The University of Iowa
IOWA INITIATIVE
FOR SUSTAINABLE COMMUNITIES

FINAL DELIVERABLE

Title	Volga Stormwater Management Engineering & Design
Completed By	Nicole Liljestrand, McKenna Mintz, Zachery Mousel
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UI Department	Department of Civil & Environmental Engineering
Course Name	CEE:4850:0001 Project Design & Management
Instructor	Rick Fosse
Community Partners	City of Volga

This project was supported by the Iowa Initiative for Sustainable Communities (IISC), a community engagement program at the University of Iowa. IISC partners with rural and urban communities across the state to develop projects that university students and IISC pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

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2020 Volga Stormwater Improvements

May 8, 2020

MLM Consultants

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Section I Executive Summary

The city of Volga suffers from severe flooding during the spring and summer months, causing mosquito problems and flooding for residents as water pools in low areas. MLM Consultants teamed up with Volga representatives in an effort to come up with solutions for their town and mitigate their current stormwater infrastructure. Nicole Liljestrand is our project manager and qualifies through her environmental engineering studies at the University of Iowa. Other team members include McKenna Mintz and Zach Mousel, both graduating civil engineering students at the university. After the site visit, it was clear that there were three areas that needed the most attention. The two low-lying areas that straddle White St., referred to as the northern and southern regions, experience standing water during the rainy season which attracts pests and causes routine flooding for their residents. In addition to these two areas, Volga Street was identified as causing a variety of issues for the client including high maintenance costs due to the street washing out, unsightly pooling, and a system that does not get the water out. With these concerns in mind, our team set out to develop solutions that would address these issues directly. An overview of these sections can be found in Figure 1 below.

Figure 1. Areas of Interest in Yellow

The first major task completed was researching and developing alternatives to present to the client. After the desired route was chosen, each element was handed off to one of our teammates for a further in-depth design analysis. Surface runoff of the geography was studied, and drainage areas calculated for each part. Programs such as Civil3D, HydaFlow, and Raindrop were utilized during the design process, and SUDAS, Iowa DOT Design Manual, Concrete Pipe Design Manual, and NRCS standards were used. A set of working drawings was developed for the preceding engineer team to be used as guidance for the build. Lastly, a cost estimate was completed for the finished product.

Constraints that were encountered during this project include time, space, and budget. With Volga being a small town, a low cost, low maintenance solution was desired. Some challenges that were faced include not having a detailed survey of the land. This was especially difficult for addressing the issues on Volga Street. This is because the town primarily consists of dirt and gravel roads, so a solution for this problem differs by block and a more detailed survey of the area is needed. Challenges faced for the northern region include the flooding of residents' basements which is a major concern for the project and also brings along unwanted mosquitos. This compared to the south region, that also experiences standing water, but does not affect resident houses. Instead, oversaturated soils cause rutting in the soil and makes it impossible for the City to maintain grass during those seasons. Both of the regions are on private property, posing another challenge of easements or property acquisition. Our hope is that our designs can overcome these challenges and create a design that solves the needs of the community while making Volga a more attractive community to raise a family in.

Alternative solutions were considered for both the two low-lying regions and Volga Street. For the two low-lying areas it was proposed to either pump both regions, enhance both regions as wetlands, or the chosen alternative was to pump the northern region and enhance the southern region. After a further investigation, it was found that there is a potential wetland on the northern site, a wetland assessment will need to be done to ensure this is true. This is why the solution of mitigating the potential wetland on the southern region was recommended. This will save the town from any future headaches, while creating an aesthetic draw to that area. As for Volga Street, we considered retaining water upstream to decrease volume getting sent down the street. This would address the town's needs, but there was not a viable location that would make the project worthwhile. A curb and gutter system was also considered. While this would solve the client's issues, it would require a very detailed survey of the town and was out of the scope for this class. Because these two options were not feasible, it was recommended to the client to go with the storm sewer outlet design downstream. This chosen alternative is part 1 for implementing a town-wide sewer system and can be expanded as the City sees fit. This solution directly addressed the problems of pooling and diverts water away from the two existing floodgates. A unique opportunity was presented to work with the Pedestrian Bridge senior design group to make a product that works together.

The designs chosen by the client are the best fit for solving the problems within the Volga community and creates future opportunity. By enhancing the south region as a wetland, not only does it help to rid the area of an undesirable mosquito problem and overly saturated soil, it also provides a nice aesthetic to the town and presents a solution to the potential problem in the north region. With the realization that a wetland could be violated in the north region, the enhancement of one in the south helps to mitigate that loss. The decision to pump out the water in the north region also seemed like the best option because it utilizes materials already in the community and solves the main problem of flooding. Our vision for this area is that it will go back to looking the same as before, so now during the summer months those residents can enjoy their backyard.

The design for the wetland consisted of sizing the basin by calculating the water quality volume and sized-up to account for sediment buildup. The total volume was calculated to be 80,000 ft^3. An outlet design was provided as a trapezoidal weir with a bottom length of 5 ft and a height of 1.5 ft, this weir provides a direction for the water to flow in case of a bigger storm event than the wetland can handle. The wetland was sized off a 10 yr-24-hour event. The weir leads to a turf spillway to direct the water to the river.

The pump system that is designed for the north region consists of a 4-inch drainage tile entering a manhole with an outlet pipe that is a 4-inch ductile iron pipe. That pipe leads to a coupler where a fire truck or pump can be attached along with an adjacent coupler that leads to the culvert on Washington Street. In between the couplers is a 12 feet wide, 6-inch-thick gravel road to provide the fire truck access to the couplers.

As for Volga Street, our team thought it would be most beneficial to implement the outlet of a storm sewer system. Because our team believes that a city-wide storm system implementation is the only way to truly solve the issues that Volga Street experiences, our team gave you the beginning parts of this with future expansion in mind. By building at the same time as the bridge project, it could reduce costs for machinery and excavating. The finished design consisted of a concrete 415 ft. long, 18 in. diameter storm sewer system with two inlets at low areas. The inlet on Volga Street will be standard frame and grate whereas an elevated cover is recommended for reflection park, to minimize clogging. A total of 12 cfs of water will be diverted from the existing floodgates and will exit from an outlet near the new pedestrian bridge. The new system will be unnoticeable from the surface except for the two inlets. Our hope for this design is to slowly introduce modern stormwater practices and test it out. If the city likes the design, it could be easily expanded in the future.

We recommend that this project gets broken up into phases. Phase A is the wetland construction, Phase B is the pumping of the northern region, and Phase C is the storm sewer construction. Costs include all materials, labor, equipment, overhead, profit, contingencies, and final engineering and administration costs. The total cost of Phase A is $39,500. The total cost of Phase B is $39,500. Lastly, the total cost for Phase C is $52,400, making the total cost for the project to be $131,500.

Section II Organization Qualifications and Experience

1. **Name of Organization**

   MLM Consultants

2. **Organization Location and Contact Information**

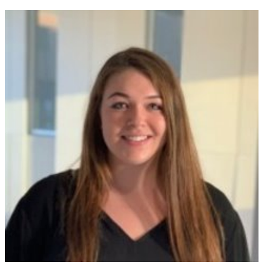
   Project Manager: Nicole Liljestrand

   Cell Phone Number: (630) 297-1552

   Email: nicole-liljestrand@uiowa.edu

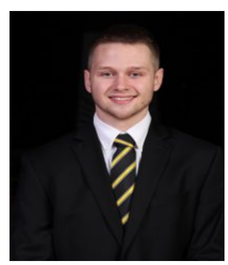
3. **Organization and Design Team Description**

Our design team consists of three students studying at the University of Iowa. All three students are seniors majoring in Civil/Environmental Engineering. The project manager is Nicole Liljestrand and she is majoring in Environmental Engineering with an emphasis in Water Treatment/Quality. Nicole will be focusing on the wetland design. McKenna Mintz majors in Civil Engineering with an emphasis in general civil practice. McKenna will focus on the storm sewer system for Volga Street. Zach Mousel majors in Civil Engineering with an emphasis in management. Zach will be focusing on the pumping of the northern region.



