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FINAL DELIVERABLE

Title	Sustainable Nature Center
Completed By	Han Gao, Xinyu Hu, Logan Kirby, Ruijie Wang
Date Completed	May 2019
UI Department	Department of Civil & Environmental Engineering
Course Name	CEE:4850:0001 Senior Design
Instructor	Paul Hanley, Timothy Mattes
Community Partners	Boone County Conservation Board

This project was supported by the Provost's Office of Outreach and Engagement at the University of Iowa. The Office of Outreach and Engagement partners with rural and urban communities across the state to develop projects that university students and faculty complete through research and coursework. Through supporting these projects, the Office of Outreach and Engagement pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

> [Student names], led by [Professor's name]. [Year]. [Title of report]. Research report produced through the Office of Outreach and Engagement at the University of Iowa.

This publication may be available in alternative formats upon request.

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Sustainable Nature Center

Boone County Conservation Executive Director: Tanner Scheuermann
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HAWK Engineering Company

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<u>Section I</u> Executive Summary

HAWK Engineering has designed nature center as requested by the Boone County Conservation Board. The scope of this project was to complete the preliminary design of a nature center, parking lot, access route, pavement, septic system, and drainage plan. This structure will be utilized as an educational space to learn more about the natural life in the surrounding area. The project location is Madrid, Iowa near the Grant's Woods trailhead.

The nature center was designed as a 60'x90', two-story steel structure, with a curved wall of windows and balcony facing the nearby river. Three exterior finish alternatives were considered: a modern look consisting of many steel elements, a natural look consisting of stone and wood elements, and a combination of the two ideas. It was ultimately decided that the combination would be the best look, and that would consist of some exposed steel elements, with wood paneling and short stone walls around the base of the building. The final exterior design can be seen in figures 1.1 and 1.2 below.

Figure 1.1: Nature Center Back View

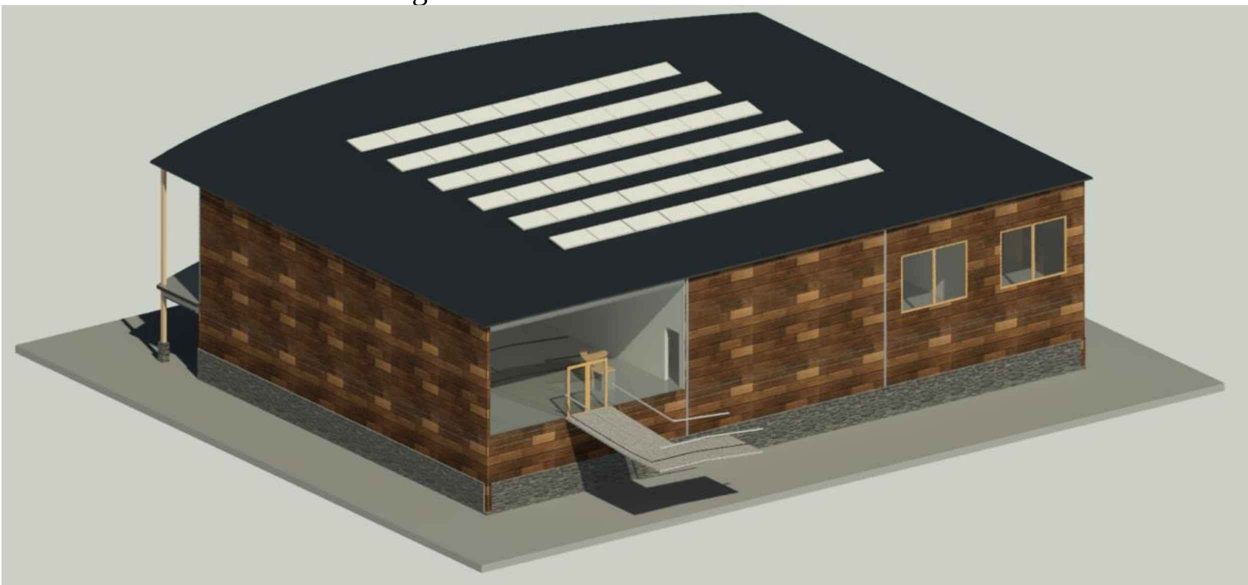

Figure 1.2: Nature Center Front View

The interior of the nature center will have many amenities, including a library, office space, classrooms, interactive display room, kitchen, and an animal display area. There were a few interior design alternatives that we considered during the design process. The first was adding a ramp, or an elevator and stairs. Keeping cost in mind, it was decided to install a ramp instead of the elevator. Another alternative we contemplated was the addition of a raptor rehabilitation center. It was ultimately decided to not include the raptor rehabilitation center as a part of the nature center design, and the space was utilized for the previously mentioned amenities.

The structure of the building was determined to be steel framing with light gauge walls. All steel framing was designed according to the International Building Code (IBC) and American Institute of Steel Construction standards (AISC). The exterior wall panels will consist partially of stone and partially of wood. Large windows were incorporated to the entrance and balcony area to allow for a large amount of natural light. The exterior columns above and below the balcony are to be wood, while the rest of the steel columns will be inside the walls of the building. The wood columns were designed according to National Design Specifications for Wood Construction and IBC standards. Spread footings are to be placed at the base of every column, and were designed using IBC standards.

The access route has a total length of 1410 ft. The access route was designed based on the requirements of Iowa DOT manual. The parking lot design and pavement design were according to the Iowa Statewide Urban Design and Specifications (SUDAS). The preliminary design of the septic system followed the guidance of Iowa Administrative Code (IAC).

The site drainage uses the Rational Method from SUDAS. Based on calculation, the runoff rate slightly increased after construction due to the paved areas of access road, parking lot and building.Vegetative open channels were designed to lead the water in the ditches and parking lot to streams.

Using data from RSMeans, the rough cost estimate for entire project is $1,820,000.00. This includes the cost of the building components, building appliances, siteworks, as well as contractor and architect fee. See table 1.1 below.

Table 1.1: Cost Estimates

	Cost
Building Components	$1,106,000.00
Building Appliances	$45,110.00
Siteworks	$220,625.00
Contractor Fee	$339,582.50
Architect Fee	$108,666.40
Total	$1,820,000.00

<u>Section II</u> Organization Qualifications and Experience

2.1 Name of Organization

HAWK Engineering Company.

2.2 Organization Location and Contact information

Location: Seamans Center, Iowa city, IA, 52240.

Contact: Ruijie Wang / Project Manager

Cell Phone: 224-704-6644

E-mail: ruijie-wang@uiowa.edu

2.3 Organization and Design Team Description

HAWK Engineering Company was established in 2019 to undertake sustainable civil construction projects in the state of Iowa. HAWK Engineering is involved in construction of nature centers, educational buildings, and other civil engineering works related to sustainability in the state of Iowa. Our company is mainly founded by four people. Ruijie Wang, Han Gao, Logan Kirby, and Xinyu Hu. Ruijie Wang is the project manager. Ms. Wang has strong communication skills, and can always build good relationships with clients. Han Gao is the graphics editor. Ms. Gao is proficient in a variety graphic softwares, such as AutoCad, and Civil 3D. Logan Kirby is the text editor. Mr. Kirby has excellent writing skills, and has done a very good job in text revisions. Xinyu Hu is the tech support. Mr. Hu is an expert of using all kinds of softwares related to civil engineering construction works.

<u>Section III</u> Design Services

3.1 Project Scope

The proposed project consists of a sustainable nature center building, a parking lot and an access route located in Grants' Woods Park. The sustainable nature center building is to be a split level building utilizing the natural slope of the site. It is to be environmentally friendly, incorporating environmentally sustainable technologies, such as solar panels. It will contain amenities such as offices, classrooms, interactive displays and a kitchen. There will also be a place to keep live animals, such as fish and reptiles, inside the nature center. A parking lot with 28 parking spots including 2 handicapped spots will be designed next to the building. An access route will connect the parking lot with a nearby local street. Items incorporated with the design of the nature center included but are not limited to access route design, parking lot design, pavement design, drainage design, sustainable nature center building design, septic system design and cost estimates.

3.2 Work Plan

The actual date to start the design was February 2nd, and the end date of this project is May 3rd, which gave us about three months. We divided our task into seven major parts: access route design, nature center building design, parking lot design, drainage design, pavement design, septic system design, and septic system design. Figure 3.2.1 shows the work list while figure 3.2.2 shows the Gantt chart.

Task Name	Start Date	Due Date	Duration
Proposal	1/15	2/1	18
Proposal presentation	1/15	2/1	18
Site visit	1/22	2/1	11
Access route design	2/2	3/1	28
Nature center building layout	2/2	3/1	28
Nature center building design	3/2	4/5	35
Parkinglot design	3/2	3/29	28
Drainage design	3/16	4/3	19
Pavement design	3/23	4/5	14
Septic system design	4/3	4/12	10
Cost estimation and calculation	4/1	4/12	12
Drafts due	2/2	4/12	70
On campus presentation	4/13	4/26	14
Client presentation	4/27	5/3	7
Final due	4/27	5/3	7

Figure 3.2.1 Work Plan list

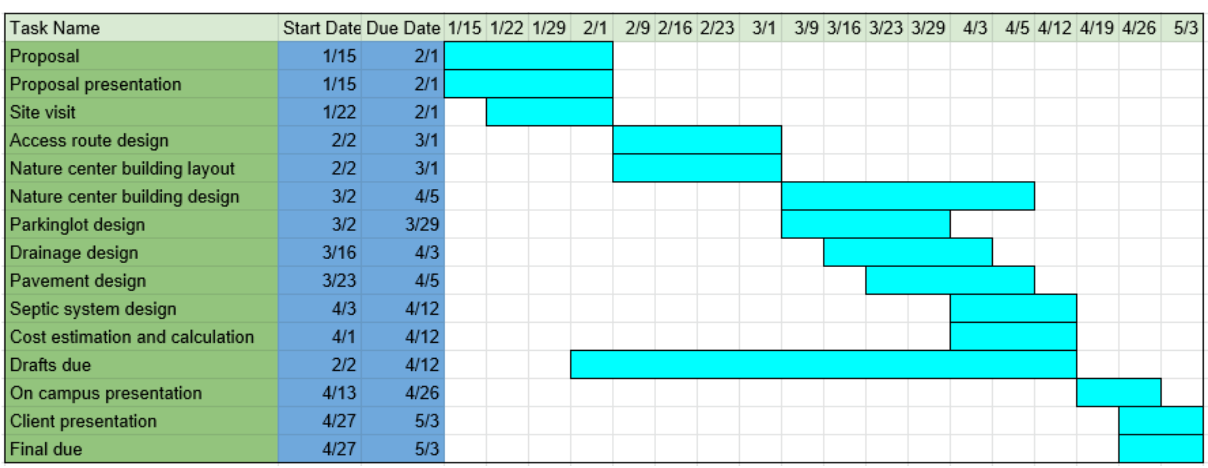

Figure 3.2.2 Gantt Chart

Section IV Constraints, Challenges and Impacts

4.1 Constraints

The restrictions and limitations on the project include budget and time. Both of them play an important role in this project.

Time: Time was a major constraint in this project. There almost no existing facilities in our site, so we needed to design some additional components associated with sustainable nature center building. For example, we needed to design a septic system which required extra time. However, the end date of this project is 5/3/2019, which only gives us 3 months to finish designing the project. After this date, our design team will no longer be spending time on this project.

Budget: No specific budget was given for the project. However, from our understanding the funds are limited, that is a huge constraint for a big project like this. For example, the sustainable nature center building will be a split level which requires a ramp or an elevator. Since we have limited budget, we have to design a ramp which is much more complicated than directly putting an elevator.

4.2 Challenges

The biggest challenge of this project is the location of the building. The building is planned to be designed into the hillside along the Des Moines River. Thus, the building location requires a sturdy foundation, while it needs to be above the floodplain. The knowledge of the site elevations and the contours of the land should be considered during this design process. Since the site has no existing buildings facilities, we need to build access road to the center and parking lot around the center. One challenge we faced was trying to create a floor plan that included all of the clients requests. We had very limited experience in this process, and it required some research to create the floor layout and to size all of the rooms.

The access road connects Qf Lane to the center with different elevation and soil types in the site, so we need to consider cut and fill, soil infiltration rate and so on. Furthermore, since the site has no existing drainage system, rainfall and catchment area analysis are considered in the site. According to the analysis result, corresponding drainage facilities should be displayed in access road and parking lot.

4.3 Social Impacts

Community: Visitors will have the opportunity to learn about nature and the local environment through the library, a variety of animal displays, aquarium tanks, and learning interactive areas. The large windows and the balcony on the upper floor will provide a great view, overlooking the Des Moines River. The large rooms with retractable walls can service various group of people, from classrooms for small learning programs to a big conference room for meetings. These new amenities will draw visitors from all over the state to the beautiful nature center and the scenic trail network. The effects on the nearby communities are limited, parking is designed to limit overflow parking in the neighboring properties. The noise level will be monitored 24/7 to ensure the neighboring properties are not disturbed.

Traffic: An increase in trial use and traffic is expected after the nature center is built. The parking lot and the access road are designed to handle peak tourist seasons, allowing the tourists to travel freely without any restrictions. Additional parking spots are available in nearby trail information center for those peak visiting days.

Environment: After going through many design alternatives, the nature center was designed to minimize the environmental impact of the construction. The building itself equipped many sustainable technologies to reduce environmental impact. Solar panels designed to convert light into electricity more efficiently to cut down costs. Geothermal system was selected for the building to make heating and cooling more efficient and to reduce fossil fuels burning. The drainage system would lead the rainwater through vegetative open channels which would allow it to become naturally filtered before it gets transported to streams.

Economy: The economic growth of Boone county is expected to accelerate due to tourist attractions of the nature center. The large conferences rooms and classrooms, the free public library, and the educational displays provide a seamless working and learning environment. Gaining visitors from tourist and the locals. The public kitchen and the fire pit will encourage the campers to continue staying close in the area, which will also help the economy.

Public: All the new amenities that comes with the nature center are expected to gain interests from the public, which would improve the public perception of Boone County.

<u>Section V</u> Alternative Solutions That Were Considered

5.1: Site Plan Alternatives:

Due to the special location of sustainable nature center building showed in the figure 5.1.1, there are two alternatives of access route along with parking lot.

