Final Report

The University of Toledo Main Campus
River Pathway Design

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Disclaimer

This report is student work. The contents of this report reflect the views of the students who are responsible for the facts and the accuracy of the data presented. The contents do not necessarily reflect the views of the University of Toledo or the Ohio Department of Transportation. The recommendations, drawings and specifications in this report should not be used without consulting a professional engineer.
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Fall Semester 2014

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Problem Statement
To facilitate pedestrian travel between Main Campus and Engineering Campus, this project aims to design a pathway that is an efficient form of travel between campuses and to highlight the improving condition of the Ottawa River.

Objectives
- Determine an effective pathway
- Develop pavement and pathway design
- Create cost estimates for the desired route
- Incorporate outlooks into the design and costing

Solution Approach
The design of the pathway will follow methods and standards set by the Ohio Department of Transportation and the University of Toledo.

Constraints
- ODOT Regulations
- University of Toledo Regulations
- Separation of project into stages
- University of Toledo and Surrounding Area Aesthetics

Economics
There is no limit on the cost of the project. No funds have been allocated to the completion of the pathway. Funds will be raised using this design as an example.
River Pathway Design Project

Fall Semester 2014

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Deliverables
The project deliverables will include, but are not limited to:

- Final Presentation and Report
- Pathway Route and Pavement Design
- Aesthetic Renderings
- Cost Analysis for Desired Pathway

Conclusions and Recommendations
In addressing the issues of traveling between Main Campus and Engineering Campus, multiple alternatives will be analyzed. These paths should showcase the Ottawa River and provide an efficient and aesthetically pleasing means of transportation for students to their destination.
University of Toledo Background Information
The University of Toledo is a well-known major college in western Toledo, Ohio. The campus contains many obstacles that make it difficult to easily and safely guide the public throughout Campus. Near the south side of campus there is a rail line that travels through campus dividing it into two parts. On the north side of campus the Ottawa River also cuts through the campus dividing the campus again. Over the years the University has overcome these obstacles by putting in multiple safe rail crossing and multiple bridges over the river in order to create safe pathways for the students and public to navigate campus. As the University continued to grow and their need for space grew they built an engineering campus on the east side of Douglas Road. Students now are required to cross four lanes of traffic to travel between the campuses. The designated crosswalk to cross the street is in an inefficient location, which causes students to jaywalk across Douglas Rd. This is by no means a safe way to cross this street; therefore the university began looking into solutions. After multiple ideas they decided to place a pedestrian bridge over Douglas Road and have the students go up and over the road. The location of this bridge will be north of the engineering college and come down on main campus near savage arena, where there is a defined walking path cut into the grass. After construction of the pedestrian bridge is the completed the plan is to put in a path that follows the river across campus and makes a safe, efficient route for students to navigate to their destination, whether that is the parking garage, Student Union, Carlson Library, dorms, or any other buildings on main campus for class. A site layout can be seen below in Figure 1.

Figure 1: Site Layout
Objective and Problem Statement
This goal of this pathway design project is to make it more efficient for students to get to their destination. In many places on campus, the existing pathways that run along the river do not provide a direct route and is not aesthetically pleasing. There are a few existing problem areas along the river that this project will encounter. On the east end of campus (between Douglas road and the David C. Root Bridge) there is currently one existing pathway made from gravel that runs about one third the length of this section of the river along the North side. This current path is made of gravel, which winds through the trees and has a steep incline which makes it difficult for students to navigate. This pathway also experiences flooding during significant rainfall events. Photo 1 below shows this current pathway after there was three inches of rain.

![Photo 1: Gravel Pathway along North Side of River](image-url)
As shown in the picture above, this path is not in the most useful location for students. In this same section of river on the South side has a levy that runs the length of it where there is a path worn in the grass where students have been walking. Photo 2 shows this worn walkway. This shows that there is a clear need for a path, and in addition to the path that’s worn there is a beautiful outlook on the river that could be easily integrated into the pathway to allow for better access to the river.

To the East of West Rocket Drive Bridge there are newly placed fish habitats in the river that may be desirable to have better access to or an improved view of. Also to the South of the Law Library there is an area that is desired to have access to walk down part of the river bank to get closer to the river. Photo 3 below shows this area.
Alternative Routes
Multiple routes for this possible pathway along the Ottawa River have been considered. Three possible options have been analyzed for this project. None of these three options travel across the river by the East parking garage where the gravel path is located because of the issues that were mentioned above. Figures of these three alternatives can be found in Appendix A. The options that have been looked at follow, including the selected alternative that will be used going forward.

Pathway 1
The first alternative route that we looked at can be seen by looking at Figure 2 in Appendix A. The path would start where the future pedestrian bridge over Douglas Road will come down on the main campus side of Douglas Rd. It will then run down past Savage Arena to existing pathway along the south side of the Ottawa River. It would continue to follow the South Side of the river until the David C. Root Bridge, which will be widened to allow for safer travel in a future project. The path would then cross the bridge and continue along the North side of the Ottawa River until Secor Road allowing for a walkway down the bank of the river by the Law Library. A table of the advantages and disadvantages for this alternative can be seen below in Table 1.
Table 1: Pathway 1 Advantages and Disadvantages

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Allows for use of existing overlooks by Savage Arena and Snyder Memorial</td>
<td>• There are space constraints by Savage Arena and Carlson Library</td>
</tr>
<tr>
<td>• The tree line on the North side of the river is more open allowing for a better view</td>
<td>• This route travels through the Performing Arts Amphitheater which deviates from the river</td>
</tr>
<tr>
<td>• This route passes the courtyard in front of Carlson Library</td>
<td>• This route travels by loading docks and exposed dumpsters.</td>
</tr>
<tr>
<td>• This route allows for access to fish habitats</td>
<td>• There is a lack of visible foot traffic around the Performing Arts building</td>
</tr>
</tbody>
</table>

Pathway 2
The second alternative route that we looked can be seen in Figure 3 in Appendix A. This route crosses the Ottawa River at the pedestrian bridge by the Carlson Library. The pathway would begin similarly to Pathway 1. It would continue running along the south side of the Ottawa River until the pedestrian bridge by Carlson Library. The path would cross the bridge and continue running along the North side of the river and ending at Secor Road. This option would also use the same pathway down the river bank by the Law Library. A table of the advantages and disadvantages can be seen below in Table 2.

