Harrisburg Master Drainage Plan

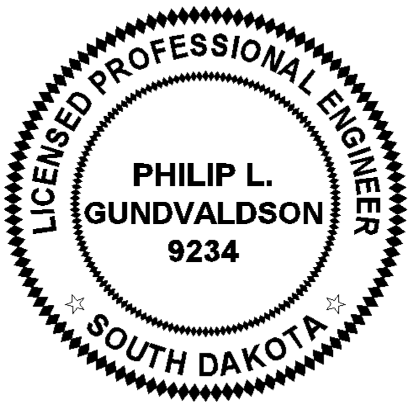
Final Report

Prepared for:

The City of Harrisburg
Lincoln County, South Dakota

Prepared by:
Howard R. Green Company

November 2007



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Harrisburg Master Drainage Plan
The City of Harrisburg
Lincoln County, South Dakota

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INTRODUCTION

The City of Harrisburg is located in Lincoln County, South Dakota and is a suburb of Sioux Falls (Figure 1). The population was 727 in the 1990 census and 958 at the 2000 census. However, based on the Census Bureau's 2006 data the population is estimated to be approximately 2,507 – a growth rate of over 160% over six years and over 240% in 16 years. Although Harrisburg currently has a total approximate area of only 0.9 square miles, it is facing significant water resource challenges as it quickly develops.

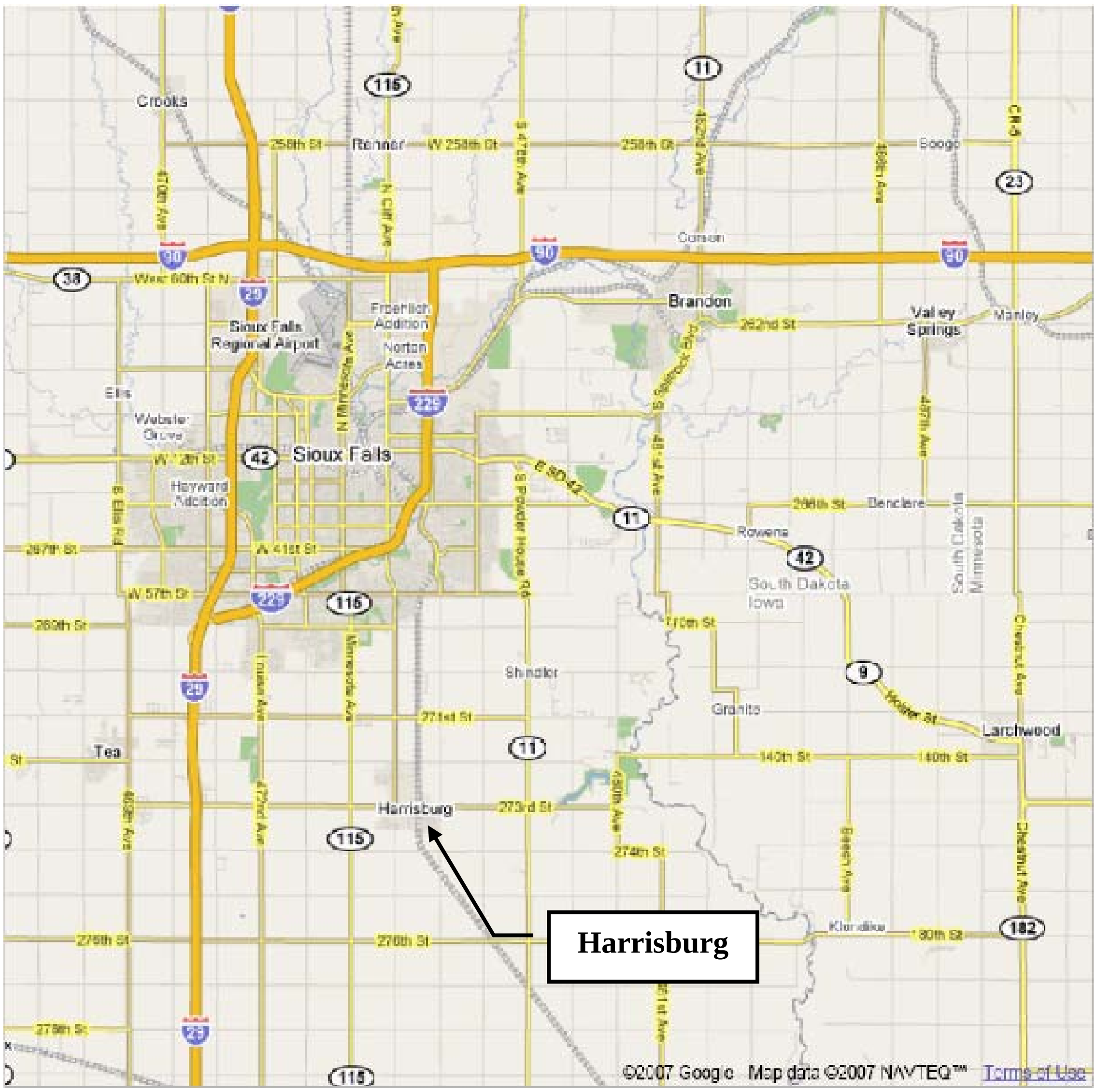

Figure 1 – Location Map

The following drainage Master Plan is developed for the City of Harrisburg based on survey data, hydrologic and hydraulic modeling, site assessments, proposed construction plans, and the following existing drainage studies:

A. “Lincoln County Drainage Study”, prepared for Lincoln County by Schmucker, Paul, Nohr & Associates, March 3 1995.
B. “East Side Harrisburg Drainage Study”, prepared for the City of Harrisburg by Howard R. Green Company, July 19, 2004.

GOALS AND POLICIES

The goals of the Stormwater Master Plan are to address the flooding issues currently occurring with the City and identify opportunities for managing stormwater runoff as an amenity in areas of future growth. This report is part of a holistic effort by the City of Harrisburg to preserve rural attractiveness of the community through proactive land stewardship, while accommodating growth.

Typically, a city is required to develop stormwater policy by the Department of Environmental & Natural Resources (DENR) due to federal requirements listed in the National Pollutant Discharge Elimination System (NPDES) Phase II program. Once a city’s population reaches 10,000 citizens, the city is classified as a small municipal separate storm sewer system (small MS4), which requires a general stormwater permit. The City of Harrisburg may be classified as a MS4 due to its proximity to the City of Sioux Falls. If classified as an MS4, the City’s General Permit must include provisions for post-construction stormwater management, which would typically regulate runoff rates and water quality. The City of Harrisburg does not currently meet the population size requirements to submit a general city and will likely not hit the 10,000 person threshold for five or more years, based on its current growth rate.

Many cities determine, only after reaching an MS4 size, that stormwater infrastructure built and approved prior to a formalized policy, do not meet the long-term needs of the city. The City of Harrisburg is able to take a proactive role in developing policy and its infrastructure now that will serve the City for many years to come. This report is being developed in conjunction with the ongoing process of reviewing stormwater management standards from the City of Sioux Falls and amending them for application to the City of Harrisburg. Through the application of those standards, in conjunction with the stormwater planning provided in this document, the City of Harrisburg should have the appropriate tools to address current and future stormwater issues.

LAND CHARACTERISTICS

Topography of the City of Harrisburg is nearly level with minor undulations. The predominant land use is agricultural and residential. Soil data is provided by the USDA Natural Resources Conservation Service. The primary Hydrologic Soil Group present has a B rating with C rated soils along the creeks and drainage areas. See the soils survey and additional information in Appendix A. B rated soils generally have moderate infiltration rate even when thoroughly wet, while C rated soils are not conducive to infiltration. The predominant B soils are moderately well drained or well drained and have moderately fine texture to moderately coarse texture. Type B soils allow for a variety of Best Management Practices (BMPs)[1] including those requiring infiltration capacity such as infiltration basins or rain gardens. The current zoning map was utilized to determine existing land uses for stormwater runoff calculations. The zoning map is included in Appendix B.

DRAINAGE / STREAM CORRIDORS

The City of Harrisburg topography is such that stormwater generally drains south and east, primarily to Ninemile Creek and its tributaries. Ninemile Creek located at the southern limits of the City, has a drainage basin of approximately 50 square miles, most of which is currently comprised of agricultural land uses. Future land use in the City of Harrisburg is predominantly single family residential. The general drainage patterns flooding areas within the City are indicated in the drainage issues figure included in Appendix C. Flooding is primarily due to conveyance restrictions and increased from from developed areas. Existing flooding areas and other areas of concern include:

- Elementary School / Willow Street
- Industrial Park at pond discharge area
- Area between Harrisburg Homesites and Green Meadows.
- Cliff Avenue Culvert at Green Meadows

Average yearly rainfall for the area is approximately 25 inches with peak rainfall rates occurring in May and June (Figure 2). Rainfall events for design of stormwater facilities are based on data compiled by the National Oceanic & Atmospheric Administration Technical Paper 40 Precipitation Frequency Atlas.

[1] Best Management Practices (BMPs) are techniques used to control stormwater runoff, sediment control, and soil stabilization, as well as management decisions to prevent or reduce nonpoint source pollution. The EPA defines a BMP as a "technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner."

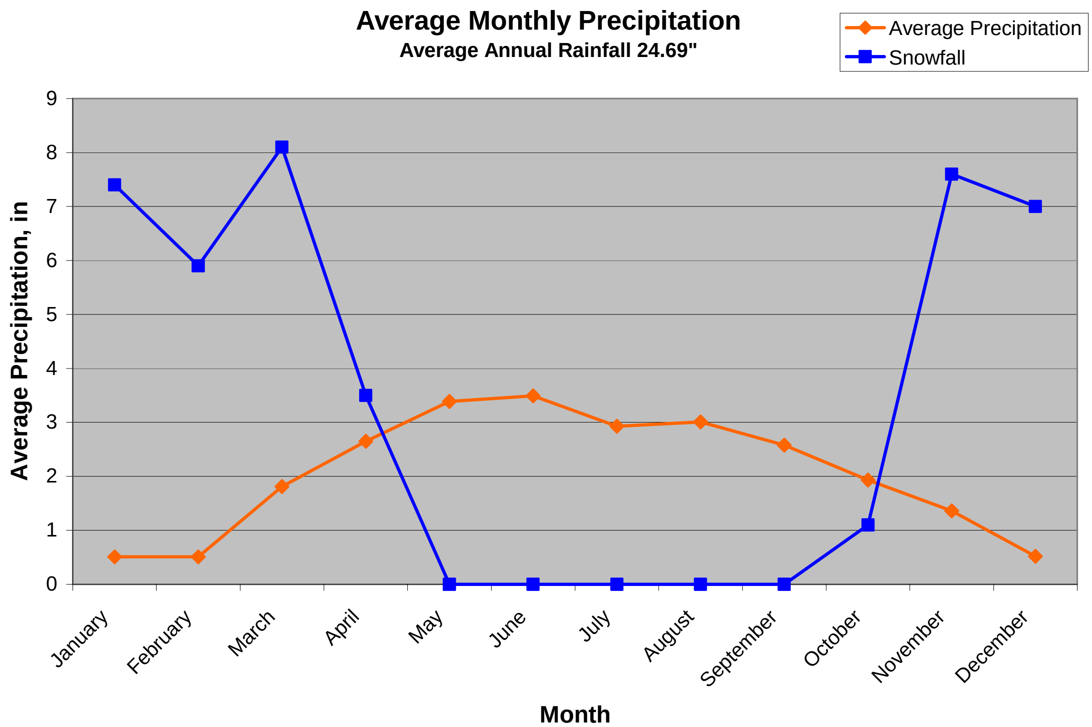

Figure 2 – Sioux Falls Monthly Precipitation Data

STORMWATER MANAGEMENT

Complete stormwater management is the proactive effort of community planning, technical regulations, and public information to protect water resource amenities. Planning and regulations are concurrently being addressed by the City; therefore, the focus of this report is on infrastructure design for runoff rate control, surface water quality, and stormwater volume control.

Stormwater runoff is defined as that portion of precipitation that flows over the ground surface during, and for a short time after, a storm as well as runoff due to snowmelt events. The quantity of runoff is dependent on the intensity of the storm, the length of storm, the amount of previous rainfall, the type of surface the rain falls onto, and the slope of the ground surface.

The intensity of a storm is described by the amount of rainfall that occurs over a given time interval. A specific rainfall amount over a given time interval will statistically occur in a given time span, usually defined in years. A 5-year frequency storm (3.5 inches in 24 hours) has a 20 percent chance of occurring or being exceeded in any given year, whereas a 100-year, 24-hour frequency storm (5.9 inches in 24 hours) has a 1 percent chance of occurring or being exceeded in any given year. A return frequency designates the average time span during which a single storm of a specific magnitude is likely to occur. Thus, the degree of protection afforded by storm sewer facilities is determined by selecting a return frequency to be used for design based on good economic sense and current engineering practices.

As Harrisburg expands, stormwater management will continue to be an important concern. Proactive stormwater management is required to protect property owners and prevent erosion of Ninemile Creek and the Big Sioux River. Ideally, the City of Harrisburg's stormwater management requirements will address both improvements in water quality and a reduction in runoff rates. Stormwater quality is improved through natural channels, sedimentation basins, wetlands, as well as various other BMPs. Rate control is often achieved through various basin designs, which allow for temporary storage of stormwater runoff. Stormwater volume reduction is achieved through infiltration basins, rate control basins, and weirs. Utilizing these tools will reduce flooding risks, minimize bank erosion within channels and streams, improve community aesthetics with additional green space, provide habitat for wildlife, and likely reduce the need for future capital expenditures to solve stormwater-related problems.

Stormwater Quantity / Rate Control

As land is converted from rural to urban, the volume and rate of stormwater runoff increases. Increases in runoff lead to flooding and erosion. Incorporating rate control practices to all developments will allow the City to expand while minimizing risks (and future costs) of flooding and stream damage. Stormwater quantity can be controlled through site specific facilities or regional facilities. At a minimum, the City should require each individual development to design, construct, and maintain or contribute to a maintenance fund for stormwater facilities to control runoff. As the City continues to develop, many residential stormwater facilities will be turned over to the City to manage and maintain. The City should set up a stormwater facility maintenance fund to help offset the cost of common maintenance issues such as sediment removal. The City can reduce the number of stormwater facilities it will need to maintain by consolidating individual facilities into a regional facility. Regional facilities can provide a cost-conscious solution to stormwater management as well as mitigate for existing developed areas which do not have adequate stormwater management BMPs.

The City of Harrisburg uses a 24-hour 5-year frequency storm event (3.5 inches) for storm sewer design, while the greater of the 100-year, 24-hour frequency rainfall event (5.9 inches) is used for overland drainage, basin storage design, and large culverts. Complete protection against large, infrequent storms with return intervals greater than 100 years are typically justified only for very large flood control projects. For most developing areas, the cost of constructing a large capacity storm drainage system is much greater than the amount of property damage that would result from flooding caused by a storm that a smaller capacity system could not accommodate.

The excess runoff caused by storms greater than that used for design should be accommodated by ponding in low spots in streets for short periods of time and providing outflow through designated overland drainage routes. This short-term flooding and overland drainage will minimize much of the damage to property that would occur if those facilities were not provided. Provisions should be made to provide or preserve overland drainage routes for emergency overflows. When possible, stormwater basin designs should include an emergency overflow to provide an outlet below the lowest floor elevation of any adjacent structure for added safety.

Stormwater Quality

The main purpose of the stormwater quality portion of the Surface Water Management Plan is to provide guidelines for protecting and improving the water quality of Harrisburg's streams. This section of the report provides the recommended practices for implementing post construction BMPs. Post construction BMPs are intended to reduce the pollutant loads associated with urban land use.

Post development BMPs can be separated into two categories; prevention and treatment. Prevention focuses on reducing the amount of pollutants released into the environment by educating the public on such issues such as responsible lawn care practices and the proper storage and disposal of waste material.

Examples of treatment type BMPs include; vegetative swales, buffer areas, infiltration basins and sedimentation basins. Sedimentation basins are the most common and effective BMP used for treatment of storm water runoff. Stormwater basins are an essential part of reducing the amount of pollutants being transported downstream by providing locations where ponding will allow sediments and many pollutants to settle out and be effectively removed from stormwater runoff.

STORMWATER FACILITIES

Stormwater facilities can be divided into five types depending on their storage characteristics and water quality function. These basin types use differing number of cells and wet volumes to achieve their intended function for quantity and quality. All basin types can be used to varying degrees for rate control.

Rate Control Basin

This type of facility normally contains no water during dry weather. These basins are usually located in a naturally occurring depression and are produced by an embankment constructed across the drainage way. The controlled outlet of this type of basin is located to provide complete drainage of the basin. Inlets discharging into the area are normally located at the upper end of the basin so that some overland flow exists from any storm condition. A shallow ditch-shaped passageway should be constructed into these ponds to confine overland flow from the inlets to the outlet points during storms of low intensity and during emptying periods. In cases where development and economics allow, a small diameter pipe could be placed below the basin bottom to allow low flows to be carried directly to the outlet. This would help eliminate nuisance flows and erosion of the basin bottom during an average small storm.

If it is desirable and economically feasible, a permanent wet pond can also be constructed in this type of basin. This can be done either by dredging out material below the present bottom of the basin or, in cases where hydraulics of the system allows it; the outlet can be raised to provide a desired depth of water in the basin.

Sedimentation Basin

This basin consists of a one-cell pond with open water to a minimum mean depth of four feet. Storage volume for discharge rate control is acquired by a differential in water levels. The outlet operates by gravity when the water elevation of the pond is above the normal water level. This type of pond allows larger suspended solids to settle below the normal water level and, thus, be removed from water draining down stream. Maintenance access must be provided around the perimeter of this type of basin to remove sediment buildup over time. While the sedimentation basin does provide some nutrient removal due to particle settlement, the pond is not specifically designed to meet nutrient removal goals.

Nutrient Removal Basin

This type of basin consists of a two cell pond. The first cell consists of a sedimentation basin to remove large particles prior to discharging to the second cell. The second cell must be designed to maximize the detention time for nutrient removal and promote plug flow[2] treatment to remove fine particles. This requires the pond design to maximize the distance between the intake and outlet structure for the pond. Special attention should be given in the design to provide access for maintenance work to the first cell and outlet structure of this type of basin. Total suspended soils removal should be greater than 90 percent. Total phosphorus removal should be greater than 65 percent. Nutrient removal basins should have outlets with the capability of preventing floating materials, such as an oil spill, from flowing from the pond. This would reduce potential contamination of downstream creeks and water bodies.

Vegetation Filter Basin

Basin areas, identified as vegetation filter basins are intended to be designed as three-cell pond systems. The first two cells should be similar to a nutrient removal basin. The third cell should consist of a shallow, highly vegetated wetland cell containing wetland species with high nutrient and pollutant uptake characteristics. Submerged berms should be incorporated into the design to promote plug flow throughout the entire pond. The third cell should be terraced to provide a mean depth between 0 and 2.0 feet. The maximum water level fluctuation for the 10-year, 24-hour storm event should generally not exceed two feet to protect vegetation within the third cell.

Created or Restored Wetlands

This type of basin consists of created or restored wetland area intended to improve water quality. Stormwater detention is not a dominant design factor in this design. The variation in water level should be less than two feet for a 10-year, 24-hour storm event. These ponds are usually located where runoff from upstream drainage areas has been treated or consist of undeveloped or undisturbed areas.

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[2] Plug flow is a flow regime in which velocity is constant through a channel or pipe and a slug of water can move through without dispersing or mixing. Plug flow is ideal for promoting settlement of fine particles within the water column.

MODELING SOFTWARE SYSTEM DESCRIPTION

The City of Harrisburg was modeled using the XP Stormwater & Wastewater Management Model (XPSWMM). XPSWMM is dynamic software that can model gravity sewer systems, with pumps, weirs, bypasses, and surcharging. In the case of the City of Harrisburg, it is important to be able to integrate the effects of surcharges into the system model to identify potential solutions. The system model consists of nodes and links. Nodes generally represent drainage structures, ponding locations, or an outfall from the system. Links generally represent channels, pipes, or other means of stormwater conveyance. A figure of the XPSWMM model is located in Appendix D and will be referred to in the following descriptions of the model.

Drainage calculations for developments in the City were provided by the various developers (See Appendix K). The data utilized included drainage areas, time of concentration (Tc), and runoff coefficients. This data was combined with similar data developed by the Howard R. Green (HRG) design team for undeveloped areas within the City. The data was entered into the XPSWMM model and the system was analyzed for various rainfall events. A free outfall condition was used at Southeastern Avenue due to lack of flood level data for Nine Mile Creek.

EXISTING SYSTEM ANALYSIS

Harrisburg can be split into two drainage basins. The northeast portion of the City can be analyzed independently of the remainder of the City as a unique drainage basin. The northeast basin begins in the Industrial Park; the industrial area drains approximately 40 acres into a 7.75 ac-ft stormwater basin. The Industrial Park stormwater basin discharges to the southeast and flows east under the Chicago Minneapolis and St. Paul Railway Railroad. This flow continues east through Legendary Estates; Legendary Estates is approximately 120 acres of residential property. An 8.1 ac-ft stormwater basin on the southeast corner of Legendary Estates receives the runoff and provides some rate control. The basin discharges east across agricultural land and flow continues east overland until reaching Ninemile Creek. The existing basins for these two developments appear to provide enough rate control to maintain predevelopment runoff flows. Although channel flow provides some water quality, the Legendary Estates basin appears to not allow particle settlement in low flows thus not providing any water quality treatment. A weir placed in this location would improve the system and provide for additional water quality treatment.

The larger basin drains the rest of the City and starts west of the Harrisburg Homesites Development. There is approximately 1,900 acres of agricultural land flowing southeast to the west edge of Harrisburg Homesites and then flowing south towards Willow Street. Harrisburg Homesites is approximately 120 acres of residential property; this development does not have onsite rate control. The culvert at Willow Street provides some rate control to the flow prior to it entering the Green Meadows Development. The Green Meadows development receives runoff from approximately 1,960 acres to the north and 450 acres to the west, Green Meadows contributes 180 acres, primarily residential drainage, with minimal rate control only in large storm events. The runoff continues east under Cliff Avenue, just south of the cemetery, to a culvert that provides some rate control per the analysis provided above. The runoff combines with runoff from the Elementary School, Harvest Acres, and the High School; in the meadow south of the High School.

Runoff from the Elementary School and 140 acres of agricultural land drain south, under Willow Street and along Columbia Avenue, to intakes on Elm Street. The intakes on Elm Street continue south collecting runoff from the city west of the railroad tracks, the High School, and Harvest Acres; this system outlets to the stream south of the High School. This area includes undersized stormsewer which results in flooding on the streets and in the field west of the Elementary School. The combined runoff flows south under 274th Street and then east to the bridge on Southeastern Avenue where it combines with flows from the City east of the railroad tracks, Lincoln Meadows Addition, and Greyhawk Addition. Runoff from the City east of the railroad tracks flows overland south through Lincoln Meadows to a stormwater basin on the north side of the sanitary ponds. Half of the runoff from Lincoln Meadows flows east to the ditch along Southeastern Avenue, the other half combines with flow from Greyhawk Addition in basins along the west edge of Greyhawk. The runoff then is conveyed south and combines with the flows from the west prior to discharging east under Southeastern Avenue. All XPSWMM model inputs and results are in Appendix E.

EXISTING SYSTEM CONCERNS & SOLUTIONS

The existing conveyance system has multiple areas of concern including:

- East Side Drainage Area
- Anna Way Flooding Area
- Industrial Park to Legendary Estates.
- Harrisburg Homesites to Green Meadows.
- Cliff Avenue Culvert at Green Meadows.
- Channel Maintenance Downstream of Green Meadows
- Channel Maintenance Downstream of High School
- Elementary School/Willow Street.

A location map of the following concern areas is included in Appendix F. Many of the areas of concern coincide with drainage channels and existing creeks. These areas coincide with the general patter of flood zones identified in Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps included in Appendix L.

<u>East Side Drainage Area</u>

The drainage study completed for this area in 2004 included solutions to the drainage issues associated with 476th Avenue. The Alternative #2 recommendations, listed in the report, including a new ponding area adjacent to the Greyhawk development area were implemented by the City in 2005. The full recommendations, including reconstructed ditch conveyance and rate control ponding along 476th Avenue have not been implemented at this juncture, but will likely be implemented once 476th Avenue is reconstructed.

Anna Way Flooding Area
The flooding that occurs in the Anna Way area can be resolved when Willow Street is converted to an urban section. Conversion from the rural section to an urban section will include lowering portions of the road, adding curb and gutter, and adding stormsewer intakes.

Industrial Park to Legendary Estates
The model shows some flooding in the Industrial Park; currently the stormwater basin for the Industrial Park outlets onto the southeast parcel of the Industrial Park and flows overland to a culvert under the railroad. The culvert has a negative slope which requires the runoff to pond on the west side of the tracks in the Industrial Park and just south of the Industrial Park prior to flowing east into the Legendary Estates. The size and inverts need to be adjusted to mitigate flooding; additional survey as well as coordination with the Legendary Estates developer would be required to avoid flooding of future development. Preliminary estimated costs for a reconstructed culvert and grading are $56,000. The cost estimate breakdown is included in Appendix G.

