CAMPUS-WIDE STORMWATER MANAGEMENT PLAN

Prepared For:

College of William & Mary

204-18004

Mr. Wayne Boy, P.E.

DEQ Submittal: July 13, 2015

Prepared By:

Draper Aden Associates

Engineering • Surveying • Environmental Services

DAA Project Number: R06714-32

3RD PARTY REVIEW

This Report has been subjected to technical and quality reviews by:

Name: Wayne Boy, P.E. College of William & Mary	Signature	Date
Name: Glenn H. Telfer, P.E. Lead Author/Project Manager	Signature	Date
Name: W. Charles Kreye, II, P.E. Quality Reviewer	Signature	Date

TABLE OF CONTENTS

TABLES

APPENDICES

1.0 EXECUTIVE SUMMARY

This report addresses stormwater at the College of William & Mary, specifically the requirements of the university's Municipal Separate Storm Sewer System (MS4) permit, future planned projects, and water quality issues raised by the broader university community.

The Chesapeake Bay Total Maximum Daily Load (TMDL) provision of the MS4 permit requires the university to reduce nutrients (nitrogen, phosphorus, and total suspended solids) discharged from existing land cover on an annual basis. The reductions are tied to the next three permit terms, which are five years each. The first term (2013-2018) requires removal of approximately 5% of the total of the required reduction, the second term (2018-2023) requires an additional 35%, and the third term (2023-2028) requires the remaining 60% of the total. At this point, the required removals in the second and third permit terms can only be estimated. It is highly likely that Virginia Department of Environmental Quality (DEQ) will change the required removals state-wide, either upward or downward, based on further sampling and modeling.

Required removals in the first term can be readily achieved by measures the university has already taken. Required removals in the second and third terms will require the construction of stormwater BMPs. The BMPs proposed for permit compliance will also make significant contributions toward improving water quality on campus and in Lake Matoaka.

The proposed Chesapeake Bay TMDL action plan as described in this report relies on existing BMPs for compliance with the first permit term. For future permit terms, this report presents a series of proposed BMPs that can be selected. Construction of BMPs for each permit term will need to be completed by the end of that term.

The university must post the Chesapeake Bay TMDL action plan for public comment to its website by June 30, 2015, make appropriate revisions, and submit the final action plan to DEQ by October 1, 2015.

In addition to construction of BMPs to achieve TMDL compliance, future construction projects at the university will need to comply with Virginia's new stormwater standards and local standards where they are more stringent. These regulations require a higher level of pollutant

removal for redevelopment projects utilizing a combination of reductions in runoff volume and peak runoff flow rate for projects in the watersheds of on-campus streams.

Project specific BMPs will be developed on a project by project basis as project scopes and corresponding pollutant levels are determined.

2.0 GOALS & OBJECTIVES

The primary goal of this plan is to provide a campus-wide approach to address runoff from existing impervious cover in compliance with the university's Municipal Separate Storm Sewer System (MS4) permit (Appendix 1). The Chesapeake Bay Act TMDL condition of this permit provides requirements for the removal of phosphorus (P), nitrogen (N), and Total Suspended Solids (TSS) from stormwater runoff over a 15 year period. Additionally, this master plan addresses non-regulatory stormwater concerns raised by the university community and provides recommendations for future university building projects to comply with the new Virginia stormwater regulations for new construction.

A glossary of terms is provided at Appendix 2. A campus map is provided at Appendix 3 for general reference.

3.0 APPLICABLE STORMWATER REGULATIONS

3.1 General

The university is subject to regulations and laws pertaining to stormwater runoff issued by the Commonwealth of Virginia, James City County, the City of Williamsburg, and the university's own regulations. Some laws and regulations cover new building projects to mitigate impact, while others (such as the MS4 permit) address the stormwater impact of the existing development.

3.2 Commonwealth of Virginia Regulations

3.2.1 Chesapeake Bay Act Regulations (1988)

The Chesapeake Bay Act resulted in the creation of protected buffer areas for perennial streams. The Resource Protection Area (RPA) is a 100 foot buffer from perennial streams and associated wetlands where disturbance of the vegetation is generally not allowed. A Resource Management Area (RMA) is an additional 500 foot buffer landward of the RPA that can be expanded to include floodplains, highly erodible soils, steep slopes, highly permeable soils; and non-tidal wetlands not included in the RPA. Land disturbance is allowed in the RMA. Land disturbance is generally not allowed in the RPA except for utilities and road crossings. Land disturbance for other uses may be permitted if mitigated by RPA restoration and other conditions.

3.2.2 MS4 Regulations (2003, updated 2013)

Since 2003, the university has been subject to the MS4 General Permit under the small, Phase 2 category. In general, the MS4 regulations provide requirements for operating existing storm sewer systems in a way that reduces the potential for stormwater pollution. The permit also requires compliance for systems discharging to a waterbody with a TMDL that assigns a Waste Load Allocation (WLA) to the permit holder for specific pollutants. This requires the permit holder to create a TMDL Action Plan to reduce the applicable pollutants, either through the construction of structural stormwater BMPs, through non-structural operational measures or a combination of these measures.

Currently, there are two TMDLs that directly imposes requirements on the university; the Chesapeake Bay TMDL and the Powhatan/Mill Creek TMDL. DEQ has issued two guidance

documents for TMDL compliance. The Chesapeake Bay TMDL document, "*Guidance Memo No. 14-2012*" provides guidance concerning the removal efficiencies for a range of structural BMPs and methodologies for calculating nitrogen, phosphorus and TSS reductions for each. This document was finalized on March 19, 2015, DEQ issued a revision to this document with changes and clarifications. This document is included at Appendix 4. DEQ may issue additional updates in the future. The document covering all other TMDLs, "*Local TMDL MS4 Guidance*" was issued May 29, 2015 as a draft. This document provides a summary of permit requirements with guidance on developing TMDL Action Plan. DEQ has not issued a schedule for the issuance of the final document. This document is included at Appendix 5.

3.2.3 VSMP Regulations (2005, updated 2013)

5The Virginia Stormwater Management Program (VSMP) regulations govern the post-construction quality and quantity control of stormwater runoff from land development projects. Revised regulations were adopted in 2011 that apply to all university projects for which funding was appropriated after June 30, 2012 and obtained a VSMP permit after June 30, 2014. The VSMP regulations calculate the post-development pollutant load based on proposed land cover which is defined in regulations as either open space, managed turf, or impervious surfaces. The regulations also require the reduction of post-developed peak flow rate and/or runoff volume to protect stream channels from erosion. A guide to complying with these regulations and required forms can be found on the DEQ website at the following link:

http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/VSMPPermits/ConstructionGeneralPermit.aspx

3.3 Local Regulations

3.3.1 City of Williamsburg (updated 2014)

All university property, with the exception of the western portion of the Dillard Complex, is located within the City of Williamsburg. As a state agency, the university must comply with local stormwater regulations where they are more stringent than the state regulations. For the university, the local regulations are currently equivalent to the state regulations. The City requires stormwater quality and quantity to be addressed in compliance with the Virginia regulations for all projects with over 2,500 square feet of land disturbance located within the

Resource Management Area (RMA) buffer and those outside the RMA buffer which are 1.0 acre or larger in disturbed area.

The City adopted a revised stormwater ordinance. Conversations with the City have indicated that the proposed stormwater ordinance is similar to the model ordinance issued by DEQ. City of Williamsburg stormwater regulations can be found at the following link:

https://www.municode.com/library/va/williamsburg/codes/code_of_ordinances?nodeId=PTIITHCO_CH7ENPR

The City of Williamsburg Stormwater Manual can be found at the following link:

http://www.williamsburgva.gov/Index.aspx?page=236

3.3.2 James City County (updated 2014)

The western portion of the Dillard Complex is located within James City County and drains to the Powhatan Creek watershed. Projects in the portion of the Dillard Complex that drain to this watershed are required to comply with County stormwater regulations. The County considers the entire County to be within the RMA buffer and therefore requires all projects with over 2,500 square feet of disturbance to address stormwater quality and quantity in compliance with the Virginia regulations.

The County has also adopted a revised stormwater ordinance. Conversations with the County have indicated that the proposed stormwater ordinance is similar to the model ordinance issued by DEQ with changes to reflect the Powhatan Creek Watershed Management Plan. Projects in the watershed must also comply with the County Special Stormwater Criteria which requires Low Impact Development (LID) measures beyond those required for Virginia regulation compliance. James City County stormwater regulations and guidance can be found at the following link:

http://www.jamescitycountyva.gov/resourceprotection/index.html

In approximately 2003, the university committed in writing to construct a BMP at the Dillard Complex, pending available funding, to detain the runoff from the one-year storm event for 2

hours. Funding was never received and this BMP was never constructed. The detention requirement was the channel protection requirement at the time, but the revised regulations also allow the use of the energy balance method in accordance with Virginia regulations. Conversations with the County indicate that while the County desires a BMP to provide downstream channel protection at the Dillard Complex, there is no desire on the part of the County to have a large central BMP at the northern point of Dillard Complex that would destroy the existing tree buffer and impact RPA. When the Dillard Complex is re-developed, multiple smaller BMPs should be installed in the upper reaches of the watershed to comply with the channel protection criteria.

