Deery Property Subdivision Design Report

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609 W Mt. Pleasant St & Attached Acreage

West Burlington

Friday, December 13th, 2024

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<u>Section I</u> Executive Summary

A group of three graduating students from the University of Iowa's College of Engineering created these designs as part of their capstone in Civil and Environmental Engineering. The client was the City of West Burlington which sought the evaluation of an existing track of land of 15.12 acres at 609 W. Mt. Pleasant Street for redevelopment into high-end residential housing. This was important to the client because nearly half of public school students in West Burlington are open enrolled from the surrounding district. As such, the goal of this project is to increase tax for the city and local enrollment in the school system by attracting young families.

The design directive focused on a subdivision that ties into the existing neighborhood; this includes infrastructure, utility, and house-style connectivity. Maximization of the number of single-family houses took precedence over other factors. The addition of a pocket park and connection to an existing trail network was ideal only so long as neither limited the maximum number of houses.

The final layout allowed for 38 buildable lots, ranging in size from 0.22 acres to 0.49 acres. The .645 acre pocket park was determined to best fit into the northwest corner of the subdivision because zoning codes made a lot in this area unbuildable. Eight distinct house designs were selected from housing catalogues to match the various lot sizes. They range from 2,258 sq ft to 2,832 sq ft. For visuals, please see Figures 6-13 in Appendix B.

Located near the high-traffic, Mt. Pleasant Street, it was determined not to have subdivision access from this street. Instead, the existing Glasgow and Wheeler Streets were used as connecting streets for this design. This increased connectivity to the existing neighborhoods as there were multiple points of entrance and exit to the subdivision. Wheeler Street was extended almost 700 feet to the west. Glasgow was extended clockwise and reattached to the existing intersection of Glasgow and Vernon. This addition would be 1,850 feet long. Both new streets were designed with the same vertical cross-section. The depth of the pavement, base, and subbase were 8", 6", and 1', respectively. The width of the lane was 11.5', while the curb and gutter span would be 2'. The class B sidewalk would have buffer widths of 3' and 8.5', and the sidewalk itself would be 5' wide. The sidewalk was designed to be PCC and 6" deep. This brought the total Right of Way width to 60', which was in line with SUDAS standards for a local residential road. SUDAS Chapter 5: Roadway Design was used to make all calculations.

It was determined that the trail would be on the western side of the western drainage ditch. It would run north to south, connecting West Mt. Pleasant Street to the bridge spanning the drainage ditch in the southwestern corner of the proposed subdivision. This bridge would connect to a short trail running diagonally between the two proposed lots in the southwestern corner that would run up to the newly paved street. The trail would be composed of PCC of 6-inch depth. The bridge, which would be prefabricated by Bridge Brothers, would be a Pratt Truss 115 ft-long and 6 ft-wide.

The storm sewer system would be located between the back of the curb and the sidewalk, along the south side of the roadway. Regulation requires the storm sewer system must be on the opposite side of the road as the sanitary sewer system. This system consisted of 12 sewer structures and approximately 2,050 feet of piping made from HDPE material 27" wide. The system design calculations were completed in accordance with the guidelines specified in Chapter 2 of SUDAS.

The sanitary sewer system would be situated between the back of the curb and the sidewalk, positioned along the north side of the roadway. This system was comprised of 22 sewer structures and approximately 2,500 feet of 20 inches wide PVC piping. The calculations for the system design were performed in accordance with the guidelines outlined in SUDAS Chapter 3: Sanitary Sewers.

The water main system would be located between the back of the curb and the sidewalk, on the north side of the roadway. Like the storm sewer system, the water main must be placed opposite the sanitary system. This system included four fire hydrants and approximately 2,450 feet of piping, constructed from PVC material. The design calculations for the system were completed in accordance with the guidelines outlined in SUDAS Chapter 4: Water Mains.

Please note that there was no design for electricity, gas, or fiber optics because it was determined that MidAmerican was ideal to consult for gas, electric, and fiber optics (if desired).

The cost for Site Work and Landscaping was determined via RSMeans data. The cost of the bridge was determined via an estimate from Bridge Brothers. The cost of earthwork was partially determined by the Iowa Public Works Service Bureau and partially using RSMeans data. The cost of houses was determined using RSMeans square feet data. The rest of the costs (demolition, streets, storm and sanitary sewers, and water) were determined by consulting the Iowa Public Works Service Bureau. Contingencies were set at 10% due to the relatively low risk of residential construction, which would cover any unforeseen obstacles that might arise. Engineering Administration was set at 20% due to the engineers' need for overhead and profit in addition to their work, and accounts for the need of an engineering firm to design and adminster the process of land preparation and construction. See below for a summary table of costs:

Earthwork and Demolition	$308,100.00
Streets	$1,607,500.00
Storm Sewers	$181,000.00
Sanitary Sewers	$38,500.00
Water	$304,100.00
Bridge	$445,200.00
Site Work and Landscaping	$56,000.00
Site Preparation	$87,000.00
Contingencies at 10%	$302,700.00
Engineering Admin at 20%	$605,500.00
Total:	**$3,935,600.00**
House Construction	$16,609,500.00
Contingencies at 10%	$1,661,000.00
Engineering and Admin at 20%	$3,321,900.00
Total:	**$21,592,400.00**
Overall Total:	**$25,528,000.00**

Table 1: Summary of Cost Estimates

To reiterate, this project focused on maximizing the number of lots in a proposed high-end residential housing subdivision that connected to the existing neighborhood. This included determining the ideal layout of lots and finding a location for a pocket park. Housing catalogues were consulted to find houses that fit within zoning codes and matched the style of the existing neighborhood. Roads and a pedestrian trail were designed and incorporated into the final product. Additionally, Bridge Brothers was consulted on design of a prefabricated pedestrian bridge. Storm sewers, sanitary sewers, and water mains were designed and connected to existing infrastructure. Finally, a cost estimate was performed to determine the cost of land development and of house construction.

Section II Organization Qualifications and Experience

1. Organization and Design Team Description
    a. We are a team composed of dedicated students participating in senior design from the University of Iowa, each bringing a specialized skill set to the project. Nikki Tirrito is pursuing a degree in Civil Engineering and focused on the infrastructure, residential, and community aspects of the subdivision project. Owen Murphy is pursuing degrees in Environmental Engineering and Philosophy and concentrated on the environmental and sustainability portions of the project. Kendall Maloney is also pursuing a degree in Civil Engineering and addressed the site layout and planning. Each team member brought distinct expertise to ensure a well-rounded approach to the project.
2. Description of Experience with Similar Projects
    a. **Owen Murphy**: Brought experience in sidewalk and road design, as well as expertise in sewer and water system planning and implementation.
    b. **Kendall Murphy**: Specializes in utility design and equipment calculations for intersections. Kendall has also worked with traffic impact studies and generated forecasts for future traffic and trip generation.
    c. **Nikki Tirrito**: Offers a background in construction, with notable design experience including the development of a parking lot for a gym using Civil 3D.

Section III Design Services

1.Project Scope

The project involved subdividing the Deery Property on Mt. Pleasant Street with the goal of maximizing the number of residential units. This comprehensive undertaking includes planning for lot sizes, grading, stormwater and sanitary sewer systems, water lines, local roadways, and housing specifications, with the incorporation of a pocket park. The site design, completed in Civil 3D, details the site location, construction boundaries, existing and proposed utility locations, and infrastructure such as road extensions, new roadways, trails, and sidewalks. The utility design includes plan and elevation views of piping systems, specifying materials, sizes, invert elevations, and manholes. Access road designs, also conducted in Civil 3D, feature a visual drive-through, horizontal and vertical alignments, cross-sections, and details on pavement types and thickness, as well as drainage. Housing designs present renderings to showcase the style and size of the homes, including plan views, elevation views, architectural renderings, and a comprehensive material list. Tasks undertaken include site layout and planning, infrastructure design, residential design, community amenities, environmental and sustainability considerations, regulatory compliance, and safety and security assessment.

2.WorkPlan

Please refer to Figure 26 in the Appendix for the detailed Gantt chart outlining the project timeline and key milestones for the subdivision project.

3.MethodsandDesignGuides

The design for the infrastructure within the proposed subdivision was the most extensive component. Local ordinances and zoning codes were followed for lot sizing from the west. Most of the design followed specifications from Iowa Statewide Urban Design and Specifications (SUDAS). The stormwater management also followed specifications from the SUDAS. Given that the City of West Burlington is updating its local codes and ordinances, special attention was given to mentioning how potentially problematic codes conflicted with the goal of maximizing residential housing. Furthermore, building catalogs were consulted to find housing examples for the subdivision that echoed existing architectural themes in the neighborhood. Finally, Bridge Brothers, a bridge fabrication company, was consulted to determine design options and cost estimate for bridge installation.

Section IV Constraints, Challenges, and Impacts

Constraints

Constraints of this project included space; we needed to fit at least 30 homes on a limited amount of acreage. Another constraint was the aesthetic that has been requested by the client. Environmental considerations included the existing trees, a drainage ditch along the western border, roads, utility lines, and overall sustainability. Societal limitations for this project included public concern, funding use, and overall expectation of the town's residents.

Challenges

Utility Integration challenges included ensuring sufficient placement and connectivity of water, sewer, and stormwater systems. Adhering to zoning laws and land use regulations, which affected lot sizes and building types. Designing access roads that meet safety and design standards that come from the existing roads. Additionally, there was a steep slope along the northern edge and a house in the northeast corner that required demolition.

Societal Impact within the Community and/or State of Iowa

We are aware of the changes and implications that building this subdivision brings. The completion of this project will increase economic development, as it increases local revenue. It will also increase housing availability, which addresses the demand for more housing in the local school districts. This project also brings both community and infrastructure improvements, with enhanced facilities, new roads for better accessibility, and a park that includes ADA accessible features. We are mindful of the potential impacts that this development may have on the existing community and are committed to ensuring that it contributes positively to the area's growth while respecting and supporting current residents. We aimed to foster an inclusive and balanced approach to development. We ensured that infrastructure and public services are adequately upgraded to handle the increased demand. We engaged with the residents to understand their concerns and incorporated their feedback into the development plans.

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

The first issue that was considered when approaching alternative designs was the street layout of the subdivision—specifically how existing streets connected to entry and exit. Given the traffic level and relatively steep slope from the subdivision to the road, entry from and exit to West Mount Pleasant Street did not seem like the best option. The entry from and exit to the neighborhood via Wheeler Street and/or Glasgow Street was more ideal. This issue took precedence as the layout of the streets within the proposed subdivision, especially the entries and exits, significantly impacts the layout of the houses as well as the number of houses that can fit within the proposed subdivision. Minimizing the road infrastructure to reduce cost and maximize buildable space was a significant factor when designing concepts. Several iterations were provided for potential designs before a final concept was agreed upon. See Figures 2-4 below for layouts that were considered.

