THE UNIVERSITY OF IOWA
IOWA INITIATIVE FOR SUSTAINABLE COMMUNITIES

FINAL DELIVERABLE

Title	Maquoketa Single Family Subdivision and Drainage Plan
Completed By	Brittany Cunningham, Ethan Myers, Justin Spiekermann, and Robert Yerushalmi
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Instructor	Rick Fosse
Community Partners	City of Maquoketa

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Completed by: Brittany Cunningham, Ethan Myers, Justin Spiekermann, and Robert Yerushalmi

May 2023

Faculty Advisor: Richard Fosse

Department of Civil & Environmental Engineering

Client: City of Maquoketa, IA

Table of Contents

Section I – Executive Summary

The City of Maquoketa has requested a subdivision and drainage development plan using a set of 5 parcels in the eastern part of town. The project is bounded by E Platt Street to the north and E Maple Street to the South. The plans that were developed include a housing layout, a drainage plan, and a utility plan. The plan quantifies the value of the different aspects included in the development of this property. The overall cost ($4,471,000) of this proposed site design is displayed in the tables below. There are two phases to this project, the total cost of phase one is $3,344,500, and the cost of infrastructure per lot is $78,000. The total cost of phase two is $1,258,800, and the cost of infrastructure per lot is $57,000. Further breakdown of individual unit costs for each area of the proposal can be found in Appendix D. The higher cost per lot in phase one can be attributed to some of the streets not being able to have lots on both sides and off-site drainage improvements. Phase one has 42 lots and phase two has 21 lots, Figure 1.1 illustrates the different phases for this project. With the high costs of each lot, this project may not be considered feasible for affordable housing unless outside funding is obtained.

Table 1.1: Total Construction Cost Estimate for Phase One of the project

Site Work and Paving	$1,579,500
Storm Sewer	$514,000
Sanitary Sewer	$285,000
Water Main	$409,000
Contingencies	20%
Number of Lots	42
Total Construction Cost Estimate	**$3,268,000**
Cost of Infrastructure per lot	$78,000

Table 1.2: Total Construction Cost Estimate for Phase Two of the project

Site Work and Paving	$622,000
Storm Sewer	$185,500
Sanitary Sewer	$92,500
Water Main	$149,000
Contingencies	20%
Number of Lots	21
Total Construction Cost Estimate	**$1,203,000**
Cost of Infrastructure per lot	$57,000

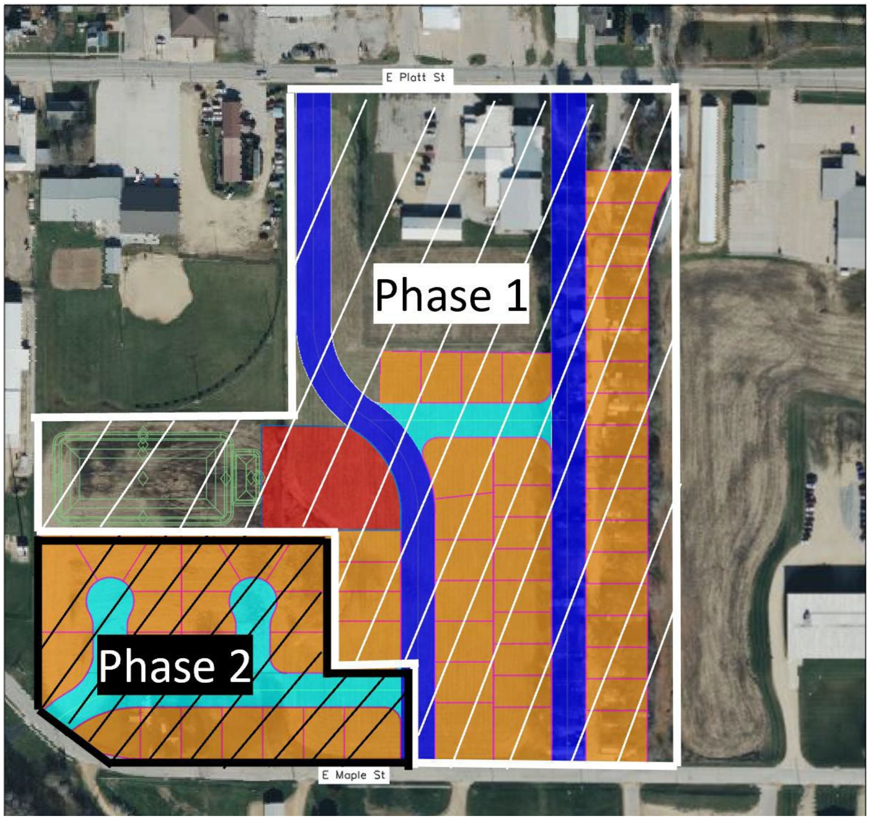


Figure 1.1: Phasing plan of 1015 E Platt St Subdivision

Designing a subdivision that can accommodate affordable housing was one of the main goals of the project for the client. They requested a focus on dense development to keep the cost down and increase the number of families that can live there. The City of Maquoketa has many residents who choose to live there for its affordable cost of living and commuting to work in another city. For this reason, developing affordable housing is important to increase the draw of new residents.

The team decided on three different types of housing options to implement on the site. The first is a double wide manufactured home that is on the east side of the site. The client preferred the double wide to the single wide as it gave it less of a mobile home feel. The lots for this were developed according to the zoning code and can be seen in section VI of the report. The second type of house is the modular home, which is the most used home within the design. The team also implemented a small stick-built home into the design. Not many of these were incorporated as they are costlier, but the client wanted a variety of homes throughout the neighborhood.

The final selected roadway design was based on SUDAS standards, the Iowa Department of Transportation AASHTO green book, and the standard pavement cross section for new developments in Maquoketa. The main design details of the road network that was created is the use of hot mix asphalt (HMA) pavement with a 3” thickness, a 10” modified subbase, along with a 12” subgrade preparation. The proposed development also involves 4-inch-thick Portland cement concrete sidewalk pavement, as well as 2-foot curb and gutter also using Portland cement concrete (PCC). This pavement design is used throughout the site, on both the collector as well as local roads, as these are the only two types of roads in the proposed development.

After finalizing pavement and curb design, the final horizontal roadway concept layout was drawn and is shown below in Figure 1.2. The dark blue represents collector roads, and the light blue represents local roads. Connections to existing roads take into account safe site distances to allow vehicles to turn onto existing roadways as well as into proposed roadways.

The roadway curves and connections utilize the existing site to its maximum potential in terms of comfortably fitting as many single-family parcels as possible. The two collector roads along with the respective local through road connecting them are planned to be part of phase one of the project, while the local cul-de-sac roads to the southwest are planned to be a part of a future phase two as it entails acquisition of a current resident’s property. The vertical roadway design follows the existing topography as close as possible to reduce fill costs, while still following SUDAS standards for an urban residential 25 mile per hour zone. The grading of the road complements the proposed drainage plan. Roads were graded so that stormwater runoff would travel towards the north on both collector roads and connect runoff to the existing storm sewer under Platt Street. This helped our drainage plan by taking some of the storm volume away from the proposed temporary detention basin so there was no risk of overtopping and flooding the existing open channel around the electric utility building.

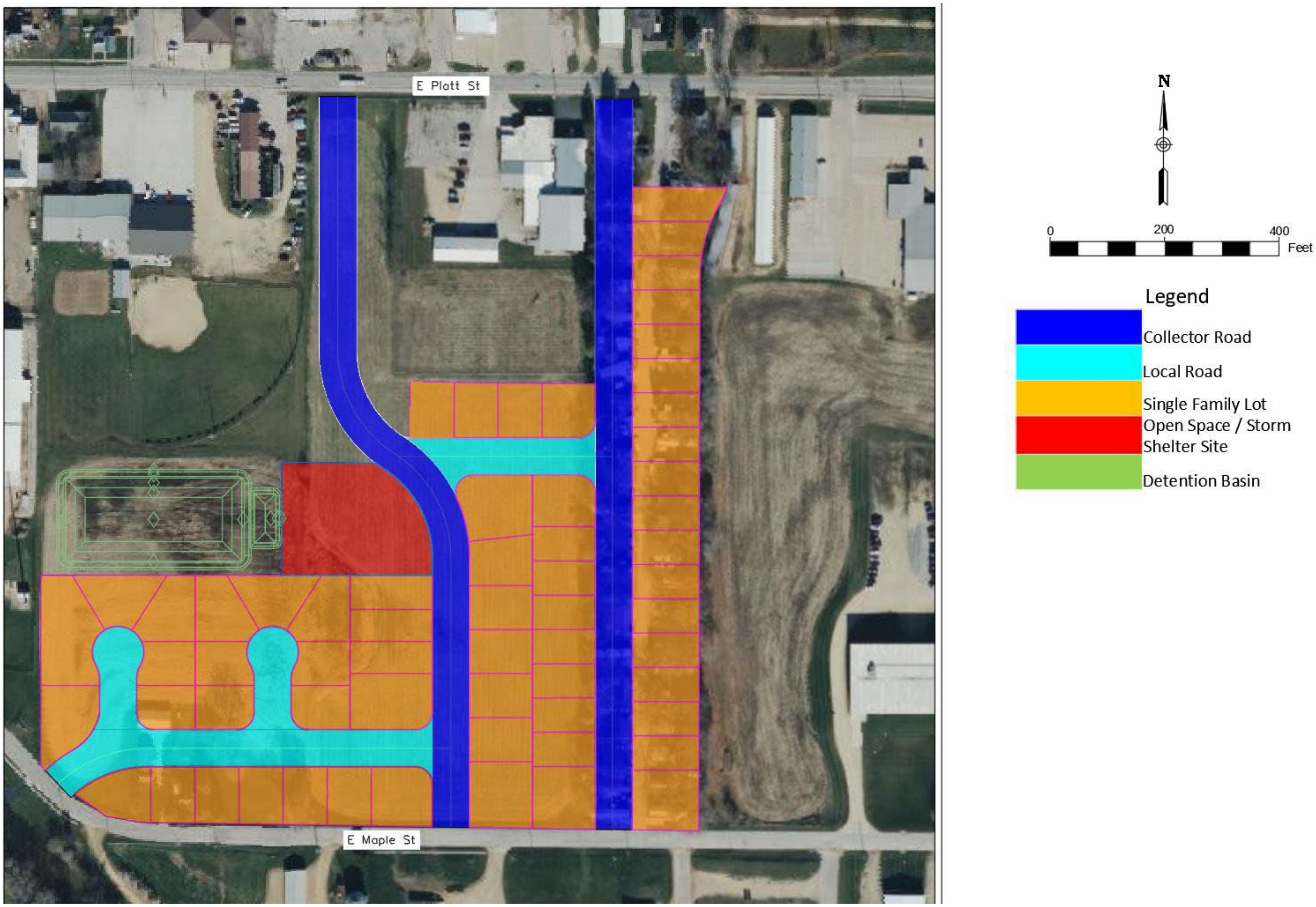


Figure 1.2: Final Roadway layout of 1015 E. Platt St

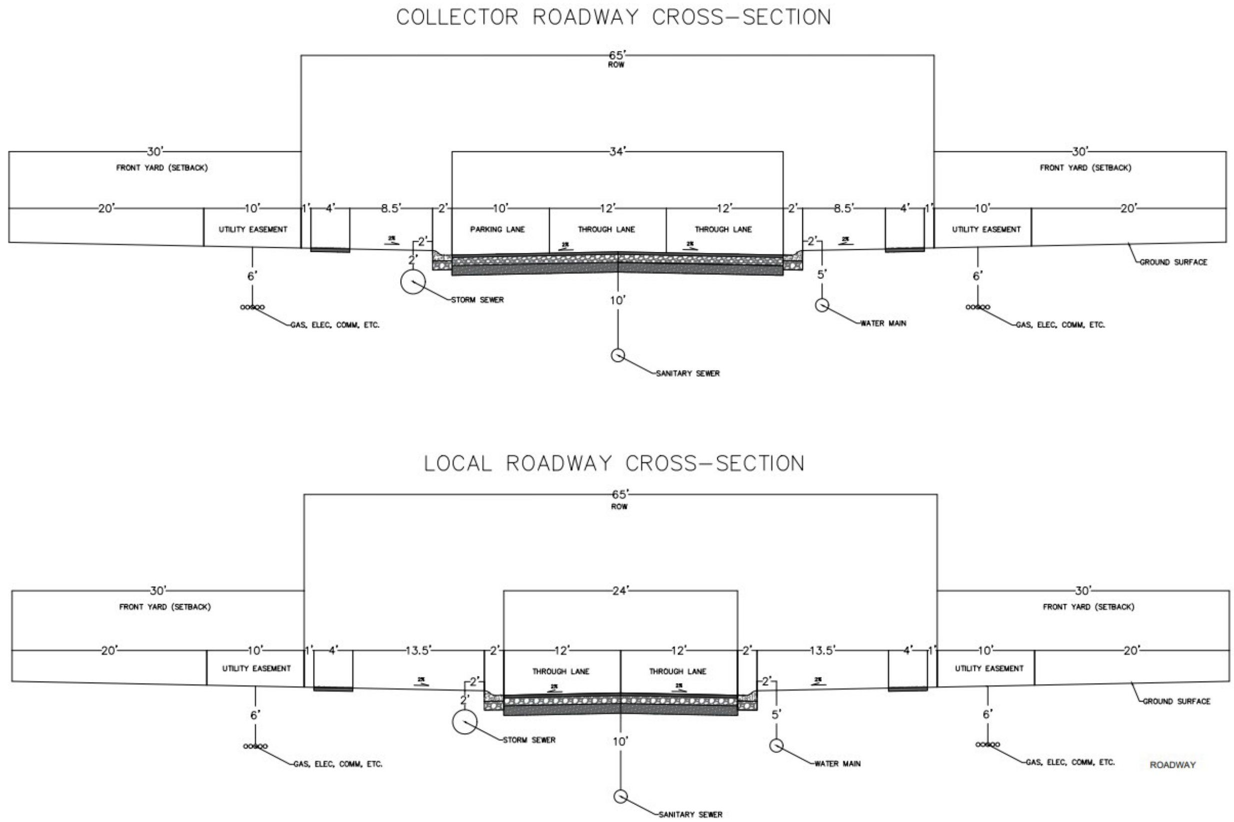


Figure 1.3 - Road Cross Sections

Runoff was calculated based on the NRCS method using WinTR-55 to simulate 24-hr rainfall depth for zone 6 (east central Iowa). Time of concentration was found using the NRCS velocity method for pre-settlement conditions, existing conditions, and post-development conditions. The required storage volume for the temporary detention basin was calculated by using the flows from the pre-settlement conditions and the post-development conditions found from WinTR-55 modeling. Calculations of the storage volume can be found in table B-3 in appendix B. The calculated required storage was determined to be 204,048 cubic feet.

