Storm Water Management Model

New Mill Creek Watershed MDPU

Chesapeake, VA

URS No. 11656366

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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 New Mill Creek Watershed using the Storm Water Management Model (SWMM) computer program. This study began in 2005 and was completed in 2006.

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. The watershed is analyzed using anticipated future land use and imperviousness, and locations and volumes of computed flooding are identified in the modeling.

After analyzing existing and potential problems in this watershed, URS has identified five specific projects that can alleviate future flooding in the subject watershed. Preliminary cost opinion computations, provided in a separate Cost Appendix, indicate that all five projects are financially feasible. 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 probably be constructed as part of private development initiatives with little or no cost to the City.

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 peak computed water surface elevations at each modeled node are presented in Appendix C for existing conditions, future conditions, and for future conditions with environmental restoration projects in place (i.e. the "environmental restoration" scenario).

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 substantiates that the prescribed improvements have been or will be effective in reducing future storm water flooding in the area.

As part of the cost sharing agreement between the City of Chesapeake and the U.S. Army Corps of Engineers, improvements to the New Mill watershed must include features that address water quality as well as master drainage and flood mitigation requirements. This study was authorized by Resolution of the Committee of Transportation and Infrastructure of the U.S. House of Representatives, Docket 2674, Dismal Swamp and Dismal Swamp Canal, Chesapeake, Virginia, adopted 22 May 2002, which states in part "*…to determine whether modifications to the existing project are advisable to address flooding problems, environmental restoration and protection, and related water resources needs in the vicinity of the Dismal Swamp Canal in Chesapeake, Virginia.*"

The City of Chesapeake worked closely with URS to develop restoration and protection concepts that could be applied in this watershed to enhance environmental resources. These conceptual improvements were reviewed with Norfolk District Corps of Engineers staff, who also offered ideas for implementation of wetland and riparian habitat corridors. After field screening, Corps staff identified two potential environmental protection and restoration projects that can be used to meet the requirements of Docket 2674. One project involves constructing a wetland and riparian habitat corridor, while the other involves constructing channel benches along a portion of the existing Lindsey Canal.

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 and the U.S. Army Corps of Engineers to conduct a watershed study on the area of New Mill Creek 1 & 2, covering approximately 3,600 acres. The New Mill Creek Watershed is bordered on the west by the Dismal Swamp Canal and to the South by the Great Dismal Swamp. The runoff discharges to the northeast corner of the watershed to New Mill Creek and ultimately drains into the southern branch of the Elizabeth River. There are two primary drainage outlets, Willis Creek and the Lindsey Canal. The Willis Creek channel conveys flow from 1,400 acres passing under an 18-foot bridge at Cedar Road (link 13621) before leaving the watershed. The Lindsey Canal conveys flow from 1,850 acres passing under a 30-foot bridge at Cedar Road (link 15921). A third crossing under Cedar Road (link 16601), consists of a 48-inch pipe and conveys flow from less than 300 acres upstream.

The 3,600-acre watershed was delineated into 125 subbasins in order to distribute point sources for inflow throughout the entire watershed. New Mill Watershed is largely agricultural and contains several large, undeveloped tracts of land that are expected to be developed in the future. This study addresses existing drainage and storm water issues, as well as expected future conditions.

An overall Master Drainage Plan study for this watershed was completed in November of 1985 by Gannett Fleming Corddry & Carpenter. The study was conducted on all four New Mill Creek study areas: The Main Channel/Willis Creek (NM-1); Lindsey Canal (NM-2); Tributary 1/Grassfield (NM-3); and Tributary 2/Shillelagh Road (NM-4). URS was directed to conduct a drainage study of only NM-1 and NM-2. At the time of the 1985 study, the New Mill Watershed was predominantly undeveloped with 85% of the area as agricultural or wooded.

Several recommendations were made to NM-1 and NM-2 in order to reduce flooding throughout these areas for the 1985-version of future conditions. These recommendations included: increasing the Willis Creek Bridge at Cedar Road from an 18-foot span to a 30-foot span; increasing the Lindsey Canal Bridge at Cedar Road, from a 30-foot span to 50-foot span; and to widen the bottom of the Lindsey Canal starting at Number Ten Lane (25-foot) to Dominion Blvd (30-foot) to Cedar Road (45-foot).