Figure 5.1.1 Location of Sustainable Nature Center

One alternative is expanding existing "High Trestle Trail Bridge Parking", and connect it with nature center building with a sidewalk. Figure 5.1.2 shows the location of the sidewalk. This sidewalk is on top of a gully, so part of design of the sidewalk which shows as pink will be a bridge. Expanding the parking lot is cheaper than building a new parking lot, but building a sidewalk with a bridge will still cost a lot. Although this long sidewalk will provide a chance for hiking, it's not convenient for handicapped access.

Figure 5.1.2 Site Plan Alternative 1

Another alternative is build a parking lot next to the sustainable nature center building. Then create an access route connect the local street “Qf Ln” and the parking lot. The sustainable nature center building will be connected to the parking lot by a short sidewalk. Figure 5.1.3 shows the configuration of alternative 2. The yellow rectangle represents the parking lot, and blue line represents the access route. This alternative include a longer access route, but it avoids the area where needs to build the bridge. In addition, the parking lot is very close to the sustainable nature center building. It is a great advantage that people don’t have to walk a lot.

Figure 5.1.3 Site Plan Alternative 2

Although both of the site plans have their own advantages and disadvantages, our client has strong preference of the second alternative. Therefore, our design will be based on the site plan alternative 2.

5.2: Nature Center Exterior Alternatives

Our first alternative exterior design option featured a lot of stone and brick elements, with some wood finishes. There would be little to no exposed steel, giving this design a more natural feel. Large windows would be installed in order to ample amounts of sunlight in. Trees and local plants would be planted around the building and walkways as well.

Figure 5.2.1 Nature Center Alternative 1

Our second alternative design option was a very modern look. This design incorporated steel exterior panels with a “cubic” layout, consisting of sharp angles. There would still be some exposed wood, but there would be an emphasis on the steel aspects of the building. This style would involve larger concrete walkways, with less nature surrounding the building.


Figure 5.2.2 Nature Center Alternative 2

The final design alternative was somewhere between the first two options. The exterior was to consist mainly of stone and wood elements with some exposed steel elements to provide a sleek, modern look while not seeming out of place among the surrounding nature. This was the design that our client decided upon.

Figure 5.2.3 Nature Center Alternative 3

Section VI Final Design Details

6.1: Access Route Design

According to Iowa DOT Design manual, Chapter 1C-1, the width of urban two-lane roadways are 12 ft per lane. There are no requirements of ditches and shoulders, but for drainage purposes, the widths of ditches and shoulders will be 3' and 4'. See drawing details from figure 8.4.1 in appendix 8.4. The acceptable design speed is 25 mph. The designed horizontal curve radius is 200', and it satisfies the minimum horizontal curve radius requirement. 6625 cubic yard sandy clay and loam needs to be cut to build the access route. See drawing details from figure 8.4.2 in appendix 8.4.

6.2: Parking lot Design

The size of parking lot is 210' x 100'. To build the parking lot, the net fill will be 108.11 cubic yard. The parking lot is designed based on the guidance of Iowa Statewide Urban Design and Specifications (SUDAS), Section 8B-1. To satisfy the requirement of our client, this parking lot is designed to have 28 parking spots that include 2 accessible spots. According to the "Trash and Recycling Enclosure Design Guide" of the City of Santa Barbara, the size of trash and recycling enclosure will be 123''x158''. We did two vehicle path analyses, one for a garbage truck and one for a school bus. See drawing details from figure 8.4.3 and figure 8.4.4 in appendix 8.4.

6.3: Hydrology Analysis

In order to check the peak rate of runoff, rational method in Iowa Statewide Urban Design and Specifications design manual, Chapter 2: Stormwater, Section 2B-4: Runoff and Peak Flow is used to achieve this goal. After done the rainfall and catchment analysis, there are about eight catchment areas in our site, and each of they has 100 ft of sheet flow and different concentrated flow length.

Table 6.3.1 Q(in cfs) value of different areas before and after construction

	Area 1		Area 2		Area 3		Area 4	
	Before	After	Before	After	Before	After	Before	After
Q_{10}	11.97	12.58	5.37	5.49	3.62	3.62	1.96	2.13
Q_{100}	22.53	23.32	10.05	10.22	6.78	6.78	3.67	3.89
	Area 5		Area 6		Area 7		Area 8	
	Before	After	Before	After	Before	After	Before	After
Q_{10}	7.19	8.83	2.51	2.79	1.66	1.68	14.60	16.17
Q_{100}	13.47	15.62	4.69	5.05	3.12	3.14	27.33	29.39

In the table above, it shows the results of runoff rate in different areas. The soils are in group C before construction, and soils in some paved areas like access road, parking lot, roofs are more likely in soil group D after construction since soil group D has lower filtration rate. The runoff rate didn't change a lot in areas like 2, 4, 7 due to the small pavement areas. The discharge of area 3 didn't change because there is no facilities or constructions in that area. There are relatively increasing in runoff rate in areas 1, 5, 6, 8 since they have larger paved areas, and lower soil filtration rate, therefore, higher runoff rate.

For the drainage of the access road, we plan to build ditches along the access road, on two sides. Based on calculation, the access road will have 56.6 cfs runoff rate, which the water will stay in ditches at about 0.75 ft, while the ditch has 2.5 depth. And two open channels (one to the north and one to the south) will be built to lead the water in ditches into the streams. The little gap in the open channel is due to the new road construction, which didn't shown on the satellite map of Civil 3D, but shown on the Google map. The drainage of parking lot will drain from west to east while using an open channel to lead the runoff to the stream. We decide to use vegetative open channel due to the low cost, stabilization of channel body and soil bed, and inhibition of erosion on channel surface. We design the channel in a trapezoidal shape with 19 feet top width, 3 feet bottom width, and 2 feet depth. The channel has 4:1 side slope, with n value of 0.05 for vegetal lining. The calculation is done by the Civil3D and a table showing open channel parameters is created (Refer to Table 8.2.1). Runoff calculation parameter in trapezoidal channel). Considering the worst case of recurrence interval equal to 100 year and the highest value of Q equal to 29.39

cfs in area 8, we decided to use Q equal to 31.77 cfs as the criteria. The depth of water is about 1.2 ft which is less than the design height of 2 feet, and the runoff velocity is about 2.17 ft/s. We plan to use Kentucky bluegrass on the two sides of the trapezoidal grass channel, which has a permissible velocity of 4.5 ft/s according to the table 3-3 Maximum Allowable Design Velocities for Vegetated Channels, Chapter 3 open channel hydraulics, Charlotte-Mecklenburg storm water design manual. With the grass permissible velocity of 4.5 ft/s, it should be feasible for the calculated runoff velocity of 3.39 ft/s. For the erosion protection, we will put gravel on the bottom to decrease erosion and maintenance. See drawing details of site drainage from figure 8.4.2 in appendix 8.4. See drawing details of detention basin design profile from figure 8.4.5 in appendix 8.4.

6.4: Pavement Design

For the pavement design, we had two alternatives. One is hot mixed asphalt (HMA) and another one is portland concrete cement (PCC). See details in appendix 8.2. Since we have limited budget, we decided to use asphalt pavement instead of concrete. For the access route, according to SUDAS Section 5F-1, the thickness of granular base is 6’’ and the thickness of subbase is 8’’. For the parking lot, we selected 6’’ HMA on 12’’ of prepared subgrade with 4’’ granular subbase from Table 8B-1.03 of SUDAS. See drawing details from figure 8.4.2 in appendix 8.4.

6.5: Preliminary Septic System Design

Based on the description of the client, we assume 2 staffs will work in the sustainable nature center building and 100 visitors will come. We did our preliminary septic system design by following the guidance of Septic System Design Iowa Chapter 69 (IAC Chapter 69). We will use gravel septic system. The calculated septic tank volume is 6108 gallons. For safety consideration, we will use 6500 gallons HS-20 Low-Boy septic tank from Phoenix Precast Products. See drawing details from figure 8.4.6 in appendix 8.4. There will be 7 trenches, and each trench has a length of 100 ft, a width of 3 ft and a depth of 18 inches. The separation distance between trenches is 6 ft. The leach field length will be 100 ft, and the width will be 63 ft. Distribution pipes will be PVC rigid plastic with inside diameter equals to 4 inches. See calculation details in appendix 8.2.

6.6: Model Design

The structure was the biggest challenge when designing the nature center. The goal was to provide a unique building, while keeping the cost of construction lower. The building was designed according to IBC, AISC, ACI and NDS standards.

The size and appearance of the building were discussed in a meeting with our client, the Boone County Conservation Board. Using Revit as our modeling software, we were able to generate a model and work with our client to create a design that met their expectations. The exterior walls consist of a layer of stone/brick, and wood paneling for the rest of the exterior walls. Large windows were incorporated at the balcony and by the main entrance. Appendix 8.5 shows the final model of the nature center.

6.7: Structural Design

Our design team determined the building framing would be composed mainly of steel, including steel beams and columns and light gauge framing. The main non-steel component was the exterior wood columns. All steel beam and column design was completed adhering to IBC and AISC standards. ASCE 7-16 was used to determine the building loading. Members were designed to have a design/capacity ratio (DCR) of between 0.85-1.05, to be conservative. Some beams were over designed (DCR > 1.05) in order to maintain a similar depth for ease of constructability.

Autodesk Robot Structural Analysis was used to determine the bending and shear stresses experienced by the beams, girders, and columns of the nature center. We then compared these stresses to the allowable stresses, which were calculated using information from the AISC Steel Construction Manual. Beams were designed to have similar depths and were designed to allow for adequate space in the ceiling to allow space for mechanical and electrical elements. The design process included ensuring the beams exceeded flexural and shear stress requirements, while staying within the deflection limits stated in the IBC.
All columns were designed for axial compression and any bending stresses caused by the wind loading.

Foundations were designed using the applied loads found using Autodesk Robot. ACI and IBC standards for foundations were followed when sizing the foundations. A bearing capacity of 1,500 psf was used in the design process, as a conservative value. They were placed at a depth of 4’ in order to avoid frost heave, and are to have a stem of 4 feet so the steel columns aren’t exposed to the soil. Any reinforcing in the foundations was designed according to ACI 314-18.

6.8: Floor Plan Design

The floor plan was designed to contain all the amenities requested by the client. The top floor consisted of the library, a display area, information center, offices, and bathrooms. The entrance utilized a two door system that allows access to the bathrooms after closing hours. The interior doors can be locked, only allowing access to the bathrooms. The exterior doors are able to be locked as well. Large windows were utilized to allow for large amounts of natural light.

The bottom floor contained the interactive display area for visitors, as well as a storage room, kitchen, bathrooms, and a large event room. The large event room will have movable divider walls in order to create smaller rooms for classes or meetings. When the walls are removed, it becomes a space for large events. The interactive display area contains a wall with aquariums and display tanks built into the wall. The room behind this wall will be a small storage room that also allows private access to the tanks.

<u>Section VII</u> Engineer's Cost Estimate

Table 7.1: Cost estimates

COST ESTIMATE FOR THE NATURE CENTER				
Building Components				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
1 1/2" Metal Roof Deck 2	5400.00	SF	$5.41	$29,214.00
ASPHALT SHINGLES ROOF COVERINGS	5400.00	SF	$2.89	$15,606.00
3" LW Concrete on 3" Metal Deck	10800.00	SF	$5.24	$56,592.00
WALL FINISHES	7155.00	SF	$3.49	$24,970.95
INTERIOR WALLS 4.5"	424.00	FT	$3.79	$1,606.96
FLOOR FINISHES	10800.00	SF	$7.73	$83,484.00
ASHLAR VENEER EXTERIOR WALL	1188.00	SF	$34.55	$41,045.40
WOOD SIDING EXTERIOR WALL	5967.00	SF	$8.88	$52,986.96
PARAPET WALL, 12" THICK PLAIN FINSIH	1510.00	SF	$22.15	$33,446.50
W SHAPES-COLUMN W8X10	587.50	FT	$12.21	$7,173.38
TIMBER-COLUMN 6X6	162.00	FT	$10.59	$1,715.58
CONCRETE-RECTANGULAR-COLUMN 12X12	31.50	FT	$5.53	$174.20
TIMBER-BEAM 8X8	93.00	FT	$15.51	$1,442.43
W SHAPES-BEAM W12X26	3094.90	FT	$14.23	$44,040.43
STANDARD FOUNDATIONS	5400.00	SF	$1.78	$9,612.00
BASEMENT WALLS 4' FOUNDATION	300.00	LF	$5.41	$1,623.00
BASEMENT EXCAVATION	5400.00	SF	$0.29	$1,566.00
WINDOWS	2160.00	SF	$20.17	$43,567.20
PLUMBING FIXTURES	43.00	EA	$15.87	$682.41
DOMESTIC WATER DISTRIBUTION	10800.00	SF	$8.00	$86,400.00
TERMINAL & PACKAGE UNITS	10800.00	SF	$28.00	$302,400.00
FIRE PROTECTION SPRINKLERS	10800.00	SF	$5.47	$59,076.00
FIRE PROTECTION STANDPIPES	10800.00	SF	$1.71	$18,468.00
400 AMPERE SERVICE, PANEL BOARD AND FEEDERS	10800.00	SF	$3.31	$35,748.00
LIGHTING & BRANCH WIRING	10800.00	SF	$8.22	$88,776.00
ALARM SYSTEMS AND EMERGENCY	10800.00	SF	$1.91	$20,628.00
EMERGENCY GENERATOR, 11.5 KW	10800.00	SF	$0.23	$2,484.00
TOILET PARTITIONS, CUNICLES,	6.00	EA	$2.46	$14.73
LAVATORY SYSTEM	4.00	EA	$1,200.00	$4,800.00
DOUBLE GLASS DOORS 12'X7'	3.00	EA	$12,150.00	$36,450.00
SINGLE LEAF WOOD INTERIOR DOORS	4.00	EA	$4.23	$16.92
			Subtotal	$1,105,811.04

