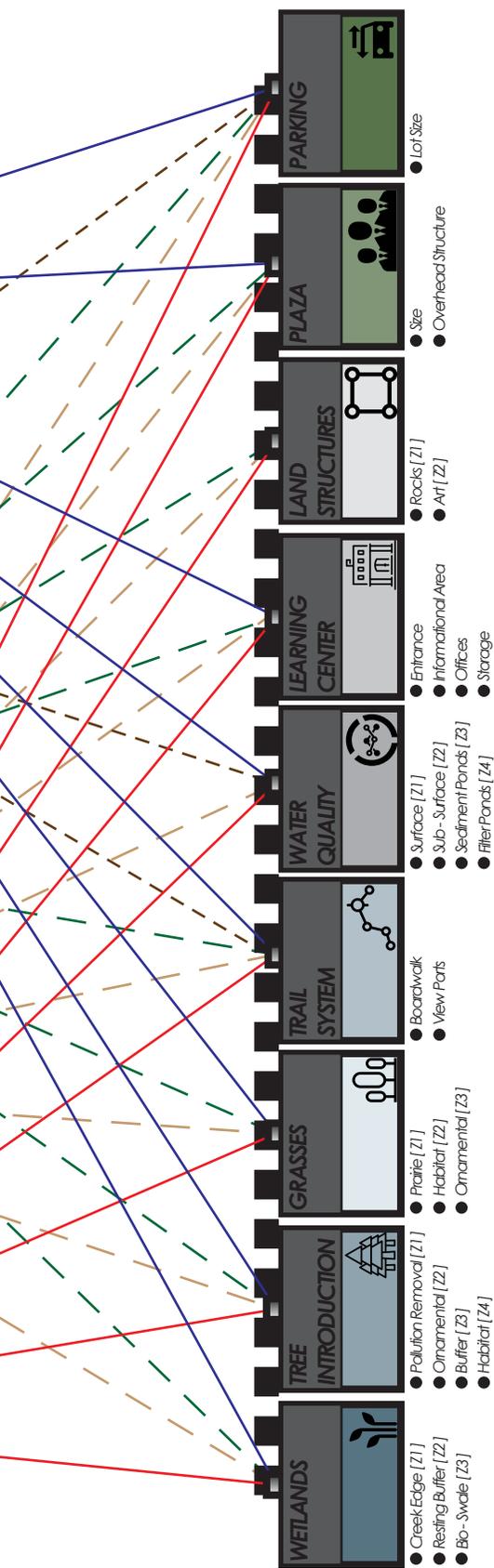
Looking into the specifics of the site, the breakdown of spaces and how they are used will show the each of the needs for them. All of the intervening programming elements will in some way interact and shape each other, this is what will make up the entire site design. The majority of the site will deal with water management, this will have specifics when it comes to what type of techniques need to be used and why they will be needed. For example, the implementation of LID, Green Infrastructure, Environmental Design will shape the overall design of the site by also tie themselves in with how the treatment of runoff will occur and the addition of aquatic buffer systems to control of it.

The major users of the site are going to be broken down into the three previously stated sections, local, 30+ miles away, and once in a life timer. These individuals can be broken down even further into categories like male, female, adult, elderly, and children, having this type of information can help in the overall design of what is needed on site. After looking at the types of users, the specification of spaces can be made. This is where sub-categories of spaces can be determined and decided in actually needed, such as personal, community, open, limited, and shared spaces. Most site design will try to incorporate all of these types but some may not be needed.

One of the main programming elements deals with the overall needs of the site. The needs of the site are large and have many issues but breaking them down can help in the clarification of what goes where. Safety on site is always needed no matter where, what time of day it is or what season, social sections must be created to connect people and connect the community to the site, it must be beautiful and aesthetically pleasing to the eye, people need and want something nice to look at, and lastly will be the circulation of the site. This is important because there needs to be a way to see the site and experience what the site is actually designed for.

The elements above are intervening factors to not only one another but to all the sub-categories of programming elements needed as well. The next section of elements that are going to be the overall design based elements, things that will actually be seen. Such as wetlands, the wetlands will be broken down as such, but the implementation of keeping the creek edge will be key for flooding, having a resting buffer to support sedimentation of pollutants, and having the bio-swale to clean any runoff before entering the resting buffer.