It is important to note that this study reported the existence of double 8-foot-by-8-foot box culverts along the Lindsey Canal, under Dominion Boulevard. During the survey efforts for the 2005 study it was found that the crossing is in fact double 8-foot-by-12-foot box culverts. Upon reviewing this finding with the City of Chesapeake, it was determined that there is no known improvement to that crossing and therefore the double 8-foot-by-12-foot box culverts most likely existed during the 1985 study. The two bridge replacements were never constructed as recommended by the 1985 study. The Lindsey Canal improvements were also not constructed, with the exception of 2,700 linear feet of channel improvements made to the section upstream of Dominion Boulevard, adjacent to the West Road Estates subdivision.

In addition to the 1985 Master Drainage Study, the City of Chesapeake conducted a 1999 West Road Drainage Study. This study addressed significant flooding during the hurricanes and storm events of October and November 1999. During these storm events, Chesapeake received in excess of 24 inches of rain in a 45-day period. The study area started behind 1009 West Road with a 15-inch culvert and ended at the 48-inch culvert crossing at Cedar Road (from node 622 to 662 in Figure 5).

The following is a list of recommendations from the 1999 drainage study:

1. Clean and re-grade the farm ditch from 905 to 1009 West Road (from node 624 to 630 in Figure 5).
2. Replace the 15-inch farm ditch culvert behind 1009 with a 36- or 48-inch RCP (from node 622 to 624 in Figure 5).
3. 48-inch pipe culvert just downstream of Dominion Boulevard be replaced with a 60-inch RCP (from node 634 to 632 in Figure 5).
4. Double 30-inch pipes be replaced with a 60-inch RCP (from node 654 to 656 in Figure 5).
5. 48-inch culvert under Cedar Road received the recommendation of an additional culvert to be placed so that the minimum equivalent opening will be equal to that of a 60-inch pipe (from node 660 to 662 in Figure 5).

As of 2005, recommendation number 3 and a portion of number 1 had been completed. In July of 2000, plans were 'APPROVED FOR CONSTRUCTION' to replace the 48-inch culvert just downstream of Dominion Boulevard with a new 60-inch RCP. In addition, over 600 linear feet of drainage improvements were made to the West Road farm ditch from the upstream side of Dominion Boulevard to 929 West Road.

Upstream of the Willis Creek Bridge crossing (node 362 in Figure 5) there exists low-lying, widely spread contours that create natural floodplain storage for this watershed. URS modeled the existing and future conditions utilizing this 'true' storage.

The City of Chesapeake provided URS with several plan sets for projects within the subject watershed, two of which have been approved for construction but have not yet been completed. The U.S. Route 17 and the Borrow Pit Recreation Lake were still under construction during the 2005 URS study. As directed by the City, URS modeled these as existing conditions. While these two developments were not expected to be complete by the end of this study, they were considered "Existing Conditions" since the approval of the project assures its near-future development. 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 three main sources—plan sets, survey data, and GIS data—to extract channel and infrastructure information, such as inverts, pipe type and size(s), and channel characteristics, throughout the subject watershed.

The City did not provide URS with any plan sets to be considered in the future conditions modeling. However the future conditions models consist of the future hydrology (reflecting the City's 2005 Adopted Land Use and Transportation Plans as applied to the New Mill Creek Watershed) along with the recommended improvements identified by URS, described elsewhere in this report.

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 Update Report presents the findings of the application of this methodology to the subject watershed.

Modeling Configurations

Three modeling configurations—Existing, Future, and Environmental Restoration—were developed for this study as described below.

Existing — Existing watershed hydrology with the drainage system configured as it existed in 2005. Channels are modeled using their existing (2005) conditions as well. This is the "existing conditions" model. A few approved development plans were considered in the existing conditions model even though construction of these projects had not been completed prior to this study. The City of Chesapeake requested that the following plan sets be considered as 'existing' because they have been approved prior to the start of this study:

1. U.S. Route 17
2. Borrow Pit Recreation Lake

Future — Future watershed hydrology with the future drainage system configuration as envisioned by the City of Chesapeake and URS. This is the "future conditions" model. There were no future development plans identified by the City of Chesapeake, therefore the future drainage consists of improvements recommended by URS, which were discussed and reviewed with the City of Chesapeake.