Table 2: Pathway 2 Advantages and Disadvantages

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Allows for use of existing overlook by Savage Arena</td>
<td>• There is a space constraint by Savage Arena</td>
</tr>
<tr>
<td>• The tree line on the North side of the river is more open allowing for a better view</td>
<td>• This route travels through the Performing Arts Amphitheater which deviates from the river</td>
</tr>
<tr>
<td>• This route passes the courtyard in front of Carlson Library</td>
<td>• This route travels by loading docks and exposed dumpsters.</td>
</tr>
<tr>
<td>• This route allows for access to fish habitats</td>
<td>• There is a lack of visible foot traffic around the Performing Arts building</td>
</tr>
</tbody>
</table>

Pathway 3
This pathway’s route can be seen in Figure 4 in Appendix A. This path will begin the same way as Pathway’s 1 and 2 starting by the Savage Arena outlook. Once the path reaches The David C. Root Bridge, it will then follow the bridge to the north side of the Ottawa River and
run to the north side of the Carlson Library Bridge. Then the path will then continue running along the South side of the Ottawa River and will run past the flatlands area until West Rocket Drive. The path will then cross the bridge on West Rocket Drive and will follow the same proposed pathway on the South end of the Law Library and on the North side of the river until Secor Road. A list of the advantages and disadvantages are listed below in Table 3.

**Table 3: Pathway 3 Advantages and Disadvantages**

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Easy to tie into existing pathways</td>
<td>• Space constraint by Savage Arena</td>
</tr>
<tr>
<td>• This route shows a clear need based on visible foot traffic</td>
<td>• The south side of the river has a thicker tree line reducing visibility</td>
</tr>
<tr>
<td>• Runs close to river allowing more opportunities for outlook locations</td>
<td></td>
</tr>
<tr>
<td>• Avoids unappealing loading docks and dumpsters</td>
<td></td>
</tr>
<tr>
<td>• Allows for use of existing outlook near Savage Arena</td>
<td></td>
</tr>
</tbody>
</table>

**Preferred Pathway**

The pathway that was selected as the best option is Pathway 3. This pathway has the most upside with very little disadvantages to it. This pathway would result in more foot traffic compared to the other routes. This route also runs closer to the river and also uses more existing pathways allowing for less cost. Also this path avoids unappealing areas which the other two paths would travel near. Because of more foot traffic on this route it gives more available points to place outlooks. These aspects make Pathway 3 the best option for this project.
Outlooks
One of the goals of this project is to incorporate outlook points into the pathway’s design. These outlooks are to resemble an existing outlook near Savage Arena. A design plan sheet for this example can be found in Appendix B. Photo 4 below and Figure 26 shows what the existing outlooks looks like.

Pathway Design
In areas along the Ottawa River between Douglas Road and Secor Road, there are already existing pathways that may be utilized in the design of the pathway. However, there are certain areas between these existing paths that new pavement construction will be needed to connect these paths. The pavement materials that will be used are stone and permeable surfaces. It is desired to construct this project in phases and is explained below in the Construction Phase Breakdown. There is a space restriction that will be encountered near Savage Arena that will need considered in the pathway design. In this area a retaining wall may be required if grading is not a viable option. An alternative to a retaining wall in this section may be a boardwalk system. These options will be analyzed and the best option will be selected and included in the final cost estimate. Ohio Department of Transportation (Ref. 1,2,3) and University of Toledo Regulations (Ref. 5) will be followed.
Construction Phase Breakdown

The time table for design and construction of the proposed pathway has been broken down into 2 different phases. Phase 1 will consist of designing the proposed pathway to match the gravel path that was already constructed on the north side of the river near lot 1S. The design of the existing gravel path consists of two sections, the bottom layer being of larger aggregate and the top layer being a fine aggregate. Phase 2 is a future plan that consists of designing the pathway after it has already been constructed of gravel to be made of permeable concrete or regular concrete, depending on the existing conditions along the river. The schedule of both phases will be broken down into 5 segments. These segments are called reaches. A reach is the span of the pathway between bridges. Figure 2 shows map of the reaches.

Reach 1
Reach 1 is the span that starts at the West Rocket Drive Bridge and runs west along the river to Secor Road. This part of the pathway will slope down the bank to the bottom area and meet up with the designed path. It will then be come back up the bank by the parking lot and follow the parking lot and dead end into the existing path that leads to Secor Road. Good depictions of how this will look are from the Renderings of Figures 7 and 8 and from the Plan View on Figures 11 and 12.

Reach 2
Reach 2 is the span that starts at the Wolfe Bridge and runs west along the river to the West Rocket Drive Bridge. There is currently a pathway that runs near the river here so a new pathway will not be designed for this reach. However, it is possible to construct an outlook within this reach. Good depictions of how this will look are from the Plan View on Figures 13 and 14.

Reach 3
Reach 3 is the span that starts at the Carlson Library Bridge and runs west along the river to the Wolfe Bridge. There is currently a pathway that runs along the river here so a new pathway will not be designed for this reach. However, it is possible to construct an outlook within this reach. The Plan View of Figures 15 and 16 illustrate this layout well.

Reach 4
Reach 4 is the span that starts at the Root Bridge and runs west along the river to the Carlson Library Bridge. The pathway will be built up on the levy near parking lot 10 and will merge into the intersection that exists with the tennis courts and the Carlson Library Bridge. Since this is a heavy area for student traffic, this is an ideal location for an outlook to be installed. Good depictions of how this will look are from the Plan View on Figures 17 and 18.

Reach 5
Reach 5 is the span that starts at the parking garage bridge and runs west along the river to the Root Bridge. More specifically, this reach will start at the existing outlook by Savage Arena to the Root Bridge. The path will follow the pedestrian foot path that has been created by student traffic. A challenging aspect for this reach will be the design of a retaining wall due to the
intensity of the slope down to the parking lot. Good depictions of how this will look are from the Rendering of Figures 9 and 10 and from the Plan View on Figures 19 and 20.

