Water Resources

Background Report

Anne Arundel 2040

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Introduction

Water resources are a vital part of Anne Arundel County's environmental and economic health as well as a valuable recreational resource. It is an important element within a comprehensive planning process because a change in land use can increase or decrease the pollution levels of water depending on the point source and non-point source pollutants generated from the type of land use activity. Protection from pollution is essential to providing sustainable watersheds for drinking water sources, protection of aquatic life, viable fishing and shellfish industries, and healthy recreation areas.

The State of Maryland and Anne Arundel County have long considered protection and preservation of the Chesapeake Bay and its tributaries to be a high priority. Quality of life and sustainability through stewardship and environmental protection of water resources through management and restoration are part of the twelve Visions adopted into the Land Use Article (§ 1-201 of the Annotated Code of Maryland). In addition, the Land Use Article (§ 1-406(a)(1)(iv)) requires that a Water Resources Element (WRE) be incorporated into the local government's comprehensive plan.

Protection of the County's water resources is a high priority to its citizens as evidenced in the Vision and goals of the 2009 General Development Plan, the 16 Small Area Plans and the results of the Plan2040 Listening Sessions. In addition, healthy water recreation opportunities, an adequate and safe drinking water supply and appropriate stormwater and wastewater management systems are important.

This report provides background information and serves as an update to the WRE that was adopted as part of the 2009 General Development Plan. It describes the current planning framework for watershed protection; assesses the County's public and private water supply capacities and demand; examines wastewater capacity and future demand; and determines pollutant loads from wastewater treatment plants, septic systems, and stormwater runoff under existing conditions and future conditions. Finally, this report will identify future needs for water resource protection.

Purpose

The principle purpose of the WRE is to address the relationship between planned development and its impacts on area water resources. Specifically, the WRE will:

1. Ensure that a safe and ample supply of drinking water sources are adequate for the needs of existing and future development proposed in the Land Use Element of the Plan; and
2. Ensure adequate treatment of wastewater for existing and future development proposed in the Land Use Element of the Plan
3. Ensure that nutrient loading impacts from wastewater treatment plants, septic systems and stormwater runoff from existing and future development proposed in the Land Use Element of the Plan are minimized.

Planning Framework

The planning framework for implementation of the water resources element includes various plans, programs and regulations that comprehensively approach the solution to ensure that a safe and ample supply of drinking water is available and that suitable receiving waters and land areas meet stormwater management and wastewater treatment and disposal needs. Anne Arundel County continues to

make progress in implementation of these plans, programs and regulations that protect and provide sustainable watersheds for drinking water sources, protection of aquatic life, viable fishing and shellfish industries, and healthy recreation areas. The various plans, programs and regulations are described below and in the following sections.

2009 General Development Plan

The 2009 *General Development Plan* (GDP) recognized the continuing impacts on water quality from wastewater discharges, septic systems and urban stormwater runoff. The GDP set forth the following goals to lessen the threat of pollution, improve water quality conditions and provide for adequate public water and sewer services.

1. Provide the highest level of wastewater treatment capabilities economically achievable in order to reduce pollutant loads to area tributaries.
2. Achieve significant reductions in nutrient loads from onsite septic systems.
3. Improve stormwater management practices throughout the County to reduce nonpoint source pollutant loads and achieve water quality standards.
4. Provide and maintain a safe and adequate capacity for wastewater treatment services and water supply to meet current and future needs.

Water and Sewer Master Plan

The Anne Arundel County *Water and Sewer Master Plan* includes goals, objectives, policies and procedures as well as background information, descriptions of facilities and service areas, population and flow projections, strategies for facility optimization, and policies to address problem areas in both water supply and sewerage systems. The most recent update to the *Water and Sewer Master Plan* was completed in 2017 and reflects the land use policies of the 2009 *General Development Plan*, the 16 Small Area Plans, the Town Center Plans and related planning policies that focus on protection of water resources.

The goals of the *Water and Sewer Master Plan* are consistent with the County's GDP and are as follows:

1. Ensure a sufficient supply of water will be collected, treated and delivered to areas programmed for service in the Master Plan.
2. Ensure wastewater will be collected from all areas programmed for service in the Master Plan and delivered to points best suited for waste treatment and disposal or reuse,
3. Both water and sewer services shall be monitored and maintained in a manner that strives to maximize the public health, safety and welfare for all while minimizing environmental impacts, and
4. Incorporate sound water and sewer planning principles and balanced land use initiatives to desired land management practices, highest water quality protection, and partnered financial support.

Clean Water Act and the National Pollutant Discharge Elimination System Program

The Federal Clean Water Act (CWA) establishes regulations for discharges of pollutants into the waters of the United States and quality standards for surface waters. Under the CWA, the Environmental Protection Agency (EPA) has implemented pollution control programs such as setting wastewater standards for industry and water quality standards for all contaminants in surface waters.

The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained. EPA's National Pollutant Discharge Elimination System (NPDES) was created in 1972 by the CWA and helps address water pollution by regulating point sources that discharge pollutants to waters of the United States. Point sources are discrete conveyances such as pipes or man- made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. The EPA's NPDES stormwater regulations were published in 1990. Phase I of these regulations require large urban jurisdictions (populations greater than 250,000 such as Anne Arundel County) to control pollution to the maximum extent practicable. In December 1999, the requirements for Phase II (smaller jurisdictions such as the City of Annapolis) began.

The Maryland Department of the Environment (MDE) is responsible for carrying out these federal laws and as such, has the regulatory authority to issue permits requiring the reduction of pollutants to surface and ground waters of the State. Reduction of nutrients from both point- and non-point sources is the focus of the permit requirements, along with control of bacterial pollution from sewage treatment plants and toxic materials from any source.

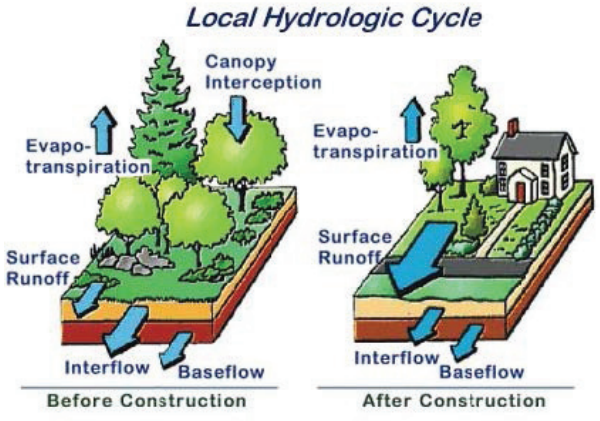
In response to EPA's NPDES stormwater regulations, MDE began issuing NPDES MS4 stormwater permits in 1993. MS4 permits are designed to regulate local government "Municipal Separate Storm Sewer System (MS4) discharges" and to require more comprehensive actions necessary to manage the complex issues related to sources of pollutants in stormwater runoff. The permits are required to be updated and renewed every five years. In general, NPDES MS4 permits issued by MDE include the following objectives to achieve the overall goal of reducing and/or eliminating sources of pollutants in stormwater runoff:

1. Completion of local watershed assessments to document current conditions and guide land use planning and implementation decisions,
2. Development of watershed restoration and preservation plans that effectively guide water quality improvement projects,
3. Implementation of integrative administrative programs designed to comprehensively approach improvement of water quality impairments, and
4. Identification of pollutant sources in stormwater runoff with a link to specific water quality impacts on a watershed basis.

Anne Arundel County's first NPDES MS4 permit was issued on 12/02/93. The most current permit was issued on 2/12/2014 and is slated for renewal in 2019. Through annual reporting to MDE, the County must demonstrate compliance with the following permit requirements of Part IV of the NPDES MS4 permit:

1. The sources of pollutants in stormwater runoff shall be identified and linked to specific water quality impacts on a watershed basis. Information on the storm drain system, industrial and commercial land uses with potential to contribute pollutants, implemented stormwater best management practices (BMPs), impervious surfaces and water quality improvement projects shall be developed and provided to MDE.
2. Management programs to reduce and control stormwater runoff and introduction of pollutants through stormwater runoff shall be implemented. These include, but are not limited to, continuance of the County's current stormwater management program, sediment and erosion control program, illicit discharge detection and elimination program, and County property management through adherence to the State's general permit for stormwater discharge from industrial facilities.
3. A public education and outreach program shall be implemented to reduce stormwater pollutants and integrated with all aspects of the County's activities.
4. The systematic assessment of water quality within the County's watersheds shall continue and include a detailed water quality analyses, the identification of water quality improvement opportunities, and the development and implementation of water quality improvement projects to control stormwater discharges to the maximum extent practicable.
5. The projects/practices identified to control stormwater discharges shall be implemented to the maximum extent practicable. By the end of the permit term, the County shall complete water quality improvement projects to manage or restore the equivalent of twenty percent of the County's unmanaged impervious surface area. Projects may include stream restoration and stormwater retrofits to previously developed lands, as well as retrofits of existing stormwater BMP facilities to achieve more water quality management.
6. The County shall develop and implement TMDL restoration plans for the stormwater waste load allocation (SW-WLA) associated with each EPA-approved TMDL (Chesapeake Bay TMDL and all local TMDLs).
7. Chemical, biological, and physical monitoring shall be used to assess watershed restoration efforts, document BMP effectiveness, and/or calibrate water quality models used to show progress toward meeting applicable SW-WLAs. Additionally, physical stream monitoring shall continue for purposes of assessing the effectiveness of the implementation of the 2000 Maryland Stormwater Design Manual. Specific monitoring requirements include watershed restoration assessment of the Parole Plaza outfall and the Church Creek in-stream station in the South River watershed and stormwater management assessment of Picture Spring Branch.

Renewal of Anne Arundel County's NPDES MS4 Permit in 2019 will likely include slightly modified compliance requirements.



Stormwater Regulations

Development may have an influence on the quality of streams and waterbodies. Traditional land development dramatically can alter the local hydrologic cycle. During initial site clearing, trees,

meadow grasses, and agricultural crops that intercept and absorb rainfall, are removed and natural depressions that temporarily pond water are graded to a uniform slope. Cleared and graded sites erode, are often severely compacted, and can no longer prevent rainfall from being rapidly converted into stormwater runoff.

Stormwater management regulations have been put in place to control the quantity and quality of the stormwater runoff as well as the cumulative impacts to the waterways. The quantity of stormwater runoff is governed by the amount of impervious surfaces (driveways, roofs, carports, sidewalks, etc.) while the quality of stormwater runoff is governed by the accumulation of pollutants on the entire surface area, regardless of whether it is grassed or paved.

Stormwater management practices help control nonpoint source pollution through the use of nonstructural and / or structural techniques to intercept surface runoff from developed areas, filter and treat this runoff, and then discharge it at a controlled rate. In addition, stormwater management reduces the adverse effects from development, reduces the effects of land use changes on stream channel erosion, preserves and enhances the environmental quality of streams and stream valleys, minimizes adverse impacts on water quality, and conserves plant, fish, and wildlife habitat and reduces flooding.

In response to requirements of the 1972 Clean Water Act and guidance from the Environmental Protection Agency, the State of Maryland developed a Stormwater Management Program. In 1982, the State passed the Stormwater Management Act and subsequently, regulations were adopted and a stormwater design manual was developed. The primary goals of the Act are to:

1. Maintain runoff characteristics to pre-development conditions,
2. Reduce stream channel erosion, siltation and sedimentation, and
3. Reduce local flooding impacts.

These goals are implemented through methods and practices set forth in the *2000 Maryland Stormwater Design Manual.* The regulations apply to development or redevelopment of land for residential, commercial, industrial or institutional uses but do not apply to agricultural land management practices. The goals of the *2000 Maryland Stormwater Design Manual* are to:

1. Protect the waters of the State from adverse stormwater runoff,
2. Provide design guidance on the most effective BMPs for development, and
3. Improve the quality of the BMPs with respect to such things as performance, longevity, and environmental benefits.

In October of 2007, the most recent statewide stormwater management regulations became effective. Those regulations, known as the Stormwater Management Act of 2007, require new development to use environmental site design (ESD) and to control stormwater runoff using nonstructural best management practices and other low impact site design techniques to the maximum extent practicable. MDE addressed the requirements of the Act including changes to State regulations and, in 2009, revised the State's 2000 Stormwater Design Manual. Prior to this Act, ESD was encouraged through a series of credits found in the 2000 Stormwater Design Manual. MDE has delegated authority to implement and enforce stormwater management to Anne Arundel County.

The Anne Arundel County Code regulations requiring stormwater management implementation are linked with land development and related activities. The County's stormwater management requirements are codified in Article 16, Title 4 of the County Code. In addition, Article 16 of the County Code requires the adoption and implementation of the County's Stormwater Practices and Procedures Manual, which is a comprehensive tool that provides specific design requirements; procedures and documentation for stormwater management plan submission; and for stormwater management facility maintenance and inspection. It promotes environmentally sensitive design and encourages infiltration of runoff rather than collection and conveyance to a downstream pond or stream.

Anne Arundel County is also required to adopt stormwater management ordinances and institute guidelines for implementation of stormwater management programs that are consistent with the 2007 Stormwater Management Act. The County Code and the Stormwater Practices and Procedures Manual were updated in 2017.

Total Maximum Daily Loads

The CWA also requires Total Maximum Daily Loads (TMDL's), which are the maximum amount of a pollutant that a waterbody can absorb and still meet water quality standards. They are based on the relationship between pollution sources and in-stream water quality conditions.

In 1998, the Chesapeake Bay and many of its tidal tributaries were added to the list of impaired waters. In response, the State of Maryland has been involved in an ongoing process of developing and promulgating individual TMDL's for specific pollutants as well as developing a watershed implementation plan for the Chesapeake Bay TMDL. Information on Maryland's TMDL development process can be found at: http://www.mde.maryland.gov/programs/water/TMDL/DataCenter/pages/index.aspx.

TMDL's represent mandatory standards for site-specific water quality goals. Section 303 (d) of the CWA established expectations for impaired waterways. Existing "use" of each respective waterway as of November 28, 1975 was established as a baseline "designated use".

Surface water sources such as rivers, streams, and reservoirs are regulated by the Code of Maryland Regulations (COMAR) water quality standards. The purpose of these standards is to protect, maintain and improve the quality of Maryland surface waters. The following are three components of water quality standards:

1. Designated Uses for each water body (e.g. recreational use, public water supply);
2. Water quality criteria to protect the designated uses; and
3. Antidegradation policy.

Designated Uses

Designated uses consider the use and value of each respective waterbody in areas such as public water supply; protection of fish, shellfish, and wildlife; recreational fishable and swimmable waters; as well as agricultural, industrial, and navigational purposes. The suitability of each water body as a designated use is based on the waterbody's physical, chemical and biological characteristics (such as imbalanced pH,

biological impairments, temperature, salinity and dissolved oxygen); geographic setting; scenic qualities; and economic considerations as a resource.

The State of Maryland (COMAR Section 26.08.02.08) has defined the following Uses:

1. **Use I:** Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life
2. **Use I-P:** Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply
3. **Use II:** Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting
    (a) Shellfish Harvesting Subcategory,
    (b) Seasonal Migratory Fish Spawning and Nursery Subcategory (Chesapeake Bay only),
    (c) Seasonal Shallow-Water Submerged Aquatic Vegetation Subcategory (Chesapeake Bay only),
    (d) Open-Water Fish and Shellfish Subcategory (Chesapeake Bay only),
    (e) Seasonal Deep-Water Fish and Shellfish Subcategory (Chesapeake Bay only), and
    (f) Seasonal Deep-Channel Refuge Use (Chesapeake Bay only)
4. **Use II-P:** Tidal Fresh Water Estuary – includes applicable Use II and Public Water Supply
5. **Use III:** Nontidal Cold Water
6. **Use III-P:** Nontidal Cold Water and Public Water Supply
7. **Use IV:** Recreational Trout Waters
8. **Use IV-P:** Recreational Trout Waters and Public Water Supply

Each major stream segment in Maryland is assigned a use. The Use is a goal for water quality and may or may not be served now, but should be attainable. Currently, within Anne Arundel County, the majority of nontidal waters are categorized as Use I. The tidal waterways (the rivers) are categorized as Use II. The Jabez Branch is categorized as a Use III, (nontidal cold water - i.e. a reproducing trout stream) and is the only Use III water in the coastal plain of Maryland. The Severn Run and the Lower North Branch of the Patapsco River are classified as a Use IV (recreational trout waters - i.e., trout are stocked annually for fishing but the waterway cannot support a reproducing population of trout).

