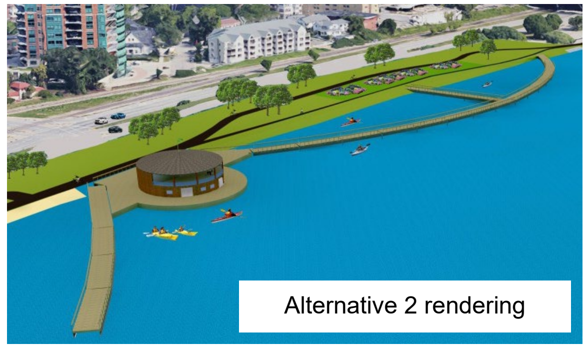
Lakefront Park Project Description

2024 NCEES Education Award Submittal: Community Enhancement Category

A multidisciplinary team of five senior engineering design students accepted the challenge to develop engineering analysis and design alternatives for a park facility to increase the usefulness of the park and local access to the waterfront.


Alternative 2 rendering

The project evaluates and designs improvements to the park in an historic, downtown location. Three alternatives were identified; a rendering of the selected alternative is shown here.

The Client for this project is a nonprofit organization dedicated to improving and protecting lakes, streams, and wetlands in their local watershed. They see a future in which everyone realizes that water resources are the center of the community.

With the community's support, the Client is working towards meeting Watershed CLEAN Report phosphorus-reduction recommendations. Where successful, they will achieve measurable water quality benefits, doubling the number of days each summer when their lakes are clear and algal-bloom free. Their goal is to raise community awareness of the issues facing the watershed and advocate for the welfare of their lakes, while also restoring and protecting the lakes through community support, advocacy, and education.

The Client provided the decisions needed to complete the project through a formal Request for Proposals (RFP) and interactions with the student team. In addition, the public and staff representing both the City and County containing this park had significant input on project options and decisions.

In recent years, the City has seen success as a "green city," with improvements to bicycle infrastructure, continued recognition as a tree city, and recent water quality milestones. Given these achievements, this park project will further enhance the City's reputation and, more importantly, the environment and local quality of life.

Project Objectives

Three design alternatives were created to revitalize the park, each fulfilling the project objectives in a unique way. The design process was governed by four main project objectives stemming from values and goals shared by the Client, City, and County, as well as public input. Project objectives include:

1. Improved water quality and swim-ability
2. Improved park sustainability
3. Enhanced accessibility for all potential users
4. Increased lakefront use and placemaking

Design Constraints and Considerations

Environmental and hydrologic constraints include riprap that heavily armors the shore. Although riprap reduces erosion, it also significantly reduces lake access, does not reduce the City's nutrient and particulate load to the lake, and is unsightly. Because the site is small and narrow, spatial constraints limit the design flexibility and constructability. The site is constrained by the adjacent six-lane U.S. highway, a set of parallel railroad tracks, a paved walking and biking path, and the municipal center. The highway speed limit is 35 MPH which cannot be changed. The project budget is approximately $20 million.

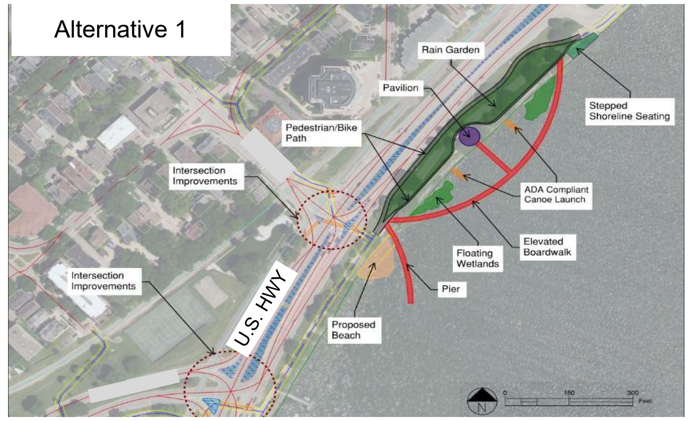
Summary of Public Input

When designing a public space like Lakefront Park, public input is imperative in creating a product that the community will use and enjoy. The student team gained a valuable understanding of how public outreach events provide a better understanding of the community's wants and needs. These events included a local design challenge and a community panel, which showcased the Client's desired changes and public discussion of what these changes would mean for the local community. Lastly, the student team attended a meeting about local highway improvements to learn more about the Cities' proposed improvements and how designs could be incorporated with potential concurrent highway projects, especially a bike/pedestrian underpass and pedestrian bridge.

