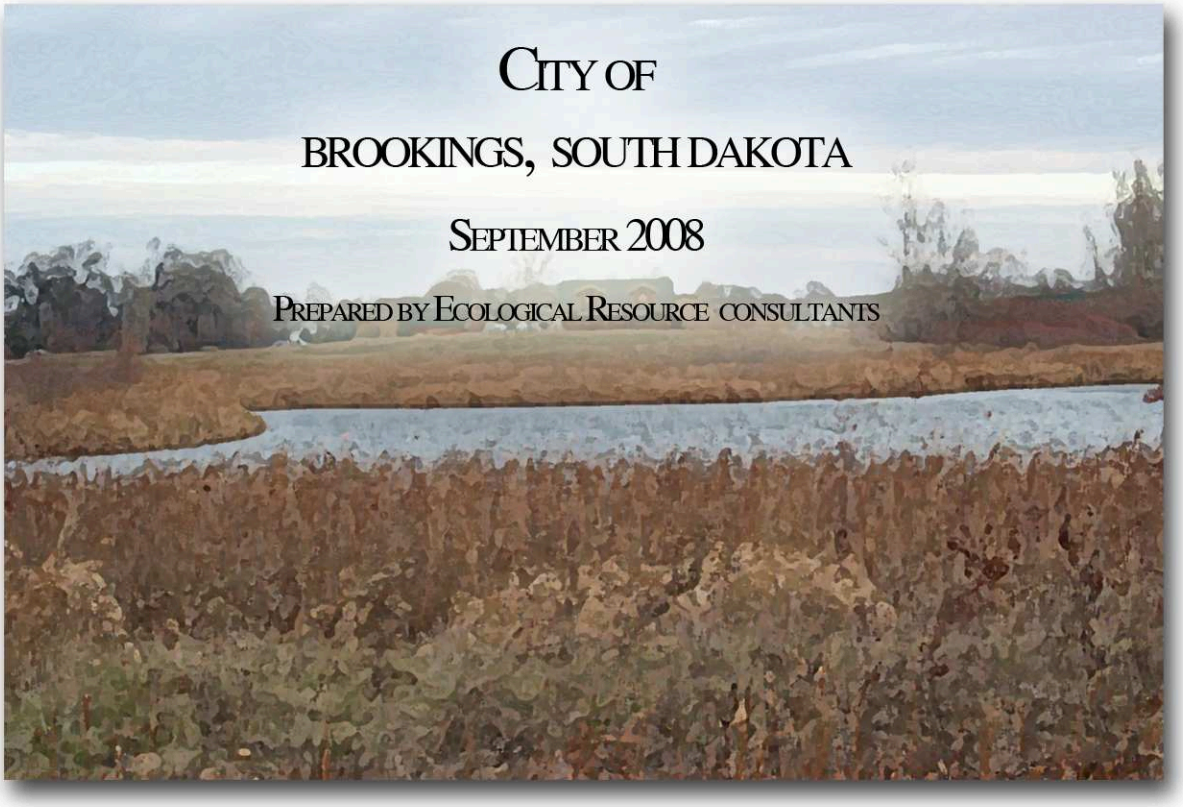
MASTER DRAINAGE PLAN



Ecological Resource Consultants, Inc.

City of BROOKINGS South Dakota

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I. INTRODUCTION

A. AUTHORIZATION

The Brookings, SD Master Drainage Plan was authorized under an agreement between the City of Brookings, SD (City) and Ecological Resource Consultants, Inc. (ERC) in August 2005. The study was sponsored by the City.

B. PURPOSE AND SCOPE

The purpose of the Study was to evaluate the major drainageways within the City and develop a comprehensive master drainage plan to help guide future development and capital improvements within the City. The basic project scope included the following task items:

- Conduct a hydrologic analyses of existing and future conditions of the City
- Establish peak flows in major basins for the minor and major storm events
- Assess flooding risk for existing development and provide hydrologic information to aid future development and planning decisions
- Develop a SWMM model of existing and future conditions of the City that can be updated in the event that future development does not follow the anticipated future conditions used in this report
- Develop and evaluate capital drainage improvements utilizing analyses of existing and future conditions to pass and or store the minor and major storm events
- Develop costs associated with recommended drainage improvements for the major storm event
- Submit a report summarizing the improvement analyses and capital cost estimates for improvements

The work scope was limited to major drainage facilities and does not include an evaluation of all components of the City's drainage infrastructure. Prior to the implementation of improvements recommended in this master drainage plan, detailed evaluations and design should be conducted on individual drainage systems within the major drainage areas evaluated herein.

C. GOALS AND OBJECTIVES

The basic goals and objectives of this Master Drainage Plan may be summarized as follows:

- Evaluate current conditions and likely future conditions to enable the City to reduce problems for existing conditions and guide future development as it relates to drainage.

D. DATA COLLECTION

Information and records were obtained from the City during the course of the study. The information included copies of previous related studies, existing storm drainage facilities data, land use data, the

Vision 2020 Comprehensive Plan (the Plan) adopted February 11, 2002, topographic data and aerial photographs.

E. MAPPING AND SURVEYS

All City mapping used in this study can be found in Appendix A.

F. PREVIOUS STUDIES

In May 2004 Banner and Associates completed the "Comprehensive Storm Drainage Study – City Of Brookings, South Dakota" (Banner Study). This study updated the previous storm drainage reports for the City and South Dakota University dated 1966 and 1970, respectively. The 2004 Banner Study reviewed studies conducted in 1966 and 1970 studies, identified City storm sewer problem areas and provided alternative capital storm water improvements, including costs of each alternative and recommendations for future growth.

The Vision 2020 Comprehensive Plan (Plan) resulted from the collaboration of the Brookings City Council and the Planning Commission and was prepared and compiled by Dan Hanson, the Planning, Zoning and Housing Administrator, in 2002. The Plan provides direction and guidance to the City in future development by recommending goals, objectives and policy initiatives for the planning strategy of the urbanized, non-urban and future urbanized sections in anticipated growth areas. The Plan also provides a snapshot of the City at the time of the Plan's completion. Maps and discussions include a socio-economic and growth area analysis, an existing land use inventory, maps and discussions of major utilities, transportation corridors, schools and parks and public buildings and facilities. It also projects future land uses and provides planning strategies needed to ensure that the City reaches the goals it has in terms of aesthetics, annexation and capital improvements.

II. STUDY AREA DESCRIPTION

A. GENERAL

The City of Brookings is located in east-central South Dakota at the intersection of Route 29 and U.S. Highway 14. The study area for this report includes the area within the City's boundaries. The study area is split into a northern and southern area by the Dakota, Minnesota and Eastern Railroad. The study area encompasses approximately 8,500 acres (13.3 square miles) and includes areas that have been developed and areas where future development is anticipated per the Plan.

Figure 1 illustrates the study area. According to the plan approximately 75% of the study area is currently developed and includes both commercial and residential development, parks, schools and government buildings. Six Mile Creek is the only major drainageway located in the study area.

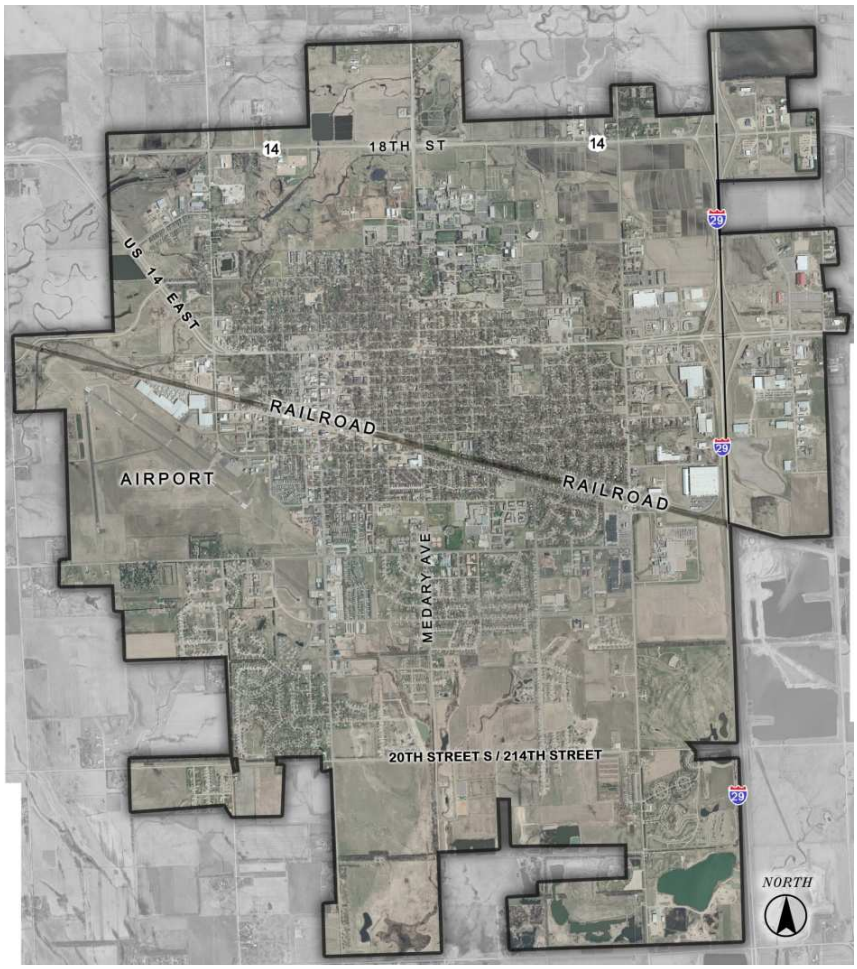

Figure 1 - STUDY AREA

B. SITE FEATURES

1. SOIL CHARACTERISTICS

Soils information for the study area was obtained from the soil survey for Brookings County, South Dakota maps prepared by the U.S. Geological Survey (Appendix B). Brookings lies within 5 soil associations. Soil associations are broad areas that have a distinctive pattern of soils, relief and drainage. The soil associations include: 7 Vienna-Brookings Association, 12 Lanona-Swenoda-Maddock Association,15 Fordtown-Renwash-Allivar Association, 16 Divide-Lamore-Marysland Association and17 Lamoure-Moritz-Divide Association. These associations have soils ranging from well drained to poorly drained, are either silty or loamy and are gently sloping to nearly level. Most soils located in the study area are B type soils using the NRCS classification system. Type B soils are characterized by having moderate infiltration rates when thoroughly wetted and consist mainly of moderately well to well drained soils with moderately fine to moderately coarse textures. Type B soils were assumed in the SWMM model in the study due to their high concentration in the study area.

2. EXISTING DRAINAGE PATTERNS

The City has five distinct drainage patterns. Drainage in the northern portion of the City either flows west to Six Mile Creek or east and under Route 29. Drainage in the southern portion of the City flows northwest to 6 Mile Creek, east and under Route 29 or South to the Big Sioux River.

3. EXISTING DRAINAGE INFRASTRUCTURE

Existing drainage infrastructure includes storm drain pipes, culverts and concrete valley gutters. Storage facilities for two subdivisions, Timberline Addition and Indian Hills, were included in this study as detailed data was available on these facilities at the time of this report. Other storage facilities that provide localized on-site storage for subdivisions exist but were not included as part of this study. Regional detention and a City wide flow path capable of effectively carrying the major storm do not currently exist.

4. DESIGNATED POSSIBLE DETENTION AREAS AND CITY OWNED LOTS

The City has designated certain areas for possible future detention. These areas are primarily located in the southern portion of the City. The two largest areas are located on the northeastern and northwestern corners of the intersection of Medary Avenue South and 20th Street South. The area located at the northwestern corner currently is not owned by the City but it was indicated that it may be used in conjunction with the land owner as detention. Two of the City owned lots are currently used as detention areas for the Timberline Addition and the Indian Hills Addition. These lots were analyzed for use as detention facilities and their future use as detention facilities is recommended in the areas where they are effective at reducing peak flow rates.

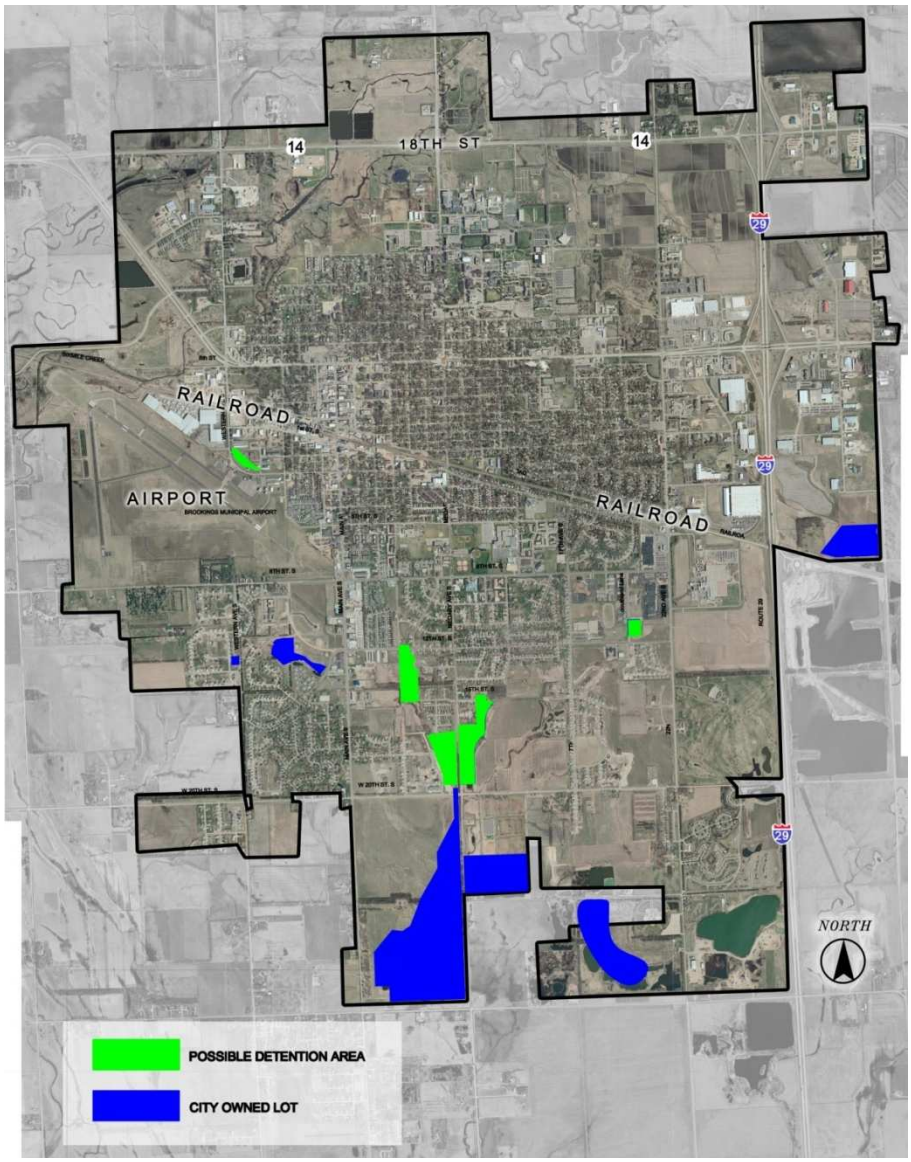

Figure 2 - POSSIBLE DETENTION AREAS AND CITY OWNED LOTS

C. MAJOR AND MINOR BASINS

1. MINOR BASINS

Minor basins were delineated as part of this assessment based on available topographic information. The study area was divided into 163 minor basins as indicated on Figure 3. Parameters for these basins used in the SWMM model can be found in Appendix C.

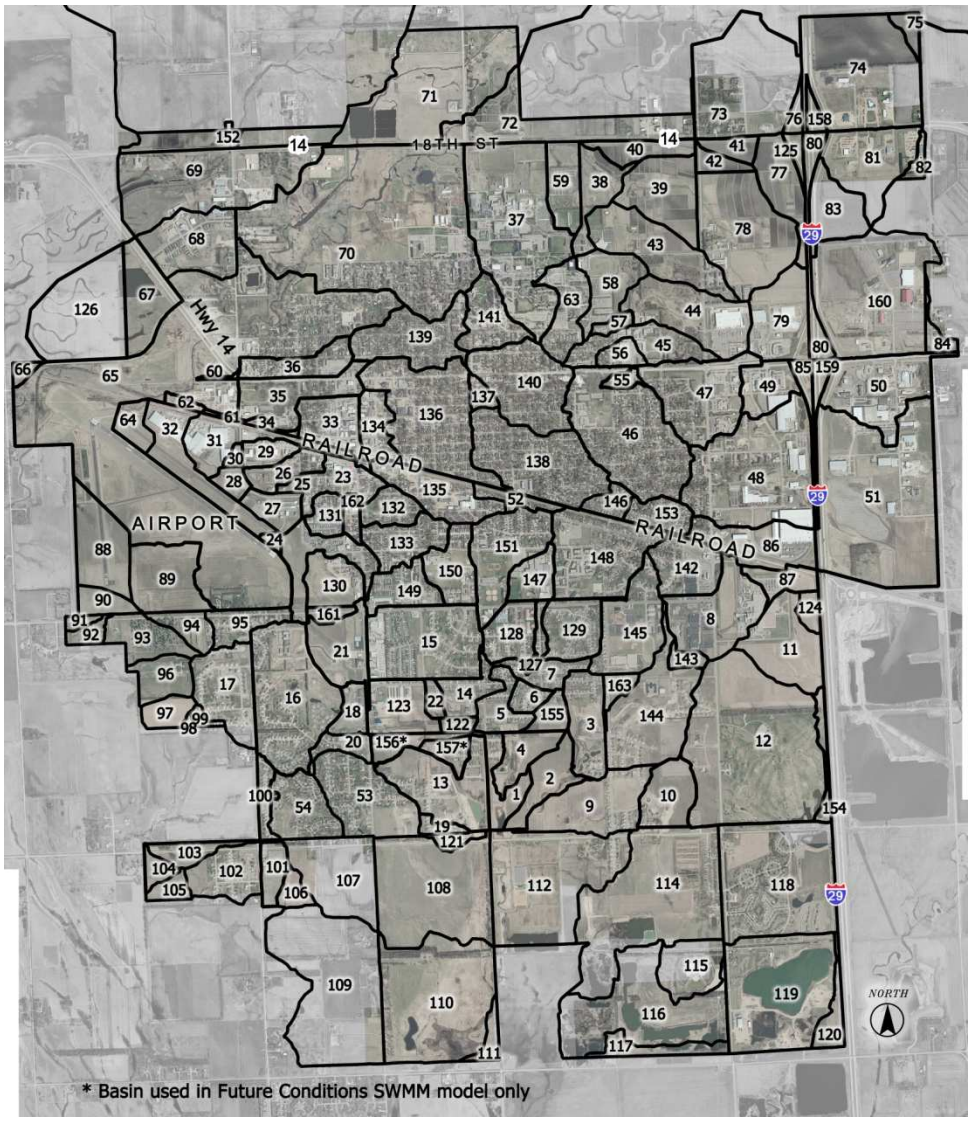

Figure 3 - MINOR BASINS

2. MAJOR BASINS

Major basins include groups of minor basins that drain stormwater to a common outfall or, in the case of a confined basin, a storage facility for the surrounding minor basins. These basins used the same identifier as their outfall or storage facility. There are 34 major basins or separate outfalls that were defined for this study. Peak flow rates were determined along the length of each major basin as part of this drainage evaluation.

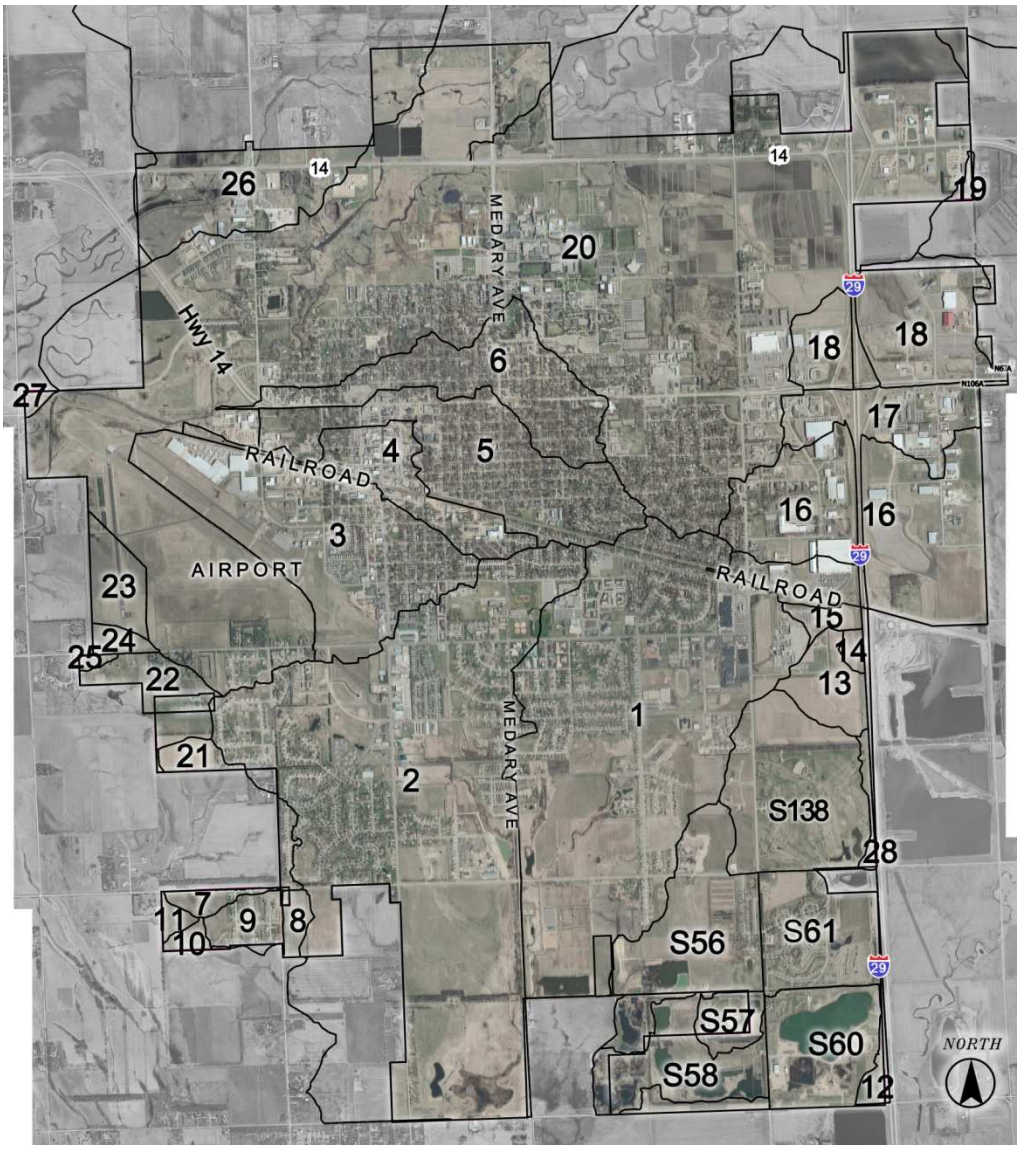

Figure 4 - MAJOR BASINS

D. HISTORICAL FLOODING AND STUDY AREAS

Historically, the City has experienced localized flooding that has led to the inundation of roadways and caused minor damage to some residences. This flooding has historically occurred during minor storm events and, if improvements are not made, could cause serious damage during larger storm events.

Thirteen specific study areas have been identified by the City as areas with existing drainage concerns that require more detailed analysis. A majority of the areas currently experience flooding issues during relatively frequent rainfall events. Other areas were included to ensure that planned development will not lead to flooding. Where needed, individual SWMM models or site specific drainage calculations have been created to more closely examine these problem areas and define possible resolutions. These thirteen areas are defined below.

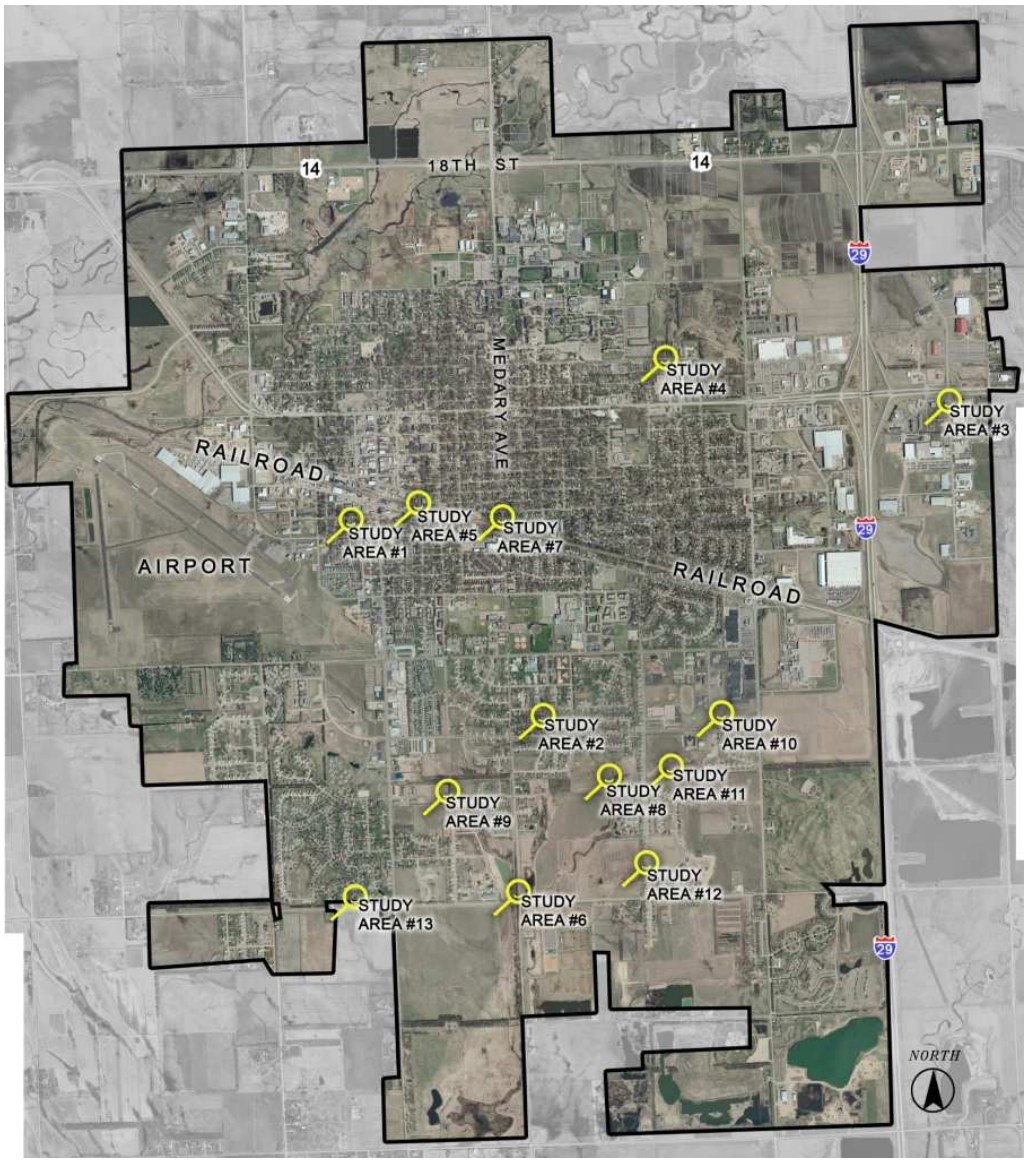

Figure 5 - STUDY AREA LOCATIONS

1. Xtra Space Storage: W. 2nd Street & W. Folsom Street

During relatively frequent storm events the storage facility at W. 2nd Street and W. Folsom Street floods. This is due to the low elevation of the storage facility and the inadequate conveyance capacity of the adjacent channel. During a storm event water enters the channel and is unable to discharge. The water elevation in the channel rises until it reaches the elevation of the storage facility and overflows onto the property. This occurs until the water has drained from the channel. Local streets are higher in elevation than the channel and act as berms providing no relief for flows in the channel. The existing drainage channel adjacent to the storage facility is heavily vegetated and has little slope.

Photo 1 – SWALE ADJACENT TO XTRA SPACE STORAGE

2. Area behind houses at Hammond Avenue & Horner Avenue, North of Squire Court

During relatively frequent storm events, ponding occurs in the backyards of houses located at Hammond Avenue and Horner Avenue. During larger storm events observed in the past several years, ponding reaches but does not flood the houses. A single slotted storm inlet services the entire area. Flooding issues have not been observed downstream of the inlet. Some flooding has been observed in the inlets in the cul-de-sac of Hammond Avenue.

Photo 2 – INLET BEHIND HOUSES

Photo 3 – AREA WEST OF INLET

Photo 4 -AREA NORTH OF INLET

3. LeFevre Drive

A single 18” pipe inlet serves a substantial impervious commercial area. The existing inlet consists of the pipe only and does not have adequate capacity. This inadequacy causes the area adjacent to the gas station to flood regularly. The inlet outfalls into a state highway owned swale adjacent to U.S .14 that is heavily vegetated and does not appear to have a high conveyance capacity.

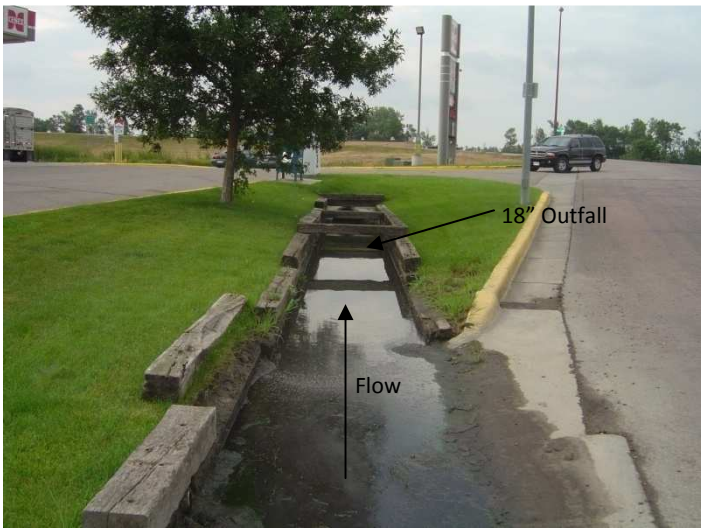

Photo 5 - 18" INLET AT LEFEVRE DRIVE

Photo 6 - FILLET UPSTREAM OF 18" RCP INLET

Photo 7 – OUTFALL OF 18" INLET AT LEFEVRE DRIVE

4. Drainage ditch between Garden Square Apartments and Garden Village Townhouses

During storm events, a concrete swale located between apartments and townhouses floods. Water rises to the garage floor of the apartments and a few inches below the front door of the lowest townhouse during larger rainfall events. The apartments were constructed very close to the channel and at an elevation lower than 8th Street. Flooding was not reported to be a problem until the townhouses were built and the channel became confined. Prior to the construction of the townhouses, the drainage was allowed to spill east onto the undeveloped property as needed. The increase in the velocity in the channel due to the channel being restricted has also caused bank erosion. A 4 foot sanitary manhole is located in the middle of the channel with its top elevation much higher than the channel bottom. Flooding problems have been observed related to this area upstream as far as the culvert at State Street. Recent flows have been high enough to move vehicles and cause a blockage of this culvert. Water from the State Street culvert enters a covered channel that runs through a shopping center parking lot. This channel used to be an open concrete swale and was covered for aesthetics. The water then flows through an open concrete swale and ultimately reaches the swale located between the apartments and townhouses. The upstream drainage area is completely developed.

Photo 8 - SWALE BETWEEN HOUSING DEVELOPMENTS

Photo 9 - CONCRETE CHANNEL UPSTREAM OF SWALE BETWEEN HOUSING DEVELOPMENTS

5. 6TH Avenue viaduct under the Dakota, Minnesota and Eastern Railroad

During normal storm events, the area floods and, for safety reasons, is closed off. The area under the railroad crossing is in a sump and is unable to adequately drain during all but the smallest of rainfall events. The area does drain north through an 18" pipe and outfalls to a swale on the north side of the railroad tracks where they cross Western Avenue South.

Photo 10 - 6th AVENUE VIADUCT

6. Medary Avenue South and 20th Street South

The area floods during normal storm events. Water crosses 20th Street South through culverts and outfalls into swales alongside Medary Avenue South that flow south. This water combines with flows from the soccer fields and travels south. The swales are heavily vegetated and appear to not let water move easily. The ground below the culvert inverts has eroded and is now lower than the pipes. The outfall pipes may not be adequately sized.

Photo 11 - PIPE OUTLET NORTHWEST OF THE INTERSECTION OF MEDARY AVE. S AND 20th ST. S

Photo 12 - PIPE OUTLETS AT NORTHEAST INTERSECTION OF MEDARY AVE. S AND 20th ST. S

7. Medary Avenue South and its intersections with 1st and 2nd Streets

This problem was identified in Banner's 2004 and 1966 study. Flooding occurs at the intersections of Medary Avenue South and its intersection with 1st and 2nd Streets. Storm drain inlets and 10" piping currently exist in the intersection with 2nd Street but do not exist in the intersection with 1st Street. During storms water floods the area and reaches the crown of the existing streets before flowing downstream and presumably entering other storm structures. Recent flood levels have been minor and have caused no damage albeit inconveniencing traffic.

8. 15th Street South & Christine Avenue Extension

A new elementary school will be built south of Westminster Drive and east of Christine Avenue. 15th Street South will be extended to provide a connection between 17th Avenue South and Medary Avenue South. A subdivision is planned east of the school and should provide its own detention pond. New roads, including Camelot Drive, will also be constructed when this subdivision is built and will provide access from 15th Street South to Westminster Drive and through the subdivision. Christine Avenue will ultimately be extended south and will connect with 20th Street South. Another subdivision is in the planning process and will be located south of the 15th Street South extension. This subdivision should be required to provide its own detention pond. This subdivision will be located on both sides of the Christine Avenue extension. There is an existing channel located east of Medary Avenue South and south of 15th Street South that may be expanded to provide detention/drainage for the new elementary school. It is not known if the new subdivisions will utilize this channel. A detention pond at 20th Street South and Medary Avenue may be constructed to provide additional storage for the area.

9. 15th Street South & 7th Avenue South Extension

15th Street South will be extended west to connect with itself and 7th Street South will be extended south to connect with itself. A large area located at this future intersection is currently owned by the City and is designated a possible detention area. The impacts it will have on downstream areas if it is used as detention were evaluated.

10. Southland Lane and 12th Street South Detention

Block 8 located at Southland Lane and 12th Street South may be acquired by the City. If it is, the City plans on using it for regional detention. The impacts it will have on downstream areas if it is used as detention and if it is not acquired were evaluated.

11. 17th Avenue South and Sawgrass Drive

The intersection of 17th Avenue S and Sawgrass Drive lies in a low spot. During storms, water floods the inlets and ponds in the roadway. An existing 18" storm line carries flows west from this location until it connects with a 48" storm line that is coming from the north. This 48" storm line heads west where it connects with a 36" storm line and enters a double 42" storm line. This outfalls to dead storage ponds located in the Blairhill Addition.

12. 17th Avenue South and Pebble Beach Drive

The intersection of 17th Avenue South and Pebble Beach Drive lies in a low spot. Currently, water flows west along Pebble Beach Drive and enters two inlets at the intersection. These inlets connect to an 18" line that outfalls onto open space. During storms, this area floods the inlets and ponds in the roadway and resident's driveways.

13. W. 20th Street South and Main Avenue South

The swale located along W. 20th Street South between Council Ridge Road and Main Avenue South floods during storm events. Driveway culverts and a swale parallel W. 20th Street South to the north. This area drains west and east with a drainage break along the swale. Currently a 24"CMP drains the western draining area and outfalls into an undeveloped area to the south of W. 20th Street South. The eastern draining area enters a 30" RCP arch pipe at the intersection of W. 20th Street South and Main Avenue South. From here it continues east and ultimately outfalls at the intersection of 20th Street South and Medary Avenue South.

III. HYDROLOGIC MODELING

A. EPA-SWMM Model

A hydrologic analysis of the entire study area was prepared to establish peak flows and volumes at key design points for both the existing and predicted future conditions. This analysis looked at the minor and major storms (5-yr and 100-yr peak flows, respectively). The Storm Water Management Model (EPA SWMM Version 5.0) was used to perform the hydraulic study. SWMM was used to develop runoff hydrographs from individual drainage basins and to route the individual hydrographs through drainage pathways**.** Models were created to represent existing and future conditions (based on the Zoning Plan). The existing conditions model included the addition of the Timberline and Indian Hills storage facilities and both 15th Street extensions. The master drainage plan SWMM models represent the system macroscopically and do not include individual neighborhood scale piping systems. Rather, they represent the system through major connection conduits like culverts and channels. Smaller models, that may include individual piping systems, were created, as needed, to more closely model the thirteen

specific study areas that were discussed previously. A schematic of the SWMM model can be found in Appendix D.

For all SWMM models, hydrographs for the 5-year and 100-year rainfall events were developed for both existing and future land use conditions. Improvements to alleviate flooding problems were analyzed using the 5-year and 100-year recurrence event storms.

B. SWMM MODELING REQUIREMENTS

SWMM hydraulic modeling requires detailed information about the drainage system being analyzed. The overall system model parameters required include: sub-basin characteristics, culvert sizes, type and length, existing, future and proposed storage volumes and outfall tailwater (flow depth) information.

For cases in which the tailwater elevation was not known, an elevation was estimated using professional judgment. Depending on the slope and geometry of the receiving system, the tailwater elevation was based on a normal depth assumption, free discharge assumption or tailwater estimated from anecdotal information.

SWMM models generated as part of this master plan considered macroscopic properties of the main drainage basins and sub-basins. When future detailed studies are conducted for a specific area or basin assumptions used in this model should be verified and adjusted as required.

C. DESIGN RAINFALL

SWMM uses the design rainfall to simulate the rainfall-runoff process. Intensity-duration-frequency (IDF) data was obtained from the Manual for the 5-yr and 100-yr storm events. This data is found in Table 1. The 5-yr 24-hour and 100-yr 24-hour storms were analyzed at 5 minute time steps.

Return Period (years)	Storm Duration (hours)	Storm Duration (min)	Precipitation Intensity (in/hr)
5	0.08	5	6.27
5	0.17	10	5.07
5	0.25	15	4.28
5	0.5	30	3.01
5	1	60	1.96
5	2	120	1.08
5	3	180	0.77
5	6	360	0.44
5	12	720	0.25
5	24	1440	0.14

Return Period (years)	Storm Duration (hours)	Storm Duration (min)	Precipitation Intensity (in/hr)
100	0.08	5	10.20
100	0.17	10	8.51
100	0.25	15	7.25
100	0.5	30	5.26
100	1	60	3.48
100	2	120	1.85
100	3	180	1.33
100	6	360	0.75
100	12	720	0.43
100	24	1440	0.24

Table 1 - IDF DATA FOR THE 5-YEAR AND 100- YEAR STORM EVENTS

D. SWMM SUB-BASIN PARAMETERS

Each sub-basin is represented within the model by defining various physical hydrologic parameters calculated from land use, soils and topographical data. The hydrologic parameters for each sub-basin include: basin area, NRCS Curve Numbers (CNs), percent impervious area, basin width, average basin slope, subarea routing, infiltration, pervious and impervious Manning roughness and pervious and impervious depression storage. The values used for this modeling can be found in Appendix C.

1. Land Use, CNs and Percent Impervious Area

The CN methodology was used by SWMM to calculate the amount of runoff (RO) and infiltration for a given drainage basin. SWMM uses the percent imperviousness to determine the amount of runoff that occurs and uses the CN to determine the amount of infiltration that occurs. Thus, the CN for only the pervious area within the basin is needed. Land use data was obtained from the Existing Land Use Map located in the Plan and the 2008 Official Zoning District Map. A summary of basin land use percentages is given in Table 2. Percent imperviousness values were taken from figures found in the Manual and from typical CNs used in this method. They can be found in Appendix C.

a) Existing Conditions

The Existing Land Use Map from the Plan was used to determine the percent imperviousness of the basins under existing conditions. Basins with the land use of residential single-family or residential with half acre lot or larger needed to be further categorized before their percent imperviousness could be determined. Their categorization was based on the type of dwelling (ranch style, split-level or two-story) and the square footage of the home. The Plan categorized residential single family units as either low density (2.5 units/acre) or med/high density (5.5-12 units/acre) on the Existing Land Use Map. A low density dwelling was assumed to be 2000-sf and, using Figure 4 from the Manual, led to 49% imperviousness. Med/high density dwellings were assumed to be equal to multi unit detached with a percent imperviousness of 60%. All pervious areas within the basins were assumed to be grass/pasture in good condition and to have a CN of 61.

Land Use	CN	Percent Imperviousness
Undeveloped /Ag	74	2
Park	74	5
Public school	88	50
Airport	88	20
Low density Res.	85	49
High/Med. density Res.	85	60
Light Comm.	92	85
Heavy Comm.	92	95
Light Indus.	88	80
Heavy Indus.	88	90
Transportation	98	95
Grass/Pasture – in good condition	61	-

Table 2 - EXSTING CONDITIONS: CNs AND PERCENT IMPERVIOUSNESS

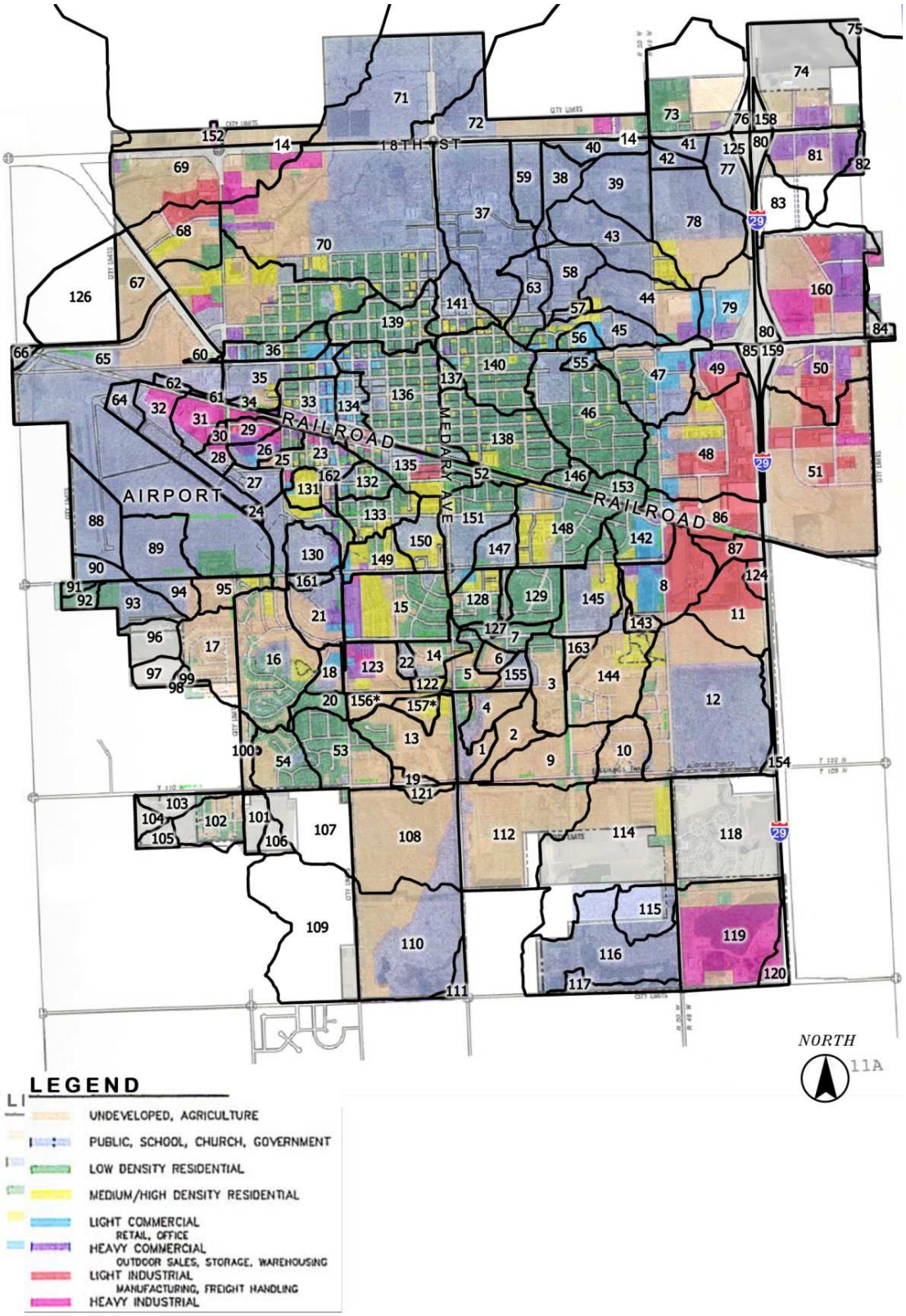

Figure 6 - EXISTING LAND USE MAP

b) Future Conditions

The Official Zoning District Map was used to revise the existing conditions model to reflect projected growth in the City. The percent impervious for areas that were labeled as undeveloped or parks in the Existing Land Use Map were updated by the Zoning Map as required. As in the existing conditions model, all pervious areas were assumed to be grass/pasture in good condition and a CN of 61 was used for all basins.