Harrisburg Homesites to Green Meadows
The XPSWMM model indicates approximately 5 feet of flooding at the south end of the 160 acres of agricultural land between the two developments during the 100-year event. The existing 10 by 10 box culvert under Lincoln County Highway 110, just west of Cliff Avenue, is restricting much of the flow and resulting in the flooding of this land. It is not advised to upgrade this culvert due to the risk of additional downstream flooding and streambank erosion. There is approximately 1,960 acres of land that drain to this culvert, of which only about 200 acres are currently developed. In the short term, HRG recommends constructing a regional stormwater basin. A regional stormwater basin could solve existing flooding issues, provide rate control for existing developments without rate control, improve the water quality, and allow for development along Cliff Avenue. Preliminary estimated costs for a regional stormwater basin are $645,000. The cost estimate breakdown is included in Appendix G. In the long-term, it is recommended that all development upstream provide rate control that meets or exceeds current rate control through ponding or ideally, infiltration.

Cliff Avenue Culvert
The existing 84” culvert under Cliff Avenue is in good condition, but is currently acting as a rate control device in large storm events, since existing capacity does not allow for conveyance of the 100-year event. Drainage calculations provided by Green Meadows development indicate the 100-year rainfall event overtops Cliff Avenue[3]. Additional capacity should be added at this crossing. HRG recommends a dual 10ft by 5ft concrete

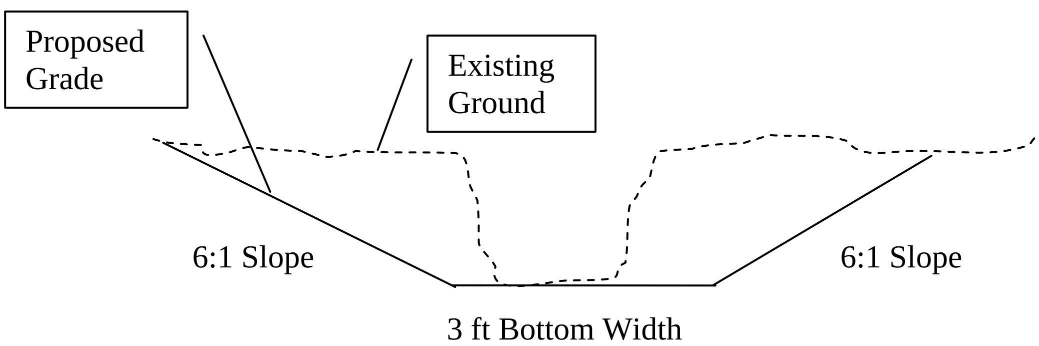
[3] This calculation assumes the channel downstream is free of sediment build up. The channel currently has approximately 2ft of sediment that has built up just downstream of the outlet. Channel maintenance recommendations are provided in the following section “Channel Maintenance Downstream of Green Meadows”.

box culvert and a weir structure should be added to the upstream end. The weir would provide rate control for smaller events while the upgraded culverts protect Cliff Avenue in the 100-year event. To complete the concept design, 100-year flow data from XPSWMM was entered into Culvert Master, a program used to size culverts, see output in Appendix H. The downstream end will require an energy dissipation device if capacity is increased and the pipe is resized. Preliminary estimated costs are $200,000. The cost estimate breakdown is included in Appendix G.

Channel Maintenance Downstream of Green Meadows[4]

The channel conveying flow from the culverts under Cliff Avenue, downstream of Green Meadows, is highly overgrown and has inadequate conveyance capacity. The proposed channel will convey approximately 490 cfs in the 10-year storm event. In the short term, HRG recommends regrading of the channel to provide the adequate conveyance. The originally constructed channel lines and grades should be determined and the channel reconstructed to those dimensions, but at a minimum, the following dimensions should be achieved.

Channel Cross-section



Longer term, HRG recommends reconstructing the channel as a meandering low flow channel with high flow flood plain areas and offline wetland pools. The high flow areas would be an ideal area for a linear park with trail system for future developments in the area. An example of a similar solution is included in Appendix M. The hybrid channel/pool design would improve conveyance capacity in the high flow events, but also improve water quality, promote infiltration, enhance the corridor aesthetics, and create a community recreational attraction. Preliminary estimated costs range from $118,000 to $562,000 based on the extent of reconstruction. The cost estimate breakdown is included in Appendix G.

[4] Per a telephone conversation with the U.S. Army Corps of Engineers permitting division on October 18, 2007, the following guidance relative to channel maintenance permitting is provided. Most channel maintenance is allowed under the national maintenance permit or general exemption. If the channel can be shown to have been a man-made conveyance channel, the City may return it to original lines and grades under a self-determined exemption. If proof of prior channel construction is not available, field investigation to determine extent of silt/sedimentation may be used to determine original channel dimensions. Hand auger samples prior to construction are adequate. Channel maintenance projects do not require advance notification to the Corps.

Channel Maintenance Downstream of High School

The channel downstream from the high school needs to be maintained to meet conveyance needs for stormwater discharge in this location. The channel requires minor sediment removal and clearing of cattails. This segment could be incorporated into the linear park concept described above at an appropriate point in the future.

Elementary School/Willow Street

This area is the primary concern for the City of Harrisburg. During large rain events and periods of wet weather, the area just west of the elementary school serves as a pond for approximately 140 acres of runoff from the north. The model results for this area confirm flooding just west of the existing Elementary School, resulting in the need to pump stormwater over Willow Street to the storm sewer system on Columbia Street. There is currently an old drain tile that drains this flooded area which connects to the existing storm sewer system on Emmett Trail. The tile has been augered out and is estimated to have the capacity of a six inch pipe. Over an extended period of time, this tile eventually drains the flooded area.

A rate control basin and additional stormsewer will be needed to protect this area from flooding in the 100-year and smaller event. This issue's solution will require higher construction costs compared to the other solutions since the natural drainage path for this area is through the developed part of town to the south.

HRG designers investigated four different options to resolve the flooding issue. All solutions propose new conveyance routes to Ninemile Creek and include a rate control basin. A rate control basin or equivalent rate control BMP is required due to the current 100-year runoff rate; the current 100-year runoff rate for the undeveloped land is 230 cfs. Without a rate control device, such as a rate control basin, it would require dual 54 inch Reinforced Concrete Pipe (RCP) to convey the 100-year event to the natural drainage way, which HRG deemed cost prohibitive. All basin costs are calculated based on a dry pond design, but HRG recommends construction of a wet pond infiltration basin to achieve water quality treatment.

It should be noted that the rate control basin proposed within the following solutions is sized only for the existing condition; all future development on the undeveloped land within the localized watershed will need to provide rate control to meet 100-year rate control requirements. The basin could be sized for full build development if the City is able to create a system to collect user fees. In additional to determining if upstream development will be included in the pond design, groundwater depths and soil borings should be taken prior to final design. The proposed stormwater basin location is based on the flow patterns in the area. Unfortunately, the proposed basin location is located within potential development area. Consequently, the design team attempted to strike a balance between the basin size and conveyance pipes in all proposed solutions.[5] The opportunity costs of the basin size were not included in the cost estimates provided for

[5] The size of the basin is inversely related to the size of the pipe and sewer structures required to convey the stormwater from the flood area.

each design option, but should be considered by the City when evaluating the potential solutions.

<u>Option 1</u>
Create a 16 ac-ft rate control basin at the northwest corner of Willow Street and Columbia Street; the basin surface area is approximately 3.1 acres. The basin in this option and following options is sized to include a 1-foot freeboard from the closest street or structure using HydroCAD, result data is provided in Appendix I. In conjunction with sanitary improvements proposed along Columbia Street, install 3,600 feet of 48-inch RCP. A figure of the proposed path is included in Appendix F. Estimated construction costs, if completed in conjunction with the Columbia Street sanitary sewer project, are $1,260,000; the cost estimate breakdown is included in Appendix G. Since the project is completed in conjunction with the sanitary sewer project, the costs of removing and reconstructing Columbia Street are not included. Options which require impacts to other roads are included within the opinion of probable cost.

<u>Option 2 (preferred alternative)</u>
Create a 13 ac-ft rate control basin at the northwest corner of Willow Street and Columbia Street, the basin surface area is approximately 2.5 acres. In conjunction with the sanitary improvements proposed along Columbia Street, install 2,000 feet of 54-inch RCP. This option would require 400 feet of street reconstruction on Walnut Street and 1,800 feet of channel creation on the eastern edge of the High School Property, channel computations are provided in Appendix J. The existing gas line which runs NW to SE along the back lot lines of the homes along Emmet Trail would be crossed in this design option. The existing gas line is 6 inches in diameter and is approximately 2 to 4 feet deep. The depth of the proposed 48" pipe is approximately nine feet below grade, which should be below the estimated elevation of the gas line in that location. This option may conflict with existing storm sewer at the intersection of Walnut Street and Emmett Trail; conflicts will need to be resolved during final design. This option would also require purchasing a drainage easement from the homeowner on the southwest corner of the Maple Street and Emmett Street intersection. A drainage easement might also be required from the High School. A figure of the proposed path is included in Appendix F. Estimated construction costs, if completed in conjunction with the Columbia Street sanitary sewer project, are $1,240,000; the construction cost estimate breakdown is included in Appendix G.

<u>Option 3</u>
Create a 19.5 ac-ft rate control basin at the northwest corner of Willow Street and Columbia Street, the basin surface area is approximately 6.9 acres. Install 400 feet of 5-by 3-foot box culvert connecting into 1,600 feet of 48-inch RCP to the west along Willow Street and cross under Cliff Avenue. This option would require an additional culvert under Willow Street from the north into Green Meadows, an additional culvert at Honeysuckle Drive in the Green Meadows development, and an additional culvert at Cliff Avenue near the cemetery. This option would add additional flow to a system already over capacity. A figure of the proposed path is included in Appendix F. Estimated construction costs are $1,221,000. This option would require an additional

$200,000 reconstruction of the Cliff Avenue culvert crossing, discussed above. The construction cost estimate breakdown is included in Appendix G.[6]

Option 4

This option required installing a pipe east under Willow Street. This option is infeasible due to lack of elevation difference required for minimal pipe slope to achieve sufficient flow. An estimated construction cost was not prepared for this option.

Option 5

This option involved upsizing the existing drain tile connection to the existing storm sewer system on Emmett Trail. This option is infeasible due to lack of capacity in the existing storm system on Emmett Trail. Model results show this system at full capacity for the 5-year event, upsizing the existing drain tile would cause surcharging/flooding of downstream catch basins. A construction cost estimate and figure was not prepared for this option.

Preferred Option

HRG Designers recommend Option 2. It is the least expensive, allows for the smallest stormwater basin footprint, and includes some potential for water quality treatment. The preliminary design of Option 1 and 2 have the potential to allow for additional storage; this storage could be used for rate control and water quality treatment when Willow is converted from a rural to urban section. The smaller footprint of Option 2 would allow for more developable land than the other options. The natural drainage channel would provide the ability for infiltration, improving water quality.

Table 1 – Estimated Improvement Costs

Improvement Area	Cost	Basin Size
Industrial Park to Legendary Estates	$56,000	
Harrisburg Homesites to Green Meadows	$645,000	10 acres
Cliff Avenue Culvert	$200,000	
Channel Maintenance	$118,000	
Channel Maintenance & Reconstruction	$562,000	
Elementary School / Willow Street		
Option 1	$1,260,000	3.1 acres
Option 2	$1,240,000	2.5 acres
Option 3	$1,421,000	6.9 acres
Option 4	N/A	
Option 5	N/A	

[6] This option requires the implementation of the Cliff Avenue culvert/weir reconstruction previously discussed. The estimated construction costs for Option 3 includes the Cliff Avenue culvert/weir reconstruction.

FUTURE SYSTEM

The City of Harrisburg is a rapidly growing community with an equally growing demand for stormwater management. Stormwater decisions made today will affect the system functionality and aesthetics of the community for years to come. As the City continues to grow, there will be an increased demand on existing natural waterways. Without proper management of stormwater runoff, many of Harrisburg's natural channels and streams may have to be converted to concrete channels. The City of Sioux Falls has had to make this conversion on some of their waterways. The City of Harrisburg should enforce rate control standards, water quality standards, and promote infiltration when feasible to maintain its rural attractiveness. Rate control will provide the minimum protection for conveyance channels. The natural streams in Harrisburg rely on groundwater to maintain flow; therefore, an increase in infiltration will lead to more consistent groundwater flow. As the City grows, impervious areas will increase leading to a decrease in infiltration. Consequently, the natural streams in Harrisburg will be more "flashy", dry during most of the year and flooding during rain events. Maintaining Harrisburg's natural streams should lead to improved habitat, stable streambanks, greater aesthetic value, and an improved quality of life for Harrisburg's residents.

The proposed High School presents multiple opportunities to reduce developed runoff rates, provide water quality treatment, and improve infiltration. The proposed site is within an already taxed drainage basin, a regional basin on or near the High School property could provide benefits for both the High School and downstream properties. A regional basin would not only provide a great education opportunity, but could also provide an irrigation source for their many athletic fields. Runoff from the school and upstream land could be detained in a large regional basin and meet stormwater runoff and quality requirements. In combination with an infiltration basin or wetland in a treatment train, this system could serve as a model for stormwater management in the region.

The Harrisburg Comprehensive Plan estimates an available future land use of 7,015 acres single family, 505 acres multi family, 244 acres combined residential, 170 acres commercial, 278 acres of industrial, and 330 acres greenway/recreational. As Harrisburg develops, it is important for the City leadership to take a proactive role in guiding development and enforcing stormwater requirements. By adhering to good practices now, the City will eliminate the need for costly stormwater facility and stream reconstruction and retrofit projects in the future.

SUMMARY AND RECOMMENDATIONS

The HRG team recommends fully implementing and enforcing adopted stormwater regulations to mitigate the impacts of future development. The City should also consider the following recommendations:

1. Implement regional impoundment facilities in conjunction with site specific impoundment facilities to address stormwater management in areas where inadequate management is in place for existing development.

2. Upgrade existing BMPs and impoundment facilities to mitigate for uncontrolled stormwater discharges.
3. Promote localized stormwater management by residents including the use of raingardens, redirecting downspouts to pervious areas, use of rain barrels, and other BMPs. The Minnesota Stormwater Manual provided by the Minnesota Pollution Control Agency is a great resource for BMP types, construction costs, maintenance costs, pollutant removal efficiency, and AutoCAD standard details.[7]
4. Maintain policies that regulate development in floodplain areas.
5. Utilize natural drainage ways when possible, ensuring that design storm runoff will not exceed allowable velocity or shear stress limitations within the channel.
6. Investigate partnerships with the County or the South Dakota Department of Environmental and Natural Resources to pursue funding to implement water quality treatment BMPs.
7. Implement BMPs that achieve NURP treatment levels for all future development to preserve the quality of the water resources in the area.

The City has many options to solve their current flooding issues and to avoid future issues. Through a proactive commitment to stormwater management, the City of Harrisburg can improve the quality of life for both its residents and communities that receive Harrisburg's runoff.

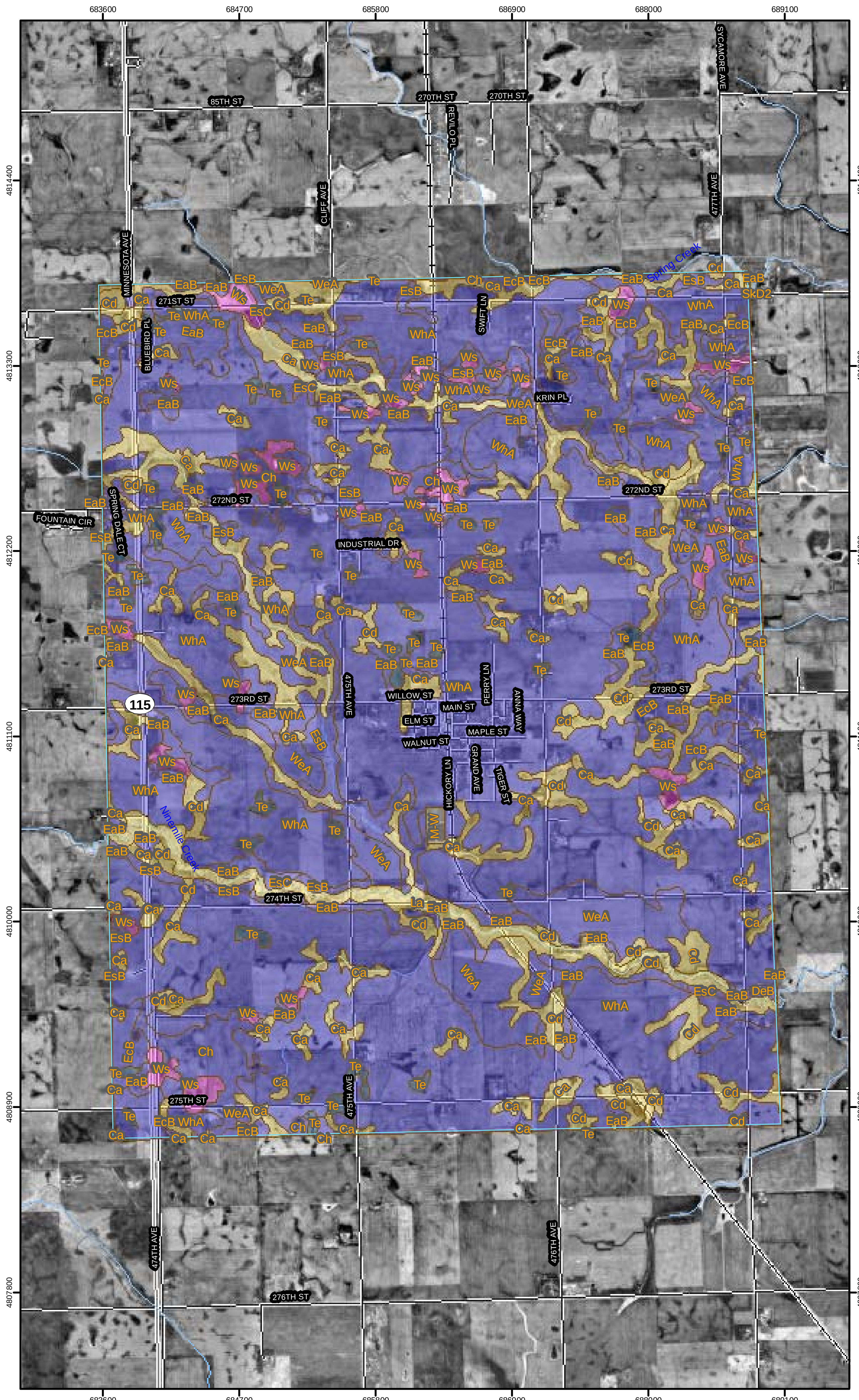
[7] http://proteus.pca.state.mn.us/water/stormwater/stormwater-manual.html

REFERENCES

1. City of Sioux Falls. Engineering Design Standards for Public Improvements. Sioux Falls, South Dakota 1999 Revised 2007.
2. CH2MHILL & Howard R. Green Company. Stormwater BMP Master Plan. Sioux Falls, South Dakota 2003.
3. Bonestroo, Rosene, Anderlik & Associates, Inc. Storm Water Management Plan. Rochester, Minnesota 1997 Revised 1999.
4. "2006 Sioux Falls Area Climate Summary" *NOAA's National Weather Service Weather Forecast Office* 2006. 21 Sept. 2007 <http://www.crh.noaa.gov/fsd/?n=fsd2006>
5. South Eastern Council of Governments. Harrisburg Comprehensive Plan. Harrisburg, South Dakota 2005.

APPENDIX A

Soil Data



N

Meters
0 250 500 1,000 1,500

Feet
0 1,000 2,000 4,000 6,000

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Soil Ratings
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Political Features

Municipalities
- Cities
- Urban Areas

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails

Roads
- Interstate Highways
- US Routes
- State Highways
- Local Roads
- Other Roads

MAP INFORMATION

Original soil survey map sheets were prepared at publication scale. Viewing scale and printing scale, however, may vary from the original. Please rely on the bar scale on each map sheet for proper map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 14N

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lincoln County, South Dakota
Survey Area Data: Version 8, Jul 31, 2007

Date(s) aerial images were photographed: 4/23/1996; 10/2/1997; 10/13/1998

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Lincoln County, South Dakota				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
Ca	Chancellor-Tetonka silty clay loams	C	985.3	10.9%
Cd	Chancellor-Viborg silty clay loams	C	330.2	3.7%
Ch	Chancellor-Wakonda-Tetonka complex	B	187.4	2.1%
DeB	Delmont loam, 2 to 6 percent slopes	B	5.2	0.1%
EaB	Egan silty clay loam, 3 to 6 percent slopes	B	1,005.7	11.1%
EcB	Egan-Chancellor silty clay loams, 0 to 4 percent slopes	B	191.3	2.1%
EsB	Egan-Shindler complex, 2 to 6 percent slopes	B	196.9	2.2%
EsC	Egan-Shindler complex, 6 to 9 percent slopes	B	22.2	0.2%
HuA	Huntimer silty clay loam, 0 to 2 percent slopes	C	1.8	0.0%
La	Lamo silty clay loam	C	169.1	1.9%
M-W	Miscellaneous water		11.0	0.1%
SkD2	Shindler-Egan complex, 9 to 15 percent slopes, eroded	C	0.8	0.0%
Te	Tetonka silty clay loam	C/D	156.0	1.7%
WeA	Wentworth silty clay loam, 0 to 2 percent slopes	B	359.0	4.0%
WhA	Wentworth-Chancellor silty clay loams, 0 to 2 percent slopes	B	5,170.8	57.2%
Ws	Worthing silty clay	D	245.8	2.7%
Totals for Area of Interest (AOI)			9,038.5	100.0%