Building Appliances				
SOLAR PANELS	2000.00	SF	$3.53	$7,060.00
ANIMAL GLASS DISPLAY	4.00	EA	$305.00	$1,220.00
BOOK SHELF	4.00	EA	$224.95	$899.80
CHAIR	50.00	EA	$17.00	$850.00
COUCH	8.00	EA	$455.00	$3,640.00
WELCOME DESK	1.00	EA	$156.00	$156.00
FIREPLACE	2.00	EA	$3,350.00	$6,700.00
OFFICE TABLES	10.00	EA	$113.00	$1,130.00
AQUARIUM DISPLAY TANK	1.00	EA	$5,000.00	$5,000.00
LIGHTS	50.00	EA	$186.00	$9,300.00
COOKING RANGE, 1 OVEN	1.00	EA	$595.00	$595.00
DISHWASHER, BUILT-IN 2 CYCLES	1.00	EA	$510.00	$510.00
MICROWAVE OVEN	1.00	EA	$275.00	$275.00
GARBAGE DISPOSER, SINK TYPE	1.00	EA	$174.00	$174.00
REFRIGERATOR	1.00	EA	$600.00	$600.00
BOOKS	100.00	EA	$40.00	$4,000.00
INTERACTIVE SCREEN	3.00	EA	$1,000.00	$3,000.00
			Subtotal	$45,109.80
Siteworks				
EXCAVATION CHANNEL	1807.57	CY	$6.00	$10,845.42
GRAVEL	5121.99	SF	$1.00	$5,121.99
KENTUCKY BLUEGRASS SOD	28157.29	SF	$0.50	$14,078.64
EXCAVATION FOR ACCESS ROUTE	6625.01	BCY	$3.25	$21,531.28
FILL FOR PARKING LOT	108.11	LCY	$2.33	$251.90
6" HMA PAVEMENT FOR ACCESS ROUTE	1226.70	TON	$75.00	$92,002.50
6" HMA PAVEMENT FOR PARKING LOT	761.25	TON	$75.00	$57,093.75
6500 GALLON SEPTIC TANK	1.00	EA	$8,790.00	$8,790.00
EXCAVATION FOR DRAIN FIELD	149.00	BCY	$3.25	$484.25
PVC RIGID PLASTIC PIPE	7.00	EA	$60.72	$425.04
INSTALLATION FEE	1.00	EA	$10,000.00	$10,000.00
			Subtotal	$220,624.77
Contractor Fee				
			Subtotal	$339,582.50
Architect Fee				
			Subtotal	$108,666.40
			TOTAL	$1,819,794.51

Including the building construction, site construction, contractor feed, and architect feed. The total cost of this project was estimated to be approximately 1.8 million dollars. Our estimates were done by utilizing RSmeans Cost Handbook, a standard estimation book for building and site constructions. The quantities of different components were first taken down and recorded. Then to find the component cost, the unit prices for each component were found. Finally, all estimates were categorized by major components and presented in the table above.

<u>Section VIII</u> Appendices

8.1 Specifications and Standards Reference

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8.2 Calculations

Calculations for pavement:

- **For access route:**

Calculation for AADT:

Assume there will be 25 passenger cars go to sustainable nature center per day. Assume design life are 20 years. Assume truck percentage will be 1%, because there will be school bus and garbage truck. Therefore AADT is about 26.

According to SUDAS, Section 5F-1:

PAVEMENT MANAGEMENT E.S.A.L. CALULATIONS

Project No. 170-2999

PROJECT DESCRIPTION: Reconstruction of Elm Street

VEHICLE TYPES	PERCENTAGES	CURRENT TRAFFIC	GROWTH FACTORS	DESIGN TRAFFIC	E.S.A.L. FACTOR	DESIGN E.S.A.L.
MOTORCYCLES	0.000	0	26.87	0	0.0001	0
PASSENGER CARS	99.000	13	26.87	126225	0.0020	252
FOUR TIRE	0.000	0	26.87	0	0.0389	0
HEAVY VEHICLES	1.000					
BUSES	0.000	0	26.87	0	0.4111	0
SINGLE UNITS						
SIX TIRE TRUCKS	0.000	0	26.87	0	0.2004	0
THREE AXLE TRUCKS	0.000	0	26.87	0	1.1384	0
FOUR AXLE TRUCKS	0.000	0	26.87	0	3.4784	0
SINGLE-TRAILER TRUCKS						
FOUR OR LESS AXLES	0.000	0	26.87	0	0.8005	0
FIVE AXLES	0.000	0	26.87	0	1.3377	0
SIX OR MORE AXLES	0.000	0	26.87	0	1.2303	0
MULTI-TRAILER TRUCKS						
FIVE OR LESS AXLES	0.000	0	26.87	0	3.0655	0
SIX AXLES	0.000	0	26.87	0	2.1102	0
SEVEN OR MORE AXLES	0.000	0	26.87	0	2.1102	0
UNCLASSIFIED	0.000	0	26.87	0	1.4500	0
SUM OF ALL TYPES	100.000	13				252 ESALs

	Annual G.Rate in %	Life (yrs)	Growth Factor
AVERAGE DAILY TRAFFIC	26		
LANE DISTRIBUTION	100		
GROWTH RATE OF CARS	3.0	20	26.87
GROWTH RATE OF TRUCKS	3.0	20	26.87

G.F. = ((1+g)^n - 1) / g

Figure 8.2.1: Calculation for EASL

The EASL number is too small, so we selected our pavement based on the minimum EASL number 300,000. For Iowa soil type, CBR = 3.

For Iowa soil type, use CBR = 3. Use 6" subbase.

From SUDAS Table 5F-1.13, for rigid PCC pavement:

Table 5F-1.13: Recommended Thickness for Rigid Pavement - *Local Roads*

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
300,000	7*	6*	6*	6*	6*	6*	7*	6*	6*	6*	6*	6*
500,000	7*	6*	6*	6*	6*	6*	7*	6*	6*	6*	6*	6*
750,000	7*	6	6	6*	6*	6*	7*	6*	6*	6*	6*	6*
1,000,000	7	6	6	6	6	6	7	6	6*	6*	6*	6*
1,500,000	7.5	6.5	6.5	6.5	6.5	6.5	7.5	6.5	6	6	6	6
2,000,000	8	7	7	7	7	7	7.5	6.5	6.5	6.5	6.5	6.5
3,000,000	8	7.5	7.5	7.5	7.5	7.5	8	7	7	7	7	7

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Select CBR = 3, EASL = 300,000, 8" Granular subbase, pavement thickness is 6''.

From SUDAS Table 5F-1.16, for flexible HMA pavement:

Table 5F-1.16: Recommended Thickness for Flexible Pavement - *Local Roads*

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
300,000	8.5	7	6.5	6*	6*	6*	8*	6	6*	6*	6*	6*
500,000	9.5	8	7	6.5	6*	6*	8	6.5	6*	6*	6*	6*
750,000	10	8.5	7.5	7	6	6*	8.5	7	6	6*	6*	6*
1,000,000	10	8.5	8	7.5	6.5	6	8.5	7	6.5	6*	6*	6*
1,500,000	11	9.5	8.5	8	7	6.5	9	7.5	7	6	6*	6*
2,000,000	11	9.5	9	8.5	7.5	7	9.5	8	7.5	6.5	6	6*
3,000,000	12	10.5	9.5	9	8	7.5	10	8.5	8	7	6.5	6*

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Select CBR = 3, EASL = 300,000, 8" Granular subbase, pavement thickness is 6''.

- **For parking lot:**

Table 8B-1.03: Pavement Thickness for Light Loads
(Parking lots with 200 or less cars/day and/or 2 or less trucks/day or equivalent axle loads)

Subgrade CBR	Surface Material	On 12"of Prepared Subgrade		On 12" of Prepared Subgrade with 4" Granular Subbase	
		Minimum	*Desirable*	*Minimum*	*Desirable*
9	Rigid	5"	6"	4"	5"
	Flexible	5"	6"	4"	5"
6	Rigid	5"	6"	4"	5"
	Flexible	5"	6"	4"	5"
3	Rigid	5"	6"	4"	5"
	Flexible	6"	6"	5"	5"

From SUDAS Table 8B-1.03:
Subgrade CBR = 3, both rigid and flexible minimum pavements are 5'' on 12'' of prepared subgrade with 4'' granular subbase. According to our site condition, 6'' thickness flexible HMA pavement will be used.

Calculation for septic system:

- **For septic tank:**

Based on the description of the client, we assume there will be 2 staffs work in the sustainable nature center building and 100 visitors will come. According to Septic System Design Iowa Chapter 69 (IAC Chapter 69):

Appendix A
Estimates of Nonhousehold Domestic Sewage Flow Rates

Source of use for sewage unit	(units)	Gallons per day per unit
Commercial/Industrial		
Retail stores	(Per square foot of sales area)	0.15
or	(Each customer)	5
	(Plus each employee)	15
or	(Each toilet room)	630
Offices	(Each employee)	18
or	(Per square foot)	0.25
Medical offices	(Per square foot)	1.6
Industrial buildings	(Each employee)	20
	(Does not include process ware or cafeteria)	
Construction camp	(Each employee)	20
Visitor center	(Each visitor)	20

Each employee will produce 18 gallons sewage per day and each visitor will produce 20 gallons sewage per day. Therefore, the predicted total sewage Qin is 2x18+20x1000=2036 gallons. Typical retention time for a septic tank is3 days. Since the tank volume equals to retention time multiplied by total sewage, the tank volume will be 3x2036 = 6108 gallons. Rounding up, 6500 gallons septic tank from the manufacturer will be our best choice. This tank volume is greater than 2 times the daily flow which satisfies the requirement from the Septic System Design Iowa Chapter 69.

- **For leach field:**

From USGS soil web survey, we found that the hydrologic soil group of our site soil was C/D.

Table C5-S1- 1: Hydrologic soil properties classified by soil texture

Soil texture class	Hydrologic soil group	Effective water capacity (C_w) (in/in)	Minimum infiltration rate (f) (in/hr)	Effective porosity, θe (in^3/in^3)
Sand	A	0.35	8.27	0.025 (0.022-0.029)
Loamy sand	A	0.31	2.41	0.024 (0.020-0.029)
Sandy loam	B	0.25	1.02	0.025 (0.017-0.033)
Loam	B	0.19	0.52**	0.026 (0.020-0.033)
Silt loam	C	0.17	0.27	0.300 (0.024-0.035)
Sandy clay loam	C	0.14	0.17	0.020 (0.014-0.026)
Clay loam	D	0.14	0.09	0.019 (0.017-0.031)
Silty clay loam	D	0.11	0.06	0.026 (0.021-0.032)
Sandy clay	D	0.09	0.05	0.200 (0.013-0.027)
Silty clay	D	0.09	0.04	0.026 (0.020-0.031)
Clay	D	0.08	0.02	0.023 (0.016-0.031)

**Minimum rate: soils with lower rates should not be considered for infiltration BMPs

Source: Rawls et al., 1982

From the Iowa Storm Water Management Manual (SWMM Chapter 5, Table C5-S1-1), the infiltration rate for "Clay loam" is 0.09 in/hr.
According to IAC Chapter 69:

Table IIIb

Maximum Soil Loading Rates Based Upon Soil Evaluations in Gallons per Square Foot per Day ($gal/ft^2/day$) for Septic Tank Effluent. Values in ( ) are for secondary treated effluent.

Soil Texture	Single Grain	Massive	Structure Granular, Blocky, or Prismatic			Platy	
			Weak	Moderate	Strong	Weak	Moderate to Strong
Coarse sand and gravel	1.2 (1.6)	X	1.2 (1.6)	X	X	1.2 (1.6)	X
Medium sands	0.7 (1.4)	X	0.7 (1.4)	X	X	0.7 (1.4)	X
Fine sands	0.5 (0.9)	X	0.5 (0.9)	X	X	0.5 (0.9)	X
Very fine sands*	0.3 (0.5)	X	0.3 (0.5)	X	X	0.3 (0.5)	X
Sandy loam	X	0.3 (0.5)	0.45 (0.7)	0.6 (1.1)	0.65 (1.2)	0.4 (0.6)	0.3 (0.5)
Loam	X	0.4 (0.6)	0.45 (0.7)	0.5 (0.8)	0.55 (0.8)	0.4 (0.6)	0.3 (0.5)
Silty loam	X	NS	0.4 (0.6)	0.5 (0.8)	0.5 (0.8)	0.3 (0.5)	0.2 (0.3)
Clay loam	X	NS	0.2 (0.3)	0.45 (0.7)	0.45 (0.7)	0.1 (0.2)	0.1 (0.2)
Silty clay loam	X	NS	0.2 (0.3)	0.45 (0.7)	0.45 (0.7)	NS	NS

For “Clay loam” and “Granular” soil, the maximum soil loading rates (Hi) is 0.45 gallons/ft^2/day.
The required area for leachate field is: Ai = Qin/Hi = 4525 square ft

Table VI-4. Linear Loading Rates Based on Limiting Conditions

Limiting Condition	Linear Loading Rate Range (gpd/linear ft) Conservative Value	Space-Limited Value
Solid bedrock	3	4
Impermeable soil layer	3	4
Seasonal high water table	3	4
Semi-permeable soil layer	5	6
Fractured compacted till	5	6
Creviced or fractured bedrock	8	10
Sand and/or gravel layer	8	10

From Table VI-4, got the linear Loading rates = 3 gallons/day/linear foot.

The width of trench can be calculated from equation: $W_T = 1.5 + LL_r / H_l$
The total width of each trench is 9ft.
According to IAC Chapter 69 - 69.9(3).b): the maximum length of trench is 100 ft. Therefore, the length of trenches are 100 ft and the number of trenches are 7. The leach field width is 63 ft and leach field length is 100 ft.

The layout of the septic system on site plan followed the Table I of IAC Chapter 69: 69.3(2):

Table I

Minimum Distance in Feet From	Closed Portion of Treatment System(1)	Open Portion of Treatment System(2)
Private water supply well	50	100
Public water supply well	200	200
Groundwater heat pump borehole	50	100
Lake or reservoir	50	100
Stream or pond	25	25
Edge of drainage ditch	10	10
Dwelling or other structure	10	10
Property lines (unless a mutual easement is signed and recorded)	10	10
Other type of subsurface treatment system	5	10
Water lines continually under pressure	10	10
Suction water lines	50	100
Foundation drains or subsurface tiles	10	10

(1) Includes septic tanks, aerobic treatment units, fully contained media filters and impervious vault toilets.
(2) Includes subsurface absorption systems, mound systems, intermittent sand filters, constructed wetlands, open bottom media filters and waste stabilization ponds.

According to IAC Chapter 69 - 69.8(1).d): The minimum liquid holding depth shall be 40 inches.
According to IAC Chapter 69 - 69.8(1).e): The maximum liquid holding depth should not exceed 6.5 feet. Therefore, the depth of the septic tank will be 5 feet.

