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Civil Engineering Design of Cornhusker Council's Outdoor Education Center

Kelly Weiler
University of Nebraska - Lincoln

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CIVIL ENGINEERING DESIGN OF CORNHUSKER COUNCIL’S OUTDOOR EDUCATION CENTER

An Undergraduate Honors Thesis
Submitted in Partial fulfillment of
University Honors Program Requirements
University of Nebraska-Lincoln

by Kelly Weiler
Civil Engineering
College of Engineering

April 29, 2019

Faculty Mentors:
Bruce Dvorak, PhD, PE, Civil Engineering
Craig Reinsch, MS, PE, BCEE, Civil Engineering
Abstract

A team of geotechnical, structural, hydraulic, environmental, and transportation experts collaborated to provide engineering solutions to the Cornhusker Council in an effort to solve the current problems facing their Outdoor Education Center. This results of this project provided the structural design of three bridges on the property, transportation plans for two parking lots and roadway design, geotechnical recommendations for soil testing and erosion prevention, and an environmental and hydraulic analysis of the property. A major challenge in the design of this project is the consideration of the dangers and regulations that accompany the floodway and floodplain regions on site. Various alternatives were identified and investigated in each civil engineering discipline to provide a comprehensive 30% design for the Outdoor Education Center.

Key Words: Engineering, Design, Boy Scouts, Environmental
Project Manager Experience

In addition to my role as the lead structural engineering designer in my senior design project, I also served as the project manager for my team. In this role, I was responsible for planning and leading weekly meetings in order to achieve the requested outcomes and to keep the project on schedule. Additionally, I was responsible for writing frequent progress reports to track the quality and quantity of work that went into my group’s design efforts. As project manager, I was also the final quality check on all submittals throughout the semester. This summation of additional tasks to my technical responsibilities, proved to be a larger time demand than I originally presumed, however, it led to a more holistic understanding of the project. Upon the completion of the project, I feel confident that my team members were able to effectively identify and analyze solutions to their emphasis area within the project. I also feel that I was able to lead my team to successful outcomes by means of frequent communication and collaboration.
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BOB THE BUILDER & ASSOCIATES

TEAM ORGANIZATION

KELLY WEILER
PROJECT MANAGER
STRUCTURAL DESIGN

QUINN BRANDT
WATER RESOURCES
DESIGN

ANDREW EDWARDS
STRUCTURAL
DESIGN

JUSTIN MCGILL
TRANSPORTATION
DESIGN

KAR SENG SIA
TRANSPORTATION
DESIGN
QUINN BRANDT

Quinn Brandt is an undergraduate student at the University of Nebraska-Lincoln. He will graduate in May 2019 with a Bachelor of Science in Civil Engineering with an emphasis in Water Resources. In the summer of 2018, he interned at Thompson, Dreessen and Dorner in Omaha, Nebraska. He is currently in leadership positions with UNL Aerospace’s Rocketry and Project 100k teams.

ANDREW EDWARDS

Andrew Edwards is a Structural Emphasis. He does not have any work or internship experience. He does, however, have an extensive list of completed courses covering topics relating to Structural Engineering. He has also completed a Foundations course past what is required from the University.

JUSTIN MCGILL

Justin McGill is a senior undergraduate student at the University of Nebraska – Lincoln and is graduating in May 2019. He is majoring in Civil Engineering with an emphasis in Transportation and Geotechnical work. Justin has worked at Alfred Benesch & Company for the past 2.5 years. He has been working mainly with the Transportation projects going on in the Omaha area as well as working in the Geotechnical lab to run a variety of soil tests for projects in the region. During his employment, he has gained valuable skills in working with design, team work, and project managing.
KAR SENG SIA

Kar Seng Sia is a senior undergraduate student at the University of Nebraska-Lincoln (UNL) from Malaysia. He is majoring in Civil Engineering and emphasizing centrally in the transportation and water areas. Kar has taken several transportations courses at the UNL. Additionally, he is currently working on steel and flow system designs before graduation. The latest internship was at Kimlun Corporation during the summer of 2018 in Malaysia and actively being part of the logistics department at Nebraska University Malaysian Student Organization (NUMSA) during his time at UNL.

KELLY WEILER

Kelly Weiler is a senior at the University of Nebraska-Lincoln anticipating to graduate in May of 2019 with a B.S. in Civil Engineering and a minor in Spanish. Her chosen emphasis area is in structural engineering. She has completed coursework in Steel Design, Concrete Design, and Advanced Structural Analysis. She also has over 2 years of professional experience as a bridge engineering intern at Olsson.
In order to develop the best solutions for Cornhusker Council, each member of Bob the Builder & Associates has effectively analyzed components of the Outdoor Education Center (OEC) applicable to his or her area of expertise. The combination of key issues that the property presents cover a spread of civil engineering disciplines and will, therefore, demand expertise from various roles. The professional individuals representing Bob the Builder & Associates range in both technical expertise and professional experience. After assessing the design implications more closely, strategies have been developed for each challenge that the OEC currently faces.
OVERVIEW
In addition to the standard disciplines of engineering, the client has also asked Bob the Builder & Associates to take a look at the general site layout. This includes the installation of lighting, the installation of new sports fields, changes to the firing range, planting of vegetation on the site, the location of RV pads, and the relocation of the Harvey Hunter Lodge. The following document will explain the current site information, challenges facing the site, and the options and recommendations that Bob the Builders & Associates has generated.

SITE INFORMATION
The Outdoor Education Center is located on 120th St in Lincoln, Nebraska. Currently on the site, there is a main building on the western part of the property as well as an amphitheater. On the portion of the property east of Scout Creek, there is a shooting range located on the northern part, a soccer field on the southern side, and the Harvey Hunter Lodge located just east of the Scout Creek. As it stands now, there is no noticeable lighting anywhere else on the property. Several components on site lack lighting, including the existing southern parking lot, the sports fields, the camping structures, and near the low-water crossing. In regards to the sports fields, there is one soccer field that is located on the central portion of the site. There are currently two firing ranges on the site located on the site. Lastly, the Harvey Hunter lodge is located just east of the Scout Creek. Now that the site has been explained, there are a number of challenges facing the site that need to be addressed.

CHALLENGES
The biggest challenge facing this project is the budget and the potential of the East Beltway going through the site in the future. Like any project of this scale, costs can accumulate quickly. A number of the requested components of the project come with considerable financial costs. Just adding a new baseball field would cost an estimated $9,000 to build and the yearly maintenance would increase the cost even more. Similarly, an additional soccer field would cost an estimated $3000 to build and again maintenance would increase the yearly cost of the field. In order to stay within the budget, the most cost-efficient choices were proposed.

Beyond financial constraints, the East Beltway presents further challenges. The current proposed location of the East Beltway goes right through the middle of the site. The East Beltway is a project is being led by the City of Lincoln and Lancaster County. Additionally, construction of the beltway isn’t expected to start for another twenty years or more which increases the uncertainty surrounding the project. Even though the beltway might not be there for the next twenty years, this is still problematic as it would dramatically decrease the size of the available land if it is built. Bob the Builder & Associates has taken this issue into account throughout the process and has worked to provide solutions that will not interfere with the proposed beltway if it is constructed in the future. As can be seen in Figure 1, the majority of structures and fields on the site are not built in the planned area of the future East Beltway. Doing this allows the client to get the most use out of the site and the features there if the beltway is indeed constructed. The client stated that they don’t mind components of the site being built in the area where the East Beltway is going to be built, but there is no guarantee that the amount they get compensated for the city taking back the land would equal the amount they lose from building a feature there.
There are also challenges to consider regarding the Harvey Hunter Lodge. The lodge is currently located in the floodway, as shown on Figure 1. This poses huge safety risks for anyone that stays there. To solve this issue, the lodge will need to be relocated. Along with it being out of the floodway, the lodge needs to retain its appearance because it was built in honor of a former scout. Therefore, it is a large priority of Bob the Builder & Associates that the lodge still looks the same after it is moved from the floodway.

**ALTERNATIVES**

For any engineering project, there are many different options. In the following section, Bob the Builder & Associates has prepared a number of different alternatives for each component of the project. One option for the lighting on site is to simply install lighting where it is necessary, such as the parking lots and the low water crossing and forgo installing it in places such as the sports fields. Alternatively, the client can install lighting at the necessary spots as well as places that can be benefit from lighting with extended use of those components, such as the soccer fields and amphitheater.

In regards to the sports fields, there are a number of options. Currently, there is one soccer field located on the eastern part of the property. The client mentioned that this component is a source of income for the site, so with this in mind, Bob the Builder & Associates came up with the following options. One option is to only build a new baseball field near the current soccer field and proposed parking lot, which can be seen in Figure 1. Another option would be to just build two new soccer fields. With three soccer fields, larger tournaments can be held on site which has the potential to increase revenue. Another option is to put in a baseball field and one additional soccer field. Finally, there is the option to not put in any new sports field and use that part of the budget elsewhere.

