CITY OF MANASSAS, VIRGINIA
TOTAL MAXIMUM DAILY LOAD (TMDL) ACTION PLAN FOR:

THE CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS AND SEDIMENT

PHASE II

City of Manassas
Department of Public Works
8500 Public Works Drive
Manassas, VA 20110
703-257-8226
October 31, 2019

City of Manassas
Phase II Chesapeake Bay TMDL Action Plan
October 31, 2019

Action Plan Certification

As required by the MS4 General Permit, Part III K 4

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Name: Tony H. Dawood Signature: _____

Title: Director of Utilities Date: Nov. 1, 2019

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ATTACHMENTS

ACRONYMS

BMP	Best Management Practice
CWA	Clean Water Act
DC	District of Columbia
DEQ	Department of Environmental Quality
DPU	Department of Public Utilities
EPA	Environmental Protection Agency
GIS	Geographic Information System
L2	Level 2 Scoping Run
LBS	Pounds
MD	Maryland
MS4	Municipal Separate Storm Sewer System
MS4 General Permit	VPDES General Permit for Stormwater Discharges from Small MS4s
NMP	Nutrient Management Plan
USOA	Upper Occoquan Service Authority
POC	Pollutant of Concern
SWM	Stormwater Management
SWU	Stormwater Utility
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
UA	Urbanized Area
U.S.	United States
VA	Virginia
VPDES	Virginia Pollutant Discharge Elimination System
VRRM	Virginia Runoff Reduction Method
VSMP	Virginia Stormwater Management Program

DEFINITIONS

Existing Sources	Pervious and impervious urban land uses served by the MS4 as of June 30, 2009.
New Sources	Pervious and impervious urban land uses served by the MS4 developed or redeveloped on or after July 1, 2009.
Pollutants of Concern	Total nitrogen, total phosphorus, and total suspended solids.
Transitional Sources	Regulated land disturbing activities that are temporary in nature and discharge through the MS4.

CHAPTER 1. INTRODUCTION

The Chesapeake Bay is a shallow estuary stretching approximately 200 miles from Havre de Grace, Maryland to Virginia Beach, Virginia. The Bay's approximately 64,000 square mile watershed covers parts of six (6) states – Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia – and the District of Columbia. Since the late 1990s, the Chesapeake Bay has been identified by surrounding states as impaired, or not meeting its designated water quality standards, due to excessive pollutants, (i.e., nitrogen, phosphorus, and sediment) causing algae blooms, creating dead zones, reducing sunlight penetration into the water and smothering wildlife. In 2010, the United States EPA published the Chesapeake Bay TMDL for Nitrogen, Phosphorus and Sediment, which established a "pollution diet" for each of the POC in order to address the impairments.

To address the TMDL, Virginia has developed and continues to implement a multi-faceted plan to reduce the quantity of POCs discharged to the Bay from Virginia waters including four major rivers - James, Potomac, Rappahannock, and York. Virginia's plan includes the inclusion of POC reduction requirements in VPDES permits for operators of DEQ-regulated point-source discharges, including MS4s. As a result of the 1987 revisions to the CWA, small MS4s are considered regulated point sources. Small MS4s are best described as storm sewer systems owned or operated by a government entity within an UA, as delineated by the latest decennial U.S. Census.

The City operates a small MS4 within the Washington DC-VA-MD UA, which is located within the Potomac River watershed, a major tributary of the Chesapeake Bay (Figure 1). As a regulated MS4 operator, the City is subject to the POC loading reduction requirements included in the TMDL for Transitional Sources, New Sources, and Existing Sources. These POC loading reductions are mandated in VPDES permits issued by the Virginia DEQ, the designated State authority for CWA implementation and compliance.

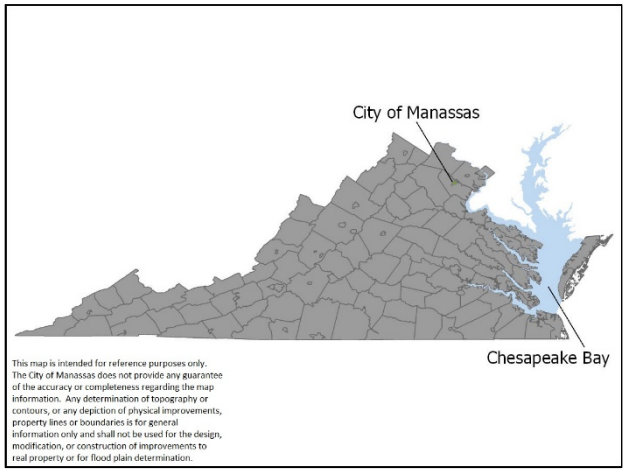


Figure 1. Map indicating location of Manassas, Virginia

The MS4 General Permit, under which the City MS4 has coverage (Permit Registration Number VAR040063), contains a Special Condition that the City must address in order to 1) comply with the MS4 General Permit and 2) make adequate progress towards achieving TMDL wasteload allocations[1] in a manner consistent with the assumptions and requirements of the TMDL. The City must submit an updated Phase II TMDL Action Plan no later than 12-months after the effective date of the MS4 General Permit (November 1, 2018) "for the reductions required" no later than the expiration of the MS4 General Permit (October 31, 2023). The permit spells out a series of specific steps regulated MS4s must address. The following chapters cover those steps, beginning with a review of local regulations to see what, if any, modifications are needed to meet permit requirements.

[1] POC load reductions from Existing Sources are based on having three consecutive MS4 General Permit cycles to meet the required reductions and for which the cumulative POC reductions per permit cycle reductions are 5% (2013 MS4 General Permit), 40% (2018 MS4 General Permit), 100% (2023 MS4 General Permit).

CHAPTER 2. REGULATORY REVIEW

The City has reviewed its regulatory authorities to determine the need for "*any new or modified legal authorities, such as ordinances, permits, policy, specific contract language, orders, and interjurisdictional agreements, implemented or needing to be implemented to meet the requirements Part II A 3, A 4, and A.*" [2]

The City believes that it has sufficient legal authority to implement the POC reductions for both new and existing sources. However, the City does not believe that it has been provided sufficient guidance by DEQ to ensure that the City's proposed efforts identified in this Phase II TMDL Action Plan will meet the required POC reductions by October 31, 2023, regarding the following:

- Section 9VAC25-870-69 of the Virginia Administrative Code allows for the use of off-site compliance options to meet VSMP water quality design criteria under certain conditions. § 62.1-44.15:35 I.1. of the Code of Virginia provides for a 1:1 credit towards MS4 compliance with the Chesapeake Bay TMDL WLA when nutrient credits are used to meet nutrient reduction requirements associated with redevelopment. § 62.1-44.19:21.1.A of the Code of Virginia provides authority for MS4 permittees to *"acquire and use sediment credits for purposes of compliance with any waste load allocations established by total maximum daily loads for the Chesapeake Bay or its tidal tributaries applied in an MS4 permit."*

  The City believes that this provides authority for the City to apply sediment reductions associated with offsite nutrient credit purchases as part of redevelopment projects towards its sediment load reduction requirements. To date, the City has not seen clarification of the statement contained in the MS4 General Permit, Part II A 11 a., 'Sediment credits shall not be associated with phosphorus credits used for compliance with the stormwater nonpoint nutrient runoff water quality criteria established pursuant to § 62.1-44.15:28 of the Code of Virginia" nor has the City seen sediment rates associated with the individual nutrient banks from which credits have been purchased.

  In order to properly apply sediment reductions associated with nutrient credit purchases that it is required to approve as part of its VSMP program, the City believes that these sediment issues must be resolved.

- On October 7, 2019, DEQ distributed an e-mail to its list of MS4 contacts in which it provided written notification that DEQ Guidance GM15-2005 was being updated (Attachment 1). Among the proposed updates includes the proposed change that would result in "phasing out the mass loading approach to reflect the Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices Final Report, dated May 19, 2016."

  The City utilized the mass loading approach in this TMDL Action Plan to recalculate the POC reductions previously approved by DEQ in a May 23, 2016 letter regarding the City's Phase I TMDL Action Plan pollutant reductions (Attachment 2). This proposed modification will further impact both the City's long-term plans for meeting the required POC reductions by October 31, 2023, as well as its ability to develop a Chesapeake Bay TMDL Action Plan that demonstrates compliance with the MS4 General Permit Special Condition.

  This TMDL Action Plan is submitted with the full understanding that DEQ intends to modify the existing guidance associated with the development of Chesapeake Bay TMDL Action Plans. However, in order to comply with the MS4 General Permit requirement to submit an updated

[2] MS4 General Permit, Part II A 11 a

Chesapeake Bay TMDL Action Plan for the reductions required in Part II, A 3, A 4 and A 5, the City has calculated the expected annual POC load reductions associated with its street sweeping utilizing the mass load approach. Given the very short timeframe between publication of DEQ's written notification of its intentions and the required action plan submission date, the City has not had sufficient time to consider the implications associated with this pending modification nor select alternative POC load reduction strategies to meet the October 31, 2023 POC reduction requirements. The City will modify this TMDL Action Plan as necessary to incorporate any final guidance changes published by DEQ and the City looks forward to working with DEQ on any adjustments as the modifications are phased in.

In addition to the issues noted above, the City is also currently undertaking a significant structural reorganization of its stormwater management functions. Historically, responsibility for stormwater management and related services (i.e., stormwater pollution control, floodplain management, dam safety, etc.) in the City has been divided among several different departments in the City's administrative structure. The City's DPU, which operates the City's other enterprise fund-based utilities for water, wastewater, and electricity, only recently took over the management of the City's SWU, and with it – the lead role of the City's Stormwater Program. Since being assigned responsibility for the SWU, DPU has worked diligently to gain a more thorough understanding of its programmatic framework, resource levels, and service expectations. In the development of this Chesapeake Bay TMDL Action Plan, DPU has taken a conservative approach by only including City efforts of which were verified at the time of submission of this TMDL Action Plan. DPU will continue to update and modify this TMDL Action Plan as necessary to incorporate additional information regarding City efforts.

CHAPTER 3. CITY OF MANASSAS MS4 POC LOADS TO THE POTOMAC RIVER

The regulated portion of the City's MS4 service area expanded with the increase of the Washington DC-VA-MD UA boundaries associated with the 2010 U.S. Census (Figure 2). The following estimated POC loads and required POC reductions to the Potomac River incorporate the expanded regulated area associated with the increased UA boundary.

Estimated POC Loads

Existing Sources

In developing POC load estimates from Existing Sources listed in Table 1, the City incorporated the expanded UA, separately permitted VPDES facilities and the estimated City tree canopy using the assumptions to provide estimated regulated areas (Attachment 3).

Table 1. POC Load Estimates from City of Manassas MS4 Existing Sources

POC	Estimated Load (lbs./year)[3]
Nitrogen	50,477
Phosphorus	3,949
Sediment	2,659,905

The calculations for determining the Estimated Load and POC Reductions from Existing Sources are found in Attachment 4.

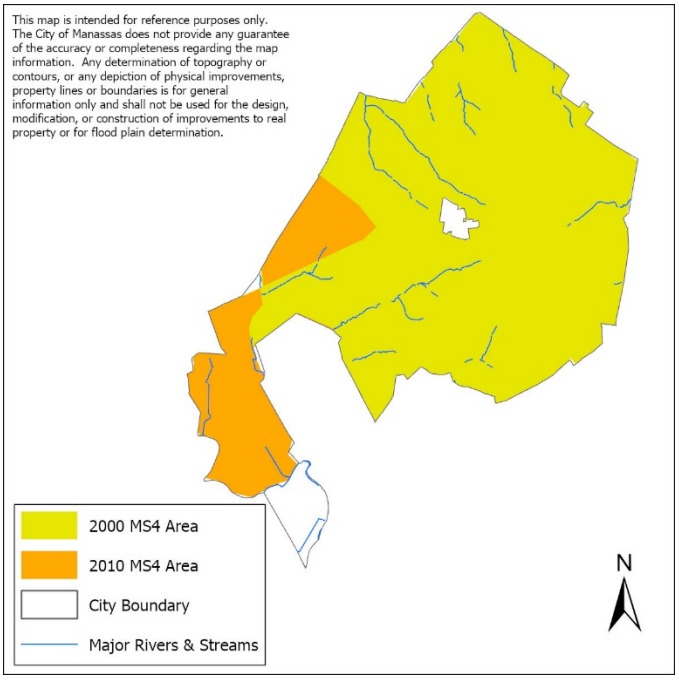


Figure 2. 2000 and 2010 Washington DC-VA-MD UA Boundaries

Increases in POC Loads Associated with New Sources

The City identified increases in POC from New Sources associated with development that occurred between July 1, 2009 and June 30, 2014 in which the stormwater design criteria was greater than 0.45 lbs./acre/year and the potential projects that met the grandfathering criteria as outlined in 9VAC25-870-48.

POC Increases Associated with Greater than 0.45 lbs./acre/year Design Criteria

In the City's Phase I Chesapeake Bay TMDL Action Plan, the City identified that the regulated impervious acreage increased by 9.6 acres between July 1, 2009 and June 30, 2014 and included an associated increase of POC loads as outlined in Table 2.

[3] Per Part II A 8 of the MS4 General Permit Loading and reduction values greater than or equal to 10 pounds calculated in accordance with Part II A 3, A 4, and A 5 shall be calculated and reported to the nearest pound without regard to mathematical rules of precision. Loading and reduction values of less than 10 pounds reported in accordance with Part II A 3, A 4, and A 5 shall be calculated and reported to two significant digits.

Table 2. POC Load Estimates from City of Manassas MS4 New Sources

POC	Estimated Load (lbs./year)
Nitrogen	65
Phosphorus	12
Sediment	9,557

At the time of submission of this TMDL Action Plan, the City has not verified that the projects associated with the identified increased impervious area meet the conditions found in Part II A 4 of the MS4 General Permit. As a conservative approach, the City will keep the entire increase in loads associated with New Source loads in its TMDL Action Plan.

POC Increases Associated with Grandfathered Projects

In the Phase I TMDL Action Plan, the City listed three (3) projects for which plans had been approved that met the grandfathering provision in 9VAC25-870-48 (Table 3).

Table 3. Future Projects With Approved Plans Meeting the Grandfathering Criteria in 9VAC25-870-48

Project	Address	Project Size (acres)
Firestone Complete Auto Care	9850 Liberia Avenue	2.5
Prescott Court	9214 Prescott Avenue	1.62
Grant Corner	Orchard Lane	1.47

The Phase I TMDL Action Plan identified an increase in POC loads associated with these projects (Table 4).

Table 4. POC Load Estimates from City of Manassas MS4 Grandfathered Sources

POC	Estimated Load (lbs./year)
Nitrogen	37
Phosphorus	5.34
Sediment	2,506

At the time of submission of this TMDL Action Plan, the City has learned that the Firestone Complete Auto Care project included in the City's Phase I Chesapeake Bay TMDL Action Plan as a grandfathered project will not proceed. The City will remove the increase in POCs associated with this project once the individual POC loads are identified. In the meantime, the City will keep the entire increase in loads associated with grandfathered loads in its TMDL Action Plan in order to continue its conservative approach at ensuring the necessary POC reductions are met.

CHAPTER 4. CITY OF MANASSAS MS4 REQUIRED CUMULATIVE POC REDUCTIONS TO THE POTOMAC RIVER

To comply with the MS4 General Permit, the City must meet the following by October 31, 2023:

- Implement sufficient strategies to attain 40% of the POC reductions calculated using the L2 Scoping Run Reductions for Existing Sources. The L2 Scoping Run assumes
  - Reduce the total discharge of nitrogen as follows: 9% from impervious regulated lands, 6% from pervious regulated lands
  - Reduce the total discharge of phosphorus as follows: 16% from impervious regulated lands, 7.25% from pervious regulated lands
  - Reduce the following total discharge of sediment as follows: 20% from impervious regulated lands, 8.75% from pervious regulated lands;
- Offset 40% of the increased loads from new sources initiating construction between July 1, 2009 and June 30, 2019 where the construction activity
  - Disturbed one acre or greater
  - The resulting total phosphorus load was greater than 0.45 lbs./acre/year; and
- Offset 100% of the increased loads from projects grandfathered in accordance with 9VAC25-870-48 where the construction activity
  - Began after July 1, 2014
  - Disturbed one acre or greater
  - The resulting total phosphorus load was greater than 0.45 lbs./acre/year.

Required POC reductions associated with the City's Potomac River POC loads are found in Table 5.

Table 5. Required Potomac River POC Reductions from City MS4 Required by October 31, 2023

Pollutant Load	Required Reduction	Pollutant	Required Reduction (lbs./year)
Existing Load[4]	40% of the L2 Scoping Run Assumptions	Nitrogen	1,622
		Phosphorus	230
		Sediment	200,002
Increase in New Load	40% of the Increase in New Source Load	Nitrogen	26
		Phosphorus	4.65
		Sediment	3,823
Grandfathered Projects[5]	100% of Completed Grandfathered Projects	Nitrogen	37
		Phosphorus	5.34
		Sediment	2,506

[4] Existing Source load reduction calculations are included as part of Attachment 3.
[5] Includes Firestone Complete Auto Care project, which will not be constructed. The associated grandfathered load will be removed once the associated POC loads are identified.

The summation of individual POCs in Table 5 demonstrates that the City must implement sufficient strategies, including SWM facilities, BMPs, off-sets and credits by October 31, 2023, to account for the following reductions in POC loads:

- Nitrogen –1,685 lbs./year
- Phosphorus –240 lbs./year
- Sediment –206,300 lbs./year

CHAPTER 5. BMPs IMPLEMENTED BY THE CITY OF MANASSAS PRIOR TO JULY 1, 2018

As previously referenced, the City received a letter from DEQ on May 23, 2016 (Attachment 2) that its Phase I Chesapeake Bay TMDL Action Plan would result in the following annual POC reductions:

- Nitrogen – 5,785 lbs.
- Phosphorus – 951 lbs.
- Sediment – 2,257,911 lbs.

These reductions were calculated based on the verification of permanent SWM facilities and annual street sweeping efforts and were used in the development of the draft Phase II TMDL Action Plan previously submitted to DEQ.

In the development of this TMDL Action Plan, the City has only verified the Phase I TMDL Action Plan permanent POC reductions found in Table 6.

Table 6. Verified Permanent POC Reductions Implemented Prior to July 1, 2018

BMP Type	Location	Date of Implementation	Creditable Reduction (lbs./year)		
			Nitrogen	Phosphorus	Sediment
Historical BMP/ Dry Pond	Fairview Square Shopping Center	June 30, 2015	0.47	2.76	327.15
Oversized BMP/ Level 1 Wet Pond[6]	Prince William Hospital Regional SWM Facility	June 30, 2017	641.87	146.95	86,977.51
Phase I TMDL Action Plan Total Existing Source POC Reductions			**642**	**150**	**87,305**

Additionally, the POC reduction estimates for street sweeping included in the May 23, 2016 DEQ letter (Attachment 2) were not calculated by either the mass loading approach or the qualifying street lanes method as provided for in the DEQ Guidance GM15-2005 Appendix V G.[7] To correct this oversight, the City averaged its street sweeping collections reported to DEQ in its MS4 Annual Reports from 2016 to 2019 to determine the average tonnage collected, 387.68 tons (775,350 lbs.), associated with its street sweeping program.[8] The City then calculated the annual POC reductions over the four (4) years based on the average tonnage collected using the mass loading approach (Table 7).

[6] Total annual POC removal associated with the Prince William Hospital Regional SWM Facility was 860.1 lbs. nitrogen, 200.41 lbs. phosphorus and 254,360.91 lbs. sediment. The difference between the total annual POC removal and the credited loads was utilized to meet water quality criteria requirements associated with new development.

[7] DEQ, GM15-2015 Chesapeake Bay TMDL Special Condition Guidance, May 18, 2015

[8] The City's street sweeping schedule was not modified during the permit years included in the analysis.

Table 7. Verified Annual POC Load Reductions Implemented Prior to July 1, 2018

BMP Type	Location	Date of Implementation	Creditable Reduction (lbs./year)		
			Nitrogen	Phosphorus	Sediment
Street Sweeping	City-wide	Prior to July 1, 2015	1,357	543	162,824

The summation of POC reductions in Tables 6 and 7 show that the City has implemented verifiable strategies prior to July 1, 2018 equivalent to the following POC load reductions:

- Nitrogen – 1,999 lbs./year
- Phosphorus – 692 lbs./year
- Sediment – 250,128 lbs./year

CHAPTER 6. FUTURE PLANNING

The City commits to a good faith effort in the continued implementation of the strategies necessary to ensure that the required POC reductions are implemented by October 31, 2023. In recognition that the draft Phase II TMDL Action Plan is only a planning document, the City acknowledges that revisions to the TMDL Action Plan and implementation strategies may be necessary while pursuing the ultimate POC reduction goals. As previously identified in Chapter 2, Regulatory Review, there are several identified issues that the City knows may require modification to the City's intended strategies included in this document. Until such time, the City's plan for moving forward in an effort to meet the required annual POC reductions is based on those reductions remaining after reducing the required loads by the verified permanent loads implemented prior to July 1, 2018 (Table 8).

Table 8. Verified POC Reductions Implemented Prior to July 1, 2018

POC	Reduction Required by October 31, 2023 (lbs./year)	Verified Permanent Reductions as of July 1, 2018 (lbs./year)	Remaining Reductions (lbs./year)
Nitrogen	1,685	642	1,043
Phosphorus	261	150	111
Sediment	206,300	87,305	118,995

The City plans to utilize the following BMPs to ensure that the remaining reductions are met by October 31, 2023.

BMP 1. Annual Street Sweeping

The City will continue its street sweeping program. The City will sweep 2,755 lane miles per year. Using the mass loading approach published in DEQ's GM15-2005 guidance and the *minimum* tonnage reported as collected in the 2016-2019 MS4 Annual Reports (2017 – 381.52 tons), the estimated annual POC load reductions are calculated in Table 9.

Table 9. Estimated Minimum Annual POC Reductions Associated with City Street Sweeping Program

Total Sweepings Collected (lbs.)	Dry Weight	Dry Weight (lbs.)	Nitrogen, lbs.		Phosphorus, lbs.		Sediment, lbs.	
			Lb./lb. Dry Weight	Total	lb./lb. Dry Weight	Total	lb./lb. Dry Weight	Total
763,040[9]	75%	534,128	0.0025	1,335	0.001	534	0.3	160,238

The assumed POC reductions credited to the City's street sweeping program using the Mass Load Approach provides compliance with the required October 31, 2023 POC reductions (Table 10).

[9] Reported as 381.52 tons in the 2017 City of Manassas Annual Report

Table 10. Demonstrated Compliance With The October 31, 2023 POC Reductions

POC	Reduction Required by October 31, 2023 (lbs./year)	Verified Permanent Reductions as of July 1, 2018 (lbs./year)	Remaining Reductions (lbs./year)	POC Reductions from Street Sweeping (lbs./year)	Remaining Reductions (lbs./year)
Nitrogen	1,685	642	1,043	1,335	Requirement Met
Phosphorus	261	150	111	534	Requirement Met
Sediment	206,300	87,305	118,995	160,238	Requirement Met

As discussed in Chapter 2, Regulatory Review, DEQ's proposed elimination of the mass loading approach as a method to quantify street sweeping POC reductions will greatly impact both the City's long-term plans for meeting the required POC reductions by October 31, 2023 as well as this TMDL Action Plan's ability to demonstrate compliance with the MS4 General Permit.

Alternative Strategies

The City has engaged in a long-term planning process to address the expected POC reductions associated with a third MS4 General Permit cycle. In anticipation of DEQ publishing modified Chesapeake Bay Action Plan guidance, the City will begin review and evaluation of its alternative strategies in order to identify those which may be substituted for the street sweeping reductions, which the City had relied upon. These strategies include the following:

POC Reductions Associated with Redevelopment

The City will credit POC reductions associated with future redevelopment. If SWM facilities are installed, the City will obtain associated nitrogen and phosphorus reductions from the VRRM ReDevelopment Spreadsheet based on the selected SWM facility and impervious cover. Sediment reductions will be calculated using the SWM facility efficiencies established by the Chesapeake Bay Program. If pollutant reduction requirements are met through the use of nutrient credit purchase, the City will utilize the phosphorus load purchased and the associated retired nitrogen and sediment loads (once sediment load ratios are published by DEQ).

The City will continue to identify and verify previous POC reductions associated with redevelopment as it continues to collect and review historical information as part of assuming management of the City's stormwater utility. The City is aware of at least two additional BMPs associated with redevelopment that will be credited towards meeting the required POC reductions once POC reduction calculations are verified:

- Novant Health Redevelopment, Nutrient Credit Purchase
- Manassas Station Redevelopment, Manufactured Device - BayFilter

POC Reductions Associated with Oversized BMPs

Prior to establishing its current local VSMP, the City implemented a stormwater pro-rata program. Developers were given the option of contributing a pro-rata assessment to the City in lieu of providing on-site stormwater treatment. In return, the City developed four (4) regional SWM facilities as listed in Table 11.

Table 11. City Pro-Rata Regional SWM Facilities

Name	BMP Type	Total Area Treated (Acres)
Sumner Lake Regional SWM Facility	WetPond	470
Winters Branch Regional SWM Facility	WetPond	431
Wakeman Tract Regional SWM Facility	WetPond	715.2
New Britain Regional SWM Facility	WetPond	299.12
Lucasville/Cockrell Branch Regional SWM Facility	WetPond	TBD

The City will utilize POC reduction credits associated with these oversized SWM facilities upon creditable verification of excess POC reductions.

Public Stormwater Retrofits

The City has completed an initial review of public SWM facilities to identify potential retrofit opportunities (Attachment 5). The City is evaluating the economic efficiency and pollutant removal effectiveness associated with the identified potential retrofits.[10]

Stream Restoration

The City has completed an initial review of accessible stream segments throughout the City to identify potential restoration and floodplain reconnection opportunities (Attachment 6). The City is evaluating the economic efficiency, accessibility and pollutant removal effectiveness associated with the identified stream restoration opportunities. The City is cognizant that DEQ may also propose a modification in the method used to calculate pollutant load reductions associated with stream restoration. As this will impact the City's decision-making process, the City will wait until final DEQ guidance publication to review these opportunities.

[10] Note: The data used in drainage delineations 2018 TMDL report is now legacy data as it is from December of 2017. The GIS pipe network and other cadastral data are dated as 2017 but the one-foot contour lines used in the analysis are from 2001. The most recent GIS pipe network data submitted to DEQ in July 2019 has been updated many times in comparison.

Forest Buffers

The City has acquired sections of forested buffers along numerous sections of City streams (Figure 3).

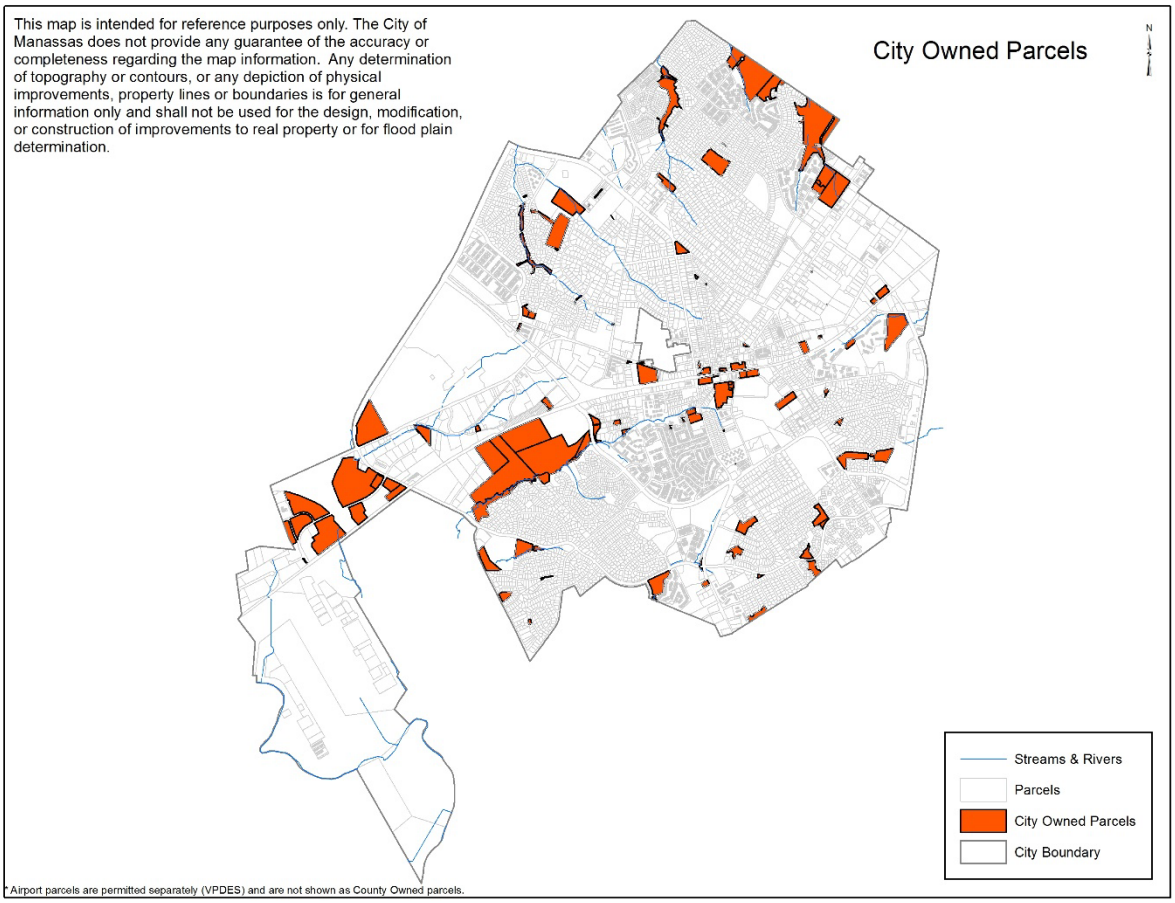


Figure 3. City-Owned Parcels Including Forested Buffers

While the City has accounted for the forested land use associated with these buffers as part of its regulated pervious area calculations, it has not taken credit for the pollutant reductions associated with the upland acres. As a result, the City may evaluate the opportunity for available credits for treating upland acres associated with its forested buffers in accordance with DEQ guidance GM15-2005 Appendix V.I.

Additional Strategies

The City also retains the right to continue to evaluate other potential strategies to meet the POC reductions required by October 31, 2023 including:

- Nonpoint Nutrient Credits;
- Private Exchanges with regulated VPDES facilities (The City entered into a water quality credit exchange agreement with UOSA on May 17, 2018 (Attachment 7)); and
- Other means and methods not included in this document.

CHAPTER 7. PUBLIC PARTICIPATION COMMENTS

The City of Manassas provided an opportunity for the public to comment on its Chesapeake Bay TMDL Action Plan from October 16, 2019 until October 31, 2019. The City provided the public notification of its acceptance of public comment by publishing notification in the Prince William Times on October 16, 2019 and October 23, 2019 (Figure 4). Additionally, the City posted notification of comment acceptance on its web page, www.manassascity.org/2504/News-and-Events. The City did not hold a public meeting to accept comments or address public concerns.

As required by Part II A 11 f, the following information is included:

1. A summary of comments received as a result of the public comment period.

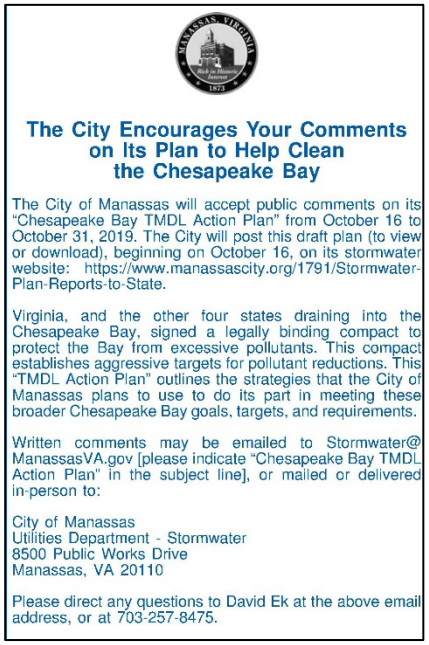
   The City did not receive any public comments as a result of the published notification.

2. The City's response to any public comments.

   The City did not receive any public comments and therefore no response is necessary.

3. Revisions made to the Chesapeake Bay TMDL Action Plan as a result of public participation.

   At the City's request, the following revisions were made to the Chesapeake Bay TMDL Action Plan:
   - Disclaimers were added regarding the use of City GIS data.
   - The Lucasville/Cockrell Branch Regional SWM Facility was added to Table 11.



The City Encourages Your Comments on Its Plan to Help Clean the Chesapeake Bay

The City of Manassas will accept public comments on its "Chesapeake Bay TMDL Action Plan" from October 16 to October 31, 2019. The City will post this draft plan (to view or download), beginning on October 16, on its stormwater website: https://www.manassascity.org/1791/Stormwater-Plan-Reports-to-State.

Virginia, and the other four states draining into the Chesapeake Bay, signed a legally binding compact to protect the Bay from excessive pollutants. This compact establishes aggressive targets for pollutant reductions. This "TMDL Action Plan" outlines the strategies that the City of Manassas plans to use to do its part in meeting these broader Chesapeake Bay goals, targets, and requirements.

Written comments may be emailed to Stormwater@ManassasVA.gov [please indicate "Chesapeake Bay TMDL Action Plan" in the subject line], or mailed or delivered in-person to:

City of Manassas
Utilities Department - Stormwater
8500 Public Works Drive
Manassas, VA 20110

Please direct any questions to David Ek at the above email address, or at 703-257-8475.

Figure 4. Public Notification Posted in the Prince William Times on October 16 and 23, 2019 to Solicit Public Comment on the City's Action Plan.

Attachment 1

DEQ TMDL Action Plan Update – Selengut E-Mail (October 7, 2019)

Subject: FW: TMDL Action Plan Update

From: **Selengut, Jeffrey** <jeffrey.selengut@deq.virginia.gov>
Date: Mon, Oct 7, 2019 at 1:09 PM
Subject: TMDL Action Plan Update
To: Jason Papacosma <Jpapacosma@arlingtonva.us>, <Heather.ambrose@fairfaxcounty.gov>, <maveni@pwcgov.org>, <mmohan@pwcgov.org>, Flanigan, Scott <FlaniganS@chesterfield.gov>, <smedleys@chesterfield.gov>, <Jen.Cobb@henrico.us>, <Bbrumba@cityofchesapeake.net>, <gkhawkins@hampton.gov>, <awatts@nnva.gov>, <june.whitehurst@norfolk.gov>, <quattlebaumt@portsmouthva.gov>, <MCoffey@vbgov.com>, <dstjohn@vbgov.com>, Christopher Swanson <Chris.Swanson@vdot.virginia.gov>, Parrish, James T CIV DLA INSTALLATION SUPPORT (USA) <Jimmy.Parrish@dla.mil>, <leighanne.weitzenfeld@roanokeva.gov>, Andrew Conti <andrew.conti@dbhds.virginia.gov>, Norris, Craig A CIV USARMY ID-TRAINING (US) <craig.a.norris10.civ@mail.mil>, Hawkins, Erin <erin.hawkins@lynchburgva.gov>, <chisolk@colonialheightsva.gov>, <cvanallman@salemva.gov>, <istenbjorn@town.ashland.va.us>, <mjdieter@hanovercounty.gov>, Darryl Walker <dwalker@petersburg-va.org>, <jbattiata@hopewllva.gov>, Simmons, Bryce M. <bryce.simmons@danvilleva.gov>, <khoward@blacksburg.gov>, Cindy Linkenhoker <clinkenhoker@roanokecountyva.gov>, Ellen Roberts <ellen.roberts@poquoson-va.gov>, Patricia Colatosti <pcolatosti@christiansburg.org>, Joey Hiner <jhiner@vintonva.gov>, Aaron Small <asmall@williamsburgva.gov>, Brogan, Joe <broganj@yorkcounty.gov>, Sherry Earley <searley@suffolkva.us>, <kwitter@virginiawestern.edu>, <jonathon.m.colmer.civ@mail.mil>, <Toni.Small@jamescitycountyva.gov>, <gshipp@wm.edu>, <joseph.daft@bristolva.org>, Kast, Katelyn <katelyn5@exchange.vt.edu>, Finley, Dan R SAMVAMC <dan.finley@va.gov>, Dan Frisbee <frisbee@charlottesville.org>, Mark Brabham <mbrabham@vims.edu>, <kelly.henshaw@winchesterva.gov>, John Ware <jware@bridgewater.town>, Scott Rae <srae@staffordcountyva.gov>, Maines, Jesse <jesse.maines@alexandriava.gov>, John M. Saunders <jmsaunders@fredericksburgva.gov>, <cmumaw@leesburgva.gov>, <richard.smith@herndon-va.gov>, Michelle Brickner <mbrickner@ci.manassas.va.us>, <christina.alexander@fairfaxva.gov>, Jason Widstrom <jwidstrom@fallschurchva.gov>, Horner, Christine <christine.horner@viennava.gov>, Stone, Chris <chris.stone@loudoun.gov>, <richard.p.lafreniere2.civ@mail.mil>, <richard.pringle@usmc.mil>, <sgentry@staffordschools.net>, Wenger, Jess <jsw6d@virginia.edu>, John Murphy <jmurphy@albemarle.org>, Kelley K. Junco <Kelley.Junco@harrisonburgva.gov>, dalexand@odu.edu <dalexand@odu.edu>, <patricia.hunt@science.doe.gov>, <amaris.rodriguez@va.gov>, Mason, John <masonj@tncc.edu>, Bert Thompson <bthompson@tcc.edu>, Dean Whitehead <dean.whitehead@cnu.edu>, Glandorff, Monika CIV <monika.a.glandorff@uscg.mil>, Van Dyke, Peter R. (LARC-D406) <peter.vandyke@nasa.gov>, Couch, Pamela J CIV USARMY IMCOM (US) <pamela.j.couch2.civ@mail.mil>, Les Johnson (ajohnso3) <ajohnso3@umw.edu>, Trimble, David <dtrimble@nvcc.edu>, <paperkins@nsu.edu>, <uglowaf@pwcs.edu>, <Briandl1@ucia.gov>, <courtk@ucia.gov>, Eichenlaub, Joseph D CIV WHS FSD (US) <joseph.d.eichenlaub.civ@mail.mil>, Zhongyan Xu <zxu8@gmu.edu>, <mverdu@reynolds.edu>, Rebecca S. Parkhill <rparkhill@pvcc.edu>, Charles Toothman <charles.toothman@dcc.vccs.edu>, <gdunaway@jtcc.edu>, <brenda_wasler@nps.gov>, Chestnut, Dale L - chestndl <chestndl@jmu.edu>, Johnathan Lee <leejo@fcpsk12.net>, Otero, Isis K RICVAMC <isis.otero@va.gov>, <gtkac@dumfriesva.gov>, <parkerr@centralvirginia.edu>, <rochaj@centralvirginia.edu>, <jataylor@vsu.edu>, <olin.kinney@mwaa.con>, Richard Hall <richard.w.hall@dbhds.virginia.gov>, Hopewell, Andrew <andrew.hopewell@fauquiercounty.gov>, <dhermoso@warrentonva.gov>, Garland Fenwick <gfenwick@germanna.edu>, <dsbriggs@usgs.gov>, Lin, Cathy <cathy.lin@apsva.us>, Robert Wilburn <robert.wilburn@djj.virginia.gov>, <dforman@bop.gov>, <shenderson@fmauthority.com>, Morgan Shrewsbury <mshrewsbury@co.augusta.va.us>, Patrick Wilkins <wilkinspm@ci.staunton.va.us>, <allen-kayjl@ci.waynesboro.va.us>, <woodrumsa@montgomerycountyva.gov>, Jay Eanes <jay.eanes@radfordva.gov>, Thompson, Neal <lthompson@radford.edu>, <tvencill@abingdon-va.gov>, <enunley@vhcc.edu>, Rosenquist, Stacey M CIV USARMY HQDA ANC OSA (US) <stacey.m.rosenquist.civ@mail.mil>, <brenda.cook@us.af.mil>, <sharon.waligora@navy.mil>, Sauer, Mark H CIV NAVFAC MIDLANT, EV <mark.sauer@navy.mil>, <linda.hicks1@navy.mil>, <mary.stuck@navy.mil>, <tara.fisher@navy.mil>, Evans, Adam S CIV <Adam.S.Evans@uscg.mil>, <Rebecca.Stimson@harrisonburgva.gov>,

<Lisa@aqualaw.com>
Cc: Andrew Hammond <andrew.hammond@deq.virginia.gov>, Minich-Hobson Ruth sjp99657 <ruth.minich-hobson@deq.virginia.gov>, Brockenbrough Allan ion37996 <allan.brockenbrough@deq.virginia.gov>, Melanie Davenport <melanie.davenport@deq.virginia.gov>

Dear Permittees-

As you are aware, DEQ is preparing modifications to existing agency guidance on the development of Chesapeake Bay TMDL Action Plans (GM15-2005). DEQ last modified this guidance in 2015 and modifications to several sections are necessary to incorporate the recommendations of current Chesapeake Bay Program expert panel reports, changes in nutrient loads derived from the Phase 6 Watershed Model, changes in the Commonwealth's policy, etc. Unfortunately, the revised guidance will not be completed and available for use prior to the November 1, 2019 deadline for submittal of updated Chesapeake Bay TMDL Action Plans under the Phase II MS4 general permit. We recognize that these changes will affect projects undertaken by some MS4 permittees and intend to phase in the changes to minimize disruption to their MS4 program and allow time for any necessary adjustments. In the event that your TDML Action Plan is impacted by the proposed change in guidance, we will work with you on any adjustments to your plan during the phase in period. We intend to release the draft guidance to a small MS4 working group by the end of the month for initial feedback. Our goal is to publish the proposed guidance for public comment by the end of the year.

Major changes to the proposed guidance include:

1. Street Sweeping – phasing out of the mass loading approach and the qualifying street lanes method to reflect the *Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices Final Report*, dated May 19, 2016.

2. Septic – phasing out of crediting of reductions of septic disconnects in the MS4 sector as these reductions are being claimed by the Commonwealth under the onsite sector (WiP III).

3. Baseline in unregulated areas – modifications of the baseline requirements to further incentivize projects in unregulated areas.

4. Land use changes – updated nutrient and sediment reduction rates to reflect the Phase 6 Watershed Model.

5. Stream Restoration – elimination of the default reduction values for new projects.

6. Updating retrofit curves to match current expert panel recommendations.

7. Consolidation of reduction tables to reflect the cumulative 40% requirement.

If you have any questions please contact me at (804) 698-4265, or jeffrey.selengut@deq.virginia.gov.

Jeff Selengut

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Jeff Selengut
MS4 Permit Writer
Department of Environmental Quality
1111 East Main Street
Richmond, VA 23219
(804) 698-4265
jeffrey.selengut@deq.virginia.gov
www.deq.virginia.gov

Attachment 2

DEQ Approval Letter – City of Manassas Phase I Chesapeake Bay TMDL Action Plan

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY
Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 1105, Richmond, Virginia 23218
www.deq.virginia.gov

Molly Joseph Ward
Secretary of Natural Resources

David K. Paylor
Director

(804) 698-4000
1-800-592-5482

May 23, 2016

Tony Dawood
Director of Utilities
City of Manassas
8500 Public Works Dr
Manassas, VA 20110

Transmitted electronically: tdawood@ci.manassas.va.us

RE: Virginia Pollutant Discharge Elimination System (VPDES) MS4 Permit
VAR040063, City of Manassas, Chesapeake Bay TMDL Action Plan Approval

Dear Mr. Dawood:

The Department of Environmental Quality (DEQ) has reviewed the Chesapeake Bay TMDL Action Plan received on September 30, 2015 in accordance with Section I.C of the General VPDES Permit for Discharges of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4). Additional information was received November 30, 2015, January 20, 2016, April 11, 2016, April 25, 2016, April 26, 2016, and May 13, 2016.

As submitted, the action plan will result in the following annual reduction of pollutants of concern in the Potomac River Basin:

Pollutant of Concern	**Annual Load Reduction (lb/yr)**	**Percentage of L2 Reduction Achieved After Implementation**	**Percentage of New Source Reduction Achieved After Implementation**
Total Nitrogen	5,785.01	131.15%	5%
Total Phosphorus	951.16	270.36%	5%
Total Suspended Solids	2,257,911.41	589.97%	5%

The Chesapeake Bay TMDL Action Plan is hereby approved and is an enforceable part of the MS4 Program Plan. The approved action plan is based on the 2000 Urbanized Area as designated by the U.S. Census Bureau; and reductions were calculated based on land use data from 2009. Please note that additional reductions may be required to address loads from expanded urbanized area as a result of the 2010 Census in accordance with Section II.C.5 of the MS4 General Permit.

Please note any modifications to the Chesapeake Bay TMDL Action Plan shall be made in accordance with the Program Plan Modification Section of the MS4 General Permit (Section II.F).

As provided by Rule 2A:2 of the Supreme Court of Virginia, you have thirty (30) days from the date you received this decision within which to appeal this decision by filing a notice of appeal in accordance with the Rules of the Supreme Court of Virginia with the Director, Virginia Department of Environmental Quality.

Please contact Kelsey Brooks at (804) 698-4321 or at kelsey.brooks@deq.virginia.gov if you have any questions.

Sincerely,

Allan Brockenbrough II

Allan Brockenbrough II, P.E.
Manager, Office of VPDES Permits

Copies: File
Patrick Moore (pmoore@ci.manassas.va.us)
Jacob Renaud (jrenaud@ci.manassas.va.us)

Attachment 3

City of Manassas Phase II Chesapeake Bay TMDL Action Plan Regulated Land Use Calculations

City of Manassas Phase II Chesapeake Bay TMDL Action Plan
Regulated Land Use Calculations

The City has incorporated three (3) major revisions into the Phase II TMDL Action Plan to the MS4 Service Area acreage from the Phase I TMDL Action Plan. These revisions include:

- The revised MS4 service area incorporates the expanded regulated area as a result in the increase in the Washington DC-VA-MD UA 2010 U.S. Census. The 2010 Washington DC-VA-MD UA expanded the UA to include portions to the south and southwest of the City that were not previously included in the UA.
- Comparison of the "A Report on the City of Manassas' Existing and Possible Urban Tree Canopy" report[1] utilized in development of the Phase I TMDL Action Plan and more recent Planimetric and Impervious Surface data identified that the City's tree canopy had not been subtracted from the regulated pervious area in developing the Phase I TMDL Action Plan POC loads and required POC reductions. The City utilized a conservative 25% of estimated pervious area as a benchmark for tree canopy / forest within the City.
- The City calculated and subtracted the acreage associated with industrial facilities with permit coverage under the VPDES General Permit for Discharges of Stormwater from Industrial Activities.

Implementation of these modifications is outlined in Table 1. and resulted in a revised MS4 service acre comprised of 1,616.8 acres of regulated pervious land use and 2,028.2 acres of regulated impervious land use.

Table 1. Methodology for Determining Revised MS4 Service Area Acreage for Inclusion in the Phase II TMDL Action Plan

Description	Acres	
Total Acreage Located within the 2010 Washington DC-VA-MD UA (City of Manassas GIS Analysis)	6,176.9	
Land Use (City of Manassas GIS Analysis)	Pervious	Impervious
	3,742.4	2,434.5
2009 City Tree Canopy (McKee, 2009)	1,718.0	-
Potentially Regulated Acreage	2,024.4	2,371.9[2]
Individual VPDES General Permit Registrations within the City (City of Manassas GIS Analysis)	543.6	343.6
Conservative estimate of VPDES Pervious Land Accounted for in 2009 City Tree Canopy (25% of Pervious Acreage)	135.9	-
Final Individual VPDES General Permit Registrations within the City:	407.7	343.6
Micron Lockheed (VAR050907)		
City of Manassas Public Works Facility (VAR050995)		
Glen Gery Concrete (VAR050859)		
YRC Inc. (VAR051033)		
Norfolk Southern Railway (VAR051094)		
FedEx Freight East Incorporated (VAR051294)		
Manassas Regional Airport (VAR050985)		
REVISED Phase II TMDL Action Plan Regulated Urban Lands (CUMULATIVE)	**1,616.8**	**2,028.2**

[1] McKee, Jennifer, VA Geospatial Extension Program, Department of Forestry, Virginia Polytechnic Institute and State University. A Report on the City of Manassas' Existing and Possible Urban Tree Canopy. November 23, 2009.

[2] Impervious Potentially Regulated Acreage does not include 62.6 acres of surface water.

Attachment 4

Calculations for Determining the Estimated Load and POC Reductions from Existing Sources

Attachment 4 – Calculations for Determining the Estimated Load and POC Reductions from Existing Sources

Pollutant	SubLandUse	Loading Rates, lbs./acre/year	Regulated Urban Acreage Served, June 30, 2009	Estimated Loads from Urban Acres Served, June 30, 2009, lbs.	Total L2 Reductions	Existing Phase II - Cumulative Reduction	Existing Source - Cumulative Reduction Phase 1&2, lbs.
Nitrogen	Impervious Urban	16.86	2,028.20	34,195.45	9%	40%	1,231.04
	Pervious Urban	10.07	1,616.80	16,281.18	6%	40%	390.75
Existing Source Total Estimated Load, Nitrogen				**50,476.63 (50,477)**	Existing Source Total Phase II Reductions, Nitrogen		**1,621.78 (1622)**
Phosphorus	Impervious Urban	1.62	2,028.20	3,285.68	16%	40%	210.28
	Pervious Urban	0.41	1,616.80	662.89	7.25%	40%	19.22
Existing Source Total Estimated Load, Phosphorus				**3,948.57 (3,949)**	Existing Source Total Phase II Reductions, Phosphorus		**229.51 (230)**
Sediment	Impervious Urban	1,171.32	2,028.20	2,375,671.22	20%	40%	190,053.70
	Pervious Urban	175.80	1,616.80	284,233.44	8.75%	40%	9,948.17
Existing Source Total Estimated Load, Sediment				**2,659,904.66 (2,659,905)**	Existing Source Total Phase II Reductions, Sediment		**200,001.87 (200,002)**

Attachment 5

FY18 Stormwater Management Study

Task 2: Pond Evaluations Final Report

FY18 Stormwater Management Study Task 2: Pond Evaluations Final Report

City of Manassas
8500 Public Works Drive
Manassas, VA 20110

March 2017

Prepared by

4229 Lafayette Center Drive
Suite 1850
Chantilly, VA 20151
703-870-7000

Table of Contents

Introduction

The purpose of this report is to provide the City with a current condition assessment of all 22 City-owned ponds, to determine which ponds require maintenance and/or repair, and to determine which ponds are best suited for potential retrofit.

Prior to conducting the inspections, GKY reviewed the available approved plans, as-builts, and computation binders for the City's 22 publicly maintained ponds. It was determined during pre-inspection that three (3) ponds, listed below, were not required for inspection or evaluation:

- Sills Warehouse (Euclid Ind. Park) – Facility 4
- Prince William Hospital Pond – Facility 39
- VDOT (234 Bypass) Pond – Facility 42

The Sills Warehouse (Euclid Ind. Park) facility and the VDOT (234 Bypass) Pond were determined to be VDOT owned and maintained, so no evaluations of these two facilities were required. The Prince William Hospital Pond is a relatively new pond so an evaluation was not required.

Maintenance Assessment

A two person-inspection team, comprised of a DEQ certified Stormwater Management Inspector and a Professional Engineer, conducted inspections of seven (7) facilities on January 9, 2018. The inspection team assessed each facility's condition for potential retrofit opportunities and documented maintenance items for all facility components, including: Control Structure, Principal Spillway Pipe, Outfall, Embankment, Emergency Spillway, Pond Floor, and Inflows. Facility inspections continued over the course of a week with inspections of six (6) facilities on January 12, 2018 and inspections of the final six (6) facilities on January 18, 2018.

Upon completion of the facility inspections, the following ratings were applied to the inspection items:

- (1) High Priority/Non-Functional
- (2) Moderate Priority/Approaching Non-Functional
- (3) Low Priority/Functional
- (-) No Priority/Continue Routine Maintenance

The inspection reports, which include photo documentation for all inspection items, are included on a DVD in Appendix A.

Retrofit Assessment

The GKY inspection team also assessed each inspected facility for retrofit opportunities. GKY prepared nine (9) Preliminary Concept Retrofit Plans, selecting those facilities deemed to have reasonable opportunity for potential retrofit. At a meeting on February 8, 2018, City staff chose four (4) of those preliminary plans to pursue in further detail (Detailed Concept Retrofit Plans); they also requested that Lucasville Road/Cockrell Branch facility be studied for possible retrofit to Level 2 wet ponds, as improvements could potentially be made concurrently with planned maintenance operations. A high-level preliminary design and construction cost estimate was then prepared for those five facilities, and water quality benefits were analyzed in comparison to cost.

For the facilities with Detailed Concept Retrofit Plans, the pollutant loads were calculated using the Virginia Runoff Reduction Method (VRRM) based on drainage area, land cover, and hydrologic soils groups. Using the VRRM spreadsheet, Phosphorus and Nitrogen loads were computed. To calculate Total Suspended Solids (TSS), the ratio of TSS loading rate to Phosphorus loading rate (420.9 TSS lbs/ac: 1.0 TP

lbs/ac) from the Chesapeake Bay TMDL Special Conditions Guidance GM15-2005 (GM15-2005) was multiplied by the previously-calculated Phosphorus load.

A baseline pollutant removal rate was calculated using the Retrofit Pollutant Removal Adjustor Curves from GM15-2005 (Figure 1 for Total Phosphorus, Figure 2 for Total Nitrogen, and Figure 3 for Total Suspended Solids). Since the retrofit curves cannot be used for dry ponds or extended detention ponds, the VA BMP Clearinghouse established efficiencies were used for Phosphorus and Nitrogen. Since VA BMP Clearinghouse does not have established efficiencies for TSS, the Chesapeake Bay Program Established Efficiencies in Appendix V.C of GM15-2005 were used for TSS.

The pollutant removal efficiencies of the retrofit facilities (based on VA BMP Clearinghouse for Phosphorus and Nitrogen, and based on Table V.C.1 of GM15-2005 for TSS) were tabulated, and the pollutant load removed was calculated. If the retrofit facility was part of a treatment train, the downstream facility removal efficiency was multiplied by the remaining load. The retrofit load removed and the load removed by the downstream facility (if applicable) were added to produce total retrofit pollutant load removal by the full treatment train.

The total difference in pollutants removed was then calculated by subtracting the baseline pollutant load removed from the retrofit pollutant load removed. Pollutant loads, removal rates, and calculations can be found in Appendix C.

Preliminary design and construction cost estimates were prepared for each Detailed Concept Retrofit Plan. These include estimates for construction, design, and maintenance. Capital cost per pound of pollutant removed were calculated using design and construction cost. Annual costs over the lifespan of each facility (assumed to be 20 years) have also been calculated using design, construction, and maintenance costs. See Appendix D.

Considerations for the Detailed Concept Retrofit Plans, Preliminary Concept Retrofit Plans, and the facilities not selected are included in the following sections.

Detailed Concept Retrofit Plans

Based on review of the City's facilities and discussion with City staff at a meeting on February 8, 2018, the five (5) facilities chosen for Detailed Concept Retrofit Plans are:

- 02 – Public Works/New Britain SWM Facility
- 07 – Oakenshaw Section 3 (Pond 2)
- 08 – Oakenshaw Section 3 (Pond 1)
- 20 – Round Elementary School
- 30 – Lucasville/Cockrell Branch Regional Facility

02 – Public Works/New Britain SWM Facility

This facility is an existing regional wet pond. Plans SP_122-88 and SP_121-88 were provided by the City, however no stormwater management or BMP computations were included in the plans. The plans claim that the facility serves 285.5 acres, however, from a drainage area delineation based on GIS contours and pipe network, the current drainage area appears to be 310 acres.

The facility has one main inflow and multiple smaller inflows picking up runoff piped from adjacent residential developments. Based on existing grades and availability of City-owned land, a Detailed Concept Retrofit Plan was prepared, which proposes dry swales for two of the upstream inflows, forming a treatment train into the regional facility.

For proposed Dry Swale A, with drainage area of 3.81 acres, it is assumed that the baseline runoff depth treated is 0.5 inch and the retrofit depth treated is 1 inch. The required treatment volume based on VRRM calculations is 6,030 cubic feet (cf).

Dry Swale A preliminary sizing was based on a soil media depth of 3 ft, gravel depth of 1 ft, side slopes at 3:1, and longitudinal slope of 4% with 5 check dams spaced approximately 25 ft apart. The available maximum length of swale is approximately 125 feet (ft), so the minimum width to meet storage volume requirements is 13.22 ft. This yields a storage volume of 6,060 cf. This channel width is greater than the maximum width noted in the VA BMP Clearinghouse specifications, however check dams have been proposed to reduce or limit instances of braiding. Preliminary channel calculations confirm this geometry meets velocity and depth requirements for 1" and 10-year storms.

The preliminary construction cost estimate was prepared, with a total approximate design and construction cost of $137,341. The capital costs per pound of pollutant are as follows:

- Phosphorus: $118,229/lb
- Nitrogen: $12,464/lb
- TSS: $201/lb

See Appendix B.1 for the Detailed Concept Retrofit Plans, drainage area and soils map, VRRM calculations, and preliminary cost estimate for Dry Swale A.

For proposed Dry Swale B, with drainage area of 3.80 acres, it is assumed that the baseline runoff depth treated is 0.5 inch and the retrofit depth treated is 1 inch. The required treatment volume based on VRRM calculations is 4,932 cf.

Dry Swale B preliminary sizing was based on a soil media depth of 3 ft, gravel depth of 1 ft, side slopes at 3:1, longitudinal slope of 4%with 5 check dams spaced approximately 55 ft apart. The available maximum length of swale is approximately 275 ft, so the minimum width to meet storage volume requirements is 7.24 ft. This yields a storage volume of 4,932 cf. Preliminary channel calculations confirm this geometry meets velocity and depth requirements for 1" and 10-year storms.

The preliminary construction cost estimate was prepared, with a total approximate design and construction cost of $184,254. The capital costs per pound of pollutant are as follows:

- Phosphorus: $194,011/lb
- Nitrogen: $20,433/lb
- TSS: $322/lb

See Appendix B.1 for the Detailed Concept Retrofit Plan, drainage area and soils map, VRRM calculations, and preliminary cost estimate for Dry Swale A.

07 – Oakenshaw Section 3 (Pond 2)

This facility is an existing extended detention pond, serving mainly residential and roadway runoff. The plan, SD_77-86, "Oakenshaw Section III" was provided by the City. The main inflow is from an existing upstream extended detention pond, City Facility #08 – Oakenshaw Section #3 (Pond 1). The drainage area to Pond 2, based on the plans, is 116.7 acres, which includes the drainage area to the upstream facility. Based on computations shown on plan sheet 11 of 14, water quality is only provided for on-site drainage area of 13.8 acres with 5.34 acres impervious area. Also, based on computations shown on plan sheet 12 of 14, post-development flow assumes that all offsite runoff flowing into this pond will be at pre-development rates (meaning this facility is not providing detention for offsite run-on). Excluding drainage to any upstream facilities, the drainage area is delineated (based on GIS contours and pipe networks) as approximately 23 acres.

Based on existing GIS contours, a Detailed Retrofit Concept Plan was prepared to upgrade the pond to meet the BMP Clearinghouse criteria of a Level 2 Extended Detention Pond.

For the facility, the baseline runoff depth treated is 0.34 inches, based on the plans, and the retrofit depth treated is 1.25 inches for a Level 2 Extended Detention Pond design. The required treatment volume based on VRRM calculations is 51,886 cf.

The proposed treatment volume, assumed to be below the existing BMP orifice (approximate elevation 283.05), is 75,611 cf. Improvements include forebays at the two main inflows, along with a deep pool near the riser structure and a small wetlands area. Baffles will be required to elongate the flow path from the downstream inflow to the riser structure.

There are no proposed improvements to the riser, therefore the BMP water surface elevation will remain the same. This will also allow for the same pond detention hydraulics. A suspected residential sump pump outlet was noted at the time of site visit (although it was difficult to locate the source of flow), so if changes to the hydraulics were to be proposed, this outlet should be considered (in addition to all other inflows, etc.).

The preliminary construction cost estimate was prepared, with a total approximate design and construction cost of $439,725. The capital costs per pound of pollutant are as follows:

- Phosphorus: $74,543/lb
- Nitrogen: $10,824/lb
- TSS: $63/lb

See Appendix B.2 for the Detailed Concept Retrofit Plan, drainage area and soils map, VRRM calculations, and preliminary cost estimate.

08 – Oakenshaw Section 3 (Pond 1)

This facility is an existing extended detention pond, serving mainly residential and roadway runoff. The plans, SD_77-86, “Oakenshaw Section III” were provided by the City. There are multiple inflows into this pond, which is upstream of City Facility #07 – Oakenshaw Section 3 (Pond 2). The drainage area to Pond 1, based on the plans, is 73 acres. Excluding drainage to any upstream facilities, the drainage area is delineated as 65 acres, based on GIS contours and pipe networks.

The first retrofit option pursued was a Level 2 Extended Detention Pond; however, since the inflows are located on all sides of the facility including one inflow adjacent to the control structure, the Clearinghouse requirement of “Length of the shortest flow path/overall length = 0.7 or more” could not be met.

The next retrofit option pursued was to provide upstream treatment at the inflows. The City-owned property extends south of the facility, so the four southern inflows were reviewed for retrofit opportunities. Based on drainage area and required residence time, it was determined that only the southern-most inflow (Grass Channel A) could be a feasible retrofit opportunity.

For the facility, the baseline runoff depth treated is 0.33 inches, based on the plans, and the retrofit depth treated is 1 inch. The drainage area to Grass Channel A is 4.84 acres. The required treatment volume based on VRRM calculations is 8,993 cf.

Grass Channel A preliminary sizing was based on a channel slope of 0.5%, and side slopes of 3:1. The width of the channel was calculated to have a maximum flow velocity less than 1 foot per second for the 1-inch storm, to have non-erosive velocities for the 2-year and 10-years storms, and for the 10-year storm to be contained within the channel with a minimum of 6 inches of freeboard.

Based on GIS contours and field observations, a proposed channel depth of approximately 2 feet was used for this conceptual design. This drove the channel width; to maintain 6 inches of freeboard for the 10-year storm, the channel should be approximately 10' wide. Pending a detailed topographic survey of the area, it may be possible to reduce the width and increase the depth of the channel. The minimum hydraulic residence time of 9 minutes for the 1-inch storm was used to calculate a 60' minimum channel length.

The preliminary construction cost estimate was prepared, with a total approximate design and construction cost of $60,801. The capital costs per pound of pollutant are as follows:

- Phosphorus: $35,913/lb
- Nitrogen: $5,036/lb
- TSS: $44/lb

See Appendix B.3 for the Detailed Concept Retrofit Plan, drainage area and soils map, VRRM calculations, and preliminary cost estimate.

20 – Round Elementary

No design or construction plans were located for this dry pond on the Round Elementary site. The dry pond has three main inflows, and appeared to be retaining water with a clogged orifice at the time of inspection. The surrounding area is owned by City agencies and is heavily wooded.

The drainage area to this facility was delineated using GIS contours and pipe network, and was determined to be approximately 150 acres.

A Preliminary Concept Retrofit Plan was prepared for this site, assuming a Level 2 Extended Detention Pond. It was also noted that a large extent of the upstream natural inflow channel was eroded, and could be a good candidate for reinforcement and/or restoration.

Based on coordination with the City, constructed wetlands or a wet pond is more desirable in this location. A Detailed Concept Retrofit Plan was prepared assuming a Level 1 Wet Pond, which would require removal of trees in order to expand the footprint of the facility to gain enough volume for treatment. There is the potential to reach a Level 2 Wet Pond, however it would require significantly more trees to be removed. It should be noted that one of the inflows may be determined as a perennial stream, which would require additional environmental permitting.

For the facility, the baseline runoff depth treated is assumed to be 0.5 inches, and the retrofit depth treated for a Level 1 Wet Pond is 1 inch. The required treatment volume based on VRRM calculations is 264,829 cf.

The elevation of the existing pond floor was not provided on plans or as-builts and the GIS contours don't correlate with the conditions of the pond at the time of inspection. The existing BMP orifice elevation/pond floor has been assigned an elevation of 0' for concept plan purposes, and all additional storage has been proposed below this elevation. If a final plan were to be developed, the elevation of the existing BMP orifice should be surveyed, and proposed grades adjusted accordingly. The proposed storage volume below the BMP orifice elevation is 274,178 cf. The proposed shape of the facility can be modified as needed based on future survey data to minimize grading and tree impacts.

The Detailed Concept Retrofit Plan calls for a safety bench, an aquatic bench, and excavation of the facility to -11 ft. Gabion baskets would be installed to provide forebays at each end of the facility, and the existing access road would be extended to aid in maintenance of both forebays. A pump wet well would also be installed to aid in dewatering activities for future pond maintenance. It should also be noted that this

facility would be a good candidate for a perimeter chain link safety fence, due to proximity to the elementary school.

The preliminary construction cost estimate was prepared, with a total approximate design and construction cost of $1,198,938. The capital costs per pound of pollutant are as follows:

- Phosphorus: $20,697/lb
- Nitrogen: $4,041/lb
- TSS: $30/lb

See Appendix B.4 for the Detailed Concept Retrofit Plan, drainage area and soils map, VRRM calculations, and preliminary cost estimate.

30 – Lucasville Road (Cockrell Branch Regional Facility)

This regional facility is an existing wet pond, designed with plans CIP_10-01 accessed via the Scanned Plans Center. Computations were included in the plan set. The facility's drainage area was delineated in GIS to match the plans as closely as possible, but was updated for current GIS contours and pipe networks. The plans indicate a drainage area of 534 acres to this facility, but the delineated drainage area was 489 acres, including the drainage to Winterset Section 3 pond.

Based on information from the City of Manassas Capital Improvement Plan, this pond is slated for dredging in the next few years; therefore, if retrofits could be made to this facility at the same time, it could prove to be economical. A Detailed Concept Retrofit Plan was prepared for this facility to be retrofit into a Level 2 Wet Pond.

For the proposed Level 2 Wet Pond, the baseline runoff depth treated is 0.5 inches, per the plans, and the retrofit depth treated is 1.5 inches for a Level 2 design. The required treatment volume based on VRRM calculations is 1,314,105 cf. It is important to note that the original design was to treat 0.5 inches over the entire drainage area, while the retrofit design treats 1.5 inches, weighted over the various land cover and soil types within the drainage area.

The proposed improvements for this facility include a forebay at the main inflow, an upper shelf wetland/high marsh area comprising a minimum of 10% of the pond surface area, an aquatic bench, and increased storage volume below the permanent pool elevation. The proposed storage volume below the permanent pool is 1,383,126 cf and the facility will be approximately 12 feet deep. It is assumed that the existing safety benches are adequate; if they are deemed inadequate after survey, additional earthwork may be required to bring them up to standards. The maintenance access route is proposed to be extended to the forebay; pending survey, it may require additional earthwork to construct. Aerators/bubbles will be required for this facility to meet Level 2 criteria, and pump wet wells are proposed in the forebay and main body of the pond to aid in dewatering for future maintenance operations. The preliminary construction cost estimate was prepared, with a total approximate design and construction cost of $1,386,957. The capital costs per pound of pollutant are as follows:

- Phosphorus: $7,512/lb
- Nitrogen: $2,567/lb
- TSS: $67/lb

See Appendix B.5 for the Detailed Concept Retrofit Plan, drainage area and soils map, VRRM calculations, and preliminary cost estimate.

It should also be noted that this facility in its existing condition impounds more than 50 acre-feet of water and has a dam that is greater than six (6) feet in height. This means it is likely subject to the Virginia Dam Safety Act and Dam Safety Regulations. This dam is not currently listed in the inventory of State-regulated

dams. It is understood that costs and/or designs to comply with State requirements will be completed under a separate task.

Preliminary Concept Retrofit Plans

The five (5) other facilities that were initially studied for Preliminary Concept Retrofit Plans are:

- 09 – Metz Junior High
- 14 – Owens Brooke Section 1
- 15 – Winterset Section 3
- 27 – Lee Manor, Section 7B
- 33 – Fairview Meadow Section 2

See Appendix E for all Preliminary Concept Retrofit Plans.

09 – Metz Junior High

This facility is an existing extended detention pond adjacent to the running track at Metz Junior High. The existing low flow channel is a trapezoidal concrete channel, which was retaining water at the time of inspection.

The drainage area was not listed on the plans accessed online from the Scanned Plans Center (plan SP_05-88, Manassas Middle School), but GKY delineated the drainage area based on GIS contours and pipe networks. The drainage area to this facility is approximately 55 acres.

The facility has three main inflows picking up stormwater from on-site and adjacent residential developments. Access to the outfall was limited as it was outside the school chain-link fence, and additional easement research would be required to determine means of access.

This facility was determined to be a potential candidate for retrofit, and a Preliminary Concept Retrofit Plan for a Level 2 Extended Detention pond was prepared.

At the February 8, 2018 meeting with City staff, this preliminary concept was not chosen to be developed into a Detailed Concept Retrofit Plan.

14 – Owens Brooke Section 1

This facility is an existing wet pond shown on Owens Brooke Section One plans by Bengtson, DeBell, Elkin & Titus. It is downstream of Facility 13. It has multiple inflows, and the current state of the pond does not appear to be per the approved plans/as-built. This drainage area was not provided on the plans, but as delineated based on GIS contours and excluding the flow from Facility 13, the drainage area is approximately 27 acres.

The constraints of this existing facility, including multiple inflows along the perimeter of the pond, vertical walls, and modified riser structure, did not make the overall facility a good candidate for retrofit; however, a Preliminary Concept Retrofit Plan for a potential infiltration trench was proposed for the inflow from the north. A portion of the proposed trench is on a parcel owned by the adjacent homeowners' association. At the February 8, 2018 meeting with City staff, this preliminary concept was not chosen to be developed into a Detailed Concept Retrofit Plan.

15 – Winterset Section 3

This dry pond was constructed with Winterset Section 1 (Plan SD_43-83). It appears that an adjacent site was constructed after the Winterset Section 1 plans were designed, but no design plans were available for the adjacent subdivision. Based on field visits, the observed fence lines and accessory structures seemed very close in elevation to the existing dry pond floor. Based on conversations with an adjacent

owner, Doug Cook, at 9286 Allen Street, water levels in previous storms have risen in the facility to the finished floor of his shed on private property. The drainage area, according to the plans, was 28.2 acres, but the drainage area as delineated using GIS contours and accounting for upstream development was approximately 20 acres.

This facility was selected for a Preliminary Concept Retrofit Plan as a Level 2 Extended Detention facility, with an additional grass channel upstream treating the runoff from one of the inflows. It is very important that the dry storage volume not be altered and water levels not increase with this plan.

At the February 8, 2018 meeting with City staff, this preliminary concept was not chosen to be developed into a Detailed Concept Retrofit Plan.

27 – Lee Manor, Section 7B

This dry pond facility is located in a residential subdivision, and receives 72.89 acres, according to plan SP_60-88. The drainage area delineated in GIS was approximately 73 acres. This facility has one pipe inflow and is on a parcel with adequate area for access and maintenance.

A Preliminary Concept Retrofit Plan was prepared for this site, assuming a Level 2 Extended Detention Pond. Based on available surface area, a Level 1 or 2 wet pond may be feasible as well.

This facility is similar to Facility 20 in that it is an existing dry pond with a limited number of inflows and adequate area on-site for access and construction, but it has a smaller drainage area than Facility 20. Therefore, at the February 8, 2018 meeting with City staff, this preliminary concept was not chosen to be developed into a Detailed Concept Retrofit Plan.

33 – Fairview Meadow Section 2

This small dry pond facility is located in a residential subdivision. According to the plans (SP_35-87, accessed from the Scanned Plans Center) it receives 12.64 acres of runoff. The drainage area delineated from GIS contours and pipe networks was found to be approximately 15 acres. This facility has a small footprint, with three main inflows.

This facility was selected for a Preliminary Concept Retrofit Plan for a Level 2 Extended Detention facility. Limitations, however, include access to future forebays, as access is only provided to one corner of the facility (at one inflow) and there is not adequate room to propose extending the access road to the other two inflows. Retrofitting would also be constrained to the existing footprint of the facility. At the February 8, 2018 meeting with City staff, this facility was not selected for retrofit concept plans.

Facilities Not Selected for Retrofit Study

The remaining facilities were not selected for retrofit study:

- 04 – Sills Warehouse (Euclid Industrial Park)
- 11 – Kinsley Mill
- 13 – Owens Brooke Section 1
- 22 – Wakeman Tract SWM Pond (Pond 1)
- 28 – Jackson Manor
- 34 – Fairview Meadow Section 2 Infiltration Trench
- 35 – Winterset Section 3 (Pond 2)
- 36 – Sumner Lake (Smitherwood Lake Regional Pond)
- 39 – Prince William Hospital Pond
- 42 – VDOT (234 Bypass)
- 50 – Winter's Branch Regional Pond

- 64 – Wakeman Tract SWM Pond (Pond 2)

04 – Sills Warehouse (Euclid Industrial Park)

Based on guidance from the City, it was determined that this pond would not be included in the retrofit assessments.

11 – Kinsley Mill

This facility is an existing extended detention pond downstream of Metz Junior High facility and Baldwin Oaks facility (privately maintained). The drainage area was digitized to exclude Metz and Baldwin drainage areas. The footprint was limited, without much fall from inflows to outfall, so this facility was not selected for a Preliminary Concept Retrofit Plan.

13 – Owens Brooke Section 1

This facility is an existing wet pond, upstream of Facility #14. This facility has multiple inflows distributed around the pond. Plan SP_90-86, Owens Brooke Section One by Bengtson, DeBell, Elkin & Titus, was provided by the City, however the pond does not appear to be built as designed with these plans. The drainage area was not provided on the plans, but as delineated from GIS contours, the drainage area is approximately 90 acres.

When considering this pond for retrofit, the multiple inflows would make it hard to comply with requirements for forebay(s). Also, the modified state of this pond (including vertical walls at the perimeter) did not lend itself well to conversion to current standards for a Level 2 Wet Pond. This pond was therefore not considered for a Preliminary Concept Retrofit Plan.

22 – Wakeman Tract SWM Pond (Pond 1)

This large wet pond facility is located on Canon Branch adjacent to the off-ramp of Prince William Parkway onto Nokesville Road. It receives significant flow from Cannon Branch, as well as other tributaries/inflows. It is upstream of Facility 64 – Wakeman Tract SWM Pond (Pond 2), however it was designed as one facility based on the calculation binders provided by the City.

The drainage area was input into GIS per the drainage area included in the calculation binder. The total drainage area to both ponds was listed in the calculations as 2,432 acres, however when the drainage area was transcribed in GIS, it appears that the drainage area to Facility 22 is approximately 2,442 acres, with an additional 34 acres going to Facility 64.

Due to the large contributing drainage area and the limited area to expand the pond footprint, this facility was not selected for retrofit concept plans.

28 – Jackson Manor

This small dry pond facility is located in a residential subdivision. The drainage area was not included on the plans provided by the City (SP_51-86), but based on drainage areas delineated from GIS contours and pipe networks, the facility receives approximately 18 acres of runoff. This facility has one main inflow, directly across the pond floor from the control structure.

Due to the small footprint and the potential for short-circuiting, this facility was not selected for Preliminary Concept Retrofit Plans.

34 – Fairview Meadow Section 2 Infiltration Trench

This small facility is located in a residential subdivision. According to the plans (SP_35-87, accessed from the Scanned Plans Center) it receives 1.14 acres of runoff. Drainage area delineated from GIS contours and pipe networks was found to be approximately 1.80 acres.

This facility was part of Fairview Meadow Section 2, SP_35-87, however no infiltration trench details were included in the plan set. It is assumed that the trench was designed to treat the full drainage area.

This facility is situated on a parcel which would allow for expansion of the footprint, however, due to topography, it was not feasible to direct any additional water to this site for treatment. Infiltration trenches receive the highest pollutant removal rates, so retrofitting to a different facility type would serve no benefit. This facility was not selected for Preliminary Concept Retrofit Plans.

35 – Winterset Section 3 (Pond 2)

No plans were available for this facility, however the drainage area delineated from GIS contours and pipe networks indicates that there is approximately 4 acres of runoff from residential and public roads going to this facility. This facility has one inflow, which is directly across from the outflow.

Due to the small footprint and the potential for short-circuiting, this facility was not selected for Preliminary Concept Retrofit Plans.

36 – Sumner Lake (Smitherwood Lake Regional Pond)

This regional facility was designed to receive 509 acres, but based on drainage area delineated from GIS contours and pipe networks, receives approximately 748 acres. It is located within a subdivision, and has many inflow points. It is recently constructed (as-built in 2002), and is bounded by a walking trail.

Since this facility is recently constructed and appeared to be functioning well at the time of inspection, it was not considered for Preliminary Concept Retrofit Plans.

39 – Prince William Hospital Pond

Based on guidance from the City, it was determined that this pond would not be included in the retrofit assessments.

42 – VDOT (234 Bypass)

Based on guidance from the City, it was determined that this pond would not be included in the retrofit assessments.

50 – Winter's Branch Regional Pond

This regional facility receives approximately 653 acres of runoff, per the calculation binders provided by the City. As delineated based on GIS contours and pipe networks, the current drainage area is approximately 606 acres. Based on conditions at inspection, this facility appears to have been recently maintained, with upstream measures installed to mitigate eroded inflows. The micropool was expanded in 1998.

This facility possesses many of the requirements of a current Level 2 Extended Detention facility, however, would require additional cells to fully meet the Clearinghouse requirements. There does not appear to be room within the facility to install these additional cells (forebays and upper marsh, etc., cells), so this facility was not selected for Preliminary Concept Retrofit Plans.

64 – Wakeman Tract SWM Pond (Pond 2)

This wet pond facility is located on Canon Branch, downstream of Facility 22. It receives the majority of its inflow from Facility 22, with additional inflows from adjacent roadways. The inflows were not easily accessed, as they are located on steep embankments off Gateway Boulevard and Prince William Parkway. It was designed with Facility 22 as one facility based on the calculation binders provided by the City.

The drainage area was transcribed into GIS to mimic the drainage area included in the calculation binder. The total drainage area to both ponds was listed in the calculations as 2,432 acres, however after the drainage area was transcribed in GIS, it appears that the drainage area to Facility 22 is approximately 2,442 acres, with an additional 34 acres going to Facility 64.

Due to the large contributing drainage area and the limited access to the inflows, this facility was not selected for Preliminary Concept Retrofit Plans.

Summary

Five detailed retrofit options have been presented in this study. Capital costs per pound of pollutant removed vary by site and facility type and are summarized in Table 1 below:

Table 1. Retrofit Pollutant Removal Cost Analysis Summary

BMP Retrofit Opportunity		Difference in Pollutant Removed			Approximate Design and Construction Cost ($) [1]	Capital Cost Per Pound of Additional Pollutant Removed [2]		
City ID #	Retrofit Type	Phosphorus (lb/yr)	Nitrogen (lb/yr)	TSS (lb/yr)		Phosphorus ($/lb)	Nitrogen ($/lb)	TSS ($/lb)
2	Dry Swale A - Level 1	1.16	11.02	682.9	$137,341	**$118,288.70**	**$12,464.21**	**$201.13**
	Dry Swale B - Level 1	0.95	9.01	572.9	$184,254	**$194,011.08**	**$20,443.15**	**$321.59**
7	Ext. Det. - Level 2	5.90	40.62	6,926.0	$439,725	**$74,543.12**	**$10,824.48**	**$63.49**
8	Grass Channel A	1.69	12.07	1,370.6	$60,801	**$35,912.73**	**$5,035.72**	**$44.36**
20	Wet Pond - Level 1	57.93	296.67	39,372.9	$1,198,938	**$20,696.84**	**$4,041.27**	**$30.45**
30	Wet Pond - Level 2	184.63	540.19	20,849.0	$1,386,957	**$7,512.10**	**$2,567.55**	**$66.52**

Notes:

1. Approximate Construction Cost estimates are based on cost estimates developed by GKY. Costs do not include dry utility locating, test pits, easements, plats, permitting, agency review fees, etc.

2. Capital Cost Per Pound = (Approximate Design and Construction Cost) / (Difference in Pollutant Removed).

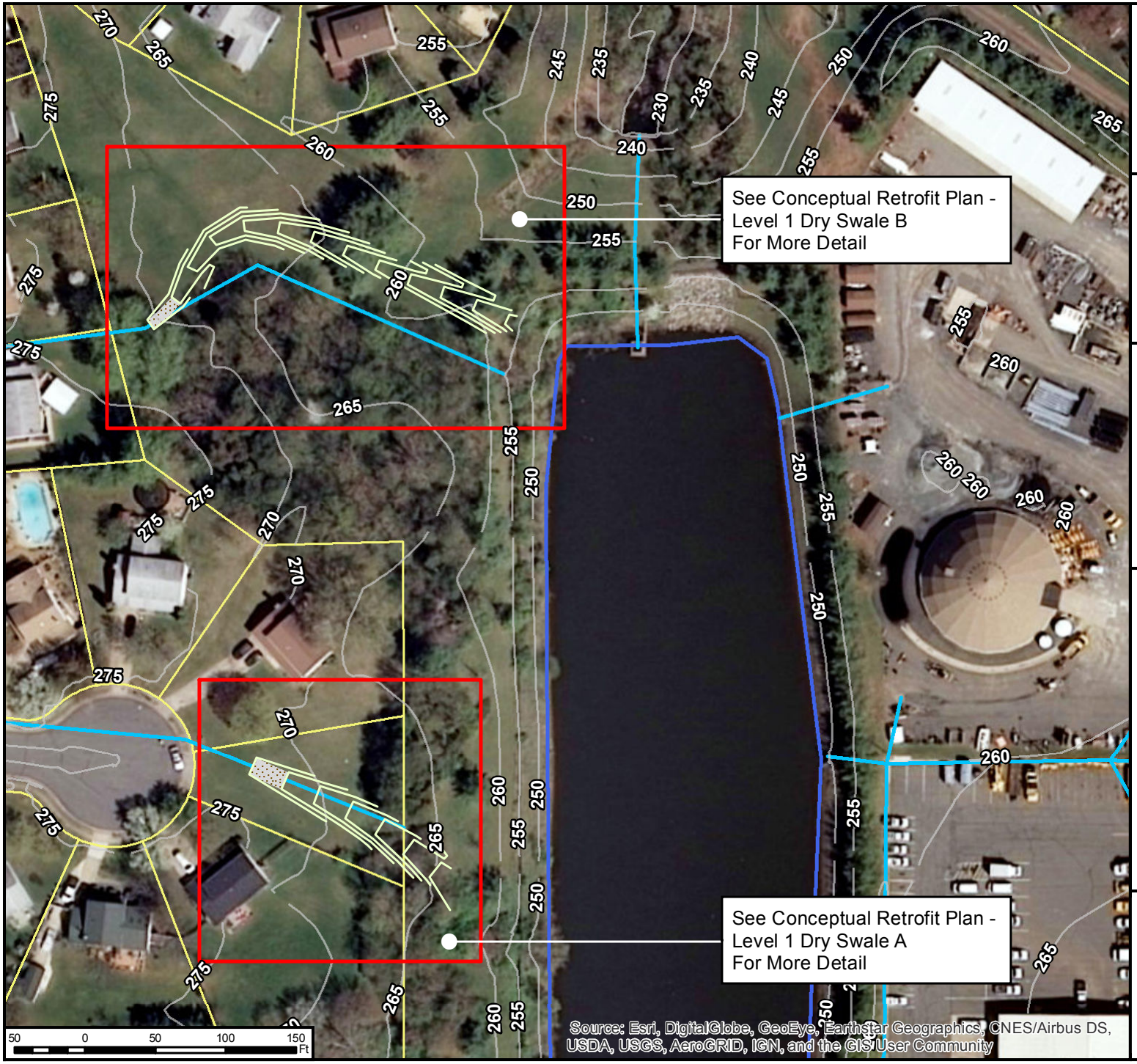
Based on capital costs per pound of Phosphorus removed, the most economical retrofits are Lucasville Road/Cockrell Branch and Round Elementary, followed by Oakenshaw Grass Channel A. The least economical retrofits are the dry swales upstream of the Public Works facility. The Oakenshaw Extended Detention retrofit was priced in the middle.

It is interesting to note that in Table V.C.1 of GM15-2005, there is only one pollutant removal rate for wet ponds, as opposed to two separate rates for Level 1 and Level 2. This means that retrofit efficiency for TSS removal for Round Elementary and Lucasville Road/Cockrell Branch are both considered 60%. Since the baseline TSS removal of Round Elementary (dry pond) is 10%, and the baseline TSS removal of Lucasville/Cockrell Branch (52% from Retrofit Curves), the difference in TSS removed by Round Elementary is greater than the difference in TSS removed by Lucasville Road/Cockrell Branch. This means that, while capital costs per additional pound of Phosphorus and Nitrogen removed are lower for the Lucasville/Cockrell Branch facility, capital cost per additional pound of TSS removed is lower for Round Elementary.

Similarly, there is not a significant difference between the TSS removal rates for grass channels (50%) and wet ponds (60%) based on facility efficiency from Table V.C.1 of GM15-2005. This yields a lower capital cost per pound of TSS for Grass Channel A than for Lucasville Road/Cockrell Branch Wet Pond Level 2.

Appendix A: Inspection Reports (Included on DVD)

Appendix B.1: Facility 02 – Public Works/New Britain Facility Detailed Concept Retrofit Plans



GKY & Associates, inc.

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CONCEPTUAL RETROFIT PLAN 02 - NEW BRITAIN S.W.M. FACILTY (PUBLIC WORKS FACILITY)

Pond # 02
New Britain S.W.M. Facility
(Public Works Facility)

Property Address:
9680 Public Works Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
111-15-00-F10

Manassas
HISTORIC HEART. MODERN BEAT.

GKY & Associates, inc.

1:600

CONCEPTUAL RETROFIT PLAN LEVEL 1 DRY SWALE A

Pond # 02

New Britain S.W.M. Facility

(Public Works Facility)

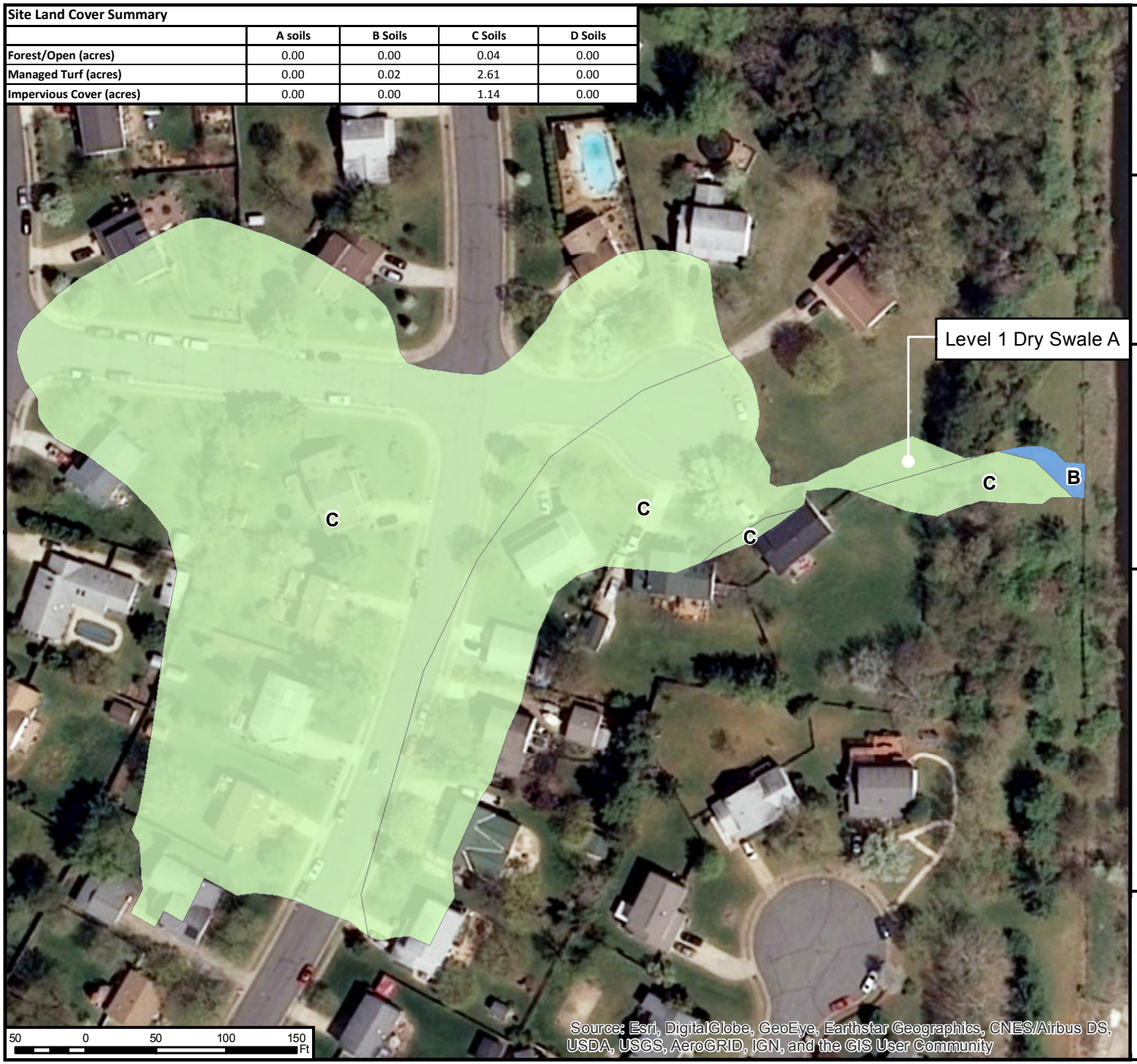
Property Address:
8941 Vicksburg Ln.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
111-15-00-91A

Manassas
HISTORIC HEART. MODERN BEAT.

Site Land Cover Summary				
	A soils	B Soils	C Soils	D Soils
Forest/Open (acres)	0.00	0.00	0.04	0.00
Managed Turf (acres)	0.00	0.02	2.61	0.00
Impervious Cover (acres)	0.00	0.00	1.14	0.00



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DRAINAGE AREA TABULATIONS LEVEL 1 DRY SWALE A

Pond # 02
New Britain S.W.M. Facility
(Public Works Facility)

Property Address:
8941 Vicksburg Ln.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
111-15-00-91A

Drainage Area:
3.81 Acres

Manassas
HISTORIC HEART. MODERN BEAT.

DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary

Project Title: Manassas Retrofits - 02_DrySwale_A

Date: 43146

Total Rainfall = 43 inches

Site Land Cover Summary

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	0.00	0.04	0.00	0.04	1
Managed Turf (acres)	0.00	0.02	2.61	0.00	2.63	69
Impervious Cover (acres)	0.00	0.00	1.14	0.00	1.14	30
					3.81	100

Site Tv and Land Cover Nutrient Loads

Site Rv	0.44
Treatment Volume (ft^3)	6,036
TP Load (lb/yr)	3.79
TN Load (lb/yr)	27.13

Total TP Load Reduction Required (lb/yr)	2.23

Site Compliance Summary

Total Runoff Volume Reduction (ft^3)	2,412
Total TP Load Reduction Achieved (lb/yr)	1.97
Total TN Load Reduction Achieved (lb/yr)	14.89
Remaining Post Development TP Load (lb/yr)	1.82
Remaining TP Load Reduction (lb/yr) Required	**0.26**

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (acres)	0.04	0.00	0.00	0.00	0.00	0.04
Managed Turf (acres)	2.63	0.00	0.00	0.00	0.00	2.63
Impervious Cover (acres)	1.14	0.00	0.00	0.00	0.00	1.14
Total Area (acres)	**3.81**	**0.00**	**0.00**	**0.00**	**0.00**	**3.81**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	1.97	0.00	0.00	0.00	0.00	1.97
TN Load Reduced (lb/yr)	14.89	0.00	0.00	0.00	0.00	14.89

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	0.00	0.04	0.00	0.04	1
Managed Turf (acres)	0.00	0.02	2.61	0.00	2.63	69
Impervious Cover (acres)	0.00	0.00	1.14	0.00	1.14	30
					3.81	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed

Total Impervious Cover Treated (acres)	1.14
Total Turf Area Treated (acres)	2.63
Total TP Load Reduction Achieved in D.A. (lb/yr)	1.97
Total TN Load Reduction Achieved in D.A. (lb/yr)	14.89

Project: 02 - New Britain SWM Facility (Public Works Facility), Dry Swale A					
Design Assumptions: 125 LF of 13.22' Wide Dry Swale Type 1					
Estimate Type: Preliminary Design, Construction and Maintenance Costs					
Prepared by: GKY & Associates, Inc.					
Date: March 30, 2018					
#	ITEM	QUANTITY	UNIT	UNIT COST	COST
1	DEMOLITION				
2	Existing Pipe Removal	115	LF	$52 / LF	$5,980
3				DEMOLITION SUB TOTAL:	$5,980
4	EROSION & SEDIMENT CONTROL				
5	E&S Controls	1	LS	$5,000 / LS	$5,000
6				EROSION & SEDIMENT CONTROL SUB TOTAL:	$5,000
7	PROPOSED IMPROVEMENTS				
8	Mobilization *	1	LS	$5,000 / LS	$5,000
9	Survey Stakeout *	1	LS	$2,000 / LS	$2,000
10	Rip Rap for Pre-treatment	25	CY	$47 / CY	$1,175
11	Soil Filter Media (3' thick)	185	CY	$99 / CY	$18,315
12	Gravel Layer (1' thick)	65	CY	$63 / CY	$4,095
13	Sod	445	SY	$8 / SY	$3,560
14	Underdrain and Gravel Base	125	LF	$14 / LF	$1,750
15	Geotextile Fabric	150	LF	$2 / LF	$300
16	Check Dams	5	EA	$270 / EA	$1,350
17	Gravel Splash Pad	4	CY	$63 / CY	$252
18				PROPOSED IMPROVEMENTS SUB TOTAL:	$37,797
19	EARTHWORK				
20	Regular Excavation	490	CY	$38 / CY	$18,620
21	Load and Haul	490	CY	$25 / CY	$12,250
22				EARTHWORK SUB TOTAL:	$30,870
23	MISCELLANEOUS *				
24	Topographic and Utility Survey	1	LS	$4,000 / LS	$4,000
25	Soils/Infiltration Testing	1	LS	$4,000 / LS	$4,000
26	Engineering Design Services	1	LS	$15,000 / LS	$15,000
27	As-built Survey	1	LS	$3,000 / LS	$3,000
28				MISCELLANEOUS SUB TOTAL:	$26,000
29					
30				CONSTRUCTION SUB TOTAL:	$105,647
31				CONTINGENCY (30% of PROJECT SUB TOTAL):	$31,694
32				CONSTRUCTION TOTAL:	$137,341
33	ANNUAL MAINTENANCE *				
34	Mowing	1	LS	$2,000 / LS	$2,000
35				ANNUAL MAINTENANCE:	$2,000

* Unit price for professional services are approximate and subject to change once contractor is selected.

** Earthwork estimates do not include shrink/swell factors. Costs assume no bedrock; field conditions shall be determined by geotechnical investigation

GKY & Associates, inc.

1:600

CONCEPTUAL RETROFIT PLAN LEVEL 1 DRY SWALE B

Pond # 02

New Britain S.W.M. Facility

(Public Works Facility)

Property Address:
9680 Public Works Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
111-15-00-F10

Manassas
HISTORIC HEART. MODERN BEAT.

Site Land Cover Summary				
	A soils	B Soils	C Soils	D Soils
Forest/Open (acres)	0.00	0.18	0.72	0.00
Managed Turf (acres)	0.00	0.46	1.44	0.00
Impervious Cover (acres)	0.00	0.28	0.72	0.00

GKY & Associates, inc.

1:1,200

DRAINAGE AREA TABULATIONS LEVEL 1 DRY SWALE B

Pond # 02
New Britain S.W.M. Facility
(Public Works Facility)

Property Address:
9680 Public Works Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
111-15-00-F10

Drainage Area:
3.80 Acres

Manassas
HISTORIC HEART. MODERN BEAT.

DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary

Project Title: Manassas Retrofits - 02_DrySwale_B

Date: 43146

Total Rainfall = 43 inches

Site Land Cover Summary

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	0.18	0.72	0.00	0.90	24
Managed Turf (acres)	0.00	0.46	1.44	0.00	1.90	50
Impervious Cover (acres)	0.00	0.28	0.72	0.00	1.00	26
					3.80	100

Site Tv and Land Cover Nutrient Loads

Site Rv	0.37
Treatment Volume (ft^3)	5,057
TP Load (lb/yr)	3.18
TN Load (lb/yr)	22.73

Total TP Load Reduction Required (lb/yr)	1.62

Site Compliance Summary

Total Runoff Volume Reduction (ft^3)	1,973
Total TP Load Reduction Achieved (lb/yr)	1.61
Total TN Load Reduction Achieved (lb/yr)	12.18
Remaining Post Development TP Load (lb/yr)	1.57
Remaining TP Load Reduction (lb/yr) Required	**0.01**

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (acres)	0.90	0.00	0.00	0.00	0.00	0.90
Managed Turf (acres)	1.90	0.00	0.00	0.00	0.00	1.90
Impervious Cover (acres)	1.00	0.00	0.00	0.00	0.00	1.00
Total Area (acres)	**3.80**	**0.00**	**0.00**	**0.00**	**0.00**	**3.80**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	1.61	0.00	0.00	0.00	0.00	1.61
TN Load Reduced (lb/yr)	12.18	0.00	0.00	0.00	0.00	12.18

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	0.18	0.72	0.00	0.90	24
Managed Turf (acres)	0.00	0.46	1.44	0.00	1.90	50
Impervious Cover (acres)	0.00	0.28	0.72	0.00	1.00	26
					3.80	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed

Total Impervious Cover Treated (acres)	1.00
Total Turf Area Treated (acres)	1.90
Total TP Load Reduction Achieved in D.A. (lb/yr)	1.61
Total TN Load Reduction Achieved in D.A. (lb/yr)	12.18

Project: 02 - New Britain SWM Facility (Public Works Facility), Dry Swale B					
Design Assumptions: 275 LF of 7.85' Wide Dry Swale Type 1					
Estimate Type: Preliminary Design, Construction and Maintenance Costs					
Prepared by: GKY & Associates, Inc.					
Date: March 30, 2018					
#	ITEM	QUANTITY	UNIT	UNIT COST	COST
1	DEMOLITION				
2	Existing Pipe Removal	280	LF	$52 / LF	$14,560
3				DEMOLITION SUB TOTAL:	$14,560
4	EROSION & SEDIMENT CONTROL				
5	E&S Controls	1	LS	$5,000 / LS	$5,000
6				EROSION & SEDIMENT CONTROL SUB TOTAL:	$5,000
7	PROPOSED IMPROVEMENTS				
8	Mobilization *	1	LS	$5,000 / LS	$5,000
9	Survey Stakeout *	1	LS	$2,000 / LS	$2,000
10	Rip Rap for Pre-treatment	15	CY	$47 / CY	$705
11	Soil Filter Media (3' thick)	230	CY	$99 / CY	$22,770
12	Gravel Layer (1' thick)	75	CY	$63 / CY	$4,725
13	Sod	800	SY	$8 / SY	$6,400
14	Underdrain and Gravel Base	275	LF	$14 / LF	$3,850
15	Geotextile Fabric	300	LF	$2 / LF	$600
16	Check Dams	5	EA	$270 / EA	$1,350
17	Gravel Splash Pad	3	CY	$63 / CY	$189
18				PROPOSED IMPROVEMENTS SUB TOTAL:	$47,589
19	EARTHWORK				
20	Regular Excavation	795	CY	$38 / CY	$30,210
21	Load and Haul	695	CY	$25 / CY	$17,375
22				EARTHWORK SUB TOTAL:	$47,585
23	MISCELLANEOUS *				
24	Topographic and Utility Survey	1	LS	$4,000 / LS	$4,000
25	Soils/Infiltration Testing	1	LS	$4,000 / LS	$4,000
26	Engineering Design Services	1	LS	$15,000 / LS	$15,000
27	As-built Survey	1	LS	$4,000 / LS	$4,000
28				MISCELLANEOUS SUB TOTAL:	$27,000
29					
30				CONSTRUCTION SUB TOTAL:	$141,734
31				CONTINGENCY (30% of PROJECT SUB TOTAL):	$42,520
32				CONSTRUCTION TOTAL:	$184,254
33	ANNUAL MAINTENANCE *				
34	Mowing	1	LS	$2,000 / LS	$2,000
35				ANNUAL MAINTENANCE:	$2,000

* Unit price for professional services are approximate and subject to change once contractor is selected.

** Earthwork estimates do not include shrink/swell factors. Costs assume no bedrock; field conditions shall be determined by geotechnical investigation

Appendix B.2: Facility 07 – Oakenshaw Section 3 (Pond 2) Detailed Concept Retrofit Plans

GKY & Associates, inc.

1:720

CONCEPTUAL RETROFIT PLAN LEVEL 2 ED POND

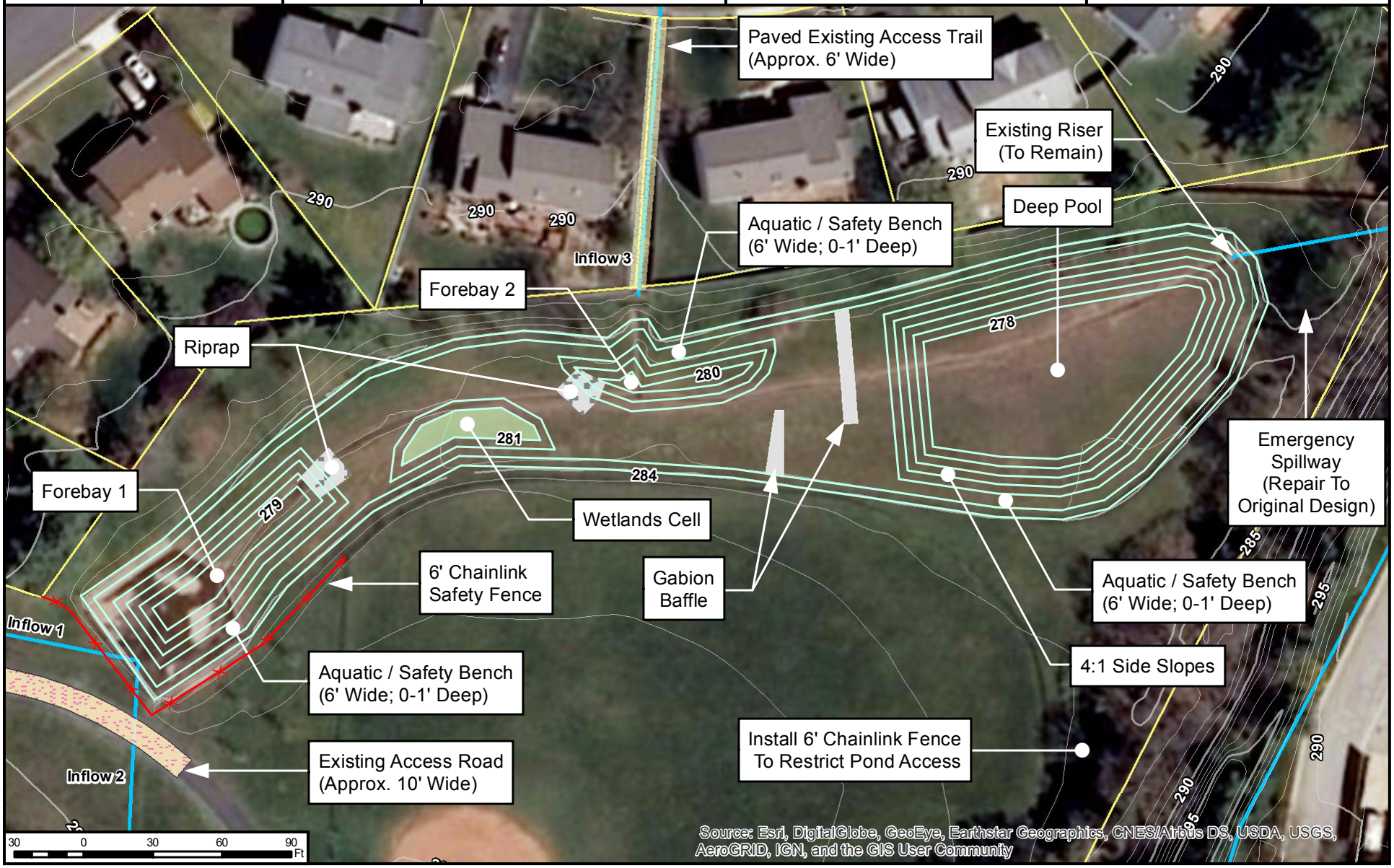
Pond # 07, Oakenshaw Sec. 3

Property Address:
9559 Oakenshaw Dr.
Manassas, VA 20110

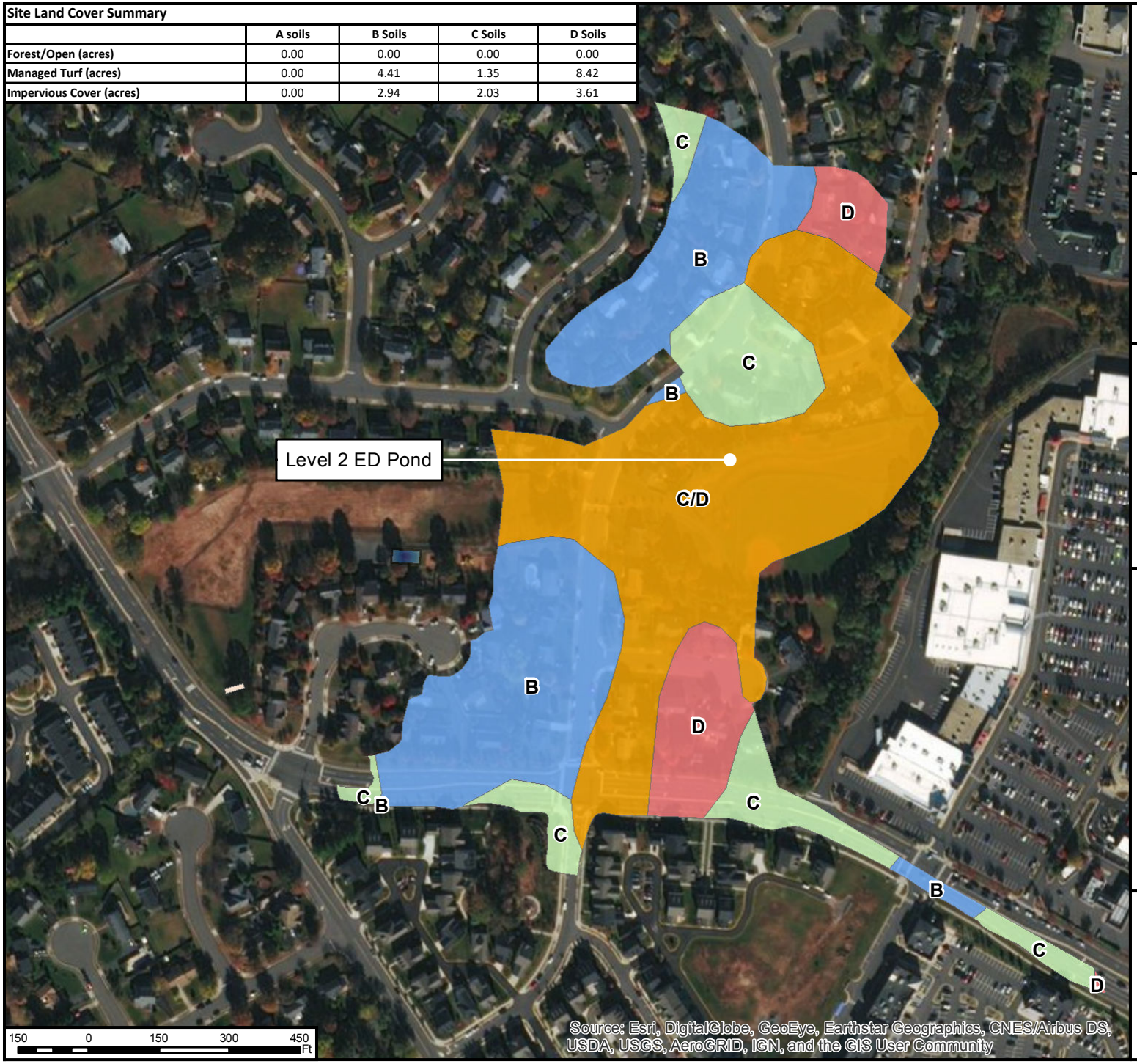
Property Owner:
City of Manassas

Tax Map ID:
100-30-00-C

Manassas
HISTORIC HEART. MODERN BEAT.



Site Land Cover Summary				
	A soils	B Soils	C Soils	D Soils
Forest/Open (acres)	0.00	0.00	0.00	0.00
Managed Turf (acres)	0.00	4.41	1.35	8.42
Impervious Cover (acres)	0.00	2.94	2.03	3.61



GKY & Associates, inc.

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DRAINAGE AREA TABULATIONS LEVEL 2 ED POND

Pond # 07

Oakenshaw Sec. 3

Property Address:
9559 Oakenshaw Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
100-30-00-C

Drainage Area:
22.76 Acres

Manassas
HISTORIC HEART. MODERN BEAT.

DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary

Project Title: Manassas Retrofits - 07_Oakenshaw (Pond 2)

Date: 43151

Total Rainfall = 43 inches

Site Land Cover Summary

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	0.00	0.00	0.00	0.00	0
Managed Turf (acres)	0.00	4.41	1.35	8.42	14.18	62
Impervious Cover (acres)	0.00	2.94	2.03	3.61	8.58	38
					22.76	100

Site Tv and Land Cover Nutrient Loads

Site Rv	0.50
Treatment Volume (ft^3)	41,509
TP Load (lb/yr)	26.08
TN Load (lb/yr)	186.57

Total TP Load Reduction Required (lb/yr)	16.75

Site Compliance Summary

Total Runoff Volume Reduction (ft^3)	6,226
Total TP Load Reduction Achieved (lb/yr)	7.23
Total TN Load Reduction Achieved (lb/yr)	43.79
Remaining Post Development TP Load (lb/yr)	18.85
Remaining TP Load Reduction (lb/yr) Required	**9.52**

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (acres)	0.00	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres)	14.18	0.00	0.00	0.00	0.00	14.18
Impervious Cover (acres)	8.58	0.00	0.00	0.00	0.00	8.58
Total Area (acres)	**22.76**	**0.00**	**0.00**	**0.00**	**0.00**	**22.76**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	7.23	0.00	0.00	0.00	0.00	7.23
TN Load Reduced (lb/yr)	43.79	0.00	0.00	0.00	0.00	43.79

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	0.00	0.00	0.00	0.00	0
Managed Turf (acres)	0.00	4.41	1.35	8.42	14.18	62
Impervious Cover (acres)	0.00	2.94	2.03	3.61	8.58	38
					22.76	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed

Total Impervious Cover Treated (acres)	8.58
Total Turf Area Treated (acres)	14.18
Total TP Load Reduction Achieved in D.A. (lb/yr)	7.23
Total TN Load Reduction Achieved in D.A. (lb/yr)	43.79

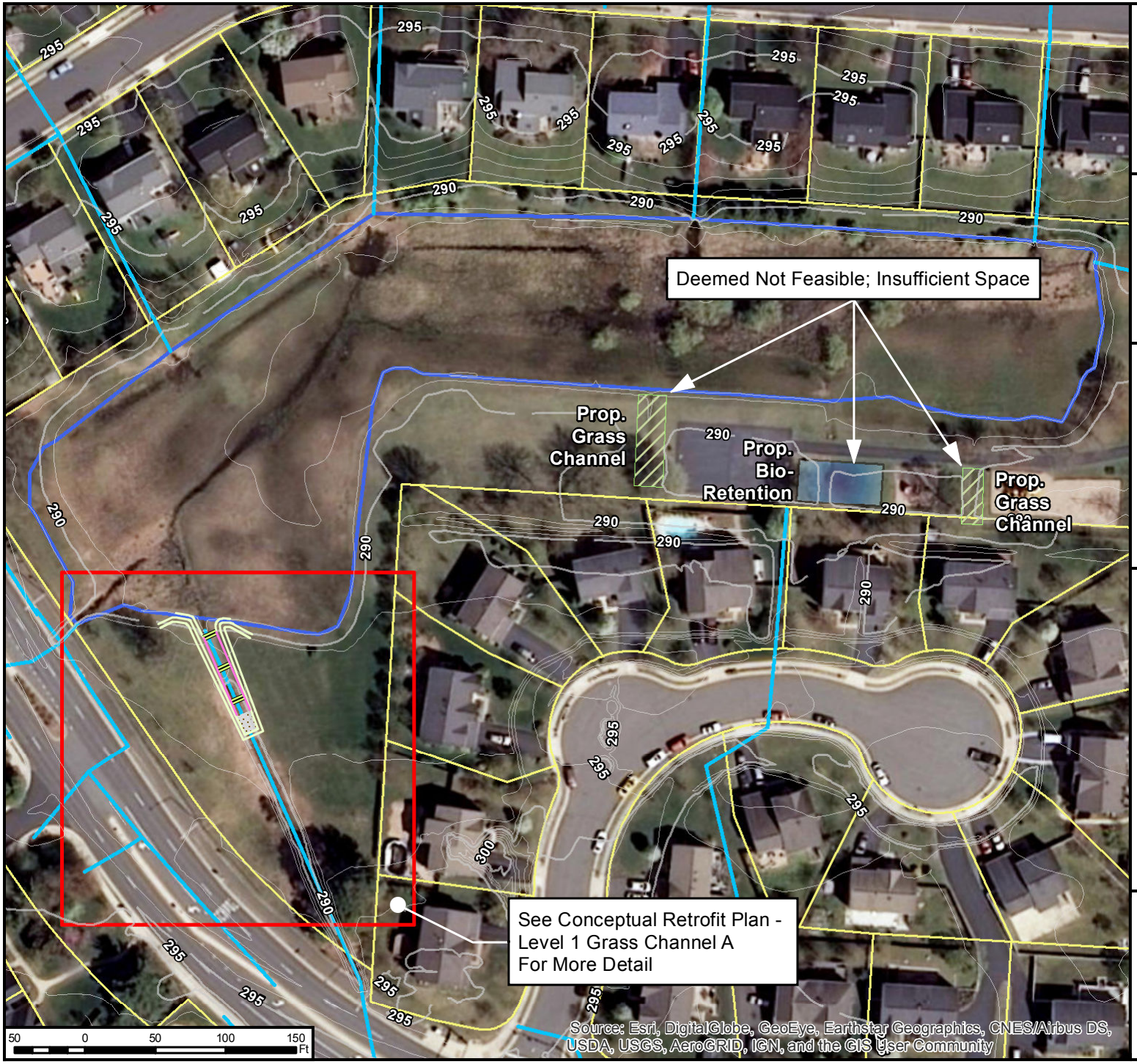
Project: 07 - Oakenshaw Sec. 3, Dry Pond					
Design Assumptions: Extended Detention Pond Level 2					
Estimate Type: Preliminary Design, Construction and Maintenance Costs					
Prepared by: GKY & Associates, Inc.					
Date: March 30, 2018					
#	ITEM	QUANTITY	UNIT	UNIT COST	COST
1	EROSION & SEDIMENT CONTROL				
2	Construction Entrance with Wash Rack	1	EA	$3,800 / EA	$3,800
3	Stream Pump Around (1 dewatering pump and 2 diversion pumps) *	1	LS	$15,000 / LS	$15,000
4	Other E&S Controls	1	LS	$25,000 / LS	$25,000
5				EROSION & SEDIMENT CONTROL SUB TOTAL:	$43,800
6	PROPOSED IMPROVEMENTS				
7	Mobilization *	1	LS	$20,000 / LS	$20,000
8	Survey Stakeout *	1	LS	$2,000 / LS	$2,000
9	Aquatic bench plantings (plugs)	630	SY	$10 / SY	$6,300
10	Gabion Baffles	60	CY	$200 / CY	$12,000
11	Wetland plantings (plugs)	143	SY	$10 / SY	$1,430
12	Rip rap (assume 10 CY at each inflow)	20	CY	$47 / CY	$940
13	6' Chainlink Safety Fence	180	LF	$41 / LF	$7,380
14				PROPOSED IMPROVEMENTS SUB TOTAL:	$50,050
15	EARTHWORK **				
16	Regular Excavation	2,800	CY	$38 / CY	$106,400
17	Load and Haul	2,800	CY	$25 / CY	$70,000
18				EARTHWORK SUB TOTAL:	$176,400
19	MISCELLANEOUS *				
20	Topographic and Utility Survey	1	LS	$8,000 / LS	$8,000
21	Soils/Infiltration Testing	1	LS	$10,000 / LS	$10,000
22	Environmental Permitting Services	1	LS	$10,000 / LS	$10,000
23	Engineering Design Services	1	LS	$35,000 / LS	$35,000
24	As-built Survey	1	LS	$5,000 / LS	$5,000
25				MISCELLANEOUS SUB TOTAL:	$68,000
26					
27				CONSTRUCTION SUB TOTAL:	$338,250
28				CONTINGENCY (30% of PROJECT SUB TOTAL):	$101,475
29				CONSTRUCTION TOTAL:	$439,725
30	ANNUAL MAINTENANCE *				
31	Mowing	1	LS	$2,000 / LS	$2,000
32	Wetland maintenance	1	LS	$2,000 / LS	$2,000
33	Forebay sediment removal	1	LS	$2,000 / LS	$2,000
34				ANNUAL MAINTENANCE:	$6,000

* Unit price for professional services are approximate and subject to change once contractor is selected.

** Earthwork estimates do not include shrink/swell factors. Costs assume no bedrock; field conditions shall be determined by geotechnical investigation

*** Maintenance road construction cost may vary depending on final topographic survey.

Appendix B.3: Facility 08 – Oakenshaw Section 3 (Pond 1) Detailed Concept Retrofit Plans



GKY & Associates, inc.

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CONCEPTUAL RETROFIT PLAN 08 - OAKENSHAW SEC. 3

Pond # 08

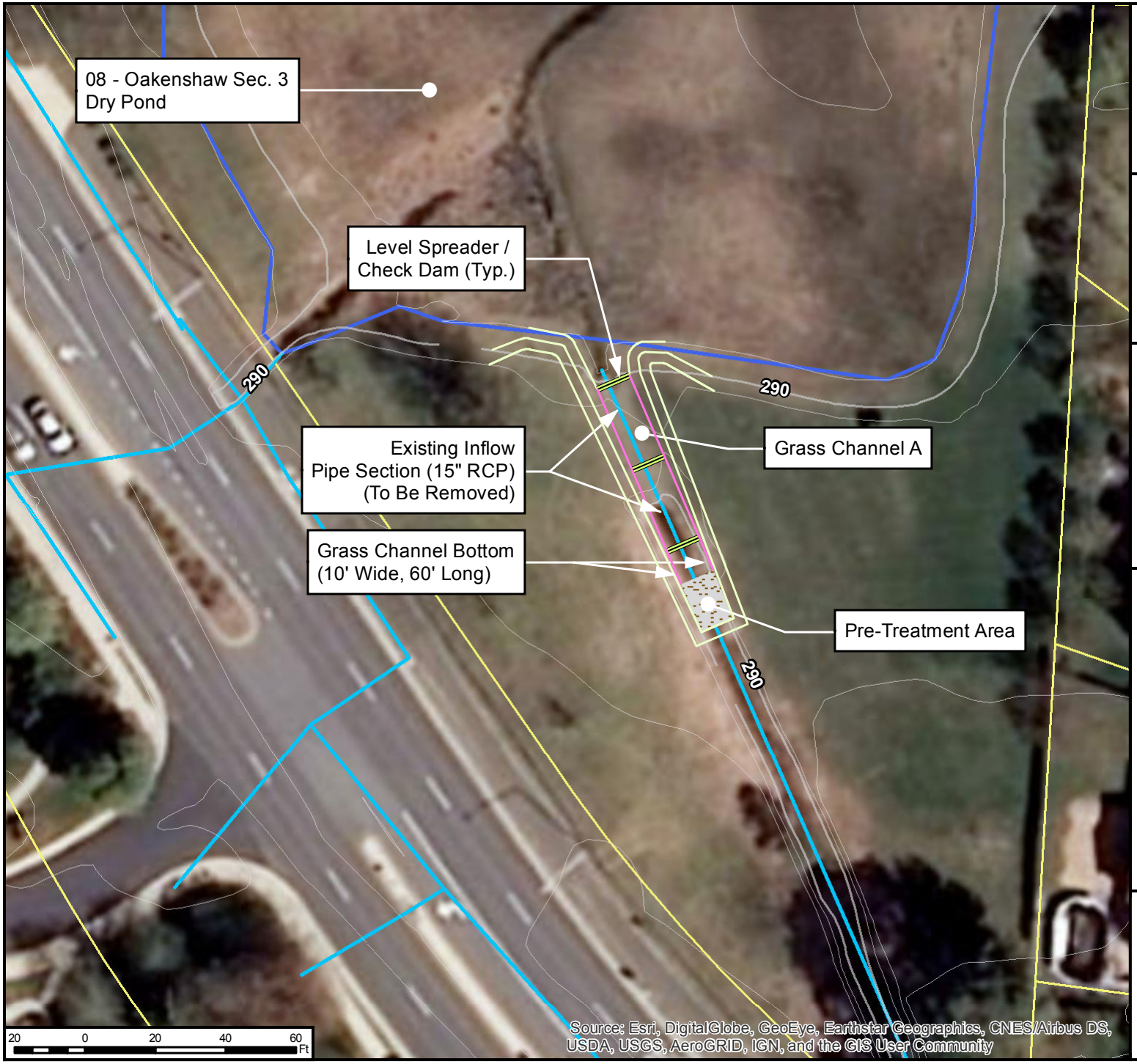
Oakenshaw Sec. 3

Property Address:
9556 Oakenshaw Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
100-30-00-B

Manassas
HISTORIC HEART. MODERN BEAT.



GKY &Associates,inc.

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CONCEPTUAL RETROFIT PLAN LEVEL 1 GRASS CHANNEL A

Pond # 08
Oakenshaw Sec. 3

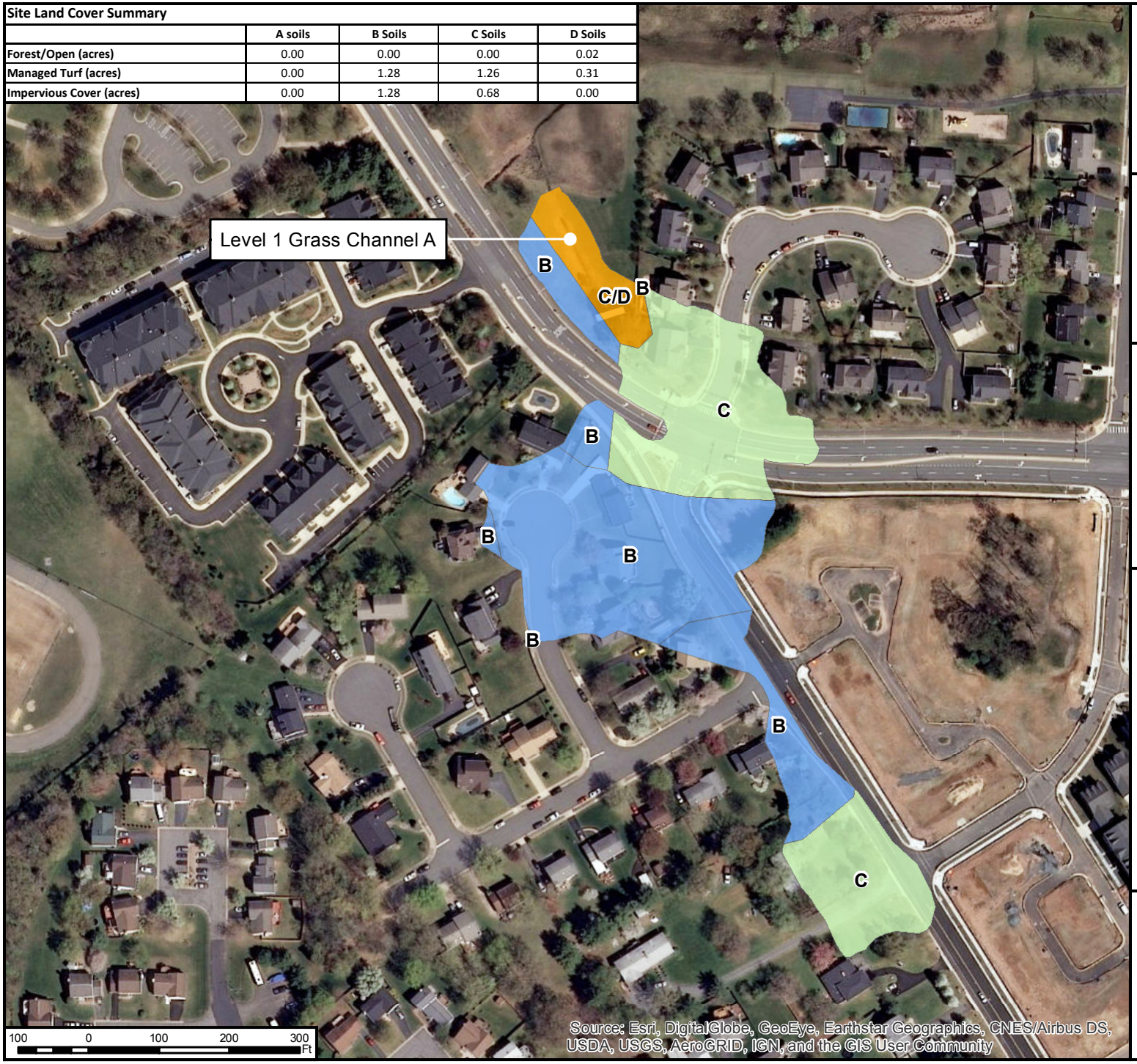
Property Address:
9556 Oakenshaw Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
100-30-00-B

Manassas
HISTORIC HEART. MODERN BEAT.

Site Land Cover Summary				
	A soils	B Soils	C Soils	D Soils
Forest/Open (acres)	0.00	0.00	0.00	0.02
Managed Turf (acres)	0.00	1.28	1.26	0.31
Impervious Cover (acres)	0.00	1.28	0.68	0.00



GKY & Associates, inc.

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DRAINAGE AREA TABULATIONS LEVEL 1 GRASS CHANNEL A

Pond # 08
Oakenshaw Sec. #3

Property Address:
9556 Oakenshaw Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
100-30-00-B

Drainage Area:
4.84 Acres

Manassas
HISTORIC HEART. MODERN BEAT.

DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary

Project Title: Manassas Retrofits - 08_GrassChannel_A

Date: 43146

Total Rainfall = 43 inches

Site Land Cover Summary

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	0.00	0.00	0.02	0.02	0
Managed Turf (acres)	0.00	1.28	1.26	0.31	2.85	59
Impervious Cover (acres)	0.00	1.28	0.68	0.00	1.96	41
					4.84	100

Site Tv and Land Cover Nutrient Loads

Site Rv	0.51
Treatment Volume (ft^3)	8,996
TP Load (lb/yr)	5.65
TN Load (lb/yr)	40.44

Total TP Load Reduction Required (lb/yr)	3.67

Site Compliance Summary

Total Runoff Volume Reduction (ft^3)	898
Total TP Load Reduction Achieved (lb/yr)	1.32
Total TN Load Reduction Achieved (lb/yr)	11.28
Remaining Post Development TP Load (lb/yr)	4.33
Remaining TP Load Reduction (lb/yr) Required	**2.34**

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (acres)	0.02	0.00	0.00	0.00	0.00	0.02
Managed Turf (acres)	2.85	0.00	0.00	0.00	0.00	2.85
Impervious Cover (acres)	1.96	0.00	0.00	0.00	0.00	1.96
Total Area (acres)	**4.84**	**0.00**	**0.00**	**0.00**	**0.00**	**4.84**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	1.32	0.00	0.00	0.00	0.00	1.32
TN Load Reduced (lb/yr)	11.28	0.00	0.00	0.00	0.00	11.28

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	0.00	0.00	0.02	0.02	0
Managed Turf (acres)	0.00	1.28	1.26	0.31	2.85	59
Impervious Cover (acres)	0.00	1.28	0.68	0.00	1.96	41
					4.84	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed

Total Impervious Cover Treated (acres)	1.96
Total Turf Area Treated (acres)	2.85
Total TP Load Reduction Achieved in D.A. (lb/yr)	1.32
Total TN Load Reduction Achieved in D.A. (lb/yr)	11.28

Project: 08 - Oakenshaw Sec. #3, Grass Channel A					
Design Assumptions: 263 LF of 41' Wide Grass Channel Type 1					
Estimate Type: Preliminary Design, Construction and Maintenance Costs					
Prepared by: GKY & Associates, Inc.					
Date: March 30, 2018					
#	ITEM	QUANTITY	UNIT	UNIT COST	COST
1	DEMOLITION				
2	Existing Pipe Removal	75	LF	$52 / LF	$3,900
3				DEMOLITION SUB TOTAL:	$3,900
4	EROSION & SEDIMENT CONTROL				
5	E&S Controls	1	LS	$5,000 / LS	$5,000
6				EROSION & SEDIMENT CONTROL SUB TOTAL:	$5,000
7	PROPOSED IMPROVEMENTS				
8	Mobilization *	1	LS	$5,000 / LS	$5,000
9	Survey Stakeout *	1	LS	$2,000 / LS	$2,000
10	Rip Rap for Pre-treatment	20	CY	$47 CY	$940
11	Level Spreaders / Check Dams	3	EA	$270 / EA	$810
12	Seeding	150	SY	$2 SY	$300
13	Biodegradable Geotextile for Stabilization	75	LF	$2 LF	$150
14				PROPOSED IMPROVEMENTS SUB TOTAL:	$9,200
15	EARTHWORK				
16	Regular Excavation	90	CY	$38 / CY	$3,420
17	Load and Haul	90	CY	$25 / CY	$2,250
18				EARTHWORK SUB TOTAL:	$5,670
19	MISCELLANEOUS *				
20	Topographic and Utility Survey	1	LS	$4,000 / LS	$4,000
21	Soils/Infiltration Testing	1	LS	$4,000 / LS	$4,000
22	Engineering Design Services	1	LS	$15,000 / LS	$15,000
23	As-built Survey	1	LS	$3,000 / LS	$3,000
24				MISCELLANEOUS SUB TOTAL:	$23,000
25					
26				CONSTRUCTION SUB TOTAL:	$46,770
27				CONTINGENCY (30% of PROJECT SUB TOTAL):	$14,031
28				CONSTRUCTION TOTAL:	$60,801
29	ANNUAL MAINTENANCE *				
30	Mowing	1	LS	$2,000 / LS	$2,000
31				ANNUAL MAINTENANCE:	$2,000

* Unit price for professional services are approximate and subject to change once contractor is selected.

** Earthwork estimates do not include shrink/swell factors. Costs assume no bedrock; field conditions shall be determined by geotechnical investigation

Appendix B.4: Facility 20 – Round Elementary Detailed Concept Retrofit Plans

GKY & Associates, inc.

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CONCEPTUAL RETROFIT PLAN LEVEL 1 WET POND

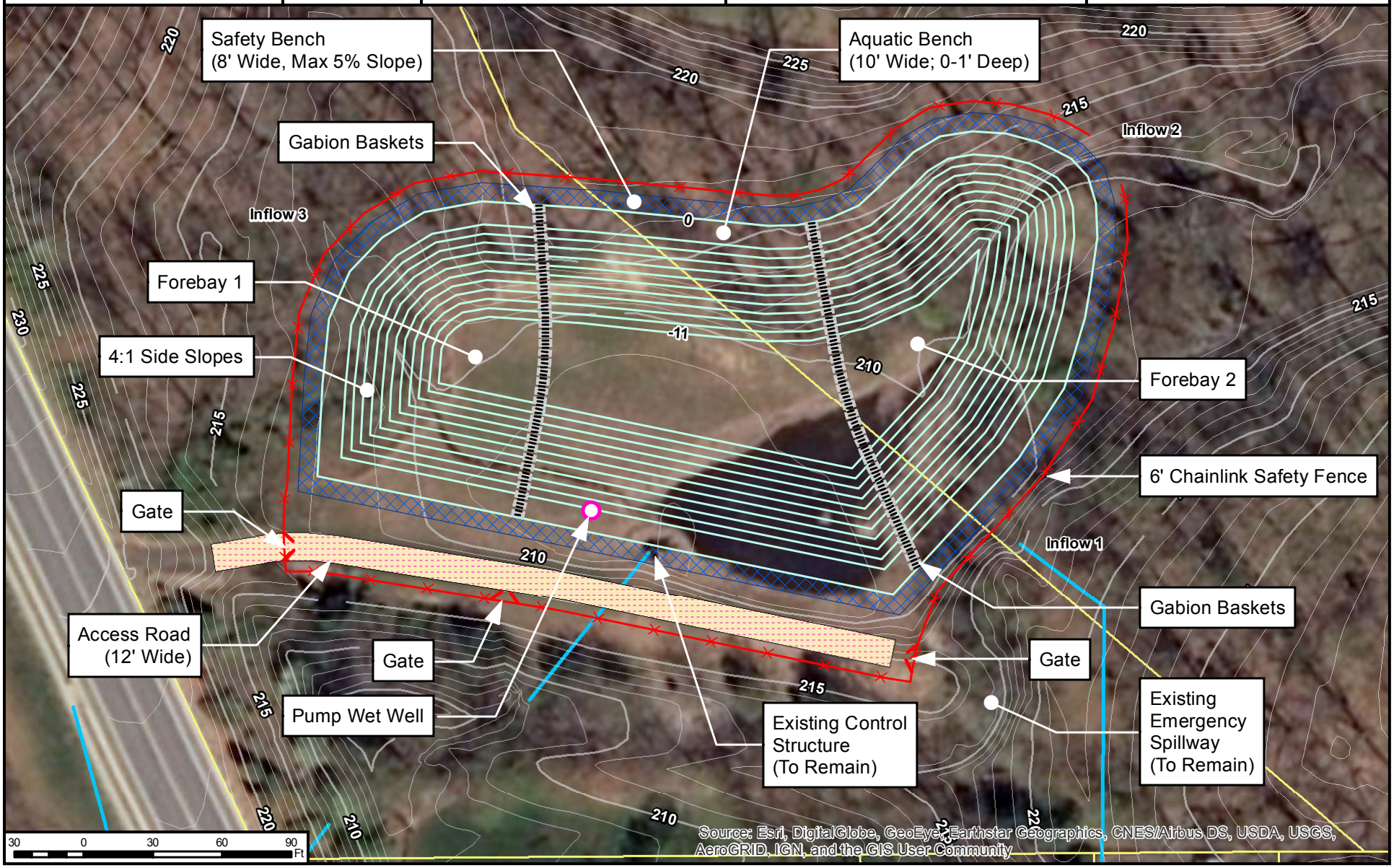
Pond # 20, Round Elementary

Property Address:
10231 Godwin Dr.
Manassas, VA 20110

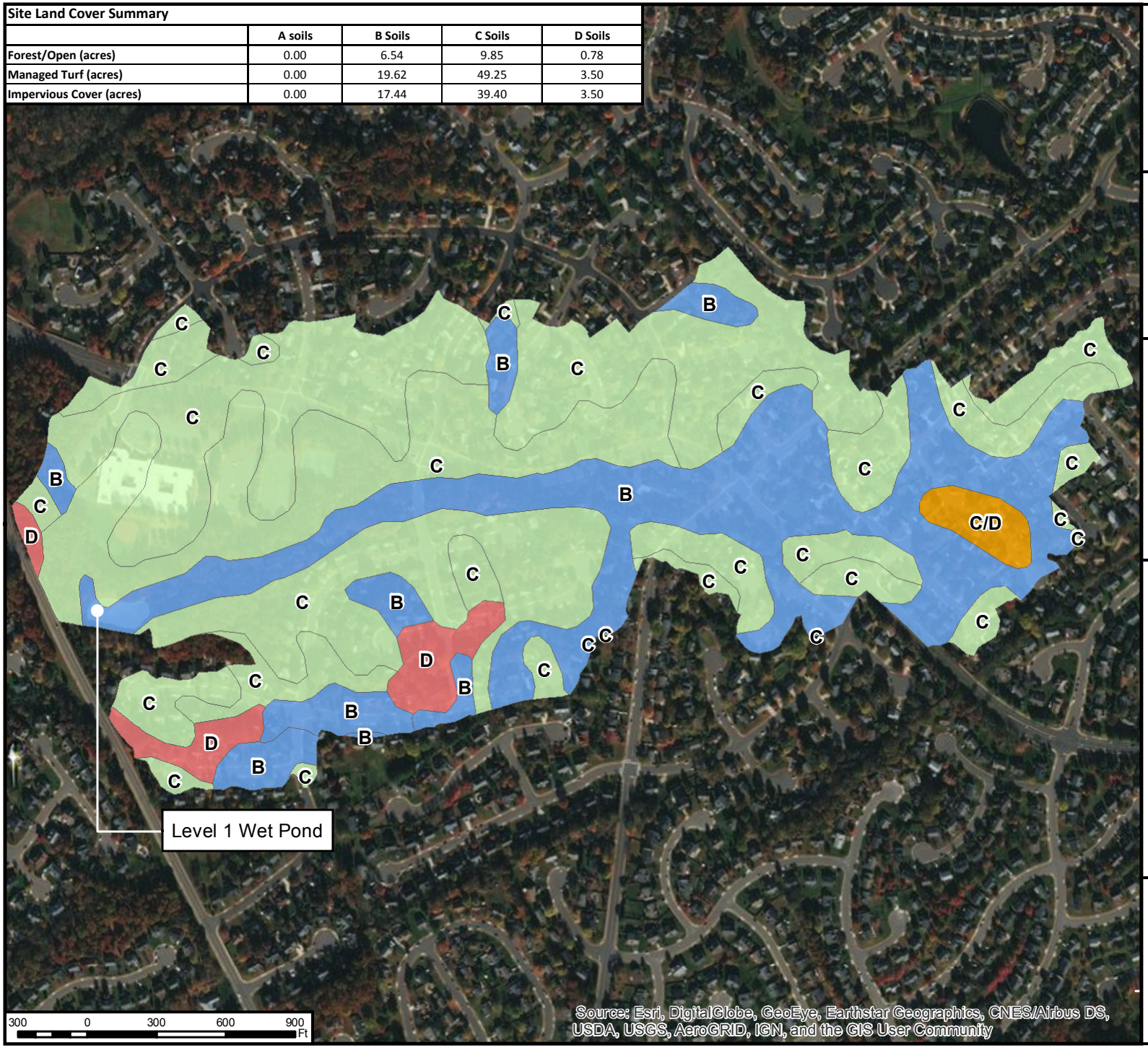
Property Owner:
City of Manassas

Tax Map ID:
091-01-00-B

Manassas
HISTORIC HEART. MODERN BEAT.



Site Land Cover Summary				
	A soils	B Soils	C Soils	D Soils
Forest/Open (acres)	0.00	6.54	9.85	0.78
Managed Turf (acres)	0.00	19.62	49.25	3.50
Impervious Cover (acres)	0.00	17.44	39.40	3.50



GKY & Associates, inc.

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DRAINAGE AREA TABULATIONS LEVEL 1 WET POND

Pond # 20

Round Elementary School

Property Address:
10231 Godwin Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
091-01-00-B

Drainage Area:
149.88 Acres

Manassas
HISTORIC HEART. MODERN BEAT.

DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary

Project Title: Manassas Retrofits - 20_Wet Pond Level 1

Date: 43151

Total Rainfall = 43 inches

Site Land Cover Summary

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	6.54	9.85	0.78	17.17	11
Managed Turf (acres)	0.00	19.62	49.25	3.50	72.37	48
Impervious Cover (acres)	0.00	17.44	39.40	3.50	60.34	40
					149.88	100

Site Tv and Land Cover Nutrient Loads

Site Rv	0.49
Treatment Volume (ft^3)	267,118
TP Load (lb/yr)	167.83
TN Load (lb/yr)	1,200.63

Total TP Load Reduction Required (lb/yr)	106.38

Site Compliance Summary

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	83.10
Total TN Load Reduction Achieved (lb/yr)	356.70
Remaining Post Development TP Load (lb/yr)	84.73
Remaining TP Load Reduction (lb/yr) Required	**23.28**

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (acres)	17.17	0.00	0.00	0.00	0.00	17.17
Managed Turf (acres)	72.37	0.00	0.00	0.00	0.00	72.37
Impervious Cover (acres)	60.34	0.00	0.00	0.00	0.00	60.34
Total Area (acres)	**149.88**	**0.00**	**0.00**	**0.00**	**0.00**	**149.88**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	83.10	0.00	0.00	0.00	0.00	83.10
TN Load Reduced (lb/yr)	356.70	0.00	0.00	0.00	0.00	356.70

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	6.54	9.85	0.78	17.17	11
Managed Turf (acres)	0.00	19.62	49.25	3.50	72.37	48
Impervious Cover (acres)	0.00	17.44	39.40	3.50	60.34	40
					149.88	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed

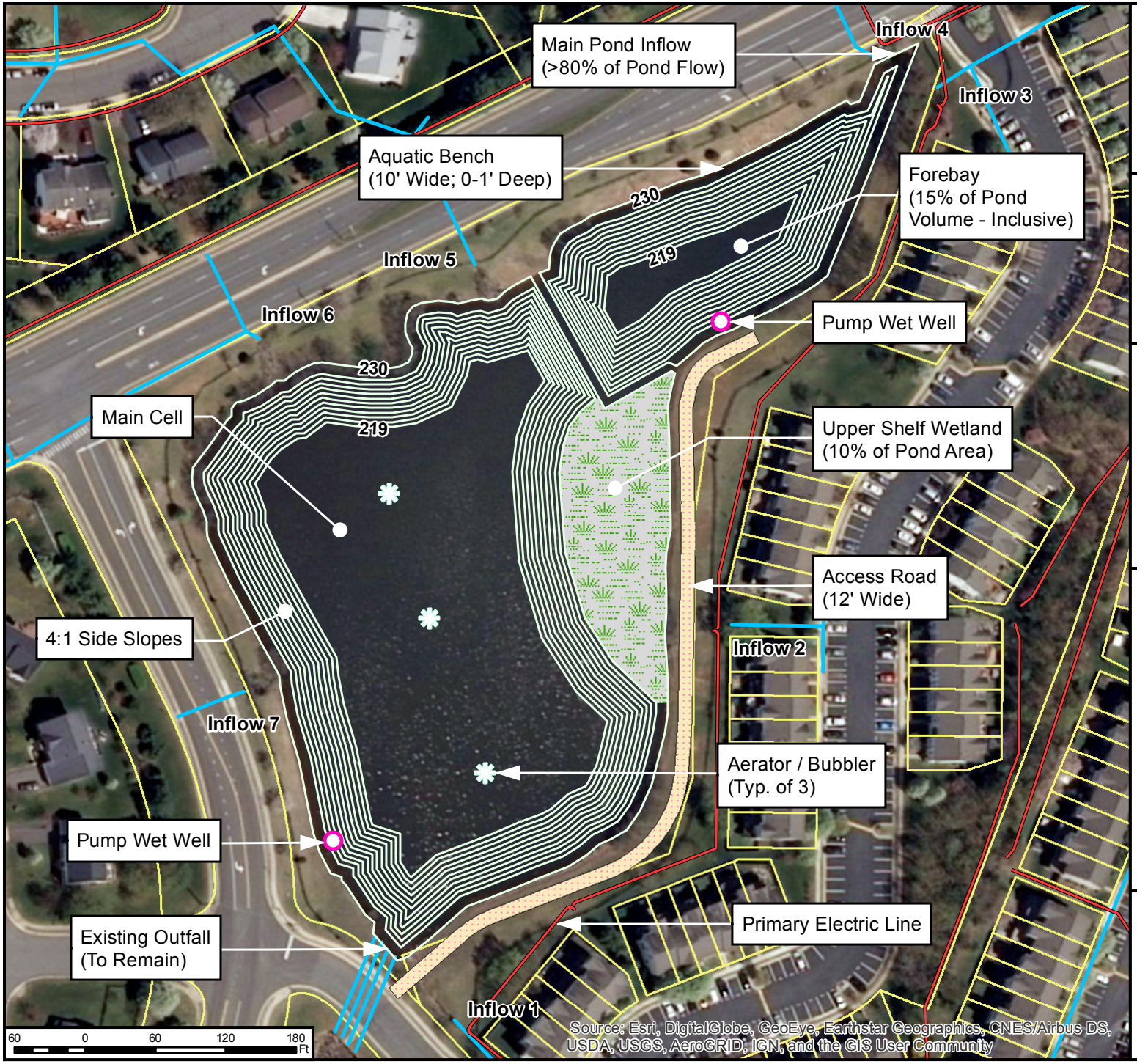
Total Impervious Cover Treated (acres)	60.34
Total Turf Area Treated (acres)	72.37
Total TP Load Reduction Achieved in D.A. (lb/yr)	83.10
Total TN Load Reduction Achieved in D.A. (lb/yr)	356.70

Project: 20 - Round Elementary School, Dry Pond					
Design Assumptions: Wet Pond Level 1					
Estimate Type: Preliminary Design, Construction and Maintenance Costs					
Prepared by: GKY & Associates, Inc.					
Date: March 30, 2018					
#	ITEM	QUANTITY	UNIT	UNIT COST	COST
1	EROSION & SEDIMENT CONTROL				
2	Construction Entrance with Wash Rack	1	EA	$3,800 / EA	$3,800
3	Stream Pump Around (1 dewatering pump and 2 diversion pumps) *	1	LS	$15,000 / LS	$15,000
4	Other E&S Controls	1	LS	$25,000 / LS	$25,000
5				EROSION & SEDIMENT CONTROL SUB TOTAL:	$43,800
6	PROPOSED IMPROVEMENTS				
7	Mobilization *	1	LS	$20,000 / LS	$20,000
8	Survey Stakeout *	1	LS	$2,000 / LS	$2,000
9	Aquatic bench plantings (plugs)	1,000	SY	$10 / SY	$10,000
10	Pump Wet Well	1	EA	$3,750 / EA	$3,750
11	Rip rap (assume 10 CY at each inflow)	30	CY	$47 / CY	$1,410
12	Gabions for Forebays	350	CY	$200 / CY	$70,000
13	Maintenance Road Construction	350	SY	$14 / SY	$4,900
14	6' Chain Link Fence	950	LF	$41 / LF	$38,950
15				PROPOSED IMPROVEMENTS SUB TOTAL:	$151,010
16	EARTHWORK **				
17	Regular Excavation	10,150	CY	$38 / CY	$385,700
18	Load and Haul	10,150	CY	$25 / CY	$253,750
19				EARTHWORK SUB TOTAL:	$639,450
20	MISCELLANEOUS *				
21	Topographic and Utility Survey	1	LS	$8,000 / LS	$8,000
22	Soils/Infiltration Testing	1	LS	$10,000 / LS	$10,000
23	Environmental Permitting Services	1	LS	$25,000 / LS	$25,000
24	Engineering Design Services	1	LS	$40,000 / LS	$40,000
25	As-built Survey	1	LS	$5,000 / LS	$5,000
26				MISCELLANEOUS SUB TOTAL:	$88,000
27					
28				CONSTRUCTION SUB TOTAL:	$922,260
29				CONTINGENCY (30% of PROJECT SUB TOTAL):	$276,678
30				CONSTRUCTION TOTAL:	$1,198,938
31	ANNUAL MAINTENANCE *				
32	Mowing	1	LS	$2,000 / LS	$2,000
33	Forebay sediment removal	1	LS	$2,000 / LS	$2,000
34				ANNUAL MAINTENANCE:	$4,000

* Unit price for professional services are approximate and subject to change once contractor is selected.

** Earthwork estimates do not include shrink/swell factors. Costs assume no bedrock; field conditions shall be determined by geotechnical investigation

Appendix B.5: Facility 30 – Lucasville Road/Cockrell Branch Regional Facility Detailed Concept Retrofit Plans



GKY & Associates, inc.

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CONCEPTUAL RETROFIT PLAN LEVEL 2 WET POND

Pond # 30
Lucasville Road (Cockrell Branch Regional Facility)

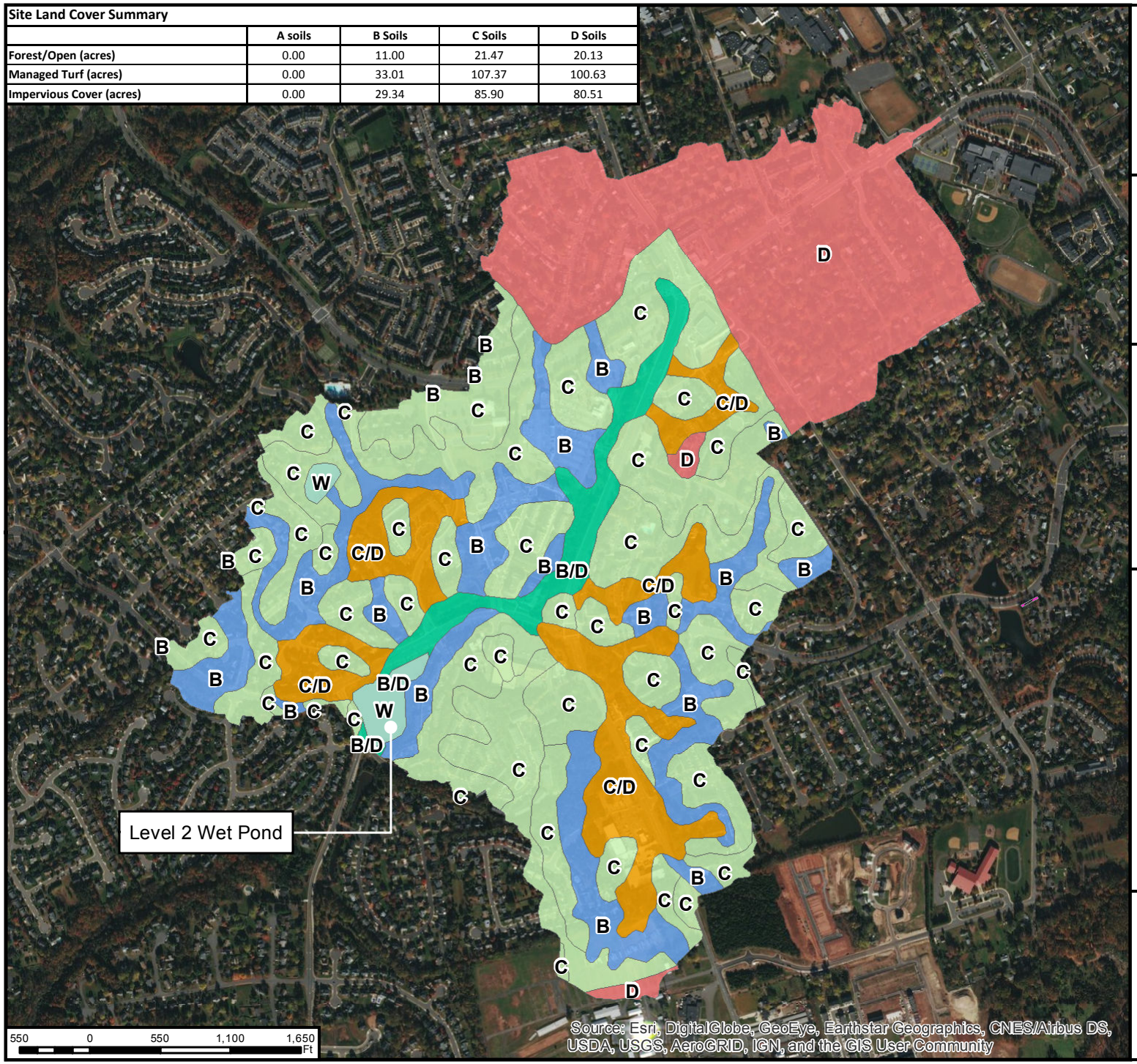
Property Address:
10216 Magnolia Grove Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
090-76-00-A

Manassas
HISTORIC HEART. MODERN BEAT.

Site Land Cover Summary				
	A soils	B Soils	C Soils	D Soils
Forest/Open (acres)	0.00	11.00	21.47	20.13
Managed Turf (acres)	0.00	33.01	107.37	100.63
Impervious Cover (acres)	0.00	29.34	85.90	80.51



GKY & Associates, inc.

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DRAINAGE AREA TABULATIONS LEVEL 2 WET POND

Pond # 30
Lucasville Road (Cockrell Branch Regional Facility)

Property Address:
10216 Magnolia Grove Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
090-76-00-A

Drainage Area:
489.37 Acres

Manassas
HISTORIC HEART. MODERN BEAT.

DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary

Project Title: Manassas Retrofits - 30_Wet Pond Level 2

Date: 43151

Total Rainfall = 43 inches

Site Land Cover Summary

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	11.00	21.47	20.13	52.61	11
Managed Turf (acres)	0.00	33.01	107.37	100.63	241.01	49
Impervious Cover (acres)	0.00	29.34	85.90	80.51	195.75	40
					489.37	100

Site Tv and Land Cover Nutrient Loads

Site Rv	0.50
Treatment Volume (ft^3)	884,046
TP Load (lb/yr)	555.44
TN Load (lb/yr)	3,973.56

Total TP Load Reduction Required (lb/yr)	354.80

Site Compliance Summary

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	412.36
Total TN Load Reduction Achieved (lb/yr)	1,573.31
Remaining Post Development TP Load (lb/yr)	143.08
Remaining TP Load Reduction (lb/yr) Required	**0.00**

**** TARGET TP REDUCTION EXCEEDED BY 57.56 LB/YEAR ****

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (acres)	52.61	0.00	0.00	0.00	0.00	52.61
Managed Turf (acres)	241.01	0.00	0.00	0.00	0.00	241.01
Impervious Cover (acres)	195.75	0.00	0.00	0.00	0.00	195.75
Total Area (acres)	**489.37**	**0.00**	**0.00**	**0.00**	**0.00**	**489.37**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	412.36	0.00	0.00	0.00	0.00	412.36
TN Load Reduced (lb/yr)	1,573.31	0.00	0.00	0.00	0.00	1,573.31

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	11.00	21.47	20.13	52.61	11
Managed Turf (acres)	0.00	33.01	107.37	100.63	241.01	49
Impervious Cover (acres)	0.00	29.34	85.90	80.51	195.75	40
					489.37	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed

Total Impervious Cover Treated (acres)	195.75
Total Turf Area Treated (acres)	241.01
Total TP Load Reduction Achieved in D.A. (lb/yr)	412.36
Total TN Load Reduction Achieved in D.A. (lb/yr)	1573.31

Project: 30 - Lucasville Road (Cockrell Branch Regional Facility), Wet Pond					
Design Assumptions: Wet Pond Level 2					
Estimate Type: Preliminary Design, Construction and Maintenance Costs					
Prepared by: GKY & Associates, Inc.					
Date: March 30, 2018					
#	ITEM	QUANTITY	UNIT	UNIT COST	COST
1	EROSION & SEDIMENT CONTROL				
2	Construction Entrance with Wash Rack	1	EA	$3,800 / EA	$3,800
3	Stream Pump Around (1 dewatering pump and 2 diversion pumps) *	1	LS	$15,000 / LS	$15,000
4	Other E&S Controls	1	LS	$40,000 / LS	$40,000
5	EROSION & SEDIMENT CONTROL SUB TOTAL:				$58,800
6	PROPOSED IMPROVEMENTS				
7	Mobilization *	1	LS	$20,000 / LS	$20,000
8	Survey Stakeout *	1	LS	$2,000 / LS	$2,000
9	Wetland plantings (plugs)	2,500	SY	$10 / SY	$25,000
10	Aquatic bench plantings (plugs)	2,700	SY	$10 / SY	$27,000
11	Pump Wet Well	2	EA	$3,750 / EA	$7,500
12	Rip rap (assume 10 CY at each inflow)	70	CY	$47 / CY	$3,290
13	Armor forebay berm	1,000	CY	$47 / CY	$47,000
14	Maintenance Road Construction ***	950	SY	$14 / SY	$13,300
15	Aerators/bubblers	3	EA	$10,000 / EA	$30,000
16	PROPOSED IMPROVEMENTS SUB TOTAL:				$175,090
17	EARTHWORK **				
18	Regular Excavation	12,750	CY	$38 / CY	$484,500
19	Load and Haul	9,500	CY	$25 / CY	$237,500
20	EARTHWORK SUB TOTAL:				$722,000
21	MISCELLANEOUS *				
22	Topographic and Utility Survey	1	LS	$8,000 / LS	$8,000
23	Bathymetric Survey	1	LS	$8,000 / LS	$8,000
24	Soils/Infiltration Testing	1	LS	$10,000 / LS	$10,000
25	Environmental Permitting Services	1	LS	$25,000 / LS	$25,000
26	Engineering Design Services	1	LS	$50,000 / LS	$50,000
27	As-built Survey	1	LS	$10,000 / LS	$10,000
28	MISCELLANEOUS SUB TOTAL:				$111,000
29					
30	CONSTRUCTION SUB TOTAL:				$1,066,890
31	CONTINGENCY (30% of PROJECT SUB TOTAL):				$320,067
32	CONSTRUCTION TOTAL:				$1,386,957
33	ANNUAL MAINTENANCE *				
34	Mowing	1	LS	$2,000 / LS	$2,000
35	Wetland maintenance	1	LS	$2,000 / LS	$2,000
36	Forebay sediment removal	1	LS	$2,000 / LS	$2,000
37	Aerator/bubbler electricity and maintenance	1	LS	$2,000 / LS	$2,000
38	ANNUAL MAINTENANCE:				$8,000

* Unit price for professional services are approximate and subject to change once contractor is selected.

** Earthwork estimates do not include shrink/swell factors. Costs assume no bedrock; field conditions shall be determined by geotechnical investigation

*** Maintenance road construction cost may vary depending on final topographic survey.

Appendix C: Pollutant Load Calculation Summary

Total Phosphorus Load Calculations														
Facility Number	Facility Name	Retrofit Facility Type	Phosphorus Load (lbs/yr) [1]	Baseline Runoff Depth Treated (in)	Depth Source	Baseline Phosphorus Removal Efficiency (%)	Removal Efficiency Source	Baseline Phosphorus Removed (lbs/yr) [2]	Retrofit Runoff Depth Treated (in) [3]	Retrofit Facility Efficiency (%) [4]	Retrofit Facility Phosphorus Removed (lbs/yr) [5]	Efficiency of Downstream Facility (%) [6]	Downstream Phosphorus Removed (lbs/yr) [7]	Total Retrofit Phosphorus Removed (lbs/yr) [8]	Retrofit Benefit: Difference in Phosphorus Removed (lbs/yr)[9]
2	Public Works	Dry Swale A - Type 1	3.79	0.50	Assumed	41%	Fig. 1 of GM15-2005*	**1.55**	1.00	52%	1.97	41%	0.75	**2.71**	**1.16**
		Dry Swale B - Type 1	3.18	0.50	Assumed	41%	Fig. 1 of GM15-2005*	**1.30**	1.00	52%	1.61	41%	0.64	**2.25**	**0.95**
7	Oakenshaw 1	Extended Detention - Level 2	26.08	0.34	Calculated (Plans: 1,250 CF/AC)	15%	BMP Clearinghouse	**1.33**	1.25	31%	7.23	N/A	N/A	**7.23**	**5.90**
8	Oakenshaw 2	Grass Channel A	5.65	0.33	Calculated (Plans: 1,200 CF/AC)	15%	BMP Clearinghouse	**0.28**	1.00	24%	1.32	15%	0.65	**1.97**	**1.69**
		Grass Channel B	0.49	0.33	Calculated (Plans: 1,200 CF/AC)	15%	BMP Clearinghouse	**0.02**	1.00	24%	0.11	15%	0.06	**0.17**	**0.15**
		Grass Channel C	0.34	0.33	Calculated (Plans: 1,200 CF/AC)	15%	BMP Clearinghouse	**0.02**	1.00	24%	0.08	15%	0.04	**0.12**	**0.10**
		Grass Channel D	2.87	0.33	Calculated (Plans: 1,200 CF/AC)	15%	BMP Clearinghouse	**0.14**	1.00	24%	0.68	15%	0.33	**1.00**	**0.86**
20	Round Elementary	Wet Pond - Level 1	167.83	0.50	Assumed	15%	BMP Clearinghouse	**25.17**	1.00	50%	83.10	N/A	N/A	**83.10**	**57.93**
30	Lucasville/Cockrell Branch	Wet Pond - Level 2	555.44	0.50	Plans	41%	Fig. 1 of GM15-2005*	**227.73**	1.50	75%	412.36	N/A	N/A	**412.36**	**184.63**

1. From the Virginia Runoff Reduction Method (VRRM) spreadsheet.
2. (Baseline Phosphorus Removed) = (Phosphorus Load) * (Baseline Phosphorus Removal Efficiency).
3. Based on BMP Clearinghouse design requirements.
4. From BMP Clearinghouse (Total Mass Load Removal including that from Runoff Reduction and Pollutant Reduction)
5. (Retrofit Facility Phosphorus Removed) = (Phosphorus Load) * (Retrofit Facility Efficiency).
6. Efficiency of Downstream Facility (%), if applicable, is the Baseline Phosphorus Removal Efficiency (%) of the original downstream, unmodified facility.
7. (Downsteam Phosphorus Removed) = (Efficiency of Downstream Facility) * [(Phosphorus Load) - (Retrofit Facility Phosphorus Removed)].
8. (Total Retrofit Phosphorus Removed) = (Retrofit Facility Phosphorus Removed) + (Downstream Phosphorus Removed).
9. (Difference in Phosphorus Removed) = (Total Retrofit Phosphorus Removed) - (Baseline Phosphorus Removed).

* Chesapeake Bay TMDL Special Conditions Guidance GM15-2005

Total Nitrogen Load Calculations															
Facility Number	Facility Name	Retrofit Facility Type	Nitrogen Load (lbs/yr) [1]	Baseline Runoff Depth Treated (in)	Depth Source	Baseline Nitrogen Removal Efficiency (%)	Removal Efficiency Source	Baseline Nitrogen Removed (lbs/yr) [2]	Retrofit Runoff Depth Treated (in) [3]	Retrofit Facility Efficiency (%) [4]	Retrofit Facility Nitrogen Removed (lbs/yr) [5]	Efficiency of Downstream Facility (%) [6]	Downstream Nitrogen Removed (lbs/yr) [7]	Total Retrofit Nitrogen Removed (lbs/yr) [8]	Retrofit Benefit: Difference in Nitrogen Removed (lbs/yr)[9]
2	Public Works	Dry Swale A - Type 1	27.13	0.50	Assumed	26%	Fig. 2 of GM15-2005*	**7.05**	1.00	54%	14.89	26%	3.18	18.07	**11.02**
		Dry Swale B - Type 1	22.73	0.50	Assumed	26%	Fig. 2 of GM15-2005*	**5.91**	1.00	54%	12.18	26%	2.74	14.92	**9.01**
7	Oakenshaw 1	Extended Detention - Level 2	186.57	0.34	Calculated (Plans: 1,250 CF/AC)	5%	App. V.C, GM15-2005*	**3.17**	1.25	24%	43.79	N/A	N/A	43.79	**40.62**
8	Oakenshaw 2	Grass Channel A	40.44	0.33	Calculated (Plans: 1,200 CF/AC)	5%	App. V.C, GM15-2005*	**0.67**	1.00	28%	11.28	5%	1.46	12.74	**12.07**
		Grass Channel B	3.49	0.33	Calculated (Plans: 1,200 CF/AC)	5%	App. V.C, GM15-2005*	**0.06**	1.00	28%	0.98	5%	0.13	1.10	**1.05**
		Grass Channel C	2.42	0.33	Calculated (Plans: 1,200 CF/AC)	5%	App. V.C, GM15-2005*	**0.04**	1.00	28%	0.68	5%	0.09	0.76	**0.72**
		Grass Channel D	20.50	0.33	Calculated (Plans: 1,200 CF/AC)	5%	App. V.C, GM15-2005*	**0.34**	1.00	28%	5.76	5%	0.74	6.50	**6.16**
20	Round Elementary	Wet Pond - Level 1	1,200.60	0.50	Assumed	5%	App. V.C, GM15-2005*	**60.03**	1.00	30%	356.70	N/A	N/A	356.70	**296.67**
30	Lucasville/Cockrell Branch	Wet Pond - Level 2	3,973.56	0.50	Plans	26%	Fig. 2 of GM15-2005*	**1033.13**	1.50	40%	1,573.31	N/A	N/A	1573.31	**540.19**

1. From the Virginia Runoff Reduction Method (VRRM) spreadsheet.
2. (Baseline Nitrogen Removed) = (Nitrogen Load) * (Baseline Nitrogen Removal Efficiency).
3. Based on BMP Clearinghouse design requirements.
4. From VRRM Spreadsheet. (Total Mass Load Removal including that from Runoff Reduction and Pollutant Reduction)
5. (Retrofit Facility Nitrogen Removed) = (Nitrogen Load) * (Retrofit Facility Efficiency).
6. Efficiency of Downstream Facility (%), if applicable, is the Baseline Nitrogen Removal Efficiency (%) of the original downstream, unmodified facility.
7. (Downsteam Nitrogen Removed) = (Efficiency of Downstream Facility) * [(Nitrogen Load) - (Retrofit Facility Nitrogen Removed)].
8. (Total Retrofit Nitrogen Removed) = (Retrofit Facility Nitrogen Removed) + (Downstream Nitrogen Removed).
9. (Difference in Nitrogen Removed) = (Total Retrofit Nitrogen Removed) - (Baseline Nitrogen Removed).

* Chesapeake Bay TMDL Special Conditions Guidance GM15-2005

Total Suspended Solids Load Calculations															
Facility Number	Facility Name	Retrofit Facility Type	TSS Load (lbs/yr) [1]	Baseline Runoff Depth Treated (in)	Depth Source	Baseline TSS Removal Efficiency (%)	Removal Efficiency Source	Baseline TSS Removed (lbs/yr) [2]	Retrofit Runoff Depth Treated (in) [3]	Retrofit Facility Efficiency (%) [4]	Retrofit Facility TSS Removed (lbs/yr) [5]	Efficiency of Downstream Facility (%) [6]	Downstream TSS Removed (lbs/yr) [7]	Total Retrofit TSS Removed (lbs/yr) [8]	Retrofit Benefit: Difference in TSS Removed (lbs/yr) [9]
2	Public Works	Dry Swale A - Type 1	1,778.27	0.50	Assumed	52%	Fig. 3 of GM15-2005*	**924.70**	1.00	80%	1,422.61	52%	184.94	1,607.55	**682.85**
		Dry Swale B - Type 1	1,492.06	0.50	Assumed	52%	Fig. 3 of GM15-2005*	**775.87**	1.00	80%	1,193.64	52%	155.17	1,348.82	**572.95**
7	Oakenshaw 1	Extended Detention - Level 2	12,236.74	0.34	Calculated (Plans: 1,250 CF/AC)	10%	App. V.C, GM15-2005*	**416.05**	1.25	60%	7,342.04	N/A	N/A	7,342.04	**6,925.99**
8	Oakenshaw 2	Grass Channel A	2,650.98	0.33	Calculated (Plans: 1,200 CF/AC)	10%	App. V.C, GM15-2005*	**87.48**	1.00	50%	1,325.49	10%	132.55	1,458.04	**1,370.56**
		Grass Channel B	229.91	0.33	Calculated (Plans: 1,200 CF/AC)	10%	App. V.C, GM15-2005*	**7.59**	1.00	50%	114.95	10%	11.50	126.45	**118.86**
		Grass Channel C	159.53	0.33	Calculated (Plans: 1,200 CF/AC)	10%	App. V.C, GM15-2005*	**5.26**	1.00	50%	79.76	10%	7.98	87.74	**82.48**
		Grass Channel D	1,346.60	0.33	Calculated (Plans: 1,200 CF/AC)	10%	App. V.C, GM15-2005*	**44.44**	1.00	50%	673.30	10%	67.33	740.63	**696.19**
20	Round Elementary	Wet Pond - Level 1	78,745.84	0.50	Assumed	10%	App. V.C, GM15-2005*	**7,874.58**	1.00	60%	47,247.50	N/A	N/A	47,247.50	**39,372.92**
30	Lucasville/Cockrell Branch	Wet Pond - Level 2	260,612.45	0.50	Plans	52%	Fig. 3 of GM15-2005*	**135,518.47**	1.50	60%	156,367.47	N/A	N/A	156,367.47	**20,849.00**

1. TSS is calculated based on ratio to Phosphorus loading rate (420.9 TSS lbs/acre : 1.0 Phosphorus lbs/acre) in the Chesapeake Bay TMDL Special Conditions Guidance GM15-2005, May 18, 2015.
2. (Baseline TSS Removed) = (TSS Load) * (Baseline TSS Removal Efficiency).
3. Depth Treated is based on BMP Clearinghouse design requirements.
4. Facility Efficiency is from Table V.C.1 in the Chesapeake Bay TMDL Special Conditions Guidance GM15-2005.
5. (Retrofit Facility TSS Removed) = (TSS Load) * (Retrofit Facility Efficiency).
6. Efficiency of Downstream Facility (%), if applicable, is the Baseline TSS Removal Efficiency (%) of the original downstream, unmodified facility.
7. (Downsteam TSS Removed) = (Efficiency of Downstream Facility) * [(TSS Load) - (Retrofit Facility TSS Removed)].
8. (Total Retrofit TSS Removed) = (Retrofit Facility TSS Removed) + (Downstream TSS Removed).
9. (Difference in TSS Removed) = (Total Retrofit TSS Removed) - (Baseline TSS Removed).

* Chesapeake Bay TMDL Special Conditions Guidance GM15-2005

Appendix D: Water Quality Cost Analysis

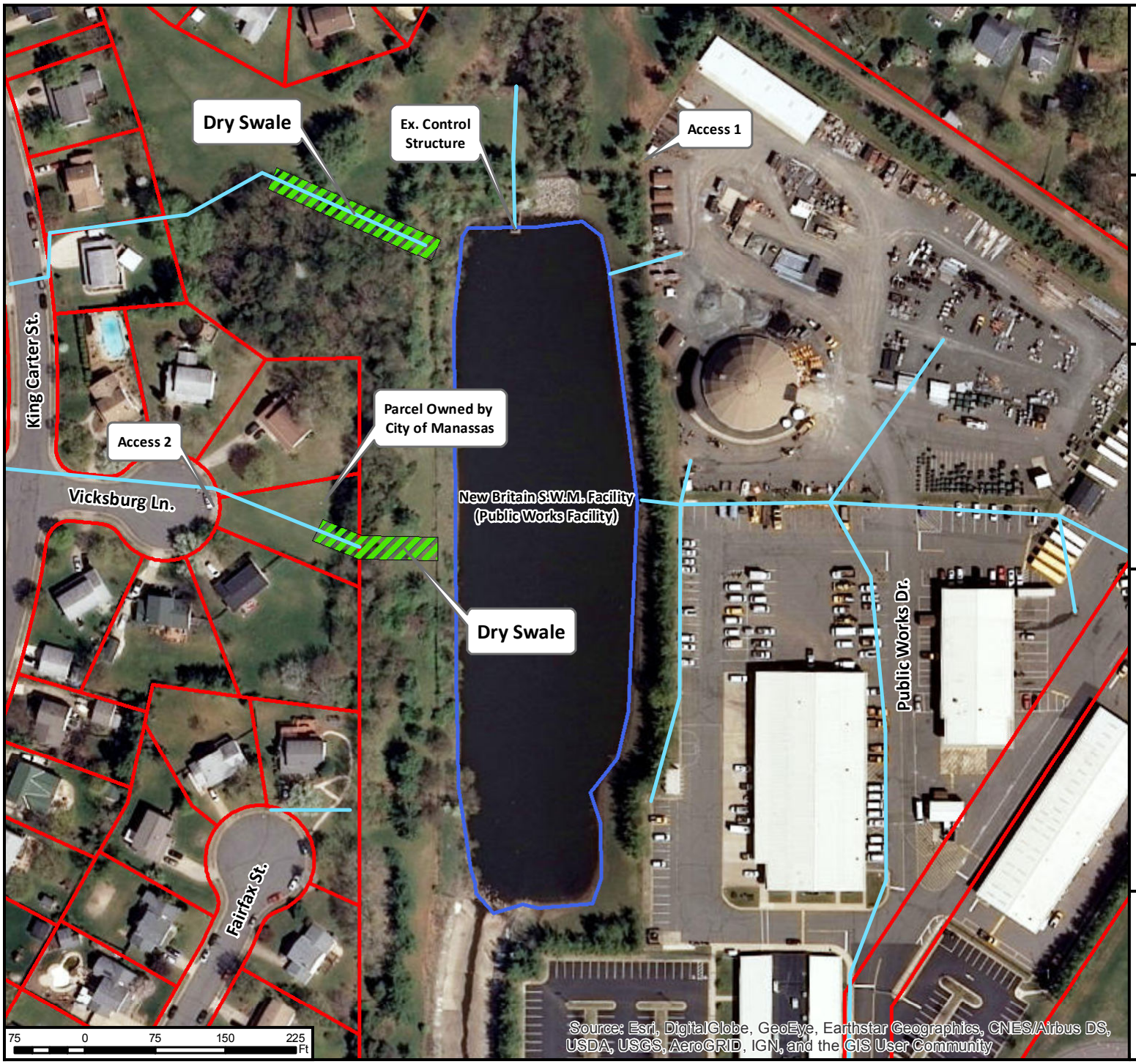
Retrofit Pollutant Removal Cost Analysis

BMP Retrofit Opportunity			Approximate Design and Construction Cost ($) [3]	Maint. Cost ($/yr) [4]	Lifecycle Total Cost per Year ($/yr) [5]	Difference in Phosphorus Removed (lb/yr)	Capital Cost Per Pound of Additional Phosphorus Removed ($/lb) [6]	Annual Cost Per Pound of Additional Phosphorus Removed ($/lb/yr) [7]	Difference in Nitrogen Removed (lb/yr)	Capital Cost Per Pound of Additional Nitrogen Removed ($/lb) [6]	Annual Cost Per Pound of Additional Nitrogen Removed ($/lb/yr) [7]	Difference in TSS Removed (lb/yr)	Capital Cost Per Pound of Additional TSS Removed ($/lb) [6]	Annual Cost Per Pound of Additional TSS Removed ($/lb/yr) [7]
ID #	Facility Name	Retrofit Type												
2	Public Works	Dry Swale A - Level 1	$137,341	$2,000	$8,867	1.16	$118,288.70	$7,636.99	11.02	$12,464.21	$804.72	682.9	$201.13	$12.99
		Dry Swale B - Level 1	$184,254	$2,000	$11,213	0.95	$194,011.08	$11,806.46	9.01	$20,443.15	$1,244.06	572.9	$321.59	$19.57
7	Oakenshaw 7	Extended Detention - Type 2	$439,725	$6,000	$27,986	5.90	$74,543.12	$4,744.29	40.62	$10,824.48	$688.92	6926.0	$63.49	$4.04
8	Oakenshaw 8	Grass Channel A	$60,801	$2,000	$5,040	1.69	$35,912.73	$2,976.96	12.07	$5,035.72	$417.43	1370.6	$44.36	$3.68
20	Round Elementary	Wet Pond - Level 1	$1,198,938	$4,000	$63,947	57.93	$20,696.84	$1,103.89	296.67	$4,041.27	$215.55	39372.9	$30.45	$1.62
30	Lucasville/Cockrell Branch	Wet Pond - Level 2	$1,386,957	$8,000	$77,348	184.63	$7,512.10	$418.93	540.19	$2,567.55	$143.19	20849.0	$66.52	$3.71

Notes:

1. Runoff Reduction Credit computed by entering the drainage area and impervious area treated into the VRRM spreadheet.
2. Adjusted Curve Number is based on the 2-year storm calculations using the the VRRM spreadsheet.
3. Approximate Construction Cost estimates are based on cost estimates developed by GKY. Costs do not include dry utility locating, test pits, easements, plats, permitting, agency review fees, etc.
4. Annual maintenance costs are based on information presented in Section 6.0 of the EPA document, "Preliminary Data Summary of Urban Stormwater Best Management Practices" and estimates developed by GKY.
5. Assumes a 20-year useful life. Total Cost per Year = [Capital Cost + (Annual Maintenance Cost * 20 years)] / (20 years).
6. Capital Cost Per Pound = (Approximate Design and Construction Cost) / (Difference in Pollutant Removed).
7. Assumes a 20-year useful life. Cost Per Pound = (Total Cost per Year) / (Total Pollutant Removed per Year).

Appendix E: Preliminary Concept Retrofit Plans



GKY & Associates, inc.

1:1,800

CONCEPTUAL RETROFIT PLAN

Pond # 02
New Britain S.W.M. Facility (Public Works Facility)

Property Address:
9680 Public Works Dr.
Manassas, VA 20110

Property Owner:
City of Manassas

Tax Map ID:
111-15-00-F10

Manassas
HISTORIC HEART. MODERN BEAT.

GKY &Associates,inc.

1:1,200

CONCEPTUAL RETROFIT PLAN

Pond # 07

Oakenshaw Sec. 3

Property Address:
9559 Oakenshaw Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
100-30-00-C

Manassas
HISTORIC HEART. MODERN BEAT.

GKY &Associates,inc.

1:1,680

CONCEPTUAL RETROFIT PLAN

Pond # 08

Oakenshaw Sec. 3

Property Address:
9556 Oakenshaw Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
100-30-00-B

Manassas
HISTORIC HEART. MODERN BEAT.

GKY & Associates, inc.

1:1,440

CONCEPTUAL RETROFIT PLAN

Pond # 09

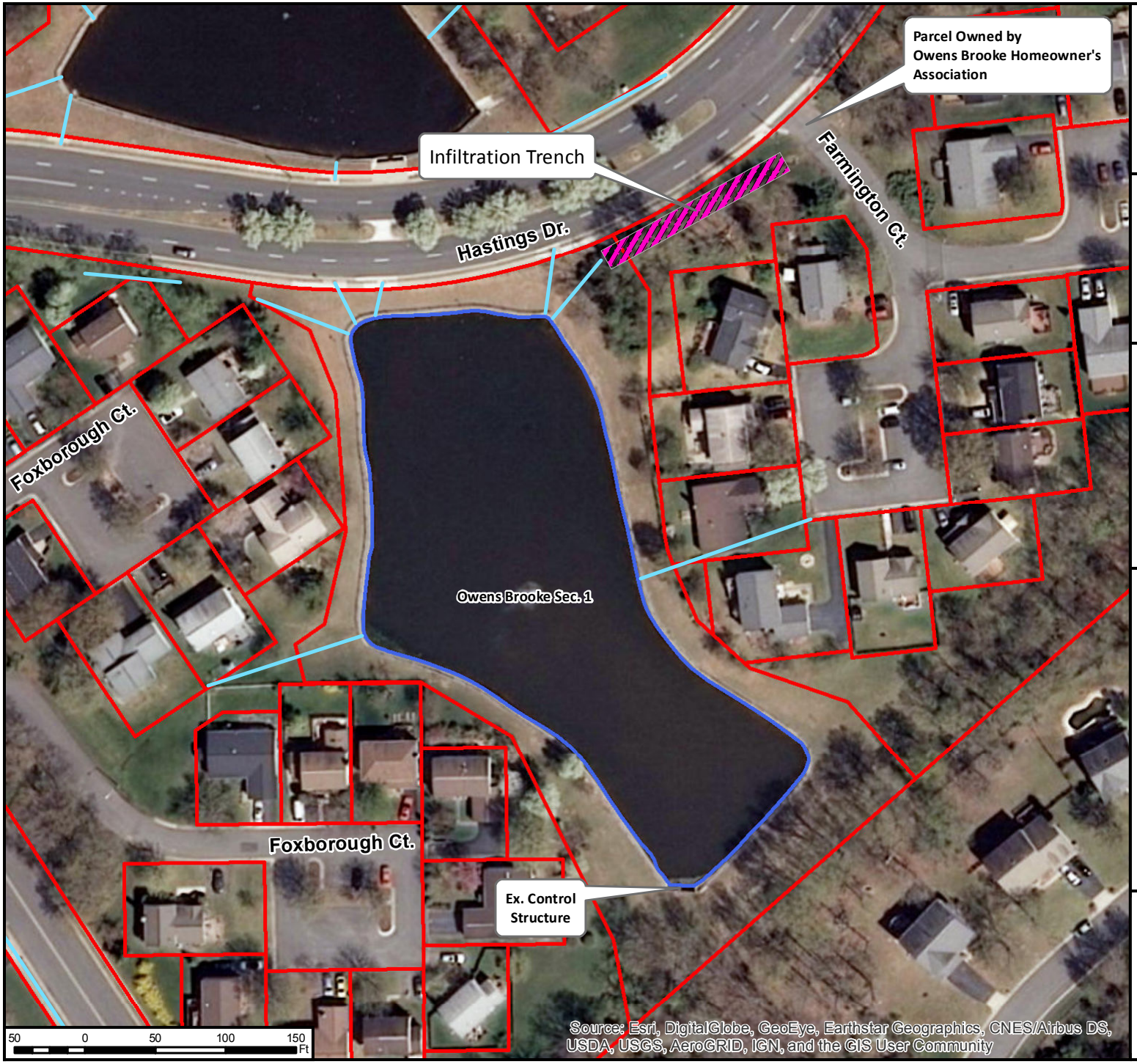
Metz Junior High

Property Address:
9950 Wellington Rd.
Manassas, VA 20110

Property Owner:
The School Board of the City of Manassas

Tax Map ID:
100-01-00-249

Manassas
HISTORIC HEART. MODERN BEAT.



GKY &Associates,inc.

1:1,200

CONCEPTUAL RETROFIT PLAN

Pond # 14

Owens Brooke Sec. 1

Property Address:
10238 Hastings Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
089-10-00-AG1

Manassas
HISTORIC HEART. MODERN BEAT.

GKY &Associates,inc.

1:960

CONCEPTUAL RETROFIT PLAN

Pond # 15

Winterset Sec. 3

Property Address:
10310 Poe Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
090-09-00-B

Manassas
HISTORIC HEART. MODERN BEAT.

GKY &Associates,inc.

1:960

CONCEPTUAL RETROFIT PLAN

Pond # 20

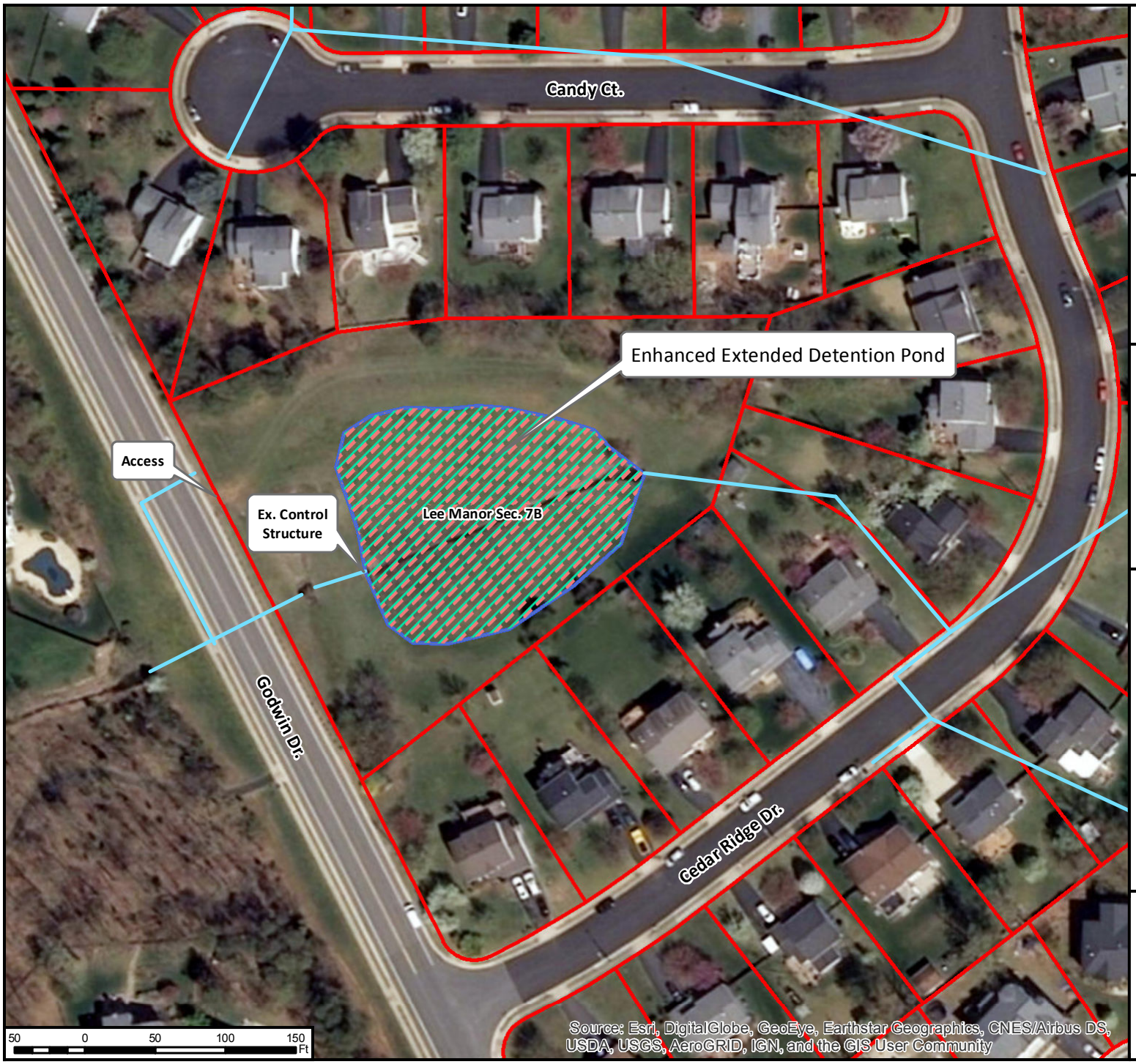
Round Elementary School

Property Address:
10231 Godwin Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
091-01-00-B

Manassas
HISTORIC HEART. MODERN BEAT.



GKY & Associates, inc.

1:1,200

CONCEPTUAL RETROFIT PLAN

Pond # 27

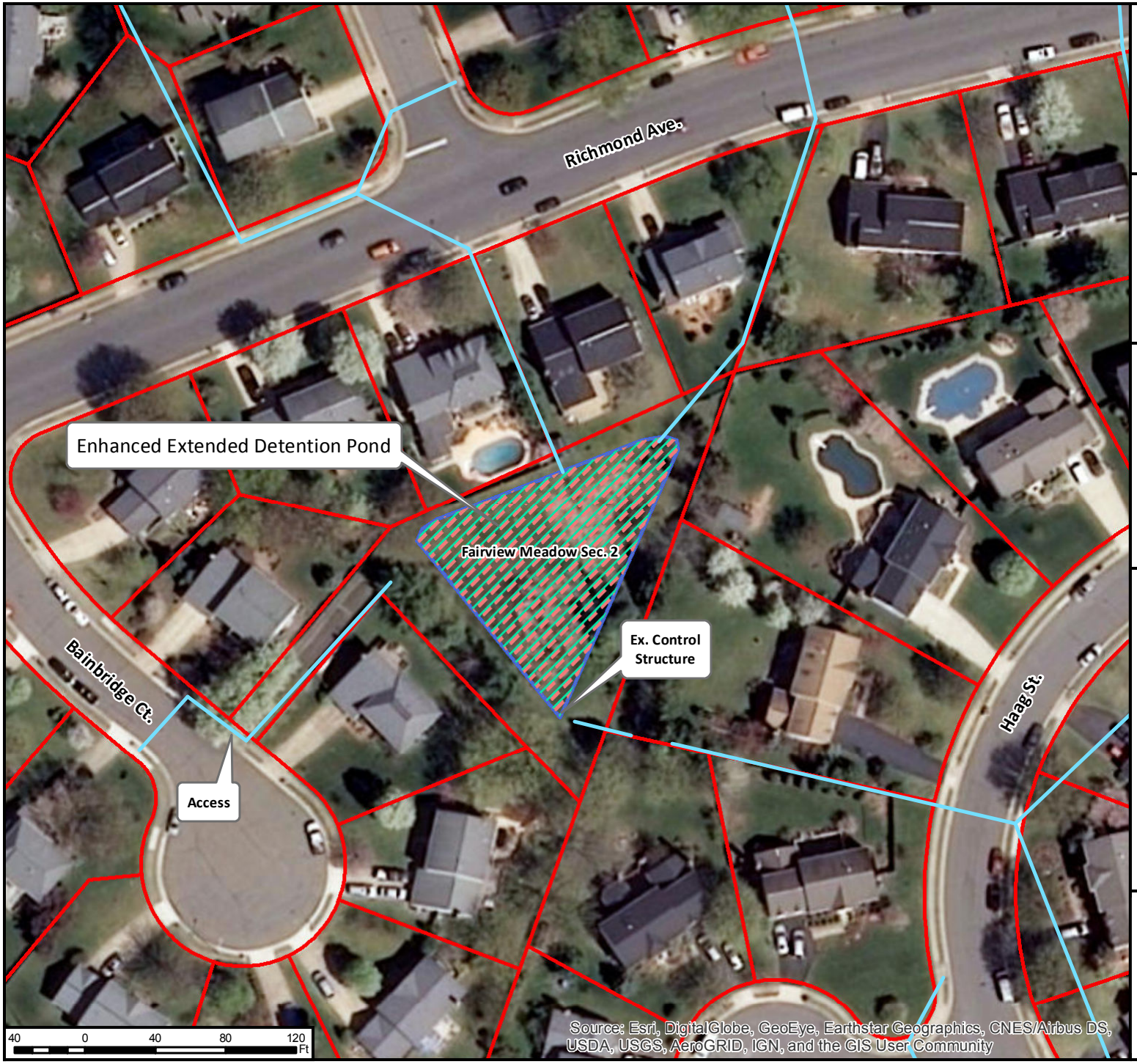
Lee Manor Sec. 7B

Property Address:
10301 Godwin Dr.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
090-12-00-D

Manassas
HISTORIC HEART. MODERN BEAT.



GKY & Associates, inc.

1:960

CONCEPTUAL RETROFIT PLAN

Pond # 33

Fairview Meadow Sec. 2

Property Address:
8625A Bainbridge Ct.
Manassas, VA 20110

Property Owner:
City of
Manassas

Tax Map ID:
100-34-00-B

Manassas
HISTORIC HEART. MODERN BEAT.

Attachment 6

Stream Stability Assessment and Prioritization Plan

STREAM STABILITY ASSESSMENT AND PRIORITIZATION PLAN

DRAFT REPORT

City of Manassas, Virginia

APRIL 20, 2018

PREPARED FOR:
CITY OF MANASSAS
DEPARTMENT OF PUBLIC WORKS
8500 PUBLIC WORKS DRIVE
MANASSAS, VA 20110

PREPARED BY:

RUMMEL, KLEPPER & KAHL
12600 FAIR LAKES CIRCLE, SUITE 300
FAIRFAX, VA 22033

EEE CONSULTING, INC.
8525 BELL CREEK ROAD
MECHANICSVILLE, VA 23116

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APPENDICES

I. EXECUTIVE SUMMARY

RK&K conducted a stream assessment of the stream system within the City of Manassas in the Winter of 2018 to capture the scale and extent of stream bank erosion in two watersheds, Flat Branch and Cannon Branch, as well as develop a prioritization plan for future restoration activities based upon observed conditions.

Background investigation was initiated including a review of past studies focusing on the City's streams and their stability and health. A desktop analysis was conducted using GIS and aerial imagery to evaluate the feasibility of stream restorations throughout the City. Field assessments were then performed on reaches in the study area. During field investigations, the streams in the study area were divided into reaches of similar geomorphic and hydraulic characteristics. A total of 5 reaches resulted with an average length of 3133 LF. Assessments were conducted using the Bank Assessment for Non-Point Source Consequences of Sediment Index (BANCS) method to quantify the stream bank scour potential. Also, visual assessments of stream accessibility, impacted properties and natural resources and nearby utilities were made and documented. The total length of stream assessed was approximately 16,000 linear feet, representing 21% of all streams in the City.

Once all reaches were assessed, BANCS scores were totaled and reach locations were mapped. It was found that over 58% of studied stream reach length had at least a high potential for stream bank degradation.

The results of the BANCS assessment were analyzed along with data on the cost per linear foot, functional uplift potential, and public education opportunity for all the studied reaches. A prioritization analysis was performed using this data producing five reaches of high priority: three from the Cannon Branch watershed and two from the Flat Branch watershed.

Three levels of restoration were assumed for a cost analysis; light, moderate and full. A range of costs were associated with each level of effort. Light restoration involves restoring short reaches of stream using low-cost efforts targeted at protecting nearby properties, resources or utilities. Full restoration includes grading back banks, using in-stream structures to control lateral and vertical migration, and producing comprehensive planting plans. Moderate restoration incorporates aspects of light and full restoration.

II. INTRODUCTION

The City of Manassas (the City) drains to four HUC12 (VAHU6) watersheds: the Broad Run-Rocky Branch (020700100504), Middle Bull Run (020700100703), Lower Bull Run (020700100705), and Occoquan River-Occoquan Reservoir- Lake Jackson (020700100504). These HUCs are divided into five watersheds, and further divided into 23 subwatersheds, with the exception of PL41, which has no stream within the City limits. Inside the City, there are approximately 14 miles of intermittent and perennial stream channels. The total length of stream assessed was approximately 16,000 linear feet, representing 21% of all streams in the City.

This report represents the desktop and field analysis of stream degradation, recommended level of stream restoration, estimate of cost, TMDL potential credit, and suggested prioritization. Assessment methods used to rank streams includes a visual assessment of the stream bed and banks, photographic documentation, Bank Assessment for Non-Point Source Consequences of Sediment Index (BANCS), desktop analysis using GIS and aerial imagery to evaluate the feasibility of potential restoration, and a decision matrix that includes cost, BEHI ranking (stream bank erosion severity), functional uplift potential, and public education opportunity.

III. GOALS

The primary goals of the stream assessment and prioritization report is to assess the current condition of stream bank stability and to prioritize stream reaches for restoration. Prioritization is influenced by the following factors: stream degradation, public/private easements, access, biological and ecological restoration opportunities, aesthetic concerns, TMDL credit potential, cost/benefit assessment, and public education opportunities.

IV. BACKGROUND

The City of Manassas (the City) drains to four HUC12 (VAHU6) watersheds, see Exhibit 1. These HUCs are divided into five watersheds, and further divided into 23 subwatersheds, with the exception of PL41, which contains no stream within the City limits. Inside the City, there are approximately 14 miles of intermittent and perennial stream channels, with Occoquan River serving as the major drainage body. The Russia Branch is a smaller watershed that drains the east portion of the City. The Buckhall Branch watershed is a small watershed that drains the southeast portion of the City. The Broad Run watershed drains a small portion on the southern tip of the City and the Manassas Regional Airport. The Flat Branch watershed drains the entire northwest portion of the City. The Cannon Branch watershed drains the majority of the southwest portion of the City.

The City is located entirely within the Piedmont physiographic region of Virginia. Elevations range from 155 feet above MSL to approximately 320 feet above MSL. The topography throughout the City is generally flat, with a few low, wide ridges and narrow, steep-sided stream valleys. Elevations along the streams comprising the watershed range from 195 to approximately 280 feet above MSL. Most of the soils in this region are well drained hydric soils with moderate permeability and erodability.

The dominant land use is single and multi-family residential, industrial with interspersed commercial development. The overall urbanized nature of the watershed, along with the infringement on floodplain areas, has led to increased stormwater flows into the streams, resulting in widespread instability of stream bed and banks, excessive sediment loading, and degradation of water quality. The location of these streams within the City is shown in Figure 1.

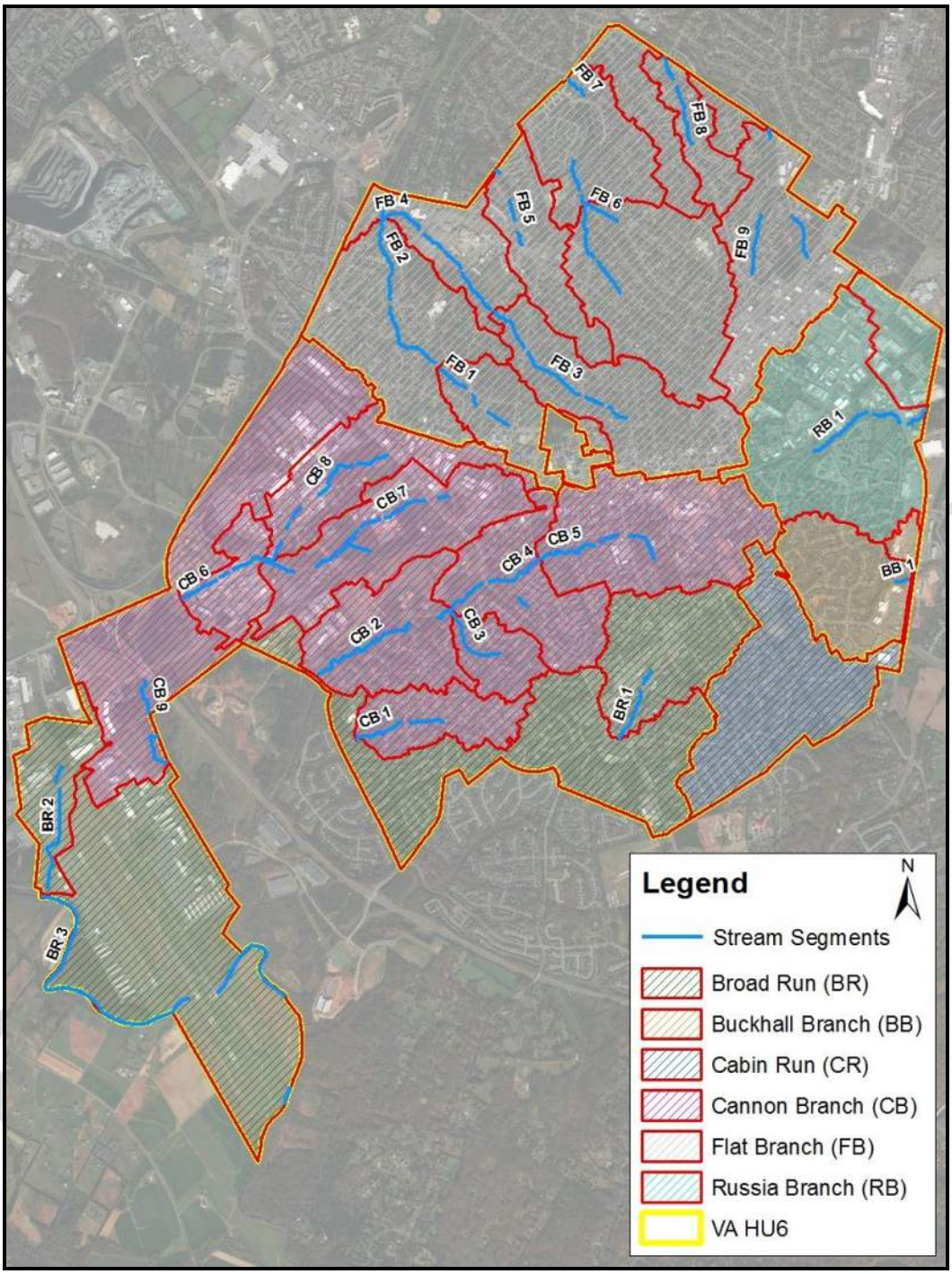


Figure 1: City Watersheds and Streams *(adapted from City of Manassas GIS data layers)*

V. METHODS

An assessment of present and potential erosion in the City stream system was conducted in March 2018. Reaches were identified based on channel features and assessed using visual observations and the BANCS assessment method which includes the following methods: Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS). Detailed methods follow.

V.A. Reach Identification

To describe and assess the stream system, it was necessary to break the streams into reaches. Reach breaks were made based upon changes in channel size and shape, slope, and vegetative patterns. Often, breaks were made at road crossings based on the influence that these crossings have on stream systems. A total of 5 reaches were identified. Average reach length was 3133 LF.

The reaches are identified by their stream name and a numbered segment; "CB" designates the reaches in the Cannon Branch watershed, "FB" designates the reaches in the Flat Branch watershed. "RB" designates the reaches in the Russia Branch watershed, "BB" designates the reaches in the Bucknall Branch watershed, and "BR" designates the reaches in the Broad Run watershed. Cannon Branch and Flat Branch watersheds were the only watersheds assessed at this time. These two watersheds had the highest potential for stream restoration based on the desktop analysis.

V.B. Visual Assessment

Visual assessment and photographic documentation of the stream was conducted to record the current conditions of the stream and to substantiate the BEHI and NBS scores given to a particular reach. Photographs taken along the stream include both upstream and downstream views, bank erosion conditions, riparian vegetation, and the condition of previous restoration efforts. At least two pictures were taken in each reach, with extra pictures denoting areas of significance. Appendix A contains photographs of each reach. Other site-specific features were noted, such as the adequacy of access to the reach, mature tree population, debris in the stream (natural or manmade), direct impacts to property, and nearby utilities that could potentially affect stream restoration opportunities.

V.C. Bank Erosion Hazard Index (BEHI)

Stream channels react to changes in watershed conditions. The changes include land use alterations (increased impervious cover), impacted riparian buffer areas, and increased obstructions to stream flow (i.e., culverts and bridges). The typical reaction process is for the stream channel to lower its channel bottom (if possible) then widen causing banks to erode.

The BEHI is an empirically developed methodology created to quickly assess and predict stream bank erosion potential based upon key features that are associated with bank erosion. Initial observations in the studied watersheds revealed stream banks were severely eroded and composed of predominantly non-cohesive material. Also, many downstream areas were aggrading due to high sediment loads. It was evident that stream bank erosion is a major factor affecting stream stability in the study area, so the BEHI methodology, which focuses specifically on stream bank erosion, was used to provide results that illustrate, quantifiably, the range of bank erosion severity.

This procedure consists of the assessment of several sensitive variables, including ratio of bank height to bankfull height, ratio of root depth to bank height, weighted root density (percent density times the ratio of root depth to bank height), bank angle, surface protection, bank material, and bank stratification. Figure 3 provides a graphical representation of these features and associated values. Each category value has a corresponding index value that standardizes scores to a scale of 5-50+, with 5-9.5 rated as very low, 10-19.5 as low, 20-29.5 as moderate, 30-39.5 as high, 40-45 as very high, and 46-50+ as extreme.

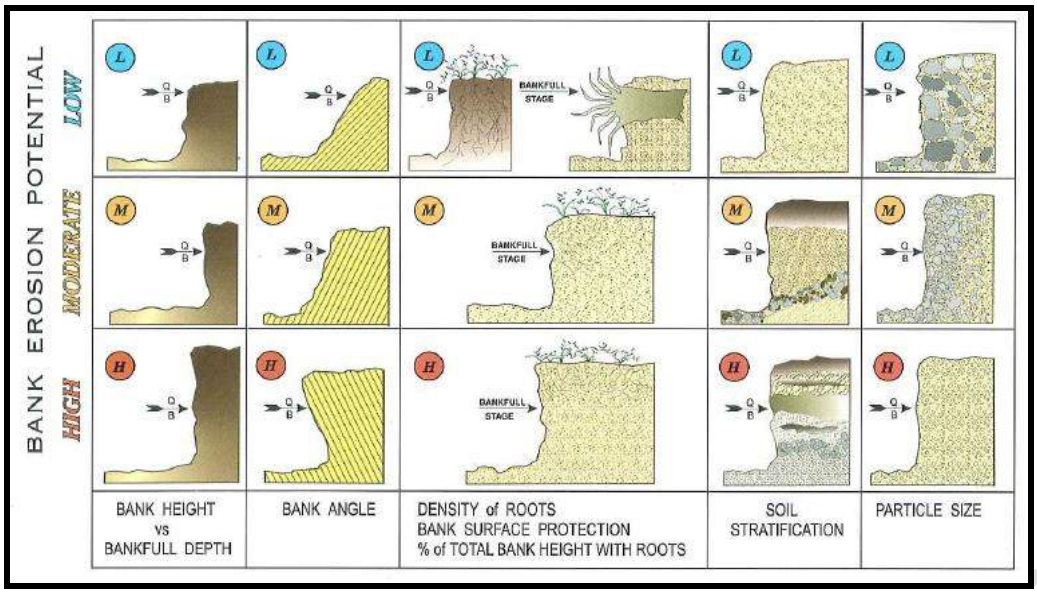


Figure 2: Bank Erosion Potential Factors ***(Rosgen, 1996)***

BEHI assessments were conducted on March 12 to March 13, 2018. The field effort was intended to be quick so that the entire system could be assessed in a short period of time. This allows comprehensive "calibration" so the assessor's scoring is as objective as possible. BEHI scores characterize the reaches rather than using a more in-depth study of individual banks that would be delineated and characterized for more precise erosional rate predictions. This study was intended to be expanded to include more precise assessment once potential restoration reaches were selected. BEHI result mapping and summary table are included in Appendices B and C, respectively.

VI. RESULTS OF ASSESSMENT

VI.A. Bank Erosion Hazard Index

BEHI scores were determined, with results reflecting the initial observations of excessive stream bank erosion. Five reaches (36.5% of the total reaches observed) were found to have low bank erosion potential and two other reaches were found to have moderate potential. The remaining 36 reaches (58.5% of the total reaches observed) have a high or very high bank erosion potential. No reaches were found to have extreme bank erosion potential. A more descriptive measure of the extent of bank erosion in the study area is the amount of total stream length in each category. Table 1 illustrates the distribution of bank erosion severity by stream length.

Table 1: BEHI-rated Stream Reach Lengths

BEHI Rating	***Stream Length (LF)***	***% of Total Stream Length***
Low	4,909	36.5%
Moderate	667	5.0%
High	5,987	44.5%
Very High	1,882	14.0%
Extreme	0	0.0%
	Total = 13,445	

BEHI ratings of very high and extreme are considered critically unstable. Table 1 shows 14% of the stream length assessed in this study falls into this category. This result illustrates that stream bank erosion is a concern for streams in City limits. Even when these systems reach a point of dynamic equilibrium, the rate of lateral

migration may continue to erode stream banks at a high rate. High bank erosion can lead to further downstream sedimentation problems at culverts and bridge crossing. Also, pollutants such as phosphorus, nitrogen and heavy metals may adsorb on to sediment particles that are flushed out to downstream water bodies, namely the Occoquan River and Chesapeake Bay. The distribution of BEHI scores are shown in Figures 3 and 4. Summary sheets of very high and high BEHI ratings are included in Appendix D.

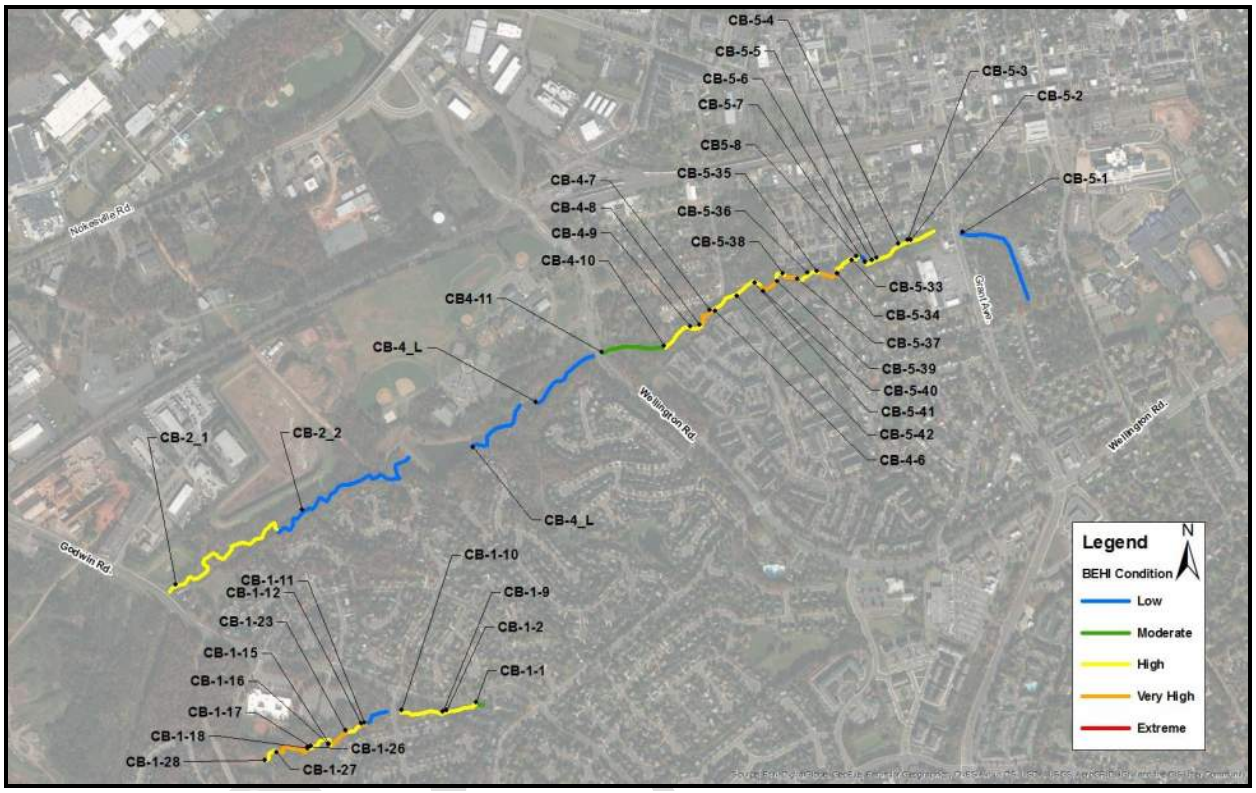


Figure 3: BEHI Score Distribution CB-5, CB-4, CB-2, CB-1

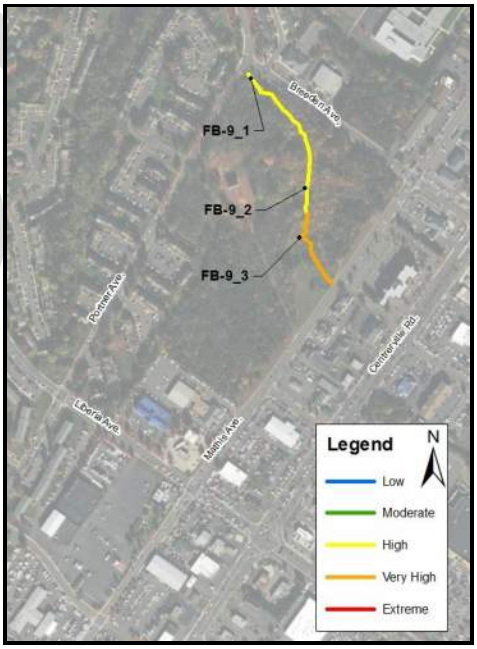


Figure 4: BEHI Score Distribution FB-9

VI.B. Feasibility Inventory

In this study, feasibility is a combination of both ease of access to the stream corridor as well as site specific constraints on construction work, such as utilities near or crossing the stream. Construction access is a key factor when planning stream stabilization or restoration efforts. Having locations with wide and flat areas for proper construction equipment ingress and egress can greatly reduce construction costs. In the same way, a stream corridor that is impinged upon by sanitary sewer crossings and manholes and other utilities is constrictive and difficult to work within. More constraints in, and near, a stream lead to less freedom in design and may limit the space required to adequately construct the appropriate stream stabilization measures.

VI.C. Costs

Costs for design, construction, and permit services were estimated for all reaches. It should be noted these costs are strictly estimates and are time sensitive. These costs were generalized based upon the severity of erosion as well as other site-specific constraints, such as access, that were observed in the field.

For the purposes of this analysis, costs were broken into three ranges based upon the level of restoration required:

- **Full Restoration:** **$1000-$2000 per LF, $1500 average**
- **Moderate Restoration:** **$600-$1000 per LF, $800 average**
- **Light Restoration:** **$200-$600 per LF, $400 average**

Full stream restoration includes activities such as:

- Laying back the stream banks to reduce near-bank shear stress over long, continuous reaches
- Reconnecting the stream to its floodplain
- Installing in-stream structures (cross-vanes, imbricated walls) to control vertical and lateral migration and to stabilize streambanks
- Adjusting plan and profile configuration of stream
- Planting native, non-invasive vegetation to enhance aesthetics and reinforce bank stability
- Installing a regenerative stormwater conveyance system

Moderate Restoration includes many aspects of full restoration; however, this work would be less intensive. Fewer in-stream structures would be used and the extent of laying back banks would be reduced. Also, this work would most likely not include alteration of the plan or profile configuration.

Light Restoration emphasizes vegetative solutions and would focus structural controls in portions of the stream that are directly impacting nearby homeowners or citizens, such as armoring an outside bend of badly eroded stream bank. It should be noted that these are generalized estimates to be used for planning and budgeting purposes only. The distribution of restoration levels are shown in Figures 5 and 6.

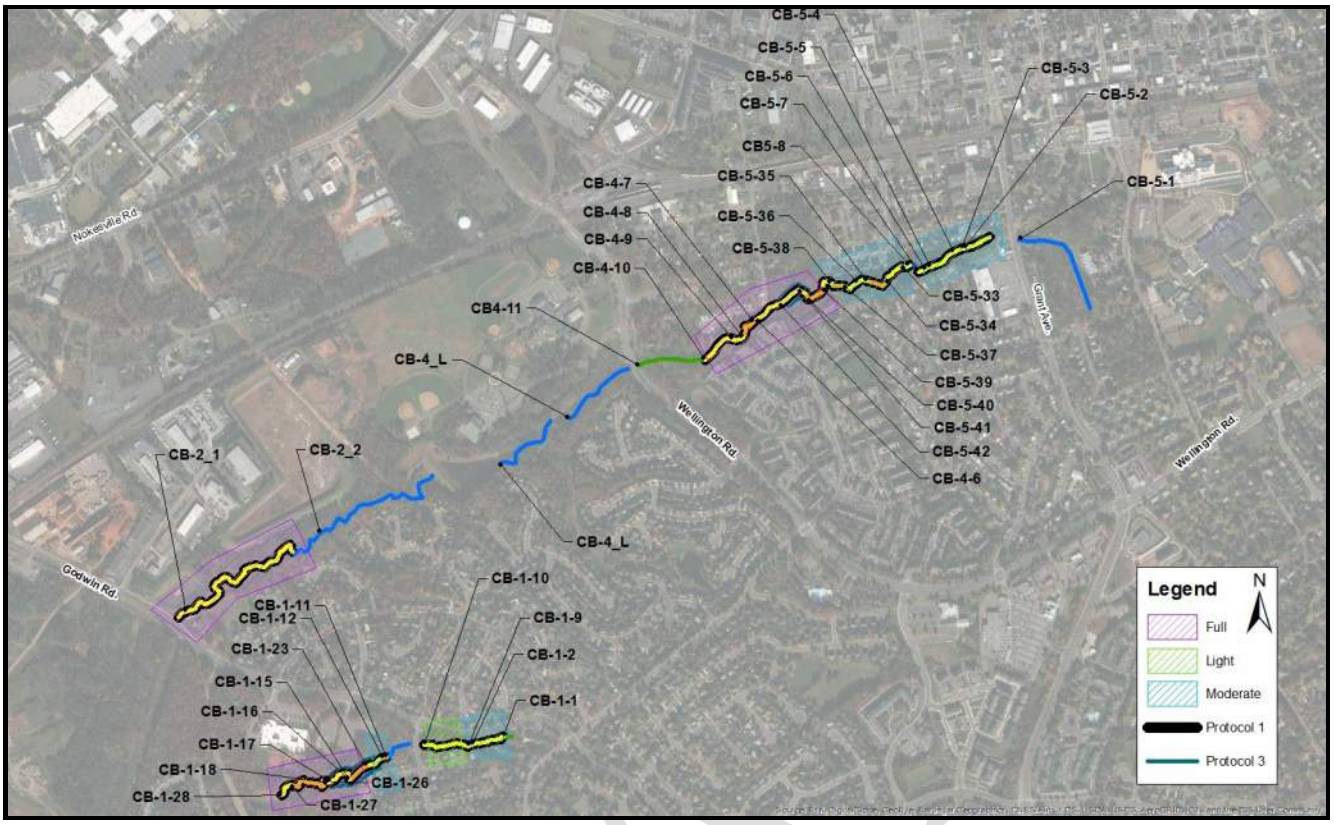


Figure 5: Restoration Efforts CB-5, CB-4, CB-2, CB-1

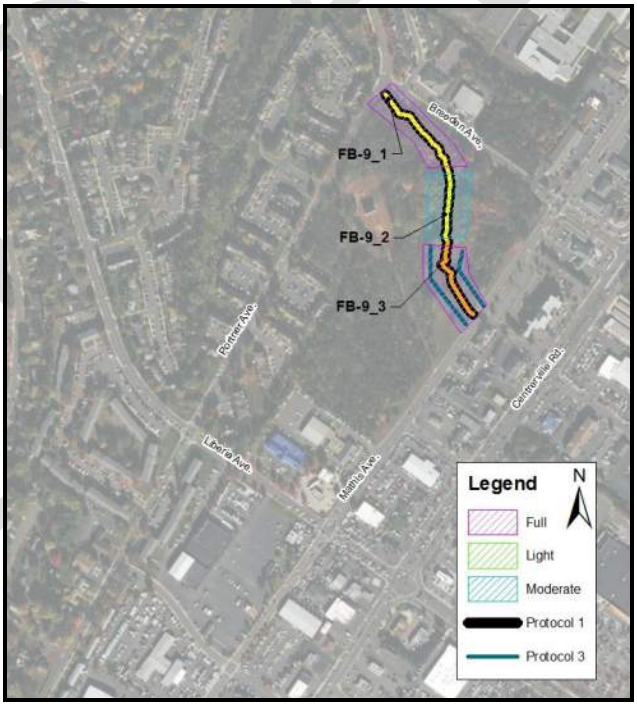


Figure 6: Restoration Efforts FB-9

VII. FUTURE PLAN

VII.A. Prioritization Ranking

Due to the number of severely impacted stream reaches relative to funding that is available to address stream erosion problems in the City, it is necessary to maximize the impact of available funds. The best way to maximize the impact of funding is by developing a priority ranking of stream projects based upon key factors. In this analysis, the key factors are: cost, BEHI ranking (stream bank erosion severity), functional uplift potential, TMDL credit potential, and public education. These factors take several viewpoints into account: objective and scientific (BEHI), practical and constructible (functional uplift), and political (public education). Finding restoration projects that intersect the optimal values for each factor will provide the top priority projects. Ideally, these top priority projects will be streams that are the most severely impacted, are the most feasible, contain great TMDL credit opportunities, have the most opportunity for public education, and are cost effective. In reality, however, projects that are the most impacted require the most restoration effort, and therefore, cost the most. Table 2 shows the key factors in prioritization.

An initial analysis of factors highlights five reaches that have high feasibility and are considered to be critically unstable.

Four reaches (FB-9_3, FB-9_1, CB-1-15, and CB-1-17) should be considered the top priority reaches. We recommend that work performed in FB-9_3 and FB-9_1 (941 LF), include full restoration due to the extensive nature of the impacts on the stream. The accessibility of the project coupled with the Liberia Plantation Master Plan which included stream improvements, the reach could provide an excellent public education opportunity, and the reach is located on publicly-owned land making this area a very good candidate for restoration. We recommend CB-1-15 and CB-1-17 (415LF) include full restoration due to extensive impacts from lateral and vertical instability throughout the stream. The proximity of the restoration areas to George C. Round Elementary School will provide an excellent opportunity to involve the public in the ecological restoration. The stream can transition into light restoration at the stream transitions into the stormwater management area located east of Godwin Drive.

VII.B. Anticipated Restoration Costs

The priority reaches have been identified, but a systematic plan to address each reach is required to determine future budgetary requirements. The goal of this analysis is to maximize the amount of restoration with assumed funding quantities. Cost per pound of phosphorous, nitrogen, and total sediment removed are shown in Table 2.

Table 2: Restoration Prioritization

Watershed	Subwatershed	Segment	Screening Factors (Weight in Percent)										
			Cost per pound of TP removed[1] (40%)	Functional Uplift[2] (40%)	Public education opportunity[3] (5%)	Presence of head cuts, blockages, exposed utilities, or failing outfalls[4] (15%)	Potential Total Phosphorus Credit (lbs P/yr)	Cost per pound of TP removed[5]	Potential Total Nitrogen Credit (lbs N/yr)	Cost per pound of TN removed[5]	Potential Total Sediment Credit (tons/yr)	Cost per pound of TSS removed[5]	**RP Score[6]**
Cannon Branch	CB-5	CB-5-1	1	5	1	1	-	-	-	-	-	-	**2.6**
	CB-5	CB-5-2	5	2	1	3	95.8	$ 1,503.16	208.02	$ 692.24	5.57	$ 25,874.00	**3.3**
	CB-5	CB-5-3	4	2	1	3	3.19	$ 5,274.23	6.92	$ 2,428.92	0.19	$ 90,785.96	**2.9**
	CB-5	CB-5-4	4	2	1	3	11.38	$ 5,274.23	24.7	$ 2,428.92	0.66	$ 90,785.96	**2.9**
	CB-5	CB-5-5	4	2	1	3	39.44	$ 5,274.23	85.63	$ 2,428.92	2.29	$ 90,785.96	**2.9**
	CB-5	CB-5-6	4	2	1	3	7.58	$ 5,274.23	16.47	$ 2,428.92	0.44	$ 90,785.96	**2.9**
	CB-5	CB-5-7	4	2	1	3	9.86	$ 5,274.23	21.41	$ 2,428.92	0.57	$ 90,785.96	**2.9**
	CB-5	CB-5-8	1	2	1	1							**1.4**
	CB-5	CB-5-33	4	2	1	3	11.18	$ 5,010.52	24.27	$ 2,307.48	0.65	$ 86,246.66	**2.9**
	CB-5	CB-5-34	5	2	1	3	132.84	$ 3,131.58	288.45	$ 1,442.17	7.72	$ 53,904.17	**3.3**
	CB-5	CB-5-35	4	2	1	3	38.87	$ 4,342.45	84.41	$ 1,999.81	2.26	$ 74,747.11	**2.9**
	CB-5	CB-5-36	1	2	1	3	3.42	$ 20,355.24	7.42	$ 9,374.12	0.2	$ 350,377.08	**1.7**
	CB-5	CB-5-37	1	2	1	3	6.13	$ 20,355.24	13.31	$ 9,374.12	0.36	$ 350,377.08	**1.7**
	CB-5	CB-5-38	4	2	1	3	22.48	$ 4,342.45	48.8	$ 1,999.81	1.31	$ 74,747.11	**2.9**
	CB-5	CB-5-39	4	2	1	5	21.71	$ 5,010.52	47.15	$ 2,307.48	1.26	$ 86,246.66	**3.2**
	CB-5	CB-5-40	4	2	1	5	43.66	$ 4,342.45	94.81	$ 1,999.81	2.54	$ 74,747.11	**3.2**
	CB-5	CB-5-41	4	4	1	5	10.7	$ 5,010.52	23.23	$ 2,307.48	0.62	$ 86,246.66	**4**
	CB-5	CB-5-42	4	2	1	5	33.53	$ 5,010.52	72.81	$ 2,307.48	1.95	$ 86,246.66	**3.2**
	Upper CB-4	CB-4-6	3	2	3	5	40.03	$ 9,553.96	86.93	$ 4,399.85	2.33	$ 164,453.39	**2.9**
	Upper CB-4	CB-4-7	3	2	3	5	5.34	$ 9,553.96	11.59	$ 4,399.85	0.31	$ 164,453.39	**2.9**
	Upper CB-4	CB-4-8	1	2	3	5							**2.1**
	Upper CB-4	CB-4-9	4	2	3	5	18.63	$ 8,052.62	40.45	$ 3,708.44	1.08	$ 138,610.71	**3.3**
	Upper CB-4	CB-4-10	3	2	3	5	53.06	$ 9,553.96	115.23	$ 4,399.85	3.08	$ 164,453.39	**2.9**
	Upper CB-4	CB-4-11	1	2	3	1							**1.5**
	Lower CB-4	CB-4_L	1	5	3	1	3.57	$ 722,732.65	7.75	$ 332,837.41	0.21	$ 12,440,480.08	**2.7**
	CB-2	CB-2_2	1	2	3	1	4.56	$ 591,326.72	9.9	$ 272,321.51	0.26	$ 10,178,574.61	**1.5**
	CB-2	CB-2_1	3	2	3	3	195.68	$ 11,636.12	424.91	$ 5,358.74	11.37	$ 200,293.95	**2.6**
	CB-1	CB-1-1	1	2	1	1							**1.4**
	CB-1	CB-1-2	4	2	1	3	18.47	$ 5,630.71	40.11	$ 2,593.09	1.07	$ 96,922.01	**2.9**
	CB-1	CB-1-9	1	2	1	3	-	-	-	-	-	-	**1.7**
	CB-1	CB-1-10	3	2	1	1	17.9	$ 9,607.39	38.87	$ 4,424.46	1.04	$ 165,373.17	**2.2**
	CB-1	CB-1-11	1	2	1	1							**1.4**
	CB-1	CB-1-12	5	2	1	3	7.38	$ 3,795.51	16.02	$ 1,747.93	0.43	$ 65,332.61	**3.3**
	CB-1	CB-1-23	3	4	1	3	23.68	$ 9,459.59	51.42	$ 4,356.39	1.38	$ 162,828.97	**3.3**
	CB-1	CB-1-15	4	4	1	5	39.81	$ 6,404.93	86.45	$ 2,949.64	2.31	$ 110,248.78	**4**
	CB-1	CB-1-16	3	2	1	5	5.2	$ 9,237.88	11.28	$ 4,254.29	0.3	$ 159,012.67	**2.8**
	CB-1	CB-1-17	3	4	1	5	34.26	$ 9,237.88	74.4	$ 4,254.29	1.99	$ 159,012.67	**3.6**
	CB-1	CB-1-18	3	2	1	5	5.14	$ 9,049.35	11.16	$ 4,167.46	0.3	$ 155,767.51	**2.8**
	CB-1	CB-1-26	4	2	1	5	9.84	$ 7,624.92	21.36	$ 3,511.47	0.57	$ 131,248.55	**3.2**
	CB-1	CB-1-27	4	2	1	5	78.69	$ 7,624.92	170.87	$ 3,511.47	4.57	$ 131,248.55	**3.2**
	CB-1	CB-1-28	3	2	1	5	22.21	$ 9,049.35	48.23	$ 4,167.46	1.29	$ 155,767.51	**2.8**
Flat Branch	FB-9	FB-9_3	4	4	5	5	118.46	$ 6,407.38	257.22	$ 2,950.77	6.88	$ 110,290.99	**4.2**
	FB-9	FB-9_2	2	2	5	3	16.65	$ 15,467.64	36.16	$ 7,123.26	0.97	$ 266,246.31	**2.3**
	FB-9	FB-9_1	5	2	5	5	177.62	$ 3,673.57	385.69	$ 1,691.77	10.32	$ 63,233.50	**3.8**

[1]Cost of TP removal: >$20,001=1; $15,001-$20,000=2; $9,001-$15,000=3; $4,001-$9,000=4; $0-$4,000=5

[2]Functional Uplift: protocol 1 reccomendation=2; protocol 1 & 3 reccomendation=4; existing concrete channel=5

[3]Public Education Opportunities: no opportunity=1; moderate opportunity=3; high opportunity=5

[4]Number of headcuts or blockages: none=1; few=3; many=5

[5]These values are for reference only. An average cost of $1500/LF was used for full restoration, $800/LF for moderate restoration, and $400/LF for light restoration.

[6]Restoration potential (RP) score for each reach is based on the weighted screening factors. A maximum score of 5 is earned for the most practical reach for restoration.

VIII. SOURCES

City of Manassas. 2018. GIS layers.

Rosgen, D. 1996. Applied River Morphology. Wildlife Hydrology, Pagosa Springs, Co.

APPENDIX A

PHOTOS OF ALL STUDY REACHES

CB-4_A 3/12/2018

CB-4_B 3/12/2018

CB-4_C 3/12/2018

CB-4_D 3/12/2018

CB-4_E 3/12/2018

CB-4_F 3/12/2018

CB-4_G 3/12/2018

CB-4_H 3/12/2018

CB-4_I 3/12/2018

CB-1_U_A 3/12/2018

CB-1_U_B 3/12/2018

CB-1_U_C 3/12/2018

CB-1_U_D 3/12/2018

CB-1_U_E 3/12/2018

CB-1_U_F 3/12/2018

CB-1_U_G 3/12/2018

CB-1_U_H 3/12/2018

CB-1_L_A 3/12/2018

CB-1_L_B 3/12/2018

CB-1_L_C 3/12/2018

CB-1_L_D 3/12/2018

CB-1_L_E 3/12/2018

CB-1_L_F 3/12/2018

CB-1_L_G 3/12/2018

CB-1_L_H 3/12/2018

CB-1_L_I 3/12/2018

CB-1_L_J 3/12/2018

CB-1_L_K 3/12/2018

CB-1_L_L 3/12/2018

CB-1_L_M 3/12/2018

CB-1_L_N 3/12/2018

CB-1_L_O 3/12/2018

CB-1_L_P 3/12/2018

CB-1_L_Q 3/12/2018

CB-1_L_R 3/12/2018

CB-5_A 3/12/2018

CB-5_B 3/12/2018

CB-5_C 3/12/2018

CB-5_D 3/12/2018

CB-5_E 3/12/2018

CB-5_F 3/12/2018

CB-5_G 3/12/2018

CB-5_H 3/12/2018

CB-5_I 3/12/2018

CB-2_1_A 3/13/2018

CB-2_1_B 3/13/2018

CB-2_1_C 3/13/2018

CB-2_1_D 3/13/2018

CB-2_2_A 3/13/2018

CB-2_2_B 3/13/2018

CB-4_L_A 3/13/2018

CB-4_L_B 3/13/2018

CB-4_L_C 3/13/2018

CB-4_L_D 3/13/2018

CB-4_L_E 3/13/2018

CB-4_L_F 3/13/2018

FB-9_A 3/13/2018

FB-9_B 3/13/2018

FB-9_C 3/13/2018

FB-9_D 3/13/2018

FB-9_E 3/13/2018

FB-9_F 3/13/2018

FB-9_G 3/13/2018

FB-9_H 3/13/2018

FB-9_I 3/13/2018

FB-9_J 3/13/2018

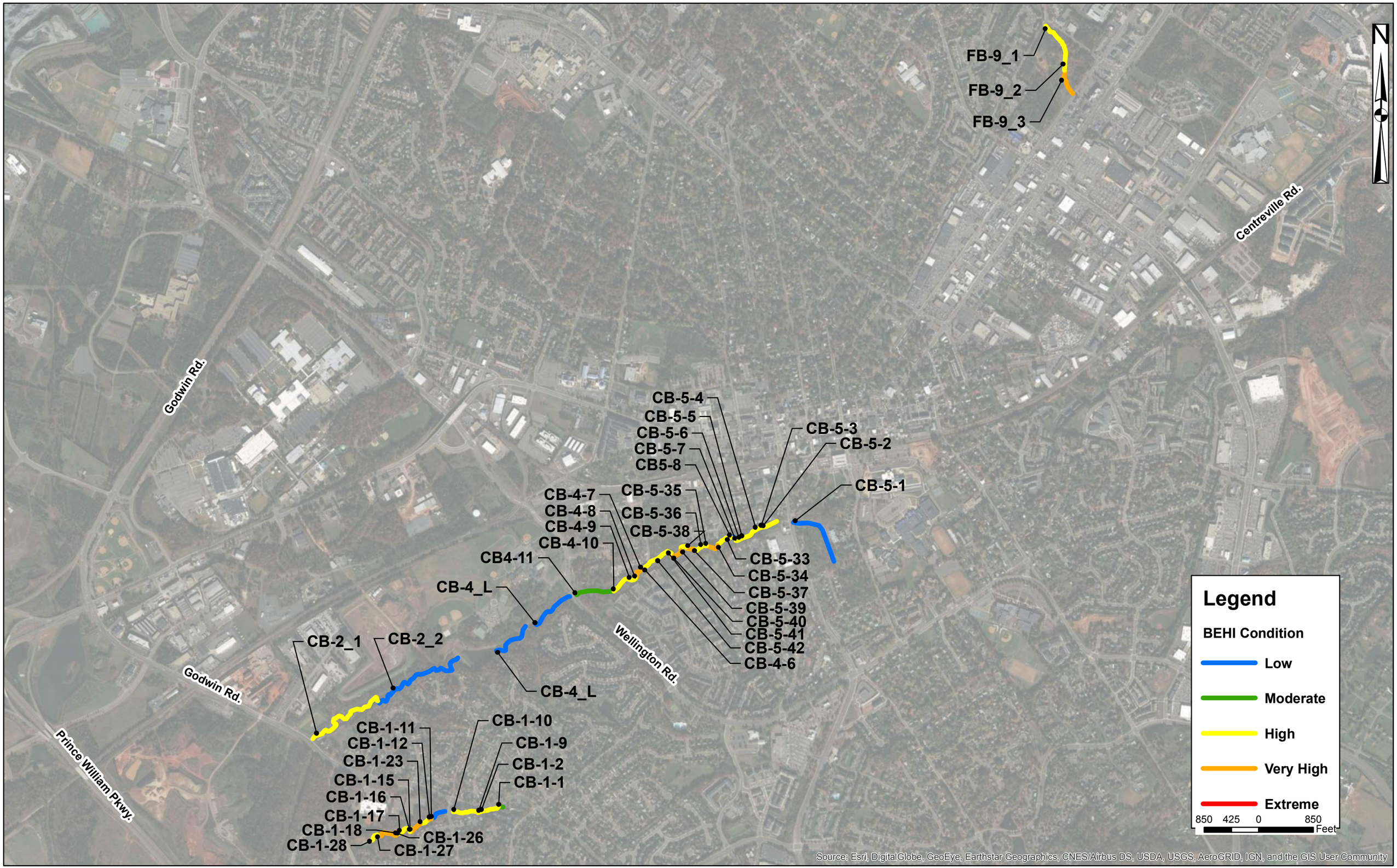
FB-9_K 3/13/2018

FB-9_L 3/13/2018

APPENDIX B

STREAM ASSESSMENT
&
BEHI RESULTS MAPPING

BEHI Score Distribution



APPENDIX C

SUMMARY TABLE OF BEHI SCORING RESULTS

Summary of BEHI Results by Reach

Reach ID	Bank Height/ Bankfull Height	Index	Root Depth/ Bank Height	Index	Weighted Root Density	Index	Bank Angle	Index	Surface Protection	Index	Materials	Stratification	Total	Condition
CB-5-1	1.01	1.0	1.00	1.0	1100	1.0	45	3.2	100	1.0	-	-	7.20	Low
CB-5-2	4	10	0.6	3.4	3	10	70	4.9	35	5.5	-	-	33.8	High
CB-5-3	3.75	10	0.53	3.8	2.67	10	70	4.9	35	5.5	-	-	34.2	High
CB-5-4	2.67	8.8	0.5	3.9	2.5	10	80	5.9	5	10	-	-	38.6	High
CB-5-5	5	10	0.4	4.9	2	10	65	4.4	10	9	-	-	38.3	High
CB-5-6	4.06	10	0.62	3.3	6.15	8.9	85	6.8	60	3.5	-	-	32.5	High
CB-5-7	4.06	10	0.62	3.3	6.1	8.9	85	6.8	60	3.5	-	-	32.5	High
CB-5-8	2.86	10	0.17	7.6	0.83	10	80	5.9	100	1	-20	-	14.5	Low
CB-5-33	5.83	10	0.43	4.6	1.29	10	80	5.9	10	9	-	-	39.5	High
CB-5-34	5.33	10	0.31	5.8	1.56	10	75	5.4	25	6.5	-	-	37.7	High
CB-5-35	2.92	10	0.23	6.8	1.14	10	90	7.9	15	7.9	-	-	42.6	Very High
CB-5-36	5	10	0.17	7.6	1.67	10	75	5.4	100	1	-	-	34	High
CB-5-37	4.17	10	0.8	2.4	8	8.7	80	5.9	30	5.9	-	-	32.9	High
CB-5-38	4.17	10	0.25	6.7	1.2	10	110	8.7	10	9	-	-	44.4	Very High
CB-5-39	5.42	10	0.31	5.8	1.54	10	58	6.8	50	4.3	-	-	37	High
CB-5-40	5	10	0.17	7.6	0.83	10	110	8.7	15	7.9	-	-	44.2	Very High
CB-5-41	3.33	10	0.25	6.5	1.25	10	80	5.9	25	6.5	-	-	39	High
CB-5-42	5.83	10	0.43	4.6	2.14	10	80	5.9	60	3.5	-	-	34	High
CB-4-6	5.83	10	0.43	4.6	2.14	10	80	5.9	60	3.5	-	-	34	High
CB-4-7	4.3	10	0.28	6.1	1.38	10	85	6.8	30	5.9	-	-	38.9	High
CB-4-8	3.46	10	0.18	7.5	0.89	10	80	5.9	20	7.2	-	-	40.6	Very High
CB-4-9	3.46	10	0.44	4.5	4.44	10	90	7.9	70	2.7	-	-	35.1	High
CB-4-10	2.69	8.8	0.23	6.8	2.29	10	90	7.9	60	3.5	-	-	37.1	High
CB-4-11	3.08	10	0.6	3.4	6	8.9	70	4.9	80	1.9	-	-	29.1	Moderate
CB-4_L	1.00	1.0	1.00	1.0	100	1.0	45	3.2	100	1.0	-	-	7.24	Low
CB-2_2	1.01	1.0	1.00	1.0	100	1.0	45	3.2	100	1.0	-	-	7.28	Low
CB-2_1	2.53	8.6	0.28	6.1	10	8.5	45	3.2	15	7.9	-	-	34.29	High
CB-1-1	3.00	10.0	0.00	10.0	0.00	10.0	65	4.4	100	1.0	-10	-	25.40	Moderate
CB-1-2	2.11	8.0	0.33	5.6	1.63	10.0	90	7.9	20	7.2	-	-	38.70	High
CB-1-9	3.13	10.0	0.60	3.4	3.00	10.0	110	8.7	20	7.2	-	-	39.30	High
CB-1-10	2.50	8.0	0.29	6.0	2.89	10.0	90	7.9	40	5.1	-	-	37.60	High
CB-1-11	1.67	6.3	0.40	4.9	4.00	10.0	45	3.2	100	1.0	-10	-	15.40	Low
CB-1-12	3.00	10.0	0.11	8.3	0.56	10.0	40	2.9	10	9.0	-	-	40.30	Very High
CB-1-23	2.00	7.9	0.50	3.9	2.50	10.0	80	5.9	50	4.3	-	-	32.00	High
CB-1-15	3.33	10.0	0.25	6.5	1.25	10.0	115	8.9	25	6.5	-	-	41.90	Very High
CB-1-16	3.33	10.0	0.40	4.9	4.00	10.0	60	3.9	70	2.7	-	-	31.50	High
CB-1-17	3.00	10.0	0.44	4.5	4.44	10.0	70	4.9	40	5.1	-	-	34.50	High
CB-1-18	3.67	10.0	0.15	0.8	1.45	10.0	80	5.9	40	5.1	-	-	31.80	High
CB-1-26	3.33	10	0.1	8.4	1.00	10	110	8.7	20	7.2	-	-	44.3	Very High
CB-1-27	3	10	0.22	7	2.22	10	110	8.7	20	7.2	-	-	42.9	Very High
CB-1-28	3	10	0.22	7	2.22	10	90	7.9	40	5.1	-	-	40	High
FB-9_3	5.00	10.0	0.20	7.2	7	8.8	90	7.9	5	10.0	-	-	43.9	Very High
FB-9_2	2.38	8.4	0.58	3.5	43	4.8	120	10.0	30	5.9	-	-	32.6	High
FB-9_1	3.91	10.0	0.47	4.2	23	6.8	108	8.6	30	5.9	-	-	35.54	High

APPENDIX D

SUMMARY SHEETS
OF
“EXTREME” & “VERY HIGH” BEHI & NBS RATINGS

Site No.:	CB-5-2
Site Score:	BEHI: High, Near Bank Stress: Extreme
Location:	Behind Grant Avenue Shopping Center

Site Description:	Drainage Area ≈ 224 acres ± The reach is between the Grant Avenue Shopping Center and the residences on Douglas Avenue. Sanitary sewer crossing downstream of reach may limit access for construction. Riparian area is comprised of steep banks on southern side of stream and maintained grass areas on the northern side of the stream.
Citizen Concerns:	None known.
Access:	Access is problematic. Residential areas to the north and northwest limit access. Grant Avenue Shopping Center to the south will provide limited access due to planned infrastructure improvements.

Site No.:	CB-5-34
Site Score:	BEHI: High, Near Bank Stress: Extreme
Location:	Behind Bragg Lane

Site Description:	Drainage Area ≈ 301 acres ± The reach is between the residences on Scarlet Oak Drive and Bragg Lane. Sanitary sewer at the midpoint of the reach. Riparian area is predominantly wooded, with a paved walking trail located on the right bank.
Citizen Concerns:	None known.
Access:	Access to the reach could be made at McKinley Avenue and travel along the established walking trail. .

Site No.:	CB-5-40
Site Score:	BEHI: Very High, Near Bank Stress: High/Very High
Location:	Behind China Grove Court

Site Description:	Drainage Area ≈ 314 acres ± The reach is behind the residences on China Grove Court and is bordered to the north by an undeveloped parcel. Riparian area is predominantly wooded, with a paved walking trail located on the right bank.
Citizen Concerns:	None known.
Access:	Access to the reach could be made at McKinley Avenue and travel along the established walking trail. .

Site No.:	CB-4-8
Site Score:	BEHI: Very High, Near Bank Stress: High/Very High
Location:	Between Clover Hill Road and McKinley Ave

Site Description:	Drainage Area ≈ 314 acres ± The reach is behind the residences on Clover Hill Road and McKinley Avenue and the riparian area is predominantly wooded, with a paved walking trail located on the right bank.
Citizen Concerns:	None known.
Access:	Access to the reach could be made at McKinley Avenue and travel along the established walking trail. .

Site No.:	CB-1-15
Site Score:	BEHI: Very High, Near Bank Stress: High/Very High
Location:	Between Cedar Ridge Drive and George C Round Elementary School

Site Description:	Drainage Area ≈ 96 acres ± The reach is behind the residences on Cedar Ridge Road and adjacent to the George C Round Elementary school. The riparian area is predominantly wooded along the northern side of the stream, and abuts maintained lawns on the southern side.
Citizen Concerns:	Local resident indicated that flooding causes debris to be deposited on her property and requires significant maintenance to remove.
Access:	Access to the reach could be made from the George C Round Elementary School. .

Site No.:	CB-1-27
Site Score:	BEHI: Very High, Near Bank Stress: High/Very High
Location:	Between Cedar Ridge Drive, Greenleaf Drive, and George C Round Elementary School

Site Description:	Drainage Area ≈ 109 acres ± The reach is behind the residences on Cedar Ridge Road and adjacent to the George C Round Elementary school. The riparian area is predominantly wooded along both sides of the stream.
Citizen Concerns:	None known.
Access:	Access to the reach could be made from the George C Round Elementary School. .

Site No.:	CB-1-10
Site Score:	BEHI: High, Near Bank Stress: Extreme
Location:	Between Cedar Ridge Drive and Hastings Drive

Site Description:	Drainage Area ≈ 70 acres ± The reach is between the residences on Cedar Ridge Drive and Hastings Drive. The riparian area is a narrow strip of early successional tree species and thick brush.
Citizen Concerns:	None known.
Access:	Limited access due to proximity of houses on Cedar Ridge Drive and the Hastings Drive right-of way. Very narrow drainage. .

Site No.:	CB – 2_1
Site Score:	BEHI: High, NBS: High/Very High
Location:	Dean Park, East of Godwin Road

Site Description:	Watershed Area ≈ 212 acres ± Currently, this segment suffers from incised and eroded banks. The streambanks in this segment are steep and there are exposed tree roots throughout. Bank stabilization has not been completed on this segment of the stream. However, it is believed stabilization, similar to the upstream segments, will be completed in the near future. There are sanitary sewer manholes along the length of the channel.
Citizen Concerns:	None known.
Access:	Access is fair, with availability using pedestrian walkways and entrance along Godwin Road.

Site No.:	FB – 9_3
Site Score:	BEHI: Very High, Near Bank Stress: High/ Very High
Location:	Grounds of Liberia Plantation, West of Mathis Avenue

Site Description:	Watershed Area ≈ 290 acres ± The majority of the streambanks in the upper portion of this reach are incised, eroded, and 10 to 15 feet high. This area was once a municipal dump so there are a lot of debris such as old concrete steps.
Citizen Concerns:	None known.
Access:	Access is fair, with availability at both ends of the reach at Mathis Avenue and Portner Avenue. Access from the west side of the reach is potentially problematic due to steep banks.

Site No.:	FB – 9_2
Site Score:	BEHI: High, NBS: High/Very High
Location:	Grounds of Liberia Plantation

Site Description:	Watershed Area ≈ 290 acres ± The middle portion of the reach suffers from low eroded banks but has connection to its floodplain. There is a historical spring house along a tributary of this segment
Citizen Concerns:	None known.
Access:	Access is fair, with availability at both ends of the reach at Mathis Avenue and Portner Avenue.

Site No.:	FB – 9_1
Site Score:	BEHI: High, NBS: Extreme
Location:	Grounds of Liberia Plantation, East of Portner Avenue

Site Description:	Watershed Area ≈ 290 acres ± The lower portion of this reach suffers from multiple blockages and downed trees. The streambanks are eroded and there are several exposed tree roots throughout the segment. A large amount of debris is located along the streambanks including what looks to be an old foundation.
Citizen Concerns:	None known.
Access:	Access is fair, with availability at both ends of the reach at Mathis Avenue and Portner Avenue. Access from the west side of the reach is potentially problematic due to steep banks.

Attachment 7

Upper Occoquan Service Authority (UOSA) Agreement

Upper Occoquan Service Authority

Leader in Water Reclamation and Reuse

14631 COMPTON ROAD, CENTREVILLE, VIRGINIA 20121-2506
(703) 830-2200

May 17, 2018

VIA ELECTRONIC AND US POSTAL MAIL

Mr. William Patrick Pate
City Manager
City of Manassas
9027 Center Street
Manassas, Virginia 20110

Mr. Bryan J. Hill
County Executive
Fairfax County
12000 Government Center Parkway
Suite 552
Fairfax, Virginia 22035

Mr. Laszlo Palko
City Manager
City of Manassas Park
One Park Center Court
Manassas Park, Virginia 20111

Mr. Christopher Martino
County Executive
County of Prince William
1 County Complex Court
Prince William, Virginia 22192

RE: Executed Water Quality Credit Exchange Agreement

Gentlemen:

Pursuant to previous correspondence, all of the Upper Occoquan Service Authority's (UOSA's) Member Jurisdictions have approved and executed the Water Quality Credit Exchange Agreement, and a fully executed copy is enclosed for your records.

Please feel free to contact me if you have any questions.

Regards,

Charles P. Boepple
Executive Director

Enclosure (1)

cc: UOSA Board of Directors
Sally H. Hostetler, UOSA Legal Counsel

WATER QUALITY CREDIT EXCHANGE AGREEMENT

THIS WATER QUALITY CREDIT EXCHANGE AGREEMENT (this "Credit Agreement") is made this 17th day of May, 2018, by and between the Upper Occoquan Service Authority ("UOSA") and the jurisdictions of the City of Manassas, the City of Manassas Park, Prince William County and Fairfax County, Virginia (each a "Jurisdiction" or "Member Jurisdiction" and jointly the "Jurisdictions" or "Member Jurisdictions").

BACKGROUND

A. **The UOSA Plant.** UOSA owns and operates a wastewater reclamation plant that is authorized to discharge the nutrients, total nitrogen ("TN") and total phosphorus ("TP") as well as sediment as total suspended solids ("TSS") to the Chesapeake Bay watershed. The UOSA Plant has TN, TP and TSS waste load allocations ("WLA") assigned by the State Water Control Board and the Virginia Department of Environmental Quality (jointly, "DEQ") pursuant to the Water Quality Management Planning Regulation, 9 VAC 25-720, and by the U.S. Environmental Protection Agency ("EPA") pursuant to the Chesapeake Bay Total Maximum Daily Load ("TMDL") and related Virginia Watershed Implementation Plan ("WIP").

The UOSA Plant provides wholesale wastewater reclamation services to the Jurisdictions under a "Service Agreement", made as of the 15th day of May, 1972, and restated and amended, by and between UOSA, a public body politic and corporate duly created to the Virginia Water and Waste Authorities Act, and the CITY OF MANASSAS and the CITY OF MANASSAS PARK, municipal corporations of the Commonwealth of Virginia, and the BOARD of SUPERVISORS OF FAIRFAX COUNTY and the BOARD OF COUNTY SUPERVISORS OF PRINCE WILIAM COUNTY, acting for and on behalf of said counties and the sanitary districts thereof, which are located in whole or in part within the Service Area, as defined in the Service Agreement.

The UOSA Plant is subject to the General Virginia Pollutant Discharge Elimination System ("VPDES") Watershed Permit Regulation for TN and TP Discharges and Nutrient Trading in the Chesapeake Bay Watershed in Virginia, 9 VAC 25-820, most recently reissued by DEQ effective January 1, 2017, as hereafter modified or reissued from time to time (the "Watershed General Permit"). UOSA's permit compliance strategy typically results in discharges of TN, TP and TSS that are consistently beneath UOSA's WLA for these parameters. Based on Virginia Statutes, upon the completion of a calendar year, the actual mass of the parameter discharged during the year subtracted from the corresponding WLA is considered a credit that can be traded or transferred to another entity.

B. **The Locality MS4.** The Jurisdictions own and operate separate municipal stormwater sewer systems ("MS4") authorized to discharge TN, TP and TSS to the Chesapeake Bay watershed. Like the UOSA plant, the MS4s are subject to the Chesapeake Bay TMDL as derived from the Virginia WIP and to a VPDES Permit issued to the Jurisdictions by DEQ. Pursuant to the TMDL, WIP and VPDES Permit for the MS4, it is anticipated that the Jurisdictions

will reduce MS4-related TN, TP and TSS discharges pursuant to individually developed and DEQ-approved TMDL Action Plans.

C. **Legal Authority.** Pursuant to Virginia Code § 62.1-44.19:21, the Jurisdictions may acquire and use TN and TP credits for purposes of compliance with the Chesapeake Bay TMDL loading reductions of its MS4 VPDES Permit, including credits generated by the UOSA Plant by discharging less TN or TP than permitted under the Watershed General Permit. Pursuant to Virginia Code § 62.1-44.19:21.1, the Jurisdictions may also acquire and use TSS credits for purposes of compliance with the Chesapeake Bay TMDL loading reductions of its MS4 VPDES Permit, including credits generated by the UOSA Plant by discharging less TSS than allocated under the Chesapeake Bay TMDL. With respect to all three parameters, it is recognized that this authority does not limit or otherwise affect the authority of DEQ to establish and enforce more stringent water quality-based effluent limitations in permits where such limitations are necessary to protect local water quality and, further, that the use of water quality credits does not relieve an MS4 permit holder of any requirement to comply with applicable local water quality-based limitations.

D. **MS4 TMDL Obligations.** The Jurisdictions may determine that utilizing UOSA-generated TN, TP and TSS credits may provide a more cost-effective alternative to the construction of stormwater retrofit projects. This agreement is designed to facilitate UOSA credit availability to the Jurisdictions where appropriate and when available.

E. **UOSA Credit Availability.** This agreement is structured to allow Member Jurisdictions to utilize the actual, historical TN, TP, and TSS credits generated in any given calendar year for MS4 compliance purposes (or for any other purpose permitted by law). **While UOSA typically generates significant credits each calendar year, UOSA cannot guarantee the availability of credits in future calendar years. Individually or in combination weather, biological, mechanical, or electrical events or circumstances can impact the amount and availability of credits. Each Member Jurisdiction shall make its own determination regarding the risk of reliance on the availability of UOSA credits in future years.**

F. **UOSA Transfer Credit Costs.** The Member Jurisdictions currently fund all the costs associated with TN, TP and TSS removal and UOSA will not incur significant additional costs to make TN, TP and TSS credits available to the Member Jurisdictions. Consequently, pursuant to this agreement, and in consideration therefore, these credits will be provided to Member Jurisdictions at no cost.

NOW, THEREFORE, in consideration of the foregoing premises (hereby incorporated as if fully set forth herein), the mutual covenants and conditions herein, and other good and valuable consideration, the receipt and sufficiency of which UOSA and the Jurisdictions acknowledge, the parties hereby agree as follows.

1. **Annual Credit Transfers Feasibility Determination.** Pursuant to the procedures herein, UOSA shall annually notify and transfer to the requesting Jurisdictions their allocated share of available water quality credits to help meet the Jurisdictions' requirements under its DEQ-

Approved Chesapeake Bay TMDL Action Plan for its MS4 (or for any other purpose permitted by law). UOSA shall notify each Jurisdiction of its prior year available credits, based on the allocations as provided in section 1.b, by January 15 of each year. By February 15 of each year, each Jurisdiction will in turn notify UOSA of the amount of its available prior year credits that they plan to utilize for MS4 compliance purposes. The annual transfer shall be made by UOSA's execution and delivery to the Jurisdictions of the Annual Water Quality Credit Transfer Form (Attachment A hereto) on or before April 1 immediately following each calendar year of UOSA's credit generation. The balance of any credits that the Jurisdictions decline to request for MS4 compliance purposes will remain as credits within the Virginia Nutrient Exchange Association with which UOSA participates. Each Jurisdiction electing to have its share of credits remain with the Virginia Nutrient Exchange Association will receive a credit for the Virginia Nutrient Exchange Association end of year valuation for those credits.

a. Credit Transfer Ceilings. UOSA's annual credit transfer obligations to the Jurisdictions shall not exceed the actual available and allocated credits to the Jurisdictions.

b. Allocation of Credits. The Jurisdictions' allocation of UOSA's annual available credits are the same as the flow allocations documented in the Restated and Amended Service Agreement and any subsequent capacity sales agreements. The UOSA annual available credits are determined by taking the difference between UOSA's annual TN, TP and TSS WLAs and its actual discharge mass of TN, TP and TSS for that calendar year.

c. Term & Termination of Initial Credit Transfers. UOSA's annual credit transfer obligations to the Jurisdictions under this Paragraph 1 shall expire upon (i) termination as specifically authorized by any other provision of this Credit Agreement, or (ii) December 31, 2036, whichever occurs first.

2. **Regulatory Plans & Approvals.** Each Jurisdiction shall be responsible for all compliance submissions necessary to DEQ or others for use of the Credit Transfers from UOSA. UOSA shall have no responsibility for the failure or refusal of DEQ or other governmental authority to approve such transfers.

a. Jurisdictions TMDL Action Plan. For purposes of annual transfers, the Jurisdictions shall include in their Chesapeake Bay TMDL Action Plan a provision for the receipt and use of TN, TP and TSS credits from the UOSA Plant (in no more than the amount of Credit Transfers available to that Jurisdiction as calculated herein).

3. **Authorized Use of Credits.** Each Jurisdiction agrees that its sole and limited use of the TN, TP, and TSS credits transferred under this Credit Agreement shall be for the purpose of MS4 Permit compliance and Chesapeake Bay TMDL implementation (or for any other purpose permitted by law) and that it shall not transfer any portion of UOSA-generated credits (or WLA, if applicable) to any other person or entity, except as provided in subparagraph 3.a.

a. Inter-Jurisdictional Trading of Credits. All Jurisdictions may make a portion or all of their annual allocation of available credits available to other Jurisdictions through mutual agreement. This annual transfer shall be made by one Jurisdiction's execution and delivery to the other Jurisdiction of the Annual Water Quality Credit Inter-Jurisdictional Transfer Form (Attachment B hereto) on or before May 20 immediately following each calendar year of UOSA's credit generation. Notification of all Inter-Jurisdictional trading of credits shall be made to UOSA at the same time.

4. **Permits & Approvals.** If for any reason any federal, state, regional or local government or agency fails to issue any necessary permit, approval or other authorization for the transfers contemplated by this Credit Agreement, UOSA shall be excused from its performance hereunder.

5. **Change in Law.** In the event of any change in applicable laws or regulations, by which UOSA is unable to perform its transfer obligations as provided herein, each Jurisdiction shall be solely responsible for otherwise meeting its TMDL and MS4 Permit obligations.

6. **Credit Supply Constraints.** UOSA makes no representation regarding the sufficiency of credits to satisfy each Jurisdiction's MS4 compliance obligations or the amount of credits that may be available for transfer to each Jurisdiction. UOSA's obligations hereunder shall be limited to transferring to each Jurisdiction its allocated share of UOSA's available credits. UOSA assumes no obligation under this Credit Agreement to install, upgrade, improve, or alter the operation of any portion of its sewerage system or treatment works for purposes of providing water quality credits (or allocations).

7. **No Third-Party Beneficiaries.** This Credit Agreement is solely for the benefit of the Jurisdictions hereto and their permitted successors and assigns and shall not confer any rights or benefits on any other person or entity.

8. **No Assignment.** No Jurisdiction may transfer or assign this Credit Agreement, or its rights or obligations hereunder, without the prior written consent of UOSA.

9. **Member Jurisdictions right of first refusal to transfer of credits to non-Member Jurisdiction entities.** Notwithstanding anything else in this agreement to the contrary, a Member Jurisdiction may request UOSA to transfer that Member Jurisdiction's credits (as identified in paragraph 1) to another appropriate entity within the same tributary (as that term is defined in the statute permitting the transfer). In such event, as a prerequisite to that transfer, the non-requesting Member Jurisdictions shall have the right to receive the requesting Jurisdiction's credits on the same terms as offered to the non-Member Jurisdiction entity. In the event no Member Jurisdiction elects to receive the requesting Jurisdiction's credits, *and* the receiving appropriate entity executes an agreement substantially similar to this agreement (with the entity substituted for Member Jurisdictions) affirming that neither the requesting Jurisdiction nor UOSA has any ongoing responsibility related to the credit transfer, UOSA shall then transfer the requesting Jurisdiction's credits to another appropriate entity.

10. **Expenses; Commissions.** Except as provided herein, each Jurisdiction shall pay its own fees and expenses, including its own counsel fees, incurred in connection with this Credit Agreement or any transaction contemplated hereby. The Jurisdictions represent and warrant to each other that they have not dealt with any business broker or agent who would be entitled to a brokerage commission or finders fee as a result of this Credit Agreement or any related transactions.

11. **Governing Law; Venue; Severability.** This Credit Agreement shall be construed in accordance with and governed for all purposes by the laws of the Commonwealth of Virginia. This Credit Agreement is a Virginia contract deemed executed and accepted in Fairfax County; and all questions with respect to any of its provisions shall be instituted, maintained, and contested in a court of competent jurisdiction in Fairfax County, Virginia. If any word or provision of this Credit Agreement as applied to UOSA or any Jurisdiction or to any circumstance is adjudged by a court to be invalid or unenforceable, the same shall in no way affect any other circumstance or the validity or enforceability of any other word or provision.

12. **Termination.** UOSA may terminate this Credit Agreement at any time for any reason by giving Ninety (90) days notice to the Jurisdictions. Any Jurisdiction that chooses not to participate in the Credit Transfers set forth herein, shall so advise UOSA in writing prior to February 15 as set forth in Paragraph 1.

13. **Entire Credit Agreement; Amendments.** This Credit Agreement contains the entire agreement between the Jurisdictions as to the subject matter hereof and supersedes all previous written and oral negotiations, commitments, proposals and writings. No amendments may be made to this Credit Agreement except by a writing signed by all Jurisdictions.

14. **Counterparts; Signatures; Copies.** This Credit Agreement may be executed in counterparts, both of which shall be deemed an original, but all of which together shall constitute one and the same instrument. A facsimile or scanned signature may substitute for and have the same legal effect as an original signature. Any copy of this executed Credit Agreement made by photocopy, facsimile or scanner shall be considered the original for all purposes.

15. **Authorization.** Each Jurisdiction represents that its execution, delivery and performance under this Credit Agreement have been duly authorized by all necessary action on its behalf, and do not and will not violate any provision of its charter or enabling legislation or result in a material breach of or constitute a material default under any agreement, indenture, or instrument of which it is a Jurisdiction or by which it or its properties may be bound or affected.

IN WITNESS WHEREOF, the Jurisdictions hereto have caused the execution of this

Credit Agreement as of the date first written above.

[SIGNATURES BEGIN ON NEXT PAGE]

SIGNATURE PAGE OF

UPPER OCCOQUAN SERVICE AUTHORITY

WATER QUALITY CREDIT EXCHANGE AGREEMENT BY AND BETWEEN

UOSA AND THE JURISDICTIONS

UPPER OCCOQUAN SERVICE AUTHORITY

By: Charles P. Boepple

Charles P. Boepple

Executive Director

SIGNATURE PAGE OF

UPPER OCCOQUAN SERVICE AUTHORITY

WATER QUALITY CREDIT EXCHANGE AGREEMENT BY AND BETWEEN

UOSA AND THE JURISDICTIONS

CITY OF MANASSAS, VIRGINIA

By: _____

William Patrick Pate

City Manager

ATTEST:

Andrea P. Madden

City Clerk

APPROVED AS TO FORM:

J. Craig Brown

~~County~~ City Attorney

SIGNATURE PAGE OF

UPPER OCCOQUAN SERVICE AUTHORITY

WATER QUALITY CREDIT EXCHANGE AGREEMENT BY AND BETWEEN

UOSA AND THE JURISDICTIONS

CITY OF MANASSAS PARK, VIRGINIA

By: _____

Laszlo Palko

City Manager

ATTEST:

_____

City Clerk

APPROVED AS TO FORM:

_____

City Attorney

Exhibit A

SIGNATURE PAGE OF

UPPER OCCOQUAN SERVICE AUTHORITY

WATER QUALITY CREDIT EXCHANGE AGREEMENT BY AND BETWEEN

UOSA AND THE JURISDICTIONS

PRINCE WILLIAM COUNTY, VIRGINIA

By: _____

Christopher E. Martino

County Executive

TB
MTA

ATTEST:

_____

County Clerk

APPROVED AS TO FORM:

_____

County Attorney

SIGNATURE PAGE OF

UPPER OCCOQUAN SERVICE AUTHORITY

WATER QUALITY CREDIT EXCHANGE AGREEMENT BY AND BETWEEN

UOSA AND THE JURISDICTIONS

FAIRFAX COUNTY VIRGINIA

By: _____

Bryan J. Hill

County Executive

ATTEST:

_____

County Clerk

APPROVED AS TO FORM:

_____

County Attorney

UPPER OCCOQUAN SERVICE AUTHORITY

WATER QUALITY CREDIT EXCHANGE AGREEMENT

ATTACHMENT A

Annual Water Quality Credit Transfer Form

Instructions: To be completed and executed by UOSA and delivered to Jurisdictions of this Agreement on or before each April 1 immediately following the calendar year of credit generation by UOSA

By execution and delivery of this Annual Credit Transfer Form, UOSA transfers the following water quality credits in the amounts specified to the Jurisdiction in accordance with, and for the specific and limited purposes of, the Upper Occoquan Service Authority Water Quality Credit Exchange Agreement.

Transferor: **Upper Occoquan Service Authority**

Transferee (MS4): See Below

Calendar Year Credits Generated: _____

Date Credits Transfer: _____

MS4	TN (lbs/yr)	TP (lbs/yr)	TSS (lbs/yr)
City of Manassas			
City of Manassas Park			
Prince William County			
Fairfax County			

Signed (for Transferor): _____

Name (Print): _____

Title: _____

UPPER OCCOQUAN SERVICE AUTHORITY

WATER QUALITY CREDIT EXCHANGE AGREEMENT

ATTACHMENT B

Annual Water Quality Credit Inter Jurisdictional Transfer Form

Instructions: To be completed and executed by one Jurisdiction of the Service Agreement and delivered to another Jurisdiction of the Agreement on or before each May 20 immediately following the calendar year of credit generation by UOSA

By execution and delivery of this Annual Credit Transfer Form, the transferor Jurisdiction transfers the following water quality credits in the amounts specified to the transferee Jurisdiction in accordance with, and for the specific and limited purposes of, the Upper Occoquan Service Authority Water Quality Credit Exchange Agreement.

Transferor: _____

Transferee (MS4): _____

Calendar Year Credits Generated: _____

Date Credits Transfer: _____

TN (lbs/yr)	TP (lbs/yr)	TSS (lbs/yr)

Signed (for Transferor): _____

Name (Print): _____

Title: _____