These recommended improvements should largely eliminate flooding at key locations, where feasible, in the future conditions. These improvements were developed during this study, are highlighted in Figure 8, and specifically include the following projects:

1. Cedar Road / Willis Creek Crossing Improvement
2. Cedar Road / Lindsey Canal Crossing Improvement
3. West Road Farm Ditch Culvert Improvement
4. West New Mill Reach Channel and Culvert Improvements
5. Borrow Pit Lake Outfall Channel and Culvert Improvements

This configuration depicts future conditions with strategic drainage and storm water improvements in place. Additional details and descriptions regarding the improvements are presented elsewhere in this report. Cost opinions are presented in a separate Cost Appendix.

Environmental Restoration — Future watershed hydrology with the future drainage system configuration as envisioned by the City of Chesapeake and URS.

This configuration is the Future scenario (described above), with additional environmental restoration improvements in place, as described elsewhere in this report.

Modeling Results

Stable RUNOFF and EXTRAN runs were obtained for all modeling scenarios, with EXTRAN continuity errors well below 0.5 percent.

Boundary conditions (water surface elevations) at the downstream outfall were set in accordance with Chapter 5, Section Q of the City of Chesapeake Public Facilities Manual (July 2001 Edition). In all cases, for all return periods, the hydraulic boundary condition was modeled as a constant water surface elevation of 3.55 feet (NAVD88).

The GIS analysis prepared in support of this modeling indicates that the New Mill Creek watershed will increase from **17.2** to **27.9** 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 storm water runoff, which have been incorporated into the future conditions models.

Figures 7 and 9 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 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 computer models should be carefully checked.

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 peak computed water surface elevations at each model node are presented in Appendix C for both existing and future conditions, and for the environmental restoration scenario. The blue shading in Tables C-1 through C-3 indicates locations where the maximum computed water surface meets or exceeds the ground elevation for the node. Many of these nodal flooding locations are very small quantity or short duration events. In the SWMM EXTRAN 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) *but the flooded water is not re-introduced into the model for subsequent routing*. If flooding occurs at a choke point in the system, downstream nodes may have computed maximum water surface elevations less than what can actually be expected due to the volume of water being 'held' upstream. At nodes in Tables C-1 through C-3 where this phenomenon is probably occurring the maximum computed water surface is indicated in ***bold, red, italic*** type. The patterns of flooding can appear to be somewhat counter-intuitive due to the complexity of hydraulic routing. For example, a given node can flood for the 10-year event, but not for the 25-year event. This could be due to computed upstream flooding, or it could be due to the timing of flooding along other hydraulic pathways.

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-3 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 EXTRAN routing computations are performed at one-second intervals, and the EXTRAN output (*.out) 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 EXTRAN output data on the other hand contains a summary of the *exact* peak values. The EXTRAN output file summaries are used to prepare Tables C-1 through C-3, and 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 storm water 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.

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.

Back-to-Back Storms Analysis

The City of Chesapeake has flood storage requirements regarding back-to-back storms. Simply stated, detention and retention facilities must recover a substantial portion of the available flood storage 48 hours after a 10-Year Type II design storm event begins. A special SWMM analysis was constructed and run to produce the results indicated in Table D-1. As shown in the table, all of the storm water basins in the watershed should recover flood storage capacity adequately within 48 hours after the onset of a 10-year Type II storm, and all of them have ample excess storage capacity above the peak 10-year water surface elevation.

The City's back-to-back storm analysis requirements are not well understood in the consulting community, and have not been consistently applied from project to project. The ultimate intent is to produce good detention and retention facility designs that can recover a reasonable amount of flood storage capacity so that flood damage can be avoided if one severe storm is followed shortly by another.

The development of specific back-to-back storm evaluation criteria is problematic for several reasons. First, back-to-back 10-year (for example) storms comprise a hydrologic design event that has a return period well beyond 10-years, and designs to accommodate such an event can be very expensive to construct, or to retrofit. Secondly, the City's current criteria—to recover 90-percent of the peak storage capacity used 24 hours after the cessation of a 10-year design rainfall—does not address how much of the total storage capacity is being used, or how much total capacity is available at the beginning of the second storm.