Zone Code	Description	CN	Percent Imperviousness
A	Agricultural	74	2
R-1	Rural Estate District (1 unit/≥3 acres)	68	26
R-1A	Single Family Residence (<3 units/acre)	85	41
R-1B	Single Family Residence (<5 units/acre)	85	49
R-2	Multiple Family Residence (6-18 units/acre)	85	60
R-3	Multiple Family Residence (7-24 units/acre)	85	75
R-3A	Multiple Family Residence (7-24 units/acre)	85	75
RMH	Residential Manufactured Housing (<9 units/acre)	85	60
RB-4	Neighborhood Business	88	85
B-1	Central Business	88	95
B-2	Medium Business	88	95
B-2A	Professional Office Business	88	95
B-3	Heavy Business	88	95
B-4	Highway Business	88	95
I-1	Light Industrial	92	80
I-2	Heavy Industrial	92	90
I-1R	Restricted Industrial	92	90
PDD	Planned Development District	88	85
-	Grass/Pasture – in good condition	61	-

Table 3 - FUTURE CONDITIONS: CNs AND PERCENT IMPERVIOUSNESS

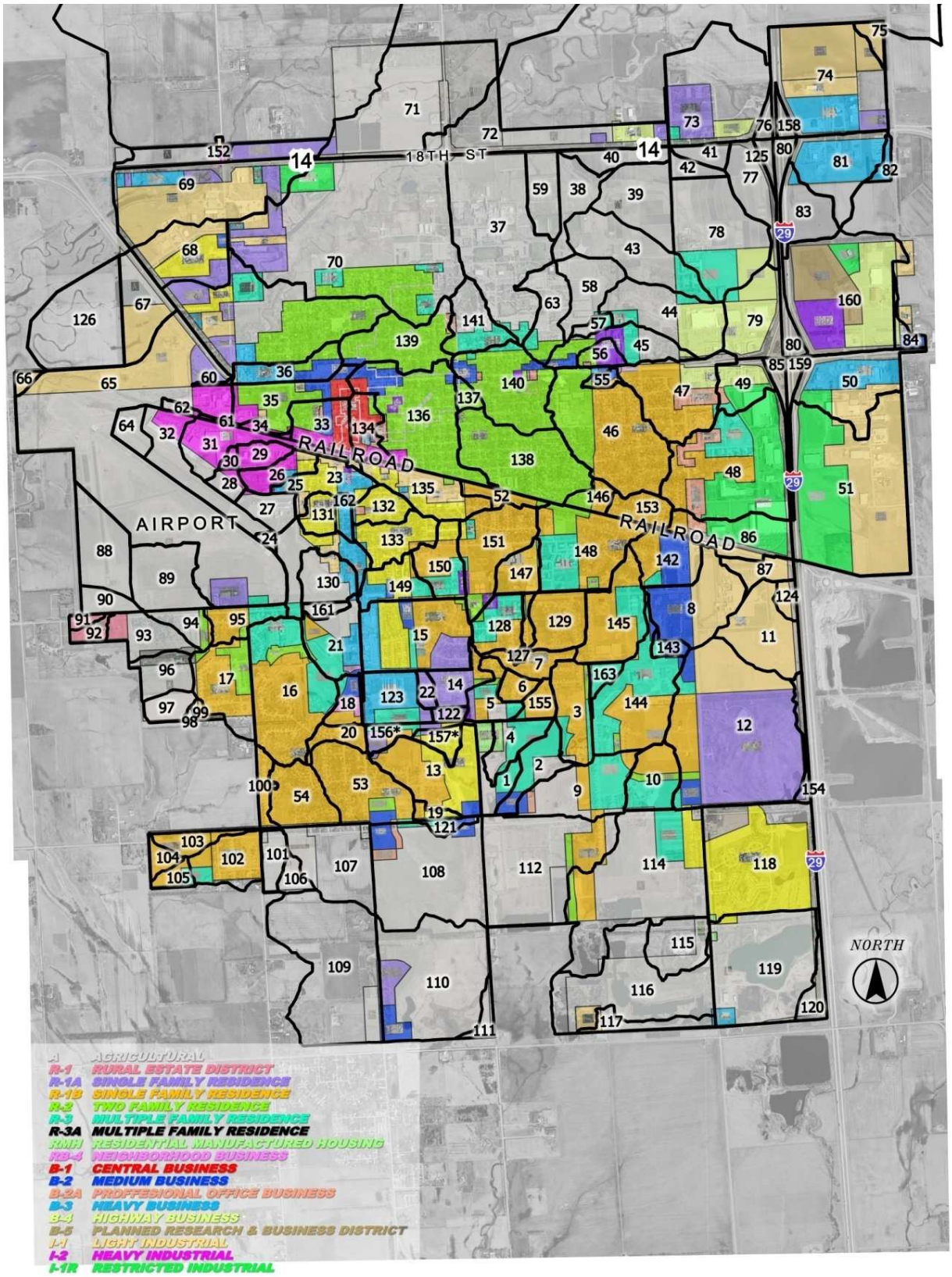

Figure 7 - ZONING MAP

2. Basin Area, Average Slope and Width

Basin area and slope was found by delineating the sub-basins in AutoCAD using existing drainage patterns and drainage divides. In order to calculate basin width the average length of overland flow was determined. Width was calculated by dividing the basin area (ft^2) by the average length of overland flow (ft). Width is used to control the rate at which RO flows out of a basin. The widths of sub-basins are given in Appendix C.

3. Subarea Routing

Subarea routing is used by SWMM to determine the amount of flow within a basin that infiltrates into the groundwater layers. The options include: water flows from an impervious area to a pervious area, water flows from a pervious area to an impervious area, and water from pervious and impervious areas reach the outlet equally. The percentage routed is also required. Unless otherwise noted, 50% of the imperviousness area for all basins was routed to pervious area prior to reaching the outlet. The values used to generate flow values presented in this report are given in Appendix C.

4. Infiltration

Infiltration rates are based on the soil type for each basin. The NRCS method of infiltration was chosen for this study. This method assumes that the total infiltration capacity of a soil can be found from its CN. It requires the pervious area's CN and the soil's saturated conductivity and drying time. All pervious areas within the basins were assumed to be grass/pasture in good condition and to have a CN of 61. Soil values used were based on SWMM recommendations for NRCS Type B soils and are given in Appendix C.

5. Pervious and Impervious Manning Roughness

Manning roughness is a parameter that defines the roughness of ground cover for different land uses as it relates to resistance to flow. SWMM uses Manning roughness values to determine flow rates and head losses in conduits. Manning's n values used were obtained from the Manual and are given in Appendix C.

6. Pervious and Impervious Depression Storage

Depression storage is the volume of water that must be filled before surface flow can occur on pervious or impervious areas. Storage deletes rapidly on pervious areas due to infiltration and evaporation during dry weather. For impervious areas, evaporation is the only means of depletion during dry weather. Depression storage for impervious Depression storage values used are given in Appendix C

E. Model Development

A schematic of the system was created depicting the area under study. The schematic includes sub-basin, major connector, storage facility and outfall identification of the elements represented by the model.

1. Model Assumptions

In areas where specific detailed information is required for the SWMM model but not available, assumptions were used. Assumptions included in the model are summarized below.

- Culverts and pipes

  - Made of RCP with a Manning's "n" value of 0.013
  - Pipes have a slope of 0.50%, culvert slope determined from topography
  - All culverts are under outlet control
  - Culverts have a headwall with 45° wingwalls, square edge
    - Entrance loss coefficient = 0.35
    - Exit loss coefficient = 1.0
  - Pipes and culverts are in full flow
- Swales and open channels
  - Manning's roughness for maintained channels = 0.027
  - Manning's roughness for heavily vegetated channels = 0.12
  - Channel's side slopes are 3:1 if they cannot be determined by the topography
  - Long swales are modeled with the average cross section of the swale
- Concrete Valley Gutters
  - Valley gutters are modeled with a typical cross section if the dimension of the valley gutter is unknown or cannot be determined by the topography. The typical cross section includes:
    - Manning's roughness = 0.013
    - Max depth = 0.5'
    - Bottom width = 4'
    - Side slopes = 6:1
- Sub-basins
  - Undeveloped areas consist of dense grass (n = 0.24)
  - No depression storage in impervious areas
  - Groundwater was excluded from the evaluation
  - Snowpack was excluded from the evaluation
  - For the CN infiltration method it was assumed that all pervious areas are grass/pasture in good condition and a CN of 61 was used
  - Unless noted, 50% of impervious area is routed to pervious area
- Junctions
  - Each sub-basin is attached to a junction
  - Junctions are used at the downstream end of culverts to account for overland flow
  - Inverts of junctions are based on available topography
- Storage Facilities
  - Each facility consists of a storage unit and an outlet
  - Existing facility information obtained from approved Drainage Plans provided by the City
  - Future storage facilities will consist of detention ponds that will lessen the impact of the 5-year and 100-year storm.
  - Future storage facilities will utilize the entire area that is dedicated to them minus an appropriate perimeter area to allow for frontage improvements like sidewalks.
  - Future storage facilities volumes do not include dead storage.
- Equivalent Conduits

- Equivalent conduits were used in areas where the piping system connection to nodes was not modeled and where two nodes were connected by overland flow. An equivalent conduit was used to account for the travel time. A conduit large enough to pass the entire 5-year or 100-year storm was not used. Head losses that would occur through a piping system were not modeled.
- Conveyances through areas with equivalent conduits were not evaluated as part of the Master Drainage Plan and will require more detailed evaluation when designing drainage improvements.
- Equivalent Swale
  - Depth = 4', Bottom = 100', s = 4:1, manning's n = 0.027
  - Length = length of overland flow
- Equivalent Pipe
  - Diam. = 6', Manning's n = 0.013
  - Length = length of drainage path through piping system

- Dummy nodes and conduits
  - Dummy nodes and conduits were used to connect a large drainage area to a node when the connecting piping system or overland flow path was not modeled. For example, Area A drains to Area B via a closed storm sewer system. An equivalent pipe is used to allow the drainage from Area A to reach Area B without the closed storm sewer system being modeled. Conveyance through areas with dummy nodes and conduits were not evaluated as part of the Master Drainage Plan and will require more detailed evaluation when designing drainage improvements. Conveyance through areas with dummy nodes and conduits were not evaluated as part of the Master Drainage Plan and will require more detailed evaluation when designing drainage improvements.
  - Dummy nodes and conduits were put in locations where only the quantity of flow was calculated.
    - Manning's roughness for Dummy node = 1
    - Length of Dummy node = 1
    - Node elevations were based on the elevations of nodes upstream and downstream of the dummy node
    - Max depth of Dummy nodes = 10'. This was required to ensure that all water passed through the dummy nodes and conduits.
- Flooding
  - Flooding up to 0.1 hours is allowed for the 100-year flood when sizing recommended drainage improvements

2. Naming Conventions

Elements in the SWMM models have the following labeling conventions:

- Sub-basin: Bas_# (ex. Bas_1)
- Junction: NSub-basin # (ex. N1)
- Downstream Junction: NSub-basin #A (ex. N1A)

- Conveyance: C# of upstream node - # of downstream node (ex. C1-1A)
- Outfall: OUT# (ex. OUT1)
- Existing Storage Facility: S# (ex. S1)
- Recommended Storage Facility: PS# (ex. PS1)

F. SWMM MODELS

SWMM models were developed as part of this study to represent the City under existing and future conditions. Since land uses and developed areas within the City have changed since the completion of the Plan and are continually changing as a result of new construction and zoning changes, a snapshot of the City was used as the base of all of the models. The snapshot included:

- The Existing Land Use map in the Plan
- The Timberline Addition
- The Indian Hills Addition
- The 15th Street South and Christine Avenue extension
- The 15th Street South and 7th Avenue South extension

These items were included in all of the models with the exception of the land uses and road extensions being updated in the future conditions model only. A model analyzing the impacts of heavily vegetated swales was also created. The five models are discussed in more depth below.

1. Model 1: Existing Land Use Conditions

Model 1 represents existing land use conditions based on the Existing Land Use Map and includes the Timberline and Indian Hills Storage facilities, the 15th Street South and Christine Avenue extensions and the 15th Street South and 17th Street South extensions. The Timberline Addition was constructed in 2006 and includes single family housing and two detention storage facilities. The facilities are connected by a 36” pipe and ultimately outfall across Western Avenue into a storage facility located in the Indian Hills addition. The Indian Hills addition detention facility was constructed in 2007 and includes multiple detention ponds. Data used to model the Timberline and Indian Hills detention facilities were derived from their respective Drainage Plans. The data used can be found in Appendix A.

Models for both the 5-year storm and 100-year storm were created. These models calculated peak flow rates for both the minor and major storm events. Results can also be used to estimate locations where flooding is likely to occur during these storm events.

2. Model 2: Future Land Conditions

A model representing future conditions and including the Timberline and Indian Hills detention facilities, the 15th Street South and Christine Avenue extensions and the 15th Street South and 17th Street South extensions was also created. Percent impervious for future land use was based on zoning. The data used can be found in Appendix C.

Models for both the 5-year storm and 100-year storm were created. These models calculated peak flow rates for both the minor and major storm events. Results can also be used to estimate locations where flooding is likely to occur during these storm events.

3. Model 3: Future Land Conditions with Recommended Improvements for the 5-year 24-hour Storm Event

A model representing the system with the recommended improvements for the 5-year storm implemented was created to ensure that the improvements allowed the controlled passage of the 5-year storm. The effects these improvements will have during a 100-year storm were also analyzed. Results for the model can be found in Section IV.

4. Model 4: Future Land Conditions with Recommended Improvements for the 100-year 24-hour Storm Event

A model representing the system with the recommended improvements for the 100-year storm implemented was created to ensure that the improvements allowed the controlled passage of the 100-year storm. Results for the model can be found in Section IV.

5. Model 5: Heavily Vegetated Channels

Many of the grass swales within the study area are heavily vegetated and as a result allow very little water to pass. This causes ponding issues within the storm water conveyance system and most likely contributes to flooding issues. To better analyze the effects of the heavy vegetation on channel conveyance capacity and overall drainage impacts, a separate model was run with the assumption that all grass conveyances are heavily vegetated. This assumption increased the Manning's roughness coefficient from 0.027 for a well maintained channel to 0.12 for a heavily vegetated channel. The model used in this analysis was the future land conditions with 100-year recommended improvements for the 5-year storm. Results show how sensitive the drainage facilities are to maintenance and upkeep of major conveyance swales. Results for the model can be found in Section IV.

G. LIMITATIONS OF THE HYDROLOGY MODEL

Models are limited by the physical limitations of the modeling program used and by the information available to use as model input. The Master Drainage Plan does not evaluate the City's drainage system on a pipe by pipe basis; rather it looks at the overall major drainage pathways. As a result, the recommended improvements model shows flow rates that are not limited by the capacities of minor conveyance elements. Pipe inverts were not used except at modeled major road crossings and, since inverts were unknown, they were determined from available topographic information or, if not determinable, were assumed to have a slope of 0.5%. This level of study does not allow for surcharge analysis of existing piping systems or for the determination of all pipe capacity problems within the system. Swales were modeled based on a typical cross section at a constant slope derived from available information. This typical cross section may not accurately represent the true physical characteristics of the channel along its entire length. Thus, the true capacity of the channel may not be properly modeled.

The drainage basins used were delineated using available two foot contour interval mapping. It is possible that the exact breaks between basins are missed, resulting in slight discrepancies in tributary areas modeled.

The land use information used to determine basin parameters does not include existing or future land uses for areas that are not within the City limits and drain into City structures. Thus, offsite drainage land use conditions may not be accurately modeled. The existing land use used in the Existing Conditions model computed basin parameters from a map created for the Plan and does not reflect new development or land use changes since the Plan. The Future Conditions model used basin parameters determined from a Zoning Map that may not reflect true future conditions.

A hydraulic study of Six Mile Creek was not completed for this analysis. It is possible that flooding from Six Mile Creek itself could occur and cause flooding not shown in this model.

Basins 152, 71 and 72 were added to the model only for the area that lies within City limits. They primarily include offsite drainage areas that would require a full river watershed analysis. These basins drain to Six Mile Creek directly and their exclusion is not expected to impact model results. They should however be added to the model when a watershed study and hydraulic study of Six Mile Creek is completed.

Detention areas other than the Timberline Addition and Indian Hills storage facilities were not included in this model. This may impact the model by allowing peak flows to reach downstream structures earlier then they will in real time. This may lead to the recommendation of oversized conveyances and control structures.

Model parameters were taken from the Manual and typical engineering values. These parameters were not analyzed in order to calibrate the model. Flow values in the City are unknown and thus could not be used to calibrate the model. This may lead to flow values and peak times that do not truly represent true flow conditions.

These model limitations should be considered when information from this Master Drainage Plan is used to implement actual drainage improvements. Detailed evaluation of the specific area of interest should be conducted as part of the engineering design of all future improvements.

IV. MODEL RESULTS

Model results included peak flows for the 5-year and 100-year storm events for existing and future conditions. These peak flows represent the flows of the entire basin reaching each outfall. All conduits were modeled as dummy conduits to obtain these results. The 100-year flows for future conditions were typically the largest flows with the 5-year flows for existing conditions being the smallest. In some areas the future conditions flows were lower than existing conditions flows because the future zoning of the area designated a lower percent imperviousness and/or CNs. For example, an area designated as a park

by the Existing Land Use map (percent imp = 5%) and zoned as agricultural by the Zoning map (percent imp = 2%) will have a small decrease in flows.

For basins where large land use changes are expected the future conditions flows are higher than flows for existing conditions. This is true in areas that are currently undeveloped and are zoned for low, med and high density residential and commercial development. Besides identifying areas that will experience significant flow increases, model results show the amount of flow expected per acre for each area. This shows areas that will experience a large increase in flows from possible future development. Percent imperviousness and CN values are also shown for comparison. In the future the City should continue to require detention facilities with all development with a goal of not allowing peak runoff from future conditions to exceed existing conditions.

Area	Total Area	Percent Imperviousness		CN		Q_5		Q_{100}		$Q_{5/ACREA}$		$Q_{100/ACRE}$	
	(acres)	Existing (%)	Future (%)	Existing	Future	Existing (cfs)	Future (cfs)	Existing (cfs)	Future (cfs)	Existing (cfs)	Future (cfs)	Existing (cfs)	Future (cfs)
1	954.2	31.7	45.7	61.0	61.0	782	1055	1458	1967	0.8	1.1	1.5	2.1
2	1,356.6	24.3	38.3	61.0	61.0	726	1048	1352	1983	0.5	0.8	1.0	1.5
3	397.2	51.5	53.7	61.0	61.0	379	397	723	764	1.0	1.0	1.8	1.9
4	126.2	62.9	63.8	61.0	61.0	154	156	290	295	1.2	1.2	2.3	2.3
5	297.4	50.7	51.8	61.0	61.0	250	254	477	487	0.8	0.9	1.6	1.6
6	217.3	53.9	53.9	61.0	61.0	211	211	395	395	1.0	1.0	1.8	1.8
7	31.7	11.4	48.4	61.0	61.0	11	35	20	64	0.3	1.1	0.6	2.0
8	17.8	12.1	12.1	61.0	61.0	7	7	11	11	0.4	0.4	0.6	0.6
9	41.9	20.9	44.7	61.0	61.0	23	36	40	67	0.5	0.9	1.0	1.6
10	10.7	2.0	54.7	61.0	61.0	1	14	6	36	0.1	1.3	0.6	3.4
11	9.8	2.0	49.0	61.0	61.0	2	15	8	24	0.2	1.5	0.8	2.4
12	17.3	90.5	90.5	61.0	61.0	32	32	72	72	1.8	1.8	4.2	4.2
13	73.7	44.7	73.6	61.0	61.0	70	100	131	190	0.9	1.4	1.8	2.6
14	9.5	80.2	80.2	61.0	61.0	17	17	32	32	1.8	1.8	3.4	3.4
15	20.2	61.7	73.2	61.0	61.0	35	35	66	66	1.7	1.7	3.3	3.3
16	451.9	36.3	72.2	61.0	61.0	30	442	557	885	0.1	1.0	1.2	2.0
17	133.3	59.4	73.7	61.0	61.0	215	249	409	491	1.6	1.9	3.1	3.7
18	229.5	53.5	66.3	61.0	61.0	210	249	400	486	0.9	1.1	1.7	2.1
19	6.5	84.8	84.8	61.0	61.0	14	14	27	27	2.2	2.2	4.2	4.2
20*	3,999.5	33.1	38.8	61.0	61.0	2254	2564	4316	4954	0.6	0.6	1.1	1.2
21	22.2	3.6	8.0	61.0	61.0	3	6	16	16	0.1	0.3	0.7	0.7
22	72.6	13.9	13.9	61.0	61.0	30	30	50	50	0.4	0.4	0.7	0.7
23	56.2	20.0	20.0	61.0	61.0	29	29	51	51	0.5	0.5	0.9	0.9
24	16.3	20.0	20.0	61.0	61.0	9	9	16	16	0.6	0.6	1.0	1.0
25	4.7	51.1	51.1	61.0	61.0	7	7	12	12	1.5	1.5	2.6	2.6
26	188.4	24.8	64.8	61.0	61.0	110	208	199	401	0.6	1.1	1.1	2.1
27	5.4	23.4	23.4	61.0	61.0	4	4	7	7	0.7	0.7	1.3	1.3
28	12.4	39.8	39.8	61.0	61.0	13	13	23	23	1.0	1.0	1.9	1.9
S56	229.9	8.0	25.2	61.0	61.0	67	173	111	315	0.3	0.8	0.5	1.4
S57	40.2	6.0	3.1	61.0	61.0	8	4	22	21	0.2	0.1	0.5	0.5
S58	151.2	6.7	6.7	61.0	61.0	30	30	119	119	0.2	0.2	0.8	0.8
S60	159.7	62.7	63.4	61.0	61.0	180	181	339	342	1.1	1.1	2.1	2.1
S61	157.5	27.1	43.8	61.0	61.0	68	90	131	178	0.4	0.6	0.8	1.1
S138	239.0	2.0	51.7	61.0	61.0	15	201	58	387	0.1	0.8	0.24	1.6

Table 4 - MAJOR BASIN PARAMETERS AND PEAK FLOWS FOR THE 5-YEAR AND 100-YEAR STORM EVENTS

1. Model 1: Existing Land Use Conditions

Flooding occurred in areas during the 5-year and 100-year storms for the existing conditions model. This indicates that structures in the study area are currently undersized for both storms. Drainage improvements presented in this report are based on future conditions and 100-year flows. However, if detention facilities are required with all new development the magnitude of future flooding resulting from future conditions flows may be smaller thereby reducing required improvements. On-site retention/detention should continue to be required by the City to minimize additional future drainage problems. Results for this model can be found in Appendix E.

2. Model 2: Future Land Conditions

Predictably, flooding occurred in areas during the 5-year and 100-year storms for the future conditions models. Drainage improvements presented later in the report were based on conveying 100-year flows resulting from future conditions. Results for this model can be found in Appendix E.

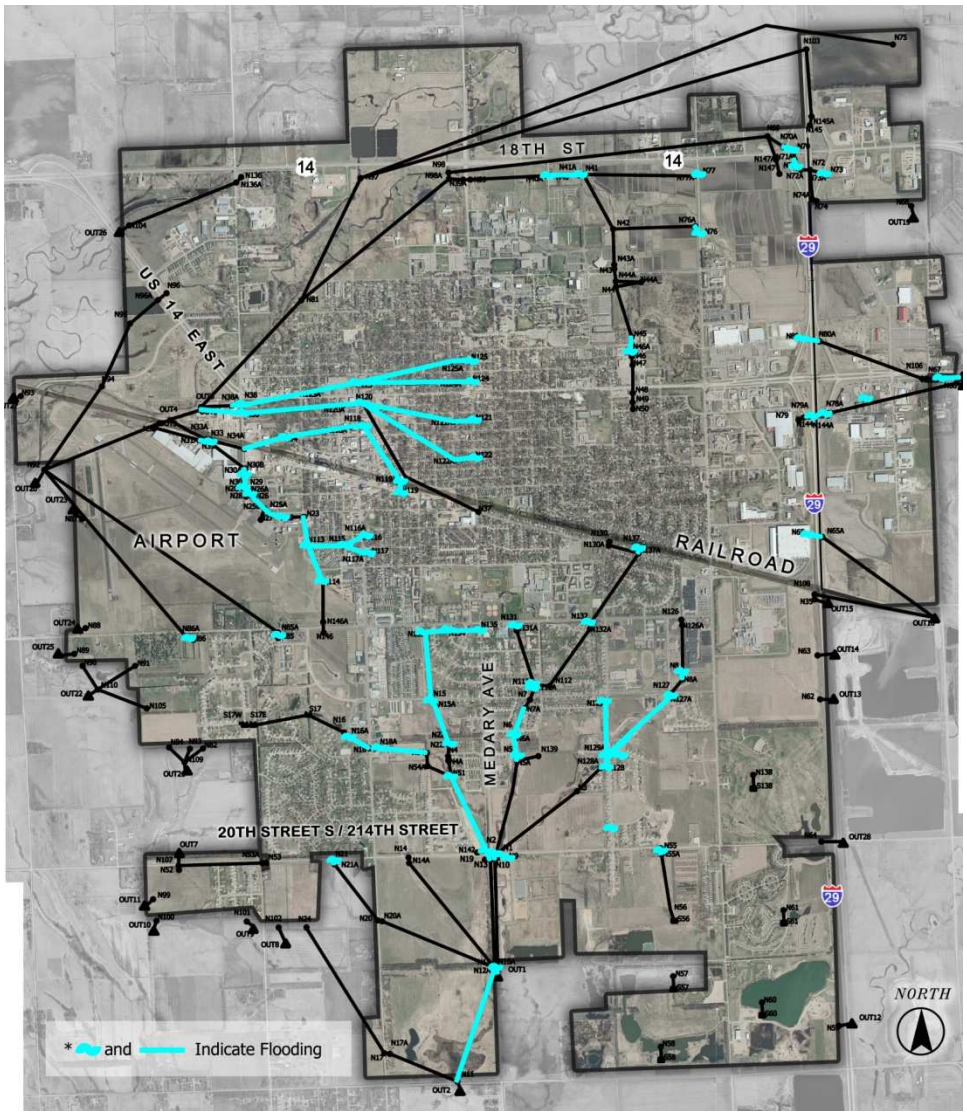

Figure 8 - FLOODING DURING THE FUTURE CONDITIONS SWMM MODEL - 5-YEAR STORM

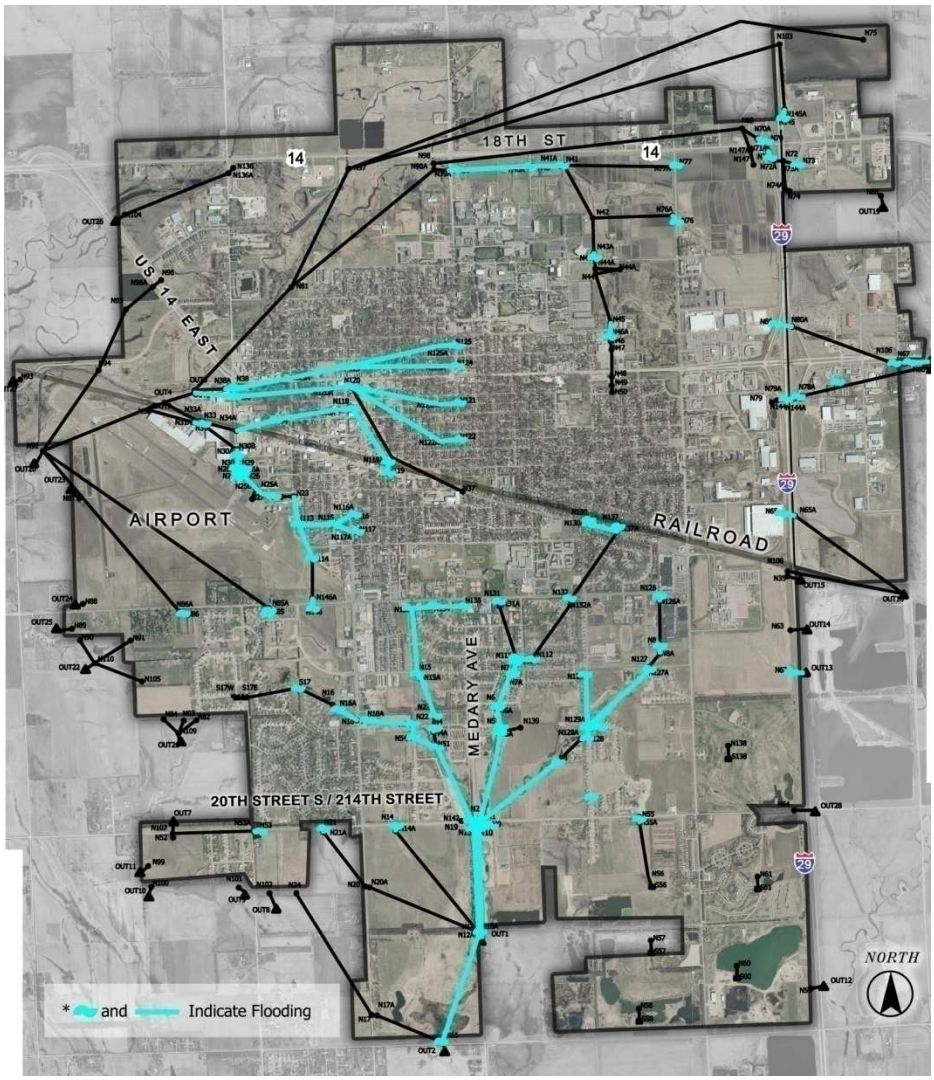

Figure 9 - FLOODING DURING THE FUTURE CONDITIONS SWMM MODEL - 100-YEAR STORM

3. Model 3: Future Land Conditions with Recommended Improvements for the 5-year 24-hour Storm Event

Minimal flooding occurred during the 5-year storm and the storage facilities were approximately 100% and 20% - 50% full for proposed detention and existing retention respectively. This model was used to determine improvements needed to effectively pass the 5-year storm. Recommended improvements can be found in the following section. Results for this model can be found in Appendix E.

4. Model 3: Future Land Conditions with Recommended Improvements for the 100-year storm event

No nodes were flooded during the 5-year storm and the proposed storage facilities were between 35% and 48% full during peak flows. Minimal flooding occurred during the 100-year storm and the storage facilities were approximately 100% and 55-89% full for proposed detention and existing retention respectively. This model was used to determine improvements needed to effectively pass the 100-year

storm. Recommended improvements can be found in the following section. Results for this model can be found in Appendix E.

5. Model 4: Heavily Vegetated Channels

Since no flooding occurred in Model 4 during the 5-year storm event it was ideal to use it to determine the magnitude of the impacts of heavily vegetated channels on the drainage system. For this sensitivity analysis the Manning's roughness coefficient was changed for grass swales to represent heavily vegetated swales (n=0.12). Given this change flooding was predicted at 13 locations throughout the model during the 5-year storm event. This means that grass swales sized to pass the 100-year storm event were unable to effectively pass the 5-year storm event because the vegetation was too dense. Results for this model can be found in Appendix E. These results underscore the need to not only construct, but to also properly maintain drainage facilities in order for them to function as intended.

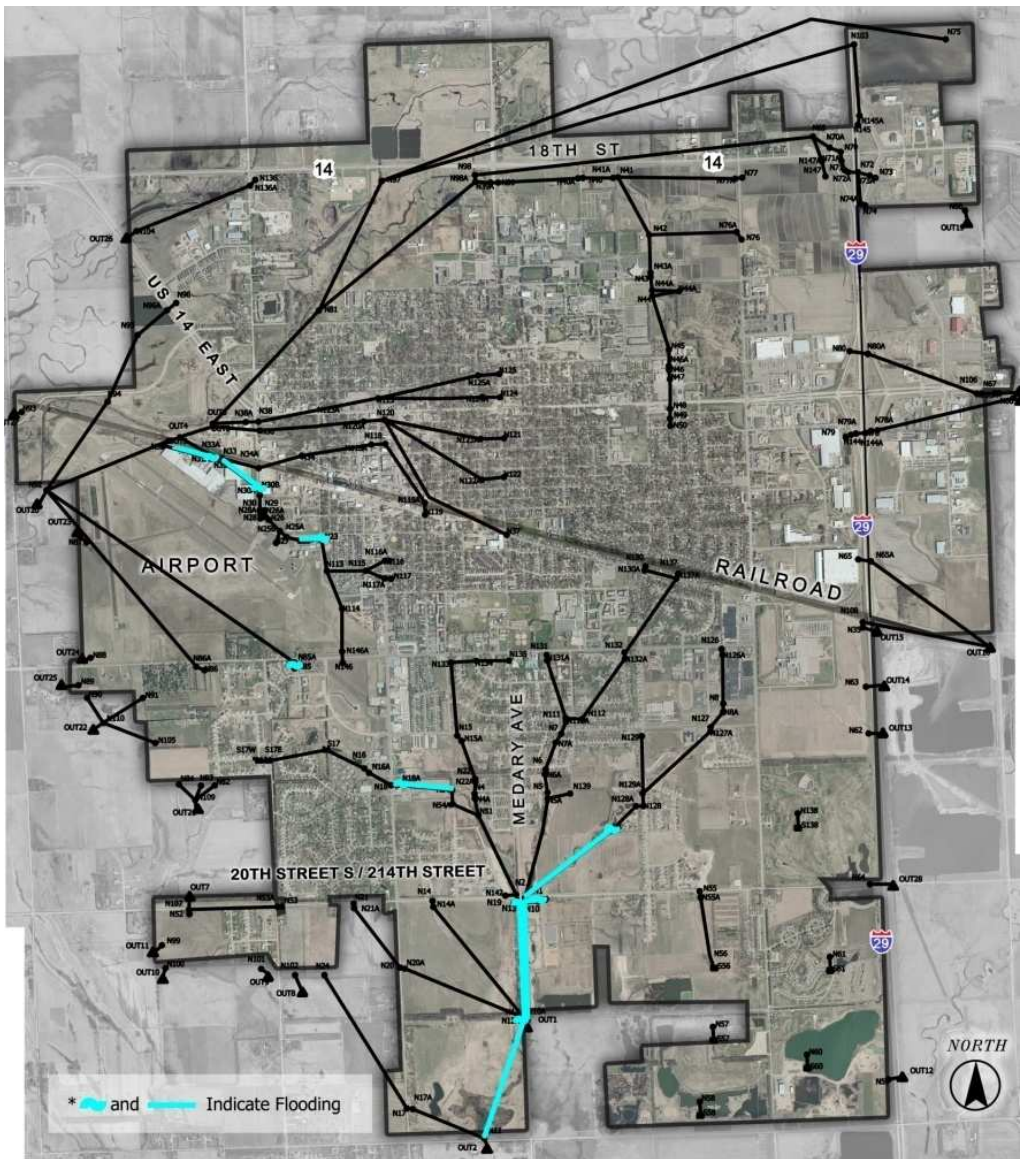

Figure 10 - FLOODING DURING THE HEAVILY VEGETATED CHANNELS SWMM MODEL

V. RECOMMENDED IMPROVEMENTS

A. INTRODUCTION

A wide array of alternatives can be examined and used to offset the impact of urbanization on drainageways. These alternatives include the "do nothing" approach, the full conveyance approach and the use of detention/retention for flood control. The "do nothing" approach has the lowest initial capital cost but does not address the impacts an urbanizing watershed will have on its receiving drainageways and downstream development. The full conveyance approach looks to channelize all waterways to fully convey large flood events or, in areas with frequent flooding problems, smaller flood events. This alternative can be cost effective but may require significant alternation of natural resources to accommodate channels and may deleteriously impact downstream areas if they are not also examined. The cost effectiveness of the full conveyance approach is greatly reduced when this approach is not planned from the beginning of development and costly retrofitting is required for downstream facilities. It may also not be feasible if existing development does not have the room for the retrofitting needed for this approach. Using the detention/retention for flood control alternative lessens the cost and size of downstream conveyance systems but also requires land resources and costs. The detention facilities can be used for other functions such as urban open spaces, athletic fields and wildlife habitat. Two categories of flood control can be considered: on-site facilities that serve individual land development projects and regional facilities that serve a larger area.

As has been observed, flooding is already a problem in the City and the problem is worsening as more development occurs and previously pervious land is converted to impervious surfaces. The "do nothing" approach therefore does not meet the City's objectives and was not used. The two alternatives that will be used are the full conveyance approach and using detention/retention for flood control.

B. RECOMMENDED IMPROVEMENTS FOR STUDY AREAS

The City requested improvement recommendations for specific areas within the project area that are currently flooding or where future development was known and drainage conduit sizes were needed. These areas were analyzed for both the 5-year and 100-year storms. In all of these recommendations it is assumed that the entire 5-year and 100-year flows reach the study area. The upstream conveyances are assumed to be capable of passing these flows. The downstream conveyances were also assumed to be capable of passing both storms. Some of the areas received recommendations in the Capital Improvement Section that follows. All calculations used for the study areas can be found in Appendix F.

1. Xtra Space Storage: W. 2nd Street & W. Folsom Street

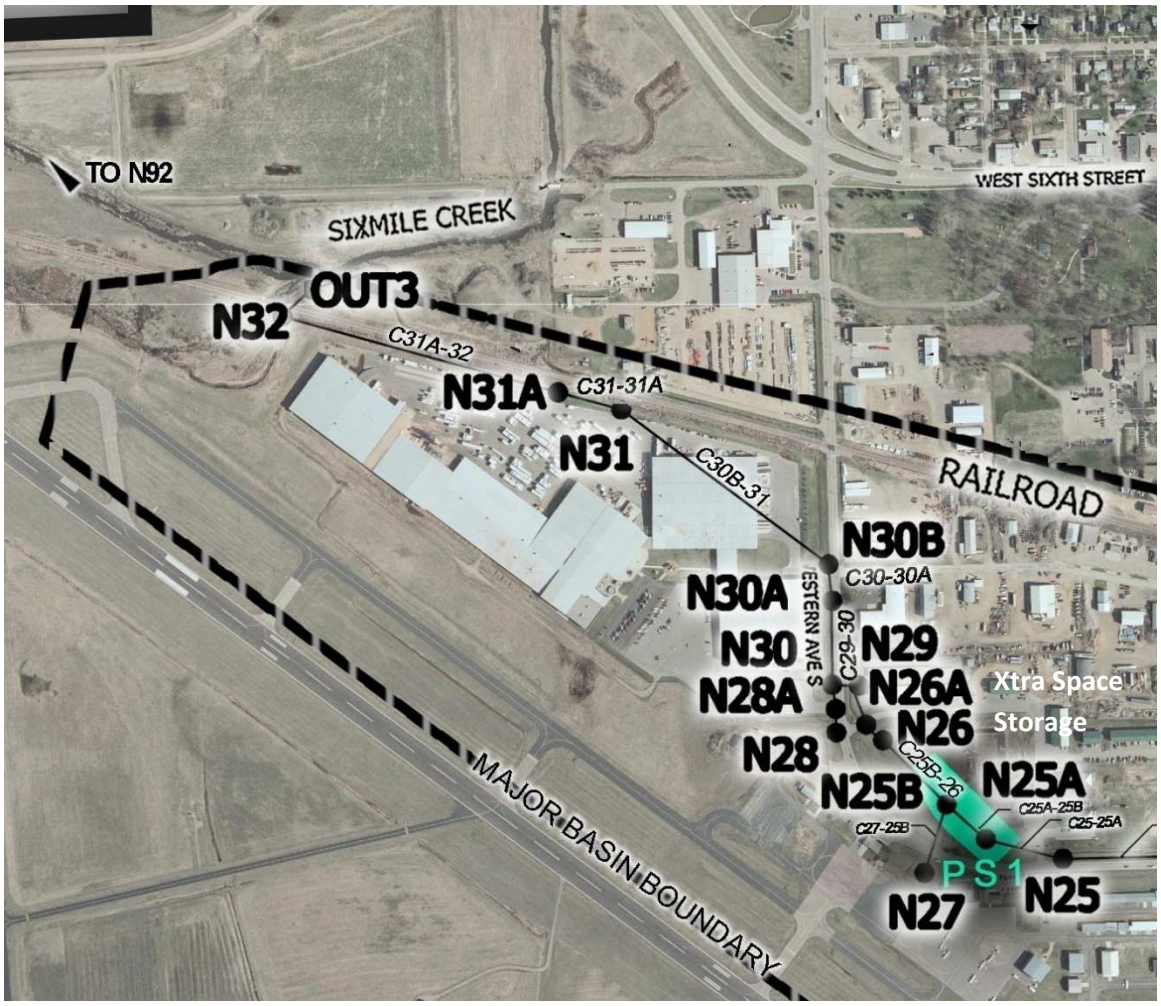

Figure 11 - STUDY AREA 1 MAP

Approximately 254.20 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate inflows to this site of 230-cfs and 466-cfs for the 5-year and the 100-year storms respectively. A swale, responsible for carrying this flow, is adjacent to Xtra Space Storage and outfalls to a 24” CMP. According to the available topography, at a flow depth greater than 2’ the water from the swale enters Xtra Space Storage and causes flooding. Based on hydraulic calculations the depth of water in the swale exceeds this two foot depth once the inflow rate exceeds approximately 130 cfs. The receiving 24” CMP cannot effectively pass the 5-year and 100-year storm. The study area was evaluated to determine the impacts of placing a detention facility in the area adjacent to Xtra Space Storage.

a) Possible Solutions – 5-year storm

- Detention

The area where the swale is currently located has been designated as a possible detention area. A pond with 3:1 side slopes was analyzed in this area and it was determined a 6.52 acre-feet (ac-ft) pond may be feasible (PS1). In order for the pond to not flood during a 5-year storm a 3.5' x 3' outlet structure with a 2.5' x 2.4'orifice would be required. The smaller opening ensures that the storage is maximized and the lowest rate possible is being released without the pond overtopping. This detention facility and outlet would decrease the 5-year flows at this location from 230-cfs to 70-cfs. It would also prevent the flooding of the Xtra Space Storage facility by the flows that reach this area. It would not, however, prevent the flooding of Xtra Space Storage from flows that reach it from the north or east. It is recommended that the existing system be replaced with concrete boxes or upsized up to the culvert under Railroad Street West (N30B) where it will return to the existing swale. Swales downstream of this culvert, other than some possible grading, do not require any improvements. The downstream railroad crossing will also require an enlargement. These improvements require that all culverts and pipes have a minimum slope of 0.5%. If a greater slope may be used the size of the closed conveyances may be able to be decreased. Recommended improvements are found below.

Xtra Space Storage is located in a low point so some flooding will occur on the property. The implementation of the detention area will lessen the extent of the flooding significantly.

Upstream Node	Conduit	Recommended Improvement 5-yr
N25	C25-25A	(2) 60" CMP (1 Exists)
N25A	C25A-25B	Pond with a 3.5' x 3' Concrete Box Culvert with a 2.5' x 2.4' orifice
N25B	C25B-26	
N26	C26-26A	
N26A	C26A-29	5' x 4' Concrete Box Culvert
N29	C29-30	7.5' x 5' Concrete Box
N30	C30-30A	8' x 5' Concrete Box
N30A	C30A-30B	(2) 42" RCP (1 exists)
N30B	C30B-31	No Improvements Recommended
N27	C27-25B	No Improvements Recommended
N28	C28-28A	No Improvements Recommended
N28A	C28A-30	24" RCP
N31	C31-31A	6.5' x 4' Concrete Box
N31A	C31A-32	No Improvements Recommended
N32	C32-3	No Improvements Recommended

Table 5 – STUDY AREA 1: RECOMMENDED IMPROVEMENTS WITH DETENTION – 5 YEAR

- No detention

The area was also analyzed to determine the impacts of no detention facility being constructed. In the event that the detention facility cannot be constructed, a way to pass the 5-year peak flow through this area will be needed. Flows through the area would then likely require larger culverts and pipes. All pipe slopes will need to be a minimum of 0.5% and the downstream conveyances starting at the culvert under Railroad Street West (N30B) will have less of a slope then was allowed with detention. Although this will not prevent Xtra Space Storage from flooding it will reduce the flooding significantly. Recommended improvements are found below.

Upstream Node	Conduit	Recommended Improvement 5-yr
N25	C25-25A	(2) 60” CMP
N25A	C25A-25B	5’ x 5’ Concrete Box Culvert or Grass Channel (b=3.5', d=2.7', z=4:1) or Concrete Channel (b=3', d=2', z=4:1)
N25B	C25B-26	
N26	C26-26A	5’ x 5’ Concrete Box Culvert
N26A	C26A-29	5’ x 5’ Concrete Box Culvert
N29	C29-30	5.5’ x 5’ Concrete Box Culvert
N30	C30-30A	6’ x 5’ Concrete Box Culvert
N30A	C30A-30B	6’ x 5’ Concrete Box Culvert
N30B	C30B-31	No Improvements Recommended
N27	C27-25B	No Improvements Recommended
N28	C28-28A	No Improvements Recommended
N28A	C28A-30	24" Reinforced Concrete Pipe (RCP)
N31	C31-31A	10' x 5' Concrete Box
N31A	C31A-32	No Improvements Recommended
N32	C32-3	No Improvements Recommended

Table 6 – STUDY AREA 1: RECOMMENDED IMPROVEMENTS WITH NO DETENTION – 5 YEAR

b) Possible Solutions – 100-year storm

- Detention

A pond with 3:1 side slopes was analyzed in this area and it was determined 6.52 acre-feet (ac-ft) pond may be feasible (PS1). In order for the pond to not flood during a 100-year storm a 7' x 4.5' outlet structure with a 5.7' x 4.3'opening would be required. The smaller opening ensures that the storage is maximized and the lowest rate possible is being released without the pond overtopping. This detention facility and outlet would decrease the 100-year flows at this location from 466-cfs to 279-cfs. It would also prevent the flooding of the Xtra Space Storage facility by the flows that reach this area. It would not, however, prevent the flooding of Xtra Space Storage from flows that reach it from the north or east. It will require the enlargement of the receiving system and that all culverts and pipes have a minimum slope of 0.5%. If a greater slope may be used the size of the closed conveyances may be able to be decreased. Recommended improvements are found below.

Xtra Space Storage is located in a low point so some flooding will occur on the property. The implementation of the detention area will lessen the extent of the flooding significantly.

Upstream Node	Conduit	Recommended Improvement 100-yr
N25	C25-25A	6.5' x 5' Concrete Box Culvert
N25A	C25A-25B	Pond with a 7' x 4.5' outlet structure with as 5.7' x 4.3' orifice
N25B	C25B-26	
N26	C26-26A	
N26A	C26A-29	7' x 4.5' Concrete Box Culvert
N29	C29-30	7.5' x 5' Concrete Box Culvert
N30	C30-30A	8' x 5' Concrete Box Culvert
N30A	C30A-30B	8' x 5' Concrete Box Culvert
N30B	C30B-31	No Improvements Recommended
N27	C27-25B	No Improvements Recommended
N28	C28-28A	(2) 24" RCP (1 Exists)
N28A	C28A-30	(2) 24" RCP (1 Exists)
N31	C31-31A	(2) 8' x 5' Concrete Box
N31A	C31A-32	No Improvements Recommended
N32	C32-3	No Improvements Recommended

Table 7 – STUDY AREA 1: RECOMMENDED IMPROVEMENTS WITH DETENTION – 100 YEAR

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-
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- No detention

The area was also analyzed to determine the impacts of no detention facility being constructed. In the event that the detention facility cannot be constructed, a way to pass the 100-year peak flow through this area will be needed. Flows through the area would then likely require larger culverts and pipes. All pipe slopes will need to be a minimum of 0.5% and the downstream conveyances starting at the culvert under Railroad Street West (N30B) will have less of a slope then was allowed with detention. Although this will not prevent Xtra Space Storage from flooding it will reduce the flooding significantly. Recommended improvements are found below.

Upstream Node	Conduit	Recommended Improvement 100-yr
N25	C25-25A	7’ x 5’ Concrete Box Culvert
N25A	C25A-25B	8.5’ x 5’ Concrete Box Culvert or Grass Channel (b=4', d=3.5', z=4:1) or Concrete Channel (b=3', d=3', z=4:1)
N25B	C25B-26	
N26	C26-26A	8.5’ x 5’ Concrete Box Culvert
N26A	C26A-29	8.5' x 5' Concrete Box Culvert
N29	C29-30	10.5' x 5' Concrete Box Culvert
N30	C30-30A	10.5' x 5' Concrete Box Culvert
N30A	C30A-30B	11' x 5' Concrete Box Culvert
N30B	C30B-31	Grass Channel (b=14.2', d=4.5', z=4:1) or Concrete Channel (b=5', d=4', z=4:1)
N27	C27-25B	No Improvements Recommended
N28	C28-28A	(2) 24" RCP
N28A	C28A-30	(2) 24" RCP
N31	C31-31A	(2) 11' x 5' Concrete Box Culvert
N31A	C31A-32	Grass Channel (b=10.5', d=5', z=4:1) or Concrete Channel (b=5', d=5', z=4:1)
N32	C32-3	Grass Channel (b=11.5', d=5', z=4:1) or Concrete Channel (b=5', d=5', z=4:1)

Table 8 – STUDY AREA 1: RECOMMENDED IMPROVEMENTS WITH NO DETENTION – 100 YEAR

2. Area behind houses at Hammond Avenue & Horner Avenue, North of Squire Court

Figure 12 - STUDY AREA 2 MAP

a) Inlet Analysis

Approximately 7.10 acres are tributary to this area and storm drainage flows via overland flow to the inlet resulting in flows of 6-cfs and 12-cfs for the 5-year storm and 100-year storm respectively. Using the weir equation and a standard length for an open inlet, the head required to allow this flow into the throat of the inlet is 0.52' and 0.84' for the 5-year and 100-year flows respectively. Based on the topography, this would cause slight ponding at the inlet but not enough to flood the houses. A more detailed survey of the area behind the houses would need to be done to determine the true extents of the flooding.

b) Pipe System Analysis

Approximately 47.67 acres flow to this study area via overland and pipe flow. This results in flows of 55-cfs and 79-cfs for the 5-year and the 100-year storms respectively. Assuming that the 30" RCP leaving the inlet has a slope of 0.5%, the pipe's capacity is 29-cfs, much lower than the flows reaching the pipe.