Three Design Alternatives Developed: exploring the range, cost, and applicability of the project goals. Essential to all three designs are environmental/water quality improvements, modifications to the park shoreline, and accessibility considerations.

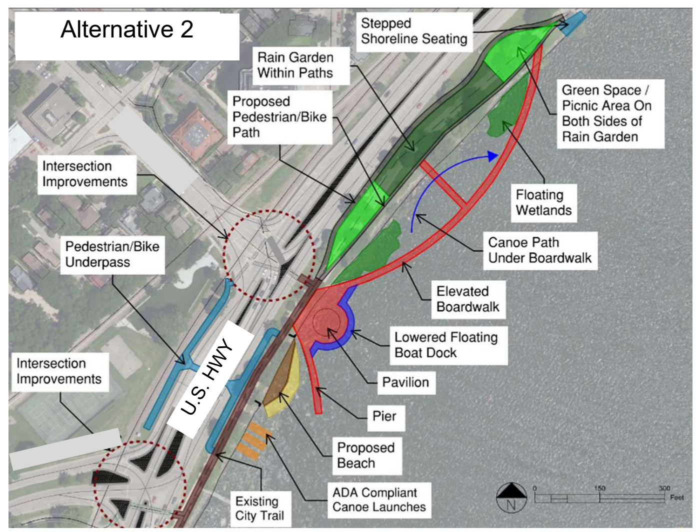
Alternative 1 - Offers a low-cost approach to meet the project goals featuring:

- Rain gardens between the bike and pedestrian path
- Floating wetlands between the boardwalk and shoreline, with a riprap reef for protection
- Two docks between the boardwalk and shoreline for canoe/kayak access
- Stepped shoreline seating
- A pavilion to provide restrooms, concession stands, and outdoor learning area
- An opinion of probable project cost of $9,200,000



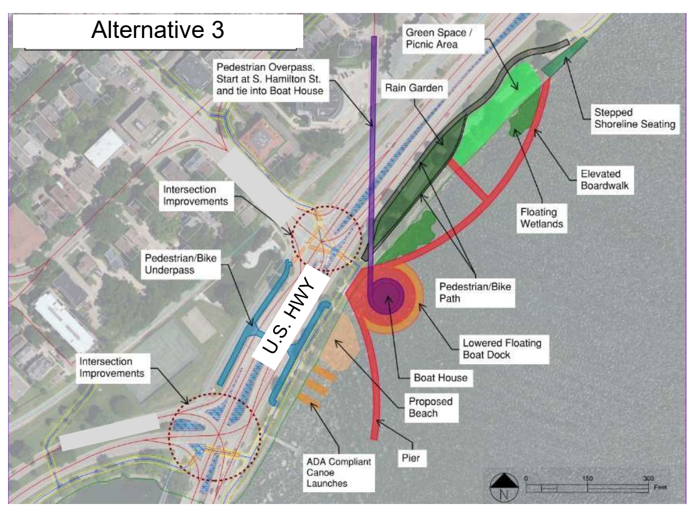
Alternative 2 - Increases accessibility of the park for users, while also increasing the overall project cost compared to Alternative 1. Features of this alternative include:

- Bike and pedestrian underpass structure below the U.S. highway and lake levels near the south end of the park with immediate connection to the bike path
- Smaller section of rain gardens between the bike and pedestrian paths, with two green spaces on either side
- Canoe path under the boardwalk and between the floating wetlands
- Americans with Disabilities Act (ADA)-compliant canoe/kayak launch over the water pavilion with the ability to support a future building expansion and pedestrian bridge
- An opinion of probable project cost of $18,300,000



Alternative 3 - Explores the "upper limit" of what could be done to incorporate all of the Client's and public's desired features if cost was not an issue. Features include:

- Pedestrian bridge over the U.S. highway offering a direct path from the city center to the heart of the park
- Similar underpass structure as seen in Alternative 2
- Large boathouse constructed over the lake that connects with the pedestrian bridge at the top floor and a spiral pathway down the outside of the structure to the ground floor
- Lake-level floating boat dock near the boat house platform
- Rain garden on the south end of the main park area with green space on the north end
- Multiple ADA-compliant canoe/kayak launches
- An opinion of probable project cost of $26,300,000



Alternative Evaluation Matrix

The students compared the three design alternatives using Multiple Criteria Decision Analysis (MCDA) in a decision matrix. MCDA emphasizes the comparison of quantifiable factors to reduce the subjectivity of the analysis. The criteria and weights were selected to represent the goals of the project, local community input, and mentor/Client feedback. The criteria data was normalized to allow comparison of each alternative.

Weighting Matrix	Input Weight	Alternative 1	Alternative 2	Alternative 3
Construction Cost	20%	8%	7%	5%
Construction Duration	10%	4%	3%	3%
Water Quality	25%	8%	8%	8%
Sustainability	10%	5%	5%	0%
Accessibility	15%	3%	5%	7%
Placemaking	20%	5%	7%	8%
Total	100%	33%	**35%**	31%

Table 1: MCDA Decision Matrix

Recommendation

Alternative 2 was the highest ranked and was recommended to the Client by the student team. According to engineering analysis and community feedback, Alternative 2 offers the highest-scoring total of the project criterion while remaining within budget.

Student-led engineering design for Alternative 2

Environmental design - includes beach improvements such as an enclosure system to reduce beach closures and provide a reliable swimming area for park visitors. Near shore improvements include a series of floating wetlands, vegetation planted above and below the riprap in the shoreline area surrounded by the boardwalk to improve stability, aesthetics, and environmental quality.

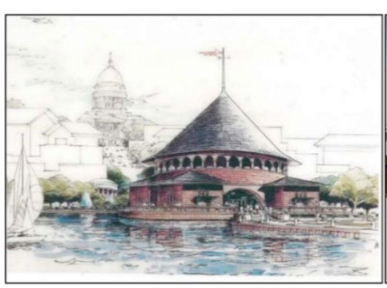
Hydrologic/stormwater design - consists of a rain garden area and four stormwater screening devices for their ability to reduce suspended solids concentrations entering the lake. The estimated reduction is nearly 30%.

Basin	Basin Area [ac]	Baseline Conditions TSS Load [lb./yr.]	Proposed Conditions TSS Load [lb./yr.]	TSS Reduction [%/yr.]
1	1.46	523.2	523.2	0.00%
2	0.06	22.4	22.4	0.00%
3	25.29	9,117.0	7,020.1	23.00%
4	1.27	777.4	598.6	23.00%
5	0.33	132.9	132.9	0.00%
6	9.75	6,500.0	5,005.0	23.00%
7	19.67	13,473.0	10,374.2	23.00%
8	7.80	3,400.0	100.4	97.05%
	Total	33,945.9	23,776.8	29.96%

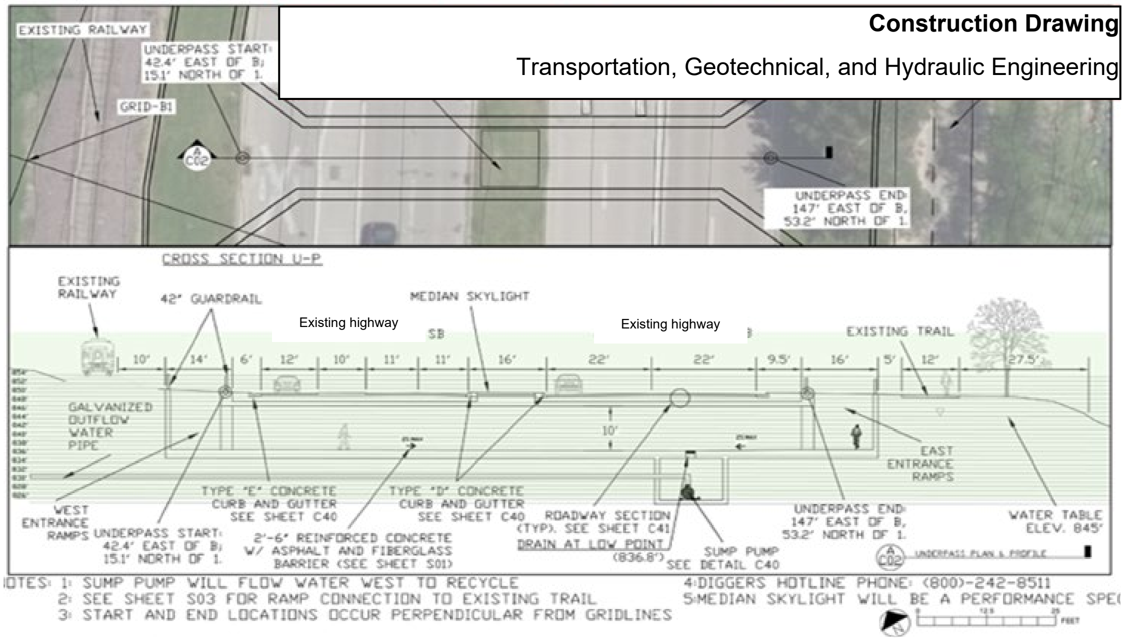
Table 2: The total suspended solids reduction for Alternative 2 is nearly 30%

