Anne Arundel County Integrated Management Plan

May 2022

DRAFT

ANNE ARUNDEL COUNTY
MARYLAND

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Abbreviations

DPW	Anne Arundel County Department of Public Works
ASR	Aquifer Storage Recovery
BAT	Best Available Technology
BMP	Best Management Practice
BRF	Bay Restoration Fund
CEC	Constituents of Emerging Concern
CIP	Capital Improvement Plan
County	Anne Arundel County
CWA	Clean Water Act
DPW	Anne Arundel County Department of Public Works
ENR	Enhanced Nutrient Removal
EPA	United States Environmental Protection Agency
FY	Fiscal Year
HDR	HDR Engineering, Inc.
IMP	Integrated Management Plan
KPI	Key Performance Indicator
LCR	Lead and Copper Rule
LF	Linear Feet
MAR	Managed Aquifer Recharge
MCDA	Multiple Criteria Decision Analysis
MDE	Maryland Department of the Environment
MGD	Million Gallons per Day
MS4	NPDES Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NRU	Nitrogen-Reducing Units
O&M	Operations and Maintenance
OSDS	Onsite Sewage Disposal Systems
OPZ	Office of Planning and Zoning
OWMPA	On-Site Wastewater Management Problem Areas
PAG	Public Advisory Group
PCB	Polychlorinated Biphenyl
PFAS	Per- and Polyfluoroalkyl Substances
PPCP	Pharmaceuticals and Personal Care Products
R&R	Repair and Replacement
SDWA	Safe Drinking Water Act
SSA	Sewer Service Area
SSO	Sanitary Sewer Overflow
SPS	Sewage Pumping Station
SWPPP	Stormwater Pollution Prevention Plan
TM	Technical Memorandum
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
WLA	Waste Load Allocation
WRF	Water Reclamation Facility
WTP	Water Treatment Plant

1 Executive Summary

The Anne Arundel County Department of Public Works (DPW) provides services to ensure safe drinking water, to treat wastewater, and to manage stormwater runoff and watershed restoration in support of a high quality of life for residents and visitors. To effectively provide these services, DPW must manage a significant number of assets. The County has made considerable investments to upgrade wastewater treatment capabilities, manage stormwater runoff, and restore impervious surfaces. However, increasingly complex water quality issues and growing service demands will continue to require major capital investments that will impact the County's financial and management resources. Key challenges facing the County include long-term compliance with nutrient limits associated with the Chesapeake Bay Total Maximum Daily Load (TMDL), long-term sustainability of water supply, modernization of systems, and management of long-term growth. The County has initiated the Our wAAter program as an overarching strategy to meet these many challenges, while strengthening the County's water supply resiliency. This management strategy will achieve long-term compliance with the Phase III Watershed Implementation Plan (WIP) and a goal to reduce Total Nitrogen by 115,000 pounds per year. This program is intended to provide long-term benefits through an integrated approach that includes five key initiatives: septic-to-sewer connections, small system upgrades, stormwater improvements, groundwater resiliency, and wastewater treatment enhancements.

Anne Arundel County Department of Public Works Mission Statement
The Department of Public Works provides services to ensure safe drinking water; to enhance wastewater treatment; to efficiently recycle, collect trash, and dispose of waste; to maintain, manage, and operate the County's road and bridge network; to design and construct County infrastructure; and to provide innovative environmental restoration projects that maintain a high quality of life for residents and visitors of Anne Arundel County.

Future program improvements will need to be prioritized for DPW to continue to provide cost effective and reliable service, protect environmental quality, and enhance the surrounding communities. Addressing the most critical environmental and public health issues first, while allowing flexibility to develop options for long-term infrastructure needs. In 2012, the US Environmental Protection Agency (EPA) recognized that municipalities require more flexibility to balance long-term system improvements with environmental needs and developed the *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* (Framework) to support communities in their planning efforts. The Framework incudes six elements that outline a planning process, while acknowledging that integrated plans should be appropriately customized to the size and needs of the community. In January 2019, Congress passed the Water Infrastructure Improvement Act (WIIA), which officially recognizes the Framework as a voluntary path that municipalities can take to comply with the Clean Water Act (CWA). In addition to "smart planning," having an established Integrated Management Plan (IMP) could position the County favorably when seeking competitive grant opportunities from the Federal and State government to invest in infrastructure improvements.

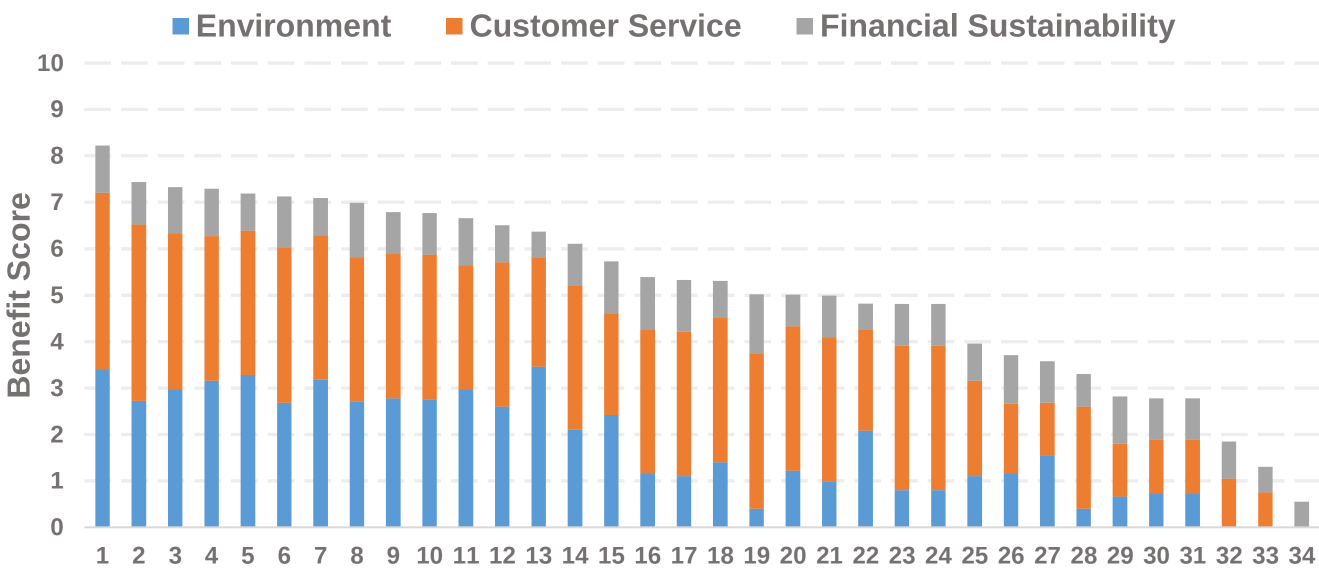
EPA's Framework provides a useful approach for developing a long-term investment strategy that addresses system-wide infrastructure needs, improves water quality, and improves regulatory certainty over time. The County initiated this IMP with the goal of developing a prioritized and balanced infrastructure investment strategy across the County's service area over the next 30 years. The IMP addresses regulatory requirements and meets programmatic and capital water, stormwater, and wastewater needs. DPW developed the voluntary IMP with a 30-year investment schedule that will inform Capital Improvement Plan (CIP) decision-making and actions. To develop the schedule, the County followed the EPA's Framework using known, near-term capital improvement projects, program expenditures, and planning level estimates of future projects and costs. These planning level estimates were based on the current understanding of system-wide service and regulatory needs. Projects and programs were evaluated with the County's existing CIP and Water and Sewer Master Plan to develop on IMP schedule that is implementable, fundable, and prioritizes the highest benefit projects early in the planning period. DPW staff from the Bureau of Engineering, as well as Health Department and Planning Department staff, participated in a series of workshops to identify utility drivers, program needs, and prioritization criteria. The County will confirm community-wide priorities by soliciting input from Maryland Department of the Environment (MDE), the County Council, and other stakeholder groups to finalize the investment schedule.

The IMP is tailored to address existing utility and regulatory drivers expected to demand resources over the coming years. From a utility management perspective, system-wide investments will be driven by nutrient reduction, climate change, sea level rise, and the beneficial reuse of waste products. Additionally, a number of significant regulatory requirements may require major water and wastewater treatment facility upgrades that must be prioritized as well. These regulatory drivers include the ongoing or anticipated nutrient reduction requirements under the Chesapeake Bay TMDL. Projects and solutions to address these regulatory needs will be prioritized in the IMP and inform implementation schedules for future National Pollutant Discharge Elimination System (NPDES) permit compliance schedules and other regulatory implementation agreements. The IMP also identifies future regulatory issues that may evolve and potentially impact the County as the IMP is implemented over time. For this reason, the IMP is structured so that it is specific enough to effectively schedule infrastructure improvements to address the known, existing drivers described above, but flexible and adaptive enough to effectively anticipate and respond to evolving issues and requirements as they arise.

DPW has identified many near- and long-term programmatic and capital improvement projects that will be needed to address the aforementioned utility and regulatory drivers. Solutions include ongoing programs and projects, Water Reclamation Facility (WRF) and Water Treatment Plant (WTP) upgrades, impervious area restoration, system expansion, asset management, and ongoing planning and support efforts. The plan also includes projects within the Our wAAter program, which is an over-arching strategy to improve the health of County waterways and the Chesapeake Bay, while strengthening the County's water resiliency. Through this effort, DPW has identified approximately $3.5 billion (in 2020 dollars) in potential projects and solutions over the next 30 years to address all currently forecasted system-wide capital and programmatic needs. These solutions and their projected costs were developed based on the results of previous planning efforts combined with the current level of system understanding. For several of the projects, these are standard planning level estimates that will evolve over time as additional information becomes available to more adequately characterize the required investments. As a result, some of the estimates will need to be reevaluated as part of the IMP adaptive management process.

DPW evaluated all of the potential projects using a multiple criteria decision analysis (MCDA) tool. The MCDA tool was used to score the relative anticipated environmental and community benefits produced by each individual project or program. The MCDA scoring system was based on DPW's community-supported mission statement and specific, weighted evaluation criteria.

Final ranked benefit scores for the individual projects reflected the importance of the utility drivers facing Anne Arundel County. The IMP process has validated that the needs addressed by the Our wAAter Program are of the highest priority to County residents. Our wAAter projects and wastewater reclamation facility upgrade projects along with collection system and facility Repair and Replacement (R&R) projects were generally expected to produce the greatest benefits, which reflects the importance of meeting regulatory obligations. Near-term capacity and expansion projects also ranked in the upper half of projects, because of positive impacts on water quality and human health. Resource recovery, waste acceptance, and future expansion projects generally produced medium to low benefits. See Figure 1-1 for the results of the MCDA.



1 - Sewer Main Replacement & Reconstruction
2 - Stormwater Infrastructure
3 - Minor Systems Upgrades
4 - Upgrade/Retrofit Sanitary Sewer Pump Stations
5 - Ongoing WRF Upgrades
6 - Septic-to-Sewer
7 - Ongoing WTP Upgrades
8 - Managed Aquifer Recharge (MAR)
9 - Broadneck WRF Upgrade
10 - Baltimore County Sewer Agreement
11 - Grinder Pump Replacements & Upgrades
12 - WRF Infrastructure Upgrades/Retrofit
13 - Stormwater Permit Cycle 3 Placeholder
14 - Sewer Extensions
15 - SPS Facility Generator Replacements
16 - Water Main Repl./Recon., Water Storage Tank Painting, & WTR Infrastr. Up/Retro
17 - Existing Well Redevelopment and Replacements
18 - Aquifer Storage and Recovery (ASR)
19 - Fire Hydrant Rehabilitation
20 - TM-M Rte 32 @ Meade & E/W TM
21 - Elevated Water Storage
22 - Planning
23 - Water Facility Emergency Generators
24 - Water Extensions
25 - Millersville WTP (10 MGD)
26 - Billing (AMI/AMR)
27 - Cox Creek WRF Expansion
28 - Wastewater Service Connections
29 - Biosolids
30 - Crofton Meadows II Expansion Phase II
31 - WTP Construction/Expansions
32 - State Highway Sewer Relocation
33 - Dorsey Road Offline
34 - Demolition

Figure 1-1 - Final Benefit Scores for DPW IMP Water and Wastewater Projects

The MCDA evaluation was limited to evaluating the benefits of potential projects and did not assess the anticipated financial impacts, implementation complexities, or project interdependencies that must be considered when developing implementable schedules. To develop a final IMP project schedule, DPW must work with its financial consultants to evaluate the projected benefits with respect to overall costs, rate impacts, and alternative funding sources. The projected program costs for the Phase 1 Integrated Plan are shown below in Figure 1-2.

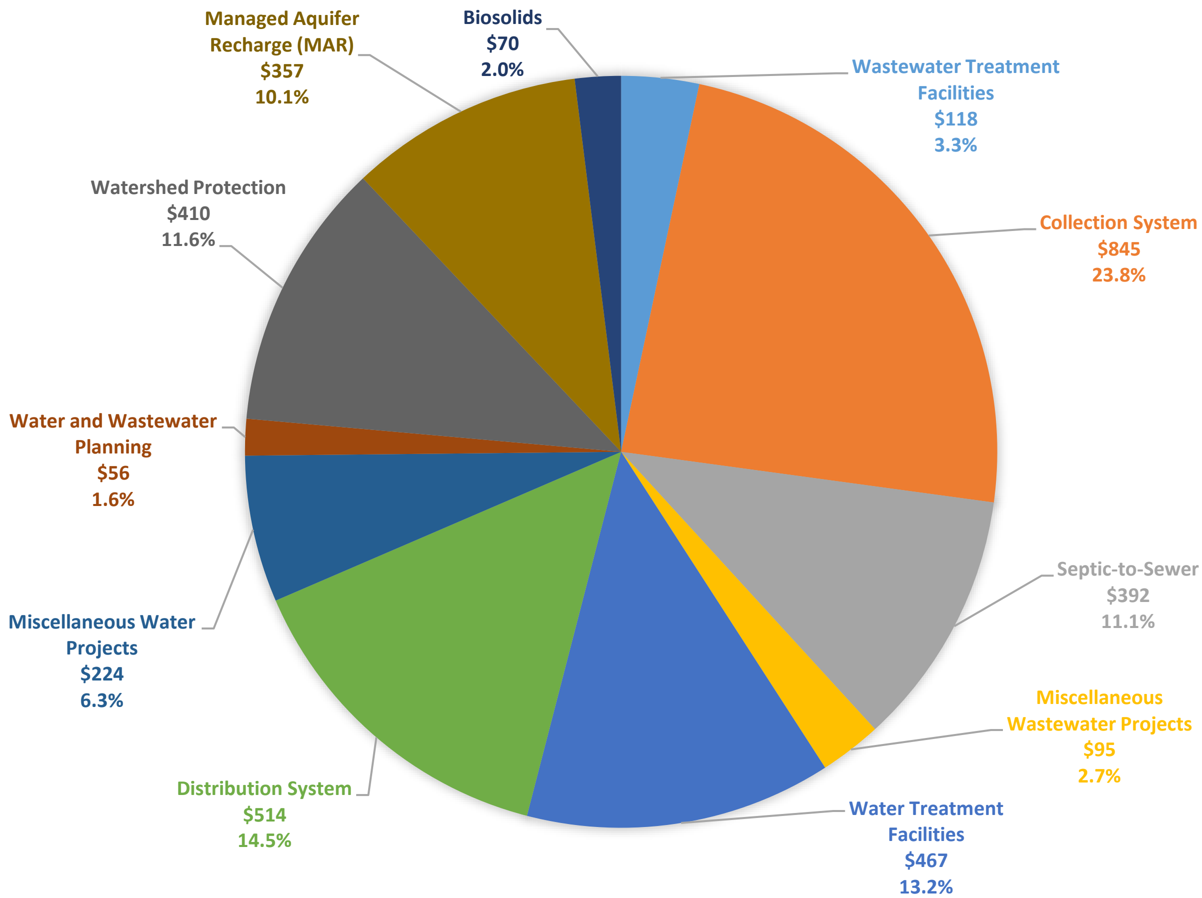


Figure 1-2 - Final IMP Program Budget for the 30-Year (2022-2051) Planning Period ($3.5B Total Budget, program budgets shown in millions, 2020 dollars)

DPW developed a 30-year project schedule that addresses critical public health and environmental issues first, while appropriately balancing revenue requirements and ability to deliver capital improvements effectively and efficiently. The implementation schedule is presented in Figure 1-3 on the following page.

	Total 30-year Project Budget (2020 $ x Million)	Years 1-6 2022 - 2027	Years 7-12 2028 - 2033	Years 13-18 2034-2039	Years 14-24 2040-2045	Years 25-30 2046-2051
Wastewater Treatment Facilities						
Ongoing WRF Upgrades	$30					
Broadneck WRF Upgrade	$8					
WRF Infrastructure Upgrades/Retrofit	$30					
Cox Creek Expansion (to 16.5 MGD)	$29					
Minor Systems Upgrades	$21					
Managed Aquifer Recharge (MAR)	$357					
Collection System						
Sewer Main Replacement & Reconstruction	$402					
Upgrade/Retrofit Sanitary Sewer Pump Stations	$330					
SPS Facility Generator Replacements	$73					
Sewer Extensions	$40					
Septic-to-Sewer	$392					
Miscellaneous Wastewater Projects						
Baltimore County Sewer Agreement	$20					
Wastewater Service Connections	$52					
Demolition	$2					
Grinder Pump Replacements & Upgrades	$15					
State Highway Sewer Relocation	$6					
Biosolids	$70					
Water Treatment Facilities						
Crofton Meadows II Expansion Phase 2 (15 to 20 MGD)	$37					
Crofton Meadows II Expansion Phase 3 (20 to 28 MGD)	$40					
Dorsey Road Offline	$1					
Arnold WTP Expansion (16 to 20 MGD)	$57					
Arnold WTP Expansion (20 to 28 MGD)	$60					
Millersville WTP (32 MGD)	$238					
Broad Creek II WTP Expansion (8 to 11 MGD)	$29					
Ongoing WTP Upgrades	$5					
Distribution System						
Water Main Repl./Reconstruction, Water Storage Tank Painting, & WTR Infrastr. Up/Retro	$514					
Miscellaneous Water Projects						
Billing (AMI/AMR)	$43					
Existing Well Redevelopment & Replacements	$72					
Fire Hydrant Rehabilitation	$15					
TM-MD Rte 32 @ Meade & E/W TM	$50					
Water Facility Emergency Generators	$5					
Water Extensions	$7					
Aquifer Storage Recovery (ASR)	$24					
Elevated Water Storage	$8					
Water and Wastewater Planning	$56					
Watershed Protection						
Stormwater Permit Cycle 3 Placeholder	$150					
Stormwater Infrastructure	$260					
Total Budget (2020 $):	$3.5 Billion	$984.6 Million	$594.4 Million	$537.5 Million	$555.4 Million	$875.5 Million

Figure 1-3 - Final IMP Project Implementation Schedule

To implement early actions and gather additional information needed to direct informed capital improvement decisions, DPW will pursue a 6-Year IMP Action Plan focused on implementing near-term projects while pursuing additional planning studies to inform the future update of the IMP. The 6-year Action Plan includes $985 million of capital projects and planning studies that DPW intends to implement. Significant elements of the 6-Year Action Plan include the initiation of the Our wAAter program, and planning studies to gain a better understanding of project scope and costs for several major program components. The Six-Year IMP Action Plan represents the total anticipated investment needs which are greater than the approved CIP budget. All IMP schedules are based upon the Phase III WIP targets and the County's current NPDES Municipal Separate Storm Sewer System (MS4) permitting schedule. If these schedules were to change, then IMP implementation schedules will be extended to the same extent.

DPW intends to refine the estimates through the final draft integrated planning efforts which will incorporate additional studies and community feedback. DPW anticipates completing a final draft of the IMP by December 2022. DPW will formally reevaluate and update the IMP at least every five years based on changing regulatory drivers, economic and financial conditions, greater system understanding, lessons learned from program and project implementation, and updated benefit evaluations. However, given its adaptable design, the IMP will also be updated as needed should conditions warrant. The IMP Action Plan includes procedures for updating the IMP.

2 Introduction

The Anne Arundel County Department of Public Works (DPW) provides services to ensure safe drinking water, to treat wastewater, and to manage stormwater runoff and watershed restoration in support of a high quality of life for residents and visitors. To effectively provide these services, DPW must manage a significant number of assets.

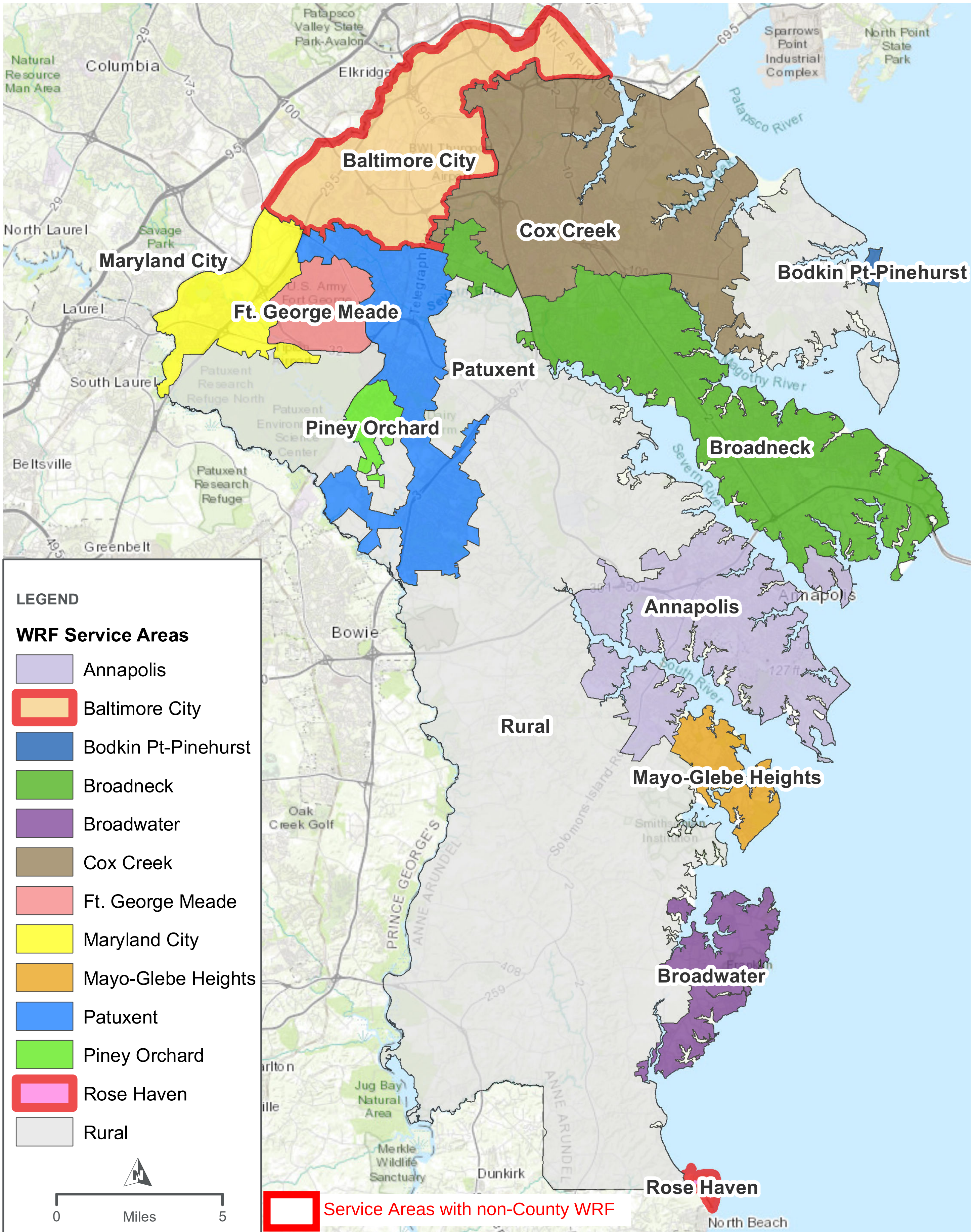
2.1 Wastewater System

The County provides sanitary sewer services for over 118,000 customers and provides water services for over 126,000 customers in Anne Arundel County, MD. Collectively, the County owns and operates seven major WRFs and more than 262 pump stations. New wastewater pumping stations are transferred to the County as they are constructed to support new development. All the County's major WRFs were upgraded to an Enhanced Nutrient Removal (ENR) level of treatment (MDE 2022) and are operating below effluent discharge limits (3-4 mg/L) for Total Nitrogen. Two other service areas have conveyance systems that are operated and maintained by the County, but the treatment facilities are operated by neighboring municipalities. Figure 2-1 illustrates the sewer service areas.

The County also manages and maintains more than 1,300 miles of gravity sewer lines, 41,000 sewer manholes, and 160 miles of force mains. Following the creation of the Bay Restoration Fund (BRF) in 2006, the County updated databases identifying existing septic systems, also known as "onsite sewage disposal systems" (OSDS). In 2008 DPW completed the Septic Strategic Plan, also referred to as the "2008 OSDS Study". This study identified and categorized OSDS by assembling a geographical information system (GIS) database of all known OSDS throughout the County (more than 41,000).

2.2 Drinking Water System

The County's public water system is divided in to twelve pressures zones and three "sub-pressure zones," which are located entirely within and supplied by one of the major pressure zones (Figure 2-2). The County owns and operates nine major water treatment facilities and 54 groundwater production wells. The County also manages and maintains more than 23 pumping facilities, 37 storage tanks and more than 1,300 miles of water mains. Connections to the Baltimore City 1st and 2nd Zones allow the County to purchase additional water as needed.

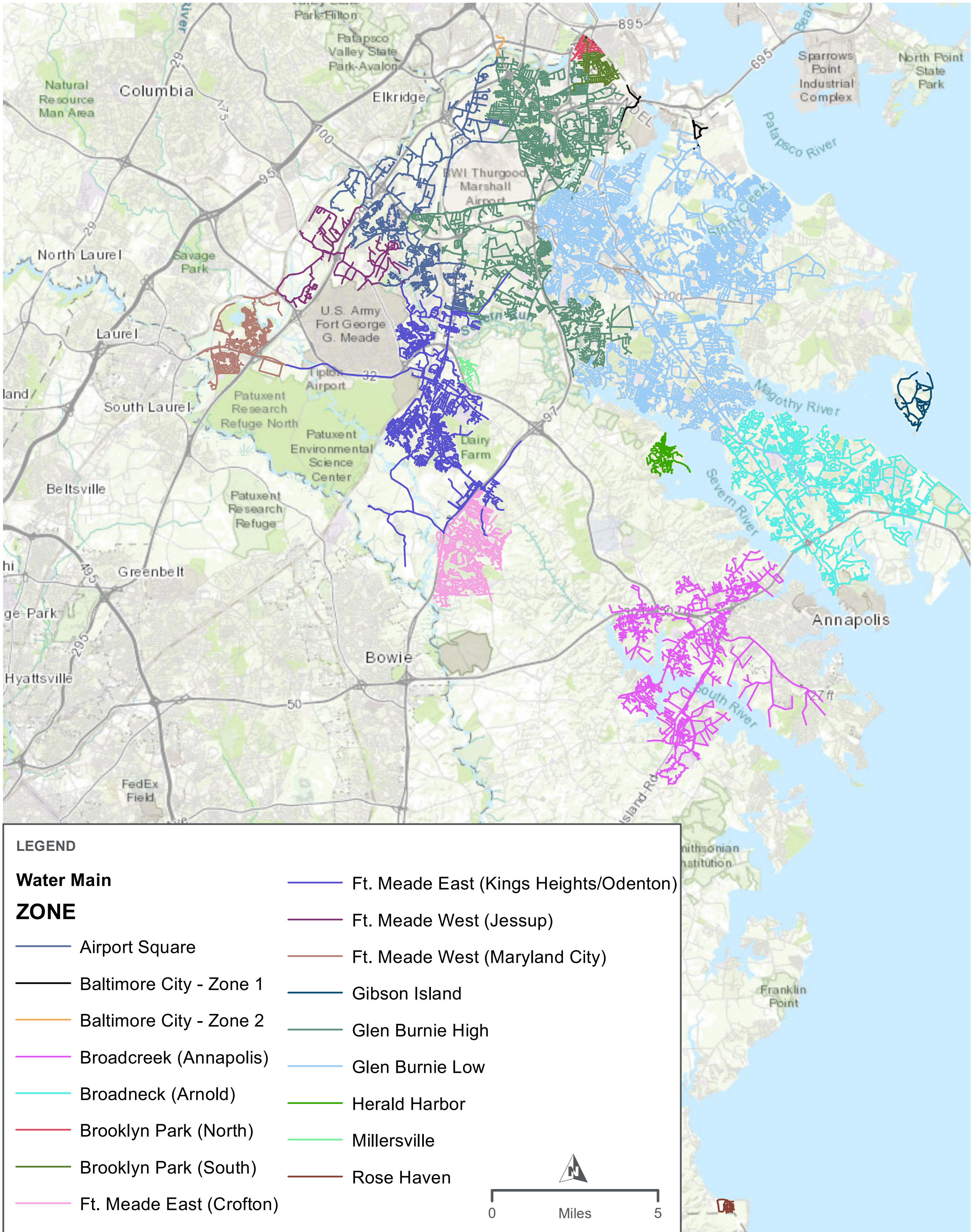


ANNE ARUNDEL COUNTY INTEGRATED MANAGEMENT PLAN

WRF SERVICE AREA MAP

FIGURE 2-1

PATH: C:\USERS\HBILLIAN\DOCUMENTS\WORK\ANNE ARUNDEL COUNTY MD\TASK 13\FIGURES\FIGURE 2-1 - AAC SEWER SERVICE AREA MAP.MXD - USER: HBILLIAN - DATE: 3/1/2021



ANNE ARUNDEL COUNTY INTEGRATED MANAGEMENT PLAN

WATER SERVICE AREA MAP

FIGURE 2-2

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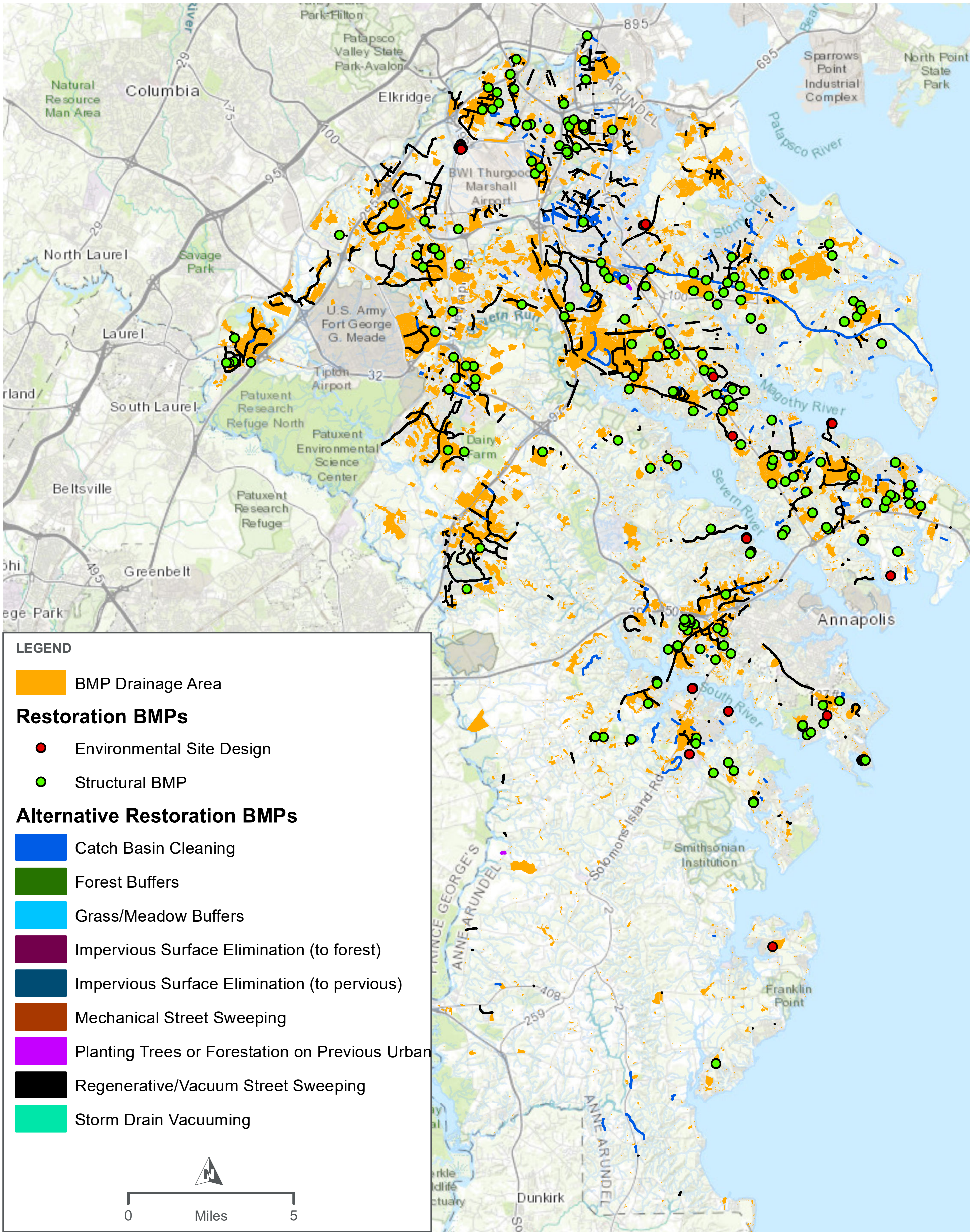
2.3 Stormwater Management

DPW maintains the County's stormwater infrastructure, which is comprised of over 38,000 storm drain inlets, more than 1,000 miles of pipe, and more than 6,200 outfalls. The County also maintains several water quality monitoring sites, where required chemical, physical, and biological monitoring of watershed restoration efforts and stormwater management application is conducted. Many of the components of the County's stormwater management program are in place to address the NPDES MS4 permit requirements (AADPW 2021). The County's MS4 permit, which came into effect February 12, 2014, covers all stormwater discharges from the MS4 owned or operated by the County. Watershed restoration is aimed at meeting several TMDLs having a wasteload allocation. Current TMDLs include Nitrogen, Phosphorus, and Sediment; Bacteria; and Polychlorinated Biphenyls (PCBs). Figure 2-1 shows the restoration and alternative restoration BMPs implemented within the County.



ANNE ARUNDEL COUNTY INTEGRATED MANAGEMENT PLAN

BMP DRAINAGE AREA MAP

FIGURE 2-3

PATH: C:\USERS\HBILLIAN\DOCUMENTS\WORK\ANNE ARUNDEL COUNTY MD\TASK 13\FIGURES\FIGURE 2-3 - AAC BMP MAP.MXD - USER: HBILLIAN - DATE: 3/1/2021

2.4 Integrated Planning

The County is committed to providing effective and affordable water and wastewater services that safeguard the environment, meet customer expectations, and facilitate financial sustainability. To this end, DPW has made considerable investments to upgrade wastewater treatment capabilities, manage stormwater runoff, and restore impervious surfaces.

Notwithstanding these significant efforts, the County continues to face increasingly complex water quality issues and growing service demands. In particular, there are a number of current and future CWA and Safe Drinking Water Act (SDWA) regulatory drivers that will require major capital investments and impact the County's financial and management resources. The County is concerned that potentially overlapping compliance timelines for multiple federal and state regulatory drivers will limit their ability to efficiently manage resources and make system improvements going forward. Key challenges facing the County include long-term compliance with nutrient limits associated with the Chesapeake Bay TMDL, long-term sustainability of water supply, modernization of systems, and management of long-term growth. The County has initiated the Our wAAter program as an overarching strategy to meet these challenges, while strengthening the County's water supply resiliency. This program is intended to provide long-term benefits through an integrated approach that includes five key initiatives: septic-to-sewer connections, small system upgrades, stormwater improvements, groundwater resiliency, and wastewater treatment enhancements.

In 2012, the US Environmental Protection Agency (EPA) recognized that when afforded the flexibility to balance wastewater and stormwater improvements, municipalities can more efficiently use their resources to make important, cost-effective environmental improvements that align with community priorities (Stoner 2011). To support communities in these efforts, EPA released the *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* (US EPA 2012). In January 2019, Congress passed the Water Infrastructure Improvement Act (WIIA), which officially recognizes the Framework as a voluntary path that municipalities can take to comply with the Clean Water Act (CWA).

EPA's Framework outlines a process that allows municipalities to meet human health and water quality objectives by using existing CWA flexibilities to appropriately prioritize and schedule wastewater and stormwater improvements according to a community's needs and financial capability. It also makes it clear that local governments may pursue integrated planning to prioritize wastewater and stormwater compliance obligations, as well as water reuse, water recycling, green infrastructure, and other innovative projects, over a long-term planning period. Anne Arundel County is adding water supply reliability to this list of priorities.

In their Framework, EPA recognizes that integrated plans should be appropriately tailored to the size of the municipality and scope of the issues, but the Agency anticipates that integrated plans will address the following six planning elements:

- **Element 1 –** A description of the water quality, human health and regulatory issues to be addressed.
- **Element 2 –** A description of existing wastewater and stormwater systems under consideration and summary information describing the systems' current performance.
- **Element 3 –** A process which opens and maintains channels of communication with relevant community stakeholders in order to give full consideration of the views of others in the planning process and during implementation of the plan.

- **Element 4 –** A process for identifying, evaluating, and selecting alternatives and proposing implementation schedules.
- **Element 5 –** A process for evaluating the performance of projects identified in a plan.
- **Element 6 –** An adaptive management process for making improvements to the plan.

The County recognizes that through the integrated planning process, they can better prioritize affordable and protective solutions to resolve the most critical environmental and public health issues first, while allowing flexibility to develop options for thoughtful infrastructure planning. With this approach, the utility can effectively provide reliable and sustainable water networks with the capacity to support the entire service area into the future. The County developed this system-wide Integrated Management Plan (IMP) to create a prioritized and balanced infrastructure investment strategy that addresses regulatory requirements and meets programmatic and capital water and wastewater needs across the County's service area over the next 30 years.

The County is developing the voluntary IMP with a 30-year investment schedule that will inform near-term CIP decision-making and actions. To develop the schedule, the County followed the EPA's integrated planning Framework in a streamlined manner using known, near-term capital improvement projects and program expenditures and planning level estimates of future projects and costs. These planning level estimates were based on current understanding of system-wide service and regulatory needs. DPW staff from the Bureau of Engineering, as well as Health Department and Planning Department staff, participated in a series of workshops to identify utility drivers, program needs, and prioritization criteria. The County will confirm community-wide priorities by soliciting input from MDE, the County Council, and other stakeholder groups to finalize the investment schedule.

DPW anticipates completing the final draft of the IMP by December 2022. The IMP will be updated at least every five years based on changing regulatory drivers, economic and financial conditions, greater system understanding, lessons learned from program and project implementation, and updated benefit evaluations. However, given its adaptable design, the IMP will also be updated as needed should conditions warrant. This adaptive management approach provides the opportunity for the reprioritization of projects and programs through informed decision-making to yield a dynamic and living long-range plan.

The IMP sections and corresponding link to EPA's six Framework elements are as follows:

- **Section 3 – Utility Drivers** highlights the major infrastructure concerns that the County is addressing through the IMP. This section addresses Element 1 of EPA's Framework.
- **Section 4 – Regulatory Drivers and Regional Water Quality** identifies the CWA regulatory drivers that will drive compliance obligations. This section addresses Element 1 and Element 2 of EPA's Framework.
- **Section 5 – Program Needs and Solutions** provides a broad review of the performance and condition of specific wastewater assets. It also outlines planning level projects and associated costs to address currently forecasted needs. This section addresses Element 2 and Element 4 of EPA's Framework.
- **Section 6 – Project and Program Prioritization and Scheduling** outlines the multiple criteria decision analysis (MCDA) process used to assess the alternatives described in Section 5. This section addresses Element 4 of EPA's Framework.
- **Section 7 – Adaptive Management and 6-Year Action Plan** summarizes the adaptive management, performance reporting, additional studies, and near-term capital the County will

pursue to implement the IMP and evaluate progress. This section addresses Elements 5 and 6 of EPA's Framework. The term of the Action Plan aligns with the County's 6-year CIP cycle.

