Storm Water Management Model

Indian River Watershed MDPU

Master Drainage Plan

April 2011

US Army Corps of Engineers
Norfolk District

Chesapeake VIRGINIA
Department of Public Works

URS
URS Corporation

Table of Contents

Figures

Tables

Appendices

Storm Water Management Model

Indian River Watershed MDPU

Chesapeake, VA

URS Nos. 11657893, 11657899

Executive Summary

Engineers from the U.S. Army Corps of Engineers, City of Chesapeake (City) and URS Corporation (URS) have completed a drainage study of the Indian River Watershed using the Storm Water Management Model (SWMM) computer program.

The analytical procedure is based on computing localized flood volumes resulting from design rainfall events such as the 2-, 5-, 10-, 25-, 50- and 100-year storms. The watershed is analyzed using modeling configurations to quantify flooding associated with both existing and future watershed conditions. Drainage improvement alternatives are carefully evaluated with respect to their potential impact to the entire watershed. The improvement alternatives are then given further consideration based on construction feasibility and potential financing constraints, with the focus on the entire watershed rather than on a few individual components. The advantage of this approach is that the entire drainage system can be evaluated on a consistent, system-wide basis.

The process of identifying candidate drainage improvement projects is based on trial-and-error modeling techniques. The watershed is analyzed using estimated existing and anticipated future land use, and locations and volumes of computed flooding are identified in the modeling.

After analyzing existing and potential problems in this watershed, the engineering team has identified ten specific projects that can alleviate future flooding in the subject watershed. Some of these projects are not considered Master Drainage Facilities (MDF's) because their contributing drainage area is not greater than 320 acres. These projects can be carried forward as Capital Improvements Projects with some assurance that the impacts on the watershed as a whole have already been adequately considered. Portions of some projects can potentially be constructed as part of private development initiatives with little or no cost to the City. It is also important to keep in mind that some of these improvements may need to be modified, as wetlands regulations, flooding issues, soil properties, and economic considerations may effectively impact future development.

There are many combinations of drainage improvements that can be evaluated in any watershed. While a substantial effort has been applied to develop this study, it is by no means exhaustive. The intent of this undertaking was not only to develop sound alternatives for watershed improvements, but also to leave the underlying data files and computer models so that they can be used in a straightforward manner in the future.

The maximum computed water surface elevation at each modeled node, and peak computed discharge at each modeled link are presented in Appendices C and D, respectively, for existing and future conditions.

Portions of this watershed associated with roadway or development projects have been evaluated by the City over the past several years. Some studies have been completed to address specific problems as described elsewhere in this report. The modeling conducted as part of this Master Drainage Plan Update incorporates the previously prescribed improvements where possible, either directly or with modifications.

FEMA flood insurance studies and rate maps are the definitive source of floodplain limits and elevations. The SWMM models developed for this drainage study are specific design scenarios based on 2-, 5-, 10-, 25-, 50-, and 100-year rainfall events—THEY ARE NOT TO BE CONSTRUED AS INDICATIVE OF EXPECTED WATER SURFACE ELEVATIONS FOR THE PURPOSES OF FLOODPLAIN MANAGEMENT AND/OR INSURANCE REQUIREMENTS. The SWMM models developed for this study could be adapted for use in the National Flood Insurance Program and submitted to FEMA for approval, but until they are subjected to that process the published flood insurance studies and rate maps remain fully in effect.

Findings or recommendations contained herein do not constitute Corps of Engineers approval of any project(s) or eliminate the need to follow normal regulatory permitting processes.

Background

URS was directed by the City of Chesapeake and the U.S. Army Corps of Engineers to conduct a study on the area of Indian River Watershed covering approximately 7,260 acres.

The Indian River Watershed is located in northern Chesapeake and is bordered on the east by the City of Virginia Beach, on the south by the Oak Grove and Kemp Woods watersheds, and on the west by Milldam Creek and South Norfolk Watersheds. Runoff from the Indian River Watershed discharges into the Eastern Branch of the Elizabeth River.

