Storm Water Management Model

Oak Grove Watershed MDPU

Master Drainage Plan

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US Army Corps of Engineers
Norfolk District

Chesapeake VIRGINIA
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URS Corporation

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Chesapeake, VA

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Executive Summary

Engineers from the U.S. Army Corps of Engineers, City of Chesapeake, and URS Corporation have completed a drainage study of the Oak Grove 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 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. Engineers analyze the watershed using anticipated future land use and imperviousness, and identify locations and volumes of computed flooding in the modeling.

After analyzing existing and potential problems in this watershed, the engineering team has identified four specific projects that can alleviate future flooding in the subject watershed. None of these projects are considered Master Drainage Facilities (MDF's) because their contributing drainage area is less than 320 acres. These projects can be carried forward with some assurance that the impacts on the watershed as a whole have been adequately considered. They could be funded 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, economic considerations, and other regulatory issues may effectively impact future development.

The City has identified several locations, throughout the subject watershed, in which chronic flooding has been an issue. The SWMM model confirmed flooding at these locations, as indicated in Figure 8. The City confirmed that other locations have either already received recent drainage improvements, or that previously reported flooding was due to maintenance issues.

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 Oak Grove Watershed covering approximately 4,590 acres.

The Oak Grove Watershed is located in the middle of Chesapeake, bordered on the west and northwest by the Crestwood Watershed, on the north by Indian River Watershed, on the east by the Northside Canal Watershed, and on the south by the Albermarle and Chesapeake Canal. Runoff from the Oak Grove Watershed discharges into two outfalls: the southeast portion (about 732 acres) discharges into the Intracoastal Waterway, while the rest of watershed discharges into the Southern Branch of the Elizabeth River.

In order to compute and distribute runoff throughout the models, the watershed was delineated into 231 subcatchments, as indicated in figures 1, 3, and 4. Most areas are well developed and there is a strong likelihood for expanded development in the future. The Oak Grove Watershed has recently received several stormwater improvements including the Kempsville Road widening and Arboretum ditch outfall culvert improvements. Other stormwater improvement projects that are scheduled for the near future include the on-site detention basins at City Park and the Tapestry Apartments complex. The City will use this study to verify whether or not these improvements, as previously designed, are adequate. Generally, the City prefers to create on-site detention facilities to handle increased runoff from new development rather than disturb natural streams.

This study addresses existing drainage and stormwater issues, as well as expected future conditions. The entire SWMM model has 442 nodes and over 467 links, providing sufficient detail and modeling resolution for master drainage planning purposes.

Findings from a 1985 study entitled *Southern Branch of Elizabeth River Drainage Basin–Oak Grove Sub-Basin Study* were incorporated into the current Oak Grove Watershed MDPU study, as summarized below.

The Southern Branch of Elizabeth River Drainage Basin–Oak Grove Sub-Basin Study was conducted in April of 1985 by Gannett Fleming Corddry & Carpenter. The study concentrated on the Chesapeake General Hospital, portions of the Greenwood Estates subdivision on the east, the Essex Meadows Subdivision to the north, parts of Greenbrier Parkway and Butts Station Road to the west and to the Great Bridge Bypass on the south. The entire area studied drains approximately 1,483 acres to the twin 6-ft. x 8-ft. box culverts under Great Bridge Bypass, where the channel passes into the wetlands bordering the Albemarle and Chesapeake Canal, before flowing into the Southern Branch of the Elizabeth River. Recommended improvements for the area were:

1. The existing channel upstream of the bypass to Kempsville Road would be widened to a 30-foot bottom width.
2. The crossing at Kempsville Road would be improved by removing the existing triple 48-inch pipes, providing two 6-ft. x 6-ft. box culverts and raising the minimum road elevation to 12.0 feet (MSL).
3. The channel running from nodes 278 to 280 should be excavated to a 30-foot bottom width.
4. On-site detention ponds should be used for future development in the Knell's Ridge vicinity.
5. Replacing the 24-inch culvert under Clearfield Avenue with 42-inch pipe.
6. The roadside ditch along Kempsville Road from Clearfield Avenue to the main channel should be reshaped with a 2-foot bottom width and 2H:1V side slopes.
7. Replacing the twin 18-inch culverts under Old Oak Grove Road with twin 48-inch culverts.
8. The channel running from nodes 345 to 360 should be excavated to a 10-foot bottom width.
9. Add one 42-inch diameter culvert under Battlefield Boulevard at Oak Grove Road.
10. Add one 66-inch pipe at Green Tree Road.
11. Replace the pipe at the intersection of Green Tree Road and Oak Grove Road with a 54-inch culvert. A new channel is required from nodes 265 to 276 to accommodate the new culvert.

Improvements 2, 5, 6, 7, 9, and 10 above have been implemented with some differences in dimensions and approaches.

In addition to the previous studies, the City of Chesapeake provided URS with several plan sets for projects within the subject watershed, some of which have been approved for construction but have not yet been completed. As directed by the City, URS modeled these as 'existing' conditions. While some of these developments are not expected to be complete by the end of this study, they were considered as "existing conditions" because it is likely when a project receives City approval that it will be completed in the near future, and the City would like these specific projects to be represented in the existing conditions models.

The City of Chesapeake surveyed selected points in the Oak Grove 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 inverts, pipe type and sizes, 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 small 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 nodal surcharges are stored as they escape from the node, then released back into the system as water surface elevations recede. 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.

URS engineers made one exception to this average-ponding-area approach for modeling the Oak Grove Watershed. Specifically, ponding areas within the Arboretum ditch (from nodes 280 to 364) were digitized using GIS contours. The proximity and configuration of residential buildings, historical flooding along the Arboretum ditch, and the City's preference to avoid disturbing conditions and grounds within the Arboretum justified this exception.

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), Existing Hydraulics with Future Hydrology (Scenario 2), and Future Hydraulics 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 2009. Channels are modeled using their existing (2009) 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 were used 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. Dominion Lakes
2. North Trail at the Arboretum Green Tree Road
3. Winston Trace, Sec.1&2
4. Dominion Forest
5. Gainsborough Square Condominiums
6. The Preserve on the Elizabeth
7. Kempsville Road (Rte.190)
8. Riverwalk Estates (As Built)
9. River Walk, Sec. MC-3, Phase1
10. River Walk, Sec. MC-1
11. River Walk P.U.D., Sec. B-2
12. Habour Cove Condo
13. River Pines, Sec. 2
14. Driftwood for Meadows
15. Oakbrooke Bus. And Tech. Center
16. Clearfield Ave. Roadway Improvement
17. English Oaks
18. The Woods of Whitehurst, Ph. 2
19. Lincolnshire
20. Peyton Estates
21. Checkered Flag Nissan
22. Republic Medical Building

23. B. Cross Property
24. Gainsborough Marketplace
25. Carroll Williamson Jr. Property
26. Priority Honda
27. Williamson Property
28. Magnolia Chase
29. River Arch Village
30. All Safe Self Storage
31. Alta Great Bridge Apt.
32. Cottage At Great Bridge II
33. Cottage At Great Bridge
34. Riverwalk Commerce Center
35. River Oak Church
36. Fernbridge
37. Oscar Smith High School
38. Oak Bridge Forest Ph. 1&2
39. GreenBrier Shoppes Additions
40. Greentree Commons
41. Oak Grove Sub-Basin Study
42. Alta Bay Apartments
43. Oakbrooke Crossing
44. Oak Grove Connector

Scenario 2 Future watershed hydrology with the drainage system configured as it existed in 2009. Channels are modeled using their existing (2009) conditions as well. This is the "Scenario 2" model. This scenario will show the flooding effects of the existing drainage system due to future land use development. In other words, if no improvements are made to the current drainage system and the remainder of the watershed is constructed as described by the City's 2005 Adopted Land Use Plan, these are the locations and volumes of flooding that can be expected.