According to IAC Chapter 69 - 69.9(3).a): Soil absorption trenches shall not exceed 36 inches depth. A shallower trench bottom depth of 18 to 24 inches is recommended. Therefore, the depth of 18 inches of trenches will be selected.

According to IAC Chapter 69 - 69.9(3).c): The separation distance of each trench is at least 6 ft. From IAC Chapter 69 - 69.9(4).b): For gravel systems, the minimum width of trench is 24 inches, and the maximum width of trench is 36 inches. Therefore, for our septic system, each trench has a width of 36 inches = 3 ft and the separation distance between trenches is 6 ft.

According to IAC Chapter 69 - 69.9(4).d): Distribution pipes should be PVC rigid plastic with inside diameter equal to or larger than 4 inches. The perforations are at least 0.5 inch and no larger than 0.75 inch. The spaces between perforations are no more than 40 inches.

Calculation for drainage and channels:

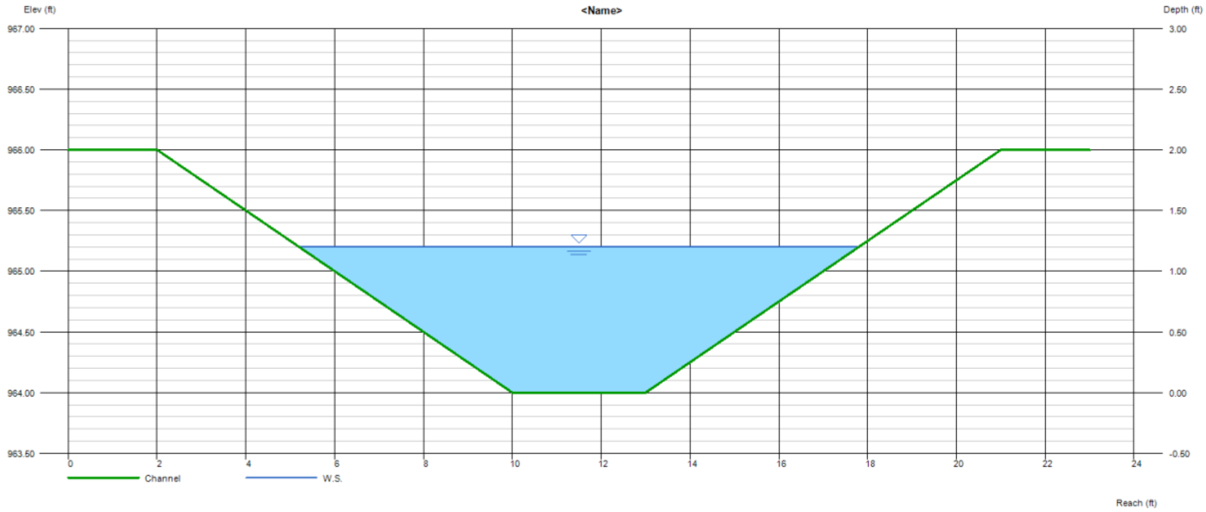


Figure 8.2.2: Trapezoidal open channel

Table 8.2.1. Runoff calculation parameter in trapezoidal channel

Depth	Q	Area	Veloc	Wp	Yc	TopWidth	Energy
(ft)	(cfs)	(sqft)	(ft/s)	(ft)	(ft)	(ft)	(ft)
0.2	0.954	0.76	1.26	4.65	0.14	4.6	0.22
0.4	3.403	1.84	1.85	6.3	0.3	6.2	0.45
0.6	7.485	3.24	2.31	7.95	0.47	7.8	0.68
0.8	13.42	4.96	2.71	9.6	0.65	9.4	0.91
1	21.44	7	3.06	11.25	0.83	11	1.15
1.2	31.77	9.36	3.39	12.9	1.01	12.6	1.38
1.4	44.61	12.04	3.71	14.54	1.19	14.2	1.61
1.6	60.17	15.04	4	16.19	1.38	15.8	1.85
1.8	78.65	18.36	4.28	17.84	1.56	17.4	2.09
2	100.2	22	4.56	19.49	1.75	19	2.32

- **For runoff calculation:**

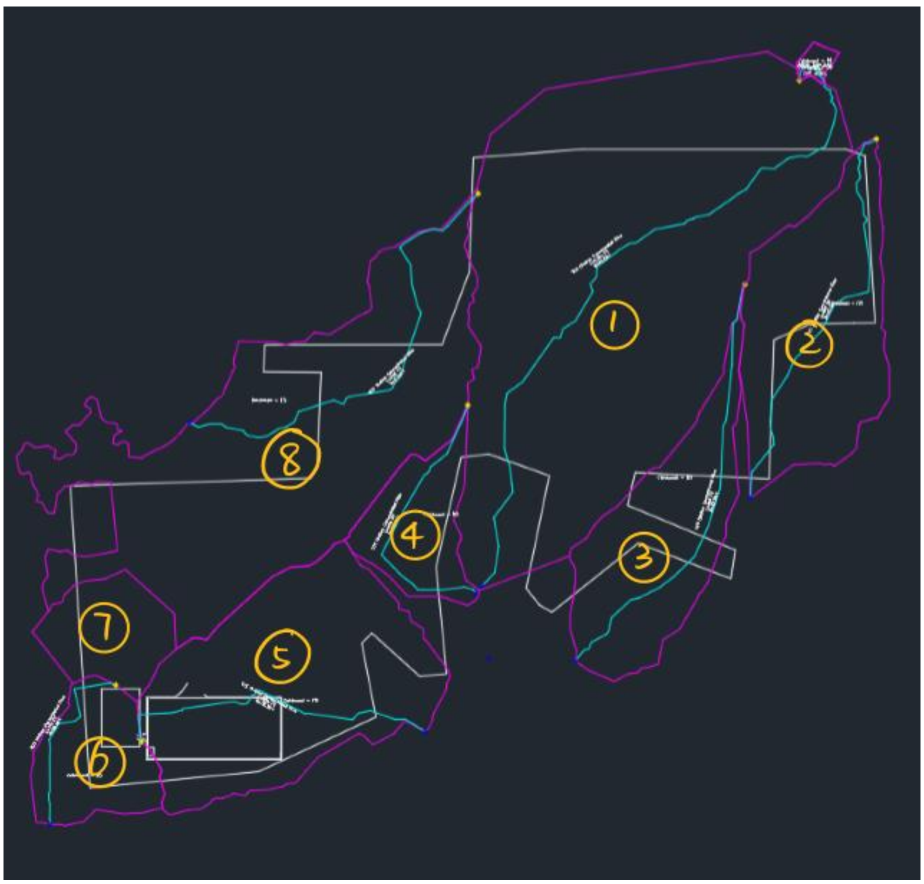


Figure 8.2.3 Eight catchment areas

According to the SUDAS, Chapter 2: Stormwater, Section 2B-3: Time of Concentration, C.NRCS Velocity Method, 1. Sheet Flow, equation 2B-3.03

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5}S^{0.4}}$$

where:

T_t = travel time, h
n = Manning's roughness coefficient (Table 2B-3.01)
ℓ = sheet flow length, ft
P_2 = 2 year, 24 hour rainfall, in
S = slope of land surface, ft/ft

We assume 100 feet sheet flow for every catchment area. The Manning's roughness coefficient is from the same chapter and section above. Considering the condition before construction, we assume the site is range(natural) with n value equal to 0.13.

Table 2B-3.01: Manning's Roughness Coefficient for Sheet Flow

Surface Description	***n***
Smooth Surface (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated Soils:	
Residue cover $\leq$ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[1]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[2]	
Light underbrush	0.40
Dense underbrush	0.80

[1] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[2] When selecting n, consider cover to a height of about 0.1 foot. This is the only part of the plant cover that will obstruct sheet flow.

For the rainfall intensity, the data was found on the National Oceanic and Atmospheric Administration (NOAA), Precipitation Frequency Data Server(PFDS), Iowa State, Boone Station,

Table 8.2.2: Rainfall intensity(in/hr) in Boone Station

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**4.73** (3.82-6.01)	**5.54** (4.48-7.06)	**6.96** (5.59-8.87)	**8.20** (6.54-10.5)	**9.98** (7.75-13.2)	**11.4** (8.66-15.2)	**13.0** (9.48-17.5)	**14.6** (10.2-20.1)	**16.8** (11.3-23.6)	**18.6** (12.2-26.3)
10-min	**3.46** (2.80-4.40)	**4.06** (3.28-5.17)	**5.09** (4.09-6.49)	**6.00** (4.79-7.66)	**7.31** (5.68-9.64)	**8.38** (6.34-11.1)	**9.50** (6.94-12.8)	**10.7** (7.48-14.7)	**12.3** (8.30-17.3)	**13.6** (8.92-19.3)
15-min	**2.82** (2.27-3.58)	**3.30** (2.66-4.20)	**4.14** (3.33-5.28)	**4.88** (3.90-6.23)	**5.94** (4.61-7.84)	**6.82** (5.16-9.05)	**7.73** (5.64-10.4)	**8.69** (6.08-12.0)	**10.0** (6.75-14.1)	**11.1** (7.25-15.7)
30-min	**2.01** (1.62-2.55)	**2.36** (1.90-3.00)	**2.97** (2.39-3.79)	**3.51** (2.80-4.48)	**4.29** (3.33-5.65)	**4.93** (3.73-6.54)	**5.59** (4.09-7.55)	**6.30** (4.41-8.67)	**7.29** (4.90-10.2)	**8.07** (5.27-11.4)
60-min	**1.30** (1.05-1.65)	**1.54** (1.24-1.95)	**1.95** (1.57-2.49)	**2.33** (1.86-2.97)	**2.87** (2.24-3.80)	**3.33** (2.52-4.43)	**3.81** (2.78-5.15)	**4.32** (3.03-5.96)	**5.04** (3.40-7.08)	**5.62** (3.67-7.93)
2-hr	**0.796** (0.650-0.996)	**0.946** (0.771-1.19)	**1.21** (0.984-1.52)	**1.45** (1.17-1.82)	**1.80** (1.42-2.35)	**2.10** (1.61-2.76)	**2.41** (1.79-3.22)	**2.75** (1.95-3.74)	**3.22** (2.20-4.47)	**3.60** (2.39-5.02)
3-hr	**0.586** (0.482-0.728)	**0.698** (0.573-0.867)	**0.897** (0.735-1.12)	**1.08** (0.877-1.35)	**1.35** (1.07-1.75)	**1.58** (1.22-2.06)	**1.82** (1.36-2.41)	**2.08** (1.49-2.81)	**2.45** (1.69-3.37)	**2.75** (1.84-3.80)
6-hr	**0.345** (0.287-0.422)	**0.408** (0.339-0.500)	**0.522** (0.433-0.640)	**0.626** (0.516-0.770)	**0.783** (0.631-1.00)	**0.915** (0.718-1.18)	**1.06** (0.802-1.38)	**1.21** (0.882-1.61)	**1.43** (1.00-1.94)	**1.61** (1.09-2.19)
12-hr	**0.196** (0.165-0.236)	**0.231** (0.195-0.279)	**0.293** (0.246-0.355)	**0.349** (0.291-0.422)	**0.429** (0.349-0.538)	**0.496** (0.393-0.626)	**0.566** (0.434-0.727)	**0.640** (0.473-0.839)	**0.745** (0.529-0.994)	**0.828** (0.572-1.11)
24-hr	**0.114** (0.097-0.135)	**0.131** (0.112-0.156)	**0.161** (0.137-0.192)	**0.189** (0.159-0.225)	**0.229** (0.189-0.284)	**0.263** (0.212-0.328)	**0.300** (0.234-0.380)	**0.338** (0.254-0.437)	**0.393** (0.284-0.518)	**0.437** (0.307-0.579)
2-day	**0.065** (0.056-0.076)	**0.074** (0.064-0.087)	**0.090** (0.078-0.106)	**0.105** (0.090-0.123)	**0.127** (0.106-0.154)	**0.144** (0.118-0.177)	**0.163** (0.129-0.203)	**0.183** (0.139-0.233)	**0.212** (0.155-0.274)	**0.234** (0.167-0.306)
3-day	**0.047** (0.041-0.054)	**0.054** (0.047-0.062)	**0.066** (0.057-0.076)	**0.076** (0.066-0.089)	**0.092** (0.077-0.110)	**0.104** (0.086-0.127)	**0.118** (0.094-0.146)	**0.132** (0.102-0.167)	**0.153** (0.113-0.196)	**0.169** (0.122-0.218)
4-day	**0.038** (0.033-0.043)	**0.043** (0.038-0.050)	**0.053** (0.046-0.061)	**0.061** (0.053-0.071)	**0.074** (0.062-0.088)	**0.084** (0.069-0.101)	**0.095** (0.076-0.116)	**0.106** (0.082-0.133)	**0.122** (0.091-0.156)	**0.135** (0.098-0.174)
7-day	**0.025** (0.022-0.029)	**0.029** (0.026-0.033)	**0.035** (0.031-0.040)	**0.041** (0.036-0.047)	**0.049** (0.042-0.058)	**0.055** (0.046-0.066)	**0.062** (0.051-0.076)	**0.070** (0.055-0.086)	**0.080** (0.061-0.101)	**0.088** (0.065-0.112)
10-day	**0.020** (0.018-0.023)	**0.023** (0.021-0.026)	**0.028** (0.025-0.032)	**0.032** (0.028-0.036)	**0.038** (0.033-0.045)	**0.043** (0.036-0.051)	**0.048** (0.040-0.058)	**0.054** (0.043-0.066)	**0.062** (0.047-0.077)	**0.068** (0.050-0.085)
20-day	**0.014** (0.013-0.015)	**0.016** (0.014-0.017)	**0.019** (0.017-0.021)	**0.021** (0.019-0.024)	**0.025** (0.022-0.028)	**0.028** (0.024-0.032)	**0.031** (0.025-0.036)	**0.034** (0.027-0.041)	**0.038** (0.029-0.047)	**0.041** (0.031-0.051)
30-day	**0.011** (0.010-0.012)	**0.013** (0.012-0.014)	**0.015** (0.014-0.017)	**0.017** (0.015-0.019)	**0.020** (0.017-0.022)	**0.022** (0.019-0.025)	**0.024** (0.020-0.028)	**0.026** (0.021-0.031)	**0.029** (0.023-0.035)	**0.031** (0.024-0.039)
45-day	**0.009** (0.009-0.010)	**0.011** (0.010-0.011)	**0.012** (0.011-0.014)	**0.014** (0.013-0.015)	**0.016** (0.014-0.018)	**0.018** (0.015-0.020)	**0.019** (0.016-0.022)	**0.021** (0.017-0.024)	**0.023** (0.018-0.027)	**0.024** (0.019-0.030)
60-day	**0.008** (0.008-0.009)	**0.009** (0.008-0.010)	**0.011** (0.010-0.012)	**0.012** (0.011-0.013)	**0.014** (0.012-0.015)	**0.015** (0.013-0.017)	**0.016** (0.014-0.019)	**0.018** (0.014-0.021)	**0.019** (0.015-0.023)	**0.020** (0.016-0.025)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

According to the SUDAS, Chapter 2: Stormwater, Section 2B-3: Time of Concentration, C.NRCS Velocity Method,equation 2B-3.01

$$T_t = \frac{\ell}{3{,}600V}$$

where:

T_t = travel time, hours
ℓ = flow length, ft
V = average velocity, ft/s
3,600 = conversion factor, seconds to hours

The equation represents the shallow concentrated flow, In the Civil 3D, the catchment area analysis will automatically calculated the flow length in each area. (The blue line in Figure 8.2.3). For average velocity, according to the table
2B-3.02, the site is assumed to be short grass prairie. So n = 0.073, V = 6.962(s)^0.5.