3 Regulatory Utility Drivers and Regional Water Quality Issues

There are a number of impactful regulatory and water quality issues that will drive future improvements across the County's service area. An overview of these drivers is presented in this section. It is important to note that the items discussed in this section and incorporated into Phase 1 of the IMP were identified based on the County's current understanding of the magnitude and timing of known regulatory drivers. During future phases of the IMP, it may be necessary to reprioritize projects and implementation schedules based on new or changing regulations as they are developed and implemented at the state or federal level.

3.1 NPDES Permits

Understanding the NPDES permit renewal schedules is important because it provides insight into the potential timing and impacts of future regulatory drivers and compliance requirements. The County comprises eleven sewer service areas, with six served by public facilities operated and maintained by DPW. These include: Cox Creek, Maryland City, Patuxent, Broadneck, Annapolis, and Broadwater WRFs. These facilities and current NPDES renewal schedules are summarized below.

3.1.1 Cox Creek WRF (NPDES Permit MD0021661)

Cox Creek WRF discharges to the Patapsco River and provides reclaimed water supply to Brandon Shores and H.A. Wagner Power Stations owned by Raven Power Fort Smallwood LLC. The plant has a design capacity of 15.0 MGD at a permitted Total Nitrogen (TN) limit of 4 mg/L and a Total Phosphorus (TP) limit of 0.4 mg/L with a total TN waste load allocation (WLA) of 183,000 lb/year. The County may consider expansion in the future to 20 mgd with a TN limit of 3 mg/L and a TP limit of 0.3 mg/L to continue compliance with the current WLA. The existing permit was issued in January 2020 and expires in December 2025.

3.1.2 Maryland City WRF (NPDES Permit MD0062596)

Maryland City WRF discharges to the Patuxent River. The plant has a design capacity of 3.33 MGD at a permitted TN limit of 3 mg/L and a TP limit of 0.3 mg/L with a TN WLA of 30,000 lb/year. The existing permit was issued in April 2015 and expired in March 2020. The permit renewal application is being processed.

3.1.3 Patuxent WRF (NPDES Permit MD0021652)

Patuxent WRF discharges to the Little Patuxent River. The plant has a design capacity of 10.5 MGD at a permitted TN limit of 3 mg/L and a TP limit of 0.3 mg/L with a TN WLA of 96,000 lb/year. The existing permit was issued in April 2015 and expired in March 2020. The permit renewal application is being processed.

3.1.4 Broadneck WRF (NPDES Permit MD0021644)

Broadneck WRF discharges to the Little Patuxent River. The plant has a design capacity of 6 MGD at a permitted TN limit of 4 mg/L and a TP limit of 0.3 mg/L with a TN WLA of 73,000 lb/year. The County may consider expansion in the future to 8 mgd with a TN limit of 3 mg/L and a TP limit of 0.3 mg/L to continue compliance with the current WLA. The existing permit was issued in November 2017 and expires in October 2022.

3.1.5 Annapolis WRF (NPDES Permit MD0021814)

Annapolis WRF discharges to the Little Patuxent River. The plant has a design capacity of 13 MGD at a permitted TN limit of 4 mg/L and a TP limit of 0.3 mg/L with a TN WLA of 158,000 lb/year. The County may consider expansion in the future to 17.3 mgd with a TN limit of 3 mg/L and a TP limit of 0.3 mg/L to continue compliance with the current WLA. The existing permit was issued in October 2015 and expired in September 2020. The permit renewal application is being processed.

3.1.6 Broadwater WRF (NPDES Permit MD0024350)

Broadwater WRF discharges to the Chesapeake Bay. The plant has a design capacity of 2 MGD at a permitted TN limit of 4 mg/L and a TP limit of 0.3 mg/L with a TN WLA of 24,000 lb/year. The County may consider expansion in the future to 2.7 mgd with a TN limit of 3 mg/L and a TP limit of 0.3 mg/L to continue compliance with the current WLA. The existing permit was issued in November 2017 and expires in October 2022.

3.1.7 Piney Orchard WRF (NPDES Permit MD0059145)

Piney Orchard WRF discharges to the Little Patuxent River. The plant has a design capacity of 0.7 MGD at a permitted TN limit of 4 mg/L and a TP limit of 0.3 mg/L with a TN WLA of 8,000 lb/year. The existing permit was issued in June 2019 and expired in February 2022. The permit renewal application is being processed.

3.2 MS4 Permit

The NPDES MS4 Program is intended to reduce and eliminate pollution from stormwater runoff via the County's drainage systems to local streams, ponds, and other waterways. DPW is the lead department tasked with ensuring compliance with permit conditions which requires the cooperation of multiple County agencies (AADPW 2021). The following management programs are to be implemented as part of the County's MS4 permit requirements:

1. **Stormwater Management**
2. **Erosion and Sediment Control** – This includes the fulfillment of an acceptable erosion and sediment control program and responsible personnel certification classes at least three times per year.
3. **Illicit Discharge Detection and Elimination** – This program is to ensure that all discharges to and from the MS4 that are not entirely composed of stormwater are either permitted by MDE or eliminated. The County must conduct field screening for at least 150 outfalls annually, conduct visual surveys of commercial and industrial facilities, and report appropriate illicit discharge detection and elimination activities.
4. **Litter and Floatables** – The County must address problems associated with litter and floatables in waterways that adversely affect water quality.
5. **Property Management and Maintenance** – This includes Stormwater Pollution Prevention Plan (SWPPP) development and annual documentation/MDE submittal for each County-owned municipal facility requiring NPDES stormwater general permit coverage. The County also is required to implement a maintenance program to reduce pollutants at County-owned facilities.
6. **Public Education** – The County must implement a public education and outreach program to reduce stormwater pollutants.

To identify commercial and industrial sources of water quality impacts, the County must routinely survey these areas and monitor major storm drain outfalls to identify illicit discharges. Additionally, BMP and impervious surface data must be collected and stored into the MS4 geodatabase. In May 2009, MDE developed the technology and code changes necessary to implement Environmental Site Design to the Maximum Extent Practicable statewide. The County stormwater management regulations were adopted by the County Council and became effective November 22, 2010. MDE approved the County's Stormwater Management program in September 2011. The County's Stormwater Management Practices and Procedures Manual provides developers, consultants, and County staff with guidance regarding the procedures, processes, policies, and regulations that apply to stormwater management for proposed developments within the County (Anne Arundel County 2017). This includes watershed assessments, restorations plans, nutrient trading, public participation, and TMDL Compliance.

The effectiveness of the NPDES stormwater management program and water quality improvement program is measured via chemical, biological, and physical monitoring. These efforts are also useful for model calibration efforts and watershed restoration assessment. The County has a long-term monitoring program in place in the Church Creek sub-watershed located in the South River Watershed which will continue for the duration of this administratively extended permit term or until the County successfully joins the available Pooled Monitoring Program option under the next generation NPDES MS4 Permit. The County is also monitoring the Picture Spring Branch in the Severn River watershed for channel stability and benthic macroinvertebrate health to evaluate local BMPs (AADPW 2021). To complete the detailed watershed assessments for the entire County to facilitate MS4 permit compliance, the County developed a TMDL Support Program within the Bureau of Watershed Protection and Restoration. This involved coordination with consultants, stakeholders, and County staff to facilitate field data collection, modeling, analysis, prioritization, and reporting. As of the end of FY20, the County has met the 20% impervious surface restoration (ISR) goal of 4,996 acres through restoration projects and BMPs. Credit for projects that were completed in FY21 and beyond will be applied to the next ISR goal for the permit cycle that commenced on November 5, 2021. The County will continue to maintain the 20% ISR goal through programmatic practices (i.e., street sweeping, inlet cleaning, and septic pumping) as well as an enhanced BMP maintenance inspection program.

3.3 Existing Regulatory Drivers

There are a few existing regulatory issues that will drive significant investment in the County's Our wAAter program that must be considered prioritized through the IMP process. Critical drivers include TMDL requirements. These and other regulatory drivers are summarized below.

3.3.1 Impairments and Total Maximum Daily Loads

Maryland identifies and prioritizes receiving water bodies for which effluent limits are not stringent enough to meet the State's Water Quality Standard requirements. The State dictates the TMDLs that determine the effects of point and non-point sources on the receiving water body quality. Maryland's Integrated Report (dated 2018) describes six different categories, of which Categories 4a, 4b, 4c, and 5 are impaired. Category 4a waters are waters that are still impaired but have a TMDL developed which establishes pollutant loading limits designed to bring the water body back into compliance. See Table 1 in Appendix A for a detailed list of waters that fall into this category. Category 4b waters are impaired but for which a technological remedy should correct the impairment. The County does not have any water bodies under Category 4b. Category 4c waters are impaired but not for a conventional pollutant. See Table 2 in Appendix A for a detailed list of waters that fall into this category. Category 5 includes waters that need a TMDL (traditionally known as the 303(d) list). See Table 3 in Appendix A for a detailed list of waters of Category 5. All the County's 12 watersheds are listed for several water quality impairments in the impaired waters list.

3.3.1.1 BACTERIA TMDLS

The County currently has 19 waterways with EPA-approved TMDLs associated with bacteria impairments. For 15 of the 19 waterways, fecal coliform is identified as the cause of the impairment. *E. coli* and Enterococci are identified as the impairments for two each of the four remaining watersheds (Appendix A). The County has implemented restoration strategies as required by its NPDES MS4 permit. These strategies include screening of outfalls to identify illicit connections, sanitary sewer overflow (SSO) abatement through sewage pumping station (SPS) upgrades/repairs, and OSDS retirement and connection to the public sanitary sewer system. Other strategies address non-human sources of bacteria through stormwater management projects, riparian buffer education, pet waste education, and other site-specific strategies (i.e., livestock fencing and Canada Goose management). In addition to the monitoring locations discussed in Section 3.2, the County also implements shellfish harvesting area monitoring, monitoring of public bathing beaches, bacteria trend monitoring in the Marley and Furnace Creek watersheds, and pre-outreach bacteria monitoring in two communities in conjunction with a pilot pet waste outreach campaign, all of which monitor bacteria concentration (AADPW 2020).

3.3.1.2 SEDIMENT TMDLS

EPA approved eight individual sediment TMDLs for the County. Table 3-1 shows a summary of the TMDL location, approval date, and the FY20 progress towards meeting the SW-WLA reduction requirement as part of the MS4 permit. The County's restoration plan to address the West River sediment SW-WLA currently does not include sediment load reduction modeling but will be updated to include this once the plan is finalized.

Table 3-1 - Sediment TMDLs in Anne Arundel County (AADPW 2021)

Location	Approval Date	% Reduction Required	Completion Year	Compliance Expected by Completion Year?
Little Patuxent River, 8 Digit WS 02131105	September 30, 2011	20.5	2025	Yes
Upper Patuxent River, 8 Digit WS 02131104	September 30, 2011	11.4	2025	Yes
Patapsco River Lower North Branch, 8 Digit WS 02130906	September 30, 2011	22.2	2025	Yes
South River, 8 Digit WS 02131003	September 28, 2017	28.0	2025	Yes
Other West Chesapeake, 8 Digit WS 02131005	February 9, 2018	33.0	2030	Yes
Middle Patuxent River, 8 Digit WS 02131102	July 2, 2018	56.0	2030	Yes
Lower Patuxent River, 8 Digit WS 02131101	July 2, 2018	61.0	2030	Yes
West River, 8 Digit WS 02131004	April 24, 2019	22.0	2030	Yes

3.3.1.3 PCB TMDLS

The County currently has six approved PCB TMDLs. The County focused its FY20 PCB reduction efforts in the Baltimore Harbor and Curtis Creek watersheds on source tracking via monitoring. Results of the 2020 sampling were used to determine Phase II sampling locations in a focused effort to identify geographic sources of PCBs. For the Patuxent watershed, which is multi-jurisdictional, a monitoring program remains in development.

Previous PCB remediation efforts included amending the bottom of stormwater detention ponds with activated carbon, PCB de-chlorinators and aerobic degraders.

Table 3-2 - PCB TMDLs for Anne Arundel County (AADPW 2021)

Location	Approval Date	% Reduction Required
Subsegment of 8 Digit WS 02130903 Baltimore Harbor Curtis Creek/Bay	October 1, 2012	 91.1 93.5
Magothy River 8 Digit WS 02131001	March 16, 2015	0
Severn River 8 Digit WS 02131002	July 19, 2016	0
South River 8 Digit WS 02131003	April 27, 2015	0
West and Rhode Rivers 8 Digit WS 02131004	January 8, 2016	0
Patuxent Mesohaline, Oligohaline, Tidal Fresh PCB Segments 8 Digit WS 02131101 and 02131102	September 19, 2017	99.9

3.3.2 Enhanced Nutrient Removal

Starting in 2006 with the signing of a Memorandum of Understanding between the County and the Maryland Department of the Environment (MDE), the County initiated a series of procurements to provide design services for the upgrade of each of its wastewater facilities to achieve ENR. All the County's major WWTPs were recently upgraded to ENR level of treatment (MDE 2022). The following table summarizes the facilities with their nitrogen and phosphorus reductions achieved in CY20 (MDE 2022).

Table 3-3 - Anne Arundel County ENR Plants and Nitrogen and Phosphorus Reductions in CY20

ENR WWTP	CY20 Average Flow (MGD)	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)
Annapolis	8.76	165,331	49,600
Broadneck	4.646	91,929	27,296
Broadwater	1.233	25,523	7,207
Cox Creek	11.227	228,980	66,302
Maryland City	1.407	27,840	8,438
Patuxent	5.808	109,617	33,239
Total	33.08	649,220	192,080

3.3.3 Wet Weather Discharges

As per COMAR 26.08.10.01, the State defines "overflow" to include any overflow or discharge of raw or diluted sewage onto the surface of the ground, into waterways, storm drains, ditches or other manmade or natural drainage conveyance to surface or ground waters that are more than 50 gallons and not cleaned up within 1 hour of its occurrence. Since January 1, 2009, the State initiated a Sanitary Sewer Overflow Enforcement Initiative that involves monetary penalties per day for each overflow.

The County adopted a Capacity, Management, Operation, Maintenance (CMOM) program in 2005 which has been implemented continuously since then. The program has been successful in keeping SSOs at a very low level.

3.3.4 EPA Lead and Copper Rule (LCR) Changes

The EPA recently issued a revision to the Lead and Copper Rule that will require water utilities to take a progressive set of actions to reduce lead levels at the tap. Highlights of the proposed rule changes include the following:

- Increased sampling reliability

- Increased customer outreach communications
- Development of a Lead Service Line (LSL) inventory or demonstrate absence of LSLs within first 3 years of final rule publication (the rule was finalized and enforceable starting Dec. 2021, so the deadline for the inventory is Dec. 2024). LSL inventory must be updated annually as long as service lines consisting of either lead, galvanized iron connected to lead goosenecks, or of unknown materials are in use. Utilities that certify they have no lead or unknown pipes still need to annually attest to the regulator that they don't have these materials, but they do not need to update the inventory. All systems with known or possible LSLs must develop an LSL replacement plan.

Lead service lines are not believed to be prevalent in the County's distribution system. This program is not anticipated to require a major investment. However, LCR implications must be studied so that the impact can be evaluated in detail.

3.4 Evolving Regulatory Drivers

Future regulatory issues with potential to impact the County will continue to develop and evolve as the IMP is implemented over time. For this reason, it is important that the IMP be specific enough to effectively schedule infrastructure improvements to address the known, existing drivers described above, but flexible and adaptive enough to effectively respond to new issues as they arise. Potential regulatory drivers with the potential to impact future IMP planning efforts are discussed below.

3.4.1 Phase III Watershed Implementation Plan (WIP)

Beyond the above regulatory obligations of the County, non-regulatory requirements are defined by the State of Maryland's commitment to reducing nitrogen, phosphorus, and sediment loading to the Chesapeake Bay. The State is required to provide strategies to the EPA for meeting the Chesapeake Bay TMDL goals by 2025. The State developed Maryland's Phase II WIP in 2012. MDE finalized the Phase III WIP on August 23rd, 2019. It set updated goals for 2025 for the state overall and charts a road map for each county as well. The primary focus of the Phase III WIP pertains to Nitrogen reduction strategies since Maryland is on track to meet the state's 2025 phosphorus and sediment goals (MDE 2019). Table 3-4 provides the County estimate of nitrogen discharges assuming the current trajectory of stormwater and septic improvements. It is estimated that to maintain the 2025 Phase III WIP nitrogen allocations, the County will need to provide an additional 77,000 lb TN/year reduction by 2050. In addition, the future nitrogen discharge limits to the Chesapeake Bay remain a moving target as models account for climate change and a better understanding of the science. The County will need an adaptive management strategy for long-term compliance to the Chesapeake Bay TMDL.

Table 3-4 - Anne Arundel County Future Nutrient Accounting (Total Nitrogen)

Sector	2017	Phase III WIP	Est. 2025	Est. 2050
Stormwater[1]	1,020,200	993,630	1,000,000	1,000,000
Natural[2]	444,127	416,729	438,278	420,000
Septic[3]	415,000	399,568	409,528	392,428
Wastewater[4]	316,586	313,500	319,631	388,123
Total	***2,195,913***	***2,123,427***	***2,167,437***	***2,200,551***

1. Assume no net gain in stormwater after MS4 met
2. Assume 100,000 LF of stream restoration by 2050
3. Assume 100 NRUs per year only
4. Assume 3 mg/L (County guidance) at predicted flows

3.4.2 Constituents of Emerging Concern (CECs)

Constituents of emerging concern (CECs) include compounds such as pharmaceuticals, personal care products, endocrine disruptors, and industrial contaminants. CECs are introduced into water bodies through various sources; however, they are often detected in surface waters and groundwater that are downstream of wastewater or industrial discharges (Kiesling 2019). This is especially important to potable reuse systems, such as Managed Aquifer Recharge (MAR), where advanced water treatment is utilized to treat wastewater effluent.

CECs have been increasingly detected at low levels due to improvements in measuring detection levels. CECs have been reported as ubiquitous in surface water which poses concern due to the adverse impacts on aquatic life (Bai 2018). The EPA currently has no specific guidelines or regulations in place for allowable concentrations for most CECs in wastewater or drinking water. Monitoring CECs is encouraged and frequently conducted to assess the risk and treatability of wastewater effluent in potable reuse scenarios.

Key CECs include:

- Pharmaceuticals and Personal Care Products (PPCPs)
- Unregulated Disinfection Byproducts
- Industrial CECs
- Per- and Polyfluoroalkyl Substances (PFAS)
- Bromate

Several disinfection by-products (DBPs) exist that are not currently regulated. Guidance levels for NDMA vary throughout the country. For example, California's Department of Public Health (CDPH) set 10 ng/L notification levels for three nitrosamines (i.e., NDMA, NDEA, NDPA), and California's Office of Environmental Health Hazard Assessment (OEHHA) set a 3 ng/L public health goal for NDMA.

While the U.S. EPA's lifetime health advisories for PFAS compounds perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) in drinking water remain unchanged (0.070 ug/L PFOA and PFOS, individually or combined), significant national and local funding has been allocated to encourage PFAS detection and investigation of emerging PFAS. Several states have developed independent guidelines or regulations for PFOA, PFOS, and several other PFAS.

Bromate is categorized as a potential carcinogen in humans with a federal drinking water maximum contaminant level (MCL) of 10 µg/L.

3.4.3 Biosolids Management

The CWA Amendments of 1987 required the EPA to develop new regulations pertaining to sewage sludge and biosolids. Biosolids are regulated in 40 CFR Part 503 (Part 503) published by EPA in 1993. The Part 503 regulation is a complex, risk-based assessment of potential environmental effects of pollutants that may be present in biosolids. These guidelines regulate pollutant and pathogen concentrations as well as vector attraction reduction. The guideline defines biosolids as Class A or Class B, depending on the potential level of pathogens. Biosolids in both classes must meet established vector attraction reduction and pollutant concentration requirements.

The United States Office of Inspector General (OIG) conducted an audit of EPA in relation to land application of sewage sludge and published a report in November 2018. The report concluded that "the EPA identified 352 pollutants in biosolids but cannot yet consider these pollutants for further regulation due to either lack of data or risk assessment tools.” While the EPA’s position is that it lacks the data and tools necessary to conduct health and environmental risk assessments of many of the pollutants identified in biosolids, the OIG report provided 13 recommendations to which EPA has responded. Estimated completion dates have been established for each of the recommendations over a period spanning from March 2019 to December 2022.

Environmental impacts of PFAS is a growing concern in the US, including accumulation in municipal biosolids. PFAS are a group of man-made chemicals used in a variety of industries that are pervasive throughout the environment and represent a growing health concern. Early in 2019, EPA issued a PFAS Action Plan to address this issue but took no specific regulatory action. However, the Agency is continuing to gather information and movement towards regulatory action is growing. In July 2019, the US House of Representatives approved an amendment to the defense authorization bill (H.R. 2500) that would require EPA to add PFAS to the CWA list of toxic pollutants and develop technology-based effluent limits within one year. The Senate is currently considering a separate bill (S. 1790) that would address PFAS through the Safe Drinking Water Act, Toxic Substances Control Act, and Toxic Release Inventory rather than the CWA. At this time, neither of these bills have been codified into law.

While potential federal regulatory initiatives are largely focused on developing Maximum Contaminant Levels (MCL) or technology-based effluent limits, some states environmental agencies are exploring biosolids regulations. In many instances, measured levels of PFAS in biosolids significantly exceed proposed regulatory standards. For example, recent State regulatory initiatives in Maine effectively bans land application of biosolids due to PFAS unless monitoring data are available to alleviate environmental concerns. Should Maryland adopt similar regulatory standards for PFAS, it would have the potential to significantly disrupt the County’s biosolids management options.

3.4.4 **Federal 304(a) Water Quality Criteria**

Recent and potential future federal recommendations for Section 304(a) criteria could trigger revisions to Maryland Surface Water Quality Standards during upcoming triennial reviews. EPA periodically publishes and revises scientific guidance for water quality criteria to accurately reflect the latest scientific knowledge. Although EPA’s 304(a) criteria recommendations do not impose legally binding requirements, EPA recommends that states consider the Agency’s guidance when developing criteria. Recent updates to EPA’s Section 304(a) criteria are shown below.

- New federal recommended Section 304(a) criteria for the protection of human health – In 2015, EPA updated water quality criteria intended to protect public health from 94 chemical pollutants. MDE has indicated that they intend to adopt the new criteria in an upcoming rulemaking.

- New federal recommended Section 304(a) criteria for the protection of aquatic life - EPA has recently updated a number of aquatic life criteria recommendations including: aluminum, bacteria/pathogens, cyanide and hydrogen sulfide, sulfate and chloride, selenium, iron, and by petition chronic cadmium and lead.

In addition to recent updates, EPA is also working on revisions to other 304(a) criteria including the following:

- Recreational Water Quality Criteria (WRQC) for coliphages – Coliphages are viruses that infect *E. coli* and are considered a promising alternative to traditional fecal indicator bacteria (FIB) for predicting gastrointestinal illnesses. Treatment efficiency can significantly differ between FIB and coliphages depending on the treatment process. Further study and evaluation will be required to determine appropriate treatment processes if coliphages are adopted for RWQC.

- Human health recreational criteria and/or swimming advisories for cyanotoxins, microcystins and cylindrospermopsin – Cyanotoxins, such as microcystins or cylindrospermopsin, are produced by cyanobacteria and are typically associated with harmful algal blooms.

If EPA 304(a) criteria are adopted by MDE, additional study would be required to determine necessary improvements on the County's existing infrastructure design and treatment processes.

4 Utility Drivers

The first element of an integrated plan within EPA's Framework should identify the water quality, human health, and regulatory issues to be addressed in the plan. This includes an assessment of existing challenges in meeting present and future CWA requirements, identification and characterization of human health threats and water quality impairments, identification of sensitive areas and environmental justice concerns, and metrics for evaluating and meeting human health and water quality objectives (US EPA 2012). This section discusses a broad overview of the County's non-regulatory utility drivers that are aimed at improving overall system performance and CWA compliance. The following drivers are based on the understanding of the existing system and may evolve during future phases of the IMP.

4.1 On-Site Wastewater Management Problem Areas

The Anne Arundel County Health Department has identified 33 on-site wastewater management problem areas (OWMPAs) within the County that present greatest risk for operational problems. These problems include high water table, small lot size, impermeable soil, or excessive slope (Figure 4-1) (Anne Arundel County 2017). Septic systems that are in disrepair pose a significant risk to nearby domestic wells and surface water bodies. The County works with homeowners to administer State Bay Restoration Fund (BRF) grants that subsidize septic system repairs and installation of Best Available Technology (BAT) for nitrogen reduction. This includes the installation of Nitrogen-Reducing Units (NRUs). For homes located in OWMPAs, the sustainable long-term approach for wastewater management is to convert these areas to public sewer service.

4.2 Resource Recovery and Waste Acceptance

The County utilizes a progressive approach to beneficially reuse waste byproducts to more efficiently use resources and reduce overall environmental impacts and operating costs. The County's Bureau of Utility Operations contracts with private companies to manage the processing and utilization/disposal of all generated wastewater biosolids. All seven of the County's operating wastewater treatment plants provide secondary treatment with activated sludge processes. These plants also have been or are being modified to accomplish ENR that includes various types of activated sludge processes.

Synagro Technologies is currently contracted to manage the wastewater biosolids generated by Annapolis, Broadneck, Broadwater, Cox Creek, Maryland City, and Patuxent WRFs through dewatering and post-lime treatment. All land-applied biosolids must meet the Class B pathogen reduction standards, at minimum, and the new contract with Synagro requires that 25% of annual biosolids production meet class A. Land application on agricultural and marginal sites is the primary method of biosolids disposal in the County with off-site storage available for periods when land application is restricted. Recently, the County's contractor has experienced storage limitations related to the inability to land apply during wet weather. Capital projects were recently completed to upgrade the dewatering equipment at four other WRFs to provide redundancy, increase reliability, improve efficiency, and optimize the biosolids handling operations. In addition, Anne Arundel County is undergoing a Regional Biosolids Facility Study that will examine biosolids sustainability and evaluate alternatives for recycling biosolids in future operations (Anne Arundel County 2017). Recently, the County has completed Phase 1 of the Biosolids Master Plan. The County is proceeding with Phase 2 which includes technology selection and definition of milestones that will trigger capital projects.

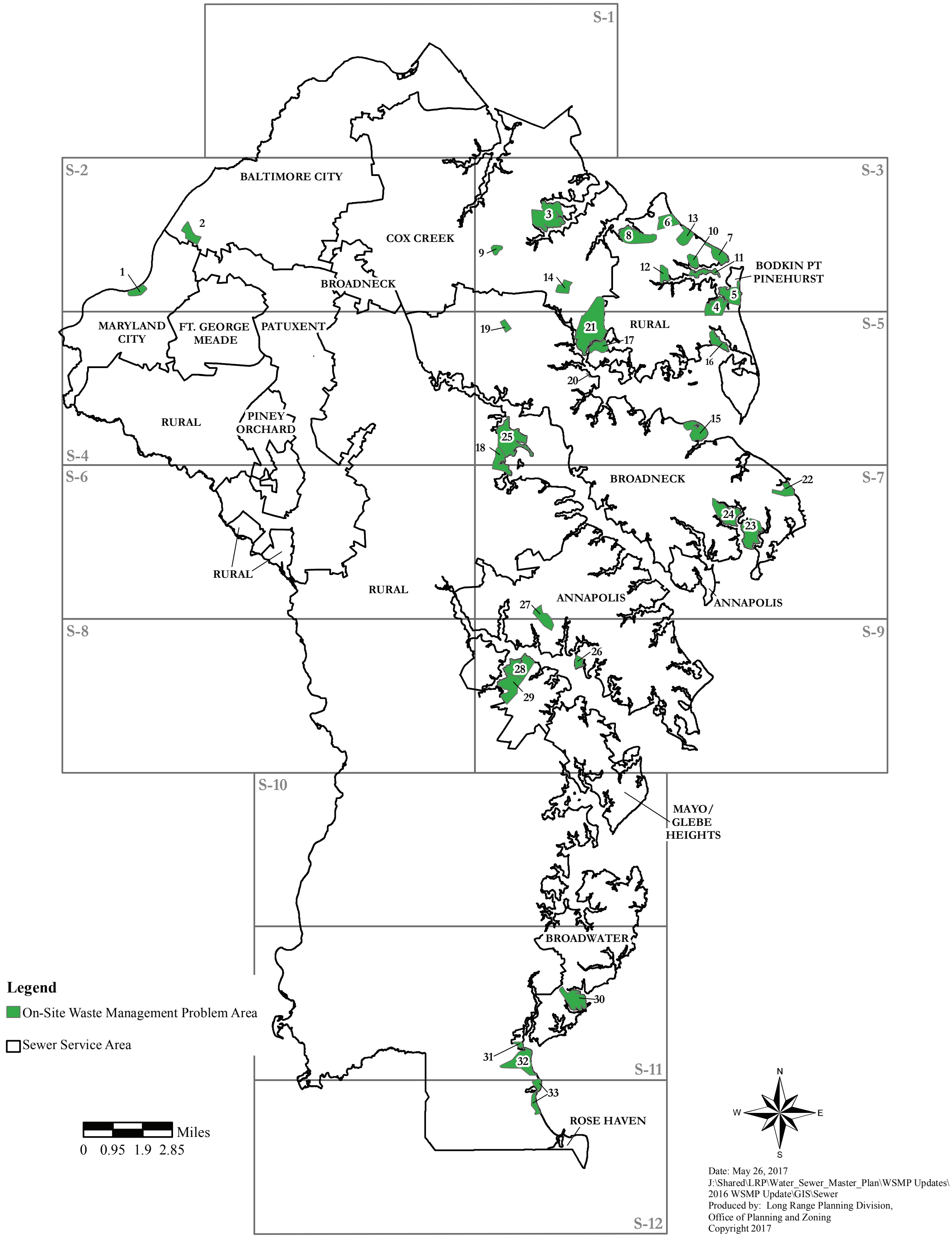


Figure 4-1 - On-Site Wastewater Management Problem Areas

4.3 Sea Level Rise / Inundation

Sea level changes have played a historic role in shaping Anne Arundel County's coastal environment. Uncertainty associated with projecting sea level rise and its specific localized impacts led to the development of the County's Sea Level Rise Strategic Plan through partnership with the Maryland Department of Natural Resources (Anne Arundel County Office of Planning and Zoning 2011). As part of the Strategic Plan, a County-wide LiDAR-based model of sea level rise was provided by the Maryland Department of Natural Resources (DNR). This model indicated that County-owned sewer systems are among the areas vulnerable to sea level rise inundation. Public sewer lines within vulnerable areas are located all along coastal areas, but there are small concentrations of sewer lines at risk in Glen Burnie along Marley Creek, in Severna Park, along the coastal areas on the Annapolis Neck, Mayo, and Deale peninsulas, and in Rose Haven. Sewer pump stations that could be vulnerable are in the Broadneck (6 stations), Annapolis (10 stations), Mayo-Glebe Heights (5 stations), and Broadwater (3 stations) sewer service areas. No public water or sewer treatment facilities are located in the inundation areas, although the Broadwater Water Reclamation facility that serves the Deale/Shady Side area just borders the five-foot inundation area (Anne Arundel County Office of Planning and Zoning 2011). Tidal influences in combination with sea level rise can cause water to back up into gravity processing units within County WRF's which requires enhanced pumping to overcome these influences. Table 4-1 shows a summary of public utility infrastructure at risk as described in the County's Sea Level Rise Strategic Plan.

Table 4-1 - Public Utility Infrastructure at Risk from Sea Level Rise

Facility	0-2 ft Inundation	0-5 ft Inundation
Sewer Gravity Lines (pipe length in feet)	12,169	169,202
Sewer Force Mains (pipe length in feet)	21,602	137,663
Sewer Manholes	36	591
Sewer Pumping Stations	1	24
Storm Drainpipes (pipe length in feet)	22,880	66,212
Stormwater Management Facilities	1	9

Private wells and septic systems are also susceptible to the impacts of sea level rise, either due to surface inundation or to high water tables associated with a rise in sea level. In areas where private wells are in close proximity to septic systems, there is a risk of contamination from septage intrusion in addition to saltwater. Table 4-2 shows the number of properties with private facilities at risk as described in the County's Sea Level Rise Strategic Plan.

Table 4-2 - Private Wells and Septic Systems at Risk (# of properties)

Facility	0-2 ft Inundation	0-5 ft Inundation
Septic Systems	5,206	7,238
Private Wells	4,718	7,633
Community Wells	69	123

4.4 Water Supply Resiliency

In recent years, the County's average day water demand has been approximately 34 MGD, and the County's total groundwater appropriation is 57.7 MGD on an annual average basis. Groundwater withdrawals are not currently imposing any adverse impacts on the aquifer. At the build-out scenario of 66.4 MGD average day demand, modeling by the Maryland Geological Survey predicts that domestic wells will begin to be negatively impacted (Maryland Geological Survey, 2020).

Further growth in neighboring jurisdictions and additional growth within Anne Arundel County could call in to question the sustainability of the current practice of withdrawing groundwater for drinking water supply and discharging treated wastewater to surface water. Innovative solutions for recharging the aquifers may be desirable.

The County's current agreement with Baltimore City provides up to 32.5 MGD maximum daily flow. City water is purchased at non-contract wholesale rates, as there is not currently a capacity commitment. The County last purchased City water in 2018 at a non-contract rate of nearly $4 per thousand gallons. The County is currently not purchasing any water from Baltimore City.

In the past, infrastructure failures in the City's transmission infrastructure have impacted the reliability of water service for Anne Arundel County's customers. This includes service disruptions in both major connections, which rely on aging PCCP transmission pipes that are at a high risk of failure. Also, during drought or emergency conditions, there is uncertainty about the amount of water that the City would be able to provide the County.

There are also water quality limitations related to the City water supply. Anne Arundel County has installed re-chlorination capabilities at both connections to properly manage the chlorine residual in the distribution system. This introduces concerns about the potential formation of disinfection byproducts. To date, the County has not experienced any violations related to disinfection byproducts as a result of using City water. However, this could become a significant issue if the County were to begin purchasing larger quantities of water from the City. There is an expectation that in the future, Baltimore City may draw increasing amounts of source water from the Susquehanna River. This further increase uncertainty about water quality management for City water supplied to Anne Arundel County.

4.5 Diversity, Equity, and Inclusion

To establish a meaningful approach for performing project planning and implementation, the County strives to recognize underprivileged communities within its service areas by considering sources of inequity. The County's primary focus lies in increasing customer affordability, increasing water and sewer system access and reliability in disadvantaged areas, and managing sanitation and wastewater to provide safe access to water for recreation.

4.6 Other Drivers Considered

The following additional drivers were also considered but were not classified as significant drivers for the integrated management plan.

4.6.1 Aging Infrastructure

The County's sewer system is relatively young with an average age of 43 years. Approximately 13% of all sewer piping are older than 60 years based on the pipe material summary provided in the most recent Sewer Strategic Plan (CH2MHill 2007). The County's water distribution system is also relatively young with an average age of 42 years. Approximately only 17% of all water piping are older than 60 years (Black & Veatch 2009). In summary, aging infrastructure is not expected to be a key driver for the County in the near-term.

4.6.2 Smart Growth

The County must continue system expansion efforts as community growth and redevelopment occurs. Current master plans embrace Smart Growth principles. The County's Sewer Strategic Plan and Water Strategic Plan provide a strategy for optimizing existing facilities, designates approximate locations and sizes of future facilities, and includes recommendations for existing infrastructure upgrades required to meet future service area needs. It is expected that ever-increasing growth in the Baltimore-Washington corridor will continue to apply pressures on land use and water demand. This will make future planning efforts all the more challenging, and while growth is not currently viewed as a critical driver for the IMP, an adaptive management approach should consider regional changes over time that could strain infrastructure.

4.6.3 Wet Weather Management

In 2021, across the nearly 1,800 miles of sewer lines throughout the County's service area, DPW experienced two SSO events greater than 10,000 gallons, eight SSOs between 2,000 and 10,000 gallons, and 36 minor SSOs less than 2,000 gallons (Anne Arundel County DPW 2020). In terms of number of SSO events per 100 miles of pipe, the County is performing at a very high level compared to peer utilities. The overall risk does not merit wet weather management for consideration as a critical driver. However, the high number of pump stations present many opportunities for failure, where a single overflow event can be magnified in the public's perception. For this reason, the level of continued investment in pump station assets should reflect their criticality. Additionally, sea level rise and increased frequency of extreme precipitation events due to climate change have the potential to impact the County's utility infrastructure (Maryland Commission on Climate Change 2020) (Anne Arundel County Office of Planning and Zoning 2011). As a result, the budget for managing wet weather (e.g., stormwater conveyance, sanitary sewer capacity) may need to increase in the future.

5 Program Needs and Solutions

The County has evaluated WIP II and WIP III (Section 3.4.1) targets and identified programmatic solutions that will be needed for long-term WIP compliance and water supply resiliency (Section 4.4). Through a strategic planning process, different management alternatives were considered to address these program needs (Appendix C) which formed the basis for the County's Our wAAter Program and the Integrated Planning process. This program is a holistic approach to meeting water quality and water supply resiliency challenges facing the County.

The solutions and associated projected costs in this section were developed based on the results of previous planning efforts and the current level of system understanding and anticipated regulatory and utility drivers. For several of the projects, additional information is needed to characterize the required investments more adequately. Therefore, the solutions and projected costs of program improvements outlined in this section should be considered planning level estimates for use in the IMP. The estimates will be reevaluated as part of the adaptive management process (Section 8).

The solutions identified include ongoing projects, as well as forecasted programmatic and capital improvement projects. All cost estimates are presented in 2020 dollars. The projects and associated costs are summarized in the sections that follow according to the following categories:

- **New Projects Identified Through the Our wAAter Program -** This category outlines the current projects identified to meet the Our wAAter Program's nutrient reduction goals and long-term water resiliency strategy. This includes the County's OSDS conversion program, level of service, connection to existing systems, MAR, and minor systems upgrade projects.
- **Major Facilities -** This category includes all WRF and WTP improvements and R&R projects. "R&R projects" refers to projects that aren't specifically driven by changes in permit requirements or capacity needs but are focused on replacement and/or upgrade of existing facilities to prolong life and improve efficiency and/or functionality.
- **Stormwater Management -** This category includes stormwater management infrastructure improvements required to comply with Federal and State clean water requirements.
- **Collection System**
    - Rehabilitation and Replacement Program - This category includes collection system R&R and public sector I/I reduction programs.
    - System Expansion - This category identifies collection system projects required to address community growth or redevelopment within existing service areas.
- **Distribution System**
    - Rehabilitation and Replacement Program - This category includes distribution system R&R and public sector I/I reduction programs.
    - System Expansion - This category identifies distribution system projects required to address community growth or redevelopment within existing service areas.
    - Water Supply Resiliency – This category includes projects that address capacity limitations and level of service, as well as connection to existing systems and impacts to existing water reclamation facilities.
- **Other Programs and Capital Expenses -** This category includes other necessary and ongoing capital programs and miscellaneous expenditures.
- **Program Planning and Support -** This category outlines the efforts and planning studies needed to refine existing cost estimates and enhance program development and support implementation.

5.1 New Projects Identified Through the Our wAAter Program

As part of the Our wAAter Program, the County engaged in the evaluation of various Management Strategies to reduce nutrients and strengthen water resiliency. The Phase II WIP had previously identified the need to convert up to 20,000 septic systems to public sewer at a cost of over $1 billion. The County decided on a goal of a long-term reduction in TN of 115,000 lb/year to maintain long-term compliance with the WIP while also accounting for potential future changes. Through strategic planning, as documented in the Technical Memorandum (TM) in Appendix C, the selected management strategy to meet both the nutrient requirements and long-term water resiliency includes:

- 200 conversions per year of septic systems to public sewer
- 7.5 mgd MAR at the Patuxent WRF
- 15,000 lb/yr TN reduction from conversion of minor wastewater treatment systems to ENR

5.1.1 Existing System

5.1.1.1 ON-SITE DISPOSAL SYSTEMS

The County has identified the infrastructure, estimated costs, and policies necessary to convert several areas within the County that currently rely on OSDS to public sewer (AADPW Septic Task Force 2020). The County has identified large CIPs, which are characterized by large clusters of homes that can be served in a common sub-drainage area and small CIPs, typically consisting of fewer units and are in the direct vicinity of existing sewer infrastructure or proposed large CIPs. Historically, the small CIP projects have been implemented through the existing petition process, or some version thereof. Both large and small CIPs have the potential to reduce the direct nutrient impact of OSDS on tributary and bay water quality upon connection. There is also potential to realize other environmental and health benefits. Connections may be of higher value if they are in on-site wastewater management problem areas as identified by the County and critical area, in areas of denser development and/or where septics drain to an impaired waterway, ground water is high, soils are poor draining etc.

