STORMWATER ANALYSIS REPORT FOR:

GARDEN CITY STORMWATER MASTER PLAN CHATHAM COUNTY, GEORGIA

PREPARED FOR: GARDEN CITY, GEORGIA

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INTRODUCTION

As part of the Georgia Coastal Management Program, the City of Garden City (Garden City) received a two–year Coastal Incentive Grant (CIG) in 2011 (Cycle 14) to complete a Coastal Hazards Risk and Vulnerability Assessment and a GIS Database Planning Tool. The purpose of the Cycle 14 CIG project was to identify areas where the City was vulnerable to coastal hazards, including flooding due to more severe storm events, sea level rise, storm surge, etc. and to identify necessary updates to the City's Comprehensive Plan, land development codes and design standards. Through this effort, the City identified several areas within City limits that were susceptible to flooding due to the location, condition, elevation, and design of the stormwater management system and other water resource features in Chatham County (i.e. canals.) As a result of the Cycle 14 CIG assessment and Outcome 1 of Cycle 16 CIG, four major drainage basins were identified as key areas within Garden City most vulnerable to flooding and stormwater runoff impacts.

Following the Cycle 14 CIG project, Garden City subsequently secured a Cycle 16 CIG with the purpose of developing a Stormwater Master Plan. The Stormwater Master Plan would touch on all areas within Garden City, but specifically target via more detailed study of the four major drainage basins identified in the Cycle 14 CIG assessment. In addition to this effort, Garden City was tasked with establishing short and long term strategies for the City to implement as development progresses within City limits.

Historically, development within Garden City has been typically centralized around the Port of Savannah. With the pending completion of the Savannah River deepening project, it is anticipated that growth and development will increase and expand throughout Garden City. Previously developed areas located north of Interstate 16 may experience a high volume of redevelopment caused by the Savannah River deepening. These areas typically exhibit a high percentage of impervious surface and minimal green spaces for stormwater quality treatment. Given the potential for this area to be further urbanized in the future, stormwater runoff quality and quantity management is a high priority. Areas south of Interstate 16 consist of primarily agricultural and low density residential areas with small pockets of commercial development. The portion of Garden City located south of Interstate 16 is not expected to develop at as high a rate as the portion of the City located north of Interstate 16. It is anticipated the portion of the City south of Interstate 16 may experience marginal growth but the rate of development is expected to be slower due to the present land uses and further distances from the Port as well as the lack of public sewer and water services.

As development increases, Garden City will need to mitigate the impacts of increased stormwater runoff and ensure that water quality is maintained. Presently two canals within the City are designated as impaired waters on the Georgia Environmental Protection Division (GA EPD) 303d List. Water quality data indicates Pipemaker's Canal and Salt Creek Tributary do not support the canals' designated fishing use due to fecal coliform bacteria found within a portion of the coastal streams located in Garden City. Possible sources for this growth of bacteria in the stream may be due to urban runoff, septic tanks, and/or wildlife within the area. The GA EPD is expected to develop a total maximum daily load (TMDL) in order to start the process of restoring the water of the Salt Creek Tributary and Pipemaker's Canal in the near future. In the meantime, as development continues, the City will need to develop and implement strategies to address water quality and protect local waterways from future runoff pollutants.

The City previously identified current areas at risk for flooding throughout the City and the City has also taken into account future citywide growth impacts which resulted in six outcomes, or

goals, being identified in the Cycle 16 CIG. The intent of these outcomes or objectives was to create a Stormwater Master Plan that would serve as a guide for the City in generating sustainable watershed management into the future as development and redevelopment continue. The six objectives of the Stormwater Master Plan are as follows:

- Perform engineering studies on the four major drainage basins identified from the Cycle 14 CIG project and assess the volume, discharge rate and quality of the stormwater runoff within each of the four drainage basins. (CIG Outcome 2)

- Identify City streets that will need to be closed in the event of a major rainfall event so that evacuating residents and emergency responders will not place themselves at risk by crossing flooded City streets or roads (CIG Outcome 4)

- Identify emergency evacuation routes for residents to follow that will direct them away from closed streets and will direct them to the safest routes out of the City (CIG Outcome 4)

- Develop a Capital Improvement Projects List which will prioritize projects that address existing drainage system deficiencies for future implementation using Stormwater Utility funds as they become available. (CIG Outcome 3)

- Develop basin–specific storm water management standards/criteria that reduce runoff quantity impacts in an effort to reduce flooding impacts within watersheds that are already stressed in terms of capacity (CIG Outcome 5)

- Update applicable City Codes to incorporate basin specific requirements in the "Special Drainage District" section of the City's current Post Construction Stormwater Management Ordinance (enacted on April 1, 2012) (CIG Outcome 5)

Thomas & Hutton was selected by the City of Garden City through a request for qualifications procurement process to develop the Stormwater Master Plan with the Cycle 16 CIG objectives/outcomes listed above. The scope of work included: performing an engineering assessment on the four identified basins, developing basin–specific stormwater runoff control strategies for the City to incorporate in the "Special Drainage District" section of the Post Construction Stormwater Management Ordinance, creating a capital improvement projects list based on the deficiencies observed throughout the City, and identifying road closures in each basin during a major rainfall flooding event. The four basin assessments are discussed in further detail in the following sections of this report. In addition to the detailed studies on the four basins, Thomas & Hutton performed additional basin assessments in other basin areas of the City where expected growth or known water quality issues were present. These additional assessments serve to assist the City with future land development plans and will likely require further study as additional funding becomes available.

It should be noted that this report does not include emergency evacuation routes for each basin. However, this report is intended to provide the City with pertinent information and road closure suggestions, so that the City may develop emergency evacuation routes.

OBJECTIVE

The purpose of this report is to assist the City in meeting the six outcomes defined in the Cycle 16 CIG. The six outcomes include:

1. Identification of priority drainage basin areas and basins of higher risk.
2. Perform additional engineering studies on the four priority drainage basins within the City.
3. Develop a system to select identified capital improvement projects for implementation.
4. Develop a Garden City Road Closure Plan.
5. Identify basin specific requirements for consideration as ordinance amendments.
6. Provide a stakeholder education meeting.

In addition to meeting the Cycle 16 CIG objectives, it is intended that this report serve as a living document for the City that will require periodic updates as development progresses within the City, with the intent to ultimately form a comprehensive City Stormwater Master Plan. Several basins, such as the Raspberry Watershed, North Springfield Watershed, Horseshoe Creek Watershed and Salt Creek Watershed, reside within the City limits, are not assessed to the same level of detail that the four priority basins have been studied. Most of these unstudied basins are primarily undeveloped; or are basins that did not exhibit a high risk for flooding based on the Cycle 14 assessment performed in 2011. As the City continues to grow and develop, these basins may require more detailed analysis. Funding should be allocated to provide detailed engineering study of these basins in the future as land development conditions dictate. However, the City's existing ordinance and design standards are very comprehensive and should offer a level of protection resulting from stormwater runoff impacts that will adequately address most issues.

Furthermore, this report examines the runoff impacts of each basin on neighboring municipalities. The City currently has five outfall points that lead into other jurisdictions, where it appears that most of the downstream infrastructure is undersized. As such, Garden City may not have the ability to correct all the issues that may arise within the City system, with causes outside Garden City jurisdiction. Specifically, if issues are caused by oversized or undersized conveyance systems in neighboring municipalities, Garden City will not be able to correct these issues without multi–jurisdictional cooperation and collaboration. As a proactive measure, Garden City desires to maintain its commitment to environmental stewardship and water resources sustainability by addressing how future development/ redevelopment stormwater runoff is treated within City limits prior to discharging from the site and/or the City's jurisdiction limits. An example of the city's commitment is to investigate long term runoff treatment strategies, such as "Special Drainage Districts", intended to have more stringent runoff treatment requirements depending on the basin condition, basin conveyance capacity or basin water quality status. Multi–jurisdictional long term strategies will involve working with neighboring jurisdiction and entities, such as the railroad, the City of Savannah, Chatham County, etc., to increase downstream capacity for flood control and possibly establishing collaborative Capital Improvement Projects (CIPs) and areas requiring further engineering study.

This report focuses on identifying short and long term flood and stormwater management control strategies. Short term strategies may include a street closure implementation plan and maintenance items, while long term strategies may include multi–jurisdictional projects, CIP project construction and ordinance amendments based upon best management practices that

will better manage stormwater quantity and quality over time. All projects that have been identified in the Stormwater Master Plan are based on mapping grade survey and preliminary hydrologic and hydraulic modeling. As such, further levels of analysis and design will be required for each identified project prior to project construction.

Thomas & Hutton has compiled a CIP List based on the analysis from this report. The CIP summary includes a description and location of each drainage system, its existing condition, a proposed improvement or system maintenance and a preliminary engineer's opinion of probable budget. It should be noted that the preliminary budgets provided for each proposed maintenance/improvement project should be used for budgeting purposes only and may not reflect cost related to actual construction of the projects adequately. Further surveying, design, engineering calculations and permits are needed prior to construction of the projects.

LIMITATIONS

The results and models used to formulate conclusions in the Garden City Stormwater Master Plan have inherent limitations. By its nature, a master plan is preliminary and subject to further refinement as information becomes available. Limitations of this Stormwater Master Plan can be found below.

- The master plan should be used as a policy guide only. The master plan should be maintained as a "living document" that is regularly updated as additional, more definitive information is submitted or becomes available. Prior to the final programming of CIPs for execution, additional refined analysis is required.
- Given the varying techniques used in the existing models provided by the City for use in the master plan, and the project budget constraints, model calibration was difficult to achieve. The 100–year, 24–hour storm events were compared to FEMA FIRM Base Flood Elevations and are typically lower values in the master plan, most likely due to differing tailwater criteria (i.e. no tidal surge data used in master plan).
- Pursuant to the scope of services for this project, models provided for use in the stormwater master plan were used "as–is" for the most part. It is recommended the existing models be further assessed for consistent design assumptions, such as allowable flow over road crossings, exit and entrance loss coefficients, roadway overflow weir geometry and channel geometry.
- Elevation data was extracted from Chatham County 3' digital elevation model information. As such, all elevations are approximate and for informational purposes only. It is recommended conventional, ground–run survey be completed, and subsequent refined engineering analysis be undertaken prior to identified projects being executed.
- Budgets for identified CIPs are for budget programming only and are subject to change prior to construction.
- For the models provided by the City, it is assumed all elevations used in modeling were completed on NAVD1988 datum. This is consistent with published reports, if available, and conversations with the original modeling consultants.
- While the master plan calls for interim strategies to manage roadway flooding such as road closures, Garden City staff should continue to monitor all streets for safe passage during rain events. Road closures listed herein may not be all inclusive. As such, Garden City should prepare for additional road closures during rain events, as may be deemed necessary by staff observation.

KEY DEFINITIONS

For clarification purposes, we have included the following key definitions for certain terms used throughout the document. A list of key terms and corresponding definitions are noted below:

Watershed or Basin – areas of land where surface water drains to a common point, usually a canal, river or the ocean.

Sub–basins – a sub–unit of a watershed or basin consisting of a land area where surface waters drain to a point within a watershed.

Level of Service (LOS) – a qualitative measure used to relate the extents to which infrastructure is designed.

Cursory Study – a study of a watershed, basin or sub–basin using non–numeric (modeling) analysis. Analysis is based on physical watershed characteristics such as level of development, topographic information, soil data, historical flooding and other factors controlling hydrologic and hydraulic behaviors.

Limited Detailed Study – an analysis of a watershed, basin or sub–basin using numeric modeling analysis. Limited detail refers to the quality of data used as model input. Data used in the model includes MS4 data sizes and materials of drainage infrastructure, LiDAR generated 3' grid digital elevation model for elevations and field reconnaissance. With the exception of the Heidt Basin, all other limited detail studies were completed using existing modeling information provided by the City that was appended and modified for use in the master plan.

Alert Stage – An elevation corresponding to a critical elevation at which a location will flood, by overtopping its channel banks or road elevation.

EXISTING DRAINAGE SYSTEM

Garden City consists of approximately 14.6 square miles of predominantly undeveloped land, with developed residential, commercial, and industrial areas. The majority of heavily developed property can be found within the City limits located north of Interstate 16. Areas south of Interstate 16 are predominantly rural in character. The topography of the area ranges from fairly flat to gently rolling and consists primarily of soils that exhibit poor drainage qualities. In general throughout the City, groundwater elevations and soils types are not conducive to infiltration for stormwater runoff treatment. Overall, the City is comprised of seven major watersheds. The locations of these watersheds within the City boundaries are shown on Exhibit A1 in Appendix A. The table below displays the seven watersheds and corresponding acreages:

Table 1 – Garden City Watersheds

Watershed	Total Acreage	Acreage within Garden City	Percent of Watershed in Garden City Limits	Limited Detail Study	Concept Study
Pipemaker's Canal	±18,000 ac	±2,740 ac	±15%	*	
Dundee Canal	±3,500 ac	±2,000 ac	±57%	*	
Springfield North	±5,600 ac	±55 ac	±1%		x
Talmadge	±1,235 ac	±1,055 ac	±86%	*	
Horseshoe	±3,450 ac	±1,670 ac	±48%		x
Raspberry	±2,600 ac	±470 ac	±18%		x
Salt Creek	±7,730 ac	±1,145 ac	±15%		x

* Represent CIG Cycle 16 Outcome 1 High Priority Drainage Areas for Limited Detailed Study

As part of the City's Cycle 14 CIG, four (4) main drainage areas within the City limits were identified as having the highest risk to flooding and stormwater runoff impacts. These four (4) drainage areas are shown in Exhibit A2 located in Appendix A. A general description and location of these four (4) areas is as follows:

1. Talmadge Basin (Talmadge Watershed) – approximately 1,055 acres located within the Talmadge Watershed. The basin boundaries are roughly Dean Forest Road, Kelly Hill Road/Deloach Avenue, the Railroad tracks, and Old Louisville Road.
2. Smith Basin (Pipemaker's Canal Watershed) – approximately 280 acres located within the Pipemaker's Canal Watershed. The basin boundaries are roughly Augusta Road (GA–21), Main Street, Bishop Avenue, and Smith Avenue.
3. Chatham City Basin (Dundee Watershed) – approximately 800 acres located within the Dundee Canal Watershed. The basin boundaries are roughly the Railroad tracks, Priscilla D Thomas Way, Augusta Road (GA–21) and Highway 80.
4. Heidt–Telfair Basin (Dundee Watershed) – approximately 620 acres located within the Dundee Canal Watershed. The basin boundaries are roughly Kelly Hill Road, the Amtrak train tracks, the Railroad tracks, and Highway 80.

The existing conveyance systems in each of the (4) four basins is made up of curb inlets, grate inlets, reinforced concrete pipe, HDPE pipe, box culverts, grassed channels/swales, concrete–lined channels, detention ponds, canals, and weir structures. Stormwater runoff is routed through a series of pipes, channels, weirs and outfall structures. Overall the existing drainage systems in the four basins are aged, undersized and in need of improvements. A limited detailed study was completed for these four basins to further evaluate potential flooding risks.

Thomas & Hutton modeled the existing drainage system of these (4) four key basin areas in order to begin development of the City Stormwater Master Plan for Garden City. An individual assessment for each basin is included in this study. Due to budgetary constraints, limited detailed study was performed for these four (4) areas, with only cursory assessment of the remaining basins within the City.

Since the goal of the stormwater master plan was to provide for "city–wide" guidance, cursory level studies were completed for the remaining watersheds located within the City. These studies were performed for the Springfield North, Horseshoe, Raspberry and Salt Creek Watersheds such that all watersheds within the City were included in the project. The cursory studies included review of the watersheds and hydrologic data, Georgia EPD 303d/305b impaired waterways, topographic information, existing development patterns, upstream and downstream constraints and review of areas exhibiting historical flooding. Typically, areas that were identified for cursory study were those that were less developed with a lesser likelihood of intense development over the next ten (10) years. These cursory studies generally resulted in preventative best management practices that will control stormwater runoff reduction in volume in the future.

Georgia 303(b)/303(d) Listed Waters

Section 305(b) and Section 303(d) of the Federal Clean Water Act required States to submit a list of waters not meeting their designated uses and that may require a Total Maximum Daily Load (TMDL) to restore water quality. States are responsible for determining the designated uses of streams and rivers within their jurisdictions and identifying the water quality criteria for each use in accordance with Chapter 391–3–6–.03 of the Rules and Regulations for Water Quality Control. Through sampling and data collection, the GA EPD can compare present conditions versus the water quality criteria required for the designated use and determine if waterways can support their designated use. Section 305(B) of the Clean Water Act (Act) requires States to assess and describe the quality of its waters every two years. Section 303(d) of the Act required States to submit a list of all waters that are not meeting their water quality standards for their designated use.

Presently, the 2012 GA EPD 305(b)/303(d) is the list of record. There is a 2014 GA EPD 305(b)/303(d) "DRAFT list" that has not been formally approved. Waterways that are included in the 2012 GA EPD 305(b) /303(d) list located within Garden City limits include a 4 mile segment of Pipemaker's Canal and a 1 mile segment of Salt Creek. It should be noted that these waterways remain on the 2014 GA EPD 305(b)/303(d) Draft list. Potential causes of impairment to these waterways include urbanized runoff and nonpoint/unknown sources. In anticipation of the preparation of a future TMDL, the implementation of special drainage districts by the City, which are intended to encourage runoff volume reduction within these watersheds, are evaluated further in subsequent sections of the stormwater master plan. If runoff volumes to receiving waterways can be reduced, overall pollutant loads can be reduced as well.

DATA COLLECTION

Municipal separate storm sewer system (MS4) inventory data was provided by Garden City. MS4 data contained informational data including structure type, structure length, pipe size and material. The MS4 data, supplemented with Light Detection and Ranging (LiDAR) topography and field reconnaissance, were utilized as basis information in preparation of the hydrologic and hydraulic studies.

LiDAR topographic data was represented in a Raster DEM on a 3 foot grid on the NAVD88 datum. Roadway centerline elevations, pipe inverts, and channel cross sections were generated from LiDAR topography. As the stormwater master plan is further refined in the future, conventional ground survey should replace LiDAR elevations utilized in the stormwater master plan models. Ultimately, conventional ground survey will provide more accurate results and better flood modeling and flooded area forecasting.

After the MS4 and LiDAR information were reviewed for general sensibility, field reconnaissance was performed to confirm identified areas that were critical to the modeling exercises. Due to inaccessibility in the field, some pipe sizes and materials were assumed in the models. These assumptions are labeled on Link/Node Map Exhibits for each basin and can be found in Appendices B through E. As previously discussed, the stormwater master plan is intended to be a living document. As such, as more detailed information is provided, or efforts are commissioned to obtain additional information, the models and results should be updated to reflect the discovered data. Additional analysis, based on conventional ground surveys, will need to be completed prior to the construction of the improvements noted in the stormwater master plan.

Garden City also provided Thomas & Hutton with existing XP SWMM model files for three of the four basins identified for further study in the CIG. Models provided for use include:

- Talmadge Basin – Existing XP SWMM model files developed by Hussey, Gay, Bell, & DeYoung (HGBD), 2011.
- Smith Basin – Existing XP SWMM model files created by Moffatt & Nichol
- Heidt–Telfair Basin – Existing XP SWMM model files developed by HGBD, 2008

Thomas & Hutton quickly discovered varying modeling techniques that were used to create the models provided. Unless data collection during the stormwater master plan preparation indicated otherwise, the existing models were used in the "as provided" state with the exception of adjustments made for modeling consistency purposes. See the following Basin Assessments Section of this report for details on the revisions made to each basin's existing XP SWMM model.

METHODOLOGY

The following is an overview of the methodology used to examine the Talmadge, Smith, Chatham City, and Heidt–Telfair Basins. Preliminary hydrologic and hydraulic analysis pertaining specifically to an individual basin is discussed in each Basin's Assessment Section.

The existing conditions and proposed CIP improvements were analyzed using the XP SWMM Software (Version 2013). The program is used to model rainfall and stormwater runoff and to perform hydraulic routing through the storm drainage system. XP SWMM allows integrated

analysis of flow in engineered conveyances, as well as natural systems including ponds, rivers, lakes, floodplains, etc.

The existing drainage system for each basin was analyzed for the 1–year, 10–year, 25–year, 50–year and 100–year, 24–hour design storm events to identify potential deficiencies within the system. The proposed improvements were analyzed based on The Garden City Stormwater Management Local Design Manual (LDM). The Garden City LDM regulations require that all pipe and culvert systems maintain a level of service (LOS) as seen in the table below.

Table 2 – Culvert & Pipe LOS Criteria

Roadway Classification/Use	Design Storm LOS	Minimum Allowable LOS
Arterial/Emergency Evacuation Route	100–year	50–year
Collector Roads	50–year	25–year
Neighborhood Roads	25–year	10–year
Roads with no other outlet	50–year	25–year
Parking lots/material storage areas/landscape areas	10–year	10–year

The hydrologic input data consists of information for each drainage basin, or sub–basin, within the project. Input variables include runoff curve number, rainfall distribution pattern, hydrograph peaking factor, area of each drainage basin, percent of impervious cover and time of concentration (see below section "Hydrologic Analysis" for specifics on the values of these variables that were used in this model). The XP SWMM program generates runoff hydrographs for each sub–basin based on the user–specified variables. For the stormwater master plan, hydrographs were generated by XP SWMM using the SCS Unit Hydrograph Method.

The model hydraulic input data consists of a system of nodes and links. Nodes represent locations where flows enter or exit the system, pipe or channel characteristics change, or where stage/storage/time relationships are provided. Links represent traditional types of hydraulic conveyance such as pipes, channels, drop structures, weirs, etc. The sizes, inverts, lengths, and Manning's "n" values for all pipes and channels are input into the model. In addition to pipe and channel information, all detention area stage–storage information and the respective outfall structure information are input into the model. The node and link conditions are analyzed within the model for a given storm event, and flow conditions are determined.

Hydrographs for each drainage area are generated within the XP SWMM program, and the hydrologic results are then combined with the hydraulic information to model the hydraulic interactions of the entire drainage system. The results include node and link discharge rates and stage/storage information for each design storm.

For the design of the storm drainage system improvements, an alert stage elevation is set for each node to evaluate potential stormwater ponding. The alert stage elevation corresponds to a critical elevation at which a location will flood, by overtopping its channel banks or road elevation. The proposed drainage system improvements are initially sized using standard hydraulic calculations. Typically, these calculations provide a reasonable first guess to the identified

improvement. The first guess is further refined through a "trial and error" process until an acceptable solution is determined.

HYDROLOGIC ANALYSIS

Using the SCS Unit Hydrograph Method, hydrologic parameters were inserted into XP SWMM to simulate rainfall/runoff throughout the watershed. Simulations were performed using a 323 peaking factor, and a SCS Type III rainfall distribution, both typical of the study area region. Table 2 below lists the rainfall depths derived from Table A–13 of the Georgia Stormwater Management Manual (GSMM) First Edition (August 2001) (Volume 2) and Section 5.0 of the Coastal Stormwater Supplement (CSS), April 2009 edition, that were used for this analysis. A 323 Hydrograph Peaking Factor was used instead of the Typical SCS 484 Peaking Factor. The 323 peaking factor is representative of the impervious nature of the highly developed and low lying (wetland) area that makes up the overall watershed for this study.

Table 3 – Rainfall Depths

Storm Event	Duration	Rainfall (in.)
1–Year	24–hour Design Storm	3.60
10–Year	24–hour Design Storm	6.72
25–Year	24–hour Design Storm	7.92
50–Year	24–hour Design Storm	8.88
100–Year	24–hour Design Storm	9.84

All five (5) design storms were simulated to estimate the rainfall excess flows realized by the existing drainage system. Refer to Appendices B through E for the XP SWMM hydrologic output summary reports for each storm event in each basin.

Sub–basin Delineation

For each of the four drainage basins, sub–basins were delineated using ArcMap software. LiDAR topography, MS4 inventory data, and field reconnaissance were used to determine sub–basin boundaries and create a geodatabase in ArcGIS. The basin delineations for each drainage area are shown on basin maps provided in Appendices B through E. It should be noted that some drainage basins included in the models provided by others were revised due to differences in topographic information.

Time of Concentration

Times of concentration were calculated according to procedures set forth in SCS Hydrology Technical Note No. N4 and using the WinTR55 software. The travel times (T_t) for overland flow, shallow concentrated flow, and channel flow are added together for the drainage basin to get the time of concentration T_c. For areas smaller than one acre, 6 minutes was used as the time of concentration pursuant to the minimum T_c used in the Urban Hydrology for Small Watersheds Technical Release 55 (TR55).

Overland Flow

The equation for overland flow travel time is as follows:

$$T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5} S^{0.4}}$$

Where: n = Manning's friction factor
24573 L = slope length (ft)
S = Slope (ft/ft)
P_2 = 2–year, 24–hour precipitation (inches)

The travel time as calculated in the above equation in hours. Multiply by 60 minutes per hour to convert to minutes.

Shallow Concentrated Flow

The equation for shallow concentrated flow travel time is as follows:

$$T_t = \frac{L}{60v} \text{ (min)}$$

Where: L = length (ft)
v = velocity (ft/sec)

Channel and Pipe Flow

The equation for channel flow travel time is as follows:

$$T_t = \frac{L}{60v} \text{ (min)}$$

Where: L = length of channel (ft)
v = velocity (ft/sec)

The velocity is determined using Manning's equation:

$$v = (1.49/n) r^{2/3} S^{1/2}$$

Where: r = hydraulic radius (ft) = A/P
A_x = cross–sectional area (sf)
P = wetted perimeter (ft)
S = slope (ft/ft)
n = Mannings coefficient of friction

Appendices B through E show the calculated time of concentration for each sub–basin.

Curve Numbers

Curve numbers were generated according to procedures set forth in SCS TR–55. Curve numbers are typically dependent on land use, soil hydrologic condition, soil antecedent moisture condition and impervious/pervious areas. The land uses in curve number calculations included impervious areas (roads, buildings, parking), water, urban and residential districts and other agricultural lands (pasture, woods, grass). Hydrologic soils group data was extracted from USDA NRCS soil survey geodatabase (SSURGO) data. Using the land use, hydrologic soil groups and land area within each parameter, weighted curve numbers were generated using ArcMap tools and WinTR55 software. Refer to Appendices B through E for the Basin Map of each drainage area. The composite curve numbers were calculated based on the curve number values included in Table 4 below. See Appendices B through E for the composite curve number values for each sub–basin.

Table 4 – Land Use Curve Numbers				
Land Use	**Hydrologic Soil Group**			
	B	**C**	**D**	**Water**
Borrow Pit	86	91	94	98
Dirt Road	82	87	89	98
Paved Roads/Parking/Building	98	98	98	98
Commercial & Business	92	94	95	98
Industrial	88	91	93	98
1/8 acre residential lot	85	90	92	98
1/4 acre residential lot	75	83	87	98
1/3 acre residential lot	72	81	86	98
1/2 acre residential lot	70	80	85	98
1 acre residential lot	68	79	84	98
2 acre residential lot	65	77	82	98
Pasture	69	79	84	98
Woods–Grass Combination	65	76	82	98
Woods	60	73	79	98
Water	98	98	98	98

HYDRAULIC ANALYSIS

The existing drainage system within each of the four basins consists of a series of concrete and plastic pipe, open channels both grassed and concrete–lined, catch basins, storm manholes, detention ponds and outfall structures. Garden City provided Thomas & Hutton with a stormwater inventory (i.e. the MS4 data) in the form of a GIS shape file that contained data including structure type, pipe size, length and material, etc.

Garden City also provided Thomas & Hutton with several existing XP SWMM models for portions of the study watershed, as previously developed by HGBD and Moffatt & Nichol. Although the XP SWMM models provided were contractually intended to be assumed correct, a limited review of the existing hydraulic models was conducted by Thomas & Hutton. When compared to the MS4 inventory data provided by Garden City, minor discrepancies were noted. These minor discrepancies have been revised in the models and their revisions are discussed in the relevant Basin Assessment section. However, due to the fact that several differing modeling strategies/ approaches were implemented, Thomas & Hutton recommends a cohesive model with uniform parameters be developed moving forward. For the creation of a preliminary stormwater master plan, the existing XP SWMM models were deemed acceptable.

Hydraulic input data was obtained from MS4 inventory data, field reconnaissance, and LiDAR topography. For existing pipes and box culverts, structure lengths and sizes were retrieved from MS4 data and field reconnaissance, while invert elevations were obtained from estimating LiDAR elevation data. For existing pipes and box culverts underneath a road crossing, the elevations along the roadway centerline were identified from LiDAR data and then used to determine a minimum invert elevation for pipes underneath roadways. Invert elevations for pipes underneath road crossings were assumed to have a minimum cover of two feet. Invert elevations based on this criterion were compared with the LiDAR topography found at the entrance and exit ends of each pipe section. The greater depth of the two was selected and utilized in the modeling efforts.

For channels, LiDAR topography was used to obtain representative cross sections. Cross section Manning's "n" coefficients were estimated from aerial photography and field reconnaissance in accordance with industry standards. The cross sections were input into the model and used to simulate channel links in the hydraulic analysis.

It should also be noted that due to absent MS4 data and inaccessibility in the field, some pipe sizes and materials were assumed. These assumptions are labeled on the Link/Node Map exhibits for each area modeled and can be found in Appendices B through E. It is imperative to note that conventional ground surveys, more detailed analysis and designs will be required prior to the construction of the improvements identified in the results of the stormwater master plan.

VOLUME CONTROL PRACTICES

Flood control and water quality improvement projects may not be feasible given funding constraints and the multi–jurisdictional nature of providing the overall solution to an issue. Non–structural best management practices are often a more practical alternative to reduce the impacts of stormwater runoff on existing conveyance systems and increasing runoff water quality. Through the adoption of ordinances and/or revision to the Garden City LDM , non–structural best management practices, such as more restrictive stormwater runoff volume control strategies, may provide for the attenuation and treatment required to assist in achieving the stormwater master plan goals of a reduced burden on existing stormwater systems and to enhance water quality. The CSS provides for a reduction in runoff volume by the treatment of runoff by various best management practices (BMPs). As previously noted, soil types and groundwater elevations throughout Garden City are not conducive to infiltration based best management practices. However, soil types and groundwater elevation have been known to be highly variable from site to site. For purposes of this stormwater master plan, volume control maybe achieved by several methods, including infiltration, stormwater re–use, irrigation, extended attenuation and detention in excess of pre–development flows. These types of volume control practices, in addition to those required by current Garden City Ordinance, will assist in relieving the current stormwater burdens on the existing stormwater systems. It is proposed that the additional stormwater runoff regulations be mandated through "Special Drainage Districts", via Section 6.0 of the Garden City LDM which was adopted in August 2011. Special Drainage District recommendations are noted later in the document.

BASIN ASSESSMENTS

The following sections address the four (4) major drainage basins that the City determined to be the most susceptible to the impacts of flooding and stormwater runoff: Talmadge Basin, Smith Basin, Chatham City Basin, and the Heidt–Telfair Basin. A basin description, hydrologic and hydraulic analysis used for modeling each basin in XP SWMM, basin deficiencies and proposed capital improvement projects, interim strategies, and basin special drainage district design standards are discussed in detail below for each basin. Refer to Appendix B for all supporting data and maps for the Chatham City Basin. Refer to Appendix C for all supporting data and maps for the Heidt–Telfair Basin. Refer to Appendix D for all supporting data and maps for the Talmadge Basin and finally refer to Appendix E for all supporting data and maps for the Smith Pipemaker's Basin.

CHATHAM CITY BASIN

Basin Description

The Chatham City Basin contains approximately 794 acres located within the Dundee Canal Watershed. The basin is located in the east–central area of Garden City and is roughly bounded by Priscilla D. Thomas Way to the north, Augusta Road (GA–21) to the east, Highway 80 to the south and railroad tracks to the west. Chatham City Basin is comprised primarily of soils that exhibit poor drainage qualities. These soils, based on SSURGO data, include largely "very poorly drained soils" having a hydrologic classification "D", with some "B/D" and "C" soil variations. The slopes in this basin are generally flat to gently sloped, with an overall slope that drains to the south end of the basin. This basin is divided by several ridges that are a result of the existing railroad tracks from CSX Transportation and Norfolk Southern.

Generally, the land within the Chatham City Basin is approximately 475 acres (60%) developed, with approximately 190 acres (40%) impervious coverage and 280 (60%) acres of pervious coverage. This area can be characterized by several land uses. The west side of the basin is mainly undeveloped land and industrial structures. Norfolk Southern's Dillard Yard encompasses approximately 100 acres out of the 794 acre basin. The undeveloped land in this western zone is predominantly wooded with the majority being classified as forested wetlands. The eastern portion of the basin consists of mostly residential subdivisions, with the exception of Groves High School and several small parcels of undeveloped land. The undeveloped lands of the eastern portion of the basin are mainly wooded with minimal forested wetland coverage. It is estimated that 40 percent of the total basin is undeveloped land. The entire basin is located outside of a Federal Emergency Management Agency (FEMA) Special Flood Hazard Area (SFHA). One critical facility, a sanitary sewage pump station, is located within the basin adjacent to Harley Drive and the CSX railroad tracks.

Although located outside the FEMA SFHA, Chatham City Basin still experiences localized flooding during larger storm events. Areas in the past that have flooded have included the Chatham Villa Subdivision, the Chatham City area and the Mobile Home Park on Harley Drive, where the City sanitary sewer pump station is also located.

Hydrologic Results (CIG Outcome 2)

Using the methodology described previously in this report, Thomas & Hutton performed a hydrologic analysis on the Chatham City Basin. Table 5, shown below, summarizes the curve numbers, time of concentrations and areas for each delineated sub–basin within the Chatham

City Basin. Thomas & Hutton's hydrologic analysis yielded 14 sub basins. Basin 14 encompasses more than 60% of the entire basin. The delineation of this basin is mainly due to flat undeveloped land in this area and the surrounding elevated railroad tracks. It should be noted that Norfolk Southern's Dillard yard divides this basin. Although there is limited data on the railroad yard, it is suspected that drainage flows underneath the yard to the east and connects to the main outfall channel of the Chatham City Basin. Due to a low percentage in impervious area, curve numbers generally were found to be in the low to mid 80's, with the exception of Basin 1 (which contained several high school buildings and parking lots.) An exhibit titled, "Chatham City Basin Map" shows each delineated basins and its accompanying time of concentration flow path in Appendix B.

Table 5 – Chatham City Hydrologic Input

Basin Name	Hydrologic Analysis		
	Area (acres)	CN	Tc (min)
Basin 1	45.07	94	59.9
Basin 2	13.18	81	34.1
Basin 3	1.76	84	16.3
Basin 4	2.77	84	19.4
Basin 5	3.62	81	16.7
Basin 6	13.19	81	22.4
Basin 7	76.54	85	63.8
Basin 8	31.90	88	43.7
Basin 9	23.44	90	40.5
Basin 10	8.31	81	23.6
Basin 11	20.47	83	38.8
Basin 12	19.11	77	31.02
Basin 13	31.19	77	80.5
Basin 14	503.13	86	125.2

Hydraulic Analysis (CIG Outcome 2)

Using the methodology described earlier in this report, Thomas & Hutton performed a hydraulic analysis on the Chatham City Basin. Most hydraulic input data was available for the drainage systems within the Chatham City Basin. Where information was not obtainable under the CSX railroad tracks, a pipe diameter of 24 inches was assumed. If invert elevations were not given, LiDAR topography was used to estimate pipe inverts. An exhibit located in Appendix B shows the hydraulic input for each link and node modeled within XP–SWMM.

Each drainage system within the basin was analyzed for the 1–year, 10–year, 25–year, 50–year, and 100–year, 24–hour design storm events. The Garden City Local Design Manual (LDM) requires that all pipe and culvert systems maintain a level of service (LOS) based on each roadway's classification or use. As such, the assessment was primarily focused on the analysis of road crossings. Critical facilities such as sewer lift stations, water tank, water wells, etc., were also assessed for potential flooding during 100–year rainfall events.

The table below displays the existing peak stage for each storm event at specific road crossings and their minimum allowable level of service within the Chatham City Basin.

Table 6 – Chatham City Basin Existing Deficiencies							
Road Crossing	Road Elevation (ft)	Existing Peak Stage (ft)					Minimum LOS at Road
		1–yr	10–yr	25–yr	50–yr	100–yr	
Davis Avenue (Top)	10.06	11.52	13.84	14.48	14.87	15.21	25 yr
Davis Avenue (Bottom)	9.72	11.35	13.68	14.31	14.69	15.02	25 yr
Byck Avenue	17.40	16.25	18.00	18.41	18.69	18.93	10 yr
Chatham Villa Drive	15.71	14.87	16.12	16.46	16.71	16.96	10 yr
Minis Avenue	23.09	23.16	23.29	23.33	23.35	23.38	25 yr
Railroad (Top)	17.79	13.34	14.89	15.36	15.73	16.09	50 yr
Railroad (Bottom)	19.60	14.41	16.32	16.80	17.15	17.48	50 yr

Blue fill in table cells indicates an increased risk to flooding.

Road crossing locations are shown on the exhibit titled, "Chatham City Basin Existing Flooding at Roadways" in Appendix B.

Despite the data shown in the table above, City staff has indicated some of the areas noted as susceptible to flooding have not exhibited persistent flooding over the past 10 years. Further detailed study using conventional, ground run survey should be completed to refine and further calibrate simulations of stormwater within this basin. See Limitations section for possible causes of conservative water surface elevations.

Based on the table above, the increased potential for flooding to occur at Minis Avenue exists as well as at both road crossings along Davis Avenue, starting with the 1–year, 24–hour storm event where the minimum allowable LOS is the 25–year storm event. Flooding also has an increased potential to occur at Byck Avenue and Chatham Villa Drive, starting with the 10–year, 24–hour storm event with a minimum allowable LOS for a 25–year storm event.

One critical facility is located within the Chatham City Basin: Garden City Sanitary Sewer Lift Station (LS) #12. Analysis showed that flooding may be experienced at LS # 12 located on Harley Drive for a 10 year storm or greater. An exhibit titled, "Chatham City Basin Existing Flooding at Roadways" shows all potential flooding deficiencies within the Chatham City Basin in Appendix B.

Proposed Capital Improvement Projects (CIG Outcome 3)

Based on the hydrologic & hydraulic analysis performed, six potential drainage related capital improvements projects (CIP) for the Chatham City Basin have been identified.

- Minis Avenue Pipe Crossing Replacement (CIP ID #1): The first CIP involves the replacement of an existing 18 inch pipe under Minis Avenue with a 36 inch pipe to accommodate larger flows. From the results shown in Table 6, the existing pipe appears to be undersized. Thomas & Hutton recommends increasing the size of the pipe to accommodate larger flows.
- Chatham Villa Community Drainage Improvements (CIP ID #2): Historically, there have been complaints from residents within the Chatham Villa Community that flooding occurs. From collected data and field reconnaissance, it appears that the existing roadside drainage system, consisting of roadside swales and driveway culverts, may be

under sized. From observations, the existing drainage system appears to be in need of maintenance, including the re–establishment of the system inverts and channel geometry. In addition, it appears that much of the development upstream of Jasper Drive has no true drainage conveyance system other than roadway surface conveyance. Due to limited data and budgetary constraints associated with this effort, Thomas & Hutton did not perform detailed roadside swale and culvert system modeling within the Chatham Villa development. The main discharge pipe was assessed for capacity. Based on the results shown in Table 6, the existing pipe could not accommodate flows for a 10–year storm or greater. Based on this preliminary analysis, it appears that the existing roadside swale and culvert system may need to be upgraded and expanded to include areas upstream that presently do not have roadside conveyance. The community discharge pipe should be upgraded to a larger pipe size capable of accommodating the runoff from a 25–year storm event. Thomas & Hutton recommends that further detailed studies be performed in order to evaluate the appropriate improvements to the existing storm water system.

- Chatham City Channel Increased Sizing and Bank Stabilization (CIP ID #3): This CIP for the Chatham City Basin involves the primary outfall channel widening and stabilization. Based on Thomas & Hutton's analysis, several areas along Chatham City's earthen channel may be at risk to overtop and flood surrounding neighborhoods. Thomas & Hutton recommends that the channel be further evaluated for possible channel widening. The extra channel width would provide for additional conveyance, detention and peak flow attenuation. Thomas & Hutton recommends that further studies be conducted on the channel to identify its current condition and propose detailed design solutions.
- Davis Avenue Roadway Improvements (CIP ID #4): This CIP consists of updating two road crossings along Davis Avenue. Both road crossings are shown to overtop for a 1–year, 24–hour storm event in Thomas & Hutton's XP SWMM model developed for this basin. LiDAR topography indicates that the elevation at Davis Avenue decreases from approximately 14 feet to 10 feet at these two pipe crossings. The existing pipes are located at the lowest points of Davis Avenue. The northern pipe crossing at Davis Avenue consists of an existing 48–inch diameter pipe and the southern pipe crossing consists of an existing 24–inch diameter pipe. Thomas & Hutton recommends raising the road elevation of Davis Avenue to 14 feet and replacing the 24–inch diameter pipe with double 48–inch pipes. Essentially, the elevations of Davis Avenue are simply too low at the pipe crossings.
- Davis Avenue – Option – Stormwater Detention Facility (CIP ID #5): The next CIP involves developing an area behind Davis Avenue near Chatham City Channel. The existing pipes (mentioned in the previous CIP) underneath Davis Avenue appear to be undersized. However, it is not recommended that these pipes be upsized as this would increase the flow for entire system downstream of the pipe and potentially cause flooding in those areas. Because of this restriction it is recommended that the City seek to detain the current runoff with a stormwater pond. The detention pond will create extra storage within the wetland area and alleviate upstream flooding. Thomas & Hutton recommends that further detailed studies be performed in order to establish design criteria for the stormwater pond.

A CIP Map is attached in Appendix F to show the improvement project locations within the Chatham City Basin.

Interim Strategies (CIG Outcome 4)

To alleviate current flooding issues and maintain public safety, Garden City is preparing interim strategies to be implemented within Chatham City Basin during large storm events. Based on the analysis performed, Thomas & Hutton recommends road closures be considered along the following routes for a 10–year, 24–hour storm event or greater:

- Minis Avenue, between 3rd Street and Shady Lane Drive.
- Davis Avenue, between 8th Street and the end of the street for a 10–year, 24–hour storm event or greater. In the proximity of the flooding locations, Davis Avenue is a sole means of ingress and egress for residents located at the end of the road. Road closures or traffic rerouting is not a viable option for this particular flooding issue. Thomas & Hutton recommends that warning signs be posted at the intersection of 8th Street and Davis Avenue to alert residents that the road may experience flooding past 8th Street and become impassable during storm events. It is also recommended Garden City evaluate evacuation options for the residents in this area.

Basin Special Drainage District Recommendations (CIG Outcome 5)

Stormwater runoff volume control is a stormwater management practice that assists in mitigating or reducing stormwater volume and peak flows otherwise discharged to downstream stormwater systems. Given the age of development within this watershed, development density and property constraints, it may not be feasible to retrofit an existing stormwater system to meet the current LOS criteria. Moreover, based on the soils composition and groundwater depths within the watershed, the use of infiltration best management practices may not be appropriate, practical and/or feasible.

Based on the watershed's physical constraints as noted above, additional basin–specific regulations should be considered to help alleviate potential flooding impacts downstream. All existing Garden City design regulations should still be applicable. The basin special drainage district regulations should supplement the existing and applicable regulations. These basin specific regulations are unique to the Chatham City Basin and are intended for the City's use of expanding their "Special Drainage District" section of the LDM. The recommended Chatham City, basin specific development/redevelopment stormwater management criteria are as follows:

- General: The City should enforce all procedures and requirements as indicated in the existing Garden City Post Construction Stormwater Management Ordinance and LDM.
- Downstream Analysis: The designer should evaluate potential projects for stormwater discharges for the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings. The downstream analysis should conform to the requirements set forth in the aforementioned ordinance and LDM, unless sub–basin specific characteristics warrant additional analysis by the designer. The designer should consult with the City staff at the Concept Plan Meeting step of the project to define the proposed limits of the downstream analysis and to obtain feedback from the City as to the proposed plan. The limits of downstream analysis shall be approved by the City Manager (or his designee) prior to generation and submittal of the Stormwater Management Plan for the project.

The City Manager (or his designee) shall notify the applicant of downstream analysis limits within a reasonable time frame after the Concept Plan Meeting with the City. The City should revise the LDM to include narrative consistent with that which is described herein.

- Stormwater Runoff Reduction: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Stormwater Quality Management and Protection: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Aquatic Resources Protection and Energy Dissipation: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Overbank & Extreme Flood Protection: Based on the watershed's physical constraints and potential of significant increases to downstream stormwater flows within the watershed, all developments/redevelopments shall provide flood protection from post–developed increases in the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events. Post–developed stormwater discharges shall be compared to pre–developed stormwater discharges at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings (public and private). It is recommended that post–developed stormwater runoff rates be reduced to 90% of pre–developed runoff rates. In no instance shall a discharge rate limit be less than an equivalent rate of the same project site in a forested condition. The City should revise the LDM to include narrative consistent with that which is described herein.
- Regional best management practices can benefit the watershed in its entirety. For that reason, regional BMPs are encouraged where feasible. Should the development have no feasible means to accommodate requirements set forth via on–site stormwater controls, the City Manager (or his designee), may entertain a "fee in lieu" payment to be applied towards the construction of drainage related CIPs in the subject basin. Upon completion of the downstream analysis provided by the developer's consultant, an opinion of probable cost for improvements can be submitted to the City for consideration and approval. If the City Manager agrees with the cost of improvements, the City Manager, may allow the Applicant to provide a fee in lieu of construction of onsite BMPs. The fee in lieu payment shall provide for all, or a portion of, construction improvements, land acquisition and professional services required to construct the regional improvement project.

HEIDT–TELFAIR BASIN

Basin Description

The Heidt–Telfair Basin consists of approximately 619 acres located within the Dundee Canal Watershed. The basin resides in the east–central area of Garden City, south of the Chatham City Basin and is bounded approximately by Highway 80 to the north, Kelly Hill Road to the west, and the train/railroad tracks to the south and east. Heidt–Telfair Basin is comprised primarily of soils that exhibit poor drainage qualities. These soils, based on SSURGO data, mainly include "poorly drained soils" having a hydrologic classification "C" and "very poorly drained soils" having a hydrologic classification "D", with some "B/D" soil variations. This basin can be characterized as having gentle slopes that direct flow to the center of the basin where the Dundee Canal flows. The Dundee Canal runs through the Heidt–Telfair Basin to the northeast and outfalls underneath the train tracks near the Savannah Amtrak Station.

Overall, the Heidt–Telfair Basin is estimated to be 60% impervious (40% pervious) land and encompasses several types of developments. The basin consists primarily of commercial and industrial facilities with some undeveloped land and residential development. The northern region of the basin differs significantly from the remaining land within the basin, as it includes the Garden City Elementary School and is comprised mostly of residential development, more specifically multi–family developments. In contrast, large parking lots and vehicle storage yards can be found south of Highway 80 in this basin as well. Most undeveloped lands are located primarily near or around the Dundee Canal. Approximately 30 percent of the Heidt–Telfair Basin is undeveloped lands of which the majority of land is forested wetlands. This renders the basin already predominantly developed when assessing future conditions. The basin is located within designated FEMA Flood Zones: X and AE. Zone AE is a FEMA SFHA and has a base flood elevation of 11 feet.

The Heidt–Telfair Basin experiences significant localized flooding during larger storm events. Areas that experience flooding regularly include Chatham Parkway between Telfair Place and the Heidt Canal, Telfair Place (West) cul–de–sac and at the western side of the Chatham Parkway and Telfair Place. In addition, the outfall of this watershed is routed under the Amtrak railroad tracks. The outfall pipe is commonly clogged with debris and the inlet side of the pipe has required regular maintenance by the City. Since the pipe is in the railroad right–of–way, it is technically outside the jurisdiction of Garden City.

It should be noted $3 million of SPLOST is currently budgeted for improvements to Chatham Parkway. Capital improvement projects identified in the Chatham Parkway right–of–way should be included as part of the Chatham Parkway Improvement Project.

Existing Basin Model

In August 2008, an XP SWMM model of the Telfair Drainage Study (Dundee Canal Watershed) was developed by the engineering firm, Hussey, Gay, Bell & DeYoung (HGBD). Thomas & Hutton was provided with this model to review and use in modeling the Heidt–Telfair Basin. After studying the existing model by HGBD, it was found that the model covers two areas, Telfair East Basin, which drains to North Springfield Canal and Telfair West Basin, which drains to the Heidt Canal. The Telfair West model included only a small portion of the Telfair West Basin (Dundee Canal Watershed) that lies within Garden City's limits. Therefore, Thomas & Hutton opted to use this model as the basis to develop a more comprehensive model of the Heidt–Telfair Basin.

Recommendations stated in the HGBD report were considered in the process of identifying CIP projects in this stormwater master plan.

Hydrologic Results (CIG Outcome 2)

Using the methodology described previously in this report, Thomas & Hutton performed a hydrologic analysis on the Heidt–Telfair Basin. Table 7, shown below, summarizes the curve numbers, time of concentrations (Tc) and areas for each delineated sub–basin within the Heidt–Telfair basin. Thomas & Hutton's hydrologic analysis yielded 13 sub basins, with three sub basins (Basin 7, 9, and 12) encompassing the bulk of the basin area. The longer time of concentration values for Sub Basins 7 and 9 can be attributed to the low lying wetlands and the flat slope of the Dundee Canal watershed. Because of the difference in elevation between the wetlands and surrounding developments, additional storage volume above normal water surface elevations were modeled in this area as well. Due to the large impervious areas (in particular the vehicle storage yard and other large parking lots) from the industrial and commercial facilities, curve numbers generally were found to be in the high 80's to mid–90's. An exhibit titled, "Heidt–Telfair Basin Map" shows each delineated basins and its accompanying time of concentration flow path in Appendix C.

Table 7 – Heidt–Telfair Basin Hydrologic Input

Basin Name	Hydrologic Analysis		
	Area (acres)	CN	Tc (min)
Basin 1	19.51	95	31.2
Basin 2	3.29	89	14.3
Basin 3	6.27	85	20.8
Basin 4	10.69	90	31.8
Basin 5	6.93	89	24.2
Basin 6	24.86	94	59.6
Basin 7	162.18	90	106.8
Basin 8	7.13	94	33.2
Basin 9	198.43	87	68.3
Basin 10	11.13	88	30.2
Basin 11	4.86	93	22.4
Basin 12	117.01	96	78.4
Basin 13	47.00	89	83.8

Hydraulic Analysis (CIG Outcome 2)

Using the methodology described in this report, Thomas & Hutton performed a hydraulic analysis on the Heidt–Telfair Basin. Hydraulic input data was available for the drainage systems within the Heidt–Telfair Basin, with the exception of three pipe locations. Where detailed information was not obtainable under the railroad tracks by the Savannah Amtrak Station, a pipe diameter of 42 inches was assumed. The other two pipes were assumed to have a diameter of 18 inches. Where invert elevations were not given, LiDAR topography was used to estimate the pipe invert. An exhibit located in Appendix C shows the hydraulic input (including the assumptions described above) for each link and node modeled within XP–SWMM.

Each drainage system within the basin was analyzed for the 1–year, 10–year, 25–year, 50–year, and 100–year, 24–hour design storm events. The Garden City LDM requires that all pipe and culvert systems maintain a LOS based on each roadway's classification or use. As such, the

assessment was primarily focused on the analysis of road crossings. Critical facilities such as sewer lift stations, water tank, water wells, etc., were also assessed for potential flooding during 100–year rainfall events.

The table below displays the existing peak stage for each storm event at specific road crossings and their minimum allowable LOS within the Heidt–Telfair Basin.

Table 8 – Heidt–Telfair Basin Existing Deficiencies

Road Crossing	Road Elevation (ft)	Existing Peak Stage (ft)					Minimum LOS at Road
		1–yr	10–yr	25–yr	50–yr	100–yr	
*Highway 80 (Left)	22.64	14.80	16.25	16.90	17.47	18.39	50 yr
*Highway 80 (Middle Left)	22.00	18.10	18.80	19.18	19.60	19.99	50 yr
*Highway 80 (Middle Right)	23.73	20.67	23.82	23.87	23.90	23.93	50 yr
Highway 80 (Right)	22.42	19.02	22.25	22.47	22.50	22.51	50 yr
Hoss Road	13.80	13.85	13.95	13.99	14.01	14.03	25 yr
Heidt Road	12.80	12.90	13.03	13.08	13.11	13.14	25 yr
**Chatham Parkway (Top)	12.50	8.61	9.70	10.10	10.42	10.74	50 yr
**Chatham Parkway (2nd from Top)	13.12	9.12	10.78	11.55	12.22	12.62	50 yr
**Chatham Parkway (@ Intersection of Telfair Pl)	12.07	10.23	12.08	12.18	12.22	12.25	50 yr
**Chatham Parkway (2nd from Bottom)	12.87	9.54	10.44	10.58	10.71	10.87	50 yr
**Chatham Parkway (Bottom)	14.85	11.85	12.42	12.64	12.88	13.07	50 yr
**Telfair Pl (West) – 1	10.20	10.24	10.36	10.39	10.60	10.91	25 yr
**Telfair Pl (West) – 2	9.92	9.52	10.38	10.50	10.61	10.81	25 yr
Railroad	18.99	8.19	9.57	10.01	10.33	10.65	50 yr

Blue fill in table cells indicates an increased risk to flooding

Road crossing locations are shown on the exhibit titled, "Heidt–Telfair Basin Existing Flooding at Roadways" in Appendix C.

* Indicates roadways within Georgia Department of Transportation jurisdiction.
** Indicates roadways that are planned to be improved as part of the Chatham Parkway SPLOST.

Despite the data shown in the table above, City staff has indicated some of the areas noted as susceptible to flooding along Chatham Parkway have not been a recurring issue. Garden City staff should monitor water surface elevations along Chatham Parkway closely during rain events. Recurring flooding has occurred on Telfair Place, Telfair Road, Heidt Road and Hoss Roads. Recurring flooding locations should be monitored for road closure during rain events. Further detailed study using conventional, ground run survey should be completed to refine and further calibrate simulations of stormwater within this basin. See the Limitations section for possible causes of conservative water surface elevations.

Based on the table above, it can be seen that flooding occurs at Heidt Road, Hoss Road, and Telfair Place (Left), starting with the 1–year, 24–hour storm event where the minimum allowable LOS is the 25–yr storm event. Similarly flooding at Telfair Road (Right) occurs starting with the 10–year, 24–hour storm event with a minimum allowable LOS as the 25–year storm event. Lastly, flooding occurs at Highway 80 (Right) starting with the 25–year, 24–hour storm event and Chatham Parkway (Middle) experiences flooding starting at the 10–year, 24–hour storm event. Both Highway 80 and Chatham Parkway are arterial routes and require a minimum LOS for a 50–year storm event.

Two critical facilities are located within the Heidt–Telfair Basin: Garden City LS #7 and Garden City LS #11. Based on the Heidt–Telfair model, Garden City LS #7, does not appear to be at risk for flooding. The lift station is located in an elevated area that drains to the wetlands/Dundee Canal. Garden City LS #11 is located off of Highway 80. This pump station was improved and elevated several years ago. However, it is unclear whether or not the facility's new frame elevation is greater than the simulated flood elevations. Therefore, the elevation of Garden City LS #11 should be compared in relation to the simulated flood elevations to confirm potential flooding.

An exhibit titled, "Heidt–Telfair Basin Existing Flooding at Roadways" shows all flooding deficiencies in Appendix C.

Proposed Capital Improvement Projects (CIG Outcome 3)

Based on the hydrologic and hydraulic analysis performed, Thomas & Hutton recommends the following drainage related CIPs for the Heidt–Telfair Basin by jurisdiction, programmed project or future CIP:

Georgia Department of Transportation (GDOT) Jurisdiction

- Highway 80 Pipe Crossing Replacement (CIP ID #6 GDOT): The first CIP involves the replacement of an existing 24–inch pipe under Highway 80 near Heidt Avenue (identified as road crossing Highway 80 "middle right" in the above table) with a 36–inch pipe. From the results shown in Table 7, the existing pipe appears to be undersized. Thomas & Hutton recommends increasing the size of the pipe to accommodate larger flows. From discussions with City staff, there has been no evidence of flooding at this location. Prior to budgeting funding for this project, a more detailed analysis should be completed to confirm the project is truly needed.

- SW Quadrant Highway 80/West Chatham Avenue Pipe Crossing Replacement (CIP ID #7 GDOT): At Highway 80 and West Chatham Avenue, the far right pipe crossing shown on the exhibit titled, "Heidt–Telfair Basin Existing Flooding at Roadways" Thomas & Hutton recommends replacing the 24–inch pipe downstream of Highway 80 with a 30–inch pipe. This pipe is labeled as "L06" on the "Heidt–Telfair Basin Node/Link Map" in Appendix C.

Garden City CIP Projects

- Telfair Place (West) – 1 Roadway & Pipe Crossing Replacement (CIP ID #8): Identified as Telfair Place (West) – 1 on the table above, it is recommended that the existing 18–inch pipe underneath Telfair Place be replaced with a 36–inch pipe to accommodate larger flows. The Telfair Place (West) cul–de–sac has historically experienced repetitive

flooding. It is recommended the road elevations be raised an additional 18" to 24" and a roadside drainage collection system be constructed (assumed to be 1,000 linear feet) to alleviate the flooding issues. However, it is recommended Telfair Place (West) should be studied in further detail, as much of the road does not have a dedicated drainage system and appears to be at a low elevation. Impacts on adjacent properties and structures should also be evaluated.

- Telfair Place (West) – 2 Roadway & Pipe Crossing Improvements (CIP ID #9): The next CIP involves increasing the pipe size at Telfair Place at the intersection of Chatham Parkway, and raising the road elevation at this pipe crossing location. Thomas & Hutton recommends that the existing double 24–inch pipes be upsized to double 30–inch pipes. Because this pipe crossing is located at a low point along Telfair Place, it is recommended that the road elevation be increased by approximately half a foot and a roadside drainage collection system be constructed (assumed to be 750 linear feet). As part of the CIP the downstream channel/ditch should also be regarded to provide a continuous flow slope.
- Chatham Parkway Pipe Crossing Replacement (CIP ID #10): An additional CIP involves the replacement of an existing 24–inch pipe underneath Chatham Parkway at the Telfair Place intersection (identified as road crossing Chatham Parkway "middle" in the above table) with a 30–inch pipe. From the results shown in Table 7, the existing pipe appears to be under sized. Thomas & Hutton recommends increasing the size of the pipe to accommodate larger flows. It is also advised that the downstream roadside ditches be re–graded to create a constant slope.
- Chatham Parkway Channel Construction (CIP ID #11): From the CIP's listed above, it can be seen that the intersection of Chatham Parkway and Telfair Place may experience flooding from several directions. While the CIP's above suggest pipe replacements, this particular CIP involves establishing an additional overflow channel that is located immediately adjacent to the western Chatham Parkway right–of–way. The channel is proposed to be located on what is currently private property, commencing at the Heidt Canal and terminating 800 linear feet south at an existing drainage channel. The creation of this channel will provide a more direct connection of stormwater flow to the outfall and potentially alleviate upstream flooding in this area by reducing the flow path length and corresponding water surface elevation. Thomas & Hutton recommends that further detailed studies be performed in order to establish design criteria for the channel and possibly detention in this area. Property acquisition may be required.
- Stormwater Detention Facility (CIP ID #12): Finally, it is recommended that the City consider establishing a ±10–acre regional stormwater storage area along the Dundee Canal outfall by the Amtrak train tracks. The existing 42–inch pipe underneath the railroad appears to be undersized. However, due to the multi–jurisdictional effects of upsizing the 42" under the railroad tracks, it is not recommended. Upsizing the railroad pipe to accommodate more flow may increase the flow for the entire system downstream of the pipe (outside Garden City's jurisdiction) and potentially cause flooding in those areas (City of Savannah jurisdiction). Because of the outfall restrictions, it is recommended that the City seek to provide storage and detention of runoff with an overbank storage area. The detention pond will provide additional storage within the channel overbank areas within the wetland, possibly alleviating upstream flooding potential. Thomas & Hutton recommends that further detailed studies be performed in order to establish design criteria for the stormwater pond.

- Chatham Parkway (South) Stage 1 Phase 1 (CIP ID: 2008 HGBD CIP 1): Pursuant to the Telfair Drainage Study, performed by Hussey, Gay, Bell and DeYoung, Inc. (HGBD), in August 2008, a CIP was identified along Chatham Parkway that would redirect 13.1 acres of drainage more directly into the receiving ditch and the Heidt Canal. The improvement project is documented in the study noted above as the "Recommended Telfair West Solution" on page 19. Improvements recommended by HGBD generally consist of the jack and bore of a 36–inch pipe under the CSX rail bed immediately north of Chatham Condominiums, widening of the outfall ditch to 6 feet and deepen by 6–inches on average, the replacement of an existing 18–inch pipe with a double 30–inch pipes and the replacement of a non–functional 24–inch pipe with a 42–inch pipe. For full and accurate detail of CIP, refer to August 2008 HGBD Study.

A CIP Map is attached in Appendix F to show the improvement project locations within the Heidt–Telfair Basin.

Interim Strategies (CIG Outcome 4)

To alleviate current flooding issues and maintain public safety, Garden City is preparing interim strategies (such as road closures) to be implemented within the Heidt–Telfair Basin during large storm events. Based on the results shown in Table 7 above, the following roads should be monitored for potential road closure during storm events:

- Telfair Place (West) – This street will likely flood as a result of a 1–year, 24–hour storm event or greater. In the proximity of the flooding locations, Telfair Place is a sole means of ingress and egress. Road closures or traffic rerouting is not a viable option for this particular flooding issue. It is recommended warning signs be posted at the intersection of Chatham Parkway and Telfair Place to notify residents/businesses that the road may experience flooding and become impassable during storm events. It is also recommended Garden City evaluate evacuation options for the facilities in this area.
- Heidt/Hoss Road Intersection – These roadways have experienced historical flooding during rain events. Roads should be monitored for roadway overtopping during rain events. Road closures are recommended should the water surface elevations exceed the edge of pavements.
- Telfair Place (East) and Telfair Road – These roadways have experienced historical flooding during rain events. Roads should be monitored for roadway overtopping during rain events. Road closures are recommended should the water surface elevations exceed the edge of pavements.

Basin Special Drainage District Regulations (CIG Outcome 5)

Stormwater runoff volume control is a stormwater management practice that assists in mitigating or reducing stormwater volume and peak flows otherwise discharged to downstream stormwater systems. Given the age of development within this watershed, development density and property constraints, it may not be feasible to retrofit an existing stormwater system to meet the current LOS criteria. Moreover, based on the soils composition and groundwater depths within the watershed, the use of infiltration best management practices may not be appropriate, practical and/or feasible.

Based on the watershed's physical and jurisdictional constraints noted above, additional basin–specific regulations should be considered to help alleviate potential flooding impacts within the watershed and downstream areas. All existing Garden City stormwater management design

regulations should still be applicable. The basin special drainage district regulations should supplement the existing and applicable regulations. These basin specific regulations are unique to the Heidt–Telfair Basin and are intended for the City's use of expanding their "Special Drainage District" section of the LDM. The recommended Heidt–Telfair basin specific development/redevelopment stormwater management criteria are as follows:

- General: The City should enforce all procedures and requirements as indicated in the existing Garden City Post Construction Stormwater Management Ordinance and LDM.
- Downstream Analysis: The designer should evaluate potential projects for stormwater discharges for the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings. The downstream analysis should conform to the requirements set forth in the aforementioned ordinance and LDM, unless sub–basin specific characteristics warrant additional analysis by the designer. The designer should consult with the City staff at the Concept Plan Meeting step of the project to define the proposed limits of the downstream analysis and to obtain feedback from the City as to the proposed plan. The limits of downstream analysis shall be approved by the City Manager (or his designee) prior to generation and submittal of the Stormwater Management Plan for the project. The City Manager (or his designee) shall notify the applicant of downstream analysis limits within a reasonable time frame after the Concept Plan Meeting with the City. The City should revise the LDM to include narrative consistent with that which is described herein.
- Stormwater Runoff Reduction: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Stormwater Quality Management and Protection: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Aquatic Resources Protection and Energy Dissipation: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Overbank & Extreme Flood Protection: Based on the watershed's physical constraints and potential for significant increases to downstream stormwater flows within the watershed, all developments/redevelopments shall provide flood protection from post–developed increases in the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events. Post–developed stormwater discharges shall be compared to pre–developed stormwater discharges at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings (public and private). It is recommended that post–developed stormwater runoff rates be reduced to 90% of pre–developed runoff rates. In no instance shall a discharge rate be less than an equivalent rate of the same project site in a forested condition. The City should revise the LDM to include narrative consistent with that which is described herein.

  Regional best management practices can benefit the watershed in its entirety. For that reason, regional BMPs are encouraged where feasible. Should the development have no feasible means to accommodate requirements set forth via on–site stormwater controls, the City Manager (or his designee) may entertain a "fee in lieu" payment to be applied towards the construction of drainage related CIPs in the subject basin. Upon

completion of the downstream analysis provided by the developer's consultant, an opinion of probable cost for improvements can be submitted to the City for consideration and approval. If the City Manager agrees with the cost of improvements, the City Manager may allow the Applicant to provide a fee in lieu of construction of onsite BMPs. The fee in lieu payment shall provide for all, or a portion of, construction improvements, land acquisition and professional services required to construct the regional improvement project.

TALMADGE BASIN

Basin Description

The Talmadge Basin contains approximately 1,025 acres located within the Talmadge Watershed. The basin resides in the west–central area of Garden City and is roughly bounded by Dean Forest Road to the west, Kelly Hill Road/Deloach Avenue to the east, Old Louisville Road to the north, and the railroad tracks to the south. Talmadge Basin consists of primarily of soils that exhibit poor drainage qualities. These soils, based on SSURGO data, include largely "very poorly drained soils" having a hydrologic classification "D", with some "B/D" and "C" soil variations. The slopes in this basin are generally flat, with little to no slope. Flow in the western region of the basin drains south to the Salt Creek Tributary channel. The channel direction flows southeast before discharging to the south of the basin. Runoff from the eastern side of the basin is directed toward the Salt Creek Tributary channel and converges into the western channel prior to discharging into Salt Creek.

In general, the land within Talmadge Basin is approximately 30% impervious (70% pervious) and can be characterized as a mix of commercial, residential and industrial lands. Undeveloped lands comprise approximately 40% of Talmadge Basin. Large blocks of undeveloped land are spread throughout the basin sporadically between developed commercial and industrial parcels. The undeveloped lands mainly consist of light woods that have some grass areas. Forested wetlands are present in small amounts of undeveloped lands. A large portion of the basin is located within the FEMA SFHA and is in Flood Zone AE with varying base flood elevations ranging from elevations 11 to 13 NAVD 88. The residential area within the basin resides within FEMA Flood Zone X, which is not a designed Special Flood Hazard Area.

Existing Basin Model

Garden City provided Thomas & Hutton with an existing XP SWMM model of the Talmadge Basin that HGBD developed in 2011. Thomas & Hutton performed a cursory review of the existing XP SWMM model developed by HGBD. When compared to LiDAR topography and MS4 inventory data provided by Garden City, as well as field reconnaissance performed by Thomas & Hutton, only minor changes were made pertaining to the hydraulic input. A pipe size was increased to reflect new construction completed within the basin. In addition road elevations within the existing model were raised or lowered to match current LiDAR topography. The remaining hydraulic parameters in HGBD's model were left "as is." This model was expanded by Thomas & Hutton with the addition of new nodes and links to the existing XP SWMM model.

Hydrologic parameters including curve number, time of concentration, and basin areas of the existing HGBD model were revised to correspond with the sub–basin delineations defined by Thomas & Hutton for the stormwater master plan. The previously delineated sub–basins by HGBD did not reflect the current MS4 inventory data and required further delineation in order to model

nodes and links were added by Thomas & Hutton during the modeling process. Therefore, instead of HGBD's six sub–basins within the Talmadge Basin, Thomas & Hutton modeled thirteen sub–basins for the stormwater master plan study. The Basin Map in Appendix D shows the revised sub–basins for Talmadge.

Hydrologic Results (CIG Outcome 2)

Using the methodology described previously in this report, Thomas & Hutton performed a hydrologic analysis on the Talmadge Basin. Table 9, shown below, summarizes the curve numbers, time of concentrations and areas for each delineated sub–basin within the Talmadge basin. Thomas & Hutton's hydrologic analysis yielded 13 sub basins. Due to the large parcels of pervious area, curve numbers generally were found to be in the low to mid 80's. Sub basins 10, 11 & 12 had higher curve numbers, based on the fact that the basins were composed of more commercial and industrial development. An exhibit titled, "Heidt–Telfair Basin Map" shows each delineated basins and its accompanying time of concentration flow path in Appendix D.

Table 9 – Talmadge Basin Hydrologic Input

Basin Name	Hydrologic Analysis		
	Area (acres)	CN	Tc (min)
Basin 1	168.07	87	42.8
Basin 2	10.4	82	13.7
Basin 3	46.2	81	31.1
Basin 4	62.19	85	56.3
Basin 5	61.27	81	56.3
Basin 6	68.5	84	58.2
Basin 7	45.18	81	31.7
Basin 8	114.14	84	67.9
Basin 9	157.68	82	93.5
Basin 10	31.77	89	12.9
Basin 11	198.44	88	97.6
Basin 12	18.22	92	16.2
Basin 13	43.28	85	24.18

Hydraulic Analysis (CIG Outcome 2)

Using the methodology described earlier in this report, Thomas & Hutton performed a hydraulic analysis on the Talmadge Basin. Most hydraulic input data was available for the drainage systems within Talmadge Basin. Where invert elevations were not given, LiDAR topography was used to estimate the pipe invert. An exhibited located in Appendix D shows the hydraulic input for each link and node modeled within XP–SWMM.

Each drainage system within the basin was analyzed for the 1–year, 10–year, 25–year, 50–year, and 100–year, 24–hour design storm events. The Garden City LDM requires that all pipe and culvert systems maintain a LOS based on each roadway's classification or use. As such, the assessment was primarily focused on the analysis of road crossings. Critical facilities such as sewer lift stations, water tank, water wells, etc., were also assessed for potential flooding during 100–year rainfall events.

The table below displays the existing peak stage for each storm event at specific road crossings and their minimum allowable level of service within the Talmadge Basin.

Table 10 – Talmadge Basin Existing Deficiencies

Road Crossing	Road Elevation (ft)	Existing Peak Stage (ft)					Minimum LOS at Road
		1–yr	10–yr	25–yr	50–yr	100–yr	
Highway 80 (Left)	13.41	6.89	8.57	9.34	10.00	10.70	50 yr
Highway 80 (Middle Left)	13.50	6.95	8.75	9.10	9.15	9.26	50 yr
Highway 80 (Middle Right)	13.50	9.06	11.50	12.28	12.74	13.11	50 yr
Highway 80 (Right)	21.49	13.31	14.71	15.19	15.55	16.10	50 yr
*Driveway 1	7.73	6.78	8.14	8.64	9.01	9.32	10 yr
*Driveway 2	7.92	6.75	8.14	8.64	9.01	9.32	10 yr
*Driveway 3	9.48	6.75	8.14	8.64	9.01	9.32	10 yr
*Driveway 4	7.92	6.74	8.14	8.64	9.01	9.32	10 yr
Old Louisville Road 1	9.56	7.22	9.46	9.64	9.68	9.71	25 yr
Old Louisville Road 2	8.75	7.00	8.72	9.14	9.18	9.22	25 yr

Blue fill in table cells indicates an increased risk to flooding

Road crossing locations are shown on the exhibit titled, "Talmadge Basin Existing Flooding at Roadways" in Appendix D.

* Indicates areas susceptible to flooding on private properties that do not qualify as CIP project. It is recommended City staff discuss private driveway flooding potential and the need for regular maintenance with property owners.

Despite the data shown in the table above, City staff has indicated some of the areas noted as susceptible to flooding have not exhibited persistent flooding over the past 10 years. Further detailed study using conventional, ground run survey should be completed to refine and further calibrate simulations of stormwater within this basin. See the Limitations section for possible causes of conservative water surface elevations.

Flooding occurs at Driveways 1, 2, & 4, starting with the 10–year, 24–hour storm event with a minimum allowable LOS for a 10–year storm event. However, since these locations are on private properties, they are not included in the Garden City Drainage CIP list. These driveway crossings should be monitored for debris and clogging, which will affect potential flood elevations upstream. Similarly flooding at both road crossings at Old Louisville Road occurs starting with the 25–year, 24–hour storm event. Garden City's LDM states that a loss of service for Old Louisville Road cannot occur for a 25–year, 24–hour storm event or less.

Six critical facilities are located within the Talmadge basin:

- Garden City LS #4
- Garden City LS #5
- Garden City LS #6
- Garden City Fire Station #2
- Garden City Well #2
- Chatham County Sharon Park Land Fill

Based on LiDAR topography, the LS #4 building appears to have a frame elevation of approximately 11.0 ft. The maximum water surface elevation experienced in the nearby channel for a 100–year, 24–hour storm event was calculated to be 9.2 ft. Therefore, based on Thomas & Hutton's analysis, the lift station has a low risk for flooding. The Garden City Fire Station #2 and Well #2 also appear to be at elevations adequately above the 100–year, 24–hour storm event flood elevation. Analysis of the channel adjacent to the structures shows that the maximum water level reaches approximately 16 feet, yielding 2 feet of freeboard from the top of the channel bank to the well and Fire Station #2 finished floor elevations. The Chatham County Sharon Park Landfill is also unlikely to experience flooding due to the nature of the facility and that it is the highest point within the entire basin. LS #5 and #6 were unable to be analyzed for flooding risks. The facilities are located in neighborhoods or developments that were are adjacent to secondary drainage facilities. Secondary drainage facilities were not included in the stormwater master plan studies.

An exhibit titled, "Talmadge Basin Existing Flooding at Roadways" shows all flooding deficiencies in Appendix D.

Proposed Capital Improvement Projects (CIG Outcome 3)

Based on the hydrologic and hydraulic analysis performed, Thomas & Hutton recommends the following drainage related CIPs for the Talmadge Basin:

- Old Louisville Pipe Crossing Improvement 1 (CIP ID #13): Old Louisville Road has experienced historical flooding. Based on Thomas & Hutton's analysis, Old Louisville Road between Griffin Avenue and Dean Forest Road may be at risk for flooding during a 25–year, 24–hour storm event or greater. This first CIP for the Talmadge Basin involves the drainage improvements of a pipe crossing along Old Louisville Road. An additional 36–inch pipe would be installed underneath the roadway to result in double 36–inch pipes. From the results shown in Table 10, the existing pipe at road crossing appears to be undersized. However, due to physical limitations, such as minimal pipe cover and existing road elevations, increasing the size of the pipe was not feasible. Therefore the pipe was doubled in order to accommodate larger flows.
- Old Louisville Pipe Crossing Improvement 2 (CIP ID #14): Similarly, another CIP consists of drainage improvements along Old Louisville Road. A 24–inch pipe would be installed at the pipe crossing labeled as "Old Louisville (Right)" to yield double 24–inch pipes underneath the road. From the results shown in Table 10, the existing pipe at road crossing appears to be undersized. However, due to physical limitations, such as minimal pipe cover and existing road elevations, increasing the size of the pipe was not feasible. Therefore the pipe was doubled in order to accommodate larger flows.
- Stormwater Detention Facility (CIP ID #15): This CIP includes developing an area in the wetlands upstream of the 84" basin outfall pipe under the railroad tracks to create a detention area to assist in minimizing upstream flooding potential. Since elevations are relatively low, the detention area would be created by excavating to the adjacent normal water elevation, resulting in additional overbank storage volume. Because upsizing the 84–inch pipe under the railroad tracks would potentially cause flooding to downstream systems, detaining the runoff in this area is suggested. This project will require property acquisition by the City and will require further study.
    - *Option* – Increase outfall pipe capacity. The 84–inch pipe underneath the railroad appears to be severely undersized, essentially choking flow and

increasing water surface elevations in the upstream system. In 2011, HGBD noted this pipe was undersized as well. However, HGBD did not recommend upsizing the 84" because the additional release of flow would negatively impact the downstream system. Presently, the downstream system appears to be mostly undeveloped lands and the Salt Creek Tributary. Given the undeveloped nature of properties downstream, now may be the time to consider upsizing the 84" outfall. Further analysis should be completed prior proceeding to determine the affects the additional culvert capacity will have on downstream conditions.

- Channel Increased Sizing and Bank Stabilization (CIP ID #16): In addition to increasing the pipe quantity under the "Old Louisville (Right)" road crossing, it is recommended that another CIP address the channel downstream of this crossing. Based on LiDAR topography, the existing channel south of this pipe crossing decreases in elevation by 0.01 feet over approximately 900 ft. This flat slope produces stagnant water in the channel that backflows into the pipe crossing. Re–grading this channel would streamline flow away from the pipe crossing.

A CIP Map is attached in Appendix F to show the improvement project locations within the Talmadge Basin.

Interim Strategies (CIG Outcome 4)

To alleviate current flooding issues and maintain public safety, Garden City is preparing interim strategies to be implemented within Talmadge Basin during large storm events. Based on the analysis performed, Thomas & Hutton recommends road closures be considered along the following routes for a 25–year, 24–hour storm event or greater:

- Old Louisville Road, between Dean Forest Road and Griffin Avenue

It should be noted that several private driveways off of Highway 80 may flood during a 10–year, 24–hour storm event or greater. Thomas & Hutton recommends that these commercial facilities respective owners' be notified that these driveways may be at an increased risk for flooding during large rainfall events.

Basin Special Drainage District Regulations (CIG Outcome 5)

Stormwater runoff volume control is a stormwater management practice that assists in mitigating or reducing stormwater volume and peak flows otherwise discharged to downstream stormwater systems. Given the age of development within this watershed, development density and property constraints, it may not be feasible to retrofit an existing stormwater system to meet the current LOS criteria. Moreover, based on the soils composition and groundwater depths within the watershed, the use of infiltration best management practices may not be appropriate, practical and/or feasible.

Based on the watershed's physical and jurisdictional constraints noted above, additional basin–specific regulations should be considered to help alleviate potential flooding impacts within the watershed and downstream areas. All existing Garden City stormwater management design regulations should still be applicable. The basin special drainage district regulations should supplement the existing and applicable regulations. These basin specific regulations are unique to the Talmadge Basin and are intended for the City's use of expanding their "Special Drainage District" section of the LDM. The recommended Talmadge basin specific development/redevelopment stormwater management criteria are as follows:

- General: The City should enforce all procedures and requirements as indicated in the Garden City Post Construction Stormwater Management Ordinance and LDM.
- Downstream Analysis: The designer should evaluate potential projects for stormwater discharges for the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings. The downstream analysis should conform to the requirements set forth in the aforementioned ordinance and LDM, unless sub–basin specific characteristics warrant additional analysis by the designer. The designer should consult with the City staff at the Concept Plan Meeting step of the project to define the proposed limits of the downstream analysis and to obtain feedback from the City as to the proposed plan. The limit of downstream analysis shall be approved by the City Manager (or his designee) prior to generation and submittal of the Stormwater Management Plan for the project. The City Manager (or his designee) shall notify the applicant of downstream analysis limits within a reasonable time frame after the Concept Plan Meeting with the City. The City should revise the LDM to include narrative consistent with that which is described herein.
- Stormwater Runoff Reduction: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Stormwater Quality Management and Protection: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Aquatic Resources Protection and Energy Dissipation: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Overbank & Extreme Flood Protection: Given the watersheds physical constraints and potential for significant increases to stormwater flows within the watershed, all developments/redevelopments shall provide flood protection from post–developed increases in the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events. Post–developed stormwater discharges shall be compared to pre–developed stormwater discharges at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings (public and private). It is recommended that post–developed stormwater runoff rates be reduced to 90% of pre–developed runoff rates. In no instance shall a discharge rate limit be less than an equivalent rate of the same project site in a forested condition. The City should revise the LDM to include narrative consistent with that which is described herein.
- Regional best management practices can benefit the watershed in its entirety. For that reason, regional BMPs are encouraged. Should the development have no feasible means to accommodate requirements set forth in the Special Drainage District on–site, the City Manager (or his designee), at his sole discretion, may entertain a "fee in lieu" donation to be applied towards the construction of Capital Improvement Projects in the subject basin. Upon completion of the downstream analysis provided by the developer's consultant, an opinion of probable cost for improvements can be submitted to the City for consideration and approval. If the City Manager agrees with the cost of improvements, the City Manager, at his discretion, may allow the Applicant to provide a fee in lieu of construction of onsite best management practices. The fee in lieu shall

provide for all, or a portion of, construction improvements, land acquisition and professional services required to construct the regional improvement project.

SMITH AVENUE PIPEMAKERS BASIN

Basin Description

The Smith Avenue Pipemaker's Basin contains approximately 281 acres located within the Pipemaker's Canal Watershed. The basin resides in the northern area of Garden City and is roughly bounded by Augusta Road (GA 21) to the west, Main Street to the east, Smith Avenue to the north, and Bishop Avenue to the south. Smith Avenue Pipemaker's Basin consists of primarily of soils that exhibit poor drainage qualities. These soils, based on SSURGO data, include soils mainly with a hydrologic classification of "D" and "B/D", with some "C" soil variations. The slopes in this basin are generally gently sloped, with some areas that are fairly flat. The overall slope of the basin drains to the north end of the basin and outfalls into Pipemaker's Canal.

The land within the Smith Avenue Pipemaker's Basin is roughly 40 percent impervious (60% pervious) and can be characterized as primarily residential with some commercial development. Approximately 80% of the basin is residential development with some commercial development located on Highway 21 in the southwest region of the basin. The basin also includes Mercer Middle School. Overall, Smith Avenue Pipemaker's Basin is mostly developed lands; only a small percentage of the basin is undeveloped. The tree coverage in the basin is not dense. Most trees are found in residential lots, intermixed within grassed yards. The basin contains very little wetlands and mostly lies within the FEMA Flood Zone X (which is not a designated SFHA). An existing channel flows through the residential developments and outfalls into Pipemaker's Canal. Areas around this channel and near Pipemaker's Canal do fall within a SFHA zone and are labeled Zone AE with a base flood elevation of 11 feet.

Historically, flooding has occurred at Smith Avenue near Wallberry Street. Historical flooding most likely can be attributed to the low elevation (<6' NAVD88) of certain portions of Smith Avenue coupled with backwater normally associated with Pipemaker's Canal.

Existing Basin Model

The Smith Basin was modeled using an existing XP SWMM model provided by Garden City. Thomas & Hutton expanded the existing model with additional links and nodes to include areas in need of further study. The existing model was developed by Moffatt & Nichol (M&N) in order to model Pipemaker's Canal and contained nearly 172 nodes and 170 links. For the purpose of this study, only the portion of the model that was within the Smith Basin was examined and updated by Thomas & Hutton. When compared to LiDAR topography and MS4 inventory data provided by Garden City, several discrepancies were found pertaining to the hydraulic input. The first discrepancy found was that the pipe network configuration near Azalea Avenue did not match current MS4 data. Thomas & Hutton performed an inspection of the pipe system in the field and confirmed that the existing model did not simulate the pipe network connectivity correctly. Thomas & Hutton revised this area in the existing XP SWMM model to reflect MS4 data and data collected from field reconnaissance. In addition, road elevations within the existing model were discovered to be significantly different from current LiDAR topography. In the M&N model, resulting stages may be extremely high as roadway overtopping (weir flow over the road) was not modeled. The M&N model was not revised to include weir flow due to roadway overtopping. It should be noted that the alert stages used to flag deficiencies and flooding

were updated using current LiDAR topography. The remaining hydraulic parameters in Moffatt & Nichol's model were left "as is."

Thomas & Hutton performed sub–basin delineations, curve number calculations and time of concentration calculations for the Smith Basin. Although the existing M&N model's sub–basin delineations and other hydrologic calculations were unknown, Thomas & Hutton found that the existing M&N hydrologic input was comparable to Thomas & Hutton's hydrologic results. Therefore, the existing model's hydrologic input was not changed. New links and nodes added to the existing model by Thomas & Hutton were updated with new hydrologic input based on the basin delineation performed by Thomas & Hutton.

Due to the limited scope of work for this study, only major discrepancies, discussed above, were revised. Other input parameters such as entrance/exit losses, a 300 shape factor, and the lack of weir flow at roadway crossings were not revised (from the M&N model) in the stormwater master plan study.

Hydrologic Results (Outcome 2)

Using the methodology described in this report, Thomas & Hutton performed a hydrologic analysis on the Smith Avenue Pipemaker's Basin. Table 11, shown below, summarizes the curve numbers, time of concentrations and areas for each delineated sub–basin within the Smith Pipemaker's basin. Thomas & Hutton's hydrologic analysis yielded 6 sub basins. Curve numbers generally were found to be in the low to mid 80's, with the exception of basin 4. Due to the volume of commercial development in this basin, the curve number was found to be higher, with value of 91. An exhibit titled, "Smith Pipemaker's Basin Map" shows each delineated basins and its accompanying time of concentration flow path in Appendix E.

Table 11 – Smith Pipemakers Basin Hydrologic Input

Basin Name	Hydrologic Analysis		
	Area (acres)	CN	Tc (min)
Basin 1	10.71	81	17.0
Basin 2	33.24	82	39.2
Basin 3	56.42	84	43.1
Basin 4	66.92	91	34.6
Basin 5	12.99	87	20.9
Basin 6	100.57	86	52.7

Hydraulic Analysis (Outcome 2)

Using the methodology described previously in this report, Thomas & Hutton performed a hydraulic analysis on Smith Avenue Pipemaker's Basin. Most hydraulic input data was available for the drainage systems within Smith Avenue Pipemaker's Basin. Where invert elevations were not given, LiDAR topography was used to estimate pipe inverts. An exhibit located in Appendix E shows the hydraulic input for each link and node modeled within XP–SWMM.

Each drainage system within the basin was analyzed for 1–year, 10–year, 25–year, 50–year, and 100–year, 24–hour design storm events. The Garden City LDM requires that all pipe and culvert systems maintain a LOS based on each roadway's classification or use. As such, the assessment was primarily focused on the analysis of road crossings. Critical facilities such as sewer lift

stations, water tank, water wells, etc., were also assessed for potential flooding during 100–year rainfall events.

The table below displays the existing peak stage for each storm event at specific road crossings and their minimum allowable level of service within the Smith Avenue Pipemaker's Basin.

Table 12 – Smith Avenue Pipemaker's Basin Existing Deficiencies

Road Crossing	Road Elevation (ft)	Existing Peak Stage (ft)					Minimum LOS at Road
		1–yr	10–yr	25–yr	50–yr	100–yr	
Redmond Avenue	12.80	10.83	12.82	13.70	14.37	14.89	25 yr
Rommel Avenue	12.83	7.77	12.26	13.29	13.89	14.36	25 yr
Varnedoe Avenue	13.14	8.81	12.58	13.19	13.53	13.81	25 yr
Camellia Avenue (Left)	10.11	6.03	9.11	9.46	9.68	9.87	25 yr
Camellia Avenue (Right)	7.69	6.59	9.11	9.52	9.75	9.95	25 yr
Azalea Avenue	7.06	5.28	6.29	6.50	6.76	7.09	25 yr
Smith Avenue (Left)	9.50	8.02	9.56	9.59	9.61	9.63	25 yr
Smith Avenue (Right)	5.63	4.18	5.74	6.22	6.61	6.95	25 yr

Blue fill in table cells indicates an increased risk to flooding

Road crossing locations are shown on the exhibit titled, "Smith Pipemaker's Basin Existing Flooding at Roadways" in Appendix E.

City staff has indicated that properties downstream of Smith Avenue (from tributary convergence with Pipemaker's Canal to Smith Avenue), adjacent to Pipemaker's Canal and Briarwood Drive have experienced recurring flooding during rain events. It should be noted that improvements are presently planned by Chatham County that may alleviate the potential flooding within the areas indicated in the table above, possibly rendering the proposed CIP project(s) unnecessary. Further evaluation will be needed prior to CIP implementation.

Flooding occurs at Redmond Avenue, Camellia Avenue (Right), and Smith Avenue (Left), starting with the 10–year, 24–hour storm event where the minimum allowable LOS is the 25–year storm event. Flooding occurs at Rommel Avenue and Varnedoe Avenue, starting with the 25–year, 24–hour storm event with a minimum allowable LOS of a 25–year storm event. Azalea Avenue floods during the 100–year, 24–hour storm event. However, because Azalea Avenue meets the minimum LOS requirements, proposed improvements are not recommended.

Four critical facilities are located within the Smith Pipemaker's Basin: Garden City LS, Garden City Water Tower, Garden City Well #1, and Savannah–Chatham County Public School System (SCCPSS) Mercer Middle School. From LiDAR topography, the building elevation of the Lift Station was found to be approximately 6.5 ft. Thomas and Hutton's analysis shows that for a 50–year, 24–hour storm event or greater, elevations may exceed 6.6 ft. Therefore, the lift station may be at risk for flooding. Thomas & Hutton also found that flooding may occur near the Garden City Water Tower and Well #1 for a 25–year, 24–hour storm event. According to Thomas & Hutton's analysis, the 60–inch pipe that crosses underneath Rommel Avenue may not be able to accommodate all the flow received for 25–year, 24–hours storm events or greater. Therefore this area, in which the Water Tower and Well are also located, may experience flooding. The last critical facility, Mercer Middle School, was not analyzed for flood risk exposure. The model

Thomas & Hutton created for this report does not extend to the area where the school is located.

An exhibit titled, "Smith Pipemaker's Basin Existing Flooding at Roadways" shows all flooding deficiencies in Appendix E.

Proposed Capital Improvement Projects (Outcome 3)

Based on the hydrologic and hydraulic analysis, Thomas & Hutton recommends the following drainage related CIP for the Smith Avenue Pipemaker's Basin:

- Redmond Avenue Roadway Improvement (CIP ID #17): CIP #17 consists of improving the drainage system underneath Redmond Avenue. The road crossing is shown to overtop for a 10–year, 24–hour storm event in Thomas & Hutton's XP SWMM model developed for this basin. LiDAR topography indicates that the elevation at Redmond Avenue decreases from approximately 17 ft to 12 ft at this pipe crossing. The existing pipe is located at the lowest point along Redmond Avenue and therefore the size pipe that can be installed with a minimum one foot of cover is limited. The pipe crossing at Redmond Avenue consists of an existing 24–inch diameter pipe. Thomas & Hutton recommends adding an additional 24–inch pipe to result in double 24–inch pipes at this road crossing to allow for larger flows to be accommodated under the road.
- Smith Avenue Roadway Improvements (CIP ID #18): Historically, this culvert crossing on Smith Avenue has experienced flooding. CIP #18 involves raising the road elevation at a location of flooding along Smith Avenue. This location currently has double 54–inch pipes crossing underneath the roadway. The double 54–inch pipes receive a significantly large portion of runoff from the upstream developments in the Smith Basin and discharges runoff via connecting channel into Pipemaker's Canal. Based on LiDAR topography, the road elevation at this pipe crossing is approximately 5.6 ft., which is the lowest elevation along the road. Most nearby roads are at an elevation of 8.0 feet or higher. Thomas & Hutton recommends raising the road elevation at this location to a minimum of 7.0 feet.
- Smith Avenue Pipe Crossing Replacement (CIP ID #19): Analysis shows that flooding may occurs along Smith Avenue in two locations for a 10–year, 24–hour storm event or greater. CIP #19 consists of the replacement of an existing pipe with a larger pipe to accommodate greater flows at one location along Smith Avenue. From the results shown in Table 12, the existing 18–inch pipe appears to be undersized. Thomas & Hutton recommends increasing the size of the pipe to a 24–inch pipe to accommodate larger flows.
- Rommel Avenue Improvements (CIP ID #20): Another CIP involves conducting further studies at the 60–inch pipe crossing along Rommel Avenue. This pipe crossing was a part of existing Moffatt & Nichol model Thomas & Hutton received and included in the modeling of the entire basin. Revisions to the Moffatt & Nichol model were not included in the scope of work for this study. Therefore, before recommendations can be made for this pipe crossing, Thomas & Hutton recommendations that additional studies be conducted.
- Varnedoe Avenue Improvements (CIP ID #21): Another CIP involves conducting further studies at the 30–inch pipe crossing along Varnedoe Avenue. This pipe crossing was a part of existing Moffatt & Nichol model Thomas & Hutton received and included in the modeling of the entire basin. Revisions to the Moffatt & Nichol model were not included

in the scope of work for this study. Therefore, before recommendations can be made for this pipe crossing, Thomas & Hutton recommends that additional studies be conducted.

- Camellia Avenue Improvements (CIP ID #22): Another CIP involves conducting further studies at the 4'x6' box culvert crossing along Camellia Avenue. This culvert crossing was a part of an existing Moffatt & Nichol model Thomas & Hutton received and included in the modeling of the entire basin. Revisions to the Moffatt & Nichol model were not included in the scope of work for this study. Therefore, before recommendations can be made for this culvert crossing, Thomas & Hutton recommends that additional studies be conducted.

A CIP Map is attached in Appendix F to show the improvement project locations within the Smith Pipemaker's Basin.

Interim Strategies (CIG Outcome 4)

To alleviate current flooding issues and maintain public safety, Garden City is preparing interim strategies to be implemented within Smith Avenue Pipemaker's Basin during large storm events. Based on the analysis performed, Thomas & Hutton recommends road closures be considered along the following routes for a 10–year, 24–hour storm event or greater:

- Smith Avenue, between Wildwood Drive/Bowman Avenue and Hickory Drive
- Camellia Avenue, between Azalea Avenue and Nelson Avenue
- Redmond Avenue, between Lee Avenue and Nelson Avenue

For a 25–year, 24–hour storm event or greater, it is recommended that barricades be placed on both sides of the pipe crossing on Rommel Avenue. Traffic would be directed away from the area of the pipe crossing in order to prevent traffic from crossing at this point in the road where it is most likely to flood. The same interim strategy is recommended for Varnedoe Avenue at the 30–inch pipe crossing.

Basin Special Drainage District Regulations (CIG Outcome 5)

Stormwater runoff volume control is a stormwater management practice that assists in mitigating or reducing stormwater volume and peak flows otherwise discharged to downstream stormwater systems. Given the age of development within this watershed, the multi–jurisdictional nature of the Pipemaker's Canal, development density and property constraints, it may not be feasible to retrofit an existing stormwater system to meet the current LOS criteria. Moreover, based on the soils composition and groundwater depths within the watershed, the use of infiltration best management practices may not be appropriate, practical and/or feasible.

Based on the watershed's physical and jurisdictional constraints noted above, additional basin–specific regulations should be considered to help alleviate potential flooding impacts within the watershed and downstream areas. All existing Garden City stormwater management design regulations should still be applicable. The basin special drainage district regulations should supplement the existing and applicable regulations. These basin specific regulations are unique to the Smith Avenue Pipemaker's Basin and are intended for the City's use of expanding their "Special Drainage District" section of the LDM. The recommended Smith Avenue Pipemaker's basin specific development/redevelopment stormwater management criteria are as follows:

- General: The City should enforce all procedures and requirements as indicated in the existing Garden City Post Construction Stormwater Management Ordinance and LDM.

- Downstream Analysis: The designer should evaluate potential projects for stormwater discharges for the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings. The downstream analysis should conform to the requirements set forth in the aforementioned ordinance and LDM, unless sub–basin specific characteristics warrant additional analysis by the designer. The designer should consult with the City staff at the Concept Plan Meeting step of the project to define the proposed limits of the downstream analysis and to obtain feedback from the City as to the proposed plan. The limits of downstream analysis shall be approved by the City Manager (or his designee) prior to generation and submittal of the Stormwater Management Plan for the project. The City Manager (or his designee) shall notify the applicant of downstream analysis limits within a reasonable time frame after the Concept Plan Meeting with the City. The City should revise the LDM to include narrative consistent with that which is described herein.
- Stormwater Runoff Reduction: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Stormwater Quality Management and Protection: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Aquatic Resources Protection and Energy Dissipation: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Overbank & Extreme Flood Protection: Based on the watershed's physical constraints and potential of significant increases to downstream stormwater flows within the watershed, all developments/redevelopments shall provide flood protection from post–developed increases in the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events. Post–developed stormwater discharges shall be compared to pre–developed stormwater discharges at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings (public and private). It is recommended that post–developed stormwater runoff rates be reduced to 90% of pre–developed runoff rates. In no instance shall a discharge rate be less than an equivalent rate of the same project site in a forested condition. The City should revise the LDM to include narrative consistent with that which is described herein.
- Regional best management practices – Due to the limited space in this watershed, regional best management practices may not be feasible at this time.

ADDITIONAL BASINS ASSESSMENT

Garden City is comprised of several other basins in addition to the four priority basins (Talmadge, Heidt–Telfair, Smith Pipemaker's, and Chatham City) studied in detail above. Additional basins include the Salt Creek Watershed, including runoff from Raspberry Canal and Horseshoe Creek, portions of Pipemaker's Canal, Springfield North (Telfair East) watersheds and a portion of the Dundee Watershed not included in the Heidt–Telfair Basin. Garden City's assessment for the Cycle 14 CIG and Outcome 1 of the Cycle 16 CIG, did not identify these watersheds as priority for critical flooding risk with a higher potential to cause flood damage within Garden City,

therefore a more generalized analytical approach was used to assess these basins. As Garden City's growth continues, it is recommended that this Master Stormwater Report be updated to include evaluation of these additional basins, which will result in preliminary hydrologic and hydraulic study of all drainage systems Citywide. Thomas & Hutton has conducted a general analysis on the current conditions of the watershed noted above.

PIPEMAKER'S CANAL BASIN

Pipemaker's Watershed is approximately 18,000 total acres in size with approximately 2,750 acres (14%) lying within the Garden City limits of jurisdiction. The Pipemaker's Watershed reaches multiple jurisdictions including Garden City, the City of Pooler, the City of Bloomingdale, the City of Port Wentworth, the City of Savannah and Chatham County. With only 14% of watershed lying within Garden City limits, it is not feasible for Garden City to address most of the watersheds deficiencies. For the purpose of this study, only portions of the watershed within Garden City's limits were reviewed by Thomas & Hutton. The Garden City portion of the Pipemaker's watershed is generally bounded to the north by the City boundary, to east by Highway 25, to the west by Dean Forest Road and the municipal boundary) and to the south by railroad tracks. The portion of Pipemaker's Watershed located within Garden City consists primarily of soils that exhibit very poor drainage characteristics. Based on SSURGO data, watershed soils include mainly hydrologic classification of "D", "C" and "B/D" soil variations. Elevations throughout the watershed range from 3 feet to approximately 30'.

Generally, Pipemaker's Watershed is moderately developed, having an estimated developed acreage of 1,000 acres located in Garden City limits. Development is concentrated along the Dean Forest Road corridor, the GA Highway 21 corridor and the Georgia Ports Authority. Most development types reflect commercial, airport support industry and logistic industrial uses. The remainder of the basin appears relatively undeveloped. Undeveloped land appears to consist predominantly of unforested wetlands. Tree coverage of the undeveloped portions of the basin appear moderately dense. A large portion of the watershed lies within FEMA SFHA Zone AE (11). Portions of Pipemaker's Canal have a FEMA Floodway designation.

Several areas located within the Garden City portion of the Pipemaker's Watershed have been subjected to flooding. Smith Avenue, as previously mentioned, has historically flooded during high tides and heavy rains. On June 23, 2014, areas in the proximity of Dean Forest Road and Commerce Boulevard experienced moderate to significant flooding during a high intensity, short duration storm event. Because the storm event exceeded a 100–year, 24–hour storm event for this area, it identified additional flooding potential and another area within Garden City for further analysis. Pipemaker's Canal is the primary conveyance channel through the Pipemaker's Watershed. Due to little topographic relief and outfall to the tidally influenced Savannah River, heavy rain events coinciding with high tides typically cause nuisance flooding throughout the watershed. Chatham County is presently working on replacing the tide gates at the Pipemaker's outfall and widening the existing channel for portions of the canal in an attempt to keep Savannah River water from diminishing valuable stormwater storage space within the channel during high tides/heavy rain events. These improvements are aimed at providing additional stormwater storage within the channel banks and enhanced maintenance of the canal.

As discussed previously, a 4 mile segment of Pipemaker's Canal extending from its outfall upstream into the basin is listed on the 2012 GA EPD 305(b)/303(d) list and the 2014 draft lists. The Pipemaker's Canal has a designated use for fishing. Water quality data indicates the stream does not support its use due to a fecal coliform bacteria criteria violation. The GA EPD notes

possible sources for the fecal coliform bacteria impairment within the stream segment as urban runoff. Reviewing the watershed characteristics, development within the watershed and the infrastructure age, elaboration of the GA EPD's findings suggest that a potential source for fecal coliform may be due to the aged sewer infrastructure and the brackish/salt water. The City is presently repairing inflow and infiltration issues of the City's sanitary sewer system in the watershed which will aid in restoring water quality in the Pipemaker's Watershed.

Since only a small portion of the Pipemaker's watershed lies within Garden City, flood control repairs to the primary conveyance systems are not cost effective until an overall, multi–jurisdictional plan is developed. The existing Garden City Stormwater Ordinance and LDM will assist in regulating stormwater runoff from future development/redevelopment within the Pipemaker's Watershed. Since there are many challenges in this multi–jurisdictional watershed, the city can further assist in minimizing flooding issues by requiring basin specific, special drainage district regulations and volume control practices.

There are many challenges to improving flood control and water quality within this watershed. Challenges include multijurisdictional coverage, low topographic relief, tidal influences and the control of future development outside the City of Garden City jurisdiction. Given the existing flooding issues within the City and the impairment of waters within the basin, several strategies should be considered within the watershed. Recommendations for consideration include:

- Sanitary Sewer Infiltration and Inflow Repair Program – Repair Infiltration & Inflow (I&I) on existing sanitary sewer infrastructure to prevent exfiltration of fecal coliform bacteria from the sewer into the surface/groundwater.
- The implementation of a Basin Specific Special Drainage District – Creating a special drainage district may be beneficial to reducing the severity of existing flood control issues and restoration of water quality. The reduction of existing flood control issues and restoration of water quality may be accomplished through the implementation of runoff volume control methods by infiltration, stringent attenuation requirements and extended detention. These measures are in addition to the current requirements. The reduction in stormwater runoff volume released will reduce the total pollutant load discharged into the receiving waterways. Furthermore, the extended detention of runoff water will provide additional residence time for total suspended solids (TSS) to settle to the bottom of the detention ponds. Detention pond discharge should discharge water from the top of water column, as opposed to the bottom, so that runoff volumes can be reduced and TSS can settle to the bottom of the pond. Since pollutants may attach to solids for transport, increasing settling time may decrease the release of TSS from the pond, thereby decreasing the pollutant load discharging into the waterways.

Basin Special Drainage District Regulations

Based on the watershed's physical constraints noted above and impaired water quality status, additional basin–specific regulations should be considered to help alleviate potential flooding impacts within the watershed/downstream and begin restoring water quality. All existing Garden City stormwater management design regulations should remain applicable to development projects. The basin special drainage district regulations are intended to supplement existing and applicable regulations. These basin specific regulations are unique to the Pipemaker's Basin and are intended for the City's use of expanding their "Special Drainage District" section of the LDM. The recommended basin specific development/redevelopment stormwater management criteria are as follows:

- General: The City should enforce all procedures and requirements as indicated in the existing Garden City Post Construction Stormwater Management Ordinance and LDM.
- Downstream Analysis: The designer should evaluate potential projects for stormwater discharges for the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings. The downstream analysis should conform to the requirements set forth in the aforementioned ordinance and LDM, unless sub–basin specific characteristics warrant additional analysis by the designer. The designer should consult with the City staff at the Concept Plan Meeting step of the project to define the proposed limits of the downstream analysis and to obtain feedback from the City as to the proposed plan. The limits of downstream analysis shall be approved by the City Manager (or his designee) prior to generation and submittal of the Stormwater Management Plan for the project. The City Manager (or his designee) shall notify the applicant of downstream analysis limits within a reasonable time frame after the Concept Plan Meeting with the City. The City should revise the LDM to include narrative consistent with that which is described herein.
- Stormwater Runoff Reduction: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Stormwater Quality Management and Protection: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Aquatic Resources Protection and Energy Dissipation: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Overbank & Extreme Flood Protection: Based on the watershed's physical constraints and potential of significant increases to downstream stormwater flows within the watershed, all developments/redevelopments shall provide flood protection from post–developed increases in the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events. Post–developed stormwater discharges shall be compared to pre–developed stormwater discharges at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings (public and private). It is recommended that post–developed stormwater runoff rates be reduced to 90% of pre–developed runoff rates. In no instance shall a discharge rate be less than an equivalent rate of the same project site in a forested condition. The City should revise the LDM to include narrative consistent with that which is described herein.

SALT CREEK BASIN

The Salt Creek Watershed is approximately 7,730 acres in size. Out of those 7,730 acres, roughly 1,140 acres lie within the Garden City limits while the remaining acreage lies outside City jurisdiction. For the purpose of this study, only portions of the watershed within Garden City limits were reviewed by Thomas & Hutton. It should be noted that the Raspberry Canal, Horseshoe Creek and the Talmadge canals discharge through the Salt Creek watershed prior to discharging to the Little Ogeechee River. The Salt Creek basin is located in the City's

southernmost region and is bounded roughly by U.S. Highway 17 to the south, Interstate 16 to the north, Dean Forest Road to the west, and the municipal boundary to the east (parallel to Salt Creek Road). The Salt Creek Basin in Garden City consists primarily of soils that exhibit very poor drainage characteristics. Based on SSURGO data, watershed soils include mainly hydrologic classification of "D", with some "A", "B/D", and "C" soil variations. The outer extents of the basin consist of relatively elevated lands with elevations as high as 22.0 feet. The central area of the basin is primarily low–lying salt marshes. The slopes in the central region of the watershed are fairly flat with lands resting at low elevations ranging from 3 to 5 feet. The overall direction of the drainage slope is toward the center of the basin where the Salt Creek Tributary flows south.

Generally, the Salt Creek Basin is relatively undeveloped, having approximately 10 percent impervious (90% pervious) coverage. The limited development within the watershed consists of sporadic residential developments with minimal commercial and industrial developments. The remainder of the basin is either undeveloped or land used for agricultural purposes. Several types of undeveloped land exist in this basin including: forested wetlands, non–forested wetlands and salt marshes. The salt marshes make up the majority of the undeveloped lands and are centered on the Salt Creek Tributary. The tree coverage in the basin is not dense. Most trees are found in residential lots, intermixed within grassed yards or in sporadic patches of forested wetlands. The basin lies within FEMA Flood Zone X and Zone AE (11).

Due to the undeveloped nature of the watershed, there does not appear to be any priority flooding issues in the basin. As with all rural type development, roadside drainage and unobstructed access to the outfall will typically be sufficient.

As discussed previously, a 1 mile segment of Salt Creek extending from U.S. Highway 17 upstream into the basin is listed on the 2012 GA EPD 305(b)/303(d) list and the 2014 draft lists. The Salt Creek Tributary has a fishing designated use. Water quality data indicates the stream does not support its use due to a fecal coliform bacteria criteria violation. The GA EPD notes possible sources for the fecal coliform bacteria impairment within the stream segment as urban runoff and nonpoint sources. Reviewing the watershed characteristics and development within the watershed, elaboration of the GA EPD's findings suggest septic tanks, wildlife and the brackish/salt water nature of the lower basin waters may be predominant contributors to the noted impairments.

Since the watershed has minimal existing developments and flood control is not an issue at this point, additional recommendations for stormwater flood control within the basin are not warranted at this time. The existing Garden City Stormwater Ordinance and LDM should sufficiently regulate the stormwater runoff generated from future development within the Salt Creek Watershed.

Given the existing water quality impairment within the basin, several strategies should be considered for enhancing the restoration of water quality within the watershed. The recommendations for consideration include:

- Septic Tank Program – A septic tank program commissioned to repair leaking systems and monitor levels of fecal coliform will indicate whether septic tank leakage is contributing the high levels of fecal coliform bacteria in the watershed. Pursuant to the City's Water First designation, a Septic Tank Ordinance stipulating requirements should be considered for adoption by the City.
- Basin Specific Special Drainage District (Water Quality only): The City should consider creation of a special drainage district that will be synergetic with the GA EPDs TMDL that

will ultimately regulate watershed activity. This could be accomplished in part through the implementation of volume control methods such as infiltration (where practical) and extended detention requirements to reduce post development discharge levels to less than pre–developed levels. The reduction in stormwater runoff volume and discharge rates will lessen the total pollutant load realized by the receiving waterways. Furthermore, the extended detention of runoff water will provide additional resonance time for TSS, which fecal coliform bacteria has been known to attach itself to, and then settle out to the bottom of the detention ponds. Detention pond discharges should release water from the top of water column, as opposed to the bottom, so that resonance time can be maximized for TSS settling.

Basin Special Drainage District Regulations

Stormwater runoff volume control is a stormwater management practice that assists in mitigating or reducing stormwater volume and peak flows otherwise discharged to downstream stormwater systems. Given the age of development within this watershed, the multi–jurisdictional nature of the Pipemaker's Canal, development density and property constraints, it may not be feasible to retrofit an existing stormwater system to meet the current LOS criteria. Moreover, based on the soil composition and groundwater depths within the watershed, the use of infiltration best management practices may not be appropriate, practical and/or feasible.
Garden City should continue to require Applicants to provide engineering and data proof that site characteristics are not conducive to true infiltration based, volume control practices. Given the general soil composition and groundwater depths of this watershed, the use of infiltration based BMPs may not be appropriate, practical and/or feasible. If infiltration based BMPs cannot be used on a project within the basin, we recommend the following be required:

Additional Attenuation of Post– developed Stormwater Runoff
Given the watersheds fecal coliform bacteria impairment (2012 GA EPD 305(b)/303(d) List) and pending TMDL to be issued by the GA EPD to restore water quality within watershed waterways, post–developed runoff release rates for all developments/redevelopments within the basin shall not exceed 90% of pre–developed runoff rates. In no instance shall a discharge rate limit be imposed that is less than an equivalent rate of the same project site in a forested condition. Post–developed stormwater discharges shall be compared to pre–developed stormwater discharges at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings (public and private). It is recommended that the City should revise Section 6 of the Local Design Manual include a "Salt Creek Special Drainage District" that indicates the requirements described herein.

HORSESHOE CANAL WATERSHED

The Horseshoe Canal Watershed is approximately 3,419 acres in size. Roughly 1,715 acres of the watershed lies within the Garden City limits while the remaining acreage lies outside City jurisdiction. For the purpose of this study, only portions of the watershed within Garden City's limits were reviewed by Thomas & Hutton. It should be noted that the Horseshoe Canal discharges into and through the Salt Creek watershed prior to discharging to the Little Ogeechee River. The Garden City portion of the Horseshoe Canal watershed is generally bounded by Interstate 16 to the south, Dean Forest Road to the west, Railroad tracks to the north, and Chatham Parkway to the east. The Horseshoe Canal Basin consists primarily of soils

that exhibit very poor drainage characteristics. These soils, based on SSURGO data, include soils mainly with a hydrologic classification of "D", with some "A", "B/D", and "C" soil variations. The slopes within the basin consist of mostly gentle slopes. Flow is directed away from this artificial ridge and toward Salt Creek Tributary. Salt Creek Tributary winds throughout the northern section of the basin, creating a "U" shape and then flows southwest through the western section. In general most of the basin lies within the FEMA designated SFHA. The zone is classified Zone AE (11). Some outlying portions of the basin lie outside of the SFHA in Zone X.

Generally, Horseshoe Canal Basin in Garden City is roughly 20 percent impervious (80% pervious) and can be characterized by mainly undeveloped land with some industrial and commercial development and few residential developments along existing roadways. Approximately 70 percent of the basin is undeveloped. Most of the undeveloped land in this basin is forested wetlands with some non–forested wetlands. Tree coverage in the undeveloped areas is mostly light woods with some grass/dirt areas. The basin contains primarily undeveloped lands that are zoned as industrial development.

This basin exhibits characteristics similar to the Salt Creek Basin. Due to the undeveloped nature of the watershed, there does not appear to be any priority flooding issues in the basin. However, the basins waterways serve as drainage conveyance for the Talmadge basin and obstructions such as beaver dams have been known to occur within the channel. Typical of the rural development in this basin, roadside drainage and unobstructed access to the outfall will typically be sufficient.

Since runoff generated from this watershed will flow into the Salt Creek Watershed and its impaired waterways, it is recommended the Salt Creek watershed interim strategies and recommendations be implemented in the Horseshoe Canal Watershed as well.

TELFAIR EAST BASIN

The Telfair East Basin contains approximately 170 acres located within the North Springfield Canal Watershed. This basin is bounded to the north by railroad tracks, to the south and east by Telfair Place ad to the west by Chatham Parkway. It is bounded roughly by railroad tracks to the north, Interstate 16 to the south, Chatham Parkway to the west, and Telfair Road to the east. The Telfair East Basin consists primarily of soils that exhibit poor and very poor drainage qualities. These soils, based on SSURGO data, include soils mainly with a hydrologic classification of "D" and "C." The slopes in this region are fairly flat to gentle slopes. The basin lies outside of a FEMA Special Flood Hazard Zone and is in Zone X.

In general, Telfair East Basin is roughly 40 percent impervious (60% pervious) with a 30 acre detention pond making up a large percentage of the impervious area. Approximately 60 percent of the basin is developed. Most of the developed lands in the basin are a mix of commercial and industrial development. Commercial development is primarily along Chatham Parkway, where industrial development can be seen mainly along Bunger Pit Road. The undeveloped lands are zoned as commercial and industrial. Currently they consist of woods with some of the lands being forested wetlands.

In 2008, Hussey, Gay, Bell & DeYoung, Inc. (HGBD) prepared the "Telfair Drainage Study" for The City of Garden City. The study included two drainage areas discharging two different basins. The total study area consisted of approximately 290 acres, with approximately 170 acres draining northward into the Heidt Canal (Dundee Canal Basin) and approximately 120 acres discharging eastward into the North Springfield Canal Basin. This basin assessment includes the

120 acre drainage area discharging into the North Springfield Canal Basin commonly known as the Telfair East Basin. The study was conducted to assess existing drainage characteristics in the basin and to determine if the existing stormwater infrastructure was adequate to accommodate runoff flows generated for a 25–year, 24–hour design storm. The existing drainage system problems resulting from the Telfair East Basin study were severe, including "significant roadway overtopping, inundation of large portions of several developed commercial and industrial properties and the threat of structure flooding on one parcel."

The Telfair East Basin improvement recommendations (CIP ID: 2008 HGBD CIP 2) and cost estimates below were extracted from the 2008 HGBD Telfair Drainage Study for the Telfair East Basin included:

1. Replace the existing 24–inch outfall pipe with a 36–inch pipe installed by jack and bore (70 linear feet). Cost: $63,000
2. Construct a new 4.5–acre (50,000 cubic yard) detention pond just upstream of the basin outfall. Cost: $450,000
3. Widen the outfall ditch between the new pond and Telfair Road to 8 feet and deepen it by an average of roughly 6 inches (1100 linear feet). Cost: $13,200
4. Remove the existing 42–inch HDPE located in the ditch roughly 560 feet south of Telfair Road (22 linear feet). Cost: $440
5. Widen the existing ditch on the south side of Telfair Road between the outfall ditch and Telfair Place to 4 feet and deepen it by an average of 6 inches (630 linear feet, net). Cost: $12,600
6. Replace two existing 18–inch and two existing 24–inch side drain pipes on the south side of Telfair Road between the outfall ditch and Telfair Place with 42–inch pipes or their hydraulic equivalent (230 linear feet, total). Cost: $25,300
7. Widen the existing ditch on the north side of Telfair Road between the existing 24–inch cross drain and Telfair Place to 3 feet and deepen it by an average of 15 inches (730 linear feet, net). Cost: $8,760
8. Replace three existing 15–inch and three existing 18–inch pipes on the north side of Telfair Road between the existing 24–inch cross drain with 24–inch pipes (300 linear feet, total). Cost: $15,000
9. Install a new 30–inch cross drain connecting the head of the main outfall ditch to the deepened collector ditch on the north side of Telfair Road (50 linear feet). Cost: $3,000
10. Install a new 30–inch cross drain connecting the north and south collector ditches on Telfair Road midway between Telfair Place and the head of the main outfall ditch (50 linear feet). Cost: $3,000
11. Install a new double 24–inch cross drain connecting the north and south collector ditches on Telfair Road just east of the Telfair Place intersection (50 linear feet). Cost: $5,000
12. Replace the existing double 15–inch cross drain under Telfair Place with double 24–inch pipes (65 linear feet). Cost: $7,150

Additional costs of 20% and Engineering & Contingencies was added to the cumulative project improvement subtotals.

Interim Strategies (CIG Outcome 4)

To alleviate current flooding issues and maintain public safety, Garden City is preparing interim strategies to be implemented within the Telfair East Basin. Based on the findings in the 2008 HGBD Telfair Basin Study and the magnitude of project costs associated with improvements, Garden City should monitor flood water surface elevations throughout the Telfair East Basin.

Depending on the severity of the rain event, road closures may be needed on the following roadways:

- Telfair Road
- Telfair Place (East)

Basin Special Drainage District Regulations

Stormwater runoff volume control is a stormwater management practice that assists in mitigating or reducing stormwater volume and peak flows otherwise discharged to downstream stormwater systems. Given the age of development within this watershed, development density and property constraints, it may not be feasible to retrofit an existing stormwater system to meet the current LOS criteria. Moreover, based on the soils composition and groundwater depths within the watershed, the use of infiltration best management practices may not be appropriate, practical and/or feasible.
Based on the watershed's physical constraints as noted above, additional basin–specific regulations will be required to help alleviate potential flooding downstream. All existing Garden City design regulations should still be applicable. The basin special drainage district regulations will be in addition to all existing and applicable regulations. These basin specific regulations are unique to the Telfair East Basin and are intended for the City's use of expanding their "Special Drainage District" section of the LDM. The recommended Telfair East Basin specific development/redevelopment stormwater management criteria are as follows:

- General: The City should enforce all procedures and requirements as indicated in the existing Garden City Post Construction Stormwater Management Ordinance and LDM.
- Downstream Analysis: The designer should evaluate potential projects for stormwater discharges for the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings. The downstream analysis should conform to the requirements set forth in the aforementioned ordinance and LDM, unless sub–basin specific characteristics warrant additional analysis by the designer. The designer should consult with the City staff at the Concept Plan Meeting step of the project to define the proposed limits of the downstream analysis and to obtain feedback from the City as to the proposed plan. The limits of downstream analysis shall be approved by the City Manager (or his designee) prior to generation and submittal of the Stormwater Management Plan for the project. The City Manager (or his designee) shall notify the applicant of downstream analysis limits within a reasonable time frame after the Concept Plan Meeting with the City. The City should revise the LDM to include narrative consistent with that which is described herein.
- Stormwater Runoff Reduction: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Stormwater Quality Management and Protection: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.
- Aquatic Resources Protection and Energy Dissipation: All requirements outlined in the Post Construction Stormwater Management Ordinance and LDM shall apply to developments and/or redevelopments within this watershed.

- Overbank & Extreme Flood Protection: Based on the watershed's physical constraints and potential for significant increases to downstream stormwater flows within the watershed, all developments/redevelopments shall provide flood protection from post–developed increases in the 1–year, 2–year, 5–year, 10–year, 25–year, 50–year and 100–year 24–hour design storm events. Post–developed stormwater discharges shall be compared to pre–developed stormwater discharges at the project development property line, all downstream confluences, in–line impoundments such as detention ponds, etc., and at downstream road crossings (public and private). It is recommended that post–developed stormwater runoff rates be reduced to 90% of pre–developed runoff rates. In no instance shall a discharge rate limit be less than an equivalent rate of the same project site in a forested condition. The City should revise the LDM to include narrative consistent with that which is described herein.
- Regional best management practices can benefit the watershed in its entirety. For that reason, regional BMPs are encouraged where feasible. Should the development have no feasible means to accommodate requirements set forth via on–site stormwater controls, the City Manager (or his designee), may entertain a "fee in lieu" payment to be applied towards the construction of drainage related CIPs in the subject basin. Upon completion of the downstream analysis provided by the developer's consultant, an opinion of probable cost for improvements can be submitted to the City for consideration and approval. If the City Manager agrees with the cost of improvements, the City Manager, may allow the Applicant to provide a fee in lieu of construction of onsite BMPs. The fee in lieu payment shall provide for all, or a portion of, construction improvements, land acquisition and professional services required to construct the regional improvement project.

FINAL RECOMMENDATIONS

The Garden City Stormwater Master Plan serves as an initial platform to assist the City in addressing its storm water management issues related to both water quantity and water quality. The Garden City Stormwater Master Plan should be considered an evolving, living document in need of updating as additional information and funding becomes available. The conclusions noted above should be further refined and studied with more detailed and definitive information to determine more accurate risks associated with the existing stormwater infrastructure and local rainfall events. As a result of the modeling and evaluation included in this master plan, the following tasks are recommended to Garden City for consideration and implementation:

- Adopt the preliminary CIP list to assist in the allocation of future stormwater utility funds for project/study implementation and to assess the suitability of stormwater utility revenues against planned CIP expenditures.
- Provide for the opportunity to further refine the modeling used to produce the resulting flooding alert stages. Existing models provided by the City exhibited inconsistent modeling techniques and inconsistent modeling parameters (i.e. entrance/exit losses, contraction/expansion losses, the allowance for roadway weir flow, etc.). Garden City may want to consider revising model platform to Interconnected Channel and Pond Routing Version 4 (ICPR) by Streamline Technologies. ICPR allows for a more user friendly model and easier display of model input and output, and can provide a snap shot of flooding during a storm event. As development proposals are submitted, the master plan model should be updated to reflect future build out conditions.

- Conventional, ground–run survey should be obtained for modeled area to better define elevations of pipes, culverts and structures of the existing stormwater system.
- Schedule or program further hydrologic and hydraulic studies for all watersheds within the City to provide for more detailed planning in anticipation of future development.
- Provide interim flood control management by monitoring rising flood waters and providing road closures throughout the City, including those recommended in the master plan.
- Consider amending Garden City LDM to include Basin Specific Special Drainage District standards and criteria as described herein. Special Drainage Districts will assist the City in controlling downstream impacts due to stormwater runoff from new developments by requiring a combination of volume control BMPs, over–attenuation of the pre– and post–development discharge rates, downstream analysis for a drainage area 10–times the site drainage area to assess downstream impacts, and other more stringent regulations as may applicable to the respective basin. The goal of these storm water control measures will be to provide a LOS for stormwater infrastructure such that proposed developments/redevelopments do not exacerbate existing flood water surface elevations as a result of future rainfall events.
- Create an educational program for distribution to the engineering and development community to introduce the revisions to the Garden City LDM.

The recommendations above are not listed in order of priority. As funding and opportunities arise, the City of Garden City should strive to enhance this stormwater master plan to include additional information as it becomes available.