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Lower

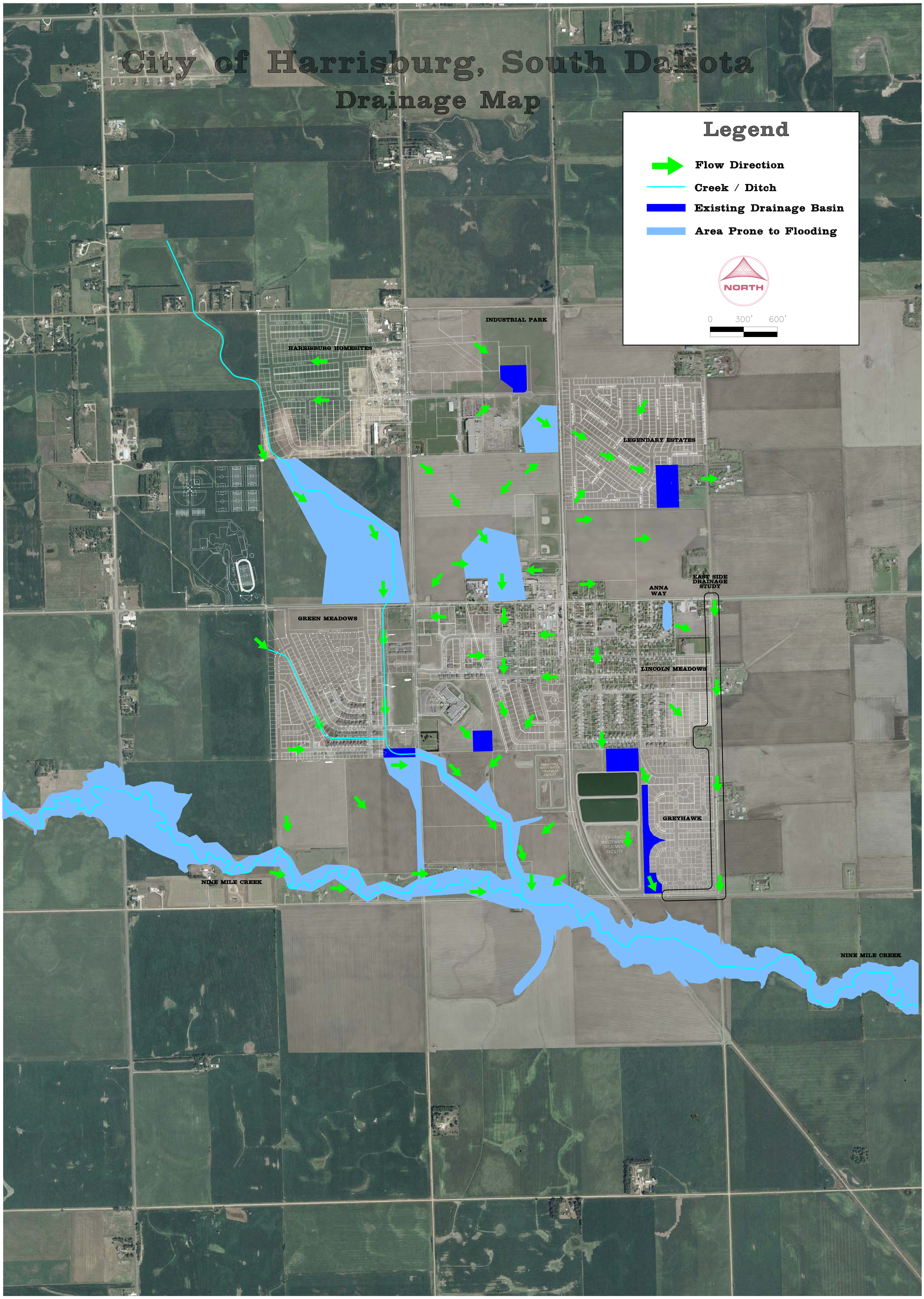
APPENDIX B

Zoning Map

City of Harrisburg, South Dakota
Zoning Map

APPENDIX C

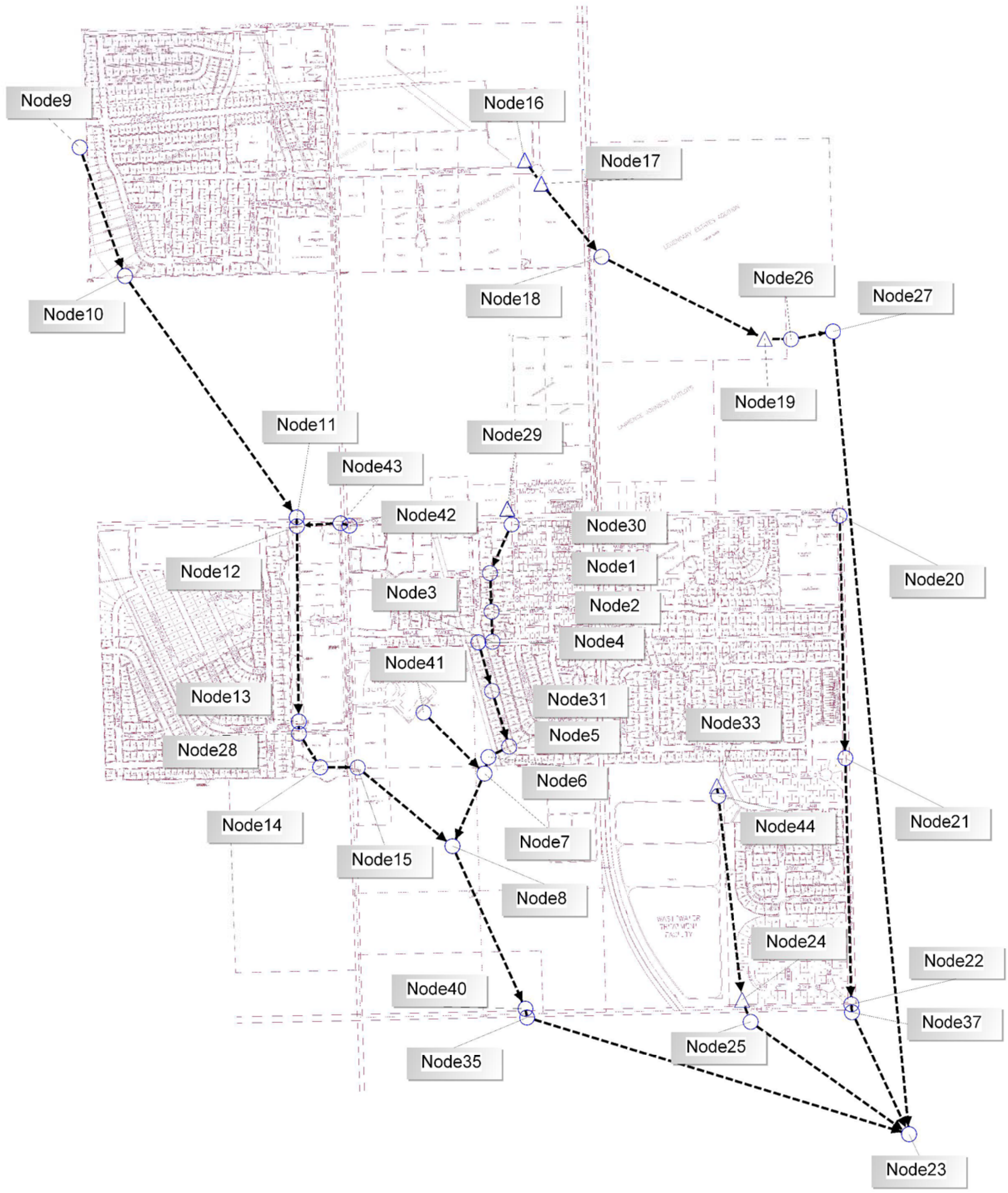
Drainage Map



Howard R. Green Company

APPENDIX D

XPSWMM Layout



Scale 1 : 52614.86

APPENDIX E

XPSWMM Inputs & Results

Table E1

Name	Storm	Link Name	Length ft	Shape	Roughness	Bottom Width ft	Diameter (Height) ft	Left-hand Side Slope ft	Right-hand Side Slope
ELM36	100 year	Link1	400.000	Circular	0.0130	0.0001	3.000	0.000	0.000
ELM36	50 year								
ELM36	10 year								
MAPLE36	100 year	Link2	391.667	Circular	0.0130	0.0001	3.000	0.000	0.000
MAPLE36	50 year								
MAPLE36	10 year								
WAL36	100 year	Link3	145.200	Circular	0.0130	0.0001	3.000	0.000	0.000
WAL36	50 year								
WAL36	10 year								
EMMID36	100 year	Link4	629.700	Circular	0.0130	0.0001	3.000	0.000	0.000
EMMID36	50 year								
EMMID36	10 year								
HARV1	100 year	Link5	244.700	Circular	0.0130	0.0001	3.000	0.000	0.000
HARV1	50 year								
HARV1	10 year								
HARV2	100 year	Link6	10.300	Circular	0.0130	0.0001	3.000	0.000	0.000
HARV2	50 year								
HARV2	10 year								
HARVOUT	100 year	Link7	356.000	Circular	0.0130	0.0001	3.000	0.000	0.000
HARVOUT	50 year								
HARVOUT	10 year								
6TRIB1	100 year	Link27	2000.000	Natural	0.0130	0.0001	6.000	0.000	0.000
6TRIB1	50 year								
6TRIB1	10 year								
Hom_chan	100 year	Link8	1500.000	Natural	0.0130	0.0001	5.000	0.000	0.000
Hom_chan	50 year								
Hom_chan	10 year								
homtogre	100 year	Link9	3780.000	Natural	0.0350	0.0001	2.000	0.000	0.000
homtogre	50 year								
homtogre	10 year								
will6x8	100 year	Link10	68.000	Rectangular	0.0130	6.0000	8.000	0.000	0.000
will6x8	50 year								
will6x8	10 year								
grenup	100 year	Link11	2320.000	Natural	0.0350	0.0001	5.000	0.000	0.000
grenup	50 year								
grenup	10 year								
honeysuc1	100 year	Link12	104.000	Circular	0.0130	0.0001	4.000	0.000	0.000
honeysuc1	50 year								
honeysuc1	10 year								
honeysuc2	100 year	Link12	104.000	Circular	0.0130	0.0001	4.000	0.000	0.000
honeysuc2	50 year								
honeysuc2	10 year								
honeysuc3	100 year	Link12	104.000	Circular	0.0130	0.0001	4.000	0.000	0.000
honeysuc3	50 year								
honeysuc3	10 year								
HoneyRD	100 year	Link12	80.000	Natural	0.0130	0.0001	2.000	0.000	0.000
HoneyRD	50 year								
HoneyRD	10 year								
cliff84	100 year	Link13	94.000	Special	0.0130	0.0001	6.000	0.000	0.000
cliff84	50 year								
cliff84	10 year								
cemetery	100 year	Link14	1615.000	Natural	0.0130	0.0001	4.500	0.000	0.000
cemetery	50 year								
cemetery	10 year								
IndPond	100 year	Link15	750.000	Circular	0.0110	0.0001	3.000	0.000	0.000
IndPond	50 year								
IndPond	10 year								
RR_30	100 year	Link16	30.000	Circular	0.0130	0.0001	2.500	0.000	0.000
RR_30	50 year								
RR_30	10 year								
backyard	100 year	Link17	1800.000	Natural	0.0300	0.0001	2.000	0.000	0.000
backyard	50 year								
backyard	10 year								
Len42a	100 year	Link22	48.000	Circular	0.0130	0.0001	3.500	0.000	0.000
Len42a	50 year								
Len42a	10 year								
Len42b	100 year	Link22	48.000	Circular	0.0130	0.0001	3.500	0.000	0.000
Len42b	50 year								
Len42b	10 year								
SEaveDit	100 year	Link18	2600.000	Natural	0.0130	0.0001	5.000	0.000	0.000
SEaveDit	50 year								
SEaveDit	10 year								
seavedit1	100 year	Link19	2600.000	Natural	0.0130	0.0001	5.000	0.000	0.000
seavedit1	50 year								
seavedit1	10 year								
274_culv	100 year	Link32	33.000	Circular	0.0130	0.0001	4.000	0.000	0.000
274_culv	50 year								
274_culv	10 year								
274tha	100 year	Link21	37.000	Circular	0.0130	0.0001	3.000	0.000	0.000
274tha	50 year								
274tha	10 year								
274thb	100 year	Link21	37.000	Circular	0.0130	0.0001	3.000	0.000	0.000
274thb	50 year								
274thb	10 year								
274thc	100 year	Link21	37.000	Circular	0.0130	0.0001	3.000	0.000	0.000
274thc	50 year								
274thc	10 year								
Outfall_3	100 year	Link31	880.000	Natural	0.0130	0.0001	4.000	0.000	0.000
Outfall_3	50 year								
Outfall_3	10 year								
lenout	100 year	Link23	554.000	Natural	0.0350	0.0001	2.000	0.000	0.000
lenout	50 year								
lenout	10 year								

Table E1

Name	Storm	Link Name	Length ft	Shape	Roughness	Bottom Width ft	Diameter (Height) ft	Left-hand Side Slope ft	Right-hand Side Slope
greensou	100 year	Link24	500.000	Natural	0.0130	0.0001	5.000	0.000	0.000
greensou	50 year								
greensou	10 year								
8drain	100 year	Link25	33.000	Circular	0.0130	0.0001	0.667	0.000	0.000
8drain	50 year								
8drain	10 year								
ditch	100 year	Link35	770.000	Natural	0.0130	0.0001	1.000	0.000	0.000
ditch	50 year								
ditch	10 year								
TIGER36	100 year	Link26	528.600	Circular	0.0130	0.0001	3.000	0.000	0.000
TIGER36	50 year								
TIGER36	10 year								
san36	100 year	Link28	100.000	Circular	0.0130	0.0001	3.000	0.000	0.000
san36	50 year								
san36	10 year								
outfall_2	100 year	Link30	3085.000	Natural	0.0130	0.0001	6.000	0.000	0.000
outfall_2	50 year								
outfall_2	10 year								
outfall_4	100 year	Link33	1210.000	Circular	0.0130	0.0001	4.000	0.000	0.000
outfall_4	50 year								
outfall_4	10 year								
Outfall_1	100 year	Link34	33.000	Circular	0.0130	0.0001	2.000	0.000	0.000
Outfall_1	50 year								
Outfall_1	10 year								
274_cul	100 year	Link29	33.000	Rectangular	0.0130	40.0000	6.000	0.000	0.000
274_cul	50 year								
274_cul	10 year								
school	100 year	Link36	33.000	Natural	0.0130	0.0001	3.000	0.000	0.000
school	50 year								
school	10 year								
cliff_lin	100 year	Link37	88.000	Circular	0.0130	0.0001	1.500	0.000	0.000
cliff_lin	50 year								
cliff_lin	10 year								
lin_na	100 year	Link38	470.000	Natural	0.0130	0.0001	3.000	0.000	0.000
lin_na	50 year								
lin_na	10 year								
sanpons	100 year	Link39	2300.000	Natural	0.0130	0.0001	3.000	0.000	0.000
sanpons	50 year								
sanpons	10 year								
chanso	100 year	Link40	800.000	Natural	0.0350	0.0001	6.000	0.000	0.000
chanso	50 year								
chanso	10 year								
bridge	100 year	Link42	33.000	Rectangular	0.0130	30.0000	6.000	0.000	0.000
bridge	50 year								
bridge	10 year								

Table E4

Name	Storm	Link Name	Upstream Node Name	Downstream Node Name	Length ft	Roughness	Upstream Invert Elevation	Downstream Invert Elevation	Shape	Diameter (Height) ft
ELM36	100 year	Link1	Node1	Node2	400.000	0.0130	1416.690	1411.890	Circular	3.000
ELM36	50 year									
ELM36	10 year									
MAPLE36	100 year	Link2	Node2	Node3	391.667	0.0130	1411.790	1407.090	Circular	3.000
MAPLE36	50 year									
MAPLE36	10 year									
WAL36	100 year	Link3	Node3	Node4	145.200	0.0130	1406.690	1406.490	Circular	3.000
WAL36	50 year									
WAL36	10 year									
EMMID36	100 year	Link4	Node4	Node31	629.700	0.0130	1406.390	1401.950	Circular	3.000
EMMID36	50 year									
EMMID36	10 year									
HARV1	100 year	Link5	Node5	Node6	244.700	0.0130	1398.890	1397.480	Circular	3.000
HARV1	50 year									
HARV1	10 year									
HARV2	100 year	Link6	Node6	Node7	10.300	0.0130	1397.480	1397.440	Circular	3.000
HARV2	50 year									
HARV2	10 year									
HARVOUT	100 year	Link7	Node7	Node8	356.000	0.0130	1397.440	1392.000	Circular	3.000
HARVOUT	50 year									
HARVOUT	10 year									
6TRIB1	100 year	Link27	Node8	Node40	2000.000	0.0130	1392.000	1378.000	Natural	6.000
6TRIB1	50 year									
6TRIB1	10 year									
Hom_chan	100 year	Link8	Node9	Node10	1500.000	0.0130	1435.500	1431.000	Natural	5.000
Hom_chan	50 year									
Hom_chan	10 year									
homtogre	100 year	Link9	Node10	Node11	3780.000	0.0350	1431.000	1410.200	Natural	2.000
homtogre	50 year									
homtogre	10 year									
will6x8	100 year	Link10	Node11	Node12	68.000	0.0130	1410.200	1410.000	Rectan	8.000
will6x8	50 year									
will6x8	10 year									
grenup	100 year	Link11	Node12	Node13	2320.000	0.0350	1410.000	1401.000	Natural	5.000
grenup	50 year									
grenup	10 year									
honeysuc1	100 year	Link12	Node13	Node28	104.000	0.0130	1400.270	1399.900	Circular	4.000
honeysuc1	50 year									
honeysuc1	10 year									
honeysuc2	100 year	Link12	Node13	Node28	104.000	0.0130	1400.270	1399.900	Circular	4.000
honeysuc2	50 year									
honeysuc2	10 year									
honeysuc3	100 year	Link12	Node13	Node28	104.000	0.0130	1400.270	1399.900	Circular	4.000
honeysuc3	50 year									
honeysuc3	10 year									
HoneyRD	100 year	Link12	Node13	Node28	80.000	0.0130	1403.000	1403.000	Natural	2.000
HoneyRD	50 year									
HoneyRD	10 year									
cliff84	100 year	Link13	Node14	Node15	94.000	0.0130	1396.950	1396.280	Special	6.000
cliff84	50 year									
cliff84	10 year									
cemetery	100 year	Link14	Node15	Node8	1615.000	0.0130	1396.280	1392.000	Natural	4.500
cemetery	50 year									
cemetery	10 year									
IndPond	100 year	Link15	Node16	Node17	750.000	0.0110	1434.400	1431.700	Circular	3.000
IndPond	50 year									
IndPond	10 year									
RR_30	100 year	Link16	Node17	Node18	30.000	0.0130	1431.380	1431.570	Circular	2.500
RR_30	50 year									
RR_30	10 year									
backyard	100 year	Link17	Node18	Node19	1800.000	0.0300	1431.570	1415.000	Natural	2.000
backyard	50 year									
backyard	10 year									
Len42a	100 year	Link22	Node19	Node26	48.000	0.0130	1414.200	1413.998	Circular	3.500
Len42a	50 year									
Len42a	10 year									
Len42b	100 year	Link22	Node19	Node26	48.000	0.0130	1414.200	1413.998	Circular	3.500
Len42b	50 year									
Len42b	10 year									
SEaveDit	100 year	Link18	Node20	Node21	2600.000	0.0130	1414.530	1400.180	Natural	5.000
SEaveDit	50 year									
SEaveDit	10 year									
seavedit1	100 year	Link19	Node21	Node22	2600.000	0.0130	1400.180	1388.000	Natural	5.000
seavedit1	50 year									
seavedit1	10 year									
274_culv	100 year	Link32	Node22	Node37	33.000	0.0130	1388.000	1388.000	Circular	4.000
274_culv	50 year									
274_culv	10 year									
274tha	100 year	Link21	Node24	Node25	37.000	0.0130	1383.000	1383.000	Circular	3.000
274tha	50 year									
274tha	10 year									
274thb	100 year	Link21	Node24	Node25	37.000	0.0130	1383.000	1383.000	Circular	3.000
274thb	50 year									
274thb	10 year									
274thc	100 year	Link21	Node24	Node25	37.000	0.0130	1383.000	1383.000	Circular	3.000
274thc	50 year									
274thc	10 year									
Outfall_3	100 year	Link31	Node25	Node45	880.000	0.0130	1383.000	1372.447	Natural	4.000
Outfall_3	50 year									
Outfall_3	10 year									
lenout	100 year	Link23	Node26	Node27	554.000	0.0350	1413.990	1411.070	Natural	2.000
lenout	50 year									
lenout	10 year									

Table E4

Name	Storm	Link Name	Upstream Node Name	Downstream Node Name	Length ft	Roughness	Upstream Invert Elevation	Downstream Invert Elevation	Shape	Diameter (Height) ft
greensou	100 year	Link24	Node28	Node14	500.000	0.0130	1399.900	1396.950	Natural	5.000
greensou	50 year									
greensou	10 year									
8drain	100 year	Link25	Node29	Node30	33.000	0.0130	1420.000	1420.000	Circular	0.667
8drain	50 year									
8drain	10 year									
ditch	100 year	Link35	Node30	Node1	770.000	0.0130	1420.000	1416.690	Natural	1.000
ditch	50 year									
ditch	10 year									
TIGER36	100 year	Link26	Node31	Node5	528.600	0.0130	1401.950	1398.890	Circular	3.000
TIGER36	50 year									
TIGER36	10 year									
san36	100 year	Link28	Node33	Node44	100.000	0.0130	1398.650	1397.610	Circular	3.000
san36	50 year									
san36	10 year									
outfall_2	100 year	Link30	Node35	Node45	3085.000	0.0130	1378.000	1372.447	Natural	6.000
outfall_2	50 year									
outfall_2	10 year									
outfall_4	100 year	Link33	Node37	Node46	1210.000	0.0130	1388.000	1370.680	Circular	4.000
outfall_4	50 year									
outfall_4	10 year									
Outfall_1	100 year	Link34	Node27	Node23	33.000	0.0130	1411.070	1410.900	Circular	2.000
Outfall_1	50 year									
Outfall_1	10 year									
274_cul	100 year	Link29	Node40	Node35	33.000	0.0130	1378.000	1377.983	Rectan	6.000
274_cul	50 year									
274_cul	10 year									
school	100 year	Link36	Node41	Node7	33.000	0.0130	1397.440	1397.440	Natural	3.000
school	50 year									
school	10 year									
cliff_lin	100 year	Link37	Node42	Node43	88.000	0.0130	1423.740	1422.210	Circular	1.500
cliff_lin	50 year									
cliff_lin	10 year									
lin_na	100 year	Link38	Node43	Node12	470.000	0.0130	1422.210	1410.000	Natural	3.000
lin_na	50 year									
lin_na	10 year									
sanpons	100 year	Link39	Node44	Node24	2300.000	0.0130	1397.610	1383.000	Natural	3.000
sanpons	50 year									
sanpons	10 year									
chanso	100 year	Link40	Node45	Node46	800.000	0.0350	1372.447	1370.680	Natural	6.000
chanso	50 year									
chanso	10 year									
bridge	100 year	Link42	Node46	Node23	33.000	0.0130	1370.680	1370.680	Rectan	6.000
bridge	50 year									
bridge	10 year									