5.1.1.2 MINOR FACILITIES

There are several wastewater collection and treatment systems within the County that are privately and/or independently owned and/or operated. It should be noted that Anne Arundel County is not responsible for operation or maintenance of any of these collection systems or facilities.

5.1.1.3 WATER SUPPLY RESILIENCY PROJECTS

In past years, the gap between the County's supply capacity and maximum day demand has been filled by additional supply purchased from Baltimore City. Projects planned in the Water Strategic Plan are intended to improve water supply system reliability and minimize reliance on Baltimore City. The County plans to focus on the development of existing production facilities and eventually a new WTP to handle additional build-out demands. The build-out projection is based on the County's current master plan, although it is expected that ever-increasing growth in the Baltimore-Washington corridor will continue to apply pressures on land use and water demand. Although groundwater withdrawals are not currently imposing any adverse impacts on the aquifer, declining aquifer levels have been documented and there is concern over the long-term sustainability of the aquifers.

5.1.2 Program Needs

5.1.2.1 MANAGED AQUIFER RECHARGE

The County is considering MAR, which will provide the dual benefit of replenishing groundwater supplies and reduced nutrient discharges to the Bay. MAR refers to deliberate augmentation of natural groundwater supply using engineered conveyances (recharge). Additionally, future wastewater treatment capacity at the sites where MAR is implemented would not require additional waste load allocation. Thus, full nutrient credits could be obtained from OSDS conversions or credit allocations could be transferred elsewhere. The cost of MAR is largely dependent on the treatment technologies required, size and type of injection wells, and waste treatment needed (e.g., residuals and brine). The County is currently exploring an initial MAR project to provide 7.5 MGD of treatment capacity for a capital cost of up to $180 Million. MAR is discussed as both a nutrient reduction alternative, as well as a water supply alternative, in the Alternatives TM included as Appendix D. This TM also includes the budget development methodology for MAR.

5.1.2.2 ON-SITE DISPOSAL SYSTEMS

The County is developing a long-term strategy to meet both the WIP III requirements and maintain nutrient loads into the future beyond 2025. Future nutrient discharges are expected to be stressed by both population growth and climate change. The total number of OSDS conversions desired is approximately 5,000 to 6,000 by 2050.

5.1.2.3 MINOR FACILITIES

The County has identified Minor Systems Upgrades as a key component to the Our wAAter integrated program for long-term compliance with the Phase III Watershed Implementation Plan (WIP III). Minor Systems Upgrades is the incorporation of privately owned/operated water reclamation facilities into the County's wastewater system. These treatment plants typically are not effective at removing nitrogen, having been designed to meet far less stringent discharge permits. There is significant potential to generate nitrogen credits through Minor Systems Upgrades. The County is currently considering a minor system upgrade of up to five plants in the southwest corner of Anne Arundel County, with an expectation of generating approximately 11,500 pound per year of nitrogen credits. In addition, there is one minor system near the Thurgood Marshall Baltimore-Washington International Airport that has the potential to generate over 4,500 pounds per year of nitrogen credits.

The price for this project was developed as part of feasibility analyses and is currently estimated at $21 million.

5.1.2.4 WATER SUPPLY RESILIENCY PROJECTS

While the projected aquifer yield for the County's well fields is much higher than projected demand, further growth in neighboring jurisdictions and additional growth within Anne Arundel County that is not currently anticipated by the County's Master Plan, could redefine groundwater as a sustainable water supply in the coming decades. As a result, long-term reliance on withdrawal with continued discharge to surface water is unlikely to be sustainable.

Water supply resiliency alternatives are discussed further in the Alternatives Technical Memorandum included as Appendix D. The County's preferred alternative is IPR, or MAR.

5.2 Major Wastewater Treatment Facilities

The following sections summarize the anticipated improvements and initiatives to address aging asset, capacity, and regulatory needs at each of the County's major facilities.

5.2.1 Existing System

Of the eleven sewer service areas, seven are served by public facilities operated and maintained by DPW. These include Cox Creek, Maryland City, Patuxent, Broadneck, Annapolis, Broadwater, and Piney Orchard. The remaining service areas have conveyance systems that are operated and maintained by the County, but the treatment facilities are in neighboring municipalities. These service areas include Baltimore City (served by Patapsco Sewage Treatment Plant in Baltimore City) and Rose Haven/Holland Point (served by the Chesapeake Beach Wastewater Treatment Plant in Calvert County). Bodkin Point contains two public operated septic systems and one mound system. Permission to transport wastewater to these facilities for treatment is governed by intra-jurisdictional agreements. Table 5-1 is a list of public treatment facilities and their rated capacities.

Table 5-1 - Wastewater Treatment Facilities and Rated Capacities

Treatment Facility (Owner/Operator)	Sewer Service Area	Permit Capacity in MGD (County Allotment)
Patapsco Sewerage Treatment Plan (AAC's Baltimore City SSA)	Baltimore City	73.0 (6.39)
Cox Creek WRF	Cox Creek	15.0
Maryland City WRF	Maryland City	2.5
Patuxent WRF	Patuxent	7.5
Broadneck WRF	Broadneck	6.0
Annapolis WRF - Jointly owned by Annapolis City and AAC (AAC Annapolis SSA)	Annapolis	13.0 (6.30)
Broadwater WRF	Broadwater	2.0
Piney Orchard WWTP (Piney Orchard Utility Co, LLC/MES)	Piney Orchard	0.70
Bodkin Mound System WRF (subsurface)	Bodkin Point	0.007
Chesapeake Beach Wastewater Treatment Plant (AAC Allotment - Calvert County)	Rose Haven/Holland Point	1.5 (0.1375)

5.2.2 Program Needs

5.2.2.1 WRF UPGRADES

The County is actively engaged in investigating the existing sewerage service areas and sub-drainage basins to ensure the expansion of infrastructure will efficiently service future planned development. The investigation is focused on ways to optimize operation and maintenance (O&M), reduce cost and consolidate facilities. In addition to planning efforts described in Section 5.8, the County is in the process of implementing upgrades at several WRF's. Major WRF upgrades and associated budgets specified in the County's CIP are outlined below along with future expansion efforts which were defined through IMP planning workshops.

- **Ongoing WRF Upgrades -** Ongoing WRF upgrades include improvements to major facilities that are already underway. The total budget for these projects is estimated to be $30 million based on the CIP.
    - **Annapolis WRF Upgrades -** Upgrades to the Annapolis WRF include the design and construction of improvements to several unit processes including preliminary treatment, primary treatment, gravity sludge thickening, secondary clarification, and shellfish protection storage. This includes the replacement and rehabilitation of associated equipment and site improvements in the vicinity of these treatment processes. The improvements are necessary to ensure continued operation and maintenance of treatment components, to increase efficiency of plant operations, and to maintain roadway infrastructure.
    - **Cox Creek Grit System Improvements -** This project will evaluate, design, and construct facilities to address grit handling during high flow events. The existing system of grit collection, classification, and disposal of influent grit loads is inadequate and has resulted in significant impacts to operations and recovery efforts during storms. Grit system alternatives will be studied, and the recommended alternative will be implemented.

- **Piney Orchard SPS and Forcemain -** This project provides for the acquisition of the Piney Orchard WRF and will consolidate the ownership of the collection and treatment systems for the Patuxent and Piney Orchard Sewer Systems. Project activities include the design and construction of upgrades to meet ENR and County operational requirements.
- **Patuxent Clarifier Rehabilitation -** This project will replace the secondary clarifier equipment that is corroded of obsolete at the Patuxent WRF, including replacement of the sludge withdrawal mechanisms and repairs to existing tanks. This project will also include any needed improvements to the scum handling equipment, and extension of the utility water lines to the clarifiers and oxidation ditches.
- **Central Sanitation Facility -** This project is to relocate the Glen Burnie Complex to meet the existing and future needs of the wastewater activities (i.e., administration, line maintenance, system evaluation and rehabilitation, bureau fleet and small engine maintenance). The facility will be located adjacent to the existing Central Water Facility in the Millersville Complex to centralize utility operations and includes an outdoor storage facility.
- **Chesapeake Beach WWTP -** This project will provide for construction of improvements to the Town of Chesapeake Beach Wastewater Treatment Plant.
- **Broadneck Clarifier Rehabilitation -** This project will repair/replace secondary clarifier equipment that is corroded or obsolete at the Broadneck WRF. The project will improve the clarifier scum handling and replace the sludge collection system with a more efficient mechanism, and it will replace sluice gates to improve operability. The project will also include modifications to sludge piping and sludge pumping equipment.
- **Broadwater WRF Blower Building Upgrade -** This project is for the design, construction, and inspection of modifications to the blower building at the Broadwater WRF
- **Cox Creek Permeate Piping Modification -** This project is for the design, construction, and inspection of modifications to the permeate piping at Cox Creek WRF.

- **Broadneck WRF Upgrade -** Broadneck WRF upgrades consist of upgrading the existing polishing pond to an emergency storage pond sized to meet the requirements of the NPDES Permit at Broadneck WRF. Work includes installing influent screening bypass, bar screen upgrades, disinfection system upgrade/expansion and other miscellaneous facility upgrades to re-rate the treatment facility to 8 MGD. This project will result in permit compliance and improved efficiency plus rehabilitation/replacement of old facilities. The CIP budget for this project is $8 million.

- **WRF Infrastructure Upgrades/Retrofit -** This project provides for the design and construction to upgrade various wastewater system infrastructure, including structures and equipment to meet current control and operational standards. The annual CIP budget for this project is $1 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.

- **WRF Expansions -** WRF Expansions include capacity expansions to existing WRFs to meet projected wastewater flows. The total budget for these projects is estimated to be $29 million based on the CIP.
    - **Cox Creek Expansion -** Based on the County's 2007 Sewer Strategic Plan, the projected 2030 flow to Cox Creek is expected to go over capacity which will require an expansion to

the facility. The County plans to accommodate the future watershed capacity by expanding Cox Creek WRF to 16.5 MGD.

- **Maryland City WRF Expansion -** The project will include the addition of a new process train, including tankage, process units, modifications to existing facilities, upgrade of the headworks, and all other necessary work for the facility's expansion to 3.7 MGD.

5.3 Major Water Treatment Facilities

5.3.1 Existing System

The County's water system is divided into 12 pressure zones or service areas, each with a distinct hydraulic grade based on the ground elevations within that zone. Eight of the 12 zones are interconnected, which enables the County to transfer water between these zones as needed. There are also 3 sub-pressure zones that are entirely within and served by a single larger pressure zone. The remaining land not contained in one of the 12 pressure zones is either served by the City of Annapolis, Fort Meade or is designated as Rural.

Table 5-2 is a list of current water treatment facilities by pressure zone and their rated capacities.

Table 5-2 - Water Treatment Facilities and Rated Capacities

Water Treatment Facility	Capacity (MGD)
Broadneck 220	
Arnold WTP	16
Glen Burnie Low - 220	
Severndale WTP	8
Glen Burnie High - 295	
Dorsey Road WTP	3.3
Crofton 290/Kings Heights Odenton 330	
Crofton Meadows II WTP	15
Independent Pressure Zones	
Broad Creek WTP	8
Gibson Island WTP	0.3
Herald Harbor WTP	0.6
Rose Haven WTP	0.25

5.3.2 Program Needs

Facility planning in the County is done in accordance with the needs identified in the Water Strategic Plan. Facilities are planned with the potential future service area taken into consideration as well as implementation of project phasing to service the existing, interim, and future conditions. These needs are based on demand projections developed by consolidating planning criteria from AADPW and the Office of Planning and Zoning (OPZ). AADPW and OPZ in conjunction with Malcolm Pirnie/Arcadis developed demand projections for the 2016 Comprehensive Water Strategic Plan. These demands were calculated for the planning period (2012 to 2030) and for buildout conditions (estimated at 2087) (Arcadis 2016). Demand projections were recently updated as part of the 2022 Water & Sewer Master Plan which extended the build-out year to approximately 2132. Figure 5-1 shows the production growth rate through the projected build-out year. In addition to planning efforts described in Section 5.8, the County is in the process of implementing upgrades at several WTP's. Major WTP upgrades and associated budgets specified in the County's CIP are outlined below. Future expansion efforts and associated budgets defined through the County's Water Strategic Plan and IMP planning workshops are also included (Arcadis 2016). These future expansions will be driven by increases in County water demand.

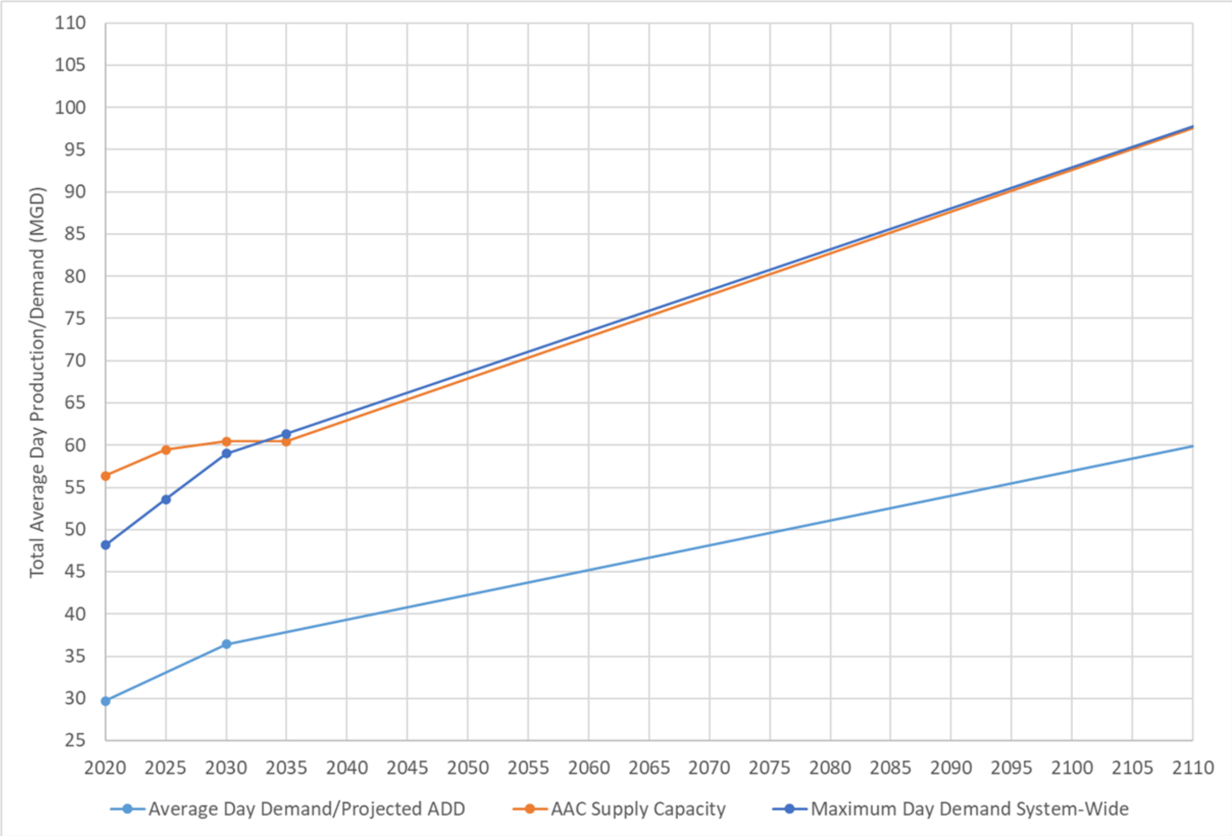


Figure 5-1 - Average Day Demand Projections

Future expansion projects have been identified by the county based on a 2007 document published by MGS related to available groundwater from the Upper Patapsco, Lower Patapsco, and Patuxent aquifers through 2044. Based on the study findings, it was recommended that any major investment in new supply sources by made only within the east or southern portions of the county. Optimizing the use of existing and potential County supply wells will minimize reliance on the Baltimore City Central Water System. The following expansions are planned to meet future demands at build-out conditions:

- **Crofton Meadows II Expansion Phase 3 -** This project will expand the Crofton Meadows II WTP capacity to 28 million gallons per day to meet future growth. This is budgeted for $40 million in the Water Strategic Plan (Arcadis 2016).
- **Arnold WTP Expansion -** This project will expand the Arnold WTP capacity to 28 million gallons per day to meet future growth. This is budgeted for $60 million in the Water Strategic Plan (Arcadis 2016).
- **Millersville WTP Construction -** This project consists of the planning and siting studies to support the design, right of way acquisition, and construction of the new Millersville WTP to serve the Glen Burnie High Zone. This new facility will provide additional capacity to support future growth and is intended to replace the Dorsey WTP. Once Crofton Meadows II and Arnold have reached their build-out capacity, the new Millersville WTP will be constructed. The plant will initially have a 10 MGD capacity and will be constructed in multiple phases as County demand increases to ultimately provide 32 MGD at build-out. Subsequent expansion phases will include expansions of the local wellfields and construction of a second raw water pipeline. This is budgeted for $238 million in the Water Strategic Plan (Arcadis 2016).

- **Broad Creek II WTP Expansion -** This project will expand the Broad Creek WTP capacity to 11 million gallons per day to meet future growth. This is budgeted for $29 million in the Water Strategic Plan (Arcadis 2016).

- **Ongoing WTP Upgrades -** Ongoing WTP upgrades include improvements to major facilities that are already underway. The total budget for these projects is estimated to be $5 million based on the CIP.
  - **Arnold WTP Upgrades -** This project will include design, construction, and inspection of a new administration building and maintenance building at the Arnold WTP. This project will also include an upgrade to the existing process control system and related SCADA system improvements, and upgrades to the facilities' fires alarm system as needed.
  - **Dorsey WTP Improvements -** This project will include design, construction, and inspection of a new administration building and maintenance building at the Dorsey WTP. This project will also include related process control system and SCADA system improvements, upgrades to the facility's fire alarm system as needed, and painting and repair of structures and equipment throughout the facility.

5.4 Collection System

5.4.1 Existing System

Eleven separate and distinct sewer service areas have been established for purposes of providing sewerage facilities to serve the County. The remaining land is designated as Rural. The boundaries of these service areas are shown in Figure 2-1. These service areas are based on topography and natural drainage areas. There are no combined sewers carrying both sewage and storm water within the public sewer service areas. Six of the County's 11 sewer service areas (SSAs) are currently anticipating significant growth. These include Cox Creek, Broadneck, Maryland City, Baltimore City, Patuxent, Mayo, and Annapolis. The remaining SSAs include Bodkin Point, Broadwater, Rose Haven, and Piney Orchard.

5.4.2 Program Needs

Collection system program needs and associated budgets specified in the County's CIP are summarized in this section.

5.4.2.1 REHABILITATION AND REPLACEMENT PROGRAM

- **Sewer Main Replacement and Reconstruction -** This is a multi-year sewer infrastructure investigation, rehabilitation, and replacement program to ensure the adequacy of the County's Wastewater Collection System. Numerous complaints of insufficient capacity, basement flooding, stoppages, and system interruptions indicate the need to investigate, rehabilitate or replace inadequate mains and service connections. Results of investigations and rehabilitation will require calibration and upgrade of the hydraulic model to accurately reflect system capacity. Additionally, data conversion and automation will be required to graphically display modeled capacity and infrastructure expansion. Studies of the forcemain network are also included in this project. The annual project budget in the CIP is $11.4 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Upgrade/Retrofit Sanitary Sewer Pump Stations -** This project will better ensure the proper operation and maintenance of stations to avoid overflows and adverse environmental impacts (e.g., odor control) through retrofits and replacements to meet state regulations. The annual

project budget in the CIP is $9.2 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.

- **SPS Facility Generator Replacements -** This multi-year project provides funding for design and construction of replacement generators and fuel tanks at sewage pumping stations throughout Anne Arundel County. The County operates approximately 250 sewage pumping stations. This project provides for installation/replacement of 10 to 15 generators per year as well as associated alterations to address code compliance issues. Generators provide a more redundant power source to ensure station operation and avoid overflows and adverse environmental impacts in the event of loss of commercial power. The annual project budget in the CIP is $2.5 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.

5.4.2.2 SYSTEM EXPANSION

- **Cattail Creek Forcemain Replacement -** This project is for design, right of way acquisition, and construction of the replacement of 17,000 LF of 24-inch and greater forcemain beginning at the Cattail Creek SPS and ending at a gravity manhole in College Parkway. Approximately 10,000 LF of this forcemain is along the MD Route 2 Right-of-Way in Severna Park. The total project budget in the CIP is $24.5 million.
- **Furnace Branch Sewer Replacement -** This project is to design and construct a new sewer line under Sawmill Creek east of Ritchie Highway in Glen Burnie. It will relieve capacity problems in an existing 21-inch sewer west of Ritchie Highway and replace an existing sewer laid at zero slope. The total project budget in the CIP is $1 million.
- **Mayo Collection System Upgrade -** This project will expand the Mayo Wastewater Collection and Conveyance System and provide for upgrades to existing facilities to accommodate growth within the Mayo Sewer Service Area. The total project budget in the CIP is $7.4 million.
- **Routine Sewer Extensions -** This project includes design extensions, land acquisition, and construction of minor extensions to the existing sewer system, as petitioned by residents or determined necessary as an integral requirement of CIP road improvements that accommodate the road design and/or avoids future excavation of the new road infrastructure. This project also enables the county to respond to emergency situations mandated by the State Health Department and/or MDE. Construction of major extensions (those estimated to cost more than $250,000) are programmed and budgeted as separate capital projects. The annual project budget in the CIP is $250,000. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.

5.5 Distribution System

5.5.1 Existing System

An overview existing water distribution system is described in Section 5.3.1. In an effort to reduce O&M costs, the County is continually focused on ways to standardize equipment, consolidate facilities, and optimize pressure zone boundaries. Distribution and transmission system piping and pump station facilities financed by the development community or the County’s Utility Enterprise Fund are reviewed with optimization and reduction of O&M costs in mind.

5.5.2 Program Needs

Distribution system program needs and associated costs specified in the County’s CIP are summarized in this section.

5.5.2.1 REHABILITATION AND REPLACEMENT PROGRAM

- **Water Main Replacement/Reconstruction -** This is a multi-year Water Infrastructure Investigation, Rehabilitation and Replacement Program. Numerous complaints of low pressure and dirty water indicate the need to investigate, rehabilitate or replace inadequate mains and service connections. Results of investigations and rehabilitation will require calibration and upgrade of the hydraulic model to accurately reflect system capacity. Additionally, data conversion and automation will be required to graphically display modeled capacity and infrastructure expansion. This is an ongoing program to replace 2" and 3" water mains and to rehabilitate or replace deteriorating 4" and larger water mains. Studies of the distribution network are also included in this project. The annual project budget in the CIP is $10.2 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Water Storage Tank Painting -** This project is initiated to ensure the integrity of the current inventory of elevated and ground storage water tanks and is part of an ongoing project to inspect, rehabilitate and paint the current inventory within an economically feasible period. Future tank rehabilitation/painting is programmed as follows: FY20: Design of Crofton Meadows and Central Ave, Continued construction of Crofton Sphere and Arundel Mills, Start Construction of Crofton Meadows, EWST Tank Evaluation, Antenna inspection; FY21: Design of Maryland City, continued construction of Crofton Meadows, EWST Tank Evaluation, Antenna inspection; FY 22: Construction of Central Ave, EWST Tank Evaluation, Antenna inspection; FY 23: Design of Old Mill, continued construction of Central Ave, EWST Tank Evaluation, Antenna inspection; FY 24: Design of Jumpers Hole, EWST Tank Evaluation, Antenna inspection; FY 25: Construction of Old Mill, Construction of Maryland City, EWST Tank Evaluation, Antenna inspection. Benefit is preventive maintenance of infrastructure. The annual project budget in the CIP is approximately $2.2 million. DPW will assume this rate will increase by $100,000 per year over the 30-year planning horizon for a total project budget of $99M.
- **Water Infrastructure Upgrades/Retrofits -** This project involves the upgrades of various water system infrastructure, including structures and equipment to meet current control and operational standards. This project will better ensure the proper operation and maintenance of water infrastructure facilities to allow upgrades, rehabilitation, or replacement of various components to improve reliability and performance. The annual project budget in the CIP is $500,000. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Water Facility Emergency Generators -** This multi-year project provides funding for the design and construction of new and replacement generator installations at water treatment plants, water booster pumping stations, water production wells, and other water related facilities located throughout the County. Generator installations will include generator, fuel storage, automatic transfer switches, sound attenuation and necessary electrical components/wiring, as well as associated alterations to address code compliance issues. The supplemental power source will allow the utility to meet domestic and fire water demands in the event of extended power outages. The total budget for this project is $2 million based on the CIP.

5.5.2.2 SYSTEM EXPANSION

- **Routine Water Extensions -** This project is for the design, land acquisition and construction of minor extensions and minor projects identified by DPW to the existing water system as petitioned by residents or determined necessary as an integral requirement of CIP Road Improvement that accommodates the road design and/or avoids future excavation of the new road infrastructure. It will also enable DPW to respond to emergency situations mandated by MDE for water service. Construction of major extensions (those estimated to cost more than $250,000) are programmed and budgeted as separate capital projects. The annual project budget in the CIP is $200,000. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.

- **12” St Margarets/Old Mill Bottom** – This project is for the design, right-of-way acquisition, and construction of approximately 7,000 LF of 12-inch water main within the 220 Broadneck Service Area. The main will extend along St. Margarets Road from the Amberly WTP to the existing distribution system located on the north side of MD Route 50 at Old Mill Bottom Road. The project will improve the pressure within the existing distribution system. The total budget for this project is $400,000 based on the CIP.
- **Hanover Road Water Main Extension** - This project is for the design, right-of-way acquisition, and construction of approximately 1,450 LF of 12-inch water main from Ridge Road to New Ridge Road in the Hanover area. The total budget for this project is $388,000 based on the CIP.

5.5.2.3 WATER SUPPLY RESILIENCY PROJECTS

The County is in the process of planning for the future water demands relative to system growth, reliability, and resiliency. As part of this process, a transmission main from the Glen Burnie Low pressure zone to the Glen Burnie High pressure zone, referred to as the East/West Transmission Main (E/WTM), is planned for design and construction in the near term. The program includes a large diameter transmission main to be designed and constructed in three phases with an estimated total project cost of nearly $100 Million. A similar water transmission resiliency project is being planned for the Route 32 corridor from Brockbridge Road and Guilford Road to the intersection of Mapes Road and Route 32. The Route 32 Transmission Main is needed to improve reliability by providing a looped transmission main and will allow flow from the 400 Zone to the 330 Zone. This project is currently budgeted for $50 million.

5.6 Stormwater Management

5.6.1 Existing System

The County stormwater management regulations were adopted by the County Council and became effective November 22, 2010. MDE approved the County’s SWM program in September 2011. The County’s Stormwater Management Practices and Procedures Manual provides developers, consultants, and County staff with guidance regarding the procedures, processes, policies, and regulations that apply to stormwater management for proposed developments within the County (Anne Arundel County 2017).

The Bureau of Highways currently manages the maintenance of 700 County stormwater management facilities, or Best Management Practices (BMP’s). These BMP’s capture upstream drainage and trap pollutants that would otherwise be directed intro streams during wet weather events. BMP inspections are a requirement of the County’s NPDES and will be used to determine maintenance needs and project budgetary program requirements. The Bureau of Highways also is responsible for the inventory, inspection, and maintenance of the County’s culverts and closed storm drain systems. There are approximately 85,000 components in the inventory currently. These components include inlets, manholes, pipes, culverts and outfalls. Other stormwater management programs include ditch/curb and gutter cleaning, drainage construction, drainpipe cleaning, drainpipe repair and replacement, the emergency storm drain program, erosion control, storm drain cleaning and repair, and street sweeping.

5.6.2 Program Needs

Stormwater management program needs and associated costs specified in the County's CIP are summarized in this section.

5.6.2.1 STORMWATER PERMIT CYCLE 3 PLACEHOLDER

The sole purpose of this project is to serve as a "place holder" in the program years of the capital improvement program (CIP). In this way funding can be allocated in the CIP for the orderly pursuit of a large list of projects with the primary purpose of addressing the County's expected "Permit Cycle 3" requirements without requiring the premature identification of the most cost efficient and programmatically effective improvements. This project will not be the subject of any appropriation and therefore no expenditures will ever accrue against this project. The total budget for this project is $150 million based on the CIP.

5.6.2.2 STORMWATER INFRASTRUCTURE

- **Culvert and Closed Storm Drain Rehabilitation -** This rehabilitation project involves design and construction to rehabilitate, upgrade and replace small culverts on local roads and minor closed storm drain systems that, although functioning, are badly deteriorated, inadequate and in need of upgrades. Where practical, environmentally sensitive design techniques to enhance water quality will be incorporated. This project will correct minor, localized ponding and flooding conditions, improve storm drain conveyance, and rehabilitate/extend the useful life of existing storm drain systems and culverts while enhancing the water quality of runoff. The annual project budget in the CIP is $5.2 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Storm Drainage/Stormwater Infrastructure -** This project involves the study, design and construction of large, regional storm drain systems and stormwater management infrastructure to relieve widespread ponding or flooding of public and private properties and existing public infrastructure. This project also involves repair, rehabilitation and replacement of major culverts that are beyond their useful life. Environmentally sensitive design techniques will be identified and incorporated into the design to enhance the water quality of stormwater runoff. This project will improve storm drain conveyance on a community wide basis, enhance the water quality of runoff, and provide protection to existing public and private properties and infrastructure. The annual project budget in the CIP is $1 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Emergency Storm Drain -** This project involves the installation of storm drain inlets, manholes, pipes, small culverts, and systems to provide for immediate relief to localized ponding or flooding of roads, public infrastructure, and private properties subject to runoff from public facilities. These improvements are countywide and will improve storm water conveyance, protect existing public and private properties and existing public infrastructure, and provide quick response to emergency storm water problems through multiple years. The annual project budget in the CIP is $2.35 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **SE-ST-02 (Severn River – Streams with Nearby Outfalls & Ponds) -** This project is for the design and construction for stormwater management infrastructure improvements necessary to comply with Federal and State clean water requirements. This project includes restoration and improvements to approximately seven outfalls, two private ponds, and five stream segments (5,044 LF). The total budget for this project is $500,000 based on the CIP.
- **Clark Station Road Resilience Improvements** - This project is for the design, permitting, and construction of drainage improvements in the vicinity of Clark Station Road and Burns Crossing Road in Severn, including acquisition of properties or easements in the vicinity that

will be negatively impacted by the improvement of drainage. Additionally, the project includes the acquisition/easement of some upstream parcels to provide additional resiliency for the drainage system and to ensure conditions do not worsen. The total budget for this project is $4 million based on the CIP.

5.7 Other Programs and Capital Expenses

The County’s CIP includes ongoing expenditures for other programs and capital expenses that do not fit into the previous categories.

5.7.1 Sewer Programs and Capital Expenses

- **Baltimore County Sewer Agreement -** Costs associated with the Baltimore County sewer Agreement include the construction of improvements to Baltimore City's Patapsco Wastewater Treatment Plant and connecting interceptors. Approved funding is the County's apportioned share of the costs, which will be contributed under agreement to Baltimore County, which in turn maintains a similar agreement with Baltimore City. Improvements are managed and executed by the City of Baltimore in accordance with needs identified by the City. The annual project budget in the CIP is $500,000. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Wastewater Service Connections -** This project consists of installing service connections and meters to existing water and sewer mains for which service laterals were not originally constructed as part of the capital budget program. This project is also used for new meter installations. All services are installed under contracts administered by DPW. The annual project budget in the CIP is $1.77 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Demolition (Facility Abandonment WW2) -** This project provides funds to demolish abandoned structures, and to dismantle, remove and dispose of unused/unwanted equipment from wastewater conveyance and treatment facilities as required by Operations. The total budget for this project is $690,000 based on the CIP.
- **Grinder Pump Replacements/Upgrades -** This project is for a multi-year sewer infrastructure investigation, rehabilitation, and replacement program to ensure the adequacy of the County's Wastewater Collection System. Aging infrastructure and changes to manufacturing and design standards have resulted in some existing low-pressure force main areas exhibiting lower overall reliability. Studies of low-pressure force main networks are also included in this project where required. This project will investigate existing systems and where practicable provide upgrades or replacements as needed to meet current best practices. The annual budget for this project is $500,000 based on the CIP.
- **State Highway Sewer Relocation -** This project is programmed for replacement and/or relocation of existing County wastewater infrastructure and water infrastructure which are required because of state highway construction. The annual project budget in the CIP is $200,000. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Biosolids –** The County renewed their contract with Synagro in 2020 for another 10 years. This is a critical step in phase 2 of the County’s master plan (i.e., technology selection and defining what milestones will trigger capital projects) as the County moves towards greater biosolids processing capabilities in the future. The total budget for this project is $70 million based on workshops with DPW.

5.7.2 Water Programs and Capital Expenses

- **Billing (AMI/AMR) -** The current water meter project is a multi-year project to support the replacement and upgrade of aging water meters. The project anticipates an annual replacement of approximately 5,500 meters from the total inventory of 142,000 metered accounts. Meter replacements will minimize revenue losses associated with the reduced accuracy of older meters. Additionally, the AMI water meter program will provide funds for design, construction, and implementation of the Advanced Metering Infrastructure System. This work will be implemented in multiple phases with the initial phase of the project including the design and engineering of architectural software and system infrastructure. Automated water meter infrastructure will provide a more enhanced data collection system with improved efficiencies and improved customer interactions. The total budget for this project is $43 million based on the CIP.
- **Existing Well Redevelopment & Replacements -** The existing raw water wells need to be redeveloped to maintain pumping rates, screens need to be cleaned, and if necessary, pumps and columns completely replaced. This project includes continue redevelopment so that each well is redeveloped approximately once every 10 years. Included in this project is the replacement and/or remediation of existing aging and failing wells as required. This is an on-going project to investigate and redevelop all existing raw water wells (approximately 56 wells) as needed to ensure that all wells will continue to operate at optimum rates. The annual project budget in the CIP is $2.4 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Fire Hydrant Rehabilitation -** This is a multi-year, ongoing project for coating maintenance on fire hydrants on an approximate 7-10-year life cycle. The annual project budget in the CIP is $500,000. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Elevated Water Storage -** this project involves the construction of elevated water storage tanks in accordance with the Water Strategic Plan. The current program includes new elevated tanks in the Broad Creek, Heritage Harbor, Broadneck, Glen Burnie Low, Crofton, and Maryland City zones to meet domestic and fire flow demands. The total budget for this project is $8 million based on the CIP.

5.8 Program Planning and Support

Consultant support will be required to complete the studies necessary to increase the County's understanding of several specific program needs, prioritize them, and incorporate them into the Phase 2 of the IMP. Support will also be required to facilitate delivery of the ambitious improvements program DPW is committing to execute through the IMP. The estimated 30-year costs for these programmatic support items are described below.

- **Wastewater Project Planning -** Associated costs include preliminary planning, engineering, and cost estimating for proposed future capital sewer projects. This is a revolving fund that will be reimbursed as the future capital projects are established and funded in the Capital Budget. The annual project budget in the CIP is $1.5 million. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.
- **Wastewater Strategic Plan -** This includes the development of Sewer Strategic Plans to achieve orderly programming and construction of sewerage facilities and to update the master plan. Work will also include development of a biosolids strategic plan to manage wastewater residuals. The annual project budget in the CIP is $150,000. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.

- **Water Project Planning -** Associated costs include preliminary planning, engineering, and cost estimating for proposed future capital water projects. This is a revolving fund that will be reimbursed as the future capital projects are established and funded in the Capital Budget. The annual project budget in the CIP is $50,000. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.

  Water Strategic Plan - This is to fund the update of the Comprehensive Strategic Water Plan, the Master Plan and to fund the County's interest in Well Head Protection. Funding through this project will also be used for the development of water strategic plans for the orderly programming and construction planning of water facilities. The annual project budget in the CIP is $50,000. DPW will assume this rate will continue un-escalated for the 30-year planning horizon.

6 Community Engagement

Anne Arundel County DPW has a proven track record of providing high quality service to County customers and takes pride in providing transparent decision-making and keeping the community well-informed. During IMP development, DPW has relied on input from multiple stakeholder groups to guide and affirm plan priorities.

- Septic Task Force – To assist with developing appropriate policy approaches, DPW convened a Septic Task Force (“Task Force”) in late 2016 to assist in the development of a septic conversion program that aimed to convert up to 20,000 septic connections. Task Force members represent a cross section of the community and area from different backgrounds to provide varying perspectives. The task force was supported by Anne Arundel County Government and program management consultant staff. The efforts of the first phase of the Task Force were summarized in a June 2018 report, which identified the consensus recommendations of the Task Force and individual recommendations of separate working groups. In July 2019, the Task Force was reconvened to discuss changes in the scale of the program, financial plan, and policy development following the WIP III update and the development of the integrated planning approach.

- Water Quality Survey – DPW surveyed residents in the fall of 2019 to collect information about water quality perceptions and opinions in the area. The results of the survey will be utilized as the County works to develop strategies to further reduce pollutants to the Chesapeake Bay.

- Our wAAter Focus Groups - DPW implemented two asynchronous virtual focus group surveys Department of Public Works (DPW) in June 2020 to test program messaging and costs ahead of publicly launching the Our wAAter Program. The focus group surveys were conducted to a sample of residents in the Edgewater Beach and Amberley communities. Both areas are eligible for the Our wAAter Program and provided feedback to help refine the overall program, and more specifically the Septic-to-Sewer Connection enrollment process.

- Septic-to-Sewer Program Community Informational Meetings– During 2021, DPW facilitated more than 20 meetings with communities that expressed interest in the Septic-to-Sewer program. These meetings included an introduction to the Our wAAter program and the County’s integrated approach to managing water resources. Additional meetings are planned for 2022.

DPW has incorporated the feedback received from these efforts into this Draft IMP. In the context of EPA’s integrated planning framework, community outreach should be an ongoing process that informs goals and outcomes over time. Therefore, DPW plans to more deeply engage the broader community as the final draft of the IMP is prepared.

The primary goal of the DPW’s Strategic Communications Plan is to inform and educate stakeholders about the Managed Aquifer Recharge and Septic System Conversion initiative and to engage them on appropriate decisions as the program is defined. The DPW team commits to:

- Facilitating an outcome-based process designed to bring the public and stakeholders along in the decision-making process.

- Fostering open communication between a diverse mix of agencies, stakeholders and the Project team to solicit and collect valuable feedback to guide the initiative.
- Using clear and concise messaging to communicate with the public and various stakeholders.
- Managing expectations of how input will be used and valued.
- Promote informed consent of the defined management alternative.

During detailed design, DPW will continue its public outreach involvement through interactive meetings with the public, further meetings with elected and appointed officials, and discussions with MDE and MDP. The Our wAAter program website, located at www.ourwAAter.com, will be instrumental in providing continuous project updates to the general public in a conveniently accessed format. DPW staff will implement an aggressive social media strategy that advertises events, shares relevant local and national media, and educates stakeholders on the initiative through compelling imagery. Social media targeting tools will be utilized to ensure messages are received in stakeholder feeds. Information provided to the media about the initiative will correspond with public input opportunities, key milestones, or points of celebration for the project.

Finally, a Public Advisory Group (PAG) is being convened during 2022 to advise on the key elements of the Our wAAter program: MAR, Septic to Sewer, and Minor Systems Upgrades. The PAG will consist of community leaders, representatives from local environmental groups, and other program advocates. DPW will work with the PAG to solicit feedback on the IMP and implementation of the Our wAAter program in general.

7 Project and Program Prioritization and Scheduling

To prioritize and schedule the investments identified in Section 5, the County developed a decision analysis tool to measure the anticipated environmental and community benefits produced by each project. Projects and programs were then evaluated with the County's existing CIP and Water and Sewer Master Plan to develop on IMP schedule that is implementable, fundable, and prioritizes the highest benefit projects early in the planning period. A 30-year IMP planning period was used for this evaluation. Project prioritization will be refined as stakeholder input is received on the draft plan and in coordination with the FY22 budgeting process.

7.1 Project Identification

The County's review of water and wastewater management needs identified approximately $3.5 billion (in 2020 dollars) in potential projects and solutions to address all currently forecasted system-wide capital and programmatic needs Table 7-1. These costs were largely derived from the County's CIP, IMP planning workshops, the County's Water Strategic Plan, and the Alternatives Evaluation (Appendix D). Planning level costs associated with these projects includes both capital costs and costs associated with conducting necessary planning activities.