Table 2B-3.02: Equations and Assumptions Developed from Figure 2B-3.01

Flow Type	**Depth (feet)**	**Manning's n**	**Velocity Equation (ft/s)**
Pavement and small upland gullies	0.2	0.025	$V = 20.238(s)^{0.5}$
Grassed waterways (and unpaved urban areas)	0.4	0.050	$V = 16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans	0.2	0.051	$V = 9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V = 8.762(s)^{0.5}$
Short-grass prairie	0.2	0.073	$V = 6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V = 5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V = 2.516(s)^{0.5}$

The time of concentration equal to the sum of travel times of each flow segments. Based on SUDAS, Chapter 2: Stormwater, Section 2B-3: Time of Concentration, C.NRCS Velocity Method,equation 2B-3.02, the total time should be the sum of sheet flow and shallow concentrated flow in each catchment area. The open channel flow is not considered in the situation because there is no available existing channels in the site. And the time of concentration remains the same before and after the construction.

$$T_c = T_s + T_c + T_o$$

where:

T_c = time of concentration, hours
T_s = travel time for sheet flow, hours
T_c = travel time of shallow concentrated flow, hours
T_o = travel time for open channel flow, hours

Table 8.2.3: Time of concentration in each area

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8
Tsheet flow (hr)	0.125	0.13	0.128	0.12	0.123	0.093	0.186	0.083
Tconc. Flow (hr)	0.319	0.172	0.154	0.121	0.128	0.055	0.128	0.162
Ttotal (hr)	0.444	0.302	0.282	0.241	0.251	0.148	0.314	0.245
Ttotal (min)	26.64	18.12	16.92	14.46	15.06	8.88	18.84	14.7
T assumed (min)	30	15	15	15	15	10	15	15

Before construction:

According to the SUDAS, Chapter 2: Stormwater, Section 2B-4: Runoff and Peak Flow, B.Rational Method, equation 2B-4.01.

$$Q_T = Ci_TA \qquad \textbf{Equation 2B-4.01}$$

where:

Q_T = estimate of the peak rate of runoff (cfs) for some recurrence interval, T
C = runoff coefficient; fraction of runoff, expressed as a dimensionless decimal fraction, that appears as surface runoff from the contributing drainage area.
i_T = average rainfall intensity (in/hr) for some recurrence interval, T, during that period of time equal to the T_c.
A = the contributing drainage area (acres) to the point of design that produces the maximum peak rate of runoff.
T_c = Time of concentration, minutes.

Runoff coefficient is determined from table 2B-4.01: Runoff Coefficients for the Rational Method. Before construction, the site is assumed to be open space with fair condition (grass over 50% to 75%). Runoff coefficient equal to 0.55 and 0.65 in recurrence interval of 10 and 100 years. Rain intensity value refers to the Table 8.2.2, with assumed time in Table 8.2.3. The area of each catchment is determined through Civil 3D.

Table 2B-4.01: Runoff Coefficients for the Rational Method

Cover Type and Hydrologic Condition		Runoff Coefficients for Hydrologic Soil Group											
		A			*B*			*C*			*D*		
	Recurrence Interval	*5*	*10*	*100*	*5*	*10*	*100*	*5*	*10*	*100*	*5*	*10*	*100*
Open Space (lawns, parks, golf courses, cemeteries, etc.)													
Poor condition (grass cover < 50%)		.25	.30	.50	.45	.55	.65	.65	.70	.80	.70	.75	.85
Fair condition (grass cover 50% to 75%)		.10	.10	.15	.25	.30	.50	.45	.55	.65	.60	.65	.75
Good condition (grass cover >75%)		.05	.05	.10	.15	.20	.35	.35	.40	.55	.50	.55	.65
Impervious Areas													
Parking lots, roofs, driveways, etc. (excluding ROW)		.95	.95	.98	.95	.95	.98	.95	.95	.98	.95	.95	.98
Streets and roads:													
Paved; curbs & storm sewers (excluding ROW)		.95	.95	.98	.95	.95	.98	.95	.95	.98	.95	.95	.98
Paved; open ditches (including ROW)		---	---	---	.70	.75	.85	.80	.85	.90	.80	.85	.90
Gravel (including ROW)		---	---	---	.60	.65	.75	.70	.75	.85	.75	.80	.85
Dirt (including ROW)		---	---	---	.55	.60	.70	.65	.70	.80	.70	.75	.85
Urban Districts (excluding ROW)													
Commercial and business (85% impervious)		---	---	---	---	---	---	.85	.85	.90	.90	.90	.95
Industrial (72% impervious)		---	---	---	---	---	---	.80	.80	.85	.80	.85	.90
Residential Districts by Average Lot Size (excluding ROW)[1]													
1/8 acre (36% impervious)		---	---	---	---	---	---	.55	.60	.70	.65	.70	.75
1/4 acre (36% impervious)		---	---	---	---	---	---	.55	.60	.70	.65	.70	.75
1/3 acre (33% impervious)		---	---	---	---	---	---	.55	.60	.70	.65	.70	.75
1/2 acre (20% impervious)		---	---	---	---	---	---	.45	.50	.65	.60	.65	.70
1 acre (11% impervious)		---	---	---	---	---	---	.40	.45	.60	.55	.60	.65
2 acres (11% impervious)		---	---	---	---	---	---	.40	.45	.60	.55	.60	.65
Newly Graded Areas (pervious areas only, no vegetation)													
Agricultural and Undeveloped													
Meadow - protected from grazing (pre-settlement)		.10	.10	.25	.10	.15	.30	.30	.35	.55	.45	.50	.65
Straight Row Crops													
Straight Row (SR)	*Poor Condition*	.33	.39	.55	.52	.58	.71	.70	.74	.84	.78	.81	.89
	Good Condition	.24	.30	.46	.45	.51	.66	.62	.67	.78	.73	.76	.86
SR + Crop Residue (CR)	*Poor Condition*	.31	.37	.54	.50	.56	.70	.67	.72	.82	.75	.79	.87
	Good Condition	.19	.25	.41	.38	.45	.61	.55	.60	.73	.62	.67	.78
Contoured (C)..............................	*Poor Condition*	.29	.35	.52	.47	.53	.70	.60	.65	.77	.70	.74	.84
	Good Condition	.21	.26	.43	.38	.45	.61	.55	.60	.73	.65	.69	.80
C+CR..	*Poor Condition*	.27	.33	.50	.45	.51	.66	.57	.63	.75	.67	.72	.82
	Good Condition	.19	.25	.41	.36	.43	.59	.52	.58	.71	.62	.67	.78
Contoured & Terraced (C&T)	*Poor Condition*	.22	.28	.45	.36	.43	.59	.50	.56	.70	.55	.60	.73
	Good Condition	.16	.22	.38	.31	.37	.54	.45	.51	.66	.52	.58	.71
C&T + CR	*Poor Condition*	.13	.19	.35	.31	.37	.54	.45	.51	.66	.52	.58	.71
	Good Condition	.10	.16	.32	.27	.33	.50	.43	.49	.65	.50	.56	.70

[1] The average percent impervious area shown was used to develop composite coefficients.

Note: Rational coefficients were derived from SCS CN method

After construction:

We still use the rational method, and assume the catchment areas remain constant so we can calculate the change of runoff rate in these areas. Due to the constant areas, the time of concentration and rainfall intensity remain the same in each area. The only variable is the runoff coefficient. In paved areas like access road, parking lot, or roofs, the soil is more likely to be hydrologic soil group D since group D has lower infiltration rate. Furthermore, the runoff coefficient in these areas is calculated by combining the C in paved areas and C in grass areas. Sample calculation of combined runoff coefficient in area 1 is shown below:

$$C = \frac{(0.578 * 0.85) + (5.622 * 0.55)}{6.2} = 0.578$$

$$C = \frac{(0.578 * 0.9) + (5.622 * 0.65)}{6.2} = 0.673$$

Surface	Area(acres)	10 year	100 year
Access road	0.578	0.85	0.9
Lawn (fair condition)	5.622	0.55	0.65
Total/Composite	6.2	0.578	0.673

When recurrence interval = 10:
C = 0.578
i= 3.51 in/hour
Q = CiA = 12.58 cfs

recurrence interval = 100:
C = 0.673
i= 5.59 in/hour
Q = CiA = 23.32 cfs

Table 8.2.4 Runoff Coefficient values before and after construction

	Area 1		Area 2		Area 3		Area 4	
	Before	After	Before	After	Before	After	Before	After
C_{10}	0.55	0.578	0.55	0.563	0.55	0.55	0.55	0.598
C_{100}	0.65	0.673	0.65	0.661	0.65	0.65	0.65	0.69
	Area 5		**Area 6**		**Area 7**		**Area 8**	
	Before	After	Before	After	Before	After	Before	After
C_{10}	0.55	0.675	0.55	0.611	0.55	0.556	0.55	0.609
C_{100}	0.65	0.754	0.65	0.7	0.65	0.655	0.65	0.699

Table 8.2.5 Rainfall intensity(in/hr) before and after construction

I (in/hr)	Area 1		Area 2		Area 3		Area 4	
Irecur interval	Before	After	Before	After	Before	After	Before	After
I_{10}	3.51	3.51	4.88	4.88	4.88	4.88	4.88	4.88
I_{100}	5.59	5.59	7.73	7.73	7.73	7.73	7.73	7.73
	Area 5		Area 6		Area 7		Area 8	
	Before	After	Before	After	Before	After	Before	After
I_{10}	4.88	4.88	6	6	4.88	4.88	4.88	4.88
I_{100}	7.73	7.73	9.5	9.5	7.73	7.73	7.73	7.73

Therefore, the final result of runoff rate in eight catchment areas before and after construction is shown in the table below:

Table 8.2.6 Q(in cfs) value of different areas before and after construction

	Area 1		Area 2		Area 3		Area 4	
	Before	After	Before	After	Before	After	Before	After
Q_{10}	11.97	12.58	5.37	5.49	3.62	3.62	1.96	2.13
Q_{100}	22.53	23.32	10.05	10.22	6.78	6.78	3.67	3.89
	Area 5		Area 6		Area 7		Area 8	
	Before	After	Before	After	Before	After	Before	After
Q_{10}	7.19	8.83	2.51	2.79	1.66	1.68	14.60	16.17
Q_{100}	13.47	15.62	4.69	5.05	3.12	3.14	27.33	29.39

For the detention basin:
I followed the example on the SUDAS, Chapter 2: Stormwater, 2G Detention Practices, D. Detention Basin Design Methods.

5 year and 100 year:

- Area 5 = 2.68 acres
- Soil Group D
- C = 0.45 for Q5 pre-developed condition
- C = 0.75 after construction
- Tc = 15 min
- I = 4.14 in/hr

Qa = CIA = 0.45 * 4.14 * 2.68 = 4.99 cfs

Table 8.2.7 Storage volume for 5 year and 100 year

Duration(hr)	Q_{100} Intensity(in/hr)	Q_{100} Inflow(cfs)	Q_{100} Volume(cubic feet)	Release Vol. Q_5 (cubic feet)	Storage(Cubic feet)
0.25	7.73	15.537	13984	4491	9493
0.5	5.59	11.236	20225	8982	11243
1	3.81	7.658	27569	17964	9605
2	2.41	4.844	34878	35928	0
3	1.82	3.658	39509	53892	0
6	1.06	2.131	46021	107784	0

We need use the duration of 0.5 hour since it has the largest storage volume of 11243 cubic feet, about 11250 cubic feet.

2 year and 100 year:

- Area 5 = 2.68 acres
- Soil Group D
- C = 0.45 for Q5 pre-developed condition
- C = 0.75 after construction
- Tc = 15 min
- I = 3.3 in/hr

Qa = CIA = 0.45 * 3.3 * 2.68 = 3.98 cfs

Table 8.2.8 Storage volume for 2 year and 100 year

Duration(hr)	Q_{100} Intensity(in/hr)	Q_{100} Inflow(cfs)	Q_{100} Volume(cubic feet)	Release Vol. Q_5 (cubic feet)	Storage(Cubic feet)
0.25	7.73	15.537	13984	3582	10402
0.5	5.59	11.236	20225	7164	13061
1	3.81	7.658	27569	14328	13241
2	2.41	4.844	34878	28656	6222
3	1.82	3.658	39509	42984	0
6	1.06	2.131	46021	85968	0

Based on 2 year and 100 year analysis, the highest storage volume is 13241 cubic feet. And this number will be used to calculate the outlet pipe size. Assume it tooks 24 hour to drain away the water in the basin.

13241/(24*60*60) = 0.153 cfs

The pipe diameter is 12 inch, and the water velocity is 0.19 feet per second.

