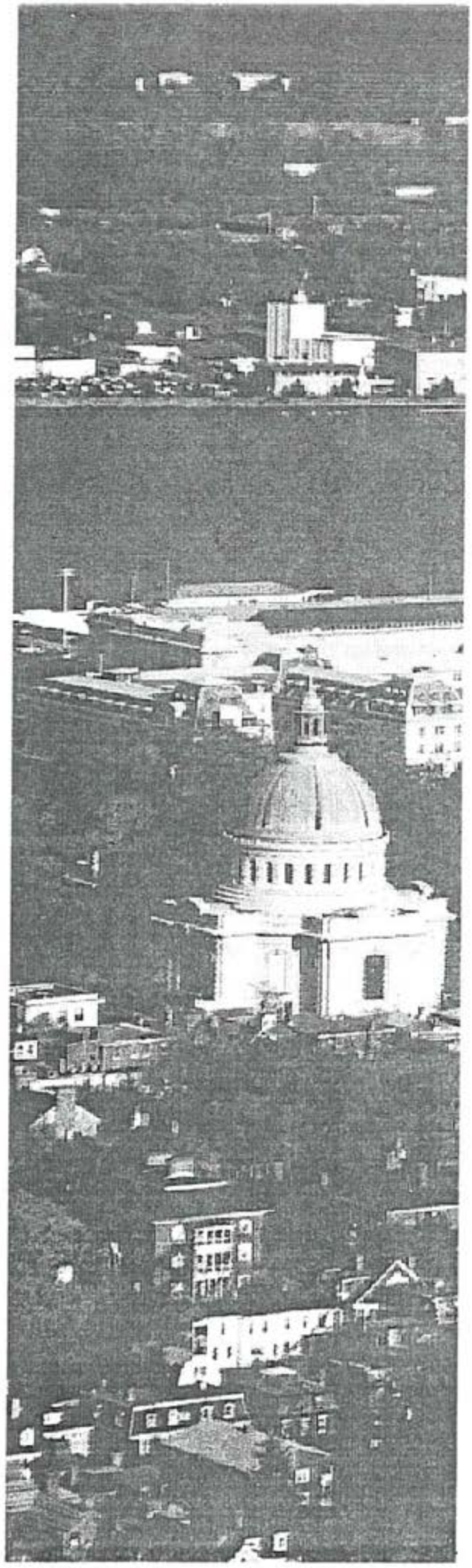
LIVING WITH THE RIVER

A Development Management Study for the Severn River Watershed to the Year 2020



the Severn River Commission

LIVING WITH THE RIVER

A Development Management Study for the Severn River Watershed to the Year 2020

prepared by:

PHASE ONE • The Study • December1993
Land Ethics and Dodson Associates

PHASE TWO and THREE • Public Input/Summary • June 1995
Environmental Resources Management, Inc.

The Severn River Commission
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All other photos, Land Ethics.

Executive Summary

The Severn River, designated as one of Maryland's Scenic and Wild Rivers, is noted for the rich and diverse bounty of its waters and the beautiful scenery along its shoreline. However, dramatic changes in the Severn River watershed are occurring. These changes are a result of direct and indirect environmental impacts, primarily resulting from development in the watershed. Examples of these impacts include:

- decline of all the major estuarine resources, such as yellow perch, rock fish, shad, oysters, and clams, to a small fraction of their historical numbers;
- loss of nearly all submerged aquatic vegetation (SAV) and many of the migratory waterfowl dependent on SAV's for food;
- poor water quality as evidenced by sores and tumors found on fish in the Severn River;
- low dissolved oxygen levels and associated impacts;
- loss of open space and forest lands; and
- loss of scenic character and quality of life.

The State of Maryland, as part of continuing efforts to restore the Chesapeake Bay, has made a commitment to develop and implement specific nutrient reduction strategies for each of the Bay's major tributaries. These tributary strategies, developed for the ten tributary watersheds within the state, establish a 40% nutrient reduction goal by the year 2000. In response to the Maryland Tributary Strategy Program, the Severn River Commission initiated efforts to develop a comprehensive Watershed Management Plan for the Severn River. Current efforts in the Severn River focus on developing specific nutrient reduction strategies.

This study concludes that equal priority should be given to repairing the environmental damage caused by existing development and the prevention of additional damage by managing future development within the watershed. Over 90% of the tidal shoreline areas are developed, and much of the existing development throughout the watershed occurred prior to current environmental and development regulations. This existing development has contributed to the decline in water quality, wildlife habitat, and quality of life, particularly along the sensitive shores of the Severn River estuary. Recommended remedial efforts include: construction of stormwater wetland basins and

vegetated swales; construction of fringe tidal wetlands; stabilization of eroding steep embankments through soil bio-engineering techniques; and protection of existing open space and forest cover.

Within the Severn River watershed, the population is projected to increase by over 18,000 people from 1993 to 2020. Future development should be guided such that it minimizes environmental impacts and maximizes preservation of riparian corridors and open space. This is particularly important for those portions of the watershed that are outside of the Chesapeake Bay Critical Area (1,000 feet from tidewater) and subject to less restrictive development regulations. Recommended methods include: concentrating development in designated growth centers; downzoning of areas outside of growth centers; protecting environmentally sensitive areas through acquisition or easement; implementing open space and cluster zoning; establishing preliminary site plan review; improving public access to the water; and enforcing boating controls.

The Commission held a series of public meetings throughout the watershed to solicit comments and suggestions on the proposed management study. In general, public comments reflected overall support for the Severn River Commission recommendations, but focused on implementing community projects, reviewing existing regulations, and developing specific regulations to address existing problems affecting the resources of the Severn River. There was acknowledgment of the need for cooperative efforts between local citizen groups, government agencies and other organizations in order to protect the valuable resources of the Severn River watershed.

Based on this study and public comments, the Commission has identified 6 key recommendations for protecting the Severn River, including:

- adopt a Severn River Policy Plan;
- consider the Severn River in the Anne Arundel County General Development Plan
- consider the Severn River in Anne Arundel County's comprehensive rezoning;
- strengthen the Maryland Scenic and Wild Rivers Act;
- review Anne Arundel County land development standards; and
- encourage community-based mitigation projects.

The following sections summarize the key elements of the proposed recommendations.

Adopt a Severn River Policy Plan

We recommend that Anne Arundel County and the City of Annapolis adopt a Policy Plan for the Severn River modeled after the Patuxent River Policy Plan. The Policy Plan would establish priorities for the protection of the scenic and natural qualities of the Severn River reflecting key issues identified in "Living with the River" and during the public meetings. The Policy Plan could then be approved by the County and State and provide policy direction in implementing programs and making policy decisions within the watershed.

We recommend that the Policy Plan incorporate strategies related to: non-point source pollution, such as vegetative buffers along stream channels and quality management objectives for stormwater runoff; retrofitting of existing development; further implementation of Best Management Practices; measures to guide future development within the watershed, such as concentrating development in designated growth centers and preservation of open space; and measures to provide increased public access to the Severn River. The Policy Plan should also incorporate the language and provisions of the proposed amendments to the Maryland State Scenic and Wild River Act.

Studies have shown that vegetated buffer strips along streams and wetlands are one of the most effective measures in protecting water quality and riparian habitat. Current State and Anne Arundel County regulations require a minimum of 25-foot buffer along non-tidal wetlands. We recommend an undisturbed 100-foot buffer of natural vegetation along each side of all "blue-line" streams as designated on the U.S. Geological Survey topographic maps, similar to those required under the Anne Arundel County-adopted Patuxent River Policy Plan. This buffer should be extended to include adjoining wetlands, floodplains, steep slopes, and other sensitive environmental features. Where these buffers are not currently vegetated, they should be planted with native plant species.

Stormwater management is the standard method of controlling nonpoint pollution from development sites. Current State and Anne Arundel County regulations require quality management of the first half inch of stormwater runoff. We recommend quality management of the first one inch of stormwater runoff as is required under the Patuxent River Policy Plan.

In order to gain public support for increased protection of the Severn River, people must be able to gain an appreciation for and hands on experience with the natural and scenic resources of the river. Most of the residents of the Severn River watershed do not live along the river. In fact, there are very few public access points along the river. We recommend that a park be established somewhere along the Severn River to preserve some of its natural and scenic qualities and provide the public an opportunity to experience the river. The proposed park would support environmental education, hiking, fishing, and non-motorized boating activities. The determination of the

appropriate location of the proposed park should be incorporated into the planning process and subsequent recommendations of the Severn River Policy Plan. The SRC should coordinate with the Severn River Association, the Severn River Land Trust and Anne Arundel County in the acquisition and development of the proposed park.

Consider the Severn River in the County General Development Plan

The watershed of the Severn River encompasses the heart of Anne Arundel County. Within its boundaries lie two Town Centers, Parole and Odenton, plus the City of Annapolis, the State Capital of Maryland. The next update of Anne Arundel County's General Development Plan (GDP) is a critical opportunity for the County to acknowledge the Severn River's attributes by affording it the recognition and protection it deserves. The GDP is the County's official policy guide for land use and sets out goals and objectives that will be implemented through plans, projects, and revised and enhanced regulations.

This study seeks to bring the Maryland Economic Growth, Resource Protection, and Planning Act of 1992 into focus within the Severn River Watershed and makes specific suggestions as to how the concepts might be implemented. The County's GDP update is the first place to start the implementation process.

The SRC's recent public participation process brought out a discussion of the need for coordination of the SRC's goals of watershed management efforts with the ongoing State and County Planning efforts. The SRC should view itself as a constituency, and it needs to take the appropriate steps to insure that its agenda is a priority in the process. In order to do this effectively, the SRC should consider focusing on specific major land use issues during the GDP update process in order to have the most significant effect on the future health and vitality of the watershed: identification of major existing communities outside of Town Centers; and delineation of the Severn River Watershed on the Land Use Plan.

The provision of RLD zoning was intended to separate existing communities in order to stop suburban sprawl. There is no real policy in the GDP to provide the basis for this concept. The RLD district is not addressed in the 1986 GDP since it did not exist at the time. The use of 5-acre lot zoning as a means to control sprawl may not be the most effective way to address the problem.

The GDP should recognize existing communities and their unique character in order to show the inherent uniqueness of certain areas and why they should not be swallowed up be the sprawl. Millersville is different from Crownsville and Severn is different from Odenton. The GDP should set forth land use policy that establishes the existence of the abundance of distinct communities in the County and also goals to preserve the character of these areas. This should be a major part of the basis for the delineation of boundaries for future growth areas, consistent with the seven visions of the Maryland Planning Act.

Probably the most effective way to establish meaningful policies to protect the Severn River is by delineating the entire Severn River watershed on the GDP's Land Use Plan. This would allow for the adoption of goals and objectives and policies that can provide for the management and protection of the integrity of the watershed and the river. This graphic depiction on the land use plan could be the basis for an adopted watershed plan, where the different development standards and environmental incentives could act as a means to achieve enhanced water quality goals.

One of the immediate benefits of this Land Use Plan designation would be the ability of the public (and County) to understand the relationship between zoning and the river, existing and future development patterns and their impact on the watershed. The current GDP does little to inform the citizenry about existing drainage patterns. The entire Land Use Plan and the GDP policy document could be updated on a watershed basis, delineating the entire County in terms of watersheds, with special designations for Wild and Scenic Rivers as well as the Chesapeake Bay Critical Area.

Regulatory Framework

Article 24, Section 1-103 (a) of the County Code requires the Office of Planning and Zoning to continually monitor the effectiveness of the General Development Plan and an annual reporting to the County Council on progress made toward achieving the goals of the Plan. Section 1-103 (b) reads as follows:

> "At intervals not to exceed five years, the Office of Planning and Zoning shall undertake a comprehensive review of the General Development Plan and its implementing mechanisms and shall recommend the revisions to the plan and implementing mechanisms as are necessary due to changes in demographic characteristics and social, economic, and environmental factors."

The last General Development Plan was adopted by the County Council on January 20, 1986, and became effective March 16, 1986. The County is required by the State Planning Act of 1992 to update its General Plan by incorporating a Sensitive Areas Element containing the "Seven Visions" by July 1, 1997. Anne Arundel County has begun updating the inventories and background studies necessary for the update. Legislation adopting the revised Plan would have to be adopted by the County Council and signed by the County Executive.

Consider the Severn River in Anne Arundel County's Comprehensive Rezoning

Anne Arundel County's General Development Plan's Land Use Plan establishes broad classifications for land use county wide, but the controlling regulations that stipulate how land can be utilized are found in the zoning ordinance. The zoning ordinance describes permitted, conditional, and special exception uses by zoning district. The process utilized to implement the general land use recommendations found in the

GDP's Land Use Plan is comprehensive rezoning which occurs on a countywide basis. This process allows any property to be reasoned to a different zoning district by County Council approval. Comprehensive rezoning is critical in that it actually shapes the way the County will develop in subsequent years by regulating densities, uses, and development standards.

"Living with the River" recommends downzoning in sections of the watershed that are open or underdeveloped in order to reduce densities and help implement a watershed greenbelt strategy. The other aspect of a greenbelt strategy is the fostering of development in the designated receiving areas such as the Town Centers (TCs) of Odenton and Parole.

The SRC's recent public participation process brought out a discussion of the need for coordination of the SRC's goals of watershed management efforts with ongoing State and County planning efforts. The SRC should view itself as a constituency, and it needs to take the appropriate steps to insure that its agenda is a priority in the process. In order to do this effectively the SRC should consider focusing on specific zoning issues during the next comprehensive rezoning process in order to have the most significant effect on the future health and vitality of the watershed.

The following items should be considered:

- the rezoning of Whitney's Landing Farm and any other State and County holdings to Open Space;

- the rezoning of the U.S. Naval Ship Research and Development Center at North Severn to RLD; and

- the zoning of all RA land within the watershed east of Rt. 3 to RLD and/or the incorporation of the RLD environmental protection standards (Article 28, Section 2-2A-12 through 15) into the RA zoning district countywide.

Whitney's Landing Farm is a large State owned property located near the south shore of the river. An Open Space (OS) zoning designation would be consistent with the County policy of zoning publicly owned land and state and county parkland OS. This action would not necessarily change anything about the land or its use, but would more accurately reflect existing conditions and be consistent with the zoning on the Severn Run.

The U.S. Naval Research property is currently zoned R1 as other Federal reservations have been in the past in Anne Arundel County. This property has been the subject of excess property discussions and may eventually enter the private market. RLD would lower the density of future development and provide enhanced environmental protection.

The RA (one unit per 20 acres) and RLD (one unit per five acres) zoning districts are very similar with one major exception. Density is not necessarily a significant distinction, since the vast majority of RA land has been and is being developed in lots smaller than 20 acres (through family conveyance, soils method special exceptions, and alternative density provisions). The real difference is the fact that RLD affords additional protection to the environment because of its provisions for protection of steep slopes, preservation of woodland and natural vegetation, streams, wetlands and floodplains and buffer requirements for non-residential uses. The actual permitted uses are almost identical.

The county should consider amending the RA zone to add the environmental protection features that now exist is RLD. An alternative approach would be rezoning the RA land on the east side of Rt. 3 (only the County Landfill is zoned RA west of Rt. 3) RLD in order to increase protection of natural features within the watershed.

Regulatory Framework

The County initiates the comprehensive rezoning process after the adoption of the updated General Development Plan. The formal process begins when the Administration releases a "proposed" rezoning map which is disseminated to the public in a series of public hearings presided over by the Planning Advisory Board (PAB). The PAB accepts applications for changes in rezonings at this time. Anyone may request a change in zoning on their own or other's property. This process is called making a "pre-file". After holding the hearings, the PAB reviews all the PAB made and is recommended to the County Executive who may or may not accept all of the PAB recommendations.

The County Executive then releases the "recommended zoning" map which begins the legislative process. It is at this time that the public can make "Petitions" to the County Council to formally request the Council to change the map by amending the ordinance for the area where the subject property lies. The Council seeks advice from the administration's staff (PACE, Law, etc.) but the decision to change the map falls to a simple majority on the Council.

The comprehensive rezoning of the county usually requires multiple ordinances since the County Council has found it easier to tackle a portion of the county at a time, given the magnitude of the task. In the past the comprehensive rezoning of the county has occurred on an Assessment District basis, and thus, new zoning has been in effect for some areas of the County while other areas were being deliberated on by the Council. It is not unusual for the County Council process to take two years or longer.

Strengthen the Maryland Scenic and Wild Rivers Act

The Maryland Scenic and Wild Rivers Act (Art. 66C § 759 - § 762; § 8-402 - § 8-410), adopted by the Maryland General Assembly in 1971, has proven to be an ineffective tool

for protecting the scenic or natural resources of the Severn River. As noted in the "Living with the River" study, the Scenic River designation has not protected the fragile resources of the Severn from the impacts associated with increased development within the watershed.

During the public meetings, participants expressed concern regarding the limited protection and lack of teeth provided by the current State Wild and Scenic River regulations. For example, the Patuxent River (not designated a SWR) has more protection than the Severn River as a result of the development and implementation of the Patuxent River Policy Plan. Participants recommended that some of the existing regulations be evaluated for their effectiveness and modified as necessary.

Assessment and restructuring of the SWR legislation could provide enhanced protection for the valuable resources of the Severn River. We recommend that the legislation be amended to clarify the language and strengthen the components of the Act. The amended Act should maintain general provisions for all rivers; however, create a separate category or classification which establishes more specific provisions. Those measures would become applicable to an individual river when that river is brought into that classification. The amended Act should clarify terms such as "free-flowing river", "related adjacent land areas" and "related shorelines".

The proposed amendments should also explicitly state that the Department of the Environment consider the goals of the Scenic and Wild Rivers Act during the review process for tidal and non-tidal wetland permits, stormwater and wastewater discharge permits, and other permits that may affect the environmental and scenic integrity of the Severn River. Such revisions to the Maryland State Scenic and Wild River Act would provide the means for better and more clearly defined protection of the scenic and natural qualities of such designated rivers.

Review Anne Arundel County Land Development Standards

Future land development within the Severn River watershed has the potential to significantly affect the river's natural and cultural resources. Over 50 percent of the watershed is still undeveloped, with nearly all of this land under the jurisdiction of Anne Arundel County. Anne Arundel County principally regulates land use and development with its Zoning Ordinance (Article 28), Subdivision Regulations (Article 26), and Design Manual.

These regulations and policies establish minimum criteria for the design and construction of residential, commercial, and industrial developments and their associated infrastructure improvements (roads, water and sewer lines, etc.) in order to protect public health and safety. In some cases, however, we believe these design standards may be excessive and inadvertently damage the environment. We list below several specific recommended changes to Anne Arundel County regulations and policies relating to road standards, stormwater management, and cluster development:

- redefine collector road standards to allow for more residences to be served with local roads where the road will not serve a large amount of through traffic (see Anne Arundel County Design Manual page R-23). This will reduce pavement widths and impervious surfaces;

- change the design speed for local and cul-de-sac roads/streets from 30 mph to 20 mph (see Anne Arundel County Design Manual page R-23). Reduced design speeds will allow for smaller horizontal curves (100 to 150 foot radius - see page R-8) and steeper road gradients (10 to 12 percent - see page R-11). These changes in alignment and grade allow the road to more closely follow the natural topography and allow for the road to avoid wetlands, steep slopes, or large trees, and will reduce grading and clearing. The County should use as a reference Residential Streets, a joint publication by the American Society of Civil Engineers, the National Association of Home Builders, and the Urban Land Institute;

- allow more flexibility in the design of local and cul-de-sac roads/streets by allowing for reverse curves with no tangents (see Anne Arundel County Design Manual page R-8), bifurcated sections, reduced lateral clearance requirements, reduced cul-de-sac pavement section, and encourage preservation of trees and natural vegetation in cul-de-sac islands. All of these measures will result in less clearing of natural vegetation;

- accept overland flow of rear roof drainage across vegetated areas as providing stormwater quality management. Collecting and piping this drainage to stormwater management facilities often results in unnecessary clearing and excessive grading. The County's "three lot rule", where drainage from no more than three lots can flow around a house, is too simplistic. The County should develop a performance standard based on the rate of flow in cubic feet per second; and

- the County should amend its cluster regulations to remove requirements that discourage developers from clustering development more often. These include requiring single family lots from not being less than 50 percent of the area normally required by the applicable zoning district (Article 26 Section 4-103 d), the requirement for a 100 foot buffer between a clustered lot and the subdivision property boundary (Article 26 Section 4-103 d), a requirement that all lots must be within 300 feet of common open space (Article 26 Section 4-103 e 3), and reduced area requirements (Article 28 Section 2-608). Lifting these restrictions will allow the required open space to be more effectively used in protecting environmentally sensitive areas. The County should take every opportunity to encourage cluster development.

Encourage Community-based Mitigation Projects

Existing development has contributed to the decline in water quality, wildlife habitat, rural character, and quality of life. Much of this development occurred prior to current environmental and development regulations. The Living with the River Study identified that over 90% of the tidal shoreline is already developed, and the environmental damage caused by existing development should share equal priority with the management of future development within the watershed.

At the public meetings community representatives expressed considerable interest in the concept of community-based mitigation, but expressed concern that they lacked the technical and financial resources to undertake these projects. Suggestions focused on providing incentives, such as potential funding sources, and eliminating disincentives which result from the complexities of existing regulations. Many communities and individuals are apprehensive to take on remedial projects due to potential costs and problems that arise from the existing regulations.

To restore the valuable resources of the Severn River watershed, restoration efforts must incorporate measures to mitigate these existing problems. We recommend that each community within the Severn River watershed undertake at least one project to help the Severn River. These projects may include stabilizing eroding riverbanks, retrofitting stormwater management facilities, and planting trees. The Severn River Association has offered to provide technical assistance to community groups desiring to implement remedial projects.