For example, a large lake could have a relatively small outlet, designed to slowly release runoff (to avoid downstream flooding while reducing the need for significant downstream channel and culvert improvements). Such a design would recover the peak storage volume being used relatively slowly, and might not strictly meet the 90-percent-recovery criterion. Yet if the computed rise in the lake is relatively small, then only a small portion of the lake's total storage capacity is being used. There is a similar situation with the proposed lake at Node 520 in the New Mill Creek future conditions model. This lake has a 39-acre surface at its proposed normal pool elevation, which provides a very large storage potential. A small outlet is proposed in order to keep future downstream channel improvements to cost-effective and practicable levels while minimizing downstream flooding. The small outlet only allows 38 percent of the peak 10-year flood storage volume to be recovered 48 hours after the 10-year design storm begins, however at the peak 10-year water surface elevation, only 51 percent of this lake's total storage capacity is being used. Further analysis indicates that the *100-year* storm runoff can be fully stored in this lake with nearly one foot of freeboard. Or stated another way, this lake can store the 100-year design storm with approximately 40 acre-feet of excess capacity.

For the design of stormwater basins that serve small parcels or land areas, the computation and analysis of back-to-back design storms can be an expensive and complicated process. However in the context of a Master Drainage Plan analysis, once a SWMM model has been constructed, it is a relatively straightforward matter to directly analyze back-to-back design storms. Master Drainage Plan updates completed recently for the City include 2-, 5-, 10- 25-, 50-, and 100-year 24-hour design storm analyses. A 72-hour design hyetograph, consisting of two 24-hour design storms separated by a 24-hour period of no rainfall, could be incorporated into the engineering design requirements for large developments, and into the Master Drainage Plan analyses themselves. The effects of flooding from back-to-back storms could be analyzed directly in these contexts.

Based on our analyses of many ponds and lakes in several large watershed studies in Chesapeake, URS recommends that the City reevaluate its back-to-back storm criteria. The City could simplify the criteria while accomplishing the goal of better flood protection by requiring that:

1. All storm water detention and retention basins serving more than 320 acres must be analyzed using the City's 72-hour design hyetograph, which is two back-to-back 10-year NRCS Type II 24-Hour hyetographs separated by 24 hours of no rainfall.
2. The maximum computed water surface in the detention or retention basin must not exceed the lowest ground elevation adjacent to the basin when using this design storm.

These two requirements would be in addition to the City's other applicable criteria, including requirements for 50-year and 100-year design analyses. Much debate could occur over using back-to-back *10-year* storms, however the City could adopt this criterion and see how it impacts proposed basins.

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, three of which will reduce the effects of flooding within the subject watershed (two bridge replacement projects are not required to accomplish the goals of this Master Drainage Plan update, but are currently under design by the Department of Public Works). These projects are by no means exhaustive, but seem to provide a reasonable amount of flooding relief at reasonable costs. 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 8, and are included in the future (and environmental restoration) modeling scenarios. Use Figures 6 and 8 of this report to find node and link numbers and view the locations of improvements that are referenced in the following project summaries.

1. Cedar Road / Willis Creek Crossing Improvement

This project is estimated to cost approximately **$ 505,428** in 2006 dollars.

This project is not required in order to accomplish the goals of this Master Drainage plan update, however it is a project that is currently under design by the Department of Public Works.

Replace the Willis Creek Bridge on Cedar Road (link 13621) with 48 linear feet of double 10’ x 6’ concrete box culverts. The culverts shall be countersunk 6 inches into the bed of the existing channel. This countersinking will create an effective opening of 10’ x 5.5’ for each culvert.

2. Cedar Road / Lindsey Canal Crossing Improvement

This project is estimated to cost approximately **$ 519,334** in 2006 dollars.

This project is not required in order to accomplish the goals of this Master Drainage plan update, however it is a project that is currently under design by the Department of Public Works.

Replace the Lindsey Canal Bridge on Cedar Road (link 15921) with 40 linear feet of double 10’ x 6’ concrete box culverts. The culverts shall be countersunk 6 inches into the soil of the existing channel bed inverts. This countersinking will create an effective opening of 10’ x 5.5’ for each culvert.

3. West Road Farm Ditch Culvert Improvement

This project is estimated to cost approximately **$ 98,255** in 2006 dollars, if constructed after surrounding land improvements are in place. If constructed as part of adjacent development projects, the cost to the City could be minimal or insignificant.