Figure 2: Reach map

Retaining Wall
Due to the space restrictions on top of the levy, a retaining wall is needed for a six foot path to be installed on it. The type of Retaining Wall that is being chosen is called a MSE wall, or known as Mechanically Stabilized Earth Wall. This type of retaining wall was chosen due to location of where the wall is going and the cost and ease of installation. There is not much excavation needed of the existing levy for this new retaining wall to be installed. The only excavation that is really needed is that for the 6” perforated pipe for drainage behind the rock façade.

This kind of wall is reinforced by each layer of Geosynthetic that extends into the soil so it is not needed for a footer to be installed under it. Since we are extending the levy at the base the full distance that is needed for the Geosynthetic material to extend without it failing, it is not needed for excavation to insert the material into the existing levy. This wall is also designed to flex a little without it failing. Referencing the MSE Wall Design Calculations that start on page 38, the Factors of Safety for Overturning, Sliding, and Bearing are 4.2, 1.112, and 1.17 respectively. Figure 30 is the Cross Section of the Retaining Wall that has been designed and the Renderings of Figures 9 and 10 show how the wall may look after installation.
General Considerations

Drainage

The drainage system that will be used for the river pathway is for all new sections of constructed pavement. Due to the use of gravel and a permeable surface design all runoff and drainage will be handled by the permeable surface. The pathway will also be sloped away from the river in the event runoff begins to form. A schematic of how the permeable surface will handle water is shown below in Figure 6.

![Permeable Surface](Figure 3: Permeable Pavement)

Lighting

It is not desired to include light poles along the entire length of the proposed pathway. Lighting will only be considered for outlook locations and bench locations. Photo 5 below shows an example of a University of Toledo light pole that will be matched.

![University of Toledo Light Pole](Photo 5: University of Toledo Light Pole)
**Plant Life**
Options for plant life along the new pathway can be aesthetically pleasing to students and non-students traveling through campus. Such ideas could be planting native plants along the campus side of the pathway without clogging and congesting the pathway. There is a list of native plant types at (Ref. 4).

**River Restoration Signs**
As of now, there are information signs along the existing pathways near the Ottawa River that provide information on the river and what has been done to improve the river. The goal is to have the pathway connect with the signs as much as possible. An example of one of these signs can be seen below in Photo 6.
River Pathway Design Project

**Emergency Stations**

There are currently many emergency station poles along existing pathways everywhere on campus. Currently there is discussion of removing emergency station poles from the campus. The need of adding these poles along the new pavement areas will be evaluated with the universities future plans. Below in Photo 7 is an example of one of these poles.

![Photo 7: Example Emergency Station Pole](image)

**Aesthetics**

Aesthetics will be implemented on this project. Aesthetics will be based off of existing University of Toledo aesthetics and implemented in feasible locations. Some examples of this will be matching the existing outlook style, existing light poles, and using the rock façade that is used widely around campus. A photo of this façade is shown below in Photo 8.

![Photo 8: Existing University of Toledo Rock Façade](image)
Cost Breakdown

Table 4: Quantities Used for Cost

<table>
<thead>
<tr>
<th>Reach</th>
<th>Length</th>
<th>concrete</th>
<th>gravel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>467.13</td>
<td>1401.39</td>
<td>942.92</td>
</tr>
<tr>
<td>1B</td>
<td>491.27</td>
<td>1473.81</td>
<td>972.71</td>
</tr>
<tr>
<td>2</td>
<td>495.18</td>
<td>1485.54</td>
<td>980.46</td>
</tr>
<tr>
<td>3</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>651.59</td>
<td>1954.77</td>
<td>1290.15</td>
</tr>
<tr>
<td>5</td>
<td>632.4</td>
<td>1897.20</td>
<td>1252.15</td>
</tr>
</tbody>
</table>

Total Quantities:
- Concrete: 2737.57
- Gravel: 8212.71
- Total: 5438.39

Table 5: Stairs Budget

<table>
<thead>
<tr>
<th>Height of stairs</th>
<th>No. of Steps</th>
<th>Cost Per Step (ODOT)</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>8</td>
<td>$120.00</td>
<td>$960.00</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>$120.00</td>
<td>$960.00</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>$120.00</td>
<td>$1,680.00</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>$120.00</td>
<td>$1,680.00</td>
</tr>
</tbody>
</table>

Table 6: Outlook Cost

<table>
<thead>
<tr>
<th>Material</th>
<th>yd^3</th>
<th>Cost Per Outlook</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backfill</td>
<td>4</td>
<td>$848.00</td>
<td>$1,696.00</td>
</tr>
<tr>
<td>Course Aggregate</td>
<td>3</td>
<td>$636.00</td>
<td>$1,272.00</td>
</tr>
<tr>
<td>Rebar (#4 bars @ 1/2&quot;x20&quot;)</td>
<td>24</td>
<td>$384.00</td>
<td>$768.00</td>
</tr>
<tr>
<td>Concrete</td>
<td>8</td>
<td>$1,696.00</td>
<td>$3,392.00</td>
</tr>
<tr>
<td>Labor</td>
<td></td>
<td>$3,650.00</td>
<td>$7,300.00</td>
</tr>
</tbody>
</table>

Total Cost: $7,214.00 | $14,428.00
### Table 7: Cost of Gravel Pathway

<table>
<thead>
<tr>
<th>Reach</th>
<th>Pathway Width (ft)</th>
<th>Pathway Section Length</th>
<th>Course Material Depth (in)</th>
<th>Fine Material Depth (in)</th>
<th>yd^3 of course material</th>
<th>yd^3 of Fine material</th>
<th>Total Cost Per Reach</th>
<th>Cost of material per foot of path</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>6</td>
<td>467.13</td>
<td>4</td>
<td>2</td>
<td>34.60</td>
<td>34.60</td>
<td>$4,013.86</td>
<td>$8.59</td>
</tr>
<tr>
<td>1B</td>
<td>6</td>
<td>491.27</td>
<td>4</td>
<td>2</td>
<td>36.39</td>
<td>36.39</td>
<td>$4,221.28</td>
<td>$8.59</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>495.18</td>
<td>4</td>
<td>2</td>
<td>36.68</td>
<td>36.68</td>
<td>$4,254.88</td>
<td>$8.59</td>
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<td>4</td>
<td>6</td>
<td>651.59</td>
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<td>2</td>
<td>48.27</td>
<td>48.27</td>
<td>$5,598.85</td>
<td>$8.59</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>632.4</td>
<td>4</td>
<td>2</td>
<td>46.84</td>
<td>46.84</td>
<td>$5,433.96</td>
<td>$8.59</td>
</tr>
</tbody>
</table>