The specific dimensions of the stormwater management area are as follows: width and length are 167 feet and 333 feet, respectively; the side slopes of the temporary detention basin must be constructed at a 4:1 slope; and the bottom of the basin is graded at a 0.6% slope, resulting in a total storage volume of 159,875 cubic feet. Calculation of the Elevation-storage volume is displayed in Table B-8 in Appendix B. Since there is limited storage volume, the runoff from the collector streets will be taken north of the property and routed to existing storm sewer plan on Platt Street.

The purposed temporary detention basin will have three outlets.One primary spillway that will carry water through a 15” diameter reinforced concrete pipe (RCP) to and attach to the existing intlet-110 by the Casey's gas station. The pipe will have a slope of 0.29% that will give a half-full velocity of 2 fps. This velocity does not meet SUDAS requirements of 3 fps. The maximum capacity of the pipe is 3.51 cfs, this will accommodate smaller storm events (2,5, and 10-yr). Larger storm events will be moved through two emergency spillways. One spillway is activated at an elevation of 680 feet and the other is activated at an elevation of 680.5 feet. Both spillways have a width of 25 feet. The first spillway carries water into the existing channel and carries the discharge north of the electricity building. This existing channel has the capacity to move 80 cfs of water into the existing intlet-110 by the Casey's gas station, northwest of the project site. This existing channel needs to be maintained and mowed regularly, so that it will maintain its capacity. The first spillway will be activated from a 25-yr storm event and larger.

This spillway will take the water into the existing channel east of the Electric utilities building, the channel will then direct water around the electricity building towards north and eventually deposit the water in intlet-110 by the Casey's gas station. The second spillway will carry water from the east side of the stormwater management area to a grass spillway past the storm shelter and onto the west collector roadway and out to the connecting storm sewer system on E Platt Street, in case of larger storm events that overtop the 6" curb and gutter. This spillway will be activated during a 100-yr storm event or larger.

One of the challenges with this site was the Trichloroethylene (TCE) plume that exists under our site. Maquoketa is working with the EPA and other authorities to assess the risk and impact on this site. Since this investigation is ongoing, we felt it prudent to take certain precautionary measures. The presence of the chemical on the site has affected the the housing design, stormwater basin design, and overall site design.

We researched the effect of TCE on proposed housing structures. Vapor intrusion, a process in which the chemical vaporizes and accumulates inside of structures, is the main issue. To combat this process, we included houses that do not have basements in our design also proposed a 20 mm vapor barrier to be installed below the concrete slab. This barrier will stop the TCE from infiltrating the house and will further protect the residents that live in this community.

The stormwater design was greatly impacted by the presence of TCE on the site. One of the main objectives of this site design was to propose a drainage structure of some sort to handle the large volume of water that flows through the area. There are several options for this situation but due to the presence of the TCE in the groundwater, it wouldn't be safe to dig a pond, and the site was too flat to just regrade and route the water without a structure. To ensure that the water in our drainage structure did not become contaminated and cause potential harm to the residents, we chose a shallow detention basin.

The last effect the TCE had on our site design was the design of the total site. Since the plume extends beyond the subdivision's border and is outside of our project scope, it was decided that we should propose a remediation method that will help screen the subdivision from further spread of the plume and provide cleanup of the existing plume. We were able to connect with University of Iowa alum Lou Licht to talk about his research involving phytoremediation, and to learn what our options were in this situation. Based on his work, we recommend phytoremediation on the site in several places. Poplar and willow tree root systems can facilitate the phytoremediation of chemicals like TCE. Methods like this have been effective at similar sites. We recommend a landscaping plan for this subdivision that creates an attractive, desirable neighborhood and has the potential to slow or reverse the spread of the TCE. Poplar and willow trees thrive in different environments. Because they thrive in wet conditions, we recommend planting willow trees in the stormwater management area. Additionally, planting trees in the basin will help decrease the flow of the water through the basin by increasing the infiltration rate. Poplar trees will be planted along the west side of the site as well as along the side of one of the main collector roads running north to south. The orientation of the line of trees is perpendicular to the flow of the ground water that is contaminated with TCE. This has the best chance of filtering the water and fits well into the overall design.

Section II – Organization Qualifications and Experience

We are a group of senior design students at the University of Iowa. We are pleased to present the following land use plan to the City of Maquoketa, IA, to design an affordable single-family dwelling subdivision and drainage plan. The following paragraphs highlight the qualifications of each team member.

From left to right; Ethan Myers (Project Manager), Brittany Cunningham, Justin Spiekermann, and Robert Yerushalmi

Ethan Myers is the project manager for the group. He studies Civil Engineering with a focus in environmental engineering and has worked two internships involved on the site design of highway as well as power plant projects. Ethan oversaw the subdivision layout as well as road design specifications and utilities.

Brittany Cunningham studies Environmental Engineering with a focus in Water Resource engineering and hydraulic modeling. She has taken water resource engineering, where she used EPANET to produce water distribution models for subdivisions in Tiffin, IA. She has also produced proposals and permit requests with an environmental consulting firm for various stream restorations and wetland delineation projects. Brittany oversaw the stormwater management plans within the subdivision.

Justin Spiekermann studies Civil Engineering with a focus in Environmental engineering. He has worked with sophisticated civil software, such as AutoCAD, Civil 3D, Geopak, and Openroads. Justin oversaw the environmental and health impacts of Trichloroethylene and ways to prevent further development of the existing groundwater plume.

Robert Yerushalmi studies Civil Engineering with a focus in General Civil Practice. He has contributed to previous roles where preliminary stormwater management analysis for industrial, commercial, and residential sites was required to develop an engineering design solution for hydraulic systems. He has utilized civil software tools in his design work such as GIS, Civil 3D, MicroStation, XPSWMM, and Excel as required per project. Robert oversaw design of the roadways, grading, utility networking, and aid in stormwater management plans and associated hydraulic systems.

Section III – Design Services

Project Scope –

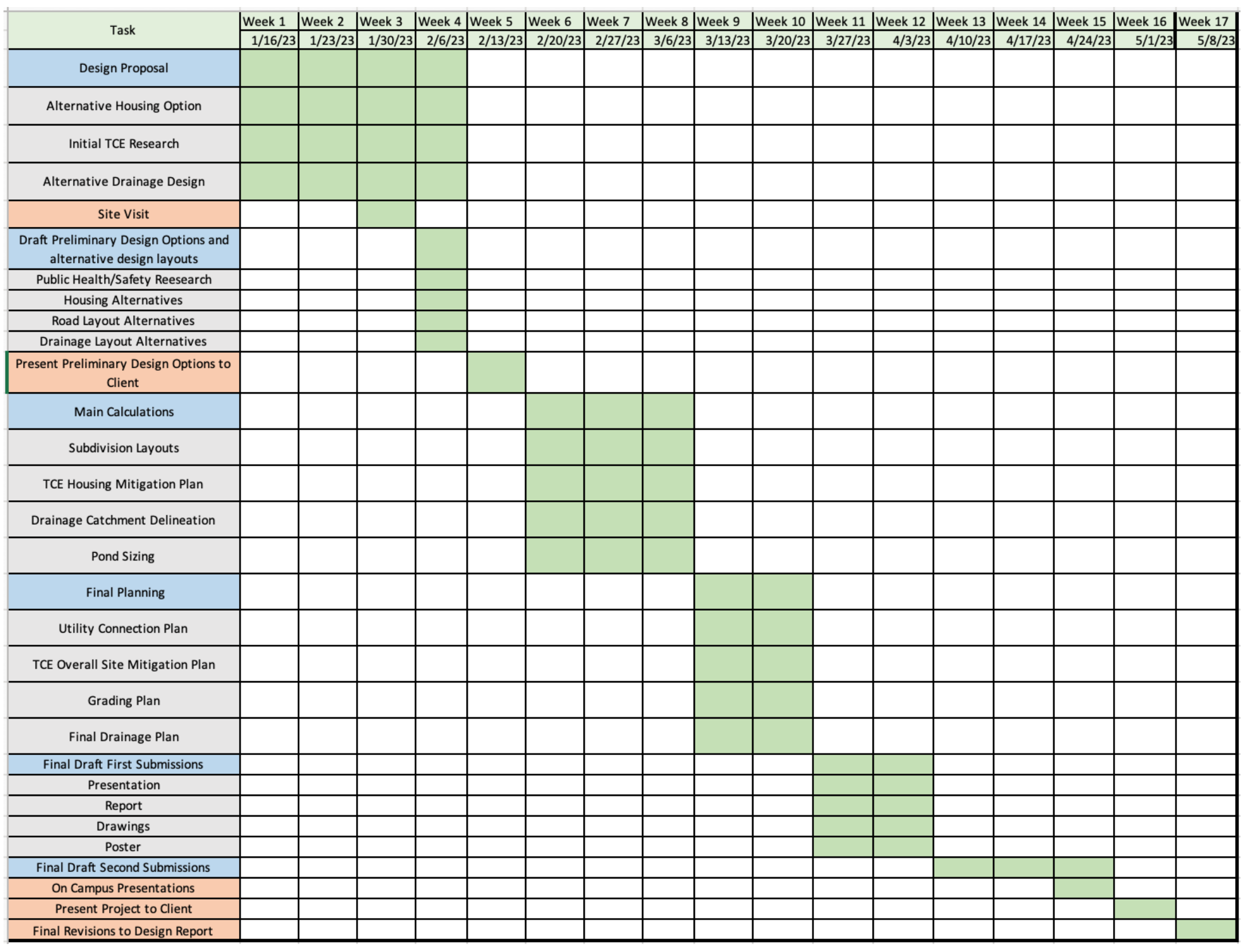
The City of Maquoketa wishes to investigate the feasibility of a subdivision and drainage development using a set of 5 parcels in the east part of town. The project is bound by Platt Street to the North and Maple to the South. The plans that were developed include a housing layout, a drainage plan, and a utility connection plan. Using our environmental background, we have also examined the Trichloroethylene plume below the site and provided an analysis on how this will affect the development of this site. Using several methods, our objective was to come up with an efficient, innovative solution, to solve the drainage issue presented to us while providing affordable housing. Below lists the steps that were taken to create our solution.

- Researched mitigation methods for Trichloroethylene by referencing current EPA standards and by speaking with STEGO, a leading company in the industry.
- Researched ways to further prevent contamination of the site using the IDNR database and by speaking with Lou Licht, an expert in phytoremediation.

- Researched lot layouts using SUDAS design standards as well as the City of Maquoketa's zoning codes.
- Researched utility specifications using SUDAS design standards and the existing surrounding utility connection plans.
- Delineated the site using HEC-HMS and used the Iowa Stormwater Management Manual as well as SUDAS design standards to size our basin and develop our drainage plan.

Work Plan –

The chart below shows the tasks that we completed and the timeline for meeting our project goals. The general phases of the project can be found in light blue on the left-hand side of the chart. Underneath these phases, we have split them into subsections that are highlighted in grey. Our important deadlines are highlighted in red. The task on the left side corresponds to the amount of time we spent and when we did the task relative to the rest of the design process, in green.



Section IV – Constraints, Challenges, and Impacts

Constraints –

Housing

The client has requested a residential design containing affordable housing. The need for affordable housing creates a few design constraints that are applicable to our consulting. Another set of constraints were City of Maquoketa zoning codes, as seen in appendix C. Our goal was to create a residential neighborhood with quality, affordable houses, while maintaining lot sizes that are compliant with the code.

Trichloroethylene (TCE) is a chemical that is present on the site due to leaching from the nearby Clinton Machine Factory, which is located southwest of the project site. Due to its hazardous nature, TCE must be obstructed from proposed housing structures, and future residents' safety must be ensured.