Figure 2: Alternate Design 1

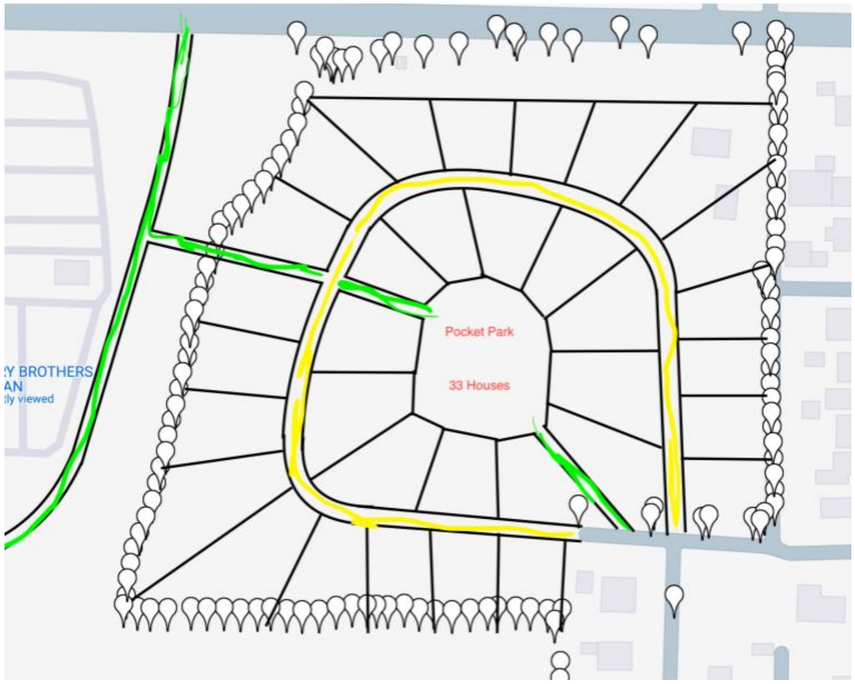


Figure 3: Alternate Design 2

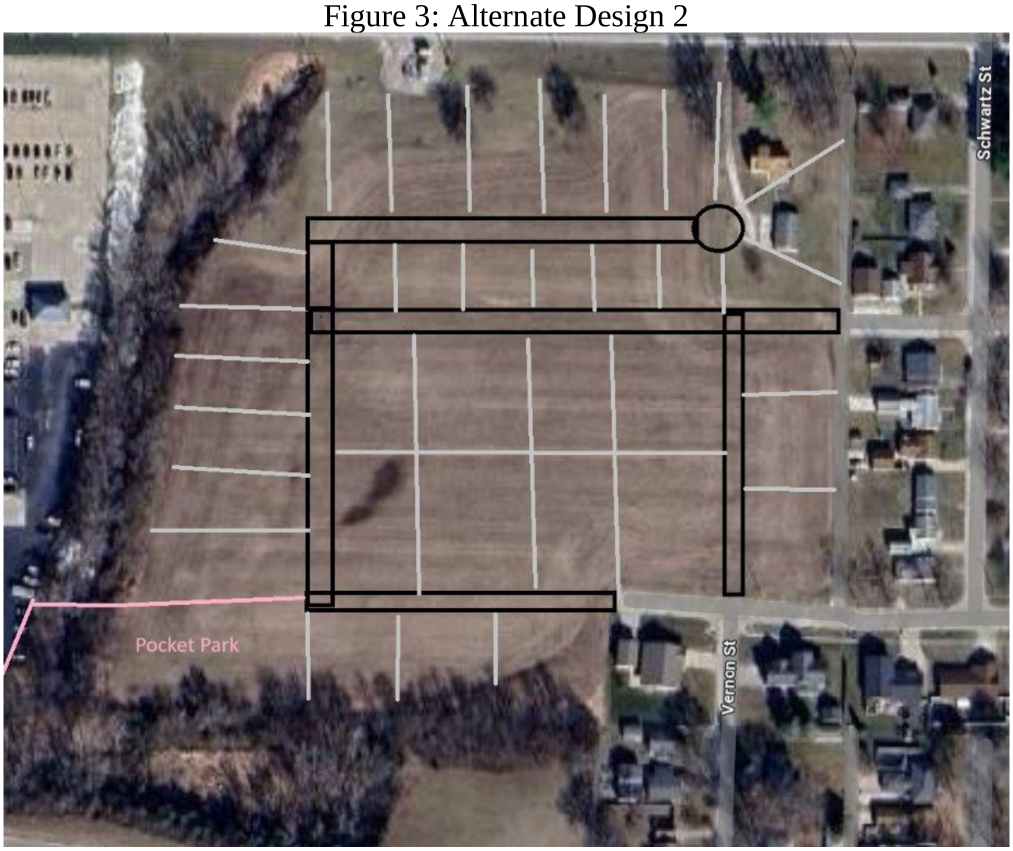


Figure 4: Alternate Design 3

The next issue addressed was the location of a potential pocket park within the new subdivision, a feature that could help attract young families. The park's size could not affect the maximum number of houses possible on the site. The client also desired an ADA-compliant playground with the potential of connecting to an existing bike path through the southern edge of the property. This supported park placement along the western edge of the property, see Figures 2-4 above. While multiple locations for the pocket park were considered, issues of visibility, safety, and accessibility ultimately took precedence. Given the housing layout of the final concept map, the pocket park would fit best in an unused section of land in the northwest corner.

Connecting the proposed bike path to Mt. Pleasant Street was ideal, providing a connection that runs down the eastern side of the western drainage ditch. However, it was determined that such a path would run behind several properties, potentially creating privacy issues. Instead, we decided this connection was best suited for the western side of the western drainage ditch. Additionally, there was the potential to include a pedestrian bridge over a drainage area to the west or south of the property. It was decided relatively early in the design process that the bike path ought to connect to the southwestern corner of the property.

The location of a proposed bridge made the most sense to be connected to the proposed bike path. This meant that, since the location of the bike path ran southwest across the ravine, this is also where the bridge would go. The design of the bridge was guided by a combination of durability and aesthetics. We chose a concrete decking as other choices would require replacement and repair sooner. The final decision regarding the bridge was whether it would be constructed on-site or prefabricated. Research found that prefabricated bridges tended to be less costly but could only cross a chasm so wide. This maximum length was determined to be 150 ft. Measurements of the drainage ditch proved it remains under this threshold; thus, a prefabricated bridge was determined to be optimal.

Section VI Final Design Details

Site Design

The site layout ultimately chosen includes 39 lots, one of which is a pocket park. The pocket park is in the northwest corner of the property on Lot 10 (see Figure 5 below) of 0.645 acres. This site layout includes a road tying in from Wheeler Street and Glasgow Street. Taking into consideration the existing alley on the east side of the property, the lots were arranged so that the backyards were adjacent to the alley. The lots range in size from 0.22 acres to 0.49 acres. This design also takes into consideration the slope along the north edge of the property. The appropriate zoning codes that needed to be met came from Chapter 165 of the West Burlington codes (Figures 29 and 30, Appendix B). Our site is an R2 zone. The relevant material for us required front setbacks of 32 ft, back setbacks 35 ft, side setbacks of 9 ft. Notably, all these setbacks were for two-story houses.

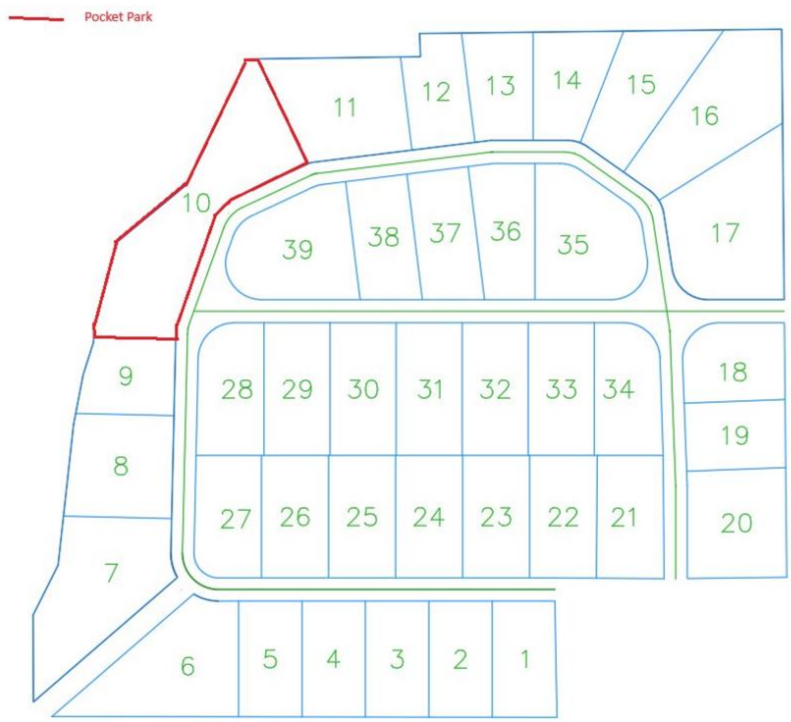


Figure 5: Pocket Park Location

House Plans

The house renderings were researched and developed with the precise final dimensions and unique characteristics of each lot. The style of the existing neighborhood was determined to most closely match the architecture of the farmhouse. The newer houses also met the criteria to be considered a part of a modern farmhouse aesthetic. To provide a diverse range of options, eight distinct designs were selected, each tailored to ensure that the size and scale of the house are well-suited to the specific lot. These houses ranged from 2258 sq ft to 2832 sq ft, from three to five bedrooms, 2.5 to 4 baths, with varying widths and depths depending on the housing plan. See Figures 6-13 below. This approach guaranteed that each property featured a home that complemented the available space and the aesthetic of the neighborhood.

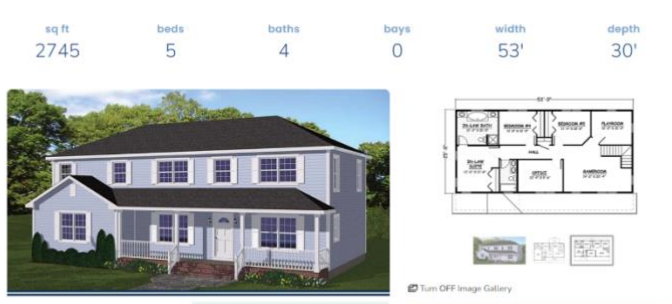


Figure 6: Housing Layout 53’ x 30’

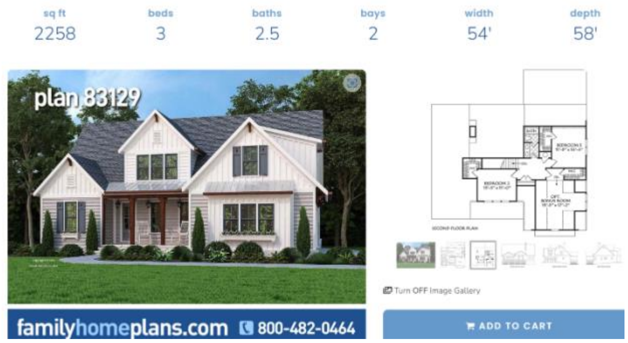


Figure 7: Housing Layout 54’ x 58’

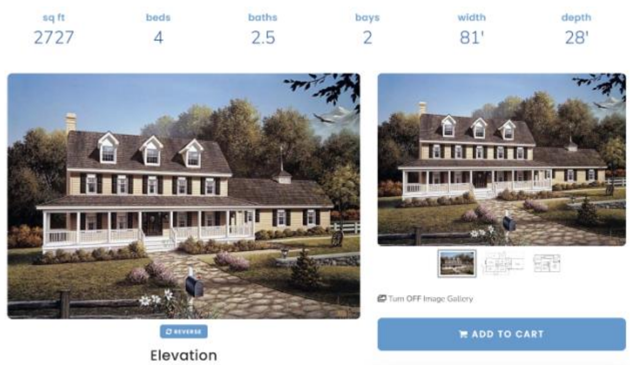


Figure 8: Housing Layout 81’ x 28’

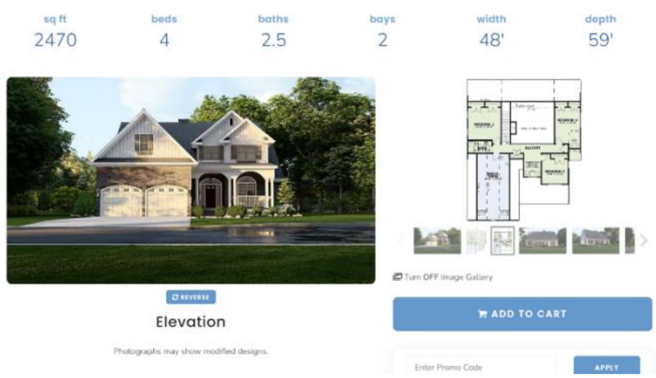


Figure 9: Housing Layout 48’ x 59’

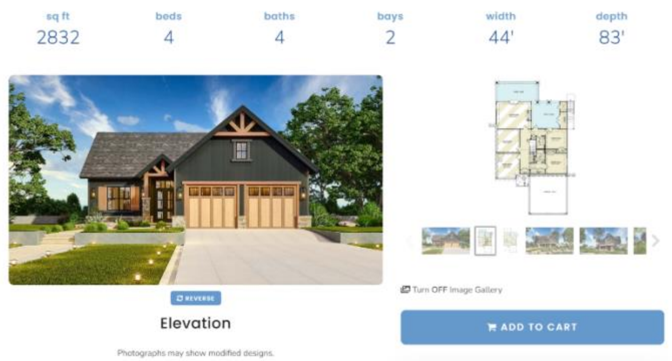


Figure 10: Housing Layout 44’ x 83’

Figure 11: Housing Layout 30’ x 59’

Figure 12: Housing Layout 59’ x 68’

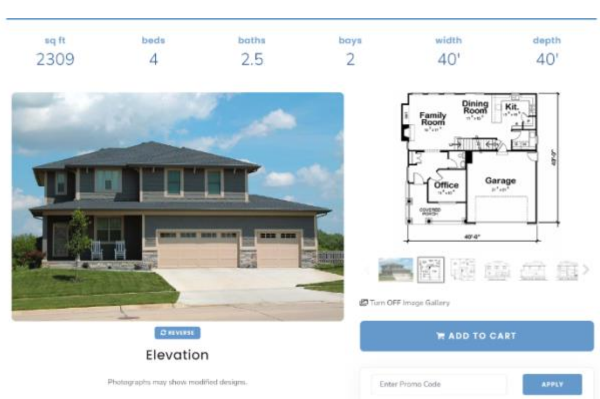


Figure 13: Housing Layout 40’ x 40’

Grading

Grading was determined according to the natural contour of the land, ensuring proper drainage. Each section of the property has a designated ridge line, serving as the highest point from which water will naturally flow. This is demonstrated in Figure 14 below. Specifically, for lots 11 through 16 located on the northern end of the site, the water will follow the site's inherent slope, flowing northward in alignment with the terrain's natural grade. On a broader scale, the site's overall drainage pattern directs water from the eastern side to the western side. This natural flow of water was a critical factor in the planning of both the utilities and drainage systems, assuring that they were strategically positioned to work with the site's topography and facilitate efficient water management throughout the property.