Next, the shooting ranges on site currently offer archery and bb ranges. There are currently no problems with the shooting ranges on site, but there could be room for potential improvement in what they offer. The first option is to build an all-purpose shooting range to replace the current ones in place. The second option is to keep the current ones. The advantage of an all-purpose shooting range is that it increases the number of people that can use it at the same time. On the other hand, retaining multiple ranges for different activities allows for more flexibility of the events that can be held on site simultaneously.

As it stands now, there are no trees or shrubs located on the central part of the site. This could be a potential issue in the future if the East Beltway is indeed built there as there will be no sight and sound barrier between it and the site. To make this barrier, trees and shrubs need to be planted on site. For the trees and shrubs that are to be planted by the potential East Beltway there are two proposed options. The first option is to plant trees in phases along the proposed location of the East Beltway. Phases means waiting a set time interval between planting trees. This is done as a precaution to destructive weather event happens so that only the newly planted trees are lost rather than all of the trees. The second option is to hold off on planting trees until the future of the beltway is decided. If the beltway is indeed built where it is planned, then tree spading can be used to move trees near Stevens Creek to the desired location as well as planting trees in phases. Tree spading involves removing a tree from the grounds, roots included and planting it in a new location. This option has both advantages and disadvantages. The pros are that there are already fully grown trees on site that can moved to the desired location. The major downside, however, is the considerable cost of moving the number of trees that will need to be relocated.
The clients want there to be low impact campsites on the sites. This led to many options being available for the site. The first option is to place the sites on the northern part of the property on both sides of Stevens Creek. There is also the option of placing sites on just the northeast part across Stevens Creek.

As mentioned, the Harvey Hunter Lodge is currently located in the floodway and needs to be moved for safety purposes. For the Harvey Hunter Lodge relocation, there are two options available. One option is to simply move the lodge as it is to a location not in the floodway. The other option is to rebuild it in a new location not in the floodway. The main challenge with this component of the project is trying to keep the lodge’s appearance similar to its current condition. So, if the lodge is to be rebuilt, extra care needs to be taken to make sure it retains its appearance.

The last component of the general civil design is the RV pads. According to the client, the ability for RV users to keep using everyday amenities is a big draw, so installing RV pads will make the property more appealing to modern users. These will be located where the RV parking spots are on the northern part of the property. One option is to install the pads to accommodate the desire of being able to keep the comfort of everyday life while not at home. Installing these pads of course would incur an additional cost. The other option is to designate new RV parking spots and not install the RV pads.

**ANALYSES**

Through visiting the site and meeting with the clients, Bob the Builder & Associates has determined that the amount of lighting on the site is noticeably low. One of the two most important parts of the general civil design of the site will be the lighting. This is due to the fact that installing lighting will have the largest impact on the safety of the site. The second biggest impact on safety would be relocating the Harvey Hunter Lodge. The lodge is currently in the floodway which puts anyone staying in it at risk during high water events. Therefore, moving the lodge to a new location was determined to be one of the most important components of the general civil portion of this project. Outside of the components that impact the safety of the site as a whole, other parts of the site were analyzed. This includes components that generate revenue for the client, such as the soccer field.

When speaking with the client they mentioned how the soccer field is a source of income for them so when taking this project, Bob the Builder & Associates made sure to keep this in mind in the recommendations. Like the soccer field, it was determined that making changes with the RV parking can help bring in more revenue. There are some components of this project that don’t generate revenue or increase the site safety so different consideration were given to those components. These components that don’t generate much or any revenue are the shooting range and plants and shrubs. It was determined that these components are fine as the currently are now, but some changes can be made to improve the quality of the site if the client wants to.

**RECOMMENDATIONS**

With regards to the lighting on the site, Bob the Builder & Associates recommends that lighting be installed in multiple locations. The first location of lighting should be the parking lots. This includes the current parking lots as well as the
proposed parking lot on the east side of Scout Creek. The current parking lot is located on the western part of the property, near 120th Street. There is currently no lighting in this small gravel parking lot. Installing lighting will improve the overall safety of the site by making driving on the site easier at night. The next proposed location of lighting is the new emergency access point. Installing lighting here will also improve the overall safety of the site by making entering and exiting the site easier at night.

It is recommended that lighting should be installed at both of the sports fields as well. Doing this allows the site to host sporting tournaments that can extend into the evenings, thus increasing their potential revenue. The last two spots it is recommended that lighting be installed are the camping shelters, which are the permanent canopy structures on site, and the amphitheater. These spots are recommended because installing lighting at these locations will allow for extended use of the shelters and amphitheater. Installing lighting in the shelters allow people who are hosting a camping picnic or some sort of gathering to use them in the evening. Similarly, installing lighting at the amphitheater can allow property users to make use of it at night as well as use the lighting in the performances. Bob the Builder & Associates made sure to not install too many sources of light to cause light pollution, preventing star gazing. Therefore, the northern part of the property has few light sources proposed to be installed.

Next, Bob the Builder & Associates recommends that a new baseball field be built just east of the new parking lot as shown in Figure 1. Building the baseball field at this spot makes it easy to transport all of the equipment to the field as it will be located near the proposed parking lot. Outside of the Scouts’ use, a new baseball field presents the opportunity to host games of youth recreation leagues which allows for the possibility of extra revenue.

In regards to the implementation of soccer fields, Bob the Builder & Associates recommends that the current soccer field remains the same and an additional soccer field is built just south of the current one. Additionally, it is recommended that an additional soccer field be built. The costs of making a new soccer field is relatively low as the only work that needs to be done is making sure the field is level. Additionally, a new set of goals and line paint will need to be purchased, as well as the planting of appropriate grass. Building a second soccer field also allows for more games or tournaments to be held on site to help provide an extra source of revenue for the clients.

In regards to the shooting range, it is recommended that they remain the same as they are now. This is is recommended because as it stands now, there is nothing wrong with the current range. The current range allows for more flexibility of events and it doesn’t necessarily take up a large portion of the property.

For the trees and shrubs, the recommendation for this component is to postpone planting of trees near the proposed location of the beltway until the future of it is decided. The trees and shrubs would provide a noise barrier between the site and the future beltway. Additionally, it would also provide the next generation of shade for the low impact camping sites that are to be installed on site near Stevens Creek. With the future of the East Beltway being an uncertain element of the project, holding off on the planting of new vegetation would be the best for the site in areas that would be affected. In regards to the vegetation that needs to be planted near future campsites, which will not be greatly impacted by the potential beltway, Bob the Builder & Associates recommends that the tree planting for the campsites begins as soon as possible and using planting phases.
With regards of the Harvey Hunter Lodge, it is recommended that the lodge be simply moved to a new location not in the floodway. This location would be just east of the newly proposed parking lot and north of the proposed baseball field. This location is best because not only is it out of the floodway, but it is conveniently located near the parking lot which makes it easy for anyone staying there to unload their items. It is recommended that the lodge be moved instead of rebuilt because it was important to the client that the lodge maintain its appearance and there is no better way to do that than maintaining the lodge as it is and moving it to the new location.

For the low impact campsites, it was decided that building them on both sides of Stevens Creek is the best option. The area west of Stevens Creek already trees in place to provide shade while the new trees are growing on one side. On the east side, there is plenty of open room so more sites can be built on this side. Building it here will keep the camp sites out of the area where the East Belt will be located.

Finally, with regards to the RV pads, Bob the Builder & Associates recommends that charging stations are installed on the RV parking pads. The locations of the RV pads can be seen in Figure 1. These charging stations would be located to the side of the RV parking. These charging stations can be used to power the RV as well as charge electric cars. Installing these charging stations will make the site more attractive to people who want to get away but are not willing to sacrifice some of the commodities of being at home. While purchasing and installing these stations can be expensive, the benefit from installing them outweighs their costs.

**CONCLUSION**

Now that the general site layout has been explained, it is now to time to look at the more technical aspects of this project starting with the Water Resources and Environmental portion.
OVERVIEW
This report contains the Environmental and Water Resources engineering design completed up to April 1, 2019 for the Cornhusker Council – Boy Scouts of America’s (CC-BSA) Outdoor Education Center (OEC) site.

The Environmental portion covers impacts on project construction from the Endangered Species Act and the Clean Water Act.

The Water Resources section covers the wastewater lagoon, an assessment of the water system and the hydraulic analysis done for initial bridge design.

ENVIRONMENTAL
SITE INFORMATION
The OEC is in Lancaster County, between Scout Creek and Stevens Creek.