Road Layout

The main constraints followed the Statewide Urban Design and Specifications manual (SUDAS) and Iowa Department of Transportation (IDOT) green book. Roadway layout design followed both documents for the varying elements pertaining to residential roadway design and specifications. Right of way (ROW) limits were proposed in accordance with client preferences, which was a 65' ROW throughout the entire project site. The final decision for ROW limits was made due to the client's comfortability with similar past projects utilizing these limits. Our project group also designed roads in a manner that effectively conveys stormwater in the necessary directions to properly drain from the site in accordance with our drainage plan.

Stormwater Management

When constructing the stormwater management plan the team identified a few constraints. First is the location of the current drainage inlet near a Casey's gas station; the stormwater from our design plan must be routed to this outlet. The existing elevation of the location for the proposed temporary detention basin is 680', and the elevation for the drainage inlet is 674.86', so we are left with 5.14' of elevation change to work with when designing the detention basin. In addition to the drainage outlet, we must take drainage from the two parcels next to the purposed subdivision. This means we cannot neglect and potentially displace more stormwater onto these locations when planning our drainage routes. Another constraint of stormwater management is to ensure the runoff does not become contaminated with TCE. Using materials that will last and not be affected by the presence of this chemical is important to maintain the safety of the residents.

Challenges –

Housing

Due to its chemical makeup, it is possible for TCE to exist in the gas form inside of structures, especially in basements. Vapor Intrusion is the process of this dangerous chemical seeping through cracks in the foundation and accumulating in potentially dangerous amounts inside structures. As a result, we propose two preventative measures. The houses we are proposing do not include basements and will use vapor barriers to further protect residents from TCE in our final design. This will be covered in detail in the **Final Design Details** section of the report.

Another challenge that comes with the housing design is making sure the houses are oriented in a way that allows drainage flow. This is a challenging task when dealing with a large volume of runoff, especially in post development conditions.

Road Layout

Roads do a great job of conveying stormwater overland. This is usually ideal but in this situation it was challenging to decide where to route the water because the site is so flat. The small change in elevation across the site made it especially challenging to route the water in a way that was efficient and effective without using a large quantity of fill.

A significant challenge is routing the roads in a way that maximizes the number of houses that can be built and minimizes the amount of road that needs to be put down. This is especially challenging because there are several specifications to follow combining the drainage routes and the available plot layouts.

Stormwater Management

The initial request for the design of a retention pond could face challenges due to the project location's flat topography. Because of the flat topography, the pond's design requires a grading plan to aid in runoff conveyance and flood prevention for the existing properties and future additional residential zones. The site has a low point of 680' elevation; this is the location of the drainage issue. In addition, the area of interest has a trichloroethylene (TCE) plume in the groundwater that will raise concerns about constructing a wet bottom pond. TCE is a known carcinogen and can form a vapor that migrates through the soil and into surface water. The team will take these concerns into consideration when designing a plan that is both affordable and safe.

Impacts –

Housing

The construction of housing on this site will increase the sense of community in the area by creating more residential space that could house new residents. The low-cost housing options will also allow for more affordable alternatives for working families. A negative impact of this site is the slab/vapor barrier combination that will slightly increase lot prices because of the TCE plume in the area.

Road Layout

The main impact of the road layout is drainage related. The routing of the water based on our road layout will impact E Platt Street to the north by increasing the quantity of flow going into its current sewer system. For more specifics, see the Stormwater Management Impacts section below.

Stormwater Management

The construction of a new subdivision will cause impacts to the impervious area of the land. The impervious area will increase, which will cause an increase in the amount of stormwater runoff. The best management practices (BPMs) following the Iowa Stormwater Management Manual will be used to reduce the impact of the increase stormwater runoff.

Section V – Alternative Solutions That Were Considered

Housing

The main objective for housing on this site is to provide affordable single-family housing. Several different models are available for this style of home and before a final design was chosen, research was completed to determine the best options. Shown below are the alternatives that were investigated, including manufactured homes, modular homes, stick built homes, and townhouses. The best alternatives were then selected to fit the client's needs as much as possible.

A stick-built house is a design in which the house is assembled on site, beam by beam or "stick by stick." This requires precision on the job and requires a lot more time to build than the other options. It is relatively similar in cost to the model(s) we have chosen, but the construction of these units is more complicated, and this layout is not typical for smaller homes. For these reasons, it was decided that this method would not be ideal for this site based on the city's requests. An example of a stick-built house is provided below for reference in Figure 5.1.

Figure 5.1: Example of a stick-built house.

Premanufactured homes are a compact housing style that typically exists within a pocket neighborhood. Although the neighborhood style wasn't what was originally pictured by the city, this housing style is a newer development, and the compact style made it a good option for the maximum number of units we could fit on the site. Even though this option fit two of the ideal constraints for housing on this site, the layout was a bit smaller and the units were typically built closer together than was preferred. We wanted to improve the area by suggesting a new style that wasn't like the mobile home park that already existed on the east end of the site. An example of a premanufactured home and what a pocket community might have looked like is included below.

Figure 5.2: Example of a pre-manufactured house.

Modular homes are a type of prebuilt house that are extremely similar to a manufactured home. Modular homes are typically slightly more expensive than manufactured homes, and they are placed on a different type of foundation that provides higher quality. These are the main homes we utilized at the site as they were a good fit of affordability and aesthetics.

Figure 5.3 – Example of a modular home

Townhouses and duplexes were also another consideration for the site. As the client requested dense housing to maximize the number of residents, buildings with multiple homes are a good choice. However, due to the clients' requests for single family homes, we did not pursue this option further.

Several methods were investigated for preventing vapor intrusion of the TCE chemical. Vapor intrusion mitigation systems are safe to use and will improve the quality of the indoor air by reducing indoor levels of chemical vapors from vapor intrusion. They can also reduce indoor levels of radon gas and soil moisture. Mitigation systems have been installed and operated at hundreds of homes near Superfund sites and at homes near many other types of sites across the country. A list of the other methods that were considered is provided below along with a short summary of each.

- **Seal Openings** – After the house is built, sealing the opening with concrete is one way that vapor intrusion and chemical contamination is prevented. This isn't the most effective because it allows for vapor intrusion through cracks in the foundation, but it is a preventative measure that has been used in similar situations before.
- **Passive Venting** – This method uses a stagnant vent to allow the vaporized TCE to escape up into the atmosphere around the base of the structure. This allows an exit path, so the TCE does not accumulate in the structure. This method is only slightly more expensive than a vapor barrier, but the construction process is a little more complicated to install beforehand.
- **Sub-Slab Depressurization** – Sub slab depressurization is like the passive venting system except there is an electrical component to it. A fan is used along with the vent system to apply a vacuum underneath the structure to remove the TCE and expel it into the atmosphere.
- Although this installation cost is like passive venting, the vacuum/fan system is more expensive to install. You also must supply electricity for the system to be effective, which makes this option much more expensive over time.

- **Building Over-Pressurization** – This approach is an active approach to preventing vapor intrusion. It includes adjusting the heat, ventilation, and air conditioning to make sure that the pressure indoors is greater than the sub slab pressure. This will prevent the TCE from seeping into the building. The downside of this approach is it requires constant monitoring and can potentially be very expensive due to the energy input required to maintain the heating, ventilation, and air conditioning systems.

Road Layout

As was discussed above, one significant challenge we faced was creating an effective road layout to meet all our criteria. There were several initial designs created to examine the pros and cons of each. After comparing the designs, we discussed possible solutions for a final design with the city. Based on their suggestions and a few preferences, we were able to move forward with a final design. The initial road layouts that were brought forward are shown in Figures 5.4-5.6 below.

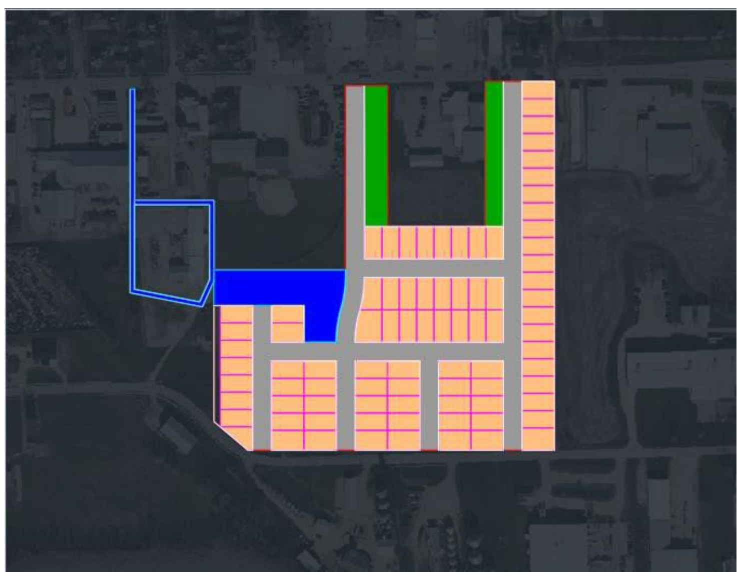


Figure 5.4: Residential One.

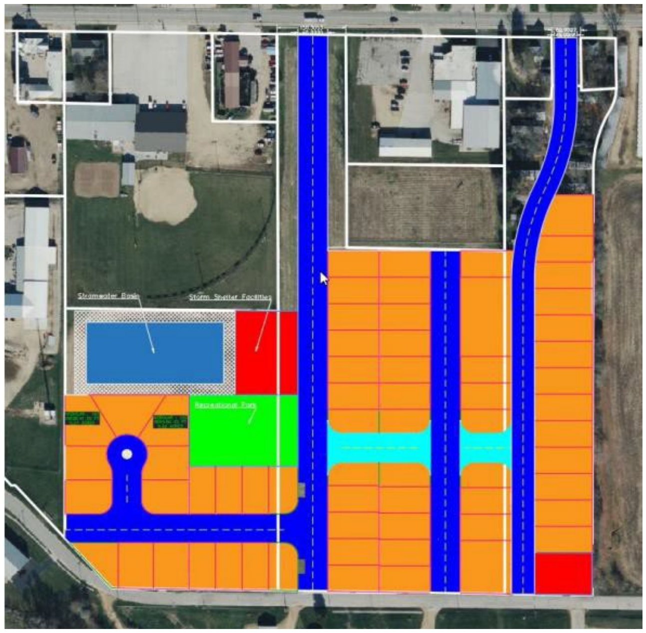


Figure 5.5: Residential two.

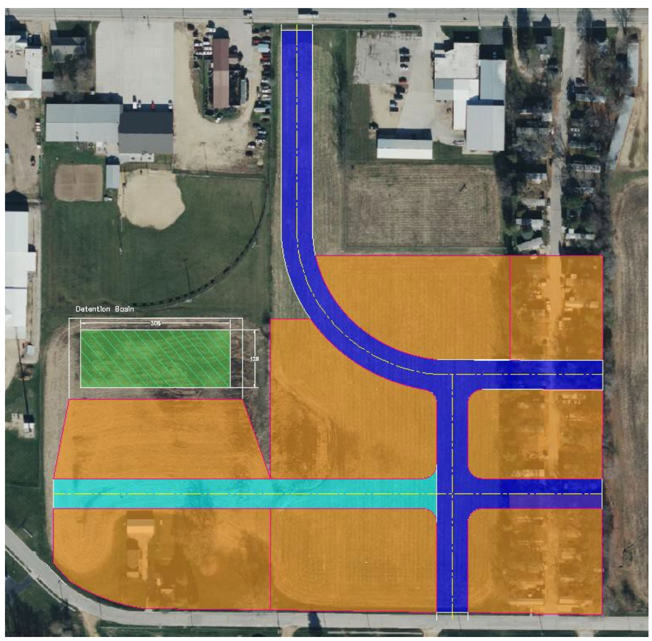


Figure 5.6: Industrial/Commercial.

Stormwater Management

We analyzed the pros and cons of three different stormwater management possibilities. The first alternative solution we researched was a wet bottom pond or retention pond for the neighborhood. However, after learning about a contaminated groundwater plume under the site we concluded that this solution would not be feasible. The area where the pond is proposed is illustrated by the black rectangle in Figure 5.7.

This area has a TCE concentration of 500 µg/L. The maximum concentration limit for TCE in groundwater is 5 µg/L. The construction of a wet bottom pond could create a higher exposure risk for the community since TCE vaporization will occur and travel through the soil eventually contaminating the water within the pond.