Table E8/E9

Name	Storm	Node Name	Ground Elevation (Spill Crest)	Max Water Elevation ft	Freeboard ft	Max Surface Area ft^2	Mean Nodal Iterations	Total Iterations
Node1	100 year	Node1	1419.690	1419.690	0.00	12.57	1.02	584753.000
Node1	50 year	Node1	1419.690	1419.626	0.06	12.57	1.03	542184.000
Node1	10 year	Node1	1419.690	1418.637	1.05	12.57	1.03	423671.000
Node2	100 year	Node2	1416.000	1416.000	0.00	12.57	1.04	592402.000
Node2	50 year	Node2	1416.000	1416.000	0.00	12.57	1.04	549550.000
Node2	10 year	Node2	1416.000	1416.000	0.00	12.57	1.04	428740.000
Node3	100 year	Node3	1414.000	1414.000	0.00	12.57	1.06	606419.000
Node3	50 year	Node3	1414.000	1414.000	0.00	12.57	1.06	558775.000
Node3	10 year	Node3	1414.000	1414.000	0.00	12.57	1.05	431813.000
Node4	100 year	Node4	1415.000	1414.021	0.98	12.57	1.05	597110.000
Node4	50 year	Node4	1415.000	1414.001	1.00	12.57	1.04	551816.000
Node4	10 year	Node4	1415.000	1413.813	1.19	12.57	1.04	428343.000
Node5	100 year	Node5	1406.000	1406.000	0.00	12.57	1.03	589606.000
Node5	50 year	Node5	1406.000	1406.000	0.00	12.57	1.03	546231.000
Node5	10 year	Node5	1406.000	1406.000	0.00	12.57	1.04	427534.000
Node6	100 year	Node6	1402.000	1401.547	0.45	12.57	1.03	590116.000
Node6	50 year	Node6	1402.000	1401.547	0.45	12.57	1.03	546721.000
Node6	10 year	Node6	1402.000	1401.547	0.45	12.57	1.04	429691.000
Node7	100 year	Node7	1401.000	1401.000	0.00	12.57	1.37	779620.000
Node7	50 year	Node7	1401.000	1401.000	0.00	12.57	1.38	730349.000
Node7	10 year	Node7	1401.000	1401.000	0.00	12.57	1.44	595186.000
Node8	100 year	Node8	1401.000	1399.309	1.69	12.57	1.07	611380.000
Node8	50 year	Node8	1401.000	1399.228	1.77	12.57	1.07	567801.000
Node8	10 year	Node8	1401.000	1398.828	2.17	12.57	1.09	447517.000
Node9	100 year	Node9	1441.000	1447.911	-7.91	1.4e+007	1.03	587471.000
Node9	50 year	Node9	1441.000	1447.700	-7.70	1.1e+007	1.03	544432.000
Node9	10 year	Node9	1441.000	1446.945	-6.95	5190896.80	1.04	427823.000
Node10	100 year	Node10	1436.000	1439.981	-3.98	267895.35	1.04	593627.000
Node10	50 year	Node10	1436.000	1439.368	-3.37	145120.63	1.04	550771.000
Node10	10 year	Node10	1436.000	1437.850	-1.85	31785.98	1.05	431156.000
Node11	100 year	Node11	1420.000	1415.240	4.76	122464.43	1.05	596857.000
Node11	50 year	Node11	1420.000	1415.007	4.99	103632.48	1.05	553052.000
Node11	10 year	Node11	1420.000	1414.348	5.65	50092.20	1.05	434359.000
Node12	100 year	Node12	1420.000	1414.194	5.81	12.57	1.10	629040.000
Node12	50 year	Node12	1420.000	1414.042	5.96	12.57	1.11	584507.000
Node12	10 year	Node12	1420.000	1413.579	6.42	12.57	1.12	463153.000
Node13	100 year	Node13	1410.000	1405.345	4.66	51936.70	1.09	620932.000
Node13	50 year	Node13	1410.000	1404.952	5.05	48203.63	1.09	577960.000
Node13	10 year	Node13	1410.000	1403.995	6.00	41203.93	1.08	446945.000
Node14	100 year	Node14	1404.000	1401.936	2.06	191173.51	1.62	923745.000
Node14	50 year	Node14	1404.000	1401.615	2.39	160114.15	3.57	1886498.000
Node14	10 year	Node14	1404.000	1400.791	3.21	94128.78	2.55	1052722.000
Node15	100 year	Node15	1404.000	1401.160	2.84	12.57	1.63	932422.000
Node15	50 year	Node15	1404.000	1400.852	3.15	12.57	3.58	1894300.000
Node15	10 year	Node15	1404.000	1400.227	3.77	12.57	2.57	1061128.000
Node16	100 year	Node16	1438.000	1437.482	0.52	172273.25	1.03	589071.000
Node16	50 year	Node16	1438.000	1437.176	0.82	169678.26	1.03	545709.000
Node16	10 year	Node16	1438.000	1436.522	1.48	163980.02	1.04	427217.000
Node17	100 year	Node17	1436.000	1434.396	1.60	223490.39	1.06	605349.000
Node17	50 year	Node17	1436.000	1434.189	1.81	166732.95	1.06	559054.000
Node17	10 year	Node17	1436.000	1433.739	2.26	43781.97	1.06	436019.000
Node18	100 year	Node18	1436.000	1434.187	1.81	12.57	1.08	615924.000
Node18	50 year	Node18	1436.000	1433.918	2.08	12.57	1.08	571958.000
Node18	10 year	Node18	1436.000	1433.429	2.57	12.57	1.09	447782.000
Node19	100 year	Node19	1420.000	1419.370	0.63	164598.53	1.06	603076.000
Node19	50 year	Node19	1420.000	1418.864	1.14	160929.77	1.06	560077.000
Node19	10 year	Node19	1420.000	1417.357	2.64	129777.50	1.07	440457.000
Node20	100 year	Node20	1419.530	1416.188	3.34	12.57	1.04	593977.000
Node20	50 year	Node20	1419.530	1416.075	3.45	12.57	1.04	549780.000
Node20	10 year	Node20	1419.530	1415.757	3.77	12.57	1.04	430070.000
Node21	100 year	Node21	1405.180	1402.287	2.89	12.57	1.05	600588.000
Node21	50 year	Node21	1405.180	1402.140	3.04	12.57	1.05	556129.000
Node21	10 year	Node21	1405.180	1401.721	3.46	12.57	1.06	434946.000
Node22	100 year	Node22	1397.000	1391.982	5.02	12.57	1.04	594781.000
Node22	50 year	Node22	1397.000	1391.658	5.34	12.57	1.04	551199.000
Node22	10 year	Node22	1397.000	1390.768	6.23	12.57	1.05	433919.000
Node24	100 year	Node24	1386.000	1385.299	0.70	143706.49	1.04	595803.000
Node24	50 year	Node24	1386.000	1385.139	0.86	136750.44	1.04	551304.000
Node24	10 year	Node24	1386.000	1384.699	1.30	111023.65	1.04	430227.000
Node25	100 year	Node25	1387.000	1384.942	2.06	12.57	1.07	612169.000
Node25	50 year	Node25	1387.000	1384.826	2.17	12.57	1.07	566206.000
Node25	10 year	Node25	1387.000	1384.482	2.52	12.57	1.07	441497.000
Node26	100 year	Node26	1420.000	1419.274	0.73	12.57	1.07	610035.000
Node26	50 year	Node26	1420.000	1418.778	1.22	12.57	1.07	566808.000
Node26	10 year	Node26	1420.000	1417.315	2.68	12.57	1.09	448473.000
Node28	100 year	Node28	1410.000	1403.567	6.43	12.57	1.08	615022.000
Node28	50 year	Node28	1410.000	1403.423	6.58	12.57	1.08	571517.000
Node28	10 year	Node28	1410.000	1402.915	7.08	12.57	1.09	450997.000
Node29	100 year	Node29	1424.000	1424.249	-0.25	627264.00	1.01	576463.000
Node29	50 year	Node29	1424.000	1423.835	0.17	627264.00	1.01	533913.000
Node29	10 year	Node29	1424.000	1422.808	1.19	627264.00	1.01	415393.000
Node30	100 year	Node30	1424.000	1420.330	3.67	12.57	1.02	579784.000
Node30	50 year	Node30	1424.000	1420.313	3.69	12.57	1.01	536457.000
Node30	10 year	Node30	1424.000	1420.276	3.72	12.57	1.02	418589.000
Node31	100 year	Node31	1410.000	1409.661	0.34	12.57	1.03	587815.000
Node31	50 year	Node31	1410.000	1409.653	0.35	12.57	1.03	545547.000
Node31	10 year	Node31	1410.000	1409.566	0.43	12.57	1.03	424682.000
Node33	100 year	Node33	1402.000	1401.471	0.53	95832.00	1.03	586549.000
Node33	50 year	Node33	1402.000	1401.177	0.82	95832.00	1.03	543521.000
Node33	10 year	Node33	1402.000	1400.536	1.46	90378.23	1.03	423955.000
Node35	100 year	Node35	1387.000	1381.692	5.31	12.57	1.08	615515.000
Node35	50 year	Node35	1387.000	1381.516	5.48	12.57	1.08	572731.000
Node35	10 year	Node35	1387.000	1380.952	6.05	12.57	1.10	453771.000

Table E8/E9

Name	Storm	Node Name	Ground Elevation (Spill Crest)	Max Water Elevation ft	Freeboard ft	Max Surface Area ft^2	Mean Nodal Iterations	Total Iterations
Node23	100 year	Node23	1414.000	1381.443	32.56	12.57	1.12	641666.000
Node23	50 year	Node23	1414.000	1381.213	32.79	12.57	1.13	597667.000
Node23	10 year	Node23	1414.000	1380.500	33.50	12.57	1.15	472646.000
Node37	100 year	Node37	1397.000	1391.693	5.31	12.57	1.05	598976.000
Node37	50 year	Node37	1397.000	1391.438	5.56	12.57	1.05	554698.000
Node37	10 year	Node37	1397.000	1390.617	6.38	12.57	1.05	433783.000
Node27	100 year	Node27	1414.000	1417.256	-3.26	129666.73	1.07	611952.000
Node27	50 year	Node27	1414.000	1416.944	-2.94	94975.49	1.07	566837.000
Node27	10 year	Node27	1414.000	1415.995	-1.99	36759.61	1.08	445084.000
Node40	100 year	Node40	1387.000	1381.708	5.29	12.57	1.09	620612.000
Node40	50 year	Node40	1387.000	1381.533	5.47	12.57	1.09	577717.000
Node40	10 year	Node40	1387.000	1380.967	6.03	12.57	1.11	458194.000
Node41	100 year	Node41	1401.000	1401.000	0.00	12.57	1.35	769370.000
Node41	50 year	Node41	1401.000	1401.000	0.00	12.57	1.38	727421.000
Node41	10 year	Node41	1401.000	1401.000	0.00	12.57	1.45	595953.000
Node42	100 year	Node42	1429.000	1429.000	0.00	12.57	1.02	580826.000
Node42	50 year	Node42	1429.000	1429.000	0.00	12.57	1.02	538680.000
Node42	10 year	Node42	1429.000	1425.098	3.90	12.57	1.02	420723.000
Node43	100 year	Node43	1429.000	1422.755	6.24	12.57	1.03	585949.000
Node43	50 year	Node43	1429.000	1422.753	6.25	12.57	1.03	543405.000
Node43	10 year	Node43	1429.000	1422.635	6.36	12.57	1.03	424761.000
Node44	100 year	Node44	1402.000	1399.077	2.92	12.57	1.05	597077.000
Node44	50 year	Node44	1402.000	1399.002	3.00	12.57	1.05	553710.000
Node44	10 year	Node44	1402.000	1398.739	3.26	12.57	1.05	432505.000
Node45	100 year	Node45	1387.000	0.000	0.00	0.00	0.00	0.000
Node45	50 year	Node45	1387.000	0.000	0.00	0.00	0.00	0.000
Node45	10 year	Node45	1387.000	0.000	0.00	0.00	0.00	0.000
Node46	100 year	Node46	1379.000	0.000	0.00	0.00	0.00	0.000
Node46	50 year	Node46	1379.000	0.000	0.00	0.00	0.00	0.000
Node46	10 year	Node46	1379.000	0.000	0.00	0.00	0.00	0.000

Table E10

Name	Storm	Link Name	Design Full Flow cfs	Design Velocity ft/s	Diameter (Height) ft	Max Flow cfs	Time to Peak hr	Max Velocity ft/s	Time of Peak Velocity	Max Flow/Design Flow	Max Water Depth	Max Water Depth ft
ELM36	100 year	Link1	73.06	10.34	3.000	65.53	12.500	9.44	12.517	0.897	3.000	4.210
ELM36	50 year		73.06	10.34		65.59	12.417	9.43	12.433	0.898	2.936	4.210
ELM36	10 year		73.06	10.34		42.34	12.350	8.74	12.117	0.580	1.947	4.210
MAPLE36	100 year	Link2	73.06	10.34	3.000	47.87	12.583	9.28	11.983	0.655	4.210	7.310
MAPLE36	50 year		73.06	10.34		47.87	12.517	9.27	12.017	0.655	4.210	7.310
MAPLE36	10 year		73.06	10.34		47.87	12.383	9.28	12.100	0.655	4.210	7.310
WAL36	100 year	Link3	24.75	3.50	3.000	38.59	11.983	5.84	11.967	1.559	7.310	7.631
WAL36	50 year		24.75	3.50		38.39	12.883	5.88	12.000	1.574	7.310	7.611
WAL36	10 year		24.75	3.50		38.71	12.683	5.90	12.100	1.566	7.310	7.423
EMMID36	100 year	Link4	56.01	7.92	3.000	58.02	12.883	8.17	11.950	1.037	7.631	8.161
EMMID36	50 year		56.01	7.92		58.04	12.817	8.18	11.983	1.038	7.611	8.153
EMMID36	10 year		56.01	7.92		58.11	12.633	8.19	12.083	1.038	7.423	8.067
HARV1	100 year	Link5	50.63	7.16	3.000	90.59	12.067	12.71	12.067	1.789	7.110	4.067
HARV1	50 year		50.63	7.16		90.59	12.100	12.71	12.100	1.789	7.110	4.067
HARV1	10 year		50.63	7.16		90.59	12.200	12.71	12.200	1.789	7.110	4.067
HARV2	100 year	Link6	24.35	3.45	3.000	90.59	12.050	12.74	12.050	3.720	4.067	3.560
HARV2	50 year		24.35	3.45		90.59	12.083	12.74	12.083	3.720	4.067	3.560
HARV2	10 year		24.35	3.45		90.59	12.217	12.74	12.217	3.720	4.067	3.560
HARVOUT	100 year	Link7	41.50	5.87	3.000	57.37	12.033	7.92	12.033	1.382	3.560	7.309
HARVOUT	50 year		41.50	5.87		57.37	12.083	7.92	12.083	1.382	3.560	7.228
HARVOUT	10 year		41.50	5.87		57.37	12.167	7.92	12.167	1.382	3.560	6.828
6TRIB1	100 year	Link27	2036.81	7.69	6.000	729.89	13.050	5.82	13.150	0.358	7.309	3.708
6TRIB1	50 year		2036.81	7.69		686.63	13.000	5.75	13.050	0.337	7.228	3.533
6TRIB1	10 year		2036.81	7.69		497.24	13.000	5.35	13.000	0.244	6.828	2.967
Hom_chan	100 year	Link8	79.77	2.85	5.000	118.17	39.767	4.22	39.750	1.481	12.411	8.981
Hom_chan	50 year		79.77	2.85		117.78	36.383	4.21	36.383	1.477	12.200	8.368
Hom_chan	10 year		79.77	2.85		116.11	29.767	4.15	29.767	1.456	11.445	6.850
homtogre	100 year	Link9	108.04	3.86	2.000	123.79	17.100	4.42	17.100	1.146	8.981	5.040
homtogre	50 year		108.04	3.86		122.52	17.600	4.38	17.600	1.134	8.368	4.807
homtogre	10 year		108.04	3.86		119.37	22.717	4.26	22.717	1.105	6.850	4.148
will6x8	100 year	Link10	426.22	8.88	8.000	609.43	12.517	20.60	12.567	1.430	5.040	4.194
will6x8	50 year		426.22	8.88		552.32	12.517	19.50	12.533	1.296	4.807	4.042
will6x8	10 year		426.22	8.88		413.33	12.483	17.61	12.350	0.970	4.148	3.579
grenup	100 year	Link11	1337.23	5.05	5.000	816.41	12.550	4.46	12.567	0.611	4.194	5.075
grenup	50 year		1337.23	5.05		725.29	12.550	4.30	12.617	0.542	4.042	4.682
grenup	10 year		1337.23	5.05		504.08	12.567	3.74	12.667	0.377	3.579	3.725
honeysuc1	100 year	Link12	85.68	6.82	4.000	189.88	12.700	15.15	12.700	2.216	5.075	3.667
honeysuc1	50 year		85.68	6.82		182.95	12.683	14.07	12.683	2.135	4.682	3.523
honeysuc1	10 year		85.68	6.82		151.01	12.717	12.61	12.717	1.763	3.725	3.015
honeysuc2	100 year	Link12	85.68	6.82	4.000	189.88	12.700	15.15	12.700	2.216	5.075	3.667
honeysuc2	50 year		85.68	6.82		182.95	12.683	14.07	12.683	2.135	4.682	3.523
honeysuc2	10 year		85.68	6.82		151.01	12.717	12.61	12.717	1.763	3.725	3.015
honeysuc3	100 year	Link12	85.68	6.82	4.000	189.88	12.700	15.15	12.700	2.216	5.075	3.667
honeysuc3	50 year		85.68	6.82		182.95	12.683	14.07	12.683	2.135	4.682	3.523
honeysuc3	10 year		85.68	6.82		151.01	12.717	12.61	12.717	1.763	3.725	3.015
HoneyRD	100 year	Link12	4.61	0.16	2.000	122.19	12.717	4.49	12.717	26.530	5.075	3.667
HoneyRD	50 year		4.61	0.16		90.20	12.700	3.48	12.700	19.590	4.682	3.523
HoneyRD	10 year		0.00	0.00		0.00	0.000	0.00	0.000	0.000	3.725	3.015
cliff84	100 year	Link13	618.58	14.39	6.000	702.67	12.767	18.48	12.667	1.136	4.986	4.880
cliff84	50 year		618.58	14.39		660.44	12.817	17.85	12.783	1.068	4.665	4.572
cliff84	10 year		618.58	14.39		464.42	12.833	14.99	12.717	0.751	3.841	3.947
cemetery	100 year	Link14	1041.00	4.16	4.500	685.63	12.967	2.74	12.967	0.659	4.880	7.309
cemetery	50 year		1041.00	4.16		643.33	12.900	2.57	12.900	0.618	4.572	7.228
cemetery	10 year		1041.00	4.16		453.88	12.917	2.22	12.883	0.436	3.947	6.828
IndPond	100 year	Link15	47.30	6.69	3.000	53.28	13.833	7.77	14.050	1.127	3.082	3.016
IndPond	50 year		47.30	6.69		52.31	13.133	7.77	13.533	1.106	2.776	2.809
IndPond	10 year		47.30	6.69		39.94	13.083	7.50	13.133	0.844	2.122	2.359
RR_30	100 year	Link16	32.64	6.65	2.500	74.92	13.267	15.03	13.267	2.295	3.016	2.617
RR_30	50 year		32.64	6.65		69.47	13.183	14.03	13.300	2.128	2.809	2.348
RR_30	10 year		32.64	6.65		52.93	12.817	11.57	12.867	1.622	2.359	1.859
backyard	100 year	Link17	139.73	4.99	2.000	141.19	12.350	5.04	12.350	1.010	2.617	5.170
backyard	50 year		139.73	4.99		140.76	12.400	5.03	12.400	1.008	2.348	4.664
backyard	10 year		139.73	4.99		109.61	12.550	4.64	12.600	0.785	1.859	3.157
Len42a	100 year	Link22	65.27	6.78	3.500	48.68	12.917	7.41	12.217	0.748	5.170	5.284
Len42a	50 year		65.27	6.78		46.31	12.750	7.37	12.267	0.710	4.664	4.788
Len42a	10 year		65.27	6.78		41.97	12.417	7.23	12.400	0.646	3.157	3.325
Len42b	100 year	Link22	65.27	6.78	3.500	48.68	12.917	7.41	12.217	0.748	5.170	5.284
Len42b	50 year		65.27	6.78		46.31	12.750	7.37	12.267	0.710	4.664	4.788
Len42b	10 year		65.27	6.78		41.97	12.417	7.23	12.400	0.646	3.157	3.325
SEaveDit	100 year	Link18	1595.03	6.02	5.000	109.99	12.383	2.95	12.350	0.069	1.658	2.107
SEaveDit	50 year		1595.03	6.02		93.54	12.383	2.84	12.350	0.059	1.545	1.960
SEaveDit	10 year		1595.03	6.02		55.48	12.400	2.50	12.367	0.035	1.227	1.541
seavedit1	100 year	Link19	1469.49	5.55	5.000	177.39	12.500	2.91	12.400	0.121	2.107	3.982
seavedit1	50 year		1469.49	5.55		149.42	12.500	2.81	12.417	0.102	1.960	3.658
seavedit1	10 year		1469.49	5.55		85.67	12.550	2.49	12.433	0.058	1.541	2.768
274_culv	100 year	Link32	4.54	0.36	4.000	133.46	12.817	10.67	12.817	29.383	3.982	3.693
274_culv	50 year		4.54	0.36		113.32	12.833	9.45	12.833	24.949	3.658	3.438
274_culv	10 year		4.54	0.36		65.26	12.900	7.08	12.900	14.366	2.768	2.617
274tha	100 year	Link21	2.11	0.30	3.000	57.20	12.650	10.01	12.650	27.119	2.299	1.942
274tha	50 year		2.11	0.30		49.00	12.683	9.24	12.683	23.233	2.139	1.826
274tha	10 year		2.11	0.30		29.15	12.733	7.17	12.733	13.819	1.699	1.482
274thb	100 year	Link21	2.11	0.30	3.000	57.20	12.650	10.01	12.650	27.119	2.299	1.942
274thb	50 year		2.11	0.30		49.00	12.683	9.24	12.683	23.233	2.139	1.826
274thb	10 year		2.11	0.30		29.15	12.733	7.17	12.733	13.819	1.699	1.482
274thc	100 year	Link21	2.11	0.30	3.000	57.20	12.650	10.01	12.650	27.119	2.299	1.942
274thc	50 year		2.11	0.30		49.00	12.683	9.24	12.683	23.233	2.139	1.826
274thc	10 year		2.11	0.30		29.15	12.733	7.17	12.733	13.819	1.699	1.482
Outfall_3	100 year	Link31	38.84	0.22	4.000	171.58	12.650	3.76	12.667	4.418	1.942	0.000
Outfall_3	50 year		38.84	0.22		147.01	12.683	3.59	12.683	3.785	1.826	0.000
Outfall_3	10 year		38.84	0.22		87.44	12.733	3.07	12.733	2.251	1.482	0.000
lenout	100 year	Link23	105.73	3.78	2.000	94.81	13.167	3.39	13.167	0.897	5.284	6.186
lenout	50 year		105.73	3.78		89.78	13.150	3.21	13.150	0.849	4.788	5.874
lenout	10 year		105.73	3.78		75.92	12.700	2.71	12.700	0.718	3.325	4.925

Table E10

Name	Storm	Link Name	Design Full Flow cfs	Design Velocity ft/s	Diameter (Height) ft	Max Flow cfs	Time to Peak hr	Max Velocity ft/s	Time of Peak Velocity	Max Flow/Design Flow	Max Water Depth	Max Water Depth ft
greensou	100 year	Link24	1649.13	6.22	5.000	690.08	12.717	4.41	12.583	0.418	3.667	4.986
greensou	50 year		1649.13	6.22		637.34	12.717	4.39	12.633	0.387	3.523	4.665
greensou	10 year		1649.13	6.22		452.18	12.733	4.20	12.617	0.274	3.015	3.841
8drain	100 year	Link25	0.04	0.11	0.667	3.59	24.550	10.49	24.550	93.807	4.249	0.330
8drain	50 year		0.04	0.11		3.34	24.550	9.82	24.550	87.258	3.835	0.313
8drain	10 year		0.04	0.11		2.69	24.533	8.05	24.533	70.402	2.808	0.276
ditch	100 year	Link35	25.68	2.33	1.000	3.59	24.633	1.17	25.467	0.140	0.330	3.000
ditch	50 year		25.68	2.33		3.34	24.633	1.14	25.467	0.130	0.313	2.936
ditch	10 year		25.68	2.33		2.69	24.617	1.05	25.433	0.105	0.276	1.947
TIGER36	100 year	Link26	50.75	7.18	3.000	58.07	12.900	8.15	12.900	1.145	8.161	7.110
TIGER36	50 year		50.75	7.18		58.06	12.817	8.15	12.833	1.146	8.153	7.110
TIGER36	10 year		50.75	7.18		58.14	12.633	8.16	12.633	1.146	8.067	7.110
san36	100 year	Link28	68.02	9.62	3.000	90.35	12.600	13.82	12.583	1.328	2.821	1.467
san36	50 year		68.02	9.62		81.03	12.583	13.43	12.583	1.191	2.527	1.392
san36	10 year		68.02	9.62		51.32	12.583	11.54	12.583	0.754	1.886	1.129
outfall_2	100 year	Link30	67.89	0.26	6.000	746.88	13.150	5.51	13.333	11.007	3.692	0.000
outfall_2	50 year		67.89	0.26		696.45	13.050	5.39	13.200	10.259	3.516	0.000
outfall_2	10 year		67.89	0.26		494.93	13.050	5.10	13.050	7.290	2.952	0.000
outfall_4	100 year	Link33	4.54	0.36	4.000	133.46	12.817	11.07	12.817	29.383	3.693	0.000
outfall_4	50 year		4.54	0.36		113.32	12.833	9.93	12.833	24.949	3.438	0.000
outfall_4	10 year		4.54	0.36		65.26	12.900	7.55	12.900	14.366	2.617	0.000
Outfall_1	100 year	Link34	16.24	5.17	2.000	82.95	15.567	26.09	15.567	5.109	6.186	3.443
Outfall_1	50 year		16.24	5.17		79.88	15.017	25.15	15.017	4.920	5.874	3.213
Outfall_1	10 year		16.24	5.17		69.73	13.900	22.01	13.900	4.295	4.925	2.500
274_cul	100 year	Link29	164.40	0.69	6.000	746.36	13.150	5.17	13.233	4.542	3.708	3.692
274_cul	50 year		164.40	0.69		696.20	13.050	5.00	13.100	4.235	3.533	3.516
274_cul	10 year		164.40	0.69		494.94	13.050	4.17	13.050	3.011	2.967	2.952
school	100 year	Link36	19.12	0.19	3.000	37.48	11.850	0.37	11.850	1.972	3.560	3.560
school	50 year		19.12	0.19		39.11	11.883	0.38	11.883	2.079	3.560	3.560
school	10 year		19.12	0.19		44.76	11.983	0.46	11.850	2.358	3.560	3.560
cliff_lin	100 year	Link37	13.85	7.84	1.500	21.61	12.167	12.91	12.167	1.560	5.260	0.545
cliff_lin	50 year		13.85	7.84		21.57	12.117	12.89	12.117	1.558	5.260	0.543
cliff_lin	10 year		13.85	7.84		13.43	12.117	8.66	12.133	0.969	1.358	0.425
lin_na	100 year	Link38	974.79	9.50	3.000	21.59	12.167	1.62	12.033	0.022	0.545	4.194
lin_na	50 year		974.79	9.50		21.42	12.133	1.65	12.067	0.022	0.543	4.042
lin_na	10 year		974.79	9.50		13.20	12.133	1.51	12.083	0.014	0.425	3.579
sanpons	100 year	Link39	482.02	4.70	3.000	88.91	12.750	2.74	12.783	0.184	1.467	2.299
sanpons	50 year		482.02	4.70		78.95	12.717	2.68	12.733	0.164	1.392	2.139
sanpons	10 year		482.02	4.70		49.41	12.733	2.39	12.733	0.103	1.129	1.699
chanso	100 year	Link40	0.00	0.00	6.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000
chanso	50 year		0.00	0.00		0.00	0.000	0.00	0.000	0.000	0.000	0.000
chanso	10 year		0.00	0.00		0.00	0.000	0.00	0.000	0.000	0.000	0.000
bridge	100 year	Link42	0.00	0.00	6.000	0.00	0.000	0.00	0.000	0.000	0.000	3.443
bridge	50 year		0.00	0.00		0.00	0.000	0.00	0.000	0.000	0.000	3.213
bridge	10 year		0.00	0.00		0.00	0.000	0.00	0.000	0.000	0.000	2.500