CHALLENGES
There are five endangered species in Lancaster County, as identified by Nebraska Game and Parks. They are Northern Long-eared Bat, Salt Creek Tiger Beetle, Saltwort, Western Prairie Fringed Orchid and Whooping Crane. Range maps are available from outdoornebraska.gov/atriskspecies/. None are known to be on site.

Being between Scout Creek and Stevens Creek, as shown in the site layout in Appendix B, places most of the site in the floodplain. Any construction that would result in the discharge of dredged or fill material into waters of the United States (Scout Creek, Stevens Creek or any wetlands) will require a Clean Water Act Section 404 Permit from the United States Army Corps of Engineers (USACE).

ANALYSIS
There are two permit classifications, individual and general. Individual permits are required for projects with potentially significant impacts that are not covered by a general permit. General (Nationwide) permits are issued for categories of projects that meet general and specific conditions. General permits allow activities to proceed with minimal delay, whereas individual permits require a public interest review, which could delay construction by six months to a year or more.
There are two primary activities in the scope of this project that will require 404 permits: bank stabilization and bridge construction.

Bank stabilization falls under Nationwide Permit (NWP) 13 Bank Stabilization, which allows for erosion control measures. If more than 500 feet of bank length is protected, the district engineer must approve construction. Bridge construction falls under NWP 14 Linear Transportation Projects. This permit allows for construction of crossings and associated temporary constructions. Each crossing is considered a single project; thus, each will require a separate permit. Details on these permits are available from USACE (usace.army.mil).

**RECOMMENDATIONS**

While no endangered species are known to be on site, if any are found, it would be illegal to move them or destroy their habitat. It is recommended to design to the specified Nationwide Permits to begin construction without delay.

**WATER RESOURCES**

**LAGOON**

**SITE INFORMATION**

On site is a wastewater lagoon measuring 57 feet by 119 feet along the crest of the side banks. Slopes were measured to be 4:1 horizontal to vertical and bank height assumed to be 6 feet. It is located along the northern property line, west of Scout Creek.

**CHALLENGES**

The lagoon has been reported to nearly overflow during events with large numbers of users. The lagoon is also located near the property line and Scout Creek, which may be in violation of regulation.

**ALTERNATIVES**

Potential options to address the lagoon capacity issues include a permanent connection to the City of Lincoln sanitary sewer along 120th Street, augmented capacity, land application, and temporary pumping of lagoon contents.

**ANALYSIS**

The maximum operating volume for the lagoon can be calculated from the geometry. This is the volume of water at a water surface height 1 foot below the top of banks.

\[
\text{Operating Volume} = \frac{(\text{Surface Area full} + \text{Surface Area empty})}{2} \times \text{operating height}
\]
ENVIROMENTAL & HYDRAULIC DESIGN
PREPARED BY QUINN BRANDT

\[ = 14,705 \text{ ft}^3 = 110,000 \text{ gal} \]

Nebraska Administrative Code (NAC) Title 124 provides an equation that can be modified to calculate the daily design inflow.

Maximum Operation Surface Area = flow *976/[(evaporation - precipitation) *1.67 + Operating Depth + Seepage*608]

Evaporation and Precipitation were taken as 44 and 28 from Figures 18.1 and 18.2 in NAC 124. Operating Depth is defined as a typical and maximum of 36 inches in NAC 124. Seepage was assumed to be zero, though up to 1/8in/day is allowed.

Solving the above for flow gives a design wastewater volume flow of 336.9 gallons per day. This is the average amount of wastewater the lagoon can process.

Yearly wastewater production was estimated using events, durations, the estimated population during events, and the wastewater production per person. The Weeklong Day Camp and Club Day of Awesomeness were assumed to have 80% of participants use temporary toilets, meaning the system has a usage rate of 20%. A summary is shown in Table 1, with population estimates provided by CC-BSA. The average wastewater production was estimated at 404 gallons per day.

The average wastewater production exceeds the design of the lagoon. This explains it being near capacity. The difference is approximately 67 gallons per day, or 24,500 gallons per year. At a pumping cost of $0.003 per gallon, removing 24,500 gallons from the lagoon would cost $75, not including mobilization, fuel or other fees.
### TABLE 1 WASTEWATER ESTIMATES

<table>
<thead>
<tr>
<th>EVENT/USE</th>
<th>PEOPLE</th>
<th>DAYS/YEAR</th>
<th>USAGE RATE</th>
<th>SYSTEM USERS</th>
<th>Gallons Per Day (GPD) Per User</th>
<th>Gallon Per Year (GPY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Staff</td>
<td>12</td>
<td>300</td>
<td>1.00</td>
<td>12</td>
<td>15</td>
<td>54000</td>
</tr>
<tr>
<td>Weekends - Staff and Scout Shop</td>
<td>24</td>
<td>100</td>
<td>1.00</td>
<td>24</td>
<td>15</td>
<td>36000</td>
</tr>
<tr>
<td>Weekends - Small Groups</td>
<td>20</td>
<td>100</td>
<td>1.00</td>
<td>20</td>
<td>15</td>
<td>30000</td>
</tr>
<tr>
<td>Evening Training</td>
<td>12</td>
<td>75</td>
<td>1.00</td>
<td>12</td>
<td>20</td>
<td>18000</td>
</tr>
<tr>
<td>Weeklong Day Camp</td>
<td>200</td>
<td>6</td>
<td>0.20</td>
<td>40</td>
<td>31</td>
<td>7440</td>
</tr>
<tr>
<td>Club Day of Awesomeness</td>
<td>300</td>
<td>1</td>
<td>0.20</td>
<td>60</td>
<td>31</td>
<td>1860</td>
</tr>
</tbody>
</table>

GYP  147300
AVG GPD  404

The lagoon flow is less than 1,000 gallons per day. This classifies it under Nebraska Administrative Code (NAC) Title 124. This Code requires minimum setback of 50 feet from the property line and 100 feet from surface water. The lagoon currently meets these requirements, but there is not enough space north, towards the property line, or east, towards Scout Creek, to safely consider expansion.

**RECOMMENDATIONS**

It is the recommendation of Bob the Builder & Associates to pump excess wastewater from the lagoon once a year, after the Weeklong Day Camp.
WATER SYSTEM

SITE INFORMATION
Drinking water is currently supplied to the site from a groundwater well capable of up to 60 gallons per minute, located on the property. There is a pressure tank in the basement of the main OEC building.

CHALLENGES
With the planned expansion of the irrigation system to the planned sports fields on property east of Scout Creek, and connected Iowa hydrants near the fields, the water system needs to be checked for suitability in supplying peak demand.

ANALYSIS
Looking back to Table 1, there are only 7 days each year where the system serves 25 or more persons. This is below the 60 days for this to be counted as a public water system, meaning the Nebraska Department of Health and Human Services classifies it as a private water system governed by Title 179.

The existing system is capable of supplying up to 60 gallons per minutes. A typical in-ground sprinkler system for a sports field is designed around 55 gallon per minute demand. Watering all three fields at the same time is not feasible with the existing system. Staggering irrigation so that only one is being watered at a time solves this.

Peak demands occur during daytime hours. Scheduling irrigation systems to run in the early morning or late evening should mitigate impact on peak demands, allowing the system to accommodate the expansion.

Connecting to the proposed fields, as shown in the hydraulic plans in Appendix B, is expected to cost $119,000. A breakdown of this is shown in the Cost Estimate.

RECOMMENDATIONS
The existing system should be suitable for the planned expansion. An irrigation schedule to water a single field each morning is advised.

BRIDGE HYDRAULICS

SITE INFORMATION
There are currently two pedestrian bridges and a low water crossing along Scout Creek that provide access to the eastern part of the property.
CHALLENGES

The low water crossing is not classified as an emergency access, meaning CC-BSA has to deny campers access during storms.

The pedestrian bridges are in the floodway. One has been pushed downstream during flood events, the other two

There are currently no bridges across Stevens Creek, restricting access to the easternmost corner of the property.

ALTERNATIVES

The proposed bridge or culvert across Scout Creek at the southern end of the property needs to be suitable as an emergency crossing, typically a 50- or 100-year event with no over-topping.

The proposed pedestrian bridge over Scout Creek does not have to serve as an emergency crossing.

The proposed pedestrian bridge over Stevens Creek needs to serve as an emergency crossing.

ANALYSIS

Using Federal Emergency Management Agency (FEMA) models of the Stevens Creek watershed in HEC-RAS (Hydrologic Engineering Center – River Analysis Software, distributed by USACE), approximate bridge profiles were developed to satisfy the conditions above.