Water Quality Criteria

Water quality "criteria" consider standards required to support designated uses. They include narrative or numeric expressions for pollutant thresholds that are not to be exceeded such as water quality mass loading; physical habitat conditions; bioaccumulation of toxins; and legacy pollutants in sediments. Designated uses drive water quality criteria and together they represent water quality standards. Water quality standards define the threshold for water quality impairments. Water quality impairments of concern include nutrients (nitrogen and phosphorus), biological impairments, sediments (legacy pollutants), toxic chemicals (metals, pesticides and others), and bacteria. Water quality impairments exceeding the defined threshold for respective waterways result with being placed on the Section 303 (d) list of impaired waters. Stream segments placed on the list leads to promulgation of TMDL allocations for the various pollutant contributors.

Each respective TMDL establishes a maximum amount of a pollutant that can be introduced to a waterbody and still meet designated "water quality standards". Primary criteria for any TMDL require that the stressor be expressed in a quantitative manner. It also requires that the stressor be linked in a cause and effect way to the relevant water quality standard cited in the 303 (d) waterbody listing. Each of Anne Arundel County's twelve watersheds is listed for four or more impairments. A complete listing of impairments to County waterways is provided on MDE's website.

Chesapeake Bay TMDL

Despite extensive restoration efforts, the EPA determined in 2010 that insufficient progress had been made to achieve necessary pollution reductions of nitrogen, phosphorus and sediment across the Bay watershed and established the Chesapeake Bay TMDL. The Chesapeake Bay TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay and its tidal rivers are in place by 2025. The TMDL is supported by rigorous accountability measures to ensure cleanup commitments are met. These measures include short-term and long-term benchmarks, tracking and accountability systems and contingency actions that can be employed if necessary to achieve progress. Wasteload Allocations (WLAs) were assigned to the Bay States. In September 2011, Maryland issued WLAs to the local jurisdictions, and required the development of Phase II Watershed Implementation Plans (WIPs) to achieve the assigned WLAs. Anne Arundel County submitted its Phase II Watershed Implementation Plan (WIP) to MDE in July 2012. The County's Phase II WIP identifies programs, policies and practices and establishes a commitment to implementation that ensures achievement of the nitrogen, phosphorus and sediment load reductions assigned by MDE. The County's Phase II WIP sets forth a strategy for implementation that identifies statutory authority, capital projects, funding mechanisms and timelines for achieving its allocated loads using Total Nitrogen as the keystone nutrient. The Countywide WLAs for Total Nitrogen that are addressed by the County's Phase II WIP are presented in Table 1.

Individual TMDLs

In addition to the Countywide Bay TMDL, TMDLs have been developed for watersheds within Anne Arundel County to address individual specific impairments. To date, TMDLs have been developed for nutrients, sediment, bacteria and Polychlorinated Biphenyl (PCB) impairments. TMDLs for other impairments including chlorides are either under development or will be developed by the MDE. The County is required through its NPDES MS4 Permit to develop implementation plans for each approved TMDL. TMDL implementation plans set forth a strategy for achieving stormwater wasteload allocations established by the TMDL and includes actions and decisions intended to "restore" and "protect" water quality standards. This is true even if the benefits of the activity or decision cannot be

Table 1: Countywide Total Nitrogen WLAs (Delivered)

Source Sector	2009 Baseline	2025 Target
Stormwater (MS4)	657,383	449,641
Septic	518,458	281,664
Wastewater (Major Municipal)	881,691	667,127

quantified. TMDL implementation practices entail both reducing excess pollutants and limiting new sources of pollutants (or prohibiting them). TMDL implementation planning is intended to establish a framework of actions for managing pollutants and quantifying the results. Evaluation of TMDL implementation practices involves verification that the pollutant control practices deemed necessary to achieve the TMDL load reductions have been implemented. Water quality monitoring is used to determine whether water quality standards have been achieved while taking into consideration potential lag times before drawing conclusions. TMDL implementation plans for approved TMDLs within Anne Arundel County can be found on the County's website at: www.aacounty.org/departments/ public-works/wprp/watershed-assessment-and-planning/chesapeake-bay-tmdl/

Antidegradation

The regulatory intent of Maryland's Antidegradation Policy (COMAR 26.08.04) is to protect the existing designated uses, and the water quality necessary to support those uses, by providing a means or assessing activities that may lower the quality of the State's high quality waters. For purposes of implementing this policy, waters of the State are categorized into one of three tiers based on their assessed water quality and biological conditions.

1. Tier I specifies the minimum standard that must be met—support of balanced indigenous populations and support of contact recreation—this is often referred to as "fishable-swimmable,"
2. Tier II protects water that is better than the minimum specified for that designated use, and
3. Tier III, Outstanding National Resource Water or ONRW, where the most stringent protection is necessary and appropriate to protect and maintain existing exceptional resources such as high quality waters of national and State parks and wildlife refuges, and waters of exceptional recreational or ecological significance.

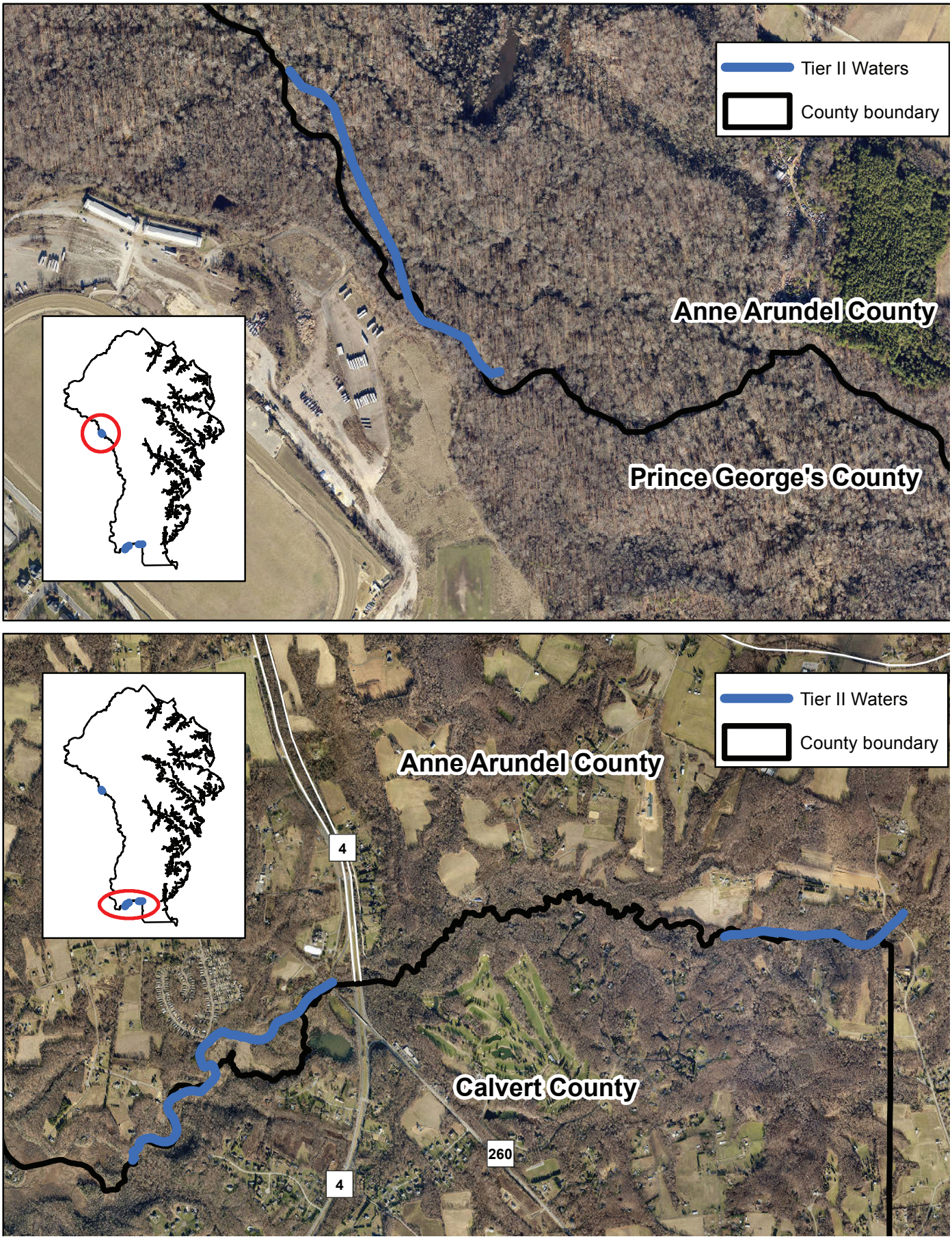
Currently, all of the waters in Anne Arundel County are within Tier 1 with the exception of three stream segments located on the Patuxent River and Lyon's Creek, which are designated as Tier 2. Figure 1 shows the location of the three Tier II stream segments that are designated "High Quality" waters due to exceptional aquatic biological community conditions (fish and aquatic benthic macroinvertebrates) within the stream. The first segment of Lyons Creek was listed as Tier II waters in 2003; the second segment was listed in 2007; the segment of the Patuxent River in the western part of the County was listed in 2009 (Table 2).

Table 2: Tier II Waters

Date Listed	Stream Name	Watershed	Baseline	
			Fish IBI*	Benthic IBI*
2003	Lyons Creek 1	Patuxent	5.00	4.71
2007	Lyons Creek 2	Patuxent	4.67	5.00
2009	Patuxent River 1	Patuxent	4.00	4.71

* IBI = Index of Biotic Integrity

Figure 1: Tier II Waters



The State and the County have a diversity of regulatory and planning programs to reduce pollutants from both point- and non-point sources to surface and groundwater. Some of the State programs include the:

1. Bay Restoration Fund - a dedicated fund that is financed by wastewater treatment plant users and is used to upgrade Maryland's wastewater treatment plants with enhanced nutrient removal (ENR) technology.
2. Onsite Disposal Systems Fund – a dedicated fund, financed by onsite septic users, that is used to upgrade septic systems and fund cover crops. Priority is given to failing septic systems in the Critical Area.
3. Watershed Protection and Restoration Fee – an impervious surfaced-based fee on properties that funds clean water restoration projects, maintenance and replacement of existing storm drainage infrastructure, the inspections of public and private stormwater facilities, and key programmatic efforts around environmental education, illicit discharge detection and elimination and the scientific monitoring of restoration projects.
4. Fish and Shellfish programs - emphasize preventing pollutants from entering the waters of the State, monitoring the quality of shellfish harvesting waters, and testing edible fish tissue to certify that fish are safe for human consumption.
5. Sediment, Stormwater and Dam Safety Program - concentrates on controlling runoff increases and mitigating water quality degradation associated with new development.
6. Water Quality Infrastructure Program (WQIP) – develops and implements capital projects to correct public health and water quality problems and provides restoration measures that lead to water quality and habitat benefits.
7. Wetlands and Waterways Program - responsible for the protection and management of Maryland's tidal and nontidal wetlands and waters.
8. Water Quality Financing Administration (WQFA) - assists in the financing of capital infrastructure costs for wastewater and drinking water projects.
9. Water Management Permits - Surface water discharges are regulated through combined State and federal permits under the National Pollutant Discharge Elimination System (NPDES). Groundwater discharges are regulated through State issued groundwater permits.

Watershed Management Plans

There are twelve distinct major watershed systems and a small portion of the Lower Patuxent River watershed that drain to the major rivers within Anne Arundel County (Figure 2). For planning purposes, the Lower Patuxent River watershed is combined with the Middle Patuxent watershed. These watersheds are encompassed by three tributary watersheds within the State (Patapsco / Back River, Patuxent and Lower Western Shore) that drain to the Chesapeake Bay.

The Patapsco/Back River basin drains 630 square miles of land. Approximately 80 square miles is within Anne Arundel County. It includes the Patapsco Tidal, Patapsco Nontidal and Bodkin Creek watersheds. These watersheds are primarily developed but do include large open areas such as the Patapsco State ark.

The Patuxent River is the largest river completely in Maryland and drains about 900 square miles of land. Approximately 124 square miles of this watershed are within the County. The portion within the County includes the Upper Patuxent, Middle Patuxent and Little Patuxent Rivers. These watersheds have a mix of high and low-density development, agricultural and undeveloped lands.

Most of the Lower Western Shore basin is within Anne Arundel County. It has a drainage area of approximately 270 square miles of land of which about 208 square miles is within the County. Land use within these watersheds is mixed with high land low-density development, agricultural and undeveloped lands. Table 3 shows acreage of different types of land cover and the amount of impervious area for each of the twelve watersheds within the County.

Watershed Management Plans have been completed for each of the 12 major County watersheds as of 2018. These plans provide technical support for the development, implementation, management, and refinement of the programs listed above. They also provide a holistic and systematic watershed perspective to land use planning and development review activities. These Plans, which are developed on a community watershed scale, include the characterization of watershed baseline conditions and resources, while identifying existing and potential concerns, along with short- and long-term opportunities for improvement of water quality issues. Analysis of the baseline conditions and resources identified in the Plan provides for an informed basis for prioritizing watershed restoration and preservation initiatives. Through the characterization and analysis of a watershed area, the plans provide recommendations necessary to facilitate daily land use and infrastructure decisions to protect watershed resources. The watershed management plans integrate and link existing watershed management business processes with watershed models and geographic information systems to provide interactive information on how changes in land use, zoning, subdivision regulations, best management practices, and other watershed conditions affect water quality and living resource habitat.

The watershed studies involved a partnership between the County, various consultants, and citizen stakeholders. The field data collection was performed primarily by consultants specifically for each watershed study effort. All modeling, analysis, and reporting was performed in-house by County staff. Once the data was collected and analyzed for a watershed, the TMDL support staff collaborated with the consultants and other citizen stakeholders via public meetings, and professional management team meetings to review the information, seek input and comments. After review and comment from stakeholders, the County published the studies, including recommended restoration and preservation actions and desired implementation strategies. The watershed assessments are posted on the County's webpage.

With the preparation of the Severn River Watershed Management Master Plan, a Watershed Management Tool (WMT) for the County was developed. This tool consists of several components to help watershed managers determine which subwatersheds and stream reaches are most in need of restoration, and evaluate the outcome of alternative land use scenarios. The WMT has four major components: database repository, modeling, management and visualization.

These components function as an integrated system the County can use to examine management practices related to watershed health.

A primary function of the WMT is to estimate pollutant loads in a watershed for both current and projected land use conditions, and to estimate pollution reductions associated with implementation

Figure 2: County Watersheds

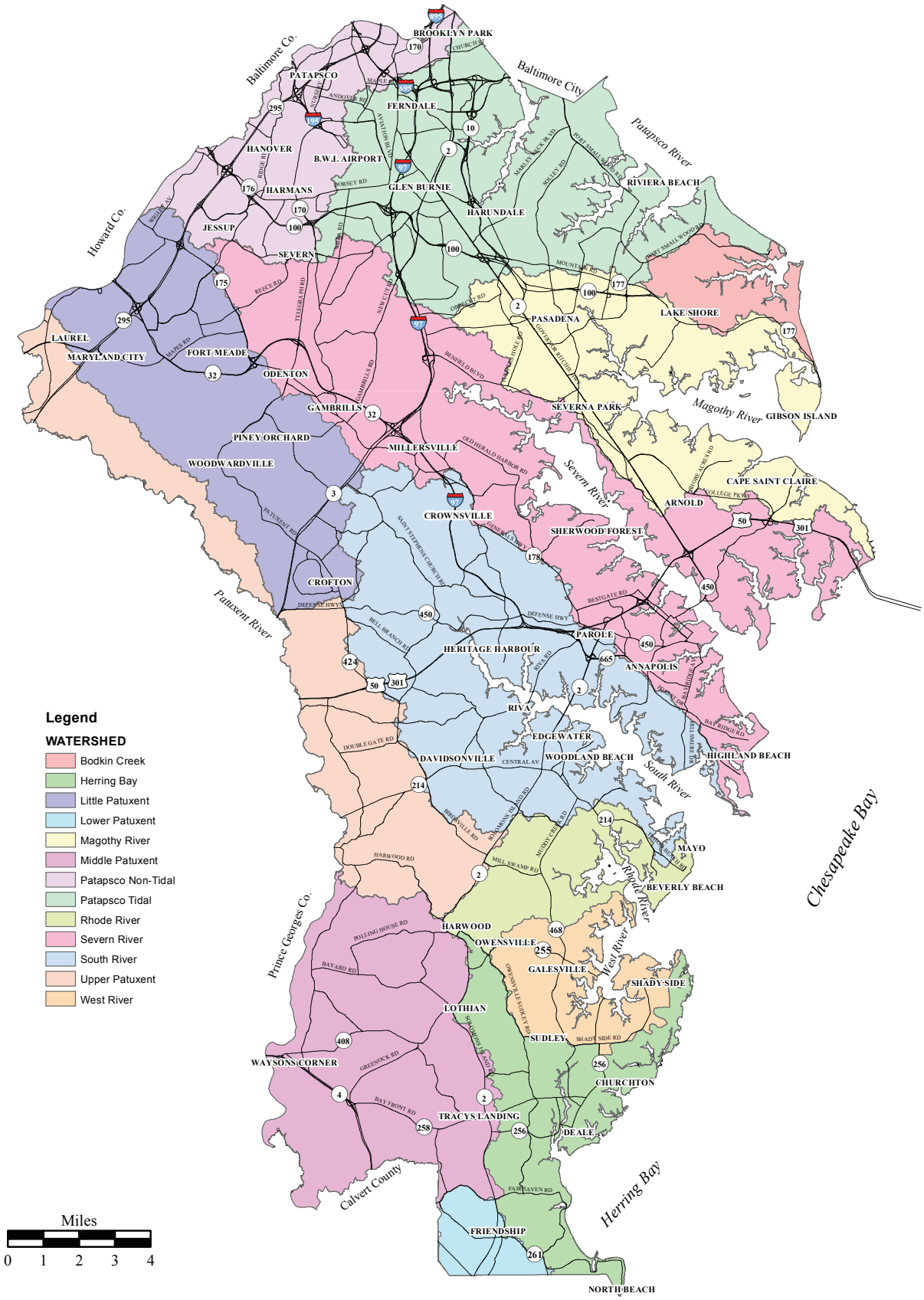


Table 3: Existing Land Cover and Impervious Area by Watershed (Acres)