Nicole Liljestrand

McKenna Mintz



Zachery Mousel

Section III Design Services

1. Project Scope

The city of Volga is a small town in Northeast Iowa that experiences flooding during the rainy summer months. After discussion with the clients, we found that there were three specific sites that needed to be focused on: a surface runoff problem on Volga Street and the two low-lying areas that retain water and remain chronically wet. Possible solutions for these problems were researched and proposed to the client. The following tasks were completed:

- Conduct surficial flow mapping for the community and surrounding areas
- Analysis and redesign of the drainage structure on Volga Street
- Identify and present best design alternatives to clients
- Identify primary locations for implementation of those practices
- Complete engineering and develop cost estimate for the priority projects

The two low-lying areas are commonly referred to by the residents as swamps. For these regions, they remain chronically wet and especially in the northern site flood basements. The standing water also attracts mosquitos. A list of services provided for this part of project can be found below:

- Estimate drainage runoff and tributary areas
- Size pipes, select material, and MH covers
- Determine pumping capacity
- Calculate water quality volume
- Design outlet
- Design site plans for systems
- Design a plan and profile for system
- Design grading plans for systems
- Cost estimate

The second area that our client identified as taking priority are the issues that Volga Street experiences. This includes washing out and unsightly pooling during heavy rain events and is said to cost the city a lot on maintenance. Another problem within the town are the two 24" floodgates that currently serve the city are overwhelmed and cannot handle the current loading. Our goal as a team was to come up with a design for Volga Street that addressed as many of these concerns as possible. A list of services provided for this part of the project can be found below:

- Estimate drainage runoff and tributary areas
- Calculate surface runoff using Rational Method
- Size pipes, select material, and MH covers
- Design outlet

- Design a site plan for the system
- Design a plan & profile for system
- Cost estimate

The figure below locates the three areas of focus.

Figure 2. Site locations shown outlined in red.

2. Work Plan

Major Tasks:

- Research Options
- Evaluate Alternatives
- Choose Alternative
  - Provided the alternatives to the client to choose one that is desired most
- Preliminary Design
- Final Design
- Cost Estimate

For our project, since we had three major areas that were focused on, each team member took one of the areas and focused on that and performed the design on it individually with help from team members when needed. Below is a Gantt chart that outlines the work plan.

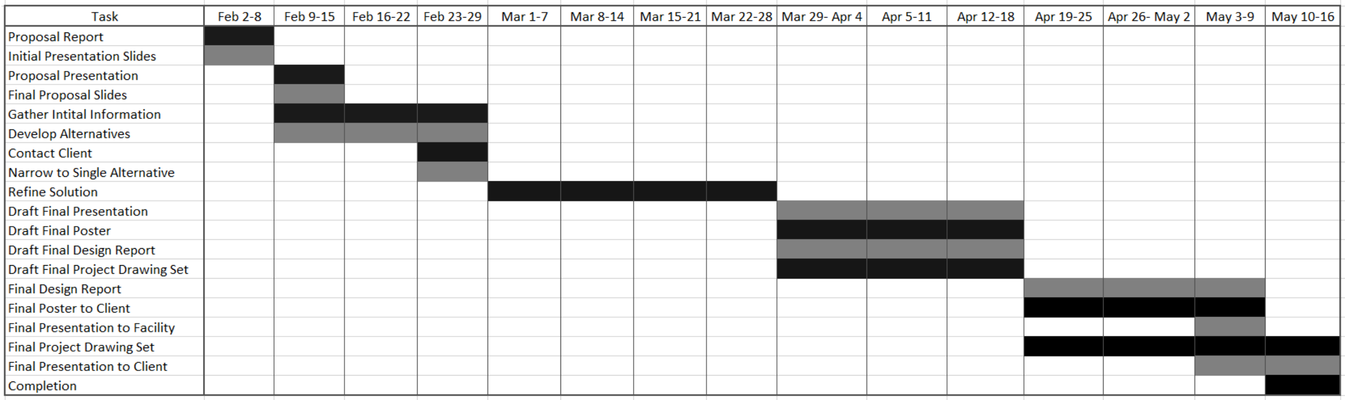


Figure 3. Gantt Chart of the tasks completed with the approximate time it took to complete each task.

<u>Section IV</u> Constraints, Challenges and Impacts

1. Constraints

Specific project constraints for the stormwater redirection are centered around time, space, and budget. Since Volga is a small town with few resources, a low price, low maintenance option for their stormwater is desirable. Another constraint would be time. There is a timely expectation to uphold when dealing with clients who depend on a schedule for completion. Additionally, we are graduating on May 17th and do not want to be working on our project after this date. The designers are constrained by space/geography of the location as well. Since the City of Volga is already built, a solution must be retrofitted to the existing land and structures. An example of this is getting the storm water past the levee that protects the town from the Volga River.

2. Challenges

There were many challenges that came with this project that made the design process more difficult. One challenge was the constant washing out of Volga Street due to heavy storm runoff. Since the streets within the town are primarily dirt and gravel with a sealcoat overlay, it was challenging to determine methods that would not require an excessive amount of capital or resources to construct. It was also difficult to reroute this runoff as that could create more problems for the town residents along the street. Another challenge is the lower region of the town where storm runoff pools, leading to the flooding of buildings within that area. The ground within this area has also become rutted from the constant saturation of the soil. After further research, there is a possible wetland on the northern swamp area. If it is, it will need to be mitigated somewhere else in Volga. Additionally, there are two 24-inch diameter floodgates that responsible for draining the city. MLM had to ensure that these floodgates provided enough capacity to drain the intended amount of area.

A big challenge faced during this 2020 Spring semester is learning through the COVID-19 pandemic. About halfway through our design project, education through the University of Iowa had been shifted to all online only. This was especially challenging because our teammates and professor could not regularly meet as before. A simple problem that could have been answered by walking up a flight of stairs to a professor's office had now become more complex and required an email and zoom session to be organized. This caused miscommunication at times and dragged the process out more than it had to be, but in the end was very rewarding when we saw what we have accomplished.

3. Societal Impact within the Community and/or State of Iowa

a. Population Characteristics

Reducing storm water problems will improve property values and make Volga a more desirable community for new families.

b. Individual and Family Changes

With the reduction in storm water problems, it becomes a more desirable place to reside, bringing in younger couples to raise families there.

c. Personal and property rights

With the addition of a wetland on the southern swamp area and the piping network in the northern swamp area, land will need to be acquired from the property owner.

d. Community Resources

Community resources are currently light because of the small population and low median household income. However, MLM hopes that by resolving stormwater management issues within the city, this will alleviate the risk associated with moving to Volga. Although this will take time, this gives Volga the opportunity to maintain support from current residents while attracting new ones that will bring more financial freedom to the city. Currently there is a volunteer firehouse located on Main Street, near the swamp. It is important to keep the water away from this infrastructure to ensure safety.

e. Sustainable Practices

Having a constructed wetland provides the city with a best management practice for storm water. A wetland is self-sustaining and provides a habitat for many species.

Section V Alternative Solutions That Were Considered

1. Other Solutions Considered for Swamps

Other possible solutions explored were pumping out both the northern and southern regions or turning both the northern and southern regions into enhanced wetlands. By pumping out both regions, the client is running the risk of destroying a potential wetland. This would be effective of clearing both areas of undesired water but could also be very cost extensive if wetland regulations later prove to have been violated. The other option of enhancing both regions as wetlands would require the least amount of maintenance in the long run. Initially, these areas can take a good amount of effort but once they are established, maintenance is minimal. However, this would require both regions to withhold water for varying amounts of time. If the wetland in the northern region is not constructed properly, it could make the flooding issue even worse than before.