We recommend that the SRC and SRA develop specific informational sheets which include examples of completed remediation projects including project description and contact and a summary sheet of contacts for technical assistance and potential funding sources.

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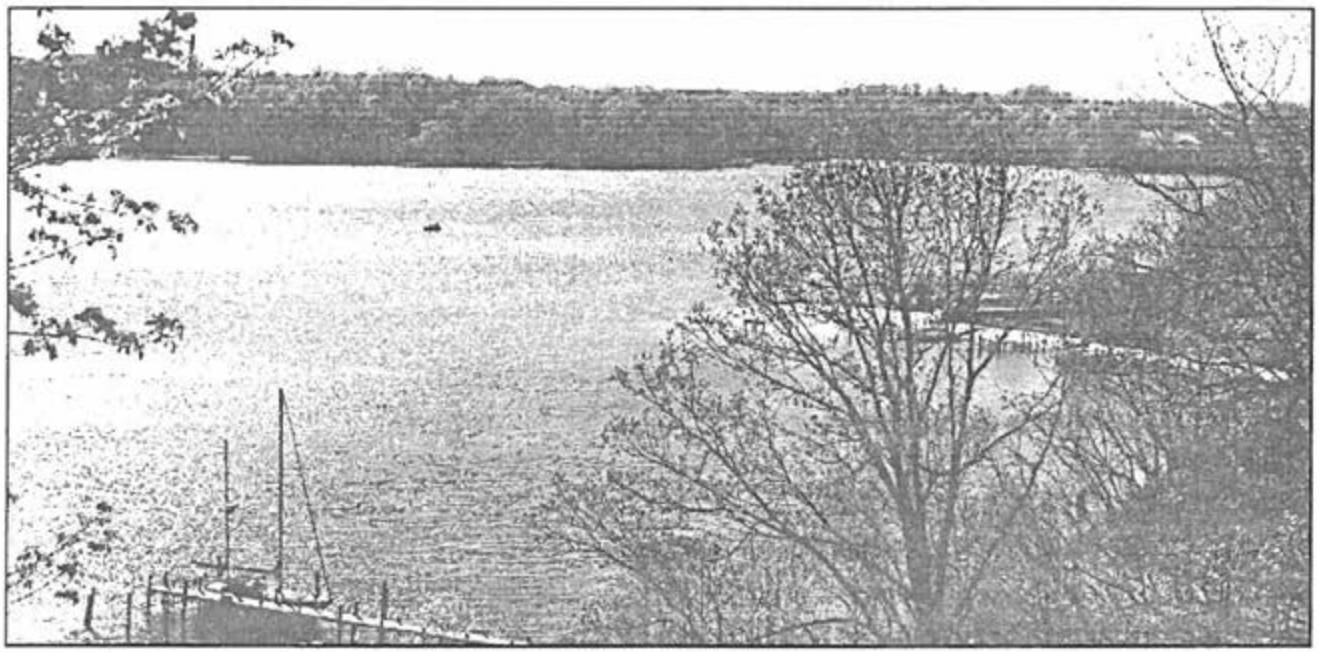
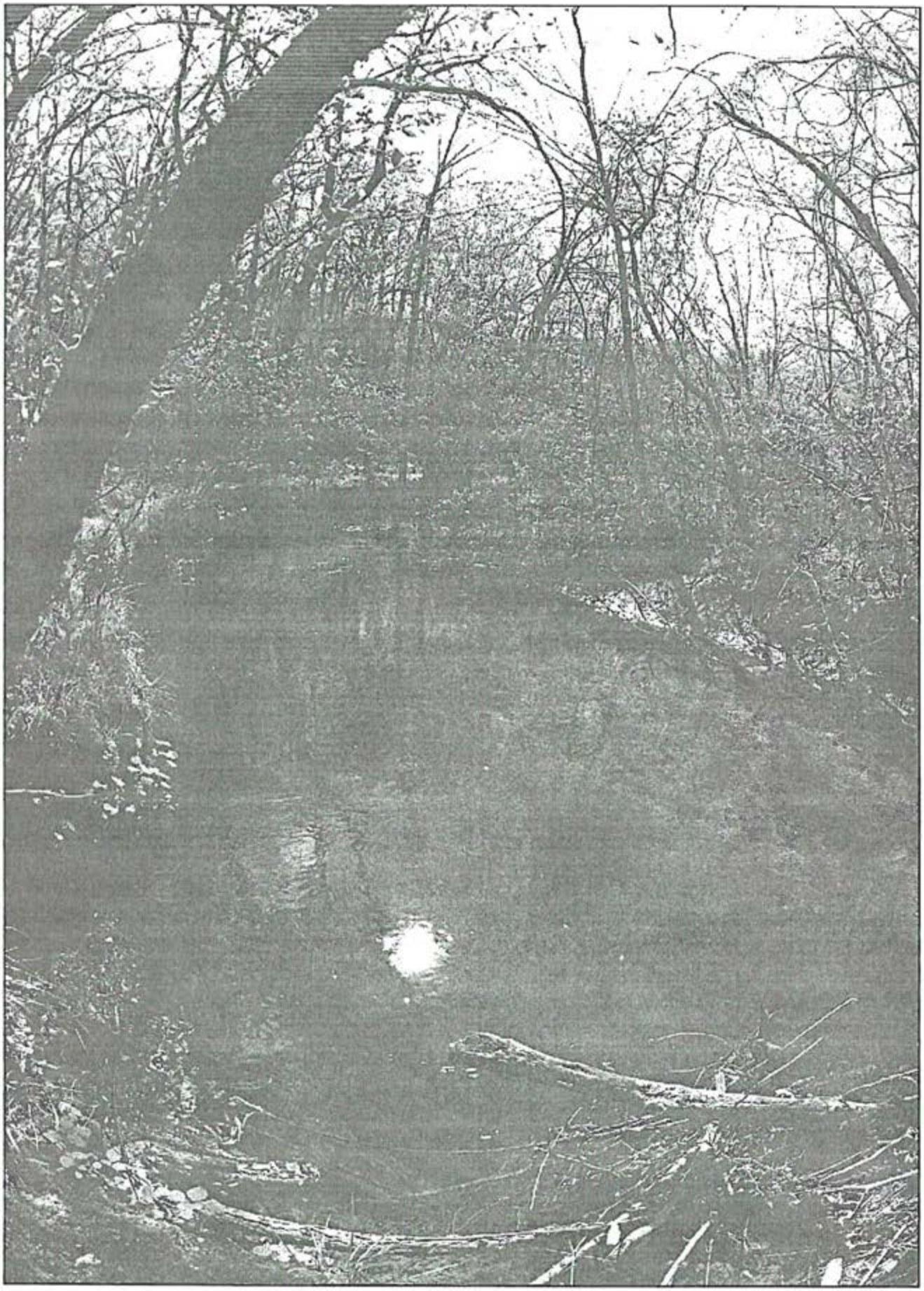


The Severn River has been called one of Maryland's greatest treasures, noted for the rich and diverse bounty of its waters and the beautiful scenery along its shoreline. Yet nearly three centuries of development has dramatically changed the natural and cultural resources of this river. In response, local governments and citizens alike have taken an increasingly active role in safeguarding those vulnerable resources which remain.

The challenge of protecting valuable resources is difficult in a watershed that continues to expand and to grow. This document explores the choices available for the future development within the watershed, development that may either protect or destroy the watershed's resources. Plans indicating patterns of buildout for the years 2000 and 2020 have been developed based on a review of current zoning regulations and regional census projections. These "buildout" plans indicate where development is likely to occur given present trends and regulations.

In addition, this report proposes a variety of measures designed to minimize the impact of future development on the watershed and to repair the degradation to the river caused by development existing today. The goal of these recommendations is not to stop development, but to advocate techniques for sustainable development - development which respects and protects the watershed.



Project Summary

The Severn River watershed is home to nearly 100,000 people (1993) in Anne Arundel County, Maryland, - with more people moving to the watershed each year. The reasons behind the continued growth of the population rest in part on the liveability and scenic quality of the region. The watershed is renown for its spectacular views of the Severn River and its intricate and complex system of upland areas, creeks, streams, wetlands, and forests. This system supports critical habitats for a variety of plants and animals many of which have been impacted by existing development with many others being further threatened by development yet to come.

Research into the current health of the watershed system, indicates that a substantial decrease in water quality over the last 30 to 40 years has accompanied a substantial increase in developmental growth. Therefore, unless additional steps are taken to change not only where development occurs but also how it occurs, the health and quality of the watershed will be lost to future generations.

*Unless additional steps are taken to change not only **where** development occurs but also **how** it occurs, the health and quality of the watershed will be lost to future generations.*

This report examines the balance between development, both existing and projected, and the conservation of existing natural and cultural resources in an already impacted watershed. By reviewing census projections for the watershed, and present zoning and development trends, buildout projections for the years 2000 and 2020 have been prepared. These buildout scenarios indicate that unless further steps are taken to protect the remaining scenic areas and areas of natural habitat and open space, much of the scenic and ecological quality of the Severn River watershed will be depleated over time.

The present protection effort is based upon several significant milestones in the protection of the river and its watershed. The first of these was the creation of the Severn River Association in 1911, followed by the designation as a Scenic and Wild River in 1971, and the creation of the Severn River

Commission in 1985. The Severn River Association is the oldest American volunteer group working for the preservation of a river and its watershed. In 1971, the Severn River was recognized for its scenic and historic value and was incorporated into the Maryland Scenic and Wild Rivers Program.

However, Scenic River designation by the state has not protected the fragile resources from the impacts associated with increased development. This is primarily because the state has vested specific land use authority to the local government, while simultaneously no special provisions exist for the protection of a designated Scenic River in Anne Arundel County or the City of Annapolis. Primarily in resonce to this, the Severn River Commission was formed and has provided counsel on developmental, environmental, and other matters regarding the Severn River Watershed to the City of Annapolis, Anne Arundel County, and the State of Maryland.

The Commission initiated this watershed study as the first phase in developing a comprehensive Watershed Management Plan for the Severn River. The purpose of this study is to review the extent and impact of present and future development in the Severn River Watershed to the years 2000 and 2020, and provide recommendations toward balanced use and sustainable development.

Objectives

The objectives of this study are four-fold:

1. To document the population and housing projections anticipated for the watershed and graphically show the likely distribution of these increases;

2. To report the current regulatory framework within which this increased development will take place and how that framework may evolve over the next 30 years;

3. To make recommendations for changes in present land use regulations and development practices which reverse the impacts of expanding future development on both the river and the watershed; and,

4. To recommend solutions to the environmental impacts caused by existing development.

Findings

The ecological integrity of the Severn River is in a state of decline. A review of historical data indicates that the Severn has already exceeded its carrying capacity for many forms of aquatic life. The river has reached the point where it can no longer absorb changes in land use without further degrading the quality of its waters and ecosystem. Thus, the challenge for incorporating further growth in the watershed lies in finding ways to minimize further environmental impacts and reverse trends in water quality degradation.

This study describes the connection between the Severn River and the people who live, work and recreate within the watershed. This connection is essential to understanding of the river, as each creek and tributary is vital to the river's health and sustainability. The context of the river and watershed are described in more detail in The Components of the Severn River Watershed chapter.

The increasing pressures from population growth and the attendant development anticipated for the watershed add to the challenges of maintaining a sustainable estuarine and riverine ecosystem. The dynamics of human impacts on the river's carrying capacity and sustainability are described in The Changing Tides of Water Quality.

Projected Population and Residential Development

Year	Population	% change	Residential Units	% change
1990	93,839		38,282	
2000	111,263	19%	46,092	20%
2020	117,689	6%	54,116	17%

The projections for the Severn's growing population are cited in The Population Dimension chapter. The key findings indicate a substantial increase in the population of the watershed over the next 25 years. The majority of this population increase is projected to occur during the 1990's. In the watershed, there is a population increase predicted of approximately 18,000 between the years 1990 and 2000, with an added increase of 6,000 for the decade following.

Solutions

The recommendations contained within this report are presented in the final chapter titled Issues and Recommendations. These recommendations can be divided along two broad issues for the watershed: 1) to repair the damage caused by existing development to water quality, wildlife habitat, and rural character, particularly along the sensitive shores of the Severn River estuary; and, 2) to guide

Paramount in the findings presented in this study is the need to restore the carrying capacity for sustaining marine and wild life by modifying human impacts in the watershed's ecology.

future development such that it minimizes impacts to both the environment and scenic quality and maximizes the preservation of sensitive ecological areas, the character, and scenic quality of the region's dwindling open space. This is particularly important for the undeveloped **inland** portions of the watershed that do not have established land-use regulations similar to those that protect the coastal fringe.

*The remediation of environmental impacts associated with **existing** development should be given the highest priority in the tidal estuary portion of the Severn.*

Existing Development

The remediation of environmental impacts associated with existing development should be given the highest priority in the tidal estuary portion of the Severn. Nearly 90% of the tidal shoreline of the Severn has experienced development. Of this, roughly 60% have been developed at a density of lots one acre and less in size and 30% at moderate densities of lots larger than one acre. Much of this existing development was built using environmentally damaging construction techniques and at densities no longer permitted in fragile coastal areas. Repairing the environmental damage caused by existing development along the tidal shoreline must share equal priority with the prevention of future development on the remaining 10% of the shore line.

Six remedial techniques are recommended for use in the restoration of the Severn River watershed:

1. construction of stormwater wetland basins and vegetated swales;

2. construction of fringe tidal wetlands;

3. incorporate soil bio-engineering techniques to minimize eroding steep embankments;

4. implementation of natural-systems sewage treatment facilities;

5. strongly encourage the use of mass native plantings for residential landscapes; and,

6. development of an environmental linkage program.

Future Development

The protection of existing open space is essential to the preservation of environmental and scenic quality within the watershed. The riparian corridors that abut freshwater tributaries should recieve the highest priority in crafting an open space protection plan. An integrated network of protected open space along these tributaries would enhance the protection of water quality in the Severn, while creating

an extensive greenway network that supports wildlife habitat and recreation. Protected corridors will vary in width but should ideally include all 100-year floodplains, contiguous non-tidal wetlands and a preserved forested buffer on either side of the tributary stream or wetland.

Additional open spaces requiring protection include large tracts of contiguous forest land, identified Natural Heritage sites, land over aquifer recharge areas, working farmland, historic and scenic landscapes, scenic vistas, recreational land, hiking trails and other sensitive landscapes.

Techniques for Ecological Protection

In addition to open space protection, techniques for protecting the ecological features and function of the Severn River watershed while accommodating future development include the following:

1. the implementation of a watershed greenbelt strategy;

2. the development of designated growth centers designed to relieve growth pressures in sensitive scenic and ecological areas;

3. the downzoning of areas outside growth centers with appropriate regulations to ensure protection of sensitive scenic and ecological areas;

4. ensure public access to the waterfront;

5. expand public transportation to reduce the need for more cars in the watershed;

6. the use of open space (cluster) zoning for the development of existing open space;

7. the implementation of preliminary site plan review to encourage development sensitive to natural and scenic resources;

8. the use of riparian protection regulations in upland regions;

9. implementation of recreational boating controls along the river; and,

10. the development of a county program for the Transfer of Development Rights (TDRs).

The Severn River has long been recognized as a significant natural and cultural resource to the State of Maryland. It is a watershed that warrants special recognition and deserves a model approach to accommodate the future growth and

development anticipated for this region. Defining the river's sustainability now and in the years to come remains the greatest challenge facing the watershed as the region enters the twenty-first century. With proper planning and greater community awareness the Severn may escape further degradation as is typically found in other, more urbanized watersheds.

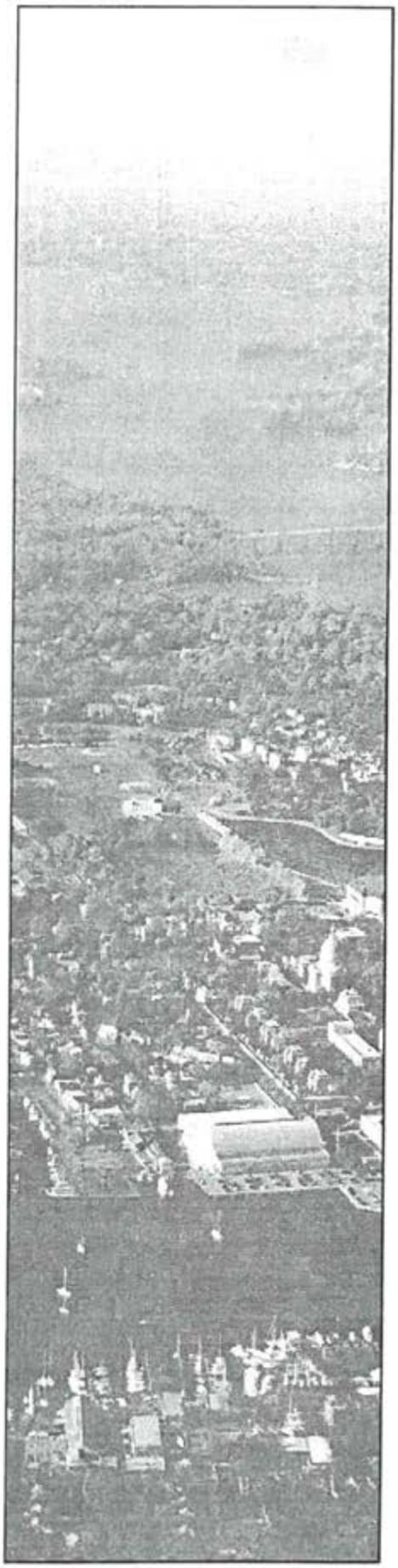
The Components of the Severn River Watershed

A Watershed Defined

A watershed or drainage basin refers to a distinct geographical region where all water flows into a common basin, river, or bay. Recognized as a discernable hydrological unit of the landscape, a watershed is surrounded on all sides by ridgelines. Typically, a watershed receives all of the rainwater which falls onto that basin. There is growing recognition that the geographic boundaries of a watershed are the most useful units in a landscape for achieving good resource management, superior to political subdivisions or other artificial boundaries[1].

Encompassing some 78 square miles and 50 sub-watersheds, the Severn River watershed is located entirely within Anne Arundel County and includes the majority of the City of Annapolis. Beginning in a myriad of tiny streams and rivulets, the navigable portions of the river proper stretch over 15 miles to its mouth. The mouth of the watershed, where it empties into the Chesapeake Bay, has been defined as stretching from Sandy Point to Tolly Point - more than five miles in distance[2]. At this point, the Severn is clearly a significant tributary of the Chesapeake Bay.

The challenge in successfully protecting the health and vitality of a watershed depends entirely on the stewardship and



1 L. Eugene Cronin, Ph.D., former Director of Chesapeake Biological Laboratory, pers. comm., 1993.

2 The Severn has also been defined from these points by the Maryland

Today, the navigable portions of Severn River stretch over fifteen miles from the Severn Run Natural Environment Area to its mouth where it flows into the Chesapeake Bay.

dedication of all members of the watershed's community. Government regulations play an important part in dictating the success of implementing a Plan, but it is ultimately the people who live and recreate within the region who determine the success of a program. People within the watershed must realize their own connection and understand how they manage their own property directly impacts the stream valleys and estuaries further down the watershed.

The River

Geologically speaking, the Severn is a drowned river valley. During the peak of the last glacial period, sea level was as much as 300 feet lower than today.[3] The Bay was a broad and deep valley of the Susquehana, and tributaries such as the Severn cut deep valleys in the coastal plain sediments. As the glaciers melted, sea levels rose and drowned the valleys. Subsequent sediment deposition buried the original river valley's floor under as much as 100 - 135 feet of sediment.[4]

Today, the navigable portions of the Severn River stretch over fifteen miles from the Severn Run Natural Environment Area to its mouth where it flows into the Chesapeake Bay. The Severn River offers a host of resources to those who live in its watershed: fishing, boating, swimming, or just viewing the scenery.

This relationship of people to river is both dynamic and extremely complex. An additional complexity links the health of the Severn River to the health of the Chesapeake Bay. The estuary depends on the daily tidal influx and outflow of water to cleanse and regenerate itself. However, both the Bay and the river suffer from decades of cumulative human impacts and abuses. Sediment runoff from agricultural fields, subdivision and highway construction have fouled the waters and smothered oyster beds.

Department of the Environment, the Water Quality Regulations Map for the Severn River Watershed, and the sub-watershed Map for the Western Chesapeake Bay. Definition of the Severn River Watershed, Report and Recommendations of the Severn River Commission, 1989.

3 Maryland Department of Natural Resources, Scenic and Wild Rivers Program, *Maryland Scenic Rivers: The Severn*, 1983.

4 Reed Huppman, Geomorphologist, *Weems Creek Restoration Study*, pers. comm., 1993.

Overharvesting of seafood coupled with mismanagement of stressed fisheries have dwindled both the finfish and shellfish resources of the River.

Historical Fishing

The Old Timer settled himself more comfortably against a piling and remarked, "Nope - fishing ain't what it used to be. Why, when I was a boy you could go out any old time and catch yourself a mess of most any kind of fish in jig time. Why, I remember one time..." and so the often repeated story goes.

Of all the resources past and present which have been documented in the Severn River, none offer as stark a testimony to the decline in riverine health as do the loss of marine resources. All the major estuarine resources have declined - some to a fraction of their historical numbers, others completely. This decline is not unique to the Severn River, and is documented Bay-wide (see graphs on the previous page).