The inadequacy of the pipe would explain the flooding that has been seen at the inlets located in the cul-de-sac of Hammond. This indicates that the pipe leaving the inlet will need to be upsized to allow for the passage of the inflows. This will require a 48" pipe at 0.5% to pass both the 5-year and 100-year storms. This will also require the replacement of the pipes downstream of the inlet. A more detailed hydrologic study including survey of the area and head losses will need to be done to ensure this upsize will relieve the flooding problems at both this inlet and the inlets located in the cul-de-sac.

Storm Event	Recommended Improvement
5- Year Storm	More detailed hydraulic analysis with survey.
100- Year Storm	More detailed hydraulic analysis with survey.

Table 9 – STUDY AREA 2: RECOMMENDED IMPROVEMENTS – 5-YEAR AND 100 YEAR

3. LeFevre Drive

a) Inlet Analysis

Approximately 19.66 acres are tributary to the existing 18" pipe inlet with drainage reaching this location via overland flow. SWMM results with future conditions indicate inflows to this site of 56-cfs and 109-cfs for the 5-year and the 100-year storms respectively. Based on available topography the flooding will occur when the flow ponds 2' thus the pipe size contributes to the flooding. According to the orifice equation, the amount of head the receiving 18" RCP requires to effectively pass the 5-year storm 100-year storm is not feasible is well above the depth at which flooding will occur. Based on available topography the flooding will occur when the flow ponds 2', thus the inlet size contributes to the flooding. Based on existing information the existing 18" RCP has a slope of 0.16% giving it a capacity of 4.2-cfs. Since the slopes required for the 18" RCP to pass these storms are not possible, the recommendation is to enlarge the 18" RCP to a 6.5' x 1.5' concrete box or 4.5' x 2' at 0.5% or a 7.5' x 2' concrete box culvert at 0.5% for the 5-year and 100-year storms respectively. The location of the inlet should be brought to the curb line if possible and placed into a sump. If a box culvert is not desirable, a series of open curb inlets may be used. If it is not possible to move the inlet to the curb line, open throated inlets and yard inlets should be investigated. Also, the area immediately surrounding the inlet should be analyzed to ensure it drains properly and the area should be regraded if it is found that it does not allow proper drainage.

b) Pipe System Analysis

Approximately 80.09 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate inflows to this site of 96-cfs and 200-cfs for the 5-year and the 100-year storms respectively. A swale, responsible for carrying this flow, is adjacent to the gas station and outfalls to double 60" CMP. Assuming these pipes have the minimum slope of 0.5%, both the 5-year and 100-year storms are passed effectively with minimal flooding. Currently, this swale and the downstream swales are heavily vegetated. To ensure that flows can pass through the swale and can reach the double 60" CMP from the inlet located on LeFevre Drive these swales need to be well maintained.

Storm Event	Recommended Improvement for 18" RCP inlet
5- Year Storm	6.5' x 1.5' Concrete Box Culvert or 4.5' x 2' Concrete Box Culvert
100- Year Storm	7.5' x 2' Concrete Box Culvert

Table 10 – STUDY AREA 3: RECOMMENDED IMPROVEMENTS – 5-YEAR AND 100-YEAR

4. Drainage ditch between Garden Square Apartments and Garden Village Townhouses

Approximately 282.52 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate flows to this site of 224-cfs and 457-cfs for the 5-year and the 100-year storms respectively. A concrete valley gutter, responsible for carrying this flow, is located between two housing developments and outfalls into a grass swale. Its western bank slope is grass at approximately 3:1 and its eastern bank is a 1' concrete block and then grass at 3:1. Based on available topography, the valley gutter has a slope of 0.6% and an allowable ponding depth of 2'. Field measurements verified that it is a 5' wide valley gutter that is approximately 300' long. A sewer manhole partially obstructs the channel. Based on hydraulic calculations the valley gutter has a capacity of 160-cfs with a 2' flow depth and a capacity of 44-cfs with a 1' flow depth. A flow depth of 2.9' and 4.6' is needed to pass the 5-year and 100-year storms respectively. These calculations assume no blockages within the channel.

a) Possible Solutions – 5-year storm

The size of the conduit necessary to pass the 5-year storm effectively is dependent on the depth allowed and whether the conduit is open or closed. The recommended improvements are an open concrete rectangular channel or a concrete box culvert. The effect of the exposed sewer manhole on the hydraulics of the channel cannot be determined based on available information. However, it does create an obstruction to the flow through this area thus; it is recommended that it is lowered to the elevation of the channel.

Allowable Depth (ft)	Recommended Improvement – 5 year
2	Rectangular Concrete Channel (b=9.5')
2.5	Rectangular Concrete Channel (b=7.5')
2	(2) Concrete Box Culverts (b=7')
2.5	Concrete Box Culvert (b=9.5')
3	Concrete Box Culvert (b=7.5')

Table 11 – STUDY AREA 4: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Possible Solutions – 100-year storm

A very high flow is being passed through this area during the 100-year storm and for safety reasons it is recommended that a closed conduit be used. Double 7.5' x 3' concrete boxes are recommended for this area. The effect of the exposed sewer manhole on the hydraulics of the channel cannot be determined based on available information. However, it does create an obstruction to the flow through this area thus; it is recommended that it is lowered to the elevation of the channel.

Recommended Improvement – 100 year
(2) 7.5' x 3' Concrete Box Culvert

Table 12 – STUDY AREA 4: RECOMMENDED IMPROVEMENTS – 100 YEAR

5. 6TH Avenue viaduct under the Dakota, Minnesota and Eastern Railroad

Approximately 51 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate flows to this site of 71-cfs and 129-cfs for the 5-year and the 100-year storms respectively. A storm sewer line and inlets currently exist in this area but are overpowered by storm flows. The existing 18" RCP storm sewer has a capacity of 7.43-cfs at 0.5%. The pipe size needed to effectively pass the 5-year and 100-year flows was evaluated and was found to be 48" RCP and 54" RCP respectively. Making the pipes at this location larger will either require the upsizing of the receiving system or a bypass system that will allow pipes of this size to outfall to an existing system in another location. An evaluation of the available existing storm sewer information places the closest connection point (without requiring the upsizing of the receiving storm sewer) at a 30" x 45" arch RCP at the intersection of Fifth Street and Second Avenue. This would require the crossing of smaller existing storm sewer systems and, based on available topography, would not allow for the minimum required pipe slope of 0.5%. Also, it would increase the amount of flow in this system significantly requiring costly upsizing. Thus, the 6th Avenue viaduct lies in a localized depression and may not have a feasible outlet.

a) Possible Solutions – 5-year and 100-year storm

The installation of a flood warning system is recommended at this location. The system should include a flashing light warning sign to indicate lesser flooding conditions and gates for flooding of 0.33' or more.

Storm Event	Recommended Improvement for 18" RCP inlet
5- Year Storm	Flashing warning system and gates
100- Year Storm	Flashing warning system and gates

Table 13 – STUDY AREA 5: RECOMMENDED IMPROVEMENTS – 5 YEAR AND 100 YEAR

6. Medary Avenue South and 20th Street South

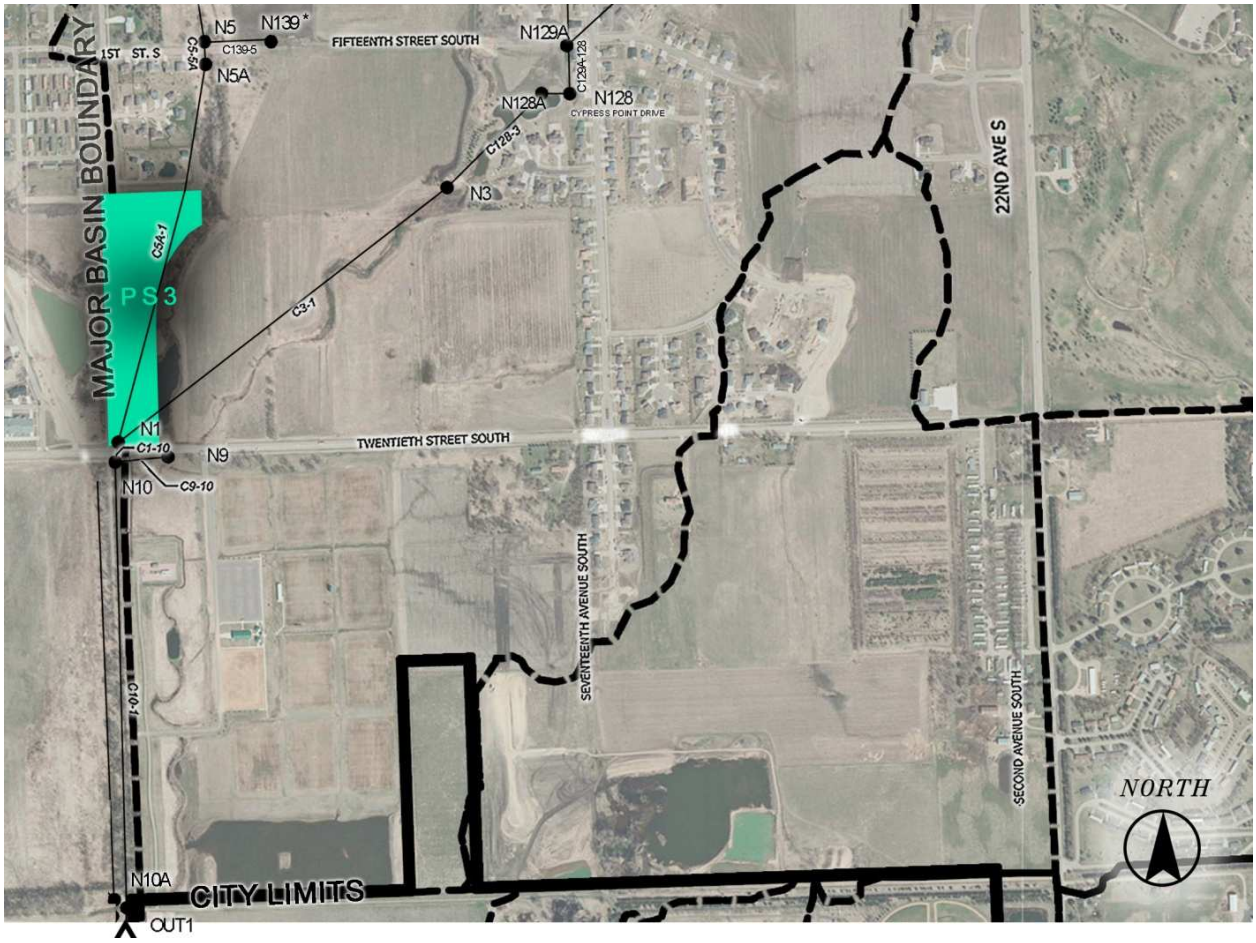

Figure 13 - STUDY AREA 6 – NORTHEAST CORNER

<u>Northeast corner</u>

Approximately 734.7 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate inflows to this site of 563-cfs and 1,087-cfs for the 5-year and the 100-year storms respectively. One 24" RCP currently serves as drainage for the Medary Avenue South street crossing. The pipe outfalls south into an existing swale located in a park. Medary Avenue South was constructed to act as an emergency spillway during larger storms. Block 8, located at Southland Avenue, has also been designated as a possible detention area. It was used as such for this analysis. The effects on this study area if the Southland Lane facility is not constructed are discussed in Study Area 10.

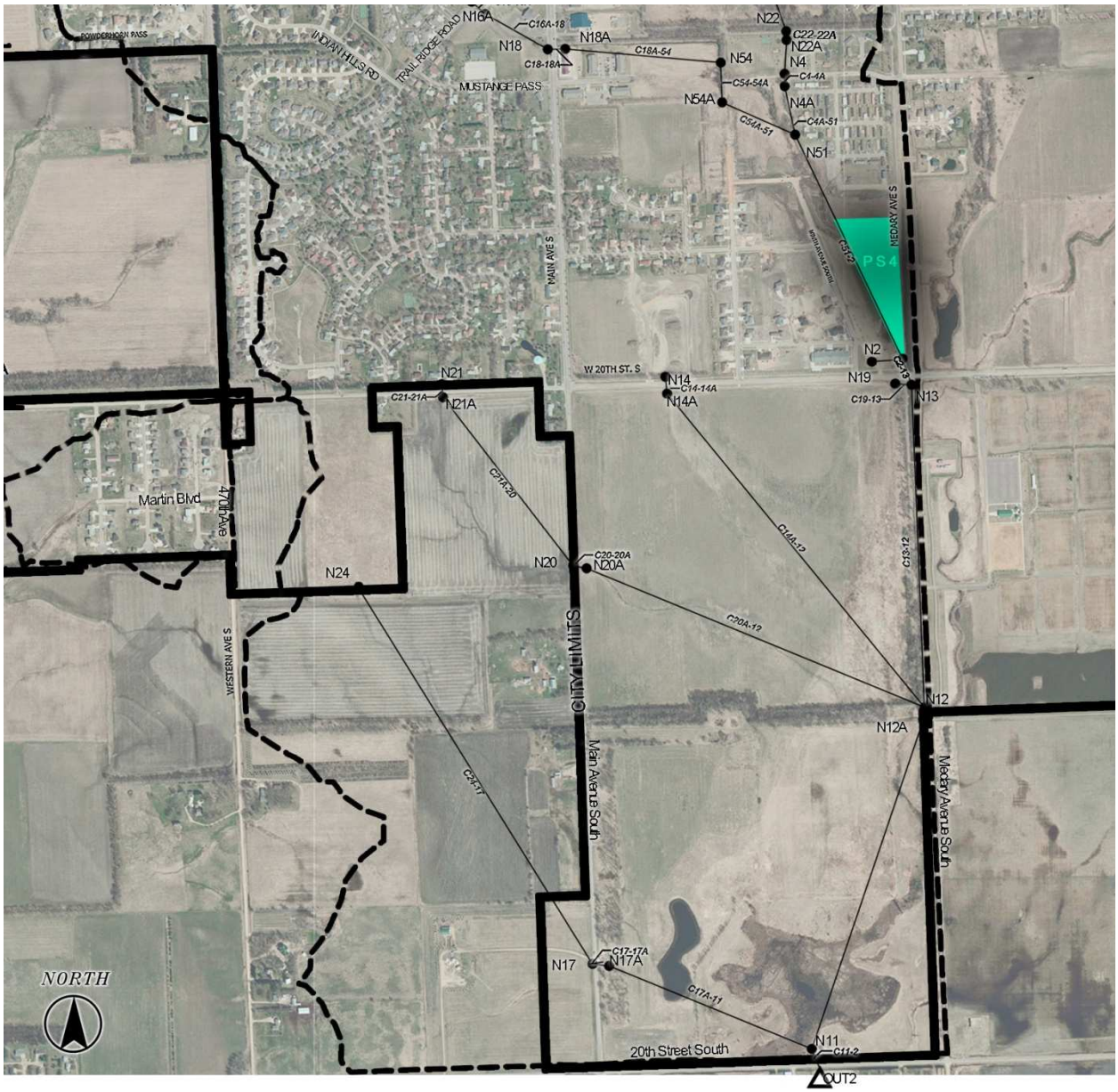

Figure 14 - STUDY AREA 6 – NORTHWEST CORNER

<u>Northwest corner</u>

Approximately 731.1 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate inflows to this site of 217-cfs and 679-cfs for the 5-year and the 100-year storms respectively. Existing detention facilities located in the Timberline Addition and the Indian Hills Addition are within the drainage basin to this location. This would account for the lower flows reaching this area during the storm events. Two 24” RCP currently serve as drainage for the Medary Avenue South street crossing. These pipes outfall into an existing swale in an undeveloped area. Medary Avenue South was constructed to act as an emergency spillway during larger storms. The City owned area located at the future intersection of 15th Street South and 7th Avenue South has also been

designated as a possible detention area. It was used as such for this analysis. The effects on this study area if this facility is not constructed are discussed in Study Area 9.

a) Possible Solutions – 5-year storm

Northeast corner

This area has been designated a possible detention area. Based on available information, a 45.16 ac-ft detention pond may be feasible (PS3). This would lessen the outflow from 563-cfs to 94-cfs with a 4' x 3.5' box outlet with a 3' x 3' orifice. The smaller opening is required to ensure the pond is maximizing its storage and releasing the lowest rate possible. This would require no improvements to the swale south of Medary Avenue South and east of 20th Street South. From here flows leave the City limits. Their effects on properties downstream would have to be evaluated during design.

Upstream Node	Conduit	Recommended Improvement 5-yr
N5A	C5A-10	8' x 4' Concrete Box Culvert outfalling into a Detention Pond with 4' x 3.5' Concrete Box Culvert Outlet with a 3'x3' Orifice
N10	C10-10A	No Improvements Recommended
N10A	C10A-1	48" RCP

Table 14 – STUDY AREA 6: RECOMMENDED IMPROVEMENTS NORTHEAST CORNER – 5 YEAR

Northwest corner

This area has been designated a possible detention area. Based on available information, a 23.44 ac-ft detention pond may be feasible (PS4). The detention would lessen the outflow from 217-cfs to 68-cfs with a 3.5' x 3' concrete box outlet with a 2.6' x 2.5' orifice. This would not require any enlargement of the swale south of Medary and west of 20th Street South. It is recommended that the culvert located midway between 20th Street South and 32nd Street South (N12), where it receives water from the northwest and the downstream swale, be enlarged. It would not require the upsizing of the culvert under 32nd Street South. From here flows leave the City limits. Their effects on properties downstream would have to be evaluated during preliminary design.

Currently this receiving area is undeveloped and will not experience significant damage by flooding. If this is acceptable then no improvements south of Medary Avenue South may be required. This area is owned by the City and may, in the future, be designated for possible detention. Using this area as detention may be costly and may only benefit downstream properties not located within the City limits.

Upstream Node	Conduit	Recommended Improvement 5-yr
N51	C51-2	3.5' X3.' Concrete Box Culvert outfalling into a Detention Pond with a 3.5' x 3' Concrete Box Culvert Outlet with a 2.6' x 2.5' Orifice
N2	C2-13	3.5' x 3' Concrete Box Culvert
N13	C13-12	No Improvements Recommended
N12	C12-12A	4'x3' Concrete Box Culvert
N12A	C12A-11	Grass Channel (b=3.4', d=4', z=4:1) or Concrete Channel (b=2.5', d=4' z=4:1)
N11	C11-2	No Improvements Recommended

Table 15 – STUDY AREA 6: RECOMMENDED IMPROVEMENTS NORTHWEST CORNER– 5 YEAR

b) Possible Solutions – 100-year storm

Northeast corner

A detention pond with the capacity of 45.16 ac-ft is also recommended for the 100-year storm (PS3). This requires a double 9'x 4 concrete outlet structure with a 16' x 4' orifice to pass the 100-year flow with no pond overtopping. This lessens the outflow from 1,087-cfs to 667-cfs and requires the swale and culvert south of Medary Avenue South and east of 20th Street South to be enlarged to pass the resultant flows. From here flows leave the City limits. Their effects on properties downstream would have to be evaluated during preliminary design. Recommended improvements can be found below.

Currently, Medary Avenue South is designed to act as an emergency spillway during high flows. It may still be used as such if the 100-year outlet structure is not built. A structure to safely pass the minor storm should be constructed in this case. The area south of Medary Avenue South and east of 20th Avenue South may not be badly impacted by flows resulting from the 100-year storm and no improvement to them may be necessary. A more detailed evaluation of this area may be warranted depending on the City's concern for flooding at this parcel.

Upstream Node	Conduit	Recommended Improvement 100-yr
N5A	C5A-10	(2) 8' x 4' Concrete Box Culverts @ 0.5% Outfalling into a Detention Pond with (2) 9' x 4' Concrete Box Culvert Outlet with a 16' x 4' Orifice
N10	C10-10A	Grass Channel (b=30' d=4' z=4:1) or Concrete Channel (b =10', d=4' z=4:1)
N10A	C10A-1	(2) 7' x 4' Concrete Box Culverts

Table 16 – STUDY AREA 6: RECOMMENDED IMPROVEMENTS NORTHEAST CORNER – 100 YEAR

Northwest corner

A detention pond with the capacity of 23.44 ac-ft is also recommended for the 100-year storm (PS4). This pond would require a 12' x 4' concrete outlet structure with a 11.9' x 4' orifice to pass the 100-year flow with no pond overtopping. The detention facility would lessen the 100-year flow from 679-cfs to 511-cfs. This would require the swale and culvert south of Medary Avenue South and west of 20th Street South to be enlarged to pass the resultant flows. From here flows leave the City limits. Their effects on properties downstream would have to be evaluated during design.

Currently, Medary Avenue South is designed to act as an emergency spillway during high flows. It may still be used as such if the 100-year outlet structure is not built. A structure to safely pass the minor storm should be constructed in this case. As was stated in the recommended solution for the 5-year storm, the area south of Medary Avenue South and west of 20th Avenue South may not be badly impacted by flows resulting from the 100-year storm and no improvement to them may be necessary. This area is owned by the City and may, in the future, be designated for possible detention. Using this area as detention may be costly and may only benefit downstream properties not located within the City limits.

Upstream Node	Conduit	Recommended Improvement 5-yr
N51	C51-2	11.5' x 4' Concrete Box Culvert outfalling into a Detention Pond with a 12' x 4' Concrete Box Culvert Outlet with a 11.9' x 4' Orifice
N2	C2-13	12' x 4' Concrete Box Culverts
N13	C13-12	Grass Channel (b=21', d=4', z=4:1) or Concrete Channel (b=4.7', d=4' z=4:1)
N12	C12-12A	9'x4' Concrete Box Culvert
N12A	C12A-11	Grass Channel (b=34.7', d=4', z=4:1) or Concrete Channel (b=11.5', d=4' z=4:1)
N11	C11-2	(2) 8.5' x 4' Concrete Box Culverts

Table 17 – STUDY AREA 6: RECOMMENDED IMPROVEMENTS NORTHWEST CORNER– 100 YEAR

7. Medary Avenue South and its intersections with 1st and 2nd Streets

Figure 15 - STUDY AREA 7

This area was originally identified in a storm water investigation conducted in 1966 by J.T. Banner and Associates and was revisited in the Banner Study. Flooding occurs in the intersection of Medary and 2nd Street and is due to the overloading of the existing 10" storm sewer system. The flooding has been reported to be moderate and of short duration. It creates minor inconveniences to traffic and does not flood buildings.

This area was modeled in SWMM for the 5-year and 100-year storms. Each pipe was assumed to have a slope of 0.5% which is the minimum slope required by the City for storm sewer pipe. Approximately 175-cfs and 330-cfs reaches the storm sewer located at the intersection of Medary and 2nd during the peak 5-year and peak 100-year storm respectively. These flows require a 60" RCP to pass the 5-year storm and a 72" RCP to pass the 100-year flow. This will require the upsizing of the entire downstream storm drain system to accommodate receiving the flows that now pond and flow away from the system. It may be that under current conditions the water enters the system at a downstream inlet after the peak has passed. The addition of inlets was analyzed and is recommended for the intersection of Medary and 1st

to lessen the amount of overland flow that reaches the inlets at Medary and 2nd. This will only be helpful if the receiving piping system is upsized to adequately pass the 5-year and/or 100-year flows.

Upstream Node	Conduit	Recommended Improvement: 5-yr
NB7	CB7-A76	36” RCP
NA7	CA7-F7	54” RCP
NE7	CE7-D7	18” RCP
ND7	CD7-F7	30” RCP
NH7	CH7-G7	18” RCP
NG7	CG7-F7	18”RCP
NF7	CF7-1	60” RCP

Table 18 – STUDY AREA 7: RECOMMENDED IMPROVEMENTS – 5 YEAR

Upstream Node	Conduit	Recommended Improvement: 100-yr
NB7	CB7-A76	48” RCP
NA7	CA7-F7	66” RCP
NE7	CE7-D7	24” RCP
ND7	CD7-F7	42” RCP
NH7	CH7-G7	24” RCP
NG7	CG7-F7	24” RCP
NF7	CF7-1	72” RCP

Table 19 – STUDY AREA 7: RECOMMENDED IMPROVEMENTS – 100 YEAR

8. 15th Street South and Christine Avenue Extension

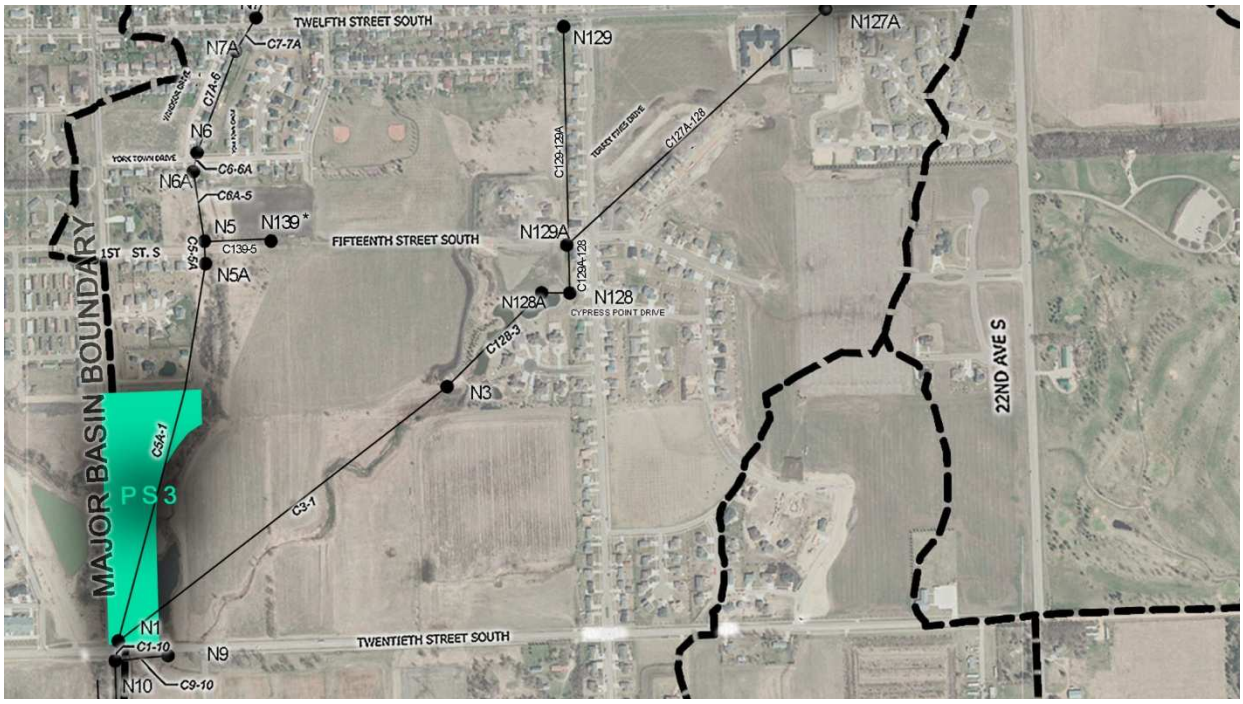

Figure 16 - STUDY AREA 8 MAP

Since the extension of 15th Street South will cross over an existing drainage swale, the size of culvert needed to pass the 5-year and 100-year storms was requested. This update was also included in the SWMM model though the addition of N139 and basin 155. In the existing conditions model, this node drains to N1 located at the northeastern corner of the intersection of Medary Avenue South and 20th Street South. In the future conditions model N139 drains to N5 which is located on the northern side of the 15th Street South extension. Approximately 306.8 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate inflows to this area of 320-cfs and 598-cfs for the 5-year and the 100-year storms respectively.

a) Possible Solutions – 5-year storm

An 8' x 4' concrete box culvert is recommended to safely pass the 5-year storm under the 15th Street S extension.

Upstream Node	Conduit	Recommended Improvement 5-yr
N5	C5-5A	8' x 4' Concrete Box Culvert at 0.5%

Table 20 – STUDY AREA 8: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Possible Solutions – 100-year storm

Double 7' x 4' concrete box culverts are recommended to safely pass the 100-year storm under the 15th Street S extension.

Upstream Node	Conduit	Recommended Improvement 100-yr
N5	C5-5A	(2) 7' x 4' Concrete Box Culvert at 0.5%

Table 21 – STUDY AREA 8: RECOMMENDED IMPROVEMENTS –100 YEAR

9. 15th Street South and 7th Street Extension

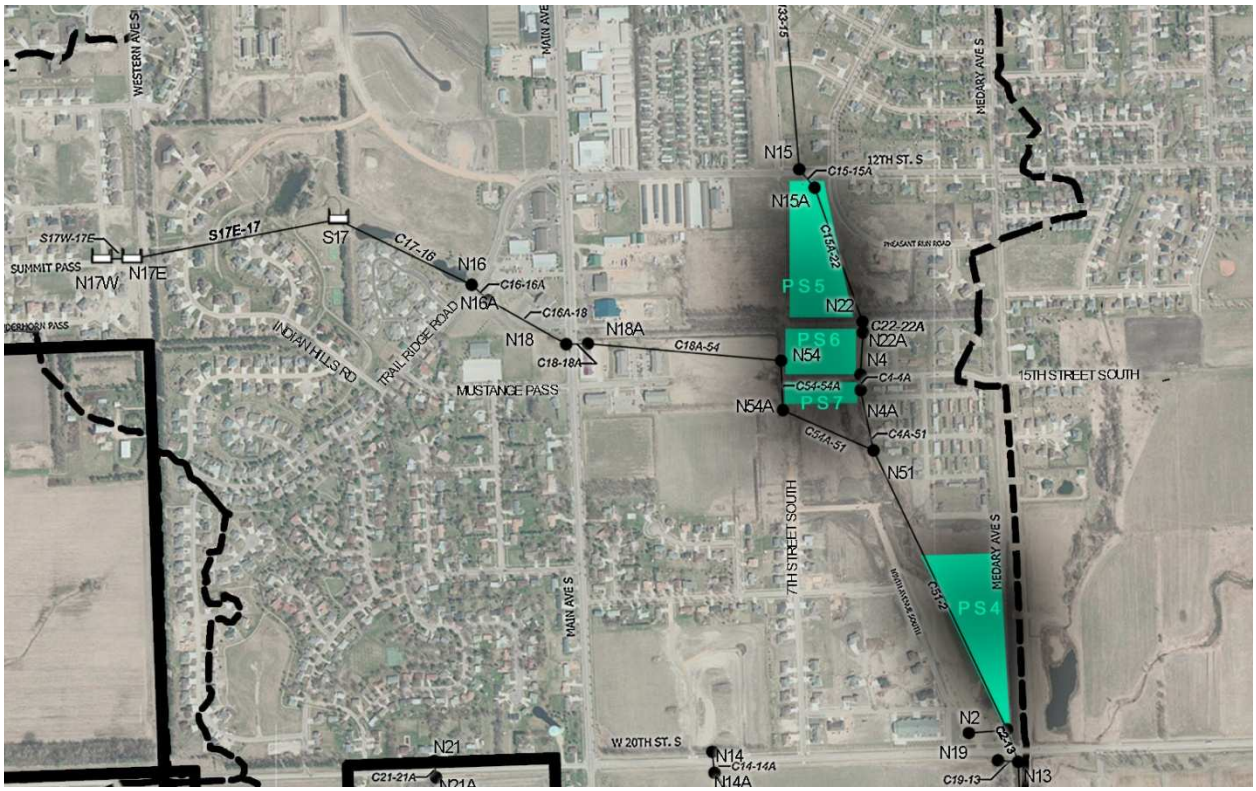

Figure 17 - STUDY AREA 9 MAP

Approximately 263.4 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate inflows to this site of 341-cfs and 677-cfs for the 5-year and the 100-year storms respectively. Existing detention facilities located in the Timberline Addition and the Indian Hills Addition are within the drainage basin to this location. This would account for the lower flows reaching this area during the storm events. Drainage that reaches this area currently flows southeast through a swale to the intersection of 20th Street South and Medary Avenue South.

This area was designated as a possible detention site and using it as such is recommended. This detention pond was divided into three ponds to accommodate an existing roadway and the future extension of 15th Street South.

a) Possible Solutions – 5-year storm

This area has been designated a possible detention area. Based on available information three ponds area feasible: PS5 (22.52 ac-ft), PS6 (8.75 ac-ft), PS7 (3.59 ac-ft). Three ponds are recommended rather than one larger pond to accommodate an existing roadway and the future extension of 15th Street South. This would lessen the outflow from 234-cfs to 99-cfs with the series of the three ponds. PS7 outfalls to PS4 located at the northwestern intersection of Medary Avenue South and 20th Street South (Study Area 6).This would require no improvements to the swale south of Medary Avenue South and east of 20th Street South but does require the upsizing of the culvert located midway between 20th Street South and 32nd Street South (N12) and the downstream swale. From here flows leave the City limits. Their effects on properties downstream would have to be evaluated during design.

Upstream Node	Conduit	Recommended Improvement 5-yr
N18	C18-C18A	No Improvements Recommended
N15	C15-N2	6' x 4' Concrete Box Culvert
N15	C15-N2	Detention Pond (PS5)
N15	C15-N2	4' x 3.5' concrete box outlet structure with a 3.4' x 3' Orifice
N15	C15-N2	Detention Pond (PS6)
N15	C15-N2	4.5' x 3.5' concrete box outlet structure with a 3.8' x3' Orifice
N15	C15-N2	Detention Pond (PS7)
N15	C15-N2	10.5' x 4' concrete box outlet structure with a 10.4' x 4' Orifice
N15	C15-N2	Detention Pond (PS4)
N15	C15-N2	(2) 6' x 4' concrete box outlet structure with a 10.9' x 4' Orifice
N2	C2-13	3.5' x 3' Concrete Box Culvert
N13	C13-12	No Improvements Recommended
N12	C12-12A	4'x3' Concrete Box Culvert
N12A	C12A-11	Grass Channel (b=3.4', d=4', z=4:1) or Concrete Channel (b=2.5', d=4' z=4:1)
N11	C11-2	No Improvements Recommended

Table 22 – STUDY AREA 9: RECOMMENDED IMPROVEMENTS WITH DETENTION– 5 YEAR

b) Possible Solutions – 100-year storm

This area has been designated a possible detention area. Based on available information three ponds area feasible: PS5 (22.52 ac-ft), PS6 (8.75 ac-ft), PS7 (3.59 ac-ft). Three ponds are recommended rather than one larger pond to accommodate an existing roadway and the future extension of 15th Street South. This would lessen the outflow from 614-cfs to 465-cfs with the series of the three ponds. PS7 outfalls to PS4 located at the northwestern intersection of Medary Avenue South and 20th Street South (Study Area 6).This requires improvements of the swales and culverts south of Medary Avenue South and 20th Street South. From here flows leave the City limits. Their effects on properties downstream would have to be evaluated during design.

Upstream Node	Conduit	Recommended Improvement 100-yr
N18	C18-C18A	Grass Channel (b=7', d=4', z=3:1) or (2) 7' x 4' Concrete Box Culverts
N15	C15-N2	6' x 4' Concrete Box Culvert
N15	C15-N2	Detention Pond (PS5)
N15	C15-N2	4' x 3.5' concrete box outlet structure with a 3.4' x 3' Orifice
N15	C15-N2	Detention Pond (PS6)
N15	C15-N2	11.5' x 4' Concrete Box Culvert Outlet with a 4' x 10.5' Orifice
N15	C15-N2	Detention Pond (PS7)
N15	C15-N2	11.5' x 4' Concrete Box Culvert Outlet with a 11.1' x 4' Orifice
N15	C15-N2	Detention Pond (PS4)
N15	C15-N2	12' x 4' Concrete Box Culvert Outlet with a 11.9' x 4' Orifice
N2	C2-13	12' x 4' Concrete Box Culverts
N13	C13-12	Grass Channel (b=21', d=4', z=4:1) or Concrete Channel (b=4.7', d=4' z=4:1)
N12	C12-12A	9'x4' Concrete Box Culvert
N12A	C12A-11	Grass Channel (b=34.7', d=4', z=4:1) or Concrete Channel (b=11.5', d=4' z=4:1)
N11	C11-2	(2) 8.5' x 4' Concrete Box Culverts

Table 23 – STUDY AREA 9: RECOMMENDED IMPROVEMENTS WITH DETENTION– 100 YEAR

10. Southland Lane and 12th Street South Detention

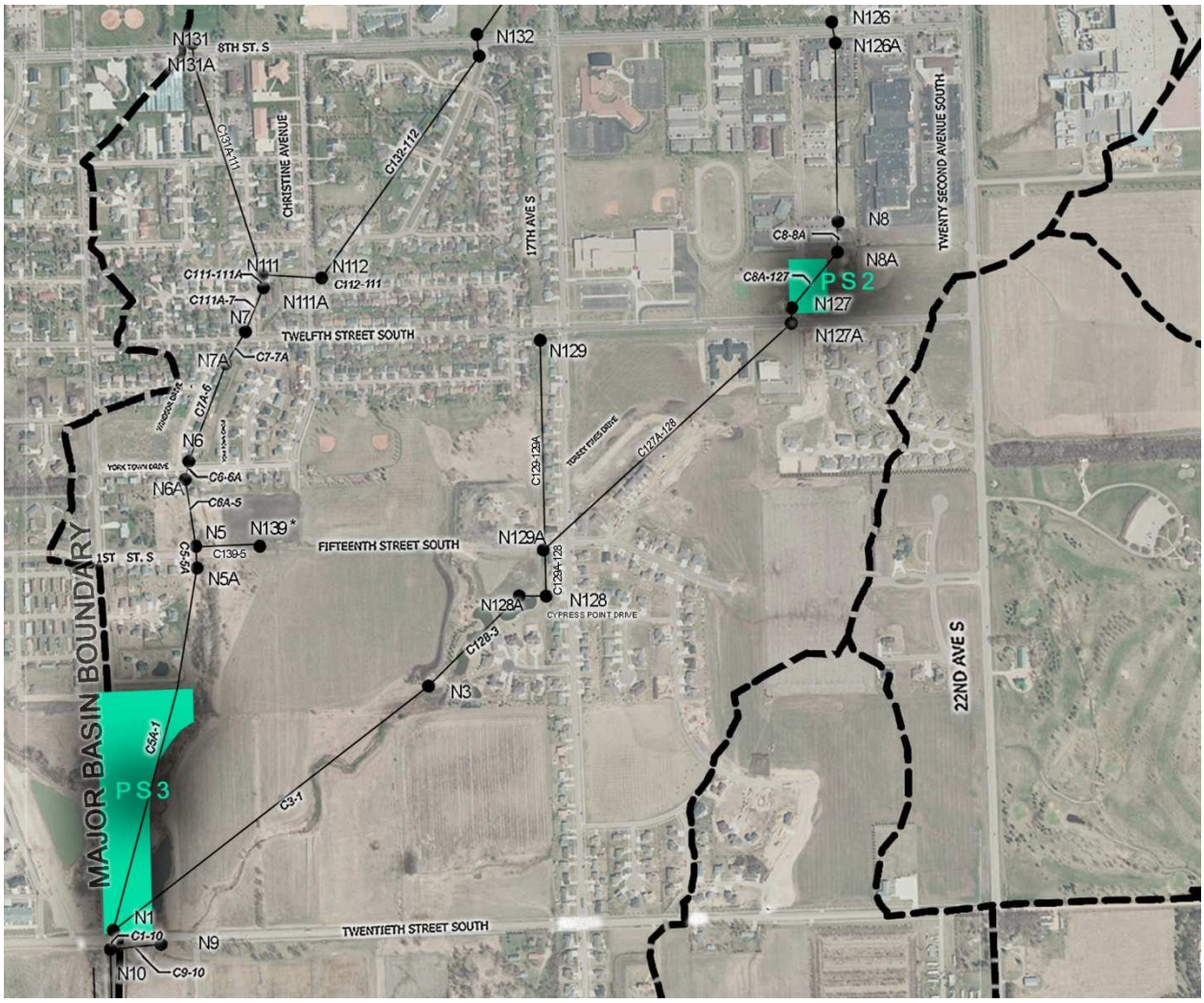

Figure 18 - STUDY AREA 10

Approximately 123.96 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate inflows to the area of 226-cfs and 442-cfs for the 5-year and the 100-year storms respectively. A grass swale, responsible for carrying this flow, currently exists in this area and outfalls to a 48" RCP.

a) Possible Solutions – 5-year storm

- Detention

This area will be designated as a possible detention area if it is acquired by the City. Based on available information, a detention pond the size of approximately 6.85 ac-ft is feasible. This detention pond would lessen the outflow from 226-cfs to 81-cfs with a 48" RCP outlet with a 3'x3.6' orifice. The smaller opening is required to ensure the pond is maximizing its storage and releasing the lowest rate possible. This indicates that the existing 48" RCP does not require upsizing. However, the entire downstream

system was not modeled and it is recommended that a more detailed analysis is completed to determine any improvements that may be required.

The proposed storage facility located at the northeastern corner of Medary Avenue South and 20th Avenue South and the grass swale entering the pond from the west are also affected by the addition of upstream detention. The existing downstream swale does not require an enlargement. The effects of this proposed detention facility on the proposed detention pond at the northeastern corner of Medary Avenue South and 20th Avenue South is discussed in great detail in Study Area 6.

Upstream Node	Conduit	Recommended Improvement 5-yr
N8A	C8A-127A	Existing grass swale or 8' x 3' Concrete Box Culvert outfalling into Detention Pond with a 48" RCP Outlet with a 3' x 2.6' Orifice
N127A	C127A-129A	Upsizing of piping system or the construction of an overflow path may be required
N129A	C129A-128	5.5 x 4' Concrete Box Culvert
N128	C128-128A	6.5' x 3.5' Concrete Box Culvert
N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N3	C3-1	No Improvements Recommended
N5A	C5A-10A	8' x 4' Concrete Box Culvert outfalling into a Detention Pond with a 4' x 3.5' concrete box outlet structure with a 3' x 3' Orifice
N10	C10-10A	No Improvements Recommended
N10A	C10A-1	48" RCP

Table 24 – STUDY AREA 10: RECOMMENDED IMPROVEMENTS WITH DETENTION – 5 YEAR

- No detention

The area was also analyzed to determine the implication of no detention facility being constructed. In the event that the detention area cannot be constructed, a way to pass the total 5-year peak flow through this area will be needed. The existing grass swale has the capacity to pass the 5-year storm. However, the receiving 48” does not and it is recommended that it be replaced with a 6.5’ x 4’ concrete box culvert. This indicates that the entire downstream storm sewer system to the outfall at 17th Avenue South and Pebble Beach Drive may need to upsized to effectively pass the 5-year flow. A more detailed analysis of this system on a pipe by pipe basis will need to be conducted to determine the size of this enlargement.

The proposed storage facility located at the northeastern corner of Medary Avenue South and 20th Avenue South and the grass swale entering the pond from the west are also affected by the removal of upstream detention. A cross section of b=4’, d=3.5,’ z=4 is recommended for this swale. The flow to the proposed storage facility increases to 675-cfs and with the improvements discussed in Study Area 6 for the 100-year storm no improvements are required at the detention pond or downstream.

Upstream Node	Conduit	Recommended Improvement 5-yr
N8A	C8A-127	No Improvements Recommended
N127	C127-127A	6.5' X 4' Concrete Box Culvert
N127A	C127A-129A	Upsizing of piping system or the construction of an overflow path.
N129A	C129A-128	9' x 4' Concrete Box Culverts
N128	C128-128A	9' x 4' Concrete Box Culverts
N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N3	C3-1	Grass swale (b=4', d=3.5', z=4:1)
N5A	C5A-10A	8' x 4' Concrete Box Culvert outfalling into a Detention Pond with a 4' x 3.5' concrete box outlet structure with a 3' x 3' Orifice
N10	C10-10A	No Improvements Recommended
N10A	C10A-1	48" RCP

Table 25 – STUDY AREA 10: RECOMMENDED IMPROVEMENTS WITH NO DETENTION – 5 YEAR

b) Possible Solutions – 100-year storm

- Detention

As was stated above, this area will be designated a possible detention area if it is acquired by the City. Based on available information, a detention pond approximately 6.85 acre-ft is feasible at this location. The detention pond would lessen the outflow from 442-cfs to 262-cfs and require a 9.5' x 4' concrete box culvert with a 6.3'x4' orifice. The smaller opening is required to ensure the pond is maximizing its storage and releasing the lowest rate possible. This would require the existing 48" RCP to be replaced with a 6.5' x 4' concrete box. This indicates that the entire downstream storm sewer system to the outfall at 17th Avenue South and Pebble Beach Drive may need to upsized to effectively pass the 100-year flow. A more detailed analysis of this system on a pipe by pipe basis will need to be conducted to determine the size of this enlargement.

The proposed storage facility located at the northeastern corner of Medary Avenue South and 20th Avenue South and the grass swale entering the pond from the west are also affected by the addition of upstream detention. A cross section of b=4.3', d=4,' z=4 is recommended for this swale. The effects of this proposed detention facility on the proposed detention pond at the northeastern corner of Medary Avenue South and 20th Avenue South is discussed in great detail in Study Area 6.

Upstream Node	Conduit	Recommended Improvement 100-yr
N8A	C8A-127A	Existing grass swale or 9.5' x 4' Concrete Box Culvert outfalling into Detention Pond with 6.5 x 4' Concrete Box Culvert Outlet with a 6.3' x 4' Orifice
N127A	C127A-129A	Upsizing of piping system or the construction of an overflow path.
N129A	C129A-128	(2) 6.5 x 4' Concrete Box Culverts
N128	C128-128A	(2) 6.5' x 4' Concrete Box Culverts or (1) 11' x 4' Concrete Box Culvert
N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N3	C3-1	Grass Channel (b=4.3', d=4', z=4:1)
N5A	C5A-10A	(2) 8' x 4' Concrete Box Culverts @ 0.5% Outfalling into a Detention Pond with (2) 9' x 4' Concrete Box Culvert Outlet with a 16' x 4' Orifice
N10	C10-10A	Grass Channel (b=30' d=4' z=4:1) or Concrete Channel (b =10', d=4' z=4:1)
N10A	C10A-1	(2) 7' x 4' Concrete Box Culverts

Table 26 – STUDY AREA10: RECOMMENDED IMPROVEMENTS WITH DETENTION –100 YEAR

- No detention

The area was also analyzed to determine the implication of no detention facility being constructed. In the event that the detention area cannot be constructed, a way to pass the total 100-year peak flow through this area will be needed. With a depth of 5.5’ the existing grass swale has the capacity to pass the 100-year storm. In this modeled it has a depth of 5.3’. However, the receiving 48” does not and it is recommended that it be replaced with a 10’ x 4’ concrete box culvert. This indicates that the entire downstream storm sewer system to the outfall at 17th Avenue South and Pebble Beach Drive may need to upsized to effectively pass the 100-year flow. A more detailed analysis of this system on a pipe by pipe basis will need to be conducted to determine the size of this enlargement.

The proposed storage facility located at the northeastern corner of Medary Avenue South and 20th Avenue South and the grass swale entering the pond from the west are also affected by the removal of upstream detention. A cross section of b=10.1’, d=4,’ z=4 is recommended for this swale. The flow to the proposed storage facility increases to 1,354-cfs and, with the improvements discussed in Study Area 6 for the 100-year storm no improvements are required at the detention pond or downstream.