Watershed	Total Area (Acres)	Land Cover (Acres)							
		HDU	OS	AG	RES	TU	NF	FL	Imp
Severn River	44,248	3,460	2,560	1,266	19,687	1,999	1,126	14,150	8,825
South River	36,167	1,712	1,482	2,276	14,270	1,654	3,299	11,471	4,741
Magothy River	22,845	1,361	982	151.2	12,998	914	597	5,842	4,706
Rhode River	8,764	175	298	1,121	2,154	185	659	4,172	551
West River	7,297	185	198	1,675	1,806	190	340	2,903	499
Herring Bay	14,662	345	522	1,477	3,426	631	2,135	6,126	955
Upper Patuxent River	22,551	825	1,438	3,110	4,889	822	1,729	9,738	1,526
Middle Patuxent	29,632	731	1,109	7,638	6,436	664	1,761	11,293	1,445
Little Patuxent	27,750	3,661	2,559	890	5,494	1,595	1,595	11,957	4,875
Patapsco Tidal	30,841	4,711	2,921	119	12,858	1,946	748	7,539	9,135
Patapsco Non-Tidal	15,275	3,296	1,583	18	4,007	1,102	465	4,803	4,401
Bodkin Creek	5,036	178	294	54	2,351	118	214	1,827	653
Total	**265,067**	**20,639**	**15,945**	**19,796**	**90,377**	**11,821**	**14,667**	**91,822**	**42,313**

Notes:
1. Watershed and Total area in acres (rounded off);
2. Watershed acreages and impervious acreages are based on Anne Arundel County 2014 impervious and Land Cover ;
3. Land Cover Codes: HDU = High-Intensity includes Industrial, Commercial, Airport and Mining; FL= Forest Lands; RES = Residential; AG = Agricultural; NF = Natural Features; TU = Transportation / Utility; IMP = Impervious Area

of various preservation and restoration actions. This was done by conducting stream walks to assess physical and biological parameters, scoring each reach based on the results, using the Simple Method to estimate runoff and pollutant loadings, and conducting hydrologic and hydraulic modeling. Runoff and pollutant loadings were estimated for existing land use conditions, and for future projected land use conditions. The effects of proposed preservation and/or restoration efforts on reducing these pollutant loads were modeled. One component is a GIS-based data repository in which all data pertaining to local waterways and land is stored, maintained and updated. A second component consists of several engineering models that are used to evaluate existing and future conditions of hydrology, hydraulics, and water quality. The WMT helps assess the data, prioritize where to focus restoration and preservation investment as well as selection of the most appropriate alternative solutions or best management practices. This information also allows reassessment of current land use plans relative to where future development is being directed, its zoning potential, and policy decisions regarding development regulations, which designate the character of site planning and development. The reassessment of these existing policies can be modeled to predict future watershed water quality conditions more favorable to meeting defined water quality standards.

The watershed modeling capabilities allow environmental impacts of land use changes to be analyzed through simulation of stormwater runoff water quality; soil erosion from the land surface; flooding and changes in flow regime; groundwater and surface water interactions (watershed water budget); and stream habitat quality. It also allows simulation of point and non-point source pollutant loads; fate and transport of pollutants on land and in the waterbody; and the role of time and spatial scale.

The watershed modeling results can be used to examine "future conditions" of the watershed in categories such as pollutant loading; flooding of road crossings; stream erosion potential; and hydrology

of streams and groundwater. The WMT can also be used to evaluate certain policy considerations such as cluster zoning or septic system alternatives to predict resultant future pollutant loads for a community. Future conditions can be modeled for these policy considerations and the conditions compared to traditional community development.

Stream and Subwatershed Assessment and Ranking

Through its watershed assessments, the County has prioritized its subwatersheds and stream reaches to determine which ones are most in need of restoration or protection.

Prioritization of the stream reaches and subwatersheds are based on a set of physical, chemical and biological indicators that are assigned a weight and then combined for an overall rating for prioritization. Table 4 shows the indicators used in these assessments. All stream reach and subwatershed preservation assessments have been completed for County watersheds. The priority ranking of the watersheds for purposes of restoration can be found on the County's web page at: https://www.aacounty.org/departments/public-works/wprp/watershed-assessment-and-planning/watershed-studies/index.html

Safe Drinking Water Act

The Federal Safe Drinking Water Act was established to protect the quality of drinking water in the United States. This law focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources and authorizes EPA to establish minimum standards to protect tap water, requiring all owners or operators of public water systems to comply with these standards. It also establishes minimum standards for state programs to protect underground sources of drinking water from endangerment by underground injection of fluids.

Wellhead Protection Studies

The Safe Drinking Water Act Amendments of 1986 requires each state to develop Wellhead Protection Programs. Wellhead Protection is a strategy designed to protect public drinking water supplies by managing the land surface around a well where activities might affect the quality of the water. The EPA approved Maryland's Wellhead Protection Program in June of 1991. Maryland's program provides technical assistance, information, and funding to local governments, to help them protect their water supplies. In its continual effort to promote safe management of the land surface around public wells, the Public Drinking Water Program of the MDE has developed a model ordinance as a tool for local governments to use to protect their water supplies.

Water Supply Program

The MDE has the primary responsibility for the protection of Maryland's groundwater resources. MDE's comprehensive approach involves coordination and collaboration with a number of State agencies and various stakeholders such as, the Maryland Department of Agriculture (MDA), the Maryland Department of Natural Resources (MDNR), local governments, and other scientific organizations such as the MGS and USGS, and the general public. In addition to the many water quality protection programs, MDE's Water Supply Program manages water withdrawals to ensure against unreasonable impacts on the water resource and other water users. Through the permitting

Table 4: Indicators Used in Stream Reach, Subwatershed Restoration and Preservation Assessments

Category	Indicator Name
Stream Reach Restoration	
Stream Habitat	MPHI Rating
Stream Morphology	Rosgen Level 1 Classification
Land Cover	Contributory percent Impervious to Stream Reach
Infrastructure	Buffer Impacts
	Erosion Impacts
	Head Cut Impacts
	Dumpsite Impacts
Hydraulics and Hydrology	Potential of Emergency Road Crossings to Flood
Subwatershed Restoration	
Stream Ecology	Final Habitat Score
	Bioassessment Score
303 (d) List	# of TMDL Impairments
Septic Systems	Nitrogen Loans from Septic Systems (lbs/acre/year)
BMPs	% Impervious Area Treated by BMPs
Water Quantity	Peak Flow from 1-yr Storm Event (cfs/acre)
	Peak Flow from 2-yr Storm Event (cfs/acre)
	Runoff Volume from 1-yr Storm Event (cfs/acre)
	Runoff Volume from 2-yr Storm Event (cfs/acre)
Water Quality	Nitrogen Load from Runoff (lbs/acre/yr)
	Phosphorus Loan from Runoff (lbs/acre/yr)
Landscape	% of Impervious Cover
	% of Forest Within 100-Foot Stream Buffer
	% of Existing Wetlands to Potential Wetlands
	Acres of Developable Critical Area
Subwatershed Preservation	
Stream Ecology	Final Habitat Score
Future Departure of Water Quality Conditions	% of Future Departure of Total Nitrogen
	% of Future Departure of Total Phosphorus
Soils	NRCS Erodibility Factor
Landscape	% Forest Cover
	% Wetland Cover
	Density of Headwater Streams in feet/acre
	% of Land Within the Greenway Master Plan
	Presence of Sensitive Species Project Review Area
	Presence of Bog Wetlands
	Acres of RCA Lands within the Critical Area
	Percent of Protected Lands
	Presence of Wellhead Protection Areas
Aquatic Living Sources	Presence of Trout Spawning
	Presence of Anadromous Spawning

process, groundwater withdrawals in confined aquifers in Maryland's Coastal Plain Province are managed such that water levels are not allowed to fall below a designated management level. The management level, intended to prevent dewatering of the confined aquifer, is defined as 80% of the difference between the pre pumping water level and the top of the aquifer.

The MDE's Water Supply Program implements various programs to ensure that public drinking water systems provide safe and adequate water; and that appropriate usage, planning and conservation policies are implemented for Maryland's water resources. This mission is accomplished through proper planning for water withdrawal, protection of water sources that are used for public water supplies, oversight and enforcement of water quality monitoring at public water systems, regular onsite inspections of water systems, and prompt response to water supply emergencies.

Significant work has already been done in collaboration with the State to identify potential contaminant sources in the County and to perform a hydro-geological study of the County. This effort has established the groundwork for the County to pursue a wellhead protection program using the State's model ordinance as a guideline. See Anne Arundel County's Water and Sewer Master plan for additional information on wellhead protection and groundwater quality.

In addition to the wellhead protection program conducted in cooperation with the State, the County Department of Health currently maintains a Groundwater Protection Plan (for private water supplies), which documents and summarizes Health Department policies and programs regarding on-site sewage disposal systems and the protection of groundwater where public sewer is not available.

The Water Strategic Plan

Anne Arundel County utilizes a Comprehensive Water Strategic Plan (CWSP) that addresses all significant aspects of its water supply and distribution system for current and future users. The CWSP, updated approximately every 10 years, ensures adequate supply of the highest quality water to meet the demands of its customers. The plan has enabled the County to optimize groundwater utilization and to develop a supplemental water purchase policy from the City of Baltimore consistent with forecasted interim and long-term demands.

The CWSP is a detailed engineering study of the County's water supply system. The plan includes water demand projections, and the evaluation of system performance under existing and proposed future conditions using hydraulic modeling. Recommendations for capital improvements and a proposed capital improvement schedule, with cost estimates and an implementation timeframe is also included in the plan. The most current CWSP was completed in April 2016 by Malcolm Pirnie/Arcadis.

The CWSP has three primary objectives, as follows:

1. Update the future demand projections based on Baltimore Metropolitan Council reports, future land use plans, and previous studies.
2. Perform an existing system analysis using the County's hydraulic model to identify immediate needs and to serve as a baseline for comparison
3. Perform a future system analysis based on three future planning horizons: 2020, 2030, and build-out and to use those results for development of a phased Capital Improvements Program.

Onsite Disposal System Evaluation Study and Strategic Plan

In early 2008, CH2Mhill completed a Countywide evaluation of the nutrient loading impact that onsite sewage disposal systems (OSDS, or septic systems) have on its receiving waters and the service options available for properties with septic systems. The Onsite Sewage Disposal System Evaluation Study and Strategic Plan was completed in March 2008 and found that given the high number of septic systems coupled with their proximity to tidal waters and the sandy soils present along the waterways, the resulting nutrient load is significant. The Onsite Sewage Disposal System

Evaluation Study and Strategic Plan focused on the most cost-effective approach to reduce total nitrogen loads to the Chesapeake Bay. The study included four tasks. Task I involved identifying, categorizing and prioritizing OSDS Countywide. A preliminary cost analysis of OSDS upgrades, cluster community wastewater systems and sewer extensions was conducted as part of Tasks 2 and 3. Task 4 of the study was the preparation of an Implementation Plan and a Final Report.

Sewer Strategic Planning

The Systems Evaluation and Rehabilitation (SER) division within the County's Department of Public Works' (DPW) Bureau of Utility Operations is responsible for monitoring sewer flows, identification and investigation of inflow and infiltration sources and management of rehabilitation / repair projects within the existing system. Flow data from SER's metering program is utilized to calibrate the County's sewer computer model. This sewer model is part of the Sewer and Water Allocation, Management and Planning System (SWAMP) and is further described in Appendix B of the County's 2017 Water and Sewer Master Plan. The model is utilized to check capacity availability for proposed development while considering existing, allocated and estimated flows from development under the Office of Planning and Zoning subdivision review process within each service area.

Between 2003 and 2007, CH2Mhill conducted and completed a Comprehensive Sewer Strategic Plan (CSSP) for the Annapolis, Baltimore City, Broadneck, Broadwater, Cox Creek, Maryland City and Patuxent Sewer Service Areas. The CSSP was a 2-phase approach for planning the future modifications and expansion of the existing wastewater collection and treatment system. In Phase I of the study, the County's wastewater treatment plants were evaluated on a number of criteria including the State's anticipated effluent total nitrogen discharge goals and other future discharge permit requirements. Phase 2 evaluated ways to expand or modify the existing wastewater conveyance system to route flow toward treatment plants with the most available capacity to accommodate future growth in a cost effective manner. The major recommendations and findings of this study were incorporated into the Water and Sewer Master Plan.

Enhanced Nutrient Removal (ENR)

Initially, wastewater treatment plants were required to achieve a 45 to 50% reduction of pollutants through primary treatment processes. In 1972, the NPDES permit required treatment plants to use biological processes as a secondary treatment of pollutants to achieve an 85 to 90% reduction in pollutants.

Because the Chesapeake Bay continued to experience a decline in water quality from enrichment of nutrients (mainly phosphorus and nitrogen), Maryland, Virginia, Pennsylvania, and the District of

Columbia signed the Chesapeake Bay Agreement of 1983 that specified a nutrient reduction goal of 40% by the year 2000. MDE developed a strategy for achieving the desired reduction through upgrading the major 66 wastewater treatment plants to remove nitrogen through a process known as biological nutrient removal (BNR). Using the BNR process, more than 90% of pollutants are removed, while achieving nitrogen concentration below 8 mg/l total nitrogen. Consistent with the State's initiatives to address point-source pollutant loads from wastewater treatment plants, the County has upgraded and installed Biological Nutrient Reduction (BNR) processes and infrastructure at all of its major water reclamation facilities (WRFs).

Recognizing that more needs to be done, the Chesapeake Bay 2000 Agreement requires further reduction in nitrogen by about 20 million pounds and phosphorus by about 1 million pounds per year. MDE is using the Bay Restoration Fund to upgrade the 66 major wastewater treatment plants, which discharge to the Chesapeake Bay, with enhanced nutrient removal (ENR) technologies. Once upgraded, these plants are expected to reduce nitrogen and phosphorus in the wastewater down to 4 mg/l total nitrogen and 0.3 mg/l total phosphorus, achieving approximately one-third of the needed reduction under the Chesapeake Bay 2000 Agreement.

Starting in 2006 with the signing of a Memorandum of Understanding between Anne Arundel County and MDE, the County initiated a series of procurements to provide design services for the upgrade of each of its wastewater facilities to achieve Enhanced Nutrient Removal (ENR). As defined by the State, ENR is technology capable of achieving 4 mg/l total nitrogen (TN) and 0.3 mg/l total phosphorus (TP) on an annual average basis.

Under the ENR Upgrade program, each of the County's six water reclamation facilities (WRFs) (the Mayo WRF is in the process of being decommissioned) are designed to meet an annual average of 3 mg/l TN and 0.3 mg/l TP at the design flow for the facility. The total maximum pound loadings are calculated based on 4 mg/l TN and 0.3 mg/l TP at the design rated capacity as recognized in the 2017 Water and Sewer Master Plan. By reducing the TN and TP discharges below the concentration limits, the facilities will have the capacity to expand by as much as 33%, while maintaining constant nutrient loads. Once upgraded, the County shall operate each of the enhanced nutrient removal facilities in a manner that optimizes the nutrient removal capability of each facility, which may achieve better performance than the loading and concentration limits.

Upon completion of all ENR projects, the County will be in conformance with the Municipal Wastewater segment of its Watershed Implementation Plan and the County's wastewater treatment facilities will meet the assigned TMDL loads.