### Table 8: Cost of Permeable Concrete Pathway

<table>
<thead>
<tr>
<th>Reach</th>
<th>Pathway Width (ft)</th>
<th>Pathway Section Length</th>
<th>Base Gravel Depth (in)</th>
<th>Permeable Concrete depth (in)</th>
<th>yd^3 of course material</th>
<th>yd^3 of Permeable Concrete</th>
<th>Total Cost Per Reach</th>
<th>Cost of material per foot of path</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>6</td>
<td>467.13</td>
<td>4</td>
<td>6</td>
<td>34.60</td>
<td>51.90</td>
<td>8,944.67</td>
<td>19.15</td>
</tr>
<tr>
<td>1B</td>
<td>6</td>
<td>491.27</td>
<td>4</td>
<td>6</td>
<td>36.39</td>
<td>54.59</td>
<td>9,406.91</td>
<td>19.15</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>495.18</td>
<td>4</td>
<td>6</td>
<td>36.68</td>
<td>55.02</td>
<td>9,481.78</td>
<td>19.15</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>651.59</td>
<td>4</td>
<td>6</td>
<td>48.27</td>
<td>72.40</td>
<td>12,476.74</td>
<td>19.15</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>632.4</td>
<td>4</td>
<td>6</td>
<td>46.84</td>
<td>70.27</td>
<td>12,109.29</td>
<td>19.15</td>
</tr>
</tbody>
</table>

### Table 9: Cost of Regular Concrete Pathway

<table>
<thead>
<tr>
<th>Reach</th>
<th>Pathway Width (ft)</th>
<th>Pathway Section Length</th>
<th>Base Gravel Depth (in)</th>
<th>Concrete depth (in)</th>
<th>yd^3 of course material</th>
<th>yd^3 of Concrete</th>
<th>Total Cost Per Reach</th>
<th>Cost of material per foot of path</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>6</td>
<td>467.13</td>
<td>0</td>
<td>6</td>
<td>0.00</td>
<td>51.90</td>
<td>$5,501.75</td>
<td>$9.56</td>
</tr>
<tr>
<td>1B</td>
<td>6</td>
<td>491.27</td>
<td>0</td>
<td>6</td>
<td>0.00</td>
<td>54.59</td>
<td>$5,786.07</td>
<td>$9.56</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>495.18</td>
<td>0</td>
<td>6</td>
<td>0.00</td>
<td>55.02</td>
<td>$5,832.12</td>
<td>$9.56</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>651.59</td>
<td>0</td>
<td>6</td>
<td>0.00</td>
<td>72.40</td>
<td>$7,674.28</td>
<td>$9.56</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>632.4</td>
<td>0</td>
<td>6</td>
<td>0.00</td>
<td>70.27</td>
<td>$7,448.27</td>
<td>$9.56</td>
</tr>
</tbody>
</table>
Table 10: Cost of Retaining Wall

<table>
<thead>
<tr>
<th>Retaining Wall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Length (ft)</td>
<td>6</td>
</tr>
<tr>
<td>Wall Height (ft)</td>
<td>436</td>
</tr>
<tr>
<td>Wall square ft (ft^2)</td>
<td>2616</td>
</tr>
<tr>
<td>Wall Cost per sq ft per ODOT</td>
<td>$140</td>
</tr>
<tr>
<td>Total Wall Installed Cost</td>
<td>$366,240</td>
</tr>
</tbody>
</table>
River Pathway Design Project

Table 11: Labor Rates

<table>
<thead>
<tr>
<th>Labor Rates for Prevailing Wage Projects Taken From Davis Bacon Rates For Lucas County</th>
<th>Title</th>
<th>$/hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreman</td>
<td>$53.82</td>
<td></td>
</tr>
<tr>
<td>Operator</td>
<td>$41.38</td>
<td></td>
</tr>
<tr>
<td>Finisher</td>
<td>$43.62</td>
<td></td>
</tr>
<tr>
<td>Laborer</td>
<td>$37.95</td>
<td></td>
</tr>
<tr>
<td>Stone Mason</td>
<td>$42.51</td>
<td></td>
</tr>
</tbody>
</table>

Table 12: Wage Breakdown per Crew Size

<table>
<thead>
<tr>
<th>Crew Size</th>
<th># of ppl</th>
<th>pavement crew</th>
<th>cost rates for prevailing wage.</th>
<th>per</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>foreman/super</td>
<td>53.82</td>
<td>hour</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>operators</td>
<td>41.38</td>
<td>hour</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>finisher</td>
<td>43.62</td>
<td>hour</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>labors</td>
<td>37.95</td>
<td>hour</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>stone mason</td>
<td>42.51</td>
<td>hour</td>
</tr>
</tbody>
</table>

Table 13: Cost for Labor for Installation

<table>
<thead>
<tr>
<th>Material</th>
<th>Estimated Pathway FT. per day of Production</th>
<th>Cost of Proposed Crew for 8 hr day</th>
<th>Total Pathway (ft)</th>
<th>Days Required</th>
<th>Total Labor Cost for Pathway</th>
<th>Labor Cost per Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>230</td>
<td>$1,414.16</td>
<td>2737.57</td>
<td>12</td>
<td>$16,832.01</td>
<td>$6.15</td>
</tr>
<tr>
<td>Permeable Concrete</td>
<td>90</td>
<td>$1,414.16</td>
<td>2737.57</td>
<td>30</td>
<td>$43,015.13</td>
<td>$15.71</td>
</tr>
<tr>
<td>Concrete</td>
<td>130</td>
<td>$1,414.16</td>
<td>2737.57</td>
<td>21</td>
<td>$29,779.71</td>
<td>$10.88</td>
</tr>
</tbody>
</table>
Conclusion

For this project, our recommended solutions were based largely on price, and innovation, while being sure to keep negative environmental impact to a minimum. Available space at each reach was also a limiting factor. The design of this project is done by 2 phases. The first phase is to be designed by implementing a gravel path along the river along the chosen path route. The route chosen for the design is route 3 that will run from Secor Road along the North Side of the river to West Rocket Drive. It will then continue to the South Side of the river and run to the Performance Arts Bridge. It then jumps across to the North Side to the Carlson Library Bridge. From there is continues on the South Side of the river and runs to the David C. Root Bridge. From there, it continues on the South Side of the river and finishes by the existing outlook by Savage Arena. Each run between bridges is called a Reach and will be used in that order for construction. The second Phase will be implementing a more finished look by constructing the path out of either Regular Concrete or Permeable Concrete. Cross sections of each path type are Figures 27, 28, and 29 respectively.