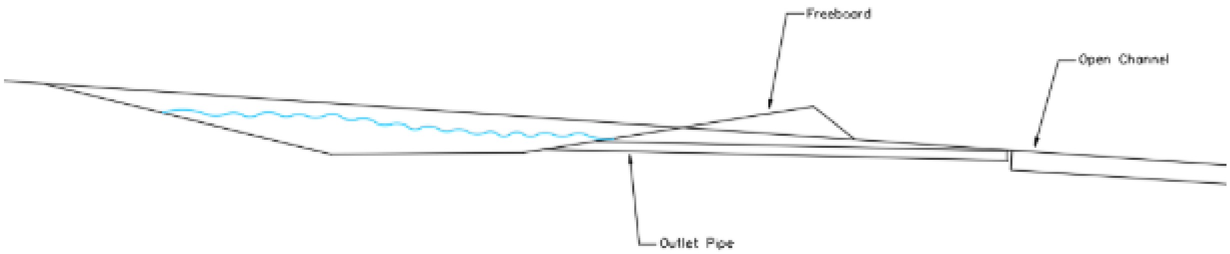


Figure 8.2.4 detention basin

In the figure shown above, the ground has a slope about 4%. The depth of the basin is 5 feet, and the right side has 2 feet freeboard. An outlet discharge pipe with diameter of 12 inch is design to drain the water slowly and constantly in 24 hours. The pipe is connect to the open channel, which will lead the water to the stream in the south.

8.3 Cost Estimation Details

For access route:

The net cut is 6625.01 cubic yard for Sandy clay & loam. For parking lot: the net fill 108.11 cubic yard. Access route length is 1410 ft and the width of this two lane road is 24 ft. The pavement area for access route is 33840 sq ft. The depth of HMA is 0.5', so the volume for HMA is 16920 cubic ft. Density of asphalt is 145 pounds per cubic foot. The weight of total HMA for access route pavement is 1226.7 tons.

For parking lot:

The parking lot size is 210' x 100'. Therefore, the pavement area for parking lot is 21000 cubic ft. The depth of HMA is 0.5', so the volume for HMA is 10500 cubic ft. Density of asphalt is 145 pounds per cubic foot. The weight of total HMA for parking lot pavement is 761.25 tons.

For septic system:

The length of leach field is 100 ft, and each trench has a width of 3 ft. There will be seven trenches in total. The depth of each trench is 18 inches. Therefore, the volume of soil that needs to be cut is 100 ft* 3 ft * 18/12 ft *7 = 3150 cubic feet.
The excavation of septic tank is about 6500 gallons (869 cubic feet). Therefore, for entire septic system, total excavation will be 4019 cubic feet (149 cubic yard).
The septic tank is $8790 plus delivery fee.
Each 100 ft long PVC rigid plastic pipe with 4 inches diameter from "The Home Depot" is $60.72. There will be 7 pipes in total.

From HomeAdvisor website, the installation cost of septic tank has a typical range from $3065-$9087. Since our septic tank is very large, we assumed the installation fee will be around $10,000.

	quantity	Unit	Labor	Equpment	Total	Totap include O&P
excavation for access route	6625.01	BCY	9142.513	7088.7607	16231.2745	$21,531.28
fill for parking lot	108.11	LCY	52.75768	111.56952	164.3272	$201.52
6'' HMA pavement for access route	1226.7	ton			75	$92,002.50
6'' HMA pavement for parking lot	761.25	ton			75	$57,093.75
excavation for leach field	149	BCY	205.62	159.43	365.05	$484.25
PVC rigid plastic pipe	7	each				$425.04
Septic tank	1	each				$8,790.00
Installation fee	1	each				$10,000.00
					Total	$190,528.34

For open channel:

The total volume of open channel is 22*1707.33 = 37561.26 cubic feet, about 1391.16 cubic yard. The total volume of detention basin is 11250 cubic feet which is 416.5 cubic yard. Unit price data from the IOWA DOT, OFFICE OF CONTRACTS, bid tabulations, 2019 Bid Tabs, 2/19/19 file.

According to the home advisor website, the gravel's average cost per 100 square feet (including labor) is about $100. Considering the bottom width is 3 feet and the total length of channel is 1707.33 feet, so the total area is 5121.99 square feet. 5121.99/100 *100 = $5121.99.

Based on improbenet website, the average price for Kentucky bluegrass sod is about $0.5 per square feet. The grass is planted on both sided areas of the open channel. The side of trapezoidal channel is 8.246 feet. 8.246*1707.33*2*0.5 = $14078.64.