Table E18

Name	Storm	Node Name	Continuity Error %
Node1	100 year	Node1	0.001
Node1	50 year	Node1	0.001
Node1	10 year	Node1	0.002
Node2	100 year	Node2	0.000
Node2	50 year	Node2	0.000
Node2	10 year	Node2	0.000
Node3	100 year	Node3	0.000
Node3	50 year	Node3	0.000
Node3	10 year	Node3	0.000
Node4	100 year	Node4	0.001
Node4	50 year	Node4	0.001
Node4	10 year	Node4	0.000
Node5	100 year	Node5	0.001
Node5	50 year	Node5	0.001
Node5	10 year	Node5	0.001
Node6	100 year	Node6	0.000
Node6	50 year	Node6	0.000
Node6	10 year	Node6	0.000
Node7	100 year	Node7	0.003
Node7	50 year	Node7	0.003
Node7	10 year	Node7	0.005
Node8	100 year	Node8	0.214
Node8	50 year	Node8	0.252
Node8	10 year	Node8	0.401
Node9	100 year	Node9	0.009
Node9	50 year	Node9	0.000
Node9	10 year	Node9	0.042
Node10	100 year	Node10	0.085
Node10	50 year	Node10	0.065
Node10	10 year	Node10	0.025
Node11	100 year	Node11	0.045
Node11	50 year	Node11	0.046
Node11	10 year	Node11	0.084
Node12	100 year	Node12	0.087
Node12	50 year	Node12	0.109
Node12	10 year	Node12	0.187
Node13	100 year	Node13	0.105
Node13	50 year	Node13	0.116
Node13	10 year	Node13	0.141
Node14	100 year	Node14	0.017
Node14	50 year	Node14	0.023
Node14	10 year	Node14	0.042
Node15	100 year	Node15	0.247
Node15	50 year	Node15	0.280
Node15	10 year	Node15	0.434
Node16	100 year	Node16	0.078
Node16	50 year	Node16	0.085
Node16	10 year	Node16	0.104
Node17	100 year	Node17	0.035
Node17	50 year	Node17	0.024
Node17	10 year	Node17	0.009
Node18	100 year	Node18	0.036
Node18	50 year	Node18	0.040
Node18	10 year	Node18	0.050
Node19	100 year	Node19	0.092
Node19	50 year	Node19	0.105
Node19	10 year	Node19	0.132
Node20	100 year	Node20	0.012
Node20	50 year	Node20	0.013
Node20	10 year	Node20	0.019
Node21	100 year	Node21	0.042
Node21	50 year	Node21	0.044
Node21	10 year	Node21	0.049
Node22	100 year	Node22	0.029
Node22	50 year	Node22	0.030
Node22	10 year	Node22	0.024
Node24	100 year	Node24	0.048
Node24	50 year	Node24	0.049
Node24	10 year	Node24	0.052
Node25	100 year	Node25	0.000
Node25	50 year	Node25	0.000
Node25	10 year	Node25	0.000
Node26	100 year	Node26	0.002
Node26	50 year	Node26	0.003
Node26	10 year	Node26	0.005
Node28	100 year	Node28	0.007
Node28	50 year	Node28	0.007
Node28	10 year	Node28	0.011
Node29	100 year	Node29	0.144
Node29	50 year	Node29	0.171
Node29	10 year	Node29	0.156
Node30	100 year	Node30	0.000
Node30	50 year	Node30	0.000
Node30	10 year	Node30	0.001
Node31	100 year	Node31	0.001
Node31	50 year	Node31	0.001
Node31	10 year	Node31	0.002
Node33	100 year	Node33	0.008
Node33	50 year	Node33	0.008
Node33	10 year	Node33	0.010
Node35	100 year	Node35	0.001
Node35	50 year	Node35	0.001
Node35	10 year	Node35	0.001

Table E18

Name	Storm	Node Name	Continuity Error %
Node23	100 year	Node23	0.000
Node23	50 year	Node23	0.000
Node23	10 year	Node23	0.001
Node37	100 year	Node37	0.000
Node37	50 year	Node37	0.000
Node37	10 year	Node37	0.000
Node27	100 year	Node27	0.002
Node27	50 year	Node27	0.002
Node27	10 year	Node27	0.005
Node40	100 year	Node40	0.062
Node40	50 year	Node40	0.071
Node40	10 year	Node40	0.127
Node41	100 year	Node41	0.000
Node41	50 year	Node41	0.000
Node41	10 year	Node41	0.001
Node42	100 year	Node42	0.000
Node42	50 year	Node42	0.000
Node42	10 year	Node42	0.000
Node43	100 year	Node43	0.003
Node43	50 year	Node43	0.003
Node43	10 year	Node43	0.004
Node44	100 year	Node44	0.001
Node44	50 year	Node44	0.002
Node44	10 year	Node44	0.003
Node45	100 year	Node45	0.000
Node45	50 year	Node45	0.000
Node45	10 year	Node45	0.000
Node46	100 year	Node46	0.000
Node46	50 year	Node46	0.000
Node46	10 year	Node46	0.000

Table E20

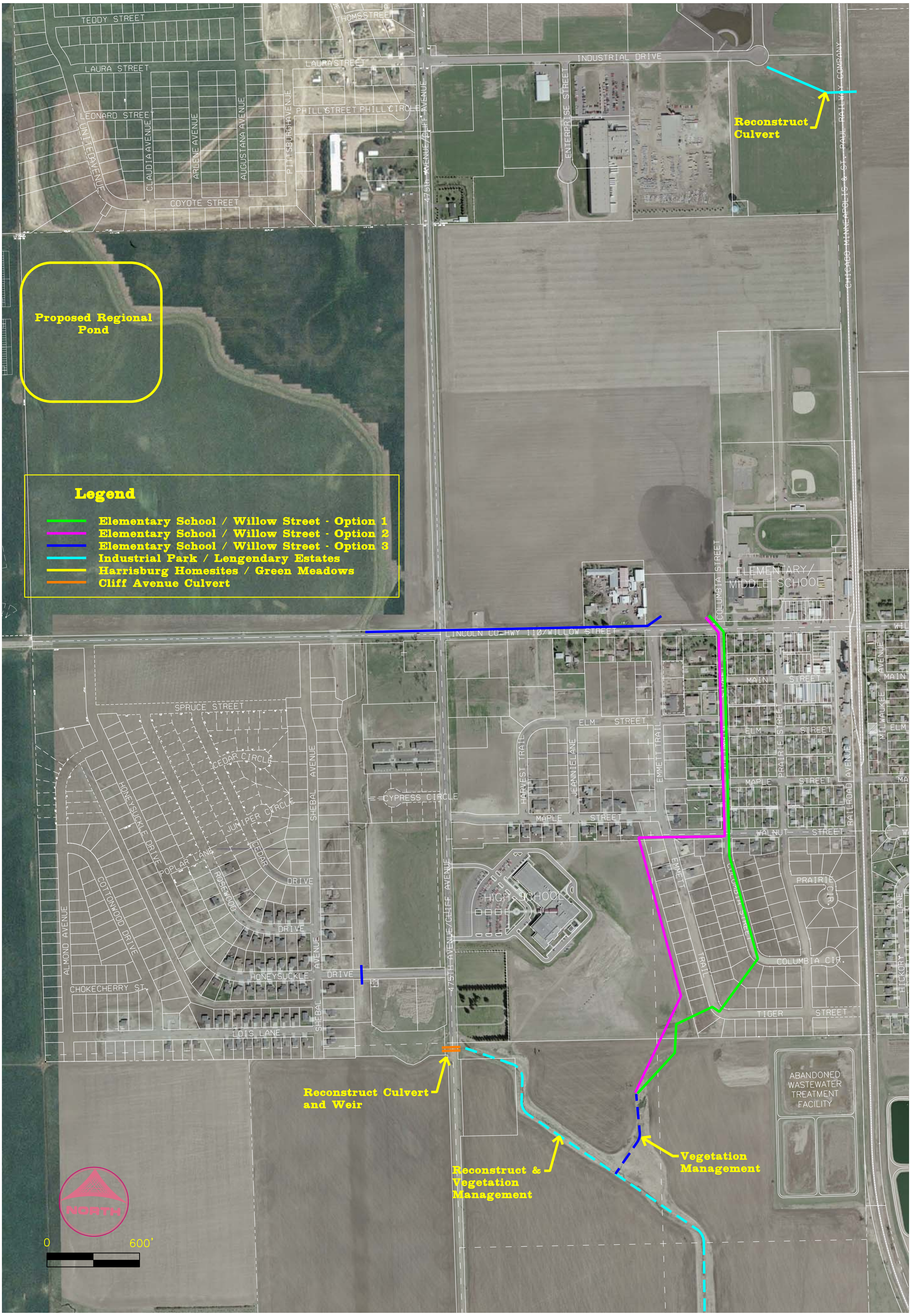
Name	Storm	Node Name	Duration of Surcharge (min)	Duration of Flooding (min) sec	Flood Loss ft^3	Max Volume ft^3
Node1	100 year	Node1	0.000	12.7	9192.661	37.698
Node1	50 year	Node1	0.000	0.0	0.000	36.906
Node1	10 year	Node1	0.000	0.0	0.000	24.473
Node2	100 year	Node2	53.158	41.6	82935.706	52.903
Node2	50 year	Node2	47.270	36.2	63084.538	52.903
Node2	10 year	Node2	29.631	17.2	8244.069	52.903
Node3	100 year	Node3	62.623	53.3	132361.506	91.857
Node3	50 year	Node3	56.284	47.4	103988.898	91.857
Node3	10 year	Node3	38.032	29.2	40496.695	91.857
Node4	100 year	Node4	63.768	0.0	0.000	96.443
Node4	50 year	Node4	57.326	0.0	0.000	96.465
Node4	10 year	Node4	38.653	0.0	0.000	93.282
Node5	100 year	Node5	91.945	39.6	66962.447	89.344
Node5	50 year	Node5	82.097	34.4	46051.881	89.344
Node5	10 year	Node5	57.219	17.3	5986.461	89.344
Node6	100 year	Node6	110.293	0.0	0.000	51.162
Node6	50 year	Node6	98.195	0.0	0.000	51.159
Node6	10 year	Node6	68.272	0.0	0.000	51.115
Node7	100 year	Node7	109.459	85.6	161604.746	44.735
Node7	50 year	Node7	97.489	77.2	142741.416	44.735
Node7	10 year	Node7	67.683	54.3	90924.045	44.735
Node8	100 year	Node8	0.000	0.0	0.000	91.846
Node8	50 year	Node8	0.000	0.0	0.000	90.830
Node8	10 year	Node8	0.000	0.0	0.000	85.802
Node9	100 year	Node9	3282.477	3259.6	-7087.551	1.36e+007
Node9	50 year	Node9	2823.273	2798.4	-7064.396	1.1e+007
Node9	10 year	Node9	1731.061	1700.1	-6787.346	5185953.340
Node10	100 year	Node10	3318.046	3173.4	-702.042	262958.176
Node10	50 year	Node10	2861.743	2716.5	-505.484	140183.457
Node10	10 year	Node10	1789.307	1555.7	-243.628	26848.811
Node11	100 year	Node11	0.000	0.0	0.000	130694.956
Node11	50 year	Node11	0.000	0.0	0.000	104500.301
Node11	10 year	Node11	0.000	0.0	0.000	53971.817
Node12	100 year	Node12	0.000	0.0	0.000	52.707
Node12	50 year	Node12	0.000	0.0	0.000	50.792
Node12	10 year	Node12	0.000	0.0	0.000	44.974
Node13	100 year	Node13	0.000	0.0	0.000	144831.796
Node13	50 year	Node13	0.000	0.0	0.000	125320.334
Node13	10 year	Node13	0.000	0.0	0.000	82564.331
Node14	100 year	Node14	0.000	0.0	0.000	418694.010
Node14	50 year	Node14	0.000	0.0	0.000	362336.372
Node14	10 year	Node14	0.000	0.0	0.000	262286.276
Node15	100 year	Node15	0.000	0.0	0.000	61.326
Node15	50 year	Node15	0.000	0.0	0.000	57.457
Node15	10 year	Node15	0.000	0.0	0.000	49.604
Node16	100 year	Node16	40.159	0.0	0.000	419823.183
Node16	50 year	Node16	0.000	0.0	0.000	367477.113
Node16	10 year	Node16	0.000	0.0	0.000	258359.738
Node17	100 year	Node17	0.000	0.0	0.000	108712.494
Node17	50 year	Node17	0.000	0.0	0.000	68274.765
Node17	10 year	Node17	0.000	0.0	0.000	21229.450
Node18	100 year	Node18	15.692	0.0	0.000	32.888
Node18	50 year	Node18	0.000	0.0	0.000	29.507
Node18	10 year	Node18	0.000	0.0	0.000	23.363
Node19	100 year	Node19	344.148	0.0	0.000	569667.289
Node19	50 year	Node19	266.041	0.0	0.000	487235.748
Node19	10 year	Node19	0.000	0.0	0.000	261108.349
Node20	100 year	Node20	0.000	0.0	0.000	20.838
Node20	50 year	Node20	0.000	0.0	0.000	19.420
Node20	10 year	Node20	0.000	0.0	0.000	15.421
Node21	100 year	Node21	0.000	0.0	0.000	26.479
Node21	50 year	Node21	0.000	0.0	0.000	24.628
Node21	10 year	Node21	0.000	0.0	0.000	19.370
Node22	100 year	Node22	0.000	0.0	0.000	50.044
Node22	50 year	Node22	0.000	0.0	0.000	45.973
Node22	10 year	Node22	0.000	0.0	0.000	34.782
Node24	100 year	Node24	0.000	0.0	0.000	173746.892
Node24	50 year	Node24	0.000	0.0	0.000	151355.132
Node24	10 year	Node24	0.000	0.0	0.000	96374.083
Node25	100 year	Node25	0.000	0.0	0.000	24.404
Node25	50 year	Node25	0.000	0.0	0.000	22.951
Node25	10 year	Node25	0.000	0.0	0.000	18.622
Node26	100 year	Node26	360.622	0.0	0.000	66.395
Node26	50 year	Node26	283.767	0.0	0.000	60.164
Node26	10 year	Node26	0.000	0.0	0.000	41.787
Node28	100 year	Node28	0.000	0.0	0.000	46.080
Node28	50 year	Node28	0.000	0.0	0.000	44.271
Node28	10 year	Node28	0.000	0.0	0.000	37.893
Node29	100 year	Node29	19146.809	0.0	0.000	2209546.210
Node29	50 year	Node29	17655.006	0.0	0.000	2105775.470
Node29	10 year	Node29	13416.567	0.0	0.000	1462014.780
Node30	100 year	Node30	0.000	0.0	0.000	4.149
Node30	50 year	Node30	0.000	0.0	0.000	3.935
Node30	10 year	Node30	0.000	0.0	0.000	3.470
Node31	100 year	Node31	70.919	0.0	0.000	105.864
Node31	50 year	Node31	64.041	0.0	0.000	106.005
Node31	10 year	Node31	44.794	0.0	0.000	102.937
Node33	100 year	Node33	0.000	0.0	0.000	176629.418
Node33	50 year	Node33	0.000	0.0	0.000	148431.093
Node33	10 year	Node33	0.000	0.0	0.000	87325.625
Node35	100 year	Node35	0.000	0.0	0.000	46.394
Node35	50 year	Node35	0.000	0.0	0.000	44.190
Node35	10 year	Node35	0.000	0.0	0.000	37.095

Table E20

Name	Storm	Node Name	Duration of Surcharge (min)	Duration of Flooding (min) sec	Flood Loss ft^3	Max Volume ft^3
Node23	100 year	Node23	0.000	0.0	0.000	43.262
Node23	50 year	Node23	0.000	0.0	0.000	40.380
Node23	10 year	Node23	0.000	0.0	0.000	31.417
Node37	100 year	Node37	0.000	0.0	0.000	46.406
Node37	50 year	Node37	0.000	0.0	0.000	43.199
Node37	10 year	Node37	0.000	0.0	0.000	32.887
Node27	100 year	Node27	583.608	539.7	0.000	124703.549
Node27	50 year	Node27	512.400	471.7	0.000	90012.311
Node27	10 year	Node27	343.639	296.4	0.000	31796.429
Node40	100 year	Node40	0.000	0.0	0.000	46.591
Node40	50 year	Node40	0.000	0.0	0.000	44.398
Node40	10 year	Node40	0.000	0.0	0.000	37.277
Node41	100 year	Node41	109.459	95.0	230163.286	44.735
Node41	50 year	Node41	97.489	83.7	184198.454	44.735
Node41	10 year	Node41	67.683	56.8	81719.670	44.735
Node42	100 year	Node42	19.489	9.6	1472.623	66.097
Node42	50 year	Node42	16.532	3.0	45.295	66.097
Node42	10 year	Node42	0.000	0.0	0.000	17.068
Node43	100 year	Node43	0.000	0.0	0.000	6.855
Node43	50 year	Node43	0.000	0.0	0.000	6.827
Node43	10 year	Node43	0.000	0.0	0.000	5.343
Node44	100 year	Node44	0.000	0.0	0.000	18.430
Node44	50 year	Node44	0.000	0.0	0.000	17.489
Node44	10 year	Node44	0.000	0.0	0.000	14.183
Node45	100 year	Node45	0.000	0.0	0.000	0.000
Node45	50 year	Node45	0.000	0.0	0.000	0.000
Node45	10 year	Node45	0.000	0.0	0.000	0.000
Node46	100 year	Node46	0.000	0.0	0.000	0.000
Node46	50 year	Node46	0.000	0.0	0.000	0.000
Node46	10 year	Node46	0.000	0.0	0.000	0.000

APPENDIX F

Drainage Issues Maps



City of Harrisburg, South Dakota

Proposed Improvements

Howard R. Green Company

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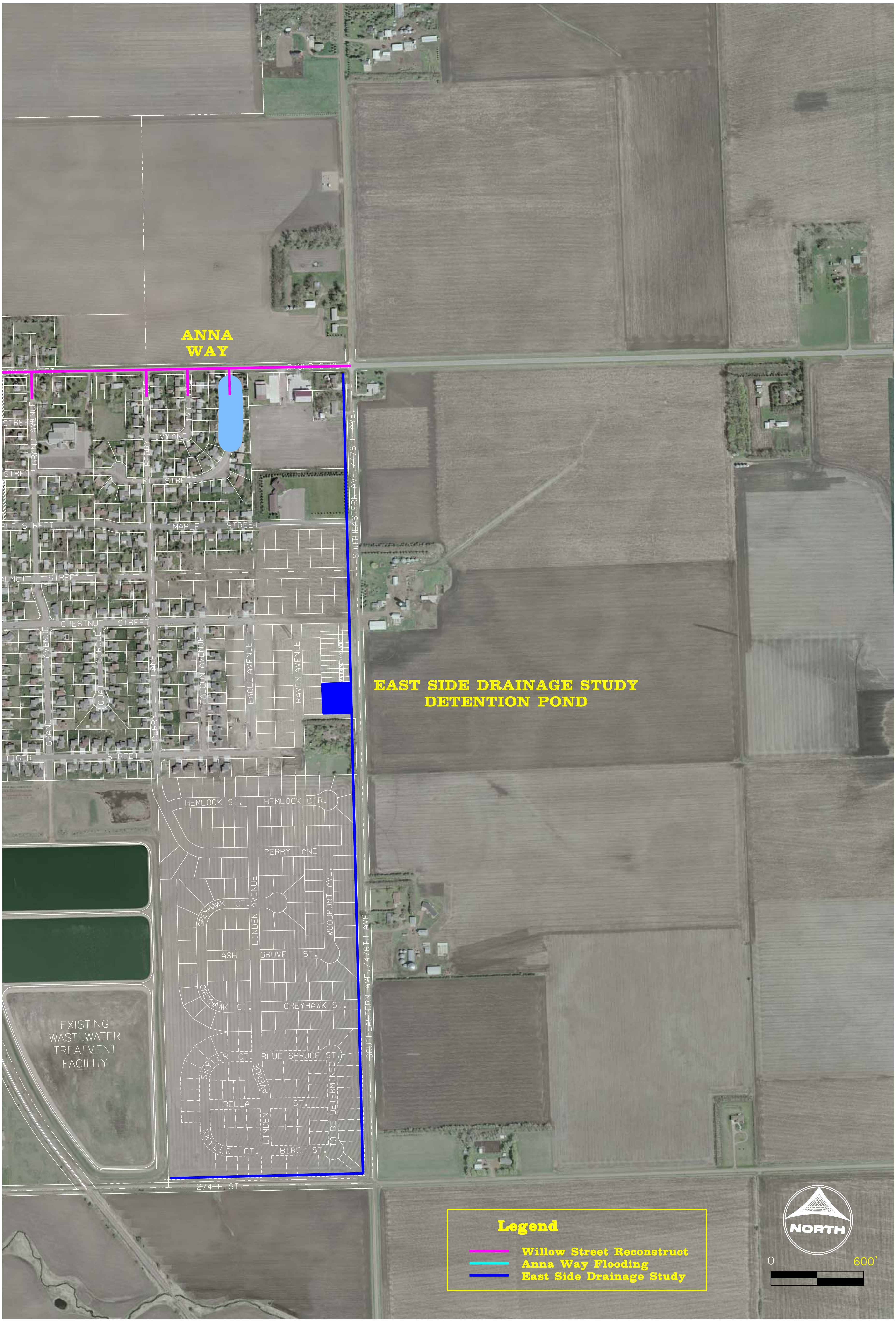

City of Harrisburg, South Dakota

Proposed Improvements

Howard R. Green Company

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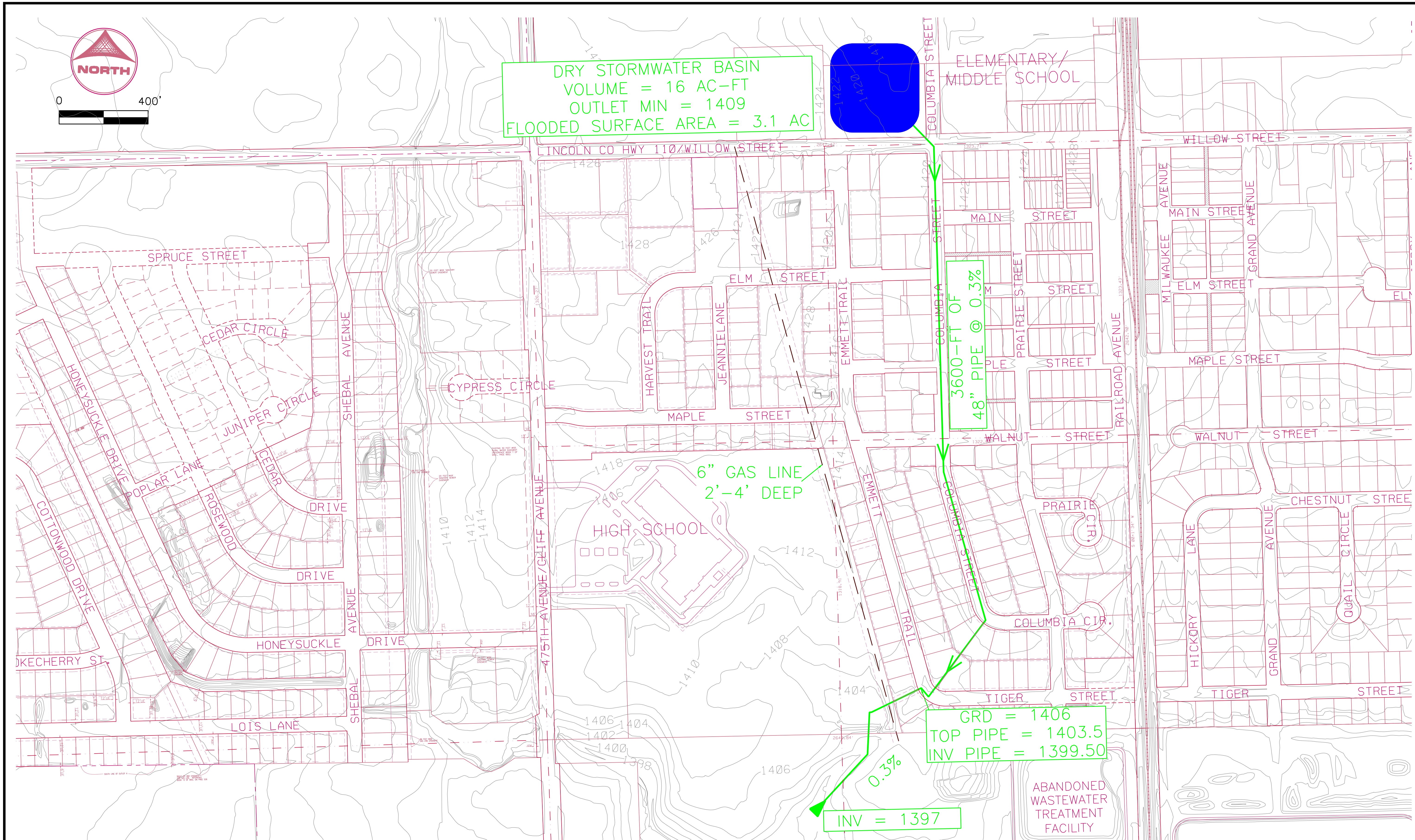