Replace the existing 15-inch corrugated metal pipe, crossing the construction entrance (link 16221), with 24 linear feet of a 4’ x 3’ concrete box culvert. The culvert inverts shall be placed at the existing channel bed inverts. This improvement will provide increased conveyance capacity in West Road farm ditch. Even though the contributing area is less than 320-acres, the City of Chesapeake expressed interest in eliminating the 10- and 50-year flooding at this crossing.

4. West New Mill Reach Channel and Culvert Improvements

This project is estimated to cost approximately **$ 1,980,050** in 2006 dollars, if constructed after surrounding land improvements are in place. If constructed as part of adjacent development projects, the cost to the City could be minimal or insignificant.

Upstream improvements to the Willis Creek natural drainage channel include widening and deepening the ravine and replacing culvert crossings. This reach is located in the western portion of the New Mill Creek Watershed (node 232 to 316) and includes over 4,500 linear feet of ditch improvements. The ditch improvements shall include widening the bottom from 8 feet at node 232 to 30-feet at node 316. This section of reach shall also receive deeper channels by “smoothing” the bottom inverts so as to create consistent positive drainage from the existing invert of 6.94 (NAVD88) at node 232 to an existing invert of 2.93 (NAVD88) at node 316. Side slopes along this reach shall be maintained at a minimum of 3 horizontal to 1 vertical. The channel shall be maintained so as to create a Manning roughness factor of 0.035.

In addition to the ditch improvement, there are four culvert crossings along this reach that will need to be replaced. All four crossings are existing 27-inch circular pipes. The most upstream crossing (link 12361) shall be replaced with triple 5’ x 3’ concrete box culverts. The next crossing downstream (link 12401) shall be replaced with triple 6’ x 3’ concrete box culverts. The next crossing downstream (link 12461) shall be replaced with triple 6’ x 4’ concrete box culverts. The next crossing downstream (link 12681) shall be replaced with triple 10’ x 5’ concrete box culverts, counter-sunk one foot into the new channel bottom. This portion of the watershed is currently open farmland that will eventually be developed. When the development occurs, the locations of these culverts will no doubt be shifted to conform to future site development plans. The locations used in the future conditions models here are based on existing culvert locations, but can be moved to accommodate future plans.

The combined channel and culvert crossing improvements will provide increased conveyance capacity and flood storage in the ravine.

Although the most upstream portion of this reach does not strictly have 320 or more acres of contributing land, the entire reach will need to convey flows from the runoff of future "regional mixed use" land use, which bears an imperviousness of 65%.

5. Borrow Pit Lake Outfall Channel and Culvert Improvements

This project is estimated to cost approximately **$ 1,214,339** in 2006 dollars, if constructed after surrounding land improvements are in place. If constructed as part of adjacent development projects, the cost to the City could be minimal or insignificant.

The borrow pit lake is located in the western portion of the subject watershed between Dominion Boulevard and the Dismal Swamp Canal. Downstream improvements to the borrow pit lake outfall include widening and deepening the existing ditches and replacing culvert crossings. This outfall reach includes over 3,500 linear feet of channels and culvert crossings, starting at the outfall of the 40-acre lake (node 520) and continue northeast to node 812. At this point (node 812) the flow splits to the east and north with the majority of the flow directed to the north where it travels to a junction (node 266) of the channel described in Improvement Number 4. In order to provide adequate drainage without causing flooding, the entire outfall ditch (nodes 520 to 266) will need to be widened and deepened.

The grading of the ditch shall be conducted in a manner such that the bottom profile from the lake outfall (node 520) invert to the junction (node 266) invert will have a consistent slope that will promote positive drainage. The ditch improvements shall also include widening the bottom from 5 feet at node 522 to 6 feet at node 266 while maintaining minimum side slopes of 2 horizontal to 1 vertical. The channel shall be maintained so as to create a Manning roughness factor of 0.035.

In addition to the ditch improvements, there are three culvert crossings between nodes 812 and 266 and a lake outlet structure that will need to be replaced. The new lake outlet structure (link 15201) shall be a single 36-inch circular concrete pipe, with an outlet invert of 8.0 (NAVD88), thus making the permanent pool elevation in the lake 8.0 (NAVD88) as well. The three culvert crossings between nodes 812 and 266 and are identified as links 12521, 12561, and 12601 will each need to be replaced with 40-linear feet of double 36-inch pipes. Several alternative configurations were modeled, however a permanent pool elevation of 8.0 feet provides a near optimum design condition (i.e. adequate positive drainage downstream with ample flood storage capacity in the lake).

