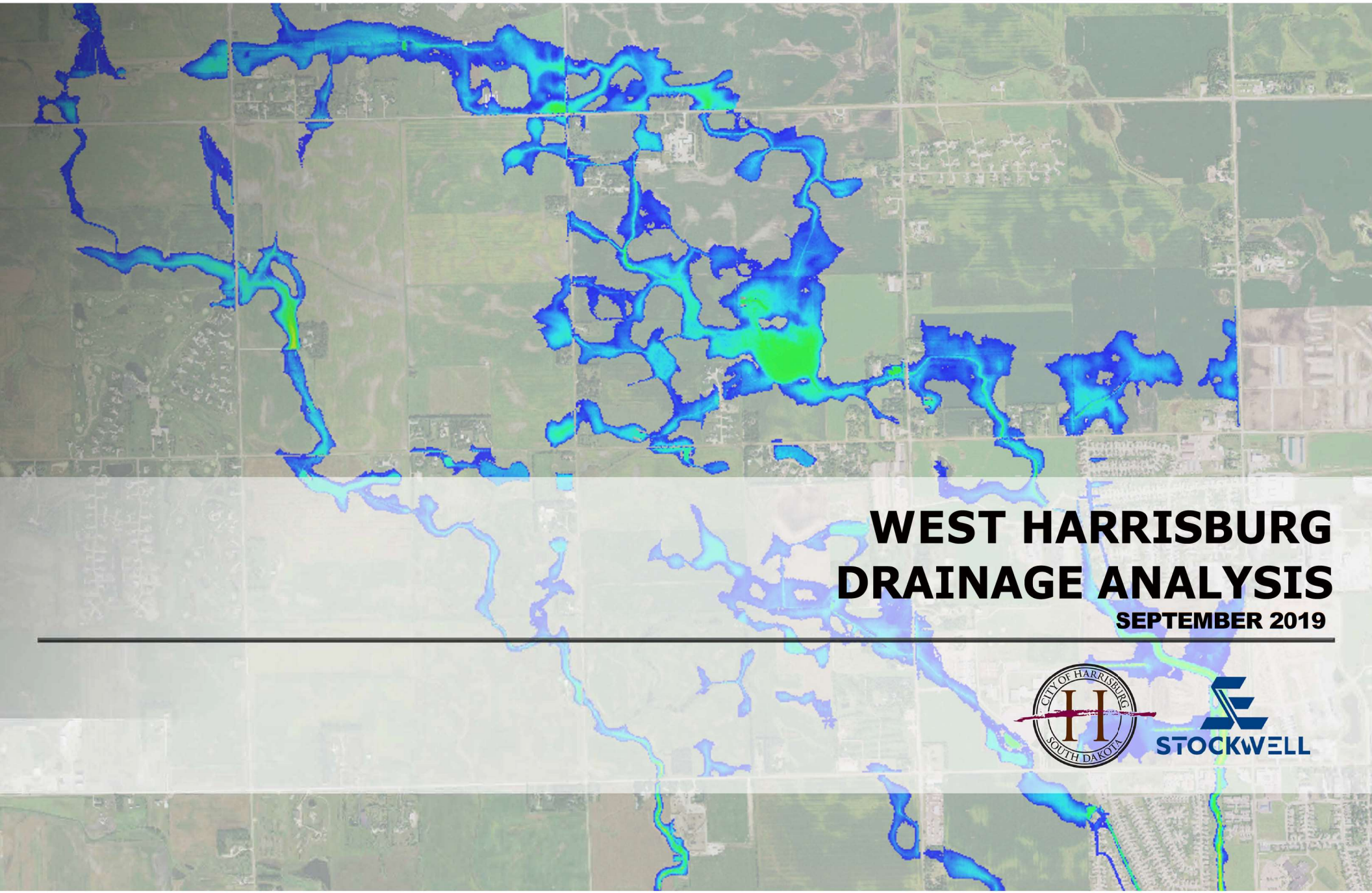

WEST HARRISBURG DRAINAGE ANALYSIS

SEPTEMBER 2019

CITY OF HARRISBURG SOUTH DAKOTA

STOCKWELL

Project: West Harrisburg Drainage Analysis
Harrisburg, South Dakota

SEI Project #: 18044

Date: September 6, 2019

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the state of South Dakota.

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Appendix A – National Wetland Inventory

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EXECUTIVE SUMMARY

The City of Harrisburg authorized Stockwell Engineers to analyze their existing storm drainage system west of Cliff Avenue and develop a Stormwater Master Plan to identify areas where drainage concerns exist and to address growth areas in the City. The primary objective of this analysis will be to identify stormwater conveyance systems that impact the City of Harrisburg. Conveyance elements will be analyzed to determine capacity and pinpoint areas where infrastructure improvements are needed. The report addresses anticipated development areas for the City of Harrisburg based on the 2019-2044 Comprehensive Plan prepared by the South Eastern Council of Governments.

SCOPE OF STUDY

The scope of services for this project include the following:

- Delineate basin boundaries using LiDAR data received from the City of Sioux Falls.
- Identify major drainageways and controlling structures within project limits.
- Provide analysis that includes existing conditions and improvement alternatives that incorporate future land uses as identified in City of Harrisburg Comprehensive Plan.
- Develop integrated 1D/2D XPSWMM Hydrologic and Hydraulic model that simulate the 5-year and 100-year SCS Type II rainfall event for existing and improved conditions.
- Develop Master Plan for Western, Minnesota, Honeysuckle and Coyote Basins.
    - ► Identify existing peak stormwater discharges at critical locations.
    - ► Identify locations where regional facilities are recommended.
    - ► Provide guidance for development that meets standards.
    - ► Identify how properties within each basin will be required to address flood control.

This study does not include a detailed layout of proposed improvements. Illustrations of any proposed storm lines or holding facilities are approximate. Carrying capacities and estimated storage volumes are provided but are meant to serve as a broad estimate of where anticipated improvements should be constructed and how much runoff those systems must store or convey. Prior to construction, each basin will require extensive surveying and a detailed analysis to determine the final design for all improvement projects.

RECOMMEDATION OF IMPROVEMENTS

Recommendations within this report are based on an existing conditions analysis of the City's existing stormwater conveyance network developed using XPSWMM modeling software. The existing conditions model is used to estimate peak flow rates along the stormwater conveyance systems and to analyze the carrying capacity of enclosed systems.

This Master Plan does not outline pipe sizes required for any of the recommended future improvement projects as site specific variables are unknown at this time. Estimated flow rates for the 5 and 100-year rainfall events are provided for in this study to be used as a planning tool for the recommended improvements to the storm water conveyance system.

Wetlands discussed in this report and shown in the Appendix figures are interpreted from U.S. Fish & Wildlife Service National Wetlands Inventory Maps. The wetlands indicated on figures are not in any way meant to represent wetlands that have been delineated. Prior to any disturbance to wetland areas, the owner must request a jurisdictional determination be made by the U.S. Army Corps of Engineers. Wetlands indicated in this study are simply meant to indicated areas that may contain wetland areas.

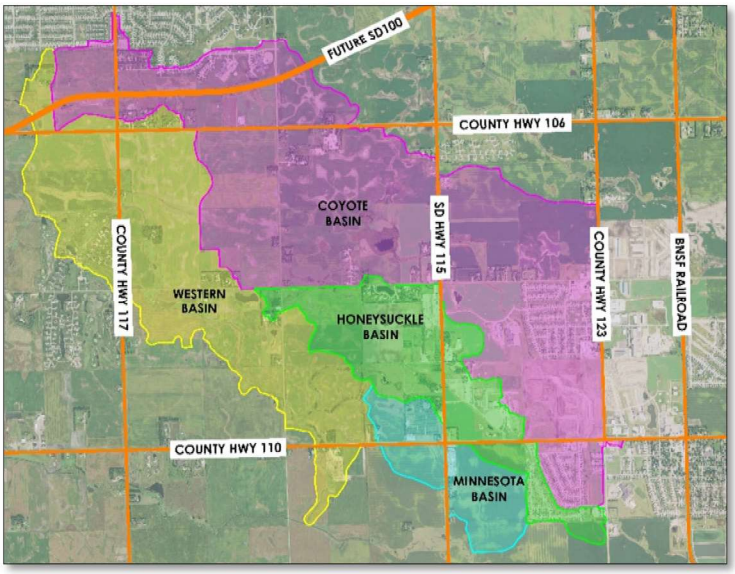
Review of the Flood Insurance Rate Maps issued by the Federal Emergency Management Agency indicates that areas adjacent to Nine Mile Tributary through Harrisburg are located within the Special Flood Hazard Area (SFHA) and are subject to inundation by the 1% annual change flood (100-year). The Nine Mile Tributary SFHA is identified as "Zone AE" areas and have Base Flood Elevations determined. The City should be advised that development in these areas should be carefully monitored to ensure that structures are not placed within the Special Flood Hazard Areas.

PROJECT OVERVIEW

PURPOSE OF ANALYSIS

The purpose of this study is to provide to the City of Harrisburg with a long-range storm sewer facilities plan based on the City's existing and future needs. This report is meant to be a guide to be referred upon during plan review of future development and as a planning tool for the capital improvement program. The study incorporates the City's future population growth needs as described in the Harrisburg Comprehensive Plan 2019-2044 prepared by South Eastern Council of Governments. Recommendations based on engineering standards are included to guide the City towards a system that will adequately serve these needs.

AREA OF STUDY



Harrisburg is located in southeast South Dakota. The heart of the City is approximately 5 miles east of Interstate 29 and situated on open terrain, north of Nine Mile Creek, tributary to the Big Sioux River. The terrain is largely consistent with very gentle slopes. The elevation is fairly consistent, ranging from 1550 at the northwest edge of the basin to 1400 at the lowest outfall at Nine Mile Tributary at South Cliff Avenue. The primary source of drainage within the study area is Nine Mile Creek which flows from west to east and is located south of Harrisburg. A tributary branch of Nine Mile Creek drains Coyote and Honeysuckle basins and reaches as far north as Sioux Falls and convey storm flows through the City of Harrisburg. All runoff from the contributing basins that are included in this analysis discharge into Nine Mile Creek and is eventually conveyed east to the Big Sioux River. Numerous intermittent tributaries extend north and south of Nine Mile Creek, draining the adjacent uplands.

The study area covers approximately 4,515 acres of land, 1,830 of which are located within the city limits. Report preparation included the collection of data pertaining to the existing storm sewer facilities and drainage basin analysis. An inventory of pipe sizes and locations were collected and compared against estimated flow data. Future regional basins were determined based on existing topographic features and existing features that obstruct, detain or restrict flow, such as elevated roadways, culverts or low-lying areas that provide natural detention. This data was used to recommend improvements to the existing facilities and to develop a plan for future storm sewer system development.