Coastal design - focuses on maintaining a stable shoreline system. Existing riprap will be removed along the entire park shoreline, although some riprap will be required at select locations. This analysis focuses on minimizing the size and extent of the replacement riprap. The analysis finds a significant wave height of 2.5 feet, requiring material that is no less than 225 pounds each and not less than 9 inches in its smallest dimension. Along with the potential accumulation of floating algae and debris, the formation of ice on the lake is the most limiting existing shoreline condition. The loads from ice formation exceed other structural considerations caused by wind or waves.

Structural design - focuses on four main structures: the underpass, park pavilion, boardwalk, and stepped shoreline seating. Renderings of the park pavilion are shown here.



Transportation design - includes an underpass under the U.S. Highway; an overview and cross-section of the underpass is shown below. The underpass would span 125 feet beneath the highway and would have the dimensions of 8 feet high and 14 feet wide. This is beneficial in this location because there is only 7.5 feet of elevation difference from the bottom of the underpass to the top of the existing bike trail.

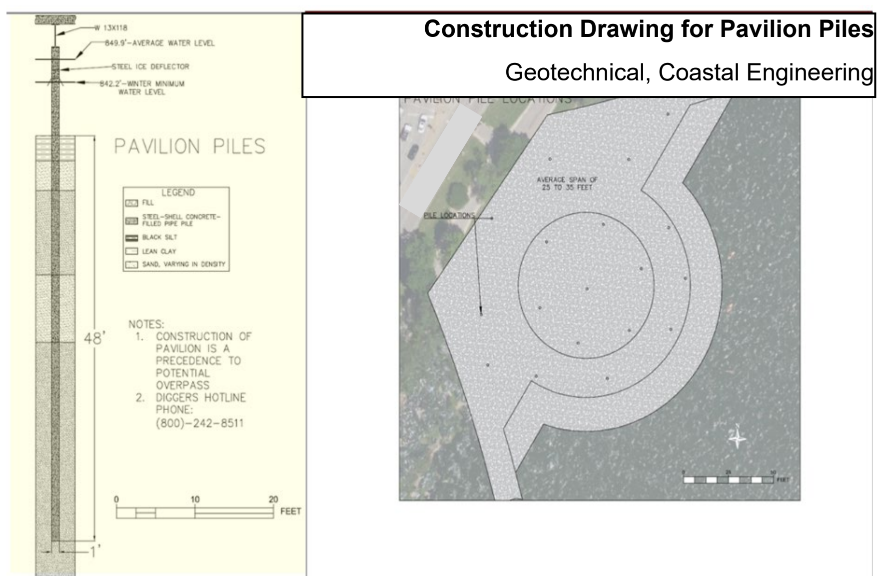


Construction Drawing
Transportation, Geotechnical, and Hydraulic Engineering

Geotechnical design - subsurface investigations consisted of soil borings. The general profile of the borings is detailed in a separate geotechnical report the students prepared as part of the project.