3.4 TOTAL MAXIMUM DAILY LOADS (TMDLS)

3.4.1 General

DEQ is involved in a continuous process of reviewing water quality data, identifying impaired waters, and drafting Total Maximum Daily Loads (TMDLs) which establish acceptable levels of pollutants in streams, lakes, and rivers. Waste Load Allocations (WLAs) are assigned to permit holders in these watersheds requiring them to take measures to reduce levels of pollutants. The university's MS4 permit requires the university to comply with TMDLs only where the university is specifically named as having a WLA. A WLA could be assigned to the university for any water body where the university's MS4 area is in the watershed (College Creek, Lower James River, and Chesapeake Bay). The link below is to the DEQ website for current TMDLs:

http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment/ApprovedTMDLReports.aspx

3.4.2 Chesapeake Bay TMDL (2013)

The MS4 permit provides a method to calculate the WLA for the Chesapeake Bay TMDL. Additional guidance is provided in the DEQ Guidance Memo No. 14-2012 mentioned at section 3.2.2. Compliance in achieving the total WLA is divided between three permit cycles. In the current permit cycle (2013 to 2018), 5% of the total WLA must be achieved. In the second (2018 to 2023) permit cycle, a cumulative 40% of the total WLA must be achieved and in the third (2023 to 2028) permit cycle, the remainder of the total WLA must be achieved.

The next MS4 permit will likely revise the total WLA based on revised watershed modeling and input from the EPA. At this point, it is unknown if WLA for each watershed will be raised or lowered.

The MS4 permit requires the permittee to develop a Chesapeake Bay TMDL Action Plan document that describes the actions that will be taken to comply with the requirements of the current permit cycle. In accordance with the permit, this document must be posted to the university's website to solicit public input. The final document will be revised to address public comment. The final Action Plan must be completed no later than 24 months after permit coverage (for the university, the due date is July 1, 2015) and submitted to DEQ with the subsequent annual report (October 1, 2015).

3.4.3 Mill Creek and Powhatan Creek TMDL (2010)

The TMDL for Mill Creek and Powhatan Creek is attached at Appendix 6. This TMDL assigns a bacteria WLA to the City of Williamsburg. This document specifies that the load from the university is aggregated with the load from the City of Williamsburg. Based on conversations with DEQ, since the university is specifically mentioned in the TMDL as included in the aggregate load, the university has an assigned WLA and must submit an Action Plan.

The TMDL covers both Mill Creek and Powhatan Creek. The area of university property draining to the TMDL watershed within the MS4 service area is limited to the northern portion of the Dillard Complex. The Action Plan will provide an analysis of possible sources of bacteria within the university property and list actions taken by the university to address sources. The Action Plan will not require the construction of any new structural stormwater BMPs, but may recommend additional actions to be taken by the university, including sampling for bacteria. Based on conversations with DEQ, sampling by itself cannot address TMDL compliance, but may be part of an Action Plan.

3.4.4 Future TMDLs

There are several TMDLs currently in development. It is important that the university is active in the public comment process during TMDL development to ensure that assigned WLAs are based on the university's actual stormwater discharge characteristics and do not place unnecessary

requirements on the university. The projected completion dates for future TMDLs are likely to change depending on DEQ priorities and available funding.

http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment/DraftTMDLReports.aspx

The list below contains near-future TMDLs that are known to be in development. It is likely that the university will be assigned additional WLAs from existing and new potential TMDLs.

3.4.4.1 James River PCB TMDL (2016-2024)

The TMDL for PCBs in the lower James River and tributaries is expected to be finalized in late 2015. The TMDL is expected to require the university to address PCBs by documenting the process and procedures the university used to identify and eliminate sources of PCBs. The following link is to the DEQ website for the PCB TMDL:

http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/PCBTMDLs.aspx

In anticipation of the TMDL, the university will perform PCB sampling at selected outfalls in the hope it will show levels below regulatory limits and therefore establish that the university is not a source of PCBs. If the university performs sampling prior to the issuance of the TMDL, DEQ does not require reporting of the results. Sampling after the issuance of the TMDL can be used to address the WLA, but the results must be reported to DEQ.

3.4.4.2 James River Chlorophyll-a TMDL (TBD)

The lower James River, including the portion downstream of College Creek, experiences algae

An additional TMDL is planned for College Creek that DEQ is listing for finalization in 2018. It is expected that this TMDL will include bacteria, but could also include nutrients and other pollutants. The university has conducted bacteria sampling in the College Creek watershed over a number of years and has found few instances of samples exceeding the regulatory threshold. These positive samples have been typically during periods of dry weather and all have been isolated incidents. Samples have indicated that the VDOT BMP located to the west of the West Woods on John Tyler Lane is a reoccurring source of bacteria, likely due to geese.

In anticipation of this TMDL, the College will perform bacteria sampling at selected outfalls to determine if bacteria levels are below regulatory limits and therefore that the university is not a significant source of bacteria.

4.0 NON-REGULATORY STORMWATER ISSUES

4.1 Monitoring Study

Since 2011, the university's Biology Department has conducted a water sampling program at three locations: Crim Dell, Health Center BMP, and Wildflower Refuge BMP. Although Crim Dell was designed to be an ornamental pond, it provides stormwater pollutant removal. Sampling takes place at inlet and outlet points for a variety of parameters including: nitrogen, phosphorus, and total suspended solids (TSS). Sampling does not take place during rainfall events. The results are published each semester. The current reports are attached at Appendix 7.

Sampling can be an effective tool to evaluate BMP performance; however, not sampling during rainfall events can produce misleading results. The inflow outside of rainfall events can be groundwater and/or heavily influenced by the conditions in the BMP. Since the sampling was conducted outside of rainfall events, the inflow could be heavily influenced by the nitrogen levels in the forebay.

The following issues raised by the reports were investigated as part of the Stormwater Management Plan:

- The levels of nitrate in the inlet to the Crim Dell are elevated. Levels at the outlet are typically less that the inlet.

The nitrate levels in the inlet of Crim Dell are contributing toward the high concentration of algae during the warmer months. The Crim Dell watershed is primarily lawn and it is possible that fertilizer runoff contributes to the nitrate concentrations even though the Sunken Garden is subject to a nutrient management plan which should reduce the levels of fertilizer applied. The fertilizer application rates upstream of /Crim Dell should be reviewed and adjusted if necessary. However, the soils in the lawn areas may have high background phosphorus levels due to fertilizer application prior to the development of the nutrient management plan that will continue to contribute toward the problem.

The aeration system in Crim Dell may also be contributing to the problem by preventing anaerobic zones which are necessary for the biological process of denitrification. The aeration system, now over 30 years old, should be replaced with a more efficient unit with a timer. The

Biology Department can provide input for the timer settings that are the most effective in maintaining optimum water conditions.

- At the Health Center BMP, the levels of phosphorus in the storm sewer from the Sadler Center are periodically elevated. Visual observations during monitoring have recorded unusual colored discharges.

The observed events at the Health Center BMP are probably due to illicit discharges of wash water or other liquids into the storm drains behind the Sadler Center. This area has a high potential for inappropriate materials entering the storm system. There are multiple storm inlets in the vicinity of dumpsters and the loading dock. The university should reinforce training of personnel on the appropriate disposal of materials. There is also the unlikely possibility of floor drains in the Sadler Center connected to the storm system. The university should conduct dye testing to confirm.

- Crim Dell has experienced elevated temperatures.

The university identified the source as a steam tunnel drain pump and corrected the problem in 2014. The temperature of the water in Crim Dell should be continued to be monitored to identify any other causes.

- Levels of TSS are typically higher at the BMP outlets than the inlet.

The report suggests that this is due to the need to restore BMP volume by removing accumulated sediment. This is likely true, although the TSS measurements may also be influenced by not sampling during rainfall events. Additionally, for Crim Dell, the aeration system is contributing to the problem by re-suspending sediment that has settled to the bottom.

4.2 Crim Dell

Crim Dell experiences algae blooms every year in the late Spring. Crim Dell occupies a prominent place on campus and the algae in unsightly. The following factors contribute toward algae growth in Crim Dell:

- High nutrient levels, particularly phosphorus. Nutrient levels in Crim Dell are maintained by accumulated sediment. Additional nutrients are added by annual leaf fall and possibly runoff from lawn areas.

- Lack of biological mechanisms that reduce nutrients. There should be zones of high and low oxygen to allow the bacterial processes of nitrification and denitrification.