LONG RANGE PLANNING

This study is meant to serve as a tool for long range planning for the City of Harrisburg. The goal of long-range planning is to project the future needs of a system and to develop a comprehensive plan that guides the owner towards meeting those needs throughout the system's development. Establishing a plan requires the acquisition of basic information such as; historical usage, development trends, planned growth, topography and existing system capabilities among other things. This information can be effectively used to plan for local extension of the existing system and to improve current facilities to meet future demands.

This Stormwater Master Plan will summarize the condition of the existing system and provide an overall plan summarizing improvements to accommodate for future growth in Harrisburg. The existing system has been analyzed to identify present day capabilities and to pinpoint the limitations of the existing system that are cause for concern. Analysis of the existing system will include a review of the core area of Harrisburg west of Cliff Avenue and outline improvements to the system that can be incorporated through capital improvement projects.

Along with recommendations for improvements to the existing system, this Stormwater Master Plan considers the City's future growth area as outlined in the 2019-2044 Comprehensive Plan so that Harrisburg can implement a plan that includes both site specific and regional stormwater detention that is based on anticipated development. This study provides a template of how to manage stormwater discharges and facilitate planned growth based upon 2044 land uses. Approximate locations for flood control facilities are identified based on topographic features for two regional basins within the limits of study. The remaining properties will require site specific facilities. This study will help the City manage existing storm sewer infrastructure as well as projected growth as it relates to stormwater management.

PROJECT BACKGROUND

POPULATION AND LAND USE

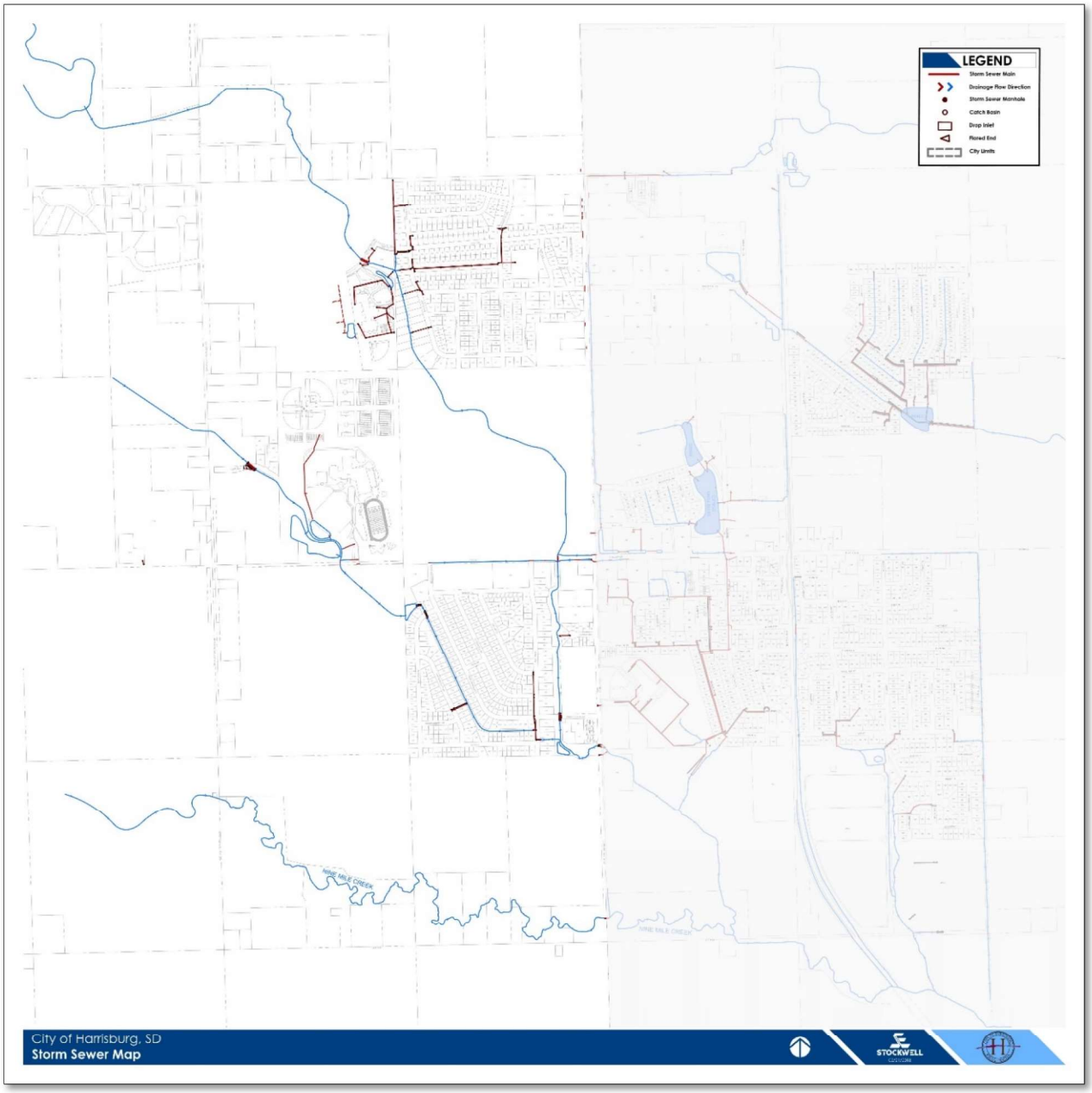
The City of Harrisburg, located in the southeast corner of South Dakota, encompasses an area of approximately 2,335 acres with land uses ranging from low density residential to thriving commercial and industrial properties. A comprehensive plan was prepared by the South Eastern Council of Governments, which was adopted by the City of Harrisburg on May 15, 2019. The plan estimates Harrisburg's population to approach 21,150 by the year 2044. It also includes a future land use map to help identify future growth areas and predict potential land uses for these areas. The comprehensive plan was analyzed during the preparation of this report and used to estimate the City's future storm sewer needs. A copy of the plan can be found at the City of Harrisburg municipal web site, http://harrisburgsd.gov/.

OVERVIEW OF EXISTING DRAINAGE FACILITIES

The City of Harrisburg accepts runoff from properties that reach as far north and west into the city limits of Sioux Falls. This analysis includes an in depth look at the contributing basins that contribute storm flows west of Cliff Avenue. Included in this study are 4 major drainage basins that convey runoff and discharge into Nine Mile Creek, bordering Harrisburg to the south. Existing drainage infrastructure includes enclosed storm sewer systems, open channels, culverts and detention facilities. Runoff is often conveyed in the streets and is considered a major component of the storm drainage collection and conveyance system. The enclosed storm sewer collection system consists primarily of RCP & CMP pipes and culverts that range in sizes. The City of Harrisburg maintains complete maps of the storm sewer collection system that can be viewed at City Hall.

Conversations with City Staff, onsite inspection during the spring thaw and previous experience in the City of Harrisburg suggest that many of the existing storm sewer facilities within the city are adequate and consistent with present day standards in place for the City of Harrisburg. City Standards require enclosed systems to convey the 5-year storm event and overflow systems designed to convey the 100-year occurrence without causing damage to property or loss of life. Development within the Harrisburg jurisdictional platting area requires discharge for any site shall not exceed the theoretical flow rates prior to development. City Standards do not presently require any water quality treatment for storm sewer, however state and federal regulations are constantly evolving and will eventually require the City of Harrisburg to treat storm sewer runoff before discharging into navigable waters of the state.

Currently, the City of Harrisburg has minimal enclosed storm sewer networks west of Cliff Avenue. Discussions with City Staff did not warrant detailed analysis of the enclosed storm sewer systems. As shown on the figure below, publicly owned enclosed storm networks serve Harrisburg Homesite Addition and Green Meadows Addition. Private facilities serve both the Harrisburg High School and Freedom Elementary. All the enclosed storm sewer systems west of Cliff Avenue have been constructed over the course of the last 20 years. The average life of RCP pipe ranges between 70-100 years. Freeze/thaw cycles in this region would suggest that the useful service life of RCP pipe in Harrisburg would expect to be around 70 years.



CHALLENGES FACED BY CURRENT SYSTEM

As Harrisburg continues to grow, new developments and redeveloping areas will be required to follow City Standards, which includes enclosed storm sewer to capture and convey the 5-year event. Consideration is also made for the 100-year event and design of new developments must accommodate for the major storm to be conveyed in public right-of-way or dedicated drainage easements.

Areas of concern that are addressed in this analysis include areas that presently see a significant amount of ponding during rainfall events and various areas throughout the west side of Harrisburg. This analysis will present options for two regional detention facilities that will address concerns, quantify anticipated storm flows and estimate approximate size of the facilities in a high-level, preliminary design.

City Staff have concerns at the open channel located at the southeast corner of Green Meadows Addition near the intersection of Honeysuckle Drive and Cliff Avenue. This open channel conveys flows from two primary basins discussed in detail in the following sections. The concern lies with residential structures adjacent to the open channel.

This report presents existing conditions and outlines how present day conveyance systems and culvert crossings handle storm flows for the 5-year and 100-year rainfall events to give a comprehensive view of the stormwater management system for the west side of Harrisburg. A proposed conditions model is also presented to give City officials a look at what that system will look like as properties within the basin develop.

As future growth areas develop and the storm drainage system is improved to accommodate development, it is important to follow guidelines already in place. The existing conditions model will provide the City with a baseline for reference as developments come in to ensure engineering design standards are being met so that existing systems are not negatively impacted by development.

PLAN DEVELOPMENT

DESIGN PROCEDURE

Storm water drainage basins were developed by analyzing existing topographic maps for the City of Harrisburg and the surrounding future growth area. Flows were developed for each of the subbasins based on existing and developed land uses for both the 5 and 100-year rainfall events. Existing trunk line sewers, culverts and drainage ways were analyzed to determine the conveyance of each segment. Flow routing calculations were then performed based on calculated flows for each sub-basin and through each segment of the conveyance system to determine where deficiencies in the systems are occurring. For the purpose of this report, all flow data used in the analysis was estimated through standard engineering practices. Actual or recorded flow data was not obtained.