The closest section to the proposed bridge location was identified, and copied 25 feet upstream and downstream of the selected section, with adjacent reach lengths and overbanks reduced by 25 feet. This keeps the overall river length the same. Roadways were then inserted 0.1 feet downstream of the original section, with a width of 24 feet for the Scout Creek emergency crossing and 8 feet for the pedestrian bridges. The low chord, the lowest point of structural span, was set to 3 feet below the deck for the Scout Creek emergency crossing and 6 feet for the pedestrian bridges.

Models were run and roadway elevation adjusted until the model showed no overtopping for the event. Events are defined as a recurrence interval, expressed in years. A 10-year event will occur, on average, once every 10 years, or a probability of 10% each year. A 100-year event will occur on average, once every 100 years, or a probability of 1% each year.

These are summarized in Tables 2-4. Note that the span is just that over water, not including abutments. The 50- and 100-year bridge results for Scout Creek Emergency Access are the same due to an approximation of length.
TABLE 2 SCOUT CREEK EMERGENCY ACCESS

<table>
<thead>
<tr>
<th>Initial Section</th>
<th>Bridge or Culvert</th>
<th>Design Event</th>
<th>Overwater Span</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.47</td>
<td>Culvert</td>
<td>10 year</td>
<td>35 feet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 year</td>
<td>125 feet</td>
</tr>
<tr>
<td></td>
<td>Bridge</td>
<td>50 year</td>
<td>125 feet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 year</td>
<td>125 feet</td>
</tr>
</tbody>
</table>

TABLE 3 SCOUT CREEK PEDESTRIAN BRIDGE

<table>
<thead>
<tr>
<th>Initial Section</th>
<th>Design Event</th>
<th>Overwater Span</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.214</td>
<td>2 year</td>
<td>80 feet</td>
</tr>
<tr>
<td></td>
<td>5 year</td>
<td>110 feet</td>
</tr>
<tr>
<td></td>
<td>10 year</td>
<td>140 feet</td>
</tr>
</tbody>
</table>

TABLE 4 STEVENS CREEK PEDESTRIAN BRIDGE

<table>
<thead>
<tr>
<th>Initial Section</th>
<th>Design Event</th>
<th>Overwater Span</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.978</td>
<td>50 year</td>
<td>60 feet</td>
</tr>
</tbody>
</table>

RECOMMENDATIONS
A recommendation of each bridge selection is included in the structural section of the report.
OVERVIEW

The structural component of the project will primarily consist of a discussion of the pedestrian bridges necessary in providing accessible routes across Scout and Stevens Creek as well as present solutions for the emergency vehicle access point that the activities of the OEC requires. A preliminary discussion of the optional warehouse structure will also be included for the client to consider.

SITE INFORMATION

Cornhusker Council’s OEC currently has two pedestrian bridges on site in need of repair in order to provide safe accessibility across the site. Additionally, there is a low water crossing on the western portion of the property. The property is in need of an emergency access route for vehicles such as fire trucks and ambulances that the low water crossing does not satisfy.

The current state of the low water crossing on the property does not allow for proper function as an emergency vehicle access to the area of land that borders Scout Creek to the east. Even during common rainfall events, the driving surface of the current low water crossing is overtopped by Scout Creek. As can be seen in Figure 2, the creek acts as a barrier across the low water crossing, making the route unusable for individuals seeking to move directly from the main parking area to the eastern portion of the property, which houses various sports fields and shooting ranges. Therefore, in the event that the low water crossing is a nonviable route, individuals are only able to access the fields by crossing one of the two pedestrian bridges that currently span Scout Creek.
The current state of the two pedestrian bridges on the project site does not reliably support one-way utility task vehicle (UTV) traffic as requested. The clear width of the existing structures does not allow adequate room for a UTV to drive across the bridge. Additionally, the on-site inspection identified concerns regarding the structural capacity of the bridge to support UTV vehicle loads. When subject to heavy pedestrian loads and vibration, the bridge reacted with noteworthy movement and deflection. Timber boards are also missing on one of the bridges spanning Scout Creek, which poses a structural deficiency as well as a safety threat. Additionally, the railing is damaged at some points, which poses another safety threat.

The debris located along the stream bank, as shown above in Figure 3, indicates that the creek reaches a much higher altitude than the current bottom elevation of the existing bridge decks. In the event of a 100-year flood, the water elevation is predicted to be over 8 feet above the top of the deck. This will result in no viable routes across Scout or Stevens Creek during flood events. Additionally, repeated exposure to a complete overtopping of water over the structure will deteriorate the bridge at an accelerated rate, which will also increase the cost of repairs. Based on the measurements performed at the initial site visit, both bridges over Scout Creek currently span about forty feet long. This means that in order to improve functionality, any new bridges will need to span, at minimum, longer than forty feet in the future. Bridge geometry will be discussed in more detail in the following sections.

**CHALLENGES**

Similar to many other aspects of the project, the prevalence of the floodway and floodplains across the Outdoor Education Center poses a large design concern. In order to provide reliable accessibility throughout the property, structural components will need to maintain high surface elevations to avoid either of the creeks acting as an obstacle at critical crossing points. In order to implement higher surface elevations of the crossing points, material and construction may increase significantly. Therefore, one of the greatest challenges that Bob the Builder & Associates
faces in addressing the flooding concerns is striking a balance between implementing the most beneficial long-term engineering solutions to current problems and maintaining economic feasibility.

Additionally, the large crowds that are expected to utilize the property during special events hosted by the Outdoor Education Center call for strategic crossing points locations. One of the main concerns expressed during preliminary design discussions is the bottleneck movement that occurs when a high volume of individuals need to utilize the low water crossing to move between the western parking on the property and the eastern fields. One of the main tasks that Bob the Builder & Associates is prepared to solve is implementing a network of routes that efficiently allow for simultaneous movement throughout the property.

**ALTERNATIVES**

The design approach in constructing the bridges has the opportunity to take the form of a variety of solutions. Some of the design alternatives that Bob the Builder & Associates suggest offer greater durability and a longer anticipated design life, but other options provide a smaller financial burden while still meeting the current needs of the Outdoor Education Center. The goal of Bob the Builder & Associates is to objectively identify solutions that meet both the financial and functional needs of the client.

Culverts offer a more economical outcome than prefabricated bridges will cost to construct. However, culverts can also act as an obstruction to the flow in either of the creeks, so any slight rise in water elevation will need to be offset by excavation. This is due to permits set by the Nebraska Department of Natural Resources, which specify that any rise in water elevations must be offset by other means.

If the “rustic aesthetic”, as described by the client, is an important component to the project, then a timber bridge may present itself as the more pleasing option. Timber beam bridges will offer simple construction, reasonable prices, and a pleasing appearance. An arch timber bridge offers a higher deck elevation without the extreme amounts of earthwork that would be necessary to raise the elevation otherwise. Arch bridges are very durable and have historically yielded a long design life. However, this option may also result in steeper upfront costs.

In regards to the requested warehouse structure that will primarily act as a storage unit on the property, there are multiple options available. A timber structure offers a “rustic” appearance that coincides well with the targeted aesthetic of the OEC, as described by the client. Implementing timber in design also offers a more financially desirable outcome. However, timber structures are far more susceptible to fires, decay and water damage than most other building materials. Therefore, using recycled steel may be another viable option, which would be sustainable by both economical and environmental standards.
ANALYSIS

In order to identify and deliver the optimal structural engineering design solutions, the structural and water resources teams at Bob the Builder & Associates have worked closely to achieve appropriate bridge lengths, elevations, and locations. The primary concern in making these decisions is to maintain a safe access route for users of the property during flood events. It is also essential to be aware of the implications that various proposed structures will have on the current water elevations in Scout and Stevens Creek.

Culverts, due to the amount of water displaced, significantly raise the water elevations in comparison to standard bridge designs. If a bridge is able to be constructed using only a single span, the two abutments may be the only structural components that will interfere with the oncoming creek flow. Therefore, the water elevations are expected to rise much less dramatically with a bridge than a culvert structure. Furthermore, this means that a culvert span length will need to be longer than a bridge span in the same location in order to withstand the same flooding event.

In order to account for the expected results of constructing a bridge or culvert along one of the suggested crossing locations, a computer software analysis program was run by the hydraulic team at Bob the Builder & Associates. The Hydrologic Engineering Center (HEC) provides a River Analysis System (RAS) software in order to determine the flood elevations that will surround a structure based on the varying soil profiles of the property and historical flood data. Modeling a structure in the software also allows the user to better understand and quantify how the flow will be altered after constructing a bridge or culvert. The combination of these hydraulic considerations allows the water resources team to determine a bridge span length that will allow the structure to avoid inundation during the appropriate design flood event.