As of now, all prices are an estimation and not finite. The cost estimate has been broken down with the entire pathway being priced out with all three pavements. However, Table 14 shows the cost breakdown per reach, both containing a material price and a labor price. Reach 1 having Gravel pavement costs $14,128, Reach 2 having Permeable Concrete pavement costs $12,513, Reach 4 having Regular Concrete pavement costs $13,314, and Reach 5 having Regular Concrete pavement costs $12,922. The cost determined for the Retaining Wall, Stairs and Outlooks are a combined price of material and labor lumped into one sum. With that being said, the cost for the Retaining Wall is $366,240, the Stairs is $12,000 and the cost of two Outlooks are $14,500. Combining all the numbers together with an inflation factor, the estimated price of this entire project is $472,755. To get a better grasp on how the cost estimate was put together, Tables 4 through 13 above go into more detail for what was considered for each pricing area. It can be said that for each Reach can be a mix of Gravel, Permeable Concrete, and Regular Concrete. Tables 7, 8, and 9 are the breakdown for Gravel, Permeable, and Regular Concrete respectively and have it broken down per reach. Not every Reach must be done with just Gravel, Permeable, or Regular Concrete. If all conditions meet regulations, then the Reaches can be mixed and matched between any of the options to show different practices are being implemented in consideration of what is best for the environment.
## Table 14: Project Cost Summary

<table>
<thead>
<tr>
<th>REACH</th>
<th>PROPOSED MATERIAL</th>
<th>ESTIMATED COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>$8,235</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>$5,893</td>
</tr>
<tr>
<td>2</td>
<td>Permeable Concrete</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>$4,732</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>$7,781</td>
</tr>
<tr>
<td>4</td>
<td>Concrete</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>$6,226</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>$7,088</td>
</tr>
<tr>
<td>5</td>
<td>Concrete</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>$6,043</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>$6,879</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>$14,500</td>
</tr>
<tr>
<td></td>
<td>RETAINING WALL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MECHANICALLY STABALIZED</td>
<td>$366,240</td>
</tr>
<tr>
<td></td>
<td>STRAIRS BUDGET</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TBD</td>
<td>$12,000</td>
</tr>
<tr>
<td></td>
<td>ESTIMATED TOTAL COST</td>
<td>$445,617</td>
</tr>
<tr>
<td></td>
<td>INFLATION FACTOR OVER TWO YEARS</td>
<td>$27,138.07</td>
</tr>
<tr>
<td></td>
<td>ESTIMATED TOTAL COST</td>
<td>$472,755</td>
</tr>
</tbody>
</table>
Qualifications of Design Team
Within this design team, many diverse qualifications can be utilized. As seen in the following resumes, each member is able to contribute differently to the group. The specific knowledge of each individual allows our team to generate unique ideas from demonstrating the different backgrounds and experiences achieved through our years of study. Along with this, the group works well with one another to fulfill specific aspects of the design. This attribute will also help to produce a well-constructed final product. From these factors our team is able to make a strong and useful design that will fulfill the needs of The University of Toledo.
OBJECTIVE

To secure a full time position in the Civil Construction or Engineering Field.

EDUCATION

The University of Toledo, Toledo, Ohio

Bachelor of Science, Civil Engineering

- Graduation Date: December 2014
- GPA – 3.24

Monroe County Community College, Monroe, Michigan

Associates Degree of Science, Engineering

- Graduating April 2012
- Grade Point Average: 2.73

COMPUTER

Microsoft Office Suite

SKILLS

AutoCAD

EXPERIENCE

The Rudolph/Libbe Inc., Walbridge, OH

Co-op Engineer

- Liaison between Project Manager and field work involved on projects
- Point contact between Customer, Engineers, & Subcontractor for Submittals and RFIs
- Schedule preparation and resource forecasting for employee job tracking

The Legacy Golf Course, Ottawa Lake, MI

Maintenance

- Maintained adequate course conditions
- Cleaned the shop and sprinkler heads
- Cut grass and raked sand traps

The Function Homes, Ottawa Lake, MI

Carpenter

- Sustained good work conditions
- Built interior and exterior walls
- Delivered wood to work site

HONORS & AWARDS

National Honor Society, Whiteford Agricultural Schools

Scholar Athlete, Whiteford Agricultural Schools

College of Engineering Deans List: Spring 2012; Spring 2014

COLLEGIATE ACTIVITIES

American Society of Civil Engineers (ASCE)

REFERENCES

Available upon request
DEREK R. HESS
2114 Timbercreek Drive, Toledo, Ohio 43615
Derek.Hess@rockets.utoledo.edu
(567)-644-8305

OBJECTIVE
Seeking a full-time position as a Structural Engineer in a Structural Engineering department.