The tremendous historical bounty of finfish and shellfish which were once found in the Severn River and Chesapeake Bay seem legendary when compared to today's catches. "In 1878 at least 14 oyster houses operated in Annapolis. But after reaching peak harvests in 1885, oyster harvesting have only declined as oyster beds were depleted."[5] Overfishing, combined with diseases, mismanagement, and water

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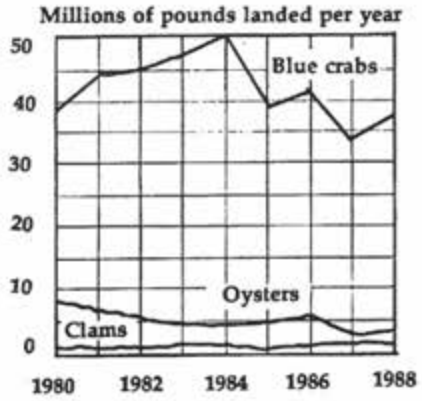
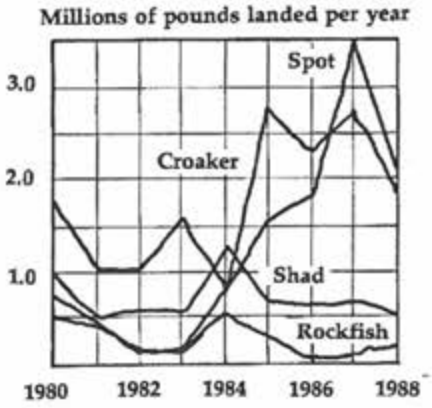




The graphs shown above indicate historic and contemporary catches of harvestable fin fish and shellfish.

5 Maryland Department of Economic and Community Development, and Department of State Planning. Maryland Historical Atlas. 1973, as cited in *Maryland Scenic Rivers: The Severn*, 1983.

Up to 200 million perch fry per year from as many as 384 boxes were reported during 1952 in Severn Run.

pollution has now reduced the oyster population in the Bay to an estimated 1% of their historical numbers,[6] causing many watermen to turn to crabbing to sustain a livelihood.

The Severn River has not had commercial harvestable stocks of oysters since the late 1960's.[7] During the late 1960's and the early 1970's, oysters were transplanted to the active bars at the mouth of the river, primarily Hacketts and Tolly's Bars. During this period, most of the river had been closed by the Health Department because the requirements for water quality could not meet state standards.[8] As of 1993, the Severn is deemed safe for oyster and clam harvesting but there are so few shellfish that only an occasional weekend recreational clammer is seen.

Landings of freshwater-spawning fish such as shad and alewife have also declined in the Severn. Striped bass landings decreased Bay-wide to the point of having the Maryland State Legislature impose a moratorium on their harvesting.

In the 1940's, the staff of the Chesapeake Biological Laboratory operated a box hatchery for yellow perch in the Severn River and Run.[9] The resulting fry were released in some 80 suitable Maryland streams throughout the tidewater counties.[10] The state continued this operation for many years, and up to 200 million perch fry per year from as many as 384 boxes were reported during this period. The Maryland Board of Natural Resources reported that in 1952 alone, 118.5 million yellow perch fry were hatched in Severn Run for distribution elsewhere.[11] This practice of harvesting yellow perch eggs from the Severn in order to re-introduce the species in other tributaries of the state continued into the early 1960's, at which time the Severn's yellow perch was also in decline. An undermining fact in many of these re-introduction programs was that even though depleted stocks were artificially bolstered, they did not remedy the

6 Tom Horton, *Turning the Tide*, Island Press, Washington D.C., 1991.

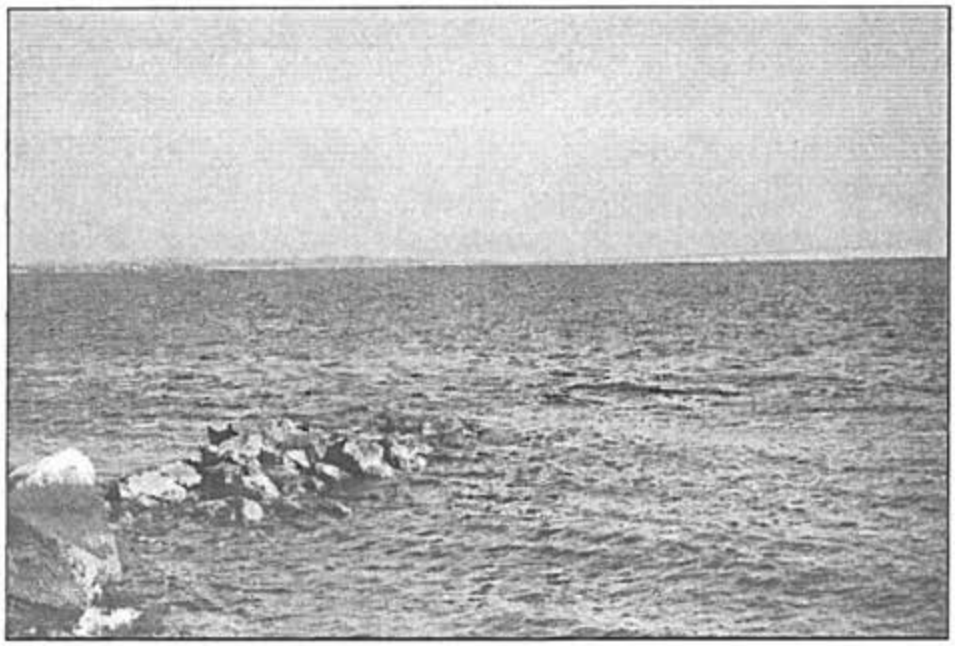
7 Lee Zeni, Director, Tidewater Administration, from a report submitted during the First Severn Symposium, 1986.

8 Zeni.

9 L. Eugene Cronin, Ph.D., former Director of Chesapeake Biological Laboratory, pers. comm., 1993.

10 Maryland Board of Natural Resources, *Third Annual Report*, 1946.

11 Maryland Board of Natural Resources, *Ninth Annual Report*, 1952.



water quality problem which led to the decline in the first place. As a result, re-introduced streams were not witnessing a rebounding sustainable fishery. Recent surveys have found only a few perch egg masses in the entire Severn System.[12]

These efforts to reintroduce a failing fishery raises the question of carrying capasity and the environment: Specifically, with an open-system such as the Severn, what is the population of fish species that it is capable of supporting when man-made pollution is to an already fragile system? Obviously, from the yellow perch scenario, the Severn's capacity for sustaining a healthy fish community had declined.

Fish communities may respond to environmental stresses in numerous ways. Sensitive species may experience reduced survival and reproductive success, the proportion of trophic and habitat generalists may increase, the proportion of insensitive and tolerant species may increase, and there may be a resultant imbalance of species diversity.[13] Dissolved oxygen (DO) conditions in tidal and non-tidal waters also decline in response to nutrient enrichment associated with urban runoff.[14] But water quality studies by themselves do

12 Jay Odell, Chief, Fisheries Division, Maryland Department of Natural Resources, pers. comm., 1993.

13 Betchel and Copeland 1970, Hughs and Noss 1992, as cited in *Fish Sampling in Eight Chesapeake Bay Tributaries*, Chesapeake Bay Research Division, Maryland Department of Natural Resources, 1992.

14 Limburg and Schmidt 1990, as cited in *Fish Sampling in Eight Chesapeake*

not always measure the health of the habitat. When coupled with an index of macro-invertebrate species, studies of water quality can provide a good indication of an estuary's health.

Various studies have documented the effects of pollution and urbanization on individual species, fish communities and aquatic habitat. [15] Most often, the best indicators of water quality are the presence of key macro-invertebrate species present in stream systems. Such indices are also adaptable for use in other regions and habitats.[16] Fish communities in estuarine systems have also shown to respond to anthropomorphic stress [17] and water quality conditions, [18] making them indicators of ecological stress.

The Coastal Edge

As a tidal river, the Severn's water quality is inseparable with that of the Chesapeake Bay. Tidal estuaries are among the world's most productive ecosystems, and support the highest concentration of diverse organisms, including man. Estuaries are semi-enclosed bodies of water which have free connection with the sea and within which sea water is measurably diluted by fresh water from land drainage.[19]

The majority of water entering the Severn system originates from the Chesapeake Bay. The fresh water contribution from the upland drainage basin is relatively small.[20] This makes the quality of water running off the urban landscape much more critical in the Severn River: the tidal pulsing tends

Bay Tributaries.

15 Karr et al.1986, Karr 1987, Plafkin et al. 1989, as cited in *Fish Sampling in Eight Chesapeake Bay Tributaries.*

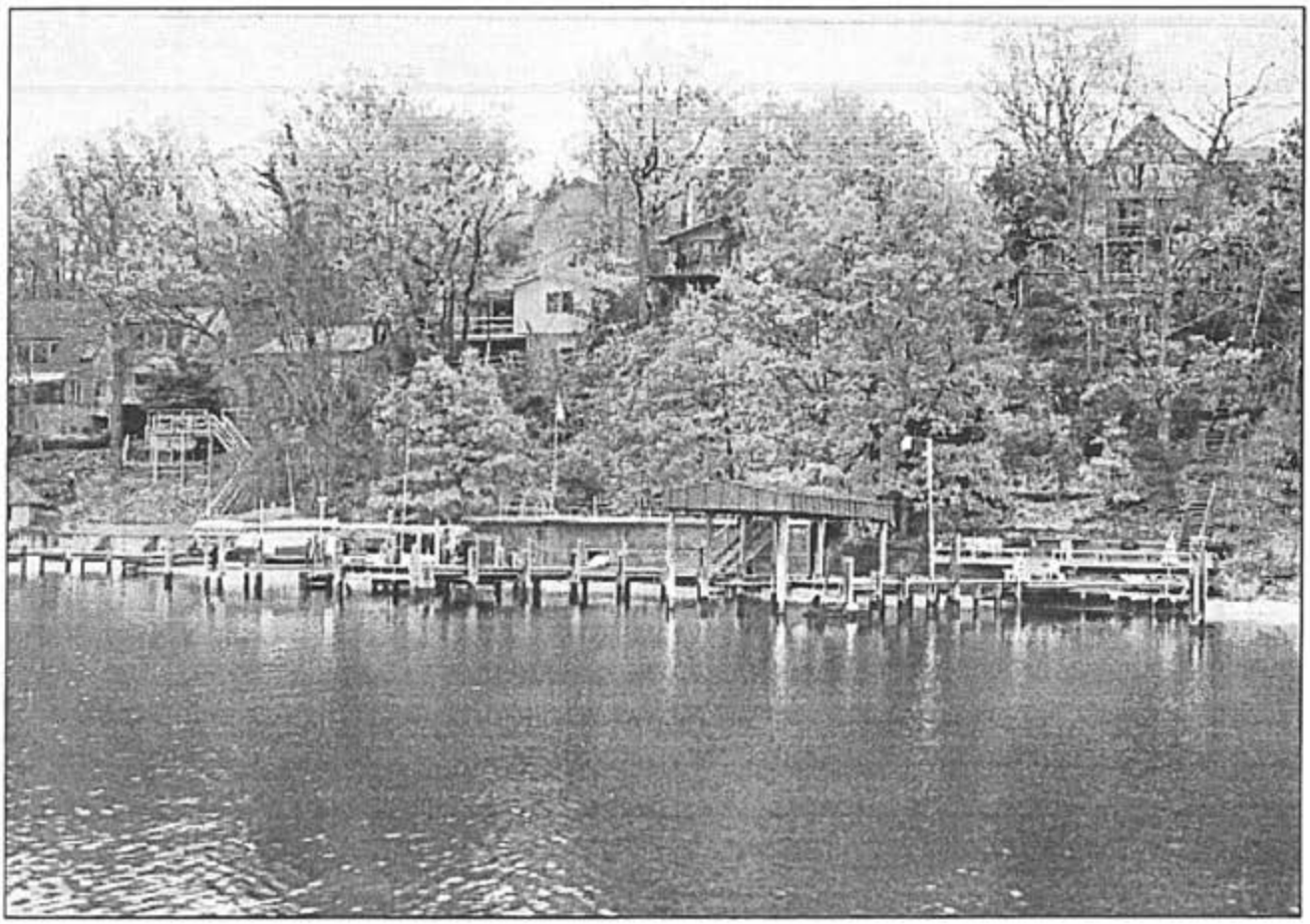
16 Miller et al. 1988, Karr 1991, Hughs and Noss 1992, as cited in *Fish Sampling in Eight Chesapeake Bay Tributaries.*

17 Betchel and Copeland 1970, Vass and Jordan 1991, as cited in *Fish Sampling in Eight Chesapeake Bay Tributaries.*

18 Jordan, et al. 1991, as cited in *Fish Sampling in Eight Chesapeake Bay Tributaries.*

19 The Severn River Commission, *Definition of the Severn River Watershed,* 1989.

20 The Severn River Commission, *Definition of the Severn River Watershed,* 1989.

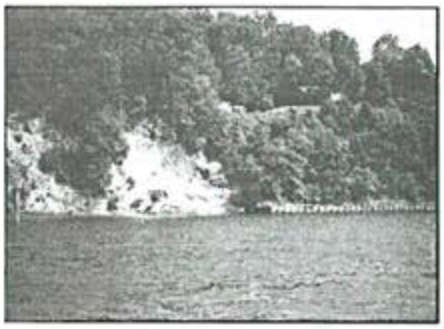


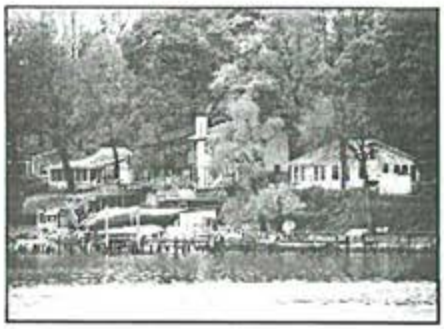
to keep pollutants, originating in the form of urban runoff, in the estuarine system longer. For this reason, the upland contributions of pollutants into the Severn are significant and should be controlled.

Shoreline Development

Coastal edges have historically attracted residential development, with the highest premium going to those lots with the most scenic view of the river. The Severn River has experienced continuous shoreline development since the early 1900's, beginning with developments based on a vacation resort theme, and later developing into year round residences.

Wardour, which was platted in the early 1900s, was the first residential community to be built along the Severn. Severna Park followed soon after. Like Odenton, on the upper watershed, Severna Park was serviced by railroad. In 1910 residential development adjacent to Round Bay "generally followed a vacation resort theme. Houses were of various





styles, some small and rustic, while others were more substantial."[21]

The community of Sherwood Forest was laid out in 1914 on "some of the highest and steepest terrain along the river. These summer cottages were small and inconspicuous, perched on stilts on the steep hillsides overlooking the river."[22] Today, local regulations would prohibit similar construction on areas containing steep slopes. However the homes of Sherwood Forest were built with a sensitivity to pre-existing conditions that would challenge subdivision developments typically found today. The developmental concept that makes communities like this unique is the manner in which existing vegetation was preserved. In addition, strict covenants have been drawn governing the use and sale of lots which serve to protect "the natural wooded character of the community"[23].

This strategy of conserving the natural site features was repeated at Pines-on-the-Severn in the early 1920s. This theme was repeated again and again in developments such as Epping Forest, Severn Heights, and Herald Harbor, a unique development where lots were granted for newspaper subscriptions to the well known Washington newspaper of the time, the "Herald."[24].

For many years residential developments followed the summer cottage/vacation home theme. Gradually, as more and more people "discovered" the Severn, these vacation cottages were winterized for year-round use. The continuing appeal of the Severn, its scenic quality and its recreational opportunities, has resulted in a tremendous influx of new residents over the past few decades.

Today, the Severn offers a wide variety of residential homes, from discreet, almost hidden homes tucked in the trees, to the obvious wide-open home sites with manicured lawns leading down to the rivers edge. Some homes seem palatial by conventional standards, such as Uchllyn on Severn, built on 550 acres near Aisquith Creek in 1906.[25] But none of

21 *Maryland Scenic Rivers: The Severn*, 1983.

22 *Maryland Scenic Rivers: The Severn*, 1983.

23 *Maryland Scenic Rivers: The Severn*, 1983.

24 *Maryland Scenic Rivers: The Severn*, 1983.

25 *Maryland Scenic Rivers: The Severn*, 1983.

these developments have been without environmental and scenic impacts.

The loss of forest cover that has followed wide spread residential developments in recent years has resulted in a tremendous increase in erosion and siltation along the tributaries and shoreline of the Severn. In addition, the construction of new homes has led to more and more shorelines being filled-in or bulk-headed and more and more natural estuary habitats lost. A dramatic increase in the numbers of docks and boat houses along the shoreline is directly associated with overall waterfront development. This has resulted in a dramatic change in the character and scenic quality of the river, for both residents and recreational boaters.

The Uplands

The Severn River watershed has been the home of man for the last 10,000 years. During this period, the watershed has experienced dramatic changes, the most significant occurring in the last 300 years of European colonization. During the 17th century, the wholesale clearing of forest cover took place in order to make way for the land-consumptive practices of growing tobacco. Typically, the soils along the Severn were well suited for tobacco cultivation which grew to dominate the local economy by the late seventeenth century.[26] During the ensuing centuries, the local economy grew to become agriculturally based, serving both the Annapolis and Baltimore Markets.

The upland areas of the watershed have experienced significant development as the suburbanization of the Baltimore - Washington metropolitan corridors have seen increased during the last decades. Although residential developments in the watershed primarily began during the early part of this century, it was not until more recent decades that the demand for housing development began to push agricultural uses out of the watershed. The first areas to be supplanted with new developments were the shorelines. Primarily because of their views and marketability, these areas were soon followed by developments crowding along the tidal creeks and coves. But now, with 90% of the shoreline areas having been developed, the demand for new

26 *Maryland Scenic Rivers: The Severn*, 1983.

residential development sites are focussed toward the upland regions.

Portions of the upland areas of the watershed have also been supplanted with expansive, new commercial developments, as evidenced by the growing Annapolis Mall. The conversion of such expansive areas from forest cover to impervious surfaces (parking lots and roof-tops) seems an inescapable trend as the demand for "modern" conveniences quickly change the face of the watershed

While these upland areas still contain most of the remaining forested open space in the watershed, they will also experience the highest concentration of future development (see The Population Dimension).

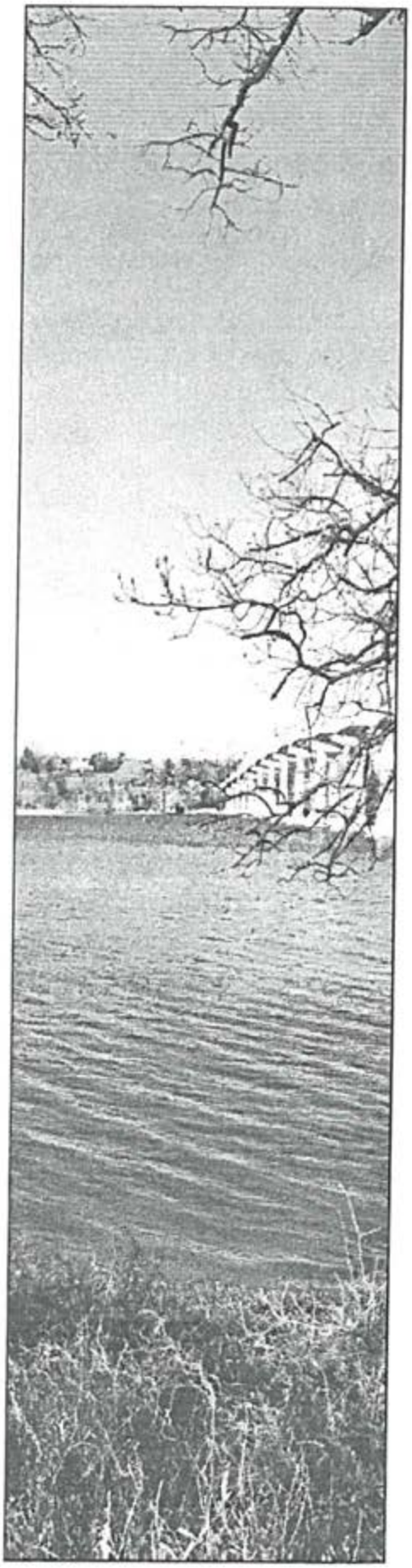
The Changing Tides of Water Quality

It has been over three centuries since the Bay's first European explorers mapped and reported the rich bounty of the Chesapeake Bay and its tributaries. "What the Bay must have looked like then..." is a reflection that many have pondered in the generations since.

In the last twenty years, local concern for declining water quality led to the documentation existing water quality in portions of the Severn River and its tributaries. State and local government, along with local citizen groups have begun sampling the Severn River and its tributary waters. Anne Arundel County took a significant step forward in documenting water quality through the establishment of the Citizen Monitoring Program in 1985, the Instream Monitoring Program in 1986, and the Esturine Monitoring Program in 1988 (discontinued in 1993). Administered at one time under the Watershed Management Program, these programs are crucial in establishing a base line of water quality information for these tributaries. Unfortunately, with the recent reorganization in Anne Arundel County Government, the Watershed Management Program no longer exists.

Impacts on Water Quality as a Result of Urban Development

The impacts of urban development on the water quality of the Severn River have been significant. Most who live along the Severn River and its tributaries today have been quick to note the changes in their river and tidal ponds. At first it may have been a murkiness of the water caused by suspended sediments. Perhaps it was the decrease of fish at a fisherman's favorite fishing hole or the notable reduction of submerged aquatic vegetation which some have noticed.



Whatever the tip-off, many who live and recreate along the river have noticed the changes in the river's water quality.