Table 7-1- Summary of Projects and Planning Level Costs[1]

Category	Project and Estimated 30-Year Budget (in 2020 $)
Wastewater Treatment Facilities	Ongoing WRF Upgrades ($30M)
	Broadneck WRF Upgrade ($8M)
	WRF Infrastructure Upgrades/Retrofit ($30M)
	WRF Expansions (Cox Creek and Maryland City) ($29M)
	Minor Systems Upgrades ($21M)
	Managed Aquifer Recharge ($357M)
Water Treatment Facilities	Crofton Meadows II Expansion Phase 2 ($37M)
	Crofton Meadows II Expansion Phase 3 ($40M)
	Dorsey Road Offline ($1M)
	Arnold WTP Expansion (16 to 20 MGD) ($57M)
	Arnold WTP Expansion (20 to 28 MGD) ($60M)
	Broad Creek II WTP Expansion ($29M)
	Ongoing WTP Upgrades ($5M)
	Millersville WTP Construction ($238M)
Collection System	Sewer Main Replacement/Reconstruction ($402M)
	Upgrade/Retrofit Sanitary Sewer Pump ($330M)
	SPS Facility Generator Replacements ($73M)
	Sewer Extensions ($40M)
Distribution System	Water Main Replacement/Reconstruction ($355M)
	Water Storage Tank Painting ($135M)
	WTR Infrastructure Upgrades/Retrofits ($25M)
Stormwater Management	Stormwater Permit Cycle 3 Placeholder ($150M)
	Stormwater Infrastructure ($260M)
Miscellaneous Projects	Baltimore County Sewer Agreement ($20M)
	Wastewater Service Connections ($52M)
	Water Facility Emergency Generators ($5M)
	Routine Water Extensions ($7M)
	Demolition ($2M)
	Grinder Pump Replacements/Upgrades ($15M)
	State Highway Sewer Relocation ($6M)
	Septic-to-Sewer ($392M)
	Biosolids ($70M)
	Billing (AMI/AMR) ($43M)

Category	Project and Estimated 30-Year Budget (in 2020 $)
	Existing Well Redevelopment & Replacements ($72M)
	Fire Hydrant Rehabilitation ($15M)
	TM-MD Route 32 at Meade and East/West Transmission Main ($50M)
	Elevated Water Storage ($8M)
	Aquifer Storage and Recovery (ASR) ($24M)
Planning	Wastewater Project Planning ($48M)
	Wastewater Strategic Plan ($5M)
	Water Project Planning ($2M)
	Water Strategic Plan ($1.5M)

[1]Projects ($3.5 billion total) included in this table were prioritized with a decision analysis tool to develop the final 30-year IMP project schedule. Presented in 2020 dollars.

7.2 Multiple Criteria Decision Analysis Tool Development

Multiple criteria decision analysis (MCDA) is a structured, quantitative technique used to solve planning problems that involve multiple decision criteria or objectives. When applied correctly, MCDA facilitates the critical thinking process in an open and transparent manner. Simplistically, a MCDA is conducted by scoring potential alternatives relative to a set of weighted criteria using a standardized rating system. After all alternatives are scored, the alternative with the highest total score should be the one that best addresses the overall planning goals. By coupling final benefit scores with costs, a prioritized implementation schedule can be developed.

A critical aspect of developing an MCDA tool is creating a decision framework that explicitly links the alternatives to evaluation criteria, which represent the interests or priorities of the community. Sub-objectives are critical to the decision framework because they provide an objective means of linking alternatives to the community objectives. Once established, the framework enables decision makers to understand how the overall goal is linked to the individual alternatives and helps facilitate the scoring process.

The MCDA tool incorporates four basic components:

1. **Goal** - The goal of the MCDA evaluation was to identify projects that provide the greatest community and environmental benefit.
2. **Projects and Programs** - The projects and programs were defined based on an assessment of forecasted needs through the year 2050.
3. **Weighted Evaluation Criteria** – Evaluation criteria represent the planning objectives that the projects are intended to address. The weighting reflects the relative importance of each criterion. In this MCDA, the evaluation criteria reflect DPW’s Mission Statement. The IMP evaluation criteria are explained in greater detail below.
4. **Benefit Scores** – Benefit scores were developed to quantify how well each project address the planning objectives. The scoring process is described in more detail below.

The final MCDA tool, as well as project rankings and benefit scores, are included in Appendix B. More detailed information regarding the evaluation criteria, scoring process, and optimization analysis used to evaluate the IMP alternatives are described below.

7.2.1 Weighted Evaluation Criteria

A key element of EPA’s Framework is ensuring that community needs and priorities are adequately considered in the integrated planning process. The County’s community-supported mission statement formed the basis for identifying community needs and priorities during initial stages of the IMP. The selected criteria were validated during meetings with the County. The County chose evaluation criteria that align with DPW's mission statement, which is:

- Safeguard the Environment
- Customer Service
- Financial Sustainability

These three primary objectives were then weighted on a 0 to 1 scale (with a sum of 1) based on a qualitative assessment of community values. After the three primary objectives were defined, the County identified and weighted seven sub-objectives that more specifically characterized the primary objectives. Descriptions of the scoring basis for each sub-objective are included in Appendix B. Objective and sub-objective weights were then multiplied together to develop a combined weight which reflects the relative importance of each sub-objective in the MCDA (Table 7-2).

Table 7-2 - Final Community Objectives, Sub-Objectives, and Priority Weightings used in the MCDA Evaluation*

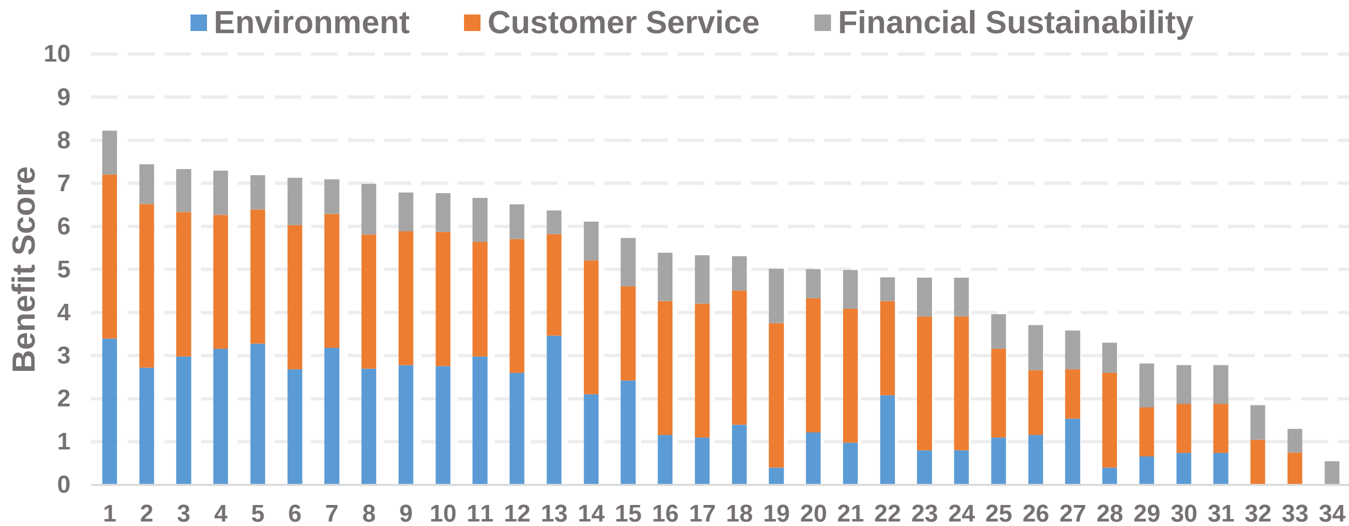
Objective (Weight)	Sub-Objective (Weight)	Combined Weight
Safeguard the Environment (0.4)	Meet Regulatory Objectives (0.4)	0.16
	Watershed Protection and Restoration (0.24)	0.10
	Sustainable, Forward-Thinking Use of Natural Resources (0.16)	0.06
	Resiliency, Ability to Adapt (0.2)	0.08
Customer Service (0.38)	Maximize Public Health, Safety, and Welfare (0.6)	0.23
	Provide for Reliable Services (0.4)	0.15
Financial Sustainability (0.22)	Affordable for Customers (0.48)	0.11
	Partnered Financial Support (0.28)	0.06
	Economic Impact (0.24)	0.05

**Note that community objective weights must total 1.0. Similarly. The sub-objective weights must total 1.0 for each corresponding community objective. The combined weight is the product of the objective and sub-objective weights.*

7.2.2 Project Rating and Benefit Score Calculation

Projects were assigned consensus-based ratings on a 0 to 10 scale to indicate how well each project addressed individual sub-objectives; a rating of 0 indicated that the project was not anticipated to benefit the sub-objective, whereas a rating of 10 indicated the highest benefit was expected. Project ratings were then multiplied by the combined weight and summed to develop final benefit scores (Appendix B).

Overall, the final ranked benefit scores reflected the importance of the utility drivers facing the County (Figure 7-1). The Integrated Planning process has validated that the needs addressed by the Our wAAter Program are of the highest priority to County residents. Our wAAter projects and wastewater reclamation facility upgrade projects along with collection system and facility Repair and Replacement (R&R) projects were generally expected to produce the greatest benefits, which reflects the importance of meeting regulatory obligations. Near-term capacity and expansion projects also tended to rank in the upper half of projects, in particular as a result of their positive impacts on water quality and human health. Resource recovery, waste acceptance, and future expansion projects generally produced medium to low benefits.



1 - Sewer Main Replacement & Reconstruction
2 - Stormwater Infrastructure
3 - Minor Systems Upgrades
4 - Upgrade/Retrofit Sanitary Sewer Pump Stations
5 - Ongoing WRF Upgrades
6 - Septic-to-Sewer
7 - Ongoing WTP Upgrades
8 - Managed Aquifer Recharge (MAR)
9 - Broadneck WRF Upgrade
10 - Baltimore County Sewer Agreement
11 - Grinder Pump Replacements & Upgrades
12 - WRF Infrastructure Upgrades/Retrofit
13 - Stormwater Permit Cycle 3 Placeholder
14 - Sewer Extensions
15 - SPS Facility Generator Replacements
16 - Water Main Repl./Recon., Water Storage Tank Painting, & WTR Infrastr. Up/Retro
17 - Existing Well Redevelopment and Replacements
18 - Aquifer Storage and Recovery (ASR)
19 - Fire Hydrant Rehabilitation
20 - TM-M Rte 32 @ Meade & E/W TM
21 - Elevated Water Storage
22 - Planning
23 - Water Facility Emergency Generators
24 - Water Extensions
25 - Millersville WTP (10 MGD)
26 - Billing (AMI/AMR)
27 - Cox Creek WRF Expansion
28 - Wastewater Service Connections
29 - Biosolids
30 - Crofton Meadows II Expansion Phase II
31 - WTP Construction/Expansions
32 - State Highway Sewer Relocation
33 - Dorsey Road Offline
34 - Demolition

Figure 7-1 - Final Benefit Scores for DPW IMP Water and Wastewater Projects

7.3 Project Scheduling and Delivery

The MCDA evaluation was limited to evaluating the benefits of potential projects and did not assess the anticipated financial impacts and implementation complexities that would result from delivering those projects. Project interdependencies are critically important in developing implementable schedules (e.g., project 1 must be operational prior to construction of project 2). Increasing the County's capital project delivery will significantly increase in demands on the County's project managers and management staff and stress local demands on engineering and construction firms given the other large capital programs within the region. These internal and external demands and constraints are equally important to scheduling as the financial impacts to DPW customers.

Given these complexities, the County identified a 30-year project schedule that addresses critical public health and environmental issues first, while appropriately balancing revenue requirements and ability to effectively and efficiently deliver these capital improvements. While these improvements are presented in monetary terms, achieving the customer service enhancement, environmental benefits, and regulatory obligations associated with project and program implementation are the primary goals with IMP delivery. However, the timing and expenditures for individual projects may be modified by the County during IMP implementation through adaptive management as these minor modifications will not significantly impact the County's primary goals. The County will pursue these actions to the extent possible but acknowledges that weather, staff availability, contractor performance, and other unanticipated constraints and needs may impede complete implementation on the proposed schedule. The IMP implementation schedule features approximately $3.5 billion worth of improvements (Figure 7-2 and Figure 7-3).

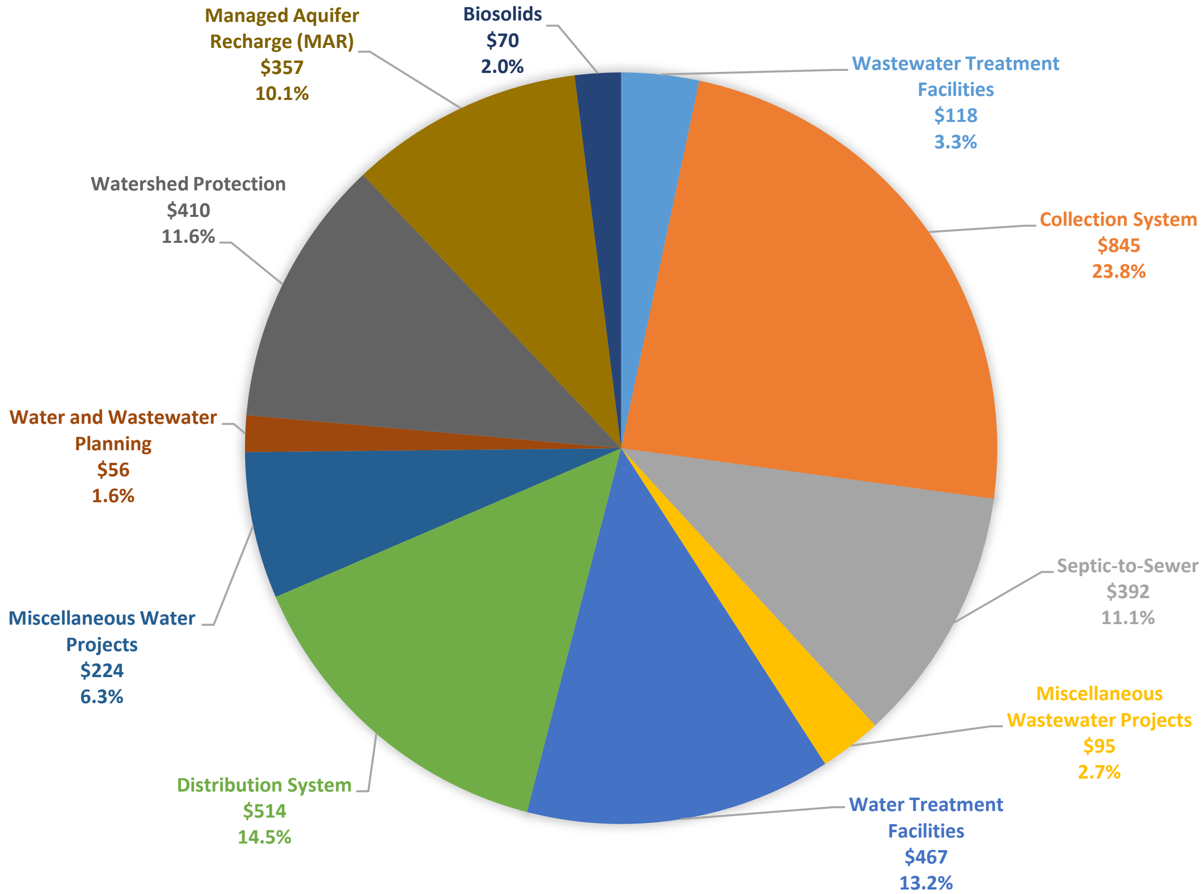


Figure 7-2 - Final IMP Program Budget for the 30-Year (2022-2051) Planning Period ($3.5B Total Budget, program budgets shown in millions, 2020 Dollars)

	Total 30-year Project Budget (2020 $ x Million)	Years 1-6 2022 - 2027	Years 7-12 2028 - 2033	Years 13-18 2034-2039	Years 14-24 2040-2045	Years 25-30 2046-2051
Wastewater Treatment Facilities						
Ongoing WRF Upgrades	$30	■	■			
Broadneck WRF Upgrade	$8	■				
WRF Infrastructure Upgrades/Retrofit	$30	■	■	■	■	■
Cox Creek Expansion (to 16.5 MGD)	$29	■	■			
Minor Systems Upgrades	$21	■	■			
Managed Aquifer Recharge (MAR)	$357	■	■			■
Collection System						
Sewer Main Replacement & Reconstruction	$402	■	■	■	■	■
Upgrade/Retrofit Sanitary Sewer Pump Stations	$330	■	■	■	■	■
SPS Facility Generator Replacements	$73	■	■	■	■	■
Sewer Extensions	$40	■	■	■	■	■
Septic-to-Sewer	$392	■	■	■	■	■
Miscellaneous Wastewater Projects						
Baltimore County Sewer Agreement	$20	■	■	■	■	■
Wastewater Service Connections	$52	■	■	■	■	■
Demolition	$2	■				
Grinder Pump Replacements & Upgrades	$15	■	■	■	■	■
State Highway Sewer Relocation	$6	■	■	■	■	■
Biosolids	$70	■	■			
Water Treatment Facilities						
Crofton Meadows II Expansion Phase 2 (15 to 20 MGD)	$37	■				
Crofton Meadows II Expansion Phase 3 (20 to 28 MGD)	$40				■	
Dorsey Road Offline	$1		■			
Arnold WTP Expansion (16 to 20 MGD)	$57			■		
Arnold WTP Expansion (20 to 28 MGD)	$60				■	
Millersville WTP (32 MGD)	$238					■
Broad Creek II WTP Expansion (8 to 11 MGD)	$29			■		
Ongoing WTP Upgrades	$5	■				
Distribution System						
Water Main Repl./Reconstruction, Water Storage Tank Painting, & WTR Infrastr. Up/Retro	$514	■	■	■	■	■
Miscellaneous Water Projects						
Billing	$43	■				
Existing Well Redevelopment & Replacements	$72	■	■	■	■	■
Fire Hydrant Rehabilitation	$15	■	■	■	■	■
TM-MD Rte 32 @ Meade & E/W TM	$50	■				
Water Facility Emergency Generators	$5	■				
Water Extensions	$7	■	■	■	■	■
Aquifer Storage Recovery (ASR)	$24	■	■			
Elevated Water Storage	$8		■	■	■	■
Water and Wastewater Planning	$56	■	■	■	■	■
Watershed Protection						
Stormwater Permit Cycle 3 Placeholder	$150	■	■			
Stormwater Infrastructure	$260	■	■	■	■	■
Total Budget (2020 $):	$3.5 Billion	$984.6 Million	$594.4 Million	$537.5 Million	$555.4 Million	$875.5 Million

Figure 7-3 - Final IMP Project Implementation Schedule

Figure 7-4 shows the final investment schedule in 6-year increments through 2051. Ongoing projects comprise the majority of the investments in the first six years. Continuous projects that include annual funding (e.g., fire hydrant rehabilitation, state highway sewer relocation, sewer main replacement & reconstruction, and stormwater infrastructure) are also included in the 30-year investment schedule.

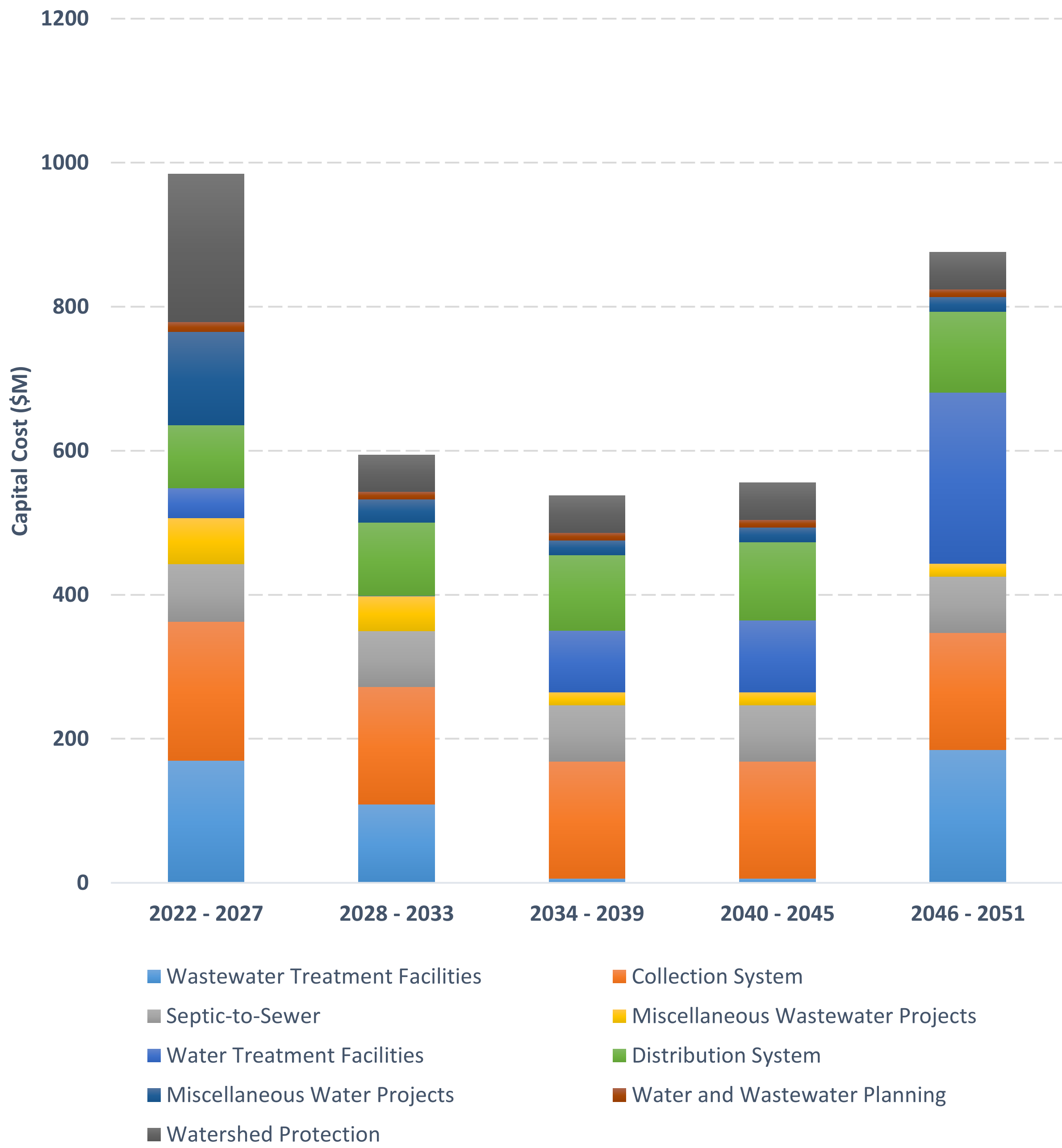


Figure 7-4 - Final IMP Investment Schedule in 6-Year Increments

8 Adaptive Management and 6-Year Action Plan

EPA's Integrated Planning Framework recognizes that adaptive management strategies are key to successful integrated planning. This means monitoring and evaluating projects and practices as work proceeds (Element 5) and adapting or revising plans and designs as new information is developed (Element 6). The IMP project schedule presented in the previous section reflects Anne Arundel County's understanding of infrastructure needs and regulatory priorities over the next 30 years with respect to the information currently available. However, uncertainties exist which could impact these priorities as additional needs or regulatory requirements are identified. Therefore, adaptive management activities will be key to refining the forecasted timing and cost of program improvements as the IMP is implemented over time. DPW will reevaluate and update the IMP at least every five years based on greater system understanding, results of program and project implementation, and updated benefit evaluations.

DPW intends to implement a long-term performance monitoring approach that measures both the environmental and programmatic improvements that result from implementing the IMP. Specific performance metrics will be linked to the project evaluation criteria identified in Section 7.2 and results will be used to adjust or enhance the program, as necessary. Performance measures include tracking DPW's applicable Key Performance Indicators (KPIs) for the collection and treatment systems, reviewing effluent monitoring and other publicly available receiving stream data to characterize water quality improvements, and creating management controls to facilitate project execution and reliably achieve significant project milestones.

DPW currently has a robust KPI monitoring program for collection system performance and is continuing to develop and improve facilities KPI monitoring. DPW will continue to track system performance measures including dry and wet weather backups and overflows and the cause of each event. Along with these performance measures, DPW is developing an asset management program that will inform KPIs associated with tracking inspection and maintenance productivity and will use these measures to prioritize resources to meet operational goals. DPW will also closely track system renewal efforts and prioritizes these efforts based on the risk associated with each pipe, in order to address the highest risk assets identified through inspection efforts. Pre- and post-renewal flow monitoring is conducted to track the effectiveness of I/I reduction efforts and adjust program strategies accordingly.

Performance measures need to be identified for the Septic to Sewer and MAR programs and should be incorporated into the next IMP update. The success of these programs will be measured through DPW's existing KPI monitoring program and through the achievement of milestones and actions outlined in the 6-Year IMP Action Plan and Investment Schedule outlined below (Figure 8-1 and Figure 8-2).

The next planned update of the IMP will coincide with the next update of the County's Master Plan for Water Supply and Sewerage Systems, which is scheduled to occur between 2025 and 2027 based on historical update cycles. At this time, DPW will evaluate progress and make necessary changes and adjustments during future phases to ensure continuing progress towards satisfying infrastructure demands and meeting regulatory obligations.

In this IMP, high level preliminary cost estimates have been included for these items and improvements have been scheduled based on current understanding. Most of these projects are in the current CIP. The FY23 budgeting process will incorporate new projects in the Action Plan. Figure 8-2 illustrates the Action Plan investments by category.

	Capital Cost (2020 $ x Million)	Year 1 2022	Year 2 2023	Year 3 2024	Year 4 2025	Year 5 2026	Year 6 2027
Wastewater Treatment Facilities							
Ongoing WRF Upgrades	$30						
Broadneck WRF Upgrade	$8						
WRF Infrastructure Upgrades/Retrofit	$6						
Cox Creek Expansion (to 16.5 MGD)	$7						
Minor Systems Upgrades	$11						
Managed Aquifer Recharge (MAR)	$107						
Collection System							
Sewer Main Replacement & Reconstruction	$80						
Upgrade/Retrofit Sanitary Sewer Pump Stations	$66						
SPS Facility Generator Replacements	$13						
Sewer Extensions	$34						
Septic-to-Sewer	$80						
Miscellaneous Wastewater Projects							
Baltimore County Sewer Agreement	$8						
Wastewater Service Connections	$10						
Demolition	$2						
Grinder Pump Replacements & Upgrades	$3						
State Highway Sewer Relocation	$1						
Biosolids	$40						
Water Treatment Facilities							
Crofton Meadows II Expansion Phase 2 (15 to 20 MGD)	$37						
Ongoing WTP Upgrades	$5						
Distribution System							
Water Main Repl./Reconstruction, Water Storage Tank Painting, & WTR Infrastr. Up/Retro	$87						
Miscellaneous Water Projects							
Billing	$43						
Existing Well Redevelopment & Replacements	$14						
Fire Hydrant Rehabilitation	$3						
TM-MD Rte 32 @ Meade & E/W TM	$50						
Water Facility Emergency Generators	$5						
Water Extensions	$2						
Aquifer Storage Recovery (ASR)	$12						
Water and Wastewater Planning	$14						
Watershed Protection							
Stormwater Permit Cycle 3 Placeholder	$150						
Stormwater Infrastructure	$56						
Total Budget (2020 $ x Million):	$984.6	$147.2	$211.7	$151.3	$154.9	$156.3	$163.2

Figure 8-1 - 6-Year Action Plan Project Schedule and Anticipated Costs

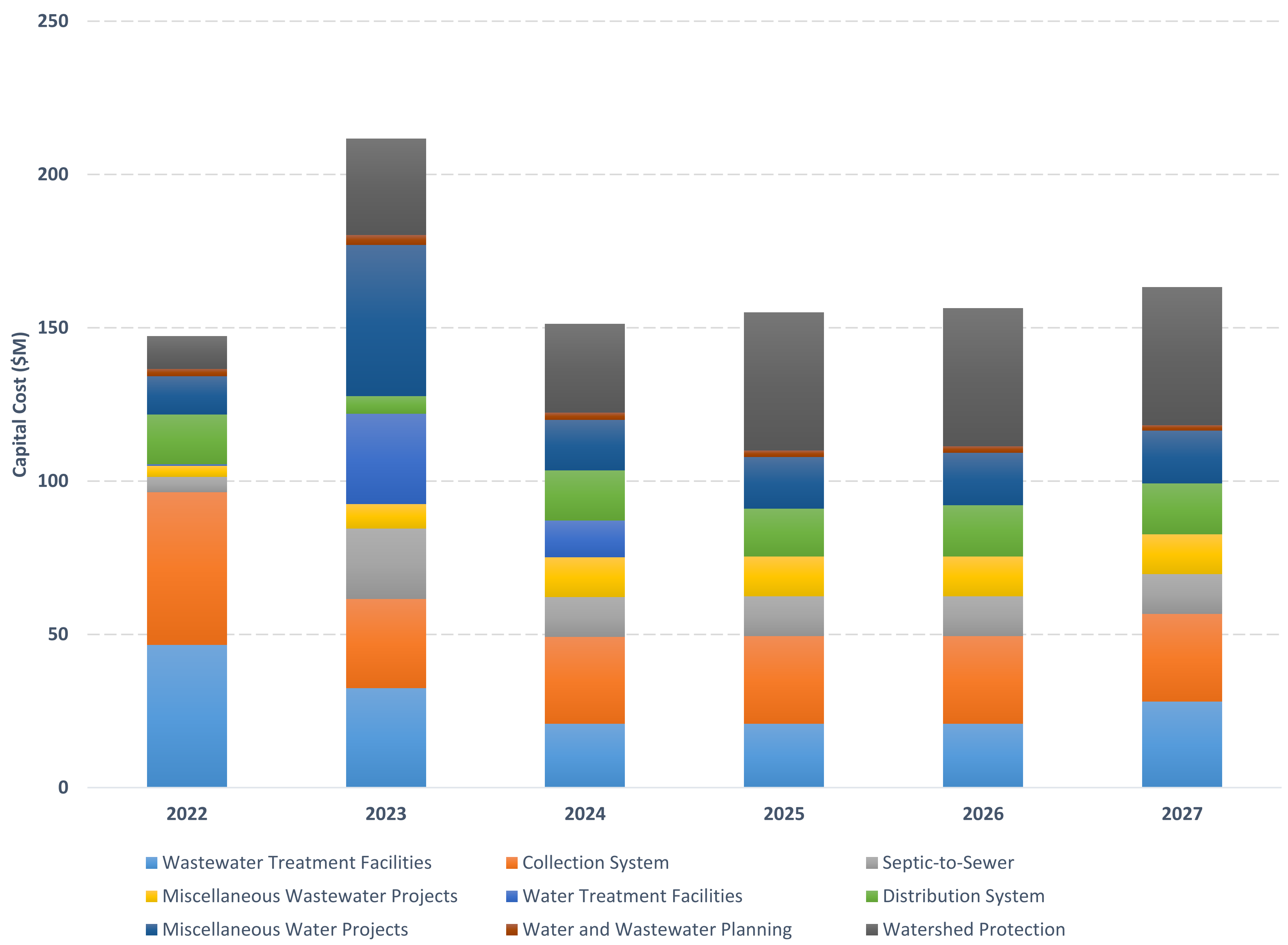


Figure 8-2 - 6-Year Action Plan Investment Schedule

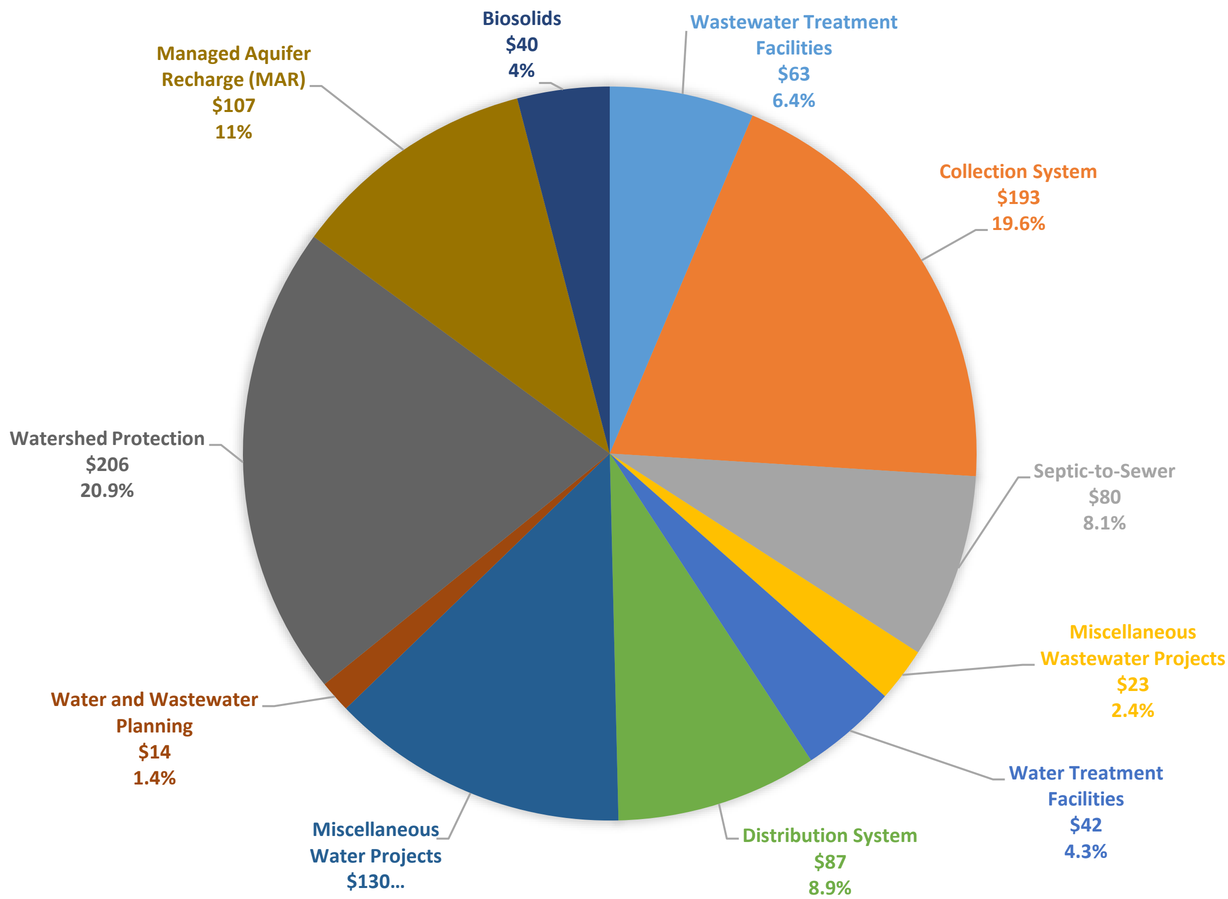


Figure 8-3 - 6-Year Action Plan Program Budget (Presented in 2020 Dollars x Million)

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Appendix A – Impaired Waters

Table A1: Category 4a Waters

Assessment Unit	Basin Name	Designated Use	Cause	Indicator	Pollution Sources
MD-PATMH-SWSAV	Patapsco River Mesohaline	Seasonal Shallow Water Submerged Aquatic Vegetation Subcategory	Total Suspended Solids (TSS)	Submerged Aquatic Vegetation (SAV) and Water Clarity	Unknown
MD-PATMH	Patapsco River Mesohaline	Open-Water Fish and Shellfish Subcategory	Nitrogen	Dissolved Oxygen (DO)	Municipal Point Source Discharges
MD-PATMH	Patapsco River Mesohaline	Open-Water Fish and Shellfish Subcategory	Phosphorus	DO	Municipal Point Source Discharges
MD-PATMH	Patapsco River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Phosphorus	DO	Municipal Point Source Discharges
MD-PATMH	Patapsco River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Phosphorus	DO	Municipal Point Source Discharges
MD-PATMH-Curtis_Bay_Creek	Patapsco River Mesohaline	Aquatic Life and Wildlife	Nitrogen	DO	Municipal Point Source Discharges
MD-PATMH-Middle-NorthwestHarbor-Littoral	Patapsco River Mesohaline	Water Contact Sports	Polychlorinated biphenyls (PCBs)	Direct Measurement	Discharges from Municipal Separate Storm Sewer Systems (MS4)
MD-PATMH	Patapsco River Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Phosphorus	DO	Municipal Point Source Discharges
MD-PATMH	Patapsco River Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Nitrogen	DO	Municipal Point Source Discharges
MD-PATMH-02130903	Baltimore Harbor Watershed	Fishing	Chlordane	Direct Measurement	Contaminated Sediments
MD-PATMH-02130 903-Mainstem	Baltimore Harbor Watershed	Fishing	PCBs in Fish Tissue	Direct Measurement	Discharges from Municipal Separate Storm Sewer Systems (MS4)
MD-PATMH-Furnace_ Creek	Patapsco River Mesohaline	Water Contact Sports	Enterococcus	Direct Measurement	Wildlife Other than Waterfowl
MD-PATMH	Patapsco River Mesohaline	Seasonal Deep-Channel Refuge Use	Phosphorus	DO	Unknown

MD-PATMH	Patapsco River Mesohaline	Seasonal Deep-Channel Refuge Use	Nitrogen	DO	Unknown
MD-PATMH-Marley_ Creek	Patapsco River Mesohaline	Water Contact Sports	Enterococcus	Direct Measurement	Wastes from Pets
MD-02130906	Patapsco River Lower North Branch	Aquatic Life and Wildlife	TSS	Habitat Evaluation	Urban Runoff/Storm Sewers
MD-02130906-Multiple_segments_ upper	Patapsco River Lower North Branch	Water Contact Sports	Escherichia coli (E.Coli)	Direct Measurement	Sanitary Sewer Overflows (SSO)
MD-02130906-Multiple_segments_ lower	Patapsco River Lower North Branch	Water Contact Sports	E.Coli	Direct Measurement	SSO
MD-MAGMH	Magothy River Mesohaline	Open-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-MAGMH	Magothy River Mesohaline	Fishing	PCBs in Fish Tissue	Direct Measurement	Contaminated Sediments
MD-MAGMH-Magothy_River	Magothy River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-MAGMH	Magothy River Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-MAGMH	Magothy River Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-MAGMH	Magothy River Mesohaline	Open-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-MAGMH	Magothy River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Nitrogen	DO	Unknown
MD-MAGMH_Tar_ Cove	Magothy River Mesohaline	Shellfishing	Fecal Coliform	DI	Wastes from Pets
MD-MAGMH	Magothy River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Phosphorus	DO	Unknown
MD-MAGMH-Forked_ Creek	Magothy River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-MAGMH-SWSAV	Magothy River Mesohaline	Seasonal Shallow Water Submerged Aquatic Vegetation Subcategory	TSS	SAV and Water Clarity	Unknown

MD-CB4MH-Whitehall_Meredith_Creeks	Middle Chesapeake Bay Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-SEVMH	Severn River Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-SEVMH-Severn_River-2	Severn River Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Nitrogen	DO	Wastes from Pets
MD-CB4MH-Mill_Creek	Middle Chesapeake Bay Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-SEVMH	Severn River Mesohaline	Open-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-SEVMH	Severn River Mesohaline	Fishing	PCBs in Fish Tissue	Direct Measurement	Contaminated Sediments
MD-SEVMH	Severn River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Nitrogen	DO	Unknown
MD-SEVMH-SWSAV	Severn River Mesohaline	Seasonal Shallow Water Submerged Aquatic Vegetation Subcategory	TSS	SAV and Water Clarity	Unknown
MD-SEVMH	Severn River Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-SEVMH	Severn River Mesohaline	Open-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-SEVMH	Severn River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Phosphorus	DO	Unknown
MD-SOUMH	South River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Phosphorus	DO	Unknown
MD-SOUMH-Duvall_Creek	South River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-SOUMH-Selby_Bay-1	South River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-SOUMH	South River Mesohaline	Fishing	PCBs in Fish Tissue	Direct Measurement	Contaminated Sediments
MD-SOUMH	South River Mesohaline	Open-Water Fish and	Phosphorus	DO	Unknown