EDUCATION
University of Toledo  Toledo, Ohio
August 2010- Present
Bachelor of Science, Civil Engineering
-Overall GPA: 3.13
-Engineering GPA: 3.57

Tri Star Career Compact, Celina, Ohio
August 2009- May 2010
One-year Engineering Technology/Computer Aided Drafting Program
- Certificate of Completion, May 2010

COMPUTER
-Microstation V8i
-AutoCAD Civil 3D -MathCAD
-LEAP Bridge -Softplan
-LARS -Microsoft Office Suite
-Conspan -Autodesk Inventor

EXPERIENCE
Mannik & Smith Group Maumee, Ohio
May 2012- Present
CAD Technician/Co-op
-Prepared detail design drawings
-Assisted in bridge design, bridge inspections, and load ratings

Brian Kremer Poultry Maria Stein, Ohio
August 2007- December 2013
General Laborer
-Collected eggs and efficiently put them into trays for shipping
-Performed miscellaneous tasks around the farm

ENGINEERING PROJECTS
Interstate 475 over Dorr Street/Hill Avenue (Toledo, Ohio)
-2 Similar Twin Structures featuring bridge widening and rehabilitation

Interstate 475 over Blossman Road (Toledo, Ohio)
-Bridge widening and rehabilitation featuring super elevation and transition on structure

Central Avenue over Interstate 475 (Toledo, Ohio)
-Bridge relocation featuring SPUI design (Currently in design phase)

State Route 66 over Maumee River (Waterville, Ohio)
-1000’+ structure featuring relocation and haunched girders
(Currently in design phase)

COLLEGIATE ACTIVITIES
Alpha Sigma Phi Fraternity
-Current Vice-President
-Former Treasurer
-Former Community Service Chairman
-Former Family Relations Chairman

REFERENCES:
Available upon request
PETER LOPEZ
317 Reese St.
Sandusky, OH 44870
419-656-0713
osupali5@gmail.com

OBJECTIVE
To obtain a co-op position in the field of civil engineering that will enhance my academic endeavors through hands-on experience.

EDUCATION
The University of Toledo
Toledo, OH
August 2010-Present
Bachelor of Science, Civil Engineering
• Anticipated Graduation Date: May 2015
• Grade Point Average: 2.326

COMPUTER SKILLS
Microsoft Office
Auto CAD

EXPERIENCE
Cedar Point
Sandusky, OH
Summer 2012 and 2013
Co-op
• Inspected rides using a safety checklist
• Studied the design and structure of the ride
• Maintained rides to O.H.S.H.A. standards
• Utilized analytical processes to solve problems

Cedar Point
Summer 2010 & 2011
Games Host
• Interacted with customers
• Handled money
Games Supervisor
• Trained employees on operating games
• Managed personnel
• Ensured quality performance and customer satisfaction

COMMUNITY ACTIVITIES
Biddy Basketball
Sandusky, OH
November 2009-February 2010
Volunteer
• Taught second-fourth graders basic basketball skills
• Portrayed leadership and good character (role model)
• Assisted players one-on-one when necessary

HONORS & AWARDS
Rocket Gold Scholarship

REFERENCES
Available upon request
OBJECTIVE
To obtain a job in the Civil Engineering field

EDUCATION
The University of Toledo, Toledo, Ohio
Bachelor of Science, Civil Engineering
• Anticipated Graduation Date: December 2014
• Grade Point Average: 3.537

AWARDS
Blue and Gold Scholar Award

AND HONORS
Dean’s List and Presidential List Recognition
Chi Epsilon

COMPUTER
AutoCAD 2010
Microsoft Windows 7/ Vista/xp
Microsoft Office Suite

SKILLS

WORK EXPERIENCE
Ferguson Construction, Co.
Co-op
May 2013-August 2014
December 2011-May 2012
• Assisted with site layout
• Performed general labor jobs; concrete, metal roofs and siding, and misc. work
• Estimated jobs using computer software and calling subcontractors
• Assisted with project managing

Choice One Engineering
Co-op
August 2012 – January 2013
• Surveyed streets and properties
• Staked site lay-out
• Performed operations on Auto-cad
• Reviewed street plans

Riethman Builders, Inc.
Summer help
June 2009–August 2011
• Poured concrete driveways and sidewalks
• Constructed homes and repaired roofs
• Performed in miscellaneous capacities on job site

COLLEGIATE ACTIVITIES
Student Member of First Year Engineers (FYRE)
Intramural sports

SPECIAL SKILLS
Possess good communication skills
Ability to work independently, and also with others in a team environment
Strong knowledge of basic tools used for construction and estimating projects
MITCHELL GENE PITSENBARGER

PERMANENT ADDRESS
9648 Pitsenbarger Road.
Versailles, Ohio 45380
(937)564-6058

LOCAL ADDRESS
1831 Evansdale Avenue
Toledo, Ohio 43607
mitch.pitsenbarger@utoledo.edu

OBJECTIVE: To obtain a full time position in the Civil Engineering

EDUCATION: The University of Toledo, Toledo, Ohio
August 2010 - Present
Bachelor of Science, Civil Engineering
• Anticipated Graduation Date: December 2014
• Grade Point Average: 3.60
Edison Community College, Piqua, Ohio
• PSEOP transfer credits

AWARDS & HONORS:
• Rocket Scholar Award
• BOSEF Scholarship (Building Ohio’s Sustainable Energy Future)
• Dean’s List, The University of Toledo: Fall 2010, 2014 Spring 2011, 2013
• State FFA Degree: 2009; American FFA degree: 2011

COMPUTER SKILLS:
• AutoCAD 2013, AutoCAD Civil 3-D
• Microsoft Office
• Bluebeam PDF Reader

EXPERIENCE: University of Toledo Transit Services
August 2010-Present
Bus Maintenance and Operation
• Operate Bus for Driving Students on Campus
• Dispatch and Manage Bus Fleet

January 2012 – January 2013
Danis Building Construction
Co-op (Three Co-ops)
• Assist Superintendent in day to day tasks
• Report weekly progress totals for labor audits
• Attend Pre bid meetings and deliver bids
• Bid preparation and Delivery

January 2014 – Present
Mote & Associates
Co-op
• Prepare Feasibility Reports
• Update AutoCAD Block References
• Integrate GIS aerials into Project Location Maps
• Assist in Topographic Survey

COLLEGIATE ACTIVITIES:
• Student Member of American Society of Civil Engineers
• Student Teachers Assistant (TA)
• Secretary of Chi-Epsilon