A classic example of what has been happening in many parts of the Severn is evidenced in Ray's Pond. Identified in the inventory of the Severn's natural resources Gems of the Severn in 1988, Ray's Pond is a tidal tributary on the north shore of the Severn between Joyce Lane and Glen Oban Drive. It is identified as "the most undeveloped tidal "pond" on the north shore of the Severn River," and one of only four left on the entire river. With a combination of seclusion, good water quality, limited boat access, and varied fish and wildlife habitats, Ray's Pond once provided "an oasis of pristine habitat in an otherwise heavily developed area."[27] Fishlife in the pond include adult white perch and sunfish and the pond serves as a nursery for species such as stripped bass, Norfolk spot, and spotted sea trout.[28]

But as development in the vicinity of Ray's Pond has increased, so too have the impacts to the water quality in the pond. Glen Oban, a residential community which began building in the early 1980s, placed an outfall for the stormwater management system directly into the pond. This outfall conveys runoff from the streets of the community, discharges a significant volume of unfiltered water and has created a large sandy shoal within the pond. The contrast is striking in that one half of the pond no longer supports the submerged aquatic vegetation or nursery fish while the other half retains its original characteristics.[29]

The net effect of urban development on receiving waters has been well documented in other rivers and watersheds.[30] The end result is typically an increase in pollutant export over pre-development levels.[31] According to a study conducted by the Metropolitan Washington Council of Governments,

27 A. Todd Davison and Colby Rucker, *Gems of the Severn*, The Severn River Commission, 1988

28 John Page Williams and Jay Schwartz, pers. comm., 1993.

29 John Page Williams and Jay Schwartz, pers. comm., 1993.

30 *Watershed Restoration SourceBook*, Metropolitan Washington Council of Governments, Anacostia Restoration Team, 1992.

31 Schueler, Tom, *Controlling Urban Runoff*, MWCOG, 1987.

some of the impacts to water quality associated with urbanization include:

- high concentrations of suspended sediments in streams;
- excess levels of nutrients such as phosphorous and nitrogen;
- bacteria levels which exceed public health standards;
- depressed dissolved oxygen (DO) levels;
- increased inputs of hydrocarbons from oil and grease;
- a wide variety of trace metals,toxic chemicals, and chlorides;
- thermal impacts; and,
- decline in living resources.

All of these elements present unique challenges for maintaining the level of water quality necessary to sustain aquatic diversity in the Severn River. As discussed earlier in this document, protection of the natural resources of the Severn requires a comprehensive approach that utilizes a variety of urban Best Management Practices (BMPs) and continued water quality monitoring. For recommendations on urban BMPs, refer the Issues and Recommendations chapter and Appendix A: Stormwater Best Management Practices.

Water Quality & Watershed Studies

The Severn Run Watershed Management Study was the first major watershed study which Anne Arundel County initiated in 1979. Prepared by CH2M HILL, this document laid a foundation for the county's short-lived Watershed Management Program (which was discontinued in 1993). Although the study focused on only the sub-watershed of Severn Run, many of the findings were applicable to all parts of the watershed, if not the entire county. The study considered the broad spectrum of watershed management, covering various problems (which still exist today), watershed

characteristics, and means of dealing with some of these problems.

Weems Creek was among the first county waterways to undergo an intensive study to identify existing and potential water quality problems as land use changes occurred.[32] The purpose for developing this series of water quality sampling stations was to document non-point source loadings to the Bay and its tributaries.

As part of the watershed management study, field surveys of streambanks and hydrologic control structures along Weems Creek were conducted. Among the study's findings:

- Sites of bank erosion, debris accumulation and stream blockage existed throughout Weems Creek.[33]
- Human activity was the most significant source of sediment loading.
- Steep slopes adjacent to nontidal portions of the stream contributed only minor sediment loading.

Citizen groups that have also been involved in establishing a baseline of water quality information in the Severn River include the Severn River Association and Maryland Save Our Streams. The Severn River Association has been collecting water quality samples since the early 1980's, establishing a base line of water quality for sections of the river.

Other water quality data for the Severn River have been compiled by the John Hopkins University, Chesapeake Bay Institute, State of Maryland 186 Water Quality Monitoring Program (funded by EPA), and the STORET National Water Quality Data Base. In addition, Anne Arundel County's Citizen Water Quality Monitoring Program, started in 1989, has compiled some documentation of fresh water streams within the Severn Watershed.[34]

Although much of this information is widely scattered and has not yet recieved interpretation, it is none-the-less valuable for establishing a partial baseline of water quality in certain portions of the Severn's stream systems. Information

32 Curtis, *Weems Creek In-Stream Monitoring Program*, 1987.

33 Greenhorne and O'Mara, *Management Plan for the Weems Creek Watershed*, 1985.

34 Patricia Haddon, Planner, past coordinator of the Citizen Volunteer Water Quality Monitoring Program for Anne Arundel County, pers. comm., (1993).

such as this will prove invaluable when compared with future testing to evaluate the impacts of existing and new development.

Carrying Capacity

The carrying capacity of an environment is determined by the resource requirements of a specific species. Most of the variation in the population density of a species in different habitats can be related to resource availability.[35]

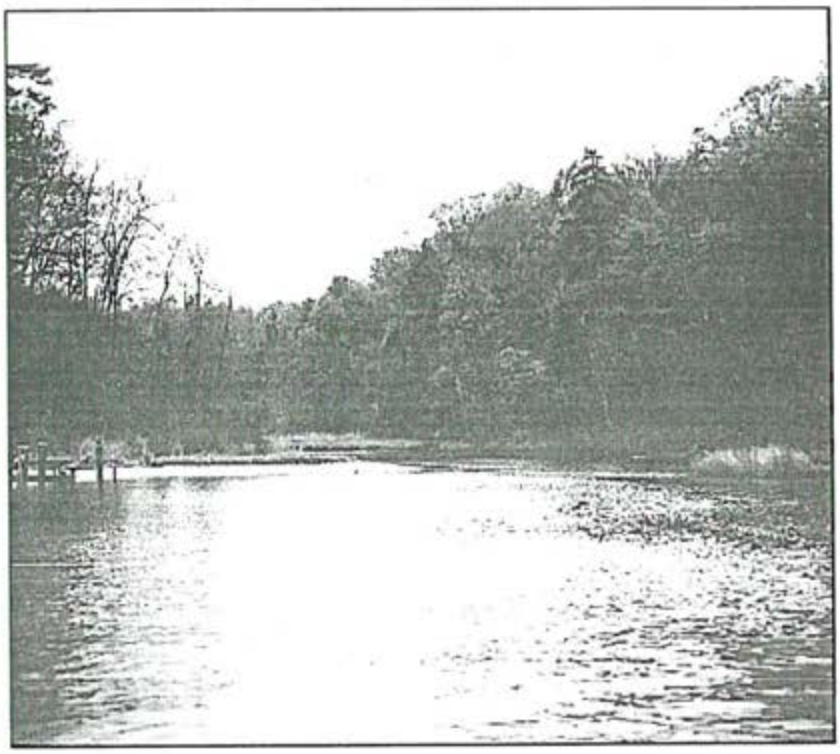
The concept of carrying capacity differs somewhat for renewable and nonrenewable resources. A population limited by nonrenewable resources (for example, space) will reach the carrying capacity of its environment when all the available resource is utilized. Populations of barnacles are limited in this way as are densities of forest trees. The availability of nesting sites can impose a similar limit on the number of breeding birds in an area.

In contrast to nonrenewable resources, renewable resources are almost never completely used up. Populations adjust to an equilibrium resource level delicately balanced among reproduction, harvesting, and habitat sustainability. When a particular population uses up the available amount of a renewable resource (overexploitation), its numbers will decline until the resource increases sufficiently to support an increase in that population. A healthy ecosystem shows a constant fluctuation in populations reflecting changes in resource amount and availability.

What is not so well understood is what the effects of external stresses, such as pollution, are to the carrying capacity of an estuarine system such as the Severn River. A species can not persist in areas where it is not adapted to the physical environment. The distribution of populations is limited by physical factors such as siltation from runoff, increased water temperature from denuded streams, and increased nutrient content in the water body. All of these physical factors combined can have a tremendous effect on the carrying capacity for a river such as the Severn.

The concept of carrying capacity is an attractive one with which most people can agree. The challenge is in the determination and implementation of such an elusive

35 Ricklefs, *Ecology*, 2nd Ed., 1979.



concept. In an effort to document basic habitat requirements, Maryland's Department of Natural Resources, in cooperation with the federal U.S. Fish and Wildlife Service produced the document: Habitat Requirements for Chesapeake Bay Living Resources in 1991. The primary purpose for this text was to provide a technical basis for the development of habitat and water quality restoration goals. Information on the life histories, ecological roles, habitat requirements, and special concerns for 31 "target species" were compiled and interpreted from extensive literature by experts in a wide variety of fields.

This information is quite valuable in considering the Severn's unique capacity for sustaining species with differing habitat requirements. Consider the habitat requirements of three distinct species; oysters, tundra swans, and humans.

The Eastern Oyster

The Eastern Oyster, for which the Chesapeake is famous, is a resilient estuarine species that was once adapted to its fluctuating environment in the Bay. It is fecund enough to produce billions of spat if brood stock abundance is high, suitable hard substrate is plentiful, and climatic conditions are optimal. Buddy Wilde, a retired waterman who is very familiar with the dramatic declines of oyster harvesting in the Severn, recalls how in the 1960's he and his fellow oystermen could harvest oysters by the bushels, often heading back to port after a few hours work, their holds filled

to capacity. However, predation, disease, and loss of suitable habitat have caused high mortality of the young stages in recent years. Pollution has further reduced oysters near industrialized and urbanized regions of the Bay. One of the biggest reasons is the lack of oxygen in the water column (anoxic conditions) which now exist on river bottoms and historic oyster bars. Overharvesting and environmental decline in the Severn has led to depressed harvests, degraded oyster grounds, and an overall weakened fishery.

- Bottom line: Oyster catches have declined dramatically from 14 million bushels in 1890 (Bay-wide) to less than 0.5 million bushels per year since 1987. The carrying capacity for oysters in the river has fallen dramatically in recent decades.

Tundra Swans

Flocks of Tundra Swans were once an "abundant and thrilling sight to see" in the Severn River. A long time resident of Sullivan's Cove, Dr. Eugene Morton, a senior research zoologist with the Smithsonian Institute's National Zoo, has studied these birds for years and recalls quite vividly the splendid rafts of swans in the Severn River. Once numbering 2000 - 5000 in the river during the winter counts, these migratory animals had been drawn to the Severn for generations because of the bountiful and succulent submerged aquatic vegetation (SAV) such as red-headed pondweed which is the preferred food of these swans. Today, a sighting of a swan is a rarity. Dr. Morton recalls that the decrease was dramatic after 1979 which coincides with the sharp decline of SAV in the Severn. Other water quality changes which has significantly affected the swans include increased nutrients and sedimentation.

- Bottom line: Of the once plentiful winter population of Tundra Swans in the Severn, none are reported today. Restoration of water quality is fundamental to improving the abundance and diversity of foods available to these swans, especially SAV. The carrying capacity of the Severn to support tundra swans has been significantly reduced.

Human Presence

The earliest evidence of humans present in the River dates to 10,000 years ago with the discovery of a fluted projectile point near the head of the Severn.[36] Those people,

36 *Maryland Scenic Rivers: The Severn*, 1983.

probably nomadic and dependant upon natural resources for their existence, undoubtedly found the river environment favorable, with its abundance of estuarine life and game animals of that post Ice-age era. Modern man no longer relies as closely on the bounty of the river. Our habitat requirements enable us to live in close proximity to one another as long as fresh water, sewage disposal, and grocery stores are available.

- Bottom line: Humans are probably the most adaptive species of the planet. This enables us to live almost completely independent of the resources of our immediate environment - so long as those resources are available somewhere. The carrying capacity of the Severn River watershed to physically absorb more people has not yet been reached. However, the carrying capacity to absorb more people has been reached on an environmentally sustainable level, as we face the increasing problems of an impacted river system, declining fisheries, traffic congestion, garbage disposal, sewage capacity, and ground water contamination. It can also be argued the we have reached the aesthetic carrying capacity of the watershed, since development is destroing the character and scenic quality of the area.

The purpose of this comparison is to call attention to the distinct resource needs of three widely differing species. When considering carrying capacity, it is perhaps more fundamental to address species sustainability both with respect to the resources that they rely on, and their individual populations. Paramount in the findings presented in this study is that we need to restore the carrying capacity for sustaining marine life and wild life by modifying human impacts to the watershed's ecosystem. Restoring the ecological balance will also ensure that continued development is sustainable.

Water quality and sustainability

Sustainability in a natural system implies an equilibrium between losses and gains to that system. Any and all inputs shift this equilibrium one way or the other after which the system adjusts. However, if too great a shift occurs, the system exceeds its ability to balance itself and collapses. We observe this in the real world as a major specie die-off with little or no observed specie regeneration.

The determination of an area's sustainability is, at best, an imperfect science, but it does offer some relevant "rules of thumb". We know that if the acidity measured in stream

water approaches that of vinegar, yellow perch will not be found spawning in the waters; if too many nutrients get washed into the rivers and tidal estuaries, the "carrying capacity" of that water to support dinoflagellate and other algal blooms sky-rockets, which result in the death of many fish and other aquatic organisms; if a constant input of sediment continues to cover old and new oyster beds, the ability of this river to produce oysters is nil.

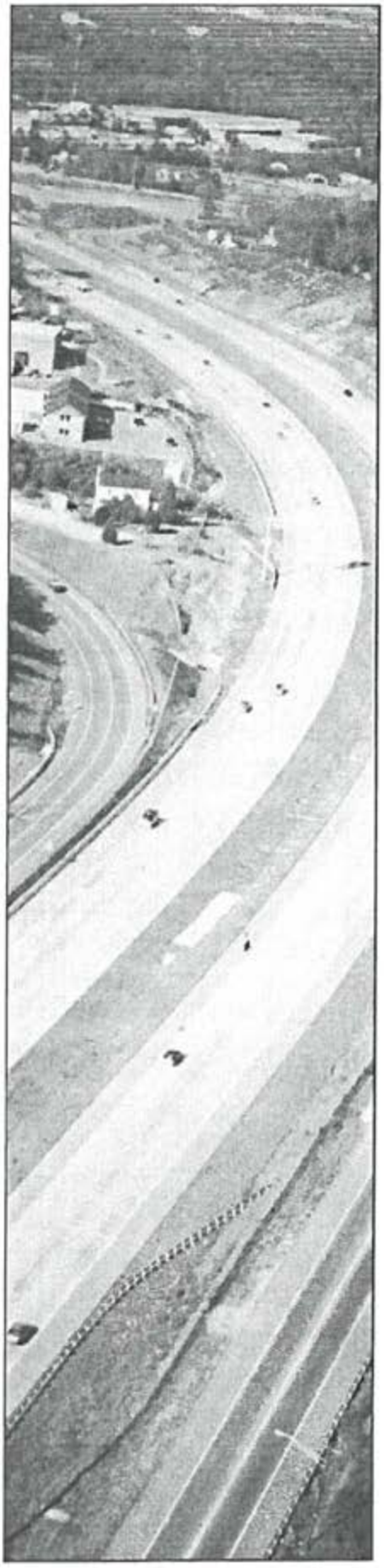
To simplify the complex carrying capacity shifts which occur within any ecological community, more emphasis has been focused on sustainable development. Sustainable development in a natural eco-system is a way by which man's impact on an environment does not throw that system out of equilibrium. Sustainability does not require simplification of the natural system; it does attempt to minimize (anthropogenic) factors which exacerbate population fluctuations due to changes in resource availability. In recent years, there has been an increased emphasis on defining and achieving sustainable development[37] to protect the complex carrying capacity shifts which occur naturally within any ecological community. This type of development provides a mechanism by which man's impact on the natural environment does not cause an irreversible or undesirable shift in a system's equilibrium.

37 This is evidenced by the President's Council on Sustainable Development and recent environmentalyl conscious books such as Al Gore's *Earth in the Balance*, 1992.

An Analysis of Future Development in the Severn River Watershed

Many efforts to preserve the Severn's natural areas have been made since its designation as a Maryland Scenic River in 1971. Some properties have been purchased by the state and county, while other properties have used techniques such as conservation easements to safeguard sensitive resources. Reports such as Severn River Natural Areas of Highest Priority for Preservation (1986) and Gems of the Severn (1988) have been published by the Severn River Commission for the purpose of identifying these dwindling natural and cultural resources. Since then, a great deal of effort has been focused on ensuring that the Severn River watershed continues to support the sustainability of these valued gems.

Instrumental to the understanding of how future development may impact the finite natural and cultural resources of the Severn River watershed, a thorough familiarity of the present regulatory framework is essential. The following section provides a general overview of existing regulations and policies. This is followed by an overview of



the population and housing projections which have been developed specific to the Severn River watershed.

The Regulatory Framework

While resource protection has been significant, there are a number of areas where additional protection is needed.

In order to assess the level of protection afforded to the resources of the Severn River, the regulations enacted by both the State and Anne Arundel County have been reviewed and analyzed. They show that while resource protection has been significant, there are a number of areas where additional protection is needed.

Anne Arundel County General Development Plan

The county's existing (1978)[38] long range General Development Plan (GDP) formally recognizes the importance of county shorelines, streams, wetlands, and other natural features. It acknowledges that these features provide county residents with many scenic, recreational, and significant financial benefits. But another of the GPD's major policies seems to create a conflict regarding the Severn River area; the county intends to concentrate most of its future growth in the established areas with existing or planned infrastructure, which include many portions of the Severn Watershed. This is also one of the visions of the State's 1992 Planning Act and one which the county must address in its next GDP.

Further examination of the GDP and its Land Use Plan reveals that, with few exceptions, the predominant zoning for the watershed area is low-density residential (2 units per acre) with some medium density residential (5-10 units per acre). Two areas of high density residential (greater than 10 units per acre) are associated with the Town Centers of Parole and Odenton. A thorough examination of the various zoning types has been conducted in order to ascertain the potential developability of the watershed.

The existing GDP is in the process of being updated to reflect current environmental concerns and developmental pressures. Among the issues which must be addressed in the update include the seven visions of the 1992 State Planning Act. Major consideration should be given by the county to safeguarding the resources of the watershed outside of the

38 This document does have a 1986 Addendum.

designated growth areas. Although it is hoped by county officials that concentrating growth in Parole and Odenton will take development pressures off the remainder of the watershed, this will never be fully realized unless downzoning occurs. The GDP contains density allotments in areas of the Severn outside of the growth areas where "allowable densities" are greater than the existing densities of developments already in place.

Generalized Comprehensive Zoning Map

The Generalized Comprehensive Zoning Map, which is part of the county's GDP, reflects existing and planned zoning densities in the Severn River Watershed. The majority of existing developments along the river are identified as R-1, R-2, and R-5 residential densities.[39] A few notable undeveloped areas within the watershed are designated RLD, meaning residential low density, which encourage development densities at one unit per 5 acres. As noted in the GDP, allowable densities surrounding the Town Centers are much higher (R-15 and R-22).

The protection of sensitive areas is indicated by the Open Space (OS) designation on the Generalized Comprehensive Zoning Map. These areas reflect dedicated open space as delineated by various subdivisions, State and County Parks, and are a component of overall land held for recreational use. To some extent, a few of these areas follow stream valleys and encompass several tidal marshes along the Severn, but this designation falls short of providing comprehensive protection for these areas. It is important to note that it was not a county requirement for developers of subdivisions to dedicate recreation, 100-year floodplains or open space acreage, either to the county or to a community association prior to 1971. Thus, most of the plats approved before 1971 do not indicate such dedicated areas.[40]

Properties located within 1000 feet of the Severn's tidal limits are subject to further scrutiny of allowable densities as explained in Anne Arundel County's Critical Area Program.

Critical Area Program

In order to safeguard sensitive shoreline areas and all land 1000 feet landward of mean high tide, Anne Arundel County

39 Meaning: R-1 = 1 unit/acre; R-2 = 2 units/acre, and; R-5 = 5 units/acre.

40 As noted in Anne Arundel County's Land Preservation, *Recreation and Open*

uses a Critical Area Overlay that when implemented, modifies in a more restrictive fashion the density and uses of a property's zoning classification. The three land use classification designations utilized in the Critical Area are Intensely Developed Areas (IDA), Limited Developed Areas (LDA), and Resource Conservation Areas (RCA). These designations are further defined as follows:

In order to safeguard sensitive shoreline areas and all land 1000 feet landward of mean high tide, Anne Arundel County uses a Critical Area Overlay that when implemented, modifies in a more restrictive fashion the density and uses of a property's zoning classification.

Intensely Developed Areas (IDA)

IDAs are those areas where residential, commercial, institutional and/or industrial developed land uses predominate and where relatively little natural habitat occurs. These areas have at least one of the following features:

1) Housing density equal to or greater than four dwelling units per acre;

2) Industrial, institutional or commercial uses are concentrated in the area; or

3) Public sewer and water collection and distribution systems are currently serving the area and housing density is greater than three dwelling units per acre.

Limited Development Areas (LDA)

LDAs are those areas which are currently developed in low or moderate intensity uses. They also contain areas of natural plant and animal habitats and the quality of runoff from these areas has not been substantially altered or impaired. These areas have at least one of the following features:

The three land use classification designations in the Critical Area are:
***Intensely Developed Areas** (IDA), **Limited Developed Areas** (LDA), and **Resource Conservation Areas** (RCA).*

1) Housing density ranging from one dwelling unit per five acres up to but not including four dwelling units per acre;

2) Areas not dominated by agriculture, wetland, forest, barren land, surface water or open space; or

3) Areas having public sewer or public water or both or property in the 6-20 year sewer and water service and is within 2000' of an existing line abutting the property.

Space Plan, prepared by Redman/Johnson Associates, Ltd. 1987.

Resource Conservation Areas (RCA)

RCAs are those areas characterized by nature-dominated environments, i.e., wetlands, forests, abandoned fields and resource-utilization activities, i.e., agriculture, forestry, fisheries or aquaculture. These areas have at least one of the following features:

1) Density is less than one dwelling unit per twenty acres; or

2) Dominant land use is in agriculture, wetland, forest, barren land, surface water or open space.