- Sunlight. Crim Dell is somewhat shaded by the tall stands of bamboo, but does not have a large number of aquatic plants that shade the surface,

- High water temperatures. The average depth of Crim Dell has decreased by the accumulation of sediment which causes the water to warm more quickly in the Spring.

Algae can be controlled on a temporary basis through the use of algaecides and dyes which shade the algae. These chemicals can harm aquatic life and change the color of the water.

4.3 Health Center and Wildflower Refuge BMPs

The Health Center and Wildflower Refuge BMPs were designed as stormwater BMPs without any consideration of aesthetics. They both collect drainage from heavily wooded stream corridors and as a result, collect a large amount of sticks, branches and leaves. The debris clogs the outlet orifices resulting in standing water long past the end of rain events and expanses of bare mud when the water finally drains. Their design makes removal of this debris by university personnel difficult and requires outside contractors to conduct major sediment removal approximately every 5 years. The berm of the Wildflower BMP is experiencing sinkholes near the outlet culverts which require repair.

4.4 Lake Matoaka

Lake Matoka was created in the early 1700's by the damming of College Creek. The lake was used by the university and the general public for a variety of purposes, including swimming and fishing. In the late 1980's, the university closed the lake to swimming and fishing as a result of high bacteria levels which were caused by the release of sanitary sewage in the watershed. The university and the City of Williamsburg have corrected the problems that caused this issue and bacteria levels in the lake are now within regulatory limits.

Water quality in Lake Matoaka is the subject of concern and research by the university community. The university portion of the watershed is approximately 80% undeveloped forest. The portion of the watershed that the university does not own is heavily developed. Although the bacteria issue has been resolved and the water quality is generally good for a lake in an urban watershed, the lake experiences annual algae blooms every year as the result of warmer water temperatures and an accumulation of nutrients in the water and sediments.

MS4 compliance projects developed by this report will reduce the amount of nutrients entering the lake from the university property and will contribute toward the improvement of lake water quality.

5.0 EXISTING CONDITIONS

5.1 Precinct Descriptions

A map of the university precincts is included at Appendix 8. The university owns approximately 1,108.5 acres of which approximately 35% is developed. The reminder is heavily wooded. There is also approximately 31.4 acres of additional property owned by the College of William and Mary Real Estate Foundation and the College of William and Mary Endowment. Both of these are private entities and are not included in the MS4 permit. The university property can be divided into six areas, or precincts. Four are contiguous to the main campus and two are satellite locations. From east to west, these precincts that are contiguous with the main campus are: Main Campus, West Woods, the School of Education, and North Woods. The satellite locations are the Law School and the Dillard Complex.

Soils are generally described by rating systems which indicate runoff potential and susceptibility to erosion. Soils information from the USDA National Resource Conservation Service (NRCS) soils mapping website is included at Appendix 9. The NRCS mapping should only be used for planning purposes since past grading activities may have changed soils characteristics and the mapping accuracy levels were not originally developed for small areas. Some developed areas of the university are classified as "urban land" which indicates that no soils data is available.

Runoff potential is expressed by classification within a Hydrologic Soil Group (HSG) ranging from A to D. An A rating is assigned to soils with the lowest runoff potential and the ability to infiltrate/absorb more of the rainfall. D soils have the highest runoff potential and absorb less runoff.

Susceptibility to erosion is indicated by an erodibility index, or K factor, ranges from 0.02 to 0.69. Lower values reflecting a lower potential for soil particles to detach. K factors can be grouped into three general ranges:

0.23 and lower – low erodibility

0.23 to 0.36 – moderate erodibility

0.36 and up – high erodibility

The vast majority of soils at the university have a K factor of 0.28, indicating moderate erodibility, although there are isolated areas of low erodability (K=0.24) and high erodability (K=0.32 to 0.43). Moderately erodible soils on steep slopes or in water conveyance channels, including streams, can be prone to erosion.

Main Campus

The Main Campus, approximately 323 acres, is the eastern portion of the campus and is generally bounded by Richmond Road to the north and Jamestown Road to the south. The majority of the developed area at the university is within the Main Campus consisting of classroom, dormitory, and associated support facilities surrounded by lawn areas. The Main Campus consists of relatively flat plateaus divided by wooded creek ravines. The area drains mainly to the wooded College Creek ravine system which drains west to Lake Matoaka. Large areas are classified as urban land with no HSG classification. Undeveloped areas are classified as HSG B and C with moderately erodible soils (K=0.28) over the entire precinct.

West Woods

The West Woods is approximately 561 acres located to the west of Lake Matoaka and south of Compton Drive. This area is undeveloped except for a system of trails and is used for research by university Faculty and a landscape disposal area in the south-west corner. The topography consists of ridges divided by stream ravines. Soils include all soils classification groups. Soils are generally moderately erodible (K=0.28), but there are some small areas with highly erodible soils at the western edge and in the northern-most reach of Lake Matoaka (K=0.37 to 0.43).

North Woods

North Woods, approximately 87 acres to the north of Monticello Avenue, is undeveloped. The topography consists of a relatively flat area (1-2%) along Monticello Avenue surrounded on the other sides by steeper slopes draining to a tributary of Lake Motoaka. Soils are classified mainly as HSG B, C and D with some small areas dual classified as A/D. Soils are generally moderately erodible (K=0.28 to 0.32), but there are some small areas with highly erodible soils along the northern edge (K= 0.37).

School of Education (SOE)

The School of Education Complex, approximately 26 acres, is home to the university's School of Education and was the site of the Williamsburg Community Hospital prior to being acquired by the university. The entire parcel is generally developed except for wooded stream ravines at the perimeter of the site. Developed areas drain to the wooded creek corridors to the south and west and subsequently to College Creek and Lake Matoaka. The developed areas are sloped moderately to the edge of developed areas, and the topography becomes steeper between the developed areas and the streams. Soils are classified as urban land and group B on the higher areas, and transition from to group D and A/D as the land drops to the streams on the west and south sides. Soils are moderately erodible (K=0.28), except for the stream channels, which are classified with as highly erodible (K=0.37).

Law School Complex

The Law School Complex, approximately 110 acres, is the home to the university's Law School, Tennis Center, Population Studies Lab, and a Buildings and Grounds greenhouse facility. The university leases the northern end of the parcel to the Center for State Courts. Development is clustered in the northern end of the parcel. Developed areas drain mainly to the east to the Colonial Parkway and subsequently to Paper Mill Creek, a tributary of College Creek. The developed areas are sloped moderately to the east and the topography becomes steeper between the developed areas and the Colonial Parkway. Soils are classified as HSG B and D. Soils are moderately erodible (K=0.28).

Dillard Complex

The Dillard Complex, approximately 33 acres, is currently used primarily for athletic facilities; associated parking and selected storage facilities in support of main campus departments. Existing facilities include the baseball stadium, a soccer/lacrosse stadium, soccer practice fields, and a Swem Library storage facility. The complex also includes six buildings (two dormitories and four cottages) that were former nurses' residences and staff cottages which were acquired with the property from Eastern State Hospital. These six buildings are not currently in use and would present challenges in renovating them to meet current building codes. The western portion

of the complex is located in James City County - the only College property located outside the City of Williamsburg.

The entire parcel is developed. Slopes are generally flat. The majority of the Dillard Complex drains south to the VDOT storm sewer in Ironbound Road. A portion of the Complex drains north to Chisel Run, a tributary of Powhatan Creek. Soils are classified as HSG A and D with some smaller areas of D soils. Soils are moderately erodible (K=0.28).

5.2 Existing Drainage

Generally, runoff from impervious surfaces such as roofs, streets, and parking lots is connected directly to storm sewers. The storm sewer segments are generally short, usually no more than four or five pipe segments before it discharges to one of the dry channels or streams that extend throughout campus. This system is very efficient as a drainage system and for space utilization, but provides fewer opportunities for rain falling on impervious surfaces, such as roofs, roads, and parking lots to soak into the ground.

5.3 Channel Erosion

As noted above, university storm sewer segments discharge into an extensive system of natural channels in wooded areas primarily in the wooded ravine system which feeds Lake Matoaka. Channel erosion is largely due to the level of development in the contributing drainage area and topographic factors such as the soils type and longitudinal slope. Reducing the volume and peak flow rate from frequent storm events can reduce the level of erosion. Sediment carried downstream by erosion degrades water quality and increases the frequency of sediment removal in downstream BMPs. The map at Appendix 10 shows the level of erosion in university channels.

5.4 RMA/RPA Areas

The majority of the university property is within an RPA or RMA. Included at Appendix 11 is a RPA/RMA map based on available City and County GIS that can be used as a general guide to plan development. For individual projects, the RPA must be field delineated to ensure that construction does not impact the RPA.