2. Other Solutions Considered for Volga Street Erosion

Two additional solutions to help mitigate the problems on Volga Street were also considered. This included adding curb and gutter to portions of the street the posed the most problems or adding detention upstream to decrease the amount of flow through the area. Implementing a curb and gutter system would be ideal for it addresses all the client's needs, however we do not have a detailed enough topography for this and is outside the scope for our class. It would also be hard to establish given the current condition of the streets and the limited resources that the town must have to pave them. The other solution of decreasing the volume of runoff that goes down Volga Street would not have the impact that is desired. There is limited space upstream to add detention for the runoff. The space that could potentially work is too far upstream and out of town to make a significant difference that would be worthwhile for the clients.

Section VI Final Design Details

1. Flooding Region

The final design solution involves pumping out the northern region and enhancing the southern region as a wetland. This solution combines the desirable qualities from both of the other solutions that were considered. Flooding occurs most when the soil in this area becomes very saturated and starts to pool. By pumping the northern region, there will no longer be standing water in this area. A low point will be established to help remove as much of the water as possible. At the bottom of this low point, a manhole will be constructed to store the water until it can be pumped. Tiles can also be drained into the manhole to gather groundwater that contributes to problems in this area.

It is beneficial to enhance the southern region as a wetland as this helps to mitigate the potential removal of a wetland in the northern region. This area also does not have the same flooding issues as that of the northern area. Therefore, having ponded water here will not have the same impact. Enhancement will also make this area look more appealing through the implementation of a variety of native vegetation.

Pumping Northern Region

Structures

For the northern region, the installation of a manhole, piping system and tiling will be required. A manhole will be the primary structure within this portion of the design. The manhole follows Iowa DOT SUDAS SW-401 design standards and will have a conventional beehive grate with a 27-inch diameter. It will be 4 feet tall with a 5-foot radius. A 4-inch drainage tile will enter the manhole 1 foot from the bottom to help decrease the amount of groundwater in the soil that is contributing to the flooding problems. Exiting the manhole will be a 4-inch ductile iron pipe leading to a coupler that is 6 inches from the bottom of the manhole.

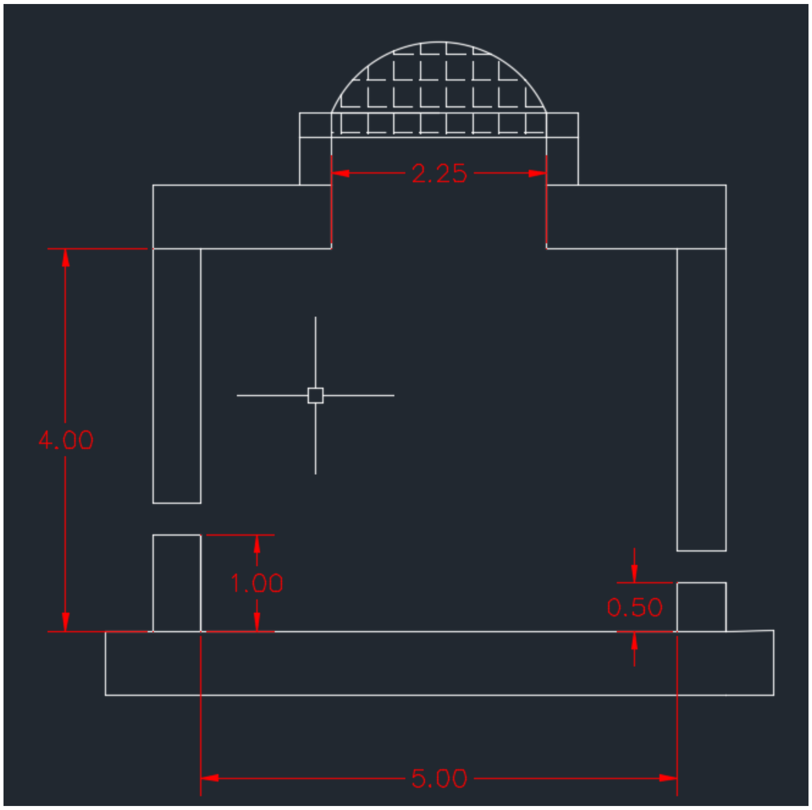


Figure 4. Basic design of manhole to be constructed for project (units of feet)

There will also be another coupler on the other side of the pump that will be attached to a four-inch PVC pipe that will lead the water to the culvert by Calvary Bible Church. There will be 12 feet between the couplers to help provide adequate space to park a fire truck in the middle to pump the water out of the system. The outlet pipe from the manhole will be filtered to prevent sediment from entering the pipes and pump.

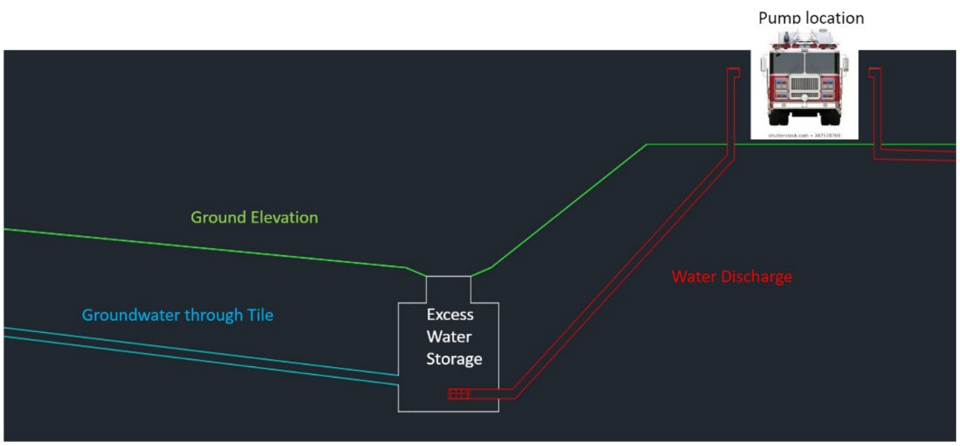


Figure 5. Basic schematic of pump system for the north low-lying region

The couplers will stick out of the ground around 2-3 feet above ground surface to provide easy accessibility. The fire truck can be attached to the couplers directly with the help of a hose.

Figure 6. Example of what it will look like to attach fire truck to coupler

<u>Grading</u>

Given the length of the area and the limited amount of width, it would be difficult to grade the entire area without adding a significant cost to the project. The manhole concept works best when it is placed at a low-point and serves as a drain to a funnel type land area. To help accomplish this, the area around the manhole will be lowered a foot less and the manhole will be placed 8 inches below that to ensure the brim of the manhole does not infringe on the flow of water. Using the dirt from the excavation for the enhanced wetland, it can be added to low points that are far from the manhole to help the area drain better. This helps make up for the lack of space that is needed to create a proper low point for the manhole. Grading will also be needed for the gravel path to be implemented to allow the fire truck access to the couplers. The path will be 12 feet wide and 6 inches thick to provide a suitable route.

<u>Permits and Regulations</u>

MLM Consultants recommend that a wetland determination be completed for this area. If it is determined that wetlands exist in this area, it is important to go through the regulatory process before beginning any construction. If wetlands do exist, it is the intent of this design strategy that the constructed wetland in the south area will serve as adequate mitigation. If it is not considered an appropriate mitigation, further actions may be needed to mitigate potential losses, such as purchasing constructed wetland from a wetland bank or constructing a larger wetland in the southern region. In the figure below, it can be seen that in the northern region, there is a potential wetland from the National Wetland Inventory Website.