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 eliminate flooding on a Master Drainage Facility level (i.e. facilities serving 320 or more acres) and/or any specific areas which City anticipates as future projects. Additionally, this scenario includes future plans previously identified by the City. The following is a list of plan sets, provided by the City, that was added to the future conditions model:

1. Drainage Study of Knell's Ridge Extension & Tapestry Apartments
2. Knell's Ridge Blvd. Extension
3. Tapestry Place Apartments
4. Tapestry Park Apartments Post Development
5. Future City Park

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

1. City Park Outfall Improvements
2. Tapestry Outfall Improvements

3. Chesapeake General Hospital Outfall Improvements
4. South Clearfield Outfall 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 City has identified six locations within the Oak Grove Watershed where chronic flooding has been an issue. These areas include (refer to Figure 6 and/or the GIS files for node locations):

1. Hollywood Drive (node 153)
2. Mapleshore Drive vicinity (nodes 728, 734, 736)
3. Doria Trail and Andrea Lane (node 706)
4. Arboretum channel outfall (node 364)
5. Arondale Crescent vicinity (node 842)
6. Welch Lane, Allsafe Storage vicinity (node 403)

The SWMM model confirms flooding at all six of these locations as well as showing potential flooding elsewhere if future developments are constructed without any additional stormwater controls.

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 conditions were modeled as constant water surface elevations of 3.60 feet and 2.30 feet (NAVD88) in the Southern Branch of the Elizabeth River and Intracoastal Waterway, respectively. Due to the natural topography and wide floodplains, the water surface elevations in the upper portions of this watershed are not very sensitive to the downstream boundary water surface elevations used in these models.

The GIS analysis prepared in support of this modeling indicates that the Oak Grove Watershed will increase from **35.8** to **42.2** 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 noticed that there are areas in the City's GIS showing lower imperviousness than actually exists. For example, the City's GIS Land Use data indicates Royal Road Court having medium-density residential (25% imperviousness) land use, when it is in fact high-density residential (50% imperviousness). Another example is the apartment complex at Willow Green Court, which is listed as high-density residential (50% imperviousness) land use, but is obviously at least 85% impervious. URS and City engineers concurred that imperviousness values in these areas needed to be adjusted in Scenarios 1, 2, and 3.

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 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

Because the Chesapeake Regional Airport is located five miles or more from the Oak Grove Watershed, only a small portion is located in an Airspace Protection Area (as indicated by the dashed line in Figure 10). None of the recommended future improvements is within the Airspace Protection Area, so requirements in FAA Advisory Circular No. 150/5200-33B, "Hazardous Wildlife Attractants On or Near Airports" do not impact the proposed 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.

Four specific projects were conceived and incorporated into the modeling during the course of this study. None of them will be considered an MDF improvement because their contributing drainage areas are less than 320 acres. All four projects appear to be feasible from a preliminary planning standpoint, but issues such as future wetlands delineations, site details, and the ability to acquire rights-of-way or parcels of land may necessitate modifications as these projects move forward. These four projects are shown in Figure 10 and are included in the future modeling scenario (Scenario 3). Refer to Figures 7 and 10 of this report to find link and node numbers and to view the locations of improvements that are referenced in the following project summaries. In some cases, due to the tight proximity of links and nodes, and the text size of their labels, it may be easier to view these links and nodes using the GIS files provided with this report.

As indicated in Figures 1 and 3, some large parts within this watershed are currently undeveloped. The timing of future development will affect which projects have to be done when. Figure 5 presents potential increases in imperviousness based on future build out according to the City's comprehensive land use plan. Other factors can affect future imperviousness, such as agreements between regulatory agencies. Likewise, although zoning may allow development, wetlands restrictions may further limit 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. City Park Outfall Improvements

Future imperviousness will increase if this site is developed. Given that the existing ground cover is extensively grass and woods, future development must carefully address stormwater management to prevent downstream erosion and flooding that could result from substantially increased runoff volumes.