The subject watershed was delineated into 383 subcatchments in order to compute and distribute runoff throughout the entire watershed. Overall, the Indian River Watershed is well developed with few vacant lots available for future development. This study addresses existing drainage and stormwater issues, as well as expected future conditions. The entire SWMM model has 688 nodes and over 700 links, providing sufficient detail and modeling resolution for master drainage planning purposes.

Two drainage studies, Indian River Park Study Area (1986) and Georgetown Study Area (1986), were previously completed within this watershed, as summarized below.

The Indian River Park Study was conducted in October of 1986 by Gannett Fleming Corddry & Carpenter. The study concentrated on the 651 acres that drained to the triple 5-ft x 6-ft box culverts at Providence Road. The study also accounted for drainage from approximately 96 acres of the City of Virginia Beach. Recommended improvements included the addition of a second 6-ft x 6-ft box culvert at Military Highway to accommodate the 50-year design storm. This recommendation has not yet been implemented as of 2011.

The Georgetown Study was also conducted in October of 1986 by Gannett Fleming Corddry & Carpenter. The study focused on drainage from 381 acres which outfall at Section 300 (near what is now known as Cedar Crossing—near node 712 in the current study). The 1986 study indicated that existing ponds were adequate to handle runoff from a 50-year storm event for both the existing and future conditions, therefore no improvements were recommended. However, recent GIS and survey data indicate that the multi-pond connectivity and outfall configurations are different from those presented in the 1986 study.

In addition to the previous studies, the City of Chesapeake provided URS with plan sets for projects within the subject watershed—some of which have been approved for construction but have yet to be completed. As directed by the City, URS modeled these as 'existing' conditions. While some of these developments were not expected to be complete by the end of this study, they were considered existing conditions because the approval of the project make its near-future development likely.

The City of Chesapeake surveyed selected points in the subject watershed at the request of URS. These selected survey points are presented in Appendix B. The City also provided URS with GIS-related topographic data. URS utilized these four main sources—past studies, plan sets, survey data, and GIS data, to extract channel and infrastructure information, such as invert elevations, pipe type and size, and channel characteristics, throughout the subject watershed.

Methodology

The engineering methodology applied in this study is summarized in a separate document, submitted by URS to the City of Chesapeake in April of 2005, entitled *Master Drainage Plan Methodology*. SWMM modeling is typically used for relatively large-scale studies. It is not generally intended to be used as a design tool for individual projects, due to its complexity and data requirements. Its strength lies in the application of very advanced hydrologic and hydraulic routing computational routines, fed with data from a geographic information system (GIS) and from plans for future roadway and parcel development projects.

This Master Drainage Plan Report presents the findings of the application of this methodology to the subject watershed.

Treatment of Nodal Flooding

The issue of how to handle nodal flooding is important when using or interpreting any rainfall-runoff model, including SWMM. Loosely speaking, nodal flooding occurs when a computed water surface elevation exceeds the maximum defined depth at a point in the system (referred to as a "node").

In previous versions of SWMM (Versions 4.x and earlier), the water leaving the node was treated as an "escape" from the system. However, the treatment of nodal flooding was enhanced in SWMM Version 5 by introducing "nodal ponding" and "nodal surcharge" capabilities. The new nodal ponding option allows the modeler to specify a constant "ponding area" over which <u>nodal surcharges are stored as they escape from the node, then released back into the system as water surface elevations recede</u>. This nodal ponding capability can produce more reliable water surface elevation computations due to the re-introduction of nodal flooding volumes and their continued downstream routing through the drainage system.

The option to compute nodal ponding in SWMM necessitates an approach to treat or develop the ponding area for each node, subject to two considerable limitations. First, the ponding area increases with depth, and in fact at some depth the ponded volume will actually combine with other nearby nodes such that deciding which node has what portion of the surface flooding becomes arbitrary at best. Secondly, it is not feasible to spend the time performing elaborate delineations at each node to compute a constant ponding area that is approximate at best, requires judgment regarding how much area to assign to which node, and ultimately varies with depth. In many locations, the situation is further complicated—when stormwater flows up and out of the ground, it runs down a gutter or downhill flow path to some other location.