Figure 7. Map taken from National Wetland Inventory Website.

All the vertical wells that are still in place/use will need to be sealed. A stormwater plan must meet local and state regulations. Along with the wetland delineation, land acquisition or an easement will be required given that the PVC portion of the piping system must go through private property to reach the culvert. The pipe goes through the bottom of the property to help reduce the amount of land needed to be acquired.

Figure 8. Map from Beacon showcasing the property needed.

Operation and Maintenance

Once the system is in place, the most typical operation needed will be to attach the fire truck or pump to the couplers sticking out of the ground to remove the water stored within the manhole. An occasional check of the manhole will be necessary to ensure that water is coming into and leaving the system without problems such as clogging. The system may need to be cleaned every so often so that sediment does not build up in the bottom from dirt, leaves, or other types of debris.

Wetland in Southern Region

Site Selection

The site of the southern region was chosen for the location of the wetland because there is a possible wetland located on the northern region, but the northern region experiences the worst of the flooding and causes residents' basements to flood while the southern region there is no report of flooding in basements. The land is flat covering most of the southern swamp, choosing a location was more focused on avoiding trees. Based on aerial photography, it was placed in the farm field. In the figure below, the proposed site can be seen outlined in green.

Figure 9. Site selection of wetland outlined in green.

With this site being chosen, the town will need to communicate with the property owner for right to the property. The figure below from beacon shows the private property and the price of the land. The site selection is not a permanent one and can be moved to another location as long as it is to another low-lying area. The residents might prefer a different area as this one is on private property. It should be noted that other mitigation methods might be needed to ensure this potential wetland is mitigated properly.

Figure 10. Map from Beacon outlining the land is on private property.

A soil report was obtained for the site and it showed that most of the soil was spillville loam, with a 0 to 2 percent slope. The figure below shows the soil report obtained from the NRCS website. According to the NRCS, spillville loam is partially hydric meaning that at least one of the major components is hydric. This provides the soil with the capability to support the growth and reproduction of hydrophytic vegetation. Hydric soil is a good indicator of wetlands. The drainage area was then determined from civil3D.

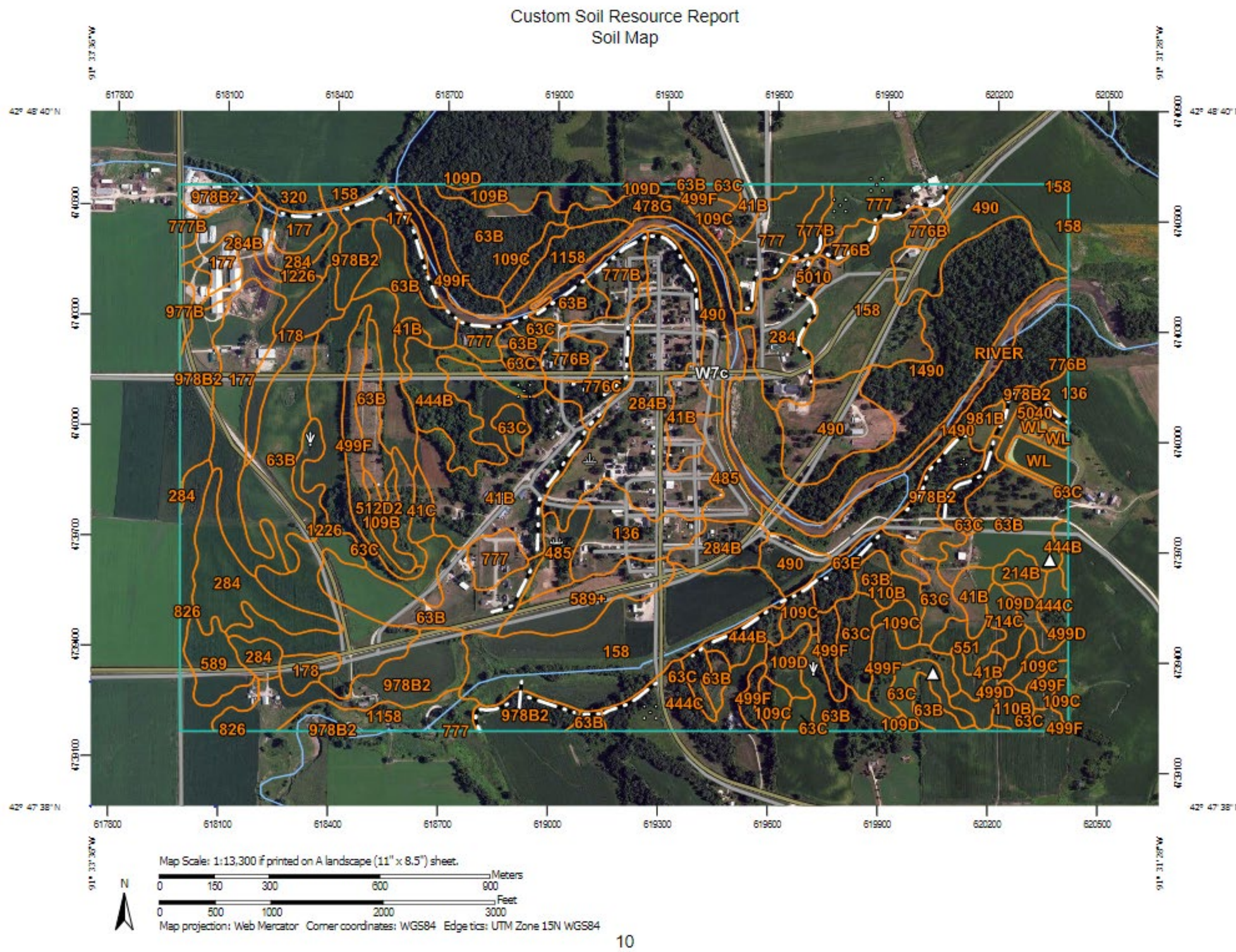


Figure 11. Soil Report obtained from NRCS.

Permits and Regulations

If it is determined that wetlands exist, it is important to go through the regulatory process before beginning any construction. If wetlands to exist, it is the intent of this design strategy that the constructed wetland in the south area will serve as adequate mitigation. Along with the wetland being implemented, all vertical wells that are still in place/use will need to be sealed.

Structures

For construction of the basin, it was decided to create a permanent pool. It was decided to not implement a forebay, but instead size up the permanent pool to account for their being no forebay. From the drainage area, sediment is expected to wash into the wetland, and this is the reason the permanent pool was oversized. The wetland was sized off a 10 year-24-hour event. According to the Iowa DOT Design Manual, Chapter 4A-5 the rainfall intensity for this size of an event is 4.5 inches. With a drainage area of almost 50 acres, calculated using AutoCAD, this led to an average of 9.5 cfs going to the wetland (See Appendix B, Calculation 1). The water quality volume was calculated assuming an impervious value of 5%, the water quality used the precipitation data from the 10 year-24-hour event and the drainage area to calculate a volume for the permanent pool of about 66,500 ft^3 and adding about 20% to this to factor in the missing forebay volume, end up with a total volume of 80,000 ft^3 (See Appendix B, Calculation 2). The side slopes are to be sloped on a 3H:1V ratio with an emergency spillway. The average depth for the entire cell is to be four feet. A deeper end, opposite where most water enters the wetland, will be built to ensure organisms survive the cold months. This deeper end will be six ft deep. Using cut and fill on civil3D, the amount of dirt that will need to be excavated is 2930 CY, as seen in the figure below.