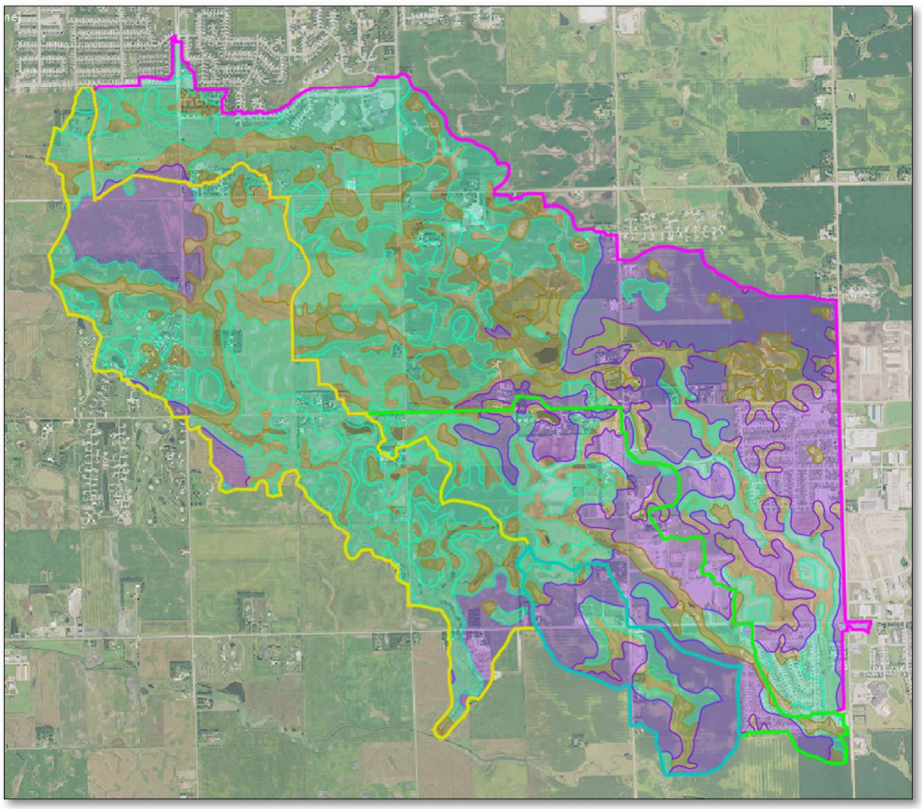
DESIGN PERIOD

The design period of this study was based upon Harrisburg's Comprehensive Plan 2019-2044 prepared by City Staff. The plan includes population and land use projections for the City based on growing trends observed during the base year of the study. The 2016 special census data indicates the population of Harrisburg to be approximately 5,698 people. The plan estimates Harrisburg's population to approach 21,153 by the year 2044.

The comprehensive plan also includes an analysis of future land uses that accommodate the City's growth pattern. The Harrisburg Planning Commission along with SECOG determined future land uses based on; drainage basin areas, compatibility of future and current land uses, and existing infrastructure.

The growth area analysis was prepared within the comprehensive plan to help illustrate the City's future plans for growth. The costs to extend water and sewer services are the primary considerations in designating future growth. Other factors such as capacity of the transportation system, environmental suitability, and compatible land uses were also considered. The analysis is intended to provide the City of Harrisburg and Lincoln County with a guide to land use decisions and direct implementation through subdivision and zoning regulations. The analysis describes both the limitations and potential for future growth within the respective growth areas. The goal of this study is to provide a comprehensive, master drainage plan to accommodate future growth areas as illustrated in the future land use map and outlined in the Comprehensive Plan.

DETERMINATION OF RUNOFF



Factors affecting runoff include the size and slope of the basin, hydrologic soil group classification, imperviousness, land use or type of crop cover, travel time and the intensity of the rainfall event. Stockwell Engineers utilized XPSWMM modeling software specifically designed for hydrologic and hydraulic modeling to determine peak flows and capacities for conveyance system. NRCS Soil Conservation Service Type II rainfall distribution was used to simulate the minor and major storm events. Soil Conservation Service Maps of the greater Harrisburg area indicate that Type B and C Soils are dominant.

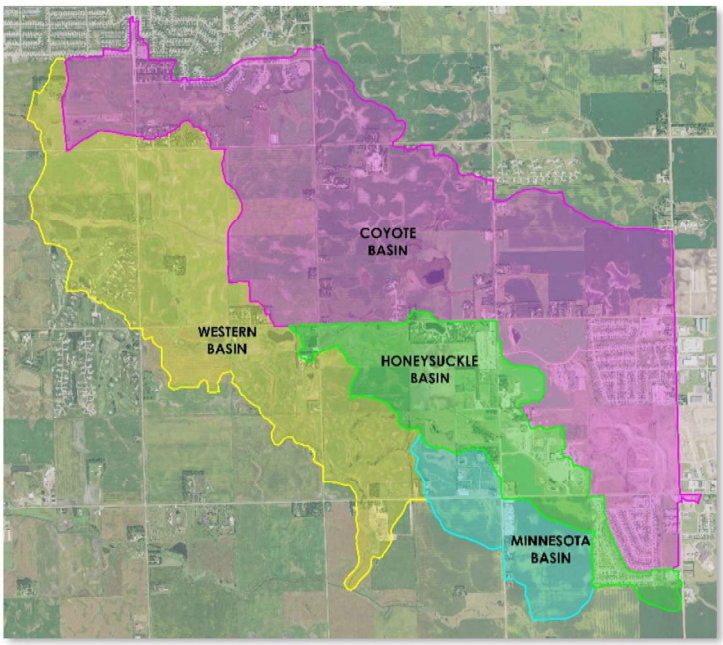
It is important to note that the XPSWMM models used for this analysis are 2D unsteady state models that vary over time. The Current Effective FIRM model is a steady state model that does not change over time, representing uniform flow in the system. Hydrology for this report has been calculated using the SCS Type II unit hydrograph method of computing storm runoff over a 24-hour duration event. The FIRM maps represent hydrology calculated using linear regional regression analysis.

City of Harrisburg design standards outline that the drainage system be designed considering the minor and major rainfall events. The minor (5-year) storm drainage system shall be designed to provide protection against regularly recurring damage, to reduce street maintenance costs, and to provide an orderly urban drainage system. Urban areas generally have two separate and distinct drainage systems. First is the enclosed system that corresponds to the minor (5-year) storm event recurring at regular intervals. The other is the overflow system that is designed to convey the major storm event which has a one percent probability of occurring in any one year, also referred to as the 100-year storm event.

AREA DESIGNATIONS

Determining flow for a storm sewer conveyance system is largely contingent upon the size of the contributing watershed boundary. The watershed boundary is determined by the topography of the basin. It is defined by the area tributary to a specific discharge point and is separated from adjacent basins by a divide or ridge that can be traced on topographic maps. Watershed boundaries can be relatively large depending on the location of the discharge point. Typically, they are divided into smaller tributary basins and sub-basins. This analysis details four primary basins which were further divided into smaller sub-basins and are discussed in further detail within this report.

Watershed boundaries delineated for the purpose of this analysis are shown in Drawing 1 and follow the naming convention used for City of Harrisburg sanitary sewer basins; identified by lift station. All basins identified and shown to the right discharge to Nine Mile Creek. Each basin has been further subdivided into sub basins to identify runoff at major crossings, or areas of interest. Subbasins are shown and identified in their respective sections.



Hydrology is calculated in the model for each individual subbasin and estimates the runoff potential using the SCS Type II rainfall event. Input variables for each subbasin include drainage area, time of concentration and CN value that considers the type of land use and hydrologic soil group. Runoff is introduced at each subbasin node. Input variables and hydrology calculations for the 5-year and 100-year events are outlined for each subbasin in the drawings attached. The schematic layout of the XPSWMM models correspond with the results tables for each basin.

Existing conditions were modeled for a basis of comparison to be used as a guide for future development in Harrisburg. Present day land uses were assigned to each property within the ultimate basin to determine existing conditions runoff potential. Stockwell Engineers gathered topographic information at all roadway crossings and input into the model as 1D elements. The results of the integrated 1D/2D model provide anticipated conveyance at all culvert crossings, inundation maps identifying natural detention occurrences for both the 5 and 100-year storm events. Proposed developments must not negatively impact downstream properties and must detain to predeveloped discharge rates.

SIZING OF STORM SEWER SYSTEMS

Specific pipe sizes are not identified in this Master Plan, however required flows to be conveyed (5-year) are identified in the tables and figures attached. Variables such as grade & type of pipe can significantly change the hydraulics of a system and many of these variables are unknown until a detailed analysis is performed for each individual system. Sizing pipes for a system prior to performing a detailed analysis is premature and can lead to systems that are either over or under sized. This Master Plan outlines the amount of flow that will be required to be conveyed in reconstructed or proposed systems and is meant to provide a comprehensive summary of the storm drainage system. It is not intended to be used for detailed design of individual systems but simply a guide for planning purposes only. This Master Plan indicates estimated developed flows in trunk line sewers and does not include analysis of individual inlets or catch basins within the system.