SWMM is a one-dimensional model—it can only compute flow depth, discharge and related properties along one-dimensional lines through the drainage network. It cannot compute lateral variations in the flow (such as can be accomplished with two-dimensional surface-flow models). Even if it were possible to precisely compute the ponding area at each node, we are still limited by the use of a one-dimensional model. It is difficult to determine a ponding area with accuracy when the computed water surface elevation exceeds the ground elevation. The problem is further complicated by the difficulty in determining the nominal "ground elevation" in a one-dimensional model.

URS has developed an approach to handle nodal flooding using SWMM Version 5, which we are using on many similar studies. The approach used is to divide the total watershed area by the number of modeling nodes to develop an average ponding area, which is then applied to all nodes that are not directly modeled as storage nodes. This approach is simple, but effective, and because the surface flooding is re-introduced into the drainage system as flood levels decrease, it gives a reliable basis upon which to compute water surface elevations in these models.

Vertical Datum

Unless specifically stated otherwise, the **North American Vertical Datum of 1988 (NAVD88)** was used throughout this study.

Modeling Configurations

Three modeling configurations—Existing Hydraulics with Existing Hydrology (Scenario 1), Future Hydraulics (without recommendations) with Future Hydrology (Scenario 2), and Future Hydraulics (with recommendations) with Future Hydrology (Scenario 3)—were developed for this study as described below.

Scenario 1 Existing watershed hydrology with the drainage system configured as it existed in 2010. Channels are modeled using their existing (2010) conditions as well. This is the "Scenario 1" model. The City of Chesapeake requested certain plan sets be considered as 'existing' because they have been approved prior to the start of this study. The following is a list of plan sets and studies, provided by the City, that are accounted for in the existing conditions model (the list includes completed past studies, projects that have been constructed, as well as approved projects not yet constructed):

1. Saturn of Chesapeake (site development plans)
2. Greenbrier Mall (site plan)
3. Norfolk Highlands Drainage System
4. Norfolk Highlands Drainage to Indian River Park
5. The Retreat
6. Greenbrier Commerce Park Section K & Part of I & J
7. Greenbrier Parkway - Phase 3
8. Greenbrier - Zone 5
9. Building One at Liberty Executive Park
10. Sparrow Road Pipe Replacements
11. Sparrow Road - Phase 1
12. AC# 1728WM (1327 Lilac Ave & 1061 Crowell Ave)

13. Tarelton Oaks SWMF / BMP Pond #2
14. Greenbrier Commerce Park - Phase 2
15. Greenbrier Water, Sewer, and Street Improvements
16. Indian River Community Center
17. The Retreat at Greenbrier
18. The Hampshires at Greenbrier
19. Woodgate Commons
20. The Towne Place at Greenbrier
21. Greenbrier Marketcenter
22. Alta Reserve
23. Greenbrier Business Centre
24. Emerald Forest on Kempsville Rd
25. The Fairways Phase 1 for Franciscus Company
26. The Fairways Phase 1 for Franciscus Company (Private Sector)
27. Greenbrier Master Drainage Plan
28. Volvo Parkway Phase IIIA
29. Volvo Parkway Phase IIIB
30. Parkview Associates
31. Bayberry Forest Phase 1 & 2
32. Mill Quarter
33. Greenbrier - Zone 6 for Greenbrier Associates
34. Greenbrier - Zone 1 Phase 1 & 2 - Industrial Park
35. Greenbrier Commerce Park Zone 4
36. Ipswich Townvillas
37. River Birch Run North
38. Greenbrier Outfall Improvements
39. Greenbrier Industrial Park Military Highway
40. Woodlake Drive Extended Utility and Road Improvements
41. Greenbrier Mall Culvert Replacement
42. Greenbrier - Road Improvement
43. Dodge City
44. River Birch Run Extension
45. CBN Fenwyck Manor
46. The Birches Sec. A
47. Priority Toyota
48. Peachtree Place
49. Ipswich Village - College Park Sec. 4A
50. Cypress Place
51. Logan's Mill
52. Juniper Cresent
53. Three Intermediate Schools
54. Professional Place
55. Holly Glen Condominiums
56. Holly Point Shopping Center
57. Georgetown Elementary - Parking Lot Addition
58. Georgetown Commons Townhouses
59. Georgetown Point - Sec. 5&6
60. Georgetown Point - Sec. 7
61. Georgetown Point - Sec. 8&9
62. Georgetown Manor - Phase I
63. Holly Point Apartments