Name	B	Mid-Ordina...	Cut Factor	Fill Factor	Style	2d Area(Sq....	Cut(adjusted)(Cu. Yd.)	Fill(adjusted)(...	Net(adjusted)(Cu. Yd.)	Net Graph
Wetland ...			1.000	1.000	Contours ...	22850.96	2929.18	0.00	2929.18<Cut>	

Figure 12. Cut and Fill amount for wetland in CY.

Soil samples should be taken to determine if a bentonite clay liner should be added to lower permeability and to ensure that the minnows and other organisms survive the winter months.

Two bat houses will also be constructed to go along the wetland. Bat houses will attract bats to the area. There are trees and a river close to the site which is a prime location for bats to establish their homes. Bats will also provide the extra help with the mosquito population. In cases that the minnows are not providing enough help with the mosquito population, the bats will help. The bats can also help in the northern swamp area with the mosquito problem. The figure below shows what the bat houses will look like surrounding the wetland.

Figure 13. Example of a bat house. The bat house is on left and the pole it stands on, on the right.

<u>Flow Control Structures</u>

For this wetland, there is no designated inlet, as the water finds its way to the area. The water will flow into the wetland from the surrounding drainage area. The purpose this constructed wetland is to manage the water in a way that is an asset to the area. The outlet in this case is a weir acting as a spillway to redirect the water where it has been going, which is back to the river. The emergency spillway is designed in case a 100-year-24-hour storm event occurs. This storm has a 1% chance of occurring each year. The figure below shows the floodplain map of Volga.

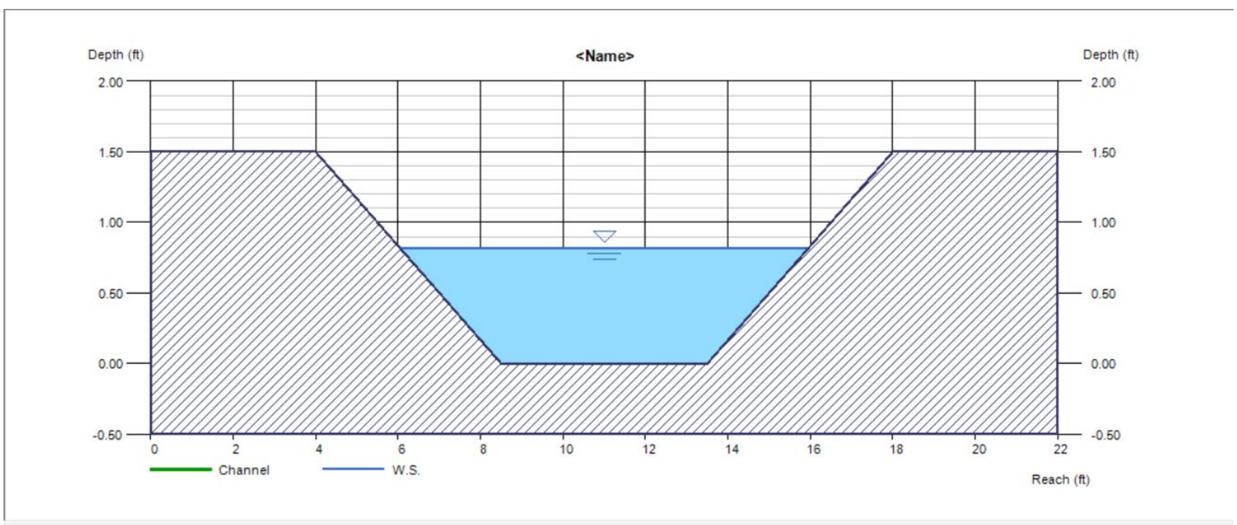
Figure 14. Floodplain map of Volga.

The flowrate for a 100 year-24-hour flood is 15.6 cfs. This is an extra almost 6 cfs that the wetland needs to be able to hold, the emergency spillway is added for this reason. Using Hydraflow Express on civil3D, the desired dimensions of the weir were obtained using the calculated flow rate of 16 cfs. A bottom width of 5 ft was chosen because in this case it is better to have a longer outlet to allow more water to rush out of it in the case that it is needed to be used. The height of the weir was found to be 1.5 ft, with the water only reaching .85 ft. The extra space is given to accommodate bigger storm events, if one occurs. An input and output of what was entered into Hydraflow Express and the output of this can be found in the figures below. The spillway is to be 5 ft wide, the same width as the outlet and is estimated to be about 100 ft long to reach the roadway. This leads to about 500 ft^2 of turf needed to cover the entire spillway. Dirt from the excavation of this wetland can be placed to help ensure the water travels down this spillway.

Section	Item	Input
Weir	Weir Type =	Trapezoidal
	Crest =	Sharp
	Bottom Len (ft) =	5.00
	Total Depth (ft) =	1.50
	Side Slope, z:1 =	3.00
Calcs	Weir Coeff =	3.10
	Compute by =	Known Q
	Q (cfs) =	16.00

Clear Run

Figure 15. Input of Hydraflow Express for wetland outlet.



Depth	Q	Area	Veloc	TopWidth	Energy
(ft)	(cfs)	(sqft)	(ft/s)	(ft)	(ft)
0.82	16.00	6.12	2.62	9.92	0.93

Figure 16. Output from Hydraflow Express for wetland weir.

This outlet design is not necessarily needed, as the clients reported the water staying in this area and not draining or running off at any location. They believe that if they do have a big enough storm event the water would drain towards the highway and into the river that way, but they have not witnessed the water ever drain out of this area. This outlet can also be moved to another location, as stated before this design was done mostly using aerial photography, a more detailed topography and site visit along with soil samples needs to be completed.

Hydrology

There should not be a hydraulic residence time since the goal is to retain the water. Groundwater exchange should be next to none in this situation.

Vegetation

There are many different types of plants that can be implemented into a wetland. Some are emergent plants including cattails and horsetails, there are floating-leaved plants including American lotus and white-water lily, there are free-floating plants including duckweeds, and lastly there are submersed plants which include coontail and northern watermilfoil and sago pondweeds. All these plants are native to Iowa wetlands. For stormwater wetlands, it is best to have a diverse vegetation for visual appeal and is more likely to resist invasive species. An increase in vegetation diversity also increases wildlife diversity. A local Iowan nursery called Ion Exchange is in Northeast Iowa, not very far from Volga. This nursery offers native Iowa wetland plants. Some of the types of plants that will be planted include Scirpus Pungens, Carex Comosa, Cassia Hebecarpa, and Acorus Calamus. These plants have a variety of growing conditions, some are more emergent type while others are submersed plants. A more detailed list of the plants can be found in the cost analysis.

Options to establish these plants, include seeds, seedlings, entire plants, or parts of plants. Seeds are the least expensive, but also the most unreliable. Seedlings are very similar and harder to establish. The best way and most expensive way are to buy plants or parts of plants from a local nursery. It is recommended by the US Army Corps of Engineers to find plants within a 100-mile radius. In preparing this site for planting, it is recommended to shallowly flood the site once it has been shaped and graded to help settle the soil. The site should be constructed in the fall and left flooded over winter and then dewatered before planting to help ensure a moist soil. The wetland can be dewatered using the firetruck and pumping it as the town has pumped water sources using the same apparatus. It is a common mistake to think that during the first year of establishing the wetland that more water is the best solution. The roots need to be established first before flooding can occur.