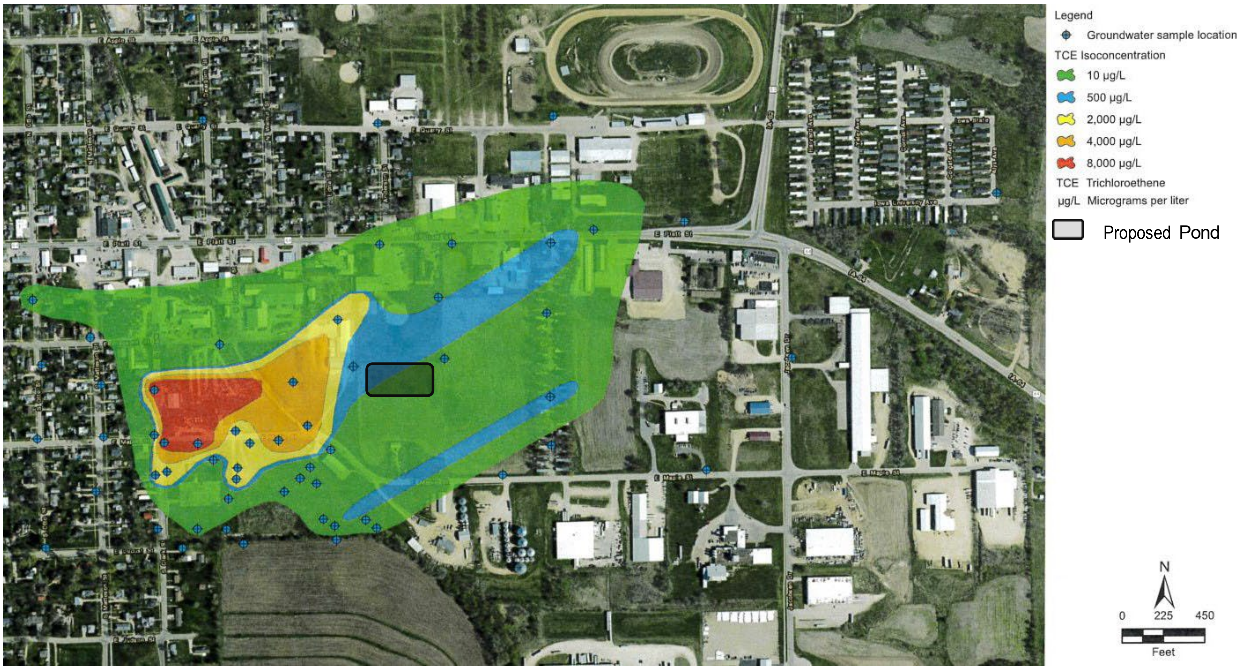


Figure 5.7: TCE heat map paired with the proposed basin location.

The second alternative we researched was filling the low points on the land to help stormwater drain off the site and into the existing open channel and drainage outlet nearby. This idea was not feasible since the topography of the site is flat. There would be an excess amount of fill required to make this alternative happen. After performing a HEC-HMS model, we determined that the increase of runoff from the developed subdivision would be too much for the current storm sewers on Platt Street during large storm events.

The third alternative we researched was a temporary detention basin. The temporary detention basin would reduce the peak flow during serve storm events, but it would have less volume and not provide the same level of water quality treatment as a retention pond would. With the constraint of minimum elevation change from the site and the drainage outlet, the detention basin would only be 2-feet deep so that SUDAS storm sewer velocity can still be met. Although this option is a slight compromise from a stormwater runoff perspective, we believe it is the best option for this development.

Section VI – Final Design Details

Housing

We utilized three different types of house options for our subdivision layout, the least expensive of which is a double wide, 27’x52’ manufactured home. This home is utilized on the east side collector road of the site. An example of this layout as well as the dimensions are provided below in Figures 6.1 and 6.2.

Figure 6.1: Example of a pre-manufactured home.

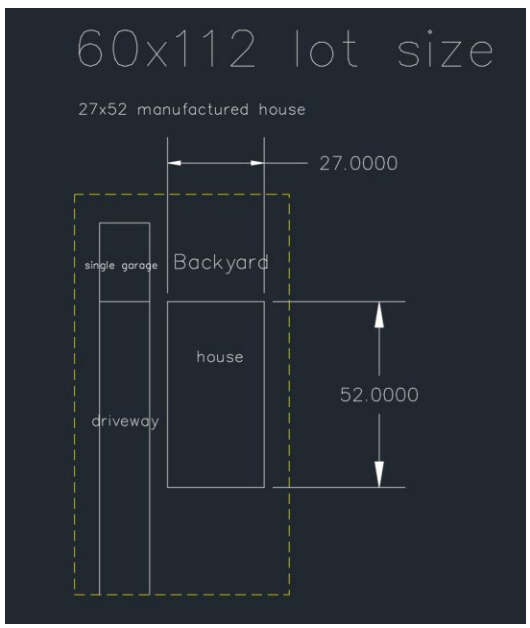


Figure 6.2: Dimensions of a pre-manufactured home.

The middle option is a 30x36 modular home, which is the most frequently utilized home throughout our site

An example of a layout that includes a 90’x77’ lot size, driveway, and optional garage is provided below in Figures 6.3 and 6.4.

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Figure 6.3: Example of a modular home with an optional garage.

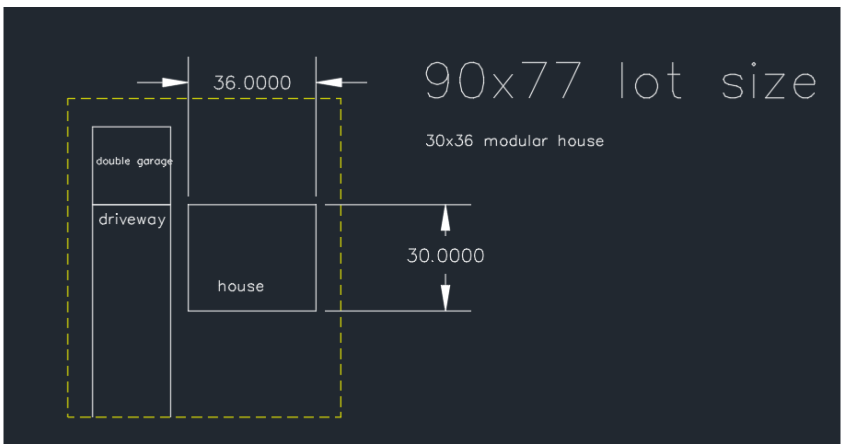


Figure 6.4: Dimensions of a modular home with an optional garage.

The third and most expensive option of the three was a stick-built house. These 40’x46’ homes are used around the cul-de-sac areas as they have shorter lot-size widths since the garage is built into the house and works well on curves. An example of this layout as well as the dimensions are provided below in Figures 6.5 and 6.6.

Figure 6.5: Example of a stick-built house.

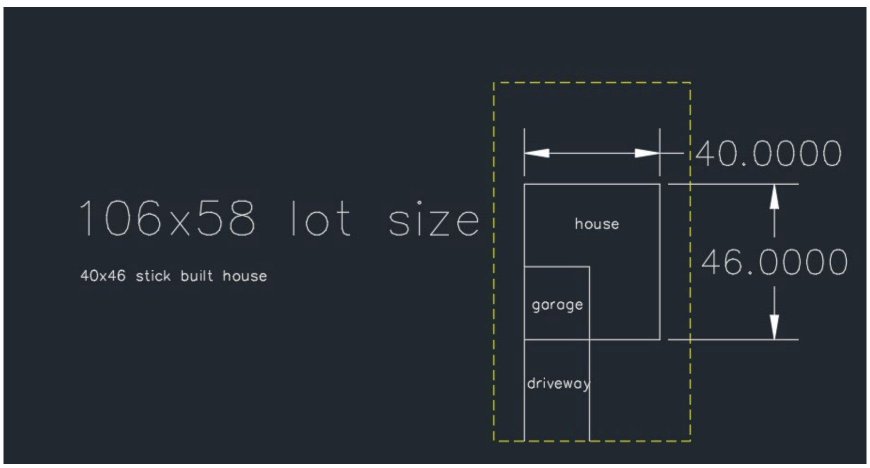


Figure 6.6: Dimensions of a stick-built house.

Using the lot designs shown above, the subdivision was developed in an efficient manner to keep the area looking spacious while also maintaining affordable prices. Items in the lot designs may be altered in multiple ways, such as switching a double garage to a single garage, removing the garage altogether and shortening the lot width. There are several combinations in which to design the lots that will be the most favorable option. The locations of the three different housing types in the subdivision can be found below in Figure 6.7.

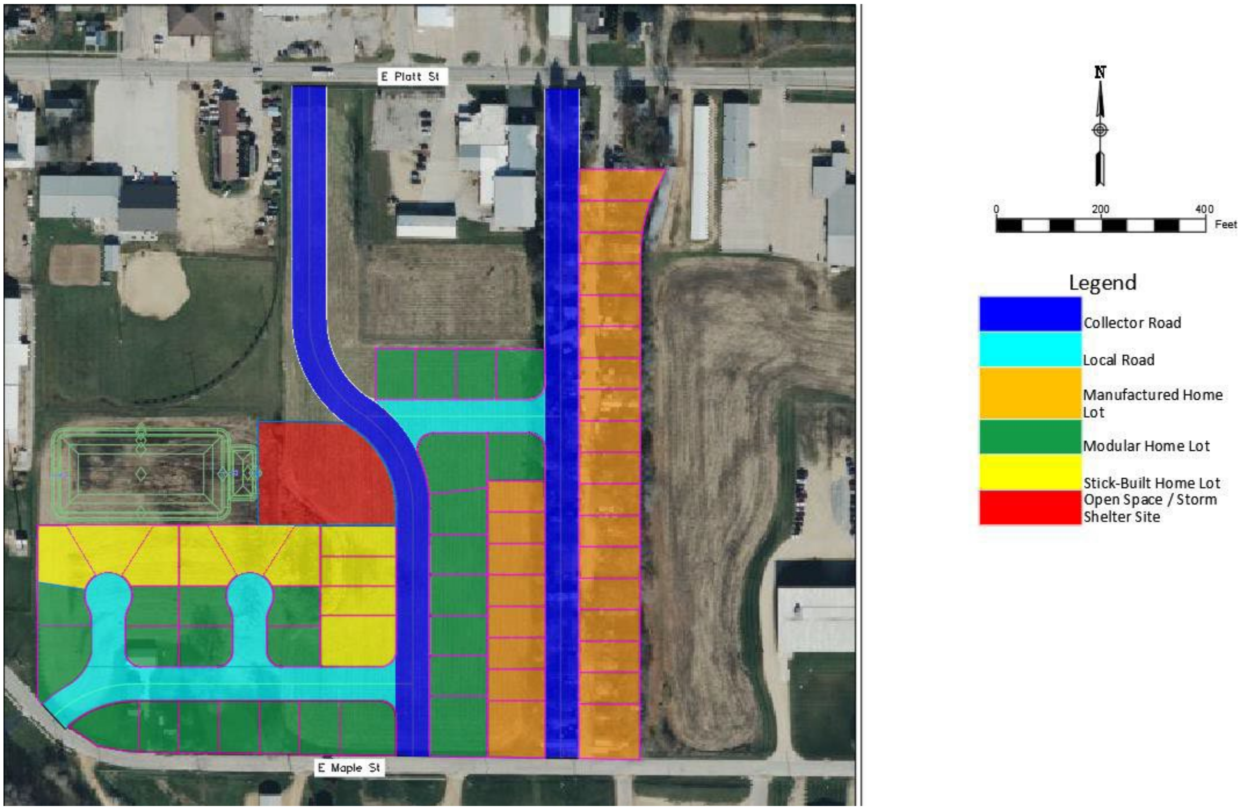


Figure 6.7: Lot Layout with different housing spots

The solutions that were chosen for preventing vapor intrusion of TCE into the housing structure are to avoid homes with basements and installation of a vapor barrier in each unit. A vapor barrier is essentially a plastic sheet that is installed before the foundation for the house is laid. It acts like a plastic bathtub in the sense that it prevents contaminant from passing through it. In this case, however, it is keeping the contaminant out. This is the least expensive of the five options initially considered and is easiest to install predevelopment because the houses aren't yet built. Working with STEGO industries, a leader in the field of vapor intrusion mitigation, it has been decided that the best option for this site is DRAGO Wrap. Drago Wrap is a 20 mm soil contaminant barrier which includes a chemical filtration layer which further prevents leaking into the structure. According to a representative from STEGO, "Drago Wrap has been used in this condition (single family slab on grade) regularly and should represent an effective solution" (Mike, STEGO).

Road Layout

The main design details of the road network that was created is the use of hot mix asphalt (HMA) pavement with a 3" thickness, a 10" modified subbase, along with a 12" subgrade preparation. The proposed development also involves 4-inch-thick Portland cement concrete sidewalk pavement, as well as 2-foot curb and gutter also using Portland cement concrete (PCC). This design is the standard pavement cross section for new developments in Maquoketa. This pavement design is used throughout the site, on both the collector as well as local roads, as these are the only two types of roads in the proposed development.

The horizontal curve road design layout followed a minimum curve radius of 198' for residential use. The minimum curb return curve radius of 30' in addition to 40' was used at intersections. The vertical curve road design followed a maximum and minimum slope/grade of 5.00% and 0.60% respectively. Th K values (horizontal distance required to achieve a 1% change in slope) adhered to the minimum 25 mph residential crest value set to 18.00 and minimum sag value set to 26.00.

The design project started with several different layouts. After options were suggested to the client, we determined the aspects of the designs they favored. Using this feedback, we were able to design an ideal layout that both maximized the available lots and met the City's requests. Our final design after this process is shown below in Figure 6.8. The dark blue represents collector roads, and the light blue represents local roads.