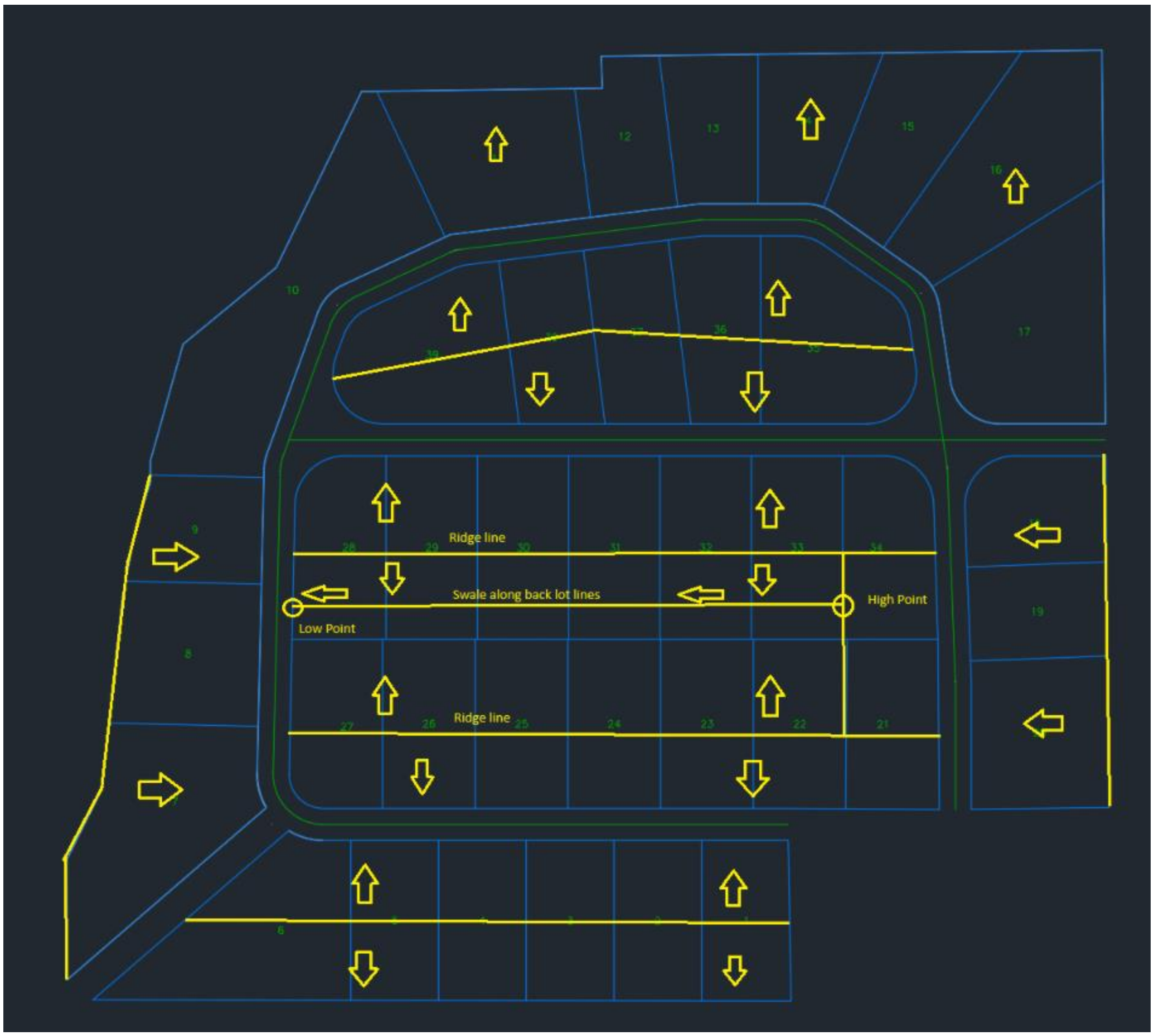


Figure 14: Drainage Plan

Storm Sewers, Sanitary Sewers, and Water Mains

Storm sewers were placed between the back of the curb and the sidewalk on the south side of the road. Inlets were placed on both sides of the road and connected to pipes that draw the water from the north side of the road to the south. Manning's Equation (Equation 1 Appendix D) was used to find the discharge in the stormwater pipes. Other factors for that equation were determined by the surrounding area and the soil type, and other standards from chapter 2 of SUDAS. The contributing area for each inlet was calculated, followed by the discharge, the rate of flow in the pipe, and the pipe diameter. The length of pipe needed was determined by drawing out the stormwater sewer system on Civil 3D and measuring all the proposed pipes. See Figure 15 below All of this resulted in 2,050 ft of HDPE piping 27 inches wide and 12 structures.

Figure 15: Final Stormwater Design

A similar process was used for the sanitary sewer system. Also situated between the back of the curb and the sidewalk, the sanitary sewer was positioned on the opposite side of the street as the storm sewer. With a Manning's Coefficient (Figure 38 Appendix D) from SUDAS, the discharge was found based on how many people would live in each house (Figure 37 Appendix D), an estimated gallons per capita per day, and how many lots would contribute to each inlet. After the discharge was calculated, so was the pipe diameter. Solid Wall PVC pipes were chosen for the sanitary sewers (Figure 44 Appendix D). The length of pipe needed was calculated from the Civil

3D drawing. See Figure 16 below. The sanitary sewer system is located on the north side of the road, opposing the storm sewer system. This design ties into the existing sanitary sewer system in a few locations on the site. In total, this system included 2,500 ft of Solid Wall PVC piping 20 inches wide and 22 structures.

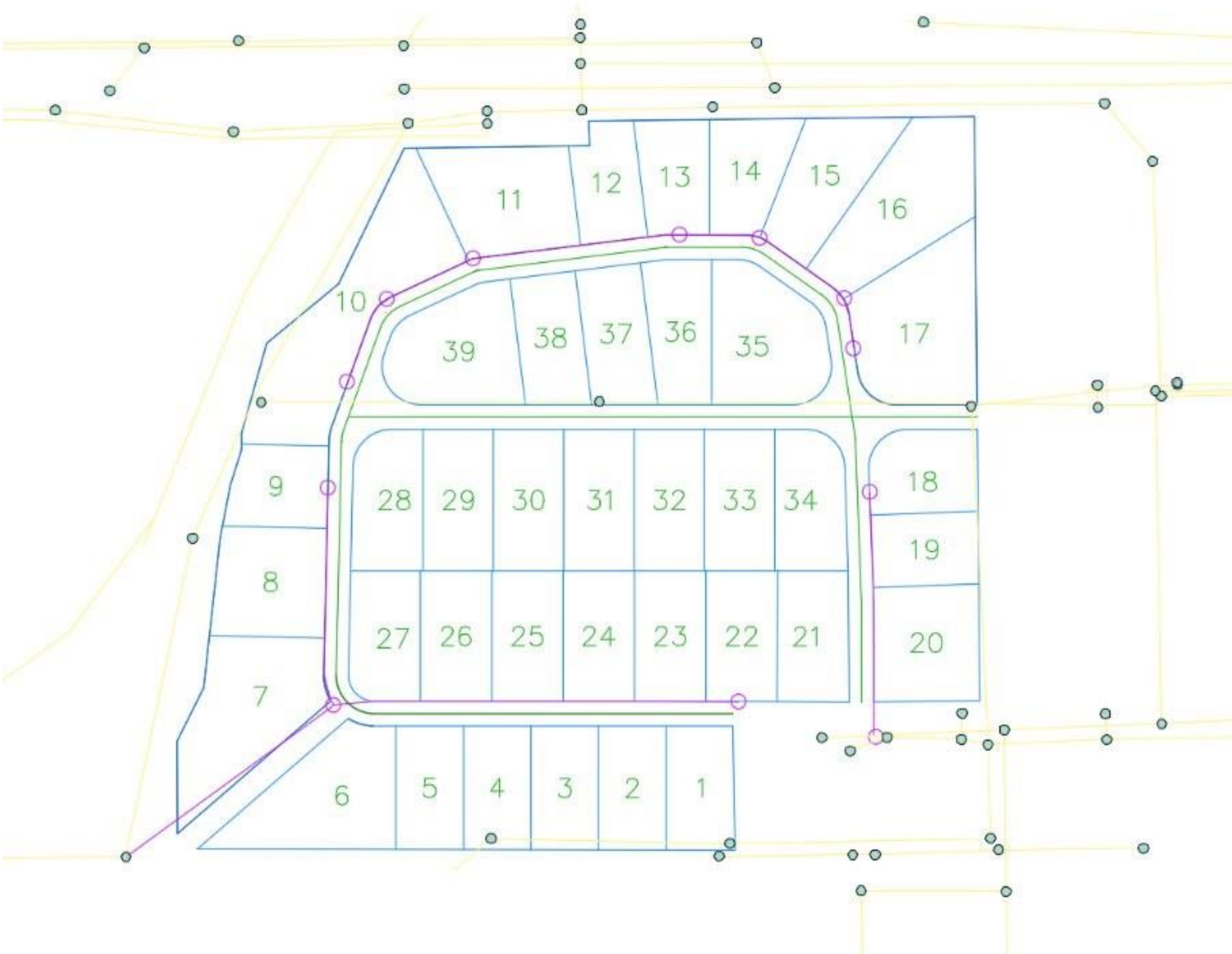


Figure 16: Final Sanitary Sewer Design with Existing Utilities

The design of the water main system was done on Civil 3D. This system was also designed to be situated on the south side of the road, opposing the sanitary sewer system. Sanitary cannot be on the same side of the road as storm or water main systems due to regulatory requirements to prevent contamination and for ease of access to each individual system. This system ties into existing water main structures near the lot. The entire system was designed utilizing chapter 4 of SUDAS and included 2,450 ft of PVC piping 12 inches wide as well as 4 structures. See Figure 17 below.

Figure 17: Final Water Main Design with Existing Utilities

Please note that there was no design for electricity, gas, or fiber optics because it was determined that MidAmerican was ideal to consult for these utilities if desired.

Pocket Park

The most suitable and cost-effective location for the pocket park was identified as lot 10. The natural slope of the land is moderate, and it is conveniently adjacent to the trail. Furthermore, and more importantly, it is the only lot on which houses cannot be built due to zoning codes. This lot is 0.654 acres. See Figure 5 in 'Site Design'.

Roads

The horizontal corridor of the subdivision runs east to west starting at the end Wheeler Street, adjacent to the existing sanitary sewer line, and ends with adequate clearance for houses along the western right-of-way. Next, the road turns south and runs parallel to Schwartz Street, until meeting with an extension of Glasgow Street. Vernon Street will extend north, intersecting with the newly extended Wheeler Street, and loop around north to connect with the point at which Wheeler Street turned south. This project would extend Glasgow Street By 1850 ft and Vernon Street by 3500 ft.

The streets are 23 ft wide with 11.5 ft wide lanes. Not included are 2 ft clearance on each side for curb and gutter, 5 ft wide sidewalk on each side, and room for inside and outside boulevard widths. This results in a 60 ft wide right-of-way. The selected curb type is urban general; the sidewalks are class B composed of PCC; and the pavement is PCC of 26.4 inches thick. See Figures 18-21 below. These specifications were made using SUDAS chapter 5.