Other Programs and Regulations

There are additional programs and regulations within Anne Arundel County that are in place to comprehensively approach the solution to water quality impairments. These include: the Zoning Code, the Subdivision and Development Code, the Erosion and Sediment Control Program, In-Stream Biological Monitoring Program, Wastewater Industrial / Commercial Pretreatment Program, the Capital Improvement Program, Agricultural and Woodland Preservation Program, the Greenways Master Plan, the Chesapeake Bay Critical Area Program, wetland and floodplain management, and grading and building permit review.

In addition to these programs, the County supports the Watershed Stewards Academy and numerous non-governmental organizations to help implement pollution prevention measures needed to address local water quality problems.

Water Supply Capacities and Future Demand

Water supply capacity can be defined as the system's technical, managerial, and financial capability to achieve and maintain compliance with all relevant local, state, and federal plans and regulations. In other words, the system has the knowledge, tools, and resources to ensure it can provide safe and reliable drinking water now and into the future.

Figure 3 is a map that shows water service within the County. The areas are depicted as 'Existing', 'Existing – City of Annapolis', 'Capital Facilities', 'Planned' and 'Future' comprise the ultimate area to be served by public water. The area of the County shown as 'No Public Service' is to be served by private wells. There are a few facilities that are privately operated, such as Fort Meade. These facilities are shown as 'Other'.

Groundwater Resources

Groundwater is a variable resource because the circulation of water through the earth and the atmosphere is dynamic. Constant replenishment, changing demand and widely varying environmental conditions mean that actual groundwater availability can only be measured on a site-specific basis. Confined aquifers receive recharge from areas where water-bearing formations crop out, from leakage through confining beds, and from lateral movement of water from adjacent aquifers. Therefore, they are much less vulnerable to drought conditions.

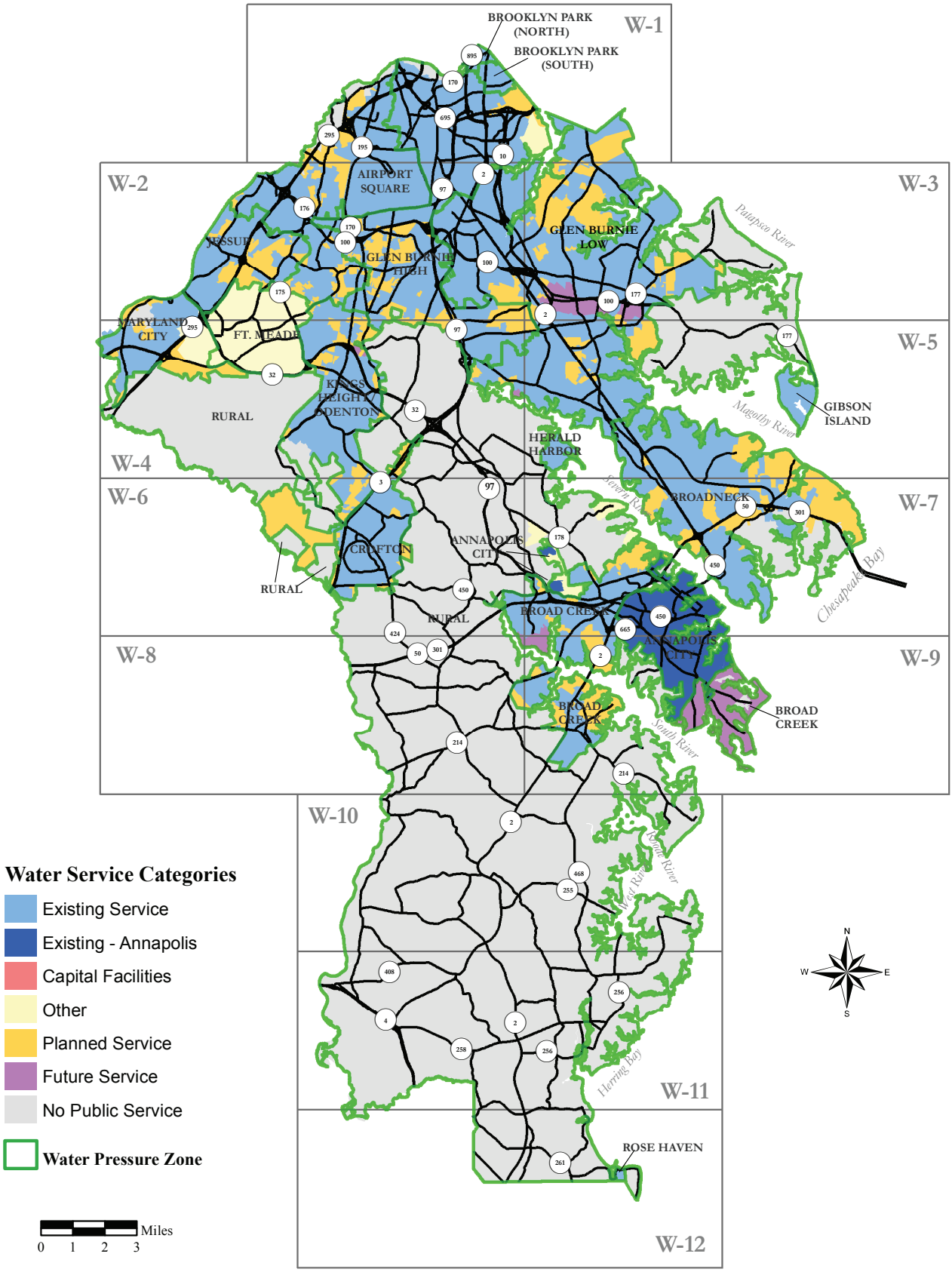
Anne Arundel County relies almost entirely on groundwater for its municipal water supply. The Patuxent, Lower Patapsco, Upper Patapsco, Magothy and Aquia are the aquifers from which the groundwater is withdrawn for the County. Additionally, water supply to the County is provided by Baltimore City. The Baltimore City water supply comes from surface water sources and makes up approximately 2.5% of the water used by the County.

The City of Annapolis owns and operates its own water supply system and uses groundwater from eight deep wells located near the water treatment plant that supplies the City's water system.

The Fort Meade Military Base has its own water supply system. The system's primary source of water is the surface water from the Little Patuxent River, which provides approximately 80 percent of the water used. The remaining 20 percent is provided by groundwater pumped from six wells. All of these wells are located on the Fort Meade base and pump water from the Patuxent Aquifer. The Rural service area utilizes individual private wells and receives water primarily from the Aquia aquifer.

Studies by the Maryland Geological Survey (MGS), Groundwater Supplies in Anne Arundel County, Bul. 26, 1962, indicated that the geologic and climatic conditions favor the availability of groundwater in the County. Subsequent investigations substantiate these conclusions. However, if the rate at which the groundwater is pumped exceeds the rate of replacement by precipitation or recharge by stream flow, a problem of brackish water intrusion may occur along the shoreline in shallow parts of the aquifers.

Figure 3: Anne Arundel County 2017 Water Service Areas



The most recent study conducted by the U. S. Geological Survey (in cooperation with the Power Plant Assessment Program of the Maryland Department of Natural Resources and the Maryland Geological Survey) assesses the regional effects of groundwater withdrawals on water levels in the Aquia, Magothy, Upper Patapsco, Lower Patapsco and Patuxent aquifers measured during September 2011 and represent groundwater levels and withdrawal amounts at an instant in time. The study concludes that in each aquifer, the water levels tend to be lower in wells farther away from the outcrop area where the aquifers receive recharge. The withdrawal data can be used to assist in determining the sustainability of the aquifer system (Andreasen, David C., Curtin, Stephen E., and Staley, Andrew W., 2016).

Aquifers

The Patuxent formation is the oldest unconsolidated deposit and ranges between 100 and 300 feet thick. It is also the deepest aquifer and it outcrops in bands several miles wide roughly parallel to the Fall line along Anne Arundel County's western and northwestern boundary. The recharge area in Anne Arundel County consists of approximately 10 square miles of a 120-square mile outcrop area. Scientific Investigations Report 2012-5165 states that water levels in the Patuxent Aquifer ranged from 168 feet above sea level to 135 feet below sea level. The report also states that withdrawal rates from the Patuxent decreased from over 21 million gallons per day (MGD) in 1990 to 13 MGD in 2010 due in part to reduced water use at Fort Meade and decreased withdrawals from well fields at Crofton Meadows as well as the City of Bowie in Prince George's County. The MGS indicates as much as 16 MGD could be withdrawn from the Patuxent aquifer in Anne Arundel County.

The Patapsco formation consists of sand and variegated clay deposits with some thin lenses of iron cemented sandstone. The thickness of the aquifer ranges between 200 and 300 feet. The outcrop area of 85 square miles extends across the northern end of the County; another 55 square miles of outcrop area is in Prince George's County. According to the Scientific Investigations Report 2012-5165, water levels in the upper Patapsco aquifer ranged from 120 feet above sea level to 110 feet below sea level in 2011 and declined by as much as 47 feet between 1990 and 2011. Water levels in the lower Patapsco aquifer ranged from 106 feet above sea level to 198 feet below sea level in 2011 and declined by as much as 71 feet between 1990 and 2011. Groundwater withdrawals from the Patapsco aquifers increased from 29 MGD in 1990 to over 40 MGD in 2010. The MGS study indicates that approximately 64 MGD could be withdrawn from the Patapsco aquifer in Anne Arundel County.

The Aquia formation is the uppermost aquifer and provides much of the water for Anne Arundel County south of Davidsonville and Annapolis. The formation has an average thickness in the County of 120 feet and dips southeastward 15-20 feet per mile. The total area of outcrop is 65 square miles through the central portion of the County in a band that extends from the western areas of Davidsonville through the Parole area to the southern shore of the Magothy River. Another 45 square miles of recharge area is located in Prince George's County. According to the Scientific Investigations Report 2012-5165, water levels in the Aquia aquifer range from 50 feet above sea level to 157 feet below sea level in 2011 and declined by as much as 112 feet between 1982 and 2011. Groundwater withdrawals have increased from about 5 MGD in 1982 to over 15 MGD in 2010.

The Magothy formation is the principal source of water for the Annapolis area. This formation has an average thickness of 175 feet and has a recharge area of approximately 70 squares miles in the County and another 8 square miles in Prince George's County. The Magothy aquifer contains iron

concentrations at levels requiring treatment. Scientific Investigations Report 2012-5165 states that water levels in the Magothy aquifer range from 88 feet above sea level to 79 feet below sea level in 2011 and declined by as much as 85 feet between 1975 and 2011. Water withdrawal from the Magothy aquifer increased from about 7 MGD in 1975 to nearly 9 MGD in 2010. In 1974, the Maryland State Department of Natural Resources indicated that the Magothy aquifer is capable of yielding 60 MGD in the Annapolis area. However, the amount of water withdrawn must be properly managed to prevent the possibility of brackish water from the Chesapeake Bay or its tributaries from being induced into the aquifer.

Deposits of marine or estuarine terrace materials of Pleistocene age occur in Anne Arundel County along the Bay and Patuxent River. These deposits may be 50 feet thick. In addition to the artesian aquifers described in preceding paragraphs, unconfined aquifers, or water-table aquifers are also formed in shallow sediments. The recharge areas of the major aquifers also may provide a water source for shallow wells in Anne Arundel County.

More detailed descriptions of the aquifers and confining units as well as graphic depictions of the hydraulic properties, aquifer altitudes and cross sections can be obtained in Open File Report No. 12-02-20 Maryland Coastal Plain Aquifer Information System: Hydrogeologic Framework compiled by the Maryland Geologic Survey and the U. S. Geologic Survey, with funding support from the MDE in 2013. This report can be accessed at http://www.mgs.md.gov/publications/reports.html.

Groundwater Water Quality and Supply

No Federal or State standards have been established for raw ground water (in the ground). There are standards that apply to a public drinking water source, but these are applied within the water distribution system, not in the ground. However, there are regulations concerning discharge of pollutants that are administered by the Water Resources Administration of MDE.

Although the groundwater supply is not as vulnerable to decline due to drought, water levels in all of the confined aquifers supplying the County have been declining for several decades due to population growth and thus increases in use. Continued water level declines could affect the long-term sustainability of groundwater resources, particularly in areas projected for heavy growth. Several studies have been conducted to determine the availability and quality of water supply from the County's aquifers. These studies were conducted by the Maryland Geological Survey (MGS) in cooperation with the County.

A study of major well fields in the County (i.e. Arnold, Broad Creek) as well as individual wells (i.e. Stevenson Road) and independent well fields (i.e. Herald Harbor) assessed the potential effects of the increased withdrawals on water levels, the 80-percent management level and domestic-well operation using an updated and recalibrated groundwater-flow model (Andreasen, David C, 2017). Well fields in the Aquia aquifer are not included in this study. Currently there is sufficient available drawdown in the Upper Patapsco, Lower Patapsco, and Patuxent aquifer systems in Anne Arundel County to support withdrawals. To assess the effects of the projected withdrawals, the calibrated groundwater-flow model (MODFLOW developed by Andreasen (2007)) was altered to simulate conditions for the period 2017 to 2086. Results of the model simulation showed water levels as deep as 100, 170, and 228 feet below sea level in the Upper Patapsco, Lower Patapsco, and Patuxent aquifer systems respectively. Water levels were above the 80-percent management level in all well fields with the exception of the Upper

Patapsco aquifer system at Severndale. Sufficient supply capacity was available in the Lower Patapsco aquifer system at Severndale, however, to shift the Upper Patapsco withdrawals (0.4 MGD by 2086) to the Lower Patapsco. Seasonal variations in withdrawals at build-out have a negligible effect on water levels. Simulated water levels do not fall below either well-casing diameter reductions or well screens in domestic wells, which indicated that well operations will not be adversely affected.

Sufficient groundwater in the Patapsco and Patuxent aquifers is available to supply the projected demand through 2040 at 73 MGD while supplying water to other users in Anne Arundel County and the surrounding counties at permitted levels (Andreasen, David C., 2007). An increase in demand could result in water levels falling below the regulatory management levels in some areas, well operational problems, increased pumping costs and reduced stream base flow. Meeting the projected demand and minimizing impacts will require construction of new wells and well fields, redistributing withdrawals to other wells and careful well-field design. However, with the advent of revised water-use projections an updated assessment of potential impacts to the resource is needed. Additionally, the 2007 study did not evaluate the potential impacts to private domestic wells (i.e. water levels declining below pump intakes or below the depth to which pumps can be lowered in telescoping wells).

In some areas of southern Anne Arundel County, water levels are approaching or have exceeded the 80% management level due to the combination of increase in localized domestic use and large users in neighboring Calvert County (Andreasen, David C., 2002).

In March 2003, the Advisory Committee on the Management and Protection of the State's Water Resources was formed and charged with assessing the adequacy of existing resources to manage and protect the State's ground and surface water resources. The Advisory Committee's final report (Wolman, Gordon W. Chairman, July 2008) made the following recommendations:

1. Maryland must develop a more robust water resources program based on sound, comprehensive data.
    (a) Maryland faces new challenges in attempting to manage water sustainably.
    (b) Critical basic data must be obtained.
    (c) A Statewide water supply plan should be developed.
    (d) State and local governments should coordinate and plan regionally
2. The staffing, programmatic and information needs of the water supply management program must be adequately and reliably funded.
    (a) Establish a permit fee to fund the cost of administering the permitting system.
    (b) Fund the hydrologic studies with a separate appropriation.
    (c) Fund an expanded monitoring network.
    (d) Provide funding for local governments.
    (e) Improve the recruitment and retention of personnel.
3. Specific legislative, regulatory and programmatic changes should be implemented.
    (a) The State should take specific steps to promote collaborative local planning and to facilitate regional planning.

(b) MDE should codify its water allocation policies.

(c) The State should require local jurisdictions to protect source waters.

(d) State and local governments should strengthen their programs for water conservation, water reuse, and demand management.

(e) Maryland should strengthen the regulation of individual wells to better protect public health.

(f) State and local governments should discourage the use of individual wells in areas at high risk for well contamination.

(g) MDE should make greater use of Water Management Strategy Areas.

(h) The General Assembly should authorize administrative penalties for violations of water appropriation permits.

(i) Maryland should develop an effective water supply outreach program.

In response to preliminary recommendations made by the Advisory Committee in 2004, the Maryland Geological Survey and the U. S. Geological Survey developed a science plan for a comprehensive assessment to be used in allocating groundwater (Bolton, David W., Cleaves, Emery T., Gerhart, James M., Nardi, Mark R., and Shedlock, Robert J., 2007). The comprehensive assessment had five goals aimed at improving the current information and tools used to understand the resource potential of the aquifer system:

1. Document the geologic and hydrologic characteristics of the aquifer system in the Maryland Coastal Plain and appropriate areas of adjacent states;
2. Conduct detailed studies of the regional groundwater-flow system and water budget for the aquifer system;
3. Improve documentation of patterns of water quality in all Coastal Plain aquifers, including the distribution of saltwater;
4. Enhance groundwater-level, streamflow, and water-quality monitoring networks in the Maryland Coastal Plain; and
5. Develop science-based tools to facilitate sound management of the groundwater resources in the Maryland Coastal Plain.