64. Wedgewood Village
65. Greenbrier Industrial & Office Park - parking Lot Addition
66. Smith Ave. and Live Oak Dr.
67. Live Oak Dr.
68. Volvo Penta Facility Expansion
69. Volvo Of America Corp. (as Built)
70. Greenbrier Tech Center
71. Given Incorporated
72. Woodlake Drive & Woodlake Cir.
73. Park Ct
74. Lambert Ct
75. Greenbrier Cir & Sara Dr. (as Built)
76. Rosewell Ave.
77. Neptune Ave. & Justis St.
78. Emerald Greens
79. Crossway Blvd & Kristina Way
80. Stephanie Way at Crossing
81. Kristina Way
82. Campostella Square Sec. II
83. Cromwell Avenue
84. Mitsubishi Kasei America
85. City View Park Trib Area
86. Christ Sanctified Holy Church
87. Country Club Square Parcel C
88. Country Club Square BMP Outfall
89. One Accord Church
90. Emerald Forest Lake Outfall
91. Priority Chevrolet Collision Center
92. Border Road Drainage
93. VA Beach Landfill Drainage
94. Providence Road Culvert
95. Parkside and Stalham
96. The Streets of Greenbrier

Scenario 2 Future watershed hydrology with the added future drainage system as it is anticipated by the City. For the most part, channels and conduits are configured as they exist in 2010, however, the addition of two future plan sets, identified by the City, have been added this scenario. This is the "Scenario 2" model. This scenario will show the flooding effects of the existing drainage system (with the added future plan sets in place) due to future land use development. The following plan sets, provided by the City, have been added to this Scenario 2:

1. Fenwyck Manor Master Plan
2. West Munden and Vicker St Drainage Improvements (60%)

Scenario 3 Future watershed hydrology with the future drainage system configured as envisioned by the City of Chesapeake and URS. This is the "Scenario 3" model. This scenario incorporates the drainage from Scenario 2 along with any recommendations from the engineering team to help reduce flooding on a Master Drainage Facility level (i.e. facilities serving 320 acres or more).

The recommended improvements should reduce flooding at key locations, where feasible, for future conditions. These improvements were developed during this study, are highlighted in Figures 10 and 10a through 10j, and specifically include the following projects:

1. Volvo Pkwy Culvert Improvement
2. South of Live Oak Drive Drainage Improvements
3. Commerce Park Drainage Improvements
4. Military Hwy Outfall Improvement
5. Woodlake Drive Drainage Improvements
6. North of Woodlake Drive Drainage Improvements
7. Hearthside Ct Drainage Improvements
8. Georgetown Blvd Drainage Improvements
9. Allison Drive Drainage Improvements
10. Eden Way Lakes Drainage Improvements

This scenario depicts future conditions with strategic drainage and stormwater improvements in place. Additional details and descriptions regarding the improvements are presented elsewhere in this report.

Modeling Results

The maximum computed water surface elevations at each modeled node and computed peak discharge at each modeled link are presented in Appendices C and D, respectively, for existing and future conditions.

Stable SWMM runs were obtained for all modeling scenarios. Continuity errors ranged from low to very low. URS engineers used PCSWMM to review dynamic hydraulic grade line results, checking the hydraulic routing for potential stability problems or any type of flow anomaly. This QA/QC procedure aids in producing reliable modeling results.

Boundary conditions (water surface elevations) at the downstream outfall were specified by the City of Chesapeake, Department of Public Works, as stated in the *Public Facilities Manual*. In all cases, for all return periods, the hydraulic boundary condition was modeled as a constant water surface elevation of 3.60 feet (NAVD88) in the Eastern Branch of the Elizabeth River. Due to the natural topography and wide floodplains, major portions of this watershed are not very sensitive to the downstream boundary water surface elevation used in these models.

The GIS analysis prepared in support of this modeling indicates that the Indian River Watershed will increase from **51.57** to **56.02** percent imperviousness in the future, as indicated in Figures 3 and 4. The procedures used to determine this increase are explained in the *Master Drainage Plan Methodology* (April 2005) report submitted previously. This increase in impervious cover produces greater volumes of stormwater runoff, which have been incorporated into the future conditions models.