		Shellfish Subcategory			
MD-SOUMH	South River Mesohaline	Open-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-02131003	South River	Aquatic Life and Wildlife	TSS	Habitat Evaluation	Urban Runoff/Storm Sewers
MD-SOUMH	South River Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-SOUMH	South River Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-SOUMH-Ramsey_ Lake	South River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-SOUMH-South_ River	South River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-SOUMH-SWSAV	South River Mesohaline	Seasonal Shallow Water Submerged Aquatic Vegetation Subcategory	TSS	SAV and Water Clarity	Unknown
MD-SOUMH	South River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Nitrogen	DO	Unknown
MD-RHDMH	Rhode River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Phosphorus	DO	Unknown
MD-RHDMH	Rhode River Mesohaline	Open-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-WSTMH-Parish_ Creek	West River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-WSTMH	West River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Phosphorus	DO	Unknown
MD-WSTMH-SWSAV	West River Mesohaline	Seasonal Shallow Water Submerged Aquatic Vegetation Subcategory	TSS	SAV and Water Clarity	Unknown
MD-WSTMH	West River Mesohaline	Open-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown

MD-RHDMH-Cadle_ Creek	Rhode River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-WSTMH	West River Mesohaline	Open-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-RHDMH	Rhode River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Nitrogen	DO	Unknown
MD-WSTMH	West River Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Nitrogen	DO	Unknown
MD-RHDMH-Bear Neck_Creek	Rhode River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Livestock (Grazing or Feeding Operations)
MD-WSTMH-West_ River	West River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Manure Runoff
MD-WST-RHDMH-02131004	West River	Fishing	PCBs in Fish Tissue	Direct Measurement	Contaminated Sediments
MD-RHDMH	Rhode River Mesohaline	Open-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-CB4MH-TracyRockhold_Creeks	Middle Chesapeake Bay Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Wastes from Pets
MD-02131005	Other West Chesapeake Bay	Aquatic Life and Wildlife	TSS	Habitat Evaluation	Anthropogenic Land Use Changes
MD-PAXTF	Upper Patuxent River Tidal Fresh	Seasonal Migratory Fish Spawning and Nursey Subcategory	Nitrogen	DO	Unknown
MD-PAXTF-SWSAV	Upper Patuxent River Tidal Fresh	Seasonal Shallow Water Submerged Aquatic Vegetation Subcategory	TSS	SAV and Water Clarity	Unknown
MD-PAXTF	Upper Patuxent River Tidal Fresh	Open-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-PAXTF	Upper Patuxent River Tidal Fresh	Open-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-PAXTF	Upper Patuxent River Tidal Fresh	Fishing	PCBs in Fish Tissue	Direct Measurement	Non-Point Source

MD-PAXTF	Upper Patuxent River Tidal Fresh	Seasonal Migratory Fish Spawning and Nursey Subcategory	Phosphorus	DO	Unknown
MD-02131104	Patuxent River Upper	Aquatic Life and Wildlife	TSS	Habitat Evaluation	Urban Runoff/Storm Sewers
MD-02131104-Lower	Patuxent River Upper	Water Contact Sports	E.Coli	Direct Measurement	Livestock (Grazing or Feeding Operations)
MD-02131105	Little Patuxent River	Aquatic Life and Wildlife	TSS	Habitat Evaluation	Urban Runoff/Storm Sewers
MD-CB3MH	Upper Chesapeake Bay Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-CB3MH	Upper Chesapeake Bay Mesohaline	Seasonal Deep-Channel Refuge Use	Nitrogen	DO	Unknown
MD-CB3MH	Upper Chesapeake Bay Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Nitrogen	DO	Unknown
MD-CB3MH	Upper Chesapeake Bay Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-CB3MH	Upper Chesapeake Bay Mesohaline	Open-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-CB3MH	Upper Chesapeake Bay Mesohaline	Seasonal Migratory Fish Spawning and Nursey Subcategory	Phosphorus	DO	Unknown
MD-CB3MH	Upper Chesapeake Bay Mesohaline	Open-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-CB3MH-SWSAV	Upper Chesapeake Bay Mesohaline	Seasonal Shallow Water Submerged Aquatic Vegetation Subcategory	TSS	SAV and Water Clarity	Unknown
MD-CB3MH	Upper Chesapeake Bay Mesohaline	Seasonal Deep-Channel Refuge Use	Phosphorus	DO	Unknown
MD-CB4MH	Middle Chesapeake Bay Mesohaline	Seasonal Deep-Channel Refuge Use	Phosphorus	DO	Unknown
MD-CB4MH	Middle Chesapeake Bay Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown

MD-CB4MH	Middle Chesapeake Bay Mesohaline	Open-Water Fish and Shellfish Subcategory	Phosphorus	DO	Unknown
MD-CB4MH	Middle Chesapeake Bay Mesohaline	Open-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-CB4MH-SWSAV	Middle Chesapeake Bay Mesohaline	Seasonal Shallow Water Submerged Aquatic Vegetation Subcategory	TSS	SAV and Water Clarity	Unknown
MD-CB4MH	Middle Chesapeake Bay Mesohaline	Seasonal Deep-Water Fish and Shellfish Subcategory	Nitrogen	DO	Unknown
MD-CB4MH	Middle Chesapeake Bay Mesohaline	Seasonal Deep-Channel Refuge Use	Nitrogen	DO	Unknown

Table A2: Category 4c Waters

Assessment Unit	Basin Name	Designated Use	Cause	Indicator	Pollution Sources
MD-02130903	Baltimore Harbor	Aquatic Life and Wildlife	Habitat Alterations	Habitat Evaluation	Channelization
MD-02130903	Baltimore Harbor	Aquatic Life and Wildlife	Riparian Buffer, Lack of	Habitat Evaluation	Urban Development in Riparian Buffer
MD-02131003	South River	Aquatic Life and Wildlife	Riparian Buffer, Lack of	Direct Measurement	Urban Development in Riparian Buffer
MD-02130906	Patapsco River Lower North Branch	Aquatic Life and Wildlife	Habitat Alterations	Direct Measurement	Channelization

Table A3: Category 5 Waters

Assessment Unit	Basin Name	Designated Use	Cause	Indicator	Pollution Sources
MD-PATMH	Patapsco River Mesohaline	Aquatic Life and Wildlife	Unknown	Benthic IBI	Unknown
MD-02130903	Baltimore Harbor	Aquatic Life and Wildlife	TSS	Fish and Benthic IBIs	Urban Runoff/Storm Sewers
MD-02130903	Baltimore Harbor	Aquatic Life and Wildlife	Chloride	Direct Measurement	Urban Runoff/Storm Sewers
MD-02130903	Baltimore Harbor	Aquatic Life and Wildlife	Sulfate	Direct Measurement	Urban Runoff/Storm Sewers
MD-PATMH-Curtis_Bay_Creek	Patapsco River Mesohaline	Aquatic Life and Wildlife	Zinc in sediment	Direct Measurement	Unknown
MD-02130906	Patapsco River Lower North Branch	Aquatic Life and Wildlife	Chloride	Direct Measurement	Urban Runoff/Storm Sewers

MD-02130906	Patapsco River Lower North Branch	Aquatic Life and Wildlife	Sulfate	Direct Measurement	Urban Runoff/Storm Sewers
MD-MAGMH-Deep_Creek	Magothy River Mesohaline	Shellfishing	Fecal Coliform	Direct Measurement	Unknown
MD-MAGMH	Magothy River Mesohaline	Aquatic Life and Wildlife	Unknown	Benthic IBI	Unknown
MD-02131001	Magothy River	Aquatic Life and Wildlife	Chloride	Direct Measurement	Urban Runoff/Storm Sewers
MD-02131002	Severn River	Aquatic Life and Wildlife	Unknown	Fish and Benthic IBIs	Unknown
MD-SEVMH	Severn River Mesohaline	Aquatic Life and Wildlife	Unknown	Benthic IBI	Unknown
MD-02131003	South River	Aquatic Life and Wildlife	Chloride	Direct Measurement	Urban Runoff/Storm Sewers
MD-SOUMH	South River Mesohaline	Aquatic Life and Wildlife	Unknown	Benthic IBI	Unknown
MD-02131004	West River	Aquatic Life and Wildlife	Sulfate	Direct Measurement	Atmospheric Deposition - Toxics
MD-02131004	West River	Aquatic Life and Wildlife	TSS	Habitat Evaluation	Urban Runoff/Storm Sewers
MD-02131102	Patuxent River Middle	Aquatic Life and Wildlife	Sulfate	Direct Measurement	Unknown
MD-02131102	Patuxent River Middle	Aquatic Life and Wildlife	TSS	Fish and Benthic IBIs	Unknown
MD-02131104	Patuxent River Upper	Aquatic Life and Wildlife	Sulfate	Direct Measurement	Urban Runoff/Storm Sewers
MD-02131104	Patuxent River Upper	Aquatic Life and Wildlife	Chloride	Direct Measurement	Urban Runoff/Storm Sewers
MD-02131104	Little Patuxent River	Aquatic Life and Wildlife	Chloride	Direct Measurement	Urban Runoff/Storm Sewers
MD-CB3MH	Northern Chesapeake Bay Oligohaline	Aquatic Life and Wildlife	Unknown	Benthic IBI	Unknown
MD-CB4MH-Herring_Bay	Middle Chesapeake Bay Mesohaline	Fishing	PCBs in Fish Tissue	Direct Measurement	Unknown
MD-CB4MH	Middle Chesapeake Bay Mesohaline	Aquatic Life and Wildlife	Unknown	Benthic IBI	Unknown

Appendix B – Multi-Criteria Decision Analysis Scoring

Table B1: Sub-Objective Scoring Basis (Integrated Plan Phase 1)

Criterion	Sub-criterion	Ranking	Scoring Basis
Safeguard the Environment	**Meet Regulatory Objectives**	10	Address regulatory objectives that present significant risk (e.g., control the discharge of untreated wastewater)
		9	
		8	
		7	Address regulatory objectives that present substantial risk (e.g., existing TMDL requirements)
		6	
		5	Address regulatory objectives that present moderate risk (e.g., future TMDL requirements)
		4	
		3	Address regulatory obligations that present limited risk (e.g., meet nutrient reduction goals)
		2	
		1	
		0	Project is not needed for regulatory compliance
Safeguard the Environment	**Watershed Protection/Restoration**	10	Project provides frequent improvements for multiple parameters in multiple water bodies.
		9	
		8	
		7	Project provides frequent improvements for at least one parameter in multiple water bodies.
		6	
		5	Project provides significant, infrequent localized improvements for at least one parameter.
		4	
		3	Project provides moderate, infrequent localized improvements for at least one parameter.
		2	
		1	
		0	Project is not necessary for watershed protection or restoration.

Safeguard the Environment	**Resiliency/Ability to Adapt**	10	Project provides significant resiliency to existing system
		9	
		8	
		7	Project provides substantial resiliency to existing system
		6	
		5	Project provides moderate resiliency to existing system
		4	
		3	Project provides limited resiliency to existing system
		2	
		1	
		0	Project does not provide resiliency to existing system
Customer Service	**Maximize Public Health/Safety/Welfare**	10	Project significantly reduces potential for direct human exposure to pathogens and the number and frequency of infrastructure failures that damage public and private property and primarily serves disadvantaged populations
		9	
		8	
		7	Project significantly reduces potential for direct human exposure to pathogens and the number and frequency of infrastructure failures that damage public and private property
		6	
		5	Project moderately reduces potential for direct human exposure to pathogens and the number and frequency of infrastructure failures that damage public and private property
		4	
		3	Project modestly reduces potential for direct human exposure to pathogens or the number and frequency of infrastructure failures that damage public and private property
		2	
		1	
		0	Project does not reduce public health/safety/welfare impacts

Customer Service	**Provide for Reliable Services**	10	Project significantly minimizes the probability of level of service failure frequency
		9	
		8	
		7	Project substantially minimizes the probability of level of service failure frequency
		6	
		5	Project moderately minimizes the probability of level of service failure frequency
		4	
		3	Project modestly minimizes the probability of level of service failure frequency
		2	
		1	
		0	Project does not minimize the probability of level of service failure frequency
Financial Sustainability	**Affordable for Customers**	10	Project significantly improves customer affordability
		9	
		8	
		7	
		6	
		5	Project has no impact on current customer affordability
		4	
		3	
		2	
		1	
		0	Project significantly impacts customer affordability (e.g., raises rates)
Financial Sustainability	**Partnered Financial Support**	10	Project provides 100% financial support to County/customers
		9	
		8	
		7	
		6	
		5	
		4	
		3	
		2	
		1	
		0	Project Provides no financial support to County/customers

Financial Sustainability	**Economic Impact**	10	Project results in a positive ROI in less than 5 years, provides major long-term financial savings, or avoids more than $10 million in sunk capital investments
		9	
		8	
		7	
		6	
		5	Project results in a positive ROI in less than 10 years, provides substantial long-term financial savings, or avoids more than $5 million in sunk capital investments
		4	
		3	
		2	
		1	Project results in a positive ROI in less than 20 years, provides minimal long-term financial savings, or avoids more than $1 million in sunk capital investments
		0	Project does not increase financial benefits

Appendix C – OSDS Strategic Planning TM

Task Order 5 Technical Memorandum

Date:	Thursday, August 29, 2019
Project:	Anne Arundel County OSDS Strategic Planning
To:	Anne Arundel County OSDS Strategic Planning Team
From:	HDR
Subject:	Task Order 5 – Conceptual OSDS Management Strategies

Table of Contents

1 Objective

Anne Arundel County (the County) has tasked the HDR Team with shortlisting three (3) feasible management strategies (MS) to meet the County's overall for total nitrogen (TN) reduction goals to the Chesapeake Bay in accordance with the latest Watershed Implementation Plan (WIP III). The County is implementing an "integrated plan" to meet this requirement. This memorandum serves as a summary of that integrated plan and the process of developing technical options for three MS's and their associated potential financial and policy impacts. A MS is defined as a collection of technical, policy, funding, and public relations solutions implemented over a defined schedule to meet Anne Arundel County objectives.

The information included in this memo was developed for the County under Task Order 5 (Develop Conceptual Onsite Disposal Systems (OSDS) Management Strategies) of the OSDS Strategic Planning program and is the result of multiple discussions and five workshops held with the County (December 20, 2018, January 17, 2019, February 25, 2019, March 29, 2019, and June 14, 2019). Meeting presentations and summaries for each workshop are provided in Appendix 2 and Appendix 3, respectively.

1.1 Target Nutrient Reduction

The goals of nutrient reduction were established in TO4 in accordance with WIP II. (See Appendix I for TO 4 Update for WIP III) HDR evaluated TN discharges from wastewater, stormwater, and septic sectors (sectors under "County Control"), and established a TN reduction target of 250,000 lb TN/yr for Phase II Watershed Implementation Plan (WIP II) shortfall + 10% initially.

The goal is revised in the final MS shortlisting as the draft Phase III Watershed Implementation Plan (WIP III) was published on April 12, 2019. In the short term, the County will meet the WIP III goal in 2025. However in the long run, with population growth and septic conversions, HDR forecasts that the County will exceed target TN load by between 100,000 lb TN/yr and 130,000 lb TN/yr[1], depending on wastewater treatment plant performance with regard to nitrogen reduction. **HDR proposed an overall TN reduction goal at 115,000 lb TN/yr halfway between the two shortfalls.** Therefore, the WIP III essentially reduced the County's overall additional reduction requirements by approximately half. (250,000 lbs under WIP II – 115,000 lbs = 115.000 lbs.)

2 Technical Option Breakdown

HDR evaluated a set of eight diverse and feasible technical solutions, reduced down from over a dozen alternatives for consideration and additional evaluation to reduce TN loads from the County, including Managed Aquifer Recharge (MAR), Large Capital Program (Large CIP) Septic Conversions (OSDS), Small Capital Program (Small CIP) Septic Conversions, Minor System Takeover (MST), Cluster Treatment, Nitrogen Reduction Units (NRU), Septic Tank Effluent Pump (STEP), and Oyster Aquaculture. These technical solutions, singularly and in combination, serve as building blocks of MS's.

Within these options, MAR and OSDS conversions provide the most potential TN removal (for range of nitrogen removal, please refer to Figure 2.1). The orange bar graph on the right is a breakdown of what options are within OSDS.

- Because cluster treatment is just an end treatment process and a variation within large CIP, it is shaded and not added to total potential nitrogen removal,

[1] See Appendix 1: Supplement to Technical Memorandum for Task Order 4 – Watershed Implementation Plan Phase III (WIP III) Update for breakdown of each sector.

- Aquaculture is seen as shaded because it is a farming practice and has various annual yield.

Please refer to Figure 2.2 for estimated cost/lb of N removed. Stormwater and OSDS conversions represent significant costs, followed by MAR and MST. The following discussion provides a detailed account of each option, followed by a table (Table 2.1) of side by side comparisons between the options in terms of benefits, policy considerations, funding considerations, public engagement issues, costs, risks, and operations and maintenance (O&M) considerations.

Figure 2.1: Range of potential nitrogen removal for all technical options.

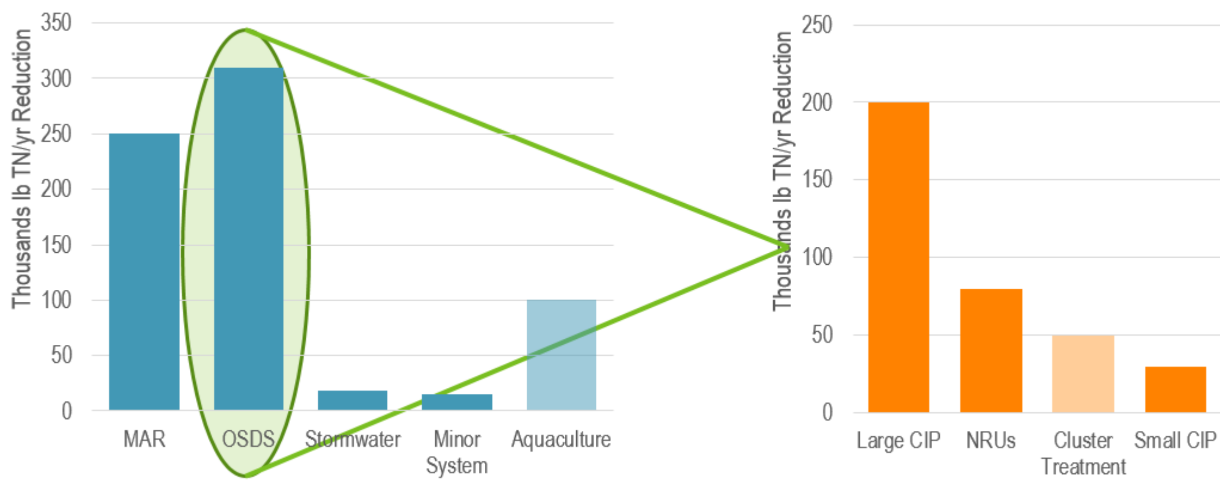
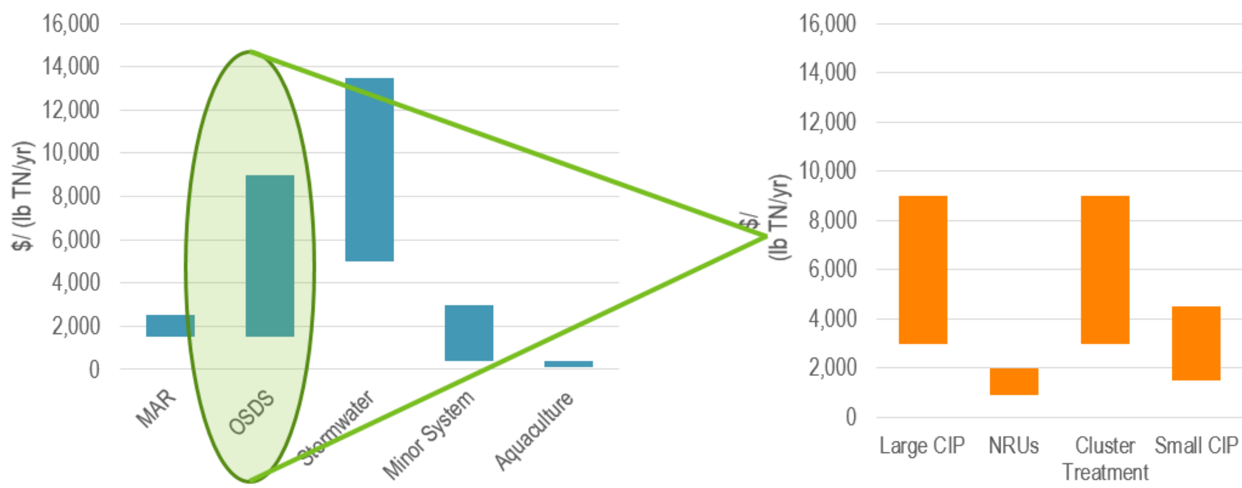


Figure 2.2: Range of capital costs for all technical options per lb TN removed.



2.1 MAR

MAR includes treating wastewater reclamation facility (WRF) ENR level effluent to National and State drinking water standards using advanced water treatment techniques for injection and recharge of the deep confined aquifer system in Anne Arundel County. MAR is an indirect potable reuse (IPR) strategy that will provide the dual benefit of replenishing diminishing groundwater supplies and reduced nutrient discharges to the Bay. Additionally, future treatment capacity at the sites where MAR is implemented would not require additional waste load allocation. Thus, full nutrient credits could be obtained from OSDS conversions or credit allocations could be transferred elsewhere.

Currently there are no advanced water treatment MAR operations in Maryland. Maryland is part of the U.S. EPA's Region 3 Underground Injection Control (UIC) Program which categorizes aquifer recharge wells as complex Class V wells. Under this program, Maryland has primacy to enforce the UIC Program. Groundwater injection is subject to groundwater discharge permit requirements with O&M, best management practices, and groundwater testing requirements. Guidance and regulation for MAR injection wells has not been provided by Maryland Department of the Environment (MDE). Based on a previously provided Feasibility Study, MDE has raised many concerns about the implementation of MAR in Anne Arundel County. HDR and the County met with MDE officials on May 14, 2019 and August 19, 2019 and will continue to communicate the overall MAR approach and testing strategies. Currently, MDE is looking favorably upon the MAR approach emphasizing water reuse practices, but recognizing there are many technical and political challenges to overcome for MAR implementation.

Federal and local funding sources may be used to generate funds for MAR. State support is generally available for WRFs and conveyance systems under the State Revolving Fund (SRF). Bay restoration fund (BRF) availability would depend on showing benefits to the Bay, so it is unknown at this time whether the State will be willing to contribute BRF funds to MAR. As there are other long term benefits are to the drinking water supply, so money may need to come from the dedicated water and wastewater (W/WW) enterprise funds as opposed to the General Fund. These projects may also be prime candidate for Water Infrastructure Finance and Innovation Act (WIFIA) funding.

Public perception and involvement is critical to the success of implementing MAR as an IPR strategy. Implementation strategies should include early engagement with the media, using consistent terminology, and addressing misinformation as soon as possible. Additionally, stakeholder involvement is critical to build trust and gain support from customers, regulators, and other stakeholders.

Risks associated with MAR and IPR are primarily focused on public health implications. A multi-barrier approach, coupled with consistent monitoring and control of finished water quality, should be used to minimize risk. Development of critical control points for measuring and assessing operation of the MAR is essential for mitigating risk.

The cost of MAR is dependent on the treatment technologies, disposal method, and residual and brine treatment methods. Overall costs at $6 – 15 million/MGD, and $700-2,500/lb TN/yr.

Depending on the treatment technologies selected, O&M requirements will vary. Some (e.g. reverse osmosis) will incur significant O&M costs because of high energy input. Highly trained operators will be needed to monitor and maintain advanced water treatment system.

2.2 OSDS Conversions

The County has identified the infrastructure, estimated costs, and policies necessary to convert several areas within the County that currently rely on OSDS to public sewer. The County has identified large CIPs, which are characterized by large clusters of homes that can be served in a common sub-drainage area and small CIPs, typically consisting of fewer units and are in the direct vicinity of existing sewer infrastructure or proposed large CIPs. Historically, the small CIP projects have been implemented through the existing petition process, or some version thereof.

Both large and small CIPs have the potential to reduce the direct nutrient impact of OSDS' on tributary and bay water quality upon connection. There is also potential to realize other environmental and health benefits. Connections may be of higher value if they are in "on-site wastewater management problem areas" (OWMPA) as identified by the County and critical area (CA), in areas of denser development and/or where septics drain to an impaired waterway, ground water is high, soils are poor draining etc.

The primary policy consideration for OSDS conversions will be determining the prioritization and efficient implementation of connection to be either voluntary or mandatory and creating incentives for connection. Specific policy discussion is in Section 3.3.2.

OSDS conversion programs will result in significant capital costs as well as O&M costs. The County may be eligible for BRF funding for up to $20,000 per connection, or what the equivalent funding for a replacement septic with Best Available Technology would be. Specific funding and financial discussions are also included in Section 3.3.2.

Educating the public on the need for converting OSDS' to public sewer will be critical as well as on the constraints for replacing systems in some of the denser locations with small lot sizes. Maintenance and system applicability can also be highlighted, especially OWMPA, where the conditions are not suitable for OSDS systems.

The current user rate is uniform throughout the County regardless of service area. Sewer flow is based on metered water use. The Large CIP results in significant new and upgraded sewer, force main and pumping station infrastructure in accordance with the County's standards and design criteria in each of the service areas. This new infrastructure will require an increase in County staff for O&M, as well as more operating costs, potentially impacting rates. However, the impact on rates will be somewhat mitigated by the increase in the user base.

2.2.1 LARGE CIP

The County has identified 133 Large CIP Management Areas (MAs) (shown below in Figure 3.2.1.1 Large CIP MA overview.) where there is the potential to connect large numbers of OSDS'. The piping layouts of large CIP MAs were planned in previous efforts, and the County have produced conceptual cost analysis and examined the impact of flow on downstream facilities. Large CIP will require construction of significant collection and conveyance systems, consisting of sanitary sewers, pumping stations, low pressure sewers and grinder pump systems. There are also significant improvements necessary in the existing conveyance system depending on which Sewer Service Area (SSA) is under consideration. Treatment plant improvements beyond planned expansions will not be necessary.

Some Large CIP pipelines were planned in no-development areas (outside of priority funding area (PFA)), which may ultimately require a "denied access" designation by MDE and Maryland Department of Planning.

Large capital septic connection costs were prepared by the County and utilized for this evaluation (HDR did not optimize the layout of pipes previously planned), and HDR escalated the cost to 2020, and added 45% engineering, construction management, and overhead costs. The average cost for per connection was approximately $60,000 not including the capital facilities connection charge. This includes site work, public side piping to cleanout, on-site piping from cleanout to house, septic tank abandonment, grinder pumps (if applicable), and regional pump stations. Overall program costs can vary based on the MAs chosen to be connected, and cost per lb TN removed can vary from $3,000 to $9,000.

2.2.2 SMALL CIP

The Small CIP has been separated into two phases, primarily by service area. Phase I includes Annapolis, Broadneck, Broadwater, and Cox Creek that include approximately 1,700 potential connections. Similar are the Phase II projects in the remaining service areas at 1,200 connections, totaling approximately 2,900 connections. Small CIP will require construction of limited collection and conveyance systems, consisting of laterals from the homeowner property line, ejector pumping or gravity piping or small diameter force main into the gravity system or low pressure grinder system. Small CIP will connect to either proposed Large CIP or existing systems. Treatment plant and backbone conveyance improvements will not be necessary.

This program is intended to be implemented on a fast track basis because of the lower cost to connect (many with costs lower than $250,000, the limit of open end contracts), allowing construction to be done by on call contractors. However, because of the small scale of each project, there will not be as much nitrogen removal per project as Large CIP.

Based on the Phase I and Phase II Small Capital Septic connection reports prepared by the County, assumptions made therein and criteria for connection to existing public sewer infrastructure, the average cost for per connection was $22,000, with $/TN cost at around $1,500 to $4,500

Figure 3.2.1.1 Large CIP MA overview.

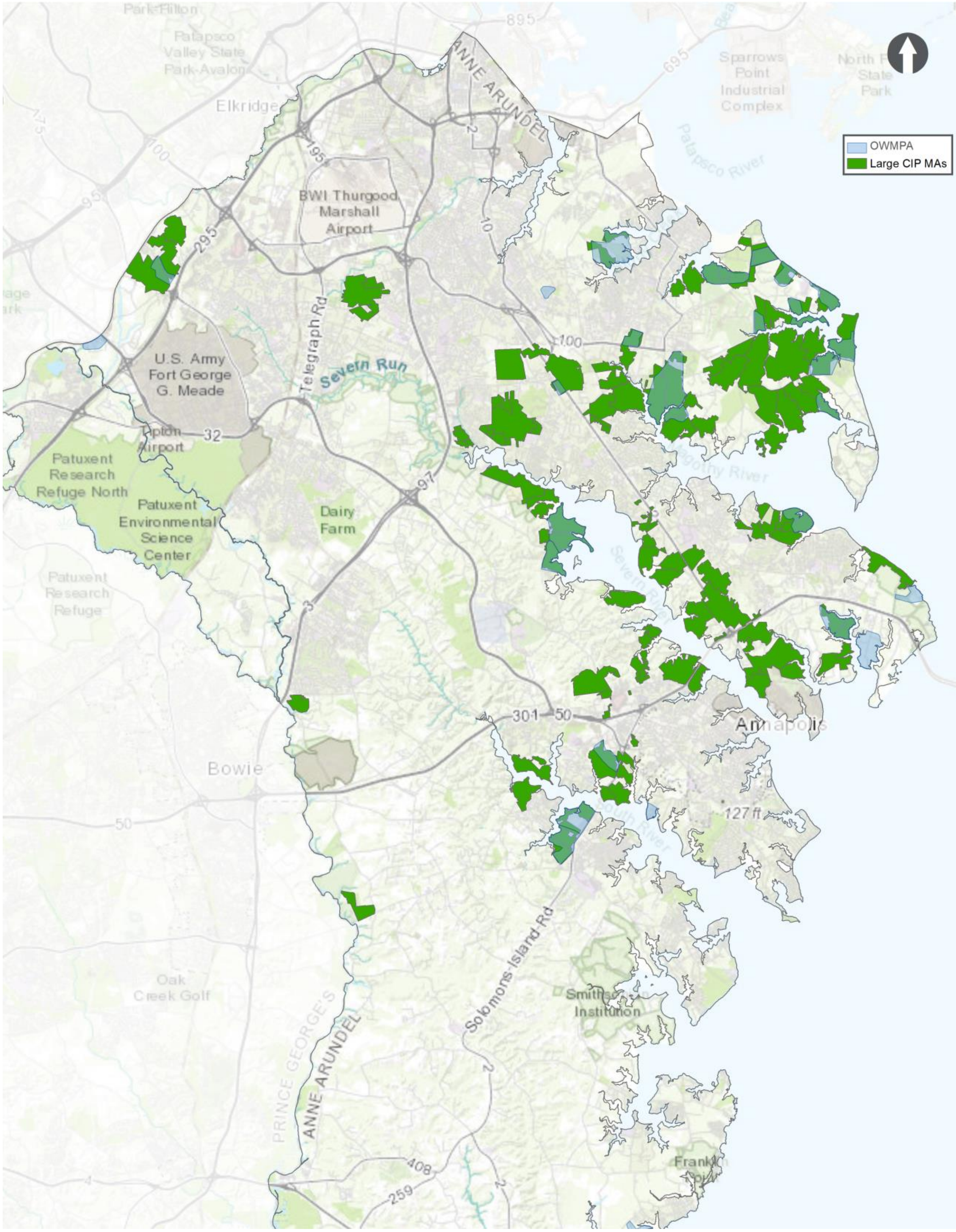
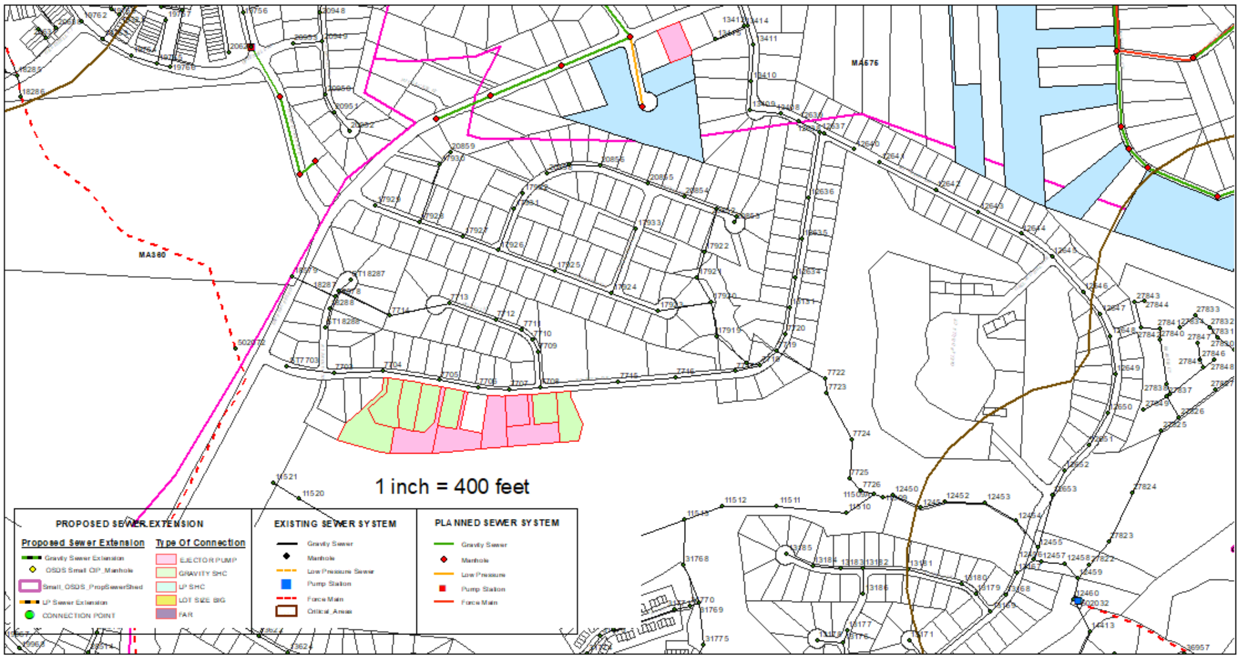


Figure 2.2 Example Small CIP area.



2.3 Minor System Takeover

MST is the incorporation of privately owned/operated water reclamation facilities into the County's wastewater system. These treatment plants typically are not effective at removing nitrogen, having been designed to meet far less stringent discharge permits. The County could take over these systems and upgrade them (to either BNR or ENR) or connect them to an existing ENR facility to take the credits associated with the upgrade. These credits could be transferred to other existing WRFs or retired toward meeting WIP goals. In a cost-benefit study completed by OBG, five projects were recommended for further consideration by the County:

- P-1. Summerhill, 0.019 MGD – MST upgrade to ENR (Not entirely cost effective due to O&M costs, but has the potential for effluent reuse).
- P-3. Holiday, 0.125 MGD – MST to be retired to an ENR facility
- P-4a. Maryland Manor, 0.09 MGD – MST upgrade to BNR
- P-4b. Maryland Manor – MST upgrade to ENR (more preferable than P-4a)
- P-5 Combination, 0.29 MGD – Combining three MSTs to be upgraded to ENR with OSDS addition.

Upon takeover, the existing private customers would become customers of the County. The County would need to determine if special districting would be required or if the costs of taking over the minor systems would be borne by the existing customer base. Outreach to the private utility customers are important – the County should show the financial and environmental benefit to justify (possibly increased) sewer bills.

In order for an upgrade project to be applicable for BRF Funding, it must have a cost range of \$50-\$100/lb. These funds must be dedicated to projects focused on nutrient removal, and can only be applied to treatment facilities already meeting their NPDES permit. If the County uses BRF funds for both BNR and ENR upgrades, it is likely that most of the credits would be retired to the state. The County would only be able to obtain performance credits, assuming that the facility can treat to 3.0 mg/L or better. If the County uses BRF funds for ENR and pays fully for BNR, the County may be able to retain the pounds reduced from BNR, in addition to potential performance credits.

2.4 Cluster Treatment

Cluster treatment involves treating flow from a group of OSDS in one area identified due to proximity or isolated geographically. As with the Large and Small CIP to existing public sewer, cluster treatment areas may also be identified by MAs, e.g. Sherwood Forest and Patuxent Manor. The Bodkin Point area would be a potential candidate for this approach.

This approach will require the implementation of an advanced wastewater treatment system designed to meet the effluent limits, including nitrogen removal, as dictated ultimately by the means of disposal. Due to the small size of proposed systems, e.g., from 5,000 GPD to 50,000 GPD (20 to 200 connections at 250 GPD/connection), the treatment plants most likely will be packaged facilities, designed for simplicity of operations and to minimize land required for the facilities. Cluster treatment is a treatment process that requires the construction of conveyance system consisting potentially of sanitary sewers, pumping stations, low pressure sewers and grinder pump systems and STEP systems. Discharge options range from surface water discharge, drip system for Class IV and various groundwater discharges, to MAR.

Cluster treatment is able to provide a high level of treatment and reliable system operation in areas that are remote from the existing systems and are not suitable for upgrading with NRUs. Due to its isolated nature, it will be easier to assign the costs directly to beneficiaries.

The primary policy consideration will be creating new “service areas” that are not connected to the main system and designed to only accommodate existing flows and not accommodating new development. If choosing surface water disposal, the County may face environmental permitting issues in certain waterways.

Costs for cluster treatment would be additive to the average cost of collection and conveyance to the system. The cost for the treatment plant would be similar to or slightly greater than the County current connection fee intended to offset the debt service on existing plants. For these reasons, the capital costs are assumed to be similar to the large cap OSDS conversion program. This new plant and collection systems for the cluster approach will require an increase in County staff for O&M.

2.5 NRU Upgrades

Nitrogen Reduction Unit (NRU) is a MDE recognized best available technology (BAT) to replace conventional OSDS. It usually involves multiple step treatment for nutrient removal and effluent disposal via a drainfeld similar to a conventional OSDS. The County has about 3,400 NRUs[2]. Currently, NRUs are required when new construction happens county wide within the Critical Area, construction additions require septic upgrade, or repair and replace existing OSDS in the Critical Areas.

NRUs offer the ability to reduce nitrogen from OSDS with minimal capital infrastructure requirements. Nitrogen credit generation is up to 10 lb TN/yr/user. O&M burden are still with the homeowners. Although for the system to function properly, the County may consider setting up a regular inspection program.

The cost to install NRUs for homeowners can be offset with BRF funding through the State. The current funding assistance from BRF is income tested, where BRF funding will cover 50% cost for units with annual income higher than $300,000, and 100% cost otherwise. It is not likely eligible for other funding.

NRUs are relatively easy to convey to the public because of the small learning curve upgrading from existing OSDS. The County may need to educate the public about proper maintenance and inspection to ensure system functions properly as designed.

[2] Data from Anne Arundel County Health Department (HD) GIS layer

Some of the challenges that exist with traditional septic systems still exist when upgraded to NRUs (steep slopes, high groundwater, etc.). It may not be suitable to install NRU's in OWMPAs. For those areas, OSDS conversions should be considered as a primary option.

The cost of upgrades is approximately $12,000 per connection (depending on BRF incentives), which makes the cost per lb TN removed around $1,200. The County has been averaging the installation of approximately 200 BATs per year, with some of these units being located in management areas that are being considered for connections under the OSDS conversion program.

2.6 Oyster Aquaculture

Oyster aquaculture crediting is currently being reviewed by an Oyster BMP Expert Panel. Until now, the panel have reviewed private aquaculture practices. Other methods are still under review. Two more reports are due to come out in the near future. Recently, a new report found that the oyster restoration project in Harris Creek is removing around 100,000 lb TN/yr. The project planted nearly 2.5 billion hatchery-spawned oysters in 351 acres of restored reefs, and the cost to date is $28.3 million dollars. More time is needed to evaluate whether the reef is self-sustaining, but the project yields measurable nutrient reduction and other ecological benefits as well.

According to the panel, nitrogen credit generation is calculated based on the size of the oyster: 0.0005732 lb TN/a 4 in length oyster (17.5 million oysters/10,000 lb TN credit). However, as of now, there is no official MDE system in place to award nitrogen credits for aquaculture yet.

The current oyster recovery project is a public-private partnership between Chesapeake and Atlantic Coastal Bay Trust Fund and US Fish and Wildlife Foundation. Funding may be available from the BRF, although it may be viewed as a pilot project. There might be WIFIA funding potential as well. Other ecosystem restoration funding options may exist. Any County funds would likely have to come from the General Fund as benefits are not specific to water/wastewater customers.