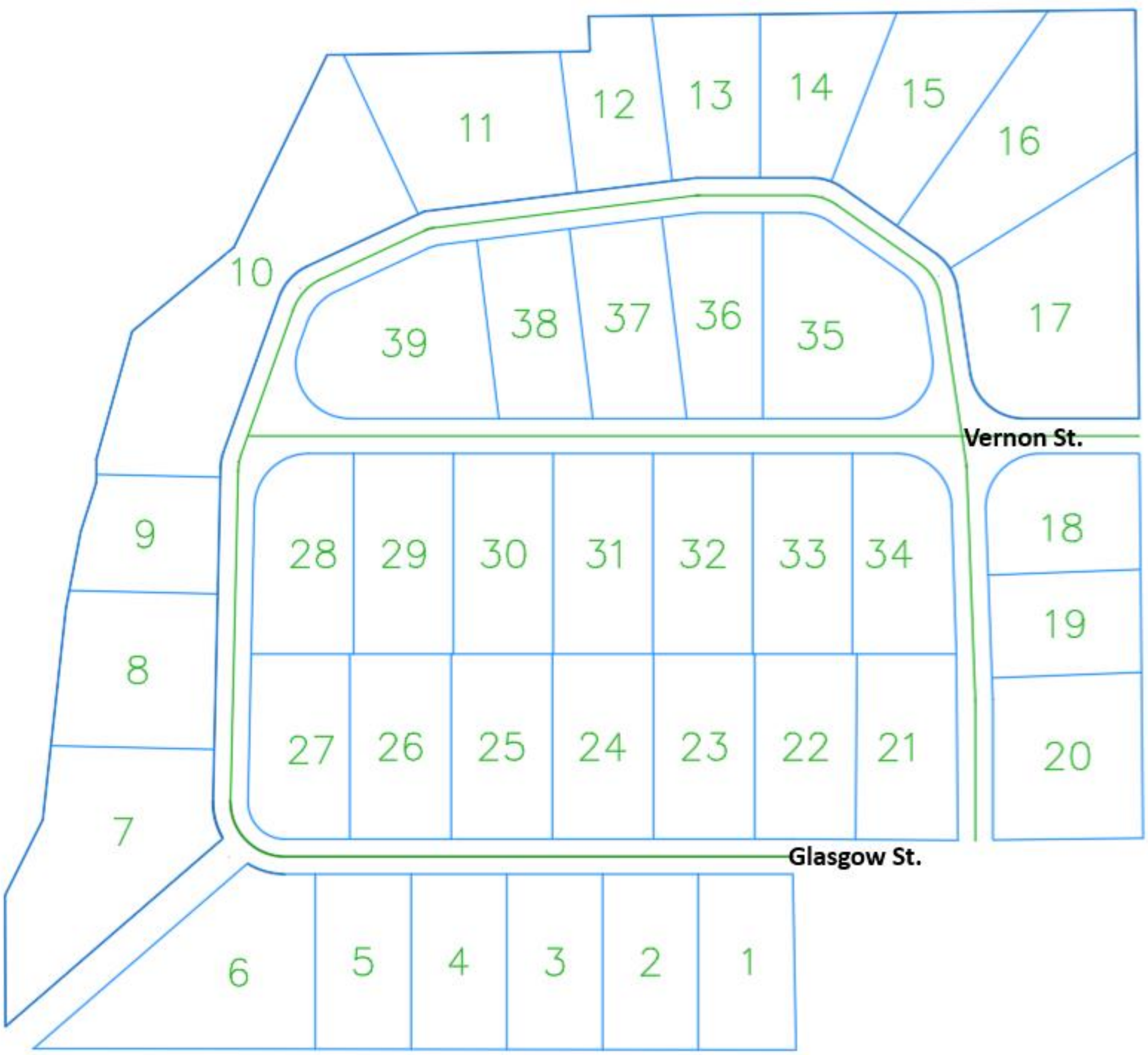


Figure 18: Roadway Design

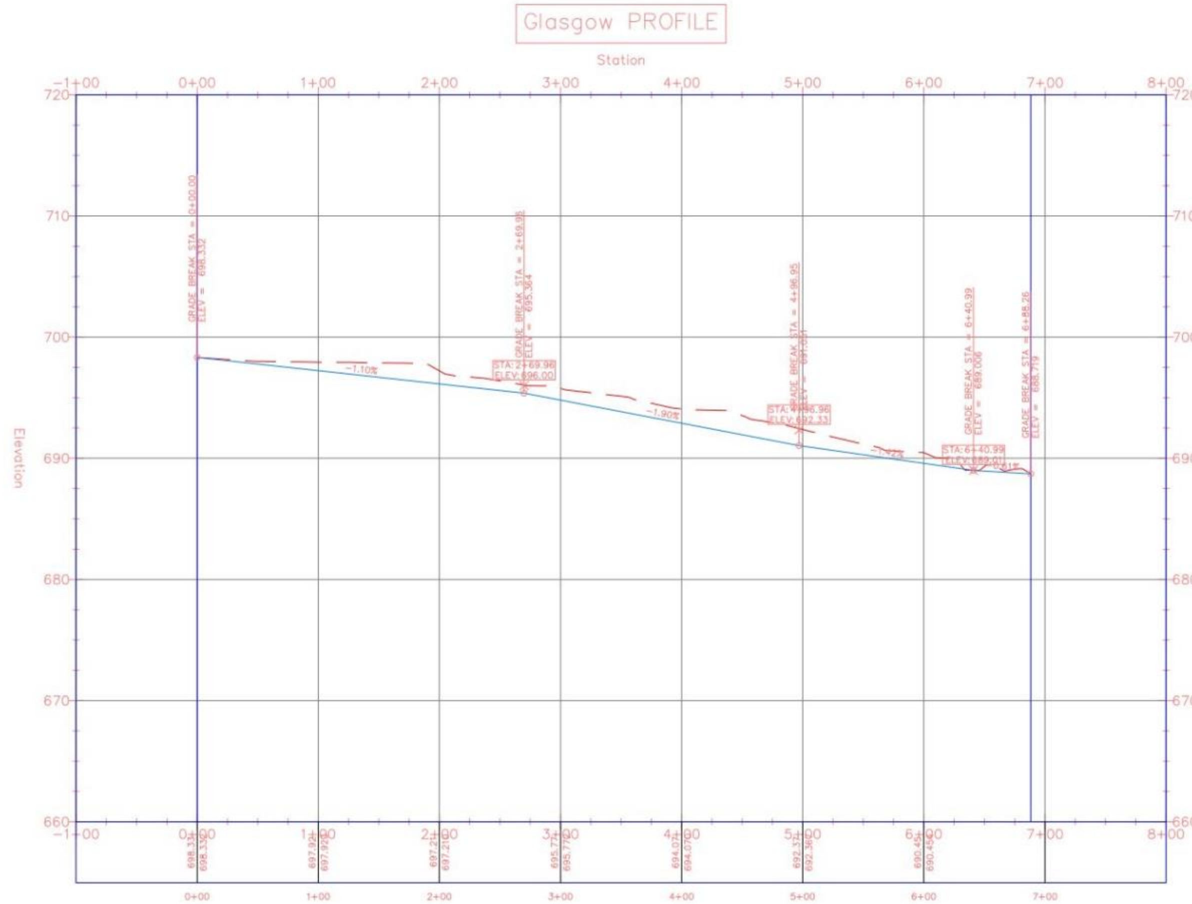


Figure 19: Glasgow Vertical Profile

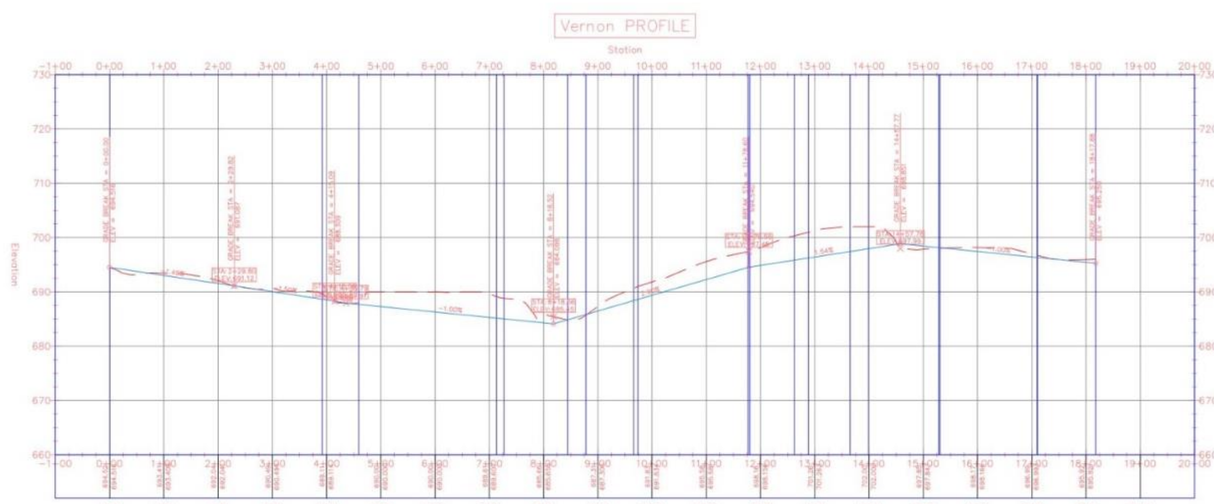


Figure 20: Vernon Vertical Alignment

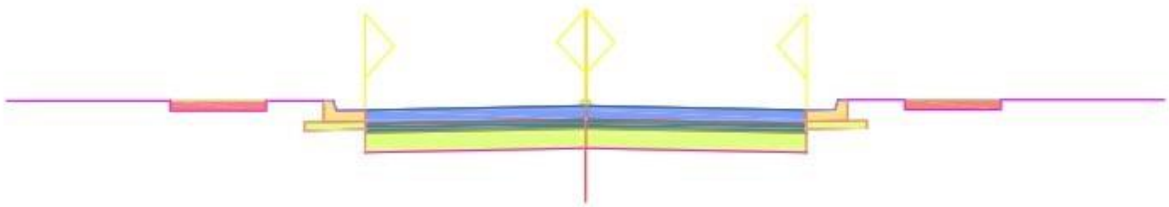


Figure 21: Road Assembly

Bike Path

Approval was granted to place the trail along the west side of the basin, bordering the Deery property. The design adhered to the SUDAS standards, which provided the required dimensions for the bike path and trail. These dimensions included a 10 ft wide trail, with 2 ft clear zone on either side. The pavement is a shared use path PCC of 6-inch depth. A partial wall will be constructed along the east side of the basin, complemented by landscaping to enhance the visual appeal and create a more cohesive aesthetic within the neighborhood. See Figure 22 below

Figure 22: Bike Path Location

Bridge

A bridge will be constructed at the southwest corner of the property to span the basin. The bridge design considered a variety of factors, both practical and aesthetic. Considerations included the bridge's structural integrity and load capacity. The design also prioritized safety and ADA accessibility for pedestrians and cyclists. Aesthetic elements were carefully integrated to ensure the bridge complements the natural surroundings and enhances the overall visual appeal of the property. Factors such as materials, color, and style were chosen to blend seamlessly with the landscape while providing a functional and attractive feature for the community. During a meeting with the client city administrator, city clerk, and a city council member, it was determined that the bridge would be concrete slab deck with horizontal railing welded to the vertical railings. Additionally, lighting was added, and the style of the bridge was determined to be Pratt with a steel frame, a cable railing system for stability, and aluminum mill to reduce weight were possible. Specifications for the bridge were 115 ft long, with a 6 ft width. After this, an estimate was provided by Bridge Brothers, the proposed fabricator of the bridge. See Figures 23 and 24 below.

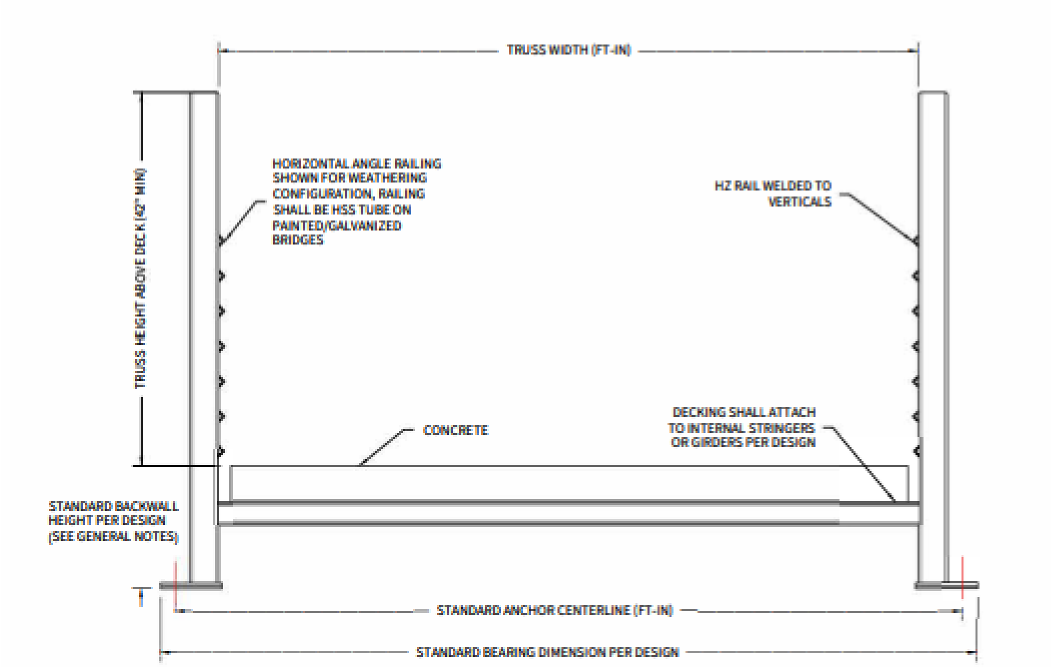


Figure 23: Bridge Profile View

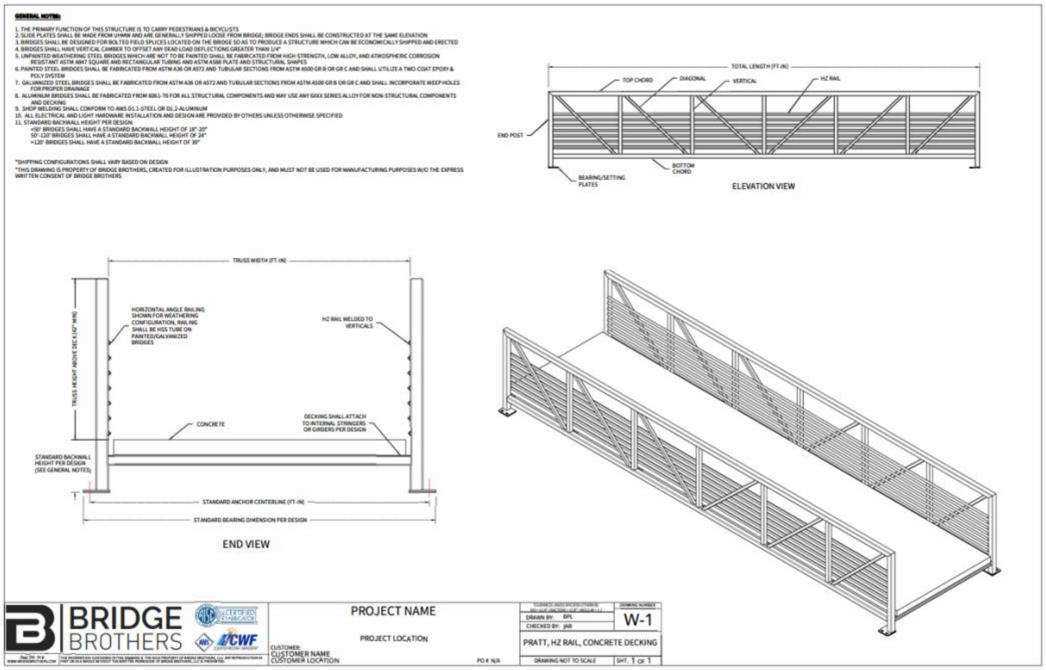


Figure 24: Bridge Brothers Bridge-Deck

<u>Section VII</u> Engineers' Cost Estimate

This cost estimate outlines the projected expenses for a residential neighborhood development project. It includes the costs for land preparation, infrastructure construction (such as roads, utilities, and drainage), as well as residential buildings, and landscaping. The scope is tailored to a neighborhood with a mix of single-family homes and communal spaces.