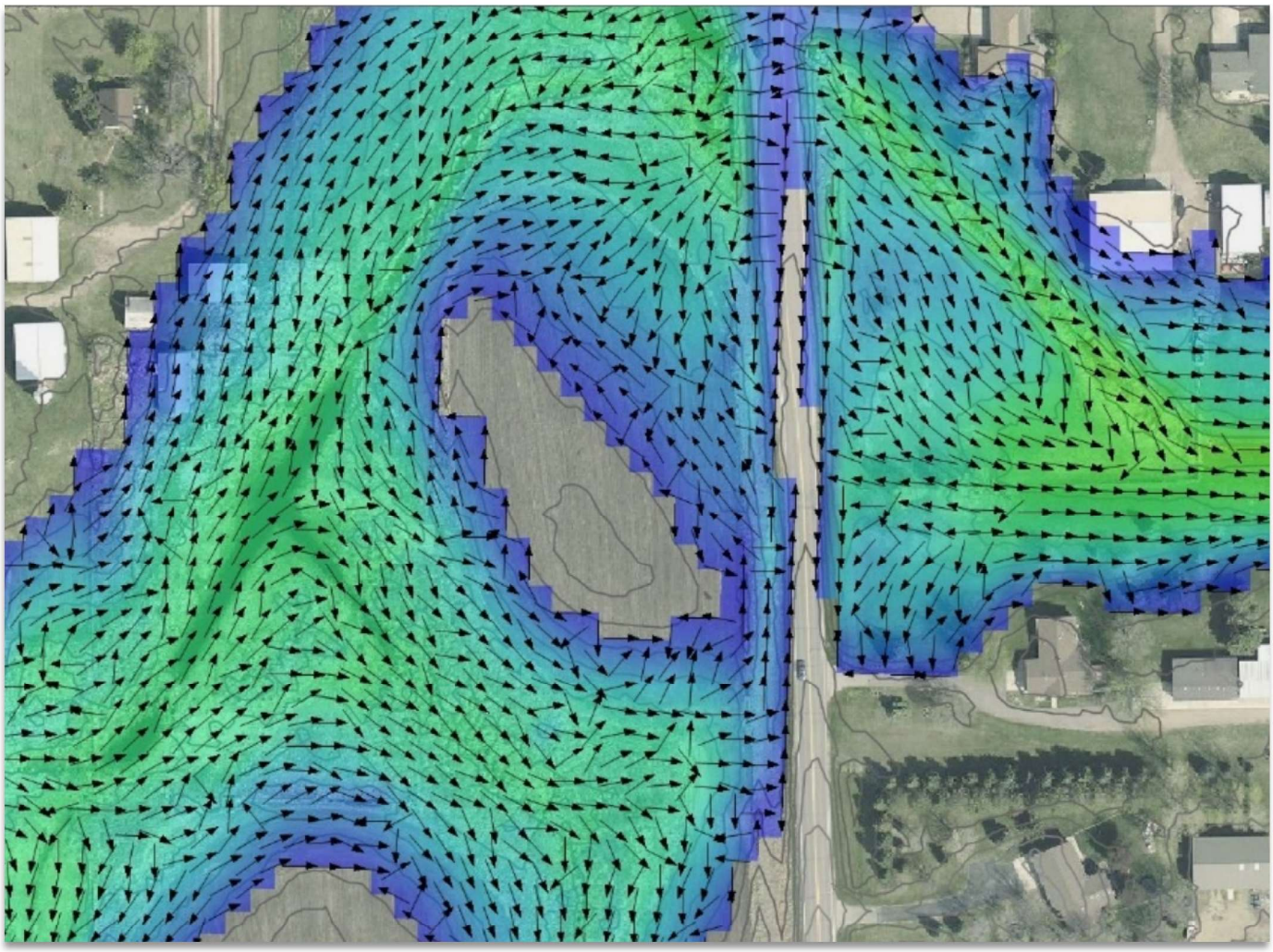
As development occurs and land uses transform from agricultural to alternate uses, the imperviousness of the basin increases, and results in increased storm water runoff as less water is absorbed into the ground. When a property develops, it is necessary as a municipality, to limit the amount of runoff that is allowed to be released to predeveloped rates. Detention facilities are a cost-effective way to control, store and limit the amount of runoff that is released from properties where the storm runoff is increased. This Master Plan identifies ideal locations where detention facilities can serve several properties with a single, regional facility.

Regional flood control facilities have been identified in Drawing 2. These facilities are located at the low point in a basin, on the downstream end and are intended to serve the upstream tributary basin. These facilities are intended to be shared use, and shared cost facilities that are required by and regulated by the City of Harrisburg. This Master Plan should be used as a guide for city staff to use when reviewing development plans to ensure that the proper flood control facilities are in place as Harrisburg continues to grow.

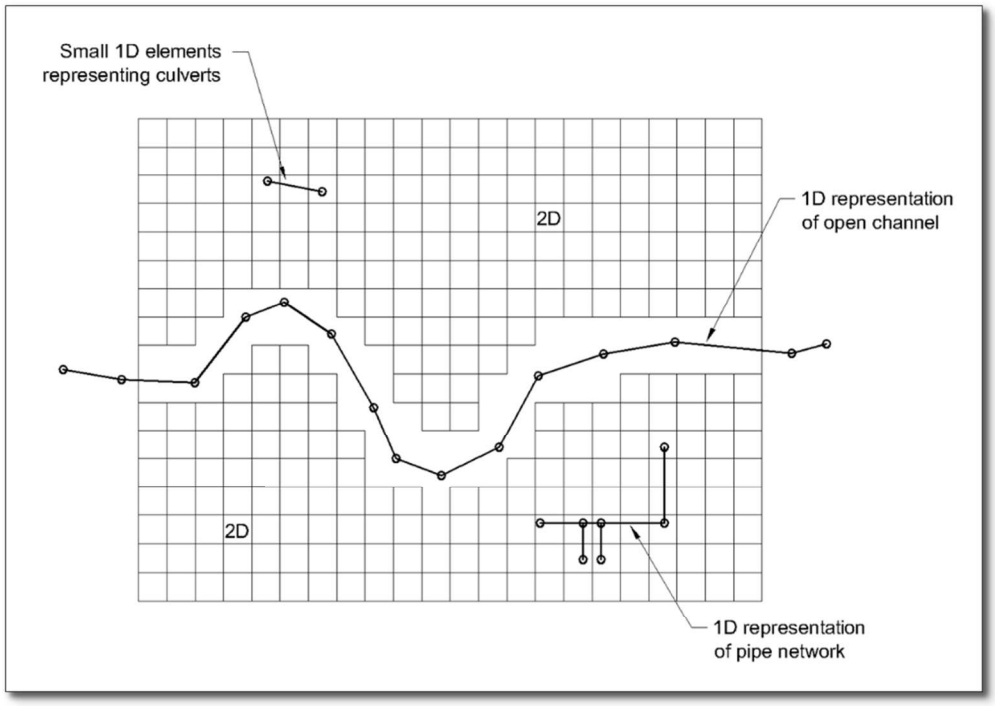
1D/2D INTEGRATED MODELING

The models created for the City of Harrisburg and for the purpose of this analysis were built using XPSWMM modeling software. Integrated 1D/2D modeling allows for flow to be simulated using both 1D and 2D elements. 1D elements include conveyance elements that transfer flow in one direction; 1D elements include pipe networks, open channels, detention facilities, culverts, pumps, orifices and weirs that can be located and input into the model based on topographic information gathered in the field.

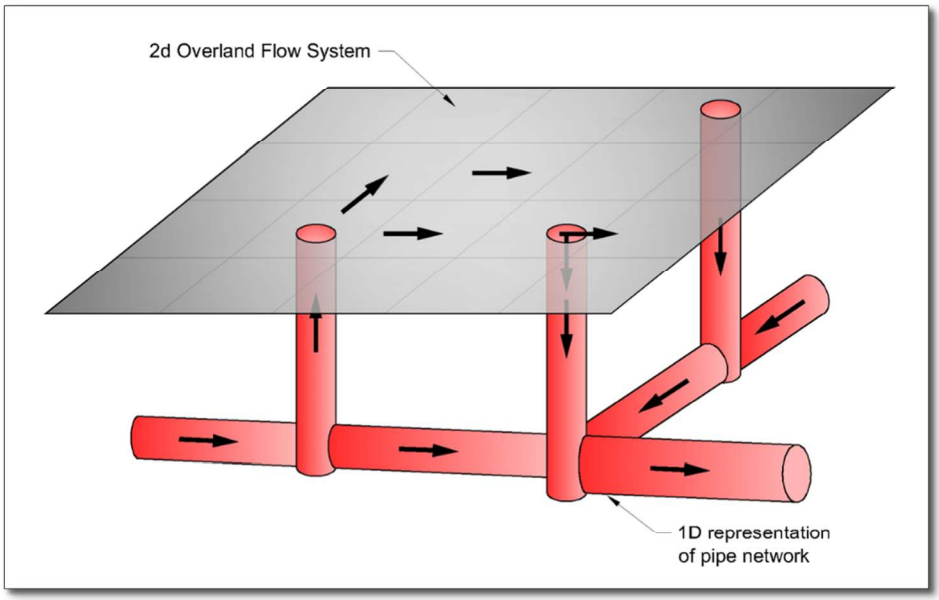
A high-resolution Digital Elevation Model (DEM) represents the 2D element of the model and is a fundamental component for two-dimensional engineering analyses. 2D elements include floodplain areas where flows, velocities, and depths can be calculated on the surface. The DEM provides a detailed representation of the terrain surface for hydraulic routing through the model area. The model integrates the 1D and 2D elements at nodes or links where flow is shared or transferred.



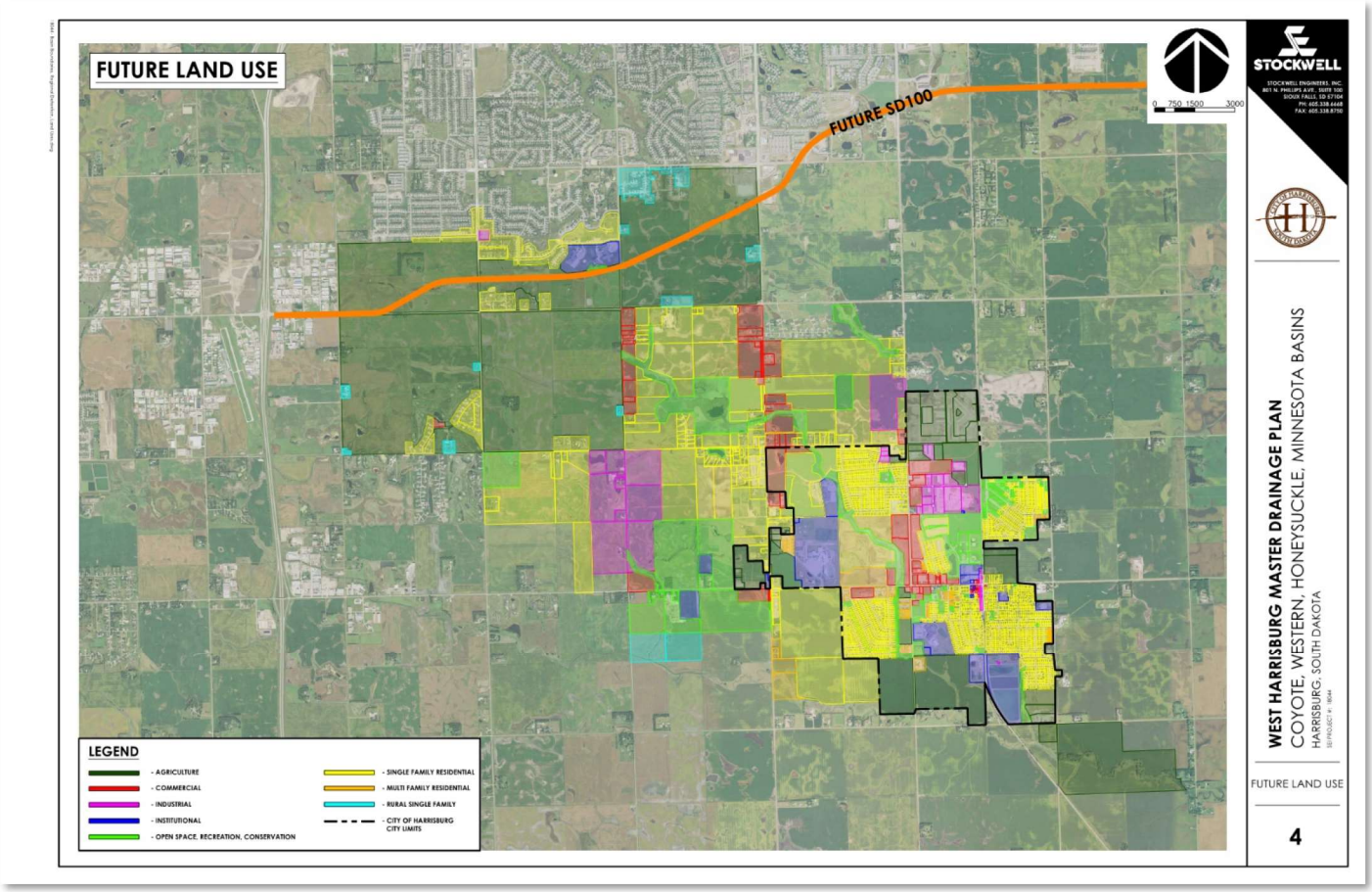
The surface that details the elevation that encompasses the tributary basin used for this analysis was derived from 2012 LiDAR data flown for the City of Sioux Falls. The 1-meter DEMs used in this study were developed for the SD Large Scale Automated Engineering (SD LSAE) project by leveraging available high-resolution gridded elevation data derived from Light Detection and Ranging (LiDAR).