5.5 Efforts to Date

5.5.1 Erosion & Sediment Control (1973)

In 1973, Virginia implemented Erosion and Sediment Control (ESC) regulations to reduce sediment leaving areas of land disturbance and to protect downstream channels from erosion due to increases in the peak flow rate of runoff due to development. The regulations are implemented by the *Virginia Erosion and Sediment Control Handbook*, including *Minimum Standard 19* for channel protection. Additionally, the Virginia Stormwater Management Program (VSMP) regulations contain requirements for the construction contractor to prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) which sets forth project requirements for construction site operation practices and documentation of the inspection, maintenance, and repair of ESC measures. At the university, project design documents are reviewed during by the university's Erosion and Sediment Control Plans Reviewer to ensure compliance with ESC regulations and the university's Annual *Standards for Erosion and Sediment Control*. Using State certified inspectors, the university ensures that all construction on campus implements and maintains ESC measures in accordance with the regulations.

5.5.2 New Development (1988)

In 1998, Virginia implemented the Chesapeake Bay Act regulations which required stormwater measures to mitigate the impacts of new development due to nutrient runoff and flooding. The latest regulations implemented in 2014 have strengthened these requirements and have added channel protection. The university requires new construction to implement stormwater Best Management Practices (BMPs) in accordance with the regulations. Project drawings are reviewed during design by the Department of Environmental Quality (DEQ) to ensure compliance. The university devotes resources to inspect and maintain BMPs in accordance with the MS4 regulations to ensure that they continue to remove stormwater pollutants.

5.5.3 College Woods Natural Preserve (1994)

The university has and continues to take measures beyond regulatory requirements which protect and improve water quality. One important area is the university's leadership in taking actions to formally preserve land from development. The College Woods is a single 660 acre area including all of the West Woods and North Woods precincts and some of the western portion of

the Main Campus precinct. In 1994, this area was formally set aside by the university's Board of Visitors for educational use "to be limited to those uses necessary to accomplish the mission of the College" (located at Appendix 12). This preserved area has a significant positive impact on water quality in College Creek and Lake Matoaka, but current stormwater regulations do not provide a mechanism to credit such conserved land toward regulatory compliance.

5.5.4 Municipal Separate Storm Sewer System (MS4) Permit (2003)

In 2003, the university was issued an MS4 permit which imposed requirements on the university's operations that could affect stormwater quality. As part of permit compliance, the university has instituted a program of Minimum Control Measures (MCMs) that address the following areas related to stormwater:

- Public education and outreach
- Public involvement and participation
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction stormwater management in new development and redevelopment
- Pollution prevention and good housekeeping for municipal operations and maintenance

The university continues to refine the MCM program and submits annual compliance reporting to the Virginia DEQ. As part of MS4 permit compliance, the university coordinates stormwater quality efforts with the City of Williamsburg, Jamestown City County, and VDOT which are also MS4 permit holders.

The university has identified facilities having the potential for discharging high levels of stormwater pollutants, on a continuous or periodic basis, and taken appropriate measures to reduce the potential for illicit discharges, though structural and operational measures.

5.5.5 Stormwater Master Plan (2005)

In 2005, the university created a Stormwater Master Plan with the primary goal of achieving regulatory compliance for future development. The selected approach provided stormwater quality compliance for planned projects in a centralized, compensatory manner rather than on a project by project basis. This approach resulted in modifications to three existing BMPs: Wildflower Refuge, Health Center, and Law School. Outlet risers in these three BMPs were modified to increase detention times to at least 30 hours which resulted in a combined water quality removal of approximately 114 pounds per year of phosphorus. This removal credit has been used to provide regulatory compliance for a number of projects. Given that these BMPs were constructed prior to 2009, they are not allowed to be counted toward MS4 permit Chesapeake Bay TMDL compliance. However, if they can be modified to increase efficiency, any additional removal may be credited toward TMDL compliance.

5.5.6 Nutrient Management Plans (2006)

Since 2006, the university has created Nutrient Management Plans for large areas of lawn. The Nutrient Management Plans establish fertilizer and lime application rates in response to the results of periodic soil testing in order to minimize the amount of nutrient runoff. A map of nutrient management planning zones is included at Appendix 13.

5.5.7 Keck Environmental Lab (2005 and ongoing)

The university's academic community has been active for a number of years in performing research investigating water quality issues on campus and the larger watershed. A complete summary of research is beyond the scope of this master plan, but the Keck Environmental Lab has performed quarterly sampling at 23 locations within the College Creek watershed since 2005 for parameters including TSS, nitrogen, phosphorus, and bacteria. Results are posted online on the website:

http://www.wm.edu/as/kecklab/watershedmonitoring/collegecreekalliance/waterquality/waterqualitydata/index.php.

Additionally, data for temperature, conductivity, and water elevation associated with storm events is continuously recorded for three sites in Lake Matoaka at 10 minute intervals.

The Keck Lab recently received a grant from the Virginia Environmental Endowment to conduct a review of 10 years of water quality data in College Creek watershed. The goal is to create a model of the watershed that will be able to predict N, P, and TSS levels and the effect of BMPs. Results are expected to be complete in 2015. The could be used to help evaluate the performance of the university's BMPs that discharge to Lake Matoaka as an integrated system which could help shape the university's MS4 compliance program in the future. Currently, this research has assembled watershed data and modeling is anticipated to start in 2015.

5.5.8 University Facilities Management Erosion and Sediment Control (ESC) Procedures (2010)

Every construction project at the university is required to comply with procedures established in *Annual Erosion & Sediment Control Standards and Specifications.* This document supplements the requirements in the *Virginia Erosion and Sediment Control Handbook* and provides direction specific to work at the university. The university's Code Review Team (CRT) Civil/Structural reviewer is currently responsible for design review and the Facilities Planning, Design, and Construction Division is responsible for program oversight to include construction phase inspection of projects for ESC compliance. Facilities Management updates the *Annual Erosion & Sediment Control Standards and Specifications* annually in accordance with DEQ requirements.

Prior to construction, design plans are reviewed by Facilities Management to ensure that the ESC design is complete and the procedures to be followed by the contractor are clear and complete. At the start of all construction projects, the Facilities Management ESC Inspector reviews these procedures with the contractor and inspects the construction site periodically during the course of construction to ensure that the procedures are followed and ESC measures are maintained.

5.5.9 University Facilities Management Stormwater Procedures (2010)

The university's standards *Facilities Management Design and Construction Manual* and *Facilities Management Technical Standards* currently require the design documents for all projects with a disturbed area in excess of 500 square feet to address stormwater management in accordance with regulatory requirements. This study recommends that the thresholds be changed to match the regulatory requirement, which are 2,500 square feet of disturbance in an RMA and one acre outside the RMA. As there are few areas of the campus as large as one acre outside the

RMA, the university could adopt a single threshold of 2,500 square feet of disturbance. Facilities Management is currently in the process of updating this document, including stormwater design requirements. Stormwater compliance for design phase review of projects is currently performed by DEQ, but this responsibility may be shifted to the university in the future.

5.6 Existing Campus Watershed Water Quality

Water quality in Lake Matoaka has greatly improved since the late 1980s. The lake supports a high diversity of fish, turtles, and other species for a lake in an urban area. However, the lake continues to experience nuisance algal blooms every year despite the university's conservation of large portions of the area around the lake. The lake is under pressure from upstream development outside the control of the university, particularly the High Street development.

Testing and analysis over the nine year period has indicated that Lake Matoaka provides a significant benefit in reducing the level of pollutants at the point of discharge. Even though Lake Matoaka was constructed well before water quality regulations (early 1700's), it functions as a BMP that allows an extensive detention which reduces the level of nutrients and sediment at its outfall to College Creek and, in turn, the James River. During normal conditions, the lake has a mean hydraulic residence time of approximately 73 days. It is estimated that the lake provides annual nutrient removals of approximately 3,000 pounds of nitrogen, 300 pounds of phosphorus, and 200,000 pounds of TSS based on the calculation methodology in the DEQ guidance document. However, as discussed later in this document, as the lake was constructed prior to 2009 and was not constructed for stormwater treatment, it cannot be credited for the MS4 permit.

5.7 Existing BMPs

The university maintains a series of structural stormwater control measures or Best Management Practices (BMPs) throughout campus. BMPs are classified as providing stormwater quality and/or quantity compliance. Quality BMPs remove some of the incoming pollutants, including N, P and TSS. Quantity BMPs reduce the runoff peak flow rate and in some locations, the runoff volume. The majority of the BMPs at the university were constructed to either provide compliance with specific Virginia regulations or specific LEED criteria.

The university's BMPs are divided into those that were constructed to provide regulatory compliance and those that were constructed for other purposes, such as LEED credit. Under the MS4 Permit, the university is responsible for maintaining only the regulatory BMPs.