During the process of determining imperviousness, URS engineers, with agreement from City engineers, visually adjusted the percentage of impervious of each subbasin based on aerial imagery. This step is necessary because the City currently does not have imperviousness mapped in its GIS.

Figures 8, 9, and 11 depict street and property flooding volumes for the 10- and 50-year design storm events. The histograms are not drawn to any scale, but they are proportional, and serve to graphically identify where flooding can be expected under each modeling configuration.

The City does not have to 'fix' all of the flooding represented by the histograms in the figures. Areas such as woodlands, deep ravines, large open spaces, ball fields and parks, and along railroad rights of way often do not require improvements unless there is a specific reason to construct them. It is also important to bear in mind that a 50-year design storm is an extreme event, and that neighborhood drainage systems are typically not required to accommodate 50-year storms.

Flooding complaints, particularly those in residential neighborhoods, often result from maintenance problems such as a clogged pipe or debris in a ditch. In considering whether or not drainage improvements might be required to correct an *existing* deficiency, the model results should indicate a flooding problem, and there should be some flooding history to support the need for improvements. If both of these conditions are not met, then the system maintenance should be reviewed or the preliminary computer models should be carefully scrutinized.

It is also important to understand when reviewing these results that there can be low-lying structures in the watershed that have finished floor elevations below the maximum water surface elevations computed in the SWMM models. In order to estimate whether or not a particular structure will be subject to flooding for a given storm condition, maximum hydraulic grade line elevations in the vicinity should be checked against the finished floor elevation.

As with all models of this size and complexity there is a great deal of detailed information required. Because it is not feasible to collect *all* of the required data, in some locations it is necessary to make educated guesses about inverts and pipe and channel dimensions and geometries. Where future designs and studies will be based on these models, engineers are strongly encouraged to field-verify all items that may critically impact their designs.

The maximum computed water surface elevations at each model node are presented in Appendix C for both existing and future condition scenarios. The blue shading in Tables C-1 and C-2 indicates locations where the maximum computed water surface meets or exceeds the ground elevation for that node. Many of these nodal flooding locations are very small quantity or short duration events. In these SWMM 5 models, the volume of water leaving the node during flooding is computed and summarized for continuity purposes (which allows for a reasonable accounting of flood volume at the node) *and the flooded water is re-introduced into the model for subsequent downstream routing*, as explained in the Treatment of Nodal Flooding section above. If flooding occurs at a choke point in the system, downstream (or nearby) nodes may have computed maximum water surface elevations less than what can actually be expected due to the volume of water being 'held' upstream. With the introduction of Nodal Ponding in SWMM 5, this phenomenon is of less concern than it was in older versions of SWMM. Where computed water surface elevations exceed the ground elevation in these models, water surface elevations in the vicinity should be considered 'approximate'. The main purpose of this ponding approach is to account for local flooding volumes and re-introduce stored water back into the drainage system as water surface elevations recede.

The <u>figures</u> that indicate nodal flood volumes in this report have been filtered so that nodal flood volumes less than 10,000 cubic feet are not represented (because less than 10,000 cubic feet of flooding cannot be practically discerned on the ground—it simply appears as heavy runoff or sheet flow in most cases). <u>Tables</u> C-1 and C-2 have not been filtered at all; where nodal flooding is indicated in many cases the duration and quantity of flooding can be very minor.

The PCSWMM.NET modeling platform contains a very helpful dynamic hydraulic grade line tool that allows the user to view animations of the computed water surface elevations. This dynamic hydraulic grade line tool takes input from a digital interface file at *a specified sampling interval*, for example every 3 minutes in these models. The SWMM routing computations are performed at one-second (or so) intervals, and the output file contains summary information based on *every* time step. If the dynamic hydraulic grade line tool is used to view the results the user should bear in mind that it is based on a sample (one out of every 180 seconds), and therefore the 'peak' values listed by the dynamic hydraulic grade line tool are peaks as sampled using a three-minute interval. The SWMM output data on the other hand contains a summary of the *exact* peak values. The SWMM output file summaries were used to prepare Tables C-1, C-2, D-1, and D-2, as well as the flooding figures in this report.