Some of the plants are needed in specific areas around the design of the wetland. All of the following information can be found on the Ion Exchange website. The Scirpus Pungen can survive water depths up to 3 ft. This plant should be inside the wetland or along the edges of the wetland. It helps with erosion control and is very common in constructed wetlands, as it is a common food source for waterfowl, beavers, and muskrats. The Carex Comosa handles deeper water than most species and is good for retention basins. This should be placed along the edges still inside the basin. The Cassia Hebecarpa is good for growing along the banks of the wetland. It is a pretty yellow flower that would bring aesthetic appeal to the wetland. The Liatris Pycnostachya grows in wet areas and is a purple flower that would contribute to the aesthetic appeal. The Lythrum Alatum is very similar to the Liatris Pycnostachya where it grows best in moist soils and it is great for planting in areas of poor drainage. It is also a purple flower. The Mertensia Virginica grows very well from seeds and should be cultivated more. This species will thrive in a wetland area. It requires a little more shade than the other species selected. The Acorus Calamus looks very similar to a cattail. It can grow on the edges and in wet fields. The figure below shows what each plant looks like when in bloom.

Figure 17. Pictures of each plant that is proposed to be planted in and around the wetland.

<u>Operation and Maintenance (O&M)</u>

A constructed wetland does not require extensive O&M since it is a self-sustaining habitat. There will need to be some O&M for ensuring the outlet structure is not damaged. There will also need to be sediment removal periodically. With the wetland itself being oversized, sediment removal will be needed less frequently. The wetland will be surrounded by the existing grasses and vegetation. Mowing the surrounding area will need to be done periodically to ensure the grass surrounding the wetland keep their root system and for aesthetics. Weeding will also need to be done to avoid invasive species from developing. The use of herbicides is not recommended for wetland plants. It is recommended to install bat houses around the constructed wetland. Bats will eat the mosquitos.

Monitoring Plan

Monitoring ensures the wetland stays healthy and performs to the standards that it needs to. Monitoring the vegetation to check for invasive species is necessary. It is also necessary to monitor the entire wetland to check for erosion of the site. More monitoring is required during the first couple years to ensure the wetland is establishing properly. The sediment depth should be monitored, sediment depth decreases the possible water depth that the wetland can hold. This decreases the effectiveness of the wetland. The emergency spillway will be used more frequently causing more runoff into the surrounding neighborhood.

2. Volga Street Erosion

Preliminary Considerations

During the site visit, our client made it clear that Volga Street had many problems that our team could potentially address. The street gets washed out during heavy rain events and causes maintenance costs, while unsightly pooling was an issue downstream. To combat this, our team paired up with the Volga pedestrian bridge expansion group and came up with a solution that worked together. A short underground storm sewer was proposed to help divert water from this area while serving a dual purpose which frees up capacity in the city's existing floodgates. The outlet would discharge right around the proposed bridge. All the property proposed to be worked on is owned by the City of Volga, which cuts down costs for the client. This can be seen from a Beacon Iowa assessment in Figure 18. Although this design does not address the issues our clients had directly, we believe a city-wide implementation of a storm sewer system is what is needed to solve the issue. Because our team did was working with aerial photography and 2-ft contours, we did not have the resources to do this for the city. However, we provided a design that could be the beginning for the system and is sized for future expansion.

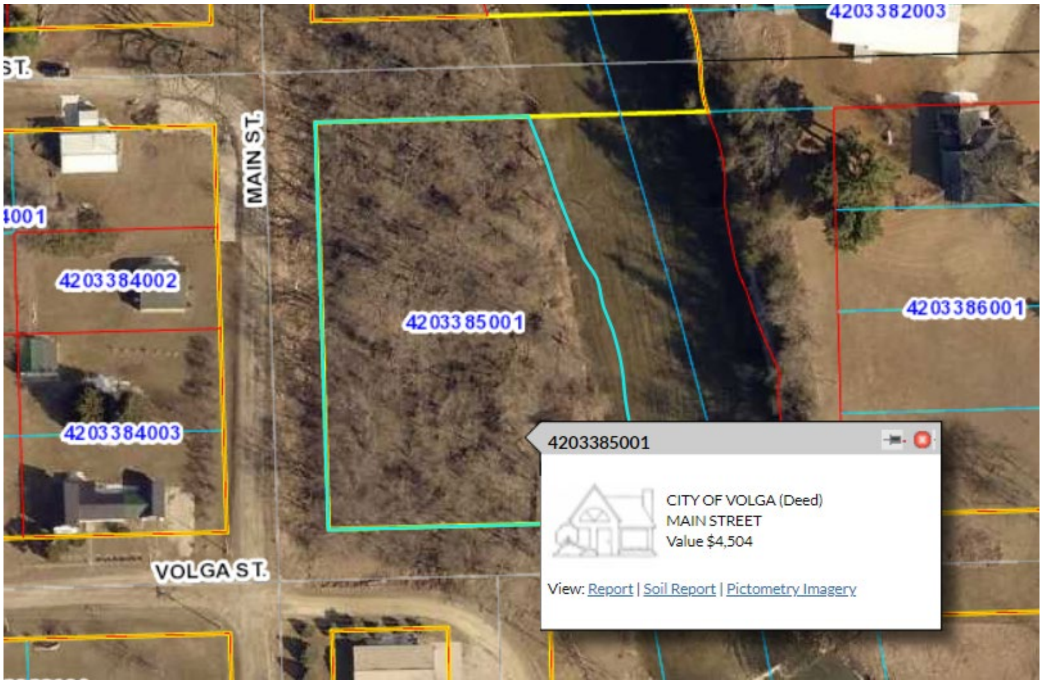


Figure 18. Beacon confirmation that City of Volga owns proposed property for sewer system outlet

Hydrology / Design Method

Using the raindrop feature on Civil3D, a drainage area of around 29 acres was found draining into the two 24" diameter floodgates. Although our design falls within this larger area, we were more interested in the area draining directly to the low-point of concern on Volga Street. The same method was repeated and found an area of around 3 acres draining to the interested point. We used this drainage area along with 2' contours from data extracted from the Iowa DNR Database and converted with ArcGIS. Once this was imported to CAD, we calculated by hand the slope of the pipe network and calculations can be seen in Calculation 3 in the appendix. We also talked to another Volga group responsible for the proposed pedestrian bridge to confirm what height the assumed riverbed level is. This was important because the without a detailed survey of the, a lot of our calculations were speculated so it was nice necessary to make sure other design teams were on the same page. We used a slope of 2.0% along with the calculated drainage area and an assumed flow path that the water will travel all as factors in our network sizing. The rational method was used in the Hydrology Express app on CAD was to calculate runoff. This method was chosen because according to the DNR's Iowa Storm Water Management Manual this is how you size sewer pipes for a drainage area of less than 160 acres. A runoff coefficient of 0.39 was used for low-density residential housing and a 10-year, 1-hour event (i = 2.17 in/hr) was used to calculated sizing. These numbers were typical values used from the Iowa DOT Design Manual Section 4A-5 . The reason for using an a more extreme rainfall intensity than advised in the manual is because Volga has a history of devastating storm events and if the city plans to expand its pipe network in the future, it has a built-in safety factor to be able to handle those loads. The equation for the Rational Method can be found in the appendix as Calculation 4. Total calculated runoff from this area was **12 cfs** diverted from the two floodgates, increasing the available capacity for those outlets during a large rain event.

Pipe Sizing

The next step to designing the storm sewer is picking out pipe material and sizing the system. Steps from the concrete pipe design manual along with Manning's Equation were used. A concrete pipe was chosen for this system because the outlet discharges into the Volga River, and since the ground in that area experiences a lot of saturation, a sturdy pipe material is needed even though it is more expensive. Concrete pipes are also float-resistant and ideal when working around large bodies of water. It is also nice because the system will require less maintenance and can serve as an outlet to a larger system if the town decides to expand. The Concrete Pipe Design Manual used to design the system recommends solving for size using either Figure 21 or Figure 22 that are both listen in the Appendix. My method was to use Figure 21 first with a flowrate of 12 cfs and an initial pipe slope of 0.02, I was able to calculate back-calculate for the constant C1 and find where this intersected using the assumed Manning's Coefficient of 0.012. The found C1 value of 84.9 fell between a 15- and 18-inch diameter pipe. I chose to design at the **18-inch diameter** to make sure the system can handle the full loads of a 10-year flood. This was double-checked with Figure 22 that needed the runoff along with initial bed slope to find an intersecting pipe diameter. I was able to confirm that the sizing fell between 15 and 18 inches.