Howard R. Green Company

Columbia Street - Option 1

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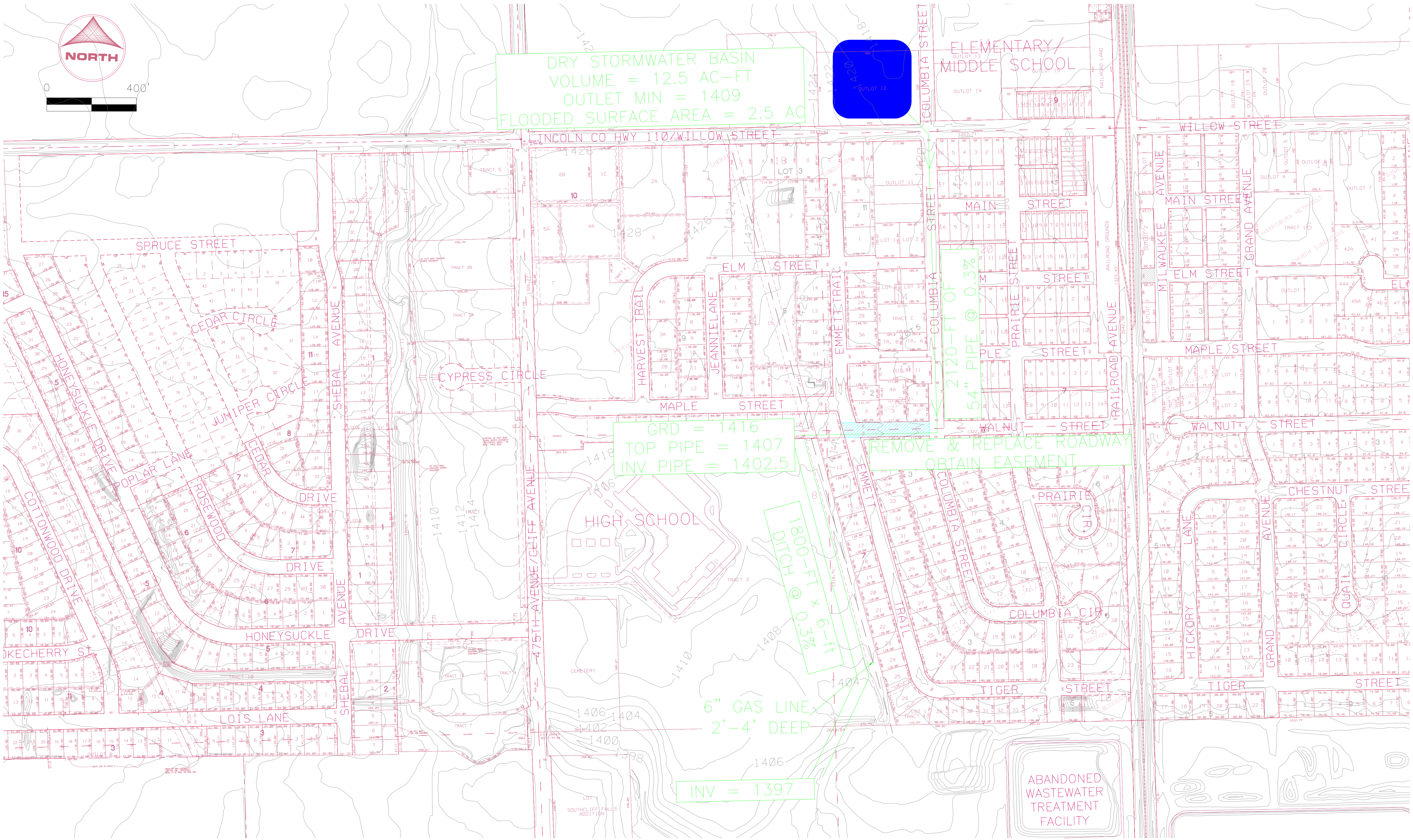

Howard R. Green Company

Columbia Street / Emmett Trail - Option 2

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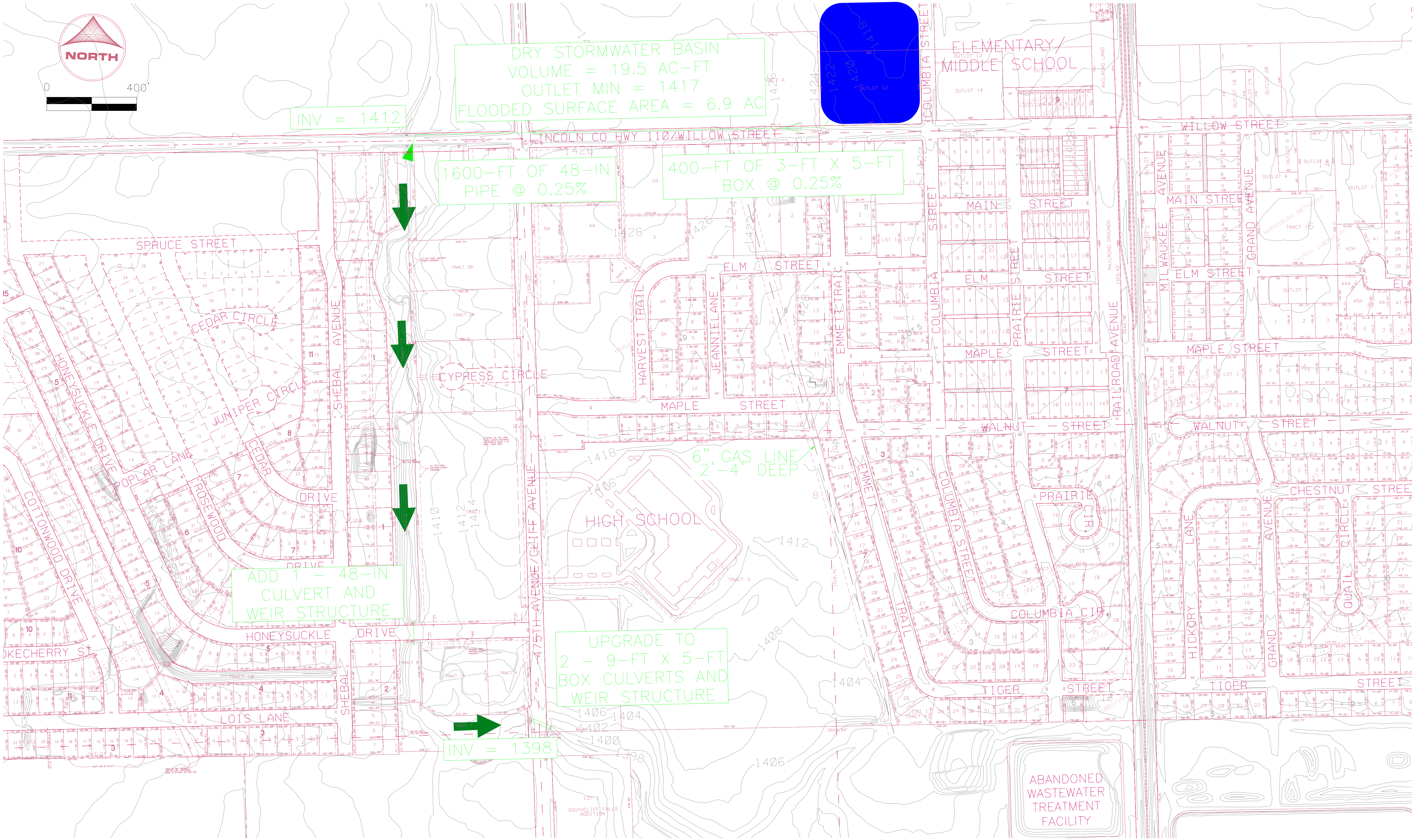

Howard R. Green Company

West on Willow Street - Option 3

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APPENDIX G

Drainage Options & Probable Costs

Harrisburg Master Drainage Plan

Harrisburg, SD

Opinion of Probable Cost

Industrial-Legendary

ITEM NO	ITEM DESCRIPTION	UNITS	UNIT COST	QUANTITY	TOTAL
	INDUSTRIAL PARK / LENGENDARY ESTATES				
1	COMMON EXCAVATION (DITCH)	CU YD	$ 8.00	2,000	$ 16,000
2	BORE & JACK 36" RCP CULVERT	LIN FT	$ 325.00	50	$ 16,250
3	36" RCP APRONS	EACH	$ 1,100.00	2	$ 2,200
	SUBTOTAL				**$ 34,450**

	MISCELLANEOUS		
	MOBILIZATION	10%	**$ 3,445**
	EROSION & SEDIMENT CONTROL	10%	**$ 3,445**
	TURF ESTABLISHEMENT	5%	**$ 1,723**
	SUBTOTAL		**$ 8,613**

	Contingency	30%	**$ 12,919**
	Total Construction Cost		**$ 56,000**

Harrisburg Master Drainage Plan

Harrisburg, SD

Opinion of Probable Cost

Homesites-Green Meadows

ITEM NO	ITEM DESCRIPTION	UNITS	UNIT COST	QUANTITY	TOTAL
	HOMESITES / GREEN MEADOWS				
1	COMMON EXCAVATION (STORMWATER BASIN)	CU YD	$ 8.00	48,400	$ 387,200
2	DRAINAGE STRUCTURE (TYP)	LIN FT	$ 300.00	10	$ 3,000
3	36" RCP CULVERT	LIN FT	$ 100.00	40	$ 4,000
4	36" RCP APRONS	EACH	$ 1,100.00	2	$ 2,200
	SUBTOTAL				**$ 396,400**

	MISCELLANEOUS		
	MOBILIZATION	10%	**$ 39,640**
	EROSION & SEDIMENT CONTROL	10%	**$ 39,640**
	TURF ESTABLISHEMENT	5%	**$ 19,820**
	SUBTOTAL		**$ 99,100**

	Contingency	30%	**$ 148,650**
	Total Construction Cost		**$ 645,000**

Harrisburg Master Drainage Plan

Harrisburg, SD

Opinion of Probable Cost

Cliff Ave Culvert

ITEM NO	ITEM DESCRIPTION	UNITS	UNIT COST	QUANTITY	TOTAL
	CLIFF AVENUE CULVERT				
1	PRECAST CONCRETE BOX CULVERT (9-FT X 5-FT)	LIN FT	$ 450.00	200	$ 90,000
3	WEIR STRUCTURE	EACH	$ 10,000.00	2	$ 20,000
4	ENERGY DISSIPATER STRUCTURE	EACH	$ 15,000.00	1	$ 15,000
	SUBTOTAL				**$ 125,000**
	MISCELLANEOUS				
	MOBILIZATION	10%			**$ 12,500**
	EROSION & SEDIMENT CONTROL	10%			**$ 12,500**
	TURF ESTABLISHEMENT	3%			**$ 3,750**
	SUBTOTAL				**$ 28,750**
	Contingency	30%			**$ 46,125**
	Total Construction Cost				**$ 200,000**

Harrisburg Master Drainage Plan

Harrisburg, SD

Opinion of Probable Cost

Channel Maintenance

ITEM NO	ITEM DESCRIPTION	UNITS	UNIT COST	QUANTITY	TOTAL
	CHANNEL MAINTENANCE				
1	CHANNEL RECONSTRUCTION	LIN FT	$ 40.00	7,850	$ 314,000
	CHANNEL MAINTENANCE	LIN FT	$ 15.00	7,850	$ 117,750
	SUBTOTAL				**$ 431,750**
	Contingency	30%			**$ 129,525**
	Total Construction Cost				**$ 562,000**

Harrisburg Master Drainage Plan

Harrisburg, SD

Opinion of Probable Cost

Columbia St - Option 1

ITEM NO	ITEM DESCRIPTION	UNITS	UNIT COST	QUANTITY	TOTAL
	COLUMBIA STREET				
1	COMMON EXCAVATION (STORMWATER BASIN)	CU YD	$ 8.00	25,820	$ 206,560
2	48" RCP STORM SEWER	LIN FT	$ 135.00	3,600	$ 486,000
3	48" RCP APRONS	EACH	$ 1,500.00	2	$ 3,000
4	DRAINAGE STRUCTURE (TYP)	LIN FT	$ 350.00	89	$ 31,150
5	REMOVE BITUMINOUS PAVEMENT	SQ YD	$ 5.00	1,500	$ 7,500
6	REMOVE CONCRETE CURB & GUTTER	LIN FT	$ 4.00	3,050	$ 12,200
7	CONCRETE CURB & GUTTER	LIN FT	$ 16.00	2,200	$ 35,200
8	BITUMINOUS PAVEMENT (4-IN THICK)	SQ YD	$ 12.00	1,500	$ 18,000
9	DRAIN TILE	LIN FT	$ 0.50	3,500	$ 1,750
10	SMALL PUMP STATION	EACH	$ 15,000.00	1	$ 15,000
	SUBTOTAL				**$ 816,360**

	MISCELLANEOUS		
	MOBILIZATION	10%	**$ 81,636**
	EROSION & SEDIMENT CONTROL	10%	**$ 81,636**
	TURF ESTABLISHEMENT	3%	**$ 24,491**
	SUBTOTAL		**$ 187,763**

	Contingency	30%	**$ 301,237**
	Total Construction Cost		**$ 1,306,000**

Harrisburg Master Drainage Plan

Harrisburg, SD

Opinion of Probable Cost

Columbia St-Emmett Tr Option 2

ITEM NO	ITEM DESCRIPTION	UNITS	UNIT COST	QUANTITY	TOTAL
	COLUMBIA ST / EMMETT TRAIL				
1	COMMON EXCAVATION (STORMWATER BASIN)	CU YD	$ 8.00	20,200	$ 161,600
2	COMMON EXCAVATION (DITCH)	CU YD	$ 8.00	15,867	$ 126,933
3	54" RCP STORM SEWER	LIN FT	$ 170.00	2,120	$ 360,400
4	54" RCP APRONS	EACH	$ 2,000.00	2	$ 4,000
5	DRAINAGE STRUCTURE (TYP)	LIN FT	$ 350.00	40	$ 14,000
6	REMOVE BITUMINOUS PAVEMENT	SQ YD	$ 5.00	800	$ 4,000
7	REMOVE CONCRETE CURB & GUTTER	LIN FT	$ 16.00	1,700	$ 27,200
8	BITUMINOUS PAVEMENT (4-IN THICK)	SQ YD	$ 12.00	800	$ 9,600
9	CONCRETE CURB & GUTTER	LIN FT	$ 16.00	1,700	$ 27,200
10	AGGREGATE BASE (CV)	CU YD	$ 17.00	467	$ 7,933
11	PERMANENT DRAINAGE AND UTILITY EASEMENT	AC	$ 50,000.00	0.07	$ 3,444
12	DRAIN TILE	LIN FT	$ 0.50	2,400	$ 1,200
13	SMALL PUMP STATION	EACH	$ 15,000.00	1	$ 15,000
	SUBTOTAL				**$ 762,510**

MISCELLANEOUS			
MOBILIZATION	10%		**$ 76,251**
EROSION & SEDIMENT CONTROL	10%		**$ 76,251**
TURF ESTABLISHEMENT	5%		**$ 38,126**
SUBTOTAL			**$ 190,628**

Contingency	30%	**$ 285,941**
Total Construction Cost		**$ 1,240,000**

Harrisburg Master Drainage Plan

Harrisburg, SD

Opinion of Probable Cost

West on Willow St - Option 3

ITEM NO	ITEM DESCRIPTION	UNITS	UNIT COST	QUANTITY	TOTAL
	WEST ON WILLOW STREET				
1	COMMON EXCAVATION (STORMWATER BASIN)	CU YD	$ 8.00	32,267	$ 258,133
2	PRECAST CONCRETE BOX CULVERT (5-FT X 3-FT)	LIN FT	$ 260.00	400	$ 104,000
3	48" RCP STORM SEWER	LIN FT	$ 135.00	1,600	$ 216,000
4	48" RCP APRONS	EACH	$ 1,500.00	3	$ 4,500
5	DRAINAGE STRUCTURE (TYP)	LIN FT	$ 325.00	40	$ 13,000
6	48" RCP CULVERT	LIN FT	$ 135.00	100	$ 13,500
7	PRECAST CONCRETE BOX CULVERT (9-FT X 5-FT)	LIN FT	$ 450.00	200	$ 90,000
8	WEIR STRUCTURE	EACH	$ 10,000.00	2	$ 20,000
9	ENERGY DISSIPATER STRUCTURE	EACH	$ 15,000.00	1	$ 15,000
10	DRAIN TILE	LIN FT	$ 0.50	4,400	$ 2,200
11	SMALL PUMP STATION	EACH	$ 15,000.00	1	$ 15,000
	SUBTOTAL				**$ 751,333**
	MISCELLANEOUS				
	MOBILIZATION	10%			**$ 75,133**
	EROSION & SEDIMENT CONTROL	10%			**$ 75,133**
	TURF ESTABLISHEMENT	5%			**$ 37,567**
	SUBTOTAL				**$ 187,833**
	Contingency	30%			**$ 281,750**
	Total Construction Cost				**$ 1,221,000**

* If this option is chosen it will also require the Cliff Avenue culvert improvement.

APPENDIX H

Culvert Master Results

Culvert Calculator Report
Cliff Avenue

Solve For: Section Size

Culvert Summary

Allowable HW Elevation	1,403.00	ft	Headwater Depth/Height	1.13	
Computed Headwater Eleva	1,402.65	ft	Discharge	677.00	cfs
Inlet Control HW Elev.	1,402.56	ft	Tailwater Elevation	1,396.00	ft
Outlet Control HW Elev.	1,402.65	ft	Control Type	Entrance Control	

Grades

Upstream Invert	1,397.00	ft	Downstream Invert	1,396.00	ft
Length	100.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	2.72	ft
Slope Type	Steep		Normal Depth	2.43	ft
Flow Regime	Supercritical		Critical Depth	3.53	ft
Velocity Downstream	13.85	ft/s	Critical Slope	0.003501	ft/ft

Section

Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	9.00	ft
Section Size	9 x 5 ft		Rise	5.00	ft
Number Sections	2				

Outlet Control Properties

Outlet Control HW Elev.	1,402.65	ft	Upstream Velocity Head	1.76	ft
Ke	0.20		Entrance Loss	0.35	ft

Inlet Control Properties

Inlet Control HW Elev.	1,402.56	ft	Flow Control	N/A	
Inlet Type	90° headwall w 45° bevels		Area Full	90.0	ft²
K	0.49500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	2	
C	0.03140		Equation Form	2	
Y	0.82000				

APPENDIX I

HydroCAD Results

Pond 1P: (new Pond)

Inflow Area = 160.000 ac, Inflow Depth > 2.89"
Inflow = 231.57 cfs @ 12.82 hrs, Volume= 38.550 af
Outflow = 84.96 cfs @ 15.43 hrs, Volume= 34.974 af, Atten= 63%, Lag= 156.3 min
Primary = 84.96 cfs @ 15.43 hrs, Volume= 34.974 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 1,415.63' @ 13.90 hrs Surf.Area= 2.811 ac Storage= 15.960 af
Plug-Flow detention time= 109.1 min calculated for 34.858 af (90% of inflow)
Center-of-Mass det. time= 81.3 min (917.7 - 836.4)

Volume	Invert	Avail.Storage	Storage Description
#1	1,409.00'	22.950 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,409.00	2.000	0.000	0.000
1,418.00	3.100	22.950	22.950

Device	Routing	Invert	Outlet Devices
#1	Primary	1,409.00'	**48.0" x 3,600.0' long Culvert** RCP, end-section conforming to fill, Ke= 0.500 Outlet Invert= 1,398.20' S= 0.0030 '/' Cc= 0.900 n= 0.013

Primary OutFlow Max=85.01 cfs @ 15.43 hrs HW=1,414.04' (Free Discharge)
└─**1=Culvert** (Barrel Controls 85.01 cfs @ 6.9 fps)

Pond 1P: (new Pond)

Inflow Area = 160.000 ac, Inflow Depth > 2.89"
Inflow = 231.57 cfs @ 12.82 hrs, Volume= 38.550 af
Outflow = 117.64 cfs @ 14.36 hrs, Volume= 36.170 af, Atten= 49%, Lag= 92.2 min
Primary = 117.64 cfs @ 14.36 hrs, Volume= 36.170 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 1,415.73' @ 13.58 hrs Surf.Area= 2.210 ac Storage= 12.487 af
Plug-Flow detention time= 71.0 min calculated for 36.050 af (94% of inflow)
Center-of-Mass det. time= 51.4 min (887.8 - 836.4)

Volume	Invert	Avail.Storage	Storage Description
#1	1,409.00'	17.775 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,409.00	1.500	0.000	0.000
1,418.00	2.450	17.775	17.775

Device	Routing	Invert	Outlet Devices
#1	Primary	1,409.00'	**54.0" x 2,120.0' long Culvert** RCP, end-section conforming to fill, Ke= 0.500 Outlet Invert= 1,402.50' S= 0.0031 '/' Cc= 0.900 n= 0.013

Primary OutFlow Max=117.68 cfs @ 14.36 hrs HW=1,414.70' (Free Discharge)
└—**1=Culvert** (Barrel Controls 117.68 cfs @ 7.5 fps)

Pond 1P: (new Pond)

Inflow Area = 160.000 ac, Inflow Depth > 2.89"
Inflow = 231.57 cfs @ 12.82 hrs, Volume= 38.550 af
Outflow = 71.75 cfs @ 14.06 hrs, Volume= 29.563 af, Atten= 69%, Lag= 74.2 min
Primary = 71.75 cfs @ 14 06 hrs, Volume= 29.563 af

Routing by Stor-Ind method, Time Span= 5 00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 1,420.04' @ 14.06 hrs Surf.Area= 6.707 ac Storage= 19.437 af
Plug-Flow detention time= 162 3 min calculated for 29.465 af (76% of inflow)
Center-of-Mass det. time= 109.1 min (945.4 - 836.4)

Volume	Invert	Avail.Storage	Storage Description
#1	1,417.00'	26.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,417.00	6.100	0.000	0.000
1,421.00	6.900	26.000	26.000

Device	Routing	Invert	Outlet Devices
#1	Primary	1,417.00'	**5.00' W x 3.00' H x 2,000.0' long Culvert** RCP, sq.cut end projecting, Ke= 0.500 Outlet Invert= 1,412.00' S= 0.0025 '/' Cc= 0.900 n= 0.013

Primary OutFlow Max=71.75 cfs @ 14.06 hrs HW=1,420.04' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 71.75 cfs @ 6.3 fps)

APPENDIX J

Open Channel Calculations

OPEN CHANNEL CAPACITY - OPTION 2

MANNING'S EQUATION
ASSUMES UNIFORM FLOW

	English		Metric Equiv.	
CHANNEL SLOPE =	*0.0030*	(FT./FT.)		
MANNING'S n=	*0.035*			
BOTTOM WIDTH =	*6.0*	(FT.)	1.83	[M.]
LEFT SIDE SLOPE =	*3.0*	(SLOPE:1)		
RIGHT SIDE SLOPE=	*3.0*	(SLOPE:1)		