O&M considerations are unknown. There is an outstanding question of whether the oysters will become self-sustaining or if additional farming would be required.

The capital cost range is $100-500/(lb TN/year) per year. Because aquaculture is a farming practice, there will be annual recurring costs, which makes capital cost calculations different from other capital projects that have a long service life.

Table 2.1: Summary of technical options

	MAR	OSDS Conversion Large CIP	OSDS Conversion Small CIP	MST	Cluster Treatment	NRU	Oyster Aquaculture
Infrastructure	Treatment Disposal	Collection	Collection	Collection Treatment Disposal	Treatment Disposal	Onsite System	Other
Permitting	Health Department MDE State & Federal UIC	Health Department MDE Critical Area Commission	Health Department MDE Critical Area Commission	MDE Local NPDES	Health Department MDE Construction NPDES Critical Area Commission	Health Department Local Trade Critical Area Commission	NPDES
Nitrogen Reduction Range (lb TN/yr)	50,000-250,000	Up to 200,000	Up to 30,000 lb for 3,000 units	Up to 15,000 lb TN/yr	Up to 50,000 lb TN/yr	Up to 100,000 lb TN/yr (if mandatory)	Uncertain, pending state review
Other Benefits	Moderate/Low $/lb TN Water Supply Sustainability	Waste Load Allocation Transfer Environmental Benefits TMDL Benefits Possible Water Service Extension	Waste Load Allocation Transfer Environmental Benefits TMDL Benefits Possible Water Service Extension	Waste Load Allocation Transfer Moderate/Low $/lb TN	Waste Load Allocation Transfer Environmental Benefits TMDL Benefits	Moderate/Low $/lb TN Environmental Benefits TMDL Benefits	Moderate/Low $/lb TN Environmental Benefits Ecological Benefits
Policy Considerations	No current operations in MD New legislation required	New local legislation required Development Impact	New local legislation required	New local Service Area Development Impact	New local Service Area	New inspection program recommended	New State legislation required
Funding Options	W/WW Enterprise Fund BRF (MDE) State Revolving Loan WIFIA	W/WW Enterprise Fund General Fund BRF (MDE) P3 Funding /Developer Funding State Revolving Loan WIFIA USDA Homeowner	W/WW Enterprise Fund General Fund BRF (MDE) USDA Homeowner	W/WW Enterprise Fund BRF (MDE) State Revolving Loan USDA	W/WW Enterprise Fund General Fund BRF (MDE) P3 Funding /Developer Funding State Revolving Loan WIFIA	BRF (MDE) Homeowner	General Fund BRF (MDE) State Revolving Loan USDA USACE US Fish & Wildlife
PR Considerations	Early involvement with media Early public outreach Build trust from all parties	Education public of failing septics Improvement to local waterways Align with Smart Growth	Education public of failing septics Improvement to local waterways Advertise speed of implementation	Coordinate with existing private utility and homeowners Educate about environmental benefit	Education public of failing septics Improvement to local waterways Align with Smart Growth	Educate about proper maintenance Educate about BRF incentives	Use as incentive for oyster farming Improve local waterways
Similar Programs	HRSD's Sustainable Water Initiative for Tomorrow (SWIFT) Orange County Groundwater Replenishment System	Neighborhood Sewer Extension at City of Olympia, WA	N/A	N/A	N/A	Florida DEP Septic Upgrade Incentive Plan for Priority Focus Areas	N/A
Risks & Challenges	Policy & Regulation Change Land Use/Acquisition Advanced Treatment Waste Production/Disposal Funding O&M, Staffing Environmental Impact Public Perception Local Well Impacts	Local Policy Change Land Use/Acquisition Funding Public Perception O&M, Staffing Public Perception	Local Policy Change Land Use/Acquisition Funding Public Perception O&M	Local Policy Change Land Use/Acquisition Advanced Treatment Funding Public Perception O&M, staffing Property Owner Rights	Local Policy Change Land Use/Acquisition Advanced Treatment Waste Production/Disposal Funding Public Perception Environmental Impacts O&M, staffing Property Owner Rights	O&M, Staffing Inspection Property Owner Rights	Local/State Policies Funding
Range of Cost	$6-15 million/MGD $700-2,500 /lbTN/year	Average $60,000/connection $3,000-9,000 /lbTN/year	$15,000 - $50,000/connection $1,500-5,000 /lbTN/year	$30 million for all 5 projects $400 - 4,000 $/lb TN/yr	Similar to Large CIP	About $12,000/unit $900 - $2,000/ lb TN/yr	$100-500/lb TN/yr per year recurring

3 Management Strategy Development

3.1 Initial Management Strategies

With the available technical options on hand, HDR assembled MS's with combinations of 11 technical options with sub-level variations, making it a total of 19 MS's covering a time period of 30 years. Since MAR and large CIP are the two options with the most potential nitrogen reduction benefits (see Figure 2.1 for comparison), they made up the backbone of the program. Other program components include stormwater (30 – 40% impervious area reduction), MST, and NRU upgrades.

The assumptions used were:

- Except for MAR, the cost of which were developed with HDR cost model, all other costs were established by the County, and escalated to 2020.
- All costs were project costs, including engineering, construction management, and overhead.
- For this analysis, "voluntary" OSDS conversion was defined as five year construction segments, and residents will connect before 2050. "Mandatory" OSDS conversion was defined as five year construction and residents will connect before 2035.
- Operational costs were not included.
- 200 NRU upgrades/year for voluntary NRU upgrade programs.
- No transfer of waste load allocation (WLA), all TN removed will be retired to meet the WIP.

The lower boundary condition was set by MS1, baseline implementation. MS1 involves: implementation of voluntary OSDS conversion to public sewer in OWMPA within existing SSA; continued stormwater program to treat 30% impervious area; voluntary NRU program; sub-options were prioritized by total N (1A) and by cost (1B). The upper boundary condition was set by MS2 including mandatory implementation of previously county defined Large CIP program. The other nine options built on top of MS1 with variations. The technical options in each MS are presented in Table 3.1.1.

It is important to note that the MS's included a goal of 250,000 lb TN/yr removal, which is much higher than the updated target as described in Section 1.1. However, the approach presented is also suitable for the reduced reduction goal of 115,000 lbs, resulting in less septics requiring conversion/connection in order to meet the goal.

Table 3.1.1: Summary of technical options within each MS

Sector		MAR				Stormwater		MST		OSDS								
Scope		Patuxent	Broadneck	Cox Creek		30%	40%	All		OWMPA in SA	MAs that include OWMPA	Impacted MAs	Bodkin Point	OWMPA Complete		Large Cap		NRUs
		10 mgd	7.5 mgd	7.5 mgd	15 mgd													
Date/Expedience		2025	2029	2033	2033	2030	2040	2025	2030	2050 / Voluntary	2050 / Voluntary	2050 / Voluntary	2050 / Voluntary	2035 / Mandatory	2050 / Voluntary	2035 / Mandatory	2050 / Voluntary	2050 / Voluntary
Management Strategies	1A – Baseline, prioritized by TN					√			√	√								○
	1B – Baseline, prioritized by Cost					√			√	√								○
	2A - Large CIP, prioritized by TN					√										√		
	2B - Large CIP, prioritized by Cost					√										√		
	3 - Baseline + 1 MAR	√				√			√	√								○
	4 - Baseline + 2 MAR	√	√			√			√	√								○
	5a - Baseline + 3 MAR	√	√	√		√			√									
	5b - Baseline + 3 MAR	√	√		√	√			√	√								
	6A - Baseline + All OWMPA Voluntary + MAR, prioritized by TN	○	○			√			√	√					√			
	6B - Baseline + All OWMPA Mandatory + MAR, prioritized by cost	○	○			√			√	√				√				
	7A – Baseline + MAs that include OWMPA + MAR to meet goals	○	○			√			√	√	√							
	7B - 7A + Impacted (Dependent) MAs	○	○			√			√	√	√	√						
	8A – Baseline + All OWMPA + MAs that include OWMPA + MAR	○	○			√			√	√	√				√			
	8B – 8A + Impacted (Dependent) MAs	○	○			√			√	√	√	√			√			
	9A -3 + Large Cap as required, prioritized by TN	√				√			√	√							○	
	9B -3 + Large Cap as required, prioritized by Cost	√				√			√	√							○	
	10A - 4 + Large Cap as required, prioritized by TN	√	√			√			√	√							○	
	10B - 4 + Large Cap as required, prioritized by Cost	√	√			√			√	√							○	
	11A - Maximize Nutrient Removal without Bodkin	√	√		√	√	√	√		√	√							√
	11B - Maximize Nutrient Removal with Bodkin	√	√			√	√	√		√	√		√					√

Note:

√ - Fully implement

○ – Implement as much as needed to achieve the goal

3.2 Refining Management Strategies

After the February workshop with the County's input, HDR proceeded to narrow down MS options.

With a modified approach, the scenarios were grouped by the number of MAR facilities installed as well as baseline improvements. The shortfall to the goal was then calculated, and made up by OSDS conversions.

The scales of MAR facilities were modified to be:

- Patuxent – 7.4 MGD
- Broadneck – 7.5 MGD
- Cox Creek – 7.5 MGD

The baseline scenario included 100 NRU upgrades/year and impervious area reductions to 30% by 2030, in 2050 the county would produce a TN load of 1,388,000 lb/yr. With 1, 2, or 3 MAR facilities installed, the shortfalls to target load (please note that the target load at this time is still WIP II) are shown in Table 3.2.1:

Table 3.2.1: 2050 TN load and shortfall with different numbers of MAR facilities built, based on WIP II.

Scenario	2050 Progress (lb/yr)	Shortfall – Goal 1,165,000 lb/yr
Baseline	1,388,000	223,000
1 MAR	1,327,000	162,000
2 MAR	1,283,000	118,000
3 MAR	1,214,000	49,000

From the results presented in the table, HDR performed analysis for OSDS conversion **(Large CIP only)** with goals of 80,000 lb TN/yr, 160,000 lb TN/yr, and 240,000 lb TN/yr. The results were presented and discussed with the County in a workshop on March 29, 2019. It is important to note that the MS's included in this stage of refinement have a goal of 250,000 lb TN/yr removal, which is much higher than the updated target as described in Section 1.1.

3.2.1 OSDS PRIORITIZATION

The starting point of the analysis was to graph the cost per connection against cost per lb of TN removed, shown in Figure 3.2.1.1 below. The lower quadrant indicates cheaper cost per connection and cost per lb of TN removed, which is the overall most cost-effective MAs. The size of the circles indicates the amount of TN removed for that particular MA. 133 MAs were identified by the County in total, some of which were dependent upon the construction of another. For an example, see Herald Harbor configuration in Figure 3.2.1.2: MA577B-3 flows into MA577B-2, which flows into MA577B-1, which means that MA577B-3 cannot be constructed without the construction of MA577B-2 and MA577B-1. For these dependent MAs, HDR grouped them into MA groups and they were performed as one greater MA, which is why some circles in Figure 3.2.1.1 are significantly larger than others.

The green circles represent MAs that include OWMPA parcels. The two red circles indicate Bodkin Point, with the larger red circle indicating the south Bodkin area and smaller one indicating the north Bodkin area (please see Section 3.2.2 for more discussions on Bodkin Point and decisions regarding OSDS conversions in that area).

Figure 3.2.1.1: Cost of connection versus cost per lb of TN removed

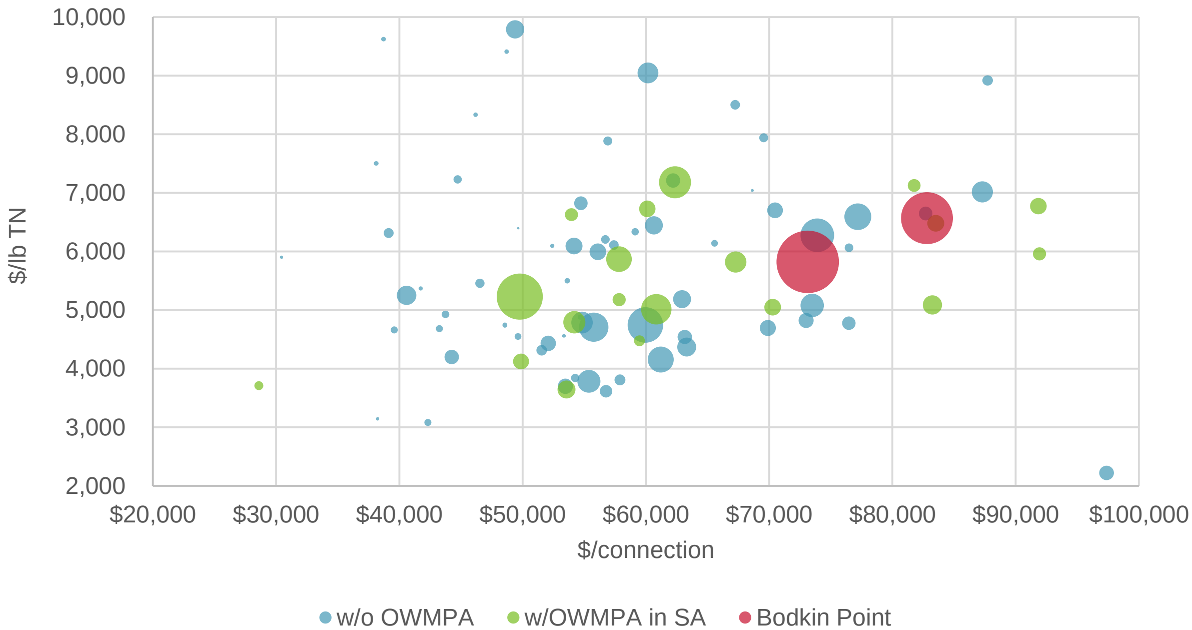
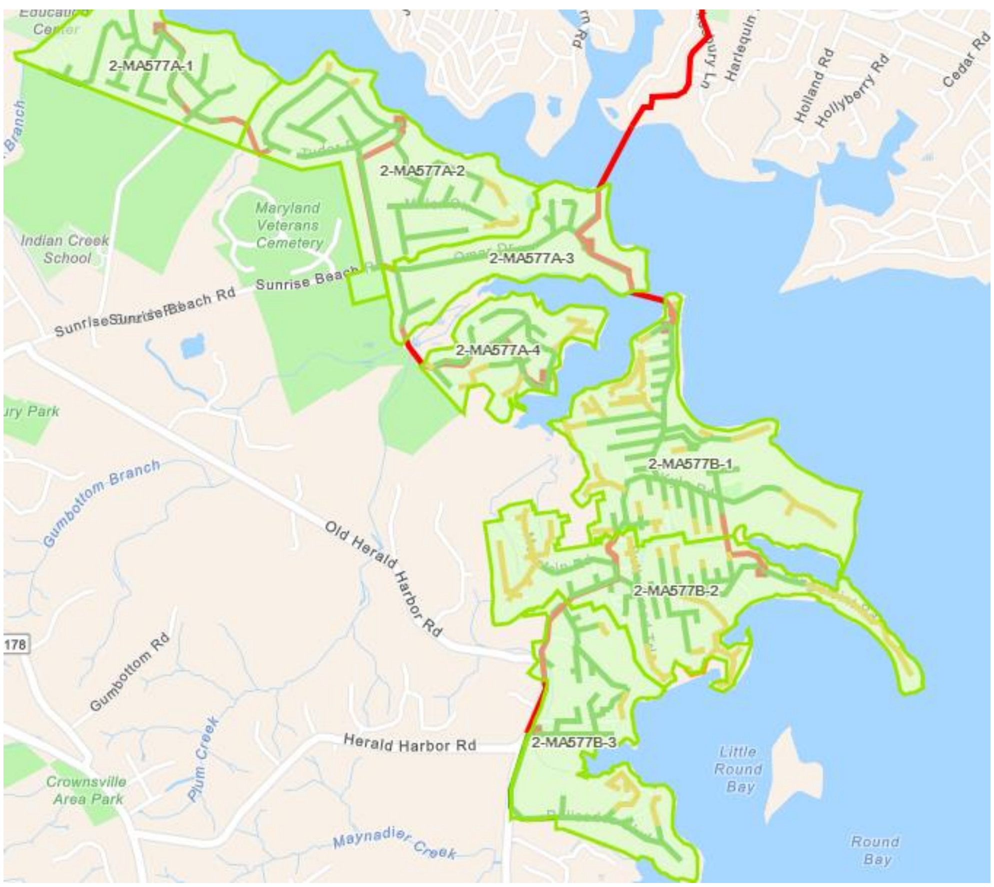
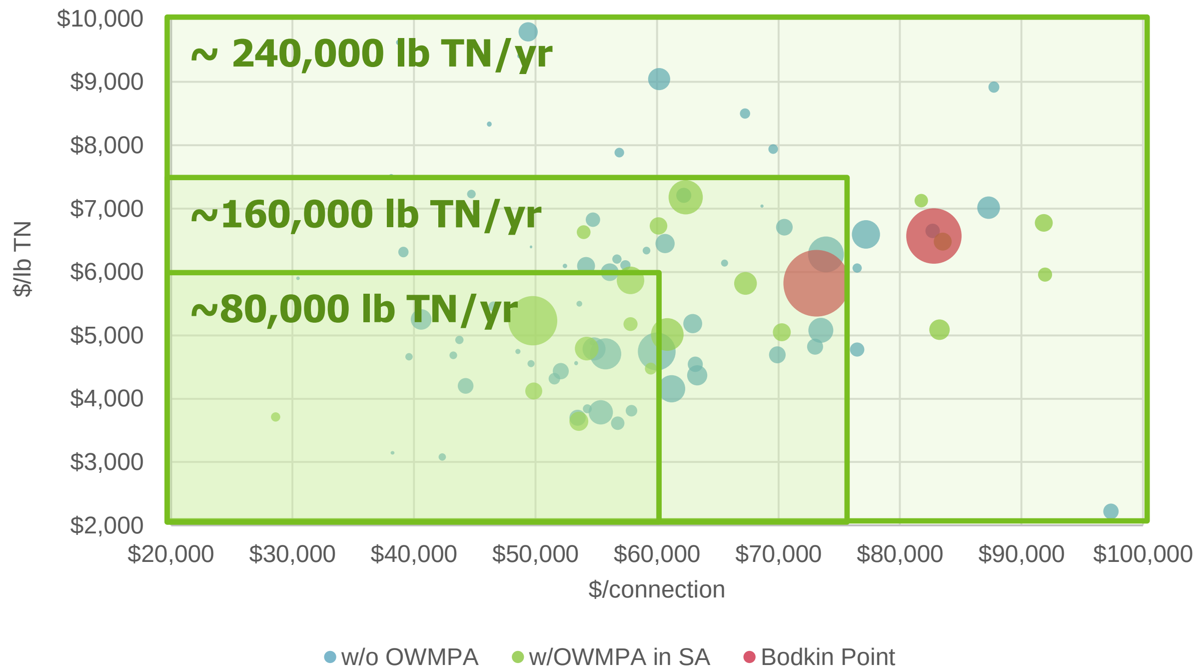


Figure 3.2.1.2: Example of a dependent MA configuration in Herald Harbor



For a goal of 80,000 lb TN/yr removal, HDR picked MAs with cost/connection lower than $60,000 and $/lb TN removed lower than $6,000, which corresponds to the most cost effective quadrant on the graph. For goals of ~160,000 lb TN/yr and 240,000 lb TN/yr, similar selections were performed graphically as follows. Please note that the outliers with $/connection greater than $100,000 or $/lb TN greater than $10,000 are not shown on the graph, and not included in the analysis because of low financial return.

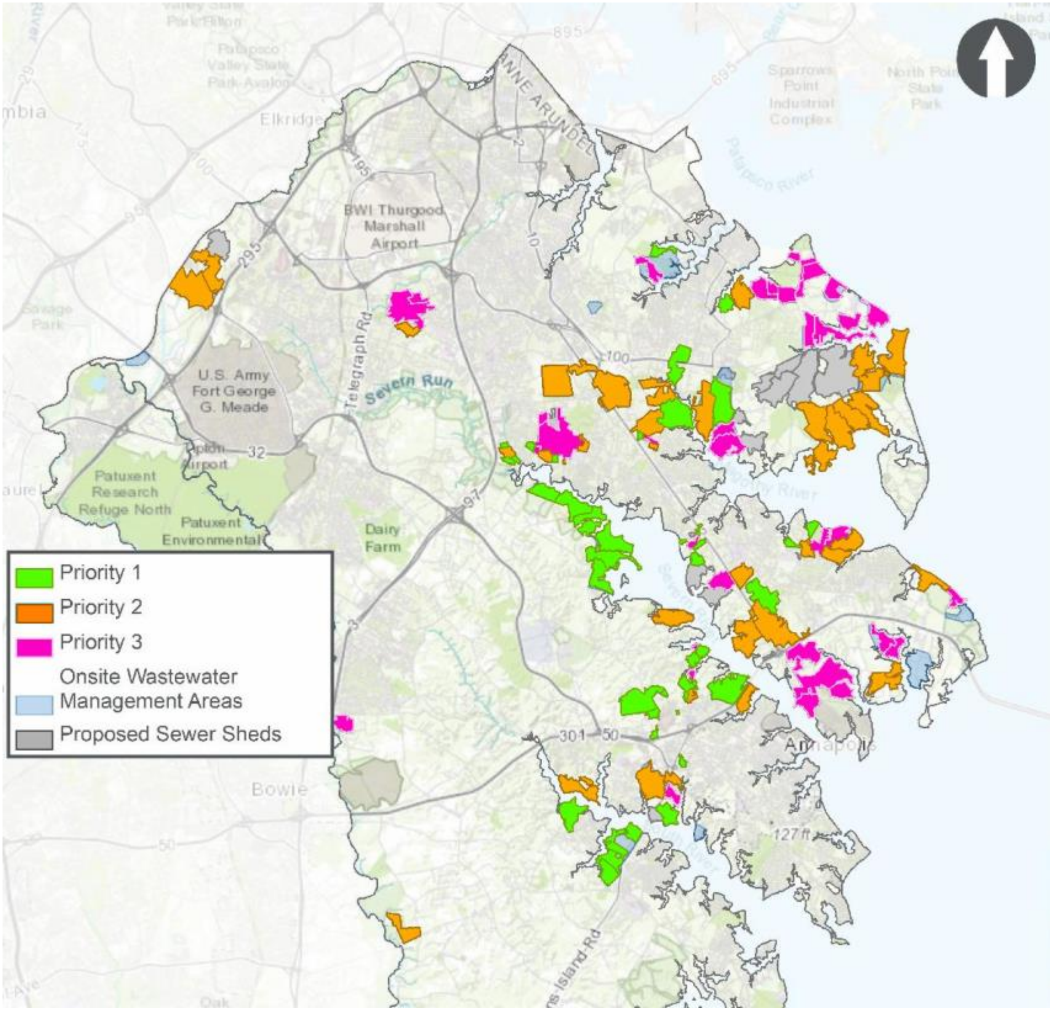
Figure 3.2.1.3: Example prioritization by cost only – selection by different tiers of goals



MAs that are covered by the 80,000 lb TN/yr rectangles were identified as Priority 1, and those between 80,000 and 160,000 lb TN/yr rectanges were identified as Priority 2. The rest were priority 3. The following map, Figure 3.3.1.4 shows the locations of the three tier priority MAs based on cost effectiveness.

The first 80,000 lb costs the County $390 million in total with 7,200 connections. Each connection costs $54,000 on average, and $/lb TN is $4,900. 160,000 lb TN removal costs the County $850 million with 14,400 connections. Each connection will on average cost $64,000, and $/lb TN is $5,800. 240,000 lb TN removal costs the County $1,375 million with 21,600 connections. Each connection on average costs $73,000, and $/lb TN is $6,600.

Figure 3.2.1.4: Example prioritization based on cost only



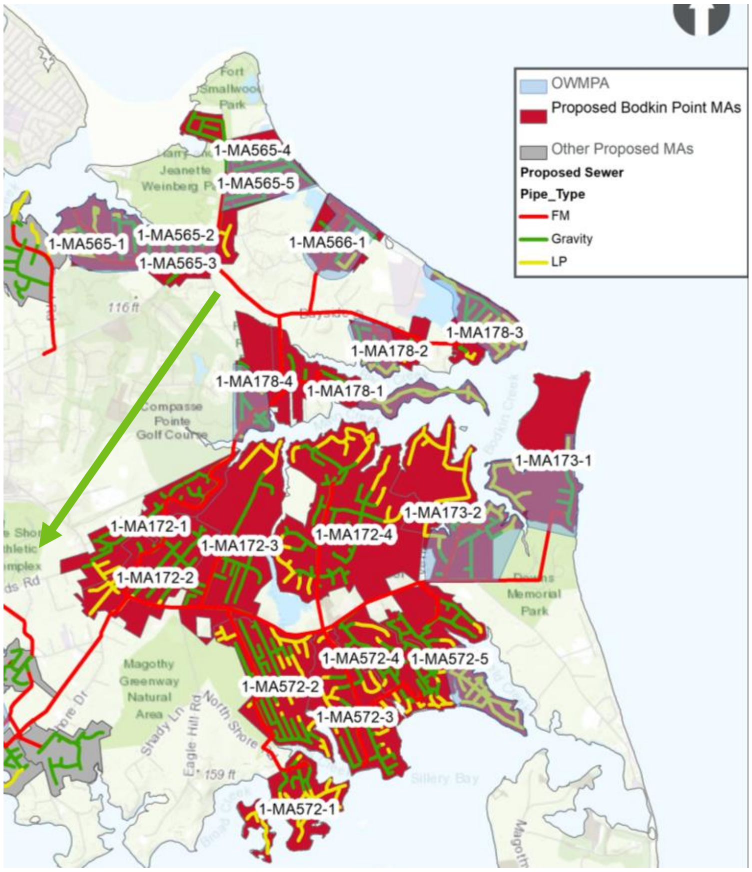
The above is just one type of sample prioritization. The MAs with OWMPA can be considered in higher priority than the ones without OWMPA parcels, which creates another set of septic prioritization strategy.

3.2.2 BODKIN POINT DISCUSSION

Bodkin Point is located in the northeastern part of the County, and is entirely outside of the existing SSAs and PFAs. Bodkin is an area of focus because of the significant amount of users (4,800), abundance of OWMPA parcels (2,000) because of high groundwater and small lots, and high number of parcels in the critical area. If all identified MAs can be implemented, it will result in 69,000 lb TN/yr removal. However, because there is no existing infrastructure in the area, it is very expensive to extend service from a point of existing infrastructure.

There are 21 County identified MAs within the Bodkin area, and the previous configuration was to convey all the wastewater flow into existing sewer in the Broadneck SSA, as shown in Figure 3.2.2.1.

Figure 3.2.2.1: Proposed MAs within Bodkin area, and original sewer layouts for each MA by County's past efforts



With this configuration, sewer pipes will have to pass through areas that are not zoned for development. The river crossing through the Magothy adds a significant cost as well. Capacity upgrades at the downstream Broadneck SSA might be triggered because of significant addition of flow from BP with 4,800 users.

As a result, Bodkin is a suitable candidate for cluster treatment because of proximity between each of the management areas. HDR performed a cluster treatment analysis – instead of conveying the flow to Broadneck, two packaged plants are proposed, one near Fort Smallwood Park, and one on the south side of Bodkin Creek. The north plant will be 0.3 MGD in capacity, and the south plant will be of 0.5 MGD capacity. This configuration eliminates significant pump station construction, pumping energy costs, and river crossing construction.

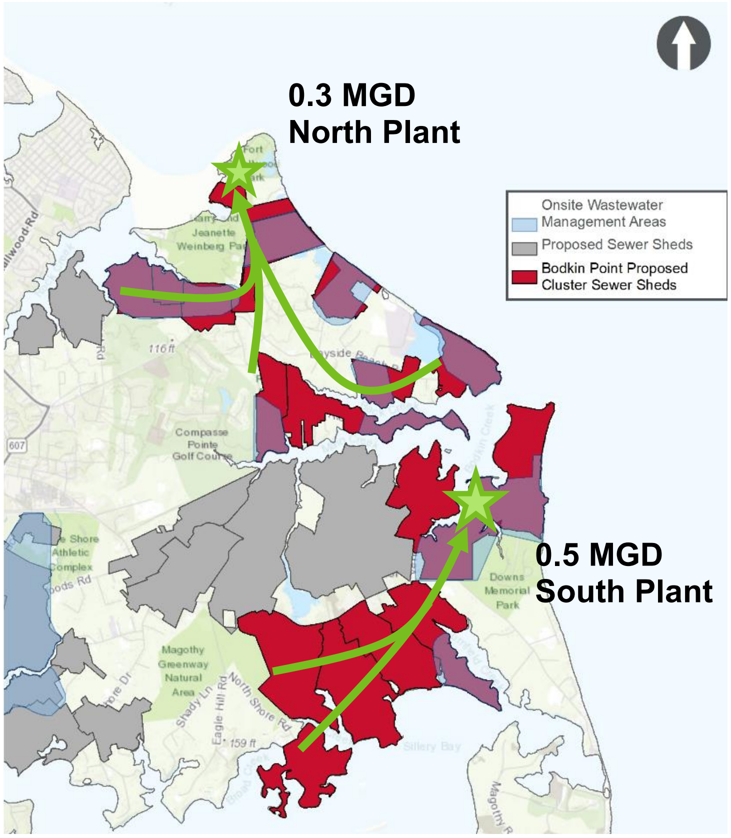
The configuration is shown in Figure 3.2.2.2. The reason to exclude the MA172-1 to MA172-4 is because they are less densely populated and cost effective.

This configuration will reduce the TN load to all three adjacent watersheds:

- It will remove 11,900 lb/yr from existing OSDS, and add 2,900 from new WRF discharge to Patapsco watershed, net reduction 9,000 lb/yr
- It will remove 23,900 lb/yr from existing OSDS, and add 4,800 from new WRF discharge to Bodkin Creek watershed, net reduction 19,000 lb/yr
- It will remove 23,900 lb/yr from existing OSDS to Magothy watershed

However, there will be increase in phosphorus discharge by 270 lb/yr in Patapsco watershed and 460 lb/yr in Bodkin watershed. Because there is no current phosphorus discharge permit in Bodkin watershed, it most likely will be difficult to obtain a new discharge permit.

Figure 3.2.2.2: Bodkin Point modified cluster treatment configuration, showing two packaged plants



After discussion with the County, it is decided that Bodkin Point will be tabled.

Although the final three MS's will not include Bodkin Point, this section serves as a record in case the County wants to reconsider implementation in Bodkin in the future.

3.3 Shortlisting Three Strategies

Between the March workshop and the June workshop, the draft WIP III was published by MDE with evaluations and modified goals for each county. After reevaluating the goals based on draft WIP III, HDR decided to modify the approach and reestablish program goals. The analysis can be found in the Supplement to TO4 Memo. **The re-established program goal is now adjusted to 115,000 lb TN/yr, with a 50,000 lb/yr TN WLA transfer.** The program includes mix of zero, one and two MAR options and different prioritized septic conversions. Bodkin Point was not included in the analysis. Only Large CIP was included in the following analysis, however, HDR has the capability to perform prioritization similarly for Small CIP areas.

3.3.1 OSDS PRIORITIZATION MODELING

HDR developed a Monte Carlo simulation model to determine the probabilistic County costs (incentives) of Large CIP OSDS conversion programs at different levels of TN removal goals with a set success rate of at least 80%.

Each MA was set up to "vote" either "yes" or "no" (based on the willingness to pay), and the percentage an MA would vote "yes" is based on the cost to the homeowner. The willingness to pay assumptions are listed in Table 3.3.1.1. The starting homeowner cost was set to $50,000, because the average cost of connections is $60,000, and it was assumed that BRF funds will cover $10,000; the County would pay the difference between the actual cost per connection and the amounts covered by the state of Maryland and the homeowner. The probability of voting “yes” was assumed to be 5%. Similarly, for each cost to the homeowner, there was an assumed probability of voting “yes”, which increased as the connection cost to homeowner decreased. Please note that these willingness to pay assumptions are not final, and are to be validated or modified by the result of the survey in TO9.

Table 3.3.1.1: Willingness to pay assumptions

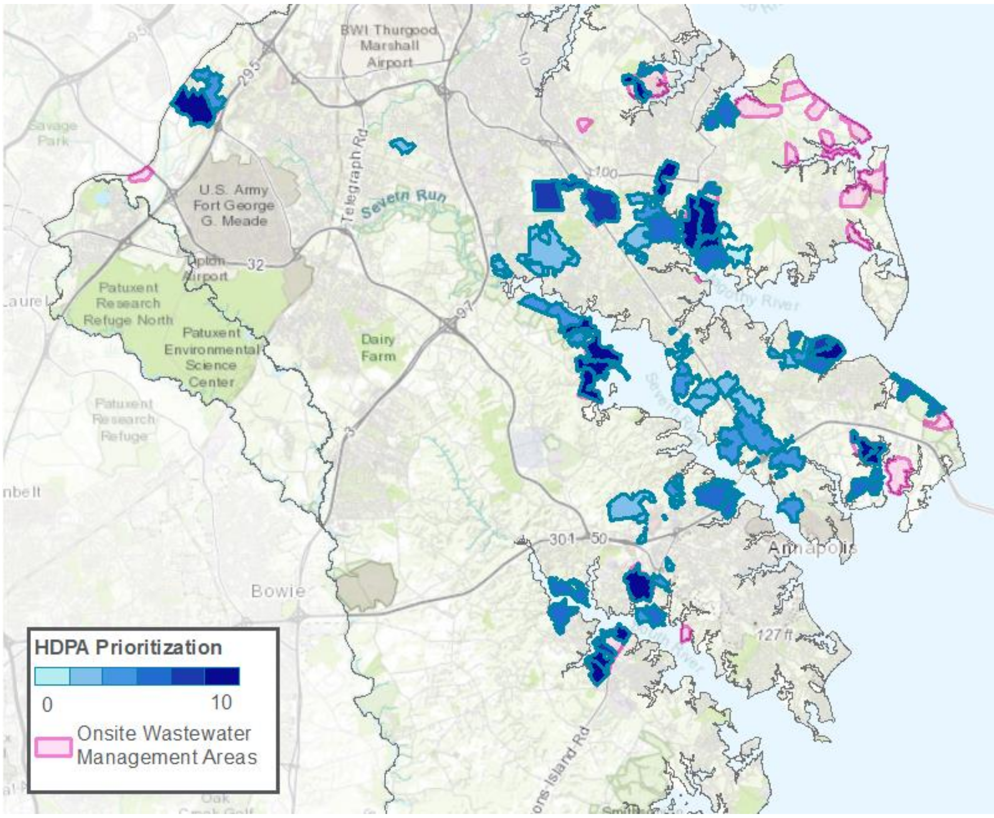
Connection cost to homeowner	Probability of voting "Yes"
$50,000	5%
$45,000	7%
$40,000	10%
$35,000	15%
$30,000	20%
$25,000	30%
$20,000	50%
$15,000	70%
$10,000	85%
$5,000	90%
$0	95%

Each MA was scored and ranked, and the scoring criteria can be revised as needed. Similar to the prioritization in Section 3.2.1, dependent MAs were grouped and treated as one large MA. In total there are combined 87 MAs (not including any in Bodkin Point). The results shown in this memo is merely an example run using just one set of scoring criteria, but the model can accommodate changing individual criteria and percentage weights:

- Number of OWMPA parcels: 60%
- Number of Critical Area parcels: 15%
- Distance to existing collection system: 15%
- Cost/lb TN: 10%

The MA list was then ranked with highest scores on top. The prioritization is visually shown below in Figure 3.3.1.1, with 10 being the highest score. Two setups were tested: in one the MAs ranked higher “vote” first, and the lower ranked MAs “vote” last (we called this “Targeted” approach); in the other, the prioritization score did not determine the order in which MAs voted (this approach was called “One size fits all”). The model stopped running once the target TN removal is achieved, and no more MAs would be added to the program. The percentiles of MAs receiving the incentive would vary from 0% to 100%, with 5% step. The rest of the MAs in that iteration receive no incentive.

Figure 3.3.1.1: Example prioritization map using criteria listed above

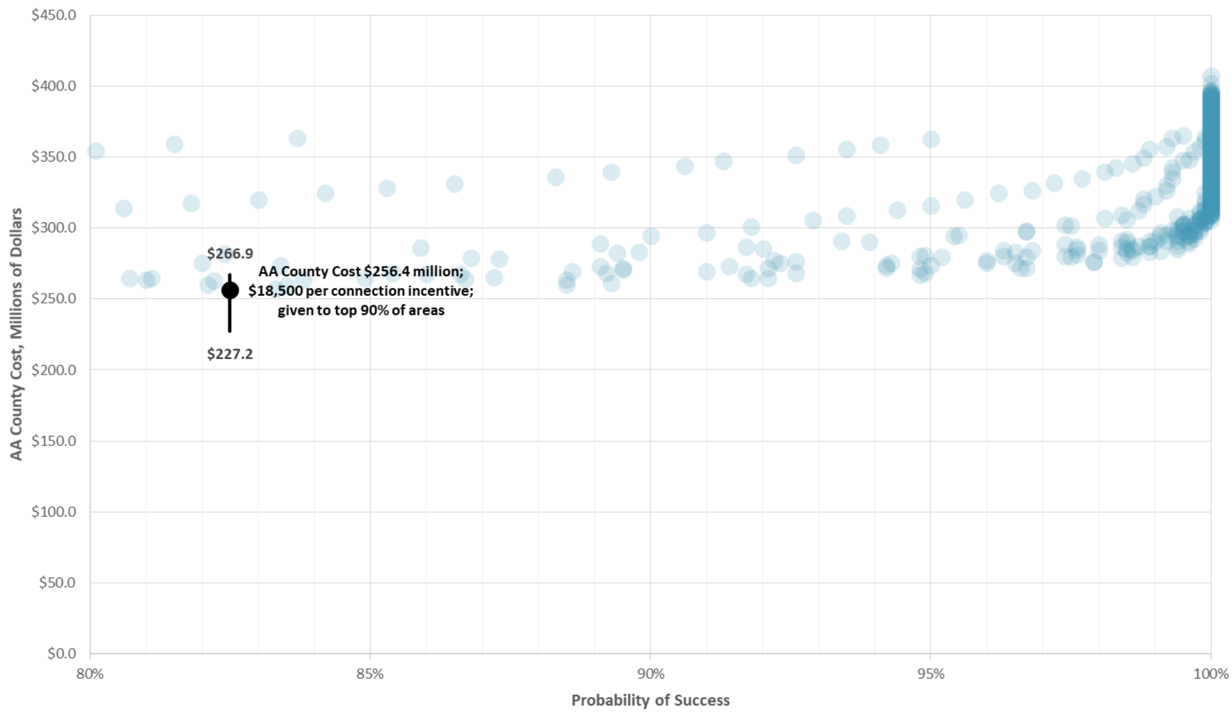


The example run includes four scenarios ("One size fits all" approach), which are combinations of the following:

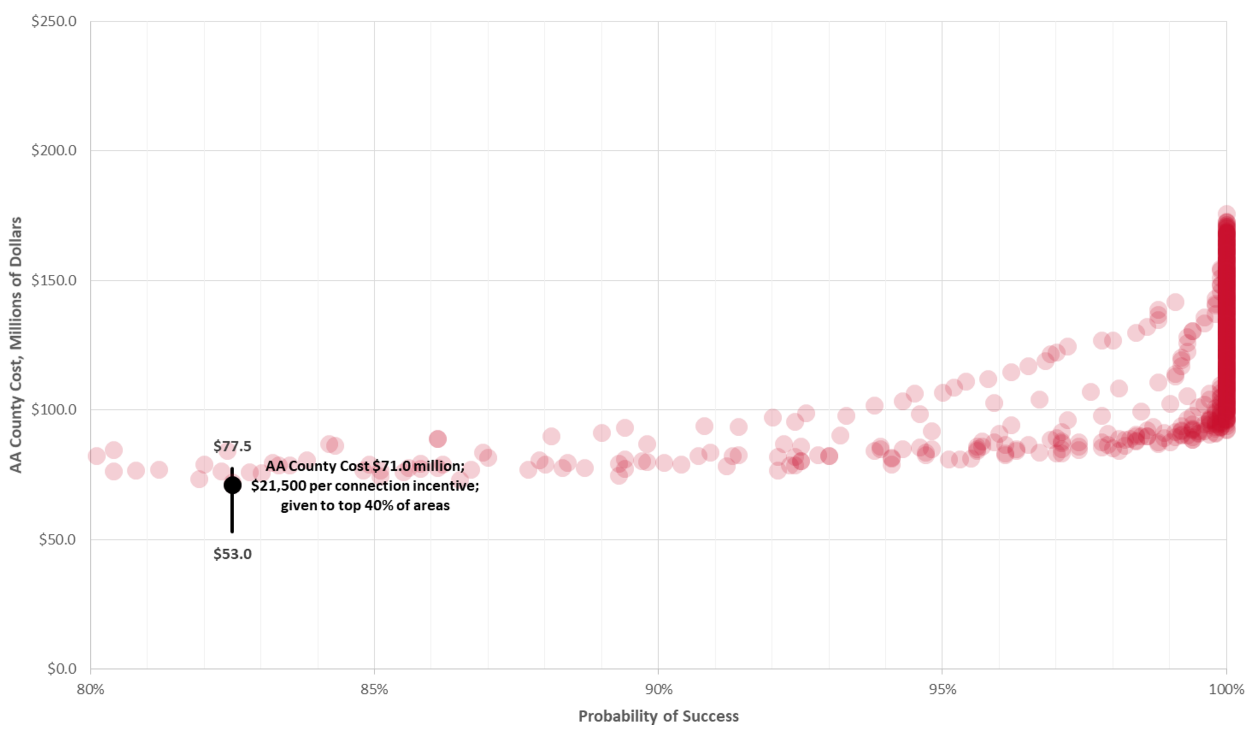
- 2 goals: 80,000 lb or 40,000 lb
- 2 levels of state BRF contribution: $10,000/connection or $20,000/connection. The rest is covered by homeowners and the County

The model runs 2,100 simulations and there are 1,000 iterations per simulation. The graph of aggregated results are shown in Figure 3.3.1.2. Two scenarios are shown here in the memo. As shown in the Figure, the scenario that has an 80,000 lb/yr TN target removal and $10,000 BRF funding results in the highest county cost: for an 80% success rate, it would cost AACo approximately $260 million. It would require $35,000 county incentives given to top 90% management areas. A total of 7,600 connections were needed to achieve the goal. The lowest county cost scenario had a goal of 40,000 lb/yr TN and a $20,000 funding from the state. For an 80% success rate, it would cost AACo approximately $70 million. It would require an $18,500 county incentive given to 40% management areas. A total of 4,100 connections were needed to achieve the goal.