3) 1/2 mile outside of public sewer system.

In August, 1993, Anne Arundel County updated their Critical Area Program, addressing many elements in their program. Two elements in particular which were addressed in this update include the "grandfathering" provision and habitat protection. These elements are described as follows:

Grandfathering

The Critical Area Criteria contain provisions for grandfathering development under certain conditions. These provisions are administered in the County in the following manner: All development in the Critical Area approved after 12/1/85, under a building permit for land that was not otherwise subject to compliance is exempted. Major and minor subdivisions, rezonings, variances and special exemptions which were submitted before 4/21/86 are also exempted. Subdivisions on the sewer allocation list have also been grandfathered since the plans were submitted and approved prior to adoption of the Critical Area Criteria.

This element presents an undeniable risk to sensitive areas in that it allows, by right, development in areas which would not be allowed under current county regulations. Many of the older subdivisions of the Severn were originally platted as vacation cottage communities prior to any real understanding of environmental impacts. This element, if not addressed, will hamper the effectiveness of the Critical Area Program.

Grandfathering presents an undeniable risk to sensitive areas in that it allows, by right, development in areas which would not be allowed under current county regulations.

Habitat Protection

The habitat protection element, as written in the State's Critical Area Criteria, protects from development plant and wildlife habitats which are of particular significance because of their uniqueness or rarity or the fact that they may become extinct in the county if they are not protected. To date, the county's Critical Area Program addresses this issue. This

element may be strengthened in other future ordinances such as the county's eminent Forest Conservation Plan.[41]

The habitat protection element of the Critical Area Plan protects sensitive plant and wildlife habitats from development.

Forest Conservation Plan

The Forest Conservation Act of 1992 required each county in the State to prepare a Forest Conservation Plan. This required jurisdictions to develop a Forest Stand Delineation Plan and Forest Conservation Plan. Anne Arundel County is currently using an interim plan which requires the more restrictive elements of its current Plan or the State's model. At this time, the County's updated Plan is undergoing in-house review and is due for public comment later this year (1993).

Habitat Assessment Manual

The Habitat Assessment Manual is the first in a series of Critical Area manuals designed to assist landowners in utilizing their property in a manner that contributes to the restoration of the Chesapeake Bay. By offering methods to assess the type and location of existing habitat on a parcel of land, this manual is designed to minimize impacts to plant and animal habitats. This document falls short in a regulatory sense in that complete avoidance is not required by accompanying ordinances. Although referral of a specific Habitat Protection Plan has been made in the General Development Plan, this document does not exist at the time of this writing.

Subdivision Regulations

The current subdivision regulations in effect for Anne Arundel County are found to be detailed and comprehensive in nature. The Subdivision Regulations consistently refer to other development regulations such as Erosion and Sediment Control, Floodplain Management and Stormwater Management.

The limiting factor in these regulations is that none of these requirements are retro-active - meaning that there exists no language to hold subdivisions built prior to the enactment of

41 At this time, the county is undergoing in-house review of their new Forest Conservation Plan. This document was not available at the time of this writing.

these regulations responsible for on-site and off-site environmental impacts resulting from the development.[42]

Erosion and Sediment Control

Cumulative impacts of land-disturbing activities on sediment loads to local streams and creeks can have a profound affect on water quality. As such, there are existing laws which govern the disturbance of soil in the Severn River watershed. Land surface erosion from construction sites is typically covered by the Grading and Sediment Control Ordinance and by the state's Sediment Control Act of 1970.

The largest population increase is occuring right now - during the 1990's. In the watershed, there is an increase predicted of approximately 18,000 people between the years 1990 and 2000.

With respect to Anne Arundel County's Erosion and Sediment Control Ordinance, development guidelines and provisions are specified such as:

1) Development shall be fitted to the topography and soils so as to create the least erosion potential;

2) Natural vegetation shall be retained and protected wherever possible;

3) Only the smallest practical area shall be exposed, and only for the shortest practical period of time;

4) Erosion control practices (such as interceptor ditches, berms, terraces, contour ripping soil erosion checks and sediment basins) shall be installed to minimize soil and water losses;

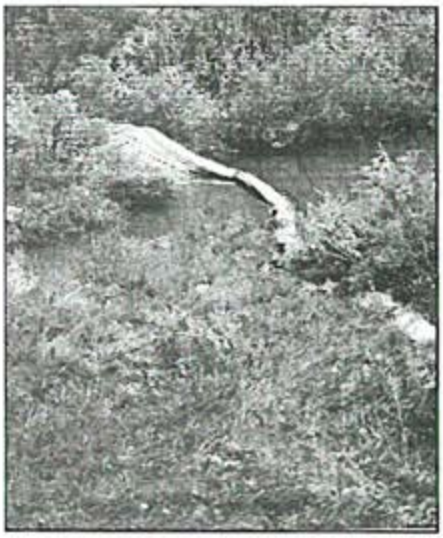
5) Temporary vegetation and/or mulching shall be used to protect critical areas exposed during the time of development;

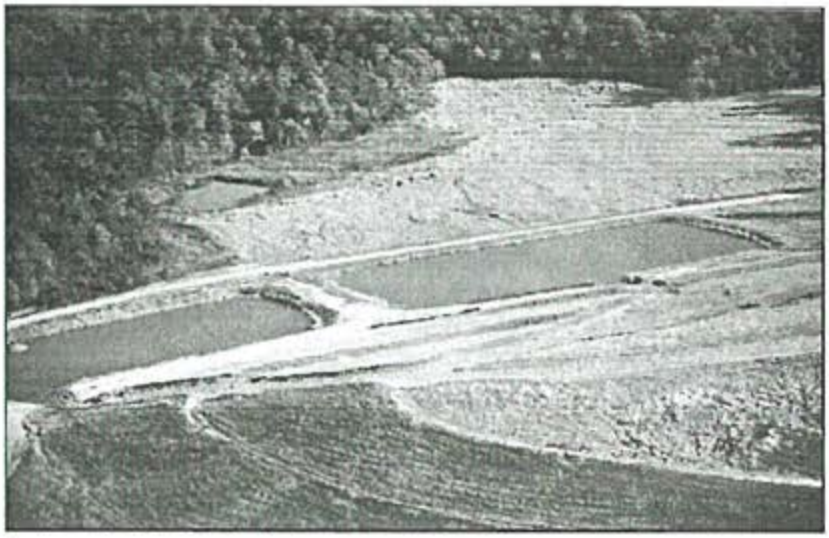
6) During and after development, provision shall be made to effectively accommodate increased runoff caused by soil and surface conditions, and to avoid siltation of receiving streams; and,

7) Permanent vegetation and structures shall be installed in the development as soon as the weather permits.

Although the sediment and erosion control regulations are basically sound, enforcement appears to be lacking in some

42 Legislative revisions deal with future projects or those currently undergoing the approval process, not those which have already gone through the approval process and had met all regulation of that time.





Siltscreen (above) and stormwater management pond (right).

areas as evidenced by the following observations in the region:

- Natural vegetation has not been maintained and protected, even within such highly regulated areas as riverfront properties;
- Large areas of soil have been exposed for long durations (in excess of 6 months);
- Temporary vegetation is seldom, if ever used, and mulching is used very little; and,
- Structures are often not sited with respect to topography to reduce the potential of erosion.

It is important to realize the fine but distinct difference between erosion and sediment control. Erosion controls are typically designed to prevent or reduce soil erosion, while sediment controls are designed to prevent or reduce water-borne eroded soil from leaving the construction site. By this, sediment controls can be considered curative in nature; i.e., the problem (erosion) has already occurred and the main intent is now to prevent offsite damage. In this respect, erosion controls are preventative in nature. By preventing or reducing erosion, the need for sediment controls diminishes.

Land Uses

The Severn watershed's present land use (based on 1989 land use maps and aerial photography) is comprised of 20% residential, 10% to 15% percent commercial or industrial, 15% open space or under cultivation. About 50% of the watershed is forested. The commercial developments are

found to be concentrated around Annapolis, Parole and Odenton.

The Population Dimension

Anne Arundel County's 1990 Census Data indicated that the Severn River Watershed (18 census tracts) can expect a projected population increase of 27,794 from 1990 through the year 2020. To provide a larger perspective regarding growth and population projections for the entire watershed, consider that at the time of the 1990 census, the tracts covering the watershed had a total population of 93,839. That number rose to 99,577 in 1993 and is projected to rise to 117,689 by 2020 - an increase of 18,112 Of the 18 census tracts, seven are projected to decrease in population (see Appendix B).

Further research revealed that 5,812 of the projected population increase for the watershed will occur in one census tract, #7027 (see Appendix B for a map of the census tracts). This tract, roughly bounded on four sides by Weems Creek; the Severn River; Hopkins Creek and River Rd; and Generals Highway and Rt. 50/301 comprises 4,431 acres and it's zoning classification is primarily low to mid-density residential. Of particular note regarding zoning classification is that the area bounded by Weems Creek, Rt. 50/301, Generals Highway and Bestgate Rd is predominantly high density (R-22 and R-15) accompanied by Town Center, Commercial and Industrial classifications.

Presently, the average number of persons per household in #7027 is just under three (2.7426). If we extrapolate using the current household size, it translates into over 2,000 additional units that are projected to occur in this tract within the next 30 years (to 2020) with a large portion of that development activity occurring in the Weems, Luce and Saltworks Creek area.

An important note concerning the census data is that there were 880 building permits issued within the 18 census tracts

Population Projections for the Severn River Watershed

1980	1990	1993	2000	% change	2020	% change
84,542	93,839	99,577	111,263	19%	117,689	6%

over a 10 year period from 1980 to 1990. Of those 880 permits, 549 of them were issued within census tract #7027. In summation, these figures are indicative of where the County is projected to allow/direct growth insofar as the Severn River Watershed is concerned.

The most revealing statistic seen when reviewing the census data is that the largest population increase seems to be occurring right now - during the 1990's. In the watershed there is an increase predicted of approximately 18,000 between the years 1990 and 2000, with an added increase of 6,000 for the decade following. This is a call for immediate action.

Land Use Projections

In order to provide an image of the effect of population projections on the ground, build-out projections of expected land use (based on extrapolated data) to the years 2000 and 2020 have been produced. The process used to develop the Projected Build-out Maps (see Appendix C: Maps) for the Severn River watershed relied heavily on two major components: existing regulatory and physical constraints to current development in the watershed and projected census data which has been researched and interpolated for future developments in the watershed. The target year for the study projects to the year 2020 and reflects the projected market demand for new housing interfaced with current zoning density.

Housing unit projections in the Severn River Watershed

Units in **1990**	Add'l **2000**	**% change**	Add'l **2020**	**% change**	Total Units **in 2020**	**% change**
38,282	7810	20%	8024	17%	54,116	15%

Instrumental to the development of the Build-Out 2000 and Build-Out 2020 maps was the prior preparation of two key maps: the Development Constraints Map and the Development Probabilities Map. These maps, coupled with an analysis of census projections, formed the cornerstone from which the Build-Out maps were developed.

Following is a brief description of these maps and census information.

Development Constraints Map

The Development Constraints Map (see Appendix C: Maps) was developed after a thorough review of physical and regulatory constraints to development. Utilizing four principal levels of constraints/review, the following categories were devised for specific geographic areas:

- Areas where development is permanently prohibited;
- Areas which would have extensive constraints/review;
- Areas which would have moderate constraints/review; and,
- Areas which would have minimal constraints/review.

The results of this mapping effort are presented in the Development Constraints Map. In general, the areas where development is permanently prohibited typically follow the stream valleys and tributaries of the Severn River where the presence of wetlands and/or steep slopes are more concentrated. Other notable areas include the Severn Run Environment Area and the area surrounding the Millersville land-fill. Areas which would offer minimal constraints for development include those properties which harbor no significant geo-physical barriers and are outside intensely regulated areas such as the Chesapeake Bay Critical Area.

Development Probability Map

The following factors have been taken into account in predicting the likelihood of future development within the Severn River watershed over the next twenty years under existing zoning and projected market and demographic conditions. These factors are not absolute but interrelate and affect each other; forces encouraging the development of a particular area (development desirability, visual quality, strong market demand, demographic projections, etc.) are offset by forces limiting the development of that area (regulatory limitations, physical limitations, weak market or demographic projections, etc.).

Typically, preparing a Development Probability Map would result in the inverse of the Development Constraints Map with one significant difference - market demand. It is often the case that the most desirable sites for building a house, such as riverfront property, offer the most restrictive

Development Constraints Factors

Development Permanently Prohibited

- Areas with slopes greater than 30%
- Parks, eased open space and conservation areas
- Tidal and non-tidal wetlands and non-tidal floodplains
- Areas zoned as Open Space
- Highway, railroad and utility corridors
- Public landfills

Extensive Constraints/Review

Co-occurrence of two or more of the following:

- Areas with slopes between 15-30%
- Soils unsuitable for septic systems in unsewered areas
- Resource Conservation Areas (Critical Area Maps)
- Forested areas
- Natural Heritage sites (rare & endangered species)
- Areas with poor access

Moderate Constraints/Review

Occurrence of one of the following:

- Areas with slopes between 15-30%
- Soils unsuitable for septic systems in unsewered areas
- Resource Conservation Areas or Limited Development Areas(Critical Area Maps)
- Existing schools and public facilities
- Archeological Sites
- National Register Properties
- County Historic Inventory Sites

Minimal Constraints/Review

No significant physical or regulatory barriers to development

regulations. However, the trend in the Severn River has shown that in spite of these more significant regulations, it is these areas which will continue to be developed.

Build-Out Maps

Two maps (see Appendix C: Maps) have been prepared which reflect the population increases for the entire watershed projected to the years 2000 and 2020. The driving factors behind the development of these maps, Build-Out 2000 and Build-Out 2020, was the interfacing

Development Probability Factors

Very Low Probability:

- Highway and Utility Corridors
- Railroad Right-of-Ways
- Slopes greater than 30%
- Parks and Conservation Areas
- Wetlands
- Areas Zoned as Open Space

Low Probability:

- Existing fully developed areas
- Existing wastewater problem areas
- Severe physical limitations to development
- Severe regulatory limitations
- Low demographic projections
- Low market demand
- Low density residential areas within 500' of major highways

Medium Probability:

- Moderate physical limitations
- Moderate regulatory limitations to development
- Moderate market demand
- Moderate demographic projections
- High density residential areas within 500' of major highways

High Probability:

- High visual quality
- Close proximity to water
- Strong market demand
- Strong demographic projections
- Few physical limitations to development
- Few regulatory limitations to development
- Industrial, Commercial, Office, Multi-family or Town Center Zoning within the Parole and Odenton Growth Centers

of projected development under existing regulations and likely future development trends. These development projections are based on the Development Constraints and Development Probability maps, combined with the 1992 population and housing projections for the years 2000 and 2020 provided by the Anne Arundel County Office of Planning and Code Enforcement and the State of Maryland Office of Planning. Development density was determined by

existing county zoning designations and Critical Area Program overlay maps.

Recommended Development Pattern

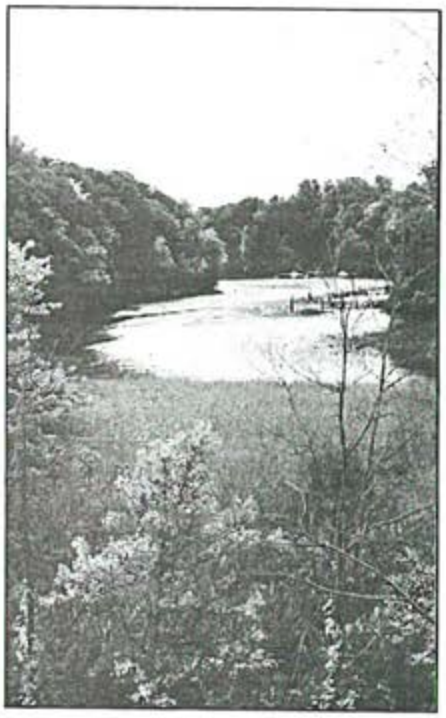
Recommended Development Pattern 2020: Weems Creek to Hopkins Creek Subsection (see Appendix C: Maps)

A specific area in the Severn River watershed has been selected so as to compare the typical development patterns (displayed on the Build-Out Maps) with more environmentally sensitive alternatives. The site selected exhibits some of the more intense increases in population, based on the projections compiled by the Maryland Office of Planning and Anne Arundel County. The area selected for this study is census tract #7027, an area bounded by Weems Creek to the south, Hopkins Creek to the north, the Severn River to the north-east, and Route 50/301 to the south-west.

Following the same criteria which led to the density projections for the Build-Out 2020 Map, a pattern of development has been projected under **modified landuse regulations**. Adoption of the following regulations, policies, incentives and educational programs, which are described in more detail in the following chapter, would lead to the creation of the recommended development patterns:

- designation of a watershed management district;
- mandatory open space (cluster) zoning;
- traditional neighborhood zoning (TND);
- riparian corridor protection;
- vegetative buffers;
- acquisition of sensitive areas; and,
- conservation of sensitive areas through easements.

The end result of the recommended development pattern exhibits the same density of development as the Build-Out Map for that area. However, the environmental impacts of this pattern of development on the existing natural resources is significantly minimized.



Weems Creek

Issues and Recommendations

Existing Environmental Impacts

Existing developments in both coastal and upland portions of the watershed have caused a number of direct and indirect environmental impacts. These have affected both the Severn and the larger Chesapeake Bay ecosystem. These impacts include, but are not limited to: untreated stormwater runoff, sedimentation from stream channel erosion, air pollution due to heavy dependence on the automobile, depletion of groundwater, destruction of near-shore and upland wildlife habitat and vegetation, loss of open space and a continuing loss of the region's character and scenic quality.

Existing development along the banks of the Severn River has been responsible for a wide range of specific environmental impacts. These include:

- loss of the river's natural banks and estuaries due to the construction of bulkheads, retaining walls and rip-rap or gabion walls;
- increased levels of freshwater runoff through storm drains into the estuary, causing salinity levels to drop, and deposition of nutrient-laden sediment and other forms of pollution to the river;
- erosion of fragile soils due to residential construction and the needless removal of vegetation;
- bacterial and nutrient pollution of the river due to inadequate or failing septic systems;

- nutrient pollution of the river due to "adequately functioning" septic systems serving high density housing in close proximity of surface waters;
- destruction of wetlands through filling, grading and erosion;
- loss of open space and forested canopy; and,
- destruction of the river's scenic quality and regional character.

Solutions: The correction of environmental impacts associated with existing development should be given the highest priority in the tidal estuary portion of the Severn. Nearly 90% of the tidal shoreline of the Severn has experienced development. Of this, roughly 60% have been developed at a density of lots one acre and less in size and 30% at moderate densities of lots larger than one acre. Much of this existing development was built using environmentally damaging construction techniques and at densities no longer permitted in fragile coastal areas. Repairing the environmental damage caused by existing development along 90% of the tidal shoreline must share equal priority with prevention of future development on the remaining 10%. The following section details techniques for watershed restoration for both future and existing development.

Environmental Planning Recommendations

Summary: The challenges for environmental planning facing the Severn River watershed can be divided into two broad categories: Those environmental impacts associated with existing development, and the impacts anticipated with future development. Two broad recommendations to address these existing and future impacts include:

1) **Guide future development** such that it minimizes environmental impacts and maximizes preservation of riparian corridors and dwindling open space. This is particularly important for the undeveloped inland portions of the watershed that do not have established land-use regulations similar to those that protect the coastal fringe.

2) **Repair the damage caused by existing development** to water quality, wildlife habitat, and rural character, particularly along the sensitive shores of the Severn River estuary.

Specific recommendations for both future and existing development are presented in the following sections.

Recommendations for Future Development

As presented in the build-out maps for the years 2000 and 2020, the majority of the development anticipated for the Severn River watershed will occur primarily in upland areas. The reasons for this become obvious when one considers the fact that nearly 90% of the tidal areas have already been developed and that the upland areas contain proportionally greater amounts of undeveloped land than the shores.

Unfortunately, these inland portions of the watershed lack stringent land use controls such as the Chesapeake Bay Critical Areas Act for protection of the tidal shoreline. It is these undeveloped areas and associated riparian corridors that play a crucial role in maintaining the ecological integrity and water quality of the estuary. For these reasons, greater land-use controls and open space protection are of critical importance in upland areas.

Solutions: A number of innovative and effective land-use management techniques can be used to allow reasonable growth in upland areas while protecting significant amounts of sensitive riparian corridors and open space. These techniques include:

- the implementation of a watershed greenbelt strategy;
- the development of designated growth centers;
- downzoning of areas otside of growth centers;
- providing access to the waterfront;
- expanding public transportation to reduce automobile use;
- implementation of open space (cluster) zoning;
- the implementation of preliminary site plan review including scenic quality criteria to ensure appropriate development;
- the implementation of riparian protection regulations in upland regions;

- the implementation of recreational boating controls on the Severn;
- the development of public boat launch and waterfront access programs; and,
- the devlopment of a program for Transferrable Development Rights (TDRs) between growth and low growth areas.

Watershed Greenbelt Strategy

Implement a Watershed Greenbelt Strategy in the Anne Arundel County General Development Plan, placing special emphasis on designated new town center plans for Odenton and Parole and open space protection. In addition, areas outside these town centers should be downzoned from present zoning classifications. The use of traditional neighborhood development performance standards in these areas will help ensure that future new town development is attractive, liveable, and diverse while remaining environmentally sensitive. It is vitally important that sewage treatment plants servicing the new town areas be built or upgraded to tertiary treatment levels. Where site conditions will allow, using natural systems sewage treatment technologies should be encouraged.

Focussing growth and population density in these designated areas will take some of the development pressure off of more sensitive open space areas in the Severn watershed only when downzoning has occured in regions outside of the growth areas. Downzoning is necessary to ensure that the new towns truly function to divert development away from environmentally sensitive open lands and waterfront areas.