The contributing storm water flows through Harrisburg and adjacent growth areas are developed from gently sloping basins. The 2D models allow for accurate representation of shallow overland flows as well as identifying potential storage in floodplains and low-lying areas throughout each basin. Properly estimating natural detention can have a significant impact on development. City of Harrisburg Engineering Design Standards require developments to contain all runoff onsite and provide a method to control the release of stormwater downstream. Discharge for any site shall not exceed the theoretical flow rates prior to development as estimated by the design engineer. It is critical that natural detention is considered, and the results of this analysis and associated models will identify areas where natural detention occurs to help guide development in Harrisburg.



Proposed Land Uses defined for each parcel are based on the 2044 Comprehensive Plan for the City of Harrisburg. Each land use is assigned an average roughness coefficient that is derived from the imperviousness of the use. This input variable that describes the 2D surface allows for runoff calculations on each grid cell within the model to accurately represent the roughness of the described land use.

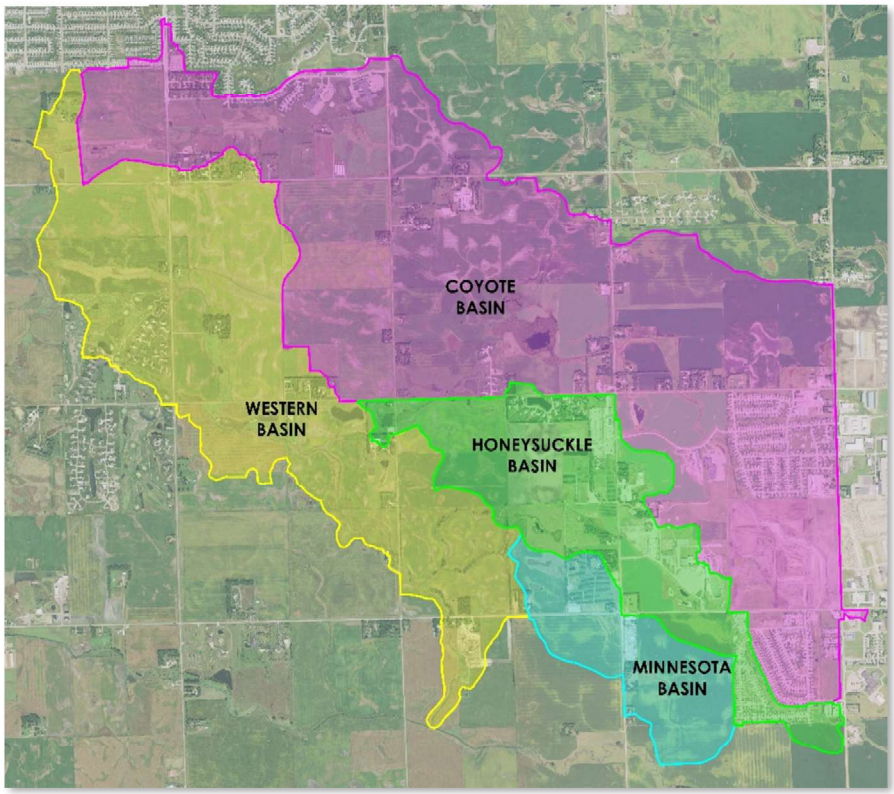


BASIN DESIGNATIONS AND AREA ANALYSIS

OVERVIEW OF EXISTING BASINS

The figure below illustrates the four primary basins that define drainage on Harrisburg's west side that are examined in this report. These primary basins listed below describe the major watershed boundaries within and adjacent to the City of Harrisburg. Each area includes unique features that pose numerous challenges regarding storm sewer construction and serviceability.

- Coyote Basin
- Honeysuckle Basin
- Western Basin
- Minnesota Basin

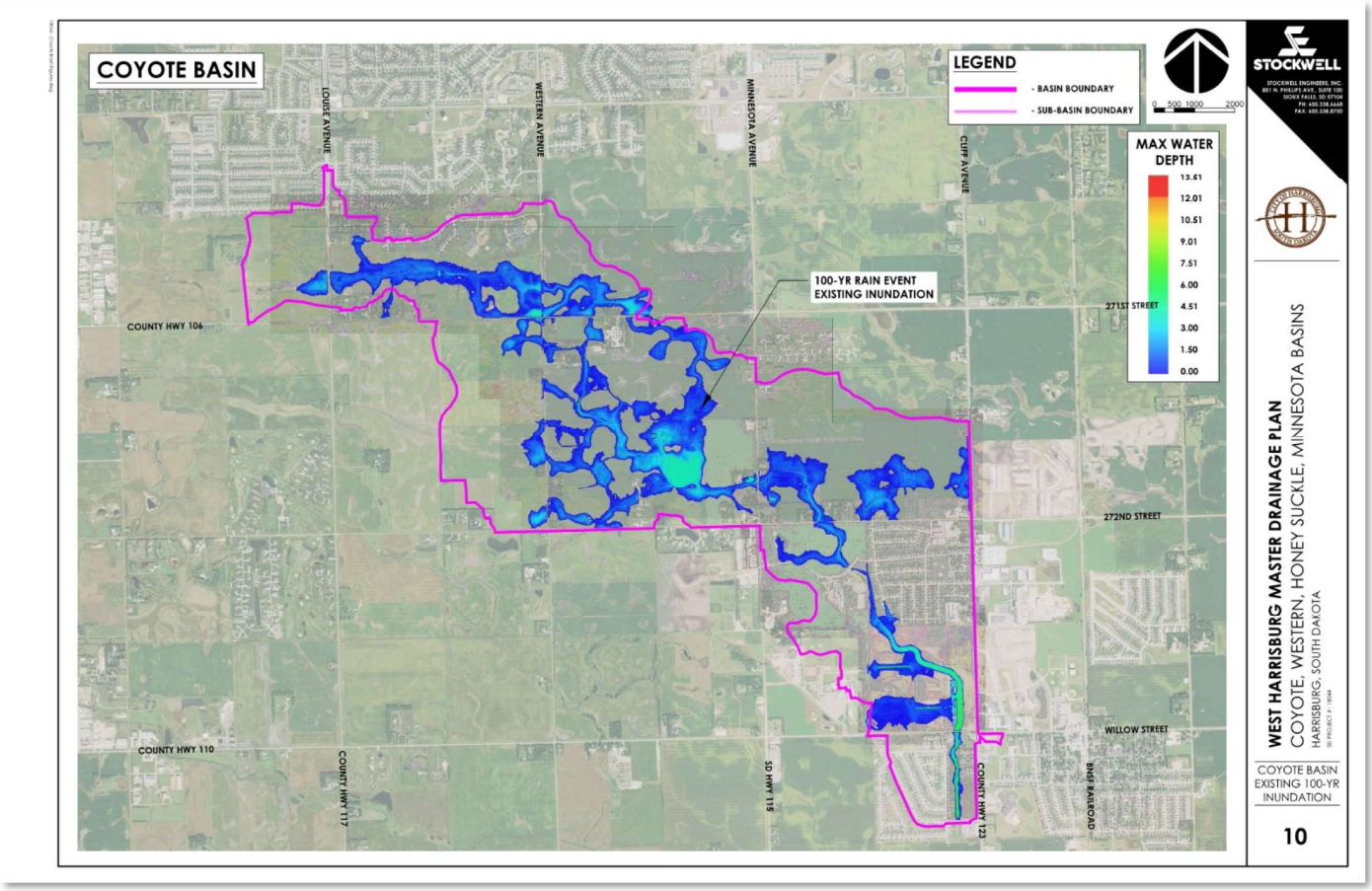


Each primary basin has been further divided into sub-basins that drain to culvert crossings, enclosed storm sewer systems, detention facilities and major drainage ways. Each sub-basin is described in detail in the following sections. Limitations of the existing system are discussed along with recommended improvements that will provide a guide to be used for planning purposes as the City continues to grow. Recommendations will include improvements to existing infrastructure along with a stormwater management plan to be used as development continues. This report is meant to provide a complete, comprehensive summary of all aspects of the present day and projected storm water management system for the City of Harrisburg.

COYOTE BASIN

Coyote Basin extends from the southern city limits of Sioux Falls, draining south and east through Harrisburg, west of Cliff Avenue and discharges to Nine Mile Creek. This primary basin includes part of Green Meadows Addition, Harrisburg Homesites Addition, and the recently developed Creekside Addition. Apart from school properties owned by the Harrisburg School District, the remainder of the basin remains largely undeveloped agricultural and rural residential properties. The contributing basin slopes gently, promoting runoff to sprawl across the terrain at shallow depths over widespread areas. The basin ultimately discharges under Honeysuckle drive, west of Cliff Avenue and joins runoff from the adjacent Honeysuckle primary Basin.

The existing conditions model results can be found in Drawings 10-16 and represent present day conditions that reflect current land uses and storm drainage infrastructure. Drawing 10 shown below indicates the inundated area anticipated during the 100-year storm within Coyote Basin. The results of the 1D/2D coupled, unsteady state model vary with time. The results presented report the maximum flow and depth over the course of the 24-hour analysis performed.