Individual Wells

There are roughly 45,700 wells in the County serving individual homes. The primary sources of water to supply these domestic systems are the Patuxent, Patapsco, Magothy and Aquia aquifers. In addition, the Piney Point aquifer supplies a few individual wells.

The Anne Arundel County Department of Health administers a Sanitary Engineering Program that is responsible for reviewing and approving properties for the installation of private wells in the County. Services provided through this program include issuing construction permits, inspecting private wells, investigating illegal installations, and testing private well water. The Department of Health also administers a Well and Septic System Assistance Program that helps eligible homeowners pay all or part of the cost to repair or replace a failed septic system or private well.

Water Quality Problem Areas

The Anne Arundel County Department of Health has identified five (5) potential groundwater problem areas within the County (Figure 4). These problem areas are due to saltwater intrusion, elevated radium, elevated nitrate levels, volatile organic compounds (VOC's) and elevated arsenic and cadmium levels. The County Department of Health will monitor these areas and, if petitions are submitted for service within the areas, action will be taken accordingly and in conjunction with the Office of Planning and Zoning. The five groundwater problem areas and the requirements for new wells in these areas are discussed below.

Annapolis Neck Salt Water Intrusion

The Annapolis Neck area south of Black Walnut Creek toward the Chesapeake Bay and the South River is vulnerable to saltwater intrusion. New wells in this area are required to be drilled and grouted (sealed) into a confined aquifer, which is screened at a depth of no less than 270 feet and grouted to a depth of no less than 200 feet to avoid saltwater intrusion problems.

Gambrills Area – Elevated Nitrate Levels

Elevated nitrate levels have been detected in some private wells in the Gambrills area near the intersection of Annapolis Road (MD 175) and Crain Highway (MD 3), just east of the Horizons Farm (the recent U.S. Naval Academy Dairy Farm). The area of concern is shown in Figure 4. New wells in this area are required to be drilled and sealed into a confined aquifer below 140 feet in depth to avoid nitrate problems.

Northern Anne Arundel County – Elevated Radium

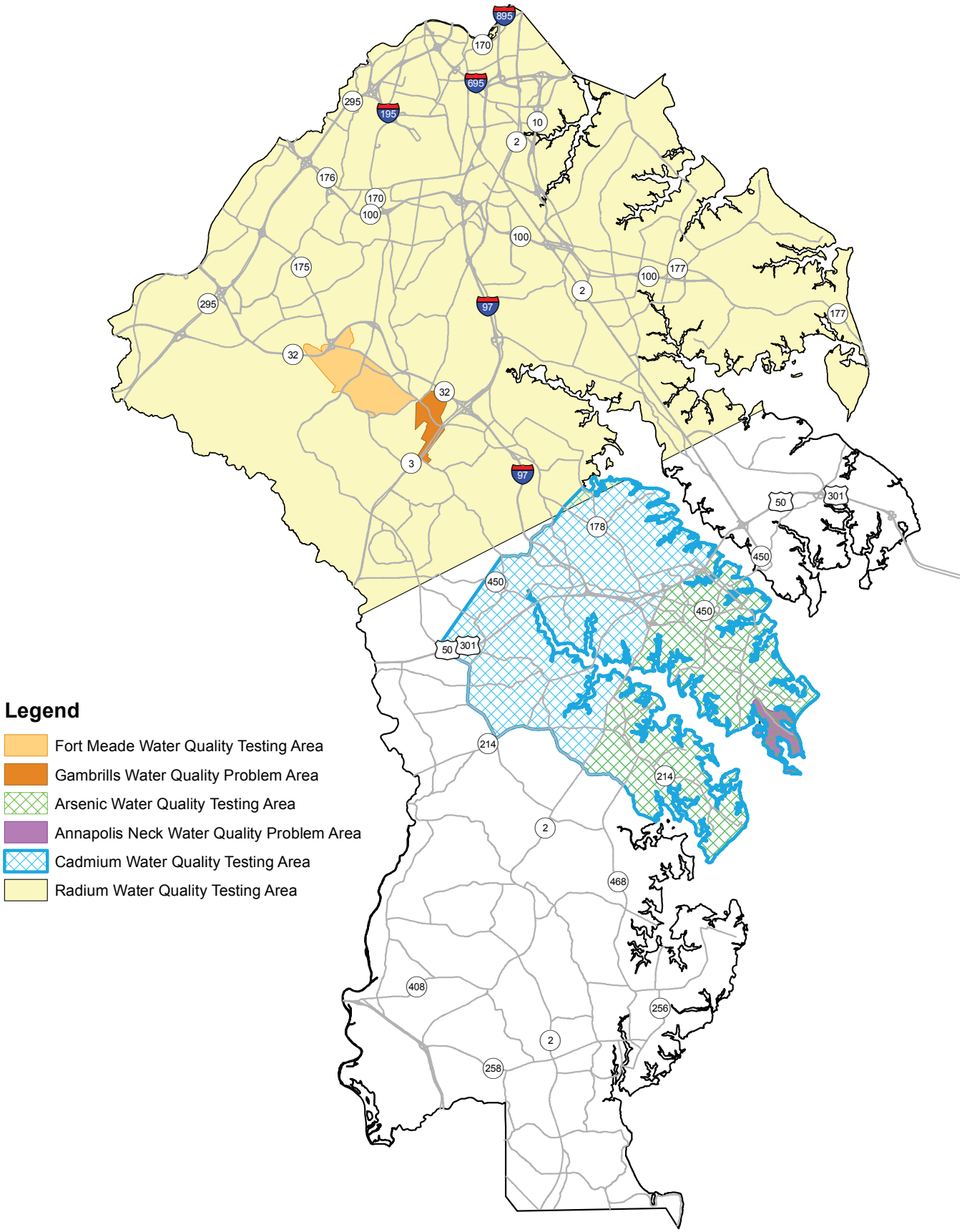
New and replacement wells in Northern Anne Arundel County are required to be installed to a minimum well depth and meet gross alpha and Radium 226 / 228 drinking water standards. The region within which wells are tested by the County for these parameters is shown in Figure 4.

A minimum well depth is determined by the Department of Health and is based on an aquifer with acceptable radionuclide concentrations. A computer model showing the distribution of radionuclide data, well depths, property elevations, and deep test wells is used to determine the minimum well depth requirements. Owners of existing private wells are encouraged to test for gross alpha particles. Where levels are found above the drinking water standards, a water treatment unit or a replacement well in a deeper aquifer is recommended. See Section 3.5.3.1.11 for more details on ongoing capital projects to reduce elevated radium in three SCWs in the Glen Burnie area.

Lower Patapsco Aquifer adjacent to Ft. Meade

A remedial investigation/feasibility study (RI/FS) identified three groundwater contaminant plumes within the Lower Patapsco Aquifer (LPA) that extends beyond the Fort Meade boundary and into an area beneath Odenton. The contaminants were identified as trichloroethene (TCE), tetrachloroethene (PCE) and carbon tetrachloroethene (CC14). To mitigate the impact on groundwater, a groundwater remediation system (GRS) was placed into service in March 2014. The GRS is estimated to take 25 years to restore the LPA to drinking water standards.

Figure 4: Water Quality Problem Areas



If a property is located within the LPA assessment area (the Fort Meade Water Quality Testing Area in Figure 4) and public water is not available, Appendix J of the RI/FS provides remedial alternatives for:

1. The continued use and long term monitoring (LTM) of existing potable wells within the LPA or an unknown aquifer and a point of entry treatment system (POET).
2. A risk evaluation for replacement wells in the Upper Patapsco Aquifer (UPA) and a water treatment device for radium where levels are found above the safe drinking water standard.
3. A property assessment for single lot and subdivision development in relation to the plumes and availability of public water.

As part of the RI/FS, the Army will perform a cost-benefit analysis every 5 years for LTM and operation and maintenance (O&M) of a POET system with the cost to extend public water where a cluster of three or more properties exist within the same geographic area. Where the LTM and O&M costs exceed the cost of extending public water, the Army must develop plans to extend public water within the 5-year LPA study assessment period. Extension of public water will follow the development of plans and will be limited to an impacted property or cluster of properties based on the cost benefit analysis.

The interim requirements for the construction of a replacement well in the UPA include the following:

1. The well must be drilled and sealed into the Upper Patapsco aquifer at a depth no greater than 200 feet below the land surface.
2. The annular space must be grouted from the gravel pack to the land surface and the gravel pack may not extend more than 5 feet above the well screen level.

Annapolis /Edgewater Peninsula – Presence of Elevated Arsenic and Cadmium

Wells drilled in this area may show a presence of Arsenic and Cadmium with levels that exceed the EPA maximum contaminant level (MCL). The presence of these chemicals occurs in wells drilled in the Aquia Aquifer. Any well drilled that exceeds the MCL for Arsenic must be re-drilled to a different depth. All new and replacement wells located specifically in the Saunders Point Community, must meet a minimum well depth of 300 feet. All other wells in the test area that exceed the MCL for Cadmium may be granted a Conditional Certificate of Potability with a water treatment system.

Public Water 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.

The County's public water supply system currently has 15 well fields that contain a total of 57 water supply wells and currently are permitted to produce up to 57.7 MGD (annual average) and 44.5 MGD (maximum day). In 2015, the County produced approximately 33.7 million gallons per day (MGD) (average day) and 43.0 MGD (max day) from groundwater sources while receiving 0.8 MGD (average day) and 2.8 MGD (max day) from Baltimore City. Agreements between Anne Arundel County and Baltimore City provide the rights for the County to purchase up to 32.5 MGD maximum day rate.

Additional details about the Baltimore City water system are available on their website or by contacting the City of Baltimore, Department of Public Works, Bureau of Water and Wastewater.

The County's 2016 Comprehensive Water Strategic Plan (CWSP) developed water demand projections for the planning period 2020, 2030 and for build-out conditions (estimated at 2087). A combination of zoning, population and employment growth forecasting, and current development were used to create detailed demand projections. The methodology incorporated flow factors by zoning, service area categories (Existing, Planned, Future, etc.) and population and household forecasting. Water billing data were used to create baseline demands and also to develop per capita water demands based on zoning type. The 2020 and 2030 projections include baseline demands, allocated flows from current development, and additional flows from projected population and employment growth based on service area timing categories. Buildout demands were based on zoning and flow factors. The projected future demands were assigned at a parcel level and applied to the WaterGEMs hydraulic model for analysis for baseline, 2020, 2030, and buildout scenarios in order to determine future infrastructure needs. Table 5 provides 2010 data based on billing records and the projected demand for annual average day, maximum day, and maximum day groundwater supply based on existing and future conditions.

Based on a review of a 2007 study by MGS related to available groundwater withdrawal from the Upper Patapsco, Lower Patapsco and Patuxent aquifers in the County, the 2016 CWSP recommended that any major investment in new supply sources be made only within the eastern or southern portions of the County. The approximate locations of the existing and future potential well fields are shown on Figure 5. Future potential well fields are summarized in Table 6.

The 2016 CWSP included detailed demand projections, a review of max day peaking factors for the system, storage gap analysis, an analysis of available groundwater supply, facility assessments, model validation, and hydraulic modeling using both steady state and extended period simulation. The 2016 CWSP developed baseline (existing 2010 demands), 2020, 2030 and buildout (2087) water demands for the County based on zoning projections. Using the Countywide hydraulic model WaterGEMs for the baseline demands, the study identified existing areas with high pipe velocities and headlosses as well as areas with minimum system pressures and where local fire flow improvements were recommended. The model was then used to analyze for the interim (2020 and 2030) and buildout periods. The analysis resulted in the sizing and siting of future system facilities including major transmission mains, pumping stations, water treatment facilities and storage facilities. For the buildout scenario, emphasis was placed on reducing reliance on the Baltimore City supply. The resulting recommended capital improvement projects (CIPs) were then used to develop a long term capital water development plan. Particular large-scale CIPs were phased over several years based on demand projections and capital budget limitations.

The 2016 CWSP identified the production facility infrastructure necessary for meeting expected growth while optimizing the use of potential County groundwater sources. The 2016 CWSP also identified locations throughout the County that were suitable for centralizing water production facilities in relation to where adequate groundwater resources are anticipated. The 2016 CWSP continued the efforts of the previous plans, providing greater reliability, building greater system flexibility by improving movement of water throughout the system, focusing plant expansion in areas with greater groundwater supply with the goal of reducing reliance on Baltimore City.

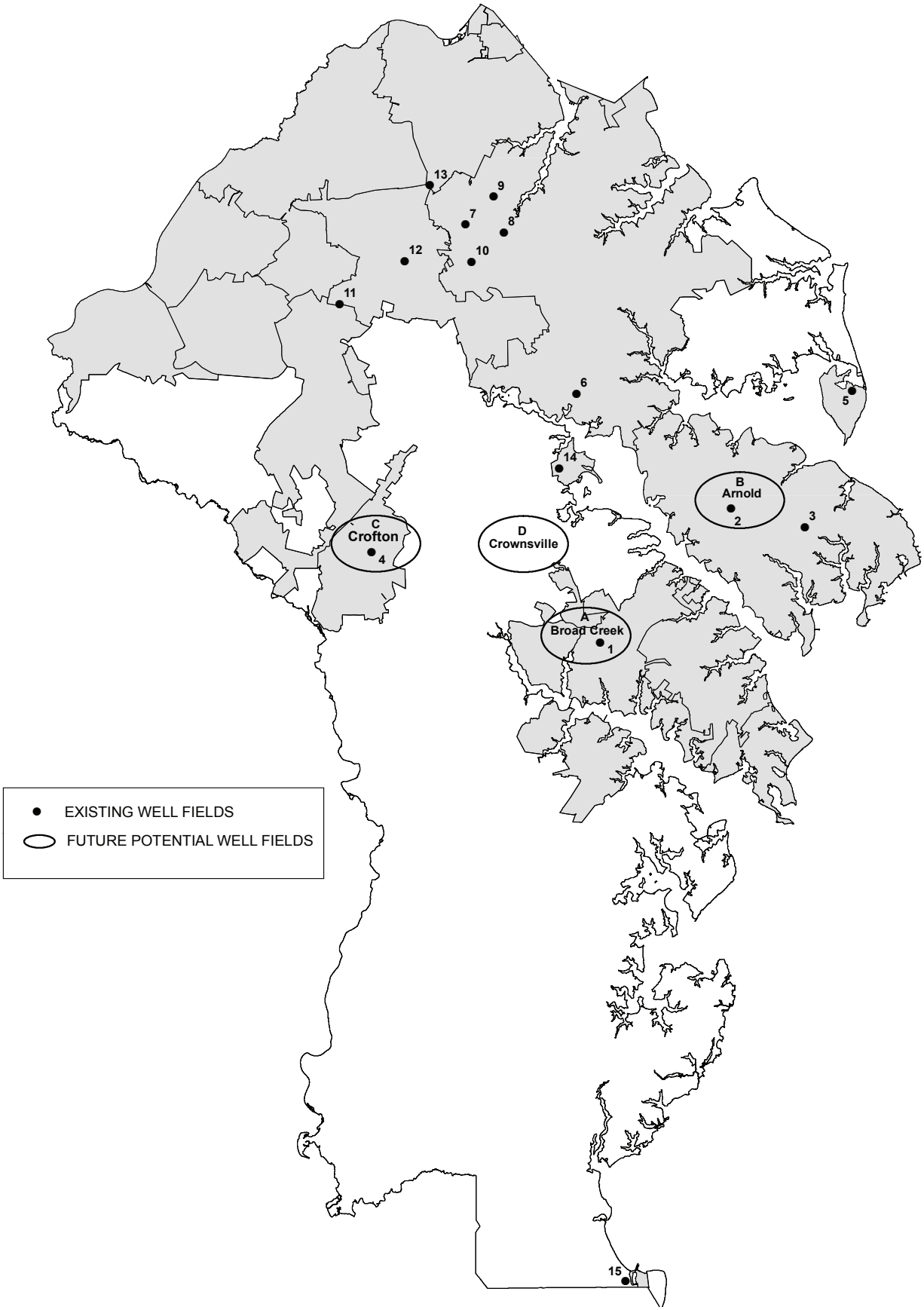
Table 5: Water Demand and Supply by Pressure Zone

Water Pressure Zone	2010 Demand (MGD)	Buildout Demand Annual Average Day (MGD)	Buildout Demand Maximum Day (MGD)	Maximum Day Groundwater Supply (MGD)
Airport Square	3.39	5.82	9.6	-
Broad Creek	2.3	5.93	11	11
Broadneck/Glen Burnie Low	12.3	24.45	39	36
Brooklyn Park	0.5	0.66	1.2	-
Croft on	1.8	2.92	3.9	28
Gibson Island	0.08	0.18	0.53	0.6
Glen Burnie High	4.48	10.22	16.3	-
Herald Harbor	0.13	0.28	0.56	0.6
Jessup	1.4	3.99	6.3	-
Maryland City	1.24	3.46	5.6	-
Kings Heights / Odenton	2.77	8.37	14.2	-
Rose Haven	0.03	0.08	0.19	0.3
Total	30.42	66.36	108.38	76.5

Table 6: Future Potenial Well Fields

Pressure Zones	Well Field (Fig. 6)	Well Field Name	Potential Average Daily Withdrawal (MGD)				
			Patuxent	Lower Patapsco	Upper Patapsco	Aquia	Total
Broad Creek (210 zone)	A	Broad Creek	0.9	3.3	2.7		6.9
Broadneck (220 zone)	B	Arnold		10.1	7.5		17.5
Crofton (290 zone)	C	Crofton Meadows	6	11.5			17.5
Gibson Island (160 zone)	5	Gibson Island			0.2		0.2
Glen Burnie Low (220 zone)	6	Severndale		4	0.4		4.4
Herald Harbor (240 zone)	14	Herald Harbor		0.3			0.3
Rose Haven (120 zone)	15	Rose Haven				0.1	0.1
Multiple Zones (via future Millersville	D	Crownsville (remote)	12	8			20
Total			18.9	37.2	10.8	0.1	66.9

Figure 5: Existing and Potential Well Fields



Other Water Supply Systems

There are over 530 wells in the County that are operated privately or by a non-County entity. The source of water for these wells is the Patuxent, Patapsco, Magothy and Aquia aquifers. These facilities typically maintain their own water treatment facilities. They are regulated by the Environmental Protection Agency who categorizes the wells into three types:

1. Community Water Systems (CWS) – those systems that serve the same people year-round such as mobile home parks or businesses,
2. Non-Transient Non Community Water Systems (NTNC) – those systems that serve the same people but not year-round such as schools, and
3. Transient Non-Community Water Systems (TNCWS) – those systems that do not consistently serve the same people such as parks, restaurants and gas stations.