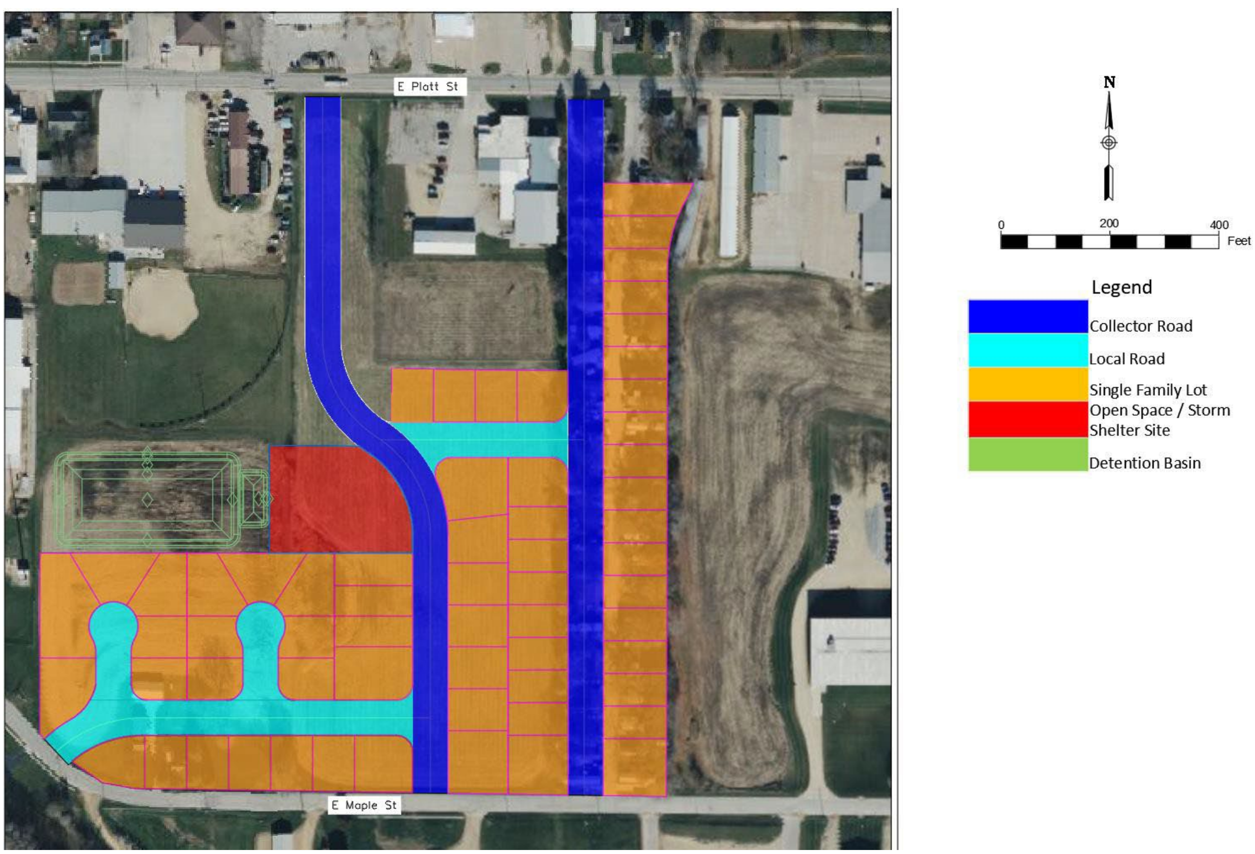


Figure 6.8: Final Road Layout

Stormwater Management

Runoff was calculated based on the NRCS method using WinTR-55 to simulate 24-hr rainfall depth for zone 6 (east central Iowa). Time of concentration was found using the NRCS velocity method for pre-settlement conditions, existing conditions, and post-development conditions. Time of concentration calculations can be found in appendix B, table B-1. Pre-settlement conditions were considered to include vegetation typically found in the Southern Iowa Drift Plain resulting in a Curve Number of 59 compared to the curve number of 79.7 for existing conditions and 83 for post-development. The difference in curve numbers resulted in a time of concentration of 40.3 minutes for pre-settlement conditions, 22.9 minutes for existing conditions, and 20.6 minutes for post-development.

The area of interest and the surrounding area were delineated into catchments to determine the storage volume required for stormwater management. The delineations of the catchments are shown in figure B-2 in appendix B. For the location of the temporary detention basin the area of zone two was used for the storage volume of the temporary detention basin. The area of zone two is 26.01 acres. To calculate the required storage volume of the detention, the flows from the pre-settlement conditions and the post-development conditions are used. Calculations of the storage volume can be found in table B-3 in appendix B. The calculated required storage was determined to be 204048 cubic feet. Due to the limited elevation change, 1 foot of fill will be added to the proposed location of the temporary detention basin resulting a basin depth of 3 feet. Since the temporary detention basin is only 3 feet deep, we do not reach the required storage volume. The specific dimensions of the temporary detention basin are as follows; width and length are 167 feet and 333 feet, respectively, the side slopes of the temporary detention basin must be constructed at a 4:1 slope, and the bottom of the basin is graded at a 0.6% slope, resulting in a total storage volume of 159,875 cubic feet. Calculation of the Elevation-storage volume is displayed in table B-8 in appendix B.

Since there is limited storage volume, some of the runoff from the collector streets will be taken north of the property and routed to the existing storm sewer plan on Platt Street. A downfall of this plan is that this area of the property will not have stormwater management, but to compensate for the area that will not be managed the temporary detention basin will take in a portion of stormwater runoff from the properties directly west of the 1015 E Platt parcel. Figure 6.9 illustrates the general flow paths that the stormwater will take during the drainage plan.

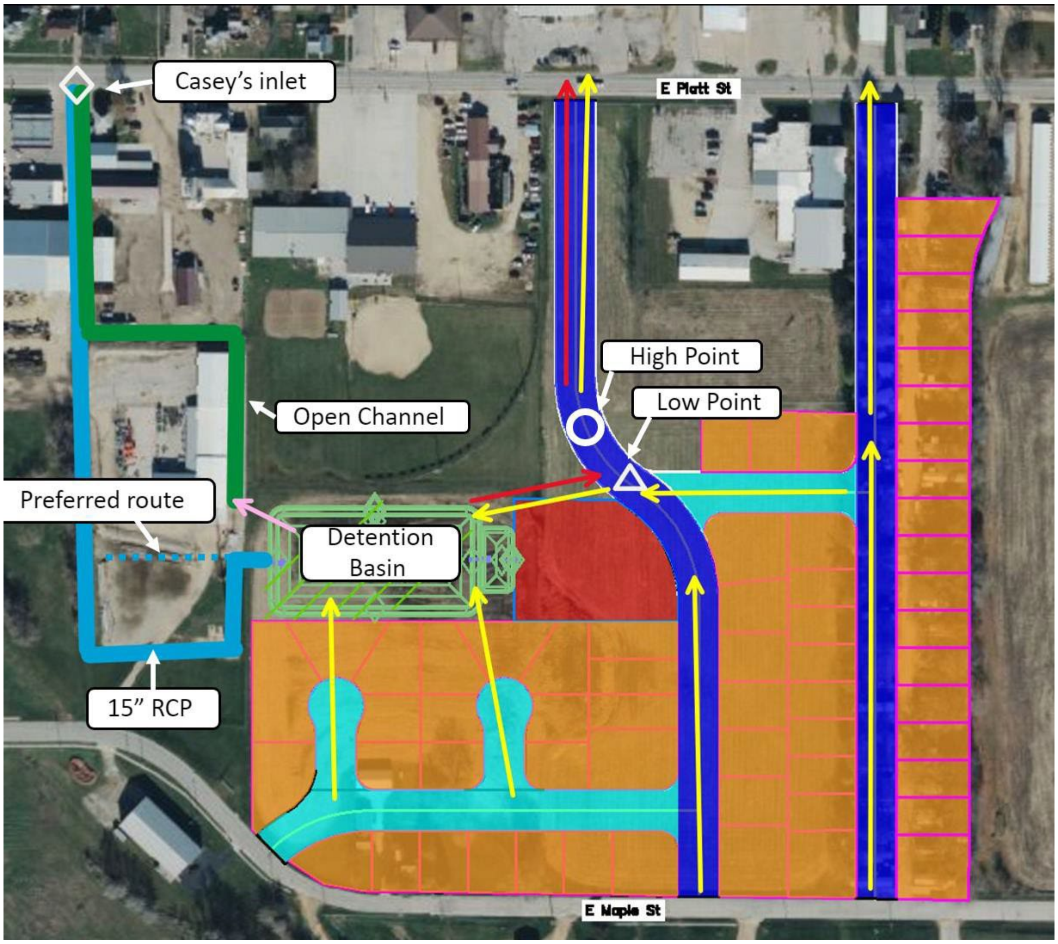


Figure 6.9: Drainage flow diagram

The purposed temporary detention basin will have three outlets. One primary spillway that will carry water through a 15" diameter reinforced concrete pipe (RCP) to and attach to the existing intlet-110 by the Casey's gas station. The pipe will have a slope of 0.29% which will give a half-full velocity of 2 fps, this velocity does not meet SUDAS requirements of 3 fps. The max capacity of the pipe is 3.51 cfs, this will accommodate smaller storm events (2,5, and 10-yr). The path for the primary spillway is shown by the blue path in figure 6.9, however the preferred path is shown by the dotted blue line in the figure. We recommend using the dotted line path for the piping if the city is willing to build under existing property and provide an additional easement.

There are two emergency spillways for larger storm events; both spillways have a weir width of 25 ft. One spillway will carry water into the existing open channel, which travels north of the electricity building. The location of the first spillway and the direction the flow will travel towards the open channel is represented by the pink arrow in figure 6.9. This spillway will be activated during a 25, 50, 100, and 500-yr storm event. The existing channel has a maximum capacity of 80 cfs, calculation shown in appendix B, table B-4. This is under the assumption that the channel will obtain a manning's roughness of 0.06. The channel needs to be mowed to maintain adequate capacity. To protect the existing channel from erosion it is suggested that class A and class B vegetation are used; these include yellow bluestem *Ischaemum,* Bermuda grass, and native grass seed mix (little bluestem, bluestem, blue gamma, and other short midwest grasses) (Mays Ch.15).

The second emergency spillway will carry water through a grass spillway passed the storm shelter and onto the west collector roadway in case of larger storm events (100 and 500- yr) that overtop the 6" curb and gutter. The flow path of the second emergency spillway is represented by the red flow lines in figure 6.9.

The second emergency spillway works with the specific grading of the west collector road. The west collector road has a local low (white triangle on figure 6.9) and a local high point (white circle on figure 6.9); toward the north side of the road there is only a 5-inch difference between the two elevation points. The local low point will allow water from small storm events to enter an overland flow past the storm shelter area in red and accumulate in the detention basin, but during a large storm event which activates the emergency spillway, the overland flow will travel east of the basin and over the 5-inch elevation change, so that water will enter E Platt street.

When designing our drainage plan, the main goals we kept in mind were the need to get water off our site, as well as reduction of the amount of flow entering the existing open channel near the Electricity building. After performing various HEC-HMS models we were able to obtain the results displayed in Table 6.1. We would expect to see a reduction greater than 70% for smaller storm events, 2- and 10-yr, and greater than 50% peak reduction for larger storm events 50, 100, and 500-yr events, with the addition of the dry bottom detention basin and the diversion of water on the two collector roads.

Table 6.1: Reduction of Peak flow entering the existing open channel with the addition of a temporary dry bottom detention basin and the diversion of water on the two collector roads.

	Flow Entering the Existing Open Channel		
Design Storm	Peak Flow: Existing Conditions (CFS)	Peak Discharge: Post-Development (CFS)	Peak Reduction %
2-yr	56.7	12.7	77.6
10-yr	105	23.4	77.7
50-yr	152.3	48.5	68.2
100-yr	184.5	76.4	58.6
500-yr	217.8	98.9	54.6

Phytoremediation

Lou Licht, the founder and president of the world's first for-profit phytoremediation company, has done research on chemical contamination in soils. He deals with chemical spills very similar to the one on the Maquoketa site. From the information Licht shared and additional research, we recommend using two techniques to help protect this site and future residents.

1. Poplar trees are the most well-known species that thrive in the conditions required for phytoremediation. It is recommended these trees be planted in rows surrounding the property or along boundaries where the space permits. The rows will be located 8-feet apart and the individual trees will be placed 4-feet apart. The orientation of these rows should be perpendicular to the leaching of the TCE plume to screen the site from further contamination. The most important rows will run north to south on the western border of the site; this is where the plume initially crosses into the site and a row of trees here will serve as a first line of defense. This row will also serve as a potential wind screen for the subdivision. There are several other potential locations where these trees can be added to the site to further reduce contamination, all following the north to south row layout to maintain the highest efficiency of phytoremediation.

These suggested locations can be seen in 6.9 below.