Structures (manholes and covers)

Two inlets will serve the network. The first was placed at the low-point that the client described as being a problem area for the city and is labeled "Structure - 1" in the design drawings, found on Volga Street. A standard frame and grate are recommended for this structure. Since the peak flow isn't too high, there is no need to purchase a special cover. However, the second structure, labeled "Structure - 2" in the design drawings, would benefit from having a stool-type ditch grate found in Figure 19 (Neenah Foundry R-4341-A). Because of the park's terrain, a raised grate was chosen because it does not clog easily, and the space isn't large enough for a child or pet could fall in. This second manhole is located just under 300 feet away from the first structure, complying with (Iowa DNR Design Standards Ch. 12) 400-foot maximum distance between structures for maintenance.

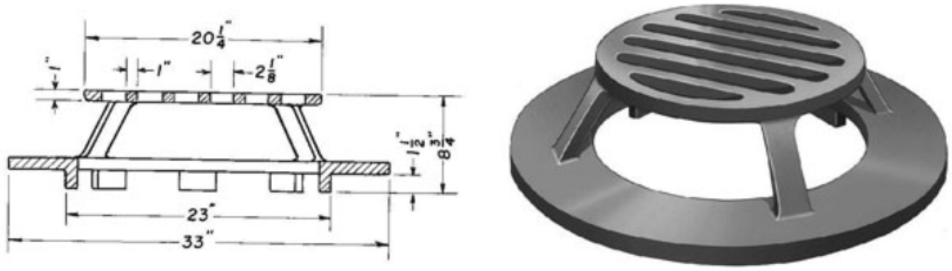


Figure 19. Stool-type ditch detail and grate, Neenah Foundry R-4341-A

The outlet into the Volga River is designed to be two feet above the river water level (assumed to be 782 from 2' contours) and equipped with a hinged back-flow preventer cap shown in Figure 20, to block sediments and debris from getting into the system during a heavy event. It allows water to flow in the desired direction but never in the other which is ideal to prevent surcharges and will result in less maintenance. It must also be noted to tie the last 3 pipe segments together near the outlet to resist soil shifts near the river.

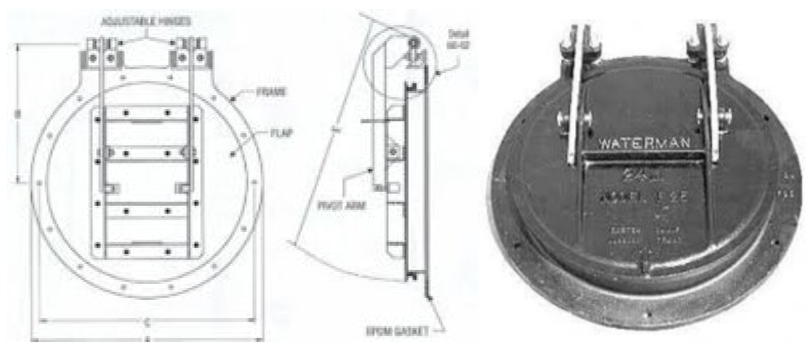


Figure 20. Backflow Preventer Detail and Picture

Operation and Maintenance (O&M)

Sewer systems are designed to require little maintenance. The back-flow preventer cap will restrict the amount of debris that can get into the sewer, but will have to be checked after heavy events to ensure the cap itself is not clogged. The same goes for the two drainage structures described in the previous section. If the system starts to not run as it should the pipes can be flushed and cleared, but this should not be a problem because the pipes are sized to handle a bigger load than expected.

Section VII Engineer's Cost Estimate

These were calculated using common prices found in Iowa DOT's public bidding records. The unit costs consist of material, labor, overhead, and profit. Contingencies was increased to 25% because our team has a lot of smaller moving parts that can fluctuate in price.

Pumping System

Table 1. Breakdown of Pumping System costs.

Task	Unit Cost	Quantity	Price
Manhole	$5200 / EACH	1	$5,200
Manhole Cover	$100 / EACH	1	$100
4" Perforated Tile	$10.50 / LF	600 LF	$6,300
Hole Plug (Vertical Wells)	$15 / EACH	10	$150
4" Ductile Iron Pipe	$27.50 / LF	150 LF	$4,125
4" PVC Pipe	$14.15 / LF	350 LF	$5,000
Gravel for path	$40 / TON	45 tons	$1,800
Grading for gravel	$12 / TON	45 tons	$540
Seeding/Erosion Control	$1,800 / ACRE	2.11 acres	$3,800
Construction Total			$27,015
Land Acquisition	$2,511 / LOT	0.10	$250
25% Contingencies			$6,755
20% Engineering and Admin			$5,400
Total Cost Phase B			**$39,500**

Constructed Wetland

Table 2. Breakdown of constructed wetland costs.

Task	Unit Cost	Quantity	Price
Excavation/Grading	$5.00 / CY	2930 CY	$11,950
Outlet-turf spillway	$12.50 / SF	500 SF	$6,250
Plants	Vary		$2,700
Seeding/Erosion Control	$1,800 / acre	2 acres	$3,600
Bat Houses/Poles	$150 / EACH	2	$300
Construction Total			$24,800
Easements and Property Acquisition	$5,500 / LOT		$3,500
25% Contingencies			$6,200
20% Engineering and Admin			$4,960
Total Cost Phase A			**$39,500**

The bat house was found at Lowe's and the poles were found on Amazon.

All plants are from a local nursery called Ion Exchange Inc. The pricing of the plants can be found in the table below.

Table 3. Breakdown of Plants costs.

Item	Unit Cost	Quantity	Total
Scirpus Pungen	$34.50 / OZ of seeds	10	$345.00
Carex Comosa	$19.75 / OZ of seeds	10	$197.50
Cassia Hebecarpa	$10.00 / OZ of seeds	10	$100.00
Acorus Calamus	$15.50 / OZ of seeds	10	$155.00
Mertensia Viginica	$100.00 / OZ of seeds	10	$1000.00
Lythrum Alatum	$69.50 / OZ of seeds	10	$695.00
Liatris Pycnostachya	$20.50 / OZ of seeds	10	$205.00
Total			**$2,700.00**

Storm Sewer Implementation

Table 4. Breakdown of Storm Sewer Implementation costs.

Task	Unit Cost	Quantity	Price
Manhole Structure	$5,200 / Each	2	$10,400
Manhole Cover	$100 / Each	2	$200
12" Concrete Pipes	$60 / FT	415	$24,900
Backflow Gate	$600/LS	1	$600
Construction Total			$36,100
25% Contingencies			$9,025
20% Engineering and Admin			$7,220
Total Cost Phase C			**$52,400**

<u>Phasing</u>

Our team believes that it would be most beneficial to phase this project as shown below. By phasing the project, it would allow extra time to gain funding and materials for the different portions. This would help relieve the pressure of having different ongoing projects occurring at once. We recommend the wetland enhancement first since it will help with the wetland assessment of the north area. Since the north area was one of the primary concerns, we believe that should be done before the Volga Street redirection. The Volga Street redirection can also be implemented with the bridge project to help cut down on machinery costs.

Table 5. Phasing of project with total cost included.

Phase	Proposed Plan	Total Expected Cost
A	South Wetland	$39,500
B	North Pumping Station	$39,500
C	Volga Street Redirection	$52,400
	Total	$131,500

Appendices

A. Figures
B. Equations and Sample Calculations

Appendix A.