EXISTING CONDITIONS

Results of the existing condtions model are shown in drawings 10-16 and include a 100-year inundation map of the Coyote Basin watershed, schematic maps of the model layout, and tabular results of the 5 and 100-year storm events. The inundated area shown in Drawing 10 is similar to what has been mapped on the current effective FIRM maps of Nine Mile Tributary through Harrisburg.

As shown on the graphic in Drawing 10, there is a significant amount of natural detention storage located within the basin, just upstream of Minnesota Avenue. This protected wetland area naturally slows the rate at which water flows towards Highway 115. An existing 4x10 RCBC conveys runoff across Minnesota Avenue at a rate of 83 cfs during the 100-year event and ponds upstream of the culvert to an elevation of 1450.14. The existing conditions model does not indicate that overtopping of Minnesota Avenue occurs during the major event, and results appear to be representative of historic events.

Drawing 10 also highlights natural storage north of 272nd Street, adjacent to Harrisburg Homesites Addition. An existing 8" drain tile is the only discharge relief at his location, and results indicate the natural storage area does not overtop 272nd Street during the 100-year rainfall event. The picture on the right was taken June 18, 2014 shortly after a significant rainfall event.

Development is currently underway for a portion of the basin (subbasins B36 & B37) that drain to this location. Conversations with City Staff indicate the desire to provide a regional detention and water quality facility at this location to accommodate for the increased runoff that will result as development continues within the basin. The multipurpose facility would also be designed with Best Management Practices (BMP) to provide an additional storage volume to improve the water quality prior to releasing downstream.

Drawings 11-14 include a schematic layout Coyote Basin that corresponds with the table of results of the model shown in Drawings 15-16. Peak flows for the 5-year and 100-year

event are reported for each crossing along with the maximum capacity of the culvert. High water elevations are reported at upstream locations.

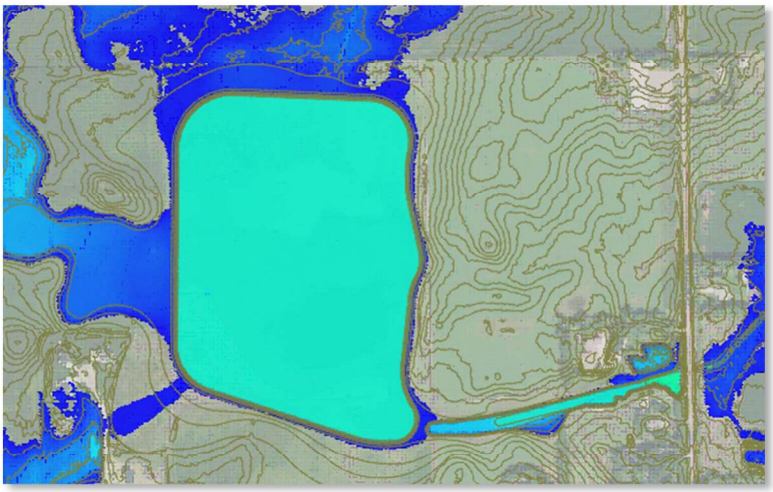
PROPOSED CONDITIONS

Upon completion of the existing conditions model, a proposed conditions model was created to simulate impacts to existing storm drainage infrastructure upon full development of the basin. The proposed conditions model incorporates future land uses as identified in the 2044 Comprehensive Plan and include 2 proposed regional detention and water quality facilities to improve drainage throughout the system.

It is important to note improvements that are currently underway to Highway 115 and discuss the impact they may have to the City of Harrisburg. The SDDOT is currently reconstructing Minnesota Avenue (Highway 115) to a four-lane urban segment from 273rd Street near Harrisburg to 85th Street in Sioux Falls. Drainage structure replacements and improvements are being installed at 5 crossing locations along the length of the project as well as enclosed storm sewer added to collect and convey runoff from the roadway surface. This project will be completed during the 2019 construction season. A single culvert is located within the Coyote Basin along Nine Mile Tributary. This culvert is being upsized from a single cell 4x10 RCBC to a twin cell 4x10 RCBC, doubling the crossing area. The twin culverts will be installed at an elevation lower than existing to allow for the accumulation of sediment at the bottom of the culvert. Existing conditions results of the XPSWMM model indicate there is no overtopping of the roadway at this location during the 100-year event.

Regional Detention Site 1

Stockwell recommends providing upstream detention from the proposed twin 4x10 RCBC to ensure the release of storm runoff is controlled from the upper reaches of Coyote Basin. Detention storage will limit the amount of runoff that is released to Nine Mile Tributary, protecting downstream properties and the City of Harrisburg. A regional facility will also provide an ideal location for water quality storage. A high-level preliminary design has been incorporated into the proposed conditions model to evaluate the storage requirements for the upstream growth area for event storage and water quality storage. The intent for a regional facility at this location is to provide the required storage for upstream properties within the future growth area, along with providing additional storage to protect downstream properties adjacent to Nine Mile Tributary.



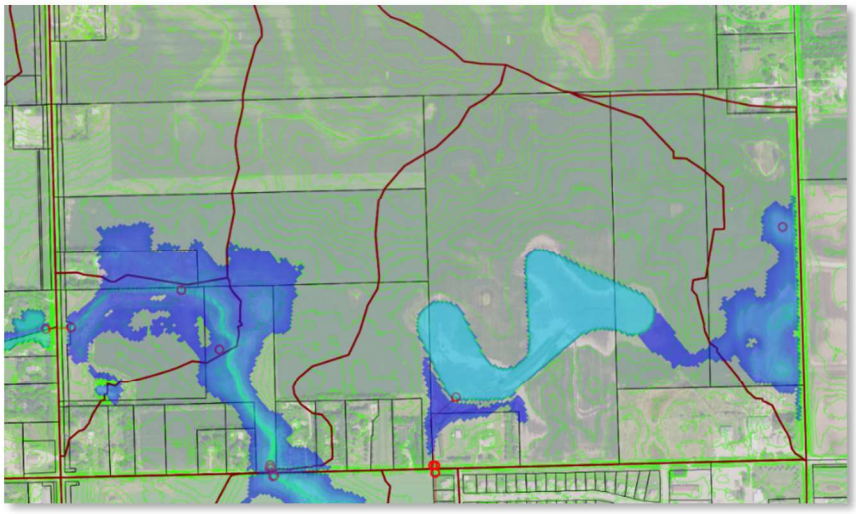
The proposed conditions model was reviewed to evaluate the possibility of providing additional storage in a regional facility to overcompensate for development of the property downstream of the regional facility located along Nine Mile Tributary north of 272nd Street (Subbasins 32,33,34 and 35). The increased runoff generated by future development would be better served by site specific facilities. Discharge from the proposed regional detention site 1 cannot be reduced enough to offset the increase in flow projected for downstream properties north of 272nd Street. Site specific detention facilities are recommended.

Regional Detention Site 1 provides an ideal site to also provide water quality storage using best management practices for the serviceable area. The proposed service area is nearly 550 acres that includes residential and commercial land uses. It is estimated that an extended detention basin that incorporates approximately 13.5 ac-ft of volume would provide adequate storage to provide water quality benefits in addition to the volume provided for event storage.

Regional Detention Site 1	
Service Area	547 acres
Event Storage	173 acft
Water Quality Storage	13.5 acft

The proposed facility at Site 1 includes improvements that will add an additional 61 acft of storage to the already 112 acft that occurs naturally for a total of 173 ac-ft of volume for storage to serve the tributary growth area.

Regional Detention Site 2



The proposed conditions model includes a preliminary design layout that would include a detention facility to serve the tributary basin. A grading plan was developed to incorporate a regional pond to detain the developed flows and release at existing rates. The figure to the right indicates the facility detains the increased flows and provides relief for the surrounding properties from the major storm event. A conveyance channel must be provided for on the Black Dog property, however a regional solution should be considered to provide both event storage and water quality storage. It is estimated that 49.6 ac-ft will be needed for event storage and 4.4 acft (extended detention basin) for water quality storage will be needed to serve the contributing 184-acre basin. A total storage volume of 54 acft is anticipated. The proposed plan closely follows the lay of the land and minimizes the grading impact

to surrounding properties. The depth of the facility shown below averages a depth of 3 feet and encompasses a footprint area of 19 acres upon completion of grading activities. The water quality volume will be provided by over-excavating the facility.

The volume of storage appears exaggerated because the rate of discharge from the facility is limited to existing discharge rates, per City Standards. The discharge will be limited to the capacity of the 8" line that crosses 272nd Street.

The storage area that was graded in 2019 on the Black Dog property, has not been considered in this analysis, however, it will impact the storage required in a regional facility used to serve both subbasins. Once the developer provides the City with a proposed plan that can be incorporated into the proposed conditions model, Stockwell Engineers can determine how much storage volume can be reduced in the regional facility.

Regional Detention Site 2	
Service Area	184 acres
Event Storage	49.6 acft
Water Quality Storage	4.4 acft

Continuing downstream along Nine Mile Tributary is Creekside Addition that is currently under construction north of Willow Street and west of Cliff Avenue. Creekside Addition is being constructed under an approved Conditional Letter of Map Revision (CLOMR) with the Federal Emergency Management Agency. The open channel that dissects the property is located within the 100-year floodplain. This analysis has incorporated the proposed grading plan, which was provided by the developer. Review of the development plan indicates that a site-specific detention facility meets engineering design standards according to the developer's submittal documents. The developer has submitted a follow-up LOMR (Letter of Map Revision) that is pending approval from FEMA.

RECOMMENDED IMPROVEMENTS

Recommendations for improvements to Coyote Basin include implementing both Regional Detention and Water Quality Detention Facilities, Sites 1 and 2 as described above. These multifunctional facilities will provide the necessary storage volume to allow for development of serviceable properties as well as protect downstream properties within the City Limits.