Recommended improvements to this area include:

1. Node 123: Construct a retention basin with a top-of-bank area equal to 150,000 square feet and side slopes of 4H:1V. The normal water surface elevation should be at 8 feet. Freeboard from the normal water surface to the top of bank should equal 8 feet, and the total storage volume should be 23.5 acre-feet. The exact layout can be determined in the future, but the shapes depicted should work for stormwater management purposes as long as the same storage volume is provided.
2. From node 120 to 123: Connect future double 60-inch RCPs to the retention basin (node 123).
3. From node 123 to 125: Construct double 42-inch RCPs connecting the basin outfall to the existing ditch at node 125.

2. Tapestry Outfall Improvements

Future imperviousness will increase if this site is developed. Given that the existing ground cover is extensively forested, future development will heavily increase runoff to downstream locations. To avoid adverse impacts, a storage basin is recommended. The exact layout can be determined in the future, but the shape depicted should work for stormwater management purposes as long as the same storage volume is provided.

Recommended improvements to this area include:

1. Node 518: Construct a retention basin with top-of-bank area equal to 103,000 square feet and side slopes of 4H:1V. The normal water surface elevation should be at 12 feet. Freeboard from the normal water surface to top of bank should equal 5 feet, and the total storage volume should be 10.4 acre-feet.
2. From nodes 518 to 525: Construct one 30-inch RCP connecting the basin outfall to the existing culvert at node 525.

3. Chesapeake General Hospital Outfall Improvements

Increases in imperviousness due to future development in this area could greatly affect the downstream outfall at Chesapeake General Hospital (Battlefield Boulevard culverts). This project will mitigate downstream flooding from future development.

Recommended improvements to this area are:

1. Node 208: Expand the existing retention basin to a top-of-bank area equal to 111,000 square feet (from 53,000 square feet) and side slopes of 4H:1V. The normal water surface elevation should be at 11.91 feet (the same as the existing outfall). Freeboard from the normal water surface to top of bank should equal 6.1 feet, and the total storage volume should be 13.0 acre-feet (from 5.5 acre-feet).
2. From node 207 to 208: Re-route the existing channel to the retention basin (node 208).
3. From node 208 to 210: Remove blockages and clean the existing basin outfall.

4. South Clearfield Avenue Outfall Improvements

Future imperviousness will increase if development occurs in this area. Given that the existing ground cover is extensively agricultural, future development must carefully address stormwater management to prevent downstream erosion and flooding that could result from substantially increased runoff volumes.

Recommended improvements to this area are:

1. Node 394: Construct a retention basin with a top-of-bank area equal to 150,000 square feet and side slopes of 4H:1V. The normal water surface elevation should be at 2.2 feet. Freeboard from the normal water surface to top of bank should equal 5.2 feet, and the total storage volume should be 16.1 acre-feet. The exact layout can be determined in the future, but the shape depicted should work for stormwater management purposes as long as the same storage volume is provided.
2. From node 394 to 397: Construct one 48-inch RCP connecting the basin outfall to the existing ditch at node 397.

Arboretum Ditch

Flooding is also indicated in the City Arboretum channel (node 280) for events in excess of the 10-year storm. Downstream culverts were designed and constructed so that the Arboretum channel would provide floodplain and stormwater storage, so the modeling confirms that the system from nodes 151 to 364 is working as an impoundment area, as intended.

The weir at Chesapeake General Hospital (node 219) is primarily designed to restrict flows from small storm events. Under Scenario 2 (future imperviousness without additional drainage and stormwater management improvements), the 10-year flood volume at node 280 would more than double. However, if Improvements 1 and 3 are constructed, flooding at node 280 would be slightly less than that which occurs under existing conditions.

A 1985 study by Gannett Fleming recommended raising Kempsville Road to elevation 12.0 on the Mean Sea Level datum, which is approximately 11.1 feet on the NAVD88 datum. The goal was to provide additional flood storage in the Arboretum property. The modeling performed for the current MDPU study indicates that Improvements 1 and 3 will provide adequate upstream storage, and that raising Kempsville Road is not required for flood protection. In fact, raising the road now would be detrimental to apartment buildings that have been constructed near node 280, and should therefore not be done.

As modeled in Scenario 3, the 100-year flood elevation at node 280 (near the apartment buildings) will be the same as for Scenario 1 existing conditions.

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 Carol Wilkinson (757.873.0559).