8.4 Design Drawings

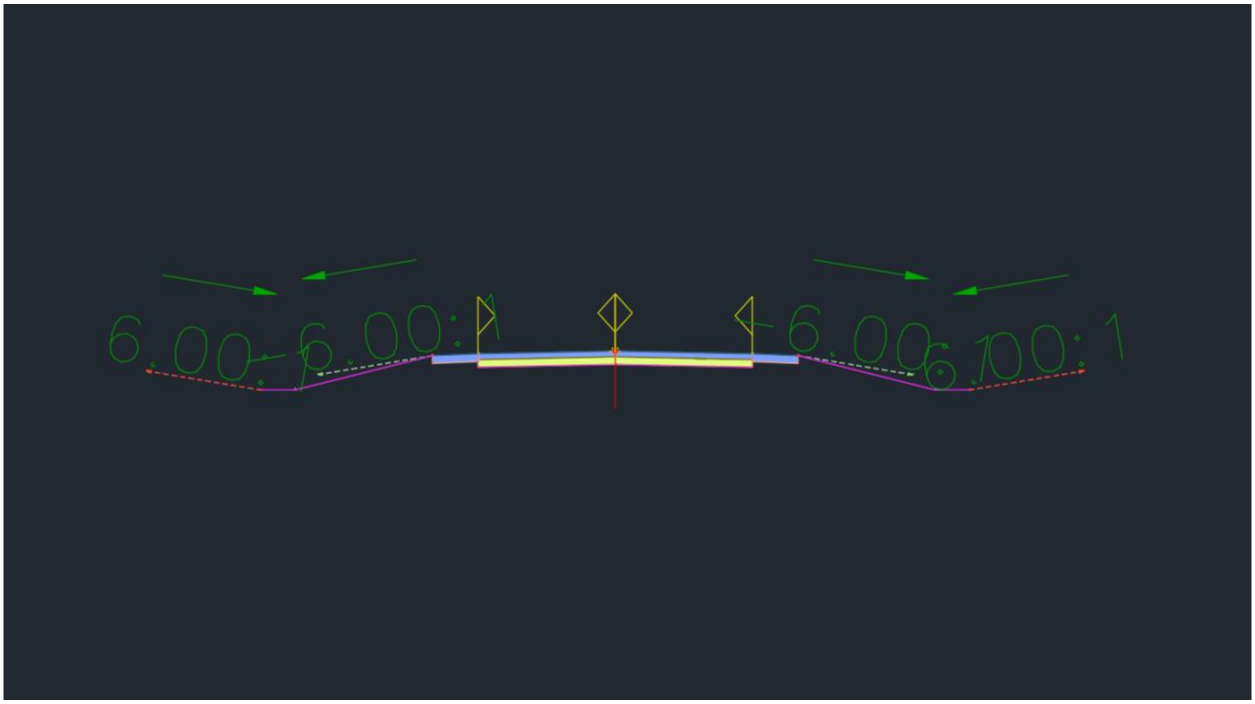


Figure 8.4.1: Road Assembly

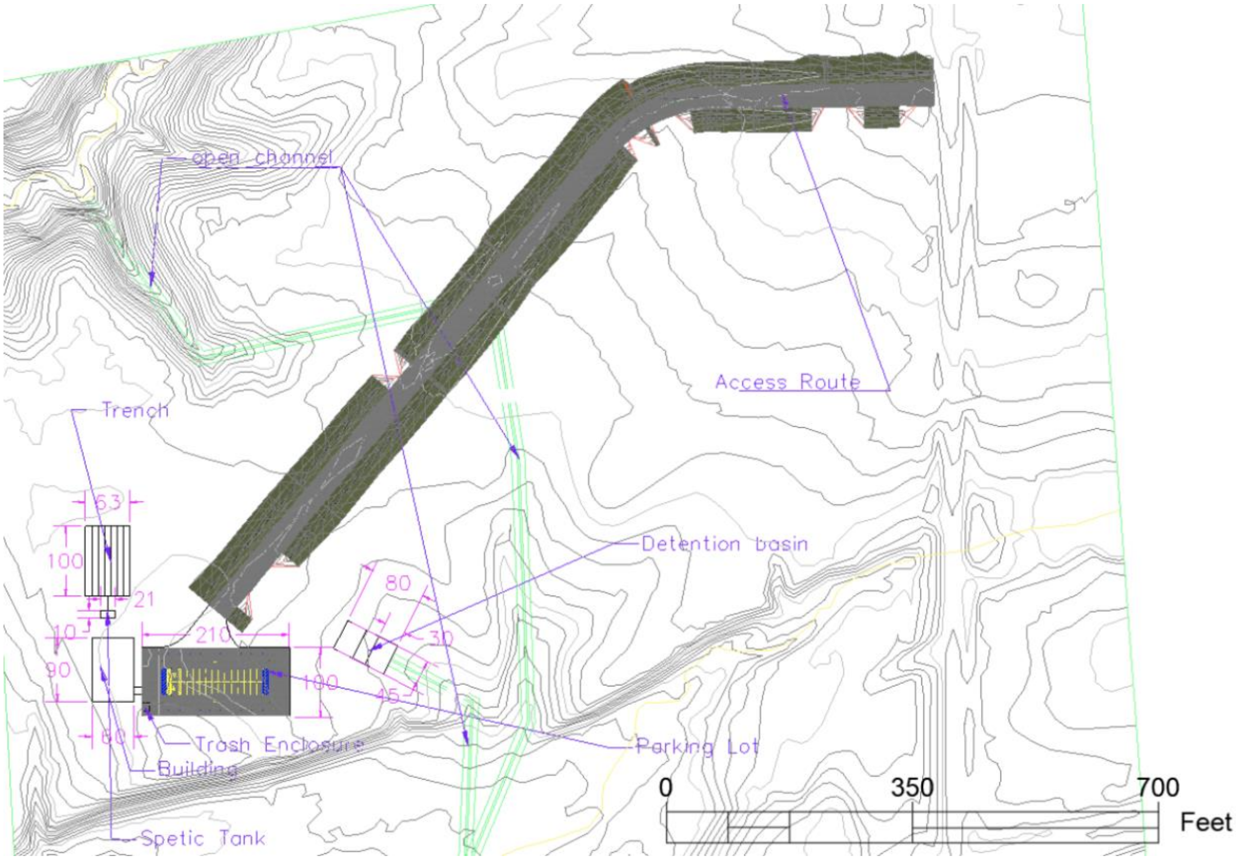


Figure 8.4.2: Site Plan

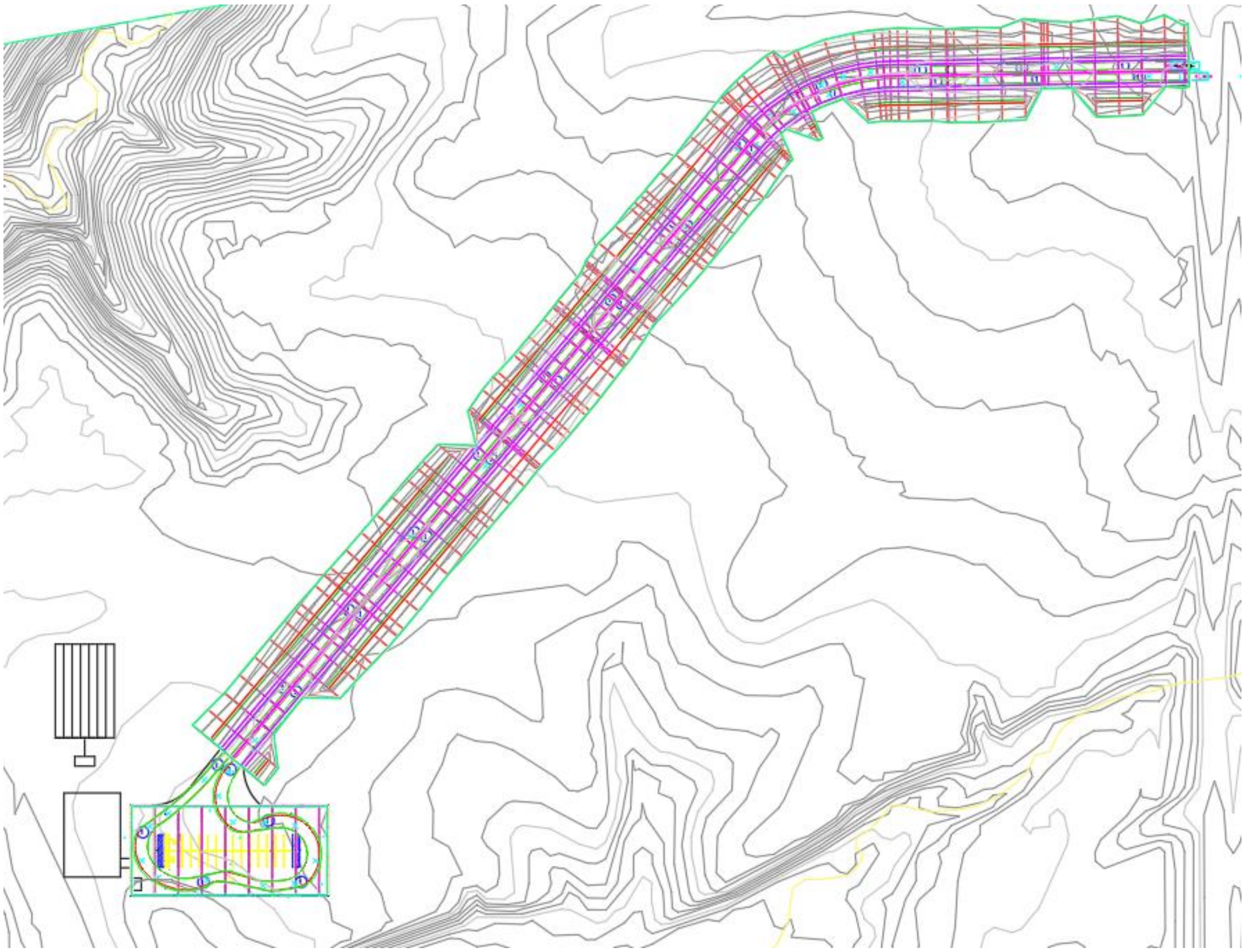


Figure 8.4.3: Swept Analysis for Garbage Truck

Figure 8.4.4: Swept Analysis for School Bus

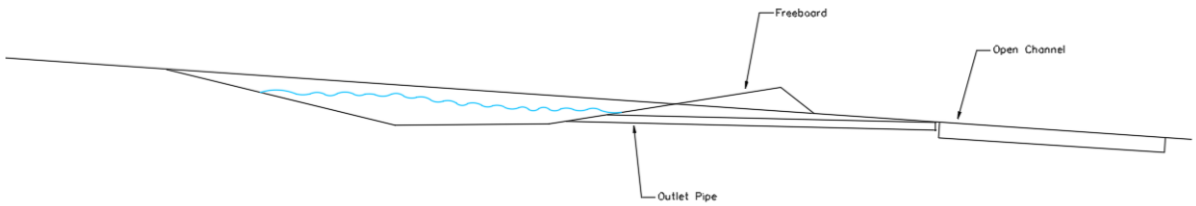


Figure 8.4.5: Detention Basin Design

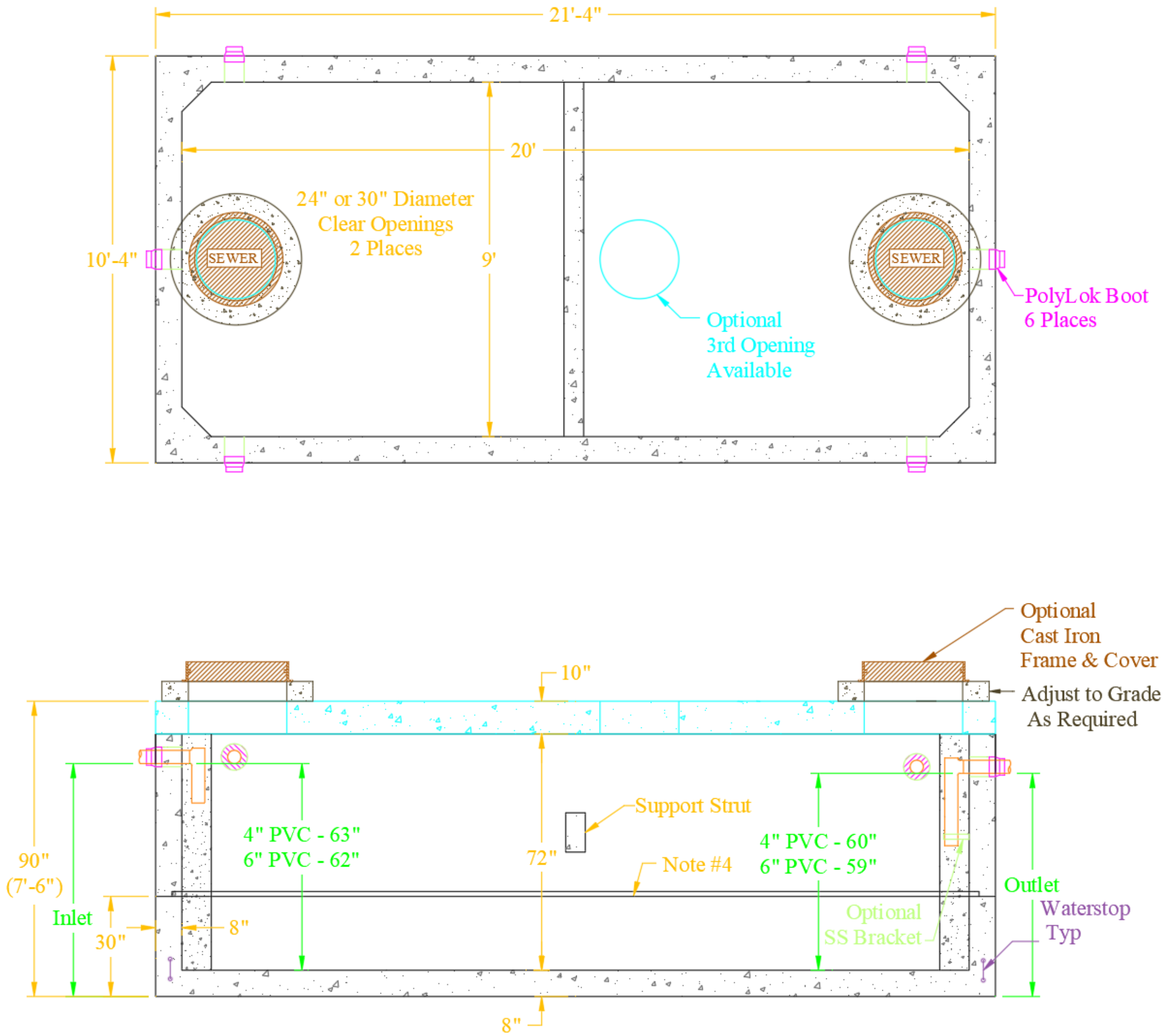


Figure 8.4.6: Low-Boy Septic Tank from Phoenix Precast Products

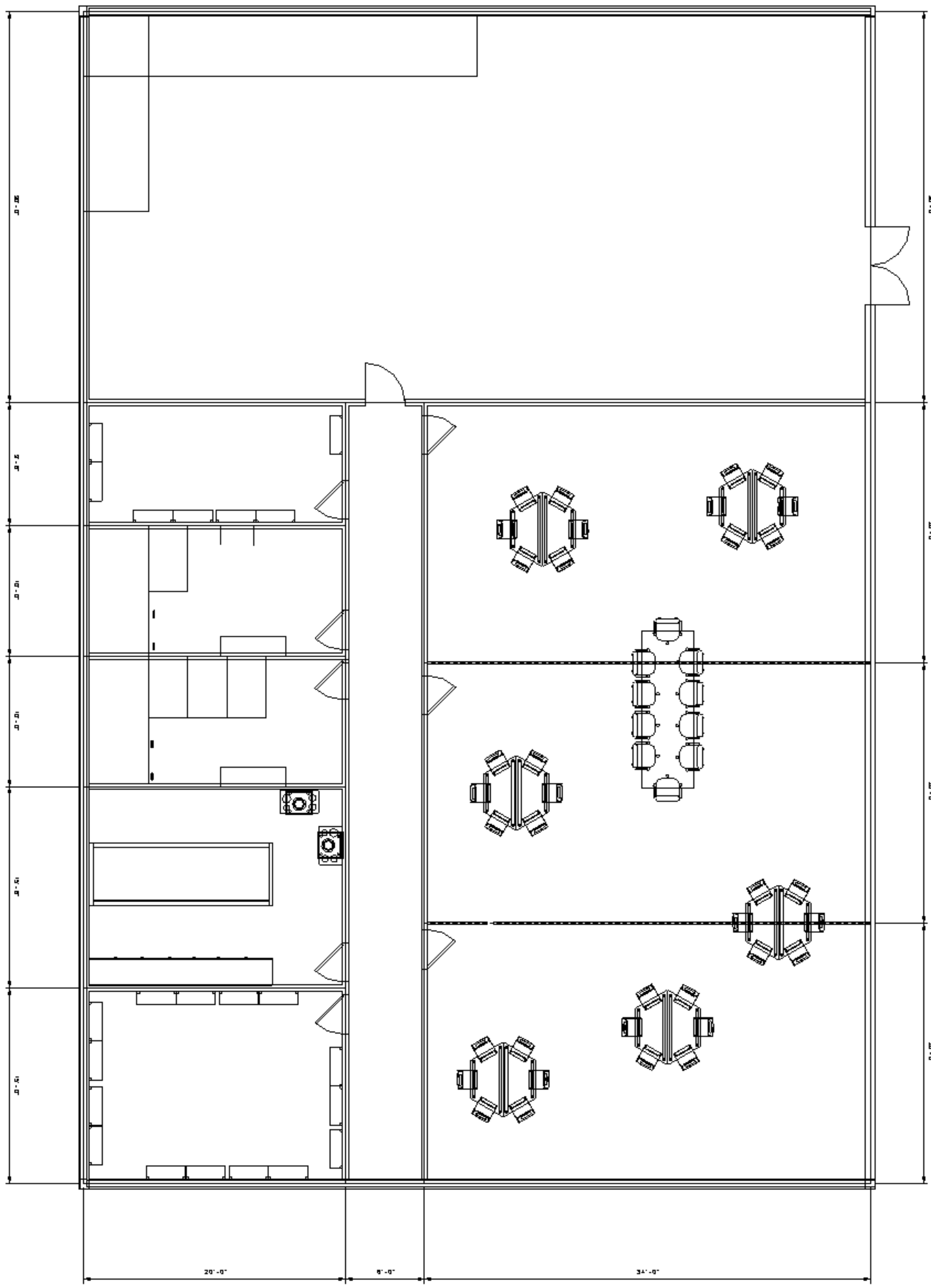


Figure 8.4.7: Upper Floor Layout

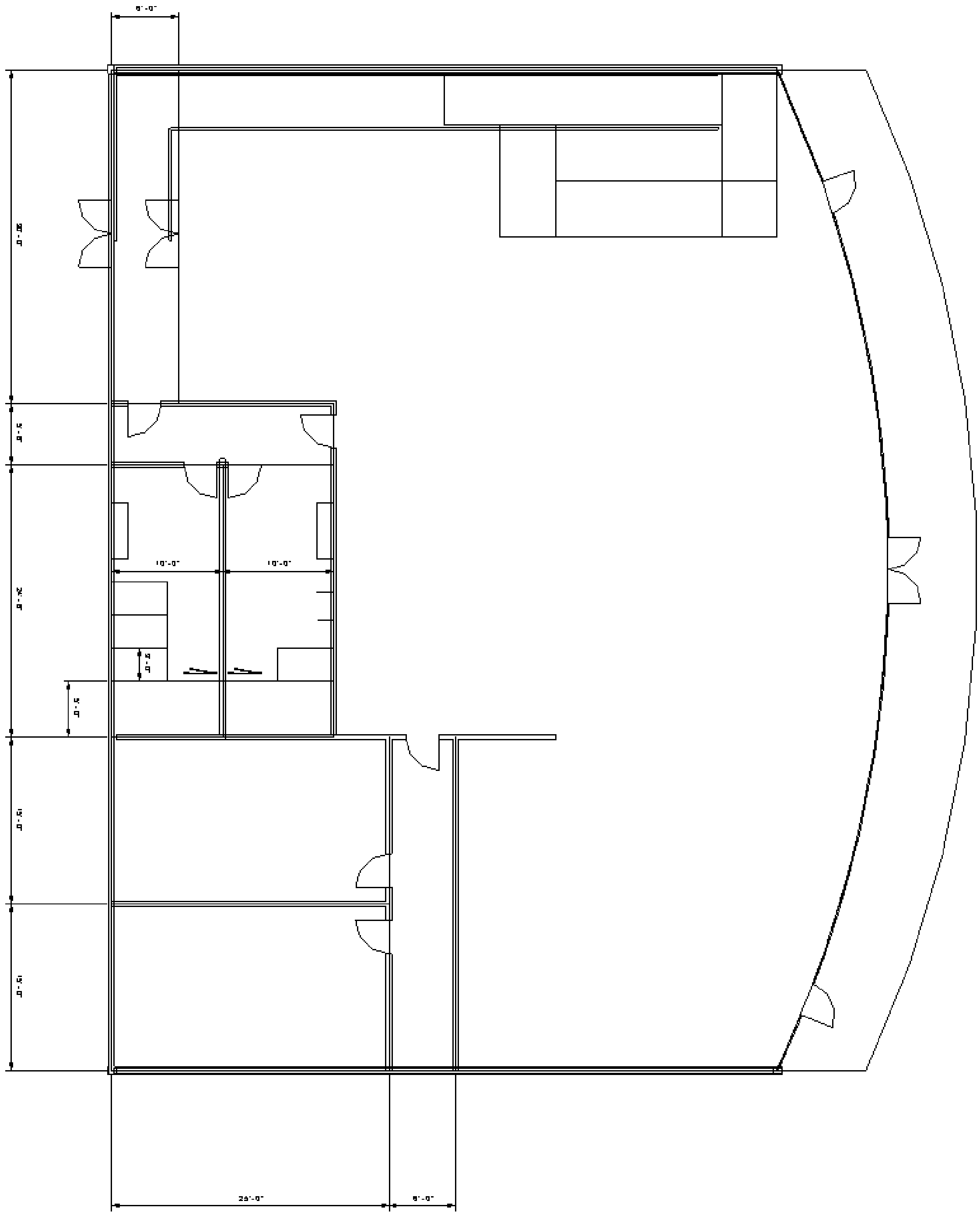
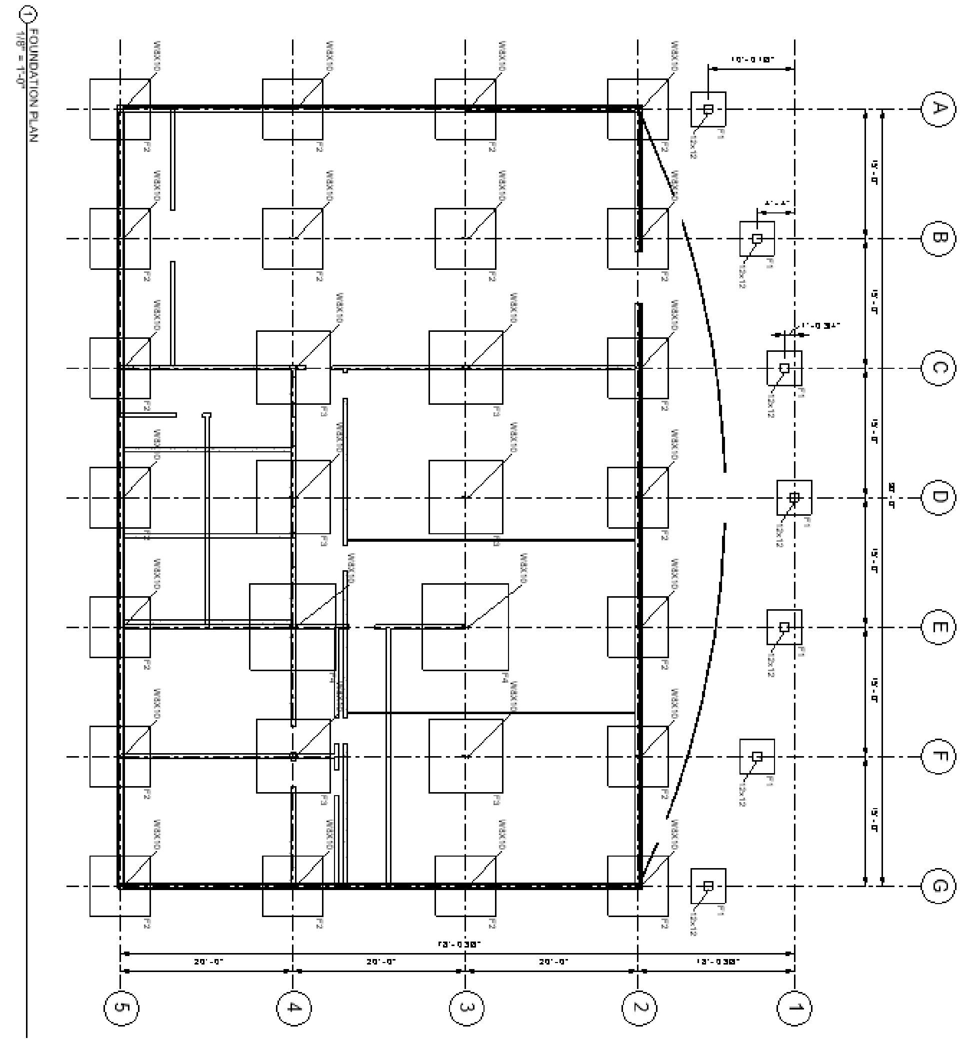
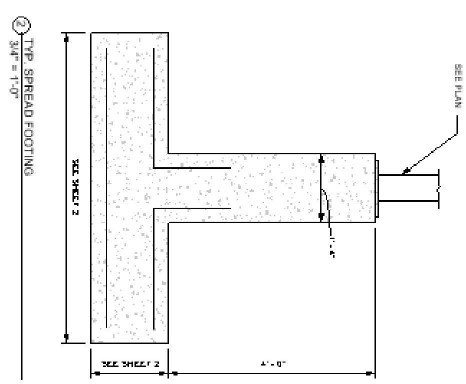