In many projects, a 100-year flood event is used as the design flooding elevations to avoid. However, in an effort to offer financially feasible solutions in a property engulfed in floodplains, the city of Lincoln allows for some relaxation in design standards. As confirmed with the client, a pedestrian bridge spanning Scout Creek or Stevens Creek is allowed to be designed for only a 2-year flood. The emergency vehicle access, however, will be need to be maintained at a 50 year or 100-year flood design due to the critical function that it may need to serve in times of emergency.

FINDINGS

Based on the HEC-RAS hydraulic analysis conducted by the Water Resources team, bridge span lengths and elevations have been determined to safely prevent the overtopping of the bridge surface during design flood events. These preliminary calculations only account for the distances spanning the waterways, so a preliminary allowance of 15 feet is added to these spans to account for both abutments to tie back far enough for proper bearing. With the allowance included, the emergency vehicle access crossing designed for a 100-year flood event will have a required total length of 140 feet.
The emergency vehicle access will need to accommodate a variety of personnel in the case that the crossing is, in fact, used for emergency vehicles. The structure will need to support the anticipated load of a fire truck or ambulance. The ambulance will be designed as for a 7'-0" wide vehicle and 12,000 pounds of loading. The fire truck, which will govern between the two vehicles, is also 7'-0" wide and is expected to weigh 37,000 pounds according to the City of Lincoln Fire and Rescue Department. This information has also been verified with the client.

While only a 2-year flood design is considered mandatory for the pedestrian bridges spanning Scout and Stevens Creek, Bob the Builder & Associates has investigated the outlook of designing for a 10-year flood event as well to maximize the design life of the bridge. For Scout Creek, a 2-year flood design yields a 95'-0" span length and a 10-year flood design yields a 125'-0" bridge including the 15'-0" allowance. Stevens Creek will yield an 85'-0" required span length in order to satisfy a 10-year flood design with the inclusion of the 15'-0" allowance again. Both of these bridges have been analyzed as a single span structure, however, if supports need to be implemented further along in the design, then bridge lengths may vary slightly in order to account for the change in flow that piers would create.

After further analysis of the span lengths required to meet flood standards, a culvert is a less effective option due to the severe amount of excavation that would be required to install such a long structure. Additionally, the creek flow would be highly disturbed, according to the HEC-RAS analysis performed, which would result in an even longer span length than those specified for the pedestrian bridges. With longer span lengths, an arch bridge is also a less effective option because it will tremendously increase in cost as the span increases. A timber beam bridge, however, will still act as a cost effective option considering the required length of the bridge spans.

In order to allow for a single utility vehicle as requested by the client. Based on many utility vehicles measuring about 65 inches in width and allowing for an additional safety clearance on either side, the bridges will require a minimum 8'-0" clear width. For pedestrian bridges less than 7'-0" wide, it is deemed unnecessary to include the live load of vehicles, but with the design width of 8'-0", a live load will be based on the estimated loading of a UTV, which could be up to 1,500 pounds for a Toro Workman, one of the common UTVs used on the property as mentioned by the client.

According to the City of Lincoln standards, a railing of a minimum of forty-inches will need to be included in all bridges designs. A rub rail is often times also implemented as well to protect the bridge railing from deterioration over time as well as to prevent vehicular users on the bridge from getting handlebars caught in the railing. An example of bridge rails is shown below in Figure 4 below.
In order to comply with the American Disability Act (ADA), the camber, or numerical amount of upward vertical deflection at the center of the bridge, will need to be limited. According to ADA requirements, the maximum slope at either end of the bridge must be limited to 5%. This results in about a 1% camber in the center of the bridge span, meaning that the amount of vertical upward deflection is approximately one percent of the total bridge length. Therefore, if an arch or cambered bridge is selected, this ADA restriction will allow individuals in wheelchairs, or other motorized devices, to comfortably cross the structure. Rails will also be implemented in order to satisfy ADA requirements.

Figure 4

RECOMMENDATIONS

After evaluation of the current condition of the low water crossing, Bob the Builder & Associates proposes to maintain the low water crossing in its current state, but to construct a new structure that will serve as the emergency vehicle access point further south that will attach to the newly proposed parking space and function as the emergency vehicle access point. This will be designed for two-way traffic with a preliminary width of twenty-four feet. Not only will this offer a vital access point that the activities of the OEC demands, but it will allow for two crossings along the western portion of Scout Creek when heavy traffic demands are placed on the property for large events.

The two pedestrian bridges that span Scout Creek will both need to be removed due to instability concerns. This will include the removal of the existing structures as well as full construction of one new pedestrian bridge to reestablish access across Scout Creek. It is recommended that the new pedestrian bridge is constructed at the location of one of the existing structures to minimize tree removal and maintain convenient routes that the current locations offer. An additional pedestrian bridge will be constructed spanning Stevens Creek to provide access to the eastern portion of the property. This access point will be vital as the low impact camping training is developed on the eastern portion of the property. Two potential locations are shown on the site layout plan, as can be seen in Figure 4. However, after further discussion on March 8th, the northernmost option was established as the preferable location for the Stevens Creek crossing due to its proximity to the main OEC lodge, as shown in the proposed site layout in Appendix B.
Amongst the number of choices provided, a timber beam bridge is recommended over all three proposed water crossings for the reasons that will be outlined shortly. A timber beam bridge will coincide with the expressed “rustic” aesthetic described by the client as well as offer economic value for structural stability. The width will be designed to accommodate one-way traffic of a single utility vehicle as requested by the client. Railings will be included for safety measures. These railings will follow the City of Lincoln standards which specifies a minimum height of forty-two inches tall. The railing will also include a rub rail connected at the top, as shown in Figure 4, which acts as an additional barrier for bicyclists whose handlebars may otherwise rub, or get caught, against the sides of the bridge. This will effectively keep the bicyclist safer and prevent repeated deterioration of the bridge. In the case of the Outdoor Education Center, the rub rail will also be an effective barrier for UTV drivers.

After further discussion with the client, the potential warehouse on the property, which will predominantly be used for storage, will be a single story building. Bob the Builder & Associates recommends the use of recycled steel in order to reliably construct a durable building as well as combat the financial strain that construction of newly fabricated steel would inflict.

In summary, Bob the Builder & Associates has analyzed the most suitable structural solutions for the current challenges faced by the OEC and recommends the construction of three timber pedestrian bridges and a recycled steel warehouse to provide effective accessibility. Our team is prepared to deliver high-quality, engineered solutions to the key issues identified and will work to satisfy the client’s budget in our effort.
OVERVIEW
With the addition of structural elements to the OEC property, such as the proposed bridges, the Outdoor Education Center will require the input from a Geotechnical Engineer. Scout Creek and Stevens Creek pose an accessibility concern to the OEC because they eliminate access to portions of the property. However, there are options available to correct the concern when it comes to accessibility to the entirety of the site. With the addition of structural crossings, there will need to be soil testing for the consideration of foundation options as well as specific soil characteristics for bridge design. Bob the Builder & Associates Geotechnical Team will implement this geological survey on the OEC Site. This will include additional boring locations at strategic positions on site as well as numerous soil tests that will be performed in the soil laboratory. Also, stream bank stabilization will need to be considered in order to protect the structural integrity of the additional structures. A hydraulic analysis will be conducted of the existing creeks to determine the size, shape, and location of the additional scour control devices. Bob the Builder & Associates Geotechnical Team will compile all soil tests and geologic information at the conclusion of the survey and will provide all information to aid in future design and development of the site.

SITE INFORMATION
The OEC is located in Lincoln, NE just east of S. 120th Street between O and A Street in the eastern portion of Lancaster County. This property has two active creek channels running the length of the east border (Stevens Creek) and the west border (Scout Creek). The OEC is composed of roughly 80 acres of land with roughly 20 acres of that land inaccessible due to the presence of Stevens Creek. The site is comprised of a few structures, the main structure being in the northwest corner, which contains a paved parking lot. There are also two additional smaller structures located in the northwest corner of the site as well as a wastewater lagoon. Scout Creek currently has two existing pedestrian bridges providing access to the northwest portion of the site to the south portion of the site. There is also an additional overflow gravel parking lot located on the west end of the site that leads to a low-water crossing, which provides vehicle access over Scout Creek to the eastern portion of the site. A general site plan can be found in Figure 5.
CHALLENGES

In order to create a plan for the OEC, a geological study needs to take place. Scout Creek and Stevens Creek pose an issue with the site causing large flood ways and the remaining landscape is a floodplain. These stream channels pose an issue with accessibility to the site, which would require the addition of two new pedestrian bridges and an access bridge for vehicles to access the east side of Scout Creek during a flood event. With this being said, a geological survey would be necessary at strategic points of the site. This would investigate the structural integrity of the soil to ensure additional structures are not compromised by lack of stability for the earth and keeping its users safe.

