CITY OF VIRGINIA BEACH

Local Bacteria Total Maximum Daily Load Action Plan

STORMWATER MANAGEMENT

Public Works Department
VSMP MS4 Permit # VA0088676

July 2025

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Acronyms and Abbreviations

Ac	acre(s)
Action Plan	Bacteria Total Maximum Daily Load Action Plan
AOI	area of interest
BMP	best management practice
BU	beneficial use
Cfu	colony forming unit(s)
CIP	capital improvement program
City	City of Virginia Beach
D	day(s)
DEQ	(Virginia) Department of Environmental Quality
DSS	Division of Shellfish Sanitation
DWS	dry weather screening
EPA	(U.S.) Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
FIB	fecal indicator bacteria
FOG	fats, oils, and grease
GIS	geographic information system
HF183	human marker which is a good indicator of sanitary sewage contamination
HRSD	Hampton Roads Sanitation District
HWSI	human waste source investigation
IDDE	illicit discharge detection and elimination
LA	load allocation
LU	land use
MF	membrane filter
mL	milliliter(s)
MPN	most probable number
MS4	municipal separate storm sewer system
N/A	not applicable
PCR	polymerase chain reaction
RM	river mile
RW	receiving water
SR	state route
SSES	sewer system evaluation study
SSO	sanitary sewer overflow
SWMF	stormwater management facility
TMDL	total maximum daily load
VDH	Virginia Department of Health
VDOT	Virginia Department of Transportation
VPDES	Virginia Pollutant Discharge Elimination System
WLA	wasteload allocation
Yr	year(s)

1. Introduction

Figure 1-1. Recreation in and on the water relies on maintaining good conditions in local waterways.

Keeping the waterways of Virginia Beach clean and healthy is important to those who live, work, and play in our community (**Figure 1-1**). The City of Virginia Beach (City) encompasses approximately 196,500 acres (ac) or 300 square miles in coastal Virginia. It is bordered by the cities of Norfolk and Chesapeake to the west, Chesapeake Bay to the north, the Atlantic Ocean to the east, and Currituck County, North Carolina, to the south. There are three primary watersheds in the City, including the Chesapeake Bay, Southern Rivers, and Atlantic Ocean watersheds. The northern portion of the City drains to the Chesapeake Bay, the eastern portion drains to the Atlantic Ocean, and the southern portion drains to the Southern Rivers. The City boundaries, as well as the primary watersheds, are shown in **Figure 1-2**. The City has more than 550 miles of streams within these three watersheds.

The Virginia Department of Environmental Quality (DEQ) is responsible for monitoring waterways to maintain beneficial uses (e.g., recreation, fishing/shellfish harvesting, drinking) in accordance with state water quality standards. When waterways do not meet these standards, they are designated as impaired. DEQ develops total maximum daily loads (TMDLs) in response to impairments identified for waterbodies. During development of a TMDL report, the entire drainage area to the impaired waterbody is evaluated to determine the maximum loading that it can receive while still meeting water quality standards. All entities contributing to the impairment are assigned load allocations (LAs) or wasteload allocations (WLAs) depending upon entity type. If a municipal separate storm sewer system (MS4) permittee is in the drainage basin, they are assigned a WLA, as are other point sources such as wastewater treatment plants. LAs are provided for nonpoint sources of pollution (e.g., agriculture). The processes and procedures used to develop the LAs and WLAs are documented in the report for each TMDL.

DEQ authorizes the discharge of stormwater from the City's drainage system to waterways via its Phase I MS4 permit (permit #VA0088676). This permit regulates discharge of stormwater runoff from residential, commercial, and industrial areas in the designated MS4 area and all City-maintained roadways (referred to as the MS4 service area). The City's MS4 permit was re-issued by DEQ on January 26, 2024 and includes provisions for addressing pollution in waterways where bacteria TMDLs have been established.

The MS4 permit requires the City to develop and maintain a TMDL Action Plan designed to reduce pollutant loadings for each WLA that the City MS4 has been assigned. This 2025 Action Plan updates the City's 2018 Bacteria TMDL Action Plan and identifies strategies the City will employ to reduce bacteria loadings in stormwater runoff for the affected waterbodies. The City has developed this Bacteria TMDL Action Plan to address bacteria impairments in eleven watersheds (see **Section 2**) in accordance with the assigned WLAs described in the MS4 Permit and individual TMDL reports.

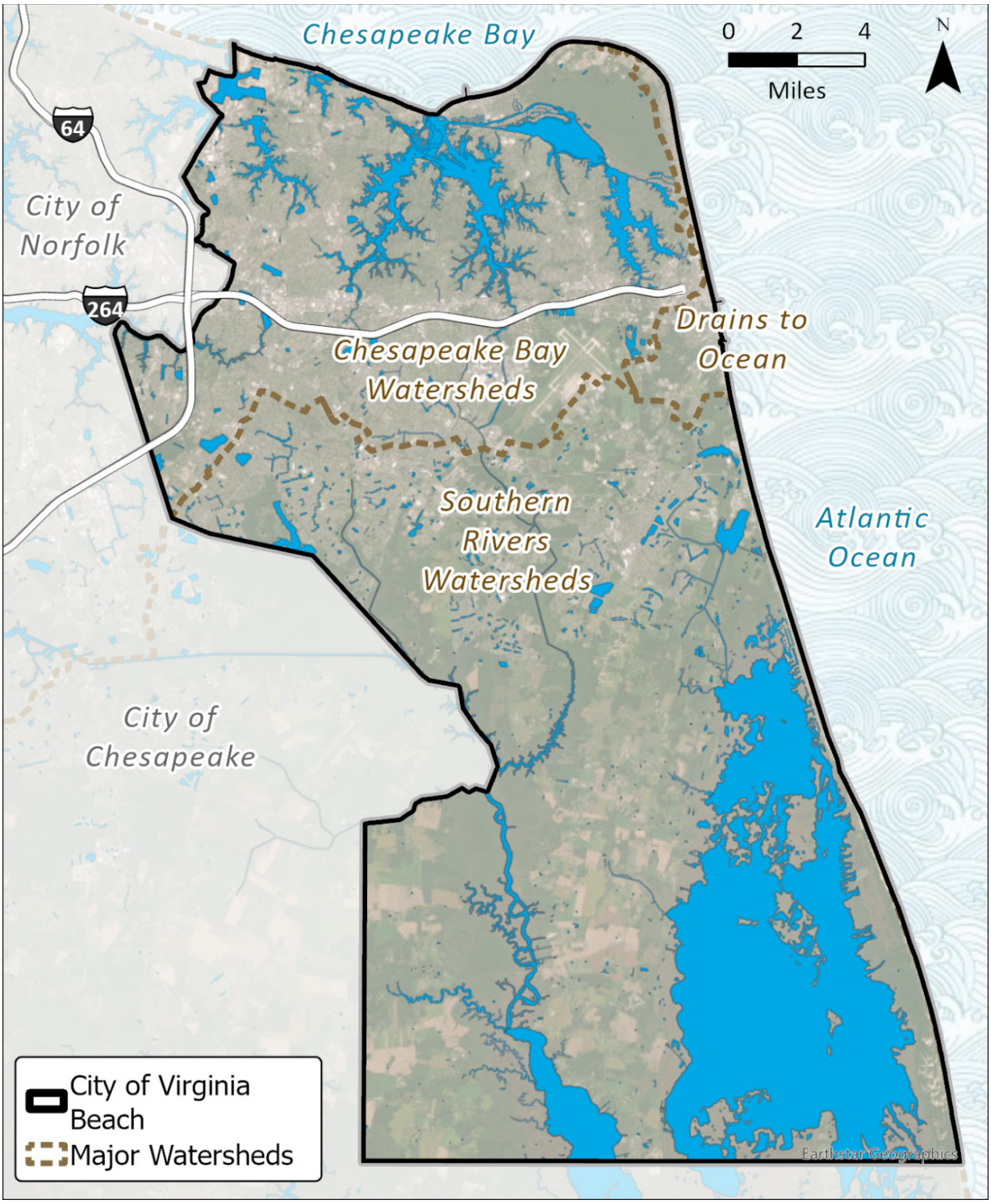

Figure 1-2. City boundaries and primary watersheds

The permit identifies specific requirements for the City as well as elements that must be addressed in the Action Plan, including the following:

- Include TMDL name and EPA-approval date, WLA and percent reduction, and identification of potential significant sources not covered under a separate discharge permit,
- Identify BMPs designed to reduce the pollutants including an outreach strategy and schedule of anticipated actions planned for implementation during the current permit term,
- Implement at least six strategies listed in Table 3 of the permit to reduce bacteria load to the MS4,
- Provide opportunity for public comment prior to submittal (Appendix C). Comment period shall be no fewer than 15 days,
- In each annual report, include summary of actions conducted to implement local TMDL action plans.

Other elements of the City's MS4 permit that relate to reducing pollutants, including bacteria, include the following:

- Maintain roads and parking lots to minimize the discharge of pollutants. This includes implementing a street cleaning program,
- Implement program to locate and eliminate illicit discharges and improper disposal into the MS4,
- Coordinate implementation of a program to prevent, contain, and respond to spills that might discharge to the MS4,
- Implement programs to maintain stormwater infrastructure, including maintenance and inspection of stormwater management facilities (SWMFs),
- Continue implementation of public education and outreach, including the promotion of the proper disposal of pet waste,
- Continue program to detect illicit connections and unauthorized discharges to the MS4.

Virginia Beach's previous Bacteria TMDL Action Plan was prepared by the City based on DEQ *Guidance Memo No. GM 16 2006,* (*TMDL Action Planning for Local Total Maximum Daily Loads as Required in the Small MS4 General Permit (VAR04) Effective July 1, 2013 and MS4 Individual Permits)* and was approved by DEQ in 2018. The 2018 Action Plan includes additional items from the DEQ guidance referenced in this action plan but not included in detail. These items can be found in greater detail in the 2018 Bacteria TMDL Action Plan located on the City's stormwater management website at virginiabeach.gov/stormwater-program. These additional items include, but are not limited to:

- Legal authority that is needed to meet the required reductions, and
- Assessment of significant sources from City facilities.

The City's legal authority to control discharges to and from the MS4 is detailed in the City's MS4 Program Plan, which is available online and is updated regularly. This description of legal authority includes the specific City ordinances related to MS4 compliance.

This Action Plan describes the bacteria sources, TMDL development approaches, and WLAs described in five TMDL reports for watersheds in the City of Virginia Beach as well as structural and non-structural strategies the City will undertake to reduce bacteria loadings to the TMDL watersheds from its MS4 service area, and methods to assess program implementation.

2. Pollutant Reductions Required

This section outlines the five TMDL reports previously prepared by DEQ for bacteria-impaired waterways within the City, water quality standards used in the development of pollutant loads and budgets for the City, potential bacteria sources within the City, and WLAs for the City MS4 as presented in the TMDL reports.

Figure 2-1. Healthy waters support local seafood

Water quality standards are maximum pollution targets set based on waterbody type and the intended use of the waterbody (beneficial use). When waterbodies are meeting certain water quality targets, they are considered healthy and supportive of beneficial uses. Depending on the waterbody, waters in the City must support recreational uses (swimming and boating), the growth of aquatic life, wildlife, and the production of fish and shellfish safe for human consumption (**Figure 2-1**).

Water quality standards specific to this Bacteria Action Plan are described in the TMDL reports issued by DEQ and are summarized in Section 2.1 of the 2018 Bacteria TMDL Action Plan.

DEQ developed five TMDL reports addressing bacteria impairments in the City based on applicable water quality standards, which have been approved by the United States Environmental Protection Agency (EPA). These TMDLs outline bacteria sources, existing loads, and load allocations and reductions required to maintain beneficial uses in each waterbody. Bacteria WLAs were assigned to the City MS4 in the following TMDLs and are the basis of this Action Plan:

1. *Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments*, approved by EPA 6/26/2014
2. *Development of Bacterial TMDLs for the Virginia Beach Coastal Area (London Bridge Creek & Canal #2, Milldam Creek, Nawney Creek, West Neck Creek (Middle), and West Neck Creek (Upper))*, approved by EPA 9/27/2005
3. *Lynnhaven Bay, Broad Bay and Linkhorn Bay Watersheds Total Maximum Daily Load (TMDL) Report for Shellfish Areas Listed Due to Bacteria Contamination*, approved by EPA 8/5/2004
4. *Bacteria Total Maximum Daily Load (TMDL) Development for the Elizabeth River Watershed*, approved by EPA 7/20/2010
5. *Total Maximum Daily Load for Bacteria and a Proactive Implementation Approach for Dissolved Oxygen Impairment for Rudee Inlet, Virginia Beach, Virginia*, approved by EPA 2/14/2019

The TMDL reports listed above assign City MS4 WLAs for eleven watersheds in the City (**Figure 2-2**):

- Ashville Bridge Creek and Muddy Creek
- Beggars Bridge Creek
- Broad Bay and Linkhorn Bay
- Elizabeth River
- Hell Point Creek, Upper and Lower
- London Bridge Creek and Canal #2
- Lynnhaven Bay
- North Landing River

- Pocaty River
- Rudee Inlet
- West Neck Creek, Upper

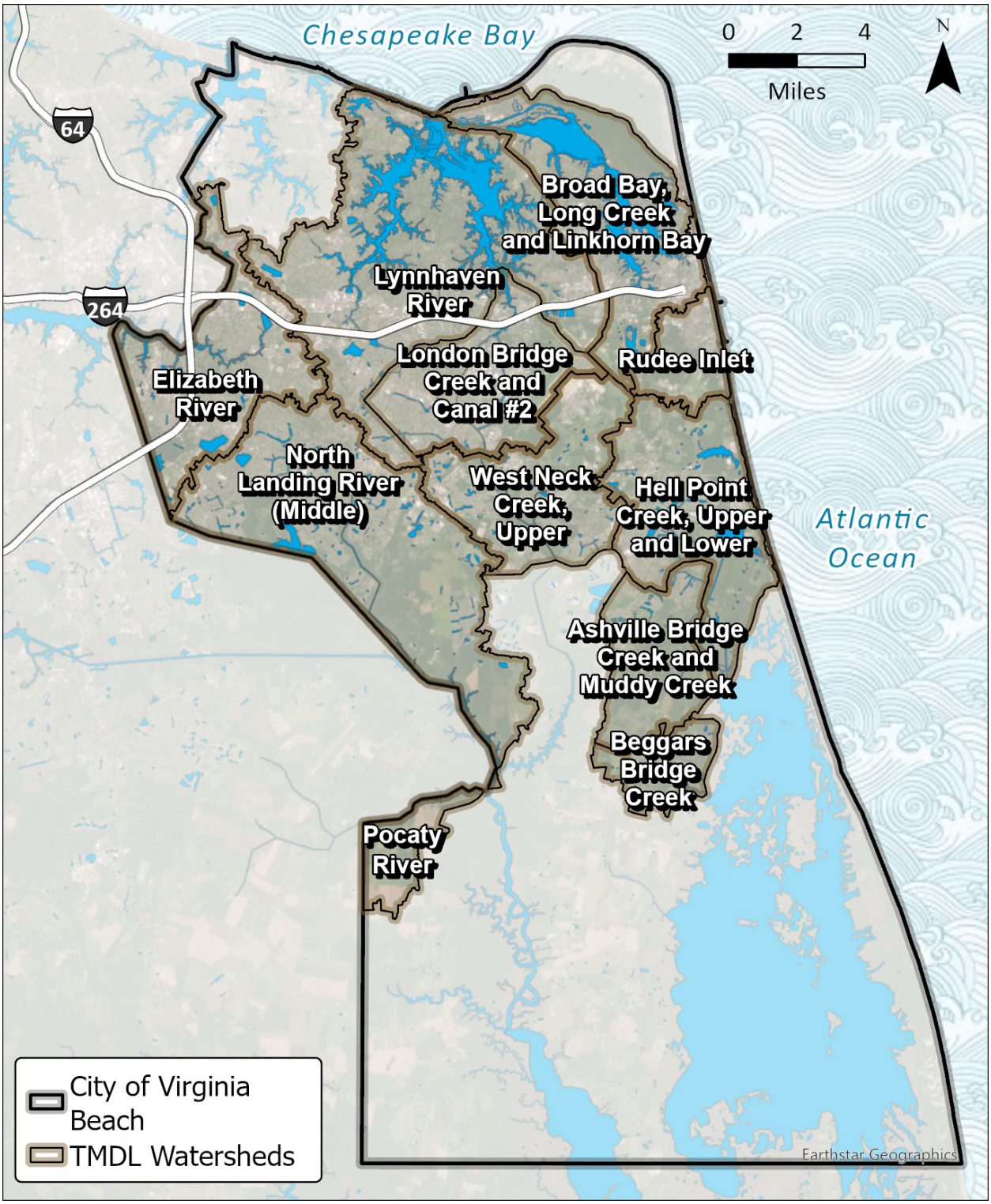

Figure 2-2. Bacteria TMDL watersheds

2.1 Bacteria Sources and Wasteload Allocations

The five TMDL reports describe potential sources of bacteria and the assigned WLAs for the eleven watersheds listed in **Table 2-1**. Potential sources of bacteria that contribute to impairments include, among others, waste from domestic animals, humans, livestock, and wildlife (**Figure 2-3**). Each watershed was evaluated during development of the TMDL reports to identify general types of bacteria sources and determine existing bacteria loading and future allocations for each responsible entity in the watershed (e.g., City of Virginia Beach, Virginia Department of Transportation). This TMDL Action Plan only considers data and allocations relevant to the City of Virginia Beach MS4, but other entities were evaluated as part of the TMDL development.

Figure 2-3. Animal sources as well as human sources contribute to bacteria loads

Table 2-1 presents a summary of the pollutant of concern and required percent reduction as outlined in each TMDL report. Potential sources as identified in the TMDL reports and other relevant information for the eleven watersheds, including watershed maps, are presented in Appendix A. Existing bacteria loads and the wasteload allocation to the City of Virginia Beach MS4, as detailed in the TMDL reports, are also provided. Human population estimates presented in Appendix A were updated using 2020 U.S. census data.

Table 2-1. Summary of impairment listings and City of Virginia Beach MS4 bacteria load reductions required

Report	Watershed	Impairment Listing (Standard)	Pollutant of Concern	Required Reduction (percent)
1[a]	Ashville Bridge Creek and Muddy Creek	Primary contact recreation	Enterococci	98
1	Beggars Bridge Creek	Primary contact recreation	Enterococci	97
1	Hell Point Creek: Upper and Lower	Primary contact recreation	Enterococci	98
1	North Landing River: Middle	Primary contact recreation	*E. coli*	94
1	Pocaty River	Primary contact recreation	*E. coli*	87
2	London Bridge Creek and Canal 2	Primary contact recreation	Enterococci	88
2	West Neck Creek: Upper	Primary contact recreation	Enterococci	85
3	Broad Bay, Long Creek, and Linkhorn Bay	Shellfish	Fecal Coliform	16.2
3	Lynnhaven Bay	Shellfish	Fecal Coliform	81.5
4	Upper Mainstem, Lower Southern Branch, Lower Eastern Branch Elizabeth River, Broad Creek, and Indian River	Primary contact recreation	Enterococci	95
5[b]	Rudee Inlet	Shellfish	Fecal Coliform	89

a. The WLAs associated with this TMDL aggregate the City's MS4 service area with that of adjacent VDOT areas.
b. In this TMDL, the target for Enterococci (recreation standard) is considered to be met if the fecal coliform TMDL (shellfish) is met.
yr = year(s), d = day(s).

3. Current Strategies to Reduce Bacteria Contributions

This section describes management practices and controls the City currently implements that are applicable to reducing bacteria contributions to TMDL waterways. As summarized in **Section 2**, the TMDL reports describe the general sources of bacteria and potential reductions that might be made from each source. In general, the TMDL reports call for a high load reduction from human sources, moderate reductions from pets and livestock, and lower expectations for reducing bacteria from wildlife sources.

The City implements numerous non-structural and structural best management practices (BMPs) to address various sources of bacteria. These are described in **Sections 3.1 and 3.2**, respectively.

3.1 Non-Structural BMPs

The City currently implements many practices and programs to address bacteria sources. These are known as "non-structural BMPs" and include, for example, promoting proper disposal of pet waste, monitoring for bacteria at stormwater outfalls, and responding to accidental sewage leaks or spills. Many of these activities are required by the City's MS4 permit, some are enhancements of permit-required actions, and others are above and beyond the permit-required elements. These current practices and programs are described below.

3.1.1 Required by Permit

The following non-structural BMPs are required by the City's MS4 permit. Many of these practices serve multiple purposes, as they are intended to reduce multiple pollutants, including bacteria.

3.1.1.1 Promote and Publicize Proper Pet Waste Disposal Through Community Outreach

Under the permit's outreach provisions (Part I B.2.j), the City is required to implement public education with the goal of reaching target audiences to increase knowledge and awareness about stormwater issues and ultimately change people's actions in ways that will reduce pollutant contributions. Public education and outreach can be focused on a variety of activities.

Reducing pet waste in a watershed reduces one key source of fecal bacteria that can enter streams, creeks, and rivers (**Figure 3-1**). The City regularly conducts activities to promote and publicize the proper disposal of pet waste, including regular, ongoing participation in regional outreach programs. For example, in FY24, an advertising campaign through askHRgreen was implemented describing the effect of pet waste on local water quality and reminding residents to clean up pet waste. The campaign included radio ads, digital display, and social media (Facebook, Twitter, and Instagram) ads. It also included news releases, print articles, interviews with local TV shows, and features in the askHRgreen.org newsletter and blog.

Figure 3-1. Pet waste station in a community park

3.1.1.2 Litter and Illicit Discharge Prevention Through Community Outreach

Under the permit's outreach requirements, the City promotes and publicizes litter prevention efforts. Also, the City promotes, publicizes, and facilitates public reporting of the presence of illicit discharges or improper disposal of materials into the MS4. Outreach on illicit discharges can also educate the public on identifying and eliminating potential illicit discharges on their property. Reducing litter directly keeps materials out of waterways, and reducing litter also reduces the potential for wildlife pollution (for example, from raccoons feeding on food waste spilled from trash cans).

3.1.1.3 Illicit Discharge Detection and Elimination Program

The City has implemented an illicit discharge detection and elimination (IDDE) program since 1996 and currently addresses MS4 permit requirements under Part I B.2.e. This program identifies and investigates potential illicit connections and unauthorized discharges to the City's stormwater system and documents the steps taken to eliminate those discharges. Illicit discharges generally include any water entering a storm sewer system that contains materials other than stormwater. Illicit discharges can contain bacteria, for example from food waste or sewage.

To coordinate efforts among departments, the City has established a Water Pollution Investigation Team that meets regularly to discuss and coordinate on illicit discharge-related issues including responsible parties, training, reporting, and enforcement. The team comprises representatives from Public Works, Public Utilities, Housing and Neighborhood Preservation, the Fire Department, the Police Department, and the office of the City Attorney.

There are several established avenues for residents and visitors to contact the City to report suspected illicit discharges. Residents can contact the City by calling VB311 or 757-385-1470, emailing vbstormwater@vbgov.com, or responding through the Website Service Request Form or VBWorks mobile application.

3.1.1.4 Dry Weather Screening

The City implements a dry weather screening program, as required by MS4 permit (Part I B.2.l), to aid in detecting illicit connections and unauthorized discharges to the stormwater system. Each year, site selection includes at least 50 stations located in areas of concern. Per the MS4 permit, areas of concern might include commercial car washes, car dealerships, pet kennels, restaurants, areas with a history of complaints, and areas upstream of sensitive ecosystems. Screening efforts are used to detect pollutant sources, including those associated with elevated bacteria inputs to waterways. Where follow up is needed, cases are referred for further investigation and reduction or elimination of illicit connection or discharges.

3.1.1.5 Sanitary Sewer Inspections

The permit (Part I B.2.e) requires the City to continue implementing a sanitary sewer inspection program to minimize exfiltration from the sanitary system to the MS4. The City regularly inspects the sanitary sewer system to assess the condition of the assets. These inspections help to determine where repairs are needed.

3.1.1.6 Staff Training Program

The City provides training for employees to help recognize illicit discharges and understand good housekeeping procedures for pollution prevention. The training sessions cover the following topics:

- Illicit discharges: The City provides biennial training to appropriate field personnel in the recognition and reporting of illicit discharges.

- Good housekeeping: The City provides biennial training to its employees in good housekeeping and pollution prevention practices that are to be employed during road, street, and parking lot maintenance; at City maintenance and public works facilities; and at City recreational facilities.
- Spill response: The appropriate emergency response employees receive training in spill response.

3.1.1.7 Street Sweeping Program

The City implements a street sweeping program (MS4 permit Part I B.2.c) to reduce sediment and debris along public roadways. Contributions of pollutants of various types entering storm drains are reduced by street sweeping, including animal waste from pets and wildlife.

3.1.1.8 Litter / Floatables Reduction

In accordance with the permit (Part I B.2 e), the City implements a program to reduce the discharge of "floatables" (i.e., litter and other human-generated solid refuse). Presence of floatables is recorded during dry weather screenings.

3.1.1.9 Spill Prevention and Response

Under Part I B.2.f, the permit requires that the City Fire Department and other City departments continue to implement a program to prevent, contain, and respond to spills that could discharge into the City's stormwater system. For example, during FY24, several sewage spills were reported and addressed, as documented in the City's MS4 Annual Report.

3.1.1.10 Stormwater Facility Maintenance and Inspections

As described in **Section 3.2**, there are many stormwater management facilities (SWMFs) throughout the TMDL watersheds that manage stormwater volume and, in many cases, provide water quality treatment. Under Part I B.2.h, the permit requires that the City maintain and implement programs to maintain its stormwater infrastructure. For SWMFs and other infrastructure maintained by the City (such as the inlets, pipes, and outfalls that convey flow to and from these facilities), the City provides for adequate long-term operation and maintenance in accordance with its inspection and maintenance procedures, as documented in the MS4 Program Plan. Regular inspections and maintenance are an important part of the program.

For privately maintained facilities, owners establish maintenance agreements or other strategies that address maintenance issues. The City conducts inspections of privately maintained facilities.

3.1.2 Enhanced Permit-Related Activities

The following non-structural BMPs are related to activities required by the permit; however, in these cases the City has gone above and beyond the minimum requirements for each activity, creating programs that are even more effective at targeting pollution.

3.1.2.1 Enhanced Pet Waste Education program

The City conducts outreach using three methods: direct, regional, and through partners. The City distributes pet waste educational materials at public events, including pamphlets and giveaways. Proper pet waste disposal techniques are also advertised on askHRgreen.org.

The City has conducted targeted pet waste disposal outreach with displays at recreation centers and libraries. City staff also conduct targeted outreach to pet owners through the Virginia Beach Animal Care and Adoption Center and other local pet facilities to distribute educational materials about proper pet waste disposal. The City provides pamphlets and giveaway materials for distribution to pet owners.

3.1.2.2 Pet Waste Disposal Stations

Pet waste stations are provided at parks and trails in locations of high dog traffic as a convenient place to properly dispose of pet waste. These stations are maintained by the City. As of FY24, there were 101 City-maintained pet waste disposal stations at 36 locations, primarily at parks and along trails. Additionally, residents at the Oceanfront's north end maintain 47 pet waste stations installed by the City at public beach access points.

The City also funds a pet waste station grant program. A resident or organization can apply for a grant directly through the City or on askHRgreen.org. These stations are maintained by the residents, typically through a homeowners' association or similar organization. As of FY24, there have been 97 pet waste stations installed through this grant program.

3.1.2.3 Adopt-a-Drain Program

The City implements an Adopt-a-Drain program that allows residents to participate in keeping their local storm drains clear of debris. When residents adopt drains, they are responsible for sweeping and raking debris from around the drain inlet and properly disposing of the litter. Keeping litter out of the storm drain system helps to keep the drain from filling with debris during rain events. This program also promotes awareness of the potential for pollution to enter the stormwater system, conveying a message of "Only Rain Down the Storm Drain" (**Figure 3-2**).

Figure 3-2. Adopt-a-Drain program storm drain design

3.1.2.4 Storm Drain Marking Program

The City's Storm Drain Marking Program is implemented to help increase public awareness of the environmental effects of urban runoff and dumping of materials into storm drains. Volunteers attach watershed-specific signs to storm drains in their neighborhoods. The signs remind community members that water entering storm drains can carry litter, motor oil, excess fertilizers, and other pollutants to nearby surface waters.

3.1.2.5 Enhanced Dry Weather Screening Program

Stormwater outfalls are inspected to detect illicit sewer connections and other potential pollution sources. Under the MS4 permit, the City screens a minimum of 50 locations annually as described above. Screenings include inspection of the outfall (or the nearby station, where tidal influence does not allow for outfall inspection), in situ sampling of any flowing water observed, source tracking, source identification, and property owner education or enforcement actions as necessary.

Through the City's enhanced program, 50 additional stations are screened each year to support the City's implementation of the Bacteria TMDL Action Plan. The additional stations are typically chosen downstream of industrial areas, commercial areas, and areas with clay sewer or potential conflict manholes due to a higher potential for illicit connections in these areas.

3.1.2.6 Sanitary Sewer Rehabilitation and Improvement Projects

The City continues to implement a sanitary sewer rehabilitation program, which includes repairing and resolving defects in the system that can cause sanitary sewer overflows (SSOs). In addition to finding and repairing defects, the City investigates locations (usually older developments) where the sanitary sewer is located above a storm sewer line. These locations have a higher chance of sewage exfiltration into the storm drain. The City also has a capital improvement program (CIP) for replacement and rehabilitation of older sanitary sewer systems throughout the City to address aging infrastructure.

3.1.2.7 IDDE Program with Microbial Source Tracking

The City continues to work with the Hampton Roads Sanitation District (HRSD) on a microbial source tracking project in the Thalia Creek watershed to identify sources of bacteria which are a higher risk to human health because of human sources, rather than wildlife sources. Microbial source tracking can be an effective method of identifying likely bacteria sources to target reduction actions. In previous years, the City was able to identify and eliminate discharges from a broken private sanitary sewer pipe, after detecting this source through sampling in a nearby creek. Follow-up sampling confirmed that the problem had been resolved. Targeted sampling at stormwater outfalls can be a useful tool to identify locations of human-related bacteria sources.

3.1.3 Exceeding Permit Requirements

The following non-structural practices are not required by the MS4 permit but are implemented by the City as additional methods to stem sources of bacteria pollution.

3.1.3.1 Septic-to-Sewer Conversions

Failing septic systems are a potential source of poorly treated or untreated sewage either into the storm sewer system or directly to receiving waters. The City implemented a septic-to-sewer conversion program and extended sanitary sewer service in existing developments with septic systems to provide a means for connection where possible. There is no sanitary sewer service in the southern portion of the City.

3.1.3.2 Education and Outreach for Boaters on Proper Disposal Practices

The City and HRSD promote the use of the Boater Pump Out Program for proper disposal of boat waste. The City installed and maintains two boat pump-out stations at the Lynnhaven Marina and Owl Creek Boat Launch. These stations are provided so that recreational vehicles can dispose of sanitary waste at no cost in a manner that does not pollute waterways. The City conducts outreach to promote the use of these free facilities as a better alternative to dumping waste into waterways.

3.1.3.3 Prohibit the Feeding of Waterfowl on Public Lands

The City continues to enforce its ordinance prohibiting people from feeding any wildlife on public property. Wildlife includes all species of wild animals, freshwater fish, and waterfowl (**Figure 3-3**). The City continues to maintain signage at City parks where feeding is problematic such as at Mount Trashmore Park. Park rules posted on the City's website include the prohibition on feeding wildlife on public land. The ordinance is intended to discourage wildlife, specifically waterfowl, from residing in or near City water bodies, thereby reducing bacteria inputs to the water.

Figure 3-3. Canada geese near a pond

3.2 Structural BMPs

This section describes current structural BMPs (SWMFs) implemented by the City that manage stormwater. In contrast with the non-structural practices discussed above, SWMFs are physical elements installed in the watershed to control bacteria sources or manage stormwater, which can help the City meet the bacteria WLAs described in this Action Plan. The most common type of SWMF implemented by the City are wet ponds, which provide water quality benefits through storage of stormwater.

The City does not explicitly install new SWMFs with the goal of reducing bacteria. Implementing non-structural programs (see **Section 3.1**) has been shown to be a much more cost-effective method of reducing bacteria, as bacteria reduction efficiencies for SWMFs vary widely (see the 2018 Action Plan for discussion on SWMF bacteria reduction efficiencies). Therefore, the City's main focus for bacteria reduction is the implementation of the non-structural programs outlined in the previous section.

However, the City does install new SWMFs with other goals in mind, including making progress on Chesapeake Bay water quality goals or other TMDLs not related to bacteria. SWMFs are also installed to support water quantity and/or quality requirements for new developments and redevelopment in the City. Despite not directly targeting bacteria, SWMFs installed for these other purposes still have a positive impact toward reducing bacteria and providing overall water quality benefits.

The following subsection documents the SWMFs installed/implemented in TMDL watersheds in the City as of January 2025. **Table 3-1** summarizes total SWMF counts, SWMF drainage area totals, and MS4 service areas treated by these SWMFs in each watershed (based on TMDL watershed boundaries). Appendix B contains tables summarizing the existing SWMF types in each TMDL watershed. Meadow management, another structural BMP program, is also discussed below.

3.2.1 Stormwater Management Facility Summary

Table 3-1 summarizes the structural BMP data for facilities in the City, by TMDL watershed. The number of SWMFs in each TMDL watershed are shown, along with each watershed's drainage area within the City, the total drainage area treated by SWMFs, the total MS4 service area, and the total MS4 service area treated by SWMFs within each watershed. Total SWMF treated drainage area is included to show the proportion of the TMDL watershed treated; this differs from the total MS4 service area treated because some areas outside the MS4 service area are also treated by SWMFs. The percentage of MS4 service area treated ranges from 0 percent in the Pocaty River watershed to 97 percent in the Hell Point Creek, Upper and Lower watershed.

Table 3-1. Current SWMF count and drainage area

TMDL Watershed	SWMF Count	TMDL Watershed Drainage Area in City (ac)	SWMF Treated Drainage Area in Watershed (ac)	Total MS4 Service Area in Watershed (ac)	MS4 Service Area Treated by SWMFs (ac)	MS4 Service Area Treated (percent)
Ashville Bridge Creek and Muddy Creek	47	5,529	1,952	1,051	741	71
Beggars Bridge Creek	2	2,553	92	200	8	4

TMDL Watershed	SWMF Count	TMDL Watershed Drainage Area in City (ac)	SWMF Treated Drainage Area in Watershed (ac)	Total MS4 Service Area in Watershed (ac)	MS4 Service Area Treated by SWMFs (ac)	MS4 Service Area Treated (percent)
Broad Bay, Long Creek, and Linkhorn Bay	503	10,946	1,048	3,426	639	19
Elizabeth River	464	9,397	4,125	5,963	2,625	44
Hell Point Creek, Upper and Lower	162	10,021	9,270	3,555	3,466	97
London Bridge Creek and Canal #2	421	8,008	3,016	4,231	2,114	50
Lynnhaven Bay	742	29,352	10,928	10,068	7,224	72
North Landing River	332	17,897	8,829	11,746	6,764	58
Pocaty River	0	2,207	0	65	0	0
West Neck Creek, Upper	237	8,580	2,870	3,533	2,032	58
Rudee Inlet	121	2,684	959	1,192	434	36
Total	3,031	107,174	43,089	45,030	26,047	58

3.2.2 Meadow Management (Riparian Buffer Grass/Shrub)

In addition to the above SWMFs, the City continues to implement a meadow management program whereby select locations adjacent to waterways are managed to help encourage meadow grass growth. Meadow management is a method of converting manicured lawn to meadows to provide a buffer to protect waterways while also establishing more efficient maintenance. Meadow management areas have a minimum 20-foot width and are mowed only once a year to control woody plant growth while allowing other vegetation to grow. City design standards for new parks require the establishment of a meadow management area adjacent to waterways. Meadow management limits woody vegetation growth by biennial mowing, while allowing grassy, native vegetation to establish. These buffers provide filtering of stormwater runoff prior to entering waterways. As an added benefit, meadows adjacent to waterways also discourage certain waterfowl (e.g., geese) from coming onshore and depositing fecal matter. The City continues to evaluate the areas established under the meadow management program to determine the acreage provided adjacent to waterbodies in each of the impaired watersheds. New locations for meadow management or installation of riparian buffers may also be evaluated.

4. Planned Strategies and Enhancements to Programs

The City is considering a suite of proposed strategies for reducing bacteria pollution; these strategies are primarily based on the options provided by DEQ in the MS4 permit. The selected approaches are

intended to build upon prior efforts and fulfill current MS4 requirements and will involve community outreach and other programmatic approaches. The draft strategies are outlined in **Section 4.1** below.

The selected strategies focus on reducing human health risk by addressing human-generated sources, as well as animal sources that are likely to be most widespread. The practices and programs to be implemented are intended to reduce bacteria contributions to local waterways and will bring co-benefits such as cleaner parks and trails from enhanced dog waste pickup efforts and better septic system maintenance that will benefit homeowners.

Monitoring within the TMDL watersheds, particularly with a focus on human health risk, will provide key information about where to target strategies and how to assess their long-term effectiveness. Planned monitoring that will help identify and track down human sources (**Section 4.2**) and support watershed-scale evaluations using a strategic risk-based approach (**Section 4.3**) are described below.

4.1 Proposed Strategies and Enhancements to Current Activities

The proposed strategies for further reducing bacteria contributions include program enhancements, which reflect or build upon programs and activities described in **Section 3.1**, as well as several proposed new strategies. Of the ten proposed strategies listed below, at least six will be selected for implementation, to address MS4 permit requirements and to support bacteria reductions in the TMDL watersheds.

Proposed strategies based on existing programs and expansions of those existing programs include:

- Implement an enhanced dry weather screening and IDDE program beyond the requirements of the MS4 Permit to identify and remove illicit connections and identify leaking sanitary sewer lines infiltrating to the MS4 and implement repairs.
- Provide signage to pick up dog waste and provide pet waste bags and disposal containers.
- Maintain dog parks by removing disposed of pet waste bags and reducing other sources of bacteria.
- Clean out storm drains, which will remove waste originating from wildlife.

New proposed strategies include:

- Educate the public on how to determine whether their septic system is failing.
- Implement a program to connect homeowners with funding or technical assistance for repair or replacement of septic systems.
- Develop BMPs for locating, transporting, and maintaining portable toilets used on permittee-owned sites. Educate third parties that deploy portable toilets on these BMPs.
- Educate the public on how to reduce food sources accessible to urban wildlife.
- Implement a program for removing animal carcasses from roadways and correctly disposing of them through proper storage or transport to a licensed facility.
- Provide public education on appropriate recreational vehicle wastewater management practices.

The strategies under consideration will build upon existing City programs and emphasize actions that are human-health focused. Below, the strategies are described and presented in order from the greatest benefit to reducing the human health risk to the lowest benefit to reducing human health risk. The rankings are based on best professional judgement. The bacteria-reducing strategies are provided in the

following categories in ranked order, with the top having the most benefit for reducing the human health risk.

- Illicit discharges and septic systems (3 strategies)
- Dogs and cats (2 strategies)
- Other sources - portable toilets
- Urban wildlife (3 strategies)
- Other sources - recreational vehicles

4.1.1 Continue to implement an enhanced dry weather screening and illicit discharge detection and elimination (IDDE) program

This program will be developed beyond the requirements of Part I.E.3 to identify and remove illicit connections and identify leaking sanitary sewer lines infiltrating to the MS4 and implement repairs**.** The City is already implementing an enhanced DWS program for illicit connections and unauthorized discharges that exceeds the minimum permit requirements, as described in **Section 3.1**. The program includes the inspection of stations to support MS4 Permit Section 1.B.2.I (Dry Weather Screening Program), stations to support the implementation of the Bacteria TMDL Action Plan, and stations to support the high-priority municipal facilities requirements set forth in MS4 Permit Section I.B.2.i.

Under this planned strategy, the City would continue to implement these enhanced activities and build on activities already in place:

- Continue expanded efforts to screen an additional 50 stations per year upstream of outfalls and screen for dry weather flows at upstream stations, in areas having higher potential for human bacterial sources and posing human health risks.
- When illicit connections or leaking sanitary lines infiltrating to the MS4 are discovered, continue the program to implement repairs; perform ongoing routine maintenance, cleaning, and investigations of the sanitary sewer system; collect bacteria samples and report related information in the annual report.
- Conduct enhanced dry weather screening, using GIS analysis of likely sources and results of City bacteria monitoring implemented in future years to target screening efforts.

4.1.2 Educate the public on how to determine whether their septic system is failing.

Through this strategy, the City would create and distribute homeowner septic system educational materials, both for hard copy and electronic distribution. The primary audience would be residents and businesses in the southern portion of the City where most of the septic systems exist. Materials will center on how to determine whether a septic system is failing and how to properly maintain a system.

4.1.3 Implement a program to connect homeowners with funding or technical assistance for repair or replacement of septic systems.

This is an enhancement to one of the management strategy options listed in the MS4 permit (see **Section 4.1.2** above). Implementation activities may include searching and obtaining grants to assist homeowners with repairs and replacements. Resources include the Virginia Department of Health Septic Systems Funding Opportunities webpage. Grant opportunities would be highlighted through public outreach including social media.

4.1.4 Provide signage encouraging picking up of dog waste and provide pet waste bags and disposal containers.

This strategy expands on MS4 Permit provisions (Part I B.2.j Public Education/Participation) through an enhanced pet waste management program to reduce bacteria and other pollutants (**Figure 4-1**). Implementation activities may include:

Figure 4-1. Encouraging owners to pick up pet waste helps keep parks and waterways clean

- Ongoing support for the regional askHRgreen campaign to promote and publicize the proper disposal of pet waste. The campaign includes radio ads, digital displays, social media (Facebook, Twitter, and Instagram) ads, news releases, print articles, local TV interviews, and features in the askHRgreen newsletter and blog.
- Conducting targeted outreach about pet waste disposal, including coordination with the Virginia Beach Animal Care and Adoption Center and other local pet facilities to distribute educational materials. The City would continue partnering with these and other organizations (e.g., animal shelters, recreation centers, libraries, local businesses) to distribute educational materials and giveaways.
- Provide signage, pet waste bags, and disposal containers to encourage dog owners to pick up waste. The City would provide the items at City events and to recreation centers, libraries, dog parks, parks and trail systems where dogs may be walked, and businesses such as dog and equine training facilities.

4.1.5 Maintain dog parks by removing disposed of pet waste bags and cleaning up other sources of bacteria.

Implementation activities may include:

- Installing, maintaining, and/or distributing pet waste stations to be installed and maintained by residents and business owners, primarily at parks and along trails. Through a grant program, the City has supported local organizations in installing numerous stations and partnered with residents to maintain stations such as those at public beach access points.
- Keeping City-maintained stations functional by routinely emptying the filled bags in the pet waste stations to encourage their use and to mitigate odors.
- Installing new pet waste signs along public streets to remind residents to dispose of used pet waste bags in local urban trashcans. Placing the signage near dog-friendly hotels and along City streets that host festivals, parades, and other pet-friendly outdoor events.
- Identifying additional locations to install pet waste stations and installing additional pet waste stations on public and private property. Developing an approach for identifying new locations and determining what analysis is needed to choose the new locations.

4.1.6 Develop best management practices (BMPs) for locating, transporting, and maintaining portable toilets used on permittee-owned sites.

This strategy would help to educate third parties that deploy portable toilets on appropriate BMPs for their use (**Figure 4-2**). Implementation activities supporting this strategy may include:

- Creating and distributing outreach material to businesses during preconstruction meetings. For example, an informational brochure will educate businesses on the proper location, transportation, maintenance, and disposal of waste at a waste disposal location or by hiring a sanitation company.
- Distributing outreach material to companies involved with the City's parades, festivals, etc. Distribute portable toilets information with the event permit.
- Ensuring the proper location, transportation, maintenance, and disposal of waste from portable toilets used during events on City-owned sites.

Figure 4-2. Proper management of portable toilets reduces the likelihood of unwanted spills and pollution

4.1.7 Clean out storm drains to remove waste from wildlife.

Activities supporting this strategy may include:

- Ongoing implementation of the City's street sweeping program (MS4 Permit Part I B.2.c) to reduce sediment and debris along public roadways.
- Promoting the City's Adopt-a-Drain program. The City sponsors a program through which volunteers adopt one or more storm drains and commit to a minimum of six cleanups per year. This program is featured on an interactive website. By keeping the curb line on either side of an adopted storm drain clear of trash, sediment, and debris, volunteers help reduce the amount of material (including animal waste) entering the storm drain system. The Adopt-a-Drain program increases public awareness of stormwater, the types of materials that should not go down a storm drain, and ways to report stormwater pollution.
- To address bacteria, catch basin cleaning may be most beneficial in commercial areas.

4.1.8 Educate the public on how to reduce food sources accessible to urban wildlife.

Urban wildlife includes deer, rats, raccoons, geese, ducks, pigeons, and other smaller mammals and birds. Bacteria from urban wildlife (along with pets) are likely contributors to fecal bacteria in waterways. This strategy would include practices such as managing restaurant dumpsters and grease traps, properly handing business and residential garbage, and feeding pets indoors. Implementation activities may include:

- Conducting public education to ensure all dumpsters and private trash cans are properly secured (closed to prevent leaks) to prevent nuisance wildlife from using the trash as a food source.
- Distributing outreach materials to restaurants with outdoor dining to clean up food quickly to deter animals and help keep customers healthy. Requesting this topic be added to the askHRGreen campaign would have additional benefits because it is an issue faced by most coastal communities who have numerous outdoor dining restaurants.
- Distributing information to day care centers to make sure their dumpsters are not leaking diaper waste and other sources of fecal bacteria.
- Posting signs at local veterinary clinics and animal shelters to encourage homeowners to feed pets indoors and cover residential garbage to discourage raccoons and other wild animals.

4.1.9 Implement a program for removing animal carcasses from roadways and correctly disposing of them through proper storage or transport to a licensed facility.

Implementation activities may include:

- Continuing support for removal of animal carcasses reported to the City. Currently, City street crews are dispatched for reported carcasses, which are then disposed of in covered trash dumpsters or through a rendering company. The City would train crews yearly to conduct the safe removal of animal carcasses by using personal protective equipment (PPE) and disposing of carcasses quickly to avoid health hazards.
- Partnering with rendering companies that follow BMPs such as safely transporting and properly disposing of any remaining waste through methods like incineration or burial while adhering to strict regulations regarding sanitation and disease control.

4.1.10 Provide public education on appropriate RV wastewater management practices.

Activities supporting this strategy would include creating and distributing educational messaging via newsletter, social media, and printed materials about the proper waste disposal for RVs. Information would be shared through nearby RV dealerships, service centers, and rental locations.

4.2 Human Waste Source Reduction Strategy and Monitoring

The City has faced multiple challenges addressing beneficial use (BU) impairments and associated TMDL requirements within local waterbodies due to indicator bacteria exceedances of receiving water quality objectives. These challenges include, among others, the need to demonstrate compliance with recreation BU requirements in waterbodies where they might not be applicable, and the presence of natural background sources of bacteria which are largely uncontrollable (e.g., birds). To address these challenges and supplement compliance efforts outlined in this Action Plan, the City plans to implement a Human Waste Source Reduction Strategy to better protect public health and support recreation BU goals. This strategy will help overcome bacteria reduction challenges and guide future monitoring, source identification, and source abatement efforts according to a human-health risk-based approach.

A human-health risk-based approach shifts the focus from the current Bacteria TMDL and MS4 permit compliance requirements for indicator bacteria toward an emphasis on tracking and eliminating sources from one of the most likely to cause illness to recreators, humans (**Figure 4-3**[1]). The use of indicator bacteria as a proxy for the protection of recreators from waterborne illnesses has a long regulatory history, but it does not isolate sources of bacteria that have a higher risk of causing illness, such as human and cattle, nor does it directly measure pathogens. A human-health risk-based approach focuses directly on prioritizing source control efforts, especially human sources of bacteria, and using the latest science and markers (e.g., the human fecal marker HF183) to identify high-risk areas and likely sources for abatement.

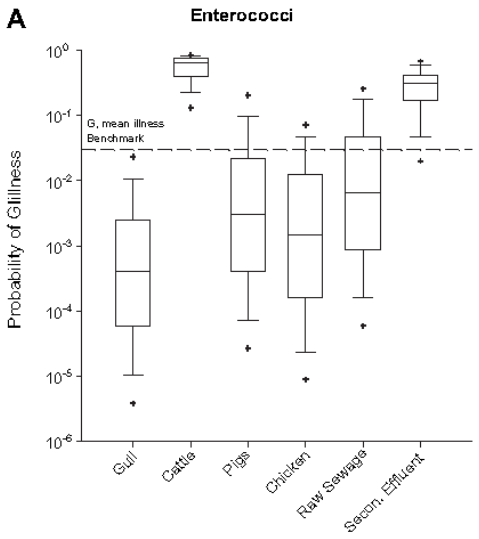

Figure 4-3. At a fixed level of enterococci (i.e., 35 most probable number per 100 milliliters), human sources present greater risk than many other sources.

A key element of this strategy is completion of human waste source investigations (HWSIs). HWSIs are designed to progressively bracket and isolate potential human sources of bacterial contamination, according to prioritized outfall catchments which are grouped according to areas of investigation (AOIs). HWSIs will first establish whether there is a health risk in surface waterbodies, and if pre-defined action levels are exceeded the HWSI will move upstream to identify and investigate water quality conditions at outfalls of interest. Based on results at the outfall monitoring relative to pre-defined action levels, the investigation may move into the individual catchments by sampling portions of the MS4 network to better isolate hot spots. This strategy allows for targeted source abatement efforts that have a high degree of certainty and efficiently allocate agency resources.

The first step is the development of an AOI, which typically entails manually identifying an area that contains three to five high priority outfall catchments. See **Figure 4-4** for a conceptual example.

[1] Soller, J.A., M.E. Schoen, T. Bartrand, J.E. Ravenscroft, and N.J. Ashbolt. 2010. Estimated human health risks from exposure to recreational waters impacted by human and non-human sources of faecal contamination. *Water Research* 44(16):4674-91. doi:10.1016/j.watres.2010.06.049

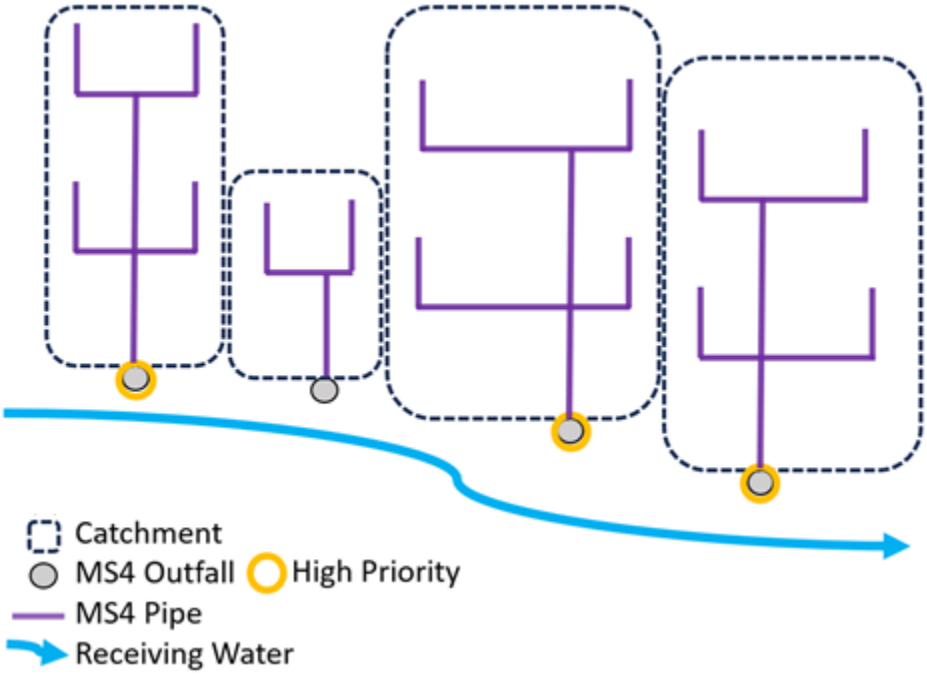

Figure 4-4. Example AOI with three High Priority outfalls

Once the AOI is selected, receiving water monitoring sites are established that place sites both upstream and downstream of each of the high priority outfalls (**Figure 4-5**). The results of these samplings, for paired analyses of FIB and HF183, will help bracket the relative influence of the outfalls on the receiving water quality conditions.

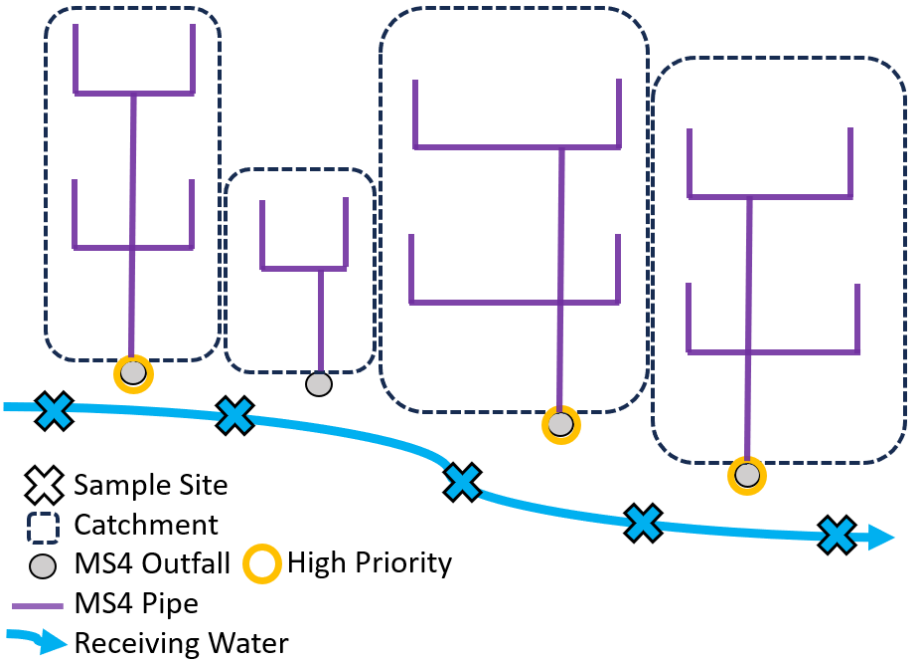

Figure 4-5. Example AOI with bracketing receiving water locations.

Based on the results, there may be a clear indication that a certain outfall has a larger impact on bacteria contributions to the receiving water (**Figure 4-6**).

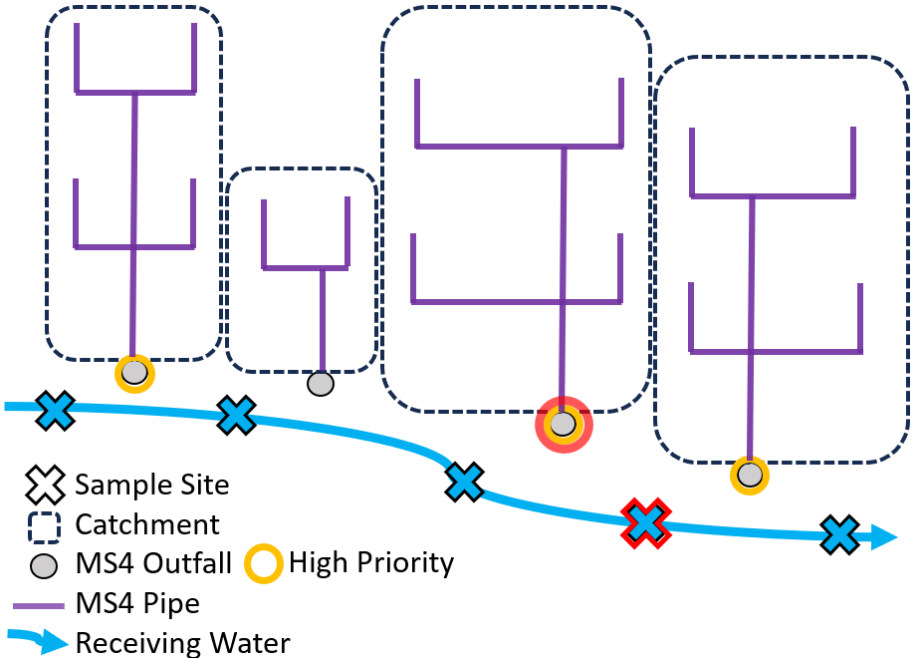

Figure 4-6. Example AOI with single high exceedance RW site showing single outfall of concern.

The catchment contributing to that outfall becomes the target of MS4-based investigations, which sample the main tributary pipes within the network via manhole-based sampling methods (**Figure 4-7**).

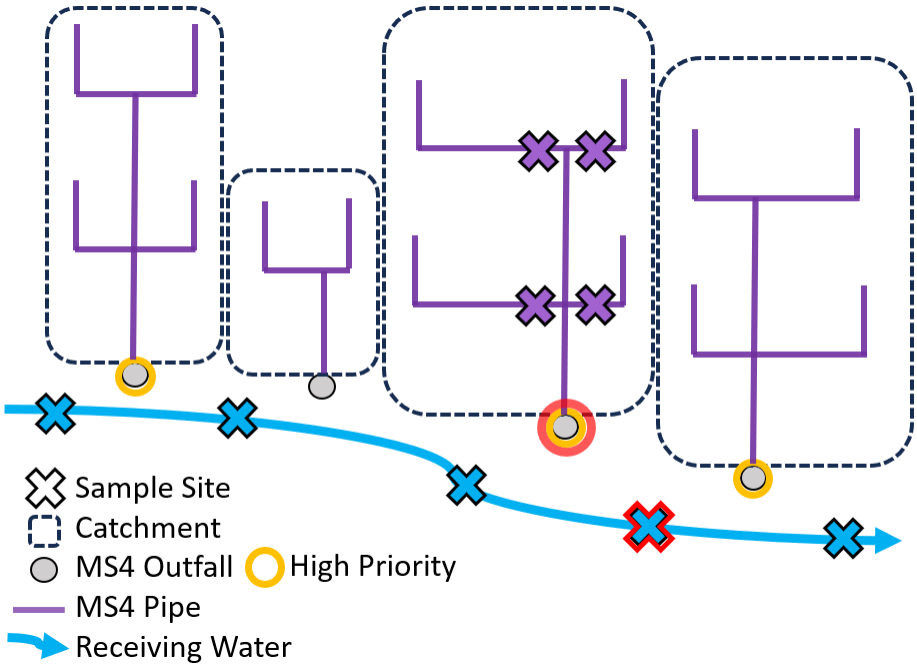

Figure 4-7. Example AOI with MS4 network sampling locations.

The results of these analyses can help further isolate potential contributing land areas with greater relative influence on bacteria loads (**Figure 4-8**).

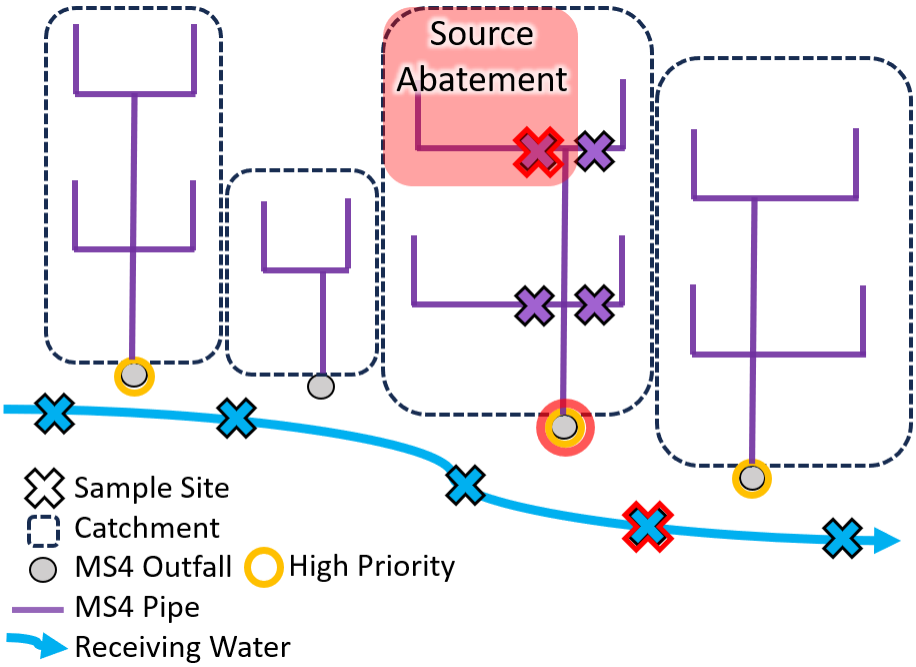

Figure 4-8. Example AOI showing upstream tracking leading to targeted source abatement.

The HWSI framework allows for the progressive spatial bracketing of potential human-derived sources of bacteria within an AOI. Once these areas are identified, the appropriate source abatement strategy can be selected (e.g. rehabilitation of aging sanitary sewer systems). This approach, coupled with monitoring at downstream water quality stations (see **Section 4.3**) will help assess the effectiveness of source abatement strategies toward achieving reduction targets.

Sampling frequencies for investigations will be developed during HWSI planning but will generally consist of multiple sampling events within a relatively short period of time to capture source information and location more accurately.

HWSIs will leverage the latest science and markers. HF183, a genetic sequence associated with the human-specific bacterial group Bacteroidetes, can be used to identify and track human sources of contamination in water bodies.[2] Ideally, HWSIs will use droplet digital polymerase chain reaction (PCR) techniques to identify human-specific source markers such as HF183. Droplet digital PCR allows for greater precision and sensitivity than alternative PCR methods (e.g., qPCR), is cost-effective, and is reliable for fecal source investigations[3].

[2] Staley, C., K.V. Gordon, M.E. Schoen, and V.J. Harwood. 2012. *Performance of Two Quantitative PCR Methods for Microbial Source Tracking of Human Sewage and Implications for Microbial Risk Assessment in Recreational Waters*. Appl. Environ. Microbiol. 78(20):7317-26. doi: 10.1128/AEM.01430-12.

[3] Cao, Y., M.R. Raith, and J.F. Griffith. 2015. *Droplet Digital PCR for Simultaneous Quantification of General and Human-Associated Fecal Indicators for Water Quality Assessment*.

4.3 Strategic Risk-Based Monitoring

The City will implement a strategic risk-based monitoring program with the goal of improving source investigation efforts and informing the Human Waste Source Reduction Strategy described in **Section 4.2**. To better understand the human health risk in BU-impaired segments, the City will implement paired fecal indicator bacteria (FIB) and HF183 data collection at select locations in the 11 watersheds with bacteria WLAs. The City intends to monitor sufficient locations to improve the spatial resolution of existing monitoring programs, increasing the overall knowledge of water quality conditions in understudied areas (e.g., North Landing River watershed). Monitoring stations will generally be sited at the bottom of TMDL waterbodies, but upstream of any tidal influence; above and below major tributaries of TMDL waterbodies; and at locations necessary to improve the spatial representatives of the monitoring program. Paired FIB and HF18 data will improve the City's understanding of those waterbodies most impacted by human sources, thereby, posing the greatest risk to recreators, while also aiding with prioritization of HWSIs (i.e., monitoring results will be used in the future to refine outfall catchment prioritization). Additional details of this Strategic Risk-Based Monitoring Program will be captured in a work plan and sampling and analysis plan to be developed in 2025.

5. Implementation Schedule

During the remainder of the MS4 permit term, the City will continue to implement the ongoing programs (non-structural BMPs and enhanced permit related activities) identified in **Section 3**. In addition, the City will continue to document new structural BMPs and activities undertaken during the permit term. The City will also initiate work on activities in support of the additional strategies described in **Section 4**.

Table 5-1 provides the schedule for ongoing and planned new activities anticipated to be undertaken to implement this TMDL Action Plan. DEQ specifies in its "*TMDL Action Planning for Local Total Maximum Daily Loads as Required in the Small MS4 General Permit (VAR04) Effective July 1, 2013 and MS4 Individual Permits*" guidance that "Demonstration of adequate progress may be achieved through tracking, monitoring, and/or reporting of BMP implementation, and/or other strategies as approved by DEQ as part of the TMDL Action Plan.". The City will document progress in each year's MS4 annual report (see Section 10).

Table 5-1. Schedule of anticipated actions planned for implementation.

BMP or Other Activity	Schedule / Milestone
Continue implementation of current non-structural BMP Programs, including: • Provide signage to pick up dog waste, providing pet waste bags and disposal containers. • Maintain dog parks by removing disposed of pet waste bags and cleaning up other sources of bacteria. • Continue to conduct enhanced dry weather screening and IDDE program • Clean out storm drains, which will remove waste originating from wildlife.	Ongoing
Evaluate an outreach strategy to educate the public on methods for reducing bacteria pollution	2027
Select and implement two new strategies designed to reduce bacteria loading	2028
Develop and begin to conduct strategic risk-based monitoring program	2028
Develop and begin human waste source investigations	2028

6. Methods of Assessment

6.1 Assessment Methods

The permit indicates the City must develop and implement methods to assess the effectiveness of the Action Plan BMPs that are designed to reduce bacteria. Assessments will include both programmatic and monitoring-based components.

Each MS4 annual report will include descriptions of progress made in implementing bacteria reduction strategies during the permit year. The City will document and closely review and evaluate information related to each of the bacteria control strategies it implements (described in **Sections 3 and 4**). For example, the City will track the number of miles of sanitary sewer rehabilitated, estimated impressions made via targeted education and outreach, and the number of sources abated via IDDE and HWSIs. The City's outreach plan contains further information on how outreach activities will be tracked and reported annually. This information will allow the City to clearly document strategy implementation over time as well as assess whether individual strategies are impactful year-over-year. Furthermore, the City will continue to use community feedback as a source of information on waterbodies, health risks, stormwater/wastewater asset condition, City strategies, and more.

The primary methods the City will use to determine the effectiveness of BMPs in this Action Plan include assessing bacteria water quality status (comparison to receiving water standards) and conducting trend analysis for monitoring stations located in TMDL waterbodies. Water quality data for TMDL waterbodies will also enable the application of other statistical analyses such as change-point analysis. The City intends to initiate a routine surface water monitoring program (refer to **Section 4.3**, Strategic Risk-Based Monitoring) to support these analyses while also leveraging monitoring data collected by the DEQ, which includes data from 21 long-term receiving water quality monitoring stations throughout Virginia Beach. Tracking bacteria concentrations in TMDL waterbodies will help to illustrate improving or declining water quality conditions and inform identification of priority areas for bacteria reduction efforts and potential source abatement. Future monitoring by DEQ and the City will provide data for tracking of water quality status and trends in the TMDL watersheds. If the analysis of water quality data or assessment of strategies show a lack of progress, the City will adapt this Action Plan accordingly.

6.2 Adaptive Management

Figure 6-1. Reducing pollutant sources depends on public and partner support

Collaboration between the City, DEQ, and watershed partners is important for successful implementation of this TMDL Action Plan (**Figure 6-1**). This document was developed using the best information available at the time of development. As implementation progresses, an adaptive management approach allows for adjustments to defined strategies as new information and technologies become available. Changes in the watershed, including an increase or decrease in flow or changes in pollutant loads, can impact the proposed restoration activities and strategies and the ability to meet regulatory requirements. For example, using water quality monitoring results, the City can adjust priorities and target areas of high bacteria concentrations. The

City can use new information as it becomes available to assess the effectiveness of its restoration program and adjust as needed. Due to the dynamic nature of adaptive management, progress should be assessed and updated based on the effectiveness and performance of the strategies in this plan.

Adaptations may include updating programs that implement non-structural BMPs, increasing effort for BMPs that are most effective, or reducing strategies that are not found to be as effective. As needed during adaptive management, the City may also consider revisions to its regulatory codes and ordinances that are intended to reduce bacteria loads.

Adaptive solutions are important because of the possibility of unanticipated incidents and obstacles. For example, pet waste public outreach depends on changing public behavior, which can take time. This might result in slower progress towards meeting water quality criteria. The adaptive process will need to acknowledge the causes of lag. Further, adaptive management allows for re-evaluating and adjusting strategies to meet the goals of this action plan.

Additionally, adaptation should apply not only to the strategies and investigations themselves, but to the source data that informs the overall risk analyses as well. For instance, as new water quality data is made available, catchment prioritization should be updated. New data on sources of potential human bacteria can also be incorporated into analyses.

Implementing this action plan will require significant time and resources. Its recommended actions will depend on the concerted effort of the City, local businesses, and local residents. Support from the public and watershed partners will be important to the success of this plan.

6.3 Evaluation of Results Achieved under Previous Action Plan

The City's previous Bacteria TMDL Action Plan outlined a suite of nonstructural and structural BMPs to aid in reducing bacteria loads in stormwater runoff in TMDL watersheds. As documented in the City's recent MS4 annual reports (2023 and 2024[4]), many of these BMPs have been successfully implemented. **Sections 3.1 and 3.2** provide details on BMPs recommended in the 2018 Action Plan and their current status of implementation.

The actions outlined in the 2018 TMDL Action Plan provide a strong foundation for planned activities, which include ongoing implementation of BMPs, enhancement of existing programs, and new initiatives that will be instituted during the current MS4 permit term (see **Section 4**). The City is continuing to develop its monitoring, source tracking, and implementation efforts, with emphasis on a human health risk-based approach. Implementing both a Human Waste Source Reduction Strategy (**Section 4.2**), which will use human markers and targeted watershed-specific source control efforts, as well as strategic risk-based monitoring (see **Section 4.3**), which will enable long-term tracking of conditions in TMDL watersheds, will enhance targeting and tracking of program effectiveness. These programs will help identify the most effective pathway towards the attainment of bacteria-related water quality objectives and reduced health risk (**Figure 6-2**). Future evaluations will also incorporate water quality monitoring data from DEQ, Virginia Institute of Marine Science, and Virginia Department of Health to assess the progress in reducing bacteria in local waters.

[4] City of Virginia Beach. 2024. *MS4 Permit Annual Report, July 1, 2023 - June 30, 2024.* Public Works Department, VSMP MS4 Permit # VA0088676.

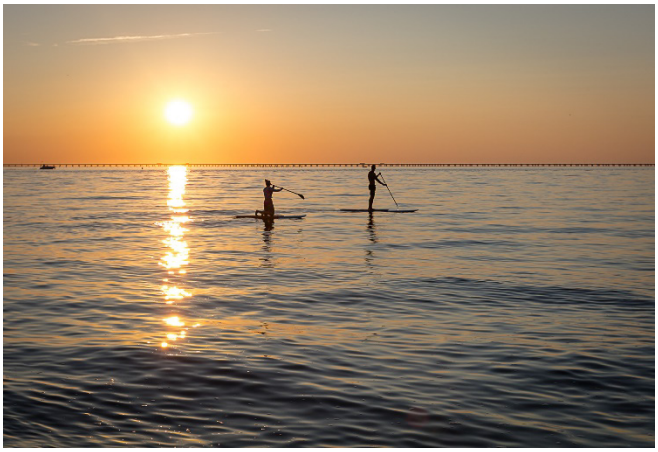

Figure 6-2. Improving water quality to support recreational use is a key goal of bacteria reduction efforts

The City's enhanced monitoring efforts in the Thalia Creek watershed have helped to identify and track down sources of bacteria which pose a higher risk to human health. As discussed in **Section 3.1**, during FY23, the City's monitoring of outfalls and nearby creek locations identified elevated levels of HF183, which led to identification of a broken sanitary sewer pipe. Re-testing in Thalia Creek downstream of this discharge indicated that the source had been successfully eliminated.

Appendix A: Details by TMDL Watershed

A1. Back Bay, North Landing River, and Pocaty River TMDLs

The Back Bay, North Landing River, and Pocaty River TMDL study area contains seven impaired waterbodies: Ashville Bridge Creek, Muddy Creek, Beggars Bridge Creek, Hell Point Creek (Upper), Hell Point Creek (Lower), North Landing River (Middle), and Pocaty River. North Landing River (Middle) and Pocaty River are both freshwater waterbodies; TMDLs were developed for these watersheds using thresholds for *E. coli*, the indicator bacteria most appropriate for freshwater waterbodies.

The remaining five waterbodies are transitional or saltwater waterbodies. Due to their hydrologic connectivity, Ashville Bridge Creek and Muddy Creek were grouped together for TMDL development, as were Hell Point Creek Upper and Lower. TMDLs were developed for (1) Ashville Bridge Creek and Muddy Creek, (2) Beggars Bridge Creek, and (3) Hell Point Creek, Upper and Lower using thresholds for enterococci, the indicator bacteria most appropriate for transitional and saltwater waterbodies.

Bacteria sources were identified and quantified in the study areas, including both point and nonpoint sources. Bacteria sources included waste from humans, livestock, wildlife, and domestic pets, as well as permitted point sources. **Table A1** summarizes the sources described in the Back Bay, North Landing River, and Pocaty River TMDL report.

Table A1. Bacteria sources identified in the Back Bay, North Landing River, and Pocaty River TMDL report

TMDL Watershed	Sources	Human Population (2020)
Ashville Bridge Creek and Muddy Creek	Point sources (fecal matter): 1 individual permit, 3 domestic single-family home permits, 2 MS4 permits (Virginia Beach and Chesapeake) Nonpoint sources: residential sewage disposal systems, land application of waste, livestock, wildlife, and pets	4,833
Beggars Bridge Creek		400
Hell Point Creek, Upper and Lower		27,879
North Landing River (Middle)		78,413
Pocaty River		103

Source: Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments. (Table 3.4, Page 3-7)

A1.1. Ashville Bridge and Muddy Creek

Ashville Bridge Creek flows south before its confluence with Muddy Creek. The lower portion of Ashville Bridge Creek between Hell Point and Muddy Creeks was listed on the 2006 303(d) list for impairments related to support of aquatic life and recreational beneficial uses. DEQ monitoring station 5BASH002.20 had a 25 percent bacteria standard violation rate per the 2010 assessment.

Muddy Creek flows south–southeast before its confluence with North Bay. Muddy Creek, from its confluence with Ashville Bridge Creek to its mouth at North Bay, was listed on the 2006 303(d) list for impairments related to support of recreational beneficial uses. DEQ monitoring station 5BMDY000.00 had a 41.7 percent bacteria standard violation rate per the 2010 assessment.

The Ashville Bridge and Muddy Creek drainage area is 5,529 acres, which is entirely within City boundaries. The MS4 service area in the watershed is 1,051 acres, which is 19 percent of the bacteria TMDL watershed area.

The total existing load, WLA, and required reduction for Ashville Bridge Creek and Muddy Creek are presented in **Table A2**. **Figure A1** shows the watershed boundary and the MS4 service area within the watershed.

Table A2. Existing load, WLA, percent reduction required, and calculated reduction: Ashville Bridge and Muddy Creek

Watershed	Existing Loading (cfu/yr)[a]	WLA (cfu/yr)[b]	Percent Reduction (percent)[a]
Ashville Bridge Creek and Muddy Creek	2.86E+13	5.72E+11	98%

a. *Source:* Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments *(Table 5.14, Page 5-26)*

b. *Source:* Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments *(Table 5.15, Page 5-27)*

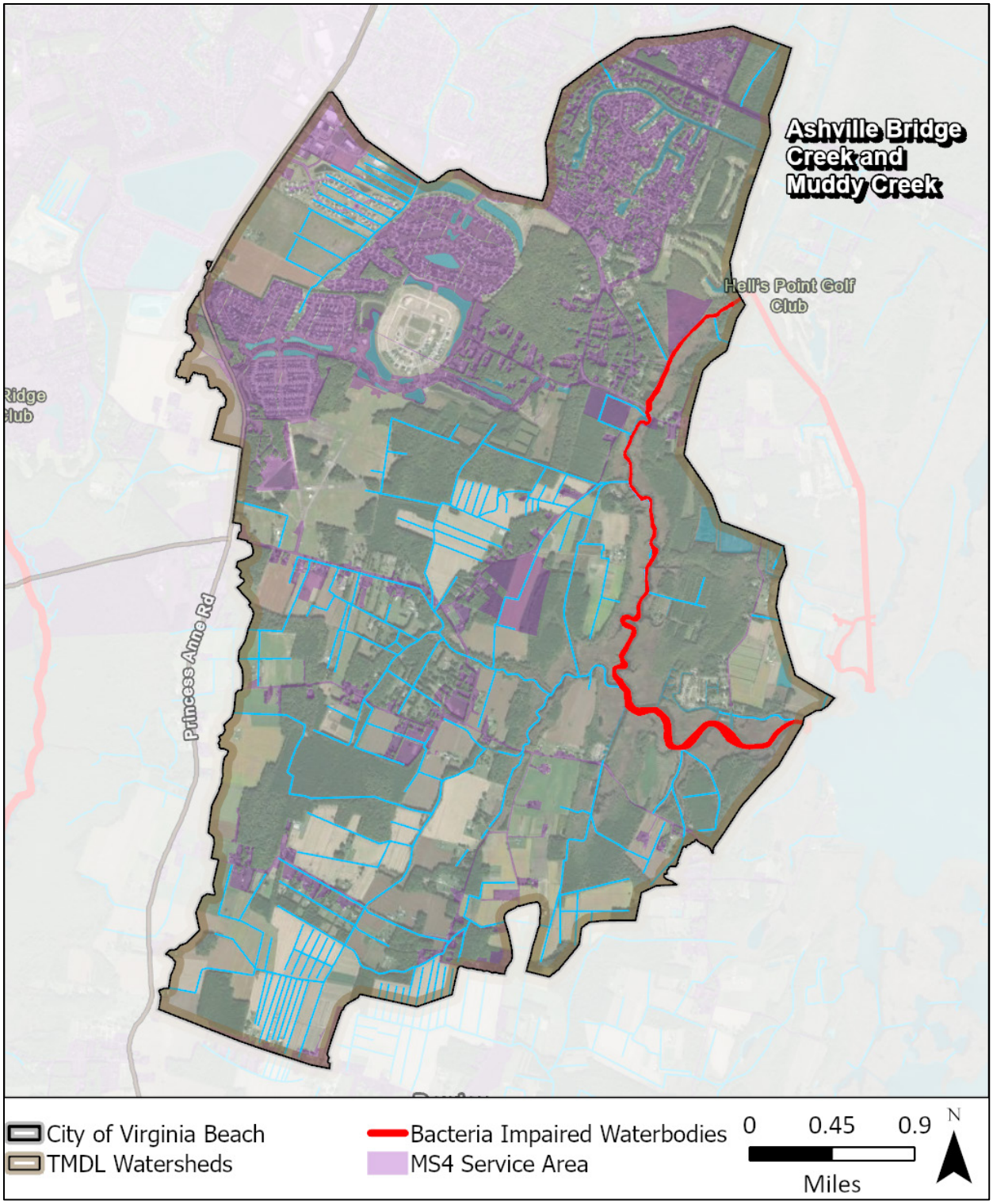

Figure A1. Ashville Bridge and Muddy Creek watershed and MS4 service area

A1.2. Beggars Bridge Creek

Beggars Bridge Creek flows east before its confluence with Shipps Bay. Beggars Bridge Creek, from its confluence with numerous unnamed tributaries near Dawley Corners (river mile [RM] 1.34) to its mouth at Shipps Bay, was listed on the 2006 303(d) list for impairments related to the support of recreational beneficial uses. DEQ monitoring station 5BBBC000.76 had a 31.4 percent bacteria standard violation rate per the 2010 assessment.

The Beggars Bridge Creek drainage area is 2,553 acres, which is entirely within City boundaries. The MS4 service area within the watershed is 200 acres, which is 8 percent of the bacteria TMDL watershed area.

The total existing load, WLA, and required reduction for Beggars Bridge Creek are presented in **Table A3**. **Figure A2** shows the watershed boundary and the MS4 service area within the watershed.

Table A3. Existing load, WLA, percent reduction required, and calculated reduction: Beggars Bridge Creek

Watershed	Existing Loading (cfu/yr)[a]	WLA (cfu/yr)[b]	Percent Reduction (percent)[a]
Beggars Bridge Creek	1.39E+13	4.17E+11	97

a. *Source:* Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments *(Table 5.10, Page 5-20)*

b. *Source:* Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments *(Table 5.11, Page 5-21)*

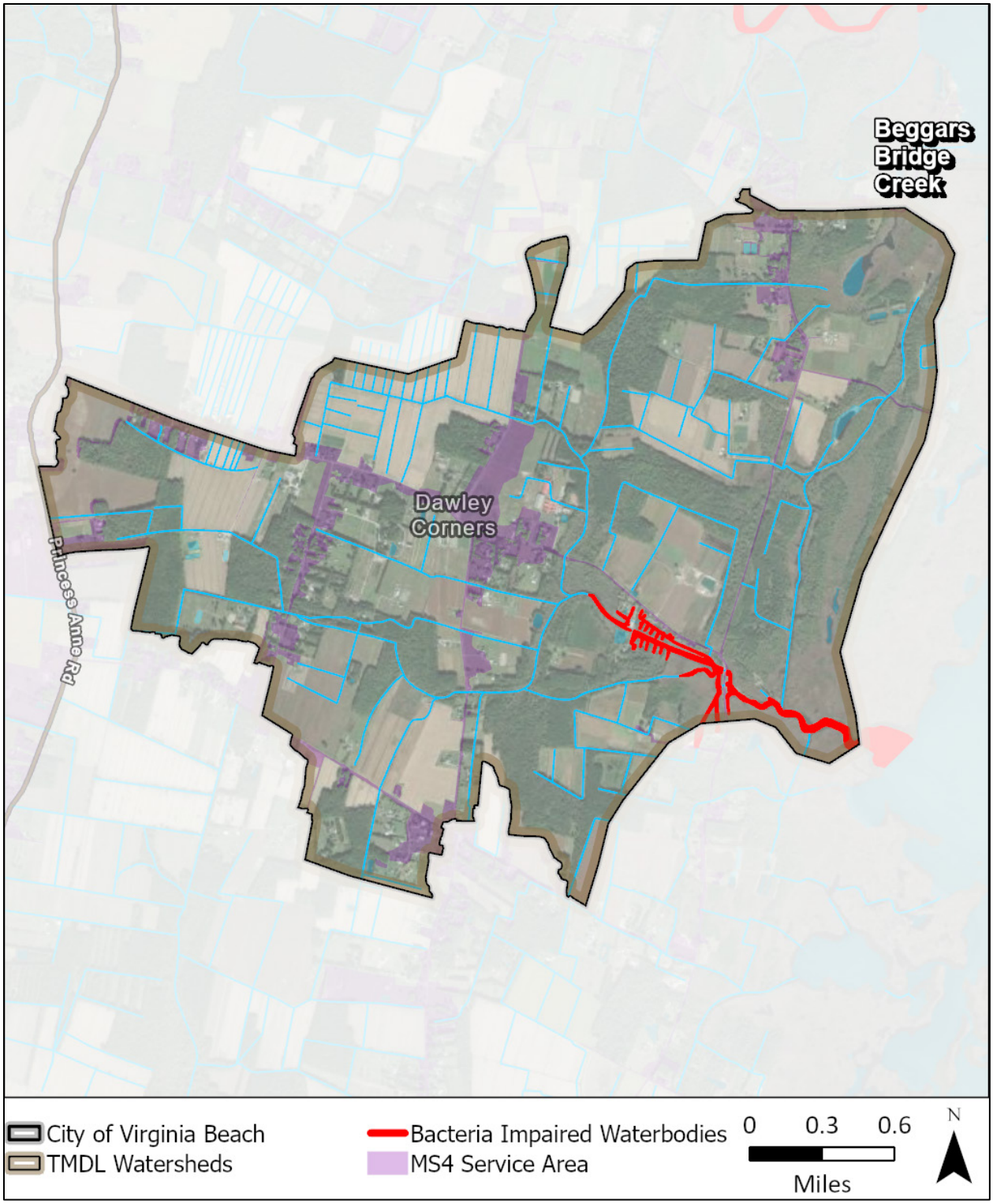

Figure A2. Beggars Bridge Creek watershed and MS4 service area

A1.3. Hell Point Creek, Upper and Lower

Hell Point Creek flows south before its confluence with North Bay. Two sections of Hell Point Creek are listed for impairments. The first section (Lower), downstream of the pedestrian bridge at Hell's Point Golf Club to the creek's mouth at North Bay, was listed on the 2004 303(d) list for impairments related to the support of recreational beneficial uses. DEQ monitoring station 5BHPC000.00 had a 38 percent bacteria standard violation rate per the 2010 assessment.

The second section (Upper), from the creek's headwaters south of Dam Neck Road to the end of the canal near Sandoval Drive, was listed on the 2006 303(d) list for impairments related to the support of recreational beneficial uses. DEQ monitoring station 5BHPC001.46 had a 27.8 percent bacteria standard violation rate per the 2010 assessment.

The Hell Point Creek, Upper and Lower drainage area is 8,580 acres, which is entirely within City boundaries. The MS4 service area within the watershed is 3,555 acres, which is 41 percent of the bacteria TMDL watershed area.

The total existing load, WLA, and required reduction for Hell Point Creek are presented in **Table A4**. **Figure A3** shows the watershed boundary and the MS4 service area within the watershed.

Table A4. Existing load, WLA, percent reduction required, and calculated reduction: Hell Point Creek

Watershed	Existing Loading (cfu/yr)[a]	WLA (cfu/yr)[b]	Percent Reduction (percent)[a]
Hell Point Creek: Upper and Lower	8.69E+13	1.74E+12	98

a. *Source: Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments (Table 5.18, Page 5-32)*

b. *Source: Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments (Table 5.19, Page 5-33)*

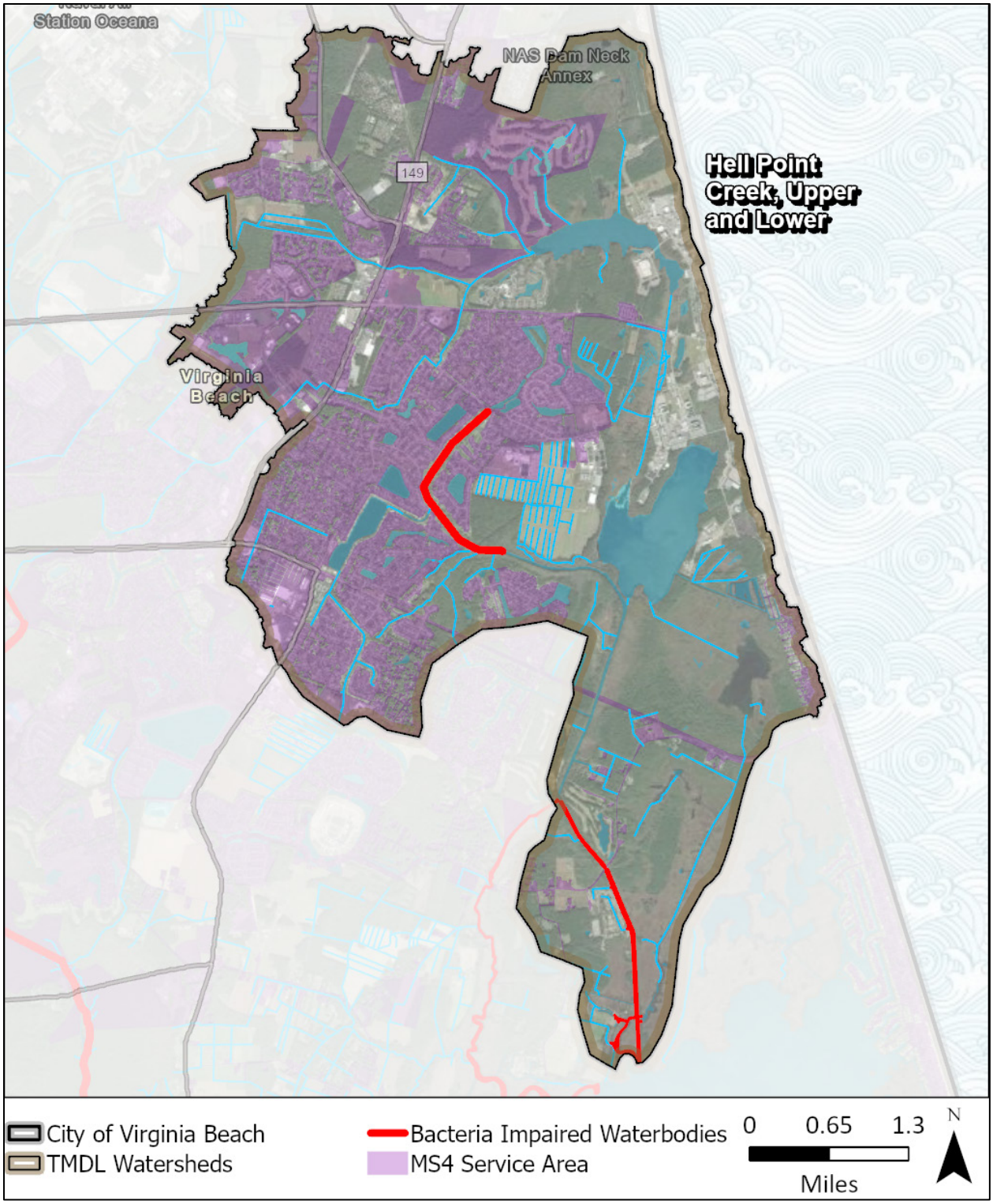

Figure A3. Hell Point Creek watershed and MS4 service area

A1.4. North Landing River

The portion of North Landing River within the City flows southeast before the Virginia/North Carolina state line. North Landing River, from the area east of Fentress Landing Field to its confluence with West Neck Creek and Pocaty River, was listed on the 2006 303(d) list for impairments related to the support of recreational beneficial uses. DEQ monitoring station 5BNLR010.75 had a 22.2 percent bacteria standard violation rate per the 2010 assessment.

The North Landing River drainage area is 41,856 acres, of which 17,898 are within City boundaries. The MS4 service area within the watershed is 11,746 acres, which is 66 percent of the bacteria TMDL watershed area within the City.

The total existing load, WLA, and required reduction for North Landing River are presented in **Table A5**. **Figure A4** shows the watershed boundary and the MS4 service area within the watershed.

Table A5. Existing load, WLA, percent reduction required, and calculated reduction: North Landing River

Watershed	Existing Loading (cfu/yr)[a]	WLA (cfu/yr)[b]	Percent Reduction (percent)[a]
North Landing River: Middle	3.86E+13	2.32E+12	94

a. *Source: Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments (Table 5.2, Page 5-8)*

b. *Source: Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments (Table 5.3, Page 5-9)*

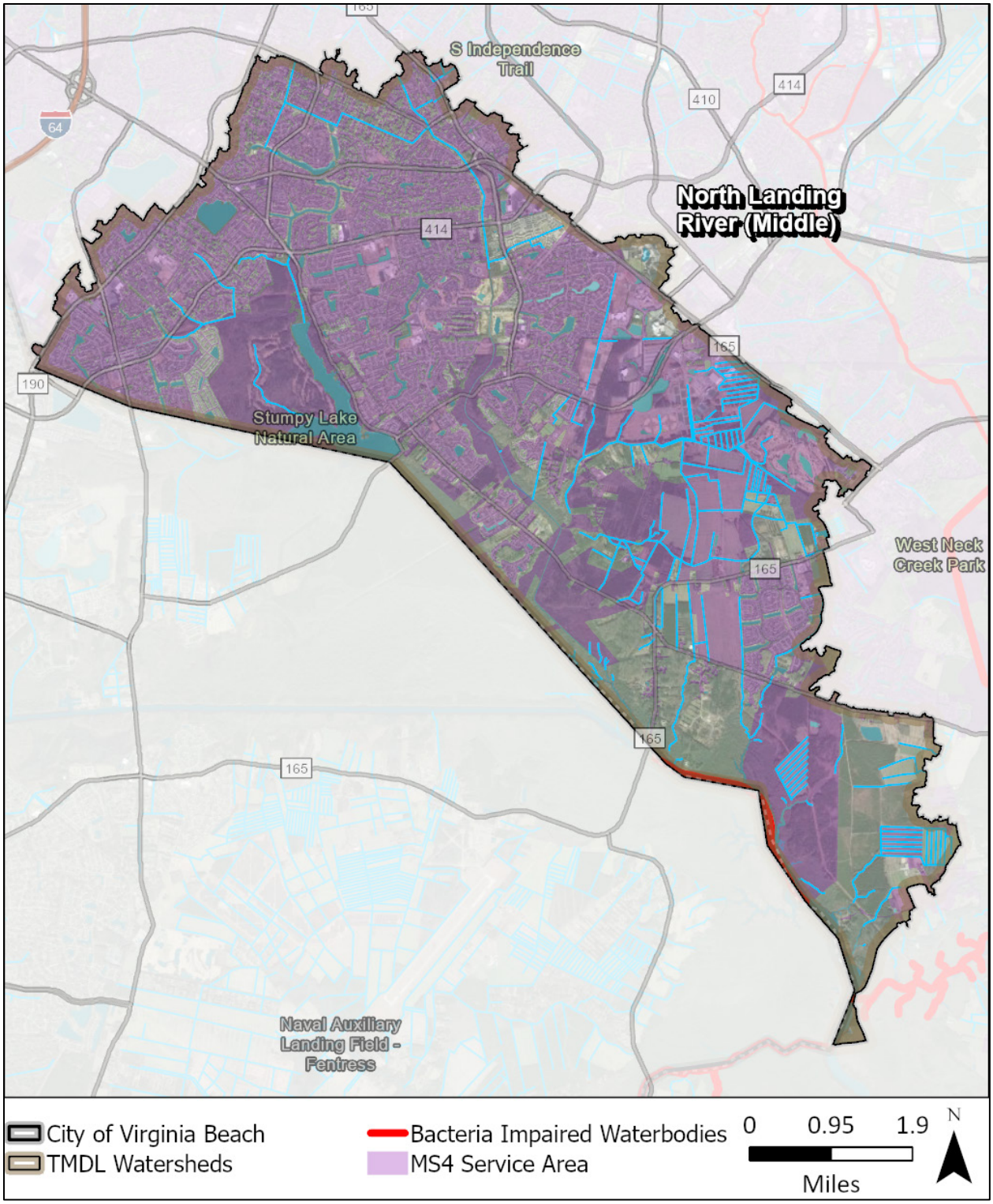

Figure A4. North Landing River watershed and MS4 service area

A1.5. Pocaty River

The portion of the Pocaty River within the City flows northeast before its confluence with the North Landing River. Pocaty River, from its headwaters at RM 3.92 to its confluence with the North Landing River, was listed on the 2002 303(d) list for impairments related to the support of aquatic life beneficial uses. It was also added to the 2012 303(d) list for impairments related to the support of recreational beneficial uses. DEQ monitoring station 5BPCT001.79 had a 14.7 percent bacteria standard violation rate per the 2010 assessment.

The Pocaty River drainage area is 16,977 acres, of which 2,207 are within City boundaries. The MS4 service area within the watershed is 65 acres, which is 0.4 percent of the bacteria TMDL watershed area within the City.

The existing total load, WLA, and required reduction for Pocaty River are presented in **Table A6**. **Figure A5** shows the watershed boundary and the MS4 service area within the watershed.

Table A6. Existing load, WLA, percent reduction required, and calculated reduction: Pocaty River

Watershed	Existing Loading (cfu/yr)[a]	WLA (cfu/yr)[b]	Percent Reduction (percent)[a]
Pocaty River	1.01E+13	1.31E+12	87

a. *Source:* Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments *(Table 5.6, Page 5-14)*

b. *Source:* Total Maximum Daily Load Development for the Back Bay, North Landing River, and Pocaty River Watersheds E. coli, and Enterococci Due to Recreation Use Impairments, and Total Phosphorus Due to Low Dissolved Oxygen in Aquatic Life Use Impairments *(Table 5.7, Page 5-15)*

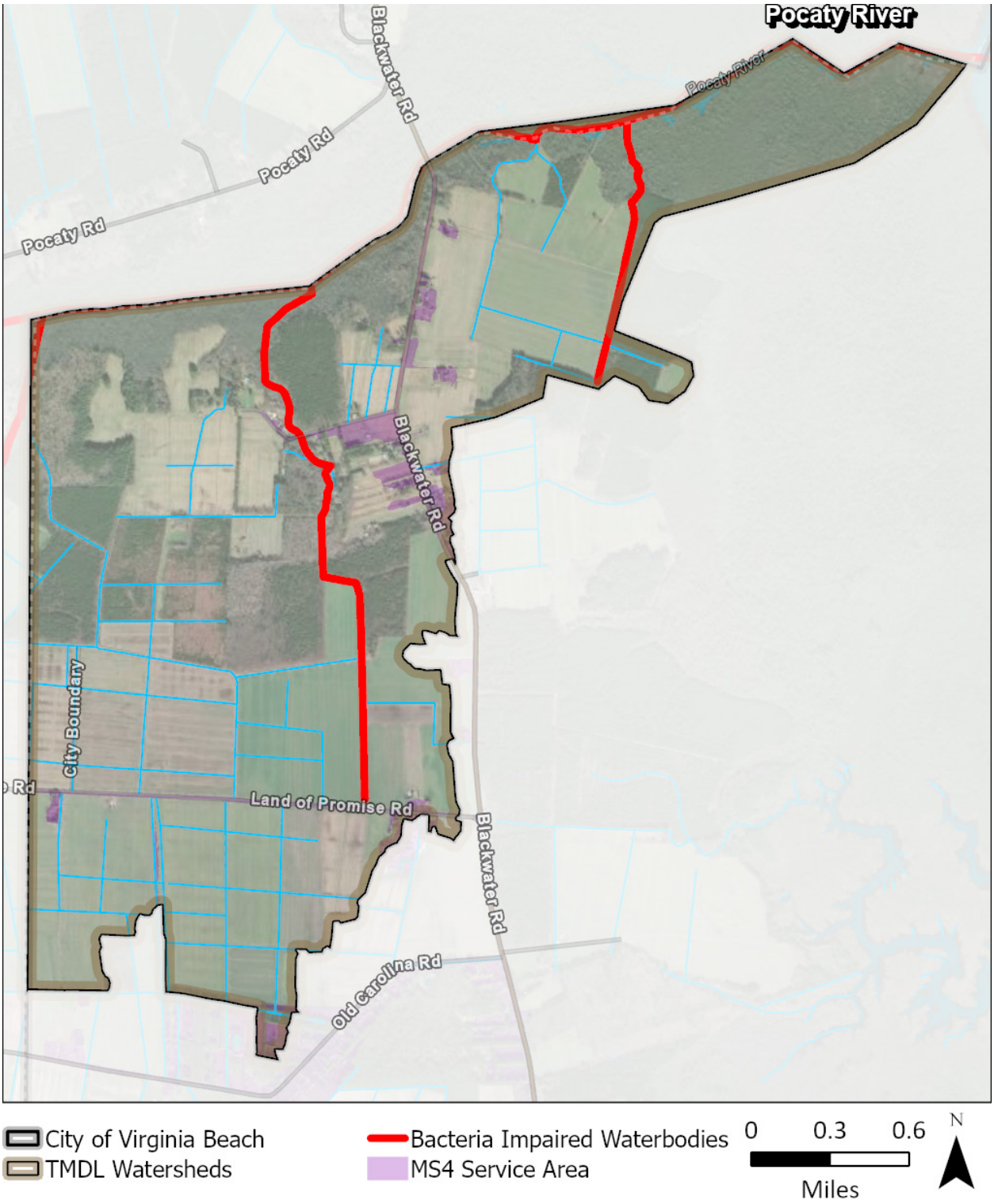

Figure A5. Pocaty River watershed and MS4 service area

A2. Coastal Area TMDLs

The Coastal Area TMDL study area contains six impaired waterbodies: London Bridge Creek and Canal #2, Milldam Creek, Nawney Creek (Upper), Nawney Creek (Lower), West Neck Creek (Middle), and West Neck Creek (Upper). Milldam Creek and West Neck Creek (Middle) are both freshwater waterbodies; TMDLs were developed for these watersheds using thresholds for *E. coli*, the indicator bacteria most appropriate for freshwater waterbodies.

The remaining four waterbodies are transitional or saltwater waterbodies. Due to their hydrologic connectivity, Nawney Creek Upper and Lower were grouped together for TMDL development. TMDLs were developed for (1) London Bridge Creek and Canal #2, (2) Nawney Creek, and (3) West Neck Creek (Upper) using thresholds for enterococci, the indicator bacteria most appropriate for transitional and saltwater waterbodies.

WLAs for the City MS4 were only assigned for the London Bridge Creek and Canal #2 and West Neck Creek (Upper) watersheds. Therefore, only those two TMDL watersheds are considered in this TMDL Action Plan.

Bacteria sources were identified and quantified in the study areas, including both point and nonpoint sources. Bacteria sources included waste from humans, livestock, wildlife, and domestic pets, as well as permitted point sources. **Table A7** summarizes the sources described in the Coastal Area TMDL report for the watersheds relevant to this Action Plan

Table A7. Source assessment data from TMDL reports: Coastal Area TMDLs

TMDL Watershed	Sources	Human Population (2020)
London Bridge Creek and Canal #2	Point sources (fecal matter): 2 MS4 permits (City and the Naval Station)	47,237
West Neck Creek, Upper	Nonpoint sources: septic systems, land application of waste, livestock, wildlife, and pets	25,110

Source: Development of Bacterial TMDLs for the Virginia Beach Coastal Area (London Bridge Creek & Canal #2, Milldam Creek, Nawney Creek, West Neck Creek (Middle), and West Neck Creek (Upper)) (Table 3.6, Page 3-8)

A2.1. London Bridge Creek and Canal #2

London Bridge Creek and Canal #2 flow north to Lynnhaven Bay. London Bridge Creek and Canal #2, between Shipps Corner and the confluence of Thurston Branch, was listed on the 1996 303(d) list for impairments related to the support of recreational beneficial uses. DEQ monitoring station 7LOB003.70 had a 59 percent bacteria standard violation rate per the 2002 assessment.

The London Bridge Creek and Canal #2 drainage area is 8,008 acres, all of which is within City boundaries. The MS4 area within the watershed is 4,231 acres, which is 53 percent of the bacteria TMDL watershed area.

The existing total load, WLA, and required reduction for London Bridge Creek and Canal #2 are presented in **Table A8**. **Figure A6** shows the watershed boundary and the MS4 service area within the watershed.

Table A8. Existing load, WLA, percent reduction required, and calculated reduction: London Bridge Creek and Canal #2

Watershed	Existing Loading (cfu/yr)	WLA (cfu/yr)[a]	Percent Reduction (percent)[a]
London Bridge Creek and Canal #2	N/A	1.82E+13	88%

a. *Source:* Development of Bacterial TMDLs for the Virginia Beach Coastal Area (London Bridge Creek & Canal #2, Milldam Creek, Nawney Creek, West Neck Creek (Middle), and West Neck Creek (Upper)) *(Table 5.7, Page 5-24)*

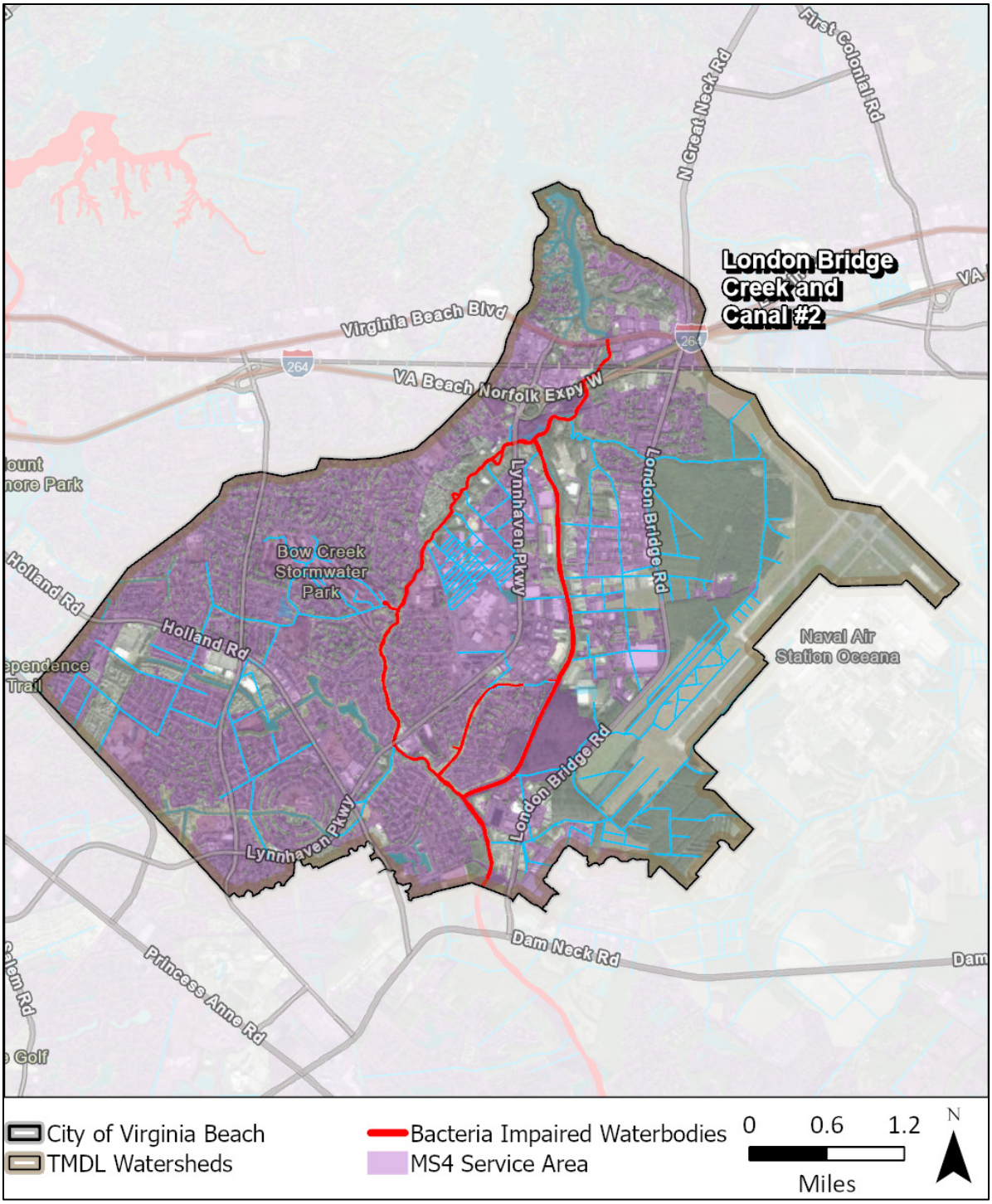

Figure A6. London Bridge Creek and Canal #2 watershed and MS4 service area

A2.2. West Neck Creek, Upper

West Neck Creek, Upper flows south to West Neck Creek, Middle before its confluence with the North Landing River. West Neck Creek, Upper, from the Princess Anne Road crossing to its junction with London Bridge Creek, was listed on the 1998 303(d) list for impairments related to the support of recreational beneficial uses. DEQ monitoring station 5BWNC010.02 had a 31 percent bacteria standard violation rate per the 2002 assessment.

The West Neck Creek, Upper drainage area is 8,580 acres, which is entirely within City boundaries. The MS4 service area within the watershed is 3,533 acres, which is 41 percent of the bacteria TMDL watershed area.

The total existing load, WLA, and required reduction for West Neck Creek, Upper are presented in **Table A9**. **Figure A7** shows the watershed boundary and the MS4 service area within the watershed.

Table A9. Existing load, WLA, percent reduction required, and calculated reduction: West Neck Creek, Upper

Watershed	Existing Loading (cfu/yr)	WLA (cfu/yr)[a]	Percent Reduction (percent)[a]
West Neck Creek: Upper	N/A	7.81E+12	85

a. *Source:* Development of Bacterial TMDLs for the Virginia Beach Coastal Area (London Bridge Creek & Canal #2, Milldam Creek, Nawney Creek, West Neck Creek (Middle), and West Neck Creek (Upper)) *(Table 5.8, Page 5-25)*

Non-applicable (N/A) is noted where the values were not present in the published TMDL reports.

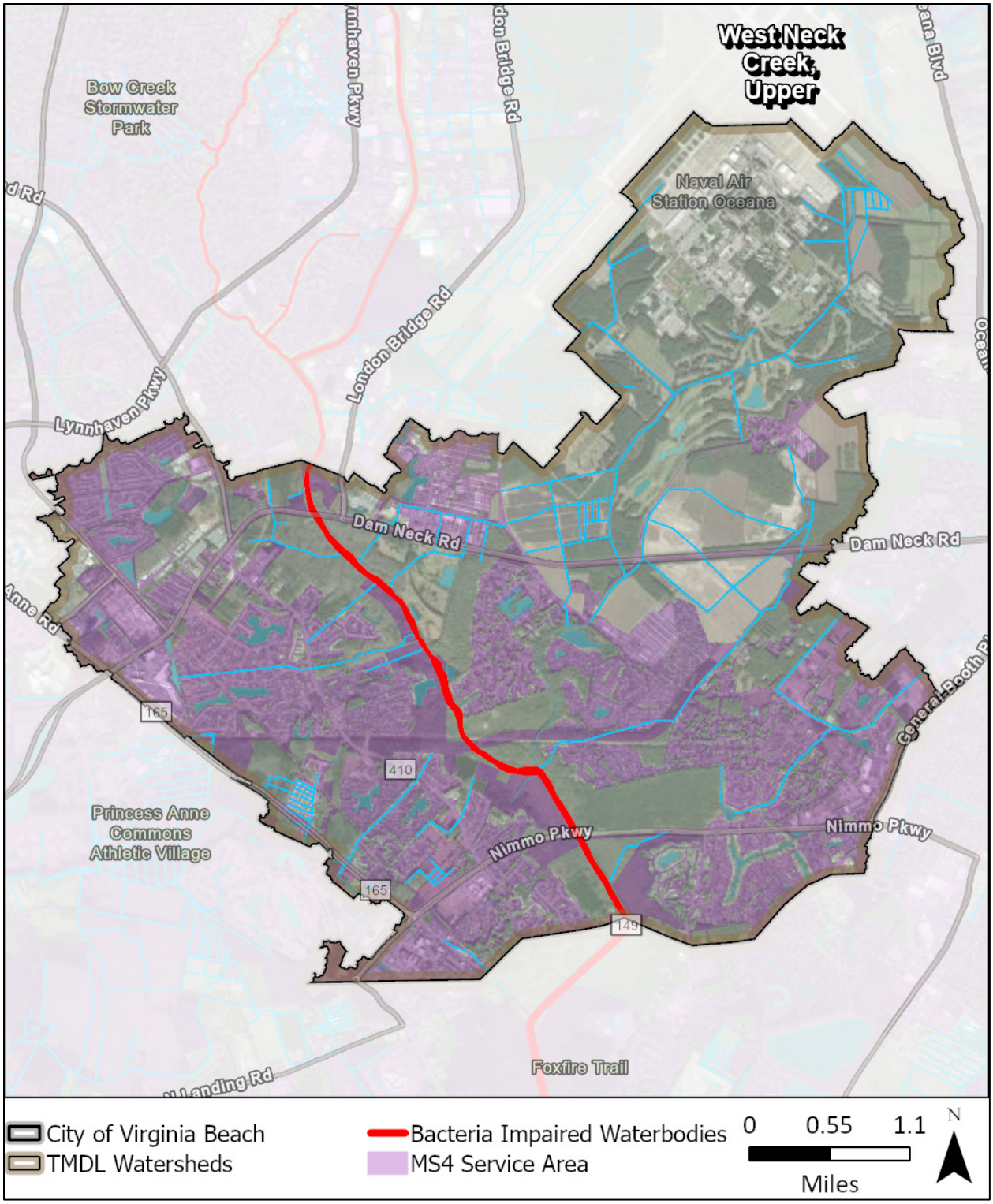

Figure A7. West Neck Creek, Upper watershed and MS4 service area

A3. Lynnhaven Bay, Broad Bay, and Linkhorn Bay TMDLs

The Lynnhaven Bay, Broad Bay, and Linkhorn Bay TMDL study area contains two impaired waterbodies: Lynnhaven Bay and its tributaries, and Broad Bay and its tributaries, including Long Creek and Linkhorn Bay. Both watersheds support the production of shellfish for human consumption; therefore, TMDLs were developed using thresholds for fecal coliform, the indicator bacteria used to assign water quality criteria for shellfishing.

Bacteria sources were identified and quantified in the study areas, including both point and nonpoint sources. Bacteria sources included waste from humans, livestock, wildlife, and domestic pets, as well as permitted point sources. **Table A10** summarizes the sources described in the Lynnhaven Bay, Broad Bay, and Linkhorn Bay TMDL report.

Table A10. Source assessment data from TMDL reports: Lynnhaven Bay, Broad Bay, and Linkhorn Bay TMDLs

TMDL Watershed	Sources	Human Population (2020)
Broad Bay, Long Creek, and Linkhorn Bay	Point sources (fecal matter): 1 MS4 permit (the City of Virginia Beach)	35,337
Lynnhaven Bay	Nonpoint sources: septic systems, marinas, livestock, biosolids, wildlife, and pets	159,458

Source: Lynnhaven Bay, Broad Bay and Linkhorn Bay Watersheds Total Maximum Daily Load (TMDL) Report for Shellfish Areas Listed Due to Bacteria Contamination (Figure 3-1, Page 5)

Both recreational and commercial shellfishing occur in these watersheds. Two segments within the Lynnhaven, Broad, and Linkhorn bays have been regulated pursuant to Title 28.2 Chapter 8, Sections 228.2-803, 228.2-808, 32.1-20, and 9-6.14:4.1 B16 of the Code of Virginia by the Virginia Department of Health (VDH), Division of Shellfish Sanitation (DSS). VDH-DSS collects monthly samples at more than 2,000 stations in Virginia shellfish growing areas. Every 6 months, VDH-HSS determines if the data show that water quality standards have been met. If the water quality standards are exceeded, the shellfish area is closed for the harvest of shellfish that go directly to market.

Monthly sampling by VDH-DSS is not conducted for the purpose of evaluating the watershed pursuant to the TMDLs. However, results could still be used to assess progress toward achieving bacteria reductions as outlined in the TMDL report.

A3.1. Broad Bay, Long Creek, and Linkhorn Bay

Broad Bay, Long Creek, and Linkhorn Bay are within the City boundaries and lie directly east of State Route (SR) 279. These waterbodies flow north and northwest before their confluence with Lynnhaven Bay near the mouth of the Chesapeake Bay. Broad Bay, Long Creek, and Linkhorn Bay were listed on the 1998 303(d) list for impairments related to the support of shellfishing beneficial uses. Half of the VDH-DSS monitoring stations showed bacteria standard violations during the time frame used for TMDL development (January 2001 to February 2003).

The Broad Bay, Long Creek, and Linkhorn Bay drainage area is 10,946 acres, all of which is within City boundaries. The MS4 service area within the watershed is 3,426 acres, which is 31 percent of the bacteria TMDL watershed area.

The total existing load, WLA, and required reduction for Broad Bay, Long Creek, and Linkhorn Bay are presented in **Table A11**. **Figure A8** shows the watershed boundary and the MS4 service area within the watershed.

Table A11. Existing load, WLA, percent reduction required, and calculated reduction: Broad Bay, Long Creek, and Linkhorn Bay

Watershed	Existing Loading (cfu/yr)[a]	WLA (cfu/yr)[a]	Percent Reduction (percent)[a]
Broad Bay, Long Creek, and Linkhorn Bay	3.28E+11	9.35E+10	16.2

a. *Source:* Lynnhaven Bay, Broad Bay and Linkhorn Bay Watersheds Total Maximum Daily Load (TMDL) Report for Shellfish Areas Listed Due to Bacteria Contamination *(Table 5-7, Page 37)*

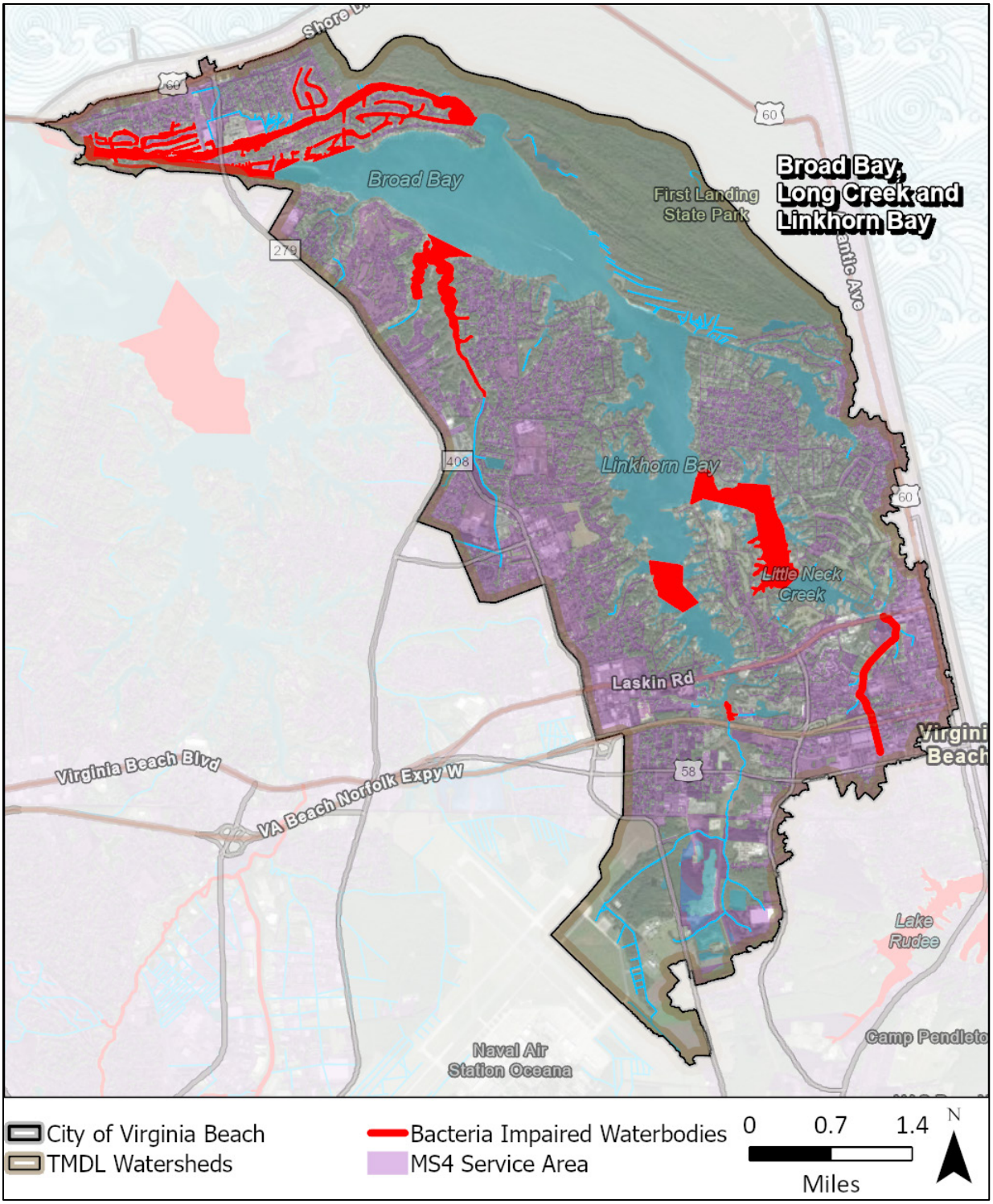

Figure A8. Broad Bay, Long Creek, and Linkhorn Bay watershed and MS4 service area

A3.2. Lynnhaven Bay

The Lynnhaven River flows north from its headwaters (bordering SR 264 to the south, SR 279 to the east, and SR 225 and SR 190 to the west) to Lynnhaven Bay. Lynnhaven Bay was listed on the 1998 303(d) list for impairments related to the support of shellfishing beneficial uses. All VDH-DSS monitoring stations in the watershed showed bacteria standard violations during the time frame used for TMDL development (January 2001 to February 2003).

The Lynnhaven Bay drainage area is 29,352 acres, all of which is within City boundaries. The MS4 service area within the watershed is 10,068 acres, which is 34 percent of the bacteria TMDL watershed area.

The total existing load, WLA, and required reduction for Lynnhaven Bay are presented in **Table A12**. **Figure A9** shows the watershed boundary and the MS4 service area within the watershed.

Table A12. Existing load, WLA, percent reduction required, and calculated reduction: Lynnhaven Bay

Watershed	Existing Loading (cfu/yr)[a]	WLA (cfu/yr)[a]	Percent Reduction (percent)[a]
Lynnhaven Bay	1.43E+13	9.01E+11	81.5%

a. *Source:* Lynnhaven Bay, Broad Bay and Linkhorn Bay Watersheds Total Maximum Daily Load (TMDL) Report for Shellfish Areas Listed Due to Bacteria Contamination *(Table 5-6, Page 37)*

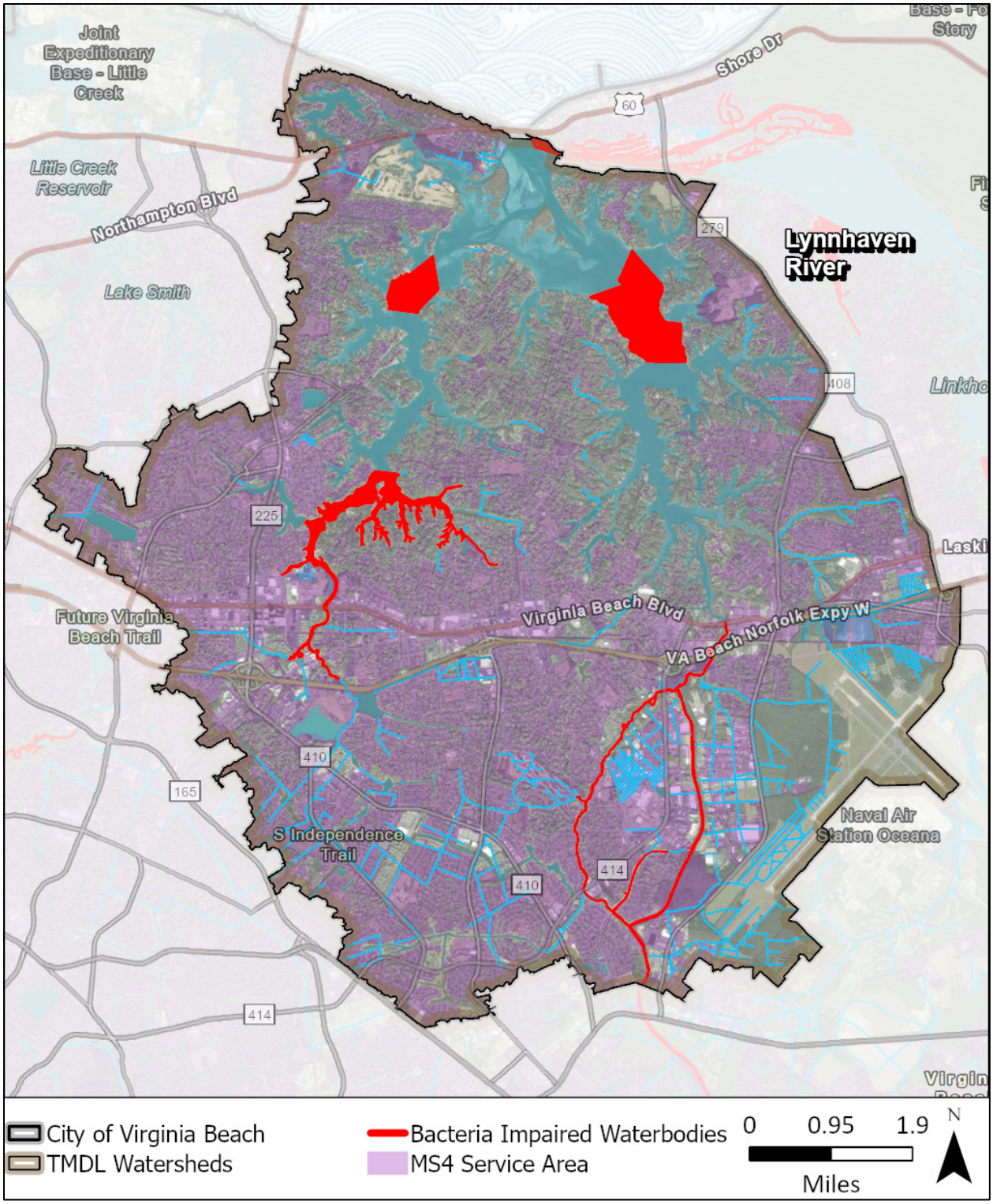

Figure A9. Lynnhaven Bay watershed and MS4 service area

A4. Elizabeth River TMDLs

The Elizabeth River TMDL study area contains nine impaired waterbodies: the Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Lower Western Branch, and Upper Western Branch of the Elizabeth River, Paradise Creek, Upper Lafayette River, and Indian River. Due to their hydrologic connectivity, some waterbodies were grouped together for TMDL development. TMDLs were developed for (1) Elizabeth River Upper Mainstem, Lower Southern Branch, and Lower Eastern Branch, Broad Creek, and Indian River, (2) Elizabeth River Upper and Lower Western Branch, (3) Upper Lafayette River, and (4) Paradise Creek using thresholds for both fecal coliform and enterococci.

WLAs for the City MS4 were only assigned for the Elizabeth River Upper Mainstem, Lower Southern Branch, and Lower Eastern Branch, Broad Creek, and Indian River watershed. Therefore, only that TMDL watershed is considered in this TMDL Action Plan. The TMDL for that watershed was developed using thresholds for enterococci.

Bacteria sources were identified and quantified in the study area, including both point and nonpoint sources. Bacteria sources included waste from humans, livestock, wildlife, agricultural activities, and domestic pets, as well as permitted point sources. **Table A13** summarizes the sources described in the Elizabeth River TMDL report.

Table A13. Source assessment data from TMDL reports: Elizabeth River TMDL

TMDL Watershed	Sources	Human Population (2020)
Upper Mainstem, Lower Southern Branch, Lower Eastern Branch Elizabeth River, Broad Creek, Indian River	Point sources (fecal matter): 51 individual permitted facilities, 94 general permitted facilities, 8 MS4 permits (4 Phase I and 4 Phase II), SSOs Nonpoint sources: septic systems, marinas, livestock, biosolids, wildlife, and pets	58,554

a. Source: Bacteria Total Maximum Daily Load (TMDL) Development for the Elizabeth River Watershed (Table 2-26, Page 2-31)

The Elizabeth River watershed is the largest described in this Action Plan. Elizabeth River collects discharge from its west, south, and east branches, and then flows north to Chesapeake Bay. The impaired segments of the Elizabeth River were first listed on the 303(d) list in various years for impairments related to the support of recreational beneficial uses:

- Elizabeth River Upper Mainstem (DEQ monitoring station: VAT-G15E_ELI01A06): first listed in 2006
- Elizabeth River Lower Southern Branch (DEQ monitoring station: VAT-G15E_SBE03A06): first listed in 1998
- Elizabeth River Lower Eastern Branch (DEQ monitoring station: VAT-G15E_EBE02A06): first listed in 1998
- Indian River (DEQ monitoring station: VAT-G15E_IND01A02): first listed in 2006
- Broad Creek (DEQ monitoring station: VAT-G15E_BRO01A02): first listed in 2006

The Elizabeth River drainage area is 82,666 acres, of which 9,397 acres are within City boundaries. The MS4 service area within the watershed is 5,963 acres, which is 63 percent of the bacteria TMDL watershed area within the City boundary.

The total existing load, WLA, and required reduction for the Elizabeth River are presented in **Table A14**. **Figure A10** shows the watershed boundary and the MS4 service area within the watershed.

Table A14. Existing load, WLA, percent reduction required, and calculated reduction: Lynnhaven Bay

Watershed	Existing Loading (cfu/d)[a]	WLA (cfu/d)[a]	Percent Reduction (percent)[a]
Elizabeth River	2.16E+14	1.03E+13	95

a. Source: Bacteria Total Maximum Daily Load (TMDL) Development for the Elizabeth River Watershed (Table 4-4, Page 4-7)

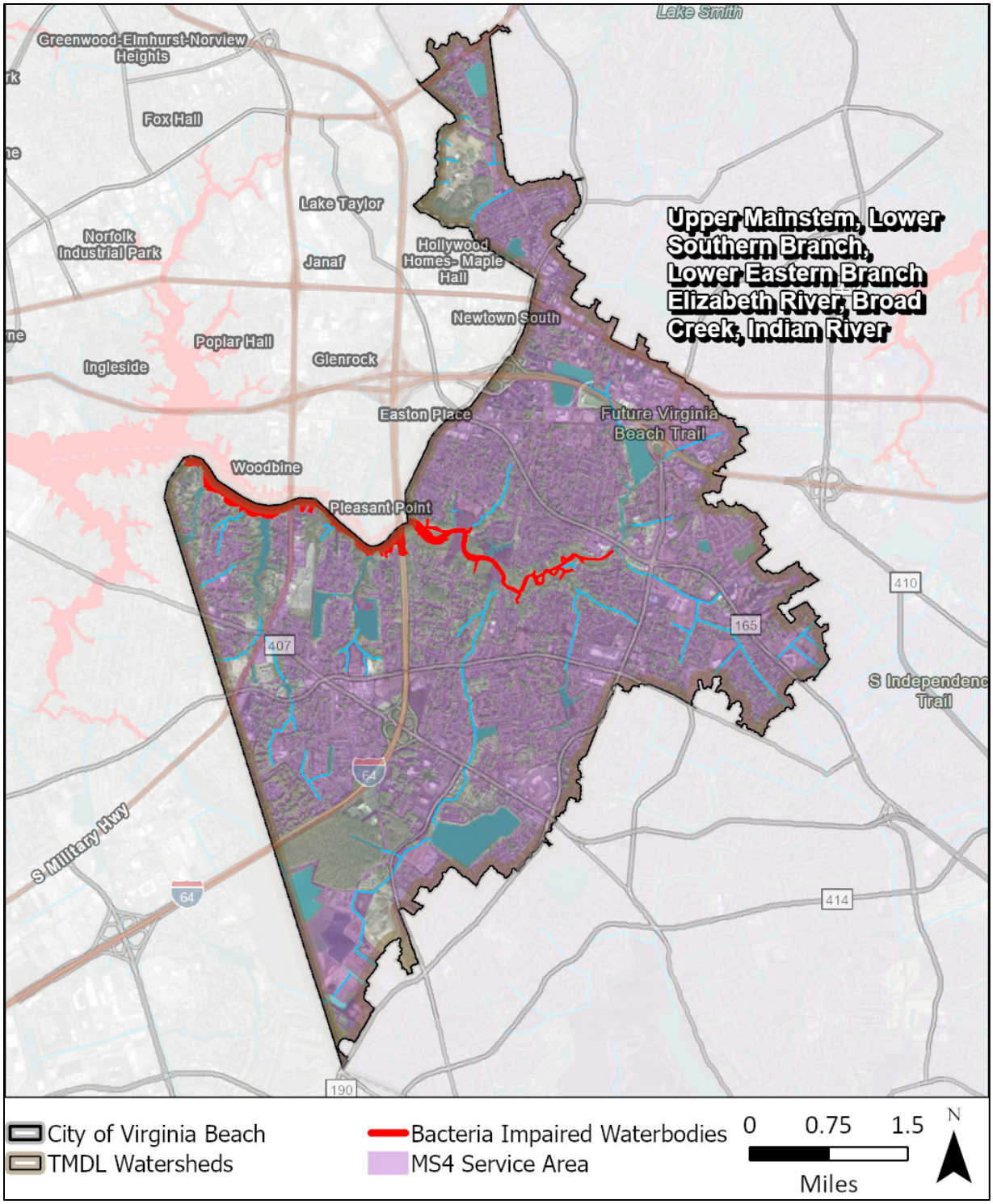

Figure A10. Elizabeth River watershed and MS4 service area

A5. Rudee Inlet TMDL

The Rudee Inlet TMDL study area contains five impaired waterbodies: Lake Wesley (Upstream Branches), Lake Rudee (Upper), Lake Rudee (Lower), Owl Creek (Upper), and Owl Creek (Lower). Due to these waterbodies' hydrologic connectivity, they were all grouped together for TMDL development. Because the Rudee Inlet watershed supports both recreational and shellfishing beneficial uses, TMDLs were developed for Rudee Inlet using thresholds for both enterococci and fecal coliform.

Bacteria sources were identified and quantified in the study areas, including both point and nonpoint sources. Bacteria sources included waste from humans, livestock, wildlife, and domestic pets, as well as permitted point sources. **Table A15** summarizes the sources described in the Rudee Inlet TMDL report.

Table A15. Source assessment data from TMDL reports: Rudee Inlet TMDL

TMDL Watershed	Sources	Human Population (2020)
Rudee Inlet	Point sources: 1 individual permitted facility, 1 MS4 permit (Phase I)[a] Nonpoint sources: recreational boating, pets, septic systems, wildlife, and SSOs[b]	11,152

a. *Source: Total Maximum Daily Load for Bacteria and a Proactive Implementation Approach for Dissolved Oxygen Impairment for Rudee Inlet, Virginia Beach, Virginia (Table 3.1, Page 21)*
b. *Source: Total Maximum Daily Load for Bacteria and a Proactive Implementation Approach for Dissolved Oxygen Impairment for Rudee Inlet, Virginia Beach, Virginia (Section 3.2, Page 22)*

Rudee Inlet flows northeast to its confluence with the Atlantic Ocean. The impaired segments of Rudee Inlet were first listed on the 303(d) list in various years for impairments related to the support of both recreational and shellfishing beneficial uses:

- Lake Wesley – Upstream Branches (DEQ monitoring station: VAT-D07E_LAE01A06): first listed in 2006 for shellfishing impairments
- Lake Rudee – Upper (DEQ monitoring station: VAT-D07E_LAI01A06): first listed in 2004 for recreation impairments and in 2006 for shellfishing impairments
- Lake Rudee – Lower (DEQ monitoring station: VAT-D07E_LAI02A06): first listed in 2006 for shellfishing impairments
- Owl Creek – Upper (DEQ monitoring station: VAT-D07E_OWL01A02): first listed in 2002 for recreation impairments and in 2006 for shellfishing impairments
- Owl Creek – Lower (DEQ monitoring station: VAT-D07E_OWL02A02: first listed in 2006 for shellfishing impairments and in 2008 for recreation impairments

The Rudee Inlet drainage area is 2,684 acres, which is entirely within City boundaries. The MS4 service area within the watershed is 1,192 acres, which is 44 percent of the bacteria TMDL watershed area.

The total existing load, WLA, and required reduction for Rudee Inlet are presented in **Table A16**. The WLA assigned for Rudee Inlet was developed using thresholds for fecal coliform to address shellfishing impairments. Attainment of WLAs for fecal coliform are assumed to satisfy recreational beneficial use requirements for enterococci. **Figure A11** shows the watershed boundary and the MS4 service area within the watershed.

Table A16. Existing load, WLA, percent reduction required, and calculated reduction: Rudee Inlet

Watershed	Existing Loading (cfu/yr)[a]	WLA (cfu/yr)[a]	Percent Reduction (percent)[a]
Rudee Inlet	1.90E+14	2.07E+13	89

a. *Source: Total Maximum Daily Load for Bacteria and a Proactive Implementation Approach for Dissolved Oxygen Impairment for Rudee Inlet, Virginia Beach, Virginia (Table 5.4, Page 43)*

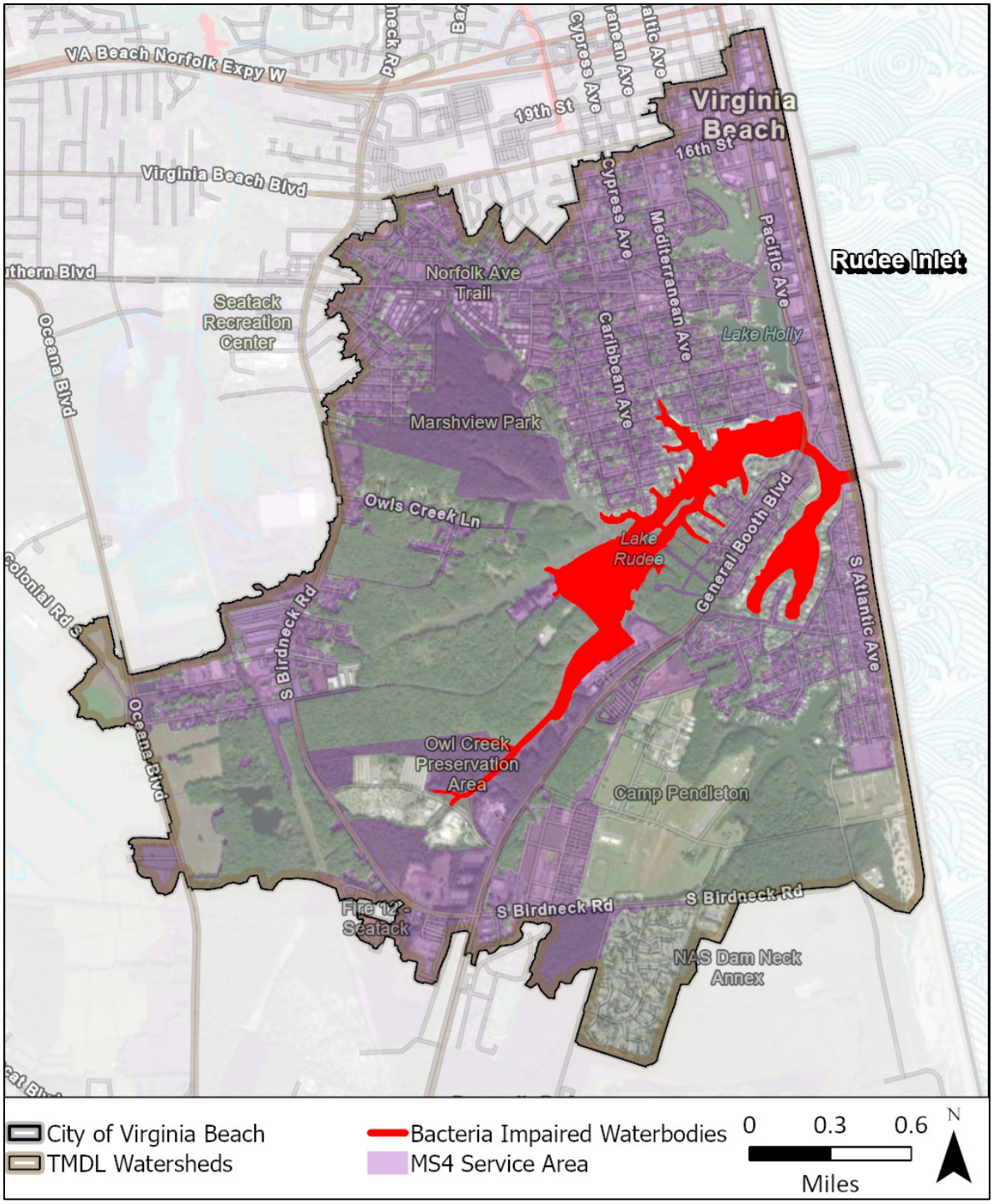

Figure A11. Rudee Inlet watershed and MS4 service area

Appendix B: SWMFs by Watershed

Appendix B presents information related to SWMFs installed in the City as of January 2025. SWMFs were assigned to TMDL watersheds based on the physical location of the facility, not the location of the SWMF drainage area. In some cases, the drainage area for a SWMF spans multiple TMDL watersheds due to drainage modifications that route drainage between watersheds.

B1. Back Bay, North Landing River, and Pocaty River TMDLs

B1.1. Ashville Bridge and Muddy Creek

There are 47 SWMFs in the Ashville Bridge and Muddy Creek watershed treating stormwater from City MS4 service areas. **Table B1** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated. Some drainage areas are treated by multiple SWMFs; those areas are included in the totals of all SWMF types that treat that area.

Furthermore, some SWMFs in this watershed may treat drainage areas from other watersheds due to drainage modifications that route drainage between watersheds. Drainage areas from other watersheds are included in values presented in **Table B1** but are not included in watershed totals presented in the following paragraph and in **Table 3-1** in the Action Plan.

The total MS4 service area in the Ashville Bridge and Muddy Creek watershed is 1,050.7 acres. Of that area, 741 acres are treated by SWMFs (both within and outside the watershed), which equates to 70.5 percent of the MS4 service area in the watershed (see **Table 3-1** in the Action Plan). This value represents the total treated MS4 service area in the watershed but not the total treated by SWMFs located within the watershed. Some MS4 service areas in the watershed are treated by SWMFs outside the watershed boundaries.

Table B1. SWMF summary: Ashville Bridge and Muddy Creek Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Extended Detention Pond	5	9.2	4.7
Grass Channels	2	4.2	0.0
Infiltration Practices	7	9.6	5.7
Permeable Pavement	1	12.5	1.2
StormTech Isolator Row	1	2.3	0.0
Wet Pond	31	957.2	336.3

NOTE: Totals in this table do not match watershed totals in Table 3-1 due to the methodology used to assign SWMFs to watersheds. Values in this table show only SWMFs in this watershed's boundaries and the drainage areas of those SWMFs (even if drainage areas extend beyond watershed boundaries).

B1.2. Beggars Bridge Creek

There are 2 SWMFs in the Beggars Bridge Creek watershed treating stormwater from City MS4 service areas. **Table B2** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated.

The total MS4 service area in the Beggars Bridge Creek watershed is 199.9 acres. Of that area, 7.9 acres are treated by SWMFs within the watershed, which equates to 4.0 percent of the MS4 service area in the watershed (see **Table 3-1**).

Table B2. SWMF summary: Beggars Bridge Creek Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Extended Detention Pond	1	15.0	6.4
Wet Pond	1	6.3	1.6

B1.3. Hell Point Creek, Lower and Upper

There are 162 SWMFs in the Hell Point Creek, Lower and Upper watersheds treating stormwater from City MS4 service areas. **Table B3** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated. Some drainage areas are treated by multiple SWMFs; those areas are included in the totals of all SWMF types that treat that area.

Furthermore, some SWMFs in this watershed may treat drainage areas from other watersheds due to drainage modifications that route drainage between watersheds. Drainage areas from other watersheds are included in values presented in **Table B3** but are not included in watershed totals presented in the following paragraph and in **Table 3-1** in the Action Plan.

The total MS4 service area in the Hell Point Creek, Lower and Upper watershed is 3,555.4 acres. Of that area, 3,466 acres are treated by SWMFs (both within and outside the watershed), which equates to 97.5 percent of the MS4 service area in the watershed (see **Table 3-1** in the Action Plan). This value represents the total treated MS4 service area in the watershed but not the total treated by SWMFs located within the watershed. Some MS4 service areas in the watershed are treated by SWMFs outside the watershed boundaries.

Table B3. SWMF summary: Hell Point Creek, Lower and Upper Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
BayFilter Stormwater Cartridge System	1	0.0	0.0
Bioretention	19	12.1	11.7
Continuous Deflective Separator	2	2.0	1.4
Extended Detention Pond	24	96.4	56.0
Filterra Bioretention Systems	3	1.0	0.9
Grass Channels	3	7.1	4.8
Infiltration Practices	18	17.3	11.1
Jellyfish Filter	1	0.6	0.6
Permeable Pavement	7	7.8	3.7

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Stormceptor STC	4	3.1	3.0
StormTech Isolator Row	1	0.6	0.5
Volume Control Facility Closed	1	4.6	4.3
Volume Control Facility Open	44	13,453.4	5,644.9
Wet Pond	33	612.8	417.9
Wet Swales	1	0.0	0.0

NOTE: Totals in this table do not match watershed totals in Table 3-1 due to the methodology used to assign SWMFs to watersheds. Values in this table show only SWMFs in this watershed's boundaries and the drainage areas of those SWMFs (even if drainage areas extend beyond watershed boundaries).

B1.4. North Landing River

There are 332 SWMFs in the North Landing River watershed treating stormwater from City MS4 service areas. **Table B4** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated. Some drainage areas are treated by multiple SWMFs; those areas are included in the totals of all SWMF types that treat that area.

Furthermore, some SWMFs in this watershed may treat drainage areas from other watersheds due to drainage modifications that route drainage between watersheds. Drainage areas from other watersheds are included in values presented in **Table B4** but are not included in watershed totals presented in the following paragraph and in **Table 3-1** in the Action Plan.

The total MS4 service area in the North Landing River watershed is 11,746.1 acres. Of that area, 6,764 acres are treated by SWMFs (both within and outside the watershed), which equates to 57.6 percent of the MS4 service area in the watershed (see **Table 3-1** in the Action Plan). This value represents the total treated MS4 service area in the watershed but not the total treated by SWMFs located within the watershed. Some MS4 service areas in the watershed are treated by SWMFs outside the watershed boundaries.

Table B4. SWMF summary: North Landing River Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
BayFilter Stormwater Cartridge System	1	0.6	0.6
Bioretention	22	9.0	5.8
Continuous Deflective Separator	4	25.0	23.8
Extended Detention Pond	54	232.2	193.4
Filterra Bioretention Systems	13	7.0	3.7
FocalPoint High Performance Modular Biofiltration System	1	1.1	0.0
Grass Channels	2	0.9	0.2
Hydroguard	1	1.2	1.2
Infiltration Practices	28	42.5	39.1
Jellyfish Filter	1	0.0	0.0

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Permeable Pavement	1	1.2	0.0
R – Tank Module Treatment/Maintenance Row	1	1.1	0.0
Stormkeeper Sediment Strip	1	3.9	0.0
StormTech Isolator Row	2	0.0	0.0
The Vortechs System	2	5.4	3.0
Volume Control Facility Closed	3	4.9	0.0
Volume Control Facility Open	94	9,963.2	7,600.7
Wet Pond	101	1,925.2	1,282.4

NOTE: Totals in this table do not match watershed totals in Table 3-1 due to the methodology used to assign SWMFs to watersheds. Values in this table show only SWMFs in this watershed's boundaries and the drainage areas of those SWMFs (even if drainage areas extend beyond watershed boundaries).

B1.5. Pocaty River

There are currently no SWMFs in the Pocaty River watershed treating stormwater from City MS4 service areas (65.2 acres).

B2. Coastal Area TMDLs

B2.1. London Bridge Creek and Canal #2

There are 421 SWMFs in the London Bridge Creek and Canal #2 watershed treating stormwater from City MS4 service areas. **Table B5** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated. Some drainage areas are treated by multiple SWMFs; those areas are included in the totals of all SWMF types that treat that area.

Furthermore, some SWMFs in this watershed may treat drainage areas from other watersheds due to drainage modifications that route drainage between watersheds. Drainage areas from other watersheds are included in values presented in **Table B5** but are not included in watershed totals presented in the following paragraph and in **Table 3-1** in the Action Plan.

The total MS4 service area in the London Bridge Creek and Canal #2 watershed is 4,231.3 acres. Of that area, 2,114 acres are treated by SWMFs (both within and outside the watershed), which equates to 50.0 percent of the MS4 service area in the watershed (see **Table 3-1** in the Action Plan). This value represents the total treated MS4 service area within the watershed but not the total treated by SWMFs located within the watershed. Some MS4 service areas in the watershed are treated by SWMFs outside the watershed boundaries.

Table B5. SWMF summary: London Bridge Creek and Canal #2 Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Aqua-Swirl Stormwater Treatment System	1	0.8	0.0
Baysaver Barracuda	1	0.0	0.0
Bioretention	15	12.3	9.3
Constructed Wetlands	2	1.1	1.0
Continuous Deflective Separator	11	13.5	10.7
Dry Swales	1	1.0	0.8
Extended Detention Pond	156	379.6	219.4
Filterra Bioretention Systems	59	30.9	21.4
Grass Channels	3	2.4	1.0
Hydroguard	1	0.5	0.5
Infiltration Practices	51	64.1	50.4
Permeable Pavement	9	9.0	2.5
Sheet Flow to a Vegetated Filter Strip or Conserved Open Space	1	1.7	0.9
Stormceptor STC	14	33.7	25.2
The Vortechs System	10	23.5	20.4
Volume Control Facility Closed	2	2.9	0.0
Volume Control Facility Open	17	1,363.7	1,051.2
Wet Pond	67	867.4	494.4

NOTE: Totals in this table do not match watershed totals in Table 3-1 due to the methodology used to assign SWMFs to watersheds. Values in this table show only SWMFs in this watershed's boundaries and the drainage areas of those SWMFs (even if drainage areas extend beyond watershed boundaries).

B2.2. West Neck Creek, Upper

There are 237 SWMFs in the West Neck Creek, Upper watershed treating stormwater from City MS4 service areas. **Table B6** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated. Some drainage areas are treated by multiple SWMFs; those areas are included in the totals of all SWMF types that treat that area.

Furthermore, some SWMFs in this watershed may treat drainage areas from other watersheds due to drainage modifications that route drainage between watersheds. Drainage areas from other watersheds are included in values presented in **Table B6** but are not included in watershed totals presented in the following paragraph and in **Table 3-1** in the Action Plan.

The total MS4 service area in the West Neck Creek, Upper watershed is 3,533.5 acres. Of that area, 2,032 acres are treated by SWMFs (both within and outside the watershed), which equates to 57.5 percent of the MS4 service area in the watershed (see **Table 3-1** in the Action Plan). This value represents the total treated MS4 service area in the watershed but not the total treated by SWMFs located within the

watershed. Some MS4 service areas in the watershed are treated by SWMFs outside the watershed boundaries.

Table B6. SWMF summary: West Neck Creek, Upper Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Bioretention	12	46.6	4.4
Constructed Wetlands	3	4.5	0.0
Continuous Deflective Separator	2	10.3	3.2
Extended Detention Pond	64	180.7	119.7
Filterra Bioretention Systems	17	9.4	7.2
Grass Channels	2	0.3	0.3
Hydroguard	2	20.5	17.5
Infiltration Practices	27	34.9	26.1
Perk Filter	1	3.4	0.0
Permeable Pavement	1	3.8	1.1
Sheet Flow to a Vegetated Filter Strip or Conserved Open Space	1	7.8	1.2
StormTech Isolator Row	4	11.1	5.8
The Vortechs System	1	0.5	0.2
Volume Control Facility Closed	2	3.3	0.0
Volume Control Facility Open	25	954.9	748.2
Wet Pond	72	1,479.4	1,060.9
Wet Swales	1	2.1	0.7

NOTE: Totals in this table do not match watershed totals in Table 3-1 due to the methodology used to assign SWMFs to watersheds. Values in this table show only SWMFs in this watershed's boundaries and the drainage areas of those SWMFs (even if drainage areas extend beyond watershed boundaries).

B3. Lynnhaven Bay, Broad Bay, and Linkhorn Bay TMDLs

B3.1. Broad Bay, Long Creek, and Linkhorn Bay

There are 503 SWMFs in the Broad Bay, Long Creek, and Linkhorn Bay watershed treating stormwater from City MS4 service areas. **Table B7** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated. Some drainage areas are treated by multiple SWMFs; those areas are included in the totals of all SWMF types that treat that area.

Furthermore, some SWMFs in this watershed may treat drainage areas from other watersheds due to drainage modifications that route drainage between watersheds. Drainage areas from other watersheds are included in values presented in **Table B7** but are not included in watershed totals presented in the following paragraph and in **Table 3-1** in the Action Plan.

The total MS4 service area in the Broad Bay, Long Creek, and Linkhorn Bay watershed is 3,426.4 acres. Of that area, 639 acres are treated by SWMFs (both within and outside the watershed), which equates to 18.6 percent of the MS4 service area in the watershed (see **Table 3-1** in the Action Plan). This value represents the total treated MS4 service area in the watershed but not the total treated by SWMFs located within the watershed. Some MS4 service areas in the watershed are treated by SWMFs outside the watershed boundaries.

Table B7. SWMF summary: Broad Bay, Long Creek, and Linkhorn Bay Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Bioretention	86	56.3	13.4
Constructed Wetlands	1	1.1	0.3
Continuous Deflective Separator	3	5.0	5.2
Dry Swales	2	6.4	6.4
Dual Vortex Separator	2	1.7	1.8
Extended Detention Pond	106	314.2	239.3
Filterra Bioretention Systems	45	26.4	18.7
Grass Channels	3	2.6	2.6
Hydroguard	2	0.0	0.0
Infiltration Practices	122	84.5	67.1
Jellyfish Filter	1	0.5	0.5
Permeable Pavement	57	17.3	10.7
Rainwater Harvesting	2	4.4	4.4
Rooftop Disconnect	3	0.4	0.4
Stormceptor STC	11	7.0	4.6
StormKeeper Sediment Strip	1	0.0	0.0
StormTech Isolator Row	6	0.6	0.6
Stream Restoration	1	4.6	3.8
The Stormwater Management StormFilter with Phosphosorb Media	1	1.8	1.8
The Vortechs System	12	21.2	11.0
Volume Control Facility Closed	7	6.0	4.3
Volume Control Facility Open	11	270.8	93.5
Wet Pond	17	299.6	190.9
Wet Swales	1	0.8	0.8

NOTE: Totals in this table do not match watershed totals in Table 3-1 due to the methodology used to assign SWMFs to watersheds. Values in this table show only SWMFs in this watershed's boundaries and the drainage areas of those SWMFs (even if drainage areas extend beyond watershed boundaries).

B3.2. Lynnhaven Bay

There are 742 SWMFs in the Lynnhaven Bay watershed treating stormwater from City MS4 service areas. **Table B8** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated. Some drainage areas are treated by multiple SWMFs; those areas are included in the totals of all SWMF types that treat that area.

Furthermore, some SWMFs in this watershed may treat drainage areas from other watersheds due to drainage modifications that route drainage between watersheds. Drainage areas from other watersheds are included in values presented in **Table B8** but are not included in watershed totals presented in the following paragraph and in **Table 3-1** in the Action Plan.

The total MS4 service area in the Lynnhaven Bay watershed is 10,067.8 acres. Of that area, 7,224 acres are treated by SWMFs (both within and outside the watershed), which equates to 71.8 percent of the MS4 service area in the watershed (see **Table 3-1** in the Action Plan). This value represents the total treated MS4 service area in the watershed but not the total treated by SWMFs located within the watershed. Some MS4 service areas in the watershed are treated by SWMFs outside the watershed boundaries.

Table B8. SWMF summary: Lynnhaven Bay Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Bioretention	47	32.0	13.8
Constructed Wetlands	2	0.0	0.0
Continuous Deflective Separator	12	536.3	375.5
Dry Swales	3	4.2	2.7
Extended Detention Pond	143	512.8	423.6
Filtering Practices	3	0.0	0.0
Filterra Bioretention Systems	58	64.5	58.0
Grass Channels	7	13.8	8.8
Hydroguard	2	1.7	1.7
Infiltration Practices	227	216.9	165.4
Modular Wetland System Linear	2	18.0	0.0
Permeable Pavement	28	35.5	26.7
R - Tank Module Treatment/Maintenance Row	1	3.7	0.0
Rainwater Harvesting	1	0.0	0.0
Sheet Flow to a Vegetated Filter Strip or Conserved Open Space	1	0.7	0.0
Stormceptor STC	19	50.1	40.3
StormTank Module Debris Row	4	9.6	0.0
StormTech Isolator Row	18	83.0	4.5

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
The Stormwater Management StormFilter with Phosphosorb Media	1	0.9	0.7
The Stormwater Management StormFilter with ZPG Media	1	0.7	0.3
The Vortechs System	18	25.4	28.4
Volume Control Facility Closed	20	28.4	10.4
Volume Control Facility Open	65	6,960.8	4,565.2
Wet Pond	56	690.8	332.2
Wet Swales	2	4.1	4.1
Wetlands Restoration	1	5.5	0.0

NOTE: Totals in this table do not match watershed totals in Table 3-1 due to the methodology used to assign SWMFs to watersheds. Values in this table show only SWMFs in this watershed's boundaries and the drainage areas of those SWMFs (even if drainage areas extend beyond watershed boundaries).

B4. Elizabeth River TMDL

There are 464 SWMFs in the Elizabeth River watershed treating stormwater from City MS4 service areas. **Table B9** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated. Some drainage areas are treated by multiple SWMFs; those areas are included in the totals of all SWMF types that treat that area.

Furthermore, some SWMFs in this watershed may treat drainage areas from other watersheds due to drainage modifications that route drainage between watersheds. Drainage areas from other watersheds are included in values presented in **Table B9** but are not included in watershed totals presented in the following paragraph and in **Table 3-1** in the Action Plan.

The total MS4 service area in the Elizabeth River watershed is 5,963.3 acres. Of that area, 2,625 acres are treated by SWMFs (both within and outside the watershed), which equates to 44.0 percent of the MS4 service area in the watershed (see **Table 3-1** in the Action Plan). This value represents the total treated MS4 service area in the watershed but not the total treated by SWMFs located within the watershed. Some MS4 service areas in the watershed are treated by SWMFs outside the watershed boundaries.

Table B9. SWMF summary: Elizabeth River Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Bioretention	41	76.5	18.4
Constructed Wetlands	3	56.8	0.0
Continuous Deflective Separator	10	19.7	5.8
CrystalCleen Separator Single Vault	1	0.0	0.0
Dry Swales	9	4.5	4.2
Extended Detention Pond	103	315.0	222.3
Filterra Bioretention Systems	50	31.6	25.1
Grass Channels	3	1.5	1.3

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Hydroguard	4	4.0	2.7
Infiltration Practices	86	86.3	68.7
Jellyfish Filter	1	2.6	0.0
Permeable Pavement	24	25.4	2.1
R - Tank Module Treatment/Maintenance Row	2	6.5	0.0
Sheet Flow to a Vegetated Filter Strip or Conserved Open Space	1	1.0	0.0
Stormceptor STC	6	3.1	3.1
StormTank Module Debris Row	1	9.4	0.0
StormTech Isolator Row	9	10.9	9.7
The Vortechs System	5	6.5	5.7
Volume Control Facility Closed	5	5.7	2.5
Volume Control Facility Open	47	2,732.2	1,883.3
Wet Pond	50	1,026.7	483.9
Wet Swales	3	2.2	2.2

NOTE: Totals in this table do not match watershed totals in Table 3-1 due to the methodology used to assign SWMFs to watersheds. Values in this table show only SWMFs in this watershed's boundaries and the drainage areas of those SWMFs (even if drainage areas extend beyond watershed boundaries).

B5. Rudee Inlet TMDL

There are 121 SWMFs in the Rudee Inlet watershed treating stormwater from City MS4 service areas. **Table B10** summarizes these SWMFs including type, count, total drainage area treated, and MS4 service area treated. Some drainage areas are treated by multiple SWMFs; those areas are included in the totals of all SWMF types that treat that area.

Furthermore, some SWMFs in this watershed may treat drainage areas from other watersheds due to drainage modifications that route drainage between watersheds. Drainage areas from other watersheds are included in values presented in **Table B10** but are not included in watershed totals presented in the following paragraph and in **Table 3-1** in the Action Plan.

The total MS4 service area in the Rudee Inlet watershed is 1,192.3 acres. Of that area, 434 acres are treated by SWMFs (both within and outside the watershed), which equates to 36.4 percent of the MS4 service area in the watershed (see **Table 3-1** in the Action Plan). This value represents the total treated MS4 service area in the watershed but not the total treated by SWMFs located within the watershed. Some MS4 service areas in the watershed are treated by SWMFs outside the watershed boundaries.

Table B10. SWMF summary: Rudee Inlet Watershed

SWMF Type	Count	Combined Drainage Area (ac)	MS4 Service Area Treated (ac)
Bioretention	10	2.0	0.1
Continuous Deflective Separator	5	34.7	1.1
Downstream Defender	3	62.0	51.5
Dry Swales	1	0.0	0.0
Extended Detention Pond	13	14.3	12.2
Filterra Bioretention Systems	8	4.2	1.4
Hydroguard	10	61.2	44.6
Infiltration Practices	27	4.3	2.2
Jellyfish Filter	2	5.1	0.0
Permeable Pavement	11	1.5	0.2
Stormceptor STC	1	2.3	2.0
Stormkleener Cartridge Filter System	1	1.5	0.0
The Vortechs System	7	13.6	13.0
Volume Control Facility Closed	7	5.5	0.3
Volume Control Facility Open	10	735.5	355.0
Wet Pond	3	45.9	20.8
Wet Swales	2	2.8	0.0

NOTE: Totals in this table do not match watershed totals in Table 3-1 due to the methodology used to assign SWMFs to watersheds. Values in this table show only SWMFs in this watershed's boundaries and the drainage areas of those SWMFs (even if drainage areas extend beyond watershed boundaries).

Appendix C: Public Comment

Public Comment Process

In June of 2025, the City of Virginia Beach posted the Draft 2025 Bacteria TMDL Action Plan to the stormwater webpage: virginiabeach.gov/stormwater-program. Solicitation of public input was announced at the start of a 15-day comment period via social media, blog post, VBTV, and distributed to over 10,000 subscribers of the City's "Be In The Know" newsletter email. Comments were gathered by a survey set up through the city's public engagement platform, SpeakUpVB. The comment period started June 5 and ended on June 19.

As the initiatives identified in this plan progress, additional opportunities for public comment will be provided.

June 2025 Public Comment Survey Results:

The City received a total of 5 comments on the 2025 Bacteria TMDL Action Plan during the comment period from a total of 9 participants from the 91 people who viewed the survey. The original comments received are listed below with the City's response shown in italics following the comment.

1. A lot of this comes down to the community caring about itself and each other. In adults who already don't have the habit of taking care of public spaces or know what happens when there is runoff— seen particularly in people who are not going to live in Virginia Beach for large amounts of time or those with money to pay fines if it ever came to that— don't particularly care enough to change. The group that should be target with education initiatives is younger children. I remember I had an assembly as a kid where we learned about wastewater and the processes involved with it (obviously at an age appropriate level) but it worked. My parents didn't know anything about picking up after animal waste— which, in curriculum, should include mentioning personal property like backyards as spaces that need to be cleaned— or monitoring storm drains for blockages and things like that. Host community days at schools to teach families together. It might only get people who are involved in schools, but that is a new group that has been educated. Similarly, involve students at the science academies. Ask them to help in developing curriculum and infrastructure. Give them projects that get them more interested in helping the community so they see there is opportunity here and come back to continue contributing to the health of the environment here.

   Response: Acknowledged. The City's outreach program for pet waste includes regional effort focused on education of children. We've developed educational materials through askHRgreen. You can view the information available at their website, Green Learning Educational Guides - askHRgreen.org.

2. Seems reasonable. I wondered about encouraging rain gardens and other natural water filtration features in residential areas. I would add discouraging the feeding of waterfowl to the public education portion.

   Response: Acknowledged. Rain gardens and other filtration practices are useful to improving water quality at the local scale, but may not have as great an impact in reducing human contributions to bacteria pollution as improvements to sewer or septic systems. The City discourages the feeding of wildlife and has enacted an ordinance that prohibits feeding of wildlife on City owned properties. Public education is provided about this with signs at our parks. The City has information available on its website about not feeding wildlife. https://parks.virginiabeach.gov/outdoors/city-parks/city-park-rules-regulations.

3. P.11 states that city ordinance prohibits feeding geese on public property. My suggestion is that the draft plan needs to go much further in addressing the environmental threat the out of control geese population presents. The city now has a large non migratory population of geese. While geese used to migrate and pass through Virginia Beach for a short time, thousands of geese now live year round in the City. They foul the waterways with massive waste. Walk on an area that geese have been in and you can see the massive waste they leave behind. All of that flows into waterways.

   I am most familiar with the Lynnhaven Bay area and geese waste is likely one of the largest contributors of pollution. The city should take water samples to estimate how much they contribute to the problem. The plan needs to add an action strategy to have the city work with USDA and other partners to cull the geese population. Prohibiting people from feeding them on public property is not enough. The city needs to cull geese which remain in the city past a normal migration date. Also, having so many geese so close to household pets and people presents public health risks. We don't want a strain of avian flu to jump from a goose a person or household pet. Culling the geese which remain past the migration time would reinstate a fear of humans and that is desirable to prevent viruses from jumping species.

   The non migratory geese need to be treated like an invasive plant specie that has many bad environmental effects.

   Response: Acknowledged. Canada geese are protected under the Migratory Bird Treaty Act. This means it is illegal to harm, harass, or kill them, or to disturb their nests and eggs without proper authorization. The US Department of Agriculture Wildlife Services helps manage Canada goose populations by issuing permits to authorize private property owners under certain conditions when they pose a threat to people or property. The USDA has developed educational materials for the public regarding geese management. https://www.aphis.usda.gov/operational-wildlife-activities/waterfowl

   In 2017, the USDA Wildlife Services removed 103 Canada geese from the Kings Grant neighborhood in Virginia Beach following a petition from residents due to concerns about the large goose population and its impact on the area. The geese were euthanized, and their remains were donated to wildlife rehabilitation centers. This action sparked controversy and debate among residents, with some supporting the removal and others expressing concerns about the methods used.

4. The root cause of TMDL is human population density. The number of times controlling pet and wildlife waste is presented as a top line action is ridiculous - animals have always pooped outside. So many of the sources mentioned such as pet waste, littler, sewage drains, runoff, etc, all come from too many people and development in a given area. In multiple areas of VB numerous high density apartment buildings and condo developments continue to spring up. How about an action to stop approval for high density housing areas of new homes and apartments which will not only continue to degrade the environment, but also cause traffic problems, eventually overload schools, and in the process degrade the residents quality of life.

   Response: Acknowledged. The City is focusing the bacteria reduction strategy to target human health risk sources above pet and wildlife sources through the Human Waste Source Investigations and Strategic Risk-Based Monitoring. The goal of this strategy is to eliminate sources with human health risks and educate the public on individual actions that can have a positive impact.

5. I didn't see any strategies to reduce the resident Canada Goose population in the urban areas of Virginia Beach.

   Why no strategy for bacteria source tracking in the urban areas to determine if the impairment is human or wildlife induced?

   I also didn't see anything about testing of the storm sewer system in sumped drainage structures and reverse graded pipes effectively being Petri dishes (year round) for bacteria.

   Next, in the County, how much of the bacteria load comes from wildlife vs human sources? If wildlife (as the majority of rural bacteria impairments come from) what does the City actually propose to do?

   Response: Acknowledged. See the response to comment 4 regarding Canada geese.

   The City performs bacteria source tracking to identify potential human sources of bacteria. The City will be implementing monitoring to identify types of sources of bacteria in waterways. A program for testing and tracking of human sources is described in the Action Plan in Section 4.2.

   Sampling of the storm sewer network would be covered within the planned Human Waste Source Investigations.

   The goal of this strategy is to eliminate sources with human health risks and educate the public on individual actions that can have a positive impact.