SPECIAL:
• Class A CDL
  Endorsements: Tanker, Passenger, Doubles & Triples

REFERENCES Available Upon Request
## Appendix A: Design Calculations

### Pathway Quantities

#### Table 15: Pathway Design Quantities

<table>
<thead>
<tr>
<th>Reach</th>
<th>Stations</th>
<th>Length (ft)</th>
<th>Slab: Concrete (Ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>1+03.22</td>
<td>467.13</td>
<td>467.13' (6'x0.5') = 1401.39</td>
</tr>
<tr>
<td>1B</td>
<td>5+85.35</td>
<td>491.27</td>
<td>491.27' (6'x0.5') = 1473.81</td>
</tr>
<tr>
<td>2</td>
<td>1+13.86</td>
<td>495.18</td>
<td>495.18' (6'x0.5') = 1485.54</td>
</tr>
<tr>
<td>3</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>0+06.49</td>
<td>651.59</td>
<td>651.59' (6'x0.5') = 1954.77</td>
</tr>
<tr>
<td>5</td>
<td>7+07.12</td>
<td>632.40</td>
<td>632.4' (6'x0.5') = 1897.20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2737.57</td>
<td>Total = 8212.71</td>
</tr>
</tbody>
</table>

Gravel: Coarse (Ft³)  
Gravel: Fine (Ft³)

<table>
<thead>
<tr>
<th>Reach</th>
<th>Length (ft)</th>
<th>Slab: Concrete (Ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>467.13' (6'x0.33') = 924.92</td>
<td>467.13' (6'x0.1667') = 467.22</td>
</tr>
<tr>
<td>1B</td>
<td>491.27' (6'x0.33') = 972.71</td>
<td>491.27' (6'x0.1667') = 491.37</td>
</tr>
<tr>
<td>2</td>
<td>495.18' (6'x0.33') = 980.46</td>
<td>495.18' (6'x0.1667') = 495.28</td>
</tr>
<tr>
<td>3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>651.59' (6'x0.33') = 1290.15</td>
<td>651.59' (6'x0.1667') = 651.72</td>
</tr>
<tr>
<td>5</td>
<td>632.4' (6'x0.33') = 1252.15</td>
<td>632.4' (6'x0.1667') = 632.53</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5420.39</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Slab</th>
<th>Gravel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concrete</td>
</tr>
<tr>
<td></td>
<td>8212.71</td>
</tr>
<tr>
<td>Yd³</td>
<td>304.17</td>
</tr>
</tbody>
</table>

### Outlook quantities

1. Rectangle = 9’ X 18’ x 0.333’ = 53.9 ft³
2. Semi-circle = ((3.14 x 9’²)/2) x 0.333’ = 42.37 ft³
3. Short wall segments = 2 x 3’ x 2.333’ x 1.333’ = 18.66 ft³
4. Wall segment = ((3.14 x 10.333’²)/2) x 2.333’–((3.14 x 9’²)/2) = 94.44 ft³

Total = 53.9 + 42.37 + 18.66 + 94.44 = 209.37 ft³
### Cut and Fill Data

| Table 16: Reach 1 Cut and Fill |

<table>
<thead>
<tr>
<th>Reach 1 (Law Library Path)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Width of Gravel Path</strong></td>
</tr>
<tr>
<td><strong>Thickness of Gravel Path</strong></td>
</tr>
<tr>
<td><strong>Area of Gravel Path</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Station</th>
<th>Volume From Cross-Sections (ft³)</th>
<th>Corrected Volume for Gravel Path (ft³)</th>
<th>Distance (ft)</th>
<th>Avg. Area (ft²)</th>
<th>Volume (ft³)</th>
<th>Running Total (ft³)</th>
<th>Station</th>
<th>Volume From Cross-Sections (ft³)</th>
<th>Corrected Volume for Gravel Path (ft³)</th>
<th>Distance (ft)</th>
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**Total** | **-51.25** (yd³) |
### Table 17: Reach 2 Cut and Fill

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**Total**: 1.21 (yd^3)
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**Total 18.85 (yd^3)**
Runoff Calculations

All Calculations are based off of the Ohio Department of Natural Resources Manual’s Best Management Practice “Chapter 02”

For this project the amount of new surface that will be partially impermeable is divided up into different sections. There are 4 reaches of the river gaining a pathway and 2 outlooks.

Area of the Outlooks: (2 Outlooks (1/2(3.14*9'^2) +18'^6')) = 470 ft^2

Area of Pathway:

- Reach 01: 5844ft^2
- Reach 02: 2970ft^2
- Reach 04: 3912ft^2
- Reach 05: 3792ft^2

Total Pathway and Outlook Areas: 16,988 ft^2 (.39 acres)

Runoff Found by using Water Quality Volume (WQv):

\[
\text{WQv (ac-ft)} = C \times P \times A
\]

C = Volumetric Runoff Coefficient
P = 0.75” Rainfall
A = Drainage area (acres)

Concrete
\[
\text{WQv (ac-ft)} = C \times P \times A = (1.0)(0.75”)(0.39 \text{ acres}) = 0.293 \text{ ac-in}
\]
\[
= 1062 \text{ ft}^3 \text{ of runoff} \\
= 0.063 \text{ ft}^3 \text{ of runoff/ft}^2
\]

Pervious Concrete
\[
\text{WQv (ac-ft)} = C \times P \times A = (0.89)(0.75”)(0.39 \text{ acres}) = 0.260 \text{ ac-in}
\]
\[
= 945 \text{ ft}^3 \text{ of runoff} \\
= 0.056 \text{ ft}^3 \text{ of runoff/ft}^2
\]

Gravel
\[
\text{WQv (ac-ft)} = C \times P \times A = (0.50)(0.75”)(0.39 \text{ acres}) = 0.146 \text{ ac-in}
\]
\[
= 531 \text{ ft}^3 \text{ of runoff} \\
= 0.031 \text{ ft}^3 \text{ of runoff/ft}^2
\]
MSE Retaining Wall Calculations

\( \phi_{sand} = 30 \)

\( \phi_f' = \frac{2}{3} \) Shear strength of soil \( = \frac{2}{3}(30) = 20 \)

\[
S_v = \frac{T_{all}}{(\gamma_1 z k_a) FS}
\]

\( T_{all} = 2000 \frac{lb}{ft} \)

\( \gamma_1 = 135 \frac{lb}{ft^3} \)

\( z = 1.5 \)