To obtain the estimate for the earthwork, costs were broken down as follows: clearing and grubbing per acre, excavation per cubic yard, subbase per square yard of a modified base with a thickness of 6 inches, and demolition work cost as a lump sum to remove existing structures on the property. These totals were provided by the Iowa Public Works Service Bureau. Additional costs for earthwork, such as rough grading and finish grading (both calculated per square foot), were sourced from the RSMeans data book from 2019, adjusted for 2024. The overall total for this category amounted to $308,100.

To calculate the total cost for the sanitary sewers, several factors were considered. These included a trenched sanitary sewer gravity main with an item type of C900 and an item size of 8 inches per linear foot, as well as a manhole of PC with an item size of 48 inches, calculated per unit. Additionally, there was an extra cost for connecting to existing manholes. These totals were provided by the Iowa Public Works Service Bureau. The overall total for this section amounted to $38,500.

The total cost for the storm sewer was calculated based on the required length of a trenched storm sewer made of PVC with an item size of 15 inches. This total, which is necessary to complete the site, amounts to $181,000.

The water calculation was based on the required information for water mains and appurtenances. The PVC water main, sized at 8 inches, was priced according to the total linear footage needed. Fittings were then calculated per unit. The water service pipes, also made of PVC, were categorized under item type 1, and their cost was included accordingly. Valves were priced per unit, and the fire hydrant assembly was similarly calculated. The totals were provided by the Iowa Public Works Service Bureau. After summing these costs, the total for the water components came to $304,100.

The total cost for the streets encompassed the pavement, sidewalks, and shared paths, along with all related work. The selected pavement material was Portland cement concrete (PCC), which was priced per square yard with an item size of 8. Additionally, the curb and gutter, also made of PCC, were calculated based on linear footage. Both the shared path and sidewalk were constructed from PCC and were similarly priced per square yard. All components utilized information from the Iowa Public Works Service Bureau. The total amounted to $1,607,500.

The Site Work and Landscaping cost was calculated based on the number of acres requiring seeding. The costs were provided by the Iowa Public Works Service Bureau. The total cost for this component amounted to $55,600.

The site preparation encompassed various earthwork activities for storm sewer, sanitary sewer, and water systems. These units were all calculated based on linear footage. The totals were derived from the 2019 RSMeans data book, with adjustments made for 2024. The overall cost amounted to $87,000.

The cost of the bridge was provided by Bridge Brothers, which divided expenses into two distinct sections. The first section covers bridge manufacturing, including the pedestrian bridge, bridge design, member sizing, painted steel finish, truss configuration, decking, and railing. The second section pertains to the bridge site work and erection, including the precast foundations and the unloading of the bridge, as outlined in the estimate. The final total, excluding sales tax, is $445,200. See Figure 25 below

Bridge Manufacturing (Excluding sales tax)

Qty (1) 6' x 115' Pedestrian Bridge Bridge Design and Member size is Based on Bridge Brothers Stamped Design Finish (Painted Steel) Truss Configuration (Pratt Truss Configuration) Decking prepped for concrete to be poured by GC Deck pan shipped attached Vehicle Loading if Applicable (H-5 10,000# 2 axle vehicle) Railing (Horizontal Cable Railing 42") Ada grabrail Integrated Bridge Brothers Lighting Bridge delivered in 2 pieces Additional Options included (Anchor Bolt Supply, Bearing Plate Supply, Expansion Plate Supply) Freight to Project Site (FOB) The bridge will be shipped in 2 pieces (1 Length splice) with a current estimated value of freight of ($30,000) Estimated total bridge weight is 35,000#
Total Cost: $239,473

Bridge Sitework & Erection (Excluding Sales Tax)

Qty (2) Precast or poured-in-place foundations - Assumed to be no more than 6' tall Unload and splice/fit-up bridge sections Erect bridge and install bridge anchors per project plans
Total Cost: $205,699

Bridge Sitework & Erection and Bridge Manufacturing

Qty (1) 6' x 115' Pedestrian Bridge Bridge Design and Member size is Based on Bridge Brothers Stamped Design Finish (Painted Steel) Truss Configuration (Pratt Truss Configuration) Decking prepped for concrete to be poured by GC Deck pan shipped attached Vehicle Loading if Applicable (H-5 10,000# 2 axle vehicle) Railing (Horizontal Cable Railing 42") Ada grabrail Integrated Bridge Brothers Lighting Bridge delivered in 2 pieces Additional Options included (Anchor Bolt Supply, Bearing Plate Supply, Expansion Plate Supply) Freight to Project Site (FOB) The bridge will be shipped in 2 pieces (1 Length splice) with a current estimated value of freight of ($30,000) Estimated total bridge weight is 35,000#
Qty (2) Precast or poured-in-place foundations - Assumed to be no more than 6' tall Unload and splice/fit-up bridge sections Erect bridge and install bridge anchors per project plans
Total Cost: $445,172

Figure 25: Bridge Costs

A 10% contingency factor was applied to the overall cost of the site work portion of the project. This was included to account for potential unforeseen circumstances that may arise during the project's execution. The 10% contingency is an industry standard, as it provides a balanced approach to managing risks while maintaining a realistic budget. Unpredictable costs, such as fluctuations in material prices, labor rates, or supply chain disruptions, can occur throughout the course of the project, and the contingency ensures adequate funds are available to address these variables.

The 20% engineering and administrative costs included in the proposal represent the overhead expenses associated with the planning, design, and management of the project. The engineering costs encompass design and planning, site analysis and surveys, permitting and regulatory compliance, as well as engineering oversight. The administrative costs primarily cover project management, office overhead, contract administration, and reporting and documentation. Including these costs in the overall estimate is essential to ensure the project can adequately address the necessary expenses for comprehensive planning, coordination, and technical management.

The housing total estimation was based on ten distinct sections: site work, foundations, framing, exterior walls, roofing, interiors, specialties, mechanical, electrical, and overhead and profit. The houses were classified as an average building class, which determined specific requirements for building type, garage type, and living area per square foot. The estimate was calculated using square footage units, with wood siding, an average item type, and item size. The living area unit cost was applied to calculate the total based on the area and specific requirements. Similarly, the basement unit cost, along with basement quantities, was used to determine the total basement area cost. The same approach was applied to the porch. To adjust for 2024 prices based on the 2019 RSMeans data book, the average cost per home is $424,312.50. The total cost to build housing units on the 38 lots is $16,609,500.

A 10% contingency factor was incorporated into the housing cost estimate to address potential unforeseen circumstances, such as fluctuations in material prices, labor rates, or supply chain disruptions. This industry-standard contingency ensures effective risk management while maintaining a realistic budget. Furthermore, the 20% engineering and administrative costs account for overhead expenses related to planning, design, project management, regulatory compliance, and continuous project coordination, ensuring adequate funds for comprehensive technical and administrative oversight. This approach is consistent with the site work calculations.

The overall total for this neighborhood development project, based on the line items specified in the cost estimate, amounts to $25,528,000.00.

Earthwork and Demolition	$308,100.00
Streets	$1,607,500.00
Storm Sewers	$181,000.00
Sanitary Sewers	$38,500.00
Water	$304,100.00
Bridge	$445,200.00
Site Work and Landscaping	$56,000.00
Site Preparation	$87,000.00
Contingencies at 10%	$302,700.00
Engineering Admin at 20%	$605,500.00
Total:	**$3,935,600.00**
House Construction	$16,609,500.00
Contingencies at 10%	$1,661,000.00
Engineering and Admin at 20%	$3,321,900.00
Total:	**$21,592,400.00**
Overall Total:	**$25,528,000.00**

Table 1: Summary of Cost Estimates

Appendices

Appendix A: Road Design

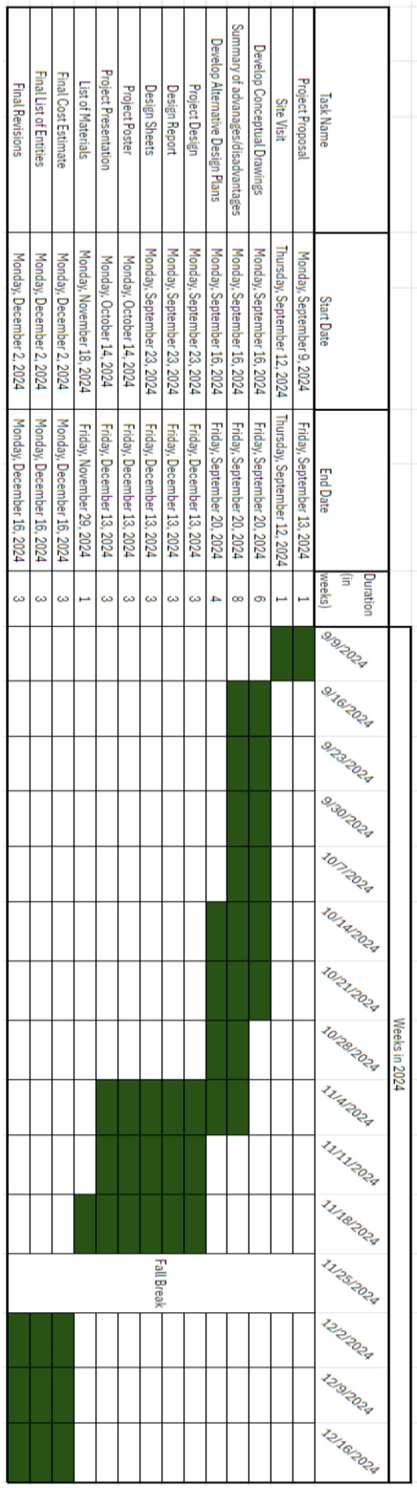


Figure 26: Gantt Chart

Chapter 5 - Roadway Design — Section 5C-1 - Geometric Design Tables

Table 5C-1.01: Preferred Roadway Elements

Elements Related to Functional Classification

Design Element	Local		Collector		Arterial	
	R	***C/I***	***R***	***C/I***	***R***	***C/I***
General						
Design level of service[1]	D	D	C/D	C/D	C/D	C/D
Lane width (single lane) (ft)[2]	10.5	12	12	12	12	12
Two-way left-turn lanes (TWLTL) (ft)	N/A	N/A	14	14	14	14
Width of new bridges (ft)[3]	See Footnote 3					
Width of bridges to remain in place (ft)[4]	----------	----------	----------	----------	----------	----------
Vertical clearance (ft)[5]	14.5	14.5	14.5	14.5	16.5	16.5
Object setback (ft)[6]	3	3	3	3	3	3
Clear zone (ft)	Refer to Table 5C-1.03, Table 5C-1.04, and 5C-1, C, 1					
Urban						
Curb offset (ft)[7]	2	2	2	3	3	3
Parking lane width (ft)	8	8	8	10	N/A	N/A
Roadway width with parking on one side[8]	26/27/31[9]	34	34	37	N/A	N/A
Roadway width without parking[10]	26	31	31	31	31	31
Raised median with left-turn lane (ft)[11]	N/A	N/A	19.5	20.5	20.5	20.5
Cul-de-sac radius (ft)	45/48[12]	45/48[12]	N/A	N/A	N/A	N/A
Rural Sections in Urban Areas						
Shoulder width (ft)						
ADT: under 400	4	4	6	6	10	10
ADT: 400 to 1,500	6	6	6	6	10	10
ADT: 1,500 to 2000	8	8	8	8	10	10
ADT: above 2,000	8	8	8	8	10	10
Foreslope (H:V)	4:1	4:1	4:1	4:1	6:1	6:1
Backslope (H:V)	4:1	4:1	4:1	4:1	4:1	4:1

R = Residential, C/I = Commercial/Industrial

Elements Related to Design Speed

Design Element	Design Speed, mph[13]							
	25	***30***	***35***	***40***	***45***	***50***	***55***	***60***
Stopping sight distance (ft)	155	200	250	305	360	425	495	570
Passing sight distance (ft)	900	1090	1,280	1,470	1,625	1,835	1,985	2,135
Min. horizontal curve radius (ft)[14]	198	333	510	762	1,039	926	1,190	1,500
Min. vertical curve length (ft)	50	75	105	120	135	150	165	180
Min. rate of vertical curvature, Crest (K)[15]	18	30	47	71	98	136	185	245
Min. rate of vertical curvature, Sag (K)	26	37	49	64	79	96	115	136
Minimum gradient (percent)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Maximum gradient (percent)	5	5	5	5	5	5	5	5

Note: For federal-aid projects, documentation must be provided to explain why the preferred values are not being met. For non-federal aid projects, the designer must contact the Jurisdiction to determine what level of documentation, if any, is required prior to utilizing design values between the "Preferred" and "Acceptable" tables.