A summary table of the university's regulatory BMPs is provided below; locations are shown at Appendix 14:

Table 1: Existing University Regulatory Stormwater BMPs

1.	Tennis Complex	Detention – Quantity Only	8.3	1991
2.	Law School	Extended Detention (dry)	11.9	1991, Modified 2006
3.	Sorority Court	Bioretention	0.1	2012
4.	Sorority Court	Infiltration	0.1	2012
5.	Facilities Management – parking lot	Detention – Quantity Only	12.1	Pre-2001
6.	Wildflower Refuge	Extended Detention (dry)	32.0 (3)	1977, Modified 2006
7.	Laycock Practice Facility	Infiltration	3.3	modified 2010
8.	Small Hall	Bioretention Filter	0.1	2004
9.	Health Center Pond	Extended Detention (dry)	55.4	Modified 2006
10.	New Fraternity Housing – North	Bioretention	3.5	2013
11.	Parking Deck	Delaware Sand Filter	1.7	2005
12.	New Fraternity Housing – South	Bioretention	1.2	2013
13.	Yates Parking Lot	Filterra	0.8	2012
14.	William & Mary Hall - parking lot	Filterra with underground Detention	0.8	2013
15.	SOE – SE	Detention, Quantity only (2)	14.6 (est.)	Modified 2010
16.	Recreation Center	Austin Sand Filter	7.4	2004
17.	SOE – helipad	Permeable Concrete	0.7	2011
18.	SOE – helipad	Bioretention (1)	0.7	2011
19.	SOE – NW	Extended Detention (dry) (2)	3.8	Modified 2010
20.	Plumeri Park	Extended Detention (dry)	4.1	1997
21.	Dillard Library Storage Pond	Infiltration Basin (1)	1.8	Modified 2010

(1) BMP has been determined to be experience problems based on inspection, further investigation required.

(2) Covered under a BMP agreement between Williamsburg Community Hospital and the City of Williamsburg.

(3) Excluding drainage area to Crim Dell and Health Center BMP.

A summary table of the university's non-regulatory BMPs is provided below; locations are shown at Appendix 15:

Table 2: Existing University Non-Regulatory Stormwater BMPs

1.	State Courts	Underground Detention (3)	3.2	2002
2.	Landfill	Inactive Sediment Basin (2)	N/A	Unknown
3.	Facilities Management – fuel area	Manufactured – Bay Saver	Less than 0.1	2010
4.	Facilities Management – landscape equipment wash area	Manufactured – Bay Saver	Less than 0.1	2010n
5.	Crim Dell	Extended Detention, wet (1)	22.0	Renovated approx. 1974
6.	Miller Hall	Bioretention	0.5	2009
7.	Miller Hall	Cistern	0.6	2009
8.	Miller Hall	Manufactured – Crystal Stream	1.0 (est.)	2009
9.	Lake Matoaka	Extended Detention (1)	614	Early 1700's
10.	Busch Field	Inactive Sediment Basin (2)	N/A	Unknown
11.	SOE	Bioretention	4.0	2010

(1) Was not constructed for stormwater purposes

(2) Not a recognized BMP

(3) Covered under a BMP agreement between Center for State Courts and the City of Williamsburg

Detailed descriptions of existing BMPs are included in Appendices 14 and 15.

The university conducts periodic inspections of BMPs as part of the normal maintenance and operations. As part of this study, each BMP was visually inspected to determine if it was still functioning. Some of the underground BMPs were not accessible and their proper operation could not be verified. Two of the BMPs appear to be experiencing issues that require further investigation. The Library Storage infiltration basin contains approximately the same level of water even when there has been over a week since the last rainfall event. The SOE helipad bioretention also holds water for extended periods. Both BMPs should be repaired or replaced to restore original design function.

The DEQ guidance makes a distinction between BMPs that have been reported to DEQ and those that have not. Theoretically, a BMP was reported to DEQ if it was included in an MS4 annual report, however some MS4 permit holders report that not all of the BMPs included in annual reports have been included. DEQ anticipates issuing a list of all reported BMPs in 2015. For the purposes of Chesapeake Bay TMDL calculations, it was assumed that all of the BMPs listed in the 2013 annual report are considered as reported.

The DEQ guidance document encourages reporting of existing non-reported BMPs to allow the Bay Program to better refine its WLAs for Virginia in the next phase of the Bay Program Model. The guidance document implies that reporting of existing BMPs could reduce the future WLAs for all MS4 permit holders in the watershed.

6.0 PROPOSED DEVELOPMENT

The university's 6-year Plan identifies a number of projects planned for the near future. The table below summarizes these projects:

Table 3: Proposed Development

Chandler Hall Renovation	Less than 0.1	2014
Cooling Plant Thermal Storage Fit Out	Less than 0.1	2014
Integrated Science Center 3 (ISC3) (including demolition of Millington Hall)	0.2	2014
Pi Phi House Addition/Renovation	Less than 0.1	2014
Tyler Hall Renovation	Less than 0.1	2014
Accessibility Improvements	0.2	2015
Law School Addition	Less than 0.1	2015
Plumeri Baseball Practice Facility	0.5	2015
Zable Stadium Improvements	0.5	2015
Integrated Wellness Center	0.3	2016
Lake Matoaka Dam Spillway	0.5	2016
Athletic Practice Facility	1.6	2017
Arts Complex, Phase 1	0.5	TBD
West Utility Plant Construction	0.2	TBD
Total	**5.0 (max.)**	

In addition to the projects currently in the planning stages, additional projects will be proposed as part of the Campus-wide Master Plan, currently in development. In general, this master plan will likely recommend the following changes that affect stormwater runoff:

- Academic/Classroom: In the Landrum loop area, Morton, Jones, Millington, will be replaced. The Arts Complex in this area was the subject of a separate study that will result in a new Music building to the west of Barksdale Field, additions to Phi Beta Kappa Hall, and a new Arts building to house studios for mediums requiring robust building/safety system support (foundry-fire suppression, sculpture – ventilation, etc.).

- Student Center: Health Center replacement by a new Integrated Wellness Center. Construction will be preceded by demolition of the Lodges (except #1) and followed by demolition of the existing Health Center.

- Dillard Complex: Remove existing cottages and dorms, construct storage building, realign existing fields, and construct permeable pavement parking.

- Building Removal and Replacement: In addition to buildings listed above, the master plan recommends renovation of Adair, and removal and replacement of Campus Center, Trinkle Hall, and Facilities Warehouse.

Proposed development projects at the university will comply with Virginia's new stormwater standards. These regulations require a higher level of pollutant removal for redevelopment projects and require a reduction in runoff volume and peak runoff flow rate for projects in the watersheds of on-campus streams.

From a stormwater standpoint, all of the planned projects at the university are re-development projects; they are built in previously developed areas. The re-development criteria of the regulations result in a neutral impact on the MS4 permit compliance, unless projects provide BMP capacity beyond that required for regulatory compliance or provide significant reductions in impervious area.

7.0 CHESAPEAKE BAY TMDL WLA CALCULATIONS

7.1 General

The Chesapeake Bay TMDL WLA is based on the impervious and lawn acreage within the MS4 service area as of June 30, 2009. The method multiplies the total impervious area and total managed turf area in the MS4 service area (June 30, 2009 base land cover condition) by coefficients to obtain the total MS4 WLA and the WLA required to be met in the first permit cycle.

7.2 Storm Sewer System Mapping

The MS4 permit requires the university to map the storm sewer system in order to provide a document to aid in system maintenance and the tracking of the source of illicit discharges. The mapping is also required to determine the MS4 service area. The university has maintained system mapping on paper, transitioned to electronic drawings, and has developed a GIS based system. As part of this study, the GIS based mapping was reviewed for readily apparent gaps and supplemented by field investigation where required. For the purposes of the MS4, storm sewer lines below 8" in size, such as individual roof drains, were not considered to be part of the MS4 storm sewer system.

7.3 MS4 Service Area Delineation

The DEQ guidance defines the MS4 service area as that area owned by the university within the 2000 US Census urbanized area that drains to the storm sewer operated and maintained by the university. This area is shown on the map at Appendix 16. This area is approximately 19% of the total university property. The reminder of the university's property either does not drain to the MS4 service area or is woods which is not included. As part of this study, the drainage area to each outfall was delineated. This information is required for MS4 permit compliance.

This map also shows areas of university property that drain to the City of Williamsburg storm sewer and areas of the City of Williamsburg that drain to the university's MS4. The guidance specifically states that in these cases, where the areas drain by sheet flow instead of piped systems, the downstream MS4 is responsible for the WLA. In cases where the areas drain by interconnected storm sewer or other conveyance system, the upstream MS4 is responsible. The

guidance states that alternatives to this approach are acceptable as long as all lands are accounted for. The university's MS4 service area has been coordinated with adjacent MS4 permit holders.