Scout Creek and Stevens Creek have both showed signs of past and present stream bank erosion by continued widening of the creek channel and shearing of the soil. The current stream banks are not reinforced and are vulnerable to high water floods and fast moving currents. The OEC is calling for new infrastructure in the form of transportation around and over the creek channels. This will be in the form of two new pedestrian bridges, one over Scout Creek and one over Stevens Creek, and a new emergency access bridge over Scout Creek. With the investment being made to the property, stream bank stabilization is necessary in order to protect these structures from scour. Scour is an engineering term that refers to the erosion of sediment around a structural element of a bridge. Fast moving currents or flash flood occurrences can remove sediment around an abutment or load-bearing pier and create holes in the sediment, which can
structurally compromise a bridge structure. In turn, this can cause undermining of the structural elements of the bridge, which can cause a failure in the system.

An additional obstacle that may be relevant during the renovation process is adding man-made alterations in a floodplain. According to the Nebraska Department of Natural Resources, a floodplain development permit is required when implementing a road, bridge, culvert, grading, land clearing, excavation, or the addition of filling. This permit ensures that all work done near the creek channel will not result in any rise of the current water levels and ensures that the work meets the National Flood Insurance Program (NFIP) requirements.

There is a potential for construction challenges with groundwater when it comes to excavation of soils near the stream channels. With a proposed option for connecting the current wastewater lagoon to the new City of Lincoln Trunk Sewer, there is a potential challenge with pumping due to the groundwater levels. These groundwater levels can be estimated from boring logs and can be anticipated prior to excavation.

**ALTERNATIVES**

Considering stream bank stabilization and the current trends of scouring/erosion, riprap is the best solution. Riprap is a material that is used to armor stream banks from water and ice erosion preventing the destabilization of the banks. Riprap comes in a variety of different forms and can be installed in different ways, which provides options. A second option that could be explored is the use of grouted riprap. Grouted riprap consists of the same foundation as normal riprap; however, this uses smaller rock, which is then cemented together with the use of grout. The grout is used to conform the rocks together but not seal the gaps, which allows for drainage and self-heal properties during a flood event.

**ANALYSES**

Considering the identified obstacles on the OEC site, further information can be gathered to better provide solutions. Multiple resources are available to gain a general understanding of the geology of the area based on past data gathering analysis. One resource that is readily accessible is the Lancaster County Soil Survey. The soil survey contains information that can be used in land planning programs in Lancaster County. It contains predictions of soil behavior in specific regions in the county and also includes limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment. Other additional public research can be found by researching other local projects in the area. The City of Lincoln is adding a trunk sewer running adjacent to the OEC, which contains soil-boring logs, which can be used to estimate the soil conditions on the OEC site.

The Lancaster County Soil Survey was created in 1977 and provides soil formation information is particular sections of the County. Lancaster County is located in southeastern Nebraska, which extends for 36 miles in the north-south direction and 24 miles in the east-west direction. The first few feet of the OEC geology is made of up Kennebec,
Nodaway, and Zook according to the Lancaster County Soil Survey. A cross-section of the soil structure can be found in Figure 6. This region is deep, nearly level and has a very gentle slope. It is poorly drained and is comprised of mostly silty soils formed by alluvium and the flood plains. Kennebec soils are nearly level, well drained and is approximately 56 inches deep. Kennebec is comprised of silt loam and firm silty clay. The Nodaway soils are generally found in the floodways and are comprised of silt loam and silty clay loam. This layer can generally run about 60 inches deep and are moderately sloped and well drained. Zook soils are generally found in lower elevation regions and are level but poorly drained. These soils are usually found at lower surface elevations and a distance away from the stream channel. Zook is comprised of silty clay loam and silty clay that can become approximately 60 inches in depth. This soil association is generally used for grain farming however; this soil association’s main hazard is flooding. Flooding is very common in this region when above average precipitation events occur and this can cause various building limitations.

![Figure 6: Cross-section view of OEC Site from the Lancaster County Soil Survey](image)

The next piece of information that has been explored are the boring logs created from the construction of the nearby Lincoln Trunk Sewer by Schemmer in June of 2017, which runs directly parallel with and on the west side of 120th Street. This information is very helpful in determining the soil conditions on the OEC site based off of the depth of the borings and the relative distance from the borings to the site. A better understanding of the general geology could be found between O and A St along 120th Street from these boring logs. The bedrock near the OEC site consists of Dakota Sandstone and was reached approximately 42 feet below the surface nearest the gravel parking lot on the west side of the property. Also Dakota Sandstone was found on the southern half of the site at approximately 46 feet below the surface. The western property line mainly consists of sand, silt, and clay materials. Deposits of loess and colluvium cover these soils and contain medium stiff lean clay, fat clay, and silt. Much of the soil in this area was deposited from glacial ice thousands of years ago. Groundwater levels were also monitored in the boring logs and were recorded at depths from 6-17 feet below the surface.
FINDINGS

Information from the Lancaster County Soil Survey as well as the Lincoln Trunk Sewer project were evaluated by Bob the Builder & Associates Geotechnical Team. The information from the Lancaster Soil Survey was helpful in determining the soil conditions for the entire OEC site. However, this survey is conducted only on the first few feet of soil so it only will give a relative identification for that specific depth. With this being said, the first few feet of the OEC site is sought to consist of silt loam and firm silty clay. These soils are generally found in floodplains and consist primarily of sand. These soils are also often used for farming but have limitations of building operations due to its high probability of flooding.

The geotechnical report completed in 2017 by Schemmer for the City of Lincoln Trunk Sewer was used in order to get a glimpse cross-section of the soils near the OEC Site. The boring logs and lab tests that were performed on the adjacent soils will give a good understanding of what is to be expected on the OEC site. First, the type and depths of particular soils were able to be determined from the boring logs. The majority of the soil around the site is comprised of sands, silts, and clays. The top layer of the soil column was clayey and silty soils with pockets of sandy soils 20-30 feet below the surface. Shelby tube samples were obtained from specific depths and sent to the soil lab to be tested for their water content, dry unit weight, soil classification, and unconfined strength. These soils were also tested using a pocket penetrometer, which is a device that estimates the unconfined strength of soils. This estimate allows the ability to quickly identify problematic soil groups. The Pocket Penetrometer gives readings from 0.0-4.5; 0.0 being very soft/weak and 4.5 being very stiff/dense. A map of the boring locations is shown in Figure 7.
Boring 16 showed signs of a soft/weak layer of soil from the surface down to approximately 8 feet. These soils were tested with a pocket penetrometer and got a reading of 0.25-0.75, which shows soft to medium material with low compressive strength. Boring 15 also shows signs of a weak soil structure, however, this is approximately 22-31 feet below the surface and is caused by a sandy layer, which tested at 0.25-1.25 showing signs of soft to medium material with low unconfined compressive strength. This is also relevant in Boring 40 where the same sand layer can be seen at 20-27 feet below the surface testing at 0.5, which indicates soft material with low unconfined compressive strength. Each of these specific areas was tested in the lab to verify the unconfined compressive strength and each area tested low.

In addition to the pocket penetrometer test and unconfined strength test, penetration tests were conducted in specific areas and depth. Penetration testing will allow for a prediction of the strength and compressibility of the soil. Driving a 2-inch sampler one foot into the soil and recording the amount of blows perform this test. The number of blows is then related to estimations of soil stiffness and density. Boring 15 had three-penetration test performed in depths between 30-50 feet. These tests were performed in sand layers resulting in loose to medium dense material. This boring also had three additional penetration tests performed in depths between 53-65 feet. These tests were performed in clay...
layers and are signified as stiff material. Lastly, Boring 40 had one penetration test performed at a depth of 35 feet and this soil signified as medium dense material.

The results of these boring logs show evidence of potential conflicts spots. Areas of interest would include deep pockets of sand, which could prove to be unstable for specific load types. Most of the soil structure has an earthly order associated with it, which means there may be a presence of organic matter in the soil, which could provide additional conflicts. Also, any spots that have been observed to test low with unconfined strength as well as density. Bedrock was found to be Dakota Sandstone only at Boring 16 at approximately 42 feet below the surface. According to the boring logs, ground water moves towards the surface in the middle of the property and tends to be around 15-17 below the surface on the north and south ends. This information was used to find compatibility of the soil with particular foundation techniques. The Lincoln Trunk Sewer boring logs gave good insight of what the soil column is comprised of in the area. From the information presented deep foundations for the additional structures may need to be utilized. However, this analysis is only an estimation of the soil structure of the OEC site and additional testing will need to be performed in order to prove soil conditions.