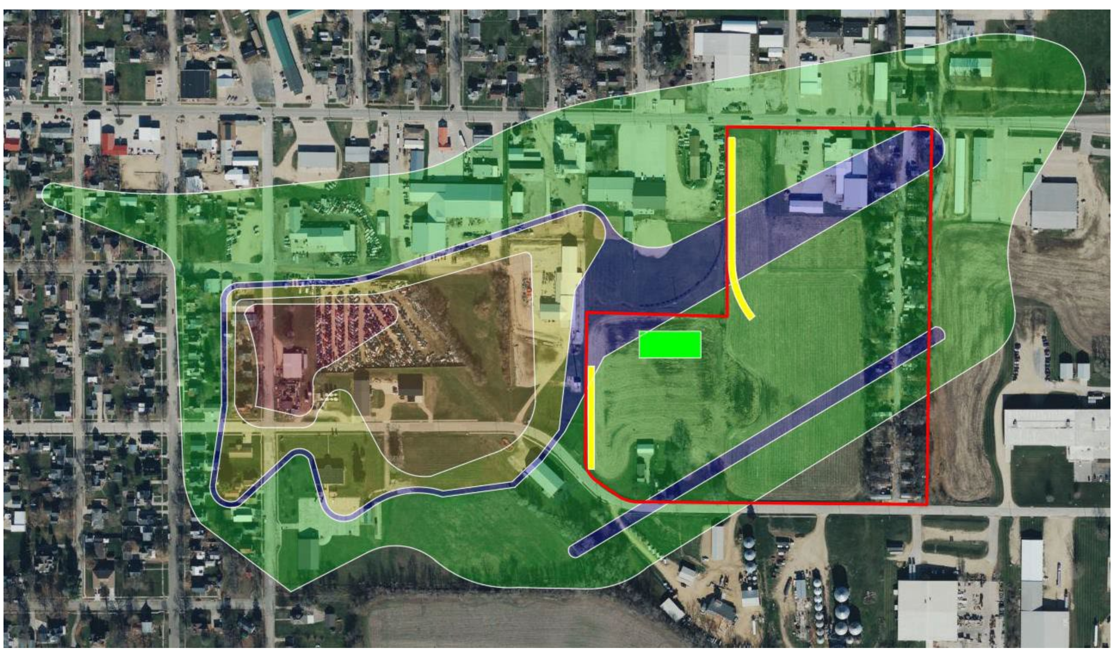


Figure 6.10: Proposed planting locations for the Willow/Poplar trees.

2. In the dry-bottom basin that is being proposed, it is recommended that willow trees be planted in rows 4-feet apart from each other and 8-feet between rows. Willow trees thrive in a wet environment, which is perfect for the proposed temporary detention basin. The willows will do a great job keeping the basin relatively dry when it is not raining and help facilitate the flow of water when storm water is prevalent. Willows are a great choice for phytoremediation. When planted in 6-foot-deep trenches that are dug and filled with biosolids, they tend to thrive. The biosolids enhance the root zone and allow microbes to thrive. These microbes will break down the existing TCE and help to filter the area from further contamination. The biosolids filling the trenches will also increase the infiltration rate and allow for the area to store more water.

Section VII – Engineer’s Cost Estimates

Below is a summary of the overall costs of this proposed site design. Further breakdown of individual unit costs for each area of the proposal can be found in Appendix D.

Table 7.1: Total Construction Cost Estimate for Phase One of the project

Site Work and Paving	$1,579,500
Storm Sewer	$514,000
Sanitary Sewer	$285,000
Water Main	$409,000
Contingencies	20%
Number of Lots	42
Total Construction Cost Estimate	**$3,268,000**
Cost of Infrastructure per lot	$78,000

Table 7.2: Total Construction Cost Estimate for Phase Two of the project

Site Work and Paving	$622,000
Storm Sewer	$185,500
Sanitary Sewer	$92,500
Water Main	$149,000
Contingencies	20%
Number of Lots	21
Total Construction Cost Estimate	**$1,203,000**
Cost of Infrastructure per lot	$57,000

Appendices –

Appendix A: Design Rendering and Models

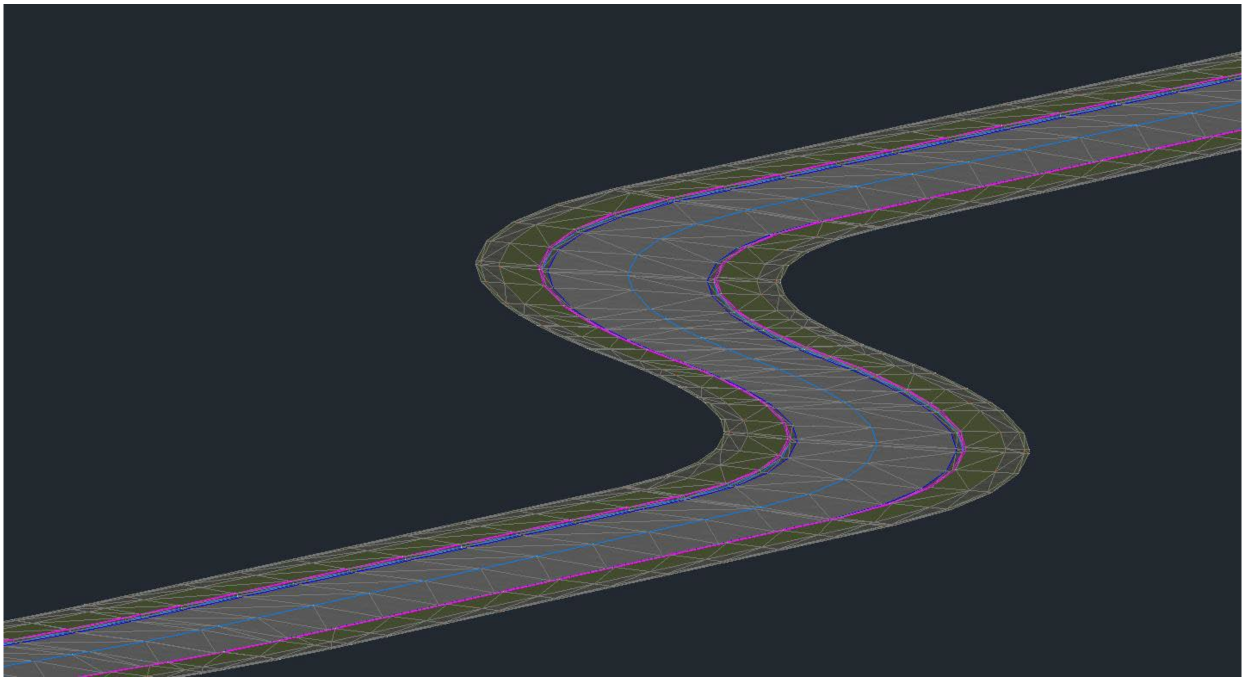


Figure A-1 Road curve model made in Civil 3d

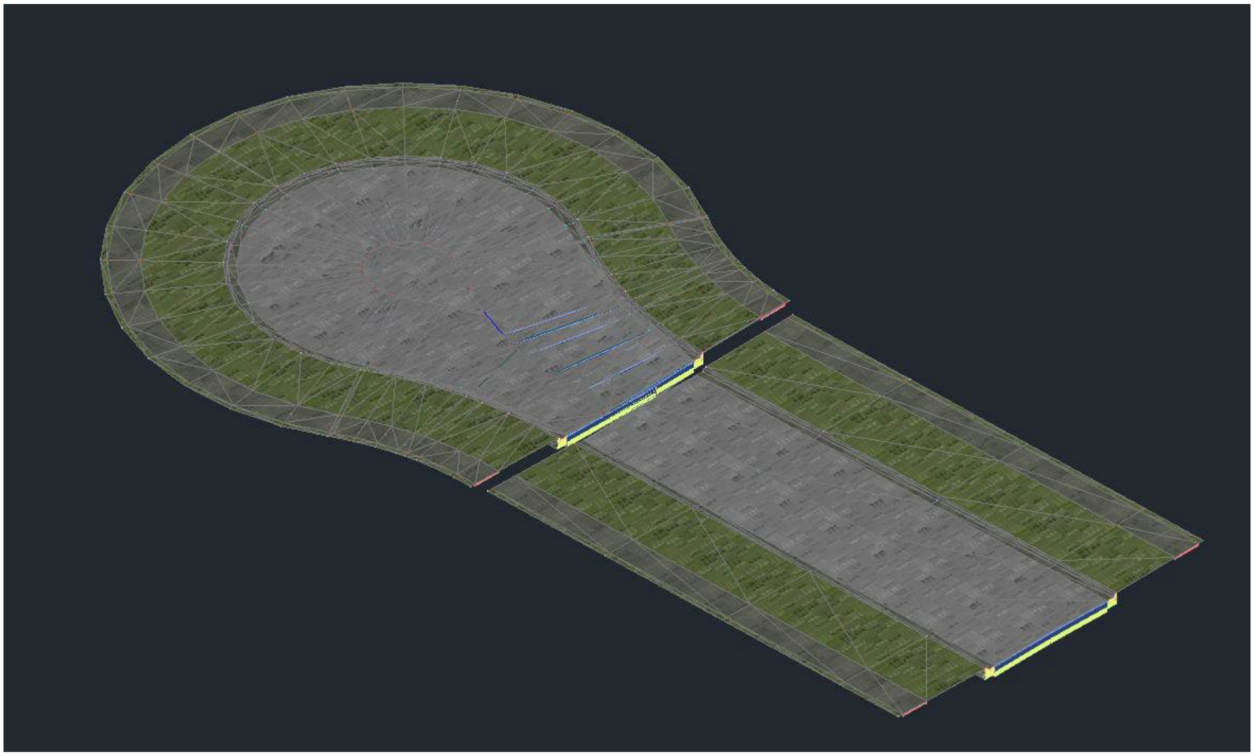


Figure A-2: Rendering of Culverts in Phase 2 of Project.

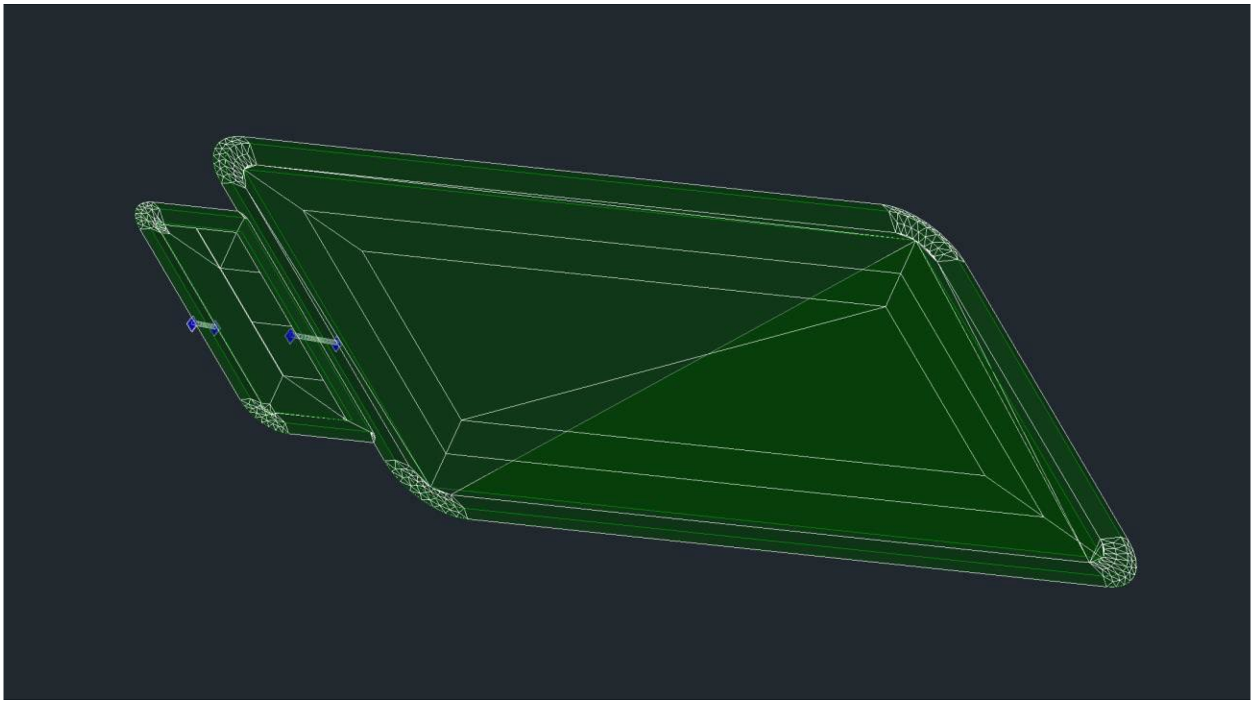


Figure A-3: Rendering of Dry Bottom Detention Basin.