Figure 27: SUDAS Preferred Roadway Elements

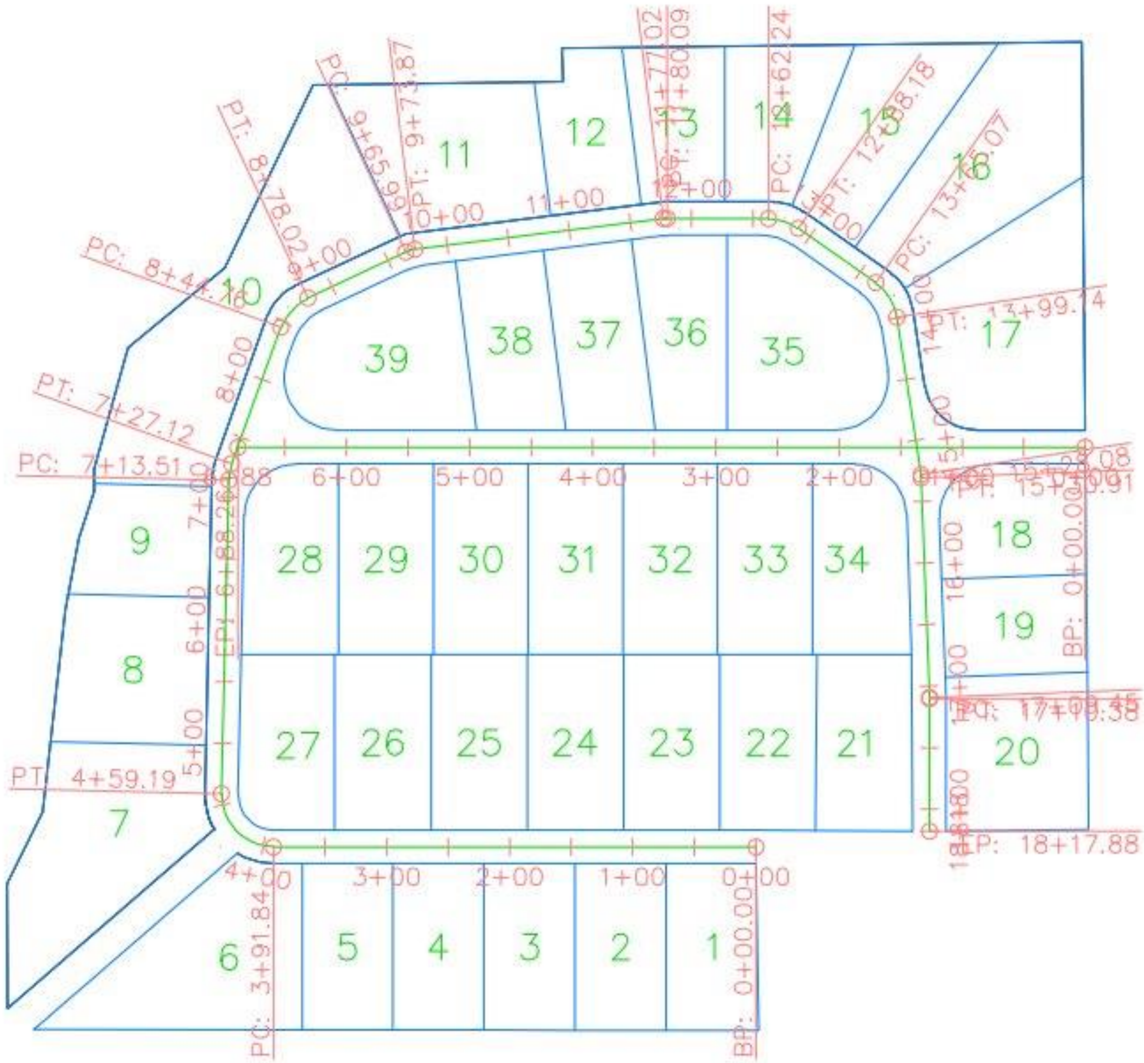


Figure 28: Horizontal Alignments

Appendix B: Plot & House Design

	R-1	R-2	R-3	R-4
Minimum Front Setback	35 ft.	1 or 1.5 stories - 30 ft. 2 or 2.5 stories - 32 ft.	20 ft.	1 to 3.5 stories - 35 ft. 4 to 4.5 stories - 40 ft. 5 to 5.5 stories - 45 ft. 6 stories - 50 ft.
Minimum Rear Setback	35 ft. (or 10 ft. for accessory buildings)	35 ft.	35 ft.	1 to 2.5 stories - 30 ft. 3 to 3.5 stories - 35 ft. 4 to 4.5 stories - 40 ft. 5 to 5.5 stories - 45 ft. 6 stories - 50 ft.
Minimum Side Setback - Least Width	n/a	1 or 1.5 stories - 7 ft. 2 or 2.5 stories - 9 ft.	1 or 1.5 stories - 6 ft. 2 or 2.5 stories - 8 ft.	1 to 2.5 stories - 6 ft. 3 to 3.5 stories - 9 ft. 4 to 4.5 stories - 11 ft. 5 to 5.5 stories - 16 ft. 6 stories - 18 ft.
Minimum Side Setback - Sum Least Width		1 or 1.5 stories - 16 ft. 2 or 2.5 stories - 20 ft. 1 or 1.5 stories - 16 ft. 2 or 2.5 stories - 20 ft.	1 or 1.5 stories - 14 ft. 2 or 2.5 stories - 18 ft.	

Figure 29: Local Housing Ordinances

	R-1	R-2	R-3	R-4
Minimum Lot Area per Dwelling unit	20,000 SF	7,500 SF	Single-family: 7,000 SF Two-family: 5,000 SF per unit	Single-family: 6,000 SF Two-family: 5,000 SF Townhome/Condo: 3,500 SF Apartment: 2,000 SF Studio/Efficiency Apartment: 1,500 SF
Minimum Lot Width	100 ft.	70 ft.	70 ft.	1 to 4.5 stories - 70 ft. 5 to 5.5 stories - 85 ft. 6 stories - 100 ft.
Maximum Height - Principal Building	3 stories (45 ft.)	2.5 stories (30 ft.)	2.5 stories (30 ft.)	6 stories (75 ft.)
Maximum Height - Accessory Building	1.5 stories (22 ft.)	1 story (18 ft.)	1 story (18 ft.)	n/a
Minimum Street Frontage	50 ft.	50 ft.	37.5 ft.	n/a

Figure 30: Local Zoning Ordinances

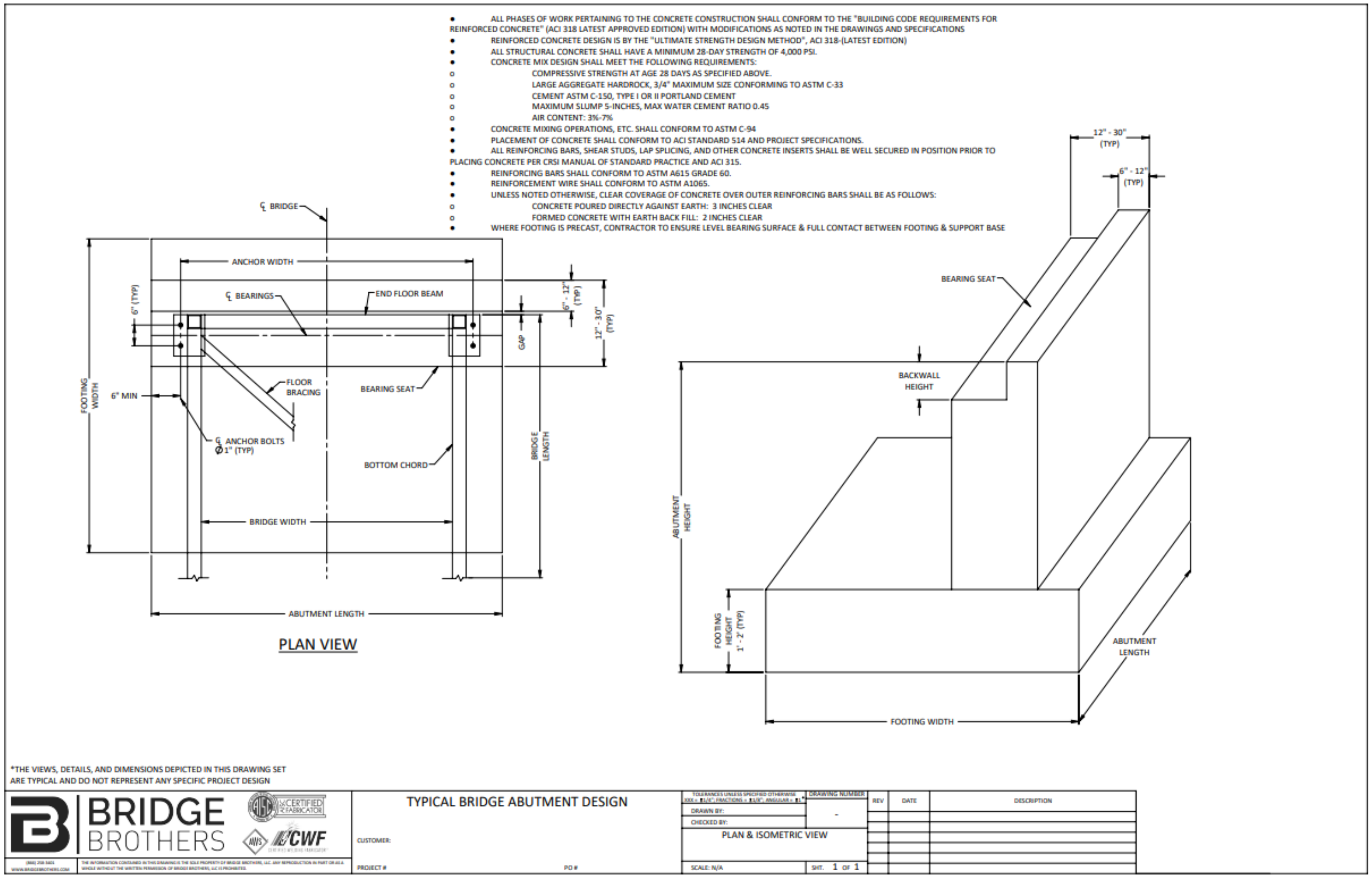
3. Permitted Accessory Uses.