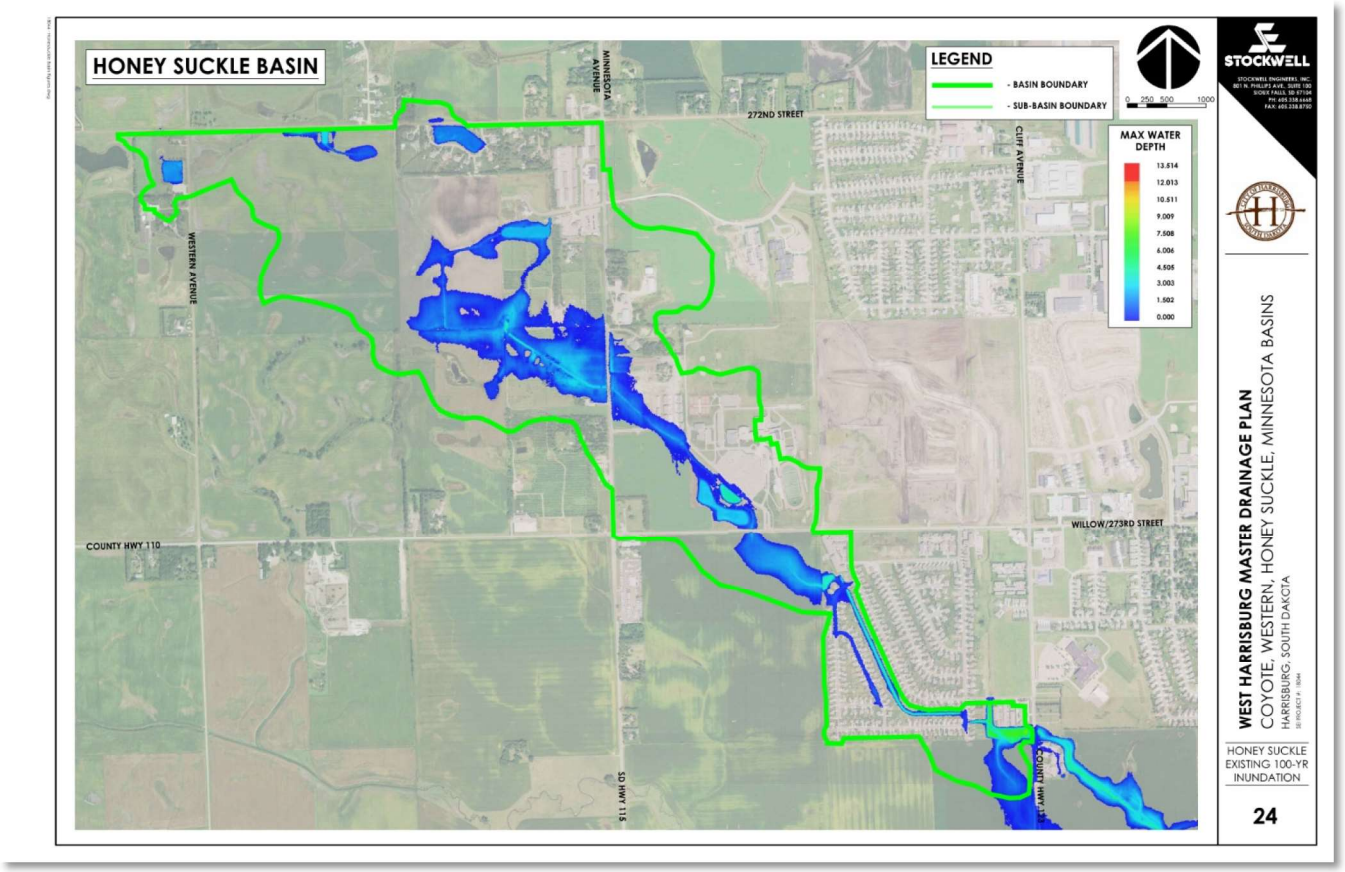
Regional Facility Site 1 appears to be the most critical improvement identified in this analysis. Model results for Coyote Basin identify improvements to the culvert on Nine Mile Tributary at Minnesota Avenue will negatively impact downstream properties. Development of this regional facility should be of high priority to the City of Harrisburg.

HONEYSUCKLE BASIN

Honeysuckle Basin, as shown below extends to 272nd Street, just west of Harrisburg. The basin is largely undeveloped west of Highway 115 and drains through Green Meadows Addition in Harrisburg. Discharge from Honeysuckle Basin joins with discharge from Coyote Basin prior to discharging into Nine Mile Creek. Honeysuckle Basin includes one crossing at Highway 115 that will be improved with the 2019 SDDOT reconstruction project.

EXISTING CONDITIONS

Results of the Existing Conditions XPSWMM analysis are presented in Drawings 24-27. As indicated by the graphic and tabular results, runoff in the upper reaches of the basin is shallow and widespread, and inundated areas include pockets of natural detention. An existing 4'x3' RCBC at a nearly flat grade conveys runoff across Minnesota Avenue without overtopping the roadway during the 100-year rainfall event.



Moving downstream along the main line channel, a site specific storm water detention facility that serves the High School intercepts runoff, just north of Willow Street before crossing through a 6'x3' RCBC without overtopping the roadway. As runoff is conveyed downstream, runoff enters another small detention pond that provides limited storage

before the channel transitions to a constructed open channel that navigates through Green Meadows Addition. Model results indicate that there is overtopping of the small detention facility at the northwest corner of Green Meadows Addition and that flooding occurs on private property through side yards before getting into Almond Avenue public right-of-way. Additional survey data may be necessary to determine if there are in fact impacts to these homes. It appears that the 2012 LiDAR data used in this analysis does not reflect fill activities that would have occurred when homes were constructed on the impacted lots. Local roadways, Almond Avenue and Shebal Street experience overtopping at crossings along the constructed channel. Another site-specific detention facility is located on the upstream side of the culvert crossing at Cliff Avenue that serves the Green Meadows Addition. Results from the existing conditions model indicate that the 100-year event overtops Cliff Avenue at this location.

There is a dog-leg turn in the constructed channel south of Honeysuckle Drive and East of Shebal Avenue before runoff enters the exiting 72" CMP culvert under Cliff Avenue. The sharp turn during significant rainfall events has been an area of concern to City officials during significant rainfall events as the water surface elevation appears to have potential to threaten buildings adjacent to the open channel and detention facility. Results from the existing conditions model indicate that the 100-year event is confined to the open channel at this location, and the low point at Cliff Avenue is such that runoff overtops Cliff Avenue prior to causing surface runoff impacts to adjacent structures.

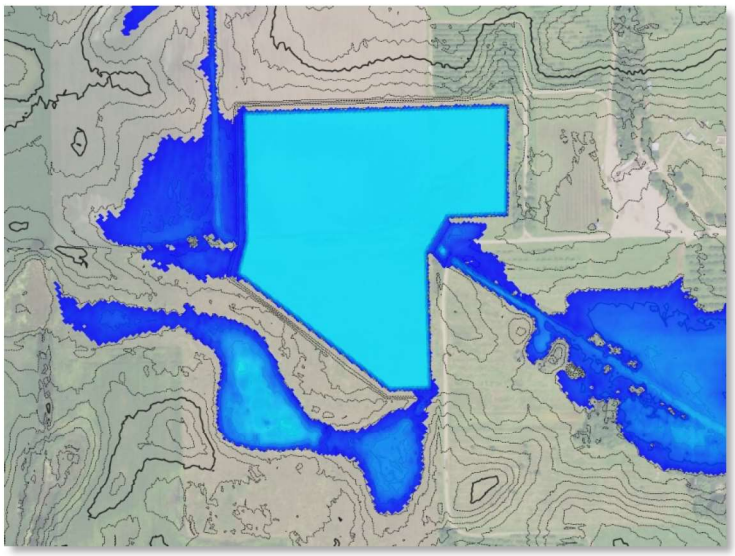
Cliff Avenue is designated as an arterial roadway. Results of the existing conditions model indicate that overtopping at Cliff Avenue occurs during the 100-year event, exceeding engineering design standards for maximum depth at arterial roadways south of Honeysuckle Drive. An existing 72" CMP conveys a peak discharge of 300 cfs under Cliff Avenue, however, does allow for storm flows to cross at grade at three locations along the roadway prior to draining into Nine Mile Creek.

PROPOSED CONDITIONS

The proposed conditions model includes anticipated development within the primary Honeysuckle basin as indicated on the future land use map shown in Drawing 4. Future land uses will increase the rate at which runoff is generated from the basin.

The proposed conditions model includes the upgraded culvert crossing at Minnesota Avenue that is part of the 2019 SDDOT reconstruction project for Highway 115. Improvements to this culvert crossing include replacing the existing 4'x3' RCBC with quadruple 36" RCP culverts at an improved grade. The roadway centerline is also being lowered by 1.7 feet which will cause overtopping of the roadway under present day conditions. Lowering the roadway may have a significant impact to downstream properties. Overtopping of Highway 115 will occur at this location where historically conditions did not indicate overtopping during the 100-year event. Recommendations include a detention facility to reduce storm water discharge upstream from the proposed quadruple 36" RCP crossing.

Regional Detention Site 3



Stockwell recommends providing upstream detention from the proposed quadruple 36" RCP culverts to reduce storm runoff crossing Highway 115 from the upper reaches of Honeysuckle Basin. Detention storage will reduce the amount of runoff that is released to protect downstream properties and the City of Harrisburg. A regional facility will also provide an ideal location for water quality storage. A high-level preliminary design has been incorporated into the proposed conditions model to evaluate the estimated storage required for the upstream growth area for event storage and water quality storage.

Regional Detention Site 3	
Service Area	302 acres
Event Storage	43 acft
Water Quality Storage	7.8 acft

A regional facility at this location is intended to provide storage to overcompensate for the improved crossing and lowered roadway in an effort to protect downstream properties adjacent to the drainageway. Site-Specific facilities will be required for properties located between Regional Detention Site 3 and Highway 115.

The proposed conditions model also includes upsizing the existing 72" CMP culvert to an 84" RCP culvert at the crossing of Nine Mile Tributary and Cliff Avenue. Although the proposed pipe does convey more runoff than existing conditions allow, the upsized crossing did not eliminate overtopping at this location. Stockwell Engineers recommends a detailed analysis of this crossing to evaluate conditions to determine if a regional stormwater detention facility would be warranted in lieu of upsizing the crossing, or a combination of both upsizing and detention would be better suited at this location.