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Table 3

FULL FLOW COEFFICIENT VALUES
CIRCULAR CONCRETE PIPE

D Pipe Diameter (inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3}$			
			n=0.010	n=0.011	n=0.012	n=0.013
8	0.349	0.167	15.8	14.3	13.1	12.1
10	0.545	0.208	28.4	25.8	23.6	21.8
12	0.785	0.250	46.4	42.1	38.6	35.7
15	1.227	0.312	84.1	76.5	70.1	64.7
18	1.767	0.375	137	124	114	105

Figure 21. Table used to size concrete pipes, Concrete Pipe Design Manual

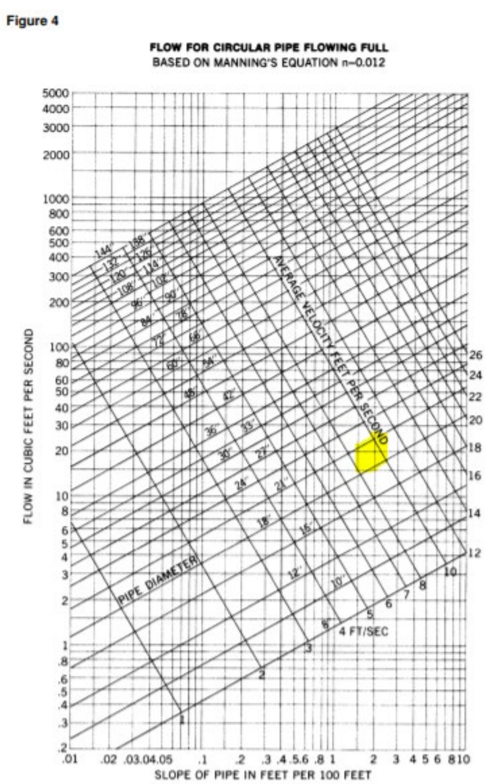

Figure 22. Chart used to double-check pipe sizing requirements,

Concrete Pipe Design Manual

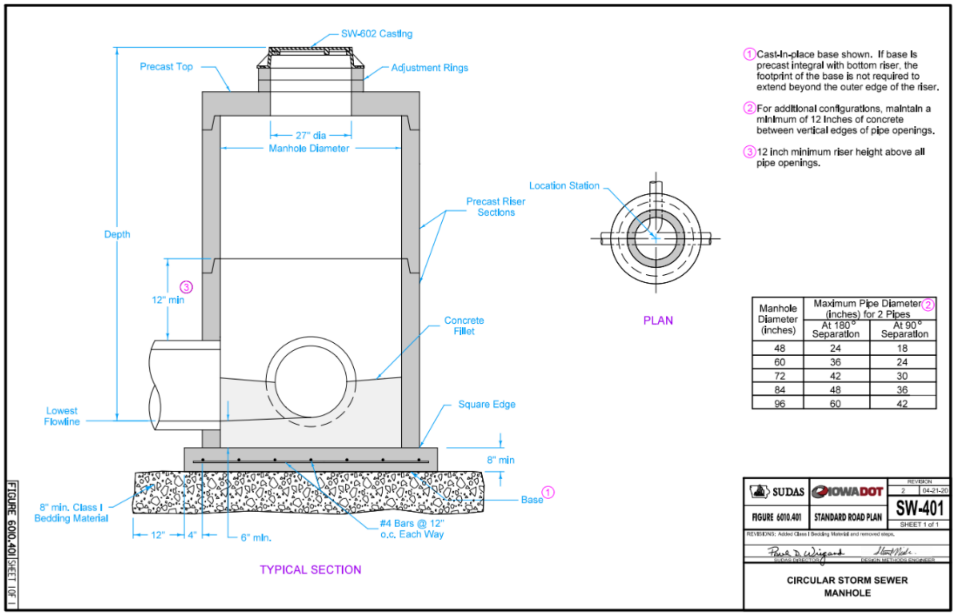

Figure 23. SUDAS SW-401 for manhole design in the north region

Appendix B

- Calculation 1 - Flowrate into the Wetland

$$\frac{4.5\ in}{day} * \frac{ft}{12\ in} * \frac{day}{24\ hours} * \frac{1\ hour}{3600\ s} * 2149857\ ft^2 = 9.4\ cfs$$

- Calculation 2 - Sizing Wetland Basin

  Assumed Precipitation, P = 4.5 in

  Drainage Area = 2149857 ft^2

  $R_v = 0.05 + 0.0009I$

  I = 5%

  $R_v = 0.05 + 0.0009(5) = 0.095$

  $WQ_v = A*P*R_v$

  = (2149857 ft^2)*(4.5 in * ft/12 in) * (0.095)

  = **66,500 ft^3**

- Calculation 3 - Storm sewer slope calculations

  Assumed height of storm structure – 4 ft

Initial elevation of Sewer 1 - 796 ft

Elevation of riverbed (confirmed with other group) - 782 ft

Length of sewer – 412 ft

Inlet elevation = 796 – 4 = 792 ft; Outlet elevation = 782 + 2 = 784 ft

Slope of pipe = 784-792/412 = **-2.0% slope**

- Calculation 4 – Rational Method Equation

  Q = C*i*A

Design Renderings and Models

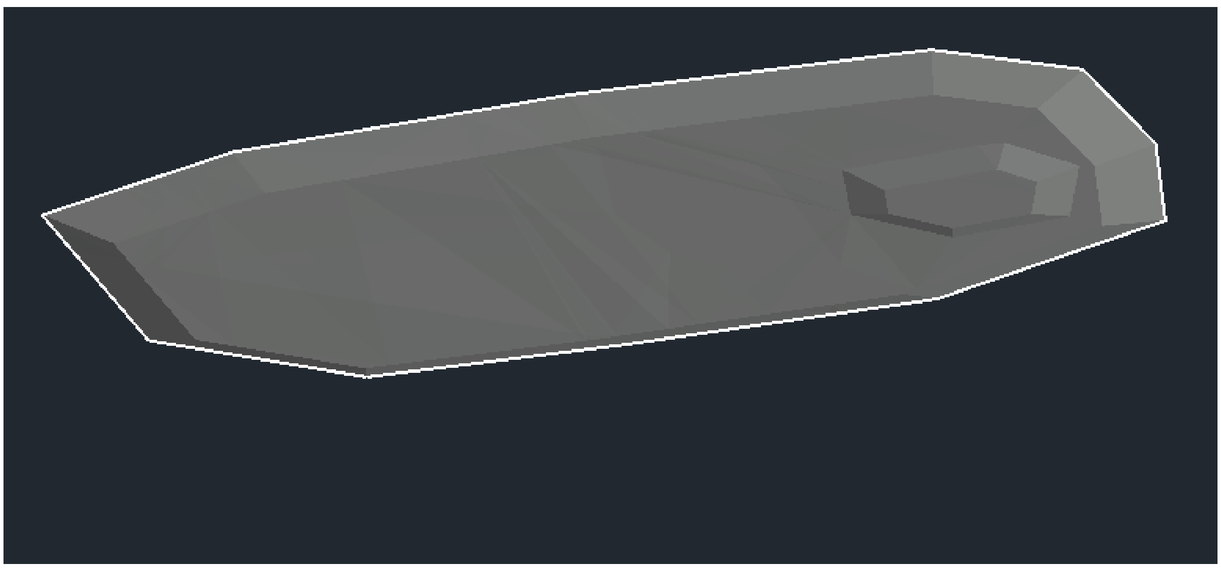

Figure 24. 3D Drawing of basin performed in civil3D.

Figure 25. Side View of basin performed in civil3D.