Storm Water Management Model

Bailey Creek Watershed MDPU

Master Drainage Plan

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URS
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Storm Water Management Model

Bailey Creek Watershed MDPU

Chesapeake, VA

URS Nos. 11658067

Executive Summary

Engineers from the City of Chesapeake (City) and URS Corporation (URS) have completed a drainage study of the Bailey Creek 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 five specific projects that can alleviate future flooding in the subject watershed. Some of these projects are not considered Master Drainage Facilities (MDFs) because their contributing drainage area is not greater than 320 acres.

These five 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, development sequencing, 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.

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.

Background

URS was directed by the City of Chesapeake to conduct a study of the Bailey Creek Watershed, covering approximately 3,425 acres. The Bailey Creek Watershed is located in the Western Branch section of Chesapeake and is bordered on the east by the City of Portsmouth, on the south by the Goose Creek watershed, and on the west by the City of Suffolk. Runoff from the Bailey Creek Watershed discharges into the Western Branch of the Elizabeth River.

The watershed was delineated into 78 subcatchments (for existing conditions) in order to compute and distribute runoff throughout the entire watershed. As further analysis was conducted for the future conditions, some subcatchments were further divided or modified to reflect how the watershed will handle stormwater from additional development. The Bailey Creek Watershed is well developed in the southeast portion of the watershed and currently has large tracts of land available for potential future development. This study addresses existing drainage and stormwater issues, as well as expected future conditions. The entire SWMM model has over 150 nodes and 170 links, providing sufficient detail and modeling resolution for master drainage planning purposes.

Portions of Suffolk drain through the western side of the Bailey Creek Watershed. In order to determine the appropriate runoff volume from Suffolk, URS used the Suffolk-approved zoning as defined in Suffolk's City basemap.mdb file. The approved zoning, and associated imperviousness, was used for the future condition scenarios. In order to derive the existing condition imperviousness, aerial imagery was used to find undeveloped areas. These areas were labeled "vacant" and given a five-percent associated imperviousness.

A drainage study for the Bailey Creek Watershed was previously completed in September 1986 by Gannett Fleming Corddry & Carpenter. The study separated the watershed into three study areas: Gum Road Outfall; Western Branch Park Outfall; and Jester Gardens Outfall. Over the past two-and-a-half decades since this study has taken place, much has changed in the Bailey Creek watershed, including the construction of Interstate I-664. Other changes include road names such as Jolliff Road became Old Jolliff Road and portions of Gum Road became the new Jolliff Road. Recommendations for culvert improvements were made in this study and while some recommended improvements were constructed (either as suggested or as a modified version of the study recommendation); other recommended improvements were not made. Recommended improvements that were not done include the culvert under Jolliff Road, North of I-664 (Gum Road in 1986) at nodes 224 to 244, and the culverts under Old Jolliff

Road (Jolliff Road in 1986 at nodes 294 to 296). Those two locations are highlighted because they are crossings that are included in the recommended improvements discussed later in this report.

In addition to the previous study, 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 one exception to this is the "Plan and Profile of Proposed State Highway Portsmouth Boulevard" plan set. This preliminary plan set was incorporated into the future conditions models as described later in this report.

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—the past study, 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. In areas where nodal flooding occurs, the nodal ponding area can be adjusted based on detailed topographic information at the node.

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 2012. Channels are modeled using their existing (2012) 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 a few approved projects not yet constructed):

1. Portsmouth Blvd. Shopping Center, "Phase One"
2. Chesapeake Square Commons
3. Grading Plan of Candlewood Suites - Lot D
4. Chesapeake Square Mall - Parcel G
5. McDonald's - Remodel Site Plan
6. Jolliff Woods Section 3
7. Jolliff Woods - Section Four
8. Jolliff Woods - Section 4B
9. West Chadswyck Terrace Section V
10. West Chadswyck Terrace Section 7