Upstream Node	Conduit	Recommended Improvement 100-yr
N8A	C8A-127	No Improvements Recommended
N127	C127-127A	10' X 4' Concrete Box Culvert
N127A	C127A-129A	Upsizing of piping system or the construction of an overflow path.
N129A	C129A-128	(2) 9' x 4' Concrete Box Culverts
N128	C128-128A	(2) 9' x 4' Concrete Box Culverts
N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N3	C3-1	Grass Channel (b=10.1', d=4', z=4:1)
N5A	C5A-10A	(2) 8' x 4' Concrete Box Culverts @ 0.5% Outfalling into a Detention Pond with (2) 9.5' x 4' Concrete Box Culvert Outlet with a 16' x 4.3' Orifice
N10	C10-10A	Grass Channel (b=32' d=4' z=4:1) or Concrete Channel (b =10', d=4' z=4:1)
N10A	C10A-1	(2) 7.5' x 4' Concrete Box Culverts

Table 27 – STUDY AREA10: RECOMMENDED IMPROVEMENTS WITH NO DETENTION – 100 YEAR

Without acquisition of Block 8 the City will lose the ability to use it as regional storage and provide relief to downstream areas. Under current conditions, the existing swale will pass the peak 100-year storm so even owning the lower half of the parcel is advantageous. The City has little slope and offers few areas for regional detention so any area that can be used is beneficial to the City for flow relief. The parcel will have to be evaluated more closely for actual available size for storage. It was assumed that the allowable area was from the parcel line 30’ in to allow for public frontage area (sidewalk, etc.) and grading since the north side of the area is higher than the south side. A depth of 4’ was chosen because it mimics existing conditions and appears feasible. If upsizing the downstream storm system is not feasible it is recommended that a 100-year flow path be designed into the overall development of the area to prevent the flooding of residential areas. In the event that it is not acquired by the City it is recommended that the any future development does not inhibit the passage of flows through this drainage pathway.

11. 17th Avenue South and Sawgrass Drive

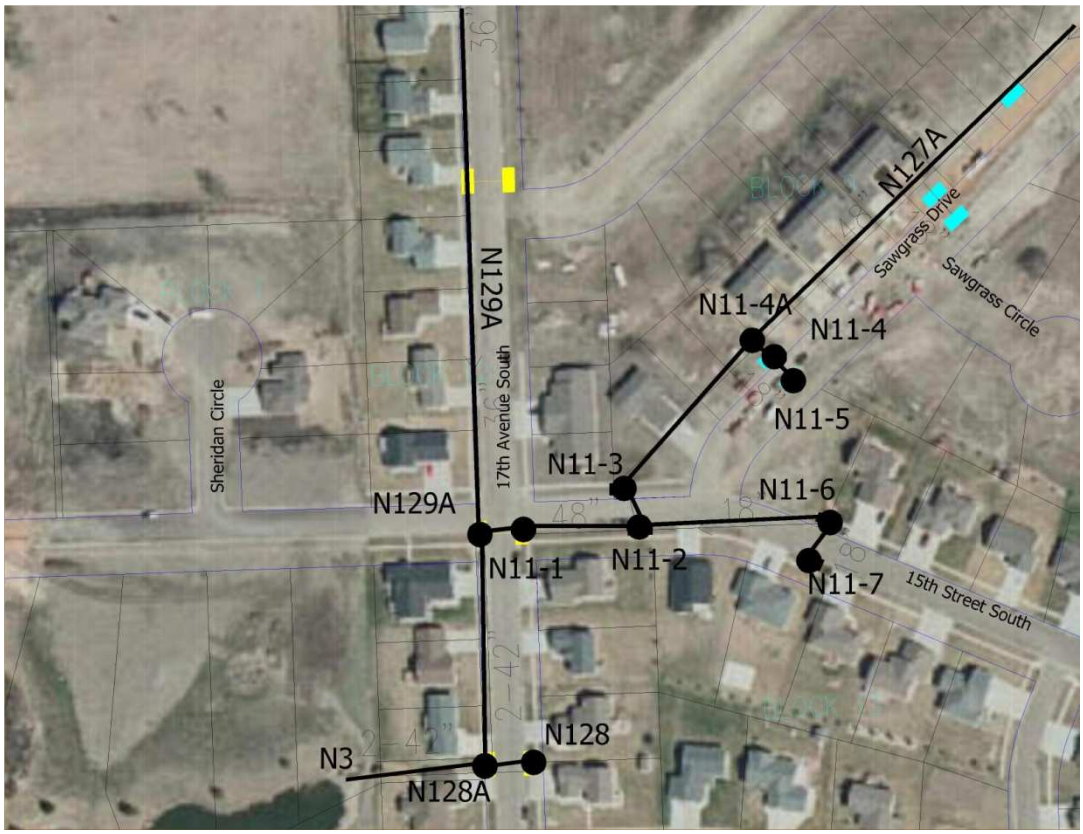

Figure 19 - STUDY AREA 11

Approximately 342.5 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate inflows to this area (N3) of 199-cfs and 472-cfs for the 5-year and the 100-year storms respectively. Currently, water flows south along Sawgrass Drive and enters inlets that outfall to a 48" RCP line. This line combines with an 18" RCP line that comes from the west just west of Sawgrass Drive's intersection with 17th Avenue South. At the intersection this line combines with a 36" RCP coming from the north and outfalls south to a double 42" RCP. This outfalls to dead storage ponds located in the Blairhill Addition. This system was modeled in SWMM from available information. For pipes that had no invert or slope information the slopes were assumed to be 0.5%. The pipe slope of the pipes with inverts shown on the construction plans was 0.5%. SWMM results indicate that the entire piping system is inadequate to carry the 5-year and 100-year storms. This analysis assumed the inlets allow the total flows to entire the system. The City owned area located at the future intersection of 15th Street South and 7th Avenue South has also been designated as a possible detention area. It was used as such for this analysis.

a) Possible Solutions – 5 year

Based on available information there are two possible options: upgrade the piping system to pass the 5-year flows or create an overflow path over or adjacent to the inlet located on the western side of 17th Avenue South. Increasing the piping system will also provide relief for any areas that may be ponding

upstream in the system. Creating an overflow path is not recommended due to the system's proximity to residences. The impacts of any improvements on downstream areas will have to be evaluated.

Upstream Node	Conduit	Recommended Improvement 5-yr
N11-7	C7-6	36" RCP
N11-6	C6-2	36" RCP
N11-5	C5-4	24' RCP
N11-4	C4-4A	24" RCP
N11-4A	C4A-3	48" RCP
N11-3	C3-2	4.5' x 4' Concrete Box Culvert
N11-2	C2-1	5' x 4' Concrete Box Culvert
N111	C111-129A	5' x 4' Concrete Box Culvert
N11-1A	C129A-128	5.5 x 4' Concrete Box Culvert

Table 28 – STUDY AREA 11: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Possible Solutions – 100 year

Based on available information there are two possible options: upgrade the piping system to handle the 100-year flows or create an overflow path either over or adjacent to the inlet located on the western side of 17th Avenue South. Increasing the piping system will also provide relief for any areas that may be ponding upstream in the system. Creating an overflow path is not recommended due to the system's proximity to residences. The impacts of any improvements on downstream areas will have to be evaluated.

Upstream Node	Conduit	Recommended Improvement 100-yr
N11-7	C7-6	48" RCP
N11-6	C6-2	48" RCP
N11-5	C5-4	30" RCP
N11-4	C4-4A	30" RCP
N11-4A	C4A-3	7' x 4' Concrete Box Culvert
N11-3	C3-2	9' x 4' Concrete Box Culvert
N11-2	C2-1	10' x 4' Concrete Box Culvert
N111	C111-129A	(2) 6' x 4' Concrete Box Culvert
N11-1A	C129A-128	(2) 6.5 x 4' Concrete Box Culverts

Table 29 – STUDY AREA 11: RECOMMENDED IMPROVEMENTS – 100 YEAR

12. 17th Avenue South and Pebble Beach Drive

Figure 20 - STUDY AREA 12

Approximately 25.6 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. SWMM results indicate inflows to this area (Out_12) of 55-cfs and 105-cfs for the 5-year and the 100-year storms respectively. A storm sewer system exists at this location and consists of three inlets and 18" RCP. Two of the inlets lie in a sump condition on the eastern and western sides of 17th Avenue South. Based on hydraulic calculations an 18" RCP with a slope of 0.5% has a capacity of 7.43-cfs.

a) Possible Solutions – 5 year

The pipes in this system do not have adequate capacity to pass the 5-year or 100-year storms thus, it is recommended that they are upsized. The creation of an overflow path either over or adjacent to the inlet located on the western side of 17th Avenue South is also an option. This would provide relief for the flows that are ponding in the roadway and would likely require an easement between the houses located along the overflow path.

Upstream Node	Conduit	Recommended Improvement 5-yr
N12-3	C3-2	30” RCP
N12-2	C2-1	42” RCP
N12-1	C1-12	42” RCP

Table 30 – STUDY AREA 12: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Possible Solutions – 100 year

The pipes in this system have do not have adequate capacity to pass the 5-year or 100-year storms thus, it is recommended that they are upsized. The creation of an overflow path either over or adjacent to the inlet located on the western side of 17th Avenue South is also an option. This would provide relief for the flows that are ponding in the roadway and would likely require an easement between the houses located along the overflow path.

Upstream Node	Conduit	Recommended Improvement 100-yr
N12-3	C3-2	36” RCP
N12-1	C2-1	48” RCP
N12-1	C1-12	48” RCP

Table 31 – STUDY AREA 12: RECOMMENDED IMPROVEMENTS – 100 YEAR

13. W. 20th Street South and Main Avenue South

Figure 21 - STUDY AREA 13

Approximately 60.0 acres are tributary to this study area with drainage reaching this location via overland and pipe flow. This area drains to a 24" RCP (N129) located south of 20th Street South and into a 30" arch RCP (Out1) located at 20th Street South and Main Avenue South. SWMM results indicate inflows to this area of 52-cfs and 60-cfs (N129) and 65-cfs and 119-cfs (Out1)for the 5-year and the 100-year storms respectively. Most of the swales and culverts in this area flow at 0.5% or higher and the area generally flows to the east. The exception was along the swale and culvert system of N6-N21. Based on overall topography a drainage divide exists along the driveway between N6 and N6A. It is recommended that this high point remain and the swales and culverts to the west draining to N21 are graded to a minimum of 0.5%. Recommended improvements can be found below.

a) Possible Solutions – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N6	C6-6A	Make high point and grade downstream swale and culverts to ensure a 0.5% minimum slope
N6A	C6A-8	Regrade to ensure a 0.5% minimum slope
N8	C8-8A	Regrade to ensure a 0.5% minimum slope
N8A	C8A-7	Regrade to ensure a 0.5% minimum slope
N7	C7-7A	Regrade to ensure a 0.5% minimum slope
N7A	C7A-21	Regrade to ensure a 0.5% minimum slope
N21	C21-21A	No Improvements Recommended
N11A	C11A-10	No Improvements Recommended
N10	C10-10A	No Improvements Recommended
N10A	C10A-15A	No Improvements Recommended
N15	C15-15A	No Improvements Recommended
N15A	C15A-9	No Improvements Recommended
N9	C9-9A	(2) 24" RCP (1 Exists)
N9A	C9A-21	No Improvements Recommended
N5	C5-5A	No Improvements Recommended
N5A	C5A-4	No Improvements Recommended
N4	C4-4A	15" RCP
N4A	C4A-3	No Improvements Recommended
N3	C3-3A	No Improvements Recommended
N3A	C3-13A	No Improvements Recommended
N13A	C13A	No Improvements Recommended
N2	C2-2A	No Improvements Recommended
N2A	C2A-1	No Improvements Recommended
N1	C1-1	No Improvements Recommended

Table 32 – STUDY AREA 13: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) *Possible Solutions – 100 year*

Upstream Node	Conduit	Recommended Improvement 5-yr
N6	C6-6A	Make high point and grade downstream swale and culverts to ensure a 0.5% minimum slope
N6A	C6A-8	Regrade to ensure a 0.5% minimum slope
N8	C8-8A	15" RCP at 0.5%
N8A	C8A-7	Regrade to ensure a 0.5% minimum slope
N7	C7-7A	Regrade to ensure a 0.5% minimum slope
N7A	C7A-21	Regrade to ensure a 0.5% minimum slope
N21	C21-21A	No Improvements Recommended
N11A	C11A-10	No Improvements Recommended
N10	C10-10A	No Improvements Recommended
N10A	C10A-15A	No Improvements Recommended
N15	C15-15A	(2) 24" RCP (1 Exists)
N15A	C15A-9	No Improvements Recommended
N9	C9-9A	(2) 30" RCP
N9A	C9A-21	No Improvements Recommended
N5	C5-5A	No Improvements Recommended
N5A	C5A-4	No Improvements Recommended
N4	C4-4A	(2) 18" RCP
N4A	C4A-3	No Improvements Recommended
N3	C3-3A	No Improvements Recommended
N3A	C3-13A	No Improvements Recommended
N13A	C13A	No Improvements Recommended
N2	C2-2A	No Improvements Recommended
N2A	C2A-1	No Improvements Recommended
N1	C1-1	No Improvements Recommended

Table 33 – STUDY AREA 13: RECOMMENDED IMPROVEMENTS – 100 YEAR

C. RECOMMENDED CAPITAL IMPROVEMENTS

The result of this study is a list of capital improvements that will allow the passage of the 5-year and 100-year peak flows through the major drainage pathways of the City. These improvements include regional detention ponds, grass and concrete lined swales and concrete box culverts. These improvements only consider the major drainage facilities and crossings. Minor components of the system were not included in the master drainage analysis and will need to be evaluated and designed as part of implementing overall drainage improvements.

In conjunction with other improvements, the five areas designated for detention are recommended to be used as detention. The storage facilities reduce the peak flows of the 5-year storm and the 100-year storm and provide relief for areas downstream. Due to space constraints, no storage facility

recommended in the report can detain enough of the flows from either storm to release them at the historical rate (as dictated by the Manual). Thus, they were sized as large as possible with release rates that prevent the pond from flooding.

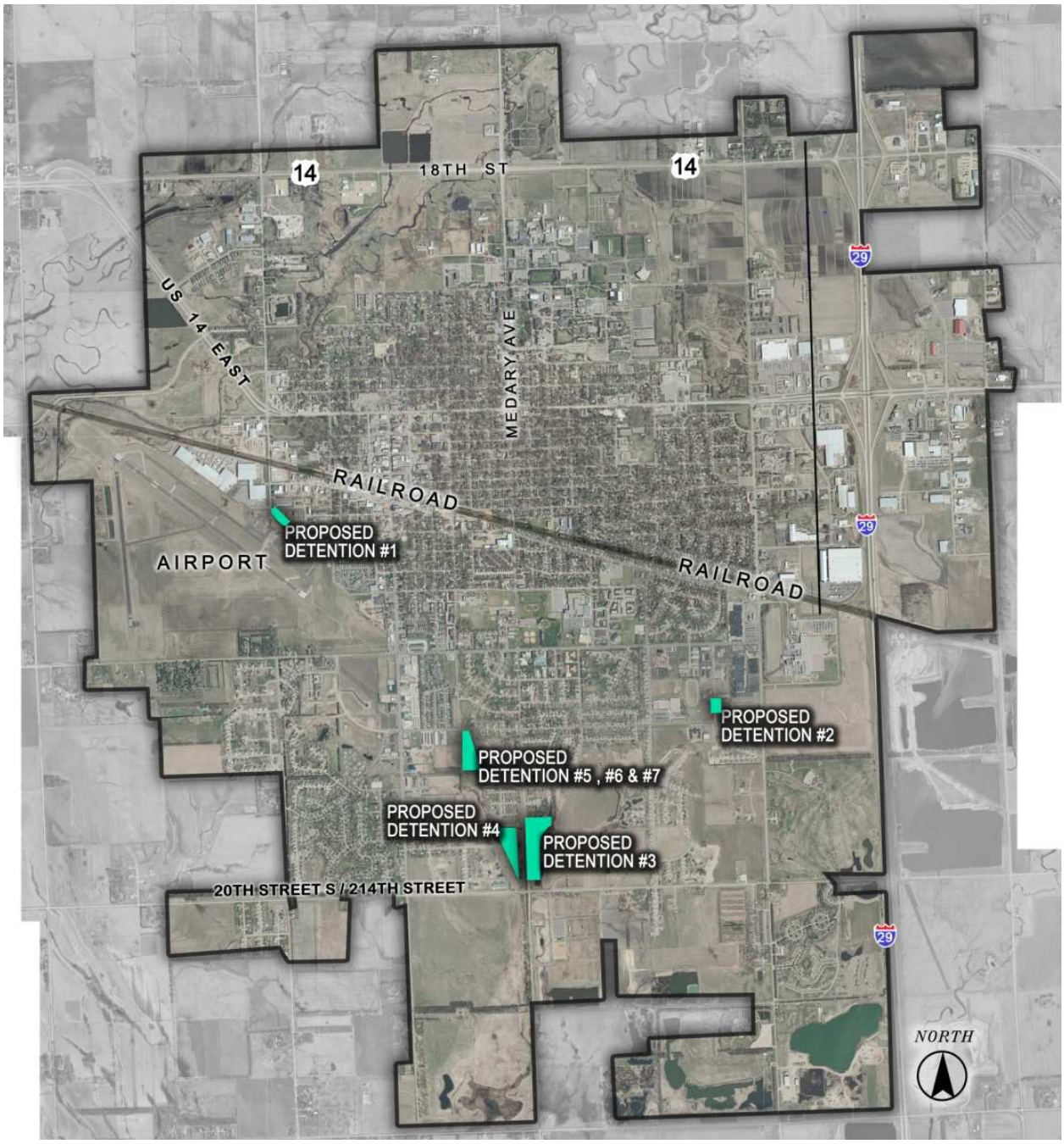

Figure 22 - PROPOSED DETENTION FACILITY LOCATIONS

The other recommended capital improvements include larger culverts at major road crossings and larger swales. In many cases the option of a grass swale, a concrete lined swale or an enclosed conduit are recommended. In these cases, analysis will have to be done to determine which improvement is the

most beneficial to the City and its citizens. For instance, many of the citizens do not like the appearance of concrete lined swales so in areas where grass swales are an option they may be chosen. Conversely the sensitivity analysis shows that the conveyance in grass lined swales is highly dependent on maintenance. These associated costs should be considered by the City.

The following are only recommendations and should not be used for construction. They are preliminary in nature only. A more detailed analysis of the contributing basin and the existing topography and structures may need to be completed before any recommendation is implemented. Pipe, swale and culvert sizes are recommended only. If the structure recommended is not desirable then an equivalent structure may be used after evaluation.

It was found that some of the major basins did not drain to an outfall. In essence, these basins are self-contained. In these cases the amount of storage required for the 100-year flow was determined. According to the City standards for retention, the volume of storage required equals 1.5 times the 100-year 24-hour storm. Based on provided information, all identified contained basins currently have storage in the form of ponds.

Recommended improvements are classified by the major basin that drains to them. Recommended improvements for the Future Conditions model with the 5-year and 100-year storm event can be found below. Please note, all flow values are the peak 5-year and 100-year flows that reach the area with no detention or control structures other than those noted above.

151. AREA 1

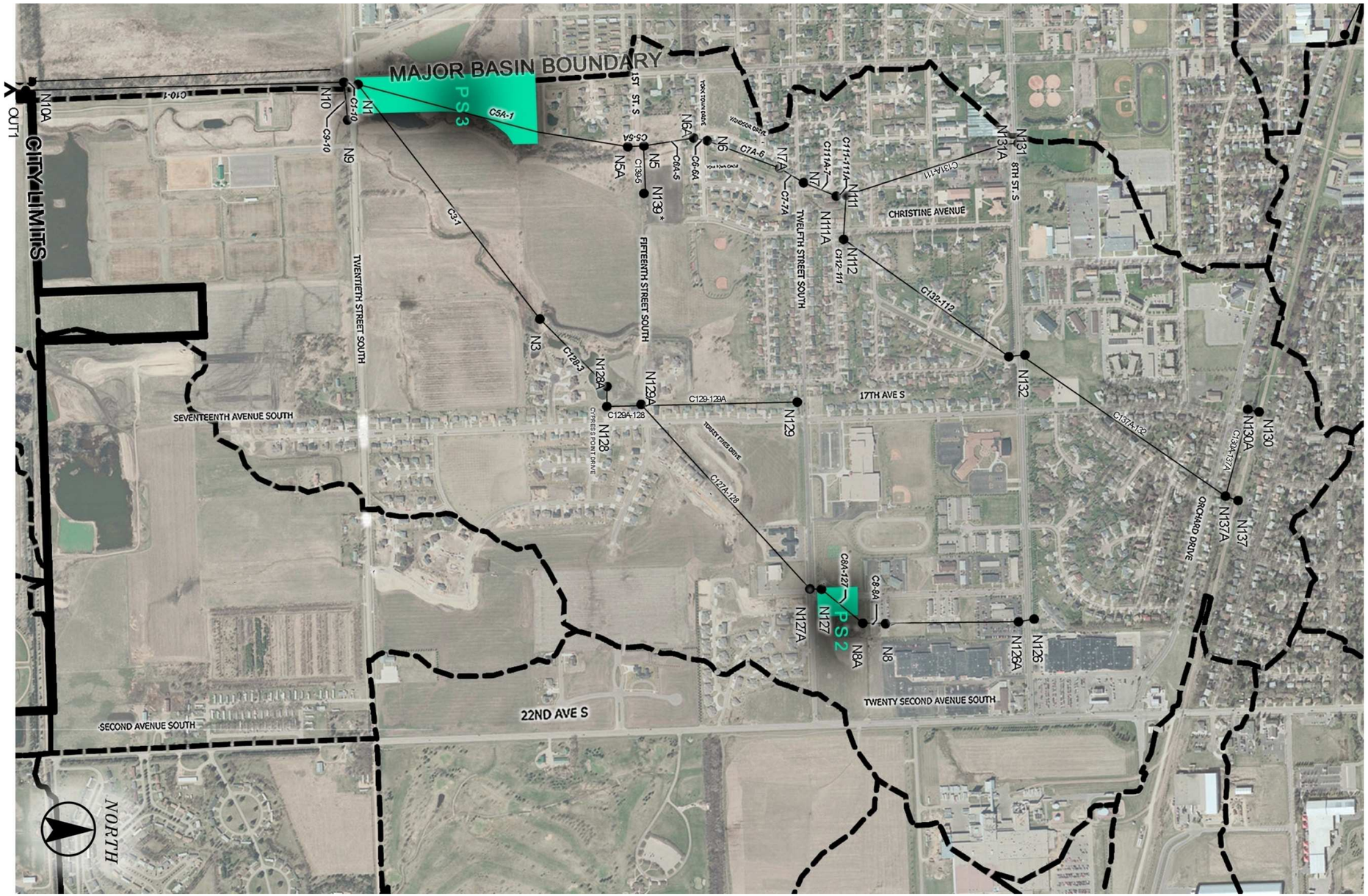

Figure 23 - AREA 1 MAP

Approximately 954.2 acres are tributary to this study area with drainage reaching this location via pipes overland flow. SWMM results indicate total inflows to this area of 1,055-cfs and 1,967-cfs for the 5-year and the 100-year storms respectively. Area 1 includes Study Area 6, 8, 10, 11, and 12.

The eastern drainage pathway flows south to a recommended storage facility in Block 8 at Southland Lane and 12th Street South (Study Area 10). The storage facility at Southland Lane consists of a detention pond and an outlet. The outlet passes enough water to prevent the pond from flooding during the 5-year and 100-year storm. With this detention facility in place the receiving storm drain system will have to be designed to allow for the passing of the 5-year and 100-year peak flows. The existing system ranges from a 48" RCP at Southland Land and combines with another system at Sawgrass Drive where it outfalls to twin 42" RCPs. This entire system will need to be analyzed more closely to determine the size of the improvements needed. From the outlet at N128 (Study Area 11) the water enters dead storage ponds at Blair Hill and enters an existing swale and flows southwest to the northeast corner of the intersection of Medary Avenue South and 20th Street South (Study Area 6). At this location it combines with water coming from the western drainage pathway.

The western drainage pathway begins at Derdall Drive and 17th Avenue South and flows southwest to Hammond Avenue and Horner Avenue (Study Area 2) where it combines with a system from 8th Street South. Water then flows through a series of culverts and concrete valley gutters and outfalls to a grass swale that flows to a double 30" RCP culvert under 15th Street South. In the future conditions models it was assumed that the 15th Street South and Christine Avenue extension (Study Area 8) and its surrounding development existed. This required the addition of basin 155 and node N139 because it was assumed that drainage north of the 15th Avenue South extension will reach the culvert at Christine Avenue after the extension is constructed. Under existing conditions this water does not enter the existing culvert at Christine Avenue. From the culvert, water enters a grass swale and flows south to the northeastern corner of the intersection of Medary Avenue South and 20th Street South where it combines with water from the eastern drainage pathway (Study Area 6).

In the western drainage pathway, a design depth of 2.5' on the open concrete swales was used to prevent the need for handrails along the edges. If, for aesthetic reasons, a deeper and skinnier swale is preferred then one should be used and a handrail added. Grass swales were not used because they required almost twice the bottom width to pass the major storm.

A detention facility consisting of a detention pond and an outlet is recommended in the area between the culverts under 15th Street South and the northeastern corner of Medary Avenue South and 20th Street South (Study Area 6). Based on flows reaching this area, a pond large enough to contain the 5-year or 100-year storm is not possible. Thus, a pond of the largest size possible is proposed. Based on the current grades of the area a pond depth of 4' was judged to be feasible. The outlet of the pond was designed to pass the amount required for the pond to not overflow during the 5-year and 100-year storms. The pond could be designed with a low flow outlet for the 5-year and Medary Ave. could be used as a weir to pass flows as needed during larger storm events. It was designed to act as a spillway during these events.

The area downstream of the proposed detention area is a park with a swale that requires no improvements for the 5-year flow but will need to be upsized to pass the 100-year flow. During larger storms flooding of the park may be reasonable and the swale may not need to be upsized. Otherwise, a larger swale (C10A-1) is required to pass the 100-year flow. This solution may not be ideal since the swale outfalls out of the City limits. The consequences of passing this flow will need to be evaluated before this recommendation can be implemented. It may be favorable to allow the flow to overflow onto the surrounding park area and lessen the amount that leaves the City limits.

Major roadway crossings were evaluated in this basin to determine the minimum pipe size required at 0.5% to pass the 5-year and 100-year flow. Recommended improvements can be found below.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N5A	C5A-10	8' x 4' Concrete Box Culvert outfalling into a Detention Pond with 4' x 3.5' Concrete Box Culvert Outlet with minimum 3'x3' Orifice
N10	C10-10A	No Improvements Recommended
N10A	C10A-1	48" RCP
N111	C111-111A	6' x 4' Concrete Box Culvert
N111A	C111A-7	Concrete Channel (b=8.5', d=2.1', z=1:1)
N112	C112-111	No Improvements Recommended
N126	C126-126A	No Improvements Recommended
N126A	C126A-8	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N127A	C127A-128	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N128	C128-128A	6.5' x 3.5' Concrete Box Culvert
N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N129	C129-129A	42" RCP
N129A	C129A-128	5.5 x 4' Concrete Box Culvert
N130	C130-130A	No Improvements Recommended
N130A	C130A-137A	No Improvements Recommended
N131	C131-131A	30" RCP
N131A	C131A-111	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N132	C132-132A	54" RCP or 4.5' x3.5' Concrete Box Culvert
N132A	C132A-112	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N137	C137-137A	30" RCP
N137A	C137A-132	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N139	C139-5	NA -Conveyance used to simulate overland flow.
N3	C3-1	No Improvements Recommended
N7	C7-7A	No Improvements Recommended
N7A	C7A-6	Concrete Channel (b=9', d=2.5', z=1:1) at 0.5%
N6	C6-6A	7' x 4' Concrete Box Culvert at 0.5%
N6A	C6A-5	Concrete Channel (b=9.5, d=2.5, z=1:1) or 7' x 4' Concrete Box Culvert at 0.5%
N5	C5-5A	8' x 4' Concrete Box Culvert at 0.5%
N8	C8-8A	8' x 3' Concrete Box Culvert
N8A	C8A-127A	Existing grass swale or 8' x 3' Concrete Box Culvert outfalling into Detention Pond with a 48" RCP Outlet with a 3' x 2.6' Orifice
N9	C9-10	Grass Channel (b=4', d=4', z=4:1) or Concrete Channel (b=2.9', d=4', z=4:1)

Table 34 - AREA 1: RECOMMENDED IMPROVEMENTS – 5-YEAR

a) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N5A	C5A-10	(2) 8' x 4' Concrete Box Culverts @ 0.5% Outfalling into a Detention Pond with (2) 9' x 4' Concrete Box Culvert Outlet with a 16' x 4' Orifice
N10	C10-10A	Grass Channel (b=30' d=4' z=4:1) or Concrete Channel (b =10', d=4' z=4:1)
N10A	C10A-1	(2) 7' x 4' Concrete Box Culverts
N111	C111-111A	9.5' x 4' Concrete Box Culvert
N111A	C111A-7	Concrete Channel (b=12', d=2.5', z=1:1)
N112	C112-111	54" RCP or 4.5' x 4' Concrete Box Culvert
N126	C126-126A	54" RCP or 4' x 4' Concrete Box Culvert
N126A	C126A-8	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N127A	C127A-128	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N128	C128-128A	(2) 6.5' x 4' Concrete Box Culverts or (1) 11' x 4' Concrete Box Culvert
N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N129	C129-129A	48" RCP
N129A	C129A-128	(2) 6.5 x 4' Concrete Box Culverts
N130	C130-130A	30" RCP
N130A	C130A-137A	30" RCP
N131	C131-131A	36" RCP
N131A	C131A-111	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N132	C132-132A	6.5' x 4' Concrete Box Culvert
N132A	C132A-112	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N137	C137-137A	36" RCP
N137A	C137A-132	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N139	C139-5	NA -Conveyance used to simulate overland flow.
N3	C3-1	Grass Channel (b=4.3', d=4', z=4:1)
N7	C7-7A	10' x 4' Concrete Box Culvert at 0.5%
N7A	C7A-6	Concrete Channel (b=16', d=2.5', z=1:1) at 0.5%
N6	C6-6A	(2) 7' x 4' Concrete Box Culvert at 0.5%
N6A	C6A-5	Concrete Channel (b=17, d=2.5, z=1:1) or (2) 7' x 4' Concrete Box Culvert at 0.5%
N5	C5-5A	(2)8' x 4' Concrete Box Culvert at 0.5%
N8	C8-8A	9.5' x 4' Concrete Box Culvert
N8A	C8A-127A	Existing grass swale or 9.5' x 4' Concrete Box Culvert outfalling into Detention Pond with 6.5 x 4' Concrete Box Culvert Outlet with a 6.3' x 4' Orifice
N9	C9-10	Grass Channel (b=16', d=4', z=4:1) or Concrete Channel (b=5', d=4', z=3:1)

Table 35 - AREA 1: RECOMMENDED IMPROVEMENTS – 100-YEAR

2. AREA 2

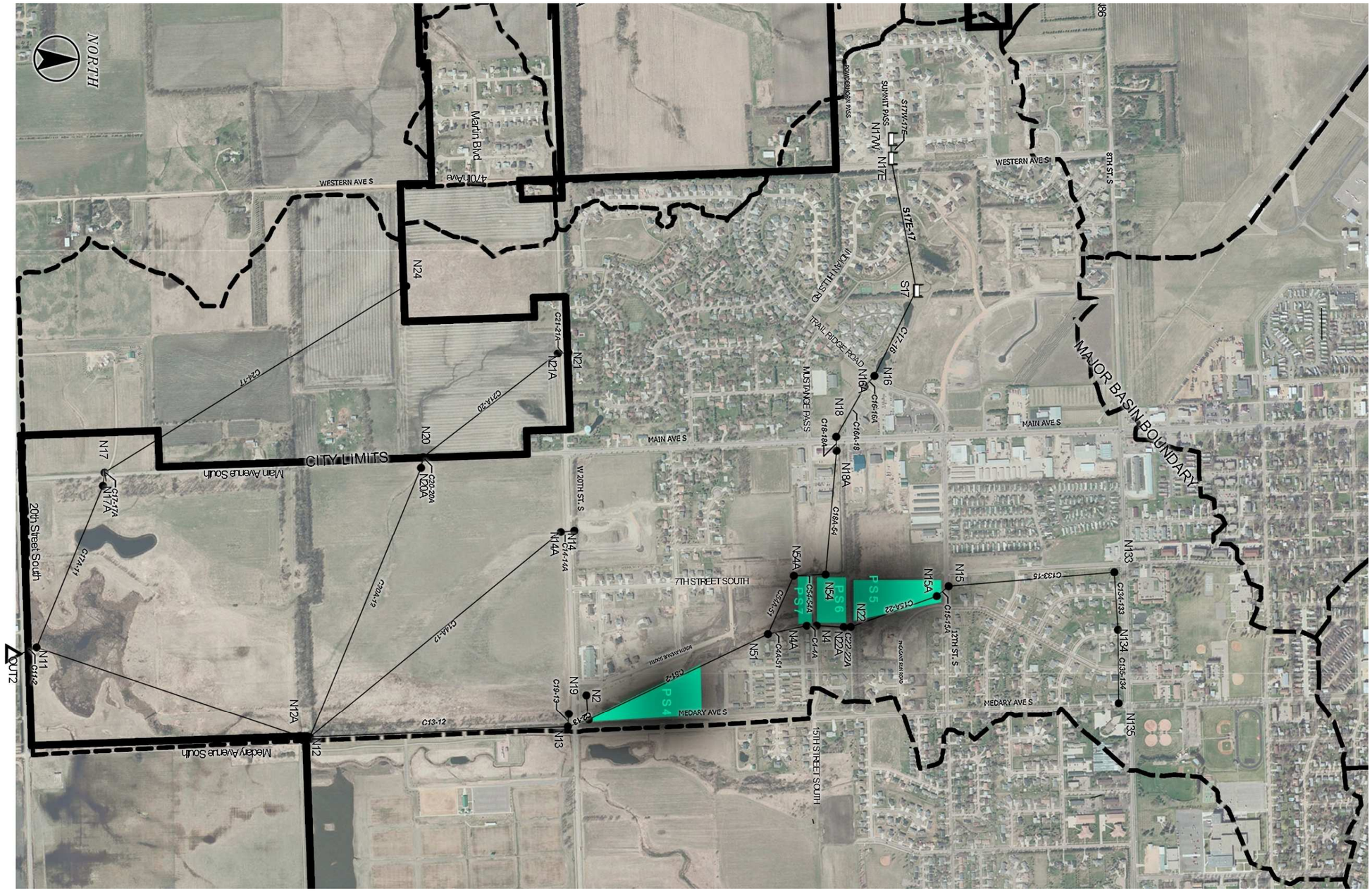

Figure 24 - AREA 2 MAP

Approximately 1,356.6 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this area of 1,048-cfs and 1,983-cfs for the 5-year and the 100-year storms respectively.

This area contains five minor drainage pathways. Two pathways begin north of the detention facility located at the northwestern corner of Medary Avenue South and 20th Street South (Study Area 6). The other three drainage pathways do not drain to the recommended storage facility. The northern drainage pathway that flows to the detention facility begins in a storm system at Medary Avenue South and 8th Street South and flows west to 7th Avenue South where it turns south and flows through a series of pipes, culverts and concrete valley gutters and outfalls to a grass swale that flows to a double 4' x 3' concrete box culvert under 15th Street South. From here water flows south and enters a grass swale where it combines with the western drainage pathway. In the future conditions model it was assumed that the 15th Street South and 7th Street South and its surrounding development existed. This required the addition of Basin 123 to allow the culvert sizes required by the 15th Street South extension (Study Area 9) to be determined.

The grass swale continues southeast to the northwest corner of intersection of Medary Avenue South and 20th Street South. The western drainage pathway begins at the Timberline Addition and Indian Hills Addition storage facilities. Water flows east through an existing 6' x 3' concrete box culvert at Trail Ridge Road and outfalls to a concrete valley gutter. Water then enters a 10' x 4' concrete box culvert at Main Street and outfalls to a grass swale. This swale travels east until turning south just upstream with its intersection with the western drainage pathway and continues southeast to the intersection of Medary Avenue South and 20th Street South. From here, flows cross Medary Avenue South through (2) 24" RCP and flow south to N12 (midway between 20th Street South and 32nd Street South along Medary Avenue South) where they combine with two drainageway pathways from areas north of Medary Avenue South and west of its intersection with 20th Street South. Flows continue south to a 46" x 72" arch RCP at 32nd Street South where they combine with the remaining drainage pathways and leave the City limits.

Four detention facilities consisting of a detention pond and an outlet are recommended in the area located at the future intersection of 7th Street South and 7th Street (Study Area 9) and the northwestern corner of Medary Avenue South and 20th Street South (Study Area 6). Based on flows reaching this area, ponds large enough to contain the 5-year and 100-year storm are not possible. Thus, ponds of the largest size possible are proposed. Based on the current grades of the area, ponds with a depth of 4' appear feasible. The outlets of these ponds were designed to pass the amount required for the pond to not overflow during the 5-year and 100-year storms. The pond located at the intersection of 20th Street South and Medary Avenue could be designed with a low flow outlet for the 5-year storm and Medary Avenue South could be used as a weir to pass flows as needed during larger storm events. It was designed to act as a as a spillway during these events.

The area downstream of the proposed detention area is undeveloped. The existing swale from midway between 20th Street South and 32nd Street South (N12) including the culvert (C12-12A) will need to be upsized to pass the 5-year flow.

During larger storms flooding of this area may be reasonable and the swale may not need to be upsized. Otherwise, a larger swale and culvert between 20th Street South and 32nd Street South is required to pass the 100-year flow. This solution may not be ideal since the swale outfalls out of the City limits. The consequences of passing this flow will need to be evaluated before this recommendation can be implemented. It may be favorable to allow the flow to overflow onto the surrounding park area and lessen the amount that leaves the City limits. Also, the City owns a large parcel south of Medary Avenue South and west of 20th Street South and this area may be usable as a storage facility. Since this area does not provide enough area to construct a retention pond the benefits of using it for detention will need to be determined. Its use as detention will primarily benefit property owners located downstream of the City limits.

Major roadway crossings were evaluated in this basin to determine the minimum pipe size required at 0.5% to pass the 5-year and 100-year flow. Recommended improvements can be found below.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N11	C11-2	No Improvements Recommended
N12	C12-12A	4'x3' Concrete Box Culvert
N12A	C12A-11	Grass Channel (b=3.4', d=4', z=4:1) or Concrete Channel (b=2.5', d=4' z=4:1)
N13	C13-12	No Improvements Recommended
N133	C133-15	54" RCP
N134	C134-133	48" RCP
N135	C135-134	48" RCP
N14	C14-14A	No Improvements Recommended
N142	C142-2	No Improvements Recommended
N14A	C14A-12	NA - Conveyance used to simulate overland flow.
N15A	C15A-2	4' x 3.5' Concrete Box Culvert outfalling into a Detention Pond with a 24" RCP Outlet with a 1' x 1' Orifice
		Detention Pond with a 4.5' x 3.5' Concrete Box Outlet with a 3.5' x 2.9' Orifice
		Detention Pond with a 3.5'x3.5' Concrete Box Culvert Outlet with a 3' x 3.2' Orifice
		Detention Pond with a 3.5' x 3' Concrete Box Culvert Outlet with a 2.6' x 2.5' Orifice
N16	C16-16A	No Improvements Recommended
N16A	C16A-18	Concrete Channel (b=6',d=1.8',z=2:1)
N17	C17-17A	No Improvements Recommended
N17A	C17A-11	NA - Conveyance used to simulate overland flow.
N18	C18-C18A	No Improvements Recommended
N18A	C18A-54	Grass Channel (b=4', d=3.44', z=3:1) or 10' x 4' Concrete Box Culverts
N19	C19-13	No Improvements Recommended
N20	C20-C20A	No Improvements Recommended
N20A	C20A-12	NA - Conveyance used to simulate overland flow.
N21	C21-21A	No Improvements Recommended
N21A	C21A-20	NA - Conveyance used to simulate overland flow.
N2	C2-13	3.5' x 3' Concrete Box Culvert
S17	S17-16	No Improvements Recommended
S17E	S17E-S17	No Improvements Recommended
S17W	S17W-S17E	No Improvements Recommended

Table 36 - AREA 2: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N11	C11-2	(2) 8.5' x 4' Concrete Box Culverts
N12	C12-12A	9'x4' Concrete Box Culvert
N12A	C12A-11	Grass Channel (b=34.7', d=4', z=4:1) or Concrete Channel (b=11.7', d=4' z=4:1)
N13	C13-12	Grass Channel (b=21', d=4', z=4:1) or Concrete Channel (b=4.7', d=4' z=4:1)
N133	C133-15	6' x 4' Concrete Box Culvert
N134	C134-133	54" RCP
N135	C135-134	48" RCP
N14	C14-14A	(2) 42" RCP
N142	C142-2	(2) 24" RCP
N14A	C14A-12	NA - Conveyance used to simulate overland flow.
N15A	C15A-2	6' x 4' Concrete Box Culvert outfalling into a Detention Pond with a 4' x 3.5' Concrete Box Culvert Outlet with a 3.4' x 3' Orifice
		Detention Pond with a 11.5' x 4' Concrete Box Culvert Outlet with a 4' x 10.5' Orifice
		Detention Pond with a 11.5' x 4' Concrete Box Culvert Outlet with a 11.1' x 4' Orifice
		Detention Pond with a 12' x 4' Concrete Box Culvert Outlet with a 11.9' x 4' Orifice
N16	C16-16A	No Improvements Recommended
N16A	C16A-18	Concrete Channel (b=6',d=2.5',z=2:1)
N17	C17-17A	No Improvements Recommended
N17A	C17A-11	NA - Conveyance used to simulate overland flow.
N18	C18-C18A	No Improvements Recommended
N18A	C18A-54	Grass Channel (b=7', d=4', z=3:1) or (2) 7' x 4' Concrete Box Culverts
N19	C19-13	No Improvements Recommended
N20	C20-C20A	No Improvements Recommended
N20A	C20A-12	NA - Conveyance used to simulate overland flow.
N21	C21-21A	No Improvements Recommended
N21A	C21A-20	NA - Conveyance used to simulate overland flow.
N2	C2-13	12' x 4' Concrete Box Culverts
S17	S17-16	Needs to be reevaluated to determine adequacy.
S17E	S17E-S17	No Improvements Recommended
S17W	S17W-S17E	Needs to be reevaluated to determine adequacy.

Table 37 - AREA 2: RECOMMENDED IMPROVEMENTS – 100 YEAR

3. AREA 3

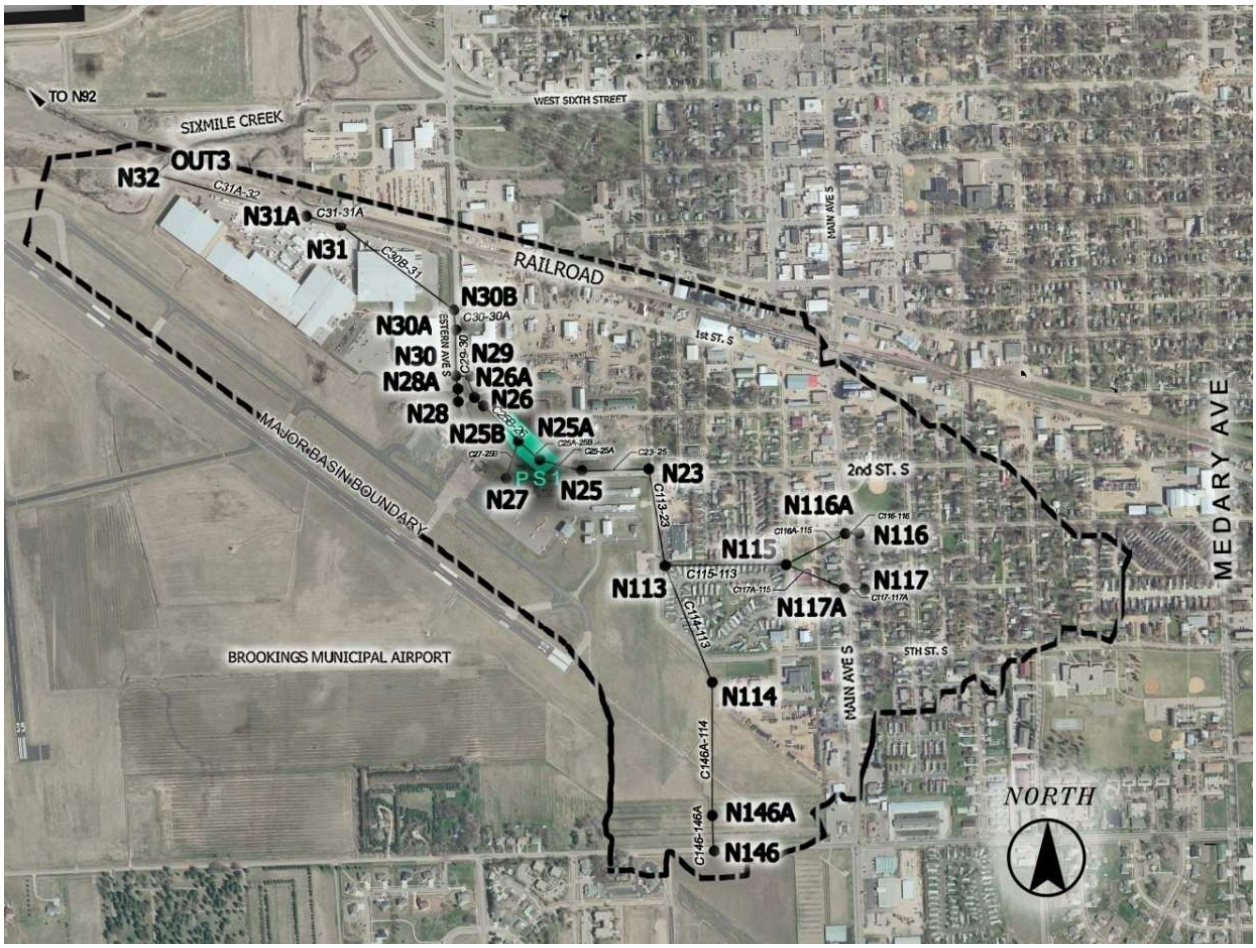

Figure 25 - AREA 3 MAP

Approximately 397.2 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 397-cfs and 764-cfs for the 5-year and the 100-year storms respectively. A detention facility consisting of a pond and outlet is recommended in the designated proposed detention area adjacent to Xtra Space Storage (Study Area 1). This facility will lessen the amount of flows that are causing flooding on the Xtra Space Storage property and will provide relief for downstream drainage structures.

Major roadway crossings were evaluated in this basin to determine the minimum pipe size required at 0.5% to pass the 5-year and 100-year flows. Recommended improvements can be found below.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N146	C146-146A	No Improvements Recommended
N146A	C146A-114	NA - Conveyance used to simulate overland flow.
N113	C113-23	5' x 3.5' Concrete Box
N114	C114-113	30" RCP
N115	C115-113	6' x 2' Concrete Box Culvert or Concrete Channel (b=6', d=1.3', z=0.5:1)
N116	C116-116A	30" RCP
N116A	C116A-115	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N117	N117-117A	36" RCP
N117A	C117A-115	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N23	C23-25	No Improvements Recommended
N25	C25-25A	(2) 60" CMP outfalling into a Detention Pond with a 3.5' x 3' Concrete Box Outlet with a 2.5' x 2.4' Orifice
N25A	C25A-25B	
N25B	C25B-C26	
N26	C26-26A	
N26A	C26A-29	3.5' x 3' Concrete Box Culvert
N29	C29-30	5' x 4' Concrete Box Culvert
N30	C30-30A	(2) 42" RCP
N30A	C30A-30B	8' x 5' Concrete Box
N30B	C30B-31	No Improvements Recommended
N27	C27-25B	No Improvements Recommended
N28	C28-28A	No Improvements Recommended
N28A	C28A-30	24" RCP
N31	C31-31A	6.5' x 4' Concrete Box
N31A	C31A-32	No Improvements Recommended
N32	C32-3	No Improvements Recommended

Table 38 - AREA 3: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N146	C146-146A	No Improvements Recommended
N146A	C146A-114	NA - Conveyance used to simulate overland flow.
N113	C113-23	7' x 4' Concrete Box
N114	C114-113	36" RCP
N115	C115-113	7' x 2.5' Concrete Box
N116	C116-116A	36" RCP
N116A	C116A-115	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N117	C117-117A	42" RCP
N117A	C117A-115	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N23	C23-25	No Improvements Recommended
N25	C25-25A	6.5' x 5' Concrete Box Culvert outfalling into a Detention Pond with a 7' x 4.5' Concrete Box Outlet with a 5.7' x 4.3' Orifice
N25A	C25A-25B	
N25B	C25B-C26	
N26	C26-26A	
N26A	C26A-29	7' x 4.5' Concrete Box Culvert
N29	C29-30	7.5' x 5' Concrete Box
N30	C30-30A	8' x 5' Concrete Box
N30A	C30A-30B	8' x 5' Concrete Box
N30B	C30B-31	No Improvements Recommended
N27	C27-25B	No Improvements Recommended
N28	C28-28A	(2) 24" RCP
N28A	C28A-30	(2) 24" RCP
N31	C31-31A	(2) 8' x 5' Concrete Box
N31A	C31A-32	No Improvements Recommended
N32	C32-3	No Improvements Recommended

Table 39 - AREA 3: RECOMMENDED IMPROVEMENTS – 100 YEAR

4. AREA 4

Figure 26 - AREA 4 MAP

Approximately 126.2 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 156-cfs and 295-cfs for the 5-year and the 100-year storms respectively.

This area is located in the western portion of the City and begins south of the railroad by the 6th Avenue viaduct (Study Area 5). Flows enter a piping system and flow north to 5th Street South where it turns west. As it flows west it combines with multiple piping systems from the south until outfalling at Western Avenue South. From here it travels west through a grass swale and a road crossing before it outfalls into Six Mile Creek. Major roadway crossings were evaluated in this basin to determine the minimum pipe size required at 0.5% to pass the 5-year and 100-year flows and it was found that no major roadway crossings have the capacity to pass the 5-year or 100-year flows. This indicates that the entire piping system located in this area may be inadequate. A more detailed study of this system is recommended to determine its true level of adequacy. The area located upstream of the outfall into 6 Mile Creek should be reevaluated in the event that this area is developed. Recommended improvements can be found below.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N118	C118-118A	48" RCP or 4' x 3.5' Concrete Box Culvert
N118A	C118-34	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N119	C119-119A	Flood warning system
N119A	C119A-118	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N33	C33-33A	4.5' x 4' Concrete Box
N33A	C33A-4	No Improvements Recommended at this Time. Area should be reevaluated when this area is developed or changed.
N34	C34-34A	5.0' x 3.5' Concrete Box
N34A	C34A-33	No Improvements Recommended

Table 40 - AREA 4: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N118	C118-118A	60" RCP
N118A	C118-34	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N119	C119-119A	Flood warning system
N119A	C119A-118	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N33	C33-33A	7' x 4' Concrete Box
N33A	C33A-4	No Improvements Recommended at this Time. Area should be reevaluated when this area is developed or changed.
N34	C34-34A	8.5' x 3.5' Concrete Box
N34A	C34A-33	No Improvements Recommended

Table 41 - AREA 4: RECOMMENDED IMPROVEMENTS – 100 YEAR

5. AREA 5

Figure 27 - AREA 5 MAP

Approximately 297.4 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 254-cfs and 487-cfs for the 5-year and the 100-year storms respectively.

This area is located in the western portion of the City just north of Area 4. It begins just east of Medary Avenue and 1st Street (Study Area 7) and drains west and north to the intersection of 4th Street and 9th Avenue where it combines with a piping system coming from the east. It travels west until outfalling directly into Six Mile Creek. The outfall and major roadway crossings were evaluated in this basin to determine the minimum pipe size required at 0.5% to pass the 5-year and 100-year flows and it was found that none of the major roadway crossings have the capacity to pass the 5-year or 100-year flows. This indicates that the entire piping system located in this area may be inadequate. A more detailed study of this system is recommended to determine its true level of adequacy. Recommended improvements can be found below.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N120	C120-120A	5.5' x 4' Concrete Box Culvert
N120A	C120A-36	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N121	C121-121A	21" RCP
N121A	C121A-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N122	C122-122A	54" RCP or 4' x 3' Concrete Box Culvert
N122A	C122A-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N36	C36-5	6' x 4' Concrete Box Culvert
N37	C37-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.

Table 42 - AREA 5: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N120	C120-120A	7' x 5' Concrete Box Culvert
N120A	C120A-36	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N121	C121-121A	30" RCP
N121A	C121A-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N122	C122-122A	60" RCP
N122A	C122A-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N36	C36-5	8' x 5' Concrete Box Culvert
N37	C37-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.

Table 43 - AREA 5: RECOMMENDED IMPROVEMENTS – 100 YEAR

6. AREA 6

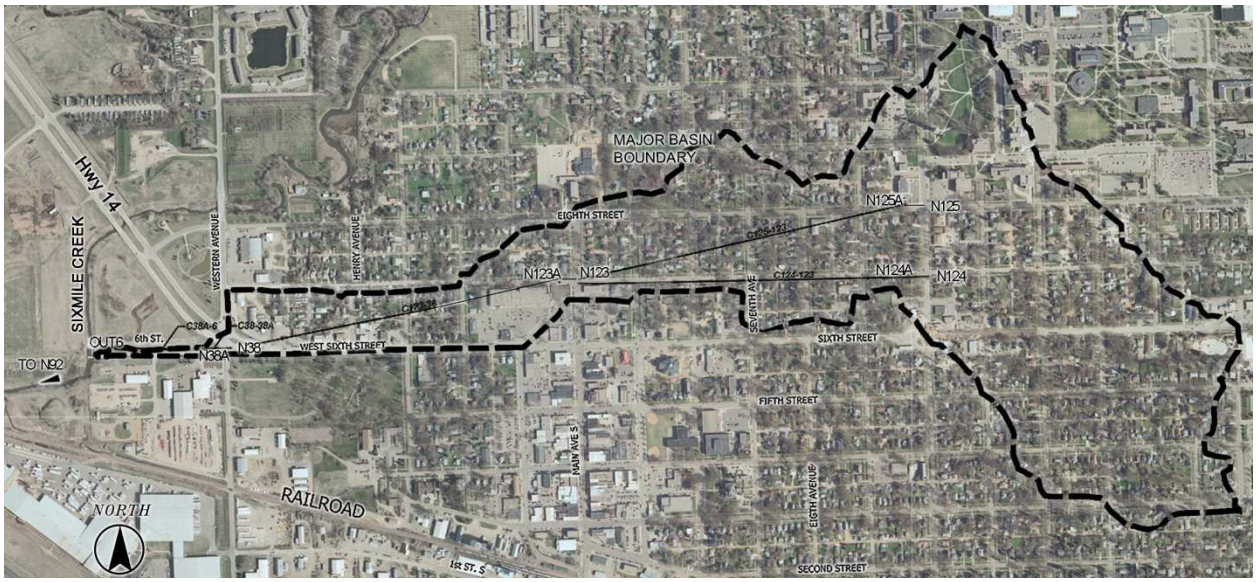

Figure 28 - AREA 6 MAP

Approximately 217.3 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 211-cfs and 395-cfs for the 5-year and the 100-year storms respectively.

This area is located in the western portion of the City just north of Area 5. It begins in a piping system located on 6th Street/US14 and flows west where it combines with flows from piping systems from the east and south before turning north at 5th Avenue. It then turns west at 7th Street and continues west combining with flows from piping systems to the north until outfalling into a grass swale at Western Avenue. From here it continues west and outfalls into Six Mile Creek. Major roadway crossings were evaluated in this basin to determine the minimum pipe size required at 0.5% to pass the 5-year and 100-year flows and it was found that none of the major roadway crossings have the capacity to pass the 5-year or 100-year flows. This indicates that the entire piping system located in this area may be inadequate. A more detailed study of this system is recommended to determine its true level of adequacy. The area located upstream of the outfall into 6 Mile Creek should be reevaluated in the event that it is developed. Recommended improvements can be found below.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N123	C123-123A	(2) 48" RCP or 5' X 5' Concrete Box Culvert
N123A	C123A-38	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N124	C124-124A	42" RCP
N124A	C124A-123	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N125	C125-125A	48" RCP
N125A	C125A-123	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N38	C38-38A	66" RCP or 5' X 5' Concrete Box Culvert
N38A	C38A-6	No Improvements Recommended at this Time. Area should be reevaluated when this area is developed or changed.

Table 44 - AREA 6: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements –100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N123	C123-123A	7.5' X 4' Concrete Box Culvert
N123A	C123A-38	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N124	C124-124A	54" RCP
N124A	C124A-123	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N125	C125-125A	48" RCP
N125A	C125A-123	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.
N38	C38-38A	(2) 60" RCP or 7' X 5' Concrete Box Culvert
N38A	C38A-6	No Improvements Recommended at this Time. Area should be reevaluated when this area is developed or changed.

Table 45 - AREA 6: RECOMMENDED IMPROVEMENTS – 100 YEAR

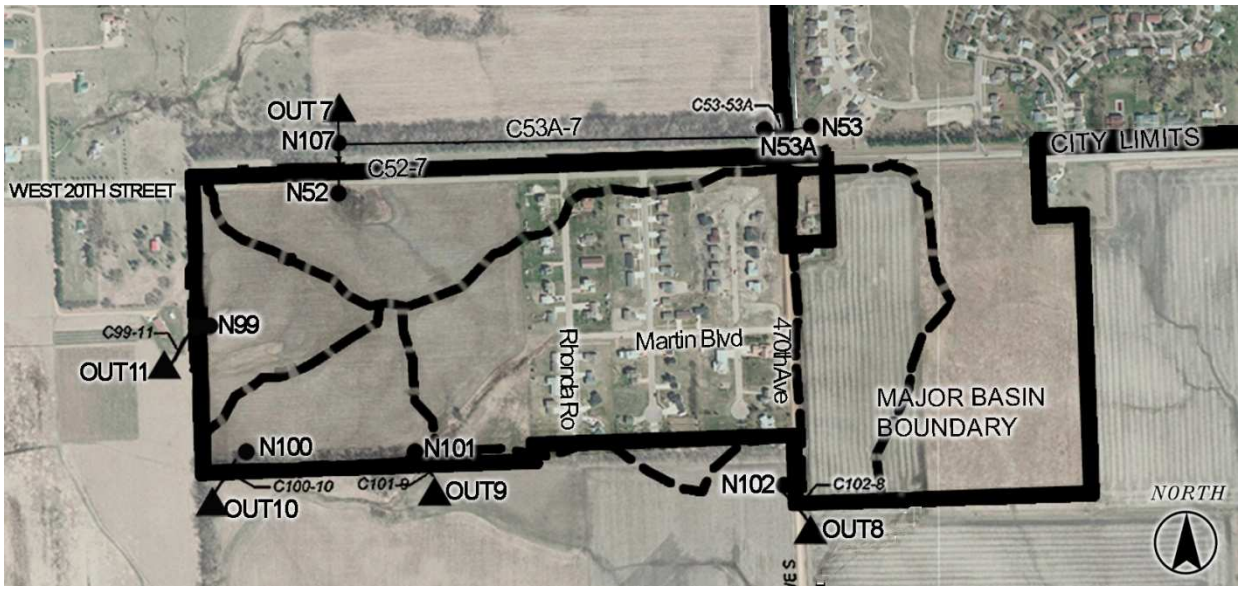

Figure 29 - AREA 7, AREA 8, AREA 9, AREA 10 AND AREA 11 MAP

7. AREA 7

Approximately 31.7 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 35-cfs and 64-cfs for the 5-year and the 100-year storms respectively. Based on SWMM results the single existing 18" RCP culvert at C53-53A does not have the capacity to pass the 100-year flow thus it is recommended that it be upgraded to a 24" RCP culvert.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N107	C107-7	NA - Dummy Conduit
N52	C52-107	No Improvements Recommended
N53	C53-53A	No Improvements Recommended
N53A	C53A-107	No Improvements Recommended

Table 46 - AREA 7: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N107	C107-7	NA - Dummy Conduit
N52	C52-107	No Improvements Recommended
N53	C53-53A	24" RCP
N53A	C53A-107	No Improvements Recommended

Table 47 - AREA 7: RECOMMENDED IMPROVEMENTS – 100 YEAR

8. AREA 8

Approximately 17.8 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 7-cfs and 11-cfs for the 5-year and the 100-year storms respectively. Area 8 is undeveloped and drains off-site. No improvements are recommended. In the event that the basin is developed the flows and their effects should be reevaluated.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N102	C102-8	NA - Dummy Conduit

Table 48 - AREA 8: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N102	C102-8	NA - Dummy Conduit

Table 49 - AREA 8: RECOMMENDED IMPROVEMENTS – 100 YEAR

9. AREA 9

Approximately 41.9 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 36-cfs and 67-cfs for the 5-year and the 100-year storms respectively. Area 9 is undeveloped and drains off-site. No improvements are recommended. In the event that the basin is developed the flows and their effects should be reevaluated.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N101	C101-9	NA - Dummy Conduit

Table 50 - AREA 9: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N101	C101-9	NA - Dummy Conduit

Table 51 - AREA 9: RECOMMENDED IMPROVEMENTS – 100 YEAR

10. AREA 10

Approximately 10.7 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 14-cfs and 36-cfs for the 5-year and the 100-year storms respectively. Area 10 is undeveloped and drains off-site. No improvements are recommended. In the event that the basin is developed the flows and their effects should be reevaluated.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N100	C100-10	NA - Dummy Conduit

Table 52 - AREA 10: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N100	C100-10	NA - Dummy Conduit

Table 53 - AREA 10: RECOMMENDED IMPROVEMENTS – 100 YEAR

11. AREA 11

Approximately 9.8 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 15-cfs and 24-cfs for the 5-year and the 100-year storms respectively. Area 11 is undeveloped and drains off-site. No improvements are recommended. In the event that the basin is developed the flows and their effects should be reevaluated.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N99	C99-11	NA - Dummy Conduit

Table 54 - AREA 11: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N99	C99-11	NA - Dummy Conduit

Table 55 - AREA 11: RECOMMENDED IMPROVEMENTS – 100 YEAR

12. AREA 12

Figure 30 – AREA 12 MAP

Approximately 17.3 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 32-cfs and 72-cfs for the 5-year and the 100-year storms respectively. Area 12 consists of a small area in the southeast corner of the City limits that mostly takes water from HWY 14 and undeveloped areas. It is adjacent to the contained storage area S60 and is adequate to take flows from this area in the event that the existing storage is inadequate and overflow occurs. The current outfall has the capacity to pass the peak minor and major storm flows and requires no improvements.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N59	C59-12	No improvements recommended at this time. Area should be reevaluated if basin 119 does not provide adequate storage and/or if basin 119 or basin 120 is changed.

Table 56 - AREA 12: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N59	C59-12	No Improvements Recommended at this Time. Area should be reevaluated if basin 119 does not provide adequate storage and/or if basin 119 or basin 120 is changed.

Table 57 - AREA 12: RECOMMENDED IMPROVEMENTS – 100 YEAR

Figure 31 - AREA 13 AND AREA 14 AND AREA 15 MAP

13. AREA 13

Approximately 73.7 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 100-cfs and 190-cfs for the 5-year and the 100-year storms respectively. A 48" RCP currently drains the basin. Based on hydraulic calculations this pipe has a capacity of 101.57-cfs. It is recommended that this pipe be replaced with a pipe adequate to pass the 100-year flow.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N62	C62-13	No Improvements Recommended

Table 58 - AREA 13: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N62	C62-13	(2) 48" RCP

Table 59 - AREA 13: RECOMMENDED IMPROVEMENTS – 100 YEAR

14. AREA 14

Approximately 9.5 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 17-cfs and 32-cfs for the 5-year and the 100-year

storms respectively. A 36" RCP currently drains the basin. Based on hydraulic calculations this pipe has a capacity of 47.16-cfs and can pass both the 5-year and 100-year storms. If the basin parameters for Area 14 change this outlet should be reevaluated.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N63	C63-14	No Improvements Recommended.

Table 60 - AREA 14: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N63	C63-14	No Improvements Recommended.

Table 61 - AREA 14: RECOMMENDED IMPROVEMENTS – 100 YEAR

15. AREA 15

Approximately 20.2 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 35-cfs and 66-cfs for the 5-year and the 100-year storms respectively. This area was modeled to determine the flows draining offsite from its basin.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N35	C35-15	NA - Dummy Conduit.

Table 62 - AREA 15: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N35	C35-15	NA - Dummy Conduit.

Table 63 - AREA 15: RECOMMENDED IMPROVEMENTS – 100 YEAR

16. AREA 16

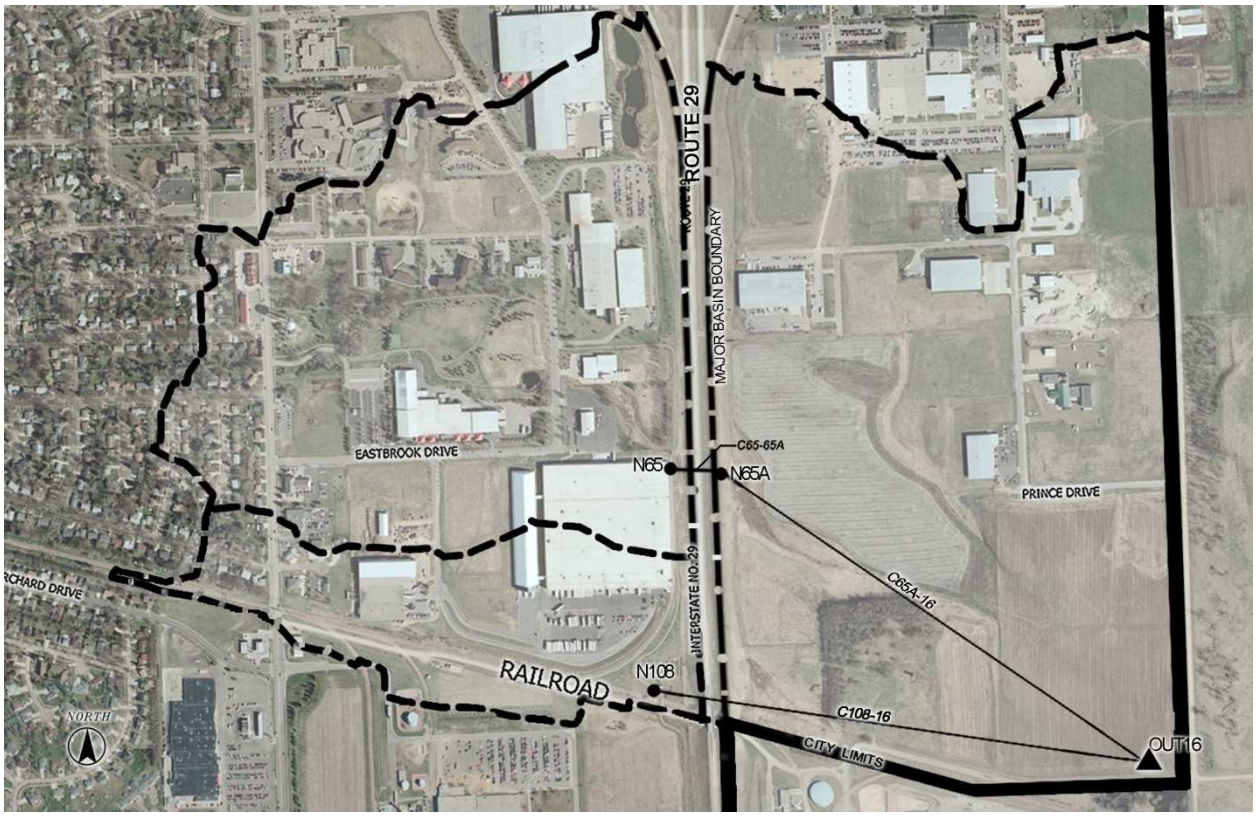

Figure 32 - AREA 16 MAP

Approximately 451.9 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 442-cfs and 885-cfs for the 5-year and the 100-year storms respectively. C108-16 and C55A-16conveyances were modeled to determine flows at these locations. Based on SWMM results, double 54" RCP or double 6.5' x 5' concrete box culvert or equivalent is needed to pass the 5-year 100-year storms respectively.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N106	C106-108	NA - Dummy Conduit
N108	C108-16	NA - Dummy Conduit
N65	C65-65A	(2) 54" RCP (1 Exists)
N65A	C65A-108	NA - Conveyance used to simulate overland flow.

Table 64 - AREA 16: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N106	C106-108	NA - Dummy Conduit
N108	C108-16	NA - Dummy Conduit
N65	C65-65A	(2) 6.5' x 4' Concrete Box Culvert
N65A	C65A-108	NA - Conveyance used to simulate overland flow.

Table 65 - AREA 16: RECOMMENDED IMPROVEMENTS – 100 YEAR

17. AREA 17

Figure 33 - AREA 17 MAP

Approximately 133.3 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 249-cfs and 491-cfs for the 5-year and the 100-year storms respectively. Water flows under a Route 29 on-ramp through a 42” RCP (N79) and flows east through a swale to a 65” x 40” arch RCP (N144). It continues east through a swale and a 48” RCP until it outfalls into a swale and continues east. Study Area 3 is located in the basin and is downstream of this pipe system. Based on available topography, it appears that C19A-144 and C144A-78 may be adequate to allow for flooding at nodes N144 and N78. This should be analyzed in more detail prior to any recommendations are implemented.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N66	C66-17	NA - Dummy Conduit
N78	C78-78A	4.5'X4' Concrete Box Culvert
N78A	C78A-66	NA - Conveyance used to simulate overland flow.
N79	C79-79A	No Improvements Recommended
N79A	C79A-144	NA - Conveyance used to simulate overland flow.
N144	C144-144A	4.5'X4' Concrete Box Culvert
N144A	C144A-78	NA - Conveyance used to simulate overland flow.

Table 66 - AREA 17: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N66	C66-17	NA - Dummy Conduit
N78	C78-78A	4.5'X4' Concrete Box Culvert
N78A	C78A-66	NA - Conveyance used to simulate overland flow.
N79	C79-79A	No Improvements Recommended
N79A	C79A-144	NA - Conveyance used to simulate overland flow.
N144	C144-144A	4.5'X4' Concrete Box Culvert
N144A	C144A-78	NA - Conveyance used to simulate overland flow.

Table 67 - AREA 17: RECOMMENDED IMPROVEMENTS – 100 YEAR

18. AREA 18

Figure 34 - AREA 18 MAP

Approximately 229.5 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 400-cfs and 486-cfs for the 5-year and the 100-year storms respectively. Water flows under Route 29 through double 30"RCP (N80) east to a 42" arch RCP (N10). From here it continues east through a swale and a triple 52" x 30" arch RCP (N67). Based on SWMM results C80-80A and C67-67A do not have the adequacy to pass the 5-year or 100-year storm. It is recommended that these structures are replaced and the swale downstream of N67A is regraded to have a minimum slope of 0.5%.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N80	C80-80A	(3) 30" RCP @ 0.5%
N80A	C80A-106	NA - Conveyance used to simulate overland flow.
N106	C106-106A	No Improvements Recommended
N106A	C106A-67	Keep Maintained
N67	C67-67A	5.5' x 4' Concrete Box Culvert @ 0.5%
N67A	C67A-18	Regrade swale to have a slope of 0.5%.

Table 68 - AREA 18: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements –100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N80	C80-80A	5'x4' Concrete Box Culvert @ 0.5%
N80A	C80A-106	NA - Conveyance used to simulate overland flow.
N106	C106-106A	5.5'x4' Concrete Box Culvert
N106A	C106A-67	Keep Maintained
N67	C67-67A	10'x4' Concrete Box Culvert @ 0.5%
N67A	C67A-18	Regrade swale to have a slope of 0.5%.

Table 69 - AREA 18: RECOMMENDED IMPROVEMENTS – 100 YEAR

19. AREA 19

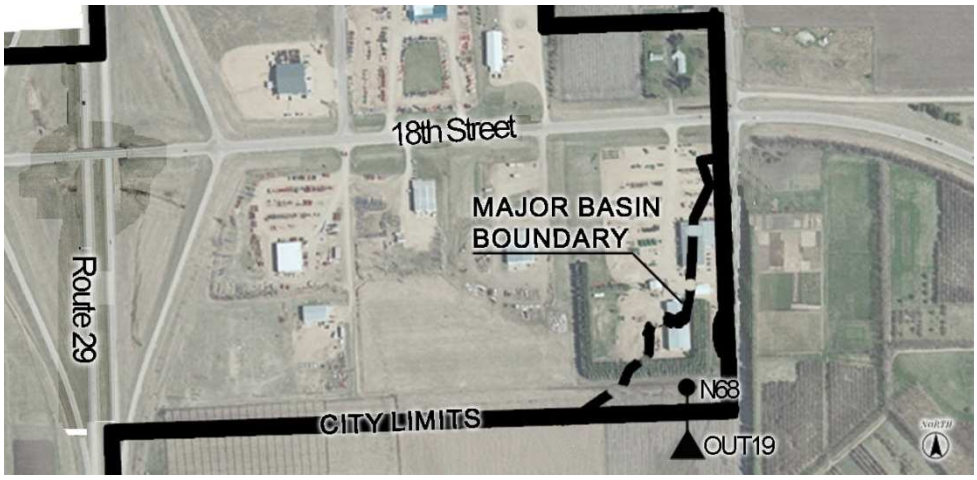

Figure 35 - AREA 19 MAP

Approximately 6.5 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 14-cfs and 27-cfs for the 5-year and the 100-year storms respectively. This area was modeled to determine the flows draining offsite from its basin. The area has no existing conveyances and requires no improvements.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N68	C68-19	NA - Dummy Conduit

Table 70 - AREA 19: RECOMMENDED IMPROVEMENTS –5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N68	C68-19	NA - Dummy Conduit

Table 71 - AREA 19: RECOMMENDED IMPROVEMENTS – 100 YEAR

20. AREA 20

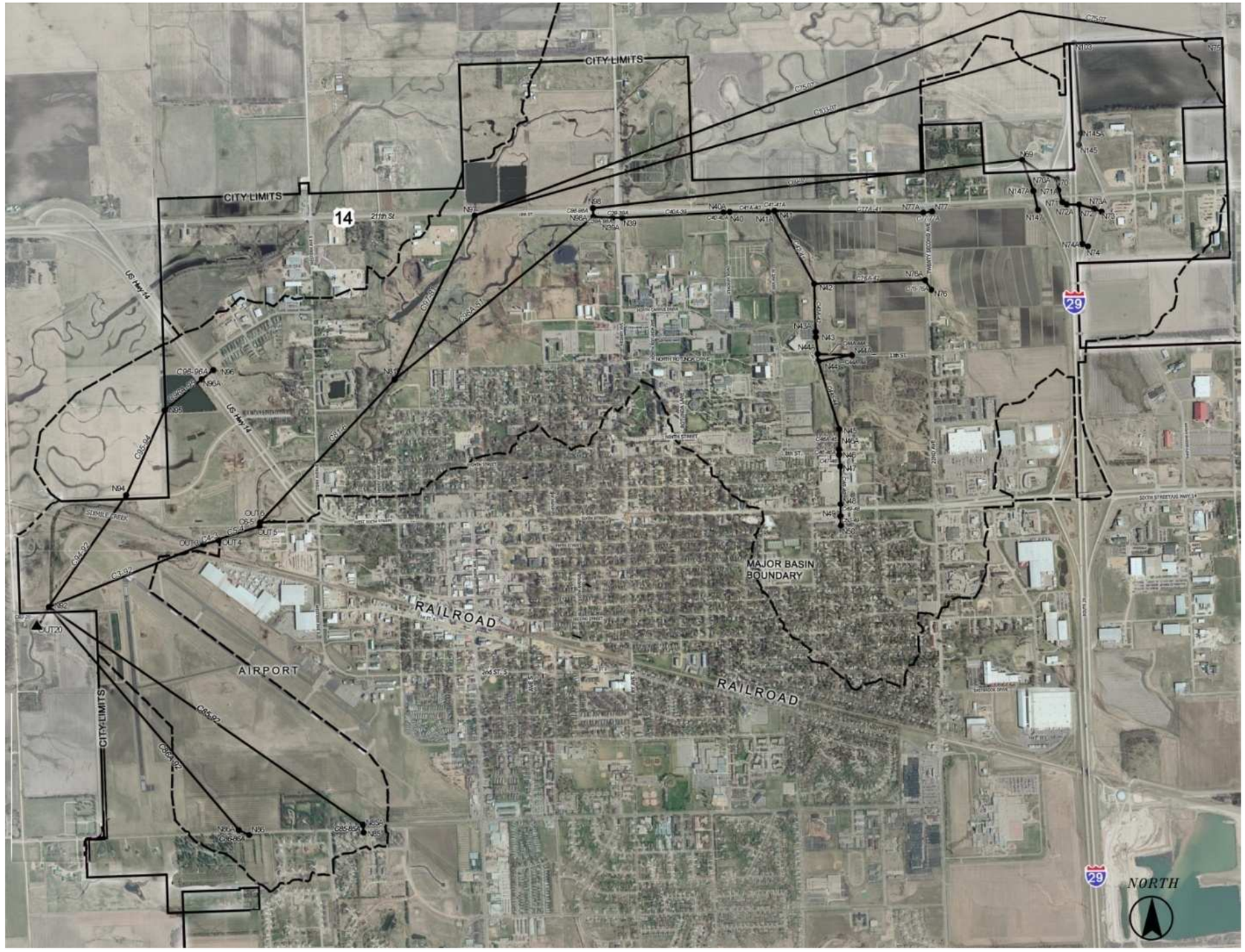

Figure 36 - AREA 20 MAP

Approximately 3,999.5 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this area of 2,564-cfs and 4,954-cfs for the 5-year and the 100-year storms respectively.

Area 20 is the largest of the areas and it includes all basins that ultimately drain to Six Mile Creek. It includes Areas 3-6 because their outfalls are located upstream of the outfall for Area 20. The outfall of Area 20 (OUT20) is located where Six Mile Creek leaves the City limits. Including these Areas, Area 20 contains eight drainage pathways. The drainage pathways located in Areas 3-6 were discussed above and will not be discussed in this section.

The southern drainage pathway begins in a piping system located on Jefferson Avenue South and travels north to where it enters a double 6' x 3' concrete box culvert at State Street. Flow continues north and outfalls into a concrete swale and then passes through a 12' x 5' concrete box culvert under 8th Street. It then enters a concrete swale between two housing developments (Study Area 2). Flow continues north through a grass swale and a concrete box culvert under 11th Street. It then enters a grass swale where it combines with flows from grass swales flowing west until entering a culvert at 18th Street. At this culvert it combines with flows from a grass swale flowing west. It continues west through a series of grass swales and culverts until outfalling into Six Mile Creek where it combines with flows from the north and east (N98). Six Mile Creek continues flowing southwest and combines with flows from the north (N81) and east (Areas 3-6) before continuing southwest and flowing out of the City Limits.

The remaining drainage pathways enter tributaries to Six Mile Creek in the north and flow southwest ultimately combining with the pathway described above at N98 (C5-98, C103-98 and C69-98) and N81 (C97-81).

The acreage of basins 71 and 72 which drain to N97 and N98 respectively was not determinable from the available information because they both basins include multiple tributaries to Six Mile Creek. A complete watershed analysis is required to determine the acreage of the basins.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N145	C145-145A	No Improvements Recommended
N145A	C145A-103	NA - Conveyance used to simulate overland flow.
N103	C103-97	NA - Conveyance used to simulate overland flow.
N39	C39-39A	No Improvements Recommended
N39A	C39A-98A	No Improvements Recommended
N40	C40-40A	7.5' x 4' Concrete Box Culverts
N40A	C40A-39	No Improvements Recommended
N41	C41-41A	7.5' x 4' Concrete Box Culvert
N41A	C41A-40	No Improvements Recommended
N42	C42-41	No Improvements Recommended
N43	C43-43A	No Improvements Recommended

N43A	C43A-42	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N44	C44-44A	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N44A	C44A-43	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N45	C45-44	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N46	C46-46A	No Improvements Recommended
N46A	C46A-45	Rectangular Concrete Channel (b=9.5',d=2')
		Rectangular Concrete Channel (b=7.5',d=2.5')
		(2) 7' x 2' Concrete Box Culvert
		9.5' x 2.5' Concrete Box Culvert
		7.5' x 3' Concrete Box Culvert
N47	C47-46	No Improvements Recommended
N48	C48-47	No Improvements Recommended
N49	C49-48	No Improvements Recommended
N50	C50-49	No Improvements Recommended
N147	C147-147A	No Improvements Recommended
N147A	C147-69	NA - Conveyance used to simulate overland flow.
N69	C69-98	NA - Six Mile Creek
N70	C70-70A	(3) 36" RCP
N70A	C70A-69	NA - Conveyance used to simulate overland flow.
N71	C71-71A	(2) 48" RCP or 5' x 4' Concrete Box Culvert
N71A	C71A-70	NA - Conveyance used to simulate overland flow.
N72	C72-72A	No Improvements Recommended
N72A	C72A-71	NA - Conveyance used to simulate overland flow.
N73	C73-73A	42" RCP
N73A	C73A-72	NA - Conveyance used to simulate overland flow.
N74	C74-74A	No Improvements Recommended
N74A	C74A-72	NA - Conveyance used to simulate overland flow.
N75	C75-97	NA - Conveyance used to simulate overland flow.
N76	C76-76A	(2) 36" CMP
N76A	C76A-42	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N77	C77-77A	15" RCP
N77A	C77A-41	No Improvements Recommended
N81	C81-92	NA - Six Mile Creek
N85	C85-85A	21" RCP
N85A	C85A-92	NA - Conveyance used to simulate overland flow.
N86	C86-86A	27" RCP
N86A	C86A-92	NA - Conveyance used to simulate overland flow.
N92	C92-20	NA - Six Mile Creek

N94	C94-92	NA - Six Mile Creek
N95	C95-94	NA - Six Mile Creek
N96	C96-96A	NA - Six Mile Creek
N96A	C96A-95	NA - Six Mile Creek
N97	C97-81	NA - Six Mile Creek
N98	C98-81	NA - Six Mile Creek

Table 72 - AREA 20: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N145	C145-145A	30" RCP
N145A	C145A-103	NA - Conveyance used to simulate overland flow.
N103	C103-97	NA - Conveyance used to simulate overland flow.
N39	C39-39A	8' x 4' Concrete Box Culvert
N39A	C39A-98A	No Improvements Recommended
N40	C40-40A	(2) 7.5' x 4' Concrete Box Culverts
N40A	C40A-39	Grass Swale (b= 12', d= 4.5', z = 4:1) or Concrete Channel (b= 8' d= 3.6' z=4:1)
N41	C41-41A	(2) 7.5' x 4' Concrete Box Culverts
N41A	C41A-40	Grass Swale (b= 9', d= 4', z = 4:1) or Concrete Channel (b= 4' d= 3.4', z=4:1)
N42	C42-41	No Improvements Recommended
N43	C43-43A	10.5 x 5' Concrete Box Culvert at 0.5%
N43A	C43A-42	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N44	C44-44A	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N44A	C44A-43	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N45	C45-44	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N46	C46-46A	No Improvements Recommended
N46A	C46A-45	(2) 7.5' x 3' Concrete Box Culverts
N47	C47-46	No Improvements Recommended
N48	C48-47	No Improvements Recommended
N49	C49-48	No Improvements Recommended
N50	C50-49	No Improvements Recommended
N147	C147-147A	No Improvements Recommended
N147A	C147-69	NA - Conveyance used to simulate overland flow.
N69	C69-98	NA - Six Mile Creek
N70	C70-70A	60" RCP
N70A	C70A-69	NA - Conveyance used to simulate overland flow.
N71	C71-71A	(2) 60" RCP
N71A	C71A-70	NA - Conveyance used to simulate overland flow.

N72	C72-72A	60" RCP
N72A	C72A-71	NA - Conveyance used to simulate overland flow.
N73	C73-73A	54" RCP
N73A	C73A-72	NA - Conveyance used to simulate overland flow.
N74	C74-74A	No Improvements Recommended
N74A	C74A-72	NA - Conveyance used to simulate overland flow.
N75	C75-97	NA - Conveyance used to simulate overland flow.
N76	C76-76A	48" RCP
N76A	C76A-42	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.
N77	C77-77A	24" RCP
N77A	C77A-41	No Improvements Recommended
N81	C81-92	NA - Six Mile Creek
N85	C85-85A	30" RCP
N85A	C85A-92	NA - Conveyance used to simulate overland flow.
N86	C86-86A	30" RCP
N86A	C86A-92	NA - Conveyance used to simulate overland flow.
N92	C92-20	NA - Six Mile Creek
N94	C94-92	NA - Six Mile Creek
N95	C95-94	NA - Six Mile Creek
N96	C96-96A	NA - Six Mile Creek
N96A	C96A-95	NA - Six Mile Creek
N97	C97-81	NA - Six Mile Creek
N98	C98-81	NA - Six Mile Creek

Table 73 - AREA 20: RECOMMENDED IMPROVEMENTS – 100 YEAR

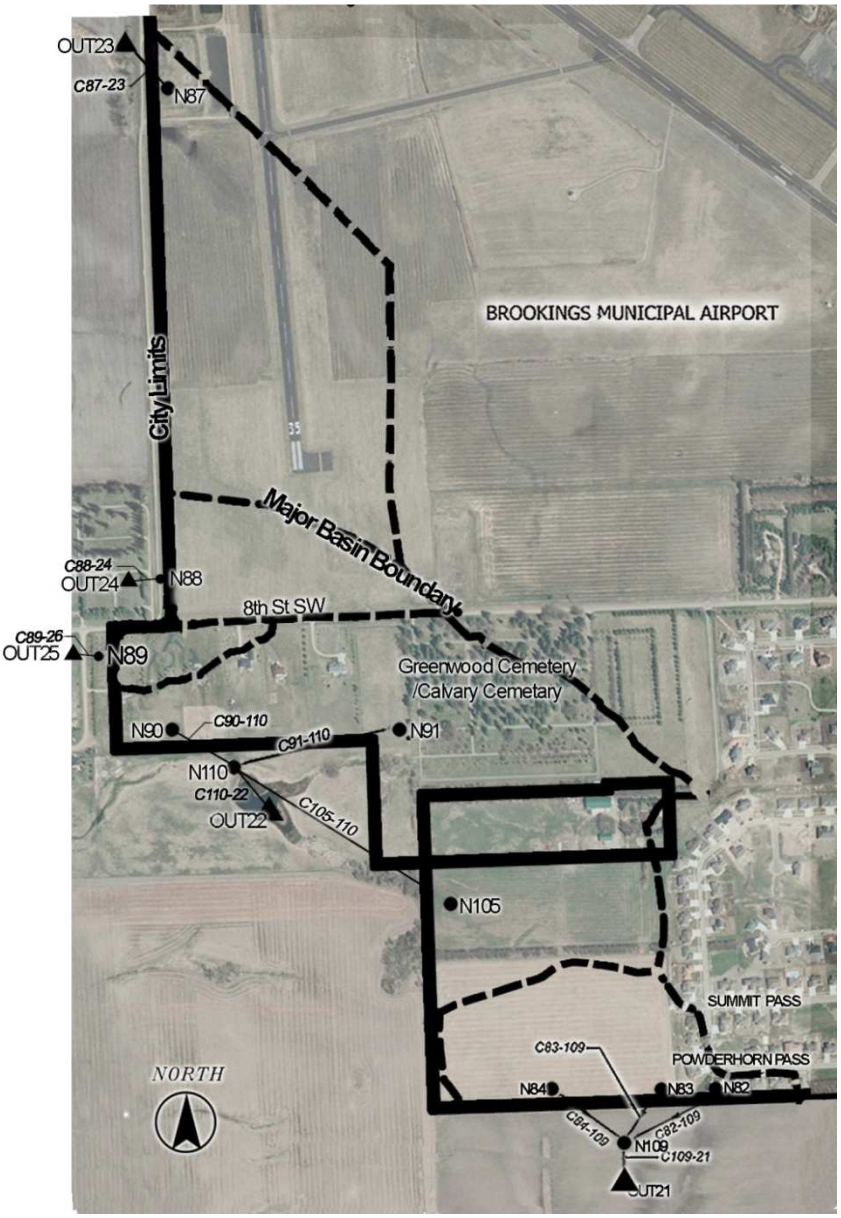

Figure 37 - AREA 21, AREA 22, AREA 23, AREA 24 AND AREA 25 MAP

21. AREA 21

Approximately 22.2 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 6-cfs and 16-cfs for the 5-year and the 100-year storms respectively. This area was modeled to determine the flows draining offsite from its basin. The area has no existing conveyances and requires no improvements.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N109	C109-21	NA - Dummy Conduit
N82	C82-109	NA - Dummy Conduit
N83	C83-109	NA - Dummy Conduit
N84	C84-109	NA - Dummy Conduit

Table 74 - AREA 21: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N109	C109-21	NA - Dummy Conduit
N82	C82-109	NA - Dummy Conduit
N83	C83-109	NA - Dummy Conduit
N84	C84-109	NA - Dummy Conduit

Table 75 - AREA 21: RECOMMENDED IMPROVEMENTS – 100 YEAR

22. AREA 22

Approximately 72.6 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 30-cfs and 50-cfs for the 5-year and the 100-year storms respectively. This area was modeled to determine the flows draining offsite from its basin. The area has no existing conveyances and requires no improvements.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N105	C105-110	NA - Dummy Conduit
N110	C110-22	NA - Dummy Conduit
N90	C90-110	NA - Dummy Conduit
N91	C91-110	NA - Dummy Conduit

Table 76 - AREA 22: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N105	C105-110	NA - Dummy Conduit
N110	C110-22	NA - Dummy Conduit
N90	C90-110	NA - Dummy Conduit
N91	C91-110	NA - Dummy Conduit

Table 77 - AREA 22: RECOMMENDED IMPROVEMENTS – 100 YEAR

23. AREA 23

Approximately 56.2 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 29-cfs and 51-cfs for the 5-year and the 100-year storms respectively. This area was modeled to determine the flows draining offsite from its basin. The area has no existing conveyances and requires no improvements.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N87	C87-23	NA - Dummy Conduit

Table 78 - AREA 23: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N87	C87-23	NA - Dummy Conduit

Table 79 - AREA 23: RECOMMENDED IMPROVEMENTS – 100 YEAR

24. AREA 24

Approximately 16.3 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 9-cfs and 16-cfs for the 5-year and the 100-year storms respectively. This area was modeled to determine the flows draining offsite from its basin. The area has no existing conveyances and requires no improvements.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N88	C88-24	NA - Dummy Conduit

Table 80 - AREA 24: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N88	C88-24	NA - Dummy Conduit

Table 81 - AREA 24: RECOMMENDED IMPROVEMENTS – 100 YEAR

25. AREA 25

Approximately 4.7 acres are tributary to this study area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 7-cfs and 12-cfs for the 5-year and the 100-year storms respectively. This area was modeled to determine the flows draining offsite from its basin. The area has no existing conveyances and requires no improvements.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N89	C89-25	NA - Dummy Conduit

Table 82 - AREA 25: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N89	C89-25	NA - Dummy Conduit

Table 83 - AREA 25: RECOMMENDED IMPROVEMENTS – 100 YEAR

26. AREA 26

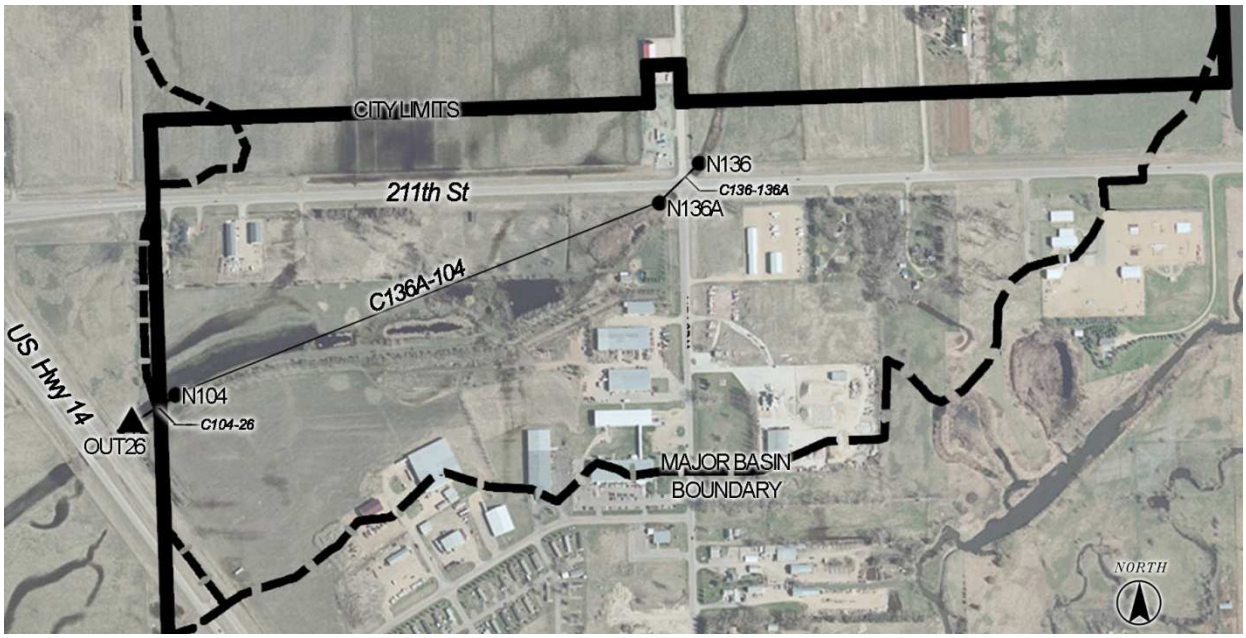

Figure 38 - AREA 26 MAP

Approximately 188.4 acres within the City limits are tributary to this area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 208-cfs and 401-cfs for the 5-year and the 100-year storms respectively. The acreage tributary to this area from offsite could not be determined with the available information. Determining total offsite flows requires a complete analysis of the Six Mile Creek watershed.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N104	C104-26	NA - Dummy Conduit
N136	C136-136A	No Improvements Recommended.
N136A	C136A-104	NA - Dummy Conduit

Table 84 - AREA 26: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N104	C104-26	NA - Dummy Conduit
N136	C136-136A	No Improvements Recommended.
N136A	C136A-104	NA - Dummy Conduit

Table 85 - AREA 26: RECOMMENDED IMPROVEMENTS – 100 YEAR

27. AREA 27

Figure 39 - AREA 27 MAP

Approximately 5.4 acres are tributary to this area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 4-cfs and 7-cfs for the 5-year and the 100-year storms respectively. This area was modeled to determine the flows draining offsite from its basin. The area has no existing conveyances and requires no improvements.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N93	C93-27	NA - Dummy Conduit

Table 86 - AREA 27: RECOMMENDED IMPROVEMENTS – 5 YEAR

a) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N93	C93-27	NA - Dummy Conduit

Table 87 - AREA 27: RECOMMENDED IMPROVEMENTS – 100 YEAR

28. AREA 28

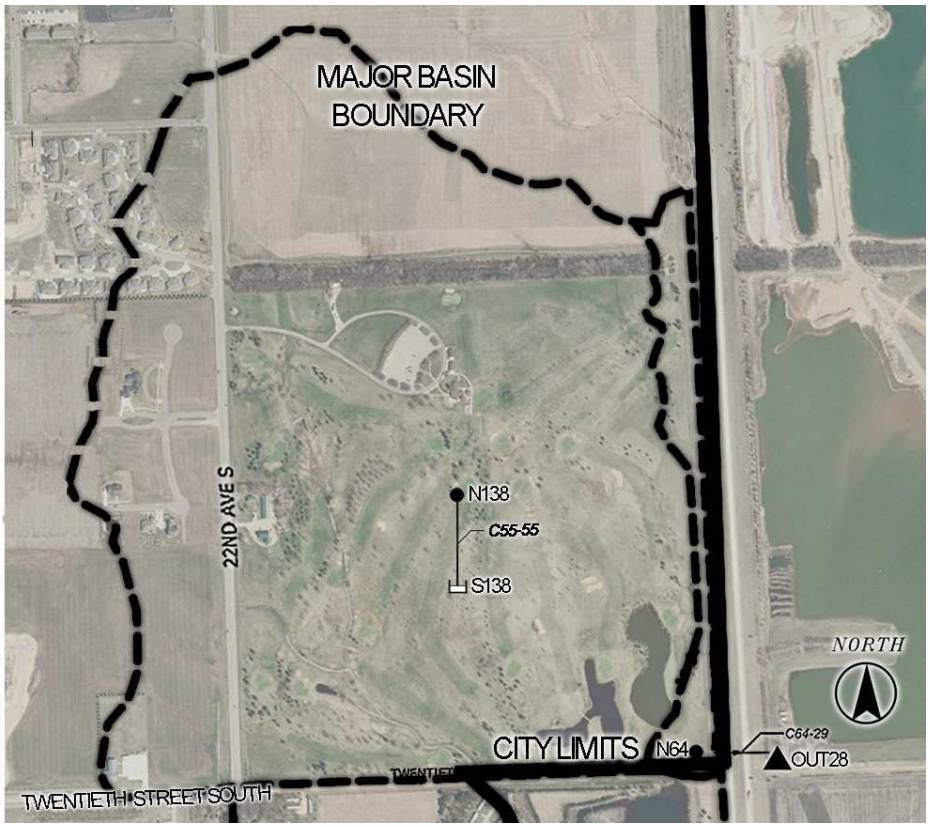

Figure 40 - AREA 28 MAP

Approximately 12.4 acres are tributary to this area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 13-cfs and 23-cfs for the 5-year and the 100-year storms respectively. The adequacy of C64-28 should be reevaluated if Area 28 or Area S138 changes significantly or if the storage in S138 is not adequate.

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N64	C64-28	36” RCP

Table 88 - AREA 28: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N64	C64-28	42” RCP

Table 89 - AREA 28: RECOMMENDED IMPROVEMENTS – 100 YEAR

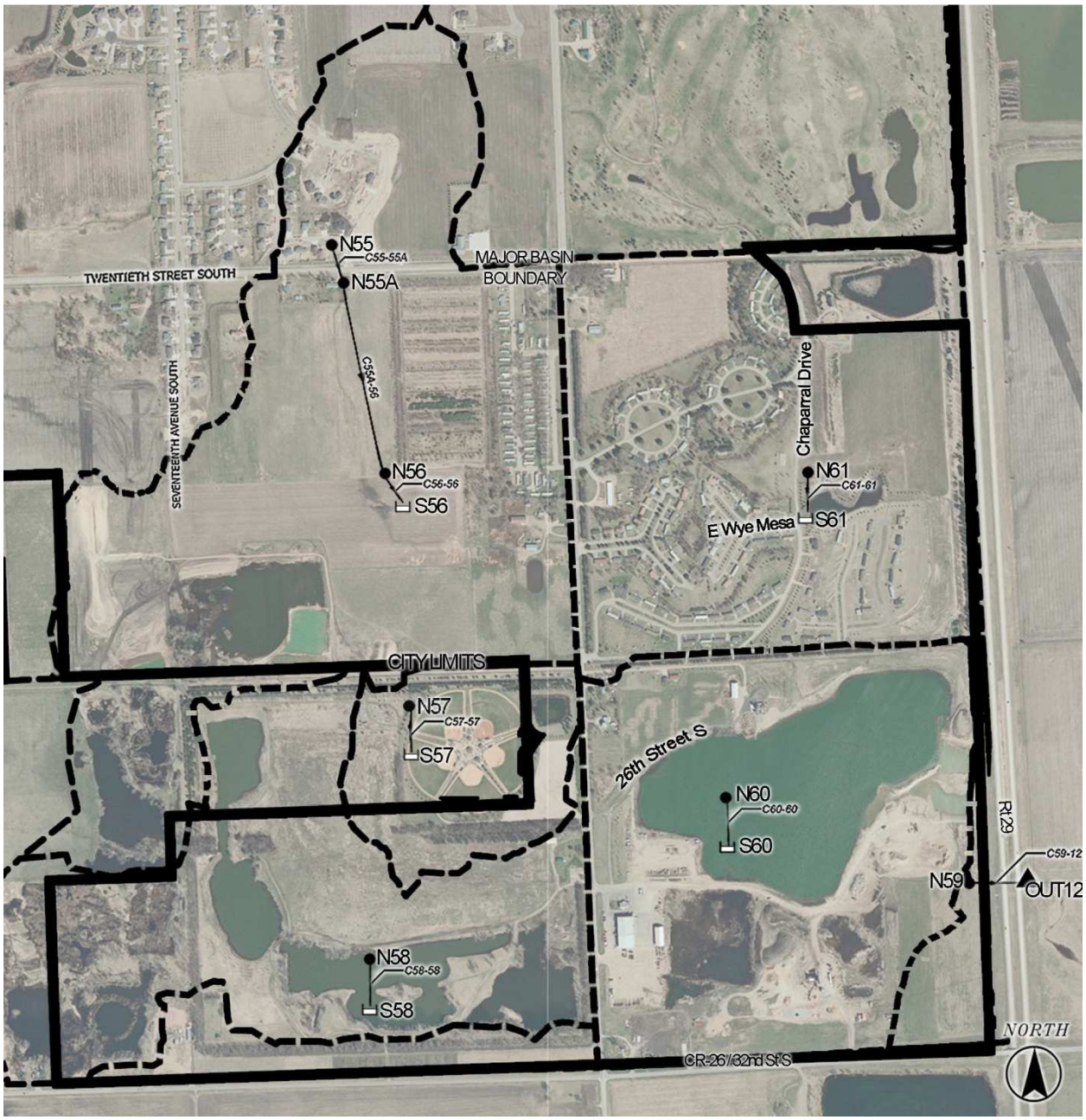

Figure 41 - AREA S56, AREA S57, AREA S58, AREA S60 AND AREA S61 MAP

29. AREA S56

Approximately 229.9 acres are tributary to this area with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 173-cfs and 315-cfs for the 5-year and the 100-year storms respectively. It is a contained basin that has existing storage. Water travels south from basin 10 through an existing pipe system and crosses under W. 20th St. S through a 36" x 23" RCP arch (N55) and outfalls onto undeveloped land in basin 114 where the existing storage is located. If existing storage is not adequate it will most likely cause only local flooding and not damage the minor development that is around it. To prevent the possibility of any flooding it is recommended that the storage facility is

increased in size or a spillway and overflow path that allows for the safe passage of overflow is constructed.

	SWMM			BROOKINGS REQ (1.5*100-year storm)		
Node	**Mgallons**	**gallons**	**Acre-Ft**	**Mgallons**	**gallons**	**Acre-Ft**
S56	19.66	19,660,000.0	60.3	29.5	29,490,000.0	90.5

Table 90 - AREA S56: RECOMMENDED STORAGE

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N55	C55-55A	4' x 2.5' Concrete Box Culvert
N55A	C55A-56	NA - Dummy Conduit
N56	C56-S56	NA - Dummy Conduit
S56	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 91 - AREA S56: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements –100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N55	C55-55A	5.5' x 3' Concrete Box Culvert
N55A	C55A-56	NA - Dummy Conduit
N56	C56-S56	NA - Dummy Conduit
S56	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 92 - AREA S56: RECOMMENDED IMPROVEMENTS – 100 YEAR

30. AREA S57

Approximately 40.2 acres are tributary to this study with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 4-cfs and 21-cfs for the 5-year and the 100-year storms respectively. Area S57 is a contained basin that is not completely located within the City limits. Based on its location it takes City flows and can have an effect on City properties. It currently has an existing storage facility and its only development is baseball diamonds. In the event that the basin's usage changes the possibility of it overflowing onto City property will need to be determined and the proper measures taken.

	SWMM			BROOKINGS REQ (1.5*100-year storm)		
Node	Mgallons	gallons	Acre-Ft	Mgallons	gallons	Acre-Ft
S57	2.74	2,740,000.0	8.4	4.1	4,110,000.0	12.6

Table 93 - AREA S57: RECOMMENDED STORAGE

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N57	C57-S57	NA - Dummy Conduit
S57	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 94 - AREA S57: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N57	C57-S57	NA - Dummy Conduit
S57	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 95 - AREA S57: RECOMMENDED IMPROVEMENTS – 100 YEAR

31. AREA S58

Approximately 151.2 acres are tributary to this study with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 30-cfs and 119-cfs for the 5-year and the 100-year storms respectively. Area S58 is located just north of the City limits west of the corner of 32nd St. S and 22nd St. S. It is a contained basin that has existing storage. If the storage is inadequate water will pond and flow to the west and out of the City limits. If existing storage is not adequate it is recommended that the storage facility is increased in size or a spillway that allows for the safe passage of overflow is constructed. Coordination with the land owners downstream of the spillway will need to occur.

	SWMM			BROOKINGS REQ (1.5*100-year storm)		
Node	Mgallons	gallons	Acre-Ft	Mgallons	gallons	Acre-Ft
S58	10.90	10,900,000.0	33.5	16.4	16,350,000.0	50.2

Table 96 - AREA S58: RECOMMENDED STORAGE

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N58	C58-S58	NA - Dummy Conduit
S58	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 97 - AREA S58: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N58	C58-S58	NA - Dummy Conduit
S58	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 98 - AREA S58: RECOMMENDED IMPROVEMENTS – 100 YEAR

32. AREA S60

Approximately 159.7 acres are tributary to this study with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 181-cfs and 342-cfs for the 5-year and the 100-year storms respectively. Area S60 is located in the southeastern corner of the City. It is a contained basin and does not have an outflow point. It currently has on-site storage. If the current storage facility is not adequate the water will pond and will leave the site via the SDSHA structure located at N59 in Area 12. This structure is currently adequate to pass existing and future flows in this condition.

	SWMM			BROOKINGS REQ (1.5*100-year storm)		
Node	Mgallons	Gallons	Acre-Ft	Mgallons	Gallons	Acre-Ft
S60	18.2	18,210,000.0	55.9	27.3	27,315,000.0	83.8

Table 99 - AREA S60: RECOMMENDED STORAGE

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N60	C60-S60	NA - Dummy Conduit
S60	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 100 - AREA S60: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N60	C60-S60	NA - Dummy Conduit
S60	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 101 - AREA S60: RECOMMENDED IMPROVEMENTS – 100 YEAR

33. AREA S61

Approximately 157.5 acres are tributary to this study with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 90-cfs and 178-cfs for the 5-year and the 100-year storms respectively. Area S61 is located in the southeastern corner of the City. It is a contained basin and does not have an outflow point. It currently has on-site storage. If the current storage facility is not adequate the water will pond and will leave the site via the SDSHA structure located at N59. This structure is adequate to pass existing and future flows in this condition.

	SWMM			BROOKINGS REQ (1.5*100-year storm)		
Node	Mgallons	Gallons	Acre-Ft	Mgallons	Gallons	Acre-Ft
S61	14.7	14,680,000.0	45.1	22.0	22,020,000.0	67.6

Table 102 - AREA S61: RECOMMENDED STORAGE

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement: 5-yr
N61	C61-S61	NA - Dummy Conduit
S61	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 103 - AREA S61: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement: 100-yr
N61	C61-S61	NA - Dummy Conduit
S61	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.

Table 104 - AREA S61: RECOMMENDED IMPROVEMENTS – 100 YEAR

34. AREA S138

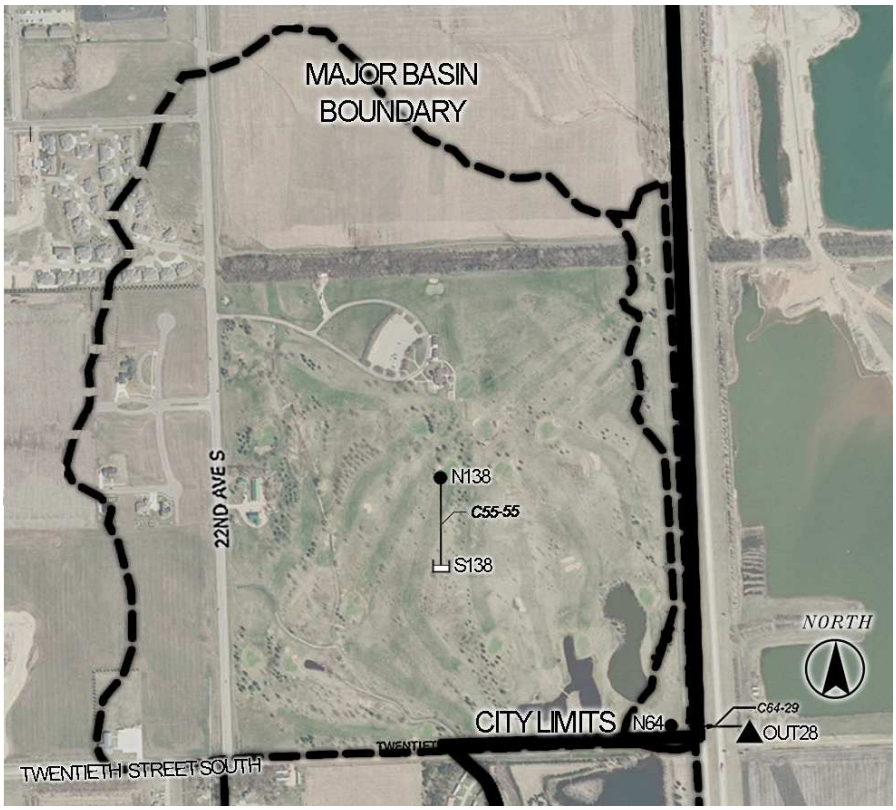

Figure 42 - AREA S138 MAP

Approximately 239.0 acres are tributary to this study with drainage reaching this location via overland flow. SWMM results indicate inflows to this site of 201-cfs and 387-cfs for the 5-year and the 100-year storms respectively. Area S138 is located in the southeastern portion of the City and includes Edgebrook Golf Course. It is a contained basin and does not have an outflow point. It currently has on-site storage. If the current storage facility is not adequate the water will pond and will leave the site via the SDSHA structure located at N64 located in Area 28. This structure is not adequate to pass existing and future flows in this condition. A minimum of an 8' x 4.5' box culvert at 0.5% will be needed to allow the passage of the full 100-year storm event if storage in this area is eliminated.

	SWMM			BROOKINGS REQ (1.5*100-year storm)		
Node	**Mgallons**	**Gallons**	**Acre-Ft**	**Mgallons**	**Gallons**	**Acre-Ft**
S138	24.6	24,600,000.0	75.5	36.9	36,900,00.0	113.2

Table 105 - AREA S61: RECOMMENDED STORAGE

a) Recommended Improvements – 5 year

Upstream Node	Conduit	Recommended Improvement 5-yr
N138	C138-138	NA - Dummy Conduit
S138	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.
N64*	C64-28	6' x 4' Concrete Box Culvert

*This node is located in Area 28.

Table 106 - AREA S138: RECOMMENDED IMPROVEMENTS – 5 YEAR

b) Recommended Improvements – 100 year

Upstream Node	Conduit	Recommended Improvement 100-yr
N138	C138-138	NA - Dummy Conduit
S138	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.
N64*	C64-28	8’ x 4.5' Concrete Box Culvert

*This node is located in Area 28.

Table 107 - AREA S138: RECOMMENDED IMPROVEMENTS – 100 YEAR

VI. IMPROVEMENT COSTS

Capital cost estimates were developed for each recommended improvement. Costs were developed for the individual improvements noted above and grouped together according to the study area or major area. As the improvements herein are preliminary, costs presented here should be considered budgetary level costs. More detailed costs should be developed as part of the final design for the improvements.

Costs contained in this plan area based on 2008 prices. Estimates were generated from known material costs, bid documents provided by the City, costs for similar projects and engineering judgment.

Costs included in this report are capital costs only and do not include all costs that will likely be associated with drainage improvements. Costs that were not considered include the following:

- Easements that may be required
- Property acquisition that may be required
- Potential utility or other conflicts
- Upgrading of facilities between major drainage structures
- Upgrading of “neighborhood” level drainage features

- Operations and Maintenance of Drainage Improvements

All cost background information can be found in Appendix G.

A. UNIT COST

Unit costs used for this evaluation included major construction items only. Costs are not intended to identify all minor components and costs associated with the recommended improvements. Minor components were included in the overall costs by assuming a set percentage of the cost of the major drainage improvement components. Minor costs assumed when generating the capital costs for drainage improvements include the following:

Site Preparation	10% of major construction items
Erosion, Water and Sediment Control	5% of major construction items
Minor Drainage Elements/Incidentals	20% of major construction items
Mobilization/Demobilization	5% of major construction items
Design and Permitting	10% of major construction items
Construction Management	8% of major construction items
Contingencies	10% of major construction items
Total	**68% of major construction items**

B. COST ASSUMPTIONS

Quantity assumptions were made in determining recommended improvement costs. The assumptions used were:

- The channel excavation volumes assume that the entire channel will need to be excavated. This volume was calculated by multiplying the cross sectional area of the recommended channel by its length.
- Pipe lengths were measured from the existing storm sewer mapping or from the available aerials. For non-culvert pipes the length represents the entire length of pipe measured from storm drain structure to storm drain structure.
- The detention pond excavation volumes assume that the entire pond will need to be excavated. This volume is equal to the volume recommended as storage.

C. STUDY AREA COST

Costs were developed for each of the 13 study areas. They include the costs of recommended improvements for each study area and of any improvements recommended downstream of the study area. In instances where items have more than one recommended improvement, the cost for a concrete channel was used. Study Area costs can be found below.

Study Area	Storm Event	Recommended Improvement Cost ($)
1	5-year Storm with Detention	1,449,134.
	5-year Storm with No Detention	1,835,266.
	100-year Storm with Detention	1,956,624
	100-year Storm with No Detention	4,017,782
2	5-year Storm	0
	100-year Storm	0
3	5-year Storm	141,473
	100-year Storm	100,787
4	5-year Storm*	1,069,192
	100-year Storm	541,477
5	5-year Storm	10,000
	100-year Storm	10,000
6	5-year Storm - Northwest Corner	1,273,517
	5-year Storm-Northeast Corner	1,391,979
	100-year Storm - Northwest Corner	2,023,489
	100-year Storm-Northeast Corner	4,050,721
7	5-year Storm	553,553
	100-year Storm	824,737
8	5-year Storm	119,523
	100-year Storm	239,046
9	5-year Storm	2,641,416
	100-year Storm	5,185,620
10	5-year Storm with Detention	1,789,304
	5-year Storm with No Detention	1,509,531
	100-year Storm with Detention	5,195,588
	100-year Storm with No Detention	5,236,964
11	5-year Storm	445,004
	100-year Storm	1,027,384
12	5-year Storm	37,654

	100-year Storm	51,023
13	5-year Storm	13,239
	100-year Storm	30,761

* Cost is for a rectangular concrete channel (d=2', b=9.5')

Table 108 – COSTS BY STUDY AREA

D. CAPITAL IMPROVEMENT COST

Costs were developed for each of the capital improvements for the 5-year and 100-year storms. They include the costs of recommended capital improvements for each Area. In instances where items have more than one recommended improvement, the cost for a concrete channel was used. Area costs can be found below.

1. Cost of Recommended Improvements – 5 year

Area	Recommended Improvement Cost ($)	Area	Recommended Improvement Cost ($)
1	2,534,668	19	0
2	5,456,466	20	5,328,294
3	1,887,962	21	0
4	768,491	22	0
5	1,737,145	23	0
6	461,153	24	0
7	0	25	0
8	0	26	0
9	0	27	0
10	0	28	0
11	0	28**	163,768
12	0	S56	30,175
13	0	S57	0
14	0	S58	0
15	0	S60	0
16	90,140	S61	0
17	0	S138	0
18	211,762	S138**	163,768
		Total	13,815,273

* This cost includes the costs for Areas 3-6

** This cost applies if S138 does not have adequate storage. It was not included in the total cost.

Table 109 – CAPITAL IMPROVEMENT COSTS BY AREA – 5 YEAR STORM

1. Cost of Recommended Improvements – 100 year

Area	Recommended Improvement Cost ($)	Area	Recommended Improvement Cost ($)
1	7,976,821	19	0
2	11,234,761	20	10,565,170
3	3,536,821	21	0
4	1,209,338	22	0
5	2,461,328	23	0
6	1,099,388	24	0
7	5,837	25	0
8	0	26	0
9	0	27	0
10	0	28	0
11	0	28**	232,298
12	0	S56	42,742
13	53,269	S57	0
14	0	S58	0
15	0	S60	0
16	490,940	S61	0
17	234,066	S138	0
18	417,184	S138**	232,298
		Total	31,567,042

* This cost includes the costs for Areas 3-6

** This cost applies if S138 does not have adequate storage. It was not included in the total cost.

Table 110 – CAPITAL IMPROVEMENT COSTS BY AREA – 100 YEAR STORM

VII. PRIORITIZATION OF IMPROVEMENTS

Given the high cost to implement the recommended improvements, the recommendations within this Plan will need to be prioritized. Final prioritization should factor in the relative need for the improvement and available financial resources. It is recommended that the proposed detention facilities have a high priority as they have the greatest effect on the amount of flooding that may occur.

VIII. REFERENCES

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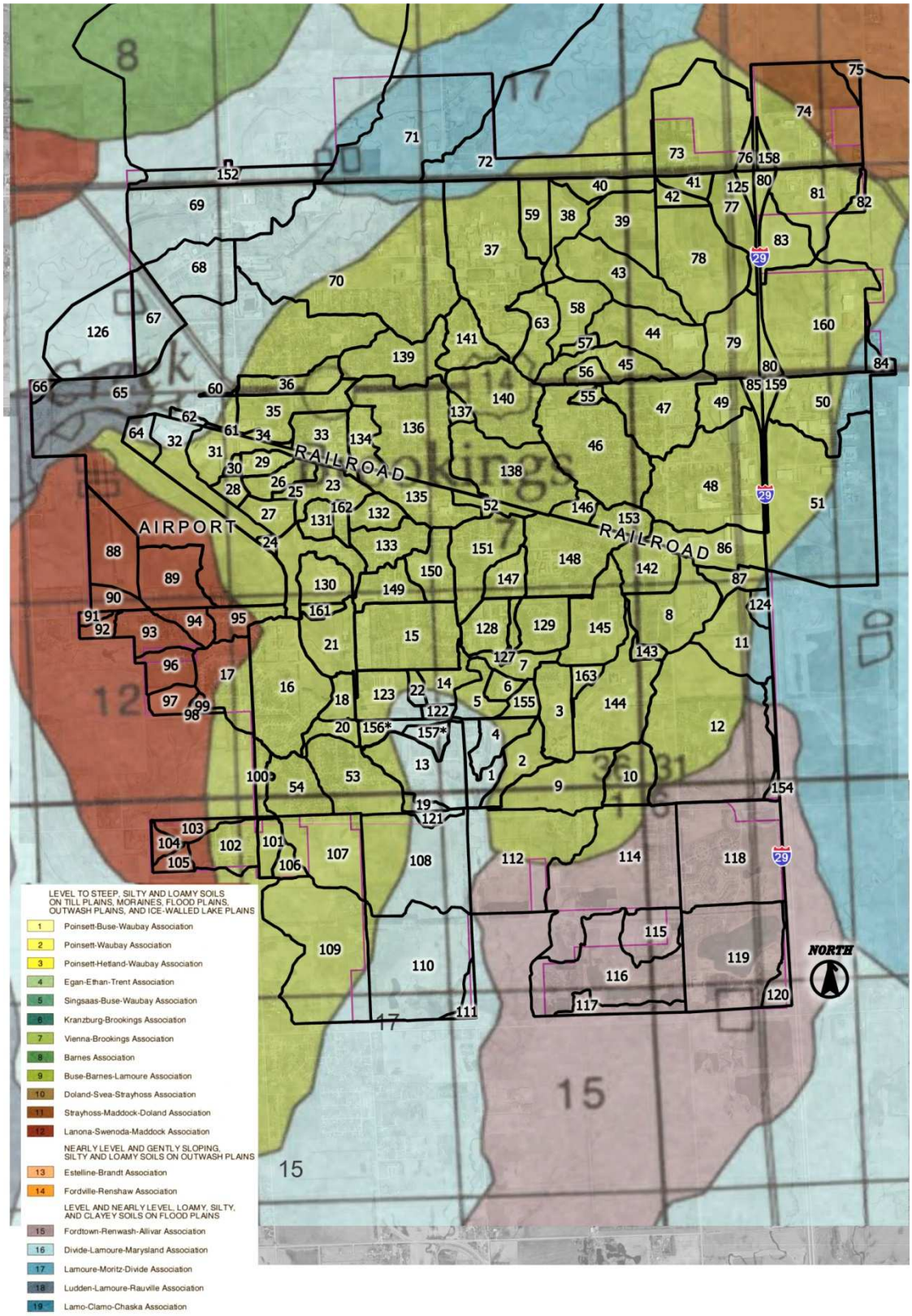
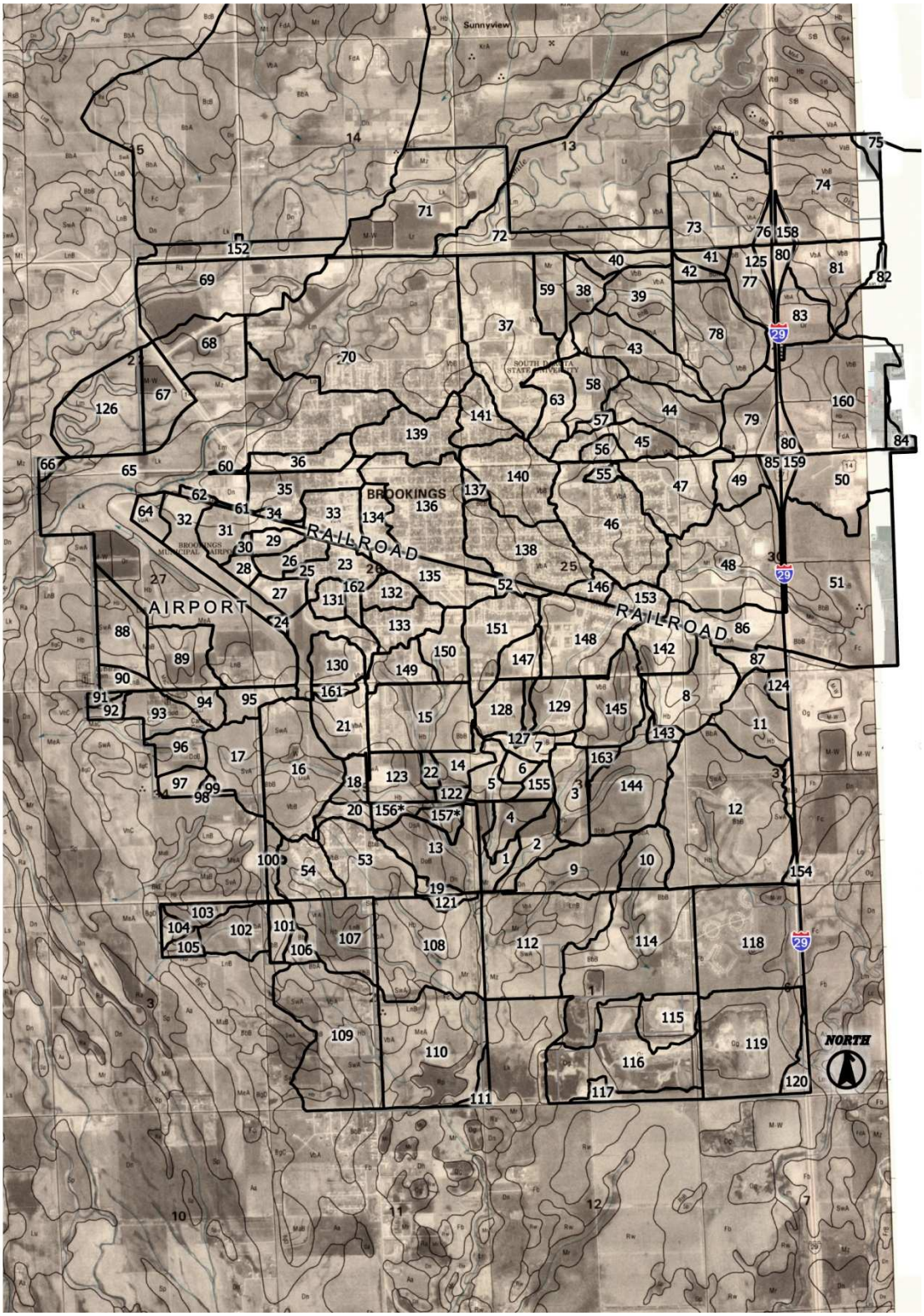
Appendix A – CITY MAPPING AND BACKGROUND INFORMATION USED – SEE DVD

Appendix B – GENERAL AND DETAILED SOILS MAPS

General Soils Map



Detailed Soils Map



Appendix C –SWMM BASIN PARAMETERS

Area	Design Point	Basin	Area	Area	Length of Overland Flow Path	Width	Percent Slope	Percent
			(sq. feet)	(acres)	(feet)	(feet)	(%)	Existing (%
1	N1	1	1101285.7	25.3	1650	667	2.9	17.1
1	N1	2	1415924.9	32.5	2509	564	1.4	2.0
1	N3	3	1994719.8	45.8	854	2336	3.0	14.6
1	N1	4	1211095.1	27.8	2748	441	1.4	5.6
1	N5	5	1127567.6	25.9	2999	376	1.9	23.3
1	N6	6	497297.2	11.4	1202	414	2.2	14.4
1	N7A	7	1183297.3	27.2	1410	839	3.2	49.0
1	N8	8	3214278.7	73.8	2038	1577	3.3	78.3
1	N9	9	3048415.9	70.0	3457	882	2.0	11.9
S56	N55	10	1675610.8	38.5	1977	848	3.3	8.5
13	N62	11	3210248.2	73.7	1848	1737	4.4	44.7
S138	N138	12	10409171.5	239.0	3215	3238	2.9	2.0
2	N2	13	4625278.7	106.2	3280	1410	2.6	12.0
2	N22	14	1072502.4	24.6	2419	443	2.8	28.1
2	N15	15	4344738.2	99.7	1331	3264	2.2	54.1
2	N16	16	4101473.9	94.2	2438	1682	3.9	32.8
2	S17	S17	1075932.0	24.7	1074	1002	4.2	85.0
2	S17W	S17W	1065477.6	24.5	1728	617	4.2	75.0
2	S17E	S17E	455202.0	10.5	1535	200	4.2	75.0
-	-	17	1074069.8	24.7	1717	350	4.2	60.0
2	N18	18	767499.0	17.6	1526	503	2.7	34.1
2	N142	19	306843.6	7.0	1893	162	2.5	8.8
2	N18A	20	654135.9	15.0	1983	330	4.6	51.1
2	N18A	21	2025921.0	46.5	1809	1120	3.7	39.6
2	N22	22	329504.1	7.6	956	345	1.3	4.5
3	N23	23	3307254.2	75.9	2701	1224	2.1	46.5
3	N27	24	155944.5	3.6	407	383	1.6	50.0
3	N25	25	133352.5	3.1	527	253	3.3	2.0
3	N26	26	988197.8	22.7	2166	456	3.6	82.7
3	N27	27	954837.6	21.9	1143	835	1.9	20.1
3	N28	28	460734.3	10.6	880	524	2.6	46.9
3	N29	29	681539.4	15.6	1286	530	3.0	90.5
3	N30A	30	168085.3	3.9	340	494	4.1	90.5
3	N31	31	1919779.0	44.1	1534	1251	2.9	81.4
3	N32	32	2284559.2	52.4	3022	756	2.8	32.6
4	N34	33	1689170.8	38.8	1315	1285	2.6	73.2

Area	Design Point	Basin	Area	Area	Length of Overland Flow Path	Width	Percent Slope	Percent
			(sq. feet)	(acres)	(feet)	(feet)	(%)	Existing (%
4	N34A	34	182708.0	4.2	910	201	2.3	5.3
5	N36	35	2288359.4	52.5	1699	1347	2.3	41.4
6	N38	36	1397421.2	32.1	1537	909	2.6	64.7
20	N39	37	7373362.4	169.3	3950	1867	3.7	5.3
20	N41	38	1480373.5	34.0	1637	904	1.5	7.4
20	N42	39	2642619.6	60.7	2303	1148	1.7	7.6
20	N41	40	1006384.1	23.1	2814	358	2.9	12.2
20	N77	41	585969.8	13.5	1455	403	3.3	8.5
20	N77	42	503586.2	11.6	665	757	1.6	8.8
20	N42	43	3258568.4	74.8	3812	855	2.1	15.7
20	N45	44	3294736.2	75.6	2937	1122	2.4	20.0
20	N46	45	1828638.6	42.0	2295	797	3.2	30.8
20	N49	46	5738498.9	131.7	2746	2090	3.1	43.0
20	N48	47	3616644.9	83.0	3000	1206	3.0	44.5
16	N65	48	6803638.1	156.2	3452	1971	4.5	51.0
17	N79	49	1346150.3	30.9	1572	856	4.0	81.4
17	N66	50	3459605.3	79.4	3000	1153	3.5	58.0
16	OUT16	51	10435458.6	239.6	5700	1831	4.5	20.7
5	N37	52	592940.9	13.6	2093	283	3.7	58.3
2	N14	53	3249962.7	74.6	2402	1353	3.0	37.4
2	N21	54	2005704.0	46.0	2092	959	6.3	31.8
20	N50	55	281145.9	6.5	990	284	3.1	69.4
20	N47	56	542406.1	12.5	966	561	2.2	74.2
20	N45	57	299426.4	6.9	1120	267	2.2	43.5
20	N44	58	1794735.9	41.2	2117	848	1.9	7.1
20	N40	59	1490021.7	34.2	1959	761	3.2	6.2
6	OUT6	60	60450.3	1.4	969	62	2.6	15.6
4	N33	61	85104.4	2.0	850	100	2.5	5.0
4	OUT3	62	198982.6	4.6	1079	184	2.3	5.0
20	N44	63	1753062.2	40.2	2526	694	1.9	18.7
3	N32	64	720145.5	16.5	1639	439	3.9	20.0
20	N92	65	24714067.3	567.4	6315	3914	2.3	22.3
27	N93	66	233460.3	5.4	405	576	2.5	23.4
20	N95	67	2126448.6	48.8	1001	2124	1.6	7.3
20	N96	68	2809565.4	64.5	1926	1459	2.4	35.3
26	N104	69	6160967.1	141.4	2663	2314	4.7	28.6

Area	Design Point	Basin	Area	Area	Length of Overland Flow Path	Width	Percent Slope	Percent
			(sq. feet)	(acres)	(feet)	(feet)	(%)	Existing (%
20	N81	70	15610466.9	358.4	10325	1512	2.6	43.5
20	N97	71**	7180100.8	164.8	5280	1360	2.3	42.1
20	N98	72**	3988508.7	91.6	5500	725	2.6	36.6
20	N69	73	5721263.9	131.3	8000	715	3.6	59.6
20	N103	74	6529551.2	149.9	4681	1395	2.3	8.7
20	N75	75	397136.8	9.1	1074	370	2.3	2.0
20	N70	76	304415.6	7.0	486	626	10.6	25.8
20	N147	77	1821809.2	41.8	2154	846	5.1	11.9
20	N76	78	4874137.1	111.9	2197	2219	1.8	6.4
18	N80	79	2557033.4	58.7	1636	1563	3.9	50.9
20	N72	80	1151736.8	26.4	5006	230	6.7	22.6
20	N73	81	3017733.1	69.3	2087	1446	2.6	47.4
19	N68	82	284587.6	6.5	533	534	2.6	84.8
20	N74	83	1769437.9	40.6	1585	1116	2.8	4.9
18	N67	84	415272.0	9.5	2658	156	2.5	95.0
17	N144	85	514783.5	11.8	3056	168	2.6	36.3
16	N108	86	2446202.0	56.2	1885	1298	6.6	61.7
15	N35	87	879664.9	20.2	1004	876	4.4	80.2
23	N87	88	2447359.7	56.2	1982	1235	2.4	20.0
20	N92	89	2497274.4	57.3	1656	1508	3.0	20.0
24	N88	90	709151.8	16.3	1448	490	2.7	20.0
25	N89	91	206803.3	4.7	765	270	4.5	51.1
22	N90	92	399911.3	9.2	585	684	3.9	48.6
22	N91	93	1517826.8	34.8	1822	833	4.0	14.5
20	N86	94	850265.2	19.5	963	883	4.3	7.5
20	N85	95	1099583.5	25.2	1511	728	4.0	18.6
22	N105	96	1245148.7	28.6	1228	1014	3.9	2.0
21	N84	97	723817.8	16.6	875	827	2.9	2.0
21	N83	98	61115.5	1.4	370	165	3.4	2.0
21	N82	99	184271.2	4.2	415	444	6.1	10.2
7	N53	100	606914.7	13.9	2191	277	6.7	15.7
8	N102	101	775494.3	17.8	1465	529	3.9	12.1
9	N101	102	1823337.3	41.9	1768	1031	2.5	20.9
7	N52	103	773357.0	17.8	718	1077	1.6	8.0
11	N99	104	425536.1	9.8	485	877	4.1	2.0
10	N100	105	464596.4	10.7	977	476	3.4	2.0

Area	Design Point	Basin	Area	Area	Length of Overland Flow Path	Width	Percent Slope	Percent
			(sq. feet)	(acres)	(feet)	(feet)	(%)	Existing (%
2	N24	106	474516.4	10.9	986	481	3.3	2.0
2	N20	107	3245616.2	74.5	2078	1562	2.5	3.3
2	N12	108	6215841.5	142.7	3314	1876	1.5	3.6
2	N17	109	7447740.4	171.0	3718	2003	1.7	5.5
2	N11	110	6854941.7	157.4	2960	2316	1.4	4.6
2	N11	111	453637.3	10.4	1955	232	1.3	12.2
1	N10A	112	6513911.4	149.5	2375	2743	1.4	3.9
-	-	113	4335359.6	99.5	3070	1412	0.5	2.0
S56	N56	114	8340345.2	191.5	1798	4639	2.9	7.9
S57	N57	115	1752354.7	40.2	1291	1357	3.4	6.0
S58	N58	116	5689675.8	130.6	555	10252	3.7	5.1
S58	N58	117	897623.6	20.6	2057	436	2.9	16.6
S61	N61	118	6861034.8	157.5	4331	1584	1.3	27.1
S60	N60	119	6958128.7	159.7	2184	3186	3.6	62.7
12	N59	120	753430.9	17.3	1503	501	3.6	90.5
2	N19	121	339705.0	7.8	1128	301	2.3	11.2
2	N4	122	274417.5	6.3	745	368	1.4	42.0
2	N54	123	1772298.7	40.7	1430	1239	1.7	46.4
14	N63	124	415651.2	9.5	987	421	4.4	81.3
20	N71	125	315108.5	7.2	1326	238	5.1	28.1
20	N94	126	4431644.7	101.7	7357	602	1.6	2.0
1	N7	127	8364.0	0.2	50	167	5.2	49.0
1	N111	128	1451581.1	33.3	1245	1166	2.2	51.9
1	N112	129	1796106.4	41.2	1690	1063	2.3	49.0
3	N114	130	1460032.7	33.5	1645	888	3.0	37.1
3	N113	131	715190.7	16.4	850	841	1.7	68.0
3	N116	132	962435.1	22.1	1419	678	1.7	47.9
3	N117	133	1663572.8	38.2	2262	735	1.9	54.3
4	N118	134	1119081.5	25.7	1015	1103	1.9	71.2
4	N119	135	2222090.5	51.0	1267	1754	4.6	63.0
5	N120	136	5256299.0	120.7	2950	1782	1.9	53.2
5	N121	137	346352.1	8.0	493	703	2.3	56.5
5	N122	138	4470432.7	102.6	3185	1404	2.7	51.1
6	N123	139	2780768.8	63.8	2177	1277	2.0	50.6
6	N124	140	3532488.9	81.1	2624	1346	2.7	53.4
6	N125	141	1695206.0	38.9	1302	1302	4.5	52.8

Area	Design Point	Basin	Area	Area	Length of Overland Flow Path	Width	Percent Slope	Percent
			(sq. feet)	(acres)	(feet)	(feet)	(%)	Existing (%
1	N126	142	1850194.7	42.5	1224	1512	2.5	67.5
1	N8A	143	335390.1	7.7	618	543	3.3	60.0
1	N129A	144	4127764.4	94.8	2181	1893	2.9	20.2
1	N129	145	2944832.2	67.6	1826	1613	2.6	40.0
1	N130	146	593602.7	13.6	725	819	3.2	49.0
1	N131	147	1115688.1	25.6	1450	769	7.2	35.7
1	N132	148	3991572.9	91.6	2141	1864	3.2	48.7
2	N133	149	1383135.4	31.8	1523	908	3.6	56.5
2	N134	150	1604021.3	36.8	1703	942	3.7	34.3
2	N135	151	2949088.4	67.7	2057	1434	3.5	35.9
26	N136	152**	2043680.3	46.9	445	4593	2.2	13.3
1	N137	153	978684.4	22.5	818	1196	2.9	49.0
28	N64	154	538591.6	12.4	1050	513	3.9	39.8
1	N139	155	620727.4	14.2	856	725	1.4	48.7
2*	PS4	13*	3300324.4	75.8	3280	1410	2.6	-
2*	PS7	156*	733499.9	16.8	1343.0	546	3.2	-
2*	N51	157*	1325208.9	30.4	1098	1207	3.2	-
20	N145	158	299780.3	6.9	891	336	5.6	95.0
17	N78	159	485800.1	11.2	2828	172	6.3	32.8
18	N106	160	7025232.9	161.3	2789	2519	2.4	51.9
3	N146	161	326267.8	7.5	810	403	3.2	55.2
3	N115	162	400497.4	9.2	607	660	2.3	70.9
1	N129A	163	443676.7	10.2	694	639	2.8	11.3

*** Future Conditions Model only**

**** Includes only the area within the City limits. Offsite flows were not determinable.**

Appendix D – SCHEMATIC OF SWMM MODEL – SEE DVD

Appendix E - SWMM RESULTS: ALL MODELS – SEE DVD

Appendix F - STUDY AREA CALCULATIONS – SEE DVD

Appendix G - COST BACKGROUND INFORMATION

Study Area Costs

Study Area	Storm Event	US Node	Conduit	Recommended Improvement	Quantity	Unit	Unit Cost	Item Cost
1	5-year Storm with Detention	N25	C25-26A	(2) 60" CMP (1 Exists)	402	LF	242.63	97,537
		N25A	C25-26A	Detention Pond (PS1)	10,525	CY	4.00	42,100
		N25B	C25-26A	3.5' x 3' concrete box outlet structure with a 2.5' x 2.4' Orifice	56	LF	285.10	15,966
		N26A	C26A-29	5' x 4' Concrete Box Culvert	174	LF	435.81	75,831
		N29	C29-30	8' x 5' Concrete Box	338	LF	724.39	244,844
		N30	C30-30A	8' x 5' Concrete Box	338	LF	724.39	244,844
		N30A	C30A-30B	(2) 42" RCP (1 exists)	111	LF	111.72	12,401
		N30B	C30B-31	No Improvements Recommended	0	LF	NA	0
		N27	C27-25B	No Improvements Recommended	0	LF	NA	0
		N28	C28-28A	No Improvements Recommended	0	LF	NA	0
		N28A	C28A-30	24" RCP	84	LF	65.55	5,506
		N31	C31-31A	6.5' x 4' Concrete Box	230	LF	537.18	123,551
		N31A	C31A-32	No Improvements Recommended	1,121	LF	NA	0
		N32	C32-3	No Improvements Recommended	30	LF	NA	0
	5-year Storm with No Detention	N25	C25-25A	(2) 60" CMP (1 EXISTS)	402	LF	242.63	97,537
		N25A	C25A-26	5' x 5' Concrete Box Culvert	576	LF	502.48	289,428
		N25A	C25A-26	Grass Channel (b=3.5', d=2.7', z=4:1)	14,458	SF	0.33	4,771
				Excavation for grass channel	623	CY	7.71	4,802
		N25A	C25A-26	Concrete Channel (b=3', d=2', z=4:1)	1,216	SY	49.50	60,192
				Excavation for concrete channel	342	CY	7.71	2,635
		N26	C26-26A	5' x 5' Concrete Box Culvert	56	LF	502.48	28,139
		N26A	C26A-29	5' x 5' Concrete Box Culvert	174	LF	502.48	87,432
		N29	C29-30	5.5' x 5' Concrete Box Culvert	93	LF	537.18	49,958
		N30	C30-30A	6' x 5' Concrete Box Culvert	338	LF	572.80	193,606
		N30A	C30A-30B	6' x 5' Concrete Box Culvert	111	LF	572.80	63,581
		N30B	C30B-31	No Improvements Recommended	1,228	LF	NA	0
		N27	C27-25B	No Improvements Recommended	234	LF	NA	0
		N28	C28-28A	No Improvements Recommended	65	LF	NA	0
		N28A	C28A-30	24" Reinforced Concrete Pipe (RCP)	84	LF	65.55	5,506
		N31	C31-31A	10' x 5' Concrete Box	230	LF	890.58	204,833
		N31A	C31A-32	No Improvements Recommended	1,121	LF	NA	0
		N32	C32-3	No Improvements Recommended	30	LF	NA	0
	100-year Storm with Detention	N25	C25-26A	6.5' x 5' Concrete Box Culvert	402	LF	609.33	244,951
		N25A	C25-26A	Detention Pond (PS1)	10,525	CY	4.00	42,100
		N25B	C25-26A	7' x 4.5' concrete box outlet structure with a 5.7' x 4.3' Orifice	56	LF	609.33	34,122
		N26A	C26A-29	7' x 4.5' Concrete Box Culvert	174	LF	609.33	106,023

		N29	C29-30	7.5' x 5' Concrete Box Culvert	93	LF	685.13	63,717
		N30	C30-30A	8' x 5' Concrete Box Culvert	338	LF	724.39	244,844
		N30A	C30A-30B	8' x 5' Concrete Box Culvert	111	LF	724.39	80,407
		N30B	C30B-31	No Improvements Recommended	1,228	LF	NA	0
		N27	C27-25B	No Improvements Recommended	234	LF	NA	0
		N28	C28-28A	(2) 24" RCP (1 Exists)	65	LF	65.55	4,261
		N28A	C28A-30	(2) 24" RCP	84	LF	131.10	11,012
		N31	C31-31A	(2) 8’ x 5’ Concrete Box Culvert	230	LF	1,448.78	333,219
		N31A	C31A-32	No Improvements Recommended	1,121	SF	NA	0
		N32	C32-3	No Improvements Recommended	30	LF	NA	0
		N25	C25-25A	7’ x 5’ Concrete Box Culvert	402	LF	646.77	260,002
		N25A	C25A-26	8.5’ x 5’ Concrete Box Culvert	576	LF	764.57	440,392
		N25A	C25A-26	Grass Channel (b=4', d=3.5', z=4:1)	14,458	SF	0.33	4,771
				Excavation for grass channel	623	CY	7.71	4,802
		N25A	C25A-26	Concrete Channel (b=3', d=3', z=4:1)	1,216	SY	49.50	60,192
				Excavation for concrete channel	342	CY	7.71	2,635
		N26	C26-26A	8.5’ x 5’ Concrete Box Culvert	56	LF	764.57	42,816
		N26A	C26A-29	8.5' x 5' Concrete Box Culvert	174	LF	764.57	133,035
		N29	C29-30	10.5' x 5' Concrete Box Culvert	93	LF	934.41	86,900
		N30	C30-30A	10.5' x 5' Concrete Box Culvert	338	LF	934.41	315,831
		N30A	C30A-30B	11' x 5' Concrete Box Culvert	111	LF	979.15	108,686
		N30B	C30B-31	Grass Channel (b=14.2', d=4.5', z=4:1)	61,646	SF	0.33	20,343
				Excavation for grass channel	3,687	CY	7.71	28,424
	100-year Storm with No Detention			Concrete Channel (b=5', d=4', z=4:1)	5,048	SY	49.50	249,898
				Excavation for concrete channel	2,912	CY	7.71	22,454
		N27	C27-25B	No Improvements Recommended	234	LF	NA	0
		N28	C28-28A	(2) 24" RCP (1 Exists)	65	LF	65.55	4,261
		N28A	C28A-30	(2) 24" RCP	84	LF	131.10	11,012
		N31	C31-31A	(2) 11' x 5' Concrete Box Culvert	230	LF	979.15	225,205
		N31A	C31A-32	Grass Channel (b=10.5', d=5', z=4:1)	56,611	SF	0.33	18,681
				Excavation for grass channel	4,155	CY	7.71	32,033
		N31A	C31A-32	Concrete Channel (b=5', d=5', z=4:1)	5,605	SY	49.50	277,448
				Excavation for concrete channel	4,154	CY	7.71	32,029
		N32	C32-3	Grass Channel (b=11.5', d=5', z=4:1)	1,545	SF	0.33	510
				Excavation for grass channel	114	CY	7.71	879
		N32	C32-3	Concrete Channel (b=5', d=5', z=4:1)	150	SY	49.50	7,425
				Excavation for concrete channel	113	CY	7.71	875
2	5- year Storm			More detailed hydraulic analysis with survey.	1	NA	NA	0

	100- year Storm			More detailed hydraulic analysis with survey.	1	NA	NA	0
3	5- year Storm	NA	18" RCP inlet	6.5’ x 1.5’ Concrete Box Culvert	128	LF	372.79	47,717
		NA	18" RCP inlet	4.5’ x 2’ Concrete Box Culvert	128	LF	285.10	36,493
	100- year Storm	NA	18" RCP inlet	7.5’ x 2’ Concrete Box Culvert	128	LF	468.69	59,992
4	5- year Storm	N46A	C46A-45	Rectangular Concrete Channel (b=9.5',d=2')	450	SY	49.50	22,275
				Excavation for concrete channel	45	CY	7.71	346
		N46A	C46A-45	Rectangular Concrete Channel (b=7.5',d=2.5')	383	SY	49.50	18,975
				Excavation for concrete channel	56	CY	7.71	432
		N46A	C46A-45	(2) 7' x 2' Concrete Box Culvert	300	LF	871.62	261,486
		N46A	C46A-45	9.5' x 2.5' Concrete Box Culvert	300	LF	646.77	194,031
				7.5' x 3' Concrete Box Culvert	300	LF	537.18	161,154
	100- year Storm	N46A	C46A-45	(2) 7.5' x 3' Concrete Box Culverts	300	LF	1,074.36	322,308
5	5- year Storm			Flashing warning system and gates	1	EA	10,000.00	10,000
	100- year Storm			Flashing warning system and gates	1	EA	10,000.00	10,000
6	5- year Storm	Northwest corner						
		N51	C51-2	Detention Pond (PS4)	37,814	CY	4.00	151,256
		N51	C51-2	3.5' x 3' concrete box outlet structure with a 2.6' x 2' Orifice	70	LF	285.10	19,957
		N2	C2-13	3.5' x 2.5' Concrete Box Culverts	75	LF	285.10	21,383
		N13	C13-12	No Improvements Recommended	2,559	NA	NA	
		N12	C12-12A	3.5' x 3' Concrete Box Culvert	42	LF	285.10	11,974
		N12A	C12A-11	Grass Channel (b=3.4', d=4', z=4:1)	77,080	SF	0.33	25,436
				Excavation for grass channel	7,809	CY	7.71	60,204
		N12A	C12A-11	Concrete Channel (b=2.5', d=4' z=4:1)	8,235	SY	49.50	407,633
				Excavation for concrete channel	7,808	CY	7.71	60,203
		Northeast corner						
		N5A	C5A-10	8' x 4' Concrete Box Culvert	786	LF	646.77	508,361
		N5A	C5A-10	Detention Pond (PS3)	72,864	CY	4.00	291,456
		N5A	C5A-10	4' x 3.5' concrete box outlet structure with a 3' x 3' Orifice	70	LF	342.65	23,986
		N10	C10-10A	No Improvements Recommended	3,358	NA	NA	0
		N10	C10A-1	48" RCP	30	LF	158.54	4,756
	100- year Storm	Northwest corner						
		N51	C51-2	Detention Pond (PS4)	37,814	CY	4.00	151,256
		N51	C51-2	12' x 4' Concrete Box Culvert Outlet with a 11.9' x 4' Orifice	70	LF	979.15	68,541

		N2	C2-13	(2) 6' x 4' Concrete Box Culverts	75	LF	1,004.96	
		N13	C13-12	Grass Channel (b=21', d=4', z=4:1)	135,627	SF	0.33	
				Excavation for grass channel	6,069	CY	7.71	
		N13	C13-12	Concrete Channel (b=4.7', d=4' z=4:1)	10,435	SY	49.50	
				Excavation for concrete channel	6,067	CY	7.71	
		N12	C12-12A	12 'x 4' Concrete Box Culvert	42	LF	979.15	
		N12A	C12A-11	Grass Channel (b=34.7', d=4' z=4:1)	219,710	SF	0.33	72,504
				Excavation for grass channel	7,812	CY	7.71	60,229
		N12A	C12A-11	Concrete Channel (b=11.7', d=4' z=4:1)	15,994	SY	49.50	791,713
				Excavation for concrete channel	7,810	CY	7.71	60,215
		Northeast corner						
		N5A	C5A-10	(2) 8' x 4' Concrete Box Culvert	786	LF	1,293.54	1,016,722
		N5A	C5A-10	Detention Pond (PS3)	72,864	CY	4.00	291,456
		N5A	C5A-10	(2) 9' x 4' concrete box outlet structure with a16' x 4' Orifice	70	LF	1,448.78	101,415
		N10	C10-10A	Grass Channel (b=30' d=4' z=4:1)	208,196	SF	0.33	68,705
				Excavation for grass channel	7,963	CY	7.71	61,396
		N10	C10-10A	Concrete Channel (b =10', d=4' z=4:1)	15,671	SY	49.50	775,698
				Excavation for concrete channel	7,962	CY	7.71	61,384
		N10	C10A-1	(2) 7' x 4' Concrete Box Culverts	30	LF	1,145.60	34,368
7	5- year Storm	NB7	CB7-A76	36” RCP	386	LF	99.26	38,314
		NA7	CA7-F7	54” RCP	434	LF	197.26	85,611
		NE7	CE7-D7	18” RCP	430	LF	39.50	16,985
		ND7	CD7-F7	30” RCP	430	LF	86.80	37,324
		NH7	CH7-G7	18” RCP	425	LF	39.50	16,788
		NG7	CG7-F7	18”RCP	413	LF	39.50	16,314
		NF7	CF7-1	60” RCP	487	LF	242.63	118,161
	100- year Storm	NB7	CB7-A76	48” RCP	386	LF	158.54	61,196
		NA7	CA7-F7	66” RCP	434	LF	293.92	127,561
		NE7	CE7-D7	24” RCP	430	LF	65.55	28,187
		ND7	CD7-F7	42” RCP	430	LF	111.72	48,040
		NH7	CH7-G7	24” RCP	425	LF	65.55	27,859
		NG7	CG7-F7	24” RCP	413	LF	65.55	27,072
		NF7	CF7-1	72” RCP	487	LF	351.13	171,000
8	5- year Storm	N5	C5-5A	8' x 4' Concrete Box Culvert at 0.5%	110	LF	646.77	71,145
	100-year Storm	N5	C5-5A	(2) 8' x 4' Concrete Box Culvert at 0.5%	110	LF	1,293.54	142,289
9	5- year Storm	N15	C15-N2	4' x 3.5' Concrete Box Culvert	184	LF	342.65	63,048

		N15	C15-N2	Detention Pond (PS5)	5,786	CY	4.00	23,144
		N15	C15-N2	24" RCP outlet structure with a 1 x 1' Orifice	100	LF	65.55	6,555
		N15	C15-N2	Detention Pond (PS6)	14,121	CY	4.00	56,484
		N15	C15-N2	4.5' x 3.5' Concrete Box Outlet with a 3.5 x 2.9' Orifice	106	LF	372.79	39,516
		N15	C15-N2	Detention Pond (PS7)	36,330	CY	4.00	145,320
		N15	C15-N2	3.5' x 3.5' concrete box outlet structure with a 3' x 3.2' Orifice	1,532	LF	313.42	480,159
		N15	C15-N2	Detention Pond (PS4)	37,814	CY	4.00	151,256
		N15	C15-N2	3.5' x 3' concrete box outlet structure with a 2.6' x 2' Orifice	70	LF	285.10	19,957
		N2	C2-13	3.5' x 2.5' Concrete Box Culverts	75	LF	285.10	21,383
		N13	C13-12	No Improvements Recommended	2,559	NA	NA	0
		N12	C12-12A	3.5' x 3' Concrete Box Culvert	42	LF	285.10	11,974
		N12A	C12A-11	Grass Channel (b=3.4', d=4', z=4:1)	77,080	SF	0.33	25,436
				Excavation for grass channel	7,809	CY	7.71	60,204
		N12A	C12A-11	Concrete Channel (b=2.5', d=4' z=4:1)	8,235	SY	49.50	407,633
				Excavation for concrete channel	7,808	CY	7.71	60,203
	100-year Storm	N15	C15-N2	6' x 4' Concrete Box Culvert	184	LF	502.48	92,456
		N15	C15-N2	Detention Pond (PS5)	5,786	CY	4.00	23,144
		N15	C15-N2	4' x 3.5' concrete box outlet structure with a 3.4' x 3' Orifice	100	LF	342.65	34,265
		N15	C15-N2	Detention Pond (PS6)	14,121	CY	4.00	56,484
		N15	C15-N2	11.5' x 4' Concrete Box Culvert Outlet with a 4' x 10.5' Orifice	106	LF	934.41	99,047
		N15	C15-N2	Detention Pond (PS7)	36,330	CY	4.00	145,320
		N15	C15-N2	11.5' x 4' Concrete Box Culvert Outlet with a 11.1' x 4' Orifice	1,532	LF	934.41	1,431,516
		N15	C15-N2	Detention Pond (PS4)	37,814	CY	4.00	151,256
		N15	C15-N2	12' x 4' Concrete Box Culvert Outlet with a 11.9' x 4' Orifice	70	LF	979.15	68,541
		N2	C2-13	(2) 6' x 4' Concrete Box Culverts	75	LF	1,004.96	
		N13	C13-12	Grass Channel ((b=21', d=4', z=4:1)	135,627	SF	0.33	
				Excavation for grass channel	6,069	CY	7.71	
		N13	C13-12	Concrete Channel (b=4.7', d=4' z=4:1)	10,435	SY	49.50	
				Excavation for concrete channel	6,067	CY	7.71	
		N12	C12-12A	12 'x 4' Concrete Box Culvert	42	LF	979.15	
		N12A	C12A-11	Grass Channel (b=34.7', d=4' z=4:1)	219,710	SF	0.33	72,504
				Excavation for grass channel	7,812	CY	7.71	60,229
		N12A	C12A-11	Concrete Channel (b=11.7', d=4' z=4:1)	15,994	SY	49.50	791,713
				Excavation for concrete channel	7,808	CY	7.71	60,203
10	5-year Storm with Detention	N8A	C8A-127A	Detention pond (PS2)	11,052	CY	4.00	44,208
		N8A	C8A-127A	48" RCP outlet structure with a 3' x 2.6' Orifice	20	LF	158.54	3,171
		N127A	C127A-129A	Upsizing of piping system or the construction of an overflow path.	1	NA	NA	0
		N129A	C129A-128	5.5 x 4' Concrete Box Culvert	262	LF	468.69	122,797
		N128	C128-128A	6.5' x 3.5' Concrete Box Culvert	132	LF	502.48	66,327

	N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N3	C3-1	No Improvements Recommended	2,831	NA	NA	0
	N5A	C5A-10	8' x 4' Concrete Box Culvert	786	LF	646.77	508,361
	N5A	C5A-10	Detention Pond (PS3)	72,864	CY	4.00	291,456
	N5A	C5A-10	4' x 3.5' concrete box outlet structure with a 3' x 3' Orifice	70	LF	342.65	23,986
	N10	C10-10A	No Improvements Recommended	3,358	NA	NA	0
	N10	C10A-1	48" RCP	30	LF	158.54	4,756
5-year Storm with No Detention	N8A	C8A-127	No Improvements Recommended	1	NA	NA	0
	N127	C127-127A	6.5' X 4' Concrete Box Culvert	59	LF	7.71	455
	N127A	C127A-129A	Upsizing of piping system or the construction of an overflow path.	1	NA	NA	0
	N129A	C129A-128	9' x 4' Concrete Box Culverts	262	LF		0
	N128	C128-128A	9' x 4' Concrete Box Culverts	132	LF		0
	N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N3	C3-1	Grass swale (b=4’, d=3.5’, z=4:1)	90,592	SF	0.33	29,895
			Excavation for grass channel	5,139	CY	7.71	39,621
	N5A	C5A-10	8' x 4' Concrete Box Culvert	786	LF	646.77	508,361
	N5A	C5A-10	Detention Pond (PS3)	72,864	CY	4.00	291,456
	N5A	C5A-10	4' x 3.5' concrete box outlet structure with a 3' x 3' Orifice	70	LF	342.65	23,986
	N10	C10-10A	No Improvements Recommended	3,358	NA	NA	0
	N10	C10A-1	48" RCP	30	LF	158.54	4,756
100-year Storm with Detention	N8A	C8A-127A	Detention pond (PS2)	11,052	CY	4.00	44,208
	N8A	C8A-127A	6.5' x 4' concrete box outlet structure with a 6.3' x 4' Orifice	20	LF	537.18	10,744
	N127A	C127A-129A	Upsizing of piping system or the construction of an overflow path.	1	NA	NA	0
	N129A	C129A-128	(2) 6.5' x 4' Concrete Box Culverts	262	LF	1,074.36	281,482
	N128	C128-128A	(2) 6.5' x 4' Concrete Box Culverts	132	LF	1,074.36	141,816
	N128	C128-128A	(1) 11' x 4' Concrete Box Culvert	132	LF	890.58	117,557
	N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N3	C3-1	Grass Channel (b=4.3', d=4', z=4:1)	102,765	SF	0.33	33,913
			Excavation for grass channel	6,712	CY	7.71	51,750
	N5A	C5A-10	(2) 8' x 4' Concrete Box Culvert	786	LF	1,293.54	1,016,722
	N5A	C5A-10	Detention Pond (PS3)	72,864	CY	4.00	291,456
	N5A	C5A-10	(2) 9' x 4' concrete box outlet structure with a16' x 4' Orifice	70	LF	1,448.78	101,415
	N10	C10-10A	Grass Channel (b=30' d=4' z=4:1)	208,196	SF	0.33	68,705
			Excavation for grass channel	7,963	CY	7.71	61,396
	N10	C10-10A	Concrete Channel (b =10', d=4' z=4:1)	15,671	SY	49.50	775,698
			Excavation for concrete channel	7,962	CY	7.71	61,384

		N10	C10A-1	(2) 7' x 4' Concrete Box Culverts	30	LF	1,145.60	34,368
	100-year Storm with No Detention	N8A	C8A-127	No Improvements Recommended	1	NA	NA	0
		N127	C127-127A	10' X 4' Concrete Box Culvert	59	LF	847.88	50,025
		N127A	C127A-129A	Upsizing of piping system or the construction of an overflow path.	1	NA	NA	0
		N129A	C129A-128	(2) 9' x 4' Concrete Box Culverts	262	LF	1,448.78	379,580
		N128	C128-128A	(2) 9' x 4' Concrete Box Culverts	132	LF	1,448.78	191,239
		N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
		N3	C3-1	Grass swale (b=10.1', d=3.5', z=4:1)	107,861	SF	0.33	35,594
				Excavation for grass channel	5,139	CY	7.71	39,624
		N5A	C5A-10	(2) 8' x 4' Concrete Box Culvert	786	LF	1,293.54	1,016,722
		N5A	C5A-10	Detention Pond (PS3)	72,864	CY	4.00	291,456
		N5A	C5A-10	(2) 9.5' x 4' concrete box outlet structure with a16' x 4.3' Orifice	70	LF	1,529.14	107,040
		N10	C10-10A	Grass Channel (b=32' d=4' z=4:1)	214,912	SF	0.33	70,921
				Excavation for grass channel	7,963	CY	7.71	61,397
		N10	C10-10A	Concrete Channel (b =10', d=4' z=4:1)	15,671	SY	49.50	775,698
				Excavation for concrete channel	7,962	CY	7.71	61,384
		N10	C10A-1	(2) 7.5' x 4' Concrete Box Culverts	30	LF	1,218.66	36,560
11	5- year Storm	N11-7	C7-6	36" RCP	38	LF	99.26	3,772
		N11-6	C6-2	36" RCP	204	LF	99.26	20,249
		N11-5	C5-4	24' RCP	32	LF	66.55	2,130
		N11-4	C4-4A	24" RCP	4	LF	65.55	262
		N11-4A	C4A-3	48" RCP	235	LF	158.54	37,257
		N11-3	C3-2	4.5' x 4' Concrete Box Culvert	40	LF	403.84	16,154
		N11-2	C2-1	5' x 4' Concrete Box Culvert	119	LF	435.81	51,861
		N111	C111-129A	5' x 4' Concrete Box Culvert	40	LF	435.81	17,432
		N11-1A	C129A-128	5.5 x 4' Concrete Box Culvert	247	LF	468.69	115,766
	100- year Storm	N11-7	C7-6	48" RCP	38	LF	158.54	6,025
		N11-6	C6-2	48" RCP	204	LF	158.54	32,342
		N11-5	C5-4	30" RCP	32	LF	86.80	2,778
		N11-4	C4-4A	30" RCP	4	LF	86.80	347
		N11-4A	C4A-3	7' x 4' Concrete Box Culvert	235	LF	572.80	134,608
		N11-3	C3-2	9' x 4' Concrete Box Culvert	40	LF	724.39	28,976
		N11-2	C2-1	10' x 4' Concrete Box Culvert	119	LF	847.88	100,898
		N111	C111-129A	(2) 6' x 4' Concrete Box Culvert	40	LF	1,004.96	40,198
		N11-1A	C129A-128	(2) 6.5 x 4' Concrete Box Culverts	247	LF	1,074.36	265,367
12	5- year Storm	N12-3	C3-2	30" RCP	60	LF	86.80	5,208

		N12-2	C2-1	42” RCP	36	LF	111.72	4,022
		N12-1	C1-12	42” RCP	118	LF	111.72	13,183
	100- year Storm	N12-3	C3-2	36” RCP	60	LF	99.26	5,956
		N12-2	C2-1	48” RCP	36	LF	158.54	5,707
		N12-1	C1-12	48” RCP	118	LF	158.54	18,708
13	5-year Storm	N6	C6-6A	Make high point and grade downstream swale and culverts to ensure a 0.5% minimum slope	30.3	LF	7.09	215
		N6A	C6A-8	Regrade to ensure a 0.5% minimum slope	174	LF	7.09	1,234
		N8	C8-8A	Regrade to ensure a 0.5% minimum slope	29	LF	7.09	206
		N8A	C8A-7	Regrade to ensure a 0.5% minimum slope	55	LF	7.09	390
		N7	C7-7A	Regrade to ensure a 0.5% minimum slope	29.9	LF	7.09	212
		N7A	C7A-21	Regrade to ensure a 0.5% minimum slope	20	LF	7.09	142
		N21	C21-21A	No Improvements Recommended	20	LF	NA	0
		N11A	C11A-10	No Improvements Recommended	44	LF	NA	0
		N10	C10-10A	No Improvements Recommended	62	LF	NA	0
		N10A	C10A-15A	No Improvements Recommended	100	LF	NA	0
		N15	C15-15A	No Improvements Recommended	100	LF	NA	0
		N15A	C15A-9	No Improvements Recommended	14	LF	NA	0
		N9	C9-9A	(2) 24" RCP (1 Exists)	65	LF	65.55	4,228
		N9A	C9A-21	No Improvements Recommended	135	LF	NA	0
		N5	C5-5A	No Improvements Recommended	21	LF	NA	0
		N5A	C5A-4	No Improvements Recommended	214	LF	NA	0
		N4	C4-4A	15" RCP	38	LF	32.92	1,254
		N4A	C4A-3	No Improvements Recommended	151	LF	NA	0
		N3	C3-3A	No Improvements Recommended	40	LF	NA	0
		N3A	C3A-13A	No Improvements Recommended	36	LF	NA	0
		N13A	C13A	No Improvements Recommended	5	LF	NA	0
		N2	C2-2A	No Improvements Recommended	30	LF	NA	0
		N2A	C2A-1	No Improvements Recommended	18	LF	NA	0
		N1	C1-1	No Improvements Recommended	43	LF	NA	0
	100-year Storm	N6	C6-6A	Make high point and grade downstream swale and culverts to ensure a 0.5% minimum slope	30.3	LF	7.09	215
		N6A	C6A-8	Regrade to ensure a 0.5% minimum slope	174	LF	7.09	1,234
		N8	C8-8A	15" RCP at 0.5%	29	LF	32.92	955
		N8A	C8A-7	Regrade to ensure a 0.5% minimum slope	55	LF	7.09	390
		N7	C7-7A	Regrade to ensure a 0.5% minimum slope	29.9	LF	7.09	212
		N7A	C7A-21	Regrade to ensure a 0.5% minimum slope	20	LF	7.09	142
		N21	C21-21A	No Improvements Recommended	20	LF	NA	0

		N11A	C11A-10	No Improvements Recommended	44	LF	NA	0
		N10	C10-10A	No Improvements Recommended	62	LF	NA	0
		N10A	C10A-15A	No Improvements Recommended	137	LF	NA	0
		N15A	C15-15A	(2) 24" RCP (1 Exists)	100	LF	65.55	6,555
		N15A	C15A-9	No Improvements Recommended	14	LF	NA	0
		N9	C9-9A	(2) 30" RCP	65	LF	86.80	5,599
		N9A	C9A-21	No Improvements Recommended	135	LF	NA	0
		N5	C5-5A	No Improvements Recommended	21	LF	NA	0
		N5A	C5A-4	No Improvements Recommended	214	LF	NA	0
		N4	C4-4A	(2) 18" RCP	38	LF	79.00	3,010
		N4A	C4A-3	No Improvements Recommended	151	LF	NA	0
		N3	C3-3A	No Improvements Recommended	40	LF	NA	0
		N3A	C3-13A	No Improvements Recommended	36	LF	NA	0
		N13A	C13A	No Improvements Recommended	5	LF	NA	0
		N2	C2-2A	No Improvements Recommended	30	LF	NA	0
		N2A	C2A-1	No Improvements Recommended	18	LF	NA	0
		N1	C1-1	No Improvements Recommended	43	LF	NA	0

Study Area Contingency Costs

Study Area	Storm Event	Recommended Improvement Cost	Contingency	Contingency Unit	Contingency Unit Cost ($)	Contingency Cost ($)
1	5-year Storm with Detention	862,580	Construction Management	LS	8% of total cost	69,006
			Contingency	LS	10% of total cost	86,258
			Design and Permitting	LS	10% of total cost	86,258
			Mobilization/Demobilization	LS	5% of total cost	43,129
			Site Preparation	LS	10% of total cost	86,258
			Erosion & Sediment Control	LS	5% of total cost	43,129
			Incidentals	LS	20% of total cost	172,516
	5-year Storm with No Detention	1,092,420	Construction Management	LS	8% of total cost	87,394
			Contingency	LS	10% of total cost	109,242

			Design and Permitting	LS	10% of total cost	109,242
			Mobilization/Demobilization	LS	5% of total cost	54,621
			Site Preparation	LS	10% of total cost	109,242
			Erosion & Sediment Control	LS	5% of total cost	54,621
			Incidentals	LS	20% of total cost	218,484
	100-year Storm with Detention	1,164,657	Construction Management	LS	8% of total cost	93,173
			Contingency	LS	10% of total cost	116,466
			Design and Permitting	LS	10% of total cost	116,466
			Mobilization/Demobilization	LS	5% of total cost	58,233
			Site Preparation	LS	10% of total cost	116,466
			Erosion & Sediment Control	LS	5% of total cost	58,233
			Incidentals	LS	20% of total cost	232,931
	100-year Storm with No Detention	2,391,537	Construction Management	LS	8% of total cost	191,323
			Contingency	LS	10% of total cost	239,154
			Design and Permitting	LS	10% of total cost	239,154
			Mobilization/Demobilization	LS	5% of total cost	119,577
			Site Preparation	LS	10% of total cost	239,154
			Erosion & Sediment Control	LS	5% of total cost	119,577
			Incidentals	LS	20% of total cost	478,307
2	5-year Storm	0				
	100-year Storm	0				
3	5-year Storm	84,210	Construction Management	LS	8% of total cost	6,737
			Contingency	LS	10% of total cost	8,421
			Design and Permitting	LS	10% of total cost	8,421
			Mobilization/Demobilization	LS	5% of total cost	4,210
			Site Preparation	LS	10% of total cost	8,421
			Erosion & Sediment Control	LS	5% of total cost	4,210
			Incidentals	LS	20% of total cost	16,842
	100-year Storm	59,992	Construction Management	LS	8% of total cost	4,799
			Contingency	LS	10% of total cost	5,999
			Design and Permitting	LS	10% of total cost	5,999
			Mobilization/Demobilization	LS	5% of total cost	3,000
			Site Preparation	LS	10% of total cost	5,999
			Erosion & Sediment Control	LS	5% of total cost	3,000
			Incidentals	LS	20% of total cost	11,998

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	5-year Storm*	636,424	Construction Management	LS	8% of total cost	50,914
			Contingency	LS	10% of total cost	63,642
			Design and Permitting	LS	10% of total cost	63,642
			Mobilization/Demobilization	LS	5% of total cost	31,821
			Site Preparation	LS	10% of total cost	63,642
			Erosion & Sediment Control	LS	5% of total cost	31,821
			Incidentals	LS	20% of total cost	127,285
	100-year Storm	322,308	Construction Management	LS	8% of total cost	25,785
			Contingency	LS	10% of total cost	32,231
			Design and Permitting	LS	10% of total cost	32,231
			Mobilization/Demobilization	LS	5% of total cost	16,115
			Site Preparation	LS	10% of total cost	32,231
			Erosion & Sediment Control	LS	5% of total cost	16,115
			Incidentals	LS	20% of total cost	64,462
5	5-year Storm	10,000	Contingencies includedi in price.			
	100-year Storm	10,000	Contingencies includedi in price.			
6	Northwest corner					
	5-year Storm	758,046	Construction Management	LS	8% of total cost	60,644
			Contingency	LS	10% of total cost	75,805
			Design and Permitting	LS	10% of total cost	75,805
			Mobilization/Demobilization	LS	5% of total cost	37,902
			Site Preparation	LS	10% of total cost	75,805
			Erosion & Sediment Control	LS	5% of total cost	37,902
			Incidentals	LS	20% of total cost	151,609
	Northeast corner					
	5-year Storm	828,559	Construction Management	LS	8% of total cost	66,285
			Contingency	LS	10% of total cost	82,856
			Design and Permitting	LS	10% of total cost	82,856
			Mobilization/Demobilization	LS	5% of total cost	41,428
			Site Preparation	LS	10% of total cost	82,856
			Erosion & Sediment Control	LS	5% of total cost	41,428
			Incidentals	LS	20% of total cost	165,712
	Northwest corner					
	100-year Storm	1,204,458	Construction Management	LS	8% of total cost	96,357
			Contingency	LS	10% of total cost	120,446

			Design and Permitting	LS	10% of total cost	120,446
			Mobilization/Demobilization	LS	5% of total cost	60,223
			Site Preparation	LS	10% of total cost	120,446
			Erosion & Sediment Control	LS	5% of total cost	60,223
			Incidentals	LS	20% of total cost	240,892
	Northeast corner					
	100-year Storm	2,411,143	Construction Management	LS	8% of total cost	192,891
			Contingency	LS	10% of total cost	241,114
			Design and Permitting	LS	10% of total cost	241,114
			Mobilization/Demobilization	LS	5% of total cost	120,557
			Site Preparation	LS	10% of total cost	241,114
			Erosion & Sediment Control	LS	5% of total cost	120,557
			Incidentals	LS	20% of total cost	482,229
7	5-year Storm	329,496	Construction Management	LS	8% of total cost	26,360
			Contingency	LS	10% of total cost	32,950
			Design and Permitting	LS	10% of total cost	32,950
			Mobilization/Demobilization	LS	5% of total cost	16,475
			Site Preparation	LS	10% of total cost	32,950
			Erosion & Sediment Control	LS	5% of total cost	16,475
			Incidentals	LS	20% of total cost	65,899
	100-year Storm	490,915	Construction Management	LS	8% of total cost	39,273
			Contingency	LS	10% of total cost	49,092
			Design and Permitting	LS	10% of total cost	49,092
			Mobilization/Demobilization	LS	5% of total cost	24,546
			Site Preparation	LS	10% of total cost	49,092
			Erosion & Sediment Control	LS	5% of total cost	24,546
			Incidentals	LS	20% of total cost	98,183
8	5-year Storm	71,145	Construction Management	LS	8% of total cost	5,692
			Contingency	LS	10% of total cost	7,114
			Design and Permitting	LS	10% of total cost	7,114
			Mobilization/Demobilization	LS	5% of total cost	3,557
			Site Preparation	LS	10% of total cost	7,114
			Erosion & Sediment Control	LS	5% of total cost	3,557
			Incidentals	LS	20% of total cost	14,229
	100-year Storm	142,289	Construction Management	LS	8% of total cost	11,383
			Contingency	LS	10% of total cost	14,229
			Design and Permitting	LS	10% of total cost	14,229

			Mobilization/Demobilization	LS	5% of total cost	7,114
			Site Preparation	LS	10% of total cost	14,229
			Erosion & Sediment Control	LS	5% of total cost	7,114
			Incidentals	LS	20% of total cost	28,458
9	5-year Storm	1,572,272	Construction Management	LS	8% of total cost	125,782
			Contingency	LS	10% of total cost	157,227
			Design and Permitting	LS	10% of total cost	157,227
			Mobilization/Demobilization	LS	5% of total cost	78,614
			Site Preparation	LS	10% of total cost	157,227
			Erosion & Sediment Control	LS	5% of total cost	78,614
			Incidentals	LS	20% of total cost	314,454
	100-year Storm	3,086,679	Construction Management	LS	8% of total cost	246,934
			Contingency	LS	10% of total cost	308,668
			Design and Permitting	LS	10% of total cost	308,668
			Mobilization/Demobilization	LS	5% of total cost	154,334
			Site Preparation	LS	10% of total cost	308,668
			Erosion & Sediment Control	LS	5% of total cost	154,334
			Incidentals	LS	20% of total cost	617,336
10	5-year Storm with Detention	1,065,062	Construction Management	LS	8% of total cost	85,205
			Contingency	LS	10% of total cost	106,506
			Design and Permitting	LS	10% of total cost	106,506
			Mobilization/Demobilization	LS	5% of total cost	53,253
			Site Preparation	LS	10% of total cost	106,506
			Erosion & Sediment Control	LS	5% of total cost	53,253
			Incidentals	LS	20% of total cost	213,012
	5-year Storm with No Detention	898,530	Construction Management	LS	8% of total cost	71,882
			Contingency	LS	10% of total cost	89,853
			Design and Permitting	LS	10% of total cost	89,853
			Mobilization/Demobilization	LS	5% of total cost	44,927
			Site Preparation	LS	10% of total cost	89,853
			Erosion & Sediment Control	LS	5% of total cost	44,927
			Incidentals	LS	20% of total cost	179,706
	100-year Storm with Detention	3,092,612	Construction Management	LS	8% of total cost	247,409
			Contingency	LS	10% of total cost	309,261
			Design and Permitting	LS	10% of total cost	309,261
			Mobilization/Demobilization	LS	5% of total cost	154,631

			Site Preparation	LS	10% of total cost	309,261
			Erosion & Sediment Control	LS	5% of total cost	154,631
			Incidentals	LS	20% of total cost	618,522
	100-year Storm with No Detention	3,117,240	Construction Management	LS	8% of total cost	249,379
			Contingency	LS	10% of total cost	311,724
			Design and Permitting	LS	10% of total cost	311,724
			Mobilization/Demobilization	LS	5% of total cost	155,862
			Site Preparation	LS	10% of total cost	311,724
			Erosion & Sediment Control	LS	5% of total cost	155,862
			Incidentals	LS	20% of total cost	623,448
11	5-year Storm	264,883	Construction Management	LS	8% of total cost	21,191
			Contingency	LS	10% of total cost	26,488
			Design and Permitting	LS	10% of total cost	26,488
			Mobilization/Demobilization	LS	5% of total cost	13,244
			Site Preparation	LS	10% of total cost	26,488
			Erosion & Sediment Control	LS	5% of total cost	13,244
			Incidentals	LS	20% of total cost	52,977
	100-year Storm	611,538	Construction Management	LS	8% of total cost	48,923
			Contingency	LS	10% of total cost	61,154
			Design and Permitting	LS	10% of total cost	61,154
			Mobilization/Demobilization	LS	5% of total cost	30,577
			Site Preparation	LS	10% of total cost	61,154
			Erosion & Sediment Control	LS	5% of total cost	30,577
			Incidentals	LS	20% of total cost	122,308
12	5-year Storm	22,413	Construction Management	LS	8% of total cost	1,793
			Contingency	LS	10% of total cost	2,241
			Design and Permitting	LS	10% of total cost	2,241
			Mobilization/Demobilization	LS	5% of total cost	1,121
			Site Preparation	LS	10% of total cost	2,241
			Erosion & Sediment Control	LS	5% of total cost	1,121
			Incidentals	LS	20% of total cost	4,483
	100-year Storm	30,371	Construction Management	LS	8% of total cost	2,430
			Contingency	LS	10% of total cost	3,037
			Design and Permitting	LS	10% of total cost	3,037
			Mobilization/Demobilization	LS	5% of total cost	1,519
			Site Preparation	LS	10% of total cost	3,037

			Erosion & Sediment Control	LS	5% of total cost	1,519
			Incidentals	LS	20% of total cost	6,074
13	5-year Storm	0	Construction Management	LS	8% of total cost	0
			Contingency	LS	10% of total cost	0
			Design and Permitting	LS	10% of total cost	0
			Mobilization/Demobilization	LS	5% of total cost	0
			Site Preparation	LS	10% of total cost	0
			Erosion & Sediment Control	LS	5% of total cost	0
			Incidentals	LS	20% of total cost	0
	100-year Storm	0	Construction Management	LS	8% of total cost	0
			Contingency	LS	10% of total cost	0
			Design and Permitting	LS	10% of total cost	0
			Mobilization/Demobilization	LS	5% of total cost	0
			Site Preparation	LS	10% of total cost	0
			Erosion & Sediment Control	LS	5% of total cost	0
			Incidentals	LS	20% of total cost	0

* Cost is for a rectangular concrete channel (d=2', b=9.5')

Recommended Capital Improvement Costs 5-Year

Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost ($)	Item Cost ($)

1	N5A	C5A-10	8' x 4' Concrete Box Culvert	786	LF	646.77	508,361
	N5A	C5A-10	Detention Pond (PS3)	72,864	CY	4.00	291,456
	N5A	C5A-10	4' x 3.5' concrete box outlet structure with a 3' x 3' Orifice	70	LF	342.65	23,986
	N10	C10-10A	No Improvements Recommended	3,358	NA	NA	0
	N10A	C10A-1	48" RCP	30	LF	158.54	4,756
	N111	C111-111A	6' x 4' Concrete Box Culvert	46	LF	502.48	23,114
	N111A	C111A-7	Concrete Channel (b=8.5', d=2.1', z=1:1)	474	SY	49.50	23,470
			Excavation for concrete channel	55	CY	7.71	426
	N112	C112-111	No Improvements Recommended	344	NA	NA	0
	N126	C126-126A	No Improvements Recommended	57	NA	NA	0
	N126A	C126A-8	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N127A	C127A-128	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N128	C128-128A	6.5' x 3.5' Concrete Box Culvert	132	LF	502.48	66,327
	N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N129	C129-129A	42" RCP	362	LF	111.72	40,443
	N129A	C129A-128	5.5 x 4' Concrete Box Culvert	262	LF	468.69	122,797
	N130	C130-130A	No Improvements Recommended	68	NA	NA	0
	N130A	C130A-137A	No Improvements Recommended	722	NA	NA	0
	N131	C131-131A	30" RCP	70	LF	86.80	6,076
	N131A	C131A-111	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N132	C132-132A	54" RCP	55	LF	197.26	10,849

	N132	C132-132A	4.5' x 3.5' Concrete Box Culvert	55	LF	372.79	20,503
	N132A	C132A-112	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N137	C137-137A	30" RCP	107	LF	86.80	9,288
	N137A	C137A-132	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N139	C139-5	NA -Conveyance used to simulate overland flow.	1	NA	NA	0
	N3	C3-1	No Improvements Recommended	2,831	NA	NA	0
	N7	C7-7A	No Improvements Recommended	177	NA	NA	0
	N7A	C7A-6	Concrete Channel (b=9', d=2.5', z=1:1) at 0.5%	1,062	SY	49.50	52,591
			Excavation for concrete channel	159	CY	7.71	1,223
	N6	C6-6A	7' x 4' Concrete Box Culvert at 0.5%	65	LF	572.80	37,232
	N6A	C6A-5	7' x 4' Concrete Box Culvert at 0.5%	440	LF	572.80	252,032
	N6A	C6A-5	Concrete Channel (b=9.5, d=2.5, z=1:1)	684	SY	49.50	33,880
			Excavation for concrete channel	82	CY	7.71	633
	N5	C5-5A	8' x 4' Concrete Box Culvert at 0.5%	110	LF	646.77	71,145
	N8	C8-8A	8' x 3' Concrete Box Culvert	81	LF	572.80	46,397
	N8A	C8A-127A	Use existing swale	60	LF	NA	0
	N8A	C8A-127A	Extend 8' x 3' Concrete Box Culvert	60	LF	572.80	34,368
	N8A	C8A-127A	Detention pond (PS2)	11,052	CY	4.00	44,208
	N8A	C8A-127A	48" RCP outlet structure with a 3' x 2.6' Orifice	20	LF	158.54	3,171
	N9	C9-10	Grass Channel (b=4', d=4', z=4:1)	12,168	SF	0.33	4,015
			Excavation for grass channel	803	CY	7.71	6,189
	N9	C9-10	Concrete Channel (b=2.9', d=4', z=4:1)	980	SY	49.50	48,520
			Excavation for concrete channel	582	CY	7.71	4,487
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
2	N11	C11-2	No Improvements Recommended	59	LF	NA	0

N12	C12-12A	3.5' x 3' Concrete Box Culvert	42	LF	285.10	11,974
N12A	C12A-11	Grass Channel (b=3.4', d=4', z=4:1)	77,080	SF	0.33	25,436
		Excavation for grass channel	7,809	CY	7.71	60,204
N12A	C12A-11	Concrete Channel (b=2.5', d=4' z=4:1)	8,235	SY	49.50	407,633
		Excavation for concrete channel	7,808	CY	7.71	60,203
N13	C13-12	No Improvements Recommended	2,559	NA	NA	0
N133	C133-15	54" RCP	1,614	LF	197.26	318,378
N134	C134-133	48" RCP	566	LF	158.54	89,734
N135	C135-134	48" RCP	639	LF	158.54	101,307
N14	C14-14A	No Improvements Recommended	38	NA	NA	0
N142	C142-2	No Improvements Recommended	44	NA	NA	0
N14A	C14A-12	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N15	C15-N2	4' x 3.5' Concrete Box Culvert	184	LF	342.65	63,048
N15	C15-N2	Detention Pond (PS5)	5,786	CY	4.00	23,144
N15	C15-N2	24" RCP outlet structure with a 1 x 1' Orifice	100	LF	65.55	6,555
N15	C15-N2	Detention Pond (PS6)	14,121	CY	4.00	56,484
N15	C15-N2	4.5' x 3.5' Concrete Box Outlet with a 3.5 x 2.9' Orifice	106	LF	372.79	39,516
N15	C15-N2	Detention Pond (PS7)	36,330	CY	4.00	145,320
N15	C15-N2	3.5' x 3.5' concrete box outlet structure with a 3' x 3.2' Orifice	1,532	LF	313.42	480,159
N15	C15-N2	Detention Pond (PS4)	37,814	CY	4.00	151,256
N15	C15-N2	3.5' x 3' concrete box outlet structure with a 2.6' x 2' Orifice	70	LF	285.10	19,957
N16	C16-16A	No Improvements Recommended	130	NA	NA	0
N16A	C16A-18	Concrete Channel (b=6',d=1.8',z=2:1)	909	SY	49.50	45,012
		Excavation for concrete channel	149	CY	7.71	1,150
N17	C17-17A	No Improvements Recommended	53	NA	NA	0
N17A	C17A-11	NA - Conveyance used to simulate overland flow.	2,256	NA	NA	0

	N18	C18-18A	No Improvements Recommended	120	NA	NA	0
	N18A	C18A-54	Grass Channel (b=4', d=3.44', z=3:1)	33,412	SF	0.33	11,026
			Excavation for grass channel	1,784	CY	7.71	13,753
	N18A	C18A-54	10' x 4' Concrete Box Culverts	1,450	LF	847.88	1,229,426
	N19	C19-13	No Improvements Recommended	196	NA	NA	0
	N20	C20-C20A	No Improvements Recommended	51	NA	NA	0
	N20A	C20A-12	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N21	C21-21A	No Improvements Recommended	48	LF	NA	0
	N21A	C21A-20	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N2	C2-13	3.5' x 3' Concrete Box Culverts	75	LF	285.10	21,383
	S17	S17-16	No Improvements Recommended	1	NA	NA	0
	S17E	S17E-S17	No Improvements Recommended	1	NA	NA	0
	S17W	S17W-S17E	No Improvements Recommended	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
3	N146	C146-146A	No Improvements Recommended	247	LF	NA	0
	N146A	C146A-114	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N113	C113-23	5' x 3.5' Concrete Box	710	LF	403.84	286,726
	N114	C114-113	30" RCP	865	LF	86.80	75,082
	N115	C115-113	6' x 2' Concrete Box Culvert	843	LF	372.79	314,262
	N115	C115-113	Concrete Channel (b=6', d=1.3', z=0.5:1)	684	SY	49.50	33,846
			Excavation for concrete channel	27	CY	4.00	106
	N116	C116-116A	30" RCP	333	LF	86.80	28,904
	N116A	C116A-115	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0

	N117	C117-117A	36" RCP	178	LF	99.26	17,668
	N117A	C117A-115	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N23	C23-25	No Improvements Recommended	513	NA	NA	0
	N25	C25-26A	(2) 60" CMP (1 Exists)	402	LF	242.63	97,537
	N25	C25-26A	Detention Pond (PS1)	10,525	CY	4.00	42,100
	N25	C25-26A	3.5' x 3' concrete box outlet structure with a 2.5' x 2.4' Orifice	56	LF	285.10	15,966
	N26A	C26A-29	5' x 4' Concrete Box Culvert	174	LF	435.81	75,831
	N29	C29-30	7.5' x 5' Concrete Box	93	LF	685.13	63,717
	N30	C30-30A	8' x 5' Concrete Box	338	LF	724.39	244,844
	N30A	C30A-30B	(2) 42" RCP (1 exists)	111	LF	111.72	12,401
	N30B	C30B-31	No Improvements Recommended	1,228	LF	NA	0
	N27	C27-25B	No Improvements Recommended	234	LF	NA	0
	N28	C28-28A	No Improvements Recommended	65	LF	NA	0
	N28A	C28A-30	24" RCP	84	LF	65.55	5,506
	N31	C31-31A	6.5' x 4' Concrete Box	230	LF	537.18	123,551
	N31A	C31A-32	No Improvements Recommended	1,121	LF	NA	0
	N32	C32-3	No Improvements Recommended	30	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
4	N118	C118-118A	48" RCP	303	LF	158.54	48,038
	N118	C118-118A	4' x 3.5' Concrete Box Culvert	303	LF	342.65	103,823
	N118A	C118-34	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N119	C119-119A	Flood warning system	1	EA	10000.00	10,000

	N119A	C119A-118	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N33	C33-C33A	4.5' x 4' Concrete Box	45	LF	403.84	18,173
	N33A	C33A-4	No Improvements Recommended at this Time. Area should be reevaluated when this area is developed or changed.	1,067	NA	NA	0
	N34	C34-C34A	5' x 3.5' Concrete Box	944	LF	403.84	381,225
	N34A	C34A-C33	No Improvements Recommended	1,190	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
5	N120	C120-120A	5.5' x 4' Concrete Box Culvert	340	LF	468.69	159,355
	N120A	C120A-36	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N121	C121-121A	21" RCP	424	LF	52.53	22,273
	N121A	C121A-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N122	C122-122A	54" RCP	490	LF	197.26	96,657
	N122	C122-122A	4' x 3' Concrete Box Culvert	490	LF	313.42	153,576
	N122A	C122A-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N36	C36-5	6' x 4' Concrete Box Culvert	1,504	LF	502.48	755,730
	N37	C37-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
6	N123	C123-123A	(2) 48" RCP (1 Exists)	772	LF	158.54	122,393
	N123	C123-123A	5' X 5' Concrete Box Culvert	772	LF	502.48	387,915
	N123A	C123A-38	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N124	C124-124A	42" RCP	422	LF	111.72	47,146

	N124A	C124A-123	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N125	C125-125A	48" RCP	510	LF	158.54	80,855
	N125A	C125A-123	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N38	C38-38A	66" RCP	82	LF	293.92	24,101
	N38	C38-38A	5' X 5' Concrete Box Culvert	82	LF	502.48	41,203
	N38A	C38A-6	No Improvements Recommended at this Time. Area should be reevaluated when this area is developed or changed.	3,887	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
7	N107	C107-7	NA - Dummy Conduit	1	NA	NA	0
	N52	C52-107	No Improvements Recommended	51	LF	NA	0
	N53	C53-53A	No Improvements Recommended	53	LF	NA	0
	N53A	C53A-107	No Improvements Recommended	1,962	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
8	N102	C102-8	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
9	N101	C101-9	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
10	N100	C100-10	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
11	N99	C99-11	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
12	N59	C59-12	No Improvements Recommended at this Time. Area should be reevaluated if basin 119 does not provide adequate storage and/or if basin 119 or basin 120 is changed.	185	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost

13	N62	C62-13	No Improvements Recommended	200	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
14	N63	C63-14	No Improvements Recommended	200	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
15	N35	C35-15	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
16	N106	C106-108	NA - Dummy Conduit	1	NA	NA	0
	N108	C108-16	NA - Dummy Conduit	1	NA	NA	0
	N65	C65-65A	(2) 54" RCP (1 Exists)	272	LF	197.26	53,655
	N65A	C65A-108	NA - Conveyance used to simulate overland flow.	3,681	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
17	N66	C66-17	NA - Dummy Conduit	1	NA	NA	0
	N78	C78-78A	4.5'X4' Concrete Box Culvert	144	LF	NA	0
	N78A	C78A-66	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N79	C79-79A	No Improvements Recommended	103	LF	NA	0
	N79A	C79A-144	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N144	C144-144A	4.5'X4' Concrete Box Culvert	201	LF	NA	0
	N144A	C144A-78	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
18	N80	C80-80A	(3) 30" RCP @ 0.5%	368	LF	260.40	95,827
	N80A	C80A-106	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N106	C106-106A	No Improvements Recommended	73	LF	NA	0
	N106A	C106A-67	Keep Maintained	320	LF	NA	0

	N67	C67-67A	5.5' x 4' Concrete Box Culvert @ 0.5%	62	LF	468.69	29,059
	N67A	C67A-18	Regrade swale to have a slope of 0.5%.	164	LF	7.09	1,163
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
19	N68	C68-19	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
20	N145	C145-145A	No Improvements Recommended	206	LF	NA	0
	N145A	C145A-103	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N103	C103-97	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N39	C39-39A	No Improvements Recommended	130	LF	NA	0
	N39A	C39A-98A	No Improvements Recommended	338	LF	NA	0
	N40	C40-40A	7.5' x 4' Concrete Box Culverts	57	LF	609.33	34,732
	N40A	C40A-39	No Improvements Recommended	1,806	LF	NA	0
	N41	C41-41A	7.5' x 4' Concrete Box Culvert	45	LF	609.33	27,420
	N41A	C41A-40	No Improvements Recommended	705	LF	NA	0
	N42	C42-41	No Improvements Recommended	1,588	LF	NA	0
	N43	C43-43A	No Improvements Recommended	42	LF	NA	0
	N43A	C43A-42	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	894	LF	NA	0
	N44	C44-44A	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	71	LF	NA	0
	N44A	C44A-43	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	1,060	LF	NA	0
	N45	C45-44	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	3,265	LF	NA	0

N46	C46-46A	No Improvements Recommended	48	LF	NA	0
N46A	C46A-45	Rectangular Concrete Channel (b=9.5',d=2')	450	SY	49.50	22,275
		Excavation for concrete channel	45	CY	7.71	346
N46A	C46A-45	Rectangular Concrete Channel (b=7.5',d=2.5')	383	SY	49.50	18,975
		Excavation for concrete channel	56	CY	7.71	432
N46A	C46A-45	(2) 7' x 2' Concrete Box Culvert	300	LF	871.62	261,486
N46A	C46A-45	9.5' x 2.5' Concrete Box Culvert	300	LF	646.77	194,031
N46A	C46A-45	7.5' x 3' Concrete Box Culvert	300	LF	537.18	161,154
N47	C47-46	No Improvements Recommended	230	LF	NA	0
N48	C48-47	No Improvements Recommended	1,012	LF	NA	0
N49	C49-48	No Improvements Recommended	195	LF	NA	0
N50	C50-49	No Improvements Recommended	103	LF	NA	0
N147	C147-147A	No Improvements Recommended	341	LF	NA	0
N147A	C147-69	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N69	C69-98	NA - Six Mile Creek	1	NA	NA	0
N70	C70-70A	(3) 36" RCP	192	LF	297.78	57,174
N70A	C70A-69	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N71	C71-71A	(2) 48" RCP	208	LF	317.08	65,953
		5' x 4' Concrete Box Culvert	208	LF	435.81	90,648
N71A	C71A-70	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N72	C72-72A	No Improvements Recommended	185	LF	NA	0
N72A	C72A-71	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N73	C73-73A	42" RCP	165	LF	111.72	18,434
N73A	C73A-72	NA - Conveyance used to simulate overland flow.	1	NA	NA	0

	N74	C74-74A	No Improvements Recommended	97	LF	NA	0
	N74A	C74A-72	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N75	C75-97	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N76	C76-76A	(2) 36" CMP	176	LF	198.52	34,940
	N76A	C76A-42	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	2,294	LF	NA	0
	N77	C77-77A	15" RCP	86	LF	32.92	2,831
	N77A	C77A-41	No Improvements Recommended	2,573	LF	NA	0
	N81	C81-92	NA - Six Mile Creek	1	NA	NA	0
	N85	C85-85A	21" RCP	54	LF	52.53	2,837
	N85A	C85A-92	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N86	C86-86A	27" RCP	196	LF	76.18	14,931
	N86A	C86A-92	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N92	C92-20	NA - Six Mile Creek	1	NA	NA	0
	N94	C94-92	NA - Six Mile Creek	1	NA	NA	0
	N95	C95-94	NA - Six Mile Creek	1	NA	NA	0
	N96	C96-96A	NA - Six Mile Creek	1	NA	NA	0
	N96A	C96A-95	NA - Six Mile Creek	1	NA	NA	0
	N97	C97-81	NA - Six Mile Creek	1	NA	NA	0
	N98	C98-81	NA - Six Mile Creek	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
21	N109	C109-21	NA - Dummy Conduit	1	NA	NA	0

	N82	C82-109	NA - Dummy Conduit	1	NA	NA	0
	N83	C83-109	NA - Dummy Conduit	1	NA	NA	0
	N84	C84-109	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
22	N105	C105-110	NA - Dummy Conduit	1	NA	NA	0
	N110	C110-22	NA - Dummy Conduit	1	NA	NA	0
	N90	C90-110	NA - Dummy Conduit	1	NA	NA	0
	N91	C91-110	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
23	N87	C87-23	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
24	N88	C88-24	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
25	N89	C89-25	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
26	N104	C104-26	NA - Dummy Conduit	1	NA	NA	0
	N136	C136-136A	No Improvements Recommended	129	LF	NA	0
	N136A	C136A-104	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
27	N93	C93-27	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
28	N64	C64-28	No Improvements Recommended	194	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
S56	N55	C55-55A	4' x 2.5' Concrete Box Culvert	63	LF	285.10	17,961

	N55A	C55A-56	NA - Dummy Conduit	1	NA	NA	0
	N56	C56-S56	NA - Dummy Conduit	1	NA	NA	0
	S56	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	NA	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
S57	N57	C57-S57	NA - Dummy Conduit	1	NA	NA	0
	S57	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	NA	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
S58	N58	C58-S58	NA - Dummy Conduit	1	NA	NA	0
	S58	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	NA	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
S60	N60	C60-S60	NA - Dummy Conduit	1	NA	NA	0
	S60	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	NA	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
S61	N61	C61-S61	NA - Dummy Conduit	1	NA	NA	0
	S61	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	NA	NA	NA	0

Area	Upstream Node	Conduit	Recommended Improvement 5-yr	Quantity	Unit	Unit Cost	Item Cost
S138	N138	C138-138	NA - Dummy Conduit	1	NA	NA	0
	S138	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	NA	NA	NA	0
	N64*	C64-28	6' x 4' Concrete Box Culvert	194	LF	502.48	97,481

5-Year Contingency Costs

Area	Recommended Improvement Cost	Contingency	Contingency Unit	Contingency Unit Cost ($)	Contingency Cost ($)

1	1,508,731	Construction Management	LS	8% of total cost	120,698
		Contingency	LS	10% of total cost	150,873
		Design and Permitting	LS	10% of total cost	150,873
		Mobilization/Demobilization	LS	5% of total cost	75,437
		Site Preparation	LS	10% of total cost	150,873
		Erosion & Sediment Control	LS	5% of total cost	75,437
		Incidentals	LS	20% of total cost	301,746
2	3,247,896	Construction Management	LS	8% of total cost	259,832
		Contingency	LS	10% of total cost	324,790
		Design and Permitting	LS	10% of total cost	324,790
		Mobilization/Demobilization	LS	5% of total cost	162,395
		Site Preparation	LS	10% of total cost	324,790
		Erosion & Sediment Control	LS	5% of total cost	162,395
		Incidentals	LS	20% of total cost	649,579
3	1,123,787	Construction Management	LS	8% of total cost	89,903
		Contingency	LS	10% of total cost	112,379
		Design and Permitting	LS	10% of total cost	112,379
		Mobilization/Demobilization	LS	5% of total cost	56,189
		Site Preparation	LS	10% of total cost	112,379
		Erosion & Sediment Control	LS	5% of total cost	56,189
		Incidentals	LS	20% of total cost	224,757
4	457,435	Construction Management	LS	8% of total cost	36,595
		Contingency	LS	10% of total cost	45,744
		Design and Permitting	LS	10% of total cost	45,744
		Mobilization/Demobilization	LS	5% of total cost	22,872
		Site Preparation	LS	10% of total cost	45,744
		Erosion & Sediment Control	LS	5% of total cost	22,872
		Incidentals	LS	20% of total cost	91,487
5	1,034,015	Construction Management	LS	8% of total cost	82,721
		Contingency	LS	10% of total cost	103,401
		Design and Permitting	LS	10% of total cost	103,401
		Mobilization/Demobilization	LS	5% of total cost	51,701
		Site Preparation	LS	10% of total cost	103,401
		Erosion & Sediment Control	LS	5% of total cost	51,701
		Incidentals	LS	20% of total cost	206,803
6	274,496	Construction Management	LS	8% of total cost	21,960

		Contingency	LS	10% of total cost	27,450
		Design and Permitting	LS	10% of total cost	27,450
		Mobilization/Demobilization	LS	5% of total cost	13,725
		Site Preparation	LS	10% of total cost	27,450
		Erosion & Sediment Control	LS	5% of total cost	13,725
		Incidentals	LS	20% of total cost	54,899
7	0				
8	0				
9	0				
10	0				
11	0				
12	0				
13	0				
14	0				
15	0				
16	53,655	Construction Management	LS	8% of total cost	4,292
		Contingency	LS	10% of total cost	5,365
		Design and Permitting	LS	10% of total cost	5,365
		Mobilization/Demobilization	LS	5% of total cost	2,683
		Site Preparation	LS	10% of total cost	5,365
		Erosion & Sediment Control	LS	5% of total cost	2,683
		Incidentals	LS	20% of total cost	10,731
17	0				
18	126,049	Construction Management	LS	8% of total cost	10,084
		Contingency	LS	10% of total cost	12,605
		Design and Permitting	LS	10% of total cost	12,605
		Mobilization/Demobilization	LS	5% of total cost	6,302
		Site Preparation	LS	10% of total cost	12,605
		Erosion & Sediment Control	LS	5% of total cost	6,302

		Incidentals	LS	20% of total cost	25,210
27	0				
20*	3,171,604	Construction Management	LS	8% of total cost	253,728
		Contingency	LS	10% of total cost	317,160
		Design and Permitting	LS	10% of total cost	317,160
		Mobilization/Demobilization	LS	5% of total cost	158,580
		Site Preparation	LS	10% of total cost	317,160
		Erosion & Sediment Control	LS	5% of total cost	158,580
		Incidentals	LS	20% of total cost	634,321
21	0				
22	0				
23	0				
24	0				
25	0				
26	0				
27	0				
28	0				
28**	97,481	Construction Management	LS	8% of total cost	7,798
		Contingency	LS	10% of total cost	9,748
		Design and Permitting	LS	10% of total cost	9,748
		Mobilization/Demobilization	LS	5% of total cost	4,874
		Site Preparation	LS	10% of total cost	9,748
		Erosion & Sediment Control	LS	5% of total cost	4,874
		Incidentals	LS	20% of total cost	19,496
S56	17,961	Construction Management	LS	8% of total cost	1,437
		Contingency	LS	10% of total cost	1,796
		Design and Permitting	LS	10% of total cost	1,796
		Mobilization/Demobilization	LS	5% of total cost	898
		Site Preparation	LS	10% of total cost	1,796

		Erosion & Sediment Control	LS	5% of total cost	898
		Incidentals	LS	20% of total cost	3,592
S57	0				
S58	0				
S60	0				
S61	0				
S138	0				
S138**	97,481	Construction Management	LS	8% of total cost	7,798
		Contingency	LS	10% of total cost	9,748
		Design and Permitting	LS	10% of total cost	9,748
		Mobilization/Demobilization	LS	5% of total cost	4,874
		Site Preparation	LS	10% of total cost	9,748
		Erosion & Sediment Control	LS	5% of total cost	4,874
		Incidentals	LS	20% of total cost	19,496

* This cost includes the costs for Areas 3-6

** This cost applies if S138 does not have adequate storage. It was included in the total cost.

Recommended Capital Improvement Costs by Area 100-Year

Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
1	N5A	C5A-10	(2) 8' x 4' Concrete Box Culvert	786	LF	1,293.54	1,016,722
	N5A	C5A-10	Detention Pond (PS3)	72,864	CY	4.00	291,456
	N5A	C5A-10	(2) 9' x 4' concrete box outlet structure with a16' x 4' Orifice	70	LF	1,448.78	101,415
	N10	C10-10A	Grass Channel (b=30' d=4' z=4:1)	208,196	SF	0.33	68,705
			Excavation for grass channel	7,963	CY	7.71	61,396
	N10	C10-10A	Concrete Channel (b =10', d=4' z=4:1)	15,671	SY	49.50	775,698
			Excavation for concrete channel	7,962	CY	7.71	61,384
	N10A	C10A-1	(2) 7' x 4' Concrete Box Culverts	30	LF	1,145.60	34,368
	N111	C111-111A	9.5' x 4' Concrete Box Culvert	46	LF	764.57	35,170
	N111A	C111A-7	Concrete Channel (b=12', d=2.5', z=1:1)	635	SY	49.50	31,416
			Excavation for concrete channel	78	CY	7.71	605
	N112	C112-111	54" RCP	344	LF	197.26	67,857
	N112	C112-111	4.5' x 4' Concrete Box Culvert	344	LF	403.84	138,921
	N126	C126-126A	54" RCP	57	LF	197.26	11,244
	N126	C126-126A	4' x 4' Concrete Box Culvert	57	LF	372.79	21,249
	N126A	C126A-8	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N127A	C127A-128	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N128	C128-128A	(2) 6.5' x 4' Concrete Box Culverts	132	LF	1,074.36	141,816
	N128	C128-128A	(1) 11' x 4' Concrete Box Culvert	132	LF	890.58	117,557
	N128A	C128A-3	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N129	C129-129A	48" RCP	362	LF	158.54	57,391
	N129A	C129A-128	(2) 6.5' x 4' Concrete Box Culverts	262	LF	1,074.36	281,482
	N130	C130-130A	30" RCP	68	LF	86.80	5,902
	N130A	C130A-137A	30" RCP	722	LF	86.80	62,670

N131	C131-131A	36" RCP	70	LF	99.26	6,948
N131A	C131A-111	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
N132	C132-132A	6.5' x 4' Concrete Box Culvert	55	LF	537.18	29,545
N132A	C132A-112	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
N137	C137-137A	36" RCP	107	LF	99.26	10,621
N137A	C137A-132	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
N139	C139-5	NA -Conveyance used to simulate overland flow.	1	NA	NA	0
N3	C3-1	Grass Channel (b=4.3', d=4', z=4:1)	102,765	SF	0.33	33,913
		Excavation for grass channel	6,712	CY	7.71	51,750
N7	C7-7A	10' x 4' Concrete Box Culvert at 0.5%	177	LF	847.88	150,075
N7A	C7A-6	Concrete Channel (b=16', d=2.5', z=1:1) at 0.5%	1,594	SY	49.50	78,887
		Excavation for concrete channel	159	CY	7.71	1,226
N6	C6-6A	(2) 7' x 4' Concrete Box Culvert at 0.5%	65	LF	1,145.60	74,464
N6A	C6A-5	Concrete Channel (b=17, d=2.5, z=1:1)	1,076	SY	49.50	53,240
N6A	C6A-5	(2) 7' x 4' Concrete Box Culvert at 0.5%	440	LF	1,145.60	504,064
N5	C5-5A	(2)8' x 4' Concrete Box Culvert at 0.5%	110	LF	1,293.54	142,289
N8	C8-8A	9.5' x 4' Concrete Box Culvert	81	LF	764.57	61,930
N8A	C8A-127A	Use existing swale	60	LF	NA	0
N8A	C8A-127A	Extend 9.5' x 4' Concrete Box Culvert	60	LF	764.57	45,874
N8A	C8A-127A	Detention pond (PS2)	11,052	CY	4.00	44,208
N8A	C8A-127A	6.5' x 4' concrete box outlet structure with a 6.3' x 4' Orifice	20	LF	537.18	10,744
N9	C9-10	Grass Channel (b=16', d=4', z=4:1)	16,224	SF	0.33	5,354
N9	C9-10	Concrete Channel (b=5', d=4' z=3:1)	1,089	SY	49.50	53,911
		Excavation for concrete channel	602	CY	7.71	4,643

Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
2	N11	C11-2	(2) 8.5' x 4' Concrete Box Culverts	59	LF	1,370.26	80,845
	N12	C12-12A	9'x4' Concrete Box Culvert	42	LF	724.39	30,424
	N12A	C12A-11	Grass Channel (b=34.7', d=4' z=4:1)	219,710	SF	0.33	72,504
			Excavation for grass channel	7,812	CY	7.71	60,229
	N12A	C12A-11	Concrete Channel (b=11.7', d=4' z=4:1)	15,994	SY	49.50	791,713
			Excavation for concrete channel	7,810	CY	7.71	60,215
	N13	C13-12	Grass Channel (b=21', d=4', z=4:1)	135,627	SF	0.33	44,757
			Excavation for grass channel	6,069	CY	7.71	46,788
	N13	C13-12	Concrete Channel (b=4.7', d=4' z=4:1)	10,435	SY	49.50	516,534
			Excavation for concrete channel	6,067	CY	7.71	46,779
	N133	C133-15	6' x 4' Concrete Box Culvert	1,614	LF	502.48	811,003
	N134	C134-133	54" RCP	566	LF	197.26	111,649
	N135	C135-134	48" RCP	639	LF	158.54	101,307
	N14	C14-14A	(2) 24" RCP (1 EXISTS)	38	LF	65.55	2,491
	N142	C142-2	(2) 24" RCP (1 EXISTS)	44	LF	65.55	2,884
	N14A	C14A-12	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N15	C15-N2	6' x 4' Concrete Box Culvert	184	LF	502.48	92,456
	N15	C15-N2	Detention Pond (PS5)	5,786	CY	4.00	23,144
	N15	C15-N2	4' x 3.5' concrete box outlet structure with a 3.4' x 3' Orifice	100	LF	342.65	34,265
	N15	C15-N2	Detention Pond (PS6)	14,121	CY	4.00	56,484
	N15	C15-N2	11.5' x 4' Concrete Box Culvert Outlet with a 4' x 10.5' Orifice	106	LF	934.41	99,047
	N15	C15-N2	Detention Pond (PS7)	36,330	CY	4.00	145,320
	N15	C15-N2	11.5' x 4' Concrete Box Culvert Outlet with a 11.1' x 4' Orifice	1,532	LF	934.41	1,431,516
	N15	C15-N2	Detention Pond (PS4)	37,814	CY	4.00	151,256
	N15	C15-N2	12' x 4' Concrete Box Culvert Outlet with a 11.9' x 4' Orifice	70	LF	979.15	68,541
	N16	C16-16A	No Improvements Recommended	130	NA	NA	0

	N16A	C16A-18	Concrete Channel (b=6',d=2.5',z=2:1)	1,102	SY	49.50	54,560
			Excavation for concrete channel	288	CY	7.71	2,217
	N17	C17-17A	No Improvements Recommended	53	NA	NA	0
	N17A	C17A-11	NA - Conveyance used to simulate overland flow.	2,256	NA	NA	0
	N18	C18-C18A	No Improvements Recommended	120	NA	NA	0
	N18A	C18A-54	Grass Channel (b=7', d=4', z=3:1)	42,036	SF	0.33	13,872
	N18A	C18A-54	(2) 7' x 4' Concrete Box Culverts	1,450	LF	1,145.60	1,661,120
	N19	C19-13	No Improvements Recommended	196	NA	NA	0
	N20	C20-C20A	No Improvements Recommended	51	NA	NA	0
	N20A	C20A-12	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N21	C21-21A	No Improvements Recommended	48	LF	NA	0
	N21A	C21A-20	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N2	C2-13	12' x 4' Concrete Box Culverts	75	LF	979.15	73,436
	S17	S17-16	Needs to be reevaluated to determine adequacy.	1	NA	NA	0
	S17E	S17E-S17	No Improvements Recommended	1	NA	NA	0
	S17W	S17W-S17E	Needs to be reevaluated to determine adequacy.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
3	N146	C146-146A	No Improvements Recommended	247	LF	NA	0
	N146A	C146A-114	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N113	C113-23	7' x 4' Concrete Box Culvert	710	LF	572.80	406,688
	N114	C114-113	36" RCP	865	LF	99.26	85,860

	N115	C115-113	7' x 2.5' Concrete Box Culvert	843	LF	468.69	395,106
	N116	C116-116A	36" RCP	333	LF	99.26	33,054
	N116A	C116A-115	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N117	C117-117A	42" RCP	178	LF	111.72	19,886
	N117A	C117A-115	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N23	C23-25	No Improvements Recommended	513	NA	NA	0
	N25	C25-26A	6.5' x 5' Concrete Box Culvert	402	LF	609.33	244,951
	N25	C25-26A	Detention Pond (PS1)	10,525	CY	4.00	42,100
	N25	C25-26A	7' x 4.5' concrete box outlet structure with a 5.7' x 4.3' Orifice	56	LF	609.33	34,122
	N26A	C26A-29	7' x 4.5' Concrete Box Culvert	174	LF	609.33	106,023
	N29	C29-30	7.5' x 5' Concrete Box Culvert	93	LF	685.13	63,717
	N30	C30-30A	8' x 5' Concrete Box Culvert	338	LF	724.39	244,844
	N30A	C30A-30B	8' x 5' Concrete Box Culvert	111	LF	724.39	80,407
	N30B	C30B-31	No Improvements Recommended	1,228	LF	NA	0
	N27	C27-25B	No Improvements Recommended (currently (1) 24" RCP)	234	LF	NA	0
	N28	C28-28A	(2) 24" RCP (1 Exists)	65	LF	65.55	4,261
	N28A	C28A-30	(2) 24" RCP	84	LF	131.10	11,012
	N31	C31-31A	(2) 8' x 5' Concrete Box	230	LF	1,448.78	333,219
	N31A	C31A-32	No Improvements Recommended	1,121	LF	NA	0
	N32	C32-3	No Improvements Recommended	30	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
4	N118	C118-118A	60" RCP	303	LF	242.63	73,517

	N118A	C118-34	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N119	C119-119A	Flood warning system	1	EA	10,000.00	10,000
	N119A	C119A-118	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N33	C33-C33A	7' x 4' Concrete Box	45	LF	572.80	25,776
	N33A	C33A-4	No Improvements Recommended at this Time. Area should be reevaluated when this area is developed or changed.	1,067	NA	NA	0
	N34	C34-C34A	8.5' x 3.5' Concrete Box	944	LF	646.77	610,551
	N34A	C34A-C33	No Improvements Recommended	1,190	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
5	N120	C120-120A	7' x 5' Concrete Box Culvert	340	LF	646.77	219,902
	N120A	C120A-36	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N121	C121-121A	30" RCP	424	LF	86.80	36,803
	N121A	C121A-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N122	C122-122A	60" RCP	490	LF	242.63	118,889
	N122A	C122A-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N36	C36-5	8' x 5' Concrete Box Culvert	1,504	LF	724.39	1,089,483
	N37	C37-120	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
6	N123	C123-123A	7.5' X 4' Concrete Box Culvert	772	LF	609.33	470,403
	N123A	C123A-38	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N124	C124-124A	54" RCP	422	LF	197.26	83,244

	N124A	C124A-123	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N125	C125-125A	48" RCP	510	LF	158.54	80,855
	N125A	C125A-123	NA - Pipe system modeled as an equivalent conveyance. Area should be evaluated more closely in the future.	1	NA	NA	0
	N38	C38-38A	(2) 60" RCP (1 Exists)	82	LF	242.63	19,896
	N38	C38-38A	7' X 5' Concrete Box Culvert	82	LF	646.77	53,035
	N38A	C38A-6	No Improvements Recommended at this Time. Area should be reevaluated when this area is developed or changed.	3,887	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
7	N107	C107-7	NA - Dummy Conduit	1	NA	NA	0
	N52	C52-107	No Improvements Recommended	51	LF	NA	0
	N53	C53-53A	24" RCP (Currently (1) 18" RCP)	53	LF	65.55	3,474
	N53A	C53A-107	No Improvements Recommended	1,962	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
8	N102	C102-8	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
9	N101	C101-9	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
10	N100	C100-10	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
11	N99	C99-11	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
12	N59	C59-12	No Improvements Recommended at this Time. Area should be reevaluated if basin 119 does not provide adequate storage and/or if basin 119 or basin 120 is changed.	185	LF	NA	0

Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
13	N62	C62-13	(2) 48" RCP (1 Exists)	200	LF	158.54	31,708
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
14	N63	C63-14	No Improvements Recommended	200	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
15	N35	C35-15	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
16	N106	C106-108	NA - Dummy Conduit	1	NA	NA	0
	N108	C108-16	NA - Dummy Conduit	1	NA	NA	0
	N65	C65-65A	(2) 6.5' x 4' Concrete Box Culvert	272	LF	1,074.36	292,226
	N65A	C65A-108	NA - Conveyance used to simulate overland flow.	3,681	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
17	N66	C66-17	NA - Dummy Conduit	1	NA	NA	0
	N78	C78-78A	4.5'X4' Concrete Box Culvert	144	LF	403.84	58,153
	N78A	C78A-66	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N79	C79-79A	No Improvements Recommended	103	NA	NA	0
	N79A	C79A-144	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N144	C144-144A	4.5'X4' Concrete Box Culvert	201	LF	403.84	81,172
	N144A	C144A-78	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
18	N80	C80-80A	5'x4' Concrete Box Culvert @ 0.5%	368	LF	435.81	160,378

	N80A	C80A-106	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N106	C106-106A	5.5'x4' Concrete Box Culvert	73	LF	468.69	34,214
	N106A	C106A-67	Keep Maintained	320	LF	NA	0
	N67	C67-67A	10'x4' Concrete Box Culvert @ 0.5%	62	LF	847.88	52,569
	N67A	C67A-18	Regrade swale to have a slope of 0.5%.	164	LF	7.09	1,163
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
19	N68	C68-19	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
20	N145	C145-145A	30" RCP	206	LF	86.80	17,881
	N145A	C145A-103	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N103	C103-97	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
	N39	C39-39A	8' x 4' Concrete Box Culvert	130	LF	646.77	84,080
	N39A	C39A-98A	No Improvements Recommended	338	NA	NA	0
	N40	C40-40A	(2) 7.5' x 4' Concrete Box Culverts	57	LF	1,218.66	69,464
	N40A	C40A-39	Grass Swale (b= 12', d= 4.5', z = 4:1)	86,688	SF	0.33	28,607
			Excavation for grass channel	5,421	CY	7.71	41,792
	N40A	C40A-39	Concrete Channel (b= 8' d= 3.6' z=4:1)	7,385	SY	49.50	365,534
			Excavation for concrete channel	3,469	CY	7.71	26,746
	N41	C41-41A	(2) 7.5' x 4' Concrete Box Culverts	45	LF	1,218.66	54,840
	N41A	C41A-40	Grass Swale (b= 9', d= 4', z = 4:1)	28,905	SF	0.33	9,539
			Excavation for grass channel	1,673	CY	7.71	12,899
	N41A	C41A-40	Concrete Channel (b= 4' d= 3.4', z=4:1)	2,444	SY	49.50	120,978
			Excavation for concrete channel	1,208	CY	7.71	9,317
	N42	C42-41	No Improvements Recommended	1,588	NA	NA	0

N43	C43-43A	10.5 x 5' Concrete Box Culvert at 0.5%	42	LF	934.41	39,245
N43A	C43A-42	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	894	NA	NA	0
N44	C44-44A	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	71	NA	NA	0
N44A	C44A-43	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	1,060	NA	NA	0
N45	C45-44	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	3,265	NA	NA	0
N46	C46-46A	No Improvements Recommended	48	NA	NA	0
N46A	C46A-45	(2) 7.5' x 3' Concrete Box Culverts	300	LF	1,074.36	322,308
N47	C47-46	No Improvements Recommended	230	NA	NA	0
N48	C48-47	No Improvements Recommended	1,012	NA	NA	0
N49	C49-48	No Improvements Recommended	195	NA	NA	0
N50	C50-49	No Improvements Recommended	103	NA	NA	0
N147	C147-147A	No Improvements Recommended	341	LF	NA	0
N147A	C147-69	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N69	C69-98	NA - Six Mile Creek	1	NA	NA	0
N70	C70-70A	60" RCP	192	LF	242.63	46,585
N70A	C70A-69	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N71	C71-71A	(2) 60" RCP	208	LF	485.26	100,934
N71A	C71A-70	NA - Conveyance used to simulate overland flow.	1	NA	NA	0

N72	C72-72A	60" RCP	185	LF	242.63	44,887
N72A	C72A-71	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N73	C73-73A	54" RCP	165	LF	197.26	32,548
N73A	C73A-72	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N74	C74-74A	No Improvements Recommended	97	LF	NA	0
N74A	C74A-72	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N75	C75-97	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N76	C76-76A	48" RCP (currently (1) 36" CMP)	176	LF	158.54	27,903
N76A	C76A-42	No improvements recommended. If zoning changes or if area is developed existing should be reevaluated.	2,294	NA	NA	0
N77	C77-77A	24" RCP	86	LF	65.55	5,637
N77A	C77A-41	No Improvements Recommended	2,573	NA	NA	0
N81	C81-92	NA - Six Mile Creek	1	NA	NA	0
N85	C85-85A	30" RCP	54	LF	86.80	4,687
N85A	C85A-92	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N86	C86-86A	30" RCP	196	LF	86.80	17,013
N86A	C86A-92	NA - Conveyance used to simulate overland flow.	1	NA	NA	0
N92	C92-20	NA - Six Mile Creek	1	NA	NA	0
N94	C94-92	NA - Six Mile Creek	1	NA	NA	0
N95	C95-94	NA - Six Mile Creek	1	NA	NA	0
N96	C96-96A	NA - Six Mile Creek	212	NA	NA	0
N96A	C96A-95	NA - Six Mile Creek	1	NA	NA	0

	N97	C97-81	NA - Six Mile Creek	1	NA	NA	0
	N98	C98-81	NA - Six Mile Creek	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
21	N109	C109-21	NA - Dummy Conduit	1	NA	NA	0
	N82	C82-109	NA - Dummy Conduit	1	NA	NA	0
	N83	C83-109	NA - Dummy Conduit	1	NA	NA	0
	N84	C84-109	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
22	N105	C105-110	NA - Dummy Conduit	1	NA	NA	0
	N110	C110-22	NA - Dummy Conduit	1	NA	NA	0
	N90	C90-110	NA - Dummy Conduit	1	NA	NA	0
	N91	C91-110	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
23	N87	C87-23	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
24	N88	C88-24	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
25	N89	C89-25	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
26	N104	C104-26	NA - Dummy Conduit	1	NA	NA	0
	N136	C136-136A	No Improvements Recommended	129	LF	NA	0

	N136A	C136A-104	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
27	N93	C93-27	NA - Dummy Conduit	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
28	N64	C64-28	No Improvements Recommended	194	LF	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
S56	N55	C55-55A	5.5'x3' Concrete Box Culvert	63	LF	403.84	25,442
	N55A	C55A-56	NA - Dummy Conduit	1	NA	NA	0
	N56	C56-S56	NA - Dummy Conduit	1	NA	NA	0
	S56	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
S57	N57	C57-S57	NA - Dummy Conduit	1	NA	NA	0
	S57	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
S58	N58	C58-S58	NA - Dummy Conduit	1	NA	NA	0
	S58	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
S60	N60	C60-S60	NA - Dummy Conduit	1	NA	NA	0

	S60	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
S61	N61	C61-S61	NA - Dummy Conduit	1	NA	NA	0
	S61	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	1	NA	NA	0
Area	Upstream Node	Conduit	Recommended Improvement 100-yr	Quantity	Unit	Unit Cost ($)	Item Cost
S138	N138	C138-138	NA - Dummy Conduit	1	NA	NA	0
	S138	-	Existing storage facility needs to be analyzed to determine if it has adequate storage. If it does not have adequate storage, it should either be enlarged or a spillway and safe overflow path should be constructed.	1	NA	NA	0
	N64*	C64-28	8' x 4.5' Concrete Box Culvert	194	LF	685.13	132,915

100-Year Contingency Costs

Area	Recommended Improvement Cost	Contingency	Contingency Unit	Contingency Unit Cost	Contingency Cost
1	4,748,108	Construction Management	LS	8% of total cost	379,849
		Contingency	LS	10% of total cost	474,811
		Design and Permitting	LS	10% of total cost	474,811
		Mobilization/Demobilization	LS	5% of total cost	237,405
		Site Preparation	LS	10% of total cost	474,811
		Erosion & Sediment Control	LS	5% of total cost	237,405
		Incidentals	LS	20% of total cost	949,622
2	6,687,358	Construction Management	LS	8% of total cost	534,989
		Contingency	LS	10% of total cost	668,736
		Design and Permitting	LS	10% of total cost	668,736
		Mobilization/Demobilization	LS	5% of total cost	334,368
		Site Preparation	LS	10% of total cost	668,736
		Erosion & Sediment Control	LS	5% of total cost	334,368
		Incidentals	LS	20% of total cost	1,337,472
3	2,105,251	Construction Management	LS	8% of total cost	168,420
		Contingency	LS	10% of total cost	210,525
		Design and Permitting	LS	10% of total cost	210,525
		Mobilization/Demobilization	LS	5% of total cost	105,263
		Site Preparation	LS	10% of total cost	210,525
		Erosion & Sediment Control	LS	5% of total cost	105,263
		Incidentals	LS	20% of total cost	421,050
4	719,844	Construction Management	LS	8% of total cost	57,588
		Contingency	LS	10% of total cost	71,984
		Design and Permitting	LS	10% of total cost	71,984
		Mobilization/Demobilization	LS	5% of total cost	35,992
		Site Preparation	LS	10% of total cost	71,984
		Erosion & Sediment Control	LS	5% of total cost	35,992
		Incidentals	LS	20% of total cost	143,969
5	1,465,076	Construction Management	LS	8% of total cost	117,206
		Contingency	LS	10% of total cost	146,508
		Design and Permitting	LS	10% of total cost	146,508
		Mobilization/Demobilization	LS	5% of total cost	73,254
		Site Preparation	LS	10% of total cost	146,508
		Erosion & Sediment Control	LS	5% of total cost	73,254

		Incidentals	LS	20% of total cost	293,015
6	707,433	Construction Management	LS	8% of total cost	56,595
		Contingency	LS	10% of total cost	70,743
		Design and Permitting	LS	10% of total cost	70,743
		Mobilization/Demobilization	LS	5% of total cost	35,372
		Site Preparation	LS	10% of total cost	70,743
		Erosion & Sediment Control	LS	5% of total cost	35,372
		Incidentals	LS	20% of total cost	141,487
7	3,474	Construction Management	LS	8% of total cost	278
		Contingency	LS	10% of total cost	347
		Design and Permitting	LS	10% of total cost	347
		Mobilization/Demobilization	LS	5% of total cost	174
		Site Preparation	LS	10% of total cost	347
		Erosion & Sediment Control	LS	5% of total cost	174
		Incidentals	LS	20% of total cost	695
8	0				
9	0				
10	0				
11	0				
12	0				
13	31,708	Construction Management	LS	8% of total cost	2,537
		Contingency	LS	10% of total cost	3,171
		Design and Permitting	LS	10% of total cost	3,171
		Mobilization/Demobilization	LS	5% of total cost	1,585
		Site Preparation	LS	10% of total cost	3,171
		Erosion & Sediment Control	LS	5% of total cost	1,585
		Incidentals	LS	20% of total cost	6,342
14	0				
15	0				
16	292,226	Construction Management	LS	8% of total cost	23,378

		Contingency	LS	10% of total cost	29,223
		Design and Permitting	LS	10% of total cost	29,223
		Mobilization/Demobilization	LS	5% of total cost	14,611
		Site Preparation	LS	10% of total cost	29,223
		Erosion & Sediment Control	LS	5% of total cost	14,611
		Incidentals	LS	20% of total cost	58,445
17	139,325	Construction Management	LS	8% of total cost	11,146
		Contingency	LS	10% of total cost	13,932
		Design and Permitting	LS	10% of total cost	13,932
		Mobilization/Demobilization	LS	5% of total cost	6,966
		Site Preparation	LS	10% of total cost	13,932
		Erosion & Sediment Control	LS	5% of total cost	6,966
		Incidentals	LS	20% of total cost	27,865
18	248,324	Construction Management	LS	8% of total cost	19,866
		Contingency	LS	10% of total cost	24,832
		Design and Permitting	LS	10% of total cost	24,832
		Mobilization/Demobilization	LS	5% of total cost	12,416
		Site Preparation	LS	10% of total cost	24,832
		Erosion & Sediment Control	LS	5% of total cost	12,416
		Incidentals	LS	20% of total cost	49,665
19	0				
20*	6,481,027	Construction Management	LS	8% of total cost	518,482
		Contingency	LS	10% of total cost	648,103
		Design and Permitting	LS	10% of total cost	648,103
		Mobilization/Demobilization	LS	5% of total cost	324,051
		Site Preparation	LS	10% of total cost	648,103
		Erosion & Sediment Control	LS	5% of total cost	324,051
		Incidentals	LS	20% of total cost	1,296,205
21	0				
22	0				
23	0				
24	0				

25	0				
26	0				
27	0				
28	0				
28**	132,915	Construction Management	LS	8% of total cost	10,633
		Contingency	LS	10% of total cost	13,292
		Design and Permitting	LS	10% of total cost	13,292
		Mobilization/Demobilization	LS	5% of total cost	6,646
		Site Preparation	LS	10% of total cost	13,292
		Erosion & Sediment Control	LS	5% of total cost	6,646
		Incidentals	LS	20% of total cost	26,583
S56	25,442	Construction Management	LS	8% of total cost	2,035
		Contingency	LS	10% of total cost	2,544
		Design and Permitting	LS	10% of total cost	2,544
		Mobilization/Demobilization	LS	5% of total cost	1,272
		Site Preparation	LS	10% of total cost	2,544
		Erosion & Sediment Control	LS	5% of total cost	1,272
		Incidentals	LS	20% of total cost	5,088
S57	0				
S58	0				
S60	0				
S61	0				
S138	0				

S138**	132,915	Construction Management	LS	8% of total cost	10,633
		Contingency	LS	10% of total cost	13,292
		Design and Permitting	LS	10% of total cost	13,292
		Mobilization/Demobilization	LS	5% of total cost	6,646
		Site Preparation	LS	10% of total cost	13,292
		Erosion & Sediment Control	LS	5% of total cost	6,646
		Incidentals	LS	20% of total cost	26,583

* This cost includes the costs for Areas 3-6

** This cost applies if S138 does not have adequate storage. It was included in the total cost.

Unit Costs

Item	Unit	Unit Cost
15" RCP, FURNISH & INSTALL	LF	$ 32.92
18" RCP, FURNISH & INSTALL	LF	$ 39.50
21" RCP, FURNISH & INSTALL	LF	$ 52.53
24" RCP, FURNISH & INSTALL	LF	$ 65.55
27" RCP, FURNISH & INSTALL	LF	$ 76.18
30" RCP, FURNISH & INSTALL	LF	$ 86.80
36" RCP, FURNISH & INSTALL	LF	$ 99.26
42" RCP, FURNISH & INSTALL	LF	$ 111.72
48" RCP, FURNISH & INSTALL	LF	$ 158.54
54" RCP, FURNISH & INSTALL	LF	$ 197.26
60" RCP, FURNISH & INSTALL	LF	$ 242.63
66" RCP, FURNISH & INSTALL	LF	$ 293.92
72" RCP, FURNISH & INSTALL	LF	$ 351.13
6.5' X 1.5' CBC, FURNISH & INSTALL	LF	$ 372.79
4.5' X 2' CBC, FURNISH & INSTALL	LF	$ 285.10
6' X 2' CBC, FURNISH & INSTALL	LF	$ 372.79
7' X 2' CBC, FURNISH & INSTALL	LF	$ 435.81
7.5' X 2' CBC, FURNISH & INSTALL	LF	$ 468.69
8 X 2' CBC, FURNISH & INSTALL	LF	$ 502.48
3' X 2.5' CBC, FURNISH & INSTALL	LF	$ 231.20
4' X 2.5' CBC, FURNISH & INSTALL	LF	$ 285.10
7' X 2.5' CBC, FURNISH & INSTALL	LF	$ 468.69
9.5' X 2.5' CBC, FURNISH & INSTALL	LF	$ 646.77
3.5' X 3' CBC, FURNISH & INSTALL	LF	$ 285.10
3.5' X 3.5' CBC, FURNISH & INSTALL	LF	$ 313.42
4' X 3' CBC, FURNISH & INSTALL	LF	$ 313.42
5.5' X 3' CBC, FURNISH & INSTALL	LF	$ 403.84
6.5' X 3' CBC, FURNISH & INSTALL	LF	$ 468.69
7' X 3' CBC, FURNISH & INSTALL	LF	$ 502.48
7.5' X 3' CBC, FURNISH & INSTALL	LF	$ 537.18
8' X 3' CBC, FURNISH & INSTALL	LF	$ 572.80
8.5' X 3' CBC, FURNISH & INSTALL	LF	$ 609.33
10' X 3' CBC, FURNISH & INSTALL	LF	$ 724.39
4' X 3.5' CBC, FURNISH & INSTALL	LF	$ 342.65
4.5' X 3.5' CBC, FURNISH & INSTALL	LF	$ 372.79
5' X 3.5' CBC, FURNISH & INSTALL	LF	$ 403.84
6.5' X 3.5' CBC, FURNISH & INSTALL	LF	$ 502.48
7' X 3.5' CBC, FURNISH & INSTALL	LF	$ 537.18
8' X 3.5' CBC, FURNISH & INSTALL	LF	$ 609.33

Item	Unit	Unit Cost
8.5' X 3.5' CBC, FURNISH & INSTALL	LF	$ 646.77
12' X 3.5' CBC, FURNISH & INSTALL	LF	$ 934.41
4' X 4' CBC, FURNISH & INSTALL	LF	$ 372.79
4.5' X 4' CBC, FURNISH & INSTALL	LF	$ 403.84
5' X 4' CBC, FURNISH & INSTALL	LF	$ 435.81
5.5' X 4' CBC, FURNISH & INSTALL	LF	$ 468.69
6' X 4' CBC, FURNISH & INSTALL	LF	$ 502.48
6.5' X 4' CBC, FURNISH & INSTALL	LF	$ 537.18
7' X 4' CBC, FURNISH & INSTALL	LF	$ 572.80
7.5' X 4' CBC, FURNISH & INSTALL	LF	$ 609.33
8' X 4' CBC, FURNISH & INSTALL	LF	$ 646.77
8.5' X 4' CBC, FURNISH & INSTALL	LF	$ 685.13
9' X 4' CBC, FURNISH & INSTALL	LF	$ 724.39
9.5' X 4' CBC, FURNISH & INSTALL	LF	$ 764.57
10' X 4' CBC, FURNISH & INSTALL	LF	$ 847.88
10.5' X 4' CBC, FURNISH & INSTALL	LF	$ 860.00
11' X 2.5' CBC, FURNISH & INSTALL	LF	$ 764.57
11' X 4' CBC, FURNISH & INSTALL	LF	$ 890.58
11.5' X 4' CBC, FURNISH & INSTALL	LF	$ 934.41
12' X 4' CBC, FURNISH & INSTALL	LF	$ 979.15
6.5' X 4.5' CBC, FURNISH & INSTALL	LF	$ 572.80
7' X 4.5' CBC, FURNISH & INSTALL	LF	$ 609.33
8' X 4.5' CBC, FURNISH & INSTALL	LF	$ 685.13
9' X 4.5' CBC, FURNISH & INSTALL	LF	$ 764.57
10' X 4.5' CBC, FURNISH & INSTALL	LF	$ 847.66
10.5' X 4.5' CBC, FURNISH & INSTALL	LF	$ 890.58
11' X 4.5' CBC, FURNISH & INSTALL	LF	$ 934.41
12' X 4.5' CBC, FURNISH & INSTALL	LF	$ 1,024.80
5' X 5' CBC, FURNISH & INSTALL	LF	$ 502.48
5.5' X 5' CBC, FURNISH & INSTALL	LF	$ 537.18
6' X 5' CBC, FURNISH & INSTALL	LF	$ 572.80
6.5' X 5' CBC, FURNISH & INSTALL	LF	$ 609.33
7' X 5' CBC, FURNISH & INSTALL	LF	$ 646.77
7.5' X 5' CBC, FURNISH & INSTALL	LF	$ 685.13
8' X 5' CBC, FURNISH & INSTALL	LF	$ 724.39
8.5' X 5' CBC, FURNISH & INSTALL	LF	$ 764.57
9' X 5' CBC, FURNISH & INSTALL	LF	$ 805.66
9.5' X 5' CBC, FURNISH & INSTALL	LF	$ 847.66
10' X 5' CBC, FURNISH & INSTALL	LF	$ 890.58
10.5' X 5' CBC, FURNISH & INSTALL	LF	$ 934.41

Item	Unit	Unit Cost
11' X 5' CBC, FURNISH & INSTALL	LF	$ 979.15
11.5' X 5' CBC, FURNISH & INSTALL	LF	$ 1,024.80
12' X 5' CBC, FURNISH & INSTALL	LF	$ 1,071.37
FLOOD WARNING SYSTEM	LS	$ 10,000.00
BLOCK EXISTING PIPE	LS	$ 2,000.00
CHANNEL EXCAVATION, GRADING & SPOILS REMOVAL	CY	$ 7.71
GRASS LINED CHANNEL REVEGETATION	SY	$ 3.00
CONCRETE CHANNEL LINING	SY	$ 49.50
POND EXCAVATION, GRADING & SPOILS REMOVAL	CY	$ 4.00
CHANNEL EXCAVATION, GRADING & SPOILS REMOVAL	LF	$ 7.09