The potential for combining open space protection with future development is illustrated in the computer generated aerial perspectives of the Weems Creek area (see Appendix C: Maps). Using a variety of flexible development techniques, future development is clustered in the least sensitive portions of the watershed, allowing for the establishment of large contiguous expanses of protected open space.

The riparian corridors that abut the freshwater tributaries of the Severn should require the highest priority for open space protection. An integrated network of protected open space along these tributaries would ensure protection of scenic and water quality in the Severn, while creating an extensive open space network for wildlife habitat and recreation. Protected corridors will vary in width but should ideally include all

100-year floodplain, contiguous non-tidal wetlands and a 150 foot buffer on either side of the tributary stream or wetland.[43]

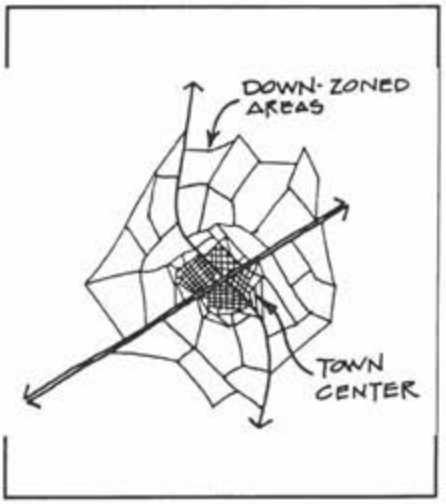
Additional open spaces requiring protection include large tracts of contiguous forest land, Natural Heritage sites, land over aquifer recharge areas, working farmland, historic rural landscapes, scenic landscapes, scenic vistas, recreational land, hiking trails and other sensitive landscapes.

Designated Growth Areas

Development of Parole, Odenton and other designated growth areas should strongly advocate the use of Traditional Neighborhood Development (TND) techniques. TNDs ensure that the new town centers are both diverse and attractive so as to provide a better alternative for developers and home-buyers from the conventional large lot suburban tract house. The many advantages and amenities provided by the neo-traditional new town center can help divert the conventional market demand for the suburban tract house. But if Parole and Odenton are not properly planned and designed, sterile and unattractive high density development in these areas will simply not meet market demand for attractive housing, resulting in increased pressures on the watershed's remaining open spaces.

Downzoning

Downzoning needs to occur in open or sparsely developed sections of the watershed currently zoned at one to five acre densities. These densities are simply too high to allow for significant open space preservation, even with cluster development. Clustering at one-acre densities results in development clusters that are too compact, especially when they are dependent on septic systems. Without downzoning, these landscapes will continue to attract substantial amounts of development, even if Odenton and Parole are highly successful. Downzoning of these districts to densities ranging from five to twenty acres, depending on the location, character and sensitivity of the landscape will reduce threats



43 This buffer is based on a survey of 117 riparian corridors by the U.S. Fish and Wildlife Service. The findings of their study, *Avian Communities in Riparian Forests of Different Widths in Maryland and Delaware*, recommended that "riparian forests be at least 100 meters wide to provide habitat for area-sensitive species". The report also added that "wider riparian forests would be preferable and should be preserved."

to these lands and provide additional incentives for new residents to locate in designated growth areas.

Waterfront Access

Provide access to the waterfront and to the protected open-space networks for residents of Odenton, Parole and other new town or cluster developments. This technique greatly increases the marketability for future land development by providing access to the resources that were protected through the use of cluster and new town development techniques. Rather than fragmenting the open space resources of the watershed, large tracts of sensitive open lands can be preserved for the use and enjoyment of all.

Public Transportation

Transportation is at the root of many of the region's (and the nation's) land-use problems. The existing density of Annapolis and future new town developments in Odenton and Parole offer the opportunity to expand public transportation services, linking them to each other and to the greater metropolitan areas of Washington and Baltimore. Opportunities exist to **provide enhanced public transit links** between urbanized areas of the watershed and the protected open space and water resources of the Severn River. Shuttles from downtown Annapolis and dense residential neighborhoods to the shoreline and protected open spaces enhance the livability of the area's urban centers while providing additional support and incentives for open space protection and stewardship.

Open Space Zoning

Open space (cluster) zoning can be a highly effective preservation tool. In areas with public sewer and water, clustering from 1 to 5 acre densities down to 1/4 to 1/2 acre densities allows almost 80% of the land area to be preserved as protected open space. In areas without public sewer or water, starting densities need to be at a minimum of 5 and preferably in the range of 10 to 20 acre densities to allow clustering down to 1 or 2 acre lots.

To be effective, open space development needs to be guided by an overall resource protection plan. Such a plan identifies large, contiguous open space areas needing protection to ensure that clustering takes place away from these sensitive networks. This will avoid the problem of "cluster sprawl" whereby fragmented open spaces are created by poorly

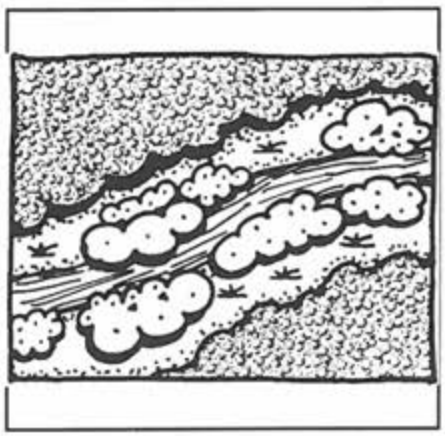
located, dispersed clusters. Individual clusters should be integrated into a larger neighborhood development plan to improve open space protection. This would serve to enhance the planning and design of the clusters themselves. The marketability of the clusters could be enhanced by providing adequate access to the shore, community boating facilities (instead of many individual, more environmentally damaging docks), and a neighborhood design character reminiscent of the turn-of-the-century vacation communities typical of the Severn River area.

Preliminary Site Plan Review

Preliminary site plan review is very useful in combination with cluster. It allows county officials and concerned citizens to modify development proposals to better protect open spaces and improve the site planning and design quality of proposed developments. Review of site plans will ensure that contiguous tracts of open space are preserved, adequate riparian corridors are protected and other environmental and site features are protected or addressed in the design of the new developments.

Riparian Protection Regulations

Incorporating riparian protection regulations along stream valley corridors would provide significant safegaurds for these sensitive areas and serve to complement and strengthen existing regulations such as wetland protection and forest conservation. The purpose of such a program would be to protect and conserve the environmental features and functions of streams, floodplains and adjacent wetlands. The goal is to develop a comprehensive program for the protection of riparian habitat and stream water quality while providing recreational and educational opportunities.



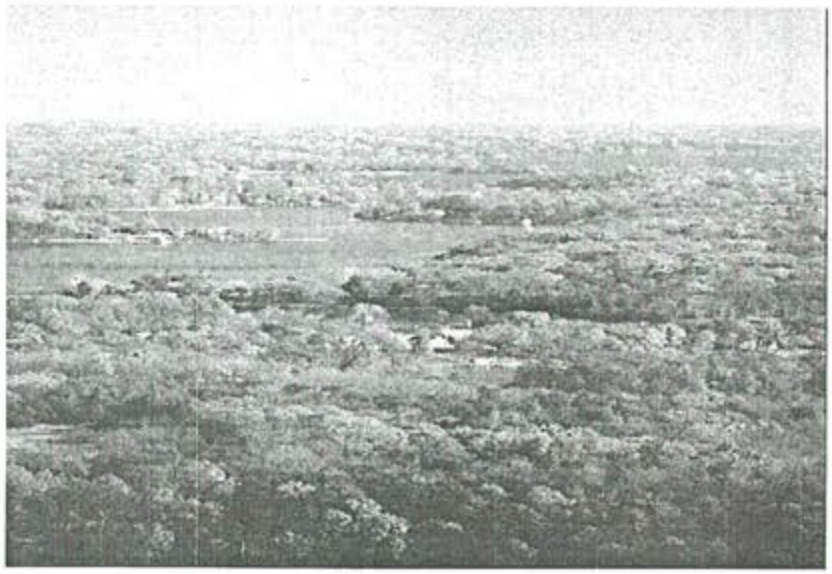
Recreational Boating Controls

Recreational boating is causing strains on the Severn River estuary. Strict enforcement of holding tank pumping regulations as well as the expansion of pump-out facilities are vital to the protection of the estuary's water quality. Encouragement or requirement of shared dock facilities, especially for new cluster developments will reduce the

environmental and aesthetic impacts caused by the proliferation of individual docks.

Public Boat Launch and Waterfront Access

The Severn's existing public boat launch and waterfront access programs should be strengthened and continued to ensure adequate and fair public access to community resources. Measures to avoid overloading of facilities and resources should also be put in place to ensure that increased public access does not strain environmental resources. Making public access a cornerstone of open space protection



will ultimately strengthen the effectiveness and acceptance of these protective measures.

Transferrable Development Rights

A program for Transferrable Development Rights (TDRs) should be developed for the Severn River watershed (if not Anne Arundel County) so that private property owners in environmentally sensitive parts of the watershed may sell developments rights to developers building in more appropriate regions of the watershed such as Parole and Odenton.

Three elements are crucial for developing a successful TDR program:

- Having a comprehensive inventory of properties located in appropriate 'sending' areas (such as sensitive areas located outside of any sewer service area);
- appropriate receiving areas - such as the new town centers or areas currently sewered; and,
- appropriate incentives for both sending and receiving areas, such as lower property tax rates for properties who have given up their development rights, and for the developers, an increase in permissible densities in areas able to absorb more intense development.

The TDR program would have two major advantages for watershed property owners and future developers. Property owners who sell the development rights would not only enjoy an equitable return for their development options, they may be eligible for lower property tax rates. Developers would enjoy an increase in permissible densities in areas more appropriate for intense development.

Recommendations for Existing Development

Existing developments in both coastal and upland portions of the watershed have caused a number of direct and indirect environmental impacts. These have impacted both the Severn as well as the larger Chesapeake Bay ecosystem. These problems include but are not limited to: untreated stormwater runoff, air pollution due to heavy dependence on the automobile, depletion of groundwater, and the loss of

near-shore and upland wildlife habitat, vegetation and scenic and regional character.

Solutions: Recommended remedial techniques of environmental impacts in existing developed coastal shoreline areas along of the estuary and upland areas include the following:

1. constructed stormwater wetland basins and vegetated swales;

2. construction of fringe tidal wetlands;

3. soil bio-engineering for eroding steep embankments;

4. natural-systems sewage treatment facilities;

5. protection of existing open space and forest cover;

6. Maintenance of the bulk, height and setback characteristics of existing historic developments;

7. residential landscape design with mass native plantings; and,

8. an environmental linkage program.

Constructed Stormwater Wetland Basins and Vegetated Swales

These two techniques both filter and absorb stormwater runoff from roadways, parking areas, rooftops and other impervious surfaces. Wetland plants remove pollutants and nutrients found in urban stormwater. Vegetated swales are a stormwater conveyance technique where runoff is filtered back into the groundwater where it replenishes the watertable rather than entering a river or stream. A detailed description of these two techniques is included in Appendix A entitled Stormwater BMPs. Both constructed wetland basins and vegetated swales should be designed to complement the residential landscape through the creation of attractive ponds with wetland features. In addition, these sites attract aquatic and terrestrial wildlife by providing additional habitat while at the same time providing educational opportunities for local residents.

Constructed Fringe Tidal Wetlands

Fringe Tidal Wetlands placed along the shorelines of the Severn will help filter pollutants and restore a dwindling environmental resource. Fringe wetlands can help prevent

the erosion and undercutting of steep slopes and eroding banks and bluffs, thus eliminating the need for environmentally damaging bulkheads and rip-rap embankments.

Constructed wetlands typically treat stormwater runoff from nearby impervious surfaces, removing nutrients and other pollutants. Some homes, parking lots and driveways located close to the shoreline lack the necessary space for the construction of a traditional wetland basin. Pumping stormwater from these areas up to upland basins is unrealistic. However, Fringe Tidal Wetlands can treat stormwater which can not be filtered in upland wetland basins. Finally, the construction of Fringe Tidal Wetlands will provide important wildlife habitat for aquatic and terrestrial species. Replacing visually obtrusive bulkheads and rip-rap embankments with Fringe Tidal Wetlands can also restore the scenic quality of the Severn River shoreline.

Soil Bio-Engineering for Eroding Steep Embankments

Soil bio-engineering for eroding steep embankments and bluffs can be more durable and effective than hard materials and at the same time provide enhanced wildlife habitat and aesthetic advantages. This technique utilizes various plantings of native plant materials in conjunction with structures of natural materials such as wattles or brush fences. This can provide an alternative to the expensive and environmentally damaging use of retaining walls, rip-rap, and concrete to stabilize eroding slopes. Bio-engineering is not only typically less expensive than conventional techniques but far outlast most conventional solutions.

Natural-Systems Sewage Treatment Facilities

Natural-systems sewage treatment facilities utilize constructed wetlands, deep aeration ponds, solar aquatic greenhouses, land application and other innovative techniques that have the capability to fully purify sewage to drinkable-quality water. This purified water is then recycled back into the water table, replenishing the freshwater aquifers and reducing the threat of saltwater intrusion. Natural-systems sewage treatment facilities use simple, natural processes to purify sewage, have significantly lower construction costs and can be built at a small neighborhood-scale (as few as 200

homes). In addition, this technique reduces the costs and environmental impacts of extensive sewer line construction.

In addition it is necessary to upgrade existing sewage treatment facilities. This could perhaps be accomplished using constructed wetlands as polishing basins to further purify effluent prior to its discharge into the Severn. Anne Arundel County and the City of Annapolis must realize that complete tertiary treatment of sewage wastes, using natural systems technologies is a vital component of the estuary recovery program. The county should seek funding to expand its future sewage treatment districts to include all densely developed portions of the estuary.

Funding for this substantial sewage treatment program can be realized through a number of sources. First, the homeowners along the Severn River who are currently contributing to the estuary's pollution should be required to shoulder some of the financial burden for this effort, perhaps based on the assessed value of their homes. Secondly, a certain percentage of the costs should be realized through the general county tax base, since all county residents benefit from a clean Severn River estuary. Third, the county may want to explore sources of financial support from the state and federal governments. Clean-up of the Severn is intrinsically linked to the larger state and federal effort to restore the entire Chesapeake estuary. Providing sewerage to densely developed areas and the upgrading of existing sewage treatment plants to tertiary levels must be a central part of the Chesapeake restoration program and is highly deserving of state and federal financial support.

Maintenance of Existing Building Characteristics

In order to ensure that the historic and scenic character of the waterfornt is not lost, it will be important to ensure that the scale, bulk and height of existing historic communities is maintained and not overwhelmed by adjacent new development.

Protection of Existing Open Space and Forest Cover

As the waterfront reaches buildout, it will become increasingly attractive for infill and upgrading of existing developments to occur. If this trend is not left unchecked, loss of existing open space and forest cover will result. Although the Forest Conservation Act does cover canopy loss

to new construction, the regulations do not properly protect trees on existing properties or those under renovation.

Residential Landscape Design with Mass Native Plantings

This technique emphasizes mass plantings of native vegetation and discourages the planting of expansive, closely mowed lawns nurtured with fertilizers and pesticides. This naturalistic residential landscape design should contain many similarities to the surrounding undisturbed forest, thus creating a diverse terrestrial wildlife habitat. This condition currently exists in some of the older residential developments on the Severn, where mature canopy trees and a dense, native forest understory surround homes.

Environmental linkage program

This technique requires that developments, upon construction, contribute funding for implementation of environmental remediation programs in existing developments along the Severn River. The linkage should be fair, avoiding placement of undue burdens on new developments, but simultaneously recognizing that developers have a responsibility to improve the communities where their developments occur. New developments could help fund and build all of the recommended remedial techniques in this section. This includes, but is not limited to, construction of stormwater wetland basins and vegetated swales, fringe tidal wetlands, natural-systems sewage treatment facilities, residential landscape design with mass native plantings, and soil bio-engineering.

A more comprehensive discussion of specific stormwater best management practices (BMPs) is provided in Appendix A.

Appendix A: Stormwater Best Management Practices (BMPs)

As coastal communities within the Severn River watershed develop non-point source pollution control programs, they must choose a series of BMP options that can reliably achieve water quality goals. It is important to recognize that no single type of BMP is ideally suited for every situation and that each technique brings with it various performance, maintenance and environmental advantages and disadvantages. A BMP typically is a structural device that temporarily stores or treats urban stormwater runoff from impervious surfaces to reduce flooding, remove pollutants, and/or provide amenities (Schueler, Kumble, Heraty, 1992).

Not all urban BMPs can reliably provide high levels of removal for both particulate and soluble pollutants. BMPs which can consistently achieve moderate to high levels of removal for both particulate and soluble pollutants include:

- Wet Ponds
- Artificial Wetland Marshes
- Sand Filters
- Infiltration Trenches

Of the preceding four BMP types, only wet ponds and artificial wetland marshes have demonstrated a general ability to continue to function as designed for relatively long

periods of time without the need for routine maintenance (Galli,1992).

Wet Ponds: The wet pond is one of the most reliable and attractive BMPs that are currently in use. This technique is very useful as a costal non-point source pollutant removal management practice (Schueler, Kumble, Heraty, 1992).

While wet ponds provide numerous community amenities and environmental benefits, they can have adverse environmental impacts if the ponded areas are not first carefully evaluated and located (Galli, 1991). Wet ponds traditionally have a permanent pool of water for treating incoming stormwater runoff. With enhanced wet pond designs, a forebay is installed in the pond to trap incoming sediments, where they can easily be removed with regular maintenance. In addition, a fringe wetland is established around the perimeter of the pool area for providing removal of soluble pollutants through the vascular system of the wetland plants (Schueler, 1992).

Artificial Wetland Marshes: Artificial wetland marshes can have great success in coastal areas as a non-point source pollutant removal management practice. Conventional designs include the use of a shallow pools suitable for the growth of marsh plants. Artificial wetland marshes are designed to maximize pollutant removal through wetland soil processes, wetland plant uptake, retention, and settling of sediments. Because these are constructed systems, they should not be located within delineated natural wetlands. In addition, artificial wetland marshes created for stormwater management do not replicate all of the functions of naturally occurring wetlands (Schueler, Kumble, Heraty, 1992).

Sand Filters: Sand filters are a widely applicable and adaptable BMP that can provide significant pollutant removal at small sites that often characterize coastal development. Sand filters are a relatively new technique for treating nonpoint stormwater runoff. Their application has traditionally been associated with treatment of sanitary sewer contaminants. When used as a stormwater management technique, the first flush of runoff is diverted into a self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes, and then returned back to the stream or channel (Troung, 1989). Some enhanced systems include the use of layers of peat, limestone, and topsoil with a grass cover crop. Sand filters should not be used when the catchment area exceeds 10 acres or more (MWCOG, 1992).

Infiltration BMPs: Infiltration BMPs have historically been presumed to be an effective technique for removing

stormwater born pollutants, yet are not found to be reliable given their poor longevity. Of particular concern are infiltration basins and porous pavement. The poor longevity of these BMPs is attributed to a number of factors: the lack of adequate pretreatment; poor construction practices; application to infeasible sites; and, a lack of regular maintenance. Very often, the life-spans of BMPs can be increased to acceptable lengths if local communities adopt enhanced designs and commit to strong maintenance and inspection programs (Galli, 1992).

Other BMPs such as grassed swales and forested filter strips cannot provide reliable levels of pollutant removal until their basic designs are greatly enhanced (Galli, 1992). Although the use of these techniques are important non-structural components of any systems' approach to reducing the impacts associated with nonpoint source pollution, grassed swales and forested filter strips should not be considered as the primary treatment technique.

As mentioned earlier, no single BMP option can be applied to all development scenarios. In addition, BMP options require careful site assessment prior to design. Pond options are applicable to the widest range of development situations, but typically require a minimum drainage area. Infiltration practices have very limited applications and require careful field verification of soils, water tables, slope and other factors (Schueler, 1991).

A Systems Approach to Best Management Application

Many of the conventional BMPs when used as a non-point source pollutant removal management practice need to be enhanced if they are expected to provide reliable pollutant removal and greater longevity. In many cases, a systems approach to BMP design is warranted where multiple BMPs, or BMPs used in series provide runoff attenuation, conveyance, and pretreatment of runoff from paved, man-made surfaces (Schueler, Galli, Herson, Kumble, Shepp, 1991).

Stormwater Management References

Galli, F. J. 1992. *Analysis of the Performance and Longevity of Urban BMPs installed in Prince George County, Maryland.* Prepared for the Department of Environmental Resources. Prince George's County, Maryland.

Galli, F. J. 1991. *Thermal Impacts Associated With Urbanization and Stormwater BMPs in Maryland.* Anacostia Restoration Team. Prepared for Maryland Dept. of the Environment. 150 pp.

Metropolitan Washington Council of Governments (MWCOG). 1992. *Watershed Restoration Source Book.* Anacostia Restoration Team. Department of Environmental Programs. Washington, DC. 268 pp.

Schueler, T. R., F. J. Galli, L. Herson, P. Kumble and D. Shepp. 1991. *Developing Effective BMP Systems for Urban Watersheds.* Urban Nonpoint Workshops. New Orleans, Louisiana. January 27-29, 1991.

Schueler, T. R. 1991. *Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Governments.* Proceedings of the National Conference Integration of Stormwater and Local Nonpoint Source Issues. Northern Illinois Planning Commission. pp. 25 - 36.

Schueler, T. R., P. A. Kumble and M. A. Heraty. 1992. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone.* Anacostia Restoration Team, Metropolitan Washington Council of Governments. Publication #92705. Washington, DC. 127pp.

Schueler, T. R. 1992. *Design of Stormwater Pond Systems.* Metropolitan Washington Council of Governments. Washington, DC.