The combined channel and culvert crossing improvements will provide increased conveyance capacity and flood storage in the ravine.

Although the most upstream portion of this reach does not strictly have 320 or more acres of contributing land, the entire reach will need to convey flows from the runoff of future "regional mixed use" land use, which bears an imperviousness of 65%. It is important to note that the three crossings recommended for replacement may not be constructed in their current locations. Their exact locations depend upon site and traffic plan configurations that have yet to be developed.

This conversion of the borrow pit lake to a large retention basin will promote better flushing through the lake than is currently available, and will make good use of existing floodplain storage that has resulted from previous excavation activities.

The goal of this type of study is not to relive *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 storm water systems are neither required nor designed to accommodate flooding from extreme events such as the 50-year storm.

Environmental Restoration and Protection Opportunities

As part of the cost sharing agreement between the City of Chesapeake and the U.S. Army Corps of Engineers, improvements to the New Mill watershed must include features that provide valuable habitat restoration or creation opportunities that may also provide ancillary flood damage reduction benefits. This study was authorized by Resolution of the Committee of Transportation and Infrastructure of the U.S. House of Representatives, Docket 2674, Dismal Swamp and Dismal Swamp Canal, Chesapeake, Virginia, adopted 22 May 2002, which states in part "…*to determine whether modifications to the existing project are advisable to address flooding problems, environmental restoration and protection, and related water resources needs in the vicinity of the Dismal Swamp Canal in Chesapeake, Virginia."*

There are five categories under which potential restoration opportunities are evaluated: scarcity, connectivity, special species status, plan recognition, and self-sustainability.

The City of Chesapeake worked closely with URS to develop restoration and protection concepts that could be applied in this watershed to enhance environmental resources. The most practical opportunities involve benching of drainage outfall ditches and channels, using the typical channel sections presented in Figure 10. These conceptual improvements were reviewed with Norfolk District Corps of Engineers staff, who also offered ideas for implementation of wetland and riparian habitat corridors. After discussing these ideas at several meetings between the City of Chesapeake, the Norfolk District and URS, technical staff from the District visited the candidate sites, and further pared the list of potential improvement projects based on the five requirements noted above. After field screening, Corps staff identified two potential environmental protection and restoration projects, as shown in Figure 11.

The first potential project is a passageway for threatened and endangered (T&E) species to travel from the Great Dismal Swamp, across the Dismal Swamp Canal and into the subject watershed through a wetland and riparian habitat corridor. This corridor facilitates access because it is sufficiently wide to encourage animals to travel through it to the 40-acre borrow pit recreation lake (which will be connected to the Elizabeth River through future outfall improvements described elsewhere in this report). Studies have shown that the corridor must be wide enough that animals will not see predators or they won't use it. This corridor could be re-graded and planted with wetlands vegetation while providing positive drainage towards the borrow pit recreation lake. The re-creation of wetlands will restore this corridor area to be more like the original land cover (Dismal Swamp) conditions that existed before development activities began.

It would be most feasible to construct this wetlands area utilizing the least number of land parcels. It is also intended, as described in the future conditions scenario, that drainage from the areas surrounding the lake will be graded to drain into the constructed wetlands and lake. The grading of future development into the 40-acre lake is strategic in that increased drainage into the lake will promote flushing, which will result in enhanced water quality in the lake, while taking advantage of the existing storage afforded by the old borrow pit. This pit is sufficiently large that with steady flushing the quality of water in the lake should be very good.

The second potential project involves benching the northwest bank of a lower portion of the existing Lindsey Canal. This benching would extend upstream of the Cedar Road crossing approximately 1,000 feet, as indicated in Figure 11. The benching area just adjacent to Cedar Road is already in pretty good shape. The proposed benching would enhance water quality by increasing wetland plant uptake of pollutants, and result in a restoration of this portion of the canal to be more like its natural condition. The area targeted is tidal.

Approximately a dozen other potential benching projects were considered, but did not meet the five requirements for one or more reasons. For example, benching a farmer's ditch does not provide connectivity for T&E species if there is no potential habitat at the upstream end of the ditch. The two selected projects should meet all of the five requirements used in the Corps evaluation process.

Contact Information

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