11. West Chadswyck Terrace Section 8
12. Dock Harbour Subdivision
13. Subdivision of Waterstone
14. Amelia Estates - Sewer & Storm Drainage Construction Record Drawings
15. Lisa's Cove
16. King's Pointe at Western Branch
17. Leeward Dr. Box Culvert Plan & Profile
18. Portsmouth Blvd. Extension - Box Culvert & Utility Relocations
19. Chesapeake Square Mall for Chesapeake J.C.P. Associates Ltd.
20. Olde Woodland Estates
21. Olde Woodland Estates-Phase 2
22. Lori Place
23. Weaver Spring
24. West Chadswyck Section 5 (Subdivision of Bailey's Creek)
25. Happy Boxes Located on Gum Road
26. Crossroads Shopping Center
27. Crossroads Shopping Center
28. Chesapeake Center
29. Portsmouth Blvd. Extension Coffman Blvd. to Capri Circle
30. West Chadswyck Terrace
31. Raleigh Place
32. Western Branch Community Church Phase 1B
33. Jolliff Landing Commercial Center Subdivision, Phase I
34. Plan and Profile of Proposed State Highway I-664
35. Chesapeake Center Portsmouth Blvd.
36. Wal Mart Supercenter & Sam's Club
37. Western Branch Elizabeth River Drainage Basin

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 2012; however, one future plan set identified by the City has been added to 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 set in place) due to future land use development. The following plan set, provided by the City, has been added to this Scenario 2:

1. Plan and Profile of Proposed State Highway Portsmouth Boulevard

During the early stages of this study, the Pine Grove project was anticipated to be built in the future—which would become part of the future scenarios. The Pine Grove Master Plan was provided by the City and indicated not only land use changes but also a modification to the existing drainage divides. During this study Pine Grove was rejected by the City Council and therefore will not be constructed as shown in the Pine Grove Master Plan. It was further stated by the City that even though the plan was rejected, it is still anticipated that the area will be rezoned to medium density mixed use. This scenario will show the flooding effects of the existing drainage system (with the added future plan set in place) due to future land use development.

During this study the City also received preliminary plans (titled above) for the widening of Portsmouth Boulevard—from the Suffolk/Chesapeake City line to the

westbound ramp to Interstate I-664. These plans also include the stormwater retention pond that is proposed to handle all of the runoff from the newly widened road design.

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) as well as key locations identified by the City.

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

1. Jolliff Road—North, BMP and Channel Improvements
2. Jolliff Road to I-664, BMP and Culvert Improvements
3. Old Jolliff Road Culvert and Channel Improvements
4. Jolliff Road—South, BMP and Channel Improvements
5. Dirt Road Culvert Improvement

These scenarios depict 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 Western 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 Bailey Creek Watershed will increase from **27.75** to **45.86** 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 through C-4 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 figures 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). Tables C-1 through C-4 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 through C-4 and D-1 through D-4 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.

Five specific projects were conceived and incorporated into the modeling during the course of this study, two 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 five 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 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.

The City of Chesapeake recently received the preliminary plans for the widening of Portsmouth Boulevard—from the Interstate I-664 on ramp to the Suffolk/Chesapeake city line. These plans were incorporated in the future conditions models to reflect the impact of that construction. The existing culvert passing under Portsmouth Boulevard at the city line is a 24-inch-diameter concrete pipe. The preliminary plans have not yet established a new proposed pipe size for that crossing. The City requested that URS model that crossing—increasing the pipe diameter—in order to maximize the capacity of that culvert without creating a need to make further improvements in the downstream drainage system, in addition to the recommendations below. During the modeling process of Scenario 3, the crossing at the city line remained a 24-inch culvert while all five of the below recommendations were derived. After the five recommended improvements were in place, the city line culvert pipe size was enlarged to a 30-inch concrete pipe for the 50-year storm event. As was expected, the larger pipe allowed additional flows in the downstream drainage system. Because this downstream system is already at maximum capacity at key locations for future conditions, it is not recommended that the culvert at the city line, under Portsmouth Boulevard, be upgraded from a 24-inch pipe without simultaneously providing additional improvements (in addition to the five recommendations below) to the downstream system.

1. **Jolliff Road – North, BMP and Channel Improvements**

   This improvement is not considered a Master Drainage Facility because its contributing drainage area is less than 320 acres. The following recommendations will help to alleviate flooding caused by the 10-year design storm. Recommended improvements to this area include:

   1. Node 222: Construct a BMP (dry detention pond) by placing a berm with a top of bank elevation equal to 18.0 feet. The total storage volume for the BMP should be 22.5 acre-feet.
   2. From Nodes 222 to 223: Place double 24-inch outfall pipes with inverts equal to the pond bottom. Construct a trapezoidal emergency spillway with a crest elevation 8 feet above the pond bottom, with a 10-foot crest length and 2(H):1(V) side slopes.
   3. From Nodes 214 to 222: Modify 300 linear feet of existing channel to represent a trapezoidal channel with a 30-foot bottom width and 2(H):1(V) side slopes.
   4. From Nodes 220 to 222: Modify 200 linear feet of existing channel to represent a trapezoidal channel with a 30-foot bottom width and 2(H):1(V) side slopes.