Appendix B: Population and Housing Unit Projections for the Severn River Watershed

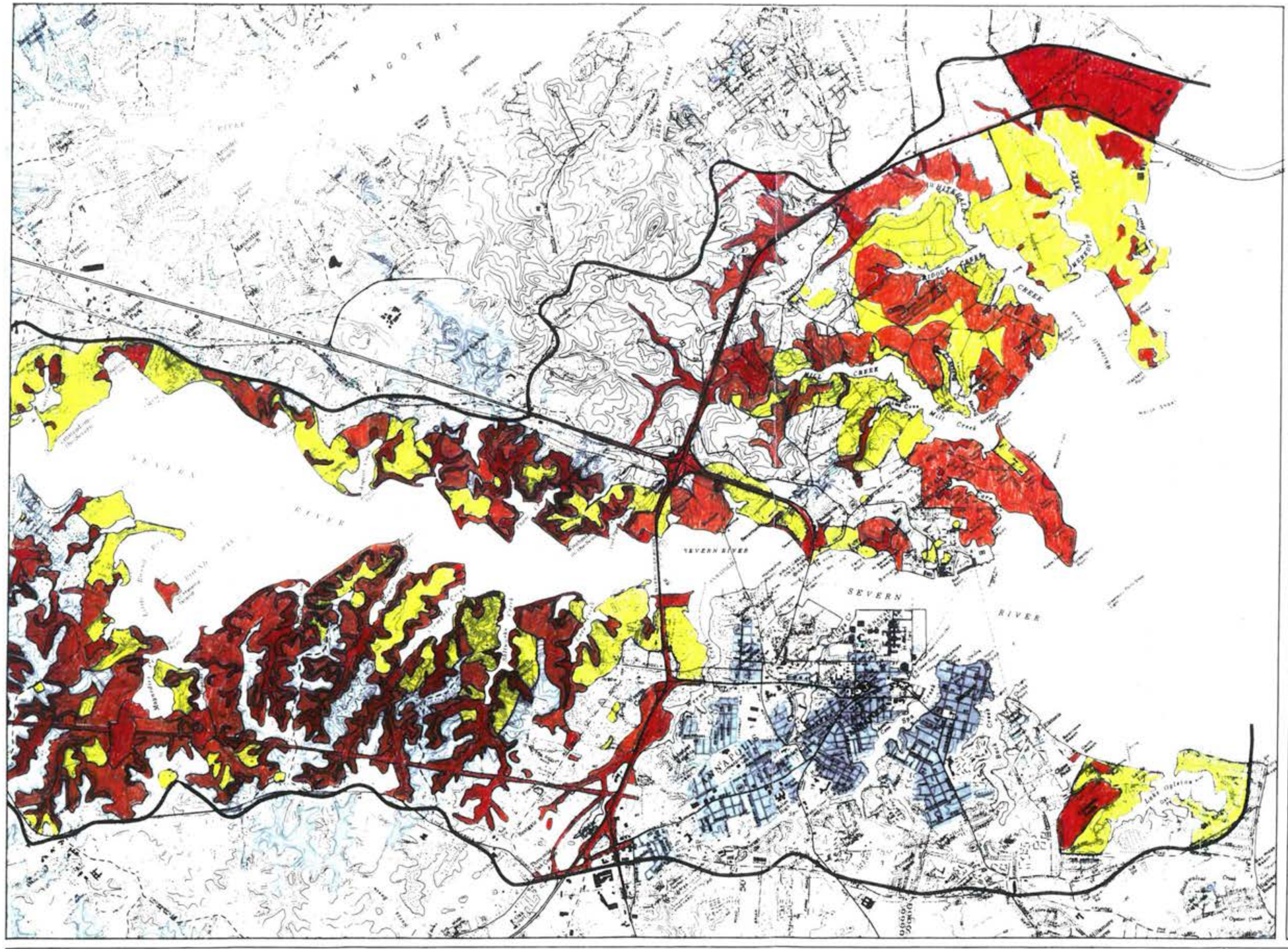
Population Projections for the Severn River Watershed by Census Tract

Census Tract#	Percent in Watershed	1980	1990	1993	2000	% change	2020	% change	10yr Permitting Activity 1980-90
7021	100%	5043	5792	6027	5908	17	5833	-16	28
7026	30%	1838	2966	2215	3041	3	3405	12	15
7027	100%	3890	5143	7383	8996	74	10955	22	549
7061.1	100%	3989	3813	3742	3604	-5	3394	-6	0
7063	100%	6358	7435	7312	7090	-5	6701	-5	2
7064	100%	8424	8683	8742	8671	0	8393	-3	45
7065	100%	7353	4507	4623	4763	6	4999	7	23
7066	100%	5716	4896	4837	4683	-4	4999	7	9
7305.04	60%	3192	4747	4653	4518	-5	4503	0	-
7306.01	90%	3837	5208	5410	5798	11	6128	6	2629
7306.02	20%	1208	1616	1616	1697	5	1806	6	-
7307	80%	4960	5030	4982	4851	-4	4766	-2	8
7308	90%	1945	1971	1966	1905	-3	2273	19	6
7309.01	100%	2477	2917	2886	2787	-4	2961	6	2
7309.02	100%	2052	2069	2072	2059	0	2303	12	2
7310.02	40%	646	892	900	880	-1	975	11	-
7310.03	100%	538	801	869	895	12	969	8	-
7311.03	50%	1114	2417	2472	2471	2	2813	14	8
7401.01	55%	7198	8741	9224	10089	15	11458	14	45
7402.01	18%	1313	1270	1247	1194	-6	1250	5	1
7402.02	20%	427	555	562	547	-1	639	17	4
7402.03	100%	2649	3623	3943	4242	17	5086	20	72
7403.01	100%	1986	2413	5525	13783	471	17669	28	528
7403.03	100%	2275	2372	2338	2751	16	4031	47	4
7408	50%	2384	2249	2322	2296	2	2366	3	2
7410.10	100%	1730	1713	1709	1744	2	2013	15	-
Totals		84,542	93,839	99,577	111,263	19	117,689	6	

Housing unit projections in the Severn River Watershed

Tract Number	Percent in Watershed	Units in 1990	Add'l 2000	Add'l 2020	Total Units in 2020
7021	100%	2233	124	248	2605
7026	30%	1154	40	262	1456
7027	100%	1980	1503	1303	4786
7061.1	100%	1882	-103	-104	1675
7063	100%	4284	-199	-224	3861
7064	100%	3857	-5	-26	3826
7065	100%	1986	113	104	2203
7066	100%	2243	-98	145	2270
7305.04	60%	1705	-82	-76	1547
7306.01	90%	1633	361	364	2358
7306.02	20%	519	76	115	1229
7307	80%	1920	69	199	2188
7308	90%	1764	22	263	1049
7309.01	100%	937	3	184	1124
7309.02	100%	805	41	214	1060
7310.02	40%	337	19	105	439

Appendix C: Maps



Development Constraints

- Development Permanently Prohibited
- Extensive Constraints/Review
- Moderate Constraints/Review
- Minimal Constraints/Review

Development Constraints

Development Permanently Prohibited

Slopes greater than 30%
Parks, Conservation Areas
Wetlands and Floodplains
Areas Zoned as open Space
Highway, Railroad and Utility Corridors
Landfills

Extensive Constraints/Review

Co-occurances of two or more of the following:
15-30% Slopes
Soils unsuitable for septic systems in unsewered areas
Resource Conservation Areas identified in the Anne Arundel County Critical Area Maps
Forested Areas
Endangered Species habitat
Areas with poor access

Moderate Constraints/Review

One of the following:
15-30% Slopes
Soils unsuitable for septic systems in unsewered areas
Resource Conservation or Limited Development Areas identified in the Anne Arundel County Critical Area Maps
Existing schools and public facilities
Archaeological sites
National Register Properties
Anne Arundel County Historic Inventory sites

Minimal Constraints/Review

No significant physical or regulatory barriers to development

Severn River Watershed Management Plan

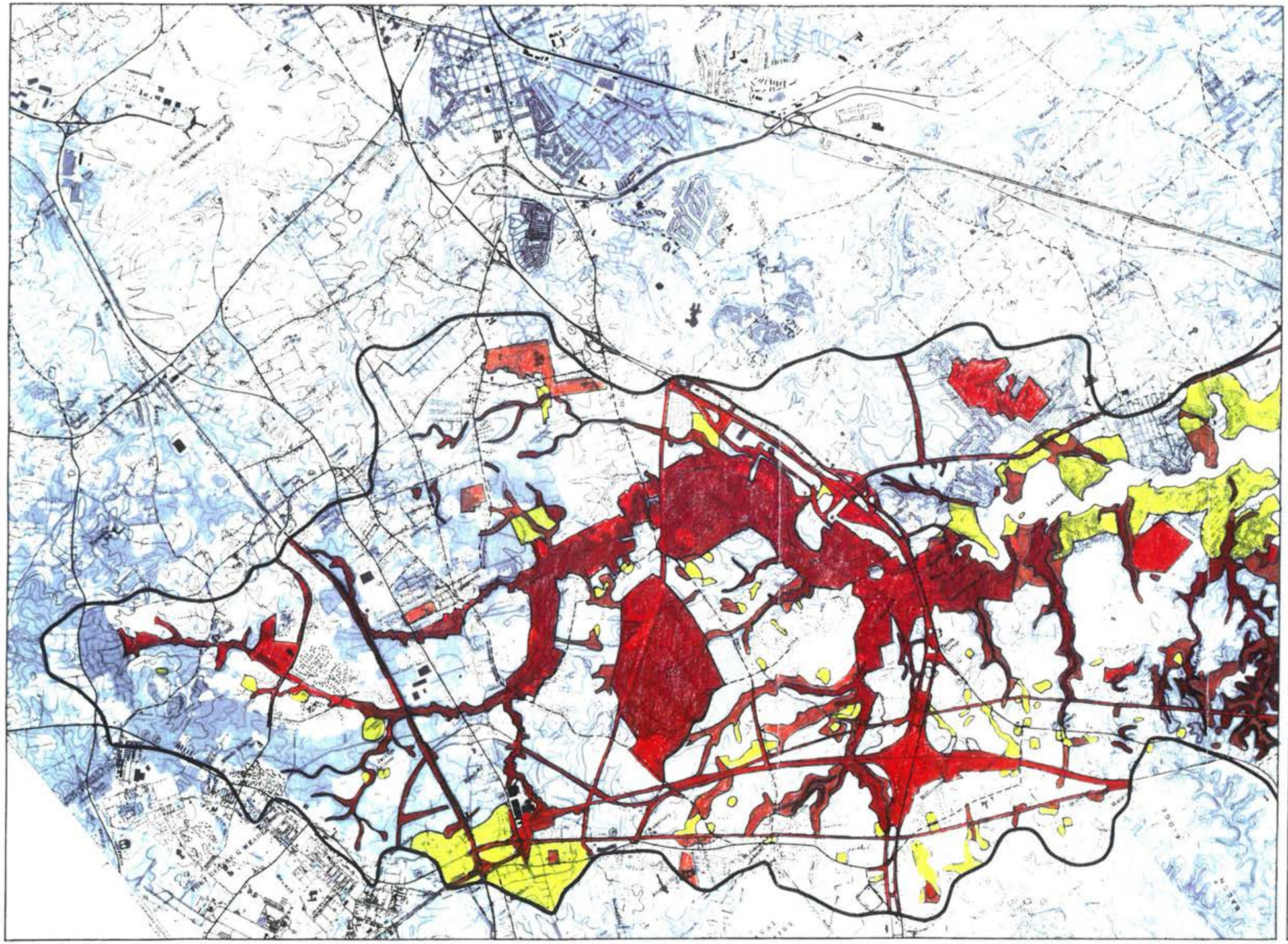
Prepared for:
The Severn River Commission, c/o Anne Arundel Co. Office of Planning & Zoning
Heritage Office Center, 2664 Riva Road, Annapolis, MD 21404

Prepared by:
Dodson Associates
P.O. Box 160, Ashfield, MA 01330

Land Ethics
1400 16th Street N.W., Washington, DC 20036

Scale: 1" = 2,000'
Date: 5/3/93

North



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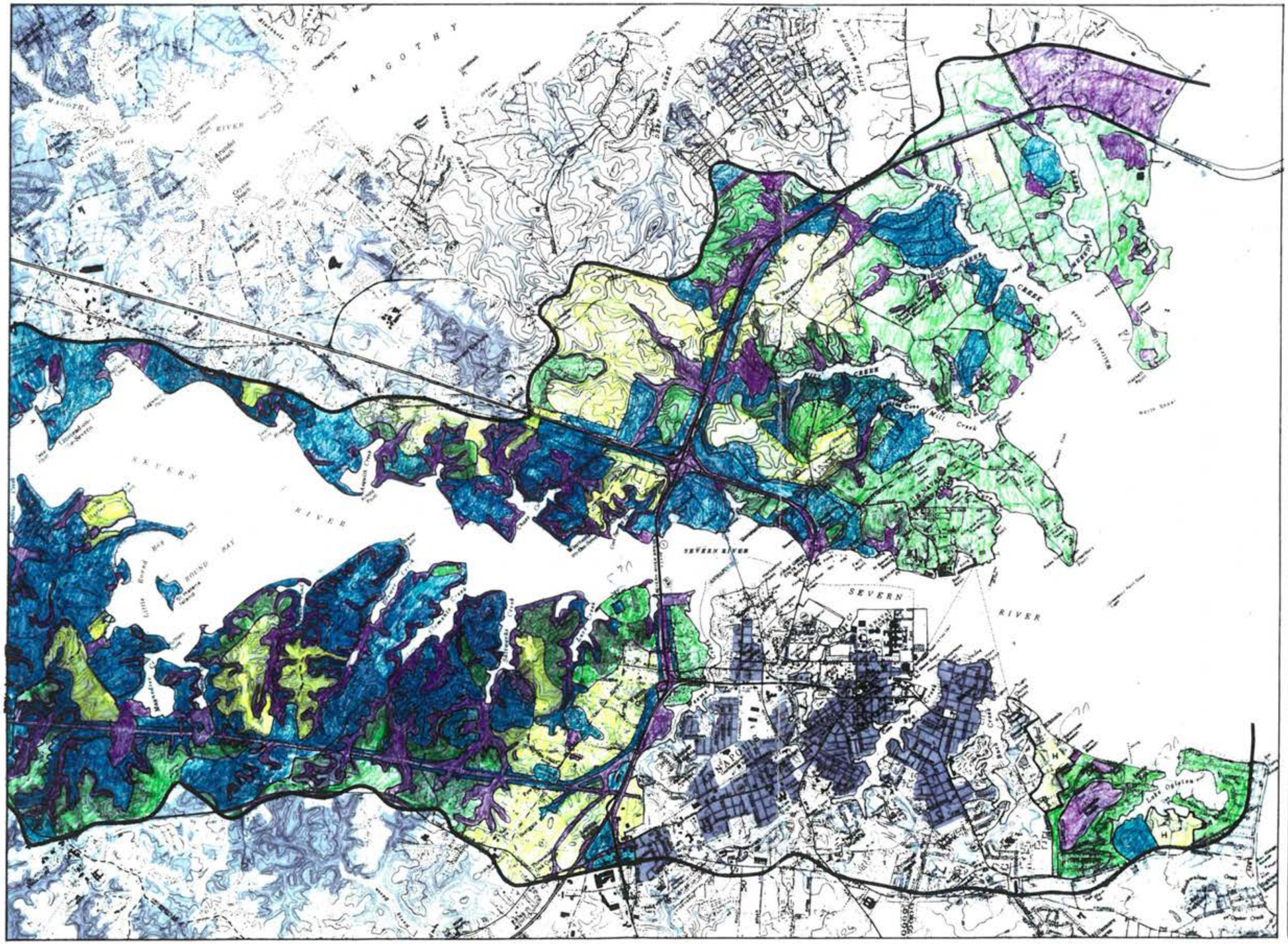

Development Probability

- Very Low Probability
- Low Probability
- Medium Probability
- High Probability

Development Probability Factors

The following factors have been taken into account in predicting the likelihood of future development within the next twenty years under existing zoning and projected market and demographic conditions in the Severn Watershed Area. Factors are not absolute but interrelate and affect each other. Forces encouraging the development of a particular area (development desirability: visual quality, strong market demand, demographic projections, etc.) are offset by forces limiting the development of that area (regulatory limitations, physical limitations, weak market or demographic projections, etc.).

Very Low Probability:

Highway and Utility Corridors
Railroad Right-of-Ways
Slopes Greater Than 30%
Parks, Conservation Areas
Wetlands
Areas Zoned for Open Space

Low Probability:

Existing Fully Developed Areas
Existing Wastewater Problem Areas
Severe Physical Limitations to Development
Severe Regulatory Limitations
Low Demographic Projections
Low Market Demand
Low Density Residential Areas within 500' of Major Highways

Medium Probability:

Moderate Physical Limitations to Development
Moderate Regulatory Limitations to Development
Moderate Market Demand
Moderate Demographic Projections
High Density Residential Areas Within 500' of Major Highways

High Probability:

High Visual Quality
Proximity to Water
Strong Market Demand
Strong Demographic Projections
Low Physical Limitations to Development
Low Regulatory Limitations to Development
Industrial, Commercial, PRWoG, Multi Family or Town Center Zoning Within
Parole/Odenton Growth Centers

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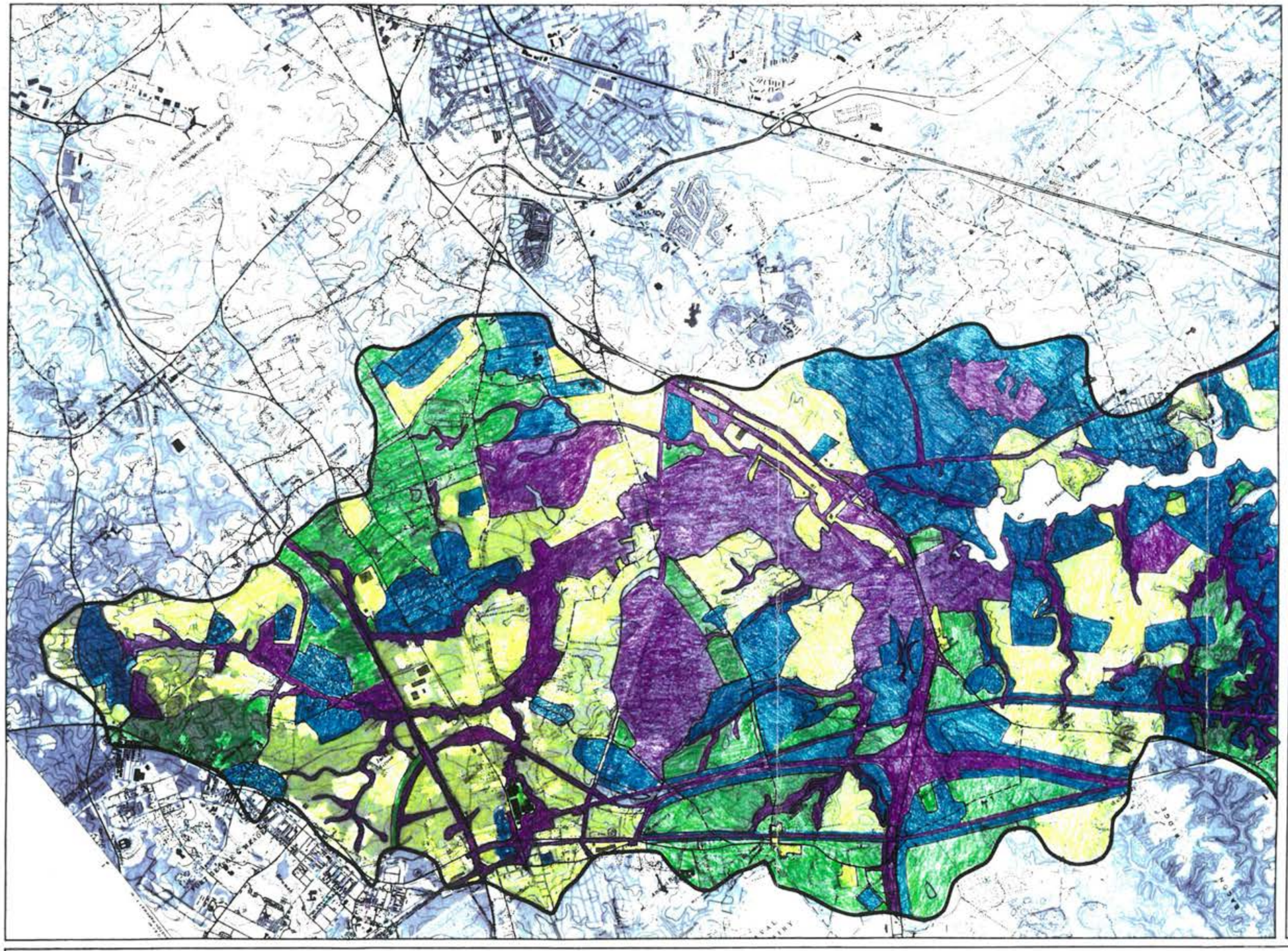

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- Very Low Probability
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- High Probability

Development Probability Factors

The following factors have been taken into account in predicting the likelihood of future development within the next twenty years under existing zoning and projected market and demographic conditions in the Severn Watershed Area. Factors are not absolute but interrelate and affect each other: forces encouraging the development of a particular area (development desirability, visual quality, strong market demand, demographic projections, etc.) are offset by forces limiting the development of that area (regulatory limitations, physical limitations, weak market or demographic projections, etc.)