RECOMMENDATIONS
This site is proposed to have two new pedestrian bridges as well as a new bridge carrying two-lane traffic. Bob the Builder & Associates would recommend drilling their own borings on the property. The Lincoln Trunk Sewer project provides relevant information about the site, however, design specifications cannot be determined until test samples are collected closer to the final location of the additional structures. Once the location of these additions is confirmed, the number of borings and the depths of the borings will then be determined. We would recommend drilling a boring (at minimum) at one abutment/pier per pedestrian bridge. With the long span over Stevens Creek, it is recommended to have a boring on each end of the new pedestrian bridge. Additional borings can be added to each pedestrian bridge if further information or samples are needed. Bob the Builder & Associates would also recommend having a boring on each end of the new proposed emergency access road bridge. Lastly, it is recommended to have a minimum of one boring for each of the new proposed paved parking lots. All recommended boring locations can be found on Figure 8. The addition of these borings will allow for more representable samples of the site, which will result in higher quality design. The boring depths will all be unique, however, the depths of borings for the parking lots will be more shallow at approximately 10’-20’ and the boring depths for the bridges will be deeper at approximately 60’-80’.

The drilling will be done with a drill rig truck, which will allow the engineer to get Shelby Tube samples of the soil at specified depths. Once these have been drilled, the samples will be taken to the soils lab to be processed and accessed. These samples will be tested for soil stability, moisture/density/strength relationship, the compressibility of the soil, and soil classification. With the completion of the soil testing and the boring logs the location, depth, and size of the footings for the bridges can then be determined. In addition, this will provide insight for the process that will need to take place for the addition of fill to the site and specific locations. During the construction phase, the areas that are receiving large amounts of fill will be tested on site. The fill will be placed in lifts and every lift will be tested for compaction and moisture content to assure a strong and stable base. The cost associated with borings is dependent
upon depth, number of borings, man-hours, and type of tests that are needed. The cost for drilling a single boring and necessary lab results can be roughly estimated to cost approximately $2,000-$5,000 per boring.

For the OEC, Bob the Builder & Associates would recommend the use of normal riprap because it is more suited for abutments/pier protection that is setback from the creek channel. Installing riprap the correct way and determining the most critical locations for it to be placed is important to keep on budget. Bob the Builder & Associates would recommend installing riprap in strategic locations around both Scout Creek and Stevens Creek. The locations in concern are any place with previous indications of scouring and any areas around structural elements. Riprap locations can be found in Figure 8.

![Figure 8: Boring & Riprap installation locations.](image)

With the location of the riprap determined, the grading of the soil will begin ensuring that the slope of the banks does not exceed 2:1 ratio. Exposed soil will then be compacted and verified by a field technician to test the soils for compaction and moisture content. When the soil is verified and passed, the soil will be blanketed with a synthetic membrane, which will incapacitate the soil and prevent it from exiting the riprap. Rocks of approximately 18”-30” will be used which will be able to withstand freezing and thawing will be placed on the slope making sure to create good toe protection and is recommended that the layer thickness should be two times as thick as the largest diameter rock used. Toe protection is at the base of the slope and prevents the water from undermining the riprap. The riprap should be continued up the incline and overtopping the apron to allow for the best protection. This form of stream stabilization
will help alleviate the effects of scour and is a cost effective solution coming in at roughly 55 dollars per ton. A Riprap Typical Section can be found in Figure 9.

With the completion of soil testing and geological survey, the next phase can begin. The information that is gathered from the geological survey will be handed off to the Transportation Engineer as well as the Structural Engineer. This will provide the proper information to be known for material design and implementation of those materials for specific cases.

*Figure 9: Riprap Typical Section*
OVERVIEW

The Cornhusker Council, BSA has requested the expertise of Bob the Builders & Associates to develop a master plan for the Outdoor Education Center (OEC) site. This document is specifically for the transportation design to assist the Cornhusker Council, BSA with their facility goals. The recommended solutions provided in this document will try to minimize the pollution of stormwater runoff, provide convenient access throughout the site, optimize the recycled concrete, and enhance the surrounding environment, where possible.

SITE INFORMATION

Figure 10. Master Plan for General Transportation Design Layout.
This site is located at 600 South 120th Street, near Walton, and within Section 29, Township 10 North, Range 8 East. In addition, the potential East Beltway is bisecting the property causing a split in the middle. There are a parking lot which only accommodates 30 vehicles, and two entrances to allow traffic to move in and out of the existing parking lot.

**CHALLENGES**

Every summer, the OEC will host events such as others and the Market to Market relay to support local programming and activities. During these events, it is estimated that up to 300 vehicles will be present on the site, which is far more than the current parking lot is able to provide. Therefore, the current site layout has insufficient parking during the peak season. In addition to the parking issue, there is not enough space or utilities for recreational vehicles. There is also an absence of available routes to access the eastern side of Scout Creek when the water rises above the low water crossing during high water events. This will be further addressed by the structural design team.

Bob the Builder & Associates proposes to install a total of 8 camping sites along both sides of Steven Creek in our plan. The challenge for the additional camping sites is the ease to access the area designated for camping sites across Steven Creeks because there is currently no direct access to it. Site access after the future completion of the East Beltway, as shown in Figure 4, has posed many challenges with this project. The plan of the proposed Beltway, as it currently stands, is to bisect the existing property, creating a divide at the entire west side of Steven Creek. With this in mind, that can have positive and negative impacts on the property creating a unique obstacle but also provides the opportunity for possible unique solutions.

**ALTERNATIVES**

To meet the needs of the Request for Proposal (RFP), Bob the Builders & Associates has investigated several options to ensure they are effectively meeting the requested needs. The challenge with the current low water crossing is that it is meant to act as an emergency vehicle access point across the Scout Creek during high water events, although it is easily overtopped during non-flooding events. This problem will be addressed by implementing a different emergency access point at the southwest corner of the property, which can be seen from Figure 6. The proposed roadways will be 24 feet wide, including the shoulder, to meet the American Association of State Highway and Transportation Officials’ (AASHTO) minimum design width of 20 feet for two-way traffic. This will ensure enough space during flood, or other emergency, evacuations for multiple emergency vehicles to quickly access the portion of the property separated by Scout Creek. The maximum grade of the road should not exceed 16 percent so that heavy vehicles, such as fire trucks, will not excessively tilt while using the roadways. Further parameters of a car tilt can be seen in Figure 11. The current parking lots on the west side of the property are capable of serving the maximum capacity during events that could incur around 300 vehicles. In order to address this problem, it is recommended that the existing parking lot should be paved and a newly paved parking lot that can hold up to 320 additional vehicles is constructed near the southwest section of Scout Creek. These parking lots on the site will provide a more systematic way to handle the traffic during high-volume events. To complete the design successfully, rainwater must be controlled on the current site as water...
exposure will erode the soil and eventually cost more money to repair. The parking lot must be graded and surfaced such that storm water runoff from the site is not allowed to discharge through the driveway approaches onto the public street or other property, but is collected on the site by an internal drainage system located on the site and carried to that existing storm sewer. Use of parking lot surfaces and surrounding landscaped areas to provide stormwater detention is encouraged.

![Figure 11. Vehicle Tilt at certain angle (The National Academic Press)](image)

Bob the Builder & Associates proposes a gravel road following from the existing low water crossing to the north side of the property. This straight road will allow 8-10 RV parking along the paved roads as can be seen in the attached drawings in Appendix B. Each RV parking stall will have dimensions of 20 feet wide and 40 feet long in accordance with the regulations set forth by the City of Lincoln Design Manual in Chapter 2.20. Towards the end of the road, there will be a Cul-de-sac (turnaround) with a radius of 45 feet starting from the centerline of the road, meeting the minimum of City of Lincoln Design Standard as well as that of AASHTO. According to the Chapter 3.45 Design Standards for Parking Lots in the Lincoln Design Standards Manual, the turnaround radius is 30 feet for a residential area and 45 feet for commercial use. While the turnaround is primarily designed for recreational and emergency vehicles, Bob the Builder & Associates has decided to select a 45 feet radius to accommodate larger vehicles.

**ANALYSIS**

According to the parking lot design standards of the City of Lincoln Design Standards Manual, regulations are used to determine the size, location, and orientation of the parking spaces and aisles as shown in Figure 12 and 13 and Table 5 below. From Table 5, City of Lincoln has provided different possible stall orientations to utilize for the parking slots layout. For stalls angled between 30 and 70 degrees, Figure 13 will be used to incorporate and analyze the design. Whereas for 90 degrees, Figure 12 will be utilized for the design. By looking at Table 5, a 90-degree parking lot will
consume more area for each parking space than angled parking, but will also allow one or two-way traffic to go through. As for angled parking will provide faster turnover rate and easy to move in and out of the parking spaces and can fit more spaces per square foot. However, angle parking requires one-way traffic and can be having traffic congestion if an emergency happens.