   Note: The size and shape of the BMP, as well as its outfall pipes and/or structures, are subject to change based upon future determinations. New Commonwealth of Virginia Runoff Reduction design standards can also be used to offset the storage requirements.

2. **Jolliff Road to I-664, BMP and Culvert Improvements**

   This improvement is not considered a Master Drainage Facility because its contributing drainage area is less than 320 acres. The following recommendations will help to alleviate flooding caused by the 10-year design storm. Recommended improvements to this area include:

   1. Node 410: Construct a BMP (dry detention pond). The total storage volume for the BMP should be 6.8 acre-feet.

2. From Nodes 410 to 412: Replace the existing 24-inch culvert with a new 36-inch culvert. Lower the proposed culvert inverts to promote positive drainage towards the downstream direction.

Note: The size and shape of the BMP, as well as its outfall pipe and/or structures, are subject to change based upon future determinations. New Commonwealth of Virginia Runoff Reduction design standards can also be used to offset the storage requirements.

3. Old Jolliff Road Culvert and Channel Improvements

This improvement is considered a Master Drainage Facility because its contributing drainage area is greater than 320 acres. The following recommendations will help to alleviate flooding caused by the 50-year design storm. Recommended improvements to this area include:

1. From Nodes 294 to 296: Replace the existing double 36-inch culverts with five (5) 3-foot by 5-foot box culverts. Lower the invert elevations and re-grade the channel upstream to promote positive drainage in the downstream direction.
2. From Nodes 296 to 298: Modify to create a trapezoidal channel with a 100-foot bottom width and 3(H):1(V) side slopes.

Note: Improvements needed to eliminate the flooding associated with the 50-yr storm at Node 294 do not necessarily need to be done by the City at this time. This is a crossing under Old Jolliff Road. Currently the road traversing north past this crossing only services a single structure. If future development is proposed in this area, the improvements may become the responsibility of the developer.

4. Jolliff Road – South, BMP and Channel Improvements

This improvement is considered a Master Drainage Facility because its contributing drainage area is greater than 320 acres. The following recommendations will help to alleviate flooding caused by the 50-year design storm. Recommended improvements to this area include:

1. Node 169: Construct a BMP (dry detention pond) by placing a weir structure just upstream from the four existing 3-foot by 5-foot box culverts under Jolliff Road (Nodes 170 to 172). The total storage volume for the BMP should be 83.7 acre-feet.
2. From Nodes 169 to 170: Place a rectangular stepped-weir with a total crest length of 40 feet and crest height above pond invert to equal 5 feet. The weir notch crest length should be 3 feet and a crest height above the pond invert of 3 feet.
3. From Nodes 169 to 170: Create a 24-inch diameter circular orifice in the bottom to promote complete drainage and to handle low flows.
4. From Nodes 168 to 169: Modify 50 linear feet of existing channel to be a trapezoidal channel with a 50-foot bottom width and 3(H):1(V) side slopes.

Note: The size and shape of the BMP, as well as the weir structure are subject to change based upon future determination. New Commonwealth of Virginia Runoff Reduction design standards can also be used to offset the storage requirements.

5. Dirt Road Culvert Improvement

This improvement is considered a Master Drainage Facility because its contributing drainage area is greater than 320 acres. The following recommendations will help to alleviate flooding caused by the 50-year design storm. Recommended improvements to this area include:

1. From Nodes 138 to 140: Replace the existing 42-inch culvert with three (3) 48-inch RCPs at the same invert elevations as the existing culvert.

Alternatively, if the existing 42-inch culvert is in good condition, it can remain in place and three (3) additional 42-inch RCPs can be placed adjacent at the same invert elevations as the existing culvert.

Note: Improvements needed to eliminate the flooding associated with the 50-yr storm at Node 138 do not necessarily need to be done by the City at this time. This is a crossing under a private dirt road that only services farm fields. Currently if this area floods above the ground elevation, the road will act as a weir and the stormwater will flow over the dirt road to the ditch on the other side. If future development is proposed in this area, the improvements may become the responsibility of the developer.

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.

Contact Information

Mr. Sam Sawan, PE (757.382.6101) served as the project manager for the City of Chesapeake on this project. Mr. John Paine, PE, PH, CFM was the project manager for URS. The modeling evaluations and report were produced by Stephanie Hood, PE. QA/QC was provided by John Paine and Sean Bradberry. Additional production assistance was provided by Libby Ludwig (757.873.0559).