Wastewater Demand and Supply

Eleven separate and distinct sewer service areas have been established for the purpose of providing sewerage facilities to serve Anne Arundel County. Figure 6 is a map that shows sewer service within the County. The areas that are depicted as 'Existing', 'Capital Facilities', 'Planned' and 'Future' comprise the ultimate area to be served by public sewer. There are some facilities that are privately operated, such as B.W.I. Airport, the US Naval Academy and Fort Meade. These facilities are shown as 'Other'. The remaining land is shown as 'No Public Service'. It is designated as Rural, is not planned for service by public sewer facilities and is or will be served by septic systems.

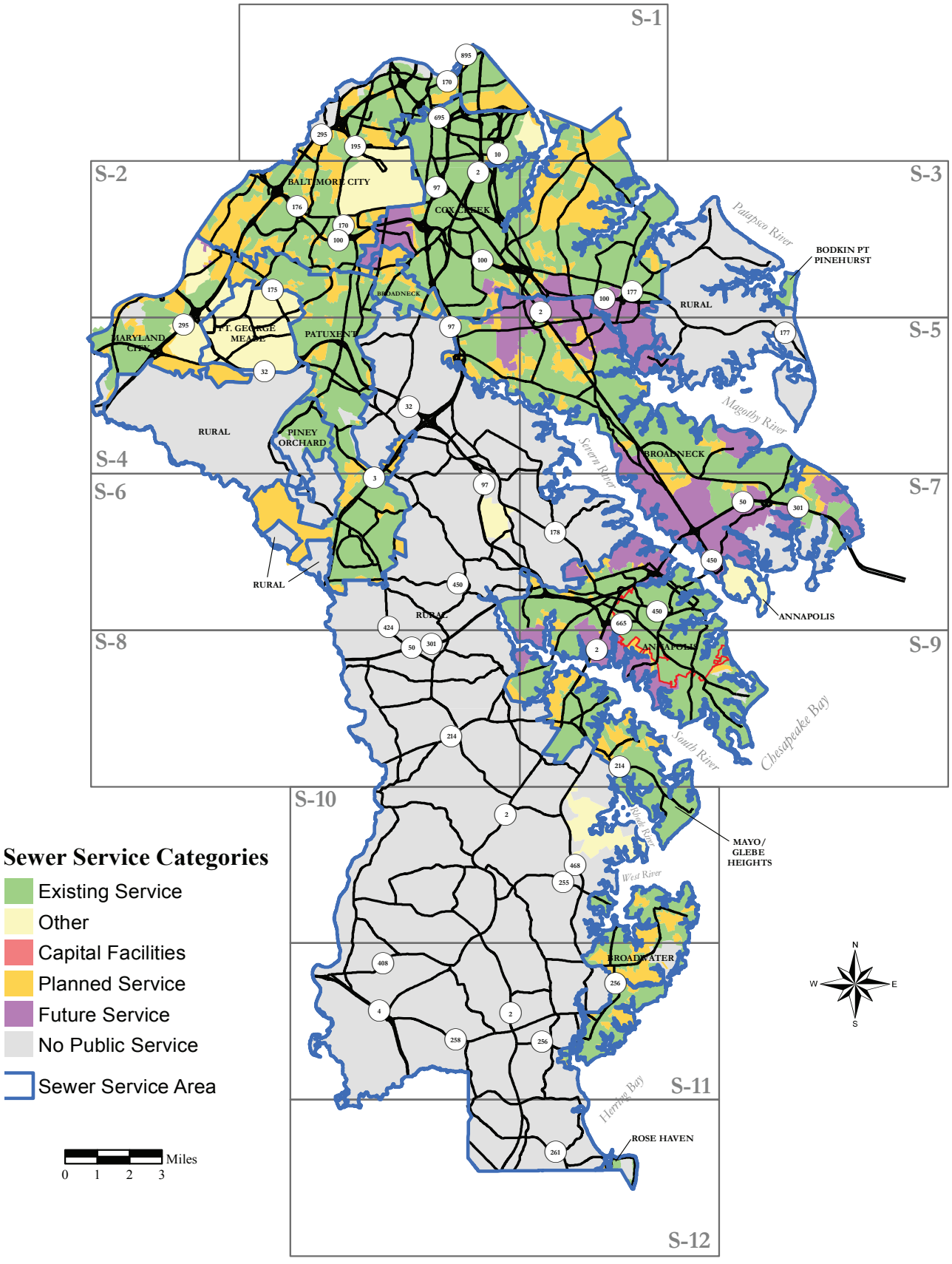
Public Sewer

According to the 2017 Water and Sewer Master Plan, the ultimate area to be served by public sewer is approximately 50% of the County. Of the eleven sewer service areas, eight are served by facilities owned and operated by the County. Two of the service areas have conveyance systems that are operated and maintained by the County but the treatment facilities are located in neighboring jurisdictions. Intra-jurisdictional agreements permit the transport of wastewater from the Baltimore City Sewer Service Area to the Patapsco Sewage Treatment Plant in Baltimore City and from the Rose Haven / Holland Point Sewer Service Area to the Chesapeake Beach Wastewater Treatment Plant in Calvert County. The Piney Orchard Sewer Service area has a privately owned and operated treatment facility; however, the collection system is owned and maintained by the County. There are over 119,000 public sewer connections and approximately 34.5 MGD (2015 total flow) are treated. The projected total flow at build-out is 71.42 MGD assuming full development of all property in the sewer service area at current zoning.

Septic Systems

Anne Arundel County has 38,708 septic systems serving residential properties, and 2,318 serving non-residential properties for a total of 41,026 septic systems (total number of OSDS from Health's Department Inventory, February 2018). A little more than half of these systems are located in the area designated for No Public Service on the County's sewer service maps. The remaining 19,192 systems are located in the area ultimately to be served by public sewer (Existing, Planned, and Future sewer service categories). Figure 7 presents the OSDS density by watershed.

Figure 6: Anne Arundel 2017 Sewer Service Areas



Spatial and data analyses were conducted using the County GIS information, for all management areas. The management area was defined as a service area that would have the same treatment approach recommended for each OSDS within the area (Figure 8). Each management area was evaluated to determine the effectiveness of four treatment approaches and divided into the following:

1. Sewer System extensions with treatment at existing centralized wastewater reclamation facilities upgraded for enhanced nutrient removal,
2. Cluster wastewater treatment facilities,
3. Upgrade each individual OSDS to an enhanced OSDS, and
4. No near-term action, which consists of low-density, low-nitrogen delivery onsite systems.

Using Maryland Department of the Environment's (MDE's) criteria regarding the delivery ratio (DR) of nitrogen to the receiving water (as a function of the septic system's distance to surface water), it is estimated that septic systems in the County annually contribute approximately 700,000 lbs of TN/ year to the Chesapeake Bay Watershed. For the computations, it was assumed that residential systems use 195 gpd and non-residential systems use 1,300 gpd with the Total Nitrogen Load per OSDS for residential systems estimated to 23.2 lbs/year* Delivery Ratio (DR).

Given the significant reduction associated with connecting to public sewer systems, the County is evaluating cost/benefit analysis to determine an appropriate strategy. In analyzing these different treatment methods, it was recognized that OSDS equipped with denitrifying systems can reduce the nitrogen load from 40 mg/l to 20 mg/l, while connection to ENR upgraded WRF's reduces the nitrogen load down to 4 mg/l.

To assist in the development and implementation of an OSDS conversion program, the County initiated a Septic Task Force 2017. The Septic Task Force was completed at the end of 2017 and had four overall goals:

1. Develop a suite of recommendations that will inform decision making
2. Identify near-term strategies to support effort
3. Identify long-term strategies and approaches
4. Identify areas requiring additional investigation for County Staff

The County also procured in 2017 the services of a consultant team to serve as the OSDS Conversion Program Manager. The OSDS Conversion Program Manager is a multi-disciplinary team that will provide a coordinated effort to assist Anne Arundel County in the development, implementation and execution of the OSDS Conversion Program. Such services include, but may not be limited to, planning, budgeting, public outreach, program monitoring, and public policy analysis related to the needs of the program.

Figure 7: Anne Arundel County Septic Density

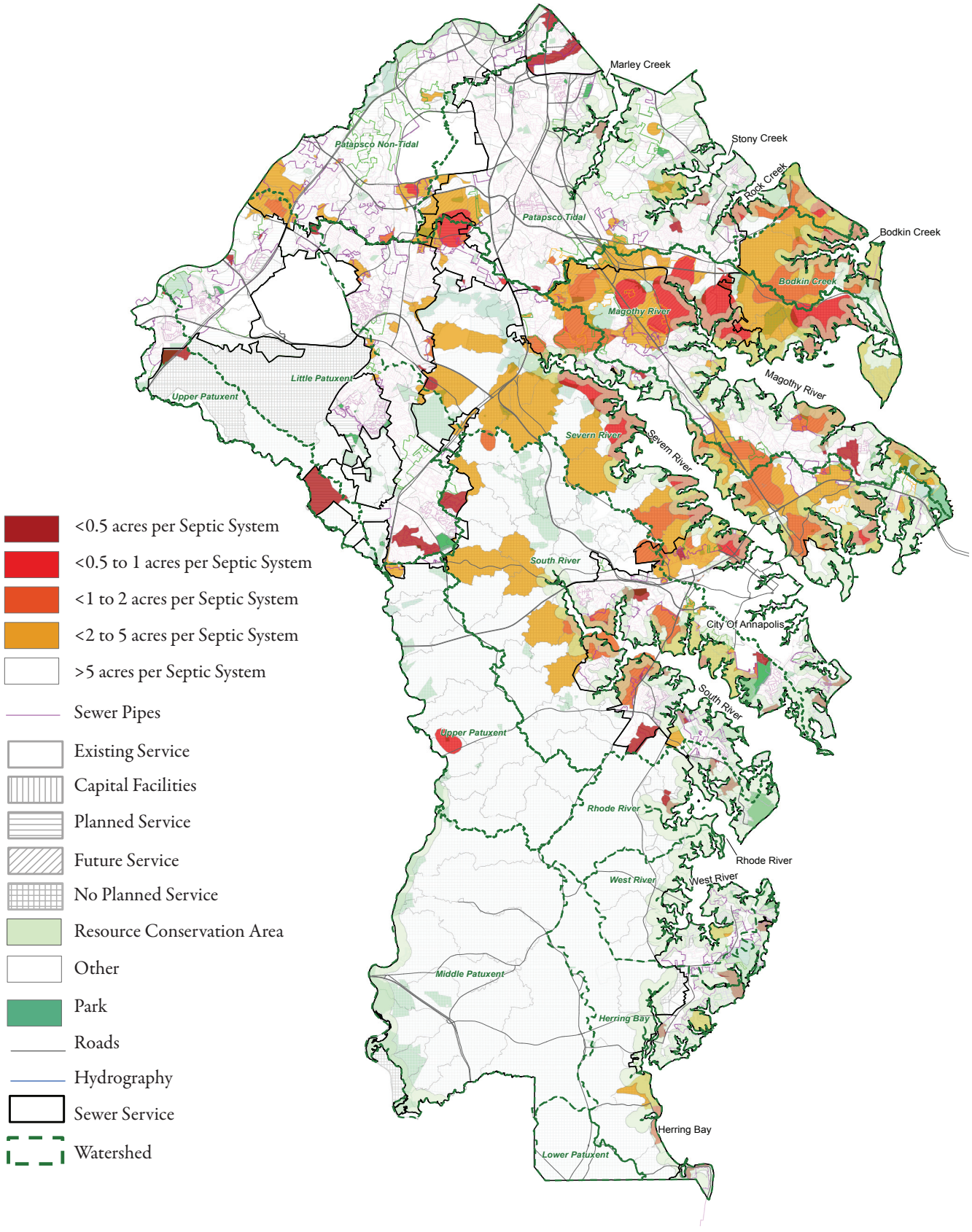
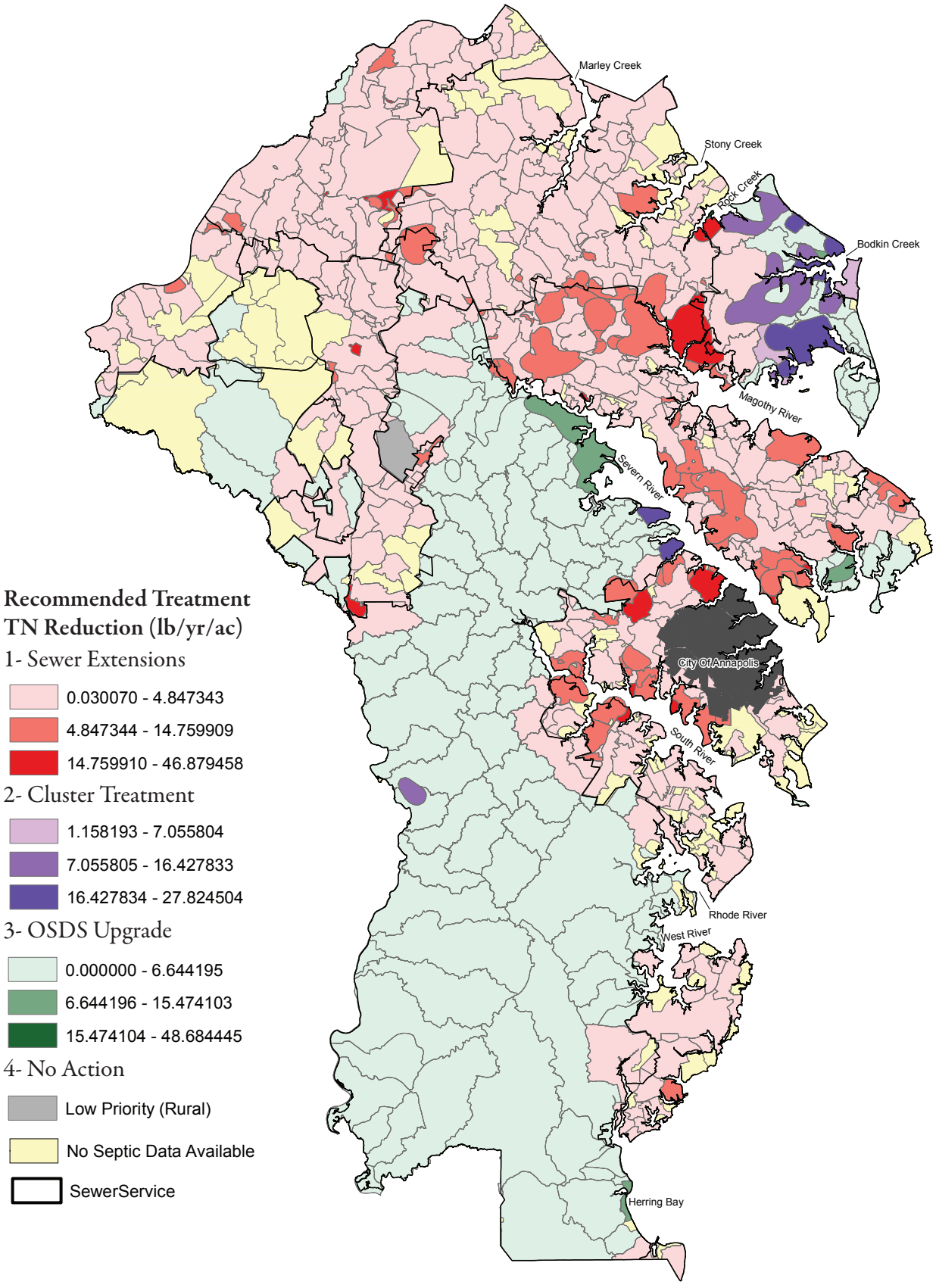


Figure 8: Anne Arundel OSDS Management Areas with Treatment Applied



Current and Projected Pollutant Loads

Wastewater Treatment Plant Loads

The current total design capacity of the County's wastewater treatment plants with BNR upgrades is 46.64 MGD. The maximum total capacity based on the nutrient caps with the ENR upgrades is 62.68 MGD.