Tree introduction to the site will be both aesthetically pleasing but also will count as a way to get rid of pollution. By adding trees, they will uptake chemicals and remove some pollution, they will provide more support for the wetlands, they will act as a wind and sound buffer but also create habitat for native animal species. The addition of grasses can be put into this category as well, they will serve much of the same as the trees. The grasses can be added to create habitat but also can make prairie zones which will clean the water before entering the wetlands.

Trail systems will support a large amount of people that will be trying to make their way around the site, learning, and enjoying the site design. This will be a boardwalk system that will be elevated over all of the water and wetland sections of the site. This will also allow for the structure to create view ports, these view ports will supply individuals with different sites and sounds along the trail system.

Improving the water quality is one of the if not the most important goal and element needed for the site. Introducing surface and sub-surface water filtering will help in cleaning the water before hitting the river, additional sedimentation ponds and filter ponds will be added to make sure that the water quality levels are safe.

The addition of the learning center will provide individuals with a specific location to see each time either entering or passing through the site. This location will be around the middle of the site so it is easy to get to but also if people are just passing through the site they are able to see it and stop. This will provide a restaurant, restrooms, and an educational section to teach people about the importance of the site. This will have a connection plaza section that will allow for individuals to site outside. This will also have a large overhead structure to capture rainwater that has hit the educational center.

The site analysis looks into what makes up the potential site location selection. This site analysis will show the existing structures, buildings, vegetation, etc., that is located there now. The majority of the site is barren and is not open to the public, this is due to the amount of pollution and the vastness of the sites location. The THUMB is a small portion of the entire TCAAP site location within Arden Hills, much of the area is zoned off because of hazards that are within it. This site analysis looking into the potential design problems that come up when planning to design a site, many of the issues that are found are then planned around and design to be fixed.



HISTORY:
Initially, the plant was known as the Twin Cities Ordnance Plant. It was renamed the Twin Cities Arsenal in 1946 and finally, in 1963, the Twin Cities Army Ammunition Plant (TCAAP).

TCAAP was built as part of the government-owned, contractor-operated (GOCO) war materials production program established by the War Department during World War II. The Minneapolis-Saint Paul area emerged as a potential GOCO candidate primarily on the basis of labor supply. TCAAP was one of six GOCO plants built to produce small arms ammunition during World War II, and was operated by the Federal Cartridge Corporation under contract to the War Department.

ISSUES:
The soil surrounding the plant was contaminated with base neutral acids, metals, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, volatile organic compounds, pesticides, cyanide, and explosives.

LOCATION:
The Twin Cities Army Ammunition Plant is an inactive United States Army ammunition plant located in the City of Arden Hills in Ramsey County, Minnesota. The 2300-acre site is bounded by County Road I to the north, I-35W to the west, U.S. Route 10 to the southwest, County Highway 96 to the south, and Lexington Avenue to the east.

ARDEN HILLS, MN

TCAAP, MN





DESIGN ELEMENTS:

This site holds many challenges concerning the various pollution and radiation issues within the soil. Much of these soils are located on or near where Rice Creek moves through the site, but also it's water shed throughout the TCAAP site.

Designing a public park where the ground and water are polluted creates many issues regarding the safety of not only the plants and new materials being brought in but mainly the humans that will be interacting with the site.

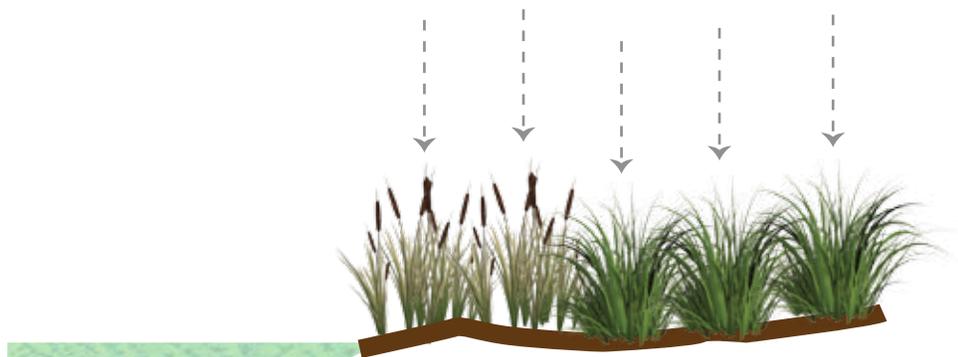
The initial site plan is to turn the low lands around Rice Creek into a series of wetlands. These wetlands areas will be constructed to clean and treat the water that runs to the creek, the runoff carries large amounts of pollutants. From this design idea a large amount of remaining pollutants on site will be filtered out within the natural systems while also creating and maintaining a healthy ecosystem.