The borings indicate it is likely that there are erratics in the sand, since it is glacial till, such as boulders, cobbles, and other material that are not shown in the boring logs. In addition to identifying the glacial till, it was determined that groundwater flows into the lake near the site.

The pavilion will be constructed over the lake and supported by 18 piles driven approximately 50 feet into the underlying lakebed. The design contemplates an estimated load of about 262,000 pounds per column with a settlement of less than one inch using a safety factor of 2.5.



Construction Drawing for Pavilion Piles
Geotechnical, Coastal Engineering

Project schedule - The students developed project schedules for all three alternatives. The estimated schedule for the selected alternative is shown here. Extensive time is allocated for additional public input, permitting on the lakeshore and within the city, highway and railroad permitting, and construction restrictions to keep the existing infrastructure in-service during construction, which the project requires.

Project Schedule

Project Phase	Duration
Design, Public Meetings, Permitting	304 days
Advertising, Bidding, Contracts	104 days
Construction	866 days
Total Project Duration	1274 days

Collaboration of faculty, students, and licensed professional engineers

Were licensed professional engineers (P.E.s) involved? Ten P.E.s were involved with the course, providing guidance/mentorship, instruction, and feedback to the student teams throughout the semester. A summary of their roles is as follows:

- 6 P.E.s providing course instruction and presentations on specialized engineering topics
- 2 P.E.s serving as team mentors
- 2 P.E.s serving as presentation judges

How did the students, faculty, and P.E.s interact? Weekly contact between mentors, faculty, and students allowed the students to gain insights and advice grounded in the working professionals' many years of experience, which helped guide project success. Project mentors provided design comments, guidance, critique and oversight for presentations and reports, and advice for client relationships and public meetings. At the same time, mentors and faculty made themselves available for phone or email discussions as necessary and provided review of the student team's deliverables. Two student team presentations (at the preliminary and final design stages) were made to a panel of judges, which included two P.E.s, from the local community, thereby widening the students' exposure to other professionals and affording opportunities for additional critiques of their work.

What did the students learn through the collaboration that would not have been learned in the classroom? Collaboration between engineers, stakeholders, regulatory agencies, and the public is difficult, if not impossible, to teach in the classroom. During this project, the student team was required to meet separately with the Client on three occasions to provide information on the progress and status of the project and receive direct feedback from the Client's staff. The team also met with the public at three public meetings to gain feedback. The Client's staff also attended both formal team presentations, enabling the students to interact with both the Client and judges simultaneously. The collective input the students gathered from the Client and their staff, as well as the public became a critical element of the three concept designs. This project also provided the student team with real-world, hands-on project experience, allowing them to apply what they have learned in the classroom and manage pre-established project goals for time management, presentations, design components, deliverables, and schedules.

Protection of health, safety and/or welfare of the public

Did the project include aspects that affect the health, safety, and/or welfare of the public? This initiative envisions lakeshore park improvements that will focus on four goals to enhance the health, safety, and welfare of the public through:

- **Improved water quality and swim-ability** - water quality protection or improvement is integral to reimagining our public lakeshores. Poor water quality can lead to beach closures due to health risks and make them less enjoyable to use.
- **Improved sustainability** - incorporating renewable or energy-efficient technologies, reused or recycled materials, water-infiltration areas, native and perennial plantings, pesticide and herbicide-free landscaping, and water efficient fixtures support the project's sustainability.
- **Improved access for all potential users** - the public will have access to in-park amenities and recreational opportunities, which will improve racial and social equity, and meet ADA standards where possible.
- **Better placemaking** - functional and engaging amenities that encompass a wide range of recreational uses (e.g., biking, fishing, paddling, sailing, swimming, and lounging) will be included in the design.

How was public protection addressed? In addition to improving the water quality and swim-ability of the park, this project protects the public through:

- **Crosswalk Improvements** - The park is visited by up to 4,000 patrons a day, most of whom reach the park by passing over the adjacent U.S. Highway. Two adjacent intersections were recently the location of fatal vehicle-pedestrian accidents. This project simplifies those two intersections, installs pedestrian push buttons, and adds a bicycle queuing area.