Figure 3.3.1.2: results of model run. (a) 80,000 lb TN/yr target removal, $10,000/connection from BRF. (b) 40,000 lb TN/yr target removal, $20,000/connection from BRF



(a)



(b)

3.3.2 MANAGEMENT STRATEGIES – INTEGRATED APPROACH

With the probabilistic analysis in Section 3.3.1, informed decisions can be made regarding combinations of technical options in MS's. HDR further narrowed the options down to three MS's, the compositions of which are listed in the Table 3.3.2.1 below. The idea is similar to that of Section 3.2.1, based around the number of MAR installed, and the rest of the nitrogen reduction shortfall can be filled by OSDS conversions.

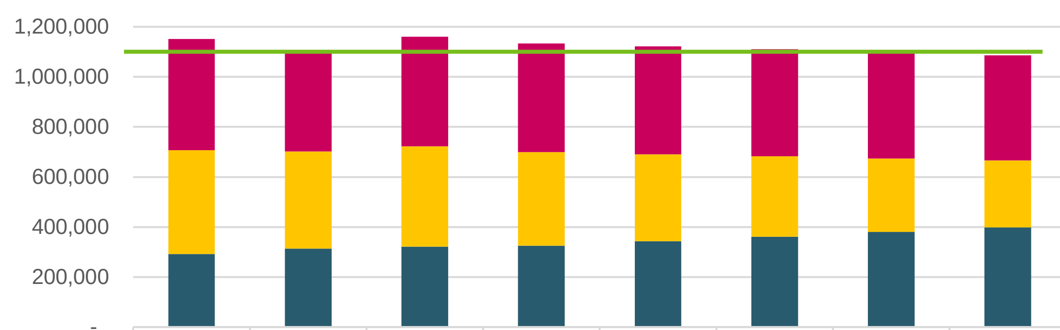
For each of the MS, stormwater stays at status quo of 30% impervious area reduction, consistent NRU upgrade program at 100 per year, and MST reducing 15,000 lb TN/yr.

Table 3.3.2.1 Shortlisted MS summary.

	MAR	OSDS Conversions	Stormwater	NRU Upgrades	MST
MS A	/	520/yr	No change	100/yr	15,000 lb/yr
MS B	Patuxent	200/yr	No change	100/yr	15,000 lb/yr
MS C	Patuxent & Broadneck	100/yr	No change	100/yr	15,000 lb/yr

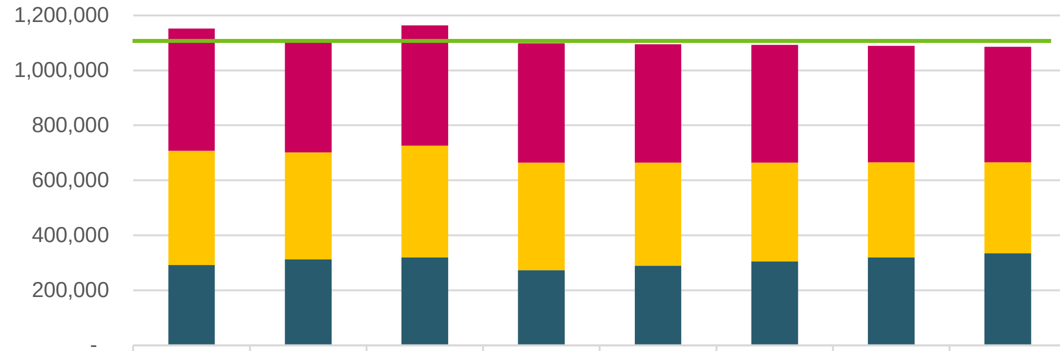
The nutrient loading of each sector for each MS scenario can be found in Figure 3.3.2.1 below. It is important to note that none of the options achieves the WIP target reduction by 2025. MS A achieves the total reduction target in 2040, MS B in 2030, and MS C in 2035.

Figure 3.3.2.1 nutrient loading of each sector of 2017, WIP III goal, and up to 2050 under each MS.



	2017	Phase III WIP	2025	2030	2035	2040	2045	2050
Natural	444,127	400,000	438,278	434,622	430,967	427,311	423,656	420,000
Septic	415,000	388,183	400,774	374,069	347,364	320,659	293,954	267,249
Wastewater @ 3 mg/L	292,234	313,500	321,518	324,936	343,353	361,771	380,188	398,606
Total w/o SW	1,151,361	1,101,683	1,160,570	1,133,627	1,121,684	1,109,741	1,097,798	1,085,855

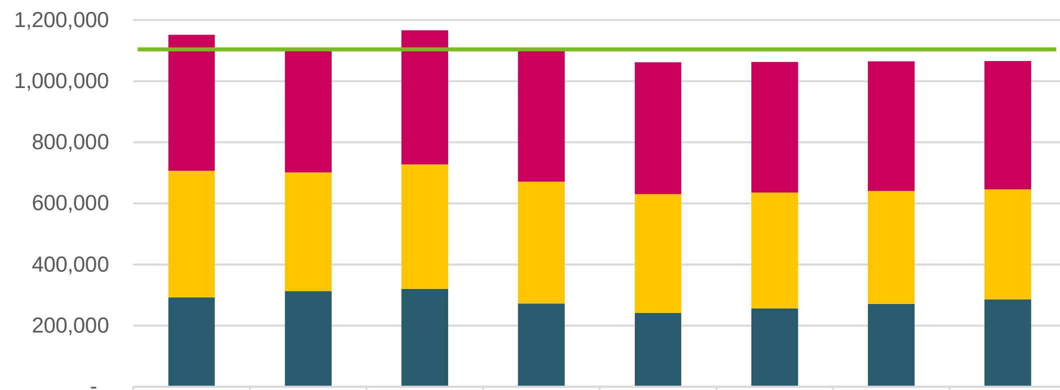
(a) MS A.



	2017	Phase III WIP	2025	2030	2035	2040	2045	2050
Natural	444,127	400,000	438,278	434,622	430,967	427,311	423,656	420,000
Septic	415,000	388,183	405,398	390,252	375,107	359,962	344,817	329,671
Wastewater @ 3 mg/L	292,234	313,500	320,343	273,822	289,301	304,781	320,260	335,739
Total w/o SW	1,151,361	1,101,683	1,164,018	1,098,697	1,095,375	1,092,054	1,088,732	1,085,410

Wastewater @ 3 mg/L ■ Septic ■ Natural ■ Total w/o SW

(b) MS B.



	2017	Phase III WIP	2025	2030	2035	2040	2045	2050
Natural	444,127	400,000	438,278	434,622	430,967	427,311	423,656	420,000
Septic	415,000	388,183	407,632	398,071	388,511	378,950	369,390	359,830
Wastewater @ 3 mg/L	292,234	313,500	319,987	272,576	242,164	256,753	271,342	285,931
Total w/o SW	1,151,361	1,101,683	1,165,896	1,105,269	1,061,642	1,063,015	1,064,388	1,065,760

Wastewater @ 3 mg/L ■ Septic ■ Natural ■ Total w/o SW

(c) MS C.

3.3.3 PATHS FORWARD

After discussion with the County and reviewing the similar conversion programs across the country, the Team agreed that the program will be voluntary for the management area to vote/yes or no with robust incentives to make conversions appealing and affordable to the public. After a “yes” vote by the community, connections would then be mandatory.

Under current County code, the OSDS conversions are done through resident petitions. Residents can vote on the project at each checkpoint, and a majority (51%) must vote yes before proceeding. HDR recommends that the County adopt new policies to facilitate the implementation of OSDS conversions at a timely pace. The specifics of policy discussions will follow in the subsequent TO6, in a series of meetings with the Septic Task Force and Working Groups.

Coordination with other state and local agencies are critical for the program success as well:

- 82% of Large CIP parcels and 91% of OWMPA parcels are located outside of the PFA. In order to build in the areas not intended for growth, the County needs to coordinate with the Maryland Department of Planning and Zoning and local communities.
- To ensure the projects are done on a timely pace, the County would need to negotiate with local permitting agencies for a blanket permitting instead of individual sites.

The specific policy framework and procedure of this program will be further discussed in TO6. HDR will develop a draft OSDS conversion policy framework and a legal evaluation based on MS's developed in this report. The framework will include elements such as funding mechanisms, conversion procedure and process, utilization of low pressure systems, and operations and maintenance. TO6 will also aim to refine the cost analyses and further update the financial and prioritization models.

Specific financial discussion will be included in TO 6 as well. This will include deciding on levels of incentives, determining financing methods, identifying sources of funding, and analyzing rate impacts. Together with the user survey, these discussions will eventually inform and lead to a financially sustainable and affordable program.

HDR will also host a series of meetings to inform policy and funding issues with the Septic Task Force. The meetings will review progress since the last task force meeting, present a draft policy framework, and discuss funding and homeowner incentives. The meetings are intended to obtain feedback that is representative of both the community and the utility.

Appendix 1: Supplement to TO 4: WIP III updates

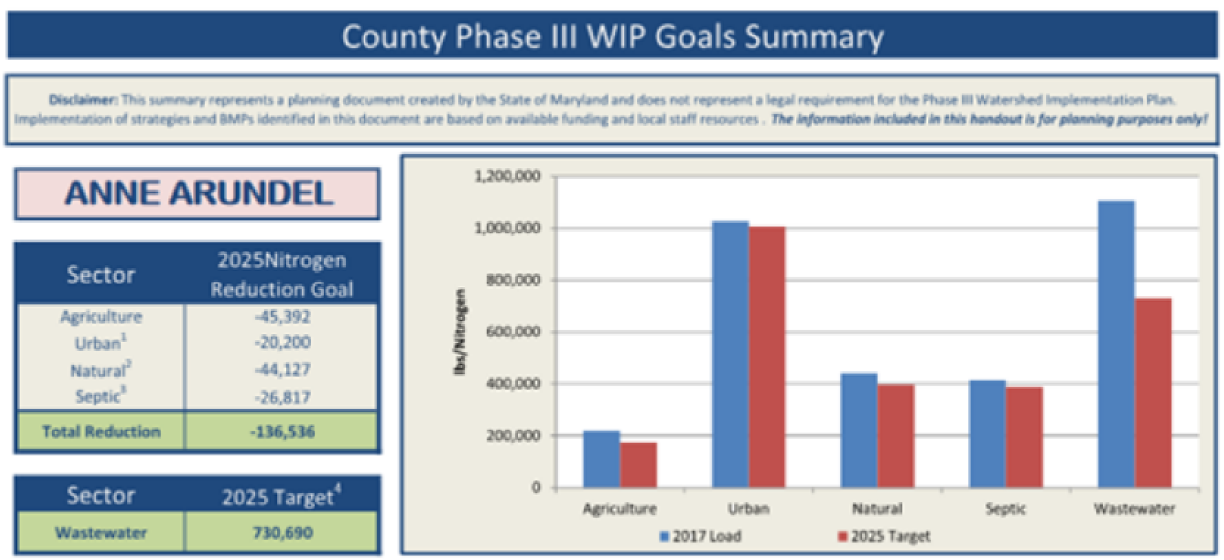
Supplement to Technical Memorandum for Task Order 4 – Watershed Implementation Plan Phase III (WIP III) update

MDE came out with the draft Phase III WIP on April 12th, 2019. It set updated goals for 2025 for the state overall, and charts a road map for each county as well. This document is to supplement the TM for TO4, and will update the goals for next TOs based on WIP III.

The following figure from WIP III outlines the goals for the county in 2025.

- The urban sector is essentially stormwater, which will fulfill its 20% area reduction goal for MS4 permits in 2024. The area reduction will satisfy the 20,200 lb TN/yr reduction goal.
- Natural sector was predicted to reduce 44,127 lb TN/yr with the assumptions that the county will restore 204,609 feet of urban streams.
- Septic sector reduction was based on 403 septic conversions, 2024 NRUs, and 6211 septic tank pumpouts.
- Wastewater sector: Out of a total target load of 730,690 lb TN/yr, the county owned portion is 313,500 lb TN/yr. Based on an assumed 3.25 mg TN/L concentration, the assumed wastewater flow from county facilities is approximately 31.7 MGD.

Figure 1: Anne Arundel County Phase III WIP Goals Summary



With the change in goals of each sector, HDR reevaluated the County goal of WIP III compliance from the septic, stormwater, natural, and wastewater sectors. Figure 2 shows the nutrient loads today, state goal in WIP III, and projected nutrient loads without any management strategies from 2025 and beyond, with the assumptions as follows.

- Stormwater: there will be no additional planned actions for stormwater after meeting the MS4 permit. Future MS4 permit reduction requirements are pending.
- Natural: the assumption In WIP III that 204,609 feet of urban streams restored in 2025 is unrealistic. HDR assumed that 100,000 feet of urban streams will be restored in 2050, and linearly interpolated them in between.

- Septic: only a baseline of 100 NRUs were assumed to be installed per year.
- Wastewater: Wastewater nitrogen concentration was assumed to be 3.25 mg/L.

Table 1: WIP III goal and nutrient forecast breakdown for 2025 and 2050, assuming wastewater nitrogen concentration at 3.25 mg/L

Sector	2017	Phase III WIP	Est. 2025	Est. 2050
Stormwater[1]	1,020,200	1,000,000	1,000,000	1,000,000
Natural[2]	444,127	400,000	438,278	420,000
Septic[3]	415,000	388,183	409,528	392,428
Wastewater[4]	316,586	313,500	346,266	420,466
Total	**2,195,913**	**2,101,683**	**2,194,072**	**2,232,894**

Table 2: WIP III goal and nutrient forecast breakdown for 2025 and 2050, assuming wastewater nitrogen concentration at 3 mg/L

Sector	2017	Phase III WIP	Est. 2025	Est. 2050
Stormwater[1]	1,020,200	1,000,000	1,000,000	1,000,000
Natural[2]	444,127	400,000	438,278	420,000
Septic[3]	415,000	388,183	409,528	392,428
Wastewater[4]	316,586	313,500	319,631	388,123
Total	**2,195,913**	**2,101,683**	**2,167,437**	**2,200,551**

Table 1 shows that the current gap of compliance at 2050 is around 135,000 lb TN/yr. However, if assuming that wastewater nitrogen concentration is 3 mg/L, the deficit will be reduced to ~100,000 lb TN/yr, as shown in Table 2 below. **HDR proposes to set the County goal to halfway between the two at 115,000 lb TN/yr.**

Appendix 2: Meeting presentations

Appendix 3: Meeting summaries

Appendix D – Alternatives Evaluation TM

Technical Memorandum

Date:	Tuesday, April 13, 2021
Project:	Anne Arundel County OSDS Strategic Planning
To:	Anne Arundel County OSDS Strategic Planning Team
From:	HDR
Subject:	Task Order 13 – Technology Alternatives Evaluation
Attachments:	(1) Wholesale Contract Cost Projection

1 Executive Summary

Under Task Order 13, the OSDS Strategic Planning Team is developing a Draft Integrated Management Plan (IMP) that will guide the County's approach for meeting Phase III WIP requirements for nutrient removal in coordination with long-term system improvements. Development of the IMP will follow EPA's Integrated Municipal Stormwater and Wastewater Planning Approach Framework[1]. The IMP will be used to develop a prioritized and balanced infrastructure investment strategy that addresses Clean Water Act requirements and meets programmatic and capital wastewater needs across the service area over the next 30 years. The County is including water supply resiliency in their IMP to support a One Water strategy.

One of the TO-13 tasks is to evaluate water supply resiliency alternatives and additional advanced nutrient treatment alternatives that could be implemented at the County's existing wastewater treatment plants. This evaluation includes a summary of costs and benefits to allow for comparison and prioritization of these management strategies in coordination with other features of the proposed Integrated Management Plan. The purpose of this memo is to document the evaluation of alternatives to be considered for use in the Integrated Management Plan.

The County has a need to evaluate alternatives for both water supply resiliency and nutrient reductions. Table 1 below summarizes the water supply resiliency alternatives on a Net Present Value (NPV) basis. Purchased water from the City of Baltimore under a contractual agreement has the lowest NPV. This approach, however, carries a number of unquantifiable risks that effectively diminish the value of this alternative. Managed Aquifer Recharge (MAR) has a slightly higher NPV as a water supply alternative, while providing co-benefits as a nutrient reduction strategy.

In Table 2, MAR is compared with two other alternatives that could potentially enable the County to achieve nutrient reductions to meet long-term TMDL compliance as climate change and the success of other sectors dictate the need for a scalable and adaptive strategy. At current estimates of other sector (storm, septic, and wastewater) nutrient reductions, it is estimated that the County will need an additional 47,000 lbs/year of TN reduction. An additional Total Nitrogen (TN) reduction of 47,000 lbs/year could be achieved with a 7.5 MGD MAR facility. The nutrient removal alternative with the lowest NPV involves additional oxidation

[1] Stoner, N. Memo to EPA Regional Administrators, 5 June 2012.

tanks and filter capacity at both the Patuxent WRF (10.5 MGD capacity) and Broadneck WRF (8.0 MGD capacity).

Table 1 - Comparison of Water Supply Resiliency Alternatives

Alternative	30-yr NPV (millions)		Pros / Cons
	7.5 MGD	15 MGD	
Purchased Water from Baltimore City	$240	$454	Pros: • Cost savings compared to non-contract rates • Diversifies County's existing water supply Cons: • Requires large infrastructure investment by City • Contractual terms and conditions not likely to be agreed upon • High cost uncertainty • Lack of County control over City CIP and operations • Surface water supplies vulnerable to drought and extreme weather events due to climate change • Added stress on surface supplies
Brackish Water RO WTP	$364	$552	Pros: • High quality finished water • Diversifies County's existing water supply Cons: • Inconsistent with 2008 Wolman Report • Difficulty in locating suitable site • Complexity of operations • High capital and O&M costs • Uncertain brine disposal options and costs
IPR – MAR	$350	$700	Pros: • Less stress on regional surface supplies (consistent with 2008 Wolman Report) • Expanded water re-use (consistent with 2008 Wolman Report) • Regional benefit to other jurisdictions that share aquifer • Synergistic TMDL benefits at low cost per pound of Total Nitrogen removal • Replenishes County water supply, reducing water budget imbalance • Replenishes aquifer to protect against potential subsidence and saltwater intrusion Cons: • High capital cost • Uncertain regulatory requirements
IPR – Shallow Infiltration	$478	N/A	Pros: • Less stress on regional surface supplies (consistent with 2008 Wolman Report)

			• Expanded water re-use (consistent with 2008 Wolman Report) • Replenishes County water supply, reducing water budget imbalance • Replenishes aquifer to protect against potential subsidence and saltwater intrusion <u>Cons:</u> • Significant land requirement – not feasible • High capital and O&M costs, in part due to extensive transmission capacity needs
Direct Potable Reuse	N/A	N/A	• Deemed infeasible and removed from further consideration

Table 2 – Nutrient Management: Comparison of Additional ENR Treatment Alternatives

Alternative	30-yr NPV (millions) for 47,000 lbs/yr	Pros / Cons
Additional Filtration for DON Removal	$555	<u>Pros:</u> • <u>Could reduce TN by 0.5 mg/L at each WRF</u> <u>Cons:</u> • Feasibility uncertain for further lowering TN at WRFs already at very low levels • High O&M cost for GAC replacement • Space for additional facilities limited at some WRFs • Performance will be site specific
Additional Oxidation Tanks & Filter Capacity	$162	<u>Pros:</u> • Expands facilities already in place for less impact on current operations • Space available at select WRFs <u>Cons:</u> • Added operational stress associated with tighter discharge limits • Reduced land for future expansion of WRFs
IPR – MAR	$291	<u>Pros:</u> • Scalable and adaptable to future TMDL impacts due to climate change and other sector uncertainties • Near zero nutrient discharge to Bay • Wasteload allocations not an inhibitor to planned growth demands <u>Cons:</u> • High O&M cost

The County has the need to address both long-term water resiliency and nutrient reduction, so it is necessary to combine each of the alternatives described above to determine the cost of a holistic approach. Table 3 below summarizes the combined NPV of paired alternatives. The IPR-MAR alternative has the lowest cost to provide both water supply and nutrient removal. The 30-year lifecycle NPV of a 7.5 MGD MAR facility combined with groundwater production is $350M. This alternative is 13% less expensive than the next lowest cost alternative and carries more benefits and fewer risks and uncertainties that are not easily quantified.

Table 3 NPV Comparison of Combined Water Supply & Additional ENR Alternatives (7.5 MGD and 47,000 lbs/yr TN reduction)

Alternative	Add'l Filtration for DON Removal	Add'l Oxidation Tank & Filter Capacity	MAR
Purchased Water from Baltimore City	$795	$401	
Brackish Water RO WTP	$919	$525	
Indirect Potable Reuse – MAR			$350
Indirect Potable Reuse – Shallow Infiltration	$1,033	$639	
Direct Potable Reuse	DPR Not Viable	DPR Not Viable	DPR Not Viable

As shown in Table 3, the MAR alternative is 13% less costly than the next affordable alternative (Baltimore City Water combined with Additional Oxidation and Filtration). Furthermore, this alternative retains the strategy of autonomy the County has pursued over the last three decades allowing for more self-direction; reliability; and responsiveness to the customers served. It is also more compatible with the recommendations included in the 2008 Wolman Report commissioned by the State[2]. Recommendations included: (1) state-wide water supply strategy; (2) adopting a regional approach; and (3) expanding water re-use overall including reclaimed water from POTW's. By recharging the County's groundwater supplies, the Potomac Aquifer network could better serve as a major supplemental source of supply augmenting the regional surface water supplies from the Susquehanna, Patapsco, Patuxent and Potomac Rivers. Such a strategy would reduce pressure on those surface water supplies, especially during drought conditions, and provide a possible temporary supply should water quality issues emerge in the surface supplies. An expanded portfolio of supply options would be consistent with the goals and objectives outlined in the Wolman Report.

MAR is recommended for its significantly lower NPV, and because it affords the County more control over long term water management and TMDL compliance. Further, the benefit of restoring the aquifer is a critical next step in providing for the long-term sustainability of the region's groundwater supply. As a unified solution, the MAR alternative should be included in the Integrated Management Plan, as it is believed to serve the best interests of all citizens in Anne Arundel County by providing a sustainable water supply, a scalable and adaptive nutrient management strategy, and is the most affordable.

2 Technologies Evaluated

2.1 Water Supply Resiliency Alternatives

The following water supply resiliency alternatives have been evaluated:

[2] Wolman, G. (2008). *Final Report of the Advisory Committee on the Management and Protection of the State's Water Resources, Vol. 1*. Maryland Department of the Environment.

- Additional Purchased Water from Baltimore City
- Brackish Water Treated with Reverse Osmosis (RO)
- Indirect Potable Reuse (IPR) – Managed Aquifer Recharge (MAR)
- IPR – Shallow Infiltration
- Direct Potable Reuse

Each technology has unique limitations for production capacity. For example, shallow infiltration capacity depends on the direct recharge capacity of the aquifer. Additional purchased water capacity depends on inter-jurisdictional agreements and long-term infrastructure investment planning. For the purposes of this alternatives evaluation, capacity is evaluated at up to 15 MGD over the long term. This additional capacity would close the gap between the County's current groundwater appropriation and the projected system-wide build-out demand, including a modest factor of safety. Each alternative includes infrastructure upgrades necessary to provide a reliable supply of finished water for distribution.

2.2 Additional ENR Treatment Alternatives

The following ENR treatment alternatives will be evaluated and compared to MAR for nutrient reduction:

- Additional Filtration for Dissolved Organic Nitrogen Removal
- Additional Oxidation Tank and Filter Capacity

As with water supply technologies, each ENR technology has unique limitations for treatment capacity. The existing configuration and performance of the County's wastewater treatment plants greatly impacts the feasibility of additional ENR treatment processes. For the purposes of comparing alternatives, additional ENR Treatment capacity should be evaluated at 47,000 lbs/yr of Total Nitrogen reduction. This is the planned MAR TN reduction contribution for a 7.5 MGD facility that is proposed at the Patuxent Water Reclamation Facility (WRF), and therefore offers a practical basis of comparison. Evaluated on a flow basis, a similar TN reduction would require 15.4 MGD of WRF treatment to 2 mg/L instead of 3mg/L, or 30.8 MGD of WRF treatment at 2.5 mg/L instead of 3 mg/L.

2.3 Evaluation Assumptions

The following assumptions are used for comparison of alternatives:

- Since the planning horizon of the IMP is 30 years, a Net Present Value (NPV) basis is used to compare the 30-year lifecycle costs of each alternative.
- Cost estimates are prepared at the Class 5 level for Concept Screening, per AACE guidelines.
- Costs are estimated in 2020 dollars for ease of comparison to previous OSDS planning estimates.
- Costs escalated from previous years reference the ENR Construction Cost Index.
- Costs escalated to the future assume 2% inflation.
- Anne Arundel County's weighted cost of borrowing is assumed to be 4.25%.
- Treatment plant costs are scaled by multiplying the capacity ratio and factoring by six-tenths[3].
- Capital costs are estimated from multiplying construction costs by a Capital Cost Factor of 1.4. The Capital Cost Factor accounts for engineering, construction management, program management and administration.
- Capital projects needed for each alternative are assumed to be completed by 2031 since that is the year in which nutrient reduction alternatives are needed to meet the County's long-term planning targets.

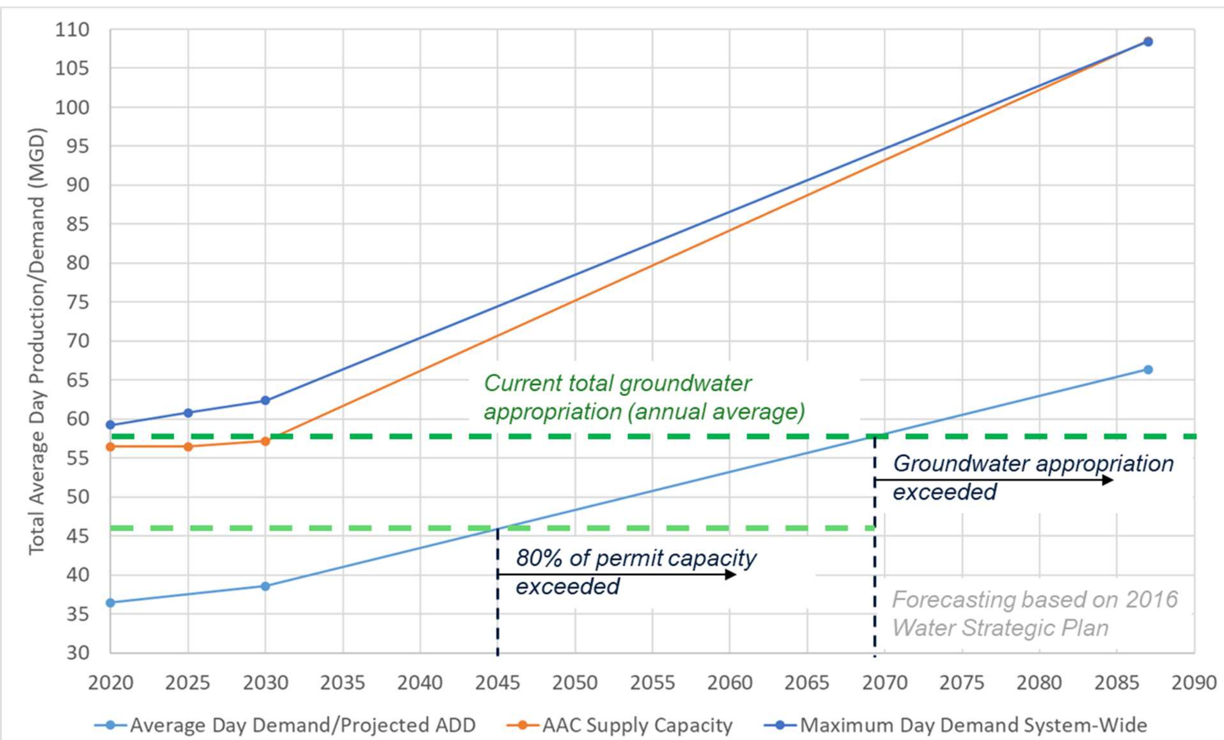
[3] American Water Works Association (2004). *Water Treatment Plant Design* (4th ed.). McGraw-Hill Companies

3 Water and Wastewater System Considerations

3.1 Existing Potable Water System and Planned Growth

In recent years, the County's average day water demand has been approximately 34 MGD. The figure below summarizes demand projections per the 2016 Water Strategic Plan (WSP). While the current average day demand is lower than what the WSP projected, the County has appropriated additional water supply to support approved development. This discrepancy reflects the relative uncertainty in the timing of projections and underscores the need for the County to plan for additional capacity. In past years, the gap between the County's supply capacity and maximum day demand has been filled by additional supply purchased from Baltimore City. Projects planned in the WSP are intended to improve water supply system reliability and also minimize reliance on Baltimore City. The County plans to focus on the development of existing production facilities and eventually a new Water Treatment Plant (WTP) to handle additional build-out demands. The build-out projection is based on the County's current master plan, although it is expected that ever-increasing growth in the Baltimore-Washington corridor will continue to apply pressures on land use and water demand.

Figure 1 - Summary of Potable Water Demand Projections



3.2 Groundwater Appropriation and Production Capacity

The County's total well capacity is about 77 MGD and treatment capacity is approximately 56 MGD. This is limited by a total appropriation of 57.7 MGD on an annual average basis and 69.9 MGD monthly maximum withdrawal rate. Although groundwater withdrawals are not currently imposing any adverse impacts on the aquifer, declining aquifer levels have been documented and there is concern over the long-term sustainability of the aquifers. As the Maryland Geological Survey (MGS) have identified through their work in 2006 with the U.S. Geologic Survey (USGS), the water budget for the aquifers is not in equilibrium with withdrawals exceeding recharge[4].

In February 2020, the Maryland Geological Survey (MGS) completed a study[5] to estimate maximum possible withdrawal rates from the major Anne Arundel County well fields. MGS estimated the aquifer yield for the County's wells at 114 MGD. At this rate, MGS believes there is potential to cause land subsidence, saltwater intrusion, and well interference. While the projected aquifer yield for the County's well fields is higher than projected demand, further growth in neighboring jurisdictions and additional growth within Anne Arundel County that is not currently anticipated by the County's Master Plan, could redefine groundwater as a sustainable water supply in the coming decades. As a result, long-term reliance on withdrawal with continued discharge to surface water is unlikely to be sustainable.

At the build-out scenario of 66.4 MGD average day demand, the MGS modeling predicts that six domestic wells will be negatively impacted. This suggests that the County's groundwater appropriation may not be allowed to increase beyond 60 to 65 MGD without significant changes in water management. To address this limitation, an additional management strategy must be considered that assures the County a higher groundwater appropriation is available in the long term. Per MDE Water Supply Capacity Management planning guidance, the County will be required to begin evaluating capacity once water use reaches 80% of the appropriated capacity. This is currently estimated to occur around 2045.

3.3 Baltimore City Purchased Water

The County's current agreement with Baltimore City is limited to transmission capacity, not supply capacity, and provides up to 32.5 MGD maximum daily flow transmission. The First Zone Agreement provides for up to 17.5 mgd maximum day transmission from the Montebello WTP, and the Second Zone Agreement provides up to 15 mgd, maximum day transmission from the Ashburton WTP. City water is purchased at non-contract wholesale rates, as there is not currently a capacity commitment. The County last purchased City water in 2018 at a non-contract rate of nearly $4 per thousand gallons. The County is currently not purchasing any water from Baltimore City.

The County's water distribution infrastructure has two major connections to Baltimore City's system. The Nursery Road Booster Pumping Station (BPS) can deliver up to 15 MGD from the City's Second Zone and the Ft. Smallwood BPS can deliver up to 17.5 MGD from the City's First Zone. In the past, infrastructure failures in the City's transmission infrastructure have interrupted the ability to transmit water from both zones to Anne Arundel County's customers. This includes service disruptions in both major connections, which rely on aging PCCP transmission pipes that are considered to be at a high risk of failure. The 54" Southwest Transmission Main, which delivers water to the Nursery Road BPS, underwent a major repair in 2017. The 72" Under Harbor Transmission Main that serves the Ft. Smallwood BPS was removed from service several years ago following a catastrophic failure in the pipe, and failures in a related PCCP main located in the Dundalk neighborhood. Given these issues, the County has accelerated its continued investments to become mostly independently served, outside of emergencies.

In addition to the risks in the City's water transmission infrastructure, the County has concerns about the City's water production and supply capabilities. The Montebello WTP would need to be taken offline in order to complete major upgrades that are needed, and this undertaking would rely on construction of a new Fullerton WTP to provide capacity while Montebello WTP is offline. Also, during drought or emergency

[4] U.S. Geological Survey. "Sustainability of the Ground-Water Resources in the Atlantic Coastal Plan of Maryland." 2006.

[5] Maryland Geological Survey. "Administrative Report for Anne Arundel County: Simulated Maximum Withdrawals from the Upper Patapsco, Lower Patapsco, and Patuxent Aquifer Systems in Anne Arundel County, Maryland." 2020.

conditions, there is uncertainty about the amount of water that the City would be able to provide Anne Arundel County. During the last significant drought of record in 2002, the County's aquifer system was minimally impacted, whereas the City surface water supply resources were stressed. Howard County's service agreement with the City includes a provision for a proportionate effort to conserve water during water supply emergencies. Anne Arundel County should expect to be subject to similar reductions in use during drought events if it enters into an agreement with the City. By remaining on groundwater, Anne Arundel County takes stress off of the regional surface water supply.

There are also water quality limitations related to the City water supply. Anne Arundel County has installed re-chlorination capabilities at both connections to assist in managing the chlorine residual in the distribution system. Because the City utilizes surface water, this introduces concerns about the potential formation of disinfection byproducts since the County's connections are on the periphery of the City's system. To date, the County has not experienced any violations related to disinfection byproducts as a result of using City water. However, this could become a significant issue if the County were to begin purchasing larger quantities of water from the City. In addition, there is an expectation that in the future, Baltimore City may draw increasing amounts of source water from the Susquehanna River. This further increases uncertainty about water quality management for City water supplied to Anne Arundel County.

The County desires to plan for the capability to utilize near zero water from the City, but to preserve the ability for inter-jurisdictional transfers as needed. Baltimore City and Baltimore County are undergoing a comprehensive business process review of their water and wastewater services. One potential outcome is the formation of a new regional water authority. This would impact Anne Arundel County, depending on the jurisdictional makeup and service area of the new entity.

3.4 Existing and Planned Wastewater Treatment Plant Nutrient Removal Performance

The County's wastewater treatment capacity for all seven major WRFs owned or jointly owned is currently about 53 MGD. This accounts for recently completed expansion projects at both the Maryland City and Patuxent WRFs. Current average total daily flow at the WRFs is approximately 39 MGD. Recently completed ENR upgrades are enabling WRFs to achieve approximately 1.6-2.0 mg/L TN discharge, which is overperforming relative to the permitted discharge rate of 3 mg/L. This level of performance is partially attributable to the fact that the actual flows are 70-80% of treatment capacity. Performance is expected to deteriorate as flows increase.

The waste load allocation under the Chesapeake Bay TMDL is 584,000 lbs/yr. This allocation is equivalent to a capacity of 64 MGD at 3 mg/L. The 2017 Master Plan for the Water Supply and Sewerage Systems projects a buildout flow at County-managed facilities of approximately 74 MGD. In order to provide those future capacities, additional nutrient reduction will be needed.

4 Water Supply Resiliency Alternatives Evaluation

4.1 Purchased Water from Baltimore City

4.1.1 DESCRIPTION OF ALTERNATIVE

Anne Arundel County would enter into a service agreement with Baltimore City, and the County would be charged per the contract capacity regardless of actual usage, similar to the recent agreement made between Howard County and the City. The capacity bases for evaluation are 7.5 MGD and 15 MGD. It is assumed that all of the flow would be provided through the existing connection at the Ft. Smallwood Booster Pumping Station from the City's First Zone via the Under-Harbor Transmission Main, upgraded as needed.

This is believed to be a more feasible alternative than a Nursery Road / Southwest Water Transmission Main infrastructure renewal project which potentially requires repairs to a significantly longer length of pipe. Also, renewal of the Under-Harbor main would not rely on participation from the City's other wholesale partners.

A reliable source of water from the City to Anne Arundel County would necessitate the following infrastructure upgrades:

1. Build the Fullerton WTP
   The concept plan for a new water treatment plant involves approximately 120 MGD of treatment capacity and related water transmission infrastructure. The City's previous planning efforts estimated a capital cost of over $500M, and discussions among stakeholders have broached the idea that a much larger investment may be required to meet the needs of the region. While stakeholder buy-in remains a challenge, it is assumed that political will exists for a $500M capital investment and that a project of this scale would sufficiently improve the City's water production resiliency.

2. Replace the Under Harbor (Key Bridge) Transmission Main
   The current Baltimore City CIP does not include a specific renewal project to re-activate this transmission main. The existing 72" PCCP transmission main would be replaced with a new transmission main sized to supply 15 MGD to the County. The total length of pipe replacement would be approximately 2.6 miles and would begin at the western end of the 72"-diameter pipe located near Fort Armistead Road in Hawkins Point. The eastern extent of the project would be the connection with the 36" main to Sparrows Point, located near the intersection of Broening Highway and the Beltway. The main would likely be sized to accommodate demand for City customers at Hawkins Point. An economical and reliable approach to construction could involve sliplining the existing transmission main with a new pipe of approximately 42" diameter. For the evaluation of a 7.5 MGD supply, it is assumed the main would still be sized for a County supply of 15 MGD in order to allow for future increases.

3. Water Treatment at Ft Smallwood BPS
   New water treatment infrastructure would provide protection from disinfection byproducts that could form in the County's distribution system as a result of the need to re-chlorinate City water. A Granular Activated Carbon filter system would be sized to treat either 7.5 MGD or 15 MGD.

4. Other Upgrades
   As part of negotiating a service agreement, the County and City may identify additional system upgrades that are needed to provide the County with a reliable water supply. While these projects would likely be included within the City's CIP over time, the service agreement may require an earlier prioritization of projects that benefit the County. These investments could represent an increase over the baseline CIP projections during the next ten years.

For the purpose of comparing this alternative to MAR, it is assumed that the infrastructure upgrades will be completed by 2031.