The site location is centered mainly around Rice Creek which flows south and eventually runs into the Mississippi River. The programming elements will be focused around controlling pollution for the biological section but also will have a intuitive feature allowing the public to learn about how the wetlands clean the area. These elements will focus of the main issues of pollutants and radiation from previous years of ammunition creation for the wars.

Introducing large amounts of walking trails, board walks, and other circulation based Infrastructure for the site will be crucial for allowing the public to truly experience what it is like to see how a wetland functions and how important it is. The park will be a learning experience as well as having a natural beauty that will draw people into it and allow them to enjoy and experience what many people take for granted.



Following graphics are representing the various building code regulations for the city of Arden Hills. These are just some specific sections that needed to be address initially, the vast majority of other building codes are not going to be a part of this book due to size and space requirements. The codes that are graphically represented are from Section 1520 - Erosion and Sediment Control Plans and Review, 1520.01 Erosion and Sediment Control Plan, ADA - Advisory Landings/Ramps Requirements. The none graphic section in a table are the specified and estimated zoning code and section requirements.



C. Establish permanent vegetation

Subd. 3 Criteria.
The Erosion and Sediment Control Plan shall minimize soil erosion or sediment from damaging adjacent land.



G. Stabilization of steep slopes and bluffs

Subd. 4 Plan Content.
The Erosion and Sediment Control Plan content shall include the following unless waived by the PWD



H. Control the storm water leaving a site

Subd. 4 Plan Content.
The Erosion and Sediment Control Plan content shall include the following unless waived by the PWD

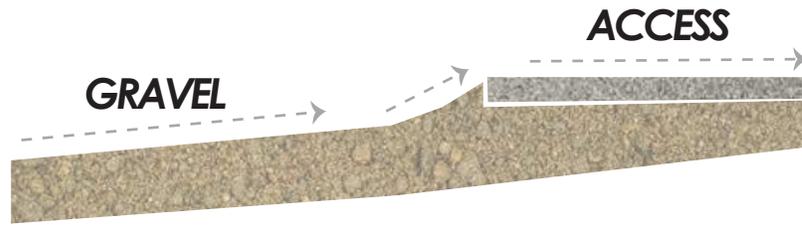
The diagram illustrates a site with three overlapping green areas representing different zones. Dashed arrows indicate the flow of stormwater from these zones towards a vertical white rectangular structure, likely representing a stormwater management feature like a detention basin or a wall.

A. Conform to the natural limitations presented by topography and soil so as to create the least potential for soil erosion.

Subd. 3 Criteria.
The Erosion and Sediment Control Plan shall minimize soil erosion or sediment from damaging adjacent land.



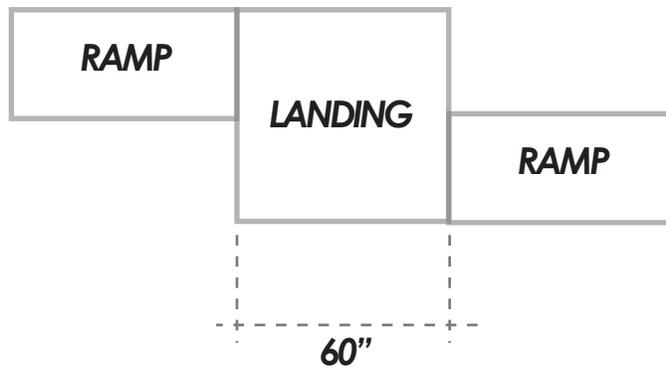
The diagram shows a cross-section of a stream bank. On the left, a green area represents the water body. On the right, a brown line represents the bank, with several clumps of green grass growing on it. Dashed lines radiate from the bank, indicating the natural slope and potential erosion paths.



N. Protect paved roads from sediment and mud brought in from access routes

Subd. 3 Plan Content.

The Erosion and Sediment Control Plan content shall include the following unless waived by the PWD



ADA 405.7 Landings.
Ramps shall have landings at the top and the bottom of each ramp run. Landings shall comply with 405.7.



ADA 405.6 Rise. The rise for any ramp run shall be 30 inches (760 mm) maximum.