RECOMMENDATIONS

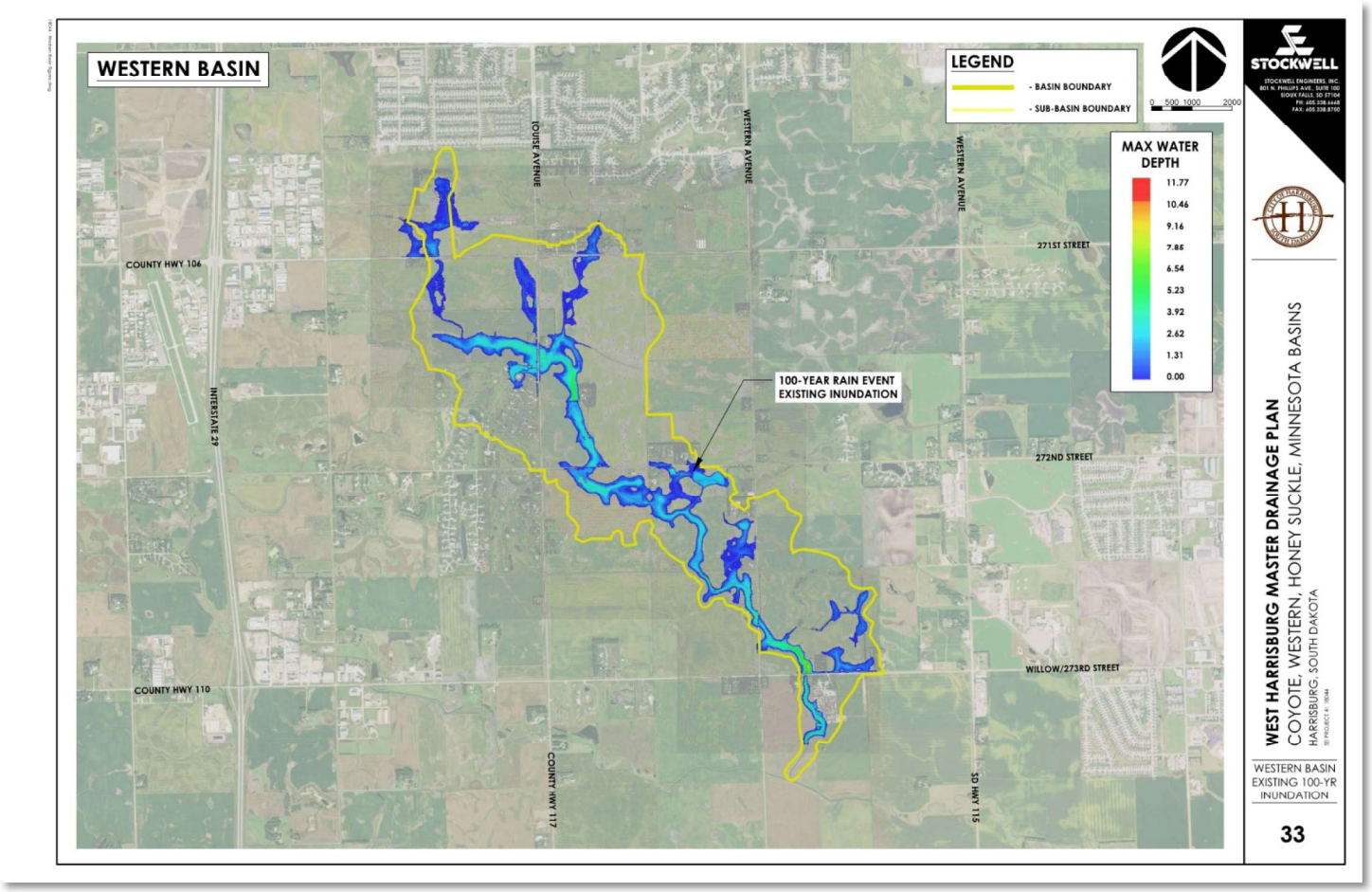
The improvements that are underway with the SDDOT reconstruction project along Highway 115 may have a significant impact to downstream properties during major storm events. Lowering the roadway by more than 20 inches allows for the overtopping of the roadway, likely impacting downstream properties. The impact will only be exacerbated as properties upstream of the crossing develop with increased impervious areas. Site-specific detention is critical for all developing properties within the basin to reduce

discharges to existing rates. It is also recommended the City consider additional detention upstream to reduce or eliminate the probability of runoff overtopping Minnesota Avenue during significant rainfall events at this location. The existing high water elevation at the upstream side of the crossing has shown in the model to rise to and elevation of 1441.20 during the major rain event. The proposed centerline grade at the low-point in the roadway is 1440.72. Once construction activities are completed, the City of Harrisburg should expect the roadway to overtop during the 100-year event.

The open channel and small holding facility located between Willow Street and Green Meadows Addition could present an opportunity for improvements that would benefit the downstream properties. The small hold facility could be expanded to provide additional storage volume to further protect downstream properties. The 6'x3' RCBC crossing immediately upstream of the small holding facility that drains into twin 24" RCP culverts presents a bottleneck along the main line conveyance route for Honeysuckle Basin. As an alternative, the City may want to discuss options to possibly expand the detention facility at the High School as well.

WESTERN BASIN

Western Basin is located entirely outside of city limits. Upper reaches of the basin extend to the south edge of Sioux Falls. Land uses within the basin include a portion of Bakker's Crossing Golf Course, several rural residential acreages, but predominately consists of agricultural properties. Drainage flows through the basin in a southeasterly direction. The Western Basin has been included as part of the West Harrisburg analysis so that existing conditions can be identified to aid City Staff as development within the basin moves forward.



EXISTING CONDITIONS

Results of the Western Basin existing conditions model are shown in Drawings 32-36. Flow across the basin is shallow and widespread with areas of natural detention holding back and slowing down stormwater flows throughout. The existing conditions model will provide a baseline of comparison for City Officials to refer to when planning and reviewing proposed developments as growth continues. The existing conditions model includes a detailed hydrologic and hydraulic analysis that represents present day land uses and evaluates all culvert crossings along the main line conveyance system.

PROPOSED CONDITIONS

The Harrisburg School District owns property at the southeast corner of 272nd Street and Louise Avenue and plans to build a new elementary school at this location. Stockwell Engineers is currently working with the City of Harrisburg to extend sanitary sewer up to the location of the future school by the end of the 2020 construction season. Extending the sanitary sewer collection system will promote development within the basin.

Drawings 37-38 include a schematic layout and results of the XPSWMM model for Western Basin for fully developed land uses. Peak flows for the 5-year and 100-year event are reported for each crossing along with the maximum capacity of the culvert. High water elevations are also reported at upstream locations. Proposed improvements to the storm water collection system will be determined as the basin develops. Upon annexation, it is anticipated that all properties that develop must meet City of Harrisburg Engineering Design Standards. This includes ensuring that properties that develop must not exceed predevelopment discharge rates. All properties will be required to detain to existing conditions. There are no regional detention facilities planned or recommended in the Western Basin. Properties within Western Basin will be required to provide site specific event storage to mitigate the increased stormwater that is generated by development.

City Staff have requested a high-level overview of possible locations for water quality facilities to be considered once the City of Harrisburg is required to implement water quality standards. If the City desires to take a regional approach to Water Quality Best Management Practices, it would be most practical to construct a single facility located downstream of the basin, where the water quality capture volume can be provided prior to discharging into Nine Mile Creek. This approach would be funded by assessing the benefitting upstream properties. Drawing 2 indicates possible locations or Regional BMP facilities to serve each primary basin.

RECOMMENDATIONS

There are no specific improvement projects within Western Basin included in this analysis. It is recommended that as growth continues with the basin, developments must meet requirements outlined in the current Engineering Design Standards for public utilities, including Chapter 6: Stormwater Management. Site specific detention facilities that limit the release of stormwater to existing rates shall be required for all developing or redeveloping properties within the basin. Enclosed storm sewer and open channel drainage systems shall be installed where warranted, and in accordance with City of Harrisburg Engineering Design Standards.

MINNESOTA BASIN

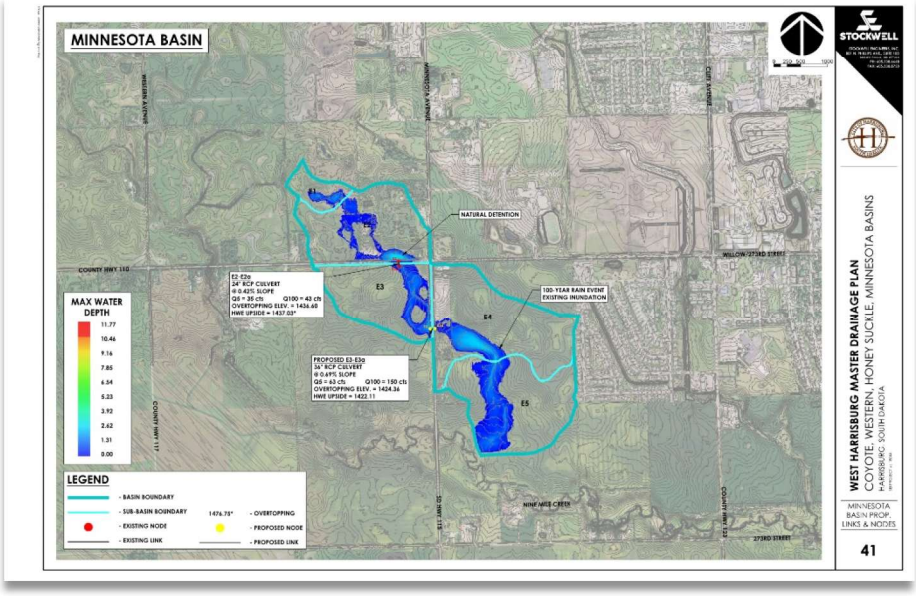
The final basin studied as part of the West Harrisburg Drainage Analysis is the Minnesota Basin. The Minnesota Basin is located completely outside city limits and encompasses agricultural properties. The major drainageway conveying storm runoff flows in a southeasterly direction and discharges directly into Nine Mile Creek.

EXISTING CONDTIONS

Present Day land uses generate runoff that is conveyed in an open channel that includes only two culvert crossings, one at Willow Street and one at Minnesota Avenue. Results of the existing conditions model are shown in Drawings 41 & 42. Natural Detention occurs at the upstream side of the crossing

PROPOSED CONDITIONS

The existing 24" RCP culvert crossing at Highway 115 is being replaced with a 36" RCP culvert the 2019 SDDOT reconstruction project. The upsizing of this culvert will increase the peak discharge through the culvert during both the 5-year and 100-year events. The increase will impact upstream and downstream properties that are located outside of Harrisburg City limits.



As development happens within the basin, site specific detention will be required to ensure discharge is limited to existing conditions. A regional water quality BMP facility to serve the basin has been identified at the downstream boundary of the basin, prior to discharge into Nine Mile Creek.

CONCLUSION

In general, drainage systems shall be designed to mitigate adverse effects of storm runoff. The overall objective of the design engineer shall be to prevent the uncontrolled or irresponsible discharge of storm water onto adjoining properties, prevent major property damage or loss of life resulting from storm runoff, and to provide and effective means of transportation and emergency access during storms.

The results of this analysis shall be used as a guide for development for West Harrisburg. Harrisburg's close to Sioux Falls, historic trends and growth minded community leaders are setting the stage for Harrisburg to see tremendous growth in the coming years. The existing conditions model as presented in this report shall be used as a baseline for analysis for developments to ensure that adverse effects of storm runoff due to development are mitigated.