Very Low Probability:

Highway and Utility Corridors
Railroad Right-of-Ways
Slopes Greater Than 30%
Parks, Conservation Areas
Wetlands
Areas Zoned Agricultural Space

Low Probability:

Existing Fully Developed Areas
Existing Wastewater Problem Areas
Severe Physical Limitations to Development
Severe Regulatory Limitations
Low Demographic Projections
Low Market Demand
Low Density Residential Areas within 500' of Major Highways

Medium Probability:

Moderate Physical Limitations to Development
Moderate Regulatory Limitations to Development
Moderate Market Demand
Moderate Demographic Projections
High Density Residential Areas Within 500' of Major Highways

High Probability:

High Visual Quality
Proximity to Water
Strong Market Demand
Strong Demographic Projections
Low Physical Limitations to Development
Low Regulatory Limitations to Development
Industrial, Commercial, Office, Multi-Family or Town Center Zoning Within
Private Undeveloped Growth Centers

Severn River Watershed Management Plan

Prepared for:
The Severn River Commission, c/o Anne Arundel Co. Office of Planning & Zoning
Heritage Office Center, 2664 Riva Road, Annapolis, MD 21404

Prepared by:
Dodson Associates
P.O. Box 160, Ashfield, MA 01330

Land Ethics
1400 16th Street N.W., Washington, DC 20036

Scale: 1" = 2,000'
Date: 5/3/93

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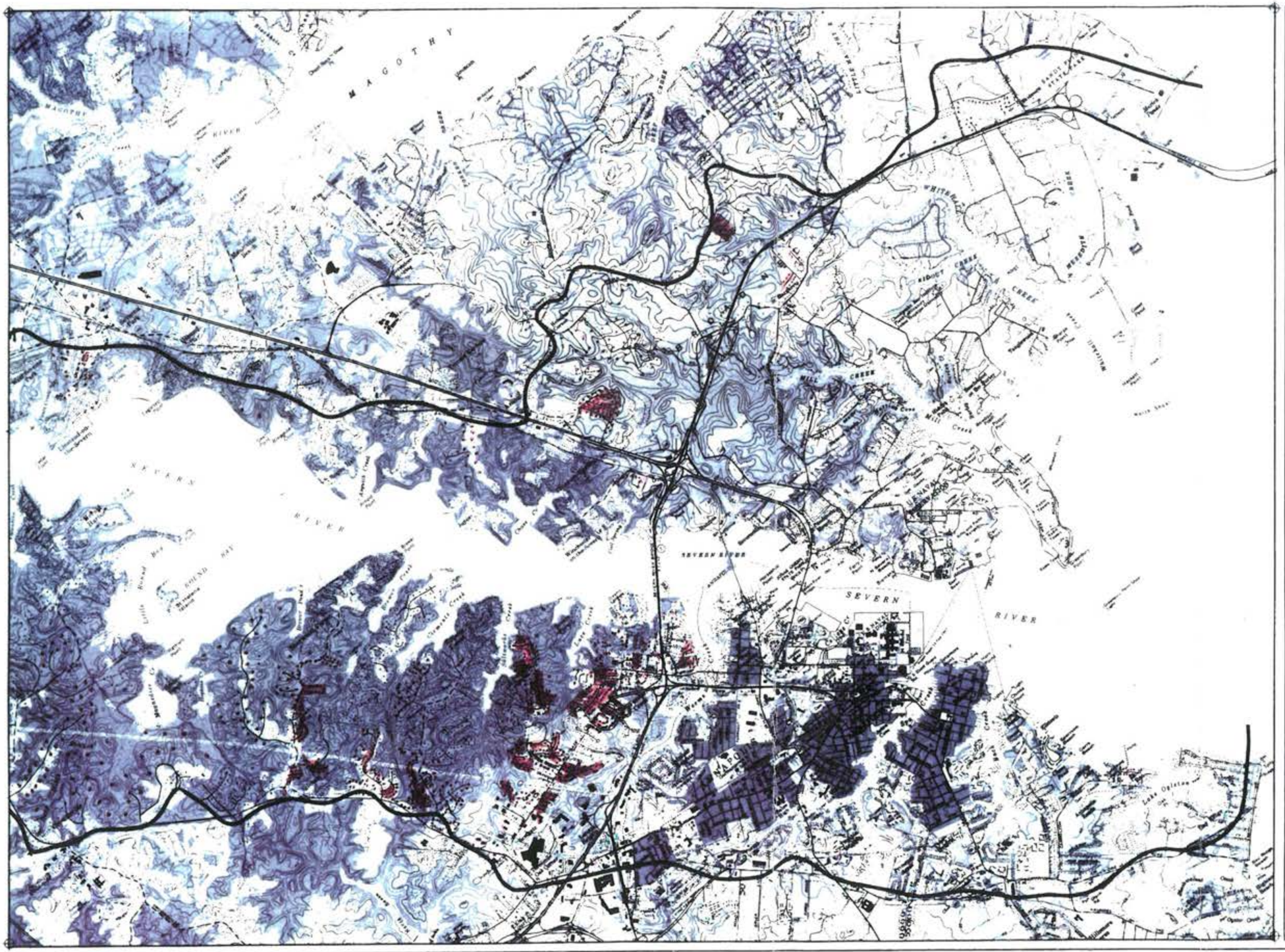

Buildout 2000

Projected development pattern under existing regulations and likely future development trends.

These development projections were based on the Development Constraints and Development Probability maps, combined with 1992 population and housing projections provided by the Anne Arundel County Office of Planning and Zoning. Development density was determined by existing county zoning and Critical Area Program overlay maps.

Development Projected by the year 2000

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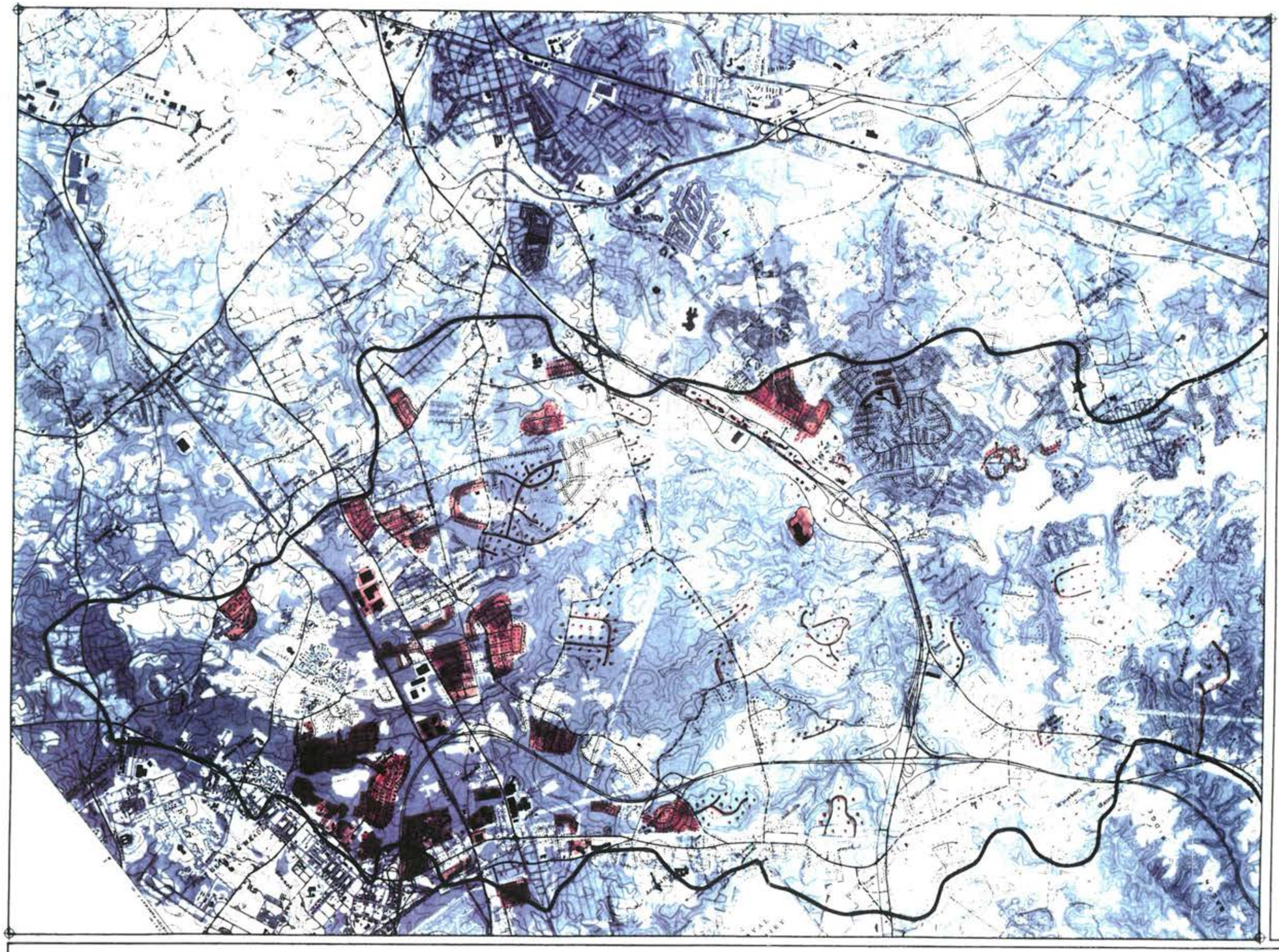

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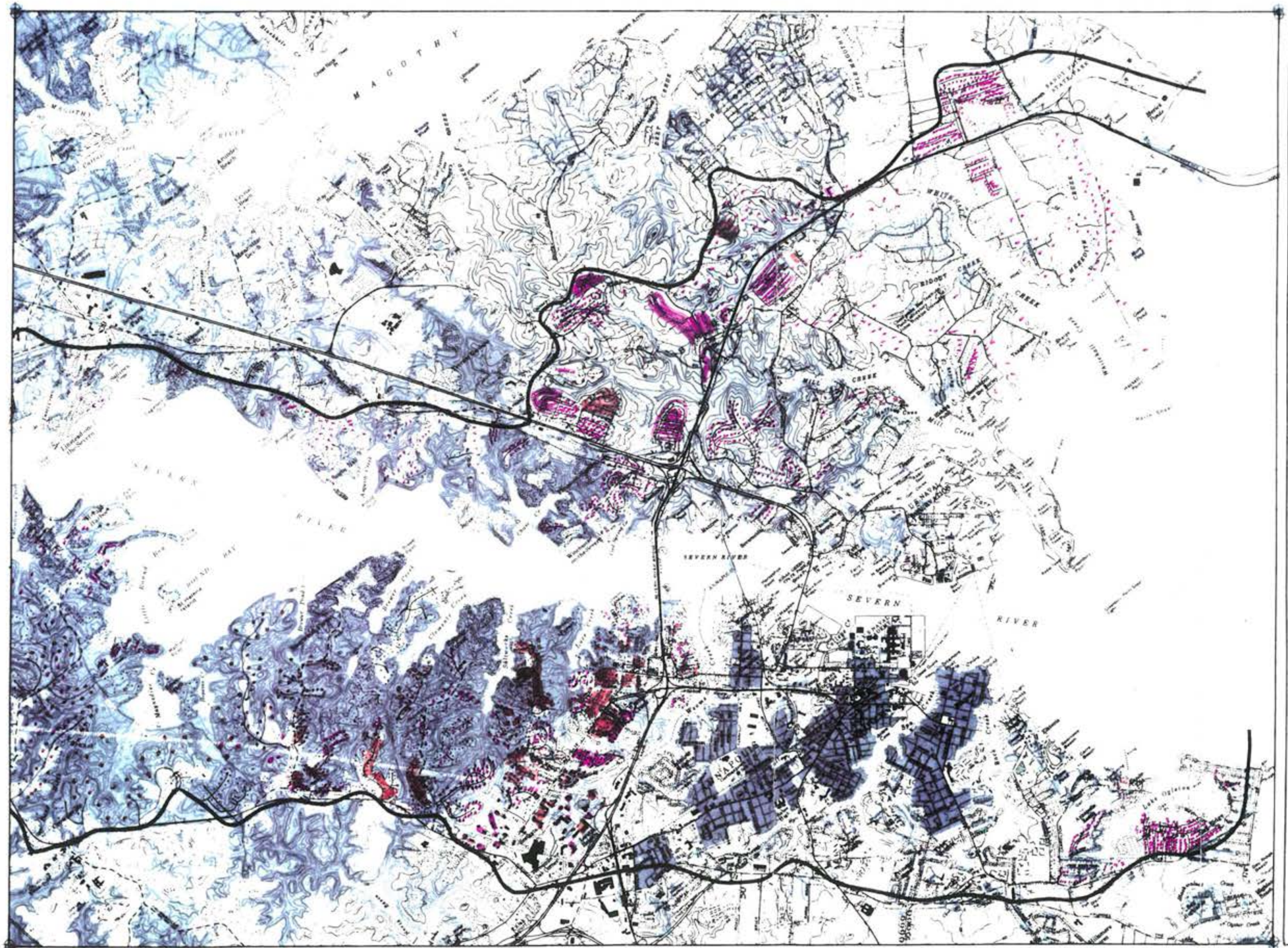

Buildout 2020

Projected development pattern under existing regulations and likely future development trends.

These development projections were based on the Development Constraints and Development Probability maps, combined with 1992 population and housing projections provided by the Anne Arundel County Office of Planning and Zoning. Development density was determined by existing county zoning and Critical Area Program overlay maps.

Development Projected by the year 2000

Development Projected by the year 2020

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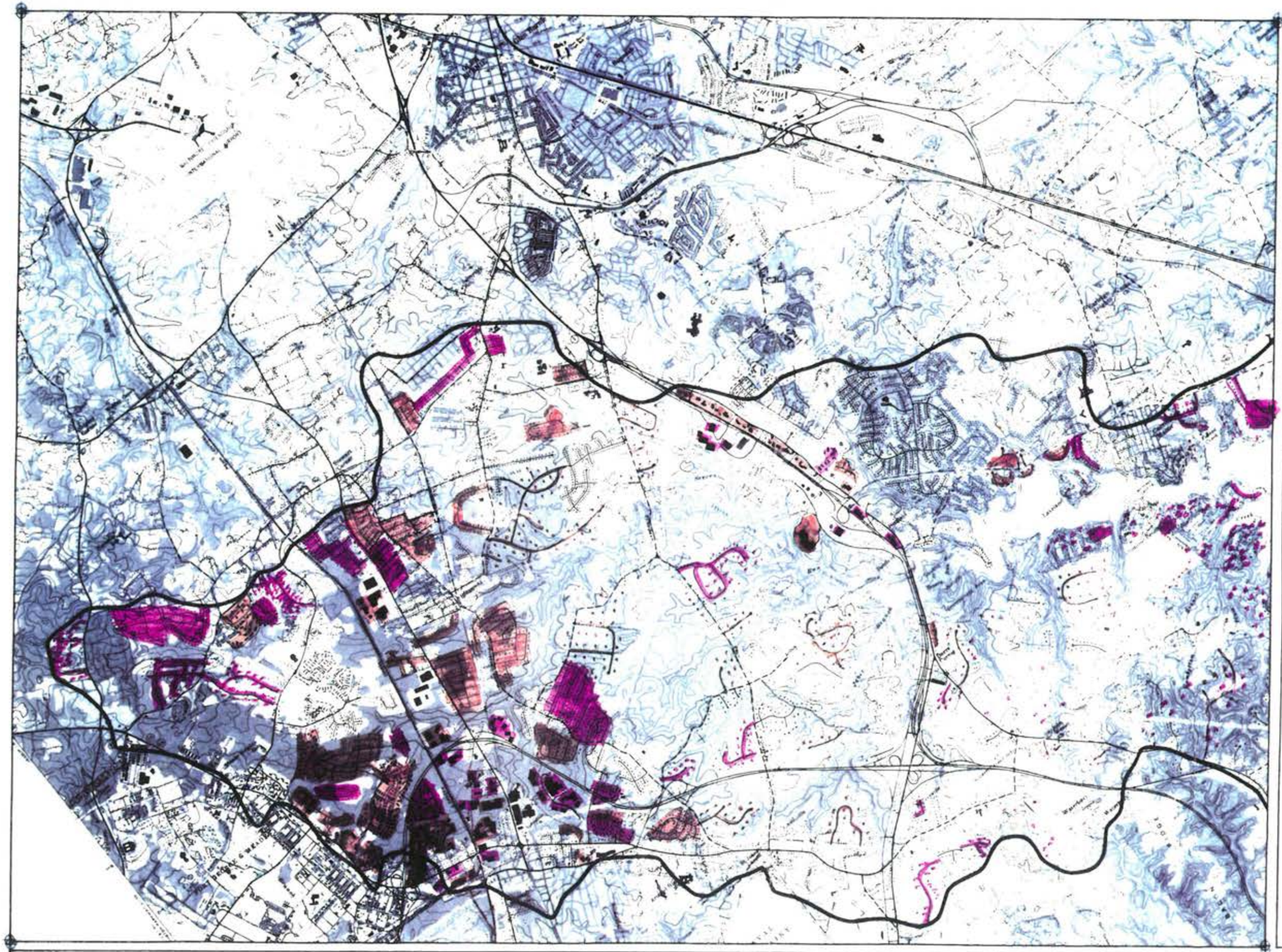

Buildout 2020

Projected development pattern under existing regulations and likely future development trends.

These development projections were based on the Development Constraints and Development Probability maps, combined with 1992 population and housing projections provided by the Anne Arundel County Office of Planning and Zoning. Development density was determined by existing county zoning and Critical Area Program overlay maps.

Development Projected by the year 2000

Development Projected by the year 2020

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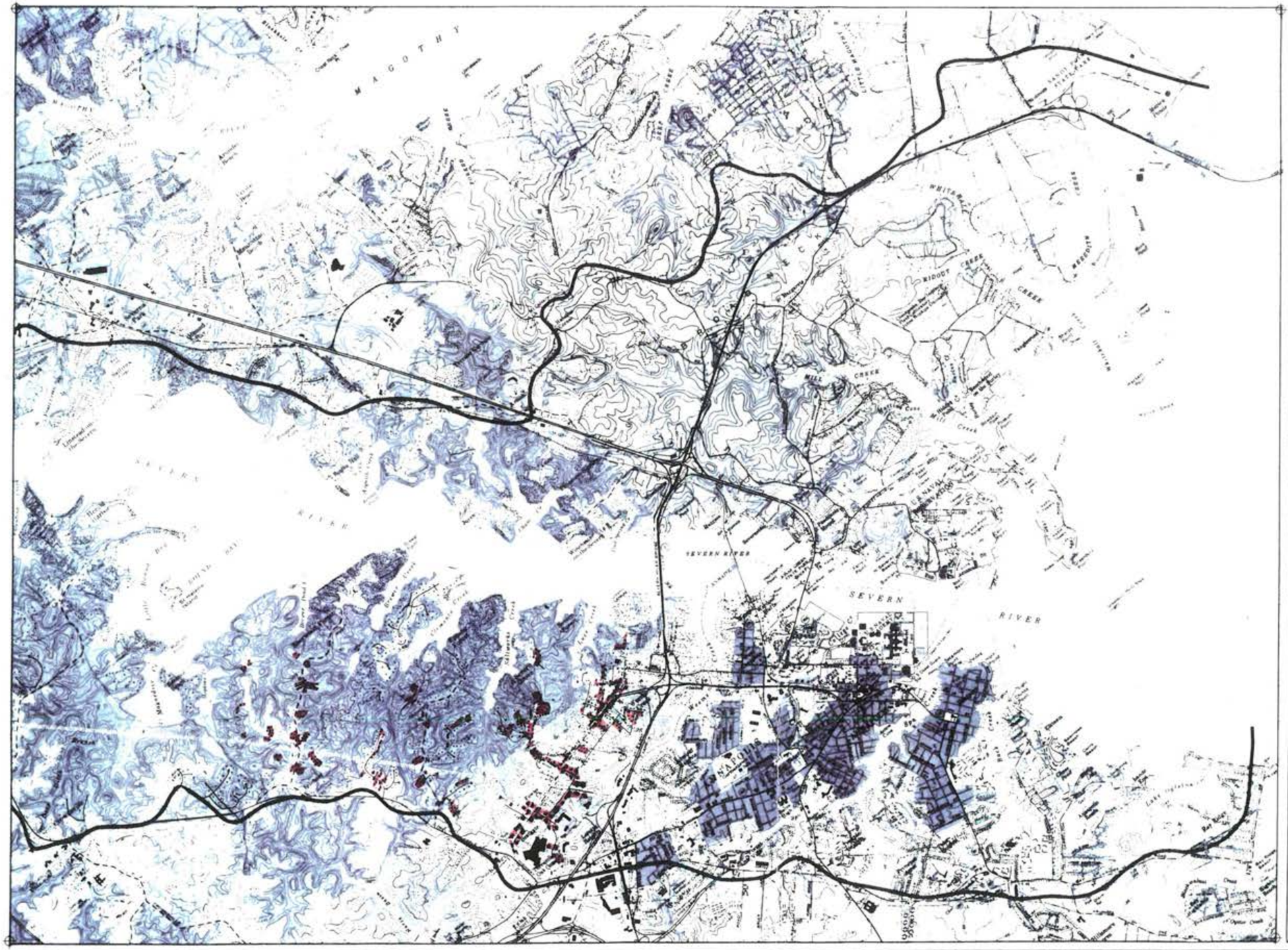

Recommended Development Pattern 2000

Weems-Hopkins Creek Subsection

Projected development pattern under modified landuse regulations and likely future development trends.

These development projections were based on the Development Constraints and Development Probability maps, combined with 1992 population and housing projections provided by the Anne Arundel County Office of Planning and Zoning. Development density was determined by existing county zoning and Critical Area Program overlay maps.

Adoption of the following regulations, policies, incentives and educational programs would lead to the creation of the recommended development patterns:

- Mandatory Open Space (Cluster