![Figure 12: 90-degree parking layout](The Department of Public Works & Utilities)  
![Figure 13: Angled parking layout](The Department of Public Works & Utilities)

<table>
<thead>
<tr>
<th>Angle, degree</th>
<th>Stall Width, ft (A)</th>
<th>Stall Depth, ft (B)</th>
<th>Aisle Width, ft (c)</th>
<th>Typical Module, ft (D)</th>
<th>Interlock Reduction, ft (E)</th>
<th>Curb Length, ft (F)</th>
<th>Rear Extension, ft (G)</th>
<th>Front Extension, ft (H)</th>
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<td>Short Term</td>
<td>Long Term</td>
<td>Short Term</td>
<td>3.7</td>
<td>17.0</td>
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<tr>
<td>30</td>
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<td>11.0</td>
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<td>41.0</td>
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<td>40.0</td>
<td>3.8</td>
<td>18.0</td>
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<tr>
<td></td>
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<td>8.5</td>
<td>17.0</td>
<td>11.0</td>
<td>12.0</td>
<td>45.0</td>
<td>46.0</td>
<td>3.0</td>
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<tr>
<td></td>
<td>9.0</td>
<td>17.0</td>
<td>10.0</td>
<td>11.0</td>
<td>44.0</td>
<td>45.0</td>
<td>3.2</td>
<td>12.7</td>
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<tr>
<td></td>
<td>50</td>
<td>8.5</td>
<td>17.7</td>
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<td>13.0</td>
<td>47.4</td>
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<td>12.0</td>
<td>46.4</td>
<td>47.4</td>
<td>2.9</td>
<td>11.7</td>
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</table>
To estimate the total difference between 90-degree parking and 45-degree parking, first we get the total area of each angle will take. Then, we will subtract them.

**Total area for 45-degree parking:**

\[
\text{Total Area, 45°} = AB + C \text{ long term} \times \text{no. of vehicles}
\]

\[
\text{Total Area, 45°} = 8.5 \times 17 + 11 \times 320
\]

\[
\text{Total Area, 45°} = 76,160 \text{ ft}^2
\]

**Total area used for 90-degree parking:**

\[
\text{Total Area, 90°} = AB + C \text{ long term} \times \text{no. of vehicles}
\]

\[
\text{Total Area, 90°} = 8.5 \times 17.5 + 23 \times 320
\]

\[
\text{Total Area, 90°} = 110,160 \text{ ft}^2
\]

**MATERIALS**

The three options for the pavement of the roadway and parking lot are gravels, asphalt, and concrete. Each of these materials has different advantages and disadvantages respectively. From our research, the Bob the Builder & Associates has found that the gravel is the cheapest option ($1.25 to $1.80 per square foot), where the asphalt comes in second with $2.50 to $4.00 per square foot. The high-end option will be having concrete coming at $5.00 to $6.00 per square foot.

By considering gravels, the total cost for construction will significantly go down at least by 50% from choosing the asphalt. The gravel can easily be placed and can be used almost immediately. On the other hand, the asphalt can allow efficient flow of the water during the raining and thawing. Lastly, the cement will be able to use for road pavement. Cement has the highest lifespan among the other two options. Coming with an average of 30 years for cement, 20 years for asphalt and five years for gravel. However, asphalt and gravels are cheaper when coming down to the cost of maintaining.
According to Chapter 3.45, Section 3.5 of City of Lincoln Design Standards for Parking Lots for all parking lots other than non permanent lots that are allowed for a maximum period of two years shall be surfaced with one of the following minimum cross sections:

1. Portland cement concrete pavement, 5-inch thick.
2. Asphaltic concrete pavement, 6-inch thick.
3. 3-inch asphaltic concrete surface on a 4-inch crushed rock or recycled concrete base course.
4. Modular pavers, open landscape paving blocks, pervious asphalt surfaces with subdrains or other permanent surfacing approved by the Public Works and Utilities Department.

RECOMMENDATIONS

Figure 24: 24 feet wide crown gravel road
Bob the Builder & Associates has recommended the location of the new emergency access bridge, new parking lot, 8 RV pads and the turnaround provisions as can be seen in Figure 15. Besides from the existing parking lot, we recommend having a 90-degree parking lot to the South East of the Scout Creek because it allows two ways traffic in each aisle to allow efficient traffic flow during events. Also, we have decided to use stall width and depth of 8.5 feet and 17.5 feet in order to reduce the area of each parking stall. This will lead to a parking lot that offers more stalls. The detailed dimension of the vehicle stalls and RV pads can be seen in Figure 18.
The total area of this parking lot will be around 111,000 square feet with each parking space of 8.5 feet wide by 17.5 feet in length according to AASHTO standards. Each aisle will allow two-way traffic and 23 feet wide with a minimum of 3 inches of asphalt slab on 4-inch crushed rock or recycled concrete base course on top of 6-inch subbase soil. Asphalt was selected because it is required by the City of Lincoln. Additionally, the concrete alternative is subject to crack easily due to freezing and thawing. The benefits of the new parking lot will allow 320 vehicles and 27 vehicles on the existing parking lot. In addition, the 111,000 square feet of land also serve as an emergency assembly point during emergency. The soccer and baseball field users would use the new parking lot more than the existing parking lot because it is very near to the field that they are heading towards.
Another recommendation is to install a 24 feet-wide gravel road at the southwest portion of the property connecting the current parking lot to the new parking lot. This 24-feet-wide gravel road will serve as emergency access during high water events and emergencies. Also, we will be using 3-inch thick base, 8-inch subbase, and 8-inch thick subgrade for the gravels roadways. The roadway is designed as of tandem axle which can hold at 34,000 pounds fire truck so that it did not damage when a fire truck was to use during an emergency.

An extension of the gravel road from the existing gravel path from the low water crossing to the North side of the property. By doing this, 8 RV pads will be added along the road with each parking space of dimension 20 feet wide and 40 feet in length along the gravel road. Each RV pad will have the same pavement as the parking lot we have proposed. Towards the end of the gravel road, there will have a 45 feet radius turnaround to allow vehicles, RVs and a fire truck to use. Moreover, notice that the turnaround is not going to go anywhere near the right of way of the potential East Beltway so that a removal or bulldoze of the cul-de-sac if the East Beltway were to be built.

**CONCLUSION**
Similar to other components of the project, the transportation team is prepared to deliver high-quality, engineered solutions to the key issues identified and will work to satisfy the client’s budget in our efforts.
## Summary of Estimated Project Costs

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<td>Emergency Access Bridge</td>
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<td><strong>Timber Railing (4X6 Boards)</strong></td>
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<td><strong>Timber Decking (4X6 Boards)</strong></td>
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<tr>
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# General Civil Cost Estimates

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| 25% Contingency | $17,710.00 |
| 20% Engineering Fees | $17,710.00 |

Total: $106,000.00

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<td>Asphalt RV Pads Pavement</td>
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<td>20% Engineering Fees</td>
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<td><strong>$923,000.00</strong></td>
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</table>
CORNHUSKER COUNCIL’S
OUTDOOR EDUCATION CENTER

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BORINGS & RIPRAP DETAILS _________________ 8
HYDRAULIC DETAILS _________________________ 9
BRIDGE OVER STEVENS CREEK

GENERAL PLAN
SCALE: 1/8" = 1'-0"

GENERAL ELEVATION
SCALE: 1/8" = 1'-0"

NOTE: SLOPE TIMBER APPROACHES AT 4% SLOPE UNTIL LEVEL WITH GROUND.

BRIDGE HYDRAULIC INFORMATION:
Q/0 ELEVATION = 1203.00

30% DESIGN SUBMITTAL
04/19/19
PEDESTRIAN BRIDGE OVER SCOUT CREEK

GENERAL PLAN
SCALE: 3/32" = 1'-0"

NOTE:
SLOPE TIMBER APPROACHES AT 4% SLOPE UNTIL LEVEL WITH GROUND.

GENERAL ELEVATION
SCALE: 3/32" = 1'-0"

BRIDGE HYDRAULIC INFORMATION:
Q10 ELEVATION = 1178.92

30% DESIGN SUBMITTAL
04/19/19
EMERGENCY VEHICLE ACCESS BRIDGE

GENERAL PLAN
SCALE: 1"/16" = 1'-0"

GENERAL ELEVATION
SCALE: 1"/16" = 1'-0"

BRIDGE HYDRAULIC INFORMATION:
Q100 ELEVATION = 1189.67

30% DESIGN SUBMITTAL
04/19/19
References

Dot.nebraska.org, Nebraska Department of Transportation, 2016, dot.nebraska.gov/media/2912/bopp-manual.pdf.