The shopping center to the east of the School of Education is privately owned, but included in the university's service area. A portion of the shopping center drains by a piped system that crosses Mt. Vernon Road and discharges into the south-east BMP at the university's School of Education. This arrangement was the result of an arrangement made during the design of the Williamsburg Community Hospital and was formalized by a BMP agreement between the Hospital and the City. When the university purchased the former hospital, the BMP agreement conveyed with the property. The BMP agreement is at Appendix 17.

The parcel at the northern end of the Law School precinct is owned by the university, but is part of the City's service area. The property is under long-term lease to State Courts. The storm sewer from this property drains through an underground detention system to a structure at the north-east corner of the property which drains to the Colonial Parkway. The underground detention structure is under a BMP agreement between State Courts and the City of Williamsburg. The BMP agreement is at Appendix 17.

The One Tribe Place parcel has been excluded from the MS4 service area because it was not owned by the university in 2009 and the storm sewer traversing the parcel is within a City of Williamsburg easement.

7.4 MS4 System Interconnects

The university's MS4 system interconnects with the City of Williamsburg system at multiple points as shown at Appendix 16. The university is in the process of evaluating the need for formalizing maintenance responsibilities for these portions of the storm sewer. The university and the City have maintained a close working relationship since the early 1700's and will continue to cooperate on shared issues.

Interconnect A - The drainage to a City curb inlet in Jamestown Road drains to the university's storm sewer.

Interconnect B1 – The City storm sewer draining a large area north of W. Francis Street ties into the university's storm sewer at a point on South Boundary Street near Grigsby Drive.

Interconnect B2 – The City storm sewer draining a small area north of Ireland Street ties into the university's storm sewer at a point on South Boundary Street near Ireland Street.

Interconnect B3 – The university's storm sewer under the Facilities Management area becomes the City's storm sewer as it leaves university property and discharges at Pollard Park.

Interconnect C – At the School of Education, the outlet of the bioretention BMP is connected to the City storm sewer in Monticello Ave.

Interconnect D – At the Dillard Complex, the outlet of the Plumeri BMP is connected to the City storm sewer in Ironbound Road.

7.5 MS4 Land Cover Determination

The land cover within the MS4 service area is shown at Appendix 18. The land cover condition as of June 30, 2009 was determined using GIS based mapping supplemented by record drawings and field observations.

7.6 Additional Loads

The guidance document requires additions to the WLA due to certain projects initiated between July 1, 2009 and June 30, 2104 under Special Condition Requirements 7 and 8. Projects at the university during this time period fall under Situation 4 of the guidance document and this requirement does not apply.

7.7 MS4 WLA Calculation

The following table provides the WLA required for each MS4 permit cycle:

Table 4: WLA for Each MS4 Permit Cycle

Permit Period	N (lb/yr)	P (lb/yr)	TSS (lb/yr)
First (2013-2018) 5%	6.8	1.3	777
Second (2018-2023) cumulative 40%, estimated	47.6	9.1	5,439
Third (2023-2028) cumulative 100%, estimated	81.6	15.6	9,324

Calculations are included at Appendix 19. The current MS4 permit provides the required removal) for the current compliance period. The required removals for subsequent removal periods can only be estimated because the total WLA will be revised by DEQ in response to additional Chesapeake Bay modeling and other factors.

8.0 EXISTING CREDITS

8.1 Non-Regulatory BMPs

Compliance credits are provided by non-regulatory BMPs. Full credit may be received for BMPs that were initially installed on or after January 1, 2006 and prior to July 1, 2009 that treat runoff from the MS4 service area. Full credit is also available for any non-regulatory BMPs installed after July 1, 2009. Three BMPs of the 11 non-regulatory BMPs meet these criteria and also provide significant removal.

Table 5: Credits from Non-regulatory BMPs

BMP		N (lb/yr)	P (lb/yr)	TSS (lb/yr)
Miller Hall – cistern	2009	2.6	0.5	190
Miller Hall – bioretention	2009	1.0	0.3	122
School of Education – bioretention	2010	8.0	1.9	773
TOTALS		**11.6**	**2.7**	**1,085**

Full calculations are provided at Appendix 20. These BMPs are required to be reported to DEQ by September 15, 2015 in order to be considered for credit.

8.2 BMP Enhancements

For all BMPs or impoundments that were installed prior to July 1, 2009, credit is given for enhancements that improve treatment. The university modified the Law School BMP to add a forebay and micro-pool at the outlet. The Law School BMP was installed as a stormwater quality BMP in 2005 and the enhancement work was completed in 2014.

Table 6: Credits from BMP Enhancements

BMP		N (lb/yr)	P (lb/yr)	TSS (lb/yr)
Law School	2014	18.0	2.7	978
TOTALS		**18.0**	**2.7**	**978**

Full calculations are provided at Appendix 20. This project is required to be reported to DEQ by September 15, 2015 in order to be considered for credit.

8.3 Re-Development Projects

The DEQ Guidance document allows WLA credits for post 2009 projects that met regulatory requirements for reducing the pollutant load. Under the "old" (pre June 30, 2014) stormwater regulations, projects with an existing land cover greater than 16% are required to achieve a post-developed pollutant load 10% less than the pre-developed load. Some of these projects utilized credits from the university's banked credit system. In these cases, the project cannot be used as an MS4 credit. The university's projects in the period 2009 to the present were almost all re-development. However, an analysis of these projects failed to provide significant credits based on the data available.

Future projects that result in a net decrease in pollutant load can also be credited towards compliance. Under the "new" (post June 30, 2014) stormwater regulations, re-development projects are required to achieve a post-developed pollutant load 20% less than the pre-developed load if they disturb more than one acre.

8.4 Banked Credits

The university has a system of banked credits created by upgrades to existing BMPs. As these upgrades were installed prior to January 1, 2006, these BMPs are considered to be part of the existing baseline condition and these credits most likely cannot be used for the Chesapeake Bay TMDL action plan.

9.0 POTENTIAL PROJECTS

9.1 General

The goal of compliance strategies is, foremost, to provide nitrogen, phosphorus & total suspended solids (N, P & TSS) removals in accordance with the Chesapeake Bay TMDL WLA requirements. Secondarily, compliance strategies should address other university water quality concerns (Crim Dell algae blooms/cloudiness, etc.) and surface and stream channel erosion, which also degrade water quality. Finally, compliance strategies should, if affordable, provide an improvement in campus aesthetics.

The tools to achieve compliance consist of structural and operational BMPs as provided by the DEQ guidance document which lists approved BMP types and corresponding treatment efficiency calculation methodology. Additional BMPs are expected to be approved by either the Virginia BMP Clearinghouse or the Chesapeake Bay program.

While the DEQ guidance document provides treatment calculation methodology, it also provides some leeway for applying engineering judgment in both the calculation methodology. It is important that all existing conditions, assumptions, and calculations are well documented in case of audit by DEQ or EPA.

WLA requirements after the first permit cycle (2013-2018) are a moving target. DEQ policy may change as new permit language and guidance documents are developed for each subsequent permit cycle. The next permit cycle will revise WLA requirements based on additional data gathering and modeling efforts. Also, the efficiencies currently assigned to various BMPs could change as more data is evaluated by DEQ through the BMP Clearinghouse. The guidance document states any changes in established efficiencies will not be retroactively applied to projects approved to meet reductions in that permit cycles. The compliance strategy was created by developing recommended projects, which were ranked by cost efficiency in nutrient removal, ability to reduce flooding and stream erosion, and accomplishing other goals important to the university as detailed in Section 10. An implementation schedule was created using the rankings to select projects which can cumulatively achieve the WLA requirement.

9.2 Project Identification Criteria

The DEQ Guidance document lists BMP types that can be considered for Chesapeake Bay TMDL compliance with corresponding removal efficiencies. Additional BMP types will be added to the guidance in the future through a DEQ review committee.

Potential projects were developed by reviewing campus mapping and identifying existing BMPs that could be retrofitted to increase efficiency and locations where a proposed BMP could collect a significant amount of drainage. Then the best retrofit or BMP for that location was selected from those available.

Potential projects were screened by using the following criteria:

- Large areas of impervious cover are the largest sources of stormwater pollutants. Large areas of lawn cover are second largest sources of stormwater pollutants. Treating impervious areas tends to produce more removal for the same BMP, but treating large athletic fields can also produce significant removals, especially for nitrogen. Treating large areas is typically more cost efficient because of economies of scale.

- Treating areas that are also treated by downstream BMPs reduces the pollutant removal of the downstream measure. The DEQ guidance document requires this reduction to be included in the compliance calculations. Potential projects that are in the upper regions of the watershed (ex. the eastern-most portion of main campus) and treat areas that are not a significant portion of the drainage areas of existing BMPs are generally more effective.

- Existing BMPs have the necessary drainage infrastructure already in place. Modifying existing BMPs to increase removal efficiency results in credit for the difference between the modified and existing removal. Modifications can also improve the appearance of the BMP and reduce maintenance costs.