Y (FT.)	Y [M.]	AREA (SQ.FT.)	AREA [SQ.M.]	P (FT.)	P [M.]	R (FT.)	R [M.]	V (FPS)	V [MPS]	Q (CFS)	Q [CMS]	Topwidth (FT.)	Topwidth [M.]	Shear [lbs/ft^2]	Shear [lbs/ft^2]
0.10	0.030	0.63	0.06	6.63	2.02	0.09	0.03	0.5	0.15	0.3	0.01	6.6	2.01	0.02	0.02
0.20	0.061	1.32	0.12	7.26	2.21	0.18	0.06	0.7	0.23	1.0	0.03	7.2	2.19	0.03	0.04
0.30	0.091	2.07	0.19	7.90	2.41	0.26	0.08	1.0	0.29	2.0	0.06	7.8	2.38	0.05	0.06
0.40	0.122	2.88	0.27	8.53	2.60	0.34	0.10	1.1	0.34	3.2	0.09	8.4	2.56	0.06	0.07
0.50	0.152	3.75	0.35	9.16	2.79	0.41	0.12	1.3	0.39	4.8	0.14	9.0	2.74	0.08	0.09
0.60	0.183	4.68	0.43	9.79	2.99	0.48	0.15	1.4	0.43	6.6	0.19	9.6	2.93	0.09	0.11
0.70	0.213	5.67	0.53	10.43	3.18	0.54	0.17	1.5	0.47	8.8	0.25	10.2	3.11	0.10	0.13
0.80	0.244	6.72	0.62	11.06	3.37	0.61	0.19	1.7	0.51	11.2	0.32	10.8	3.29	0.11	0.15
0.90	0.274	7.83	0.73	11.69	3.56	0.67	0.20	1.8	0.54	13.9	0.39	11.4	3.47	0.13	0.17
1.00	0.305	9.00	0.84	12.32	3.76	0.73	0.22	1.9	0.57	17.0	0.48	12.0	3.66	0.14	0.19
1.10	0.335	10.23	0.95	12.96	3.95	0.79	0.24	2.0	0.61	20.3	0.58	12.6	3.84	0.15	0.21
1.20	0.366	11.52	1.07	13.59	4.14	0.85	0.26	2.1	0.63	24.0	0.68	13.2	4.02	0.16	0.22
1.30	0.396	12.87	1.20	14.22	4.33	0.90	0.28	2.2	0.66	28.0	0.79	13.8	4.21	0.17	0.24
1.40	0.427	14.28	1.33	14.85	4.53	0.96	0.29	2.3	0.69	32.3	0.92	14.4	4.39	0.18	0.26
1.50	0.457	15.75	1.46	15.49	4.72	1.02	0.31	2.4	0.72	37.0	1.05	15.0	4.57	0.19	0.28
1.60	0.488	17.28	1.61	16.12	4.91	1.07	0.33	2.4	0.74	42.1	1.19	15.6	4.75	0.20	0.30
1.70	0.518	18.87	1.75	16.75	5.11	1.13	0.34	2.5	0.77	47.5	1.35	16.2	4.94	0.21	0.32
1.80	0.549	20.52	1.91	17.38	5.30	1.18	0.36	2.6	0.79	53.3	1.51	16.8	5.12	0.22	0.34
1.90	0.579	22.23	2.07	18.02	5.49	1.23	0.38	2.7	0.82	59.5	1.68	17.4	5.30	0.23	0.36
2.00	0.610	24.00	2.23	18.65	5.68	1.29	0.39	2.8	0.84	66.0	1.87	18.0	5.49	0.24	0.37
2.10	0.640	25.83	2.40	19.28	5.88	1.34	0.41	2.8	0.86	73.0	2.07	18.6	5.67	0.25	0.39
2.20	0.671	27.72	2.58	19.91	6.07	1.39	0.42	2.9	0.88	80.4	2.28	19.2	5.85	0.26	0.41
2.30	0.701	29.67	2.76	20.55	6.26	1.44	0.44	3.0	0.91	88.2	2.50	19.8	6.04	0.27	0.43
2.40	0.732	31.68	2.94	21.18	6.46	1.50	0.46	3.0	0.93	96.4	2.73	20.4	6.22	0.28	0.45
2.50	0.762	33.75	3.14	21.81	6.65	1.55	0.47	3.1	0.95	105.0	2.97	21.0	6.40	0.29	0.47
2.60	0.792	35.88	3.33	22.44	6.84	1.60	0.49	3.2	0.97	114.1	3.23	21.6	6.58	0.30	0.49
2.70	0.823	38.07	3.54	23.08	7.03	1.65	0.50	3.2	0.99	123.6	3.50	22.2	6.77	0.31	0.51
2.80	0.853	40.32	3.75	23.71	7.23	1.70	0.52	3.3	1.01	133.6	3.78	22.8	6.95	0.32	0.52

APPENDIX K

Development Drainage Calculations

Type..... Master Network Summary
Name..... Watershed
File..... S:\thadr\Pondpack\Harrisburg Dev\HARRISBURG CREEK.PPW

* CN = 75 = equivalent to L. Hart of 1887 acres
Area = 1887 acres
Ave Slope = 0.61%
T_c = 4.2 hr

MASTER DESIGN STORM SUMMARY

Network Storm Collection: sioux falls

Return Event	Total Depth in	Rainfall Type	RNF ID
2	2.6500	Synthetic Curve	TypeII 24hr
5	3.5000	Synthetic Curve	TypeII 24hr
10	4.3000	Synthetic Curve	TypeII 24hr
25	4.8000	Synthetic Curve	TypeII 24hr
50	5.4000	Synthetic Curve	TypeII 24hr
100	5.9000	Synthetic Curve	TypeII 24hr

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10	JCT	2	116.345		15.1000	222.12		
*OUT 10	JCT	5	204.711		15.1000	409.10		
*OUT 10	JCT	10	297.976		14.6000	613.39		
*OUT 10	JCT	25	359.808		14.6000	749.19 *		
*OUT 10	JCT	50	436.753		14.5500	918.01		
*OUT 10	JCT	100	502.738		14.5500	1062.84		
SUBAREA 10	AREA	2	116.345		15.1000	222.12		
SUBAREA 10	AREA	5	204.711		15.1000	409.10		
SUBAREA 10	AREA	10	297.976		14.6000	613.39		
SUBAREA 10	AREA	25	359.808		14.6000	749.19		
SUBAREA 10	AREA	50	436.753		14.5500	918.01		
SUBAREA 10	AREA	100	502.738		14.5500	1062.84		

FINAL DRAINAGE PLAN TABLES

DRAINAGE DATA SUMMARY TABLES - 5-year

Rational Method

Given Input Data:
Description .... Final Drainage – Legendary Estates Addition
IDF Curve .... C:\Program Files\Land Desktop 2004\Data\hd\sioux falls.idf
Rainfall Frequency .. 5 year(s)

Area Description	Area ac	Coef	Tc min	Intensity in/hr	Flow cfs
FDA#1	3.7642	0.5000	30.1276	3.0742	5.7860
FDA#2	1.8110	0.7000	18.8480	3.9590	5.0187
FDA#3	1.9583	0.7000	20.1986	3.8151	5.2299
FDA#4	3.5465	0.4500	32.3984	2.9713	4.7419
FDA#5	1.2431	0.7000	17.8610	4.0696	3.5413
FDA#6	0.5901	0.7000	15.0000	4.3900	1.8133
FDA#7	1.9763	0.4500	34.5704	2.8728	2.5549
FDA#8	1.5008	0.7000	17.5199	4.1078	4.3153
FDA#9	2.5408	0.4500	34.6522	2.8691	3.2804
FDA#10	1.3874	0.7000	17.4570	4.1148	3.9963
FDA#4,5 & 6	5.3797	0.4500	54.6415	2.1300	5.1565
FDA#7&8	3.4770	0.4500	36.3045	2.7942	4.3719
FDA#9&10	3.9282	0.4500	39.3672	2.6554	4.6938
FDA#11	0.7001	0.7000	15.0000	4.3900	2.1514
FDA#12	0.6436	0.7000	15.0000	4.3900	1.9779
FDA#13	1.2738	0.4500	22.9439	3.6092	2.0689
FDA#14	1.2888	0.4500	22.3164	3.6563	2.1205
FDA#15	0.9312	0.7000	15.0000	4.3900	2.8616
FDA#16	0.1431	0.7000	15.0000	4.3900	0.4397
FDA#17	0.5675	0.7000	15.0000	4.3900	1.7440
FDA#18	0.2103	0.4500	15.0000	4.3900	0.4155
FDA#19	3.1639	0.7000	43.2896	2.4775	5.4871
FDA#20	0.2784	0.7000	15.0000	4.3900	0.8556
FDA#21	0.8327	0.7000	18.9060	3.9525	2.3040
FDA#22	1.2215	0.4500	31.1031	3.0300	1.6655
FDA#23	1.8535	0.7000	20.7561	3.7733	4.8957
FDA#24	0.5993	0.7000	15.0000	4.3900	1.8416
FDA#25	0.1339	0.7000	15.0000	4.3900	0.4116
FDA#26	1.5546	0.7000	23.6713	3.5547	3.8681
FDA#27	0.1226	0.7000	15.0000	4.3900	0.3767
FDA#28	0.1223	0.7000	15.0000	4.3900	0.3760
FDA#29	0.6479	0.7000	15.0000	4.3900	1.9908
FDA#30	4.5280	0.4500	40.5435	2.6020	5.3019
FDA#31	1.2619	0.4500	24.3522	3.5036	1.9895
22,25,30,PDA26	51.8800	0.3170	77.9155	1.7322	28.4873
COMBO#31	53.3900	0.3208	84.7642	1.6374	28.0418
FDA#32	1.2876	0.7000	21.3451	3.7291	3.3610
FDA#33	0.3062	0.7000	15.0000	4.3900	0.9409
FDA#23 & 24	2.4528	0.7000	20.7561	3.7733	6.4786
FDA#26–29	2.4474	0.5412	23.6713	3.5547	4.7082
RFDA1	3.0680	0.4500	24.3996	3.5000	4.8322
RFDA2	2.6731	0.4500	24.8009	3.4699	4.1739
RFDA3	4.7972	0.4500	30.0399	3.0782	6.6450
RFDA4	1.9584	0.4500	29.5587	3.1131	2.7435
RFDA5	2.1580	0.7000	26.3608	3.3529	5.0649
RFDA6	3.1516	0.7000	26.8444	3.3167	7.3169
RFDA7	7.2293	0.4500	52.5565	2.1884	7.1193
RFDA8	1.0237	0.7000	15.2488	4.3621	3.1259
RFDA9	3.3653	0.4500	36.2609	2.7962	4.2345
RFDA10	1.9309	0.7000	21.6508	3.7062	5.0094
RFDA11	4.2337	0.4500	39.4618	2.6511	5.0507
RFDA12	0.1453	0.7000	19.3485	3.9030	0.3970
RFDA13	7.3790	0.4500	41.6794	2.5505	8.4692
RFDA5,14,15	3.9600	0.6122	48.9786	2.2886	5.5487
RFDA8,9,10	6.3200	0.5667	48.7167	2.2959	8.2229
RFDA14	0.4051	0.7000	15.0000	4.3900	1.2448
RFDA15	1.3901	0.4500	33.3410	2.9285	1.8319
RFDA16	3.6687	0.4500	38.8943	2.6768	4.4191
RFDA17	0.7617	0.7000	15.0000	4.3900	2.3407
RFDA13–17	14.0040	0.4500	49.3372	2.2786	14.3590
RFDA18	0.9975	0.7000	19.0221	3.9395	2.7507
RFDA19	0.0942	0.7000	15.0000	4.3900	0.2894
RFDA20	0.8161	0.7000	16.7138	4.1981	2.3982
FDA#15.2	1.7974	0.4500	32.1731	2.9815	2.4115
FDA100	21.8632	0.4500	48.8707	2.2916	22.5460

DRAINAGE DATA SUMMARY TABLES - 100-year

Rational Method

Given Input Data:
Description .... Final Drainage – Legendary Estates Addition
IDF Curve .... C:\Program Files\Land Desktop 2004\Data\hd\sioux falls.idf
Rainfall Frequency .. 100 year(s)

Area Description	Area ac	Coef	Tc min	Intensity in/hr	Flow cfs
FDA#1	3.7642	0.7000	30.1276	5.2900	13.9389
FDA#2	1.8110	0.8500	18.8480	6.7528	10.3946
FDA#3	1.9583	0.8500	20.1986	6.5252	10.8617
FDA#4	3.5465	0.7000	32.3984	5.1129	12.6931
FDA#5	1.2431	0.8500	17.8610	6.9265	7.3190
FDA#6	0.5901	0.8500	15.0000	7.4300	3.7266
FDA#7	1.9763	0.7000	34.5704	4.9435	6.8390
FDA#8	1.5008	0.8500	17.5199	6.9865	8.9123
FDA#9	2.5408	0.7000	34.6522	4.9371	8.7810
FDA#10	1.3874	0.8500	17.4570	6.9976	8.2523
FDA#4,5 & 6	5.3797	0.7000	54.6415	3.6544	13.7615
FDA#7&8	3.4770	0.7000	36.3045	4.8082	11.7028
FDA#9&10	3.9282	0.7000	39.3672	4.5694	12.5645
FDA#11	0.7001	0.8500	15.0000	7.4300	4.4215
FDA#12	0.6436	0.8500	15.0000	7 4300	4.0649
FDA#13	1.2738	0.7000	22.9439	6.1820	5.5125
FDA#14	1.2888	0.7000	22.3164	6.2604	5.6481
FDA#15	0.9312	0.8500	15.0000	7.4300	5.8810
FDA#16	0.1431	0.8500	15.0000	7.4300	0.9036
FDA#17	0.5675	0.8500	15.0000	7.4300	3.5843
FDA#18	0.2103	0.7000	15.0000	7.4300	1.0938
FDA#19	3.1639	0.8500	43.2896	4.2634	11.4657
FDA#20	0.2784	0.8500	15.0000	7.4300	1 7584
FDA#21	0.8327	0.8500	18.9060	6.7425	4.7725
FDA#22	1.2215	0.7000	31.1031	5.2140	4.4582
FDA#23	1.8535	0.8500	20.7561	6.4555	10.1706
FDA#24	0.5993	0.8500	15.0000	7.4300	3.7848
FDA#25	0.1339	0.8500	15.0000	7.4300	0.8459
FDA#26	1.5546	0.8500	23.6713	6.0911	8.0486
FDA#27	0.1226	0.8500	15.0000	7.4300	0.7743
FDA#28	0.1223	0.8500	15.0000	7.4300	0.7727
FDA#29	0.6479	0.8500	15.0000	7.4300	4.0915
FDA#30	4.5280	0.7000	40.5435	4.4776	14.1921
FDA#31	1.2619	0.7000	24.3522	6.0060	5.3052
22,25,30,PDA26	51.8800	0.6113	77.9155	2.9302	92.9332
COMBO#31	53.3900	0.6138	84.7642	2.7544	90.2695
FDA#32	1.2876	0.8500	21.3451	6.3819	6.9845
FDA#33	0.3062	0.8500	15.0000	7.4300	1.9338
FDA#23 & 24	2.4528	0.8500	20.7561	6.4555	13.4589
FDA#26–29	2.4474	0.7547	23.6713	6.0911	11.2508
RFDA1	3.0680	0.7000	24.3996	6.0000	12.8859
RFDA2	2.6731	0.7000	24.8009	5.9499	11.1332
RFDA3	4.7972	0.7000	30.0399	5.2969	17.7871
RFDA4	1.9584	0.7000	29.5587	5.3552	7.3412
RFDA5	2.1580	0.8500	26.3608	5.7549	10.5562
RFDA6	3.1516	0.8500	26.8444	5.6944	15.2545
RFDA7	7.2293	0.7000	52.5565	3.7572	19.0135
RFDA8	1.0237	0.8500	15.2488	7.3862	6.4271
RFDA9	3.3653	0.7000	36.2609	4.8116	11.3348
RFDA10	1.9309	0.8500	21.6508	6.3437	10.4117
RFDA11	4.2337	0.7000	39.4618	4.5620	13.5198
RFDA12	0.1453	0.8500	19.3485	6.6647	0.8232
RFDA13	7.3790	0.7000	41.6794	4.3890	22.6707
RFDA5,14,15	3.9600	0.7973	48.9786	3.9337	12.4207
RFDA8,9,10	6.3200	0.7700	48.7167	3.9466	19.2063
RFDA14	0.4051	0.8500	15.0000	7.4300	2.5583
RFDA15	1.3901	0.7000	33.3410	5.0394	4.9037
RFDA16	3.6687	0.7000	38.8943	4.6062	11.8291
RFDA17	0.7617	0.8500	15.0000	7.4300	4.8105
RFDA13–17	14.0040	0.7000	49.3372	3.9160	38.3881
RFDA18	0.9975	0.8500	19.0221	6.7221	5.6994
RFDA19	0.0942	0.8500	15.0000	7.4300	0.5949
RFDA20	0.8161	0.8500	16.7138	7.1284	4.9448
FDA#15.2	1.7974	0.7000	32.1731	5.1305	6.4552
FDA100	21.8632	0.7000	48.8707	3.9390	60.2842

STORM WATER DISCHARGES

STORM FREQUENCY	5-YR (cfs)	25-YR (cfs)	100-YR (cfs)
EXISTING CONDITIONS:			
LEGENDARY ESTATES ONLY	83.6	100 3	187.9
LEGENDARY PLUS OFF-SITE*	148 5	175.3	309.6
DEVELOPED CONDITIONS:			
LEGENDARY ESTATES ONLY	117.9	138 7	244 6
LEGENDARY PLUS OFF-SITE	185.4	216.7	371.8

* MAXIMUM ALLOWABLE DISCHARGES FROM DEVELOPMENT

POND ROUTING SUMMARY

STORM (years)	PEAK INFLOW (cfs)	PEAK OUTFLOW* (cfs)	MAX. POND ELEV (feet)	MAX. STORAGE (acre-ft)
5	185 4	137 7	1417 7	7.05
25	216 7	157 9	1418.0	8.14
100	371.8	307.4	1419.4	13.05

* POND OUTLET CONSISTS OF TWIN 42" RCP ARCH AND OVERFLOW WEIR AT ELEV = 1418.7

REGISTERED PROFESSIONAL ENGINEER & LAND SURVEYOR
REG. NO. 4888
JON D. HECK
SOUTH DAKOTA
7-16-07

LEGENDARY ESTATES ADDITION
LINCOLN COUNTY
HARRISBURG, SOUTH DAKOTA

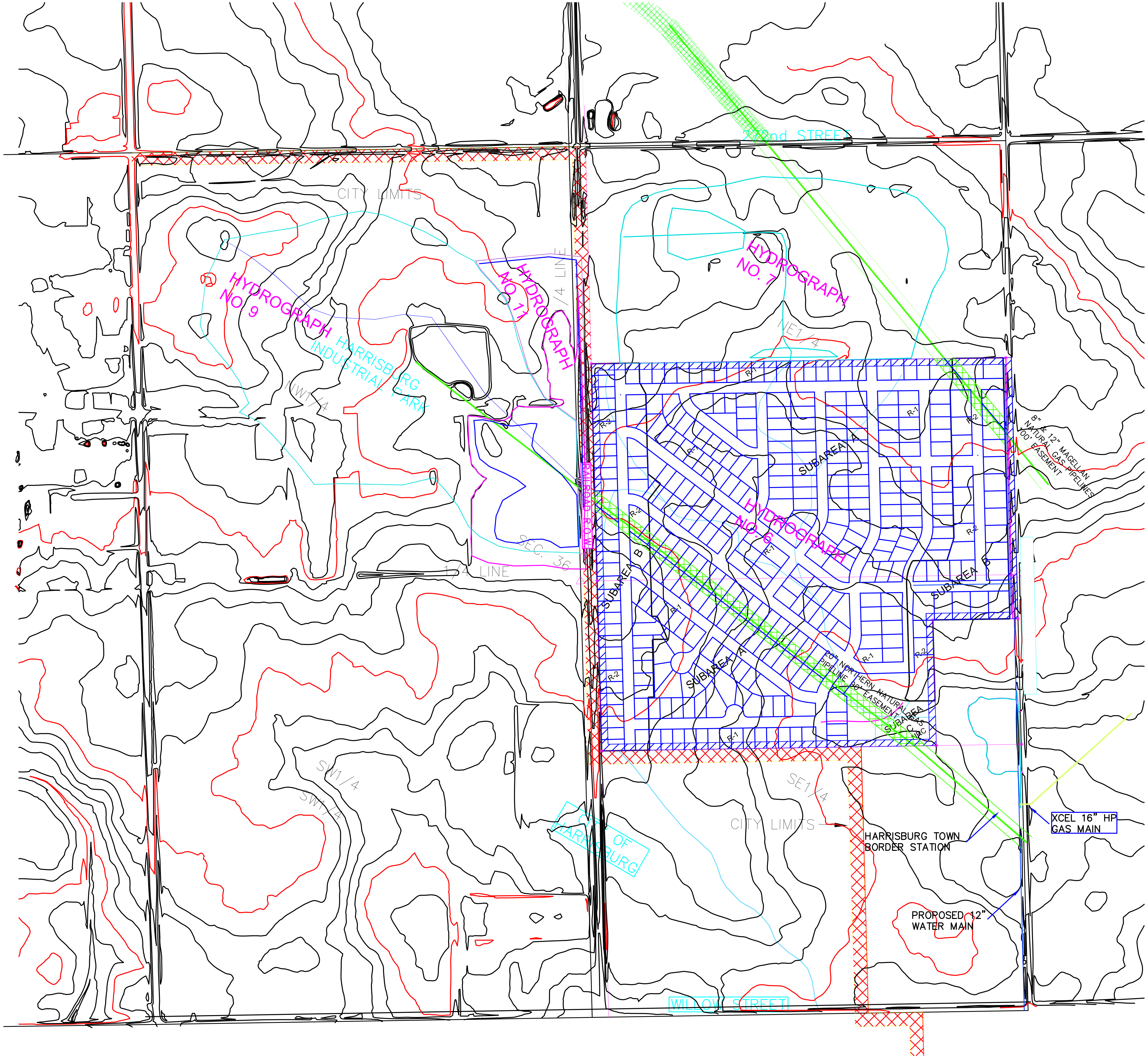
FINAL DRAINAGE PLAN TABLES

DESIGNED BY: ARS
DRAWN BY: ARS ACAD FILE: 206409–Thielen Prop. Harrisburg\dwg\Basetopo.dwg
CHECKED BY: JDH DATE: 7–10–07
REVISIONS: BY: DATE:
BY: DATE:

GOLDSMITH HECK
ENGINEERS, INC.
524 N. Sycamore Ave., Suite 1 • Sioux Falls, SD 57110 • Ph: 605.332.9685

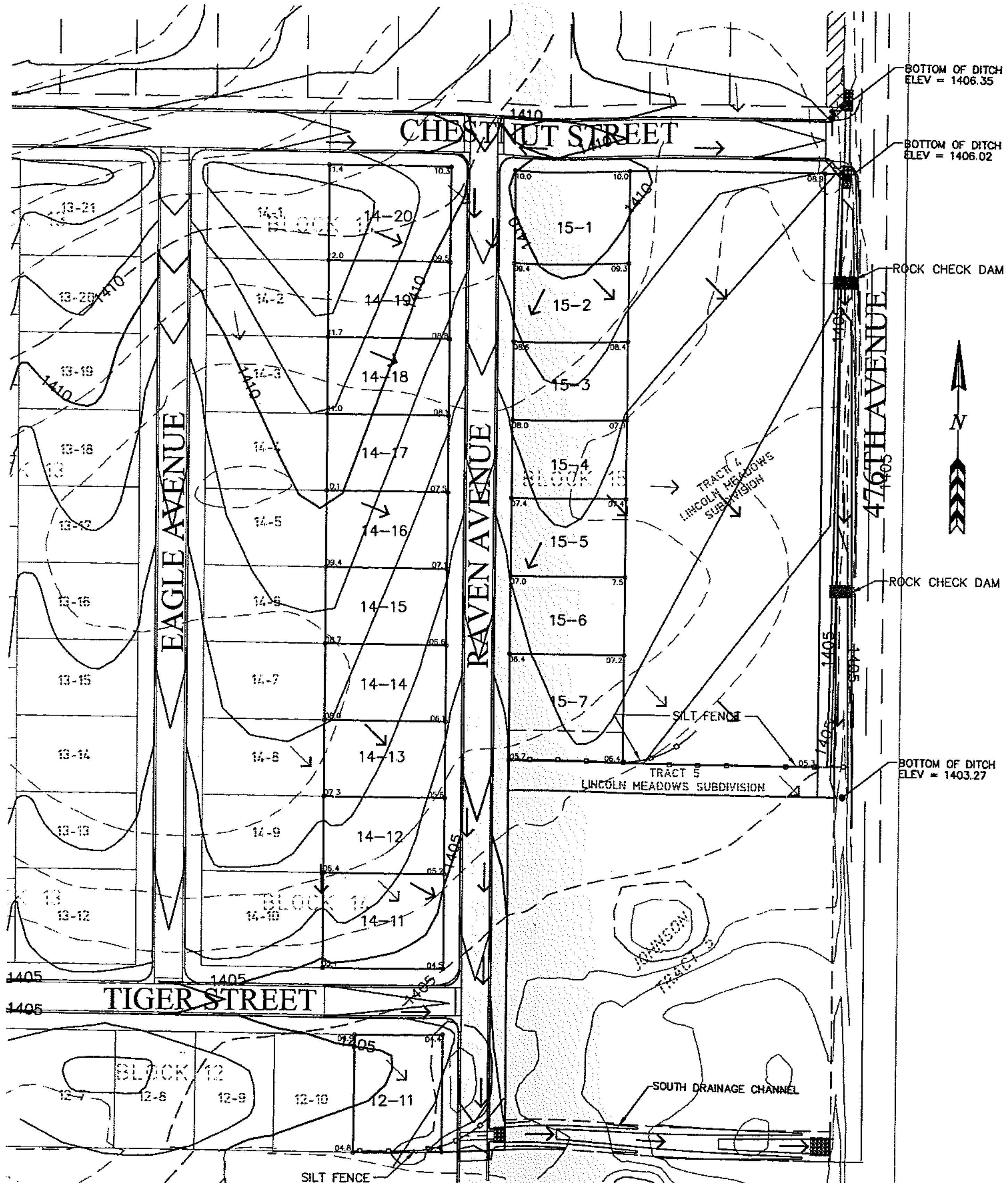
SHEET NO. D2

D2



272nd STREET
CITY LIMITS
HYDROGRAPH NO. 9
HYDROGRAPH NO. 11
HYDROGRAPH NO. 7
HYDROGRAPH NO. 6
HARRISBURG INDUSTRIAL PARK
NW1/4
NE1/4
SW1/4
SE1/4
1/4 LINE
SEC. 36
RAILROAD R.O.W.
SUBAREA A
SUBAREA B
SUBAREA C
SUBAREA E
R-1
R-2
NRC
8" & 12" MAGELLAN NATURAL GAS PIPELINES 100' EASEMENT
20" NORTHERN NATURAL GAS PIPELINE 90' EASEMENT
CITY OF HARRISBURG
HARRISBURG TOWN BORDER STATION
XCEL 16" HP GAS MAIN
PROPOSED 12" WATER MAIN
WILLOW STREET

GRADING, DRAINAGE, & EROSION CONTROL PLAN



LEGEND:

- 1 CONTOUR INTERVAL (EXIST.)
- 5 CONTOUR INTERVAL (EXIST.) 1510
- 1 CONTOUR INTERVAL (FINISH)
- 5' CONTOUR INTERVAL (FINISH) 1510
- FLOW ARROW EXISTING
- FLOW ARROW PROPOSED
- SILT FENCE

GENERAL NOTES:

SUBJECT PROPERTY APPEARS TO BE WITHIN FLOOD ZONE "C" PER FLOOD INSURANCE RATE MAP.