- **Underpass** - The underpass will provide pedestrians and cyclists with a way to safely access the Park and lakefront recreational trail. The underpass helps achieve the City's Vision Zero Initiative by reducing the likelihood of vehicle-pedestrian accidents.
- **Boardwalk/Pier Railings** - Along the edge of the 12-foot-wide pier and boardwalk, 48-inch guardrails are incorporated to protect the public from fall hazards associated with the elevated boardwalk structures.

Which project features raised students' awareness about the impact of engineering decisions? Facility siting, layout, and meeting with the Client and members of the public at regular meetings raised students' awareness of how engineering decisions can impact the local community. The students learned that their role was not necessarily to make decisions, but rather to develop and logically present alternatives and their impacts in a manner that is understandable for both technical and non-technical audiences and decision makers. Additionally, students met with community-based learning representatives three times during the semester to reflect on the social impacts associated with their project.

Did the project highlight how engineering can help solve problems faced by communities nationally or worldwide? This project demonstrated for students how the issues associated with engineering projects are both technical and non-technical in nature and must be resolved simultaneously to result in a successful project. Public perception, public input, private interests, financial considerations, and other issues are important aspects of the work engineers take on locally, nationally, and beyond.

Did the project foster student self-reliance, cooperation, or responsibility? Students were responsible for staying on schedule; managing their time; cooperating to split up tasks and pull together information; reaching out to experts as needed for guidance; and conducting research and calculations for the project. They also learned the need to balance input from numerous public and private sources while developing a major engineering project. These competing interests can be more difficult to overcome than a project's technical challenges, which encourages the students to become more resourceful, while also building their teamwork skills.

Multidiscipline and/or allied profession participation

Was more than one engineering discipline involved? Among the 10 P.E.s involved with the course and student teams throughout the semester were individuals with chemical engineering and mechanical engineering degrees, a professional hydrologist, and geotechnical engineer. The collaborative nature of the project allowed the students to interact, collaborate with, and learn from multiple engineering disciplines, including an Employee in Training (EIT) and a licensed landscape architect, providing valuable experience for the multidisciplinary nature of their future careers.

Did the project include other professions? The student team presentations (at the preliminary and final design stages) were made to a panel of judges from the local professional community, thereby widening the students' exposure to other professionals and affording opportunities for additional critiques of their work. The panel of judges consisted of a relatively wide audience including two P.E.s, local business leaders, and staff from a center for public service community-based learning on campus. The students also received mentorship from a licensed landscape architect.

Was more than one branch of a particular engineering discipline involved? The student team gained hands-on engineering experience in several branches of civil engineering including environmental design, hydrologic/stormwater design, coastal design, structural design, transportation design, and geotechnical design.

Knowledge or skills gained

What engineering and other non-technical knowledge/skills did the students gain? The team learned many skills during the proposal, preliminary design, and final design of this project, including:

- Experience in different code referencing and software
- Navigating USACE, State DOT, and IBC manuals to generate feasible solutions while meeting State environmental regulations, which was a significant portion of the design process

- Working with AutoCAD, Civil3D, and SketchUp, significantly increasing familiarity and proficiency with these programs
- Building their interpersonal skills and balancing team dynamics due to the large scale, multidisciplinary requirements of the project.
- Professional communication with other team members, the Client and their staff, mentors, and course professors, helping them prepare for collaborative, multidisciplinary projects in their future careers.
- Analysis and design in six civil engineering branches: coastal, environmental, geological, hydrologic/stormwater, structural, and transportation.

How were the knowledge/skills gained important to professional practice? The knowledge and skills gained during through this project simulate project procurement, project management, report writing, professional meeting management, note-taking, money and time management, stakeholder involvement, and preliminary project design in professional practice, which are integral aspects of their future careers.

Did the project include consideration of professional practice concepts such as project management, ethics, contracts, or law? The student team assigned a project manager who was the primary spokesperson and contact for the team's interactions with mentors and the Client. The project manager was also responsible for delegating work and keeping the project on schedule. The project manager obtained and reviewed weekly timesheets from all team members using them to prepare a bi-weekly project management report.

In both facility siting and design, the students addressed ethical issues, including impacts to the environment and the community. The students prepared construction contract documents specific to their project. As part of the design process, students also identified applicable standards and regulations and applied them to the project design, schedule, and cost.