\( k_a = 0.6 \)

\[
S_v = \frac{2000 \frac{lb}{ft}}{(135 \frac{lb}{ft^3} * 1.5 * 0.6) 1.5} = 2.74 \text{ ft}
\]

Use 1 ft since we need a 6 ft wall

\[
L = L_r - L_e = \frac{H - z}{\tan(45 + \frac{\phi_f'}{2})} + \frac{S_v * k_a * \sigma_o * FS}{2 * \sigma_o * \tan(\phi_f')}
\]

Max length at \( z=0 \)

\[
L = \frac{6 - 0}{\tan(45 + \frac{30}{2})} + \frac{1 * 0.6 * 1.5}{2 * \tan(20)} = 3.46 + 1.24 = 4.7 \text{ ft}
\]

\( L_r = 3.46 \text{ ft} \quad L_e = 1.24 \text{ ft} \)

Use \( L_e = 2.04 \text{ ft} \) so the factor of safety against sliding is larger than 1

\( L = 5.5 \text{ ft} \)

\[
L_l = \frac{S_v * \sigma_o' * FS}{2 * \sigma_o' * \tan(\phi_f')} = \frac{L_e}{2}
\]

\[
L_l = \frac{2.04}{2} = 1.02 \text{ ft}
\]
Factor of Safety Against Overturning

\[ FS_{overturning} = \frac{M_R}{M_C} \]

\[ M_O = P_a \ast \eta_{arm \ about \ ^c} \]
\[ M_O = \left( \frac{1}{2} \gamma_1 \ast H^2 \ast k_a \right) \ast \eta_{arm \ about \ ^c} \]
\[ M_O = \left( \frac{1}{2} \ast 135 \ast 6^2 \ast 0.6 \right) \ast 2 = 1458 \ast 2 = 2916 \ \text{lb ft} \]
\[ M_R = w \ast \eta_{arm \ about \ ^c} \]
\[ w = L \ast H \ast \gamma_1 \]
\[ w = 5.5 \ast 6 \ast 135 = 4455 \ \text{lb ft} \]
\[ M_R = 4455 \ast \frac{5.5}{2} = 12251.25 \ \text{lb ft} \]
\[ FS_{overturning} = \frac{M_R}{M_C} = \frac{12251.25}{2916} = 4.2 \]

Factor of Safety Against Sliding

\[ FS_{sliding} = \frac{w \tan(k \ast \phi_1^1)}{P_a} \]
\[ K = \frac{2}{3} \]
\[ FS_{sliding} = \frac{4455 \tan\left(\frac{2}{3} \ast 30\right)}{1458} = 1.112 \]
Factor of Safety Against Bearing

\[ FS_{bearing} = \frac{q_{ult}}{\sigma_o'(H)} \]

\[ q_{ult} = C_2' N_c + \frac{1}{2} \gamma_2 L_2' N_y \]

For \( \phi_2' = 15 \Rightarrow \) Table 3-3 \( N_c = 10.98 \quad N_y = 2.65 \)

\[ L_2' = L_2 - 2 e \]

\[ e = \frac{L_2}{2} - \frac{M_p - M_o}{\Sigma V} \]

\( L_2 = 5.5 \)

\[ \Sigma V = \gamma \ast H \ast L \]

\[ \Sigma V = 125 \ast 6 \ast 5.5 = 4125 \frac{lb}{ft} \]

\[ e = \frac{5.5}{2} - \frac{12251.25 - 2916}{4125} = 0.487 ft \]

\[ L_2' = L_2 - 2 e = 5.5 - 2(0.487) = 4.526 ft \]

\[ q_{ult} = C_2' N_c + \frac{1}{2} \gamma_2 L_2' N_y = 15 \ast 10.98 + \frac{1}{2} \ast 125 \ast 4.526 \ast 2.65 = 914.32 \]

\[ \sigma_o'(H) = \gamma_1 \ast H = 130 (6) = 780 \frac{lb}{ft^2} \]

\[ FS_{bearing} = \frac{q_{ult}}{\sigma_o'(H)} = \frac{914.32}{780} = 1.17 \]
Appendix B: Alternative Maps

Figure 4: Pathway 1 Traveling from Savage Arena South Side of River to David C. Root Bridge then North Side of River to Secor Road
Figure 5: Pathway 2 Traveling from Savage Arena South Side of River to Library Bridge then North Side of River to the Law Building
Figure 6: Pathway 3 Traveling from Savage Arena on South Side of River to Library Bridge then on North Side of River to Performance Arts Bridge then South Side to West Rocket Drive then North Side to Secor Road
Figure 7: Rendering 1 of Reach 1
Figure 8: Rendering 2 of Reach 1
Figure 9: Rendering 1 of Reach 5
Figure 10: Rendering 2 of Reach 5
Appendix C: Schematics

Figure 11: Reach 1 Proposed Pathway Plan View
Figure 12: Reach 1 Proposed Pathway Satellite View
Figure 13: Reach 2 Proposed Pathway & Outlook Plan View
Figure 14: Reach 2 Proposed Pathway & Outlook Satellite View
Figure 15: Reach 3 Proposed Outlook Plan View
Figure 16: Reach 3 Proposed Outlook Satellite View
Figure 17: Reach 4 Proposed Pathway Plan View
Figure 18: Reach 4 Proposed Pathway Satellite View
Figure 19: Reach 5 Proposed Pathway Plan View
Figure 20: Reach 5 Proposed Pathway Satellite View
Figure 21: Reach 1 Profile from Secor to Mid-Bench
Figure 22: Reach 1 Profile from Mid-Bench to West Rocket Drive Bridge
Figure 23: Reach 2 Profile from West Rocket Drive Bridge to Performance Arts Bridge
Figure 24: Reach 4 Profile from Carlson Library Bridge to David C. Root Bridge
Figure 25: Reach 5 Profile from David C. Root Bridge to Existing Savage Outlook
Figure 26: Existing Outlook by Savage Arena Provided by SSOE
Figure 27: Gravel Path Cross Section Design

Figure 28: Regular Concrete Path Cross Section Design
Figure 29: Permeable Concrete Path Cross Section Design
TYPICAL RETAINING WALL CROSS SECTION
(REACH 05)

Figure 30: Retaining Wall Cross Section
Works Cited