Tables 7 and 8 provide the current and build-out nitrogen and phosphorus pollutant loads for each of the water reclamation facilities. The projected build-out wastewater flows assume full development of all property in the sewer service area at current zoning.

In the Broadneck, Cox Creek, Patuxent and Maryland City sewer service areas, the build-out flows exceed the WRF's permitted capacity. The County anticipates that during the planned expansions of these facilities, TMDL requirements will result in more stringent NPDES Permit limits thereby requiring costly facility upgrades. These upgrades will decrease available acreage at each WRF plant site. In order to support planned growth and accommodation of the TMDL regulations, the County is investigating alternatives at those WRF sites with restricted acreage to redirect existing and future flows to service areas where facility sites can best support future upgrades and meet loading requirements. In the event that feasible alternatives cannot be identified or the advancement of treatment technologies lags, the TMDL regulations could restrict future land use and could conflict with Smart Growth initiatives.

Septic System Loads

Nitrogen loads were calculated for all existing OSDS Countywide without a treatment strategy and with a chosen treatment strategy. The treatment strategies used were: sewer system extensions, cluster treatment facilities, enhanced onsite septic disposal systems, or no action, and were based on the most cost-effective strategy identified in the study for each of the OSDS management areas in each watershed. Table 9 shows these nitrogen loads at a subwatershed scale. Build-out conditions without treatment based on land cover and zoning and also using a treatment strategy were also calculated. As can be seen, implementation of the various treatment strategies from the OSDS Study can result in significant nitrogen load reductions.

Nonpoint Source Loads

Pollutant loadings from nonpoint source runoff were estimated by the County for use in preparing its Watershed Management Plans and Targeted Nutrient Reduction Implementation Plans. Nonpoint source nutrient loads were estimated for existing and build-out conditions using the Watershed Management Tool and the County's 2014 land cover layer. Build-out conditions are based on the more intense use of either existing conditions or the maximum allowable development density under current zoning. The nitrogen and phosphorus loads under both conditions are shown in Table 10 for each watershed in the County.

New development projects in the County are designed to meet Maryland's current regulatory requirements and will mimic the natural hydrology of forested conditions. Current Maryland regulations require that ESD be used to the maximum extent practicable to reduce the runoff from new development and replicate the hydrologic characteristics of forested conditions. To meet this

requirement on a new development project, ESD practices must be used either exclusively or, where necessary, in combination with structural practices to provide sufficient treatment and reduce the volume of runoff from the 1-year, 24-hour design storm. For new development projects, this standard is based on the median value of the one-year storm for Maryland, or 2.7 inches of rainfall. It should be noted that the current standard for redevelopment is either to remove impervious cover or to capture and treat the runoff from one inch of rainfall from at least fifty percent of the existing impervious area within the project LOD. For most redevelopment designs, the resultant runoff depth should be close to one inch for fifty percent of the existing impervious area.

As previously discussed, the County will continue to study the potential reductions in these nutrient loads that can be achieved using a variety of alternatives such as enhanced stormwater management BMPs or stream buffers in order to determine the most cost-effective strategies for nutrient reduction.

Combined Pollutant Loads

The combined pollutant loads in the three major tributary watersheds for the current conditions, buildout conditions without treatment, and build-out conditions with treatment are shown in Tables 11 and 12 and in Figures 9 and 10. In this summary, the 'build-out conditions with treatment" loads assume that wastewater treatment plant upgrades to ENR standards and the OSDS Study recommendation strategies for septic systems have been implemented. As seen, implementation of these improvements will result in significant reductions in nitrogen loads from septic systems and from wastewater treatment plants in all watersheds, with the most significant reductions attributed to the OSDS septic system strategies. Combined phosphorus loads will also decrease due to the reduction in WWTP point source loads resulting from the ENR upgrades. The tables indicate no change in stormwater runoff nutrient loads without treatment versus with treatment because these scenarios have not been modeled countywide at this time, but as the County completes its modeling studies to assess the impact of nonpoint source runoff treatment alternatives, this information can be factored into this analysis.

Table 7: Wastewater Treatment Plants Nitrogen (TN) Pollutant Loads

	2017 Total Flows MGD			Current Design Capacity			Increase from 2017 Total Flow to reach Build-out		Additional Capacity Required to reach Build-out		Build Out			Future Design Capacity (With ENR)		
Facility/SSA	MGD	Current TN (mg/L)	TN (lbs/Yr)	MGD	Current TN (mg/L)	TN (lbs/Yr)	MGD	TN (lbs/Yr)	MGD	TN (lbs/Yr)	MGD	TN with ENR (mg/L)	TN (lbs/Yr)	MGD	TN with ENR (mg/L)	TN (lbs/Yr)
Broadneck	5.31	2.7	43,600	6.00	2.7	49,300	8.44	82,000	7.75	76,300	13.75	3.0	125,600	8.00	3.0	73,058
Annapolis (ENR 6/15)	8.72	2.6	69,000	13.00	2.6	102,900	6.29	68,100	2.01	34,200	15.01	3.0	137,100	17.33	3.0	157,989
Mayo-Glebe Heights (Abandoned)	0.57	12.8	22,200	0.64	12.8	24,900	0.57	-11,800	0.50	-14,500	1.14	3.0	10,400	0.85	3.0	7,762
Broadwater (ENR 7/15)	1.24	1.3	4,900	2.00	1.3	7,900	1.34	18,700	0.58	15,700	2.58	3.0	23,600	2.67	3.0	24,383
Chesapeake Beach	0.75	3.9		1.50	3.9						N/A			N/A		
County Portion-Rose Haven	0.10	3.9	1,200	0.14	3.9	1,600	0.10	600	0.06	200	0.20	3.0	1,800	0.14	3.0	1,256
Total Western Shore	**15.37**		**118,700**	**21.14**		**161,700**	**16.17**	**169,400**	**10.40**	**126,400**	**31.54**		**288,100**	**28.14**		**256,686**
Maryland City (ENR 12/14)	1.20	2.5	9,100	3.30	2.5	25,100	2.50	24,700	0.40	8,700	3.70	3.0	33,800	3.33	3.0	30,441
Patuxent (ENR 9/15)	5.68	1.6	27,700	7.50	1.6	36,500	8.13	98,400	6.31	89,600	13.81	3.0	126,100	10.50	3.0	95,889
Piney Orchard	0.57	2.8	4,900	0.70	2.8	6,000	0.36	3,600	0.23	2,500	0.93	3.0	8,500	0.93	3.0	8,523
Total Patuxent	**7.45**		**41,700**	**11.50**		**67,600**	**10.99**	**126,700**	**6.94**	**100,800**	**18.44**		**168,400**	**14.76**		**134,854**
Patapsco	48.70	22.9		73.00	22.9						N/A			N/A		
County Portion-Baltimore City	4.49	22.9	312,500	6.39	22.9	444,700	5.51	-221,200	3.61	-353,400	10.00	3.0	91,300	6.39	3.0	58,355
Cox Creek (ENR 12/17)	11.97	9.0	327,900	15.00	9.0	411,000	10.60	-121,800	7.57	-204,900	22.57	3.0	206,100	20.00	3.0	182,646
Bodkin Point	0.01	40.0	700	0.01	40.0	700					0.09	40.0	8,800	0.01	40.0	700
Total Patapsco/Back	**16.47**		**641,100**	**21.40**		**856,400**	**16.19**	**-334,900**	**11.26**	**-550,200**	**32.66**		**306,200**	**26.40**		**241,701**
County Flow within County:	**39.29**		**801,500**	**54.03**		**1,085,700**	**43.35**	**-38,800**	**28.61**	**-323,000**	**82.64**		**762,700**	**69.30**		**633,241**

Notes:
Data from Table 4-2 and 4-6 of the 2017 Master Plan for Water Supply and the Sewerage Systems and September 2017 Allocation Report. Load for Bodkin Point systems based on typical septic system effluent 40 mg/L using design capacity with an 80% Delivery Ratio. Baltimore City, Piney Orchard, Rose Haven/ Holland Point are operated by other jurisdictions or entities. Data for these facilities was provided by them. Mayo-Glebe WRF has been abandoned. A determination needs to be made as to where nutrient loading will be assigned. Prepared by: George Albright. DPW Utility Planning Section-3/26/18

Table 8: Wastewater Treatment Plants Phosphous (TP) Pollutant Loads

	2017 Total Flows MGD			Current Design Capacity			Increase from 2017 Total Flow to reach Build-out		Additional Capacity Required to reach Build-out		Build Out			Future Design Capacity (With ENR)		
Facility/SSA	MGD	Current TN (mg/L)	TP (lbs/Yr)	MGD	Current TP (mg/L)	TP (lbs/Yr)	MGD	TP (lbs/Yr)	MGD	TP (lbs/Yr)	MGD	TP with ENR (mg/L)	TP (lbs/Yr)	MGD	TP with ENR (mg/L)	TP (lbs/Yr)
Broadneck	5.31	0.10	1,600	6.00	0.10	1,800	8.44	7,800	7.75	7,600	13.75	0.23	9,400	8.00	0.23	5,601
Annapolis (ENR 6/15)	8.72	0.28	7,400	13.00	0.28	11,100	6.29	2,900	2.01	-800	15.01	0.23	10,300	17.33	0.23	12,112
Mayo-Glebe Heights (Abandoned)	0.57	0.75	1,300	0.64	0.75	1,500	0.57	-500	0.50	-700	1.14	0.23	800	0.85	0.23	595
Broadwater (ENR 7/15)	1.24	0.13	500	2.00	0.13	800	1.34	1,300	0.58	1,000	2.58	0.23	1,800	2.67	0.23	1,869
Chesapeake Beach	0.75	0.40		1.50	0.40						N/A			N/A		
County Portion-Rose Haven	0.10	0.40	100	0.14	0.40	200	0.10		0.06	-100	0.20	0.23	100	0.14	0.23	94
Total Western Shore	**15.37**		**9,600**	**21.14**		**13,900**	**16.17**	**12,000**	**10.40**	**7,700**	**31.54**		**21,600**	**28.14**		**19,676**
Maryland City (ENR 12/14)	1.20	0.11	400	3.30	0.11	1,100	2.50	2,100	0.40	1,400	3.70	0.23	2,500	3.33	0.23	2,331
Patuxent (ENR 9/15)	5.68	0.13	2,200	7.50	0.13	3,000	8.13	7,300	6.31	6,500	13.81	0.23	9,500	10.50	0.23	7,352
Piney Orchard	0.57	0.05	100	0.70	0.05	100	0.36	500	0.23	500	0.93	0.23	600	0.93	0.23	639
Total Patuxent	**7.45**		**2,700**	**11.50**		**4,200**	**10.99**	**9,900**	**6.94**	**8,400**	**18.44**		**12,600**	**14.76**		**10,322**
Patapsco	48.70	0.88		73.00	0.88						N/A			N/A		
County Portion-Baltimore City	4.49	0.88	12,000	6.39	0.88	17,100	5.51	-5,200	3.61	-10,300	10.00	0.23	6,800	6.39	0.23	4,377
Cox Creek (ENR 12/17)	11.97	0.74	27,000	15.00	0.74	33,800	10.60	-11,500	7.57	-18,300	22.57	0.23	15,500	20.00	0.23	14,003
Bodkin Point			N/A			N/A							N/A			N/A
Total Patapsco/Back	**16.46**		**39,000**	**21.39**		**50,900**	**16.11**	**-16,700**	**11.18**	**-28,600**	**32.57**		**22,300**	**26.39**		**18,380**
County Flow within County:	**39.28**		**51,300**	**54.03**		**69,000**	**43.27**	**5,200**	**28.52**	**-12,500**	**82.55**		**56,500**	**69.29**		**48,378**

Notes:
Data from Table 4-2 and 4-6 of the 2017 Master Plan for Water Supply and the Sewerage Systems and September 2017 Allocation Report. Load for Bodkin Point system based on typical septic system assumed to be near 0 for TP. Baltimore City, Piney Orchard, Rose Haven/ Holland Point are operated by other jurisdictions or entities. Data for these facilities was provided by them. Mayo-Glebe WRF has been abandoned. A determination needs to be made as to where nutrient loading will be assigned. Prepared by: George Albright. DPW Utility Planning Section-3/26/18

Table 9: Nitrogen Loads for Existing and Future Conditions for Septic Systems

Watershed	Area	Existing Conditions	Existing Conditions w/ Treatment	Existing Conditions w/o Treatment	Build-Out Conditions w/ Treatment
	(Acres)	TN (lbs/year)	TN (lbs/year)	TN (lbs/year)	TN (lbs/year)
Severn River	44,248	203,898	72,802	236,486	92,874
South River	36,167	99,524	34,722	111,887	42,041
Magothy River	22,845	153,513	37,098	171,527	47,393
Rhode River	8,764	7,010	3,246	8,177	3,898
West River	7,297	6,089	2,444	8,466	3,748
Herring Bay	14,662	17,383	7,470	27,363	12,888
Total Western Shore	**133,983**	**487,418**	**157,782**	**563,905**	**202,842**
Upper Patuxent River	22,551	29,476	11,665	32,370	13,634
Middle Patuxent River	29,632	33,256	16,822	44,552	22,791
Little Patuxent River	27,750	19,681	5,598	21,224	7,294
Total Patuxent	**79,933**	**82,413**	**34,085**	**98,146**	**43,719**
Patapsco Tidal	30,841	56,926	14,633	60,193	16,863
Patapsco Non-Tidal	15,275	26,556	6,449	26,581	6,598
Bodkin Creek	5,036	42,920	11,464	57,116	19,920
Total Patapsco/Back	**51,152**	**126,402**	**32,546**	**143,890**	**43,381**

Table 10: Stormwater Nitrogen (TN and Phosporous (TP) Pollutant Loads

Watershed	Area	Existing Conditions			Build-Out Conditions			Percent Departure from Existing Conditions		
	Acres	TN (lbs)	TP (lbs)	Impervious (Acres)	TN (lbs)	TP (lbs)	Impervious (Acres)	TN (lbs)	TP (lbs)	Impervious (Acres)
Severn River	44,248	233,343	30,672	8,825	265,074	32,012	10,302	14%	4%	17%
South River	36,167	171,624	23,049	4,741	189,866	23,819	5,923	11%	3%	25%
Magothy River	22,845	128,337	17,058	4,706	145,679	17,790	5,631	14%	4%	20%
Rhode River	8,764	29,784	3,966	551	31,925	4,057	695	7%	2%	26%
West River	7,297	30,637	4,195	499	32,639	4,280	650	7%	2%	30%
Herring Bay	14,662	52,073	7,065	955	56,500	7,252	1,437	9%	3%	51%
Upper Patuxent	22,551	84,465	11,343	1,526	90,816	11,611	2,062	8%	2%	35%
Middle Patuxent	29,632	121,737	16,723	1,445	127,411	16,962	1,842	5%	1%	27%
Little Patuxent	27,750	127,547	16,066	4,875	145,771	16,835	5,917	14%	5%	21%
Patapsco Tidal	30,841	192,465	30,960	9,135	225,382	32,349	10,687	17%	4%	17%
Patapsco Non-Tidal	15,275	94,801	11,791	4,401	110,800	12,467	5,195	17%	6%	18%
Bodkin Creek	5,036	22,025	2,895	653	24,686	3,007	864	12%	4%	32%