THERE ARE NO WETLANDS ON THIS SITE.

A NOTICE OF INTENT APPLICATION LETTER HAS BEEN COMPLETED AND SENT TO THE SDDENR FOR THIS SITE AND IS PENDING.

AFTER CONSTRUCTION BEGINS, SOIL SURFACE STABILIZATION SHALL BE APPLIED WITHIN 14 DAYS TO ALL DISTURBED AREAS THAT MAY NOT BE AT FINAL GRADE BUT WILL REMAIN DORMANT (UNDISTURBED) FOR PERIODS LONGER THAN AN ADDITIONAL 21 CALENDER DAYS. WITHIN 14 DAYS AFTER FINAL GRADE IS REACHED ON ANY PORTION OF THE SITE, PERMANENT OR TEMPORARY SOIL SURFACE STABILIZATION SHALL BE APPLIED TO DISTURBED AREAS AND SOIL STOCKPILES.

ALL PAVED STREETS ADJACENT TO SITE SHALL BE CLEANED AT THE END OF EACH WORKING DAY AND VEHICLE TRACKING CONTROL DEVICE WILL BE INSTALLED.

DRAINAGE NOTES:

SOUTH DRAINAGE CHANNEL

DRAINAGE AREA = 12.2 Ac.
Tc = 30 min.
i_5 = 3.08 in/hr
i_{100} = 5.30 in/hr
C_5 = .45
C_{100} = .70
Q=CiA
Q_5 = 16.47cfs
Q_{100} = 45.26 cfs
Channel Bottom = 10'
Side slopes = 4:1
Channel Slope = .006 ft/ft
Mannings n = .03
Depth of Flow
D_5 = .57'
D_{100} = 1.00'

CONSTRUCTION PLANS

DESIGNED BY: DJH	SCALE: 1" = 150'	WILSEY & ASSOCIATES Engineering Planning	SHEET F1	REV. 8-19-05
DRAWN BY: TRP			DATE: 7-26-05	REV.
CHECKED BY: PLK				REV.

DRAINAGE NOTES:

1. The detention pond in Block 14 will detain a total of 11.8 acre-feet. There is 0.4 acre-feet in the first cell, 3 acre-feet inthe second cell and 8.3 acre-feet in the third cell. The first two cells of the detention will overtop during the 100 year storm. The third cell will not overtop and has a highwater elevation of 1385.24. The adjacent back lot lines are set at 1386.0. The pipe leading from the detention pond will be 2-24" @ 0.0%. This will have a peak release rate of 31.07 cfs.

2. There is 10.0 acres that does not flow to the detention pond that will deposit into the ditch along 274th Street The 100 year runoff from this area is 31.3 cfs. This means that there will be a maximum of 62.37 cfs from this site flowing to the existing culvert under 271st Street. This is compared to 176 cfs that flowing to this culvert perviously for the 100 year event and 68 cfs for the 5 year event.

3. The detention pond will be seeded with buffalo grass and sheep fescu which will require little mowing. There will be a 10' maintenance bench located on the east side of the detention pond.

4. Storm water drainage from the development to the north will enter this development at Perry Lane but will be conveyed to the existing detention pond north of the city wastewater treatment ponds.

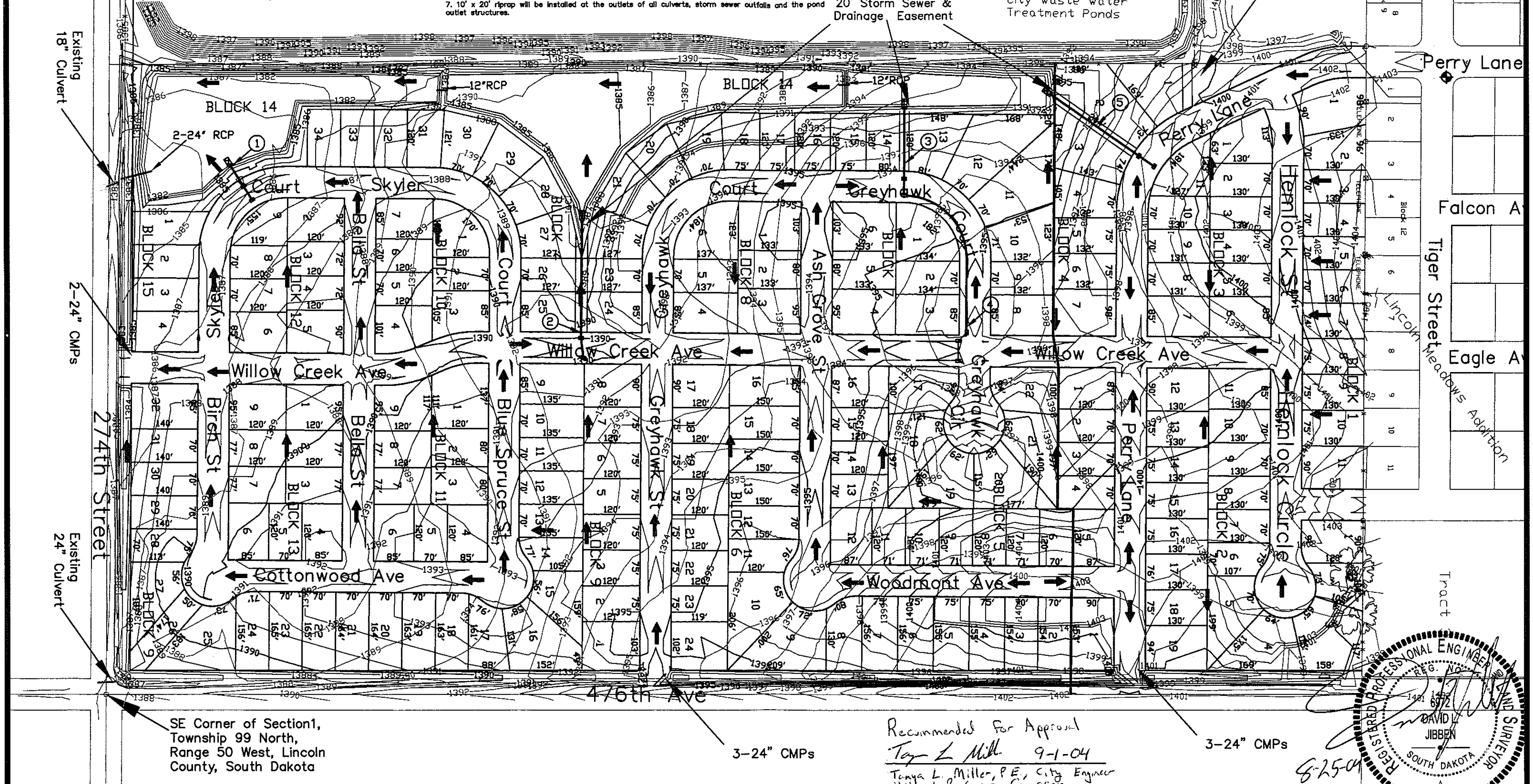
5. The drainage coming down Raven Avenue will not enter this defvelopment. It has been proposed to be collected by storm sewer and then piped to the ditch along 476th Avenue. This is according to the preliminary plan that was developed by Perry Kolb.

6. Where interior streets connect to 274th Street and 476th Avenue, the curb flow will drain off each side of the street and down into the road ditch. The 2% normal crown will be carried out until the end of the curb and gutter Rip rap will be installed where the runoff enters the ditch.

7. 10' x 20' riprap will be installed at the outlets of all culverts, storm sewer outfalls and the pond outlet structures.

STORM SEWER

Pipe Segment	Q5(cfs)	Pipe Size & Capacity
1	7.4	24" RCP @ 0.50% = 16.0
2	18.5	30" RCP @ 0.30% = 22.5
3	17.5	24" RCP @ 0.60% = 17.5
4	14.6	24" RCP @ 0.50% = 16.0
5	4.2	24" RCP @ 0.50% = 16.0
		(This will handle the 100 year for this area)



JSA

CONSULTING ENGINEERS/LAND SURVEYORS, INC.
3700 S. WEST AVENUE, SIOUX FALLS, SD 57105-6352
(605)367-1036 FAX (605)367-1002

REVISIONS

Rev:	By:	Date:
Rev:	By:	Date:
Rev:	By:	Date:
Rev:	By:	Date:

Greyhawk Addition
Drainage and Grading Plan

DATE: 6-30-2004 DRAWN BY: DLJ PROJECT: 70058-01
DESIGNED BY: DLJ CHECKED BY: RRS DRAWING: 70058-01.DWG

Sheet No. 1

for

Howard R. Green Company

Sheet No ______ of ______

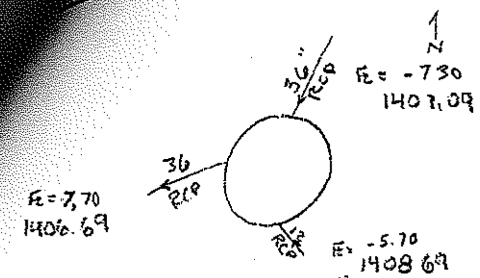
Job No ____________

By LWK Date 1/30/07

Checked ______ Date ______

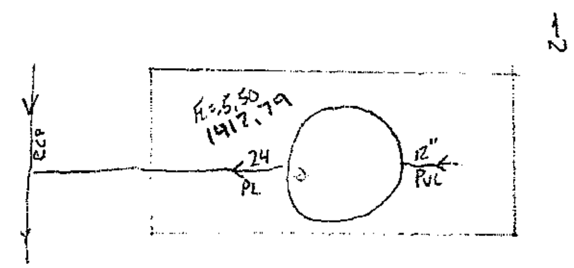
⊗ LOCATION OF WHERE IE WAS MEASURED

ALL PICTURES TAKEN FACING NORTH



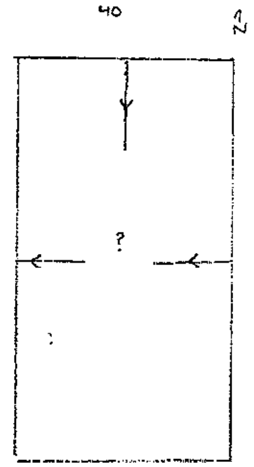
STMH - PNT# 1002

PIC - 2137
39
40

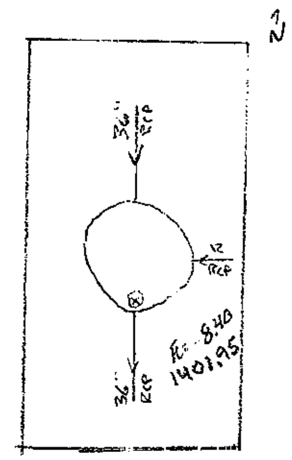


STMH-DI - PNT# 1003

PIC - 2141
42
43
45

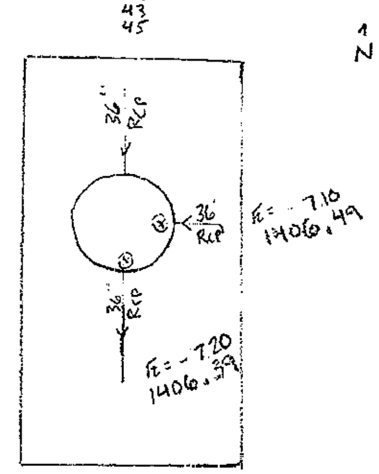


DI w/out MH PNT# 1006



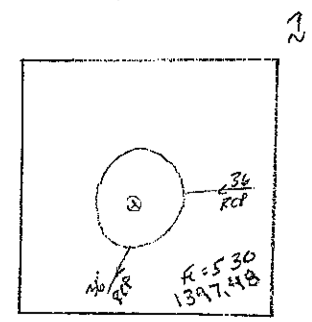
STMH - DI - PNT# 1005

PIC - 2149
50



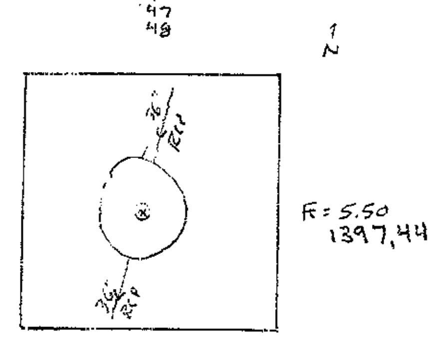
STMH - DI - PNT# 1004

PIC - 2146
47
48



STMH - Box PNT# 1008

PIC - 2154
55
56
57



STMH - INTAKE Box PNT# 1007

PIC - 2151
52
53

CITY OF HARRISBURG
STORM SEWER CAPACITY
HARVEST ACRES ADDITION

Pipe Segment	Manhole From	MH From Invert EL *(ft)*	Manhole To	MH To Invert EL *(ft)*	Distance B/W MH *(ft)*	Pipe Slope *(ft/ft)*	Pipe Diameter *(in)*	Manning's Coefficient	Pipe Area *(sf)*	Maximum Capacity *(cfs)*	Estimated Capacity *(cfs)*
P - 1	M - 1	1416.69	M - 2	1407.09	756.81	0.01268	36	0.012	7.0686	81.60	-----
P - 2	M - 2	1406.69	M - 3	1406.49	145.23	0.00138	36	0.012	7.0686	26.89	-----
P - 3	M - 3	1406.39	M - 4	1401.95	629.77	0.00705	36	0.012	7.0686	60.83	-----
P - 4	M - 4	1401.95	M - 5	1398.89	528.62	0.00579	36	0.012	7.0686	-----	55.12
P - 5	M - 5	1398.89	M - 6	1397.48	244.68	0.00576	36	0.012	7.0686	-----	55.00
P - 6	M - 6	1397.48	M - 7	1397.44	10.34	0.00387	36	0.012	7.0686	45.06	-----
P - 7	M - 7	1397.44	M - 8		191.80	-----	36	0.012	7.0686	-----	
P - 8	M - 8		M - 9		356.00	-----	36	0.012	7.0686	-----	

#9200

FLOW SUMMARY:

PREDEVELOPED (OUT EAST DRAW): PEAK FLOWS

Q_5 = 46cfs Q_{25} = 65 cfs Q_{50} = 97 cfs Q_{100} = 114 cfs

POSTDEVELOPED: PEAK FLOWS

EAST DRAW	WEST DRAW	TOTAL RUNOFF
Q_5 = 20cfs	Q_5 = 46 cfs	Q_5 = 66 cfs
Q_{25} = 31 cfs	Q_{25} = 58cfs	Q_{25} = 89 cfs
Q_{50} = 50cfs	Q_{50} = 76cfs	Q_{50} = 126 cfs
Q_{100} = 61 cfs	Q_{100} = 87 cfs	Q_{100} = 148 cfs

MAX OUTFALL REQUIRED FROM WEST DRAW: PEAK FLOWS

Q_5 = 26 cfs
Q_{25} = 34 cfs
Q_{50} = 47 cfs
Q_{100} = 53 cfs

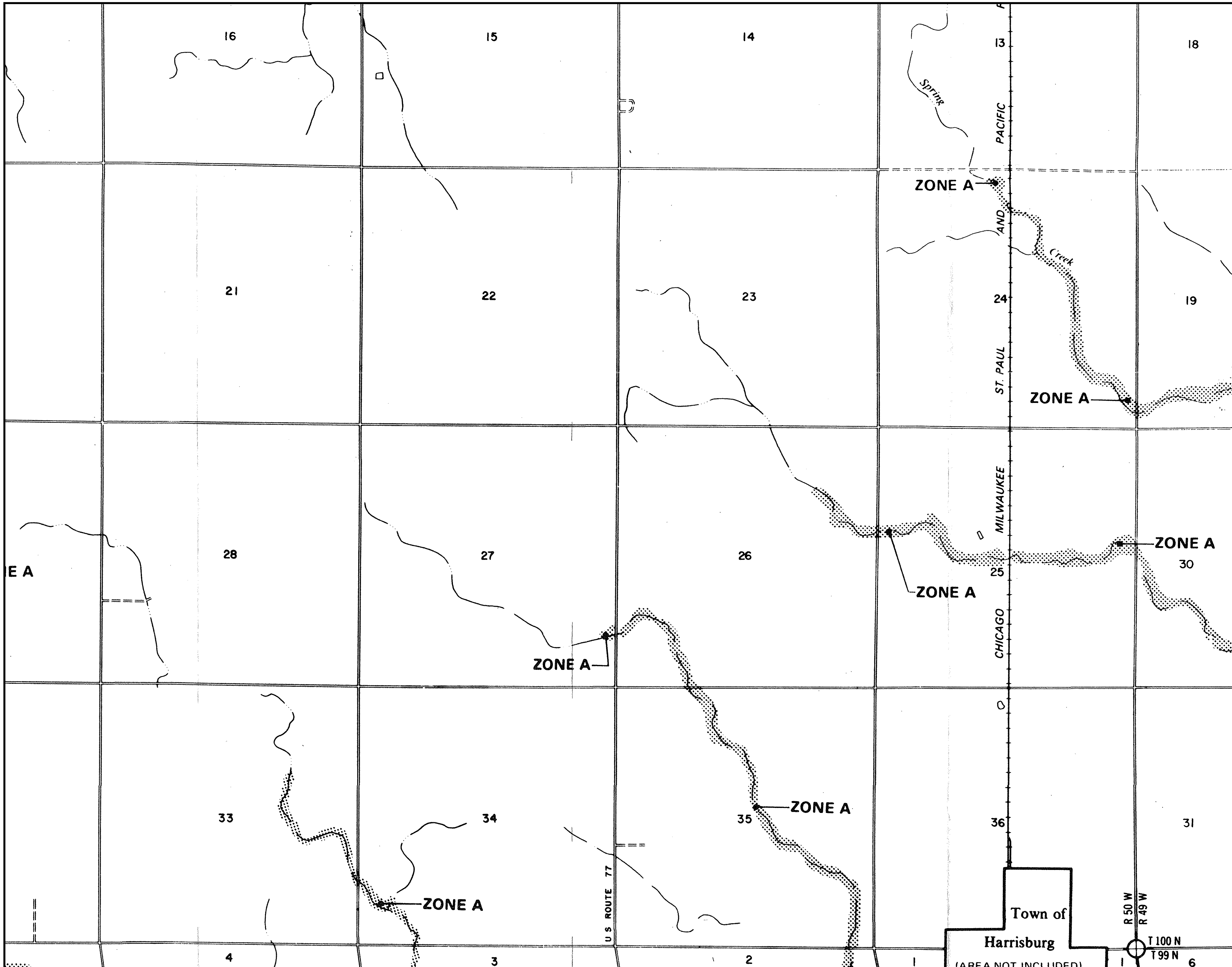
POND STORAGE REQUIRED: 1.88 AC-FT

AREA REQUIRED FOR POND: 0.80 AC (WATER SURFACE AREA)

POND OUTFALL: Q_5 = 25.7cfs PEAK FLOWS
Q_{25} = 33.9cfs
Q_{50} = 46.5cfs
Q_{100} = 53 cfs

APPENDIX L

Flood Insurance Rate Maps



APPROXIMATE SCALE IN FEET

2000 0 2000

FLOOD INSURANCE RATE MAP

LINCOLN COUNTY, SOUTH DAKOTA

UNINCORPORATED AREA

PAGE 1 OF 8

(SEE MAP INDEX FOR PAGES NOT PRINTED)

EFFECTIVE DATE:

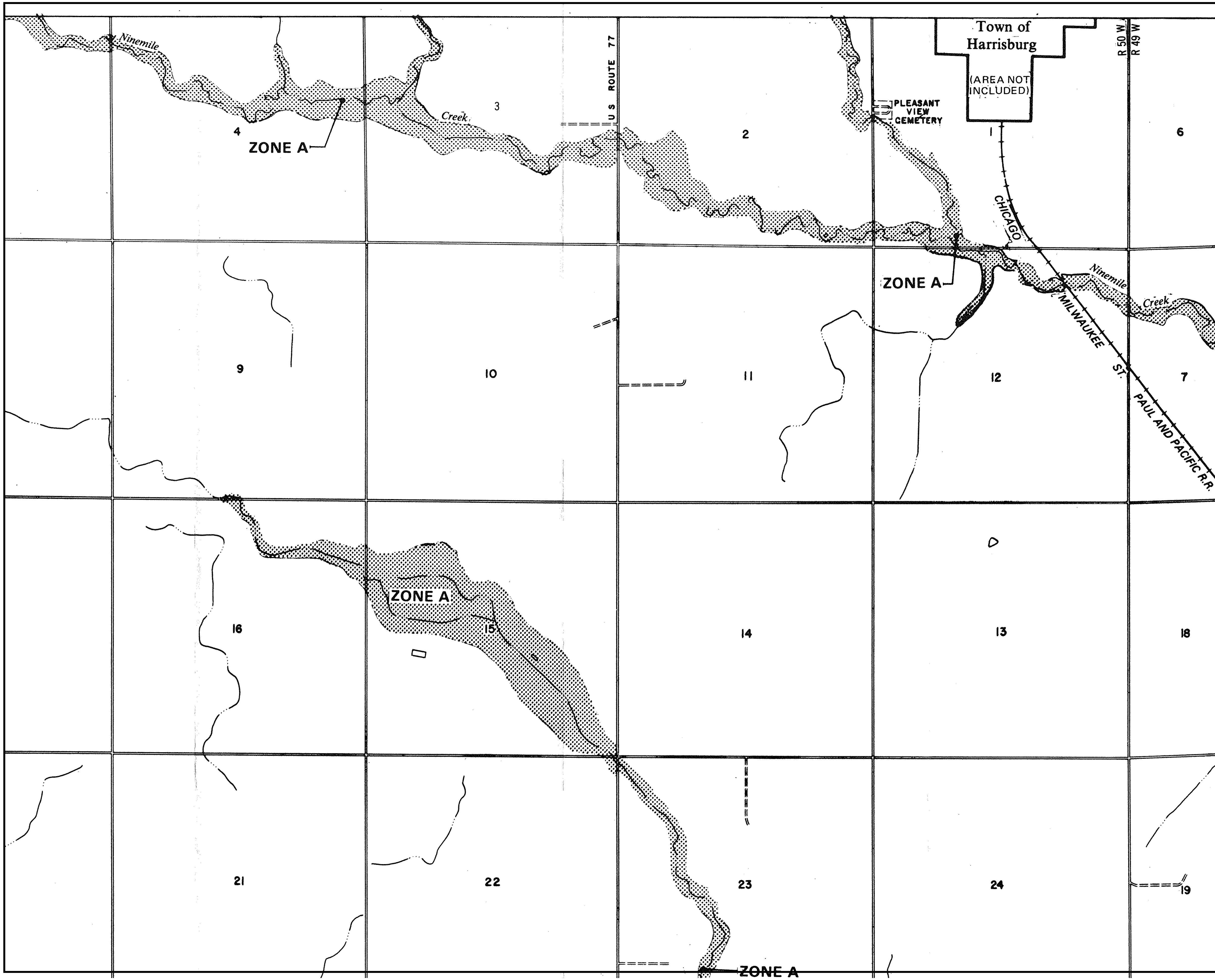
OCTOBER 1, 1986

COMMUNITY-PANEL NO.

460277 0001~~A~~B

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

FEDERAL INSURANCE ADMINISTRATION



APPROXIMATE SCALE IN FEET

2000 0 2000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

LINCOLN COUNTY, SOUTH DAKOTA

UNINCORPORATED AREA

PAGE 3 OF 8

(SEE MAP INDEX FOR PAGES NOT PRINTED)

EFFECTIVE DATE:

OCTOBER 1, 1986

COMMUNITY-PANEL NO.

460277 0003 B

Federal Emergency Management Agency

APPENDIX M

Example Linear Park

Westridge Greenbelt Trail
West Des Moines, Iowa

As with many projects, this began as a simple trail alignment design, but grew to encompass many park and community amenities as the planning progressed. Through cilent and neighborhood discussions, public meetings and project research, Howard R. Green(HRG) discovered major issues related to trail proximity to both private properties and to Ponderosa Creek. In order to bypass major neighborhood conflicts, HRG proposed successful design solutions including channel relocations, improved drainage/bridge structures, and amenities to blend with existing site features. This project is a success story that demonstrates how consultants can work with municipalities, stakeholders and communities to build consensus in what may initially appear to be impossible situations.