- Projects in areas where water quality has been identified as of concern to campus community can provide both credits and real improvements to water quality.

- Permeable pavements include permeable pavers, asphalt, concrete, gravel, and grass systems. Only the permeable pavers were considered due to concerns with maintenance and durability.

- Proprietary BMPs tended to be less cost effective, but were included in the development of compliance projects where non-proprietary options were not feasible due to space or other considerations.

- The effectiveness of rainwater harvesting, or cisterns, is dependent upon the cistern size. A larger cistern provides a higher percentage of nutrient removal, but increases in size produce diminishing returns in removal. A number of cistern locations were evaluated as part of this study. It was found that the cost of the underground cistern tank and reworking storm lines was more expensive than other systems which provided equivalent removals. Rainwater harvesting depends on economies of scale, therefore the smaller systems using an underground tank were not included in the proposed measures. Dredging of Lake Matoaka has been discussed in the past as a means to reduce the eutrophication the lake currently experiences. Although Lake Matoaka achieves significant nutrient removal, it is not considered a BMP. The current guidelines are not clear regarding whether modifications to the lake can be credited toward compliance. Additional guidance documentation from DEQ is expected to address this issue. If allowed, dredging of the lake to remove accumulated sediment would increase the detention time and increase the removal efficiency.

- Green roof retrofit projects were not considered due to the typical high cost of this type of project. Green roofs should be continued to be considered for inclusion in proposed buildings.

- Floating wetlands have been investigated by the university's Biology Department, including installations at the Health Center BMP and Crim Dell. Currently, the MS4 guidance does not allow floating wetlands, but this could change in the future.

- Algal Turf Scrubber (ATS) also have been investigated by the university's Biology Department. This technology shows some promise for the future, possibly installed in Lake Matoaka, but would require almost daily operations staff.

- Vegetative harvesting has been proposed by as a means to remove nutrients from water bodies by removing and disposing of aquatic plants, such as phragmites or duckweed. This requires continues effort to harvest aquatic plants with specialized boat mounted equipment.

- Compost soil amendments consist of tilling compost into lawn areas to a depth of 6 to 12 inches. More compost and deeper tilling results in higher nutrient removal. This could be carried out along sidewalks on campus, however, the electrical feeds to site lights and other utilities make deeper tilling depths problematic.

- Constructed wetlands are very effective in providing a variety of beneficial stormwater functions, but require significant land area in order to function and it can be difficult to create a self-sustaining plant community.

- Infiltration of runoff into the ground provides almost complete nutrient reduction and recharges groundwater aquifers. This option investigated at the Dillard Complex, the only area of university property where NRCS mapping indicates a higher probability of success. However, the university has a mixed record with the success of infiltration measures. The two systems at Laycock Football Practice Facility appear to be functioning properly, but require additional observation to confirm. The infiltration basin at the Dillard Complex has failed.

- Roof disconnect consists of removing building downspouts from direct connections to the storm sewer system and allowing the runoff to travel over lawn or landscape beds. This method is difficult to implement successfully on a college campus where overland flow paths are broken by sidewalks.

The list of projects was further screened by eliminating where the DEQ guidance was unclear and those projects where costs where excessive. Projects were divided into operational and

structural projects. Operational projects are practices that produce a pollutant removal credit only as long as they are continued. Structural projects are implemented and produce a credit as long as they are maintained.

Detailed project descriptions, conceptual drawings, and construction cost estimates for each project are provided at Appendix 21.

9.3 Proposed Operational Projects

The following operational projects were developed:

- Street Sweeping

9.4 Proposed Structural Projects

- South Sunken Garden - bioretention
- Brooks Parking - bioretention
- Commons Dining - bioretention
- Ukrop Drive Field - bioretention
- Dillard Complex - wet pond
- North Sunken Garden - filterra
- Jamestown Road Parking - filterra
- Tennis Center Parking - filterra
- Dillard Complex - improvements
- One Tribe Place - manufactured
- Crim Dell - retrofit
- Health Center BMP - retrofit
- Wildflower Refuge BMP - retrofit
- Tennis Center BMP - retrofit
- SOE-NW Basin - retrofit

- SOE–SE Basin - retrofit
- Harrison Ave - stream stabilization
- Ukrop Drive - stream stabilization
- Credit Purchase

10.0 COMPLIANCE ALTERNATIVES EVALUATION

10.1 General

Projects were ranked using a weighted formula which included the following:

- Cost efficiency for phosphorus removal
- Ability to correct known flooding issues
- Reduction of known stream erosion issue
- Other goals important to the university such as flow volume reduction, ease of maintenance, scale, and aesthetically improving areas of campus.

The ability to correct known flooding issues was weighted the most, followed by other goals, and reduction of stream erosion. The weighted formula is shown in ranking matrix at Appendix 22.

10.2 Cost Estimate Methodology

Project budget estimates are included at Appendix 23. The project budget a single cost for design and owner's costs and the opinion of conceptual construction costs with a contingency. These cost estimates were developed for the purposes of ranking projects and to establish a general budget for the Chesapeake Bay TMDL action plan. Detailed cost estimates should be developed for the projects included in the action plan based on more detailed design information.

10.3 Treatment Calculation Methodology

All treatment calculations were performed in accordance with the DEQ guidance document. DEQ was also consulted to obtain clarification. Where there were options in methodology, the most conservative approach (producing the least removal) was used. DEQ anticipates issuing clarifications to existing guidance by the end of 2014, so these calculations should be checked prior to implementing projects. Detailed calculations are included in the ranking matrix at Appendix 22.

The drainage area to each proposed BMP was delineated and the pollutant load calculated based on the impervious and pervious area and the same pollutant loading factors as used to calculate the total WLA. Forested area is not considered to produce a pollutant load.

In the case where the drainage area for a BMP included large upstream BMPs, such as the Wildflower Refuge BMP, the drainage area of the upstream BMP was not included in the calculation of the pollutant load. This is a conservative approach for developing and evaluating projects. The calculation methodology can be revised when creating final treatment calculations as part of the BMP retrofit design.

The guidance provides three sources of BMP efficiencies for N, P & TSS removal: Virginia BMP Clearinghouse, Chesapeake Bay Program, and retrofit curves. The selection of the appropriate method depends upon whether the proposed BMP will meet the design standards of the source. The Virginia BMP Clearinghouse tends to have the highest efficiencies and the most difficult design standard to meet, followed by the Chesapeake Bay Program and then the retrofit curves.

In the case of BMP retrofits, the pollutant removal from the existing BMP cannot be included in the credit. This is true even for non-BMPs, such as Crim Dell. However, the efficiency of the existing BMP can be downgraded based on the absence of a sediment forebay or outlet pool.

10.4 Other Factors Methodology

The other factors are issues that are important to the university, but cannot be quantified. These include the following:

- Ability to reduce flooding. There are two areas on campus that experience flooding on a frequent basis; the North Sunken Garden and One Tribe Place.

- Reduces stream erosion. Projects that discharge to existing eroded channels and reduce runoff volume were weighted the most heavily. Stream stabilization projects and projects that are located in existing stream channels were also weighed heavily.

- Accomplishes other goals. Improving the appearance of existing BMPs that area highly visible to the students and university community. These are primarily Crim Dell and the

Health Center and Wildflower Refuge BMPs that are located in the core of the main campus adjacent to highly travelled pedestrian paths.

11.0 RECOMMENDED MS4 COMPLIANCE PLAN

11.1 General

Projects were selected based on their rank to meet the MS4 permit periods. The removals provided are in excess of the requirements for each period in order to create a buffer in case the DEQ guidance changes the allowable BMP treatment efficiencies or questions the calculation methodology for a BMP. As compliance projects are constructed, excess P removal can be used to provide compliance for future building projects. The total removal provided exceeds the amount required for each period to provide a factor of safety in case the compliance guidance is revised or, in the case of periods 2 and 3, the WLA is increased.