Notes:

1. Watershed and Total area in acres (rounded off)
2. Existing Conditions is based on 2014 land cover impervious data
3. Existing Conditions treatment by existing BMPs
4. Loading from septic systems is not included.
5. Wetlands, floodplains, Utility Right-of-Way, Road Right of Way, Schools and Parks, and stream buffers were not allowed to be developed in the future.
6. Full-build out is based on more intense use of either the existing condition or zoning
7. Build-out conditions loads assume ESD to maximum extent practicable implementation and loads treated to wooded conditions
8. Loads calculated using EMC values and EPA simple method

Table 11: Combined Nitrogen Pollutant Loads (lbs/yr)

Combined Nitrogen Pollutant Loads (lbs/yr)									
Tributary	Existing Conditions			Build Out Conditions without Treatment			Build Out Conditions with Treatment		
	Storm	Septic	WWTP	Storm	Septic	WWTP	Storm	Septic	WWTP
Total Western Shore	645,798	487,418	118,700	721,683	563,905	288,100	721,683	202,842	256,686
Total Patuxent	333,749	82,413	41,700	363,998	98,146	168,400	363,998	43,719	134,854
Total Patapsco /Back	309,291	126,402	641,100	360,868	143,890	306,200	360,868	43,381	241,701

Table 12: Combined Phosphorus Pollutant Loads (lbs/yr)

Combined Nitrogen Pollutant Loads (lbs/yr)									
Tributary	Existing Conditions			Build Out Conditions without Treatment			Build Out Conditions with Treatment		
	Storm	Septic	WWTP	Storm	Septic	WWTP	Storm	Septic	WWTP
Total Western Shore	86,005	0	9,600	89,210	0	21,600	89,210	0	19,676
Total Patuxent	44,132	0	2,700	45,408	0	12,600	45,408	0	10,322
Total Patapsco /Back	45,646	0	39,000	47,823	0	22,300	47,823	0	18,380

Figure 9: Combined Nitrogen Pollutant Loads (lb/yr)

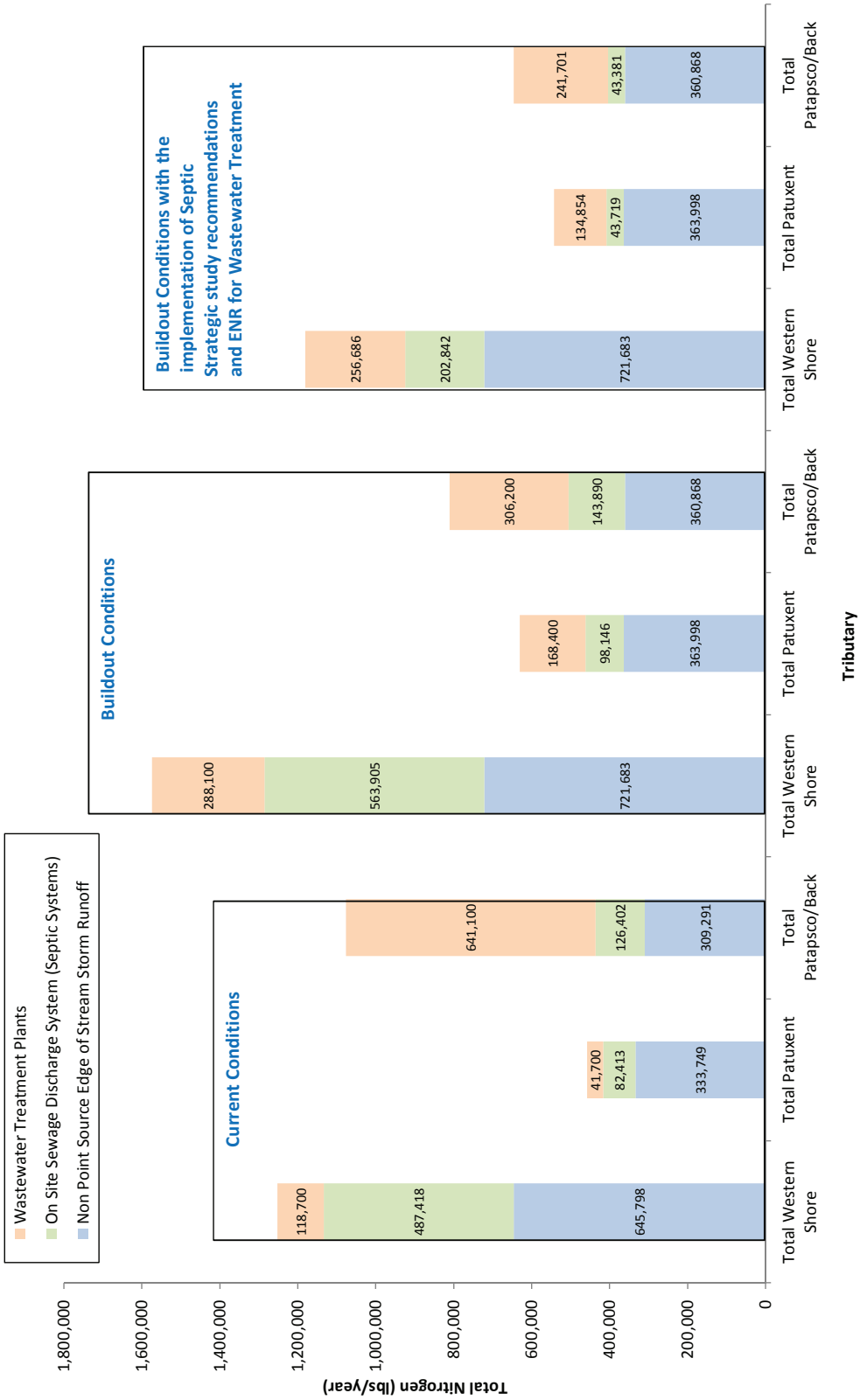
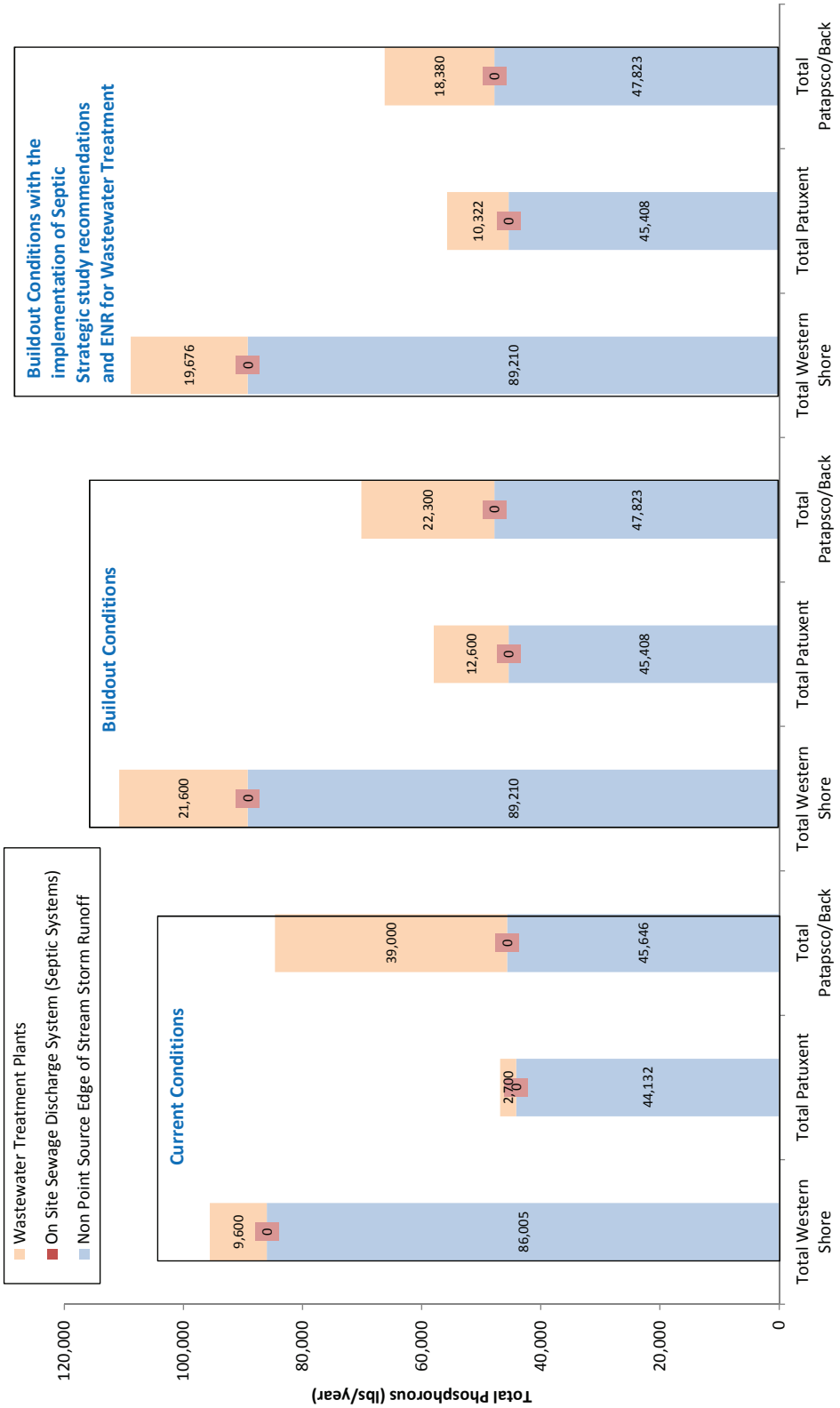


Figure 10: Combined Phosphorus Pollutant Loads (lb/yr)



Conclusions and Future Needs

Protection of the Chesapeake Bay and its tributaries will continue to be a State and regional priority in the future. To this end, local governments are now tasked with developing better methods for integrating water resources planning, policies and strategies into their overall comprehensive planning programs. As seen in this report, Anne Arundel County already has in place a wide range of plans, programs and regulations that contribute either directly or indirectly to the goal of water resource protection, and with the development of its Watershed Management Tool, the County now has an in-house capability to do watershed management planning at a technically sophisticated level. The challenge for the future will be to use these capabilities in developing sound land use and environmental policies and strategies to accomplish the County's goals in the most efficient and cost-effective manner.

In terms of planning for future growth, the potential constraints with regard to water supply are the adequacy of groundwater resources to serve additional growth in southern Anne Arundel County, and the ability to continue to purchase water from the City of Baltimore over the long term. The County has optimized the use of its public water supply wells effectively, and has identified potential locations for new well fields, so that future deficiencies in the public water supply are not likely to occur on a long-term basis, although short-term situations related to drought conditions can periodically occur.

The long-term adequacy of groundwater resources is a regional issue that will be closely monitored by the State, and local jurisdictions must coordinate with State and regional efforts to plan for long-term stability. Southern Anne Arundel County is part of the County's designated Rural Area, and large-scale or high-density development projects are not planned there. Still, there is additional development potential for rural density residential development that would be served by private individual wells. Therefore, the County will continue to participate in regional planning efforts to monitor and protect groundwater resources that serve that area as well as the entire County.

Future development potential utilizing public sewer within the sewer service areas is limited by the hydraulic capacity of the water reclamation facilities and regulatory nutrient caps. Based on the results of the AACO Flow Projection Tool, the hydraulic capacity of the Baltimore City SSA (determined by agreement with Baltimore City) and of the Cox Creek WRF will be reached or exceeded by 2035. Additionally, all of the service areas except for the Baltimore City SSA, Annapolis SSA and the Broadwater SSA could exceed the established nutrient cap limitations. Future land use plans should take into consideration these limitations to sewer capacity. The existing public sewer system is sized and was constructed based on the 2009 GDP planned land use and zoning. Upgrades to pipes and facilities will be required to accommodate new development that occurs at increased densities in certain areas.

The key needs the County should focus on over the planning horizon are:

1. Complete ENR upgrades at Water Reclamation Facilities per MOU agreement with MDE,
2. Determine the ability to increase treatment capacities at Water Reclamation Facilities using the "bubble permit" concept,
3. Develop a short and long-term strategic plan for implementing the recommendations from the OSDS Study to address problem septic areas, based on the priorities identified in that study for addressing first those areas that are potentially generating the most significant pollutant loads. This strategic plan will require feasibility and engineering studies, public outreach, and potentially other

planning studies for the various OSDS management areas, and funding strategies to implement the projects will be key,

4. In conjunction with the above, apply for funding through the State's Chesapeake Bay Restoration Fund program to implement the OSDS strategies,
5. Develop a more streamlined petition process for community connections to public sewer in order to better accomplish some of the OSDS strategies,
6. Continue to model and assess the effect of various load reduction alternatives on non-point source pollutant loads and tributary assimilative capacities for all watersheds in the County,
7. Play an active role in regional planning efforts to optimize and most efficiently use regional water supplies.

These needs and other related ones will be incorporated into Plan2040 so that land use and environmental policies can be developed comprehensively to ensure protection of water resources.

References

Andreasen, David C., Curtin, Stephen E., and Staley, Andrew W., 2016, Potentiometric Surface and Water-Level Difference Maps of Selected Confined Aquifers in Southern Maryland and Maryland's Eastern Shore, 1975-2011, Open-File Report No. 16-02-02, http://www.mgs.md.gov/reports/OFR_16-02-02.pdf, Accessed August 2018

Andreasen, David C., Staley, Andrew W. and Achmad, Grufron, 2013, Maryland Coastal Plain Aquifer Information System: Hydrogeologic Framework, Open-File Report 12-02-20, http://www.mgs.md.gov/reports/OFR_12-02-20.pdf, accessed August 2018

Andreasen, David C., 2007, Optimization of Ground Water Withdrawals in Anne Arundel County, Maryland, from the Upper Patapsco, Lower Patapsco, and Patuxent Aquifers projected through 2044, Report of Investigations77, http://www.mgs.md.gov/publications/report_pages/RI_77.html, Accessed August 2018

Andreasen, David C., 2002, Future of Water Supply From the Aquia and Magothy Aquifers in Southern Anne Arundel County, Maryland, http://www.mgs.md.gov/reports/Pamphlet_water_supply.pdf, accessed August 2018

Anne Arundel County Code, Article 16, Article 17 and Article 18

Anne Arundel County Department of Public Works, https://www.aacounty.org/departments/public-works/wprp/watershed-assessment-and-planning/chesapeake-bay-tmdl/index.html, accessed August 2018

Anne Arundel County Department of Public Works, https://www.aacounty.org/departments/public-works/wprp/watershed-assessment-and-planning/watershed-studies/index.html, accessed August 2018

Anne Arundel County General Development Plan, April 2009, https://www.aacounty.org/departments/planning-and-zoning/long-range-planning/general-development-plan/2009-gdp/index.html, accessed August 2018

Anne Arundel County Small Area Plan, 2000-2004, https://www.aacounty.org/departments/planning-and-zoning/long-range-planning/small-area-planning/index.html, accessed August 2018

Anne Arundel County National Pollutant Discharge Elimination System (NPDES) Permit #MD0068306 for discharges from municipal separate storm sewer system, February 2014, Maryland Department of Environment.

Anne Arundel County Comprehensive Sewer Strategic Plan, (CH2Mhill), Phase I, 2003; Phase II, 2007

Anne Arundel County Comprehensive Water Strategic Plan, Malcolm Piernie / Arcadis, April 2016

Annotated Code of Maryland, Land Use Article, Current through October 1, 2017, of the 2017 Regular Session of the Maryland General Assembly

Bolton, David W., Cleaves, Emery T., Gerhart, James M., Nardi, Mark R., and Shedlock, Robert J., 2007, A Science Plan for a Comprehensive Regional Assessment of the Atlantic Coastal Plain Aquifer System in Maryland, Open-File Report 2007-1205

Code of Maryland Regulations, Title 26, Department of the Environment

Maryland Department of the Environment, https://mde.maryland.gov/programs/water/pages/index.aspx, accessed August 2018

Master Plan for Water Supply and Sewerage Systems, (Anne Arundel County), 2017, https://www.aacounty.org/departments/planning-and-zoning/long-range-planning/water-and-sewer/2017-wsmp/index.html, accessed August 2018

Onsite Sewage Disposal Systems: Evaluation Study and Strategic Plan, (CH2MHILL), March 2008

The 2000 Maryland Stormwater Design Manual Volumes I and II (Maryland Department of the Environment), October, 2000, Revised May, 2009

Wolman, Gordon W. Chairman, July 2008, Water for Maryland's Future: What We Must Do Today, Final Report of the Advisory Committee on the Management and Protection of the State's Water Resources, Volume 1: Final Report, https://mde.maryland.gov/programs/Water/water_supply/Pages/wolman_fullreport.aspx, Accessed August 2018