	R-1	R-2	R-3	R-4	R-5
Private garages or parking areas limited to one detached garage per lot.	X	X	X	X	

Figure 31: Parking Garages

Appendix C: Trail & Bridge Design

Figure 32: Trail Location



• ALL PHASES OF WORK PERTAINING TO THE CONCRETE CONSTRUCTION SHALL CONFORM TO THE "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" (ACI 318 LATEST APPROVED EDITION) WITH MODIFICATIONS AS NOTED IN THE DRAWINGS AND SPECIFICATIONS
• REINFORCED CONCRETE DESIGN IS BY THE "ULTIMATE STRENGTH DESIGN METHOD", ACI 318-(LATEST EDITION)
• ALL STRUCTURAL CONCRETE SHALL HAVE A MINIMUM 28-DAY STRENGTH OF 4,000 PSI.
• CONCRETE MIX DESIGN SHALL MEET THE FOLLOWING REQUIREMENTS:
o COMPRESSIVE STRENGTH AT AGE 28 DAYS AS SPECIFIED ABOVE.
o LARGE AGGREGATE HARDROCK, 3/4" MAXIMUM SIZE CONFORMING TO ASTM C-33
o CEMENT ASTM C-150, TYPE I OR II PORTLAND CEMENT
o MAXIMUM SLUMP 5-INCHES, MAX WATER CEMENT RATIO 0.45
o AIR CONTENT: 3%-7%
• CONCRETE MIXING OPERATIONS, ETC. SHALL CONFORM TO ASTM C-94
• PLACEMENT OF CONCRETE SHALL CONFORM TO ACI STANDARD 514 AND PROJECT SPECIFICATIONS.
• ALL REINFORCING BARS, SHEAR STUDS, LAP SPLICING, AND OTHER CONCRETE INSERTS SHALL BE WELL SECURED IN POSITION PRIOR TO PLACING CONCRETE PER CRSI MANUAL OF STANDARD PRACTICE AND ACI 315.
• REINFORCING BARS SHALL CONFORM TO ASTM A615 GRADE 60.
• REINFORCEMENT WIRE SHALL CONFORM TO ASTM A1065.
• UNLESS NOTED OTHERWISE, CLEAR COVERAGE OF CONCRETE OVER OUTER REINFORCING BARS SHALL BE AS FOLLOWS:
o CONCRETE POURED DIRECTLY AGAINST EARTH: 3 INCHES CLEAR
o FORMED CONCRETE WITH EARTH BACK FILL: 2 INCHES CLEAR
• WHERE FOOTING IS PRECAST, CONTRACTOR TO ENSURE LEVEL BEARING SURFACE & FULL CONTACT BETWEEN FOOTING & SUPPORT BASE
℄ BRIDGE
ANCHOR WIDTH
℄ BEARINGS
END FLOOR BEAM
6" (TYP)
6" - 12" (TYP)
12" - 30" (TYP)
GAP
FLOOR BRACING
BEARING SEAT
FOOTING WIDTH
6" MIN
℄ ANCHOR BOLTS
Ø1" (TYP)
BOTTOM CHORD
BRIDGE LENGTH
BRIDGE WIDTH
ABUTMENT LENGTH
PLAN VIEW
12" - 30" (TYP)
6" - 12" (TYP)
BEARING SEAT
BACKWALL HEIGHT
ABUTMENT HEIGHT
FOOTING HEIGHT 1' - 2' (TYP)
ABUTMENT LENGTH
FOOTING WIDTH
*THE VIEWS, DETAILS, AND DIMENSIONS DEPICTED IN THIS DRAWING SET ARE TYPICAL AND DO NOT REPRESENT ANY SPECIFIC PROJECT DESIGN
BRIDGE BROTHERS
CWF
TYPICAL BRIDGE ABUTMENT DESIGN
CUSTOMER:
PROJECT #
PO #
DRAWING NUMBER
DRAWN BY:
CHECKED BY:
PLAN & ISOMETRIC VIEW
SCALE: N/A
SHT. 1 OF 1
REV
DATE
DESCRIPTION

Figure 33: Bridge Brothers Abutment

BRIDGE BROTHERS

e:sales@bridgebrothers.com
t: 866.258.3401

www.bridgebrothers.com

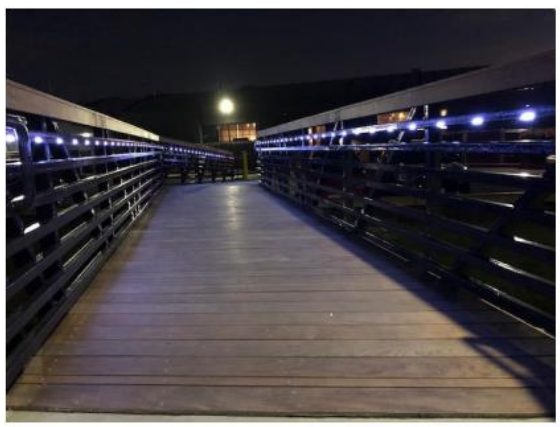
Bridge Brothers Rope Lighting Specification:

- New Oyster white 2-Wire PVC soft tubing:
High flexibility, Brighter and fascinating lighting effect, temperature sustainability, UV resistance and IP65 waterproof protection

- Extremely super bright LED lights, at least 50,000 hours long life span
- Can be cut every 19 11/16" (50 cm) at marked intervals
- Low power consumption and energy efficient
- 2pcs 4" Long and 3pcs 2" Short PVC waterproof tube covers for reinforcing the cuts
- 2 PVC splice connectors and 6 pins for easy reconnection
- UL listed and CE certificated plug and wire for safe using

Specifications:

- Color: Cool White
- Maximum Run: 50 ft (15 m)
- Color Temp.: 7000k
- Total Flux: 4000-4500 mcd
- LED Bulbs Quantity: 1200
- Bulb: 1/8" (3 mm) Dia., 1/2" (12.5 mm) Bulb Spacing
- Tube Diameter: 1/2" (13 mm) Dia.
- Beam Angle: 160 degree
- Rated Life Span: 50,000 hours
- Power: 110V
- Power Consumption: 4.8W/meter (About 72W)
- Working Temperature: -20°C to 50°C (-4°F to 122°F)
- Each Spare Power Cord Length: 5 ft (1.5m)



TURN KEY PREFABRICATED BRIDGES

Figure 34: Bridge Brothers Lighting

Appendix D: Sanitary Design

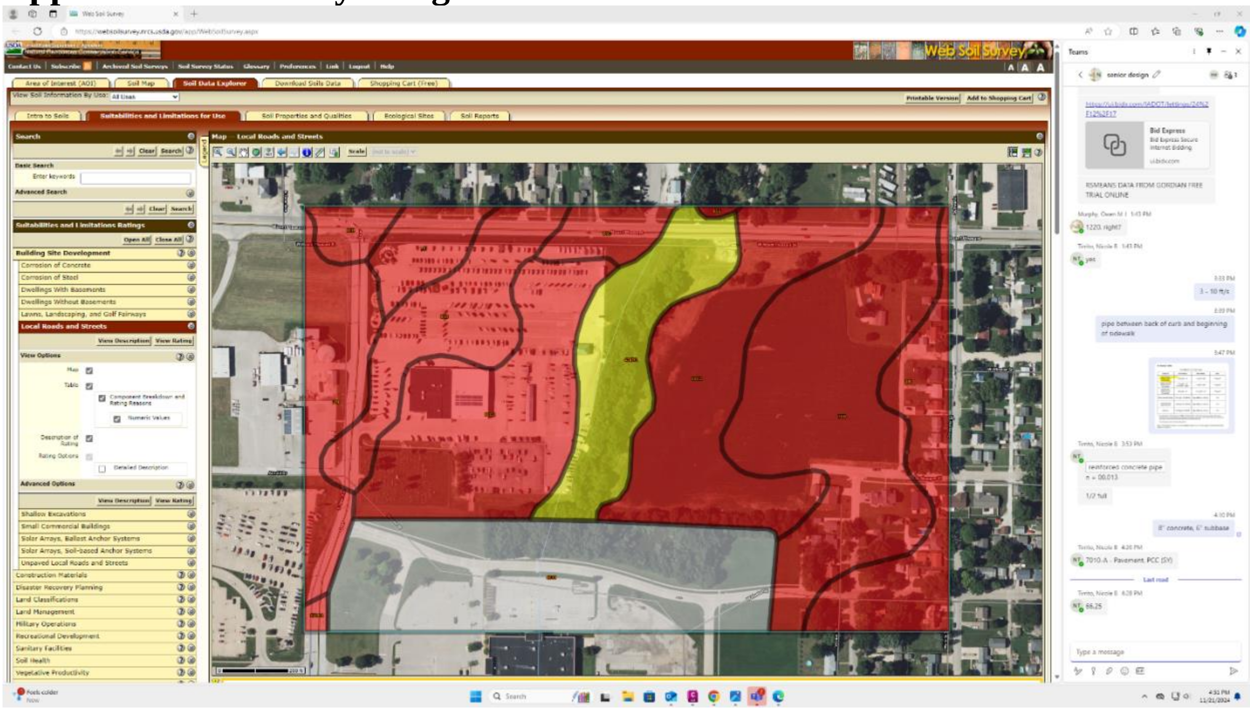


Figure 35: Land-Soil

Sanitary Sewers Design Period

The length of time used in forecasting flows and setting capacities of the sanitary sewer is called the design period. The design period is related to the planning horizon for development of the project area and the expected life of the sanitary sewer pipe. In some cases, no specific planning horizon is identified. Instead the build-out population or land use is used. This is the maximum population and/or commercial and industrial development that could occur within the project area and beyond, if appropriate. The flows are determined based on that population or land use development without regard to time frames.

For residential development, the flows can be predicted using the following densities:

1. **Discharge (Q) Average Daily Flow (minimum):**

   Area x Area Density x Flow Rate = Average Daily Flow **Equation 3B-1.01**

   Number of Units x Unit Density x Flow Rate = Average Daily Flow **Equation 3B-1.02**

2. **Discharge (Q) Peak Sewer Flow (minimum):** Average daily flow times ratio of peak to average daily flow (See Figure 3B-1.01 for ratio). NOTE: Population values shown in Figure 3B-1.01 are based on the area that discharges into the sewer.

3. **Design Density and Rate:** See Table 3B-1.01.

Figure 36: Flow Determination

Density Table

Table 3B-1.01: Minimum Values

Land Use	Area Density	Unit Density	Rate
Low Density (Single Family) Residential	10 people / AC	3 people / unit	100 gpcd*
Medium Density (Multi-Family) Residential	15 people / AC 6.0 people / duplex	3 people / unit	100 gpcd*
High Density (Multi-Family) Residential	30 people / AC	2.5 people / unit	100 gpcd*
Office and Institutional	5,000 gpd / AC (IDNR)	Special Design Density	N/A
Commercial and Light Industrial	5,000 gpd/AC (IDNR)	Special Design Density	N/A
Industrial	10,000 gpd/AC (IDNR)	Special Design Density	N/A

* Iowa Department of Natural Resources (DNR) - Dry Weather Flow - One hundred gallons per capita per day (gpcd) should be used in design calculations as the minimum average dry weather flow. This 100 gpcd value may, with adequate justification, include maximum allowable infiltration for proposed sewer lines.

The area densities listed include the peaking factor.

Figure 37: Rate Based on Density

Manning's Roughness Coefficient

The roughness coefficient to be used is $n = 0.013$. This coefficient is for all types of approved pipe materials.

Figure 38: Manning's Coefficient (n)

Minimum Grade

See Table 3C-1.01 below for the minimum slopes for each pipe diameter. Minimum grade on sanitary sewer service stubs should be 1/8 inch per foot.

Table 3C-1.01: Minimum Slope

Pipe Size (inches)	Minimum Slope (ft/100 ft)
8	0.40
10	0.28
12	0.22
15	0.15
18	0.12
21	0.10
24	0.08
27	0.067
30	0.058
36	0.046

Figure 39: Minimum Grade

Size of Sewer Pipe

Gravity public sanitary sewers should not be less than 8 inches in diameter. Minimum size of building sanitary sewer stub should be 4 inches in diameter for residential and 6 inches in diameter for commercial. The size will increase based on the proposed number of fixtures that the sewer stub serves.

Figure 40: Size of Sanitary Sewer Pipes

Depth of Sewer

Gravity sewers should be deep enough to serve basements, assuming a 2% grade plus adequate allowance for pipe fittings on house sewers (absolute minimum of 1%). They should have a minimum depth to the top of pipe of 8 feet unless the sewer can serve existing basements at a lesser

Figure 41: Depth of Sewer

1. **Sanitary Sewers in Street Right-of-way:**

   a. Sanitary sewers parallel to the right of way may be placed in the center of the street or behind the back of curb. Contact Jurisdiction for allowable location.

   b. Sanitary sewers perpendicular to the street should follow Iowa DNR clearance requirements between storm sewer, water mains, and other utilities.

2. **Sanitary Sewers Outside of Street Right-of-way:**

   a. Sanitary sewers will be placed in a sanitary sewer public easement. Public sanitary sewer easements should have a minimum total width of 20 feet or two times the depth of the sewer, whichever is greater, with the sanitary sewer centered in the easement. Additional width may be required by the Jurisdictional Engineer to insure proper access for maintenance equipment.

   b. Provisions must be made to provide public access to the sanitary sewer easements from public streets.

Figure 42: Location of Sewers

2. **Standard Manhole:** The minimum size for a manhole is 48 inches in diameter. Most Jurisdictions require eccentric manholes with the manhole opening over the centerline of the pipe or on an offset not to exceed 12 inches. The remaining Jurisdictions allow for concentric manholes. Check with Jurisdictional Engineer regarding use of eccentric and concentric manholes and built-in steps.