11.2 Period 1 – 2013 to 2018

The requirements for the first period WLA removal are met by existing projects constructed between 2009 and 2014. Removals are summarized as follows:

Table 7: Period 1 Chesapeake Bay TMDL Compliance

Project	N (lb/year)	P (lb/year)	TSS (lb/year)
Miller Hall – cistern	2.6	0.5	190
Miller Hall – bioretention	1.0	0.3	122
School of Education – bioretention	8.0	1.9	773
Law School BMP – enhancements	18.0	2.7	978
TOTALS	**29.6**	**5.4**	**2,062**
First Period WLA Requirements	6.8	1.3	777

11.3 Period 2 – 2018 to 2023

Table 8: Period 2 Chesapeake Bay TMDL Compliance

Ranking	Project	N (lb/year)	P (lb/year)	TSS (lb/year)	Individual Project Cost	Cumulative Cost
N/A	Excess Period 1 Removal	22.8	4.1	1,285	-	
1	Health Center BMP	61.2	7.4	2,489	$255,830	$255,830
2	Wildflower Refuge BMP	64.4	8.3	2,860	$402,624	$658,454
3	North Sunken Garden	1.5	0.3	137	$117,029	$775,483
4	Crim Dell/S. Sunken Garden	44.2	9.3	3,804	$562,165	$1,337,648
5	One Tribe Place	8.5	0.6	681	$590,053	$1,927,701
	TOTALS	**202.6**	**30.0**	**11,256**		
	Second Period WLA Requirements (Estimated)	47.6	9.1	5,439		

11.4 Period 3 – 2023 to 2028

Table 9: Period 3 Chesapeake Bay TMDL Compliance

Ranking	Project	N (lb/year)	P (lb/year)	TSS (lb/year)	Individual Project Cost	Cumulative Cost
N/A	Excess Period 2 Removal	155.0	20.9	5,817	$0	$1,927,701
6	Harrison Ave – Stream Restoration	24.3	23.8	15,760	$286,659	$2,214,360
	TOTALS	**179.3**	**44.7**	**21,577**		
	Third Period WLA Requirements (Estimated)	81.6	15.6	9,324		

The first period compliance plan information must be submitted with the MS4 annual report due October 1, 2015. Required information to be included in the annual report is included at Appendix 23.

12.0 DESIGN GUIDELINES FOR FUTURE DEVELOPMENT

12.1 General

While it is realized that stormwater concerns are only one part of site selection, future development should be avoided in areas of highly permeable soils; highly erodible soils; drainage areas of eroded natural channels; and RPA buffers.

Impacts to stormwater quality will be mitigated by compliance with stormwater regulations. All future projects with over 2,500 sf of disturbance located in an RMA/RPA or over one acre outside the RMA/RPA will meet the requirements of the new Virginia stormwater regulations and local regulations where they are more stringent. Projects will also meet any TMDL requirements.

12.2 Quality

The university created a bank of credits in 2006 by modifying three existing BMPs to provide increased treatment. Conversation with DEQ have indicated that the continued use of these credits for non-grandfathered projects cannot be allowed because these credits were calculated using the old (part IIC) methodology and new non-grandfathered projects must meet the new (part IIB) methodology. In other words, a pound of phosphorus credit calculated under the part IIC methodology is not equivalent to a pound of phosphorus credit calculated under the part IIB methodology.

Water quality compliance for the university property area within a single Hydraulic Unit Code (HUC) can be demonstrated by showing that the total phosphorus load is less than 0.41 lbs/acre/year in accordance with 9VAC25-870-92. The vast majority of the university property (approximately 97%) falls within the College Creek HUC. The northern portion of the Dillard Complex falls within the Powhatan Creek HUC and multiple small parcels north of Richmond Road, including One Tribe Place, fall within the Queen's Creek HUC.

Phosphorus loading calculations in accordance with part IIB methodology are included at Appendix 24. Calculations include the removal provided by existing BMPs within the HUC. Results are summarized in the table below. The phosphorus loading for the College Creek HUC

is less than the threshold of 0.41 lbs/Ac/yr. For the Powhatan and Queen's Creek HUCs, the phosphorus loading exceeds the threshold of 0.41 lbs/Ac/yr.

Table 10: Existing Phosphorus Loading Rate

College Creek	1,073.8	0.375
Powhatan Creek	27.3	1.01
Queen's Creek	8.2	1.60

The phosphorus loading was calculated by entering land cover data for each HUC into the runoff reduction spreadsheet. In the case of the College Creek HUC, the resultant load was reduced by the effect of the existing BMPs by entering the treated area into the runoff reduction spreadsheet. The ability of each BMP to BMP Clearinghouse requirements was checked by comparing the required treatment volume to the provided treatment volume. The removal percentage was reduced in cases where the BMP was missing elements required by the BMP Clearinghouse.

The phosphorus loading for the College Creek HUC was calculated by considering Lake Matoaka as impervious as required by the runoff reduction method where proposed BMPs that have standing water, such as wet ponds, are required to be considered as impervious and LID BMPs, such as bioretention, are considered as open space. In this methodology, the impervious area due to the wet pond is added to the total impervious area treated by the BMP. Lake Matoaka is not considered to be a BMP, however, the lake acts as a nutrient sump due to its extended detention time and other factors, which has been documented by research as described in earlier sections of this report. To be consistent with the methodology, this reduction was calculated based on Lake Matoaka acting as a wet pond.

For proposed project in the College Creek HUC, the calculations at Appendix 24 will be updated with changes in land cover and BMPs from the Runoff Reduction spreadsheet for the proposed project to show water quality compliance. For proposed projects in the other two HUCs, the projects will be required to demonstrate stand-alone compliance for water quality.

12.3 Quantity

Compliance with the energy balance requirements of the new regulations will likely require a decrease in the volume (as measured in cubic feet) of the runoff for all projects draining directly or indirectly to a natural waterway.

The sites of the majority of future projects at the university drain to an existing storm sewer which, in turn, discharges to a stream within several hundred feet or less of the project site. In these cases, if the project drainage area is greater than 1% of the total drainage area at the point of discharge, then the energy balance criteria applies.

For the purposes of determining if the project drainage area is greater than 1% of the drainage area at the outfall, the Health Center and Wildflower Refuge BMPs should be considered as a single BMP. When these BMPs were modified in 2005, the university paid into a fund to mitigate the impact the increase in the area of the temporary inundation. The total area of inundation included the area of the Wildflower BMP to the outfall of the Health Center BMP. In addition, the water level of the 1-year storm event in the Wildflower BMP was higher than the outlet invert of the Health Center BMP.

12.4 BMPs

The BMP Clearinghouse currently provides 15 different types of non-proprietary BMPs that can be implemented on projects. Of these, 10 can be used to reduce runoff volume. In addition, these are currently 23 manufactured BMPs approved for use, although none reduce runoff volume. It is recommended that the *Facilities Management Technical Standards* be revised to address which of these BMPs are most suitable for use at the university.

In addition, the *Facilities Management Technical Standards* should include the following additional requirements for design documents and procedures:

- All as-built record plans should be required to include information required to calculate future MS4 Chesapeake Bay TMDL compliance, including all stormwater calculations, drainage maps, and pre and post developed land cover. Having this information will allow the university to easily utilize any credits due

to redevelopment. Plans should also note any new storm outfalls with the drainage areas broken down by land cover in an easily discernible fashion. A summary of required MS4 information should be required on the cover sheet.

- All areas disturbed by construction should be restored by compost soil amendment. After construction, soil is typically heavily compacted by construction traffic which reduces its ability to absorb water and makes it more difficult to maintain lawn.
- All BMPs require periodic inspection and maintenance, however, the frequency and scope varies significantly between different types of BMPs. During design, the consultant should provide information on BMP inspection and maintenance requirements, including any proprietary filters.
- Drawings should require that bioretention risers be permanently marked with a line indicating the top of mulch to assist in maintenance.
- Drawings should require detailed procedures for the installation of bioretention areas, including prevention of sediment from entering the bioretention area and contaminating the planting soil.
- The design engineer should be required to provide a certification that the BMP was installed according to plans.

13.0 RECOMMENDED FURTHER ACTION

This report provides an MS4 compliance plan for this permit cycle (2013-2018) and the next two cycles (2018-2028). It is likely that the required WLAs and the compliance guidance will change with each new permit cycle. Additionally, it is likely that the university will be assigned additional requirements as part of future TMDLs. The plan should be re-evaluated as the new requirements are known.

14.0 CONCLUSIONS

Required removals in the first term can be readily achieved by measures the university has already taken. Based on current estimates of required removals, compliance with the second and third permit terms will require construction of BMPs. The compliance schedule is show in the following table:

Table 11: MS4 Chesapeake Bay TMDL Compliance Milestone Schedule

1.	Action Plan complete	June 30, 2015
2.	Public comment (30 days)	August 1, 2015
3.	Revised action Plan submitted to DEQ with annual report	October 1, 2015
4.	1st Permit term BMPs constructed (completed)	June 30, 2018 (completed)
5.	2nd Permit term BMPs constructed	June 30, 2023 (est.)
6.	3rdt Permit term BMPs constructed	June 30, 2028 (est.)

Even though the Action Plan is not required to be submitted prior to the Annual Report, it is advised that the university submit this report to DEQ as soon as it is complete to allow DEQ to provide feedback in time to allow modifications to the constructed BMPs.

The proposed Action Plan not only provides regulatory compliance, but the BMPs proposed for permit compliance will also make significant contributions toward improving water quality on campus and in Lake Matoaka.

Future construction projects at the university will need to comply with Virginia's new stormwater standards. These regulations require a higher level of pollutant removal for redevelopment projects utilizing a combination of reductions in runoff volume and peak runoff flow rate for projects in the watersheds of on-campus streams.