Figure 8.4.8: Lower Floor Layout





Structural Foundation Schedule

Type	Elevation at Top	Length	Width	Foundation Thickness	Count
F1	-4'-0"	4'-0"	4'-0"	1'-0"	7
F2	-4'-0"	7'-0"	7'-0"	1'-6"	20
F3	-4'-0"	8'-6"	8'-6"	1'-6"	6
F4	-4'-0"	10'-0"	10'-0"	1'-6"	2

Figure 8.4.9: Foundation Plan

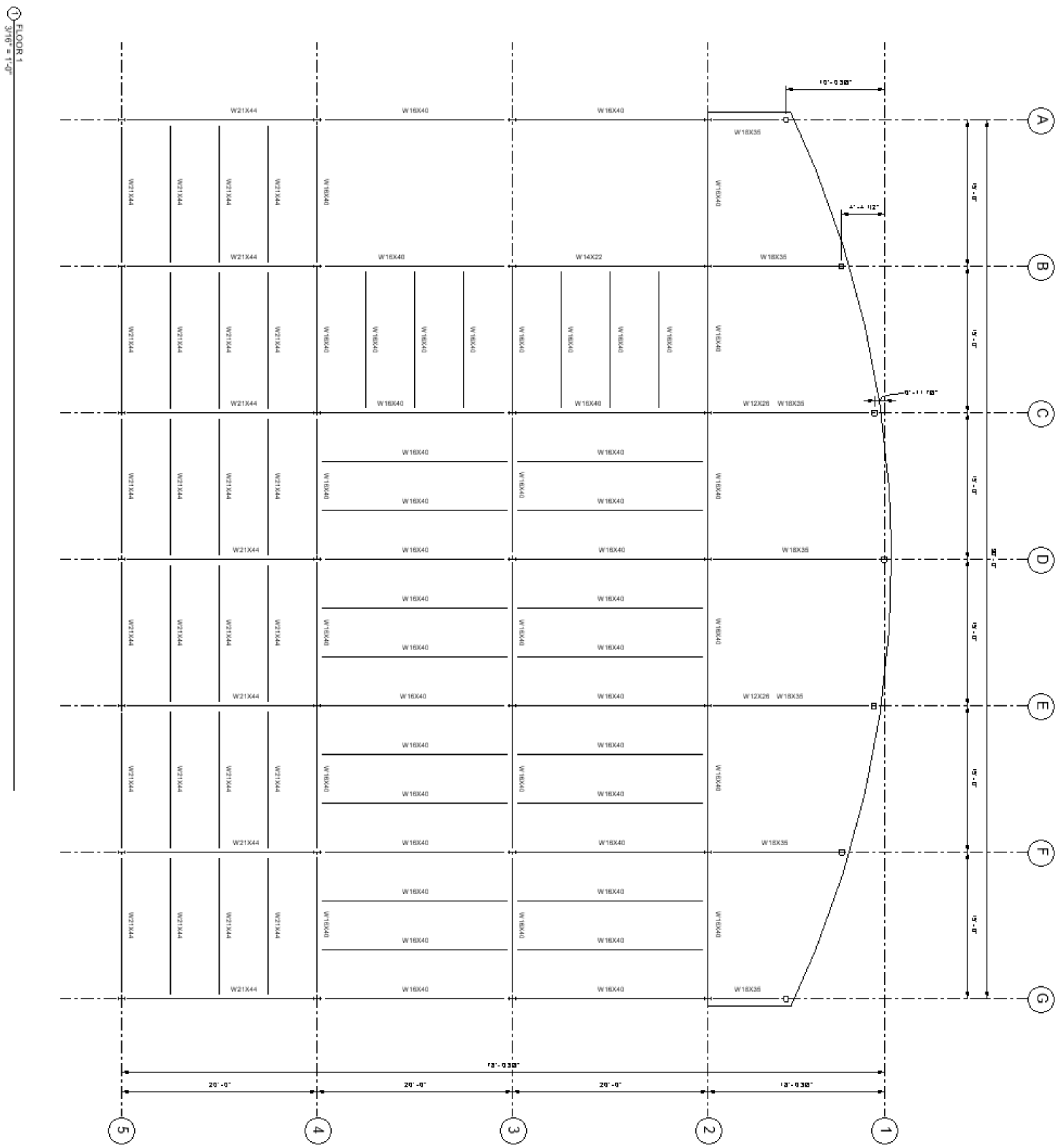


Figure 8.4.10: First Floor Framing Plan

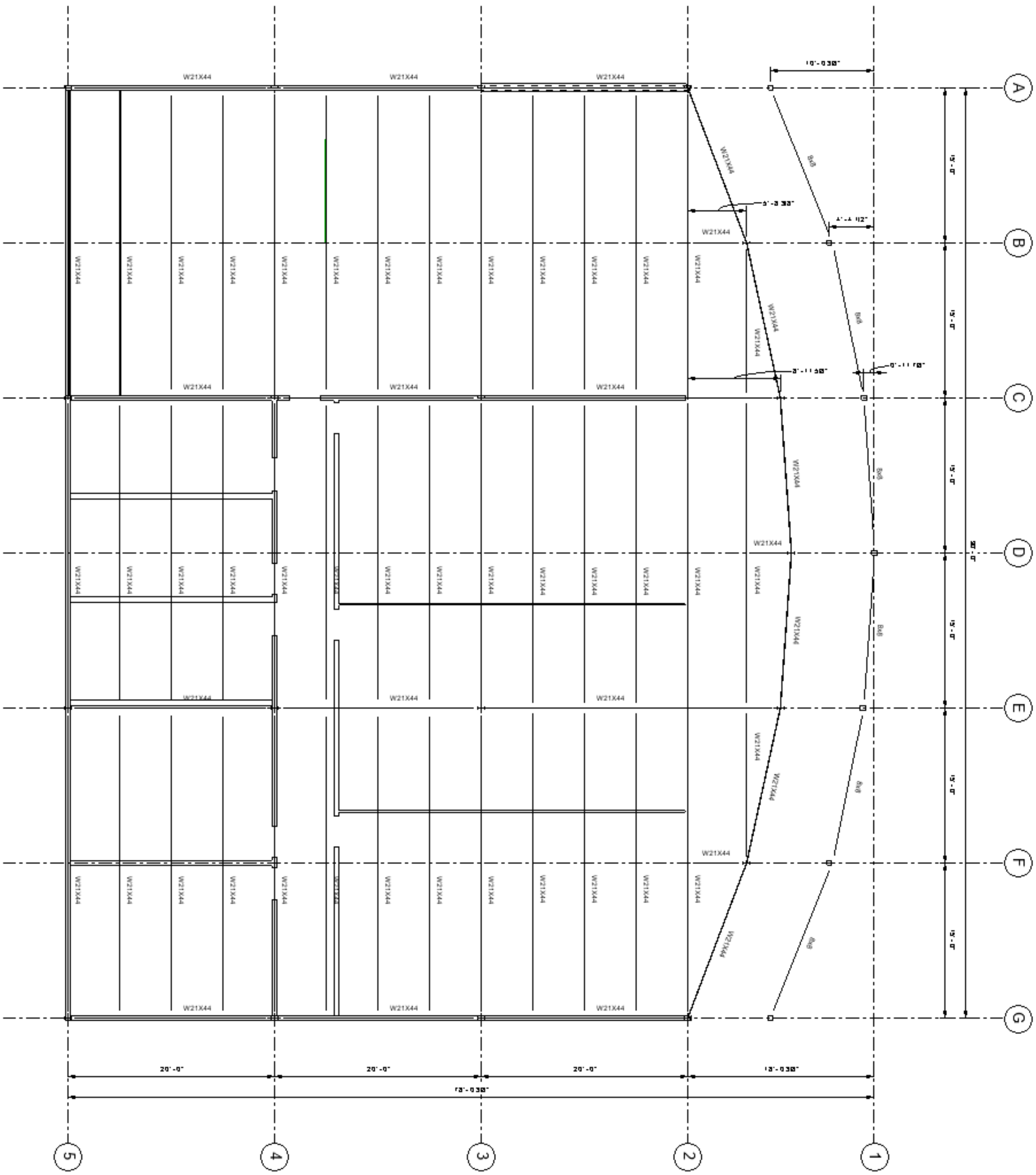


Figure 8.4.11: Roof Framing Plan

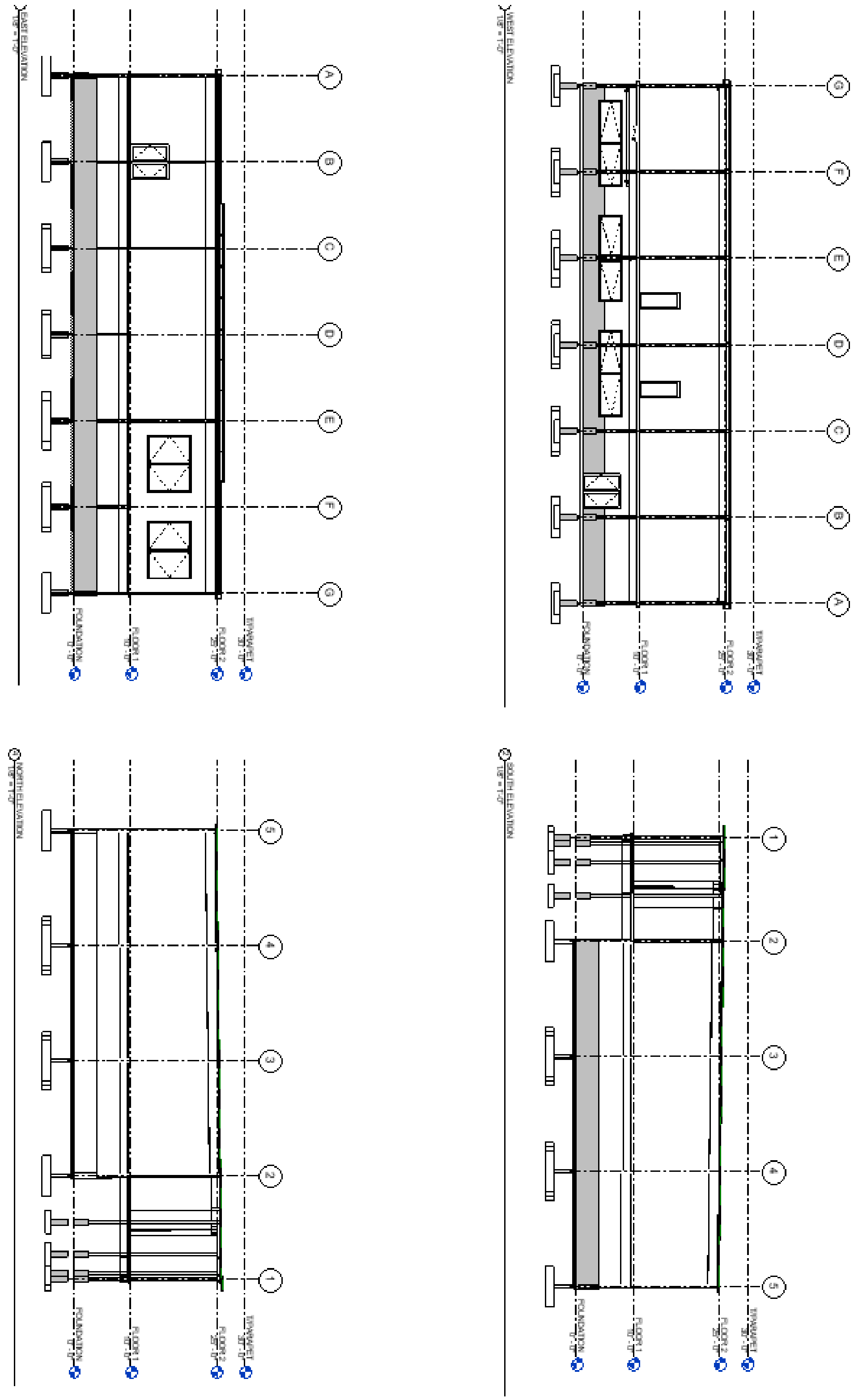


Figure 8.4.12: Building Elevation Views

8.5 Design Rendering and Models