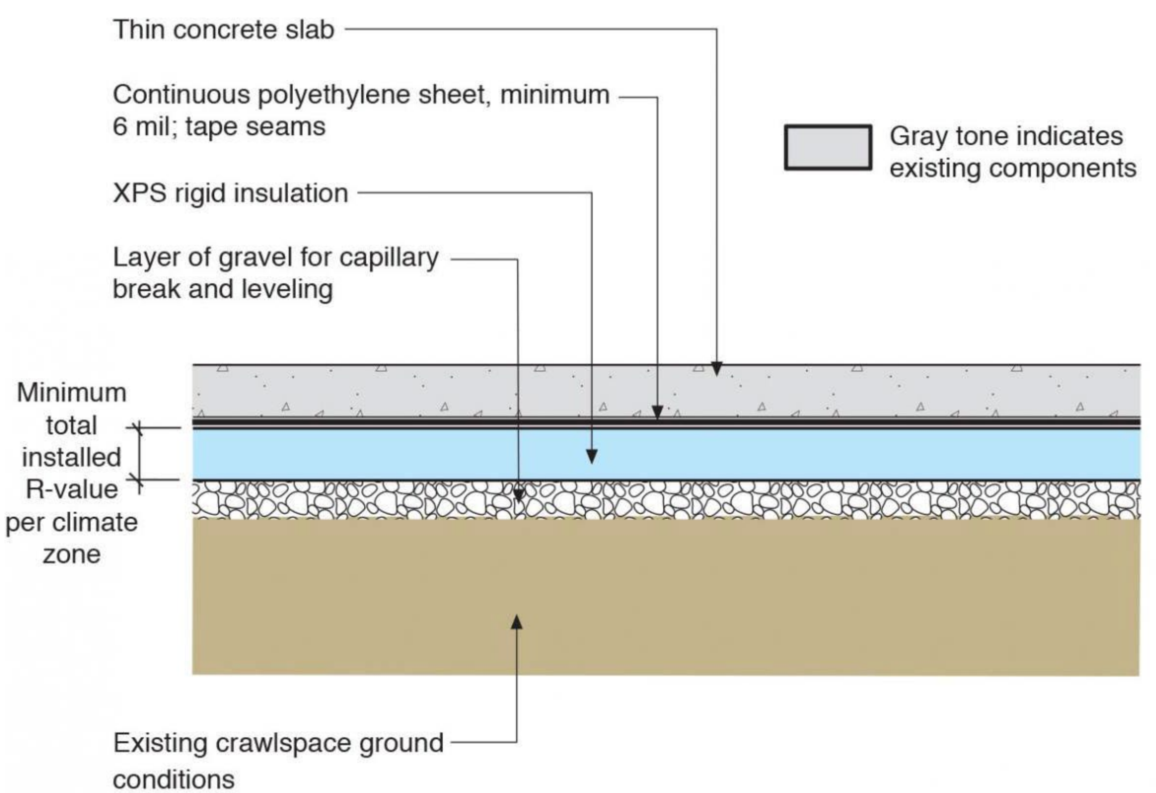


Figure A-4: Figure displaying the concrete slab recommendation for the housings.

Appendix B: Stormwater calculations

Table B-1: Time of Concentration calculations for zone two

Existing Conditions								
Subbasin	Area (ac)	Length (ft)	average slope (%)	CN	S	Lag Time	Tc (h)	Tc (min)
1	14.1	1022.5	3.65	79.7	2.54	0.17	0.28	17.08
2	26.01	1476.5	3.65	79.7	2.54	0.23	0.38	22.91
3	7.26	686.6	3.65	79.7	2.54	0.12	0.21	12.42

Post- Development								
Subbasin	Area (ac)	Length (ft)	average slope (%)	CN	S	Lag Time	Tc (h)	Tc (min)
1	14.1	1022.5	3.65	89	1.24	0.12	0.21	12.37
2	26.01	1476.5	3.65	83	2.05	0.21	0.34	20.62
3	7.26	686.6	3.65	79.7	2.54	0.12	0.21	12.42

pre-settlement								
Subbasin	Area (ac)	Length (ft)	average slope (%)	CN	S	Lag Time	Tc (h)	Tc (min)
1	14.1	1022.5	3.65	59	6.95	0.30	0.50	30.07
2	26.01	1476.5	3.65	59	6.95	0.40	0.67	40.34
3	7.26	686.6	3.65	59.0	6.95	0.22	0.36	21.86

Table B-2: Zone Two stormwater runoff for pre-settlement, existing, and post-development conditions

Zone 2		Pre-Settlement			Existing Cond			Post-Development				
Storm Event	Rainfall (in)	CN=59	TC = 40.3 min		CN=79.7	TC = 22.9 min		CN=83	TC = 20.6 min			
		CFS runoff	runoff (in)	CF Volume	CFS	runoff (in)	CF Volume	CFS	runoff (in)	CF Volume		
2-yr	3.1	2.28	0.34	31818	33.27	1.26	119153	23.18	1.53	77607		
5-yr	3.9	6.09	0.67	62787	50.3	1.88	177691	33.43	2.20	111782		
10-yr	4.4	9.15	0.91	85824	61.55	2.29	216402	40.03	2.64	134057		
25-yr	5	13.31	1.23	116510	75.23	2.80	264460	89	3.17	299583		
50-yr	5.6	17.9	1.59	149933	89.12	3.32	313840	104.18	3.72	351323	Area (ac)	26.01
100-yr	6.4	24.47	2.10	198085	108.03	4.04	381253	124.02	4.46	421380	Area (sq ft)	1132995.6

Table B-3: Zone Two Volume storage for temporary detention basin

Storm Event	QO (CFS)	QI (CFS)	QO/QI	VS/VR	VR (CF)	VS (CF)	VS*1.15 (CF)
2-yr	2.28	23.18	0.10	0.56	77607	43262	49751
5-yr	6.09	33.43	0.18	0.47	111782	52768	60683
10-yr	9.15	40.03	0.23	0.43	134057	57942	66633
25-yr	13.31	65.82	0.20	0.45	299583	136083	156496
50-yr	17.9	81	0.22	0.44	351323	154020	177123
100-yr	24.47	100.84	0.24	0.42	421380	177433	204048

Table B-4: Open Channel Flow capacity

Trapezoid:	**Dimensions**		**Area**	**Perimeter**	**Hydraulic R**	**Q**	unit/n*AR^2/3sqrt(S)
	B	4	20	16.65	1.20	SI	53.7
	Y	2	A=(B+zy)y	P=B+2ysqrt(1+z^2)	R=A/P	English	80.0
slope = 1: Z	Z	3.00					
	T = B+2zy	16					
	Manning (n)	0.06	Light Brush				
	Channel Slope (S)	0.02					

Table B-5: Open channel Shear Stress and Froude Number calculation

Bed Shear Stress:			
gamma*R*S_0	1.499	Class A and B vegetation	
Froude #:	0.498	If Fr < 1	SUBCRITICAL
		IF Fr > 1	SUPERCRITICAL

Table C-6: Class A and B vegetation with respective shear stress

Class A Vegetation	
shear Stress = 3.70 lb/sqft	Yellow bluestem *Ischaemum*
Class B Vegetation	
shear Stress = 2.10 lb/sqft	Bermuda grass

	Native Grass Mix (Little bluestem, bluestem, blue gamma, and other long and short Midwest grasses)

Table B-7: Pool Discharge route for temporary detention basin

	Circle Opening (prime)				Channel Spillway		Emergency Spillway		
Elevation	H	Orifice Q	Weir Q	MIN Circle	H	Weir Q	H	Weir Q	Q_Total
678.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00
678.25	0.25	7.82	1.01	1.01	0.00	0.00	0.00	0.00	1.01
678.50	0.50	11.05	2.86	2.86	0.00	0.00	0.00	0.00	2.86
678.75	0.75	13.54	5.26	5.26	0.00	0.00	0.00	0.00	5.26
679.00	1.00	15.63	8.10	8.10	0.00	0.00	0.00	0.00	8.10
679.25	1.25	17.48	11.32	11.32	0.00	0.00	0.00	0.00	11.32
679.50	1.50	19.14	14.88	14.88	0.00	0.00	0.00	0.00	14.88
679.75	1.75	20.68	18.75	18.75	0.00	0.00	0.00	0.00	18.75
680.00	2.00	22.11	22.91	22.11	0.00	0.00	0.00	0.00	22.11
680.25	2.25	23.45	27.34	23.45	0.25	10.00	0.00	0.00	33.45
680.50	2.50	24.71	32.02	24.71	0.50	28.28	0.00	0.00	53.00
680.75	2.75	25.92	36.94	25.92	0.75	51.96	0.25	10.00	87.88
681.00	3.00	27.07	42.09	27.07	1.00	80.00	0.50	28.28	135.36

	Given	
	g (ft/s^2)	32.2
Circle Opening	Orifice Coeff (cfs)	0.62
	Weir Coeff (cfs)	3.3
	Diameter (ft)	1.25
	Area (ft^2)	1.2
Emergency SW	Weir Coeff (cfs)	3.2
	Width	25

Table B-8: Elevation Storage of temporary detention basin

CONTOUR	AREA (acres)	ΔV (ac-ft)	V (ac-ft)
678	0		0
		0.160	
678.25	1.277		0.160
		0.319	
678.5	1.277		0.479
		0.319	

678.75	1.277		0.798		
		0.319			
679	1.277		1.117		
		0.319			
679.25	1.277		1.436		
		0.319			
679.5	1.277		1.755		
		0.319			
679.75	1.277		2.075		
		0.319			
680	1.277		2.394		
		0.638			
680.5	1.277		3.032		
		0.638			
681	1.277		3.670	159875	CF

Table B-9: RCP pipe dimensions and capacity calculations

1/ 2 Full Pipe		
Material pipe	RCP	
n =	0.013	
Pipe Diameter (ft) =	1.25	ft
Hydraulic Radius	0.19	ft
Wetted Perimeter	3.21	ft
Area	0.61	sq ft
Full Pipe		
Area of pipe	1.23	sq ft
Wetted Perimeter	3.93	ft
Hydraulic Radius	0.31	ft
slope	0.0029	ft/ft
Capacity of Pipe Full	3.51	CFS

Storm Drainage Sewer West

RIM EL	Cover (to top of pipe) (ft)	Pipe Diameter (ft)	=	Invert (ft)			Network Segment	Length (ft)	Slope (%)
689.08	2	1.25		685.83	--->	START			
						|	Segment 1	82.85	3.31 %
				683.09		|			
						|	Segment 2	249.61	0.61 %
				681.57		|			
						|	Segment 3	169.14	0.61 %
				680.53		|			
						|	Segment 4	99.6	0.66 %
				679.88		|			
						|	Segment 5	165.89	0.66 %
				678.78		|			
						|	Segment 6	297.34	0.66 %
				676.82		|			
						|	Segment 7	134.06	1.36 %
				675.00	<---	END			

Sanitary Sewer West

RIM EL	Cover (to top of pipe) (ft)	Pipe Diameter (ft)	=	Invert (ft)			Network Segment	Length (ft)	Slope (%)
688.86	10	0.6667		678.19	<---	END			
						—	Segment 1	82.37	0.82 %
				677.52		|			
						|	Segment 2		
				676.43		|			
						|	Segment 3		
				675.23		|			

Segment 4	272.07	0.40 %
	126.06	0.40 %
	173.8	0.40 %

675.23

						|	Segment 5	125.92	0.40 %
				674.73		|			
						|	Segment 6	197.22	0.40 %
				673.94		|			
						|	Segment 7	234.07	0.40 %
				673.00	--->	START			

Storm Drainage Sewer East

RIM EL	Cover (to top of pipe) (ft)	Pipe Diameter (ft)	=	Invert (ft)			Network Segment	Length (ft)	Slope (%)
694.11	2	1.25		690.86	--->	START			
						|	Segment 1	148.13	5.00 %
				683.45		|			
						|	Segment 2	380.07	0.65 %
				680.98		|			
						|	Segment 3	350.01	0.65 %
				678.71		|			
						|	Segment 4	263.92	1.40 %
				675.00	<---	END			

Sanitary Sewer East

RIM EL	Cover (to top of pipe) (ft)	Pipe Diameter (ft)	=	Invert (ft)			Network Segment	Length (ft)	Slope (%)
693.9	10	0.6667		683.23	<---	END		147.4	676.98 4.24 % |
						—			
				675.46		|		380.83	0.40 %