Figure 43: Size of Manhole

Table 3D-1.01: Sanitary Sewer Pipe Materials

Typical Application	Pipe Material	Size Range	Standard	Thickness Class (min.)	Pipe Stiffness (min.)	Joints
Gravity Flow	Solid Wall PVC	8” to 15”	ASTM D 3034	SDR 26	115 psi	Bell and Spigot
Gravity Flow	Solid Wall PVC	8” to 15”	ASTM D 3034	SDR 35	46 psi	Bell and Spigot
Gravity Flow	Solid Wall PVC	18” to 27”	ASTM F 679	N/A	46 psi	Bell and Spigot
Gravity Flow	Corrugated PVC	8” to 10”	ASTM F 949	N/A	115 psi	Bell and Spigot
Gravity Flow	Corrugated PVC	12” to 36”	ASTM F 949	N/A	46 psi	Bell and Spigot
Gravity Flow	Closed Profile PVC	21” to 36”	ASTM F 1803	N/A	46 psi	Bell and Spigot
Gravity Flow	Truss Type PVC	8” to 15”	ASTM D 2680	N/A	200 psi	Bell and Spigot
Gravity Flow	RCP	18” to 144”	ASTM C 76	Class IV Wall B	4,000 psi	Tongue and Groove
Gravity Flow	Ductile Iron	8” to 54”	AWWA C151	Class 52	300 psi	MJ or Push on
Gravity Flow	VCP	8” to 42”	ASTM C 700	N/A	N/A	Bell and Spigot
Gravity Flow	Double Walled Polypropylene	12” to 30”	ASTM F 2736	N/A	46 psi	Bell and Spigot
Gravity Flow	Triple Walled Polypropylene	30” to 36”	ASTM F 2764	N/A	46 psi	Bell and Spigot
Force Main	Ductile Iron	4” to 64”	AWWA C151	Class 52	300 psi	MJ or Push on
Force Main	PVC	4” to 30”	AWWA C 900	DR 18	150 psi	Bell and Spigot

Figure 44: Pipe Materials

# lots	people/unit	rate (gallons per capita per day)	total Q (gallons per day)		Q (ft^3/s)	D (ft)	D (in)	final pipe D (in)	length of pipe (ft)
13	3	100	3900		0.006034349	0.068843	0.826114	8	388.9359
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	128.2551
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	128.2551
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	128.2551
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	128.2551
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	128.2551
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	128.2551
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	128.2551
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	33.8635
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	33.8635
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	33.8635
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	33.8635
1	3	100	300	*lateral	0.000464181	0.026311	0.315733	8	33.8635
4	3	100	1200		0.001856723	0.044250	0.530998	8	273.3911
3	3	100	900		0.001392542	0.039725	0.476695	8	205.0811
2	3	100	600		0.000928361	0.034121	0.409456	8	25.6348
2	3	100	600		0.000928361	0.034121	0.409456	8	21.2425
3	3	100	900		0.001392542	0.039725	0.476695	8	161.6331
							total pipe length (ft)		2144

Figure 45: Sanitary Sewer Sizing

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [SI]$$

Equation 1: Manning's Equation

Appendix E: Stormwater Design

Table 2B-2.01: Chance of a Storm Equaling or Exceeding a Given Frequency During a Given Time Period

Return Period (years)	Time Period in Years					
	1	***5***	***10***	***25***	***50***	***100***
2	50%	97%	99.9%	99.9%	99.9%	99.9%
5	20%	67%	89%	99.6%	99.9%	99.9%
10	10%	41%	65%	93%	99%	99.9%
25	4%	18%	34%	64%	87%	98%
50	2%	10%	18%	40%	64%	87%
100	1%	5%	10%	22%	40%	63%

Figure 46: Chance of a Storm Equaling or Exceeding a Given Frequency During a Given Time Period

Figure 2B-2.01: Climatic Sectional Codes for Iowa

1 - Northwest	4 - West Central	7 - Southwest
2 - North Central	5 - Central	8 - South Central
3 - Northeast	6 - East Central	9 - Southeast

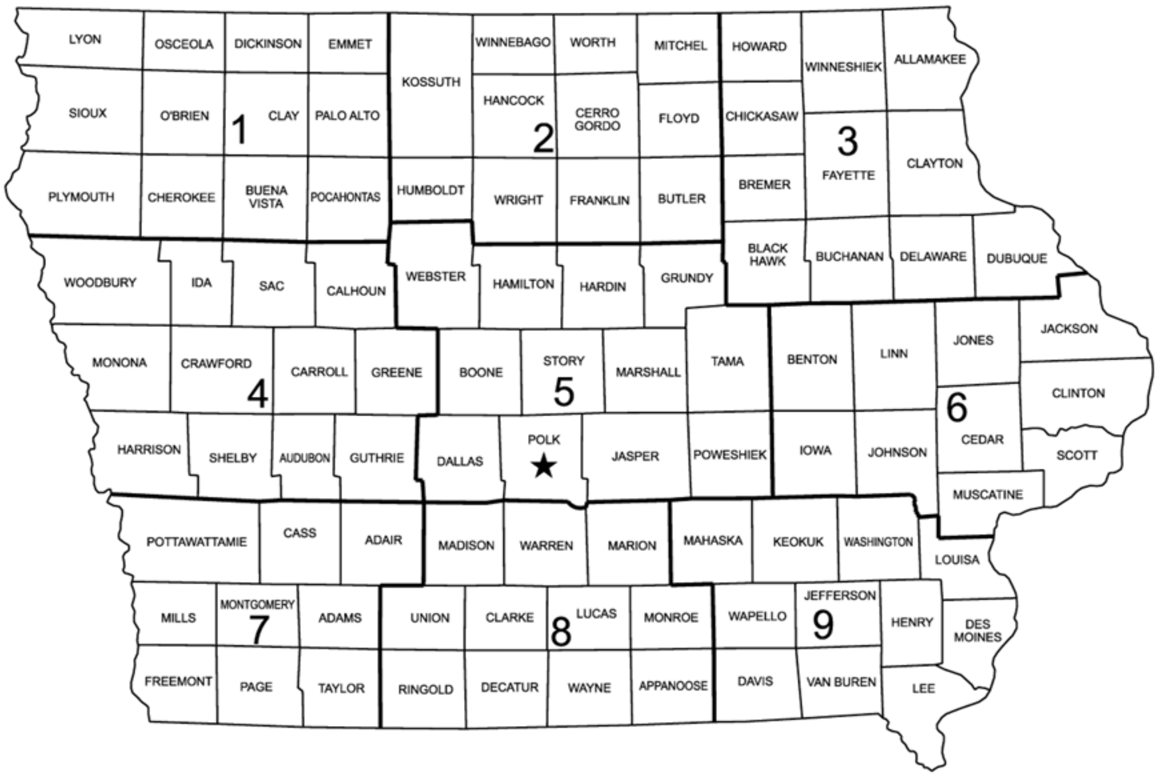


Figure 47: Climatic Sectional Codes

Table 2B-2.10: Section 9 - Southeast Iowa
Rainfall Depth and Intensity for Various Return Periods

	**Return Period**															
	1 year		***2 year***		***5 year***		***10 year***		***25 year***		***50 year***		***100 year***		***500 year***	
Duration	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***
5 min	0.38	4.57	0.44	5.33	0.54	6.58	0.64	7.68	0.76	9.22	0.87	10.4	0.97	11.7	1.24	14.8
10 min	0.55	3.34	0.65	3.9	0.80	4.82	0.93	5.62	1.12	6.76	1.27	7.66	1.43	8.60	1.81	10.8
15 min	0.68	2.72	0.79	3.17	0.98	3.93	1.14	4.57	1.37	5.49	1.55	6.23	1.74	6.98	2.21	8.85
30 min	0.95	1.9	1.11	2.22	1.38	2.76	1.61	3.22	1.94	3.88	2.20	4.40	2.46	4.93	3.12	6.25
1 hr	1.23	1.23	1.43	1.43	1.78	1.78	2.09	2.09	2.54	2.54	2.90	2.90	3.28	3.28	4.24	4.24
2 hr	1.51	0.75	1.76	0.88	2.19	1.09	2.58	1.29	3.14	1.57	3.61	1.80	4.10	2.05	5.35	2.67
3 hr	1.68	0.56	1.96	0.65	2.45	0.81	2.89	0.96	3.54	1.18	4.08	1.36	4.66	1.55	6.15	2.05
6 hr	1.99	0.33	2.32	0.38	2.91	0.48	3.44	0.57	4.25	0.70	4.92	0.82	5.63	0.93	7.50	1.25
12 hr	2.31	0.19	2.71	0.22	3.41	0.28	4.03	0.33	4.96	0.41	5.74	0.47	6.56	0.54	8.68	0.72
24 hr	2.68	0.11	3.12	0.13	3.90	0.16	4.59	0.19	5.62	0.23	6.46	0.26	7.35	0.30	9.64	0.40
48 hr	3.12	0.06	3.58	0.07	4.39	0.09	5.11	0.10	6.18	0.12	7.06	0.14	7.98	0.16	10.3	0.21
3 day	3.41	0.04	3.9	0.05	4.73	0.06	5.47	0.07	6.56	0.09	7.45	0.10	8.39	0.11	10.7	0.14
4 day	3.66	0.03	4.16	0.04	5.02	0.05	5.78	0.06	6.88	0.07	7.78	0.08	8.72	0.09	11.0	0.11
7 day	4.33	0.02	4.87	0.02	5.79	0.03	6.59	0.03	7.72	0.04	8.63	0.05	9.57	0.05	11.8	0.07
10 day	4.95	0.02	5.54	0.02	6.54	0.02	7.38	0.03	8.57	0.03	9.51	0.03	10.4	0.04	12.8	0.05

D = Total depth of rainfall for given storm duration (inches)
I = Rainfall intensity for given storm duration (inches/hour)

Figure 48: Intensity

Table 2B-3.03: Manning's Roughness Coefficients (n) for Open Channel Flow

Type of Channel and Description	n
A. Closed Conduits Flowing Partly Full	
1. Steel - Riveted and Spiral	0.016
2. Cast Iron - Coated	0.013
3. Cast Iron - Uncoated	0.014
4. Corrugated Metal - Subdrain	0.019
5. Corrugated Metal - Storm Drain	0.024
6. Concrete Culvert, straight and fee of debris	0.011
7. Concrete Culvert, with bends, connections, and some debris	0.013
8. Concrete Sewer with manholes, inlet, etc., straight	0.015
9. Concrete, Unfinished, steel form	0.013
10. Concrete, Unfinished, smooth wood form	0.014
11. Wood - Stave	0.012
12. Clay - Vitrified sewer	0.014
13. Clay - Vitrified sewer with manholes, inlet, etc.	0.015
14. Clay - Vitrified subdrain with open joints	0.016
15. Brick - Glazed	0.013
16. Brick - Lined with cement mortar	0.015
B. Lined or Built-Up Channels	
1. Corrugated Metal	0.025
2. Wood - Planed	0.012
3. Wood - Unplaned	0.013
5. Concrete - Trowel finish	0.013
6. Concrete - Float finish	0.015
7. Concrete - Finished, with gravel on bottom	0.017
8. Concrete - Unfinished	0.017
9. Concrete Bottom Float Finished with sides of:	
a. Random stone in mortar	0.020
b. Cement rubble masonry	0.025
c. Dry ruble or rip rap	0.030
10. Gravel Bottom with sides of:	
a. Formed concrete	0.020
b. Dry rubble or rip rap	0.033
11. Brick - Glazed	0.013
12. Brick - In cement mortar	0.015
13. Masonry Cemented Rubble	0.025
14. Dry Rubble	0.032
15. Smooth Asphalt	0.013
16. Rough Asphalt	0.016
C. Excavated or Dredged Channel	
1. Earth, straight and uniform	
a. Clean, after weather	0.022
b. Gravel, uniform section, clean	0.025
c. With short grass, few weeds	0.027
2. Earth, winding and sluggish	
a. No vegetation	0.025
b. Grass, some weeds	0.030
c. Dense weeds or aquatic plants in deep channels	0.035
d. Earth bottom and rubble sides	0.030
e. Stony bottom and weedy banks	0.040
3. Channels not maintained, weeds and brush uncut	
a. Dense weeds, high as flow depth	0.080
b. Clean bottom, brush on sides	0.050
D. Natural Streams	
1. Clean, straight bank, full stage, no rifts or deep pools	0.030
2. As D.1 above, but some weeds and stones	0.035
3. Winding, some pools and shoals, clean	0.040
4. As D.3 above, but lower stages, more ineffective slope and sections	0.045
5. As D.3 above, but some weeds and stones	0.048
6. As D.4 above, but with stony sections	0.050
7. Sluggish river reaches, rather weedy or with very deep pools	0.070
8. Very weedy reaches	0.100

Source: Chow, V.T. 1959

Figure 49: Manning's Coefficient (OCF)

Chapter 2 - Stormwater — Section 2B-4 - Runoff and Peak Flow

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.

Figure 50: Runoff Coefficients

paths	contributing area (ft^2)	contributing area (acre)	Q (ft^3/s)	Q full flow (ft^3/s)	D (ft)	D (in)	final pipe D (in)	length of pipe (ft)	A (ft^2)	V (ft/s)
21->2->4	75631.7891	1.736266967	4.443	4.75401	0.839516	10.07419	15	534.2589	0.553539	8.026542
13-> 18->8->6	74208.713	1.703597635	4.361	4.66627	0.833672	10.00406	15	780.4489	0.545859	7.989246
19	10655.0206	0.244605615	0.627	0.67089	0.402834	4.834008	15	87.0014	0.127451	4.91955
20	37895.4661	0.869960195	2.226	2.38182	0.647847	7.774164	15	128.0952	0.329636	6.752901
23	19261.5308	0.442183903	1.131	1.21017	0.502573	6.030876	15	97.4884	0.198376	5.701307
						total pipe length (ft)		1628		

Figure 51: Stormwater Pipe Sizing

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