4.1.2 BENEFITS

A new service agreement for City water that includes provision of reliability upgrades would provide the County with the following benefits:

- Additional resource for augmenting the County's water supply which is currently dependent on groundwater alone.
- Cost savings on a per volume basis compared to non-contract wholesale rates, which are three to five times higher than projected contract rates (see Attachment 1).

4.1.3 COSTS & RISKS

There are quantifiable costs attributed to the County's purchase of Baltimore City water, as well as other costs and risks that are subjective in nature and must be considered.

An average day commitment of 15 MGD from Anne Arundel County would only represent 6% of the City's 240 MGD capacity. It should be acknowledged that due to its size, its reliance on surface water, and the inherent complexity of managing an urban system, it may be difficult for the City to prioritize improvements related to providing service to Anne Arundel County. From reservoir protection to water main rehabilitation to future regulations on compounds such as PFAS, all water suppliers can be influenced by developing issues. As a small component of the City's distribution network, it may be very difficult for the City to commit the necessary resources at the timing or level that would meet the County's needs. While this is understandable, it creates a considerable degree of uncertainty with respect to reliance on the City as the basis for long term planning.

The estimated NPV of capital investment and O&M costs are summarized below. The County's cost for City water system upgrades can be evaluated through a projection of contract wholesale rates using the City's current rate model, which accounts for capital investment, depreciation, and O&M costs (Attachment 1). The 30-year Contract Cost referenced in Table 4 is based on the County's allocation of capital investment in the core system, based on a 15 MGD average day commitment. The projects described in section 4.1.1 are in addition to the baseline capital investment within the current CIP, and the County's share of the total investment needs are reflected in the 30-year Contract Cost.

Table 4 - Estimated Net Present Value of Purchased Water from Baltimore City

	Est. Cost ($ millions)		Notes
	7.5 MGD	15 MGD	
Baltimore City CIP Projects			
Fullerton WTP	*$500.0*	*$500.0*	Assumed capital cost of approved project for sufficient reliability improvement.
Under Harbor Transmission	*$23.6*	*$23.6*	2.6-mi 72"-dia pipe sliplined w/ 42" @ $820/LF.
Other Projects	*$261.8*	*$261.8*	50% of above projects
Subtotal CIP Investment	$785.5	$785.5	2020 costs
30-yr Contract Cost	$260.0	$528.3	Projection from City's rate model with $185M annual CIP baseline plus add'l projects above. See Attachment 1 for detail.
NPV City Service Contract Costs	**$168.7**	**$344.6**	
AACo CIP Projects			
GAC Treatment at Ft. Smallwood	*$11.3*	*$22.5*	Based on estimated ROM capital cost of $1.5/gal.
Annual O&M Costs	*$1.7*	*$2.3*	From GAC O&M cost in 2019 OSDS TO-5 cost estimates for MAR.
NPV 30-yr O&M Costs	*$36.2*	*$50.4*	
NPV County Costs	**$47.4**	**$72.9**	
Subtotal NPV	**$216.1**	**$417.5**	

50% Contingency	$23.7	$36.4	Only applied to County costs. Baltimore CIP projects must include contingency prior to use in the rate model.
Total NPV	**$239.8**	**$453.9**	

Non-monetary costs and risks include:

- Requires large infrastructure investment by City. Difficulty securing support from other City water system stakeholders for sharing in the costs of the prioritized infrastructure reliability upgrades.
- Difficulty in negotiating a service agreement with Baltimore City. Negotiating inter-jurisdictional agreements can bring to light significant disagreements over fundamental terms and conditions such as management structure, accountability, cost sharing, etc. Uncertainty about the timing and terms of a future regional water authority.
- High cost uncertainty. Uncertain status of necessary City water supply improvements, including Fullerton and Montebello WTPs. Unknown ancillary infrastructure improvement needs leading to very soft cost estimating.
- Lack of County control over City CIP and operations. Historical precedence in the timely and efficient implementation/delivery of projects by the City. Fullerton has been in the planning process since the 1950s. Potential for rate increases that exceed projections due to factors beyond the County's control. Potential for service disruptions that are outside of the County's control.
- Places stress on Baltimore's surface water supply sources; not as resilient effects of extreme weather and drought due to climate change.

4.2 Brackish Water Treated with Reverse Osmosis

4.2.1 DESCRIPTION OF ALTERNATIVE

In order to develop new production capacity with a surface water supply, the County would rely on water treatment technology that can treat brackish water. The tidal influence of the Chesapeake Bay influences the larger reaches of the County's rivers where a water supply intake could feasibly be constructed. Brackish water can be treated through reverse osmosis (RO) to produce treated water that meets drinking water standards. By using a high-pressure system to pass the highly concentrated water through a semi-permeable layer, the membrane collects sediment, bacteria, and chloride particles on one side resulting in treated water on the other side. This is similar to desalination of sea water by the removal of salt ions from sea water to get fresh water.

The County would develop a new conventional WTP with RO technology and a surface water intake. Approximately 15 acres of land would be needed for a 15 MGD plant, and it is assumed that about half of the space would be required for a 7.5 MGD facility. The plant needs to be located in proximity to existing large water transmission mains in order to effectively distribute water. Adequate space must be provided to handle nutrient disposal and to process brine concentrate using mechanical evaporation. The intake structure must be located with significant depth to account for tidal changes, and away from industrial wastewater discharges and heavy boat traffic.

4.2.2 BENEFITS

There are multiple benefits associated with developing an RO WTP for water supply resiliency, including:

- Additional resource for augmenting the County's water supply which is currently dependent on groundwater alone.
- High quality finished water, and the sustainability of the water source.

4.2.3 COSTS & RISKS

RO treatment has high capital and O&M costs. The largest components of the capital costs for RO systems are the microfiltration unit and the RO equipment. Capital costs for full advanced treatment with RO can range significantly based on the concentration disposal option. The EPA 2017 Potable Reuse Compendium[6] summarizes the cost of RO facilities based on a 2014 WateReuse Foundation (now WRF) survey of advanced treatment trains. The capital cost of a 20 MGD facility with RO concentrate disposal using mechanical evaporation was estimated to be $172M (EPA, Table 11-1). HDR reviewed actual costs for additional RO projects completed as recently as 2017, as well as more recent detailed planning level cost estimates for future projects. The EPA Compendium cost estimates are well-supported by the additional cost references.

Land acquisition costs are estimated at $3 million for a 15-acre site, based on a sample of assessed values of undeveloped waterfront land in the northern part of the County.

Variable O&M costs include costs for chemicals, power, UV lamp replacement, cartridge filter replacement, concentrate disposal, and other miscellaneous costs. Fixed O&M costs include labor, membrane replacement, and equipment repair and replacement. Annual O&M costs are estimated at $6.3 million for a 20 MGD facility (EPA 2017).

Table 5 - Estimated Net Present Value of Brackish Water Treated with RO

	Est. Cost (millions)		Notes
	7.5 MGD	15 MGD	
Capital Costs			
Conventional WTP with RO	*$101.6*	*$153.9*	Costs derived from EPA 2017 Potable Reuse Compendium Table 11-1.
Land Acquisition	*$1.5*	*$3.0*	From SDAT assessed property values, estimated for 7.5 and 15 acres.
Subtotal CIP Investment	$103.1	$156.9	
O&M Costs			
Annual O&M Costs	*$6.4*	*$9.8*	Costs derived from EPA 2017 Potable Reuse Compendium Table 11-1.
30-yr O&M Costs	$139.3	$211.1	
Subtotal NPV	**$242.3**	**$368.0**	
50% Contingency	$121.2	$184.0	
Total NPV	**$363.5**	**$552.1**	

There are a number of risks reflected in the contingency assumption:

- Finding a suitable site would be very challenging, as there is very little waterfront property available adjacent to a sizable river segment that will accommodate the water intake needs. Environmental permitting requirements, including NEPA, will introduce additional factors to be considered in site location, such as public input and fish and wildlife and forestry impacts on County residents.
- Complexity of operations.
- Residuals management and disposal adds uncertainty both in capital and O&M costs.
- High capital and O&M costs. The supply and transmission piping can vary greatly in length depending on the location of facility construction in proximity to the waterfront and the existing water distribution infrastructure. Large power utility infrastructure would be necessary to meet the

[6] EPA Office of Water. *2017 Potable Reuse Compendium.*

needs of the WTP, and this may not be currently available at sites where the other constraints can be met.

4.3 Indirect Potable Reuse – Managed Aquifer Recharge

4.3.1 DESCRIPTION OF ALTERNATIVE

Indirect Potable Reuse (IPR) includes discharging reclaimed water into an environmental buffer such as surface water or groundwater body which serves as a drinking water source. Managed Aquifer Recharge (MAR) is a type of IPR which refers to deliberate augmentation of natural groundwater supply using engineered conveyances (recharge). For this water supply alternative, MAR will be implemented at two WRFs in the County, Patuxent and Broadneck. Secondary effluent from these WRFs will be treated with Advanced Water Treatment (AWT) techniques such as ozone-biofiltration and granular activated carbon adsorption before being injected into the Patapsco aquifer. The first MAR facility will be built at Patuxent with a total treatment capacity of 7.5 MGD. Another 7.5 MGD treatment capacity will be provided by MAR implemented at Broadneck.

When MAR is evaluated as a water supply alternative, the costs to treat extracted groundwater must be included in order to have an equal comparison to alternatives that provide finished water. The County's existing well capacity exceeds maximum day demand by more than 15 MGD, and treatment capacity is only a small amount more than demand. To approximate the value of additional capacity related to MAR, additional treatment capacity must be increased to match the MAR rate of injection.

4.3.2 BENEFITS

MAR will provide the following benefits:

- Less stress on regional surface supplies (consistent with 2008 Wolman Report).
- MAR is consistent with the State's 2008 Wolman Report recommending regional strategies and expanded water re-use, including reclaimed water from wastewater treatment plants.
- Regional benefit to other jurisdictions that share aquifer.
- Synergistic TMDL benefits at low cost per pound of Total Nitrogen removal
- Sustainable solution to depleting groundwater levels by replenishing the aquifer with large storage capacity and mitigate the current imbalance of withdrawals exceeding recharge.
- High quality finished water. The quality of water used for engineered recharge is higher than that of existing creeks within developed areas that naturally recharge the aquifer.

4.3.3 COSTS & RISKS

The cost of MAR is largely dependent on the treatment technologies required, size and type of injection wells, and waste treatment needed (e.g. residuals and brine). With a treatment train consisting of ozone-biologically activated carbon filtration (BAF), the capital budget for HRSD's 15 MGD facility is $271M. This budget is based on the design-build bid cost and includes an owner's reserve contingency of about 5%. The annual O&M cost must account for the potential of increased frequency of GAC media replacement.

As a stand-alone water supply alternative, MAR is expensive because water is treated both before injection into the aquifer, and then a second time after it is extracted for distribution. Capital costs for water treatment plant capacity are assumed based on recent estimates developed for the Crofton Meadows Phase 2 Expansion. The treatment plant expansion construction was estimated at $13.3M before capital cost factors and contingency. Annual O&M costs are assumed as a percentage of the capital cost estimate. Land acquisition costs are not included, as water production capacity expansion is already planned at existing WTP sites.

Table 6 - Estimated Net Present Value of MAR for Water Supply

	Est. Cost (millions)		Notes
	7.5 MGD	15 MGD	
Capital Costs			
MAR Facility	*$119.0*	*$238.1*	Derived from HRSD SWIFT budget for a single 15 MGD facility and scaled to 7.5 MGD. The cost for a 15 MGD facility represents two 7.5 MGD facilities.
Groundwater Treatment	*$23.7*	*$47.4*	Derived from cost estimate prepared for Crofton Meadows Phase 2 Expansion.
Subtotal	$142.7	$285.4	
O&M Costs			
Annual - MAR	*$3.5*	*$7.0*	From 2019 OSDS TO-5 cost estimates
Annual – Groundwater Treatment	*$0.7*	*$1.4*	Based on actual FY20 operations expenditures.
Subtotal Annual O&M Costs	*$4.2*	*$8.4*	
NPV 30-yr O&M Costs	$90.6	$181.2	
Subtotal NPV	**$233.3**	**$466.7**	
50% Contingency	$116.7	$233.3	
Total NPV	**$350.0**	**$700.0**	

Additional risks which are not easily quantifiable include:

- Regulatory hurdles and the potential for public opposition. MAR is a new approach, and the process needs to be thoroughly vetted by regulators and communicated to the public.

4.4 Indirect Potable Reuse – Shallow Infiltration

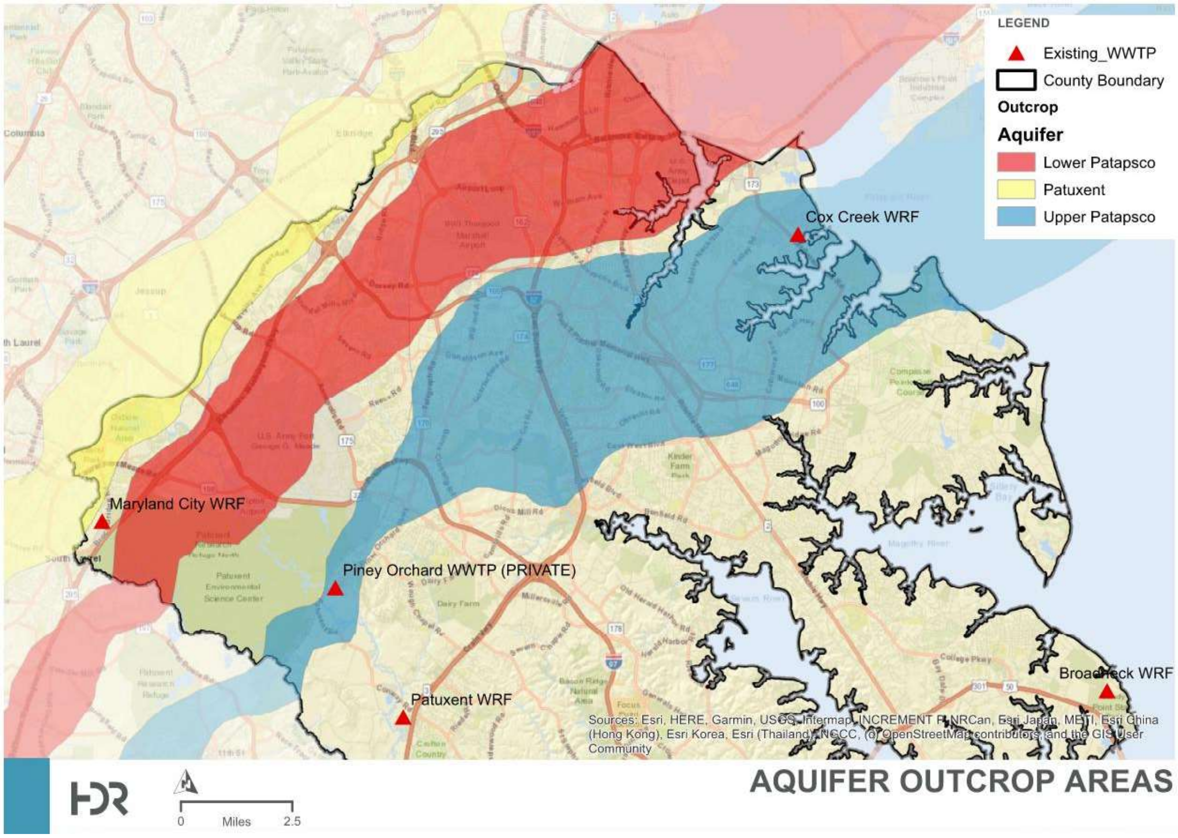
4.4.1 DESCRIPTION OF ALTERNATIVE

This alternative for IPR is similar to MAR, but instead of an injection well, treated effluent is directed to the aquifer by engineered recharge. The natural aquifer recharge rate for surface infiltration is on the order of 1.5 in/yr[7]. At this rate, the extremely large surface area requirement makes natural recharge infeasible. With engineered recharge, low permeability surface strata are breached by constructing dry wells or infiltration trenches within the aquifer outcrops. This greatly increases the recharge capacity and a rate of 2 in/day is believed to be attainable in Anne Arundel County's aquifers.

The County would need to locate the facility where large infiltration basins could be constructed in proximity to aquifer outcrops (see Figure 2). While multiple non-contiguous sites could be constructed, this would drive up transmission costs to distribute treated water for infiltration. The infiltration basin should be at least one-half mile from creeks and rivers to prevent short-circuiting or recharge to surface water. The aquifer outcrop for the Patuxent aquifer is located in a heavily developed corridor, and the few undeveloped sites are in flood plains. The Lower and Upper Patapsco aquifer outcrop areas also have very few opportunities to accommodate an infiltration basin. The Patuxent Research Refuge offers the only potential site. This site is under Federal control, and the County would need to negotiate a land lease or acquisition.

[7] Maryland Geological Survey. "Administrative Report for Anne Arundel County: Simulated Maximum Withdrawals from the Upper Patapsco, Lower Patapsco, and Patuxent Aquifer Systems in Anne Arundel County, Maryland." 2020.

Figure 2 - Aquifer Outcrops in Anne Arundel County



Infiltration columns spaced in a grid 40 feet apart would be 12" to 18" in diameter and excavated to a depth of about 40 feet. Adequate space must be provided to allow for off-line maintenance of the dry wells, which involves drying the basins and removing algae several times a year and replacing the filter layer about once each year. Also, the infiltration area must be sized to discount rainfall that would infiltrate the basin area regardless of the recharge facility. The overall land area will be larger to account for variations in topography, maintenance equipment circulation, and natural obstructions. Facility sizing needs are summarized in the table below for both a 7.5 MGD facility and a 15 MGD facility.

Table 7 - Shallow Infiltration Facility Sizing

	7.5 MGD	15 MGD	
Recharge Infiltration Area	138.1 AC	276.2 AC	For 2 in/day recharge rate
Adjusted Recharge Infiltration Area	147.7 AC	295.4 AC	For 1.87 in/day effective recharge rate
Add'l 50% Maintenance Capacity	73.9 AC	147.7 AC	
Total Infiltration Basin Area	221.6 AC	443.1 AC	
Land Area	368 AC	737 AC	Assumes 60% layout efficiency
# Infiltration Columns	6,019	12,037	Each column supports 1,600 sf recharge

The Patuxent WRF could be used to provide treated effluent, similar to the MAR alternative. There needs to be sufficient space to build AWT facilities and the treated effluent flow rates must provide at least 7.5 MGD. While the Broadneck WRF could meet the space and effluent needs, it is located too far from Fort Meade to be considered a practical option. A transmission main must be constructed to convey the water from the WRF to the infiltration site. A 30 inch-diameter pipe is needed to convey 7.5 MGD. The pipe alignment would generally need to follow existing roadway rights-of-way to minimize conflict with environmental resources and reduce the need for easement acquisition. For conveying from the Patuxent WRF to a recharge site at Patuxent Research Refuge, approximately 10 miles of transmission main would be needed. While the County's Maryland City WRF is located closer to the Patuxent Research Refuge, the current 1.4 MGD flow rate is not enough to warrant inclusion in this alternatives comparison. For these reasons, a 15 MGD capacity is not feasible for Shallow Infiltration, leaving only the option for a 7.5 MGD capacity alternative.

When Shallow Infiltration is evaluated as a water supply alternative, the costs to treat groundwater must be included. The County's existing well capacity exceeds maximum day demand by more than 15 MGD, while treatment capacity approximates demand. To utilize the additional capacity related to Shallow Infiltration additional treatment capacity will be developed to provide an average daily flow to match the design rate of recharge. The County's Master Plan already provides for expansion of capacity at existing WTP sites, therefore land acquisition is not necessary.

4.4.2 BENEFITS

Shallow Infiltration will provide many of the same benefits as with MAR:

- Less stress on regional surface supplies (consistent with 2008 Wolman Report).
- Consistent with the State's 2008 Wolman Report recommending regional strategies and expanded water re-use, including reclaimed water from wastewater treatment plants.
- Regional benefit to other jurisdictions that share aquifer.
- Sustainable solution to depleting groundwater levels by replenishing the aquifer with large storage capacity and mitigate the current imbalance of withdrawals exceeding recharge.
- High quality finished water. The quality of water used for engineered recharge is higher than that of existing creeks within developed areas that naturally recharge the aquifer.

4.4.3 COSTS & RISKS

The cost of AWT is largely dependent on the treatment technologies required and waste treatment needed (e.g. residuals and brine). With a treatment train consisting of ozone-biologically activated carbon filtration (BAF), the capital cost for treating 7.5 MGD at Patuxent WRF is comparable to MAR, not including the injection well. The annual O&M cost for a 7.5 MGD AWT facility is estimated to be $3.3M.

The County would need to negotiate a land lease or acquisition with the Federal or State Government. The land acquisition costs are estimated at $100,000 per acre in the northern part of the County, based on current assessed property values.

The estimated construction cost for each infiltration column is $915, and an additional 10% is assumed for related site work to clear land and to form the basins. Capital costs for water treatment plant capacity are assumed based on recent estimates developed for the Crofton Meadows Phase 2 Expansion. Annual O&M costs are assumed as a percentage of the capital cost estimate. Land acquisition costs for water treatment are not included, as it is assumed that water production capacity could be developed at sites currently owned by the County that are located in close proximity to sizable water distribution infrastructure.

Table 8 - Estimated Net Present Value of Shallow Infiltration

	Est. Cost (millions)		Notes
	7.5 MGD	15 MGD	
Capital Costs		*Not feasible*	
AWT Facility	*$94.0*		From previous OSDS TO-5 cost estimates for AWT component of MAR facility.
Transmission Pipe	*$51.8*		30"-dia pipe @ $981/LF; 10 mi for Patuxent
Shallow Infiltration Facility	*$11.5*		~6,000 infiltration columns per 7.5 MGD of recharge @ $915 per column; Add'l 50% for site work / civil.
Land Acquisition	*$36.7*		From SDAT assessed property values, estimated for 210 and 420 acres.
Groundwater Treatment	*$23.7*		Derived from cost estimate prepared for Crofton Meadows Phase 2 Expansion.
Subtotal	$217.8		
O&M Costs			
Annual - AWT Facility	*$3.3*		Based on cost estimate for AWT component of MAR facility without injection wells.
Annual – Transmission Pipe	*$0.5*		Assumed 1% of Capital Cost.
Annual – Shallow Infiltration	*$0.1*		Assumed 1% of Capital Cost.
Annual – Groundwater Treatment	*$0.7*		Based on actual FY20 operations expenditures.
Subtotal Annual O&M Costs	$4.7		
NPV 30-yr O&M Costs	$100.7		
Subtotal NPV	**$318.5**		
50% Contingency	$159.2		
Total NPV	**$477.7**		

Additional risks which are not easily quantifiable include:

- Significant land requirement. Negotiating a land lease or acquisition with the Federal or State Government, which would be difficult and likely not feasible. There are a few cleared sites within Patuxent Wildlife Refuge, but much of the reservation is forested or wetlands. There would be major environmental permitting hurdles to be addressed in order to construct an engineered shallow infiltration facility. In general, encumbering such large tracts of land would inhibit future development of these facilities in perpetuity.

4.5 Direct Potable Reuse

Direct potable reuse (DPR) refers to treatment of reclaimed water at an AWT facility for direct distribution. Water from the AWT can be blended with surface or groundwater before being introduced in the drinking water treatment plant. DPR was not recommended as a viable option for a couple of reasons summarized below.

Unlike IPR, DPR does not involve an environmental buffer, and thus has only been considered in the United States in areas of sever water supply stress. There is currently only one instance of full-scale implementation in the United States in Big Spring, Texas. Other municipalities have studied the use of DPR but have not implemented at full scale. The perceived human health risks associated with DPR are greater without the environmental buffer. An environmental buffer provides dilution of the treated water and allows for response time for treatment of any contaminants that make it through the AWT system. While the same level of monitoring will likely be required for MAR or DPR, the environmental buffer will provide time to react should the monitoring identify areas of concern. As an example, strategically spaced monitoring wells will be included in a MAR scenario, which would allow for the ability to pump out the injected water should contaminants be identified at the monitoring locations.In light of these issues, public opposition is anticipated to be much higher for DPR than with other alternatives.

DPR often involves a high-pressure membrane filtration such as ultrafiltration along with reverse osmosis to achieve a higher level of water quality. The costs associated with constructing and operating these membranes are typically very high. Further, the concentrate from these membranes can be challenging to dispose since discharge to the Chesapeake Bay is not feasible in Maryland. Mechanical and evaporative treatment and disposal of this concentrate will lead to an increased cost of operation.

Unlike MAR, DPR does not replenish the aquifer and does not provide a sustainable solution to the water stress in this area. Public acceptance and understanding of DPR might need more outreach effort and there might be more opposition to DPR as compared to IPR. There are no statewide guidelines or regulations governing DPR and DPR facilities are currently considered on a case-by-case basis in the United States.

DPR is not a viable alternative for addressing the needs of nutrient removal and providing a sustainable solution for water supply in the County. All these factors played a role in ruling out DPR, as was presented at the February 2020 MDE meeting.

5 Nutrient Management: Additional ENR Treatment Alternatives Evaluation

5.1 Additional Filtration for Dissolved Organic Nitrogen Removal

5.1.1 DESCRIPTION OF ALTERNATIVE

In general, the effluents from the County WRFs currently contain little ammonia, nitrite or nitrate. Additionally, the effluents are filtered and contain little suspended solids or phosphorous. As such, the effluents mostly contain residual dissolved organic nitrogen compounds (measured as TKN). Thus, additional nitrogen removal must be accomplished by enhanced removal of Dissolved Organic Nitrogen (DON).

This alternative involves the implementation of GAC adsorption for DON removal. GAC filters would be implemented at all six WRFs and sized to treat a total capacity of 30.8 MGD. This treatment level correlates to the overall reduction of 47,000 lbs/yr of Nitrogen reduction, assuming that each facility will remove 0.5 mg/L of DON. Since there is currently a total average daily flow of 39 MGD at these plants, additional flow could be treated if the initial design is not achieving the target DON removal rate.

5.1.2 BENEFITS

This is the only alternative that targets removal of DON, which is typically recalcitrant and, if feasible, can help in reducing the total nitrogen concentration by up to 0.5 mg/L at each WRF.

5.1.3 COSTS & RISKS

The construction cost estimate is based on the 2012 estimate by GHD for GAC filtration to support a future capacity expansion to 3.7 MGD at the Maryland City WRF[8].

This alternative has extremely high O&M costs directly related to GAC media replacement. The frequency of replacement can be determined by isotherm testing. For this evaluation, a one-year media replacement frequency is assumed. Additionally, GAC backwash waste needs to be treated and will add to the WRF loading rate. Depending on the WRF capacity, 3,000-15,000 ft2 additional land will be needed for constructing GAC filters at each WRF. This can be a challenge for some WRFs where land is not available and needs to be purchased.

Table 9 - Estimated Net Present Value of Additional Filtration for DON Removal

	Est. Cost (millions)	Notes
Capital Costs		
Gravity Fed GAC Beds System	*$200.6*	Based on estimate from GHD TM-M-13 for Maryland City WRF; Scaled up to 30.8 MGD and doubled to achieve 0.5 mg/L removal;
Influent Pumping Station	*$32.6*	Based on estimate from GHD TM-M-12 for Maryland City WRF; Scaled to 30.8 MGD;
Subtotal	$233.2	
O&M Costs		
Annual – GAC System	*$5.7*	One GAC media change per year at $45.50/cf for 124,666 cf;
Annual – Influent Pumping Station	*$0.7*	Assumed 2% of Capital Cost (rule of thumb for pump O&M costs).
Subtotal Annual O&M Costs	$6.3	
NPV 30-yr O&M Costs	$136.9	
Subtotal NPV	**$370.1**	
50% Contingency	$185.0	
Total NPV	**$555.1**	

Additional risks which are not easily quantifiable include:

- Feasibility uncertain for further lowering TN at WRFs that already have very low levels. The Maryland City basis of design was not specifically targeting DON removal, but for removal of any additional nitrogen that is not already removed in the biological process or effluent filters. Due to the uncertainty of how much DON removal is obtainable when TN concentrations are already at 2mg/L or below, a 50% contingency has been applied to capital costs.
- Relative lack of industry experience in removing DON. Performance will be highly site specific, and there is a significant amount of uncertainty that is reflected in both the capital cost and O&M cost contingency.

[8] GHD. "Technical Memorandum TM-M-13: Granular Activated Carbon System. 2012.

5.2 Additional Oxidation Tank and Filter Capacity

5.2.1 DESCRIPTION OF ALTERNATIVE

In order to retain high levels of nutrient removal as the flows to the WRFs increase in the future, additional treatment capacity in the form of oxidation ditches, secondary clarifiers and denitrification filters can be added to existing WRFs to maintain current loading rates. This alternative will be implemented at the Patuxent and Broadneck WRFs to provide a total of 18.5 MGD treatment capacity. The goal is to achieve 47,000 lbs/yr of TN reduction which corresponds to 0.85 mg/L of TN reduction or an effluent TN of 2.15 mg/L instead of 3 mg/L. Although the WRFs are able to meet these regulations currently, Table 10 shows that only 62% of design capacity is currently utilized at these WRFs. In order to allow for a factor of safety at future increased loads, additional treatment capacity will need to be provided.

Table 10 WRFs Design Flow and Capacity

WRF	Est. Average Daily Flow (MGD)	Capacity (MGD)	% of Capacity
Patuxent	5.4	10.5	51
Broadneck	6.1	8.0	76
Total	**11.5**	**18.5**	**62**

The Patuxent WRF currently has two oxidation ditches and three clarifiers in operation. The estimated sizing of additional facilities to retain current performance would include:

- 33-50% additional oxidation ditch to retain 24-30 hr detention time
- 50% more clarifiers to maintain overflow rate
- 50% more filters to keep denitrification loading rate down

Additional treatment capacity for Broadneck is estimated to be similar. Table 11 shows the estimated additional treatment capacity at each WRF. Land for this additional treatment is available at both the facilities.

Table 11 Additional Treatment Facilities at Patuxent and Broadneck WRF

WRF	Oxidation Ditches	Secondary Clarifiers	Denitrification Filters	Land
Patuxent	1	2	2	Available
Broadneck	1	2	1	Available

5.2.2 BENEFITS

This alternative has the following benefits:

- Achieves a reduction in total nitrogen effluent concentrations by upgrading existing WRFs. Oxidation ditches, secondary clarifiers and denitrification filters are already present at the WRFs selected. Thus, upgrading these WRFs by adding more of this equipment will require minimum infrastructure and operator training.
- Space for additional facilities is available. The Patuxent and Broadneck WRFs have land available for additional treatment capacity and thus cost of purchasing new land is eliminated.

5.2.3 COSTS & RISKS

The estimated construction cost was derived from the estimate for the 2012 Patuxent WRF Expansion[9] and escalating it to 2020 dollars using ENR's Construction Cost Index. Although this was deemed the best approach for this study given the limited data available, it does not account for significant local variations we have seen in the water and wastewater market, with some estimating local price increases for the past few years at approximately 9% per year. Annual O&M costs are assumed as a percentage of the capital cost estimate.

Table 12 - Estimated Net Present Value for Additional Oxidation Tank and Filter Capacity

	Est. Cost (millions)	Notes
Capital Costs		
Patuxent WRF Add'l Treatment	*$39.6*	Based on 2012 Patuxent WRF Expansion cost estimate; (1) Oxidation Ditch and Blowers, (2) Secondary Clarifiers, (2) Denitrification Filters, Electrical @ 40%, Instrumentation @ 10%;
Broadneck WRF Add'l Treatment	*$35.6*	Based on 2012 Patuxent WRF Expansion cost estimate; (1) Oxidation Ditch and Blowers, (2) Secondary Clarifiers, (1) Denitrification Filter, Electrical @ 40%, Instrumentation @ 10%;
Subtotal	$75.2	
O&M Costs		
Patuxent WRF Add'l Treatment	*0.8*	Assumed 2% of Capital Cost (rule of thumb for equipment O&M costs).
Broadneck WRF Add'l Treatment	*0.7*	Assumed 2% of Capital Cost (rule of thumb for equipment O&M costs).
Subtotal Annual O&M Costs	$1.5	
NPV 30-yr O&M Costs	$32.5	
Subtotal NPV	**$107.7**	
50% Contingency	$53.9	
Total NPV	**$161.6**	

Additional risks which are not easily quantifiable include:

- Reduced land for future expansion
- Increased operational pressure to achieve lower discharge limits. In order to implement this option, Anne Arundel County would be committing to operating these facilities at the lowest permitted total nitrogen loads in the State. There would be little room for error or process upsets, which if they occur could result in permit violations.

5.3 Managed Aquifer Recharge

5.3.1 DESCRIPTION OF ALTERNATIVE

Alternatives for additional ENR treatment can be compared to MAR from a nutrient reduction standpoint. Groundwater production capacity is not a part of this alternative because this is not a water supply alternative.

[9] Anne Arundel County DPW. Opinion of Probable Construction Cost for Patuxent WRF Expansion. Contract No. S806501. 2012.

5.3.2 BENEFITS

MAR will reduce the nutrient discharges to the Chesapeake Bay by 47,000 lbs TN per year and help attain the long-term Bay improvement goals. MAR is scalable and adaptable to meet the future uncertainties associated with climate change; rising water temperatures; and the success of other nutrient reduction sectors. Additionally, future wastewater treatment capacity at the sites where MAR is implemented would not require additional waste load allocation. Thus, full nutrient credits could be obtained from OSDS conversions or credit allocations could be transferred elsewhere.

5.3.3 COSTS & RISKS

The cost of MAR is largely dependent on the treatment technologies required, size and type of injection wells, and waste treatment needed (e.g. residuals and brine). With a treatment train consisting of ozone-biologically activated carbon filtration (BAF), the capital budget for HRSD's 15 MGD facility is $271M. This budget is based on the design-build bid cost and includes an owner's reserve contingency of about 5%. The annual O&M cost must account for the potential of increased frequency of GAC media replacement.

Additional risks which are not easily quantifiable include regulatory hurdles and the potential for public opposition. MAR is a new approach, and the process needs to be thoroughly vetted by regulators and communicated to the public.

Table 13 - Estimated Net Present Value of MAR for Nutrient Reduction

	Est. Cost (millions)	Notes
Capital Costs		
MAR Facility	*$119.0*	Derived from HRSD SWIFT budget for a single 15 MGD facility and scaled to 7.5 MGD. The cost for a 15 MGD facility represents two 7.5 MGD facilities.
Subtotal	*$119.0*	
O&M Costs		
Annual O&M Costs - MAR	*$3.5*	From previous OSDS TO-5 cost estimates with 50% contingency applied.
NPV 30-yr O&M Costs	$75.2	
Subtotal NPV	**$194.2**	
50% Contingency	$97.1	
Total NPV	**$291.4**	

6 Alternatives Comparison

6.1 Water Supply Resiliency

The water supply resiliency alternatives are summarized below in Table 14. Purchased water from the Baltimore City under a contractual agreement has the lowest NPV. However, there are a number of non-economic factors and risks to be considered as discussed in section 4.1.3. This approach carries a number of unquantifiable risks that effectively diminish the value of this alternative. Managed Aquifer Recharge (MAR) has a slightly higher NPV as a water supply alternative, and is consistent with the 2008 Wolman Report for expanded regional solutions, diversification, and water re-use.

Table 14 - Comparison of Water Supply Resiliency Alternatives

Alternative	30-yr NPV (millions)		Pros / Cons
	7.5 MGD	15 MGD	
Purchased Water from Baltimore City	$240	$454	Pros: • Cost savings compared to non-contract rates • Diversifies County's existing water supply Cons: • Requires large infrastructure investment by City • Contractual terms and conditions not likely to be agreed upon • High cost uncertainty • Lack of County control over City CIP and operations • Surface water supplies vulnerable to drought and extreme weather events due to climate change • Added stress on surface supplies
Brackish Water RO WTP	$364	$552	Pros: • High quality finished water • Diversifies County's existing water supply Cons: • Inconsistent with 2008 Wolman Report • Difficulty in locating suitable site • Complexity of operations • High capital and O&M costs • Uncertain brine disposal options and costs
IPR – MAR	$350	$700	Pros: • Less stress on regional surface supplies (consistent with 2008 Wolman Report) • Expanded water re-use (consistent with 2008 Wolman Report) • Regional benefit to other jurisdictions that share aquifer • Synergistic TMDL benefits at low cost per pound of Total Nitrogen removal • Replenishes County water supply, reducing water budget imbalance • Replenishes aquifer to protect against potential subsidence and saltwater intrusion Cons: • High capital cost • Uncertain regulatory requirements
IPR – Shallow Infiltration	$478	N/A	Pros: • Less stress on regional surface supplies (consistent with 2008 Wolman Report) • Expanded water re-use (consistent with 2008 Wolman Report)

			• Replenishes County water supply, reducing water budget imbalance • Replenishes aquifer to protect against potential subsidence and saltwater intrusion Cons: • Significant land requirement – not feasible • High capital and O&M costs, in part due to extensive transmission capacity needs
Direct Potable Reuse	N/A	N/A	• Deemed infeasible and removed from further consideration

6.2 Nutrient Management: Additional ENR Treatment

The additional ENR treatment alternatives are summarized below in Table 15. An additional Total Nitrogen (TN) reduction of 47,000 lbs/year could be achieved with a 7.5 MGD MAR facility. The nitrogen removal alternative with the lowest NPV involves additional oxidation tanks and filter capacity at both the Patuxent WRF (10.5 MGD capacity) and Broadneck WRF (8.0 MGD capacity). However, it requires a tightening of discharge limits, which increases performance pressures and reduces room for operational issues.

Table 15 - Comparison of Additional ENR Treatment Alternatives

Alternative	30-yr NPV (millions) for 47,000 lbs/yr	Pros / Cons
Additional Filtration for DON Removal	$555	Pros: • Could reduce TN by 0.5 mg/L at each WRF Cons: • Feasibility uncertain for further lowering TN at WRFs already at very low levels • High O&M cost for GAC replacement • Space for additional facilities limited at some WRFs • Performance will be site specific •
Additional Oxidation Tanks & Filter Capacity	$162	Pros: • Expands facilities already in place for less impact on current operations • Space available at select WRFs Cons: • Added operational stress associated with tighter discharge limits • Reduced land for future expansion of WRFs
IPR – MAR	$291	Pros: • Scalable and adaptable to future TMDL impacts due to climate change and other sector uncertainties • Near zero nutrient discharge to Bay • Wasteload allocations not an inhibitor to planned growth demands

		Cons: • High O&M cost

6.3 Combination of Water Supply and Nitrogen Reduction Alternatives

In order to meet long-term water supply needs and TMDL compliance, the County must evaluate alternatives for both water supply resiliency and nitrogen reduction. As a unified solution, MAR is designed to meet both of these needs concurrently, while it is necessary to combine each of the other alternatives described above to meet the same objective. Table 16 below summarizes the combined NPV of paired alternatives.

The IPR-MAR alternative has the lowest cost to provide both water supply and nutrient removal. The 30-year lifecycle NPV of a 7.5 MGD MAR facility combined with groundwater production is $350M. This alternative is 13% less expensive than the next lowest cost alternative and carries more benefits and fewer risks and uncertainties that are not easily quantified. Also, as a unified strategy it is more flexible, scalable, and adaptable to meet future changing obligations. Its key risks are regulatory hurdles and public acceptance. Both will be addressed in a comprehensive manner.

Table 16 - Comparison of Combined Water Supply & Additional ENR Alternatives (7.5 MGD and 47,000 lbs/yr TN reduction)

Water Supply Resiliency	Nutrient Management		
	Add'l Filtration for DON Removal	Add'l Oxidation Tank & Filter Capacity	MAR
Purchased Water from Baltimore City	$795	$401	
Brackish Water RO WTP	$919	$525	
Indirect Potable Reuse – MAR			$350
Indirect Potable Reuse – Shallow Infiltration	$1,033	$639	
Direct Potable Reuse	DPR Not Viable	DPR Not Viable	DPR Not Viable

As summarized in Section 4.1, purchasing water on a contract basis from the City is not believed to be a truly viable alternative to address the County's water supply resiliency needs. There are many factors outside of the County's control. Even if the County and City are able to reach agreement on the large investment to address infrastructure needs, the operational considerations and related risks will impact the County's water supply for several decades.

MAR is recommended for its significantly lower NPV, and because it affords the County more control over long term water supply and nutrient management. Further, the benefit of restoring the aquifer is a critical next step in providing for the long-term sustainability of the region's groundwater supply.