Segment 1

Segment 2

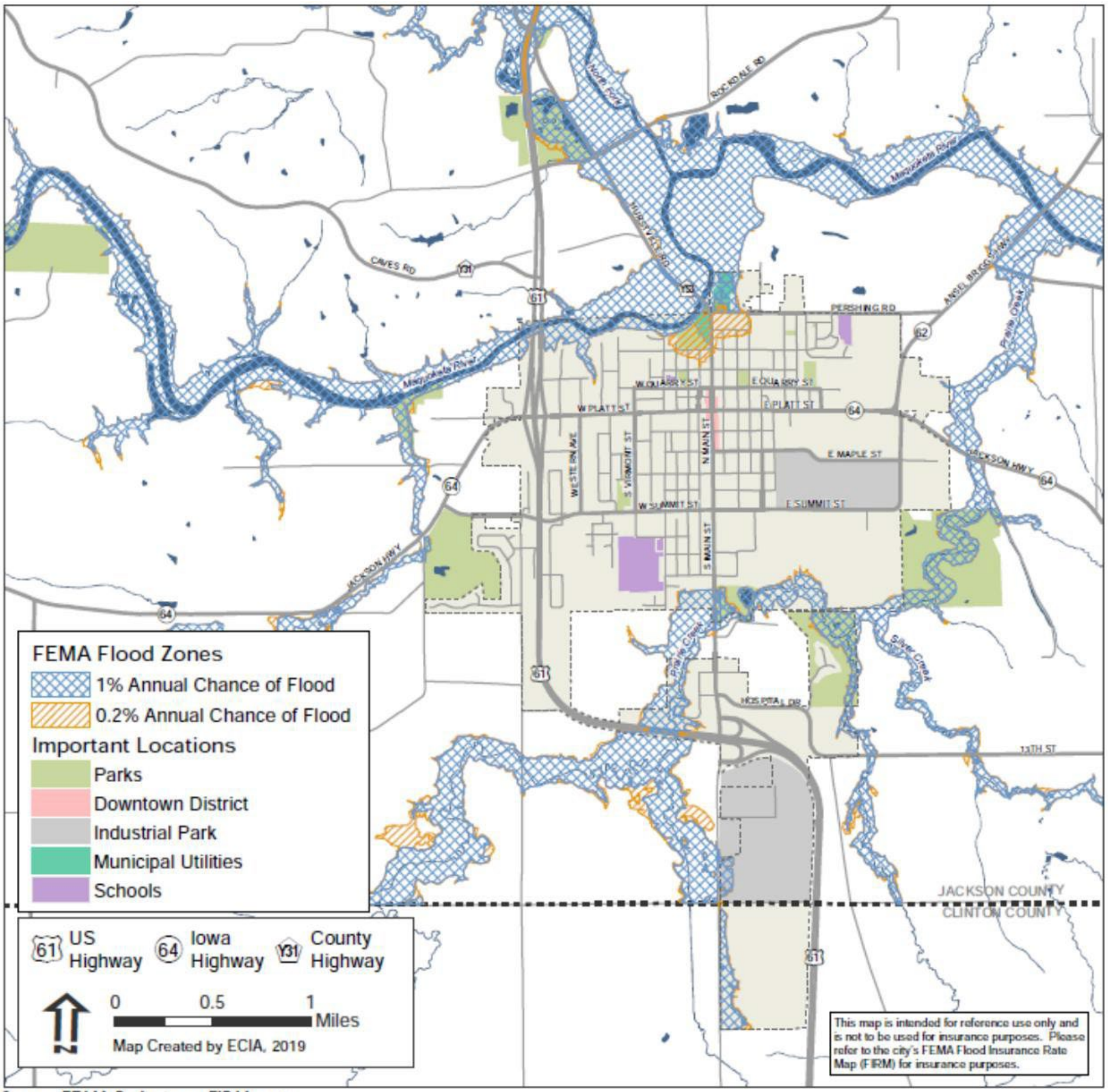
675.46

| Segment 3 350.03 0.40 %

674.06 |

| Segment 4 263.91 0.40 %

673.00 ---> START



Source: FEMA Preliminary FIRM maps.

Figure B-1: 500-yr and 100-yr FEMA flood zones for Maquoketa, IA

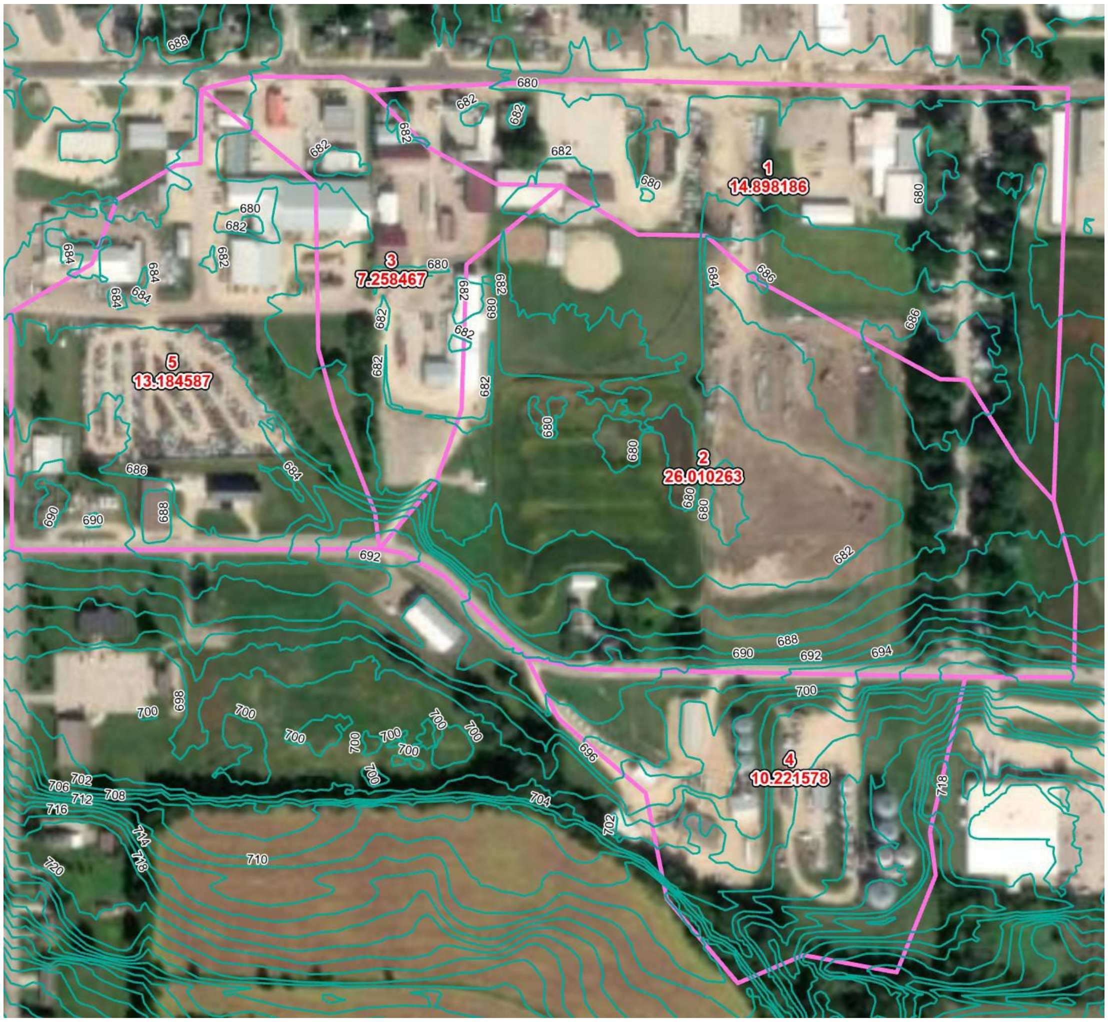


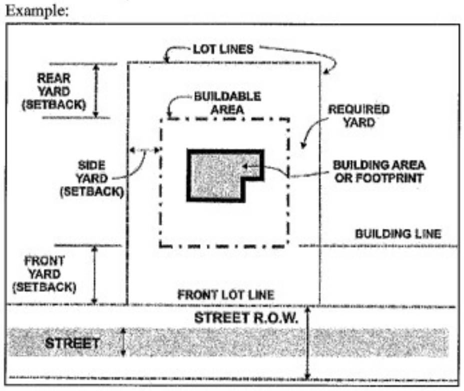
Figure B-2: 1015 E Platt St Maquoketa, IA site delineation.

Appendix C: Zoning Code

City of Maquoketa - Residential Zoning Summary

	R-1		R-2			R-3	
Number of dwellings	1	2	1	2	3+	1	2
Height, maximum	2 ½ story or 35 feet		2 ½ story or 35 feet			2 ½ story or 35 feet	
Setbacks, minimum	A **setback** is a limitation which requires a building, structure, or other item to be placed at a specific distance from a property line. Building on corner lots must meet the front setback requirement on both facing sides.						
Front	30		30			30	
Side	7		7			5	
Rear	30		30			30	
	Corner lots have front yard setback requirements on both sides facing streets						
Lots size, minimum							
Square footage	7,200	9,000	6,000	3,000 per	1,500 per	7,200	9,000
Width	60	75	50	50	60	60	75

Example:



CITY OF MAQUOKETA ONE OF A KIND

Appendix D: Cost Estimate Breakdown

Individual Lot Elements	Unit	Dollars	Quantity	Cost
Stickbuilt	EACH			$0.00
Manufactured Double Wide Home (27x52)	EACH	$127,000.00		$0.00
Modular Home (30x36)	EACH	$143,000.00		$0.00
Stick Built Home (40x46)	EACH	$198,720.00		$0.00
Single Detached Garage	EACH	$15,400.00		$0.00
Double Detached Garage	EACH	$24,200.00		$0.00
Vapor Barrier	SF	$1.50	82,868	$124,302.00
Site Work and Paving				
Claring and Grubbing	AC	$4,531.41	0	$0.00
SIDEWALK, P.C. CONCRETE, 4 IN.	SY	$63.32	975	$61,737.00
HOT MIX ASPHALT MIXTURE, COMMERCIAL MIX	TON	$96.65	1,601	$154,736.65
MODIFIED SUBBASE	CY	$46.83	2,726	$127,658.58
CURB AND GUTTER, P.C. CONCRETE, 2.0 FT.	LF	$29.20	2,598	$75,861.60
EXCAVATION, CLASS 10, ROADWAY AND BORROW (Cut)	CY	$5.68	4,827	$27,417.36
Fill	CY	$20.00	55,908	$1,118,160.00
Trees (Phyto)	AC	$16,670.00	0.83	$13,836.10
Storm Sewer				
MANHOLE, STORM SEWER, 48 IN.	EACH	$4,683.00	12	$56,196.00
STORM SEWER GRAVITY MAIN, TRENCHED, PVC, 15 IN.	LF	$87.00	2,108	$183,396.00
STORM SEWER GRAVITY MAIN, TRENCHED, RCP, 2000D (CLASS III), 15 IN.	LF	$87.50	1,084	$94,850.00
CONNECTION TO EXISTING MANHOLE	EACH	$3,405.87	2	$6,811.74
INTAKE, SW-505	EACH	$5,250.00	25	$131,250.00
Sanitary Sewer Cost Estimate				
MANHOLE, SANITARY SEWER, 48 IN.	EACH	$6,052.00	13	$78,676.00
SANITARY SEWER GRAVITY MAIN, TRENCHED, PVC, 8 IN.	LF	$76.93	2,304	$177,246.72
CONNECTION TO EXISTING MANHOLE	EACH	$3,405.87	2	$6,811.74
Water Main				
FIRE HYDRANT ASSEMBLY, WM-201	EACH	$6,124.00	6	$36,744.00
VALVE, BUTTERFLY, DIP	EACH	$6,417.52	12	$77,010.24
WATER MAIN, TRENCHED, DUCTILE IRON PIPE (DIP), 8 IN.	LF	$113.97	2,588	$294,954.36

Site Work and Paving	$1,579,500
Storm Sewer	$514,000
Sanitary Sewer	$285,000
Water Main	$409,000
Contingencies	20%
Number of Lots	42
Total Construction Cost Estimate	**$3,268,000**
Cost of Infrastructure per lot	$78,000

PHASE 2				
Site Work and Paving				
Claring and Grubbing	AC	$4,531.41		$0.00
SIDEWALK, P.C. CONCRETE, 4 IN.	SY	$63.32	357	$22,605.24
HOT MIX ASPHALT MIXTURE, COMMERCIAL MIX	TON	$96.65	636	$61,469.40
MODIFIED SUBBASE	CY	$46.83	1,083	$50,716.89
CURB AND GUTTER, P.C. CONCRETE, 2.0 FT.	LF	$29.20	803	$23,447.60
EXCAVATION, CLASS 10, ROADWAY AND BORROW (Cut)	CY	$5.68	0	$0.00
Fill	CY	$20.00	23,196	$463,920.00
Trees (Phyto)	AC	$16,670.00	0.00	$0.00
Storm Sewer				
MANHOLE, STORM SEWER, 48 IN.	EACH	$4,683.00	9	$42,147.00
STORM SEWER GRAVITY MAIN, TRENCHED, PVC, 15 IN.	LF	$87.00	753	$65,511.00
STORM SEWER GRAVITY MAIN, TRENCHED, RCP, 2000D (CLASS III), 15 IN.	LF	$96.08	0	$0.00
CONNECTION TO EXISTING MANHOLE	EACH	$3,405.87	0	$0.00
INTAKE, SW-505	EACH	$5,250.00	6	$31,500.00
Sanitary Sewer Cost Estimate				
MANHOLE, SANITARY SEWER, 48 IN.	EACH	$6,052.00	4	$24,208.00
SANITARY SEWER GRAVITY MAIN, TRENCHED, PVC, 8 IN.	LF	$76.93	885	$68,083.05
CONNECTION TO EXISTING MANHOLE	EACH	$3,405.87	0	$0.00
Water Main				
FIRE HYDRANT ASSEMBLY, WM-201	EACH	$6,124.00	2	$12,248.00
VALVE, BUTTERFLY, DIP	EACH	$6,417.52	5	$32,087.60
WATER MAIN, TRENCHED, DUCTILE IRON PIPE (DIP), 8 IN.	LF	$113.97	918	$104,624.46

Site Work and Paving	$622,000
Storm Sewer	$185,500
Sanitary Sewer	$92,500
Water Main	$149,000
Contingencies	20%
Number of Lots	21
Total Construction Cost Estimate	**$1,203,000**
Cost of Infrastructure per lot	$57,000

References

Statewide Urban Design and Specifications

Iowa Department of Transportation

Asphalt Paving Association of Iowa

Environmental Protection Agency

Iowa Department of Natural Resources

Maquoketa City Standards

Mays, *Water Resource Engineering,* Wiley.

STEGO Industries