The modeling results presented in this report are based on the assumption that the drainage and stormwater systems will be well maintained. If debris builds up to block drainage structures, or channels are allowed to fill with silt, flooding will likely be more severe than computed and represented in this report. Debris can be a significant problem in natural channel outfall systems, and should be monitored carefully to ensure that these systems function properly. Likewise, heavy buildup of vegetation can significantly worsen local flooding. Channels that are relatively free from vegetation problems in the winter months can have significantly less conveyance capacity in the summer months. Depending on the type of plant growth, the change in conditions can be dramatic.

FEMA flood insurance studies and rate maps are the definitive source of floodplain limits and elevations in all cases. The SWMM models developed for this drainage study are specific design scenarios based on 2-, 5-, 10-, 25-, 50-, and 100-year rainfall events—THEY ARE NOT TO BE CONSTRUED AS INDICATIVE OF EXPECTED WATER SURFACE ELEVATIONS FOR THE PURPOSES OF FLOODPLAIN MANAGEMENT AND/OR INSURANCE REQUIREMENTS. The SWMM models developed for this study could be adapted for use in the National Flood Insurance Program and submitted to FEMA for approval, but until they are subjected to that process, the published flood insurance studies and rate maps remain fully in effect.

Master Drainage Plan Improvements

The City of Chesapeake utilizes a 320-acre threshold for candidate Master Drainage Facility (MDF) improvements. If a project services less than 320 acres, it will generally not be constructed as part of the City's Master Drainage Plan.

Ten specific projects were conceived and incorporated into the modeling during the course of this study, seven of which are not considered MDF improvements due to their contributing drainage area being less than 320 acres. These projects are by no means exhaustive, but they seem to provide a reasonable amount of flooding relief while also maintaining a reachable economic goal. All of the projects appear to be feasible from a preliminary planning standpoint, but issues such as future wetlands delineations and the ability to successfully acquire rights-of-way or parcels of land may necessitate some modifications as these projects move forward. The ten projects are shown in Figures 10 and 10a through 10j and are included in the future modeling scenario (Scenario 3). Refer to Figures 7, 10 and 10a through 10j of this report to find node and link numbers and to view the locations of improvements that are referenced in the following project summaries. Due to the large amount of nodes and links, as well as label text size, please refer to the GIS files, provided with this submittal, to better view all of the Node and Link details.

As indicated in Figures 1 and 3, some areas within this watershed are currently undeveloped. The timing of future development may affect the order in which the improvement projects need to be implemented. Figure 5 presents potential increases in imperviousness based on future build out according to the City's comprehensive land use plan, however, other factors may affect future imperviousness, such as agreements between regulatory agencies. For example, zoning regulations may allow for the development in a particular area, however, wetlands restrictions may prohibit or severely limit development of that same area, thereby limiting actual future imperviousness. Modeling for this report reflects potential future increases in imperviousness according to the City's comprehensive plan and rights-of-way for future road projects.

1. Volvo Pkwy Culvert Improvement

The City anticipated replacing the old 10-ft metal culvert under Volvo Parkway (connecting nodes 159 and 323) with a concrete box culvert. To be consistent with surrounding plans, the recommendation for this replacement is a 6-ft x 10-ft box culvert. This proposed box culvert should be placed with invert elevations of 8.0 ft. (upstream) and 7.7 ft. (downstream) to minimize the build-up of sediment.

2. South of Live Oak Drive Drainage Improvements

Flooding occurs in this vicinity due to a shallow ditch and an under-sized outfall culvert. Recommended improvements to this area include:

1. Node 515: Lower invert to 7.0 ft.
2. Node 516: Lower invert to 6.8 ft.
3. Node 517: Lower invert to 6.3 ft.
4. Node 518: Lower invert to 6.2 ft.
5. From Nodes 514 to 515: Re-grade and widen the channel bottom to 15 ft. with side slopes of 2H:1V.
6. From Nodes 515 to 516: Re-grade and widen the channel bottom to 15 ft. with side slopes of 2H:1V.
7. From Nodes 516 to 517: Re-grade and widen the channel bottom to 15 ft. with side slopes of 2H:1V.
8. From Nodes 517 to 518: Replace existing twin 42-in RCPs with triple 54-in RCPs.
9. From Nodes 518 to 551: Re-grade and widen the channel bottom to 10 ft.

3. Commerce Park Drainage Improvements

Future development within the "Mitsubishi America" area will require improvements to the existing drainage system. Recommended improvements to this area include:

1. Node 273: Construct a BMP with a top of bank area equal to 1.8 acres, and side slopes of 3H:1V. The vertical distance from the normal water surface elevation to the top of bank should be 8.0 ft., and the total storage volume should be approximately 11.0 acre-feet.
2. From Nodes 273 to 274: Place a single 36-in RCP connecting the BMP's outfall to the existing 42-in culvert downstream.

For this recommended alternative, the BMP and its outlet structure were sized using the 100-year design storm with an assumption of approximately 75 acres of drainage area and 60-percent imperviousness at build-out. The size and shape of the BMP, as well as its outfall pipe, are subject to change based upon future determinations.

4. Military Highway Outfall Improvement

The City has encountered existing erosion in the channel connecting Military Highway and the lake at Indian River Middle School, and anticipates widening the channel to reduce head losses in the system. The recommendation for this channel improvement includes the cleaning and widening of the channel bottom to the east. The proposed channel bottom width should be 18 ft. with a side slope of 2H:1V on the east bank. The west bank of the channel is made up of a bulkhead and should remain unchanged.

5. Woodlake Drive Drainage Improvements

Recommended improvements to this area include:

1. From Nodes 380 to 381: Add one (1) 36-in RCP to the existing 36-in RCP.
2. From Nodes 381 to 382: Add one (1) 42-in RCP to the existing 42-in RCP.
3. From Nodes 382 to 383: Replace single 54-in CMP with double 54-in RCPs.
4. From Nodes 383 to 385: Replace single 54-in CMP with double 54-in RCPs.

Alternatively, due to potential utility and structure conflicts, adding a parallel system on the other side of Woodlake Drive may be more economical and easy to construct.

6. North of Woodlake Drive Drainage Improvements

Flooding in this area is mainly due to an under-sized culvert under Greenbrier Parkway.

Recommended improvements to this area include:

1. From Nodes 433 to 434: Add one (1) 42-in RCP to the existing double 42-in RCPs.
2. From Nodes 437 to 439: Replace existing double 42-in RCPs with double 54-in RCPs.
3. From Nodes 439 to 455: Add one (1) 54-in RCP to the existing 54-in RCP.

7. Hearthside Court Drainage Improvements

For this recommended improvement, the pond and its outlet structure were sized using the 10-year design storm with an assumption of approximately 6 acres of drainage area and 85-percent imperviousness at build-out.

Recommended improvements to this area include:

1. Node 634: Construct a detention basin with a top of bank area equal to 0.23 acres, and side slopes of 3H:1V. The vertical distance from the pond invert to the top of bank should be 3.0 ft., and the total storage volume should be approximately 0.6 acre-feet.
2. Place a single 27-in RCP connecting the basin outfall to the existing 24-in x 30-in elliptical pipe downstream.

An orifice-like structure exists inside of node 636 (see the GIS data and the attached photos in Appendix A of this report). The structure at node 636 is unique, and future improvements or adjustments in this area should maintain the original intended performance characteristics. There is no recommendation for an improvement at this structure resulting from the current study— this comment is merely a caution.

8. Georgetown Blvd Drainage Improvements

The following recommendations will help to alleviate flooding caused by the 10-year design storm. This project would be a difficult retrofit due to site constraints, and the City may decide not to pursue it for feasibility reasons. Alternatively, the project could be accomplished as part of future redevelopment projects.

Due to existing constraints, this improvement is configured to relieve 10-year flooding. Achieving a higher level of protection, say to the 50-year level, would not be economically feasible.

Recommended improvements to this area include:

1. From Nodes 643 to 644: Add one (1) 36-in RCP to the existing 36-in RCP.
2. Node 645: Construct a detention basin with a top of bank area equal to 0.72 acres, and side slopes of 3H:1V. The vertical distance from the pond invert to top of bank should be 8.0 ft., and the total storage volume should be approximately 4.0 acre-feet.
3. From Nodes 644 to 645: Replace existing 48-in RCP with double 48-in RCPs. The new RCPs should drain into the basin.
4. From Nodes 645 to 646: Place a single 60-in RCP connecting the basin outfall to the existing 60-in CMP downstream.

9. Allison Drive Drainage Improvements

The following recommendations will help to alleviate flooding caused by the 10-year design storm, as is required for residential areas. Providing additional system capacity (in excess of 10-year storm) could require costly improvements that are not feasible given Master Drainage priorities and funding availability.

Recommended improvements to this area include:

1. From Nodes 672 to 673: Replace existing 36-in RCP with a single 42-in RCP.
2. From Nodes 673 to 674: Replace existing 30-in PVC with a single 42-in RCP.
3. From Nodes 674 to 675: Replace existing 30-in PVC with a single 42-in RCP.

10. Eden Way Lakes Drainage Improvements

The purpose of these improvements is to limit the peak water surface elevations during storm events in the lakes along Eden Way (to the west of these improvements) to a maximum elevation of 16.0 ft. for the 100-year design storm.

Recommended improvements to this area include:

1. Node 322.2: Replace existing structure with a weir and endwall configuration (similar to the lake outfall at Indian River Middle School at node 468.1). The weir crest elevation should be 10.0 ft. and weir length should be a minimum of 20 ft.
2. From Nodes 322.2 to 323: Replace existing triple 48- in RCPs with four (4) 60-in RCPs. The proposed pipes should be placed with invert elevations of 8.0 ft. (upstream) and 7.5 ft. (downstream). Alternatively, a single 6-ft x 10-ft box could be placed and given the same proposed inverts.
3. From Nodes 323 to 324 (optional – due to maintenance issues): Replace triple 54-in RCPs with a single 6-ft x 10-ft box culvert. This improvement will help in the reduction of future blockages caused by tree branches and other large objects.

There is excess flood storage capacity in the existing retention basin at node 266. If desired in the future, a roadway could be extended over the existing basin, reducing the basin storage by as much as 15 percent (15%). In other words, the existing basin can be partially filled in, as long as 85 percent or more of the current capacity is maintained. Such filling would still meet the design criteria of limiting the peak water surface elevations during storm events in the lakes along Eden Way to a maximum elevation of 16.0 ft. for the 100-year design storm.

Master Drainage Plan Caveats

The goal of this type of study is not to relieve *all* flooding, but rather to identify Master Drainage Facility improvements that can be feasibly constructed. It is also important to consider that neighborhood and commercial parcel drainage and stormwater systems are neither required nor designed to accommodate flooding from extreme events such as the 50-year storm.

One important caveat to keep in mind is that the system, as modeled for this study, assumes a well-maintained system. Debris, sediment, pipe collapses and other maintenance issues can cause very real flooding that must be addressed. In this respect, this study highlights *capacity* issues rather than *maintenance* issues (which are best resolved from inspection or citizen reports). There is good reason to create the models in this manner. If poor maintenance conditions are modeled, the capacity problems could easily be masked to the extent that public funds could be spent unnecessarily.

These models should also be useful for obtaining starting hydraulic grade line elevations for design purposes on smaller development projects, and for designing stormwater management BMPs on specific sites. URS is providing the models completed for this study to the City in the hope that future engineering efforts will build upon this effort.

Findings or recommendations contained herein do not constitute Corps of Engineers approval of any project(s) or eliminate the need to follow normal regulatory permitting processes.

Contact Information

Mr. Sam Sawan, PE (757.382.6101) served as the project manager for the City of Chesapeake on this project. Mr. Mark Mansfield, Chief Planning and Policy Branch, and Mr. Walter Trinkala, Engineering Technical Specialist (757.201.7610) represented the Corps of Engineers, Norfolk District. Mr. John Paine, PE, PH, CFM was the project manager for URS. The modeling evaluations and report were produced by Hai Tran, PE. QA/QC was provided by John Paine and Stephanie Hood, PE. Additional production assistance was provided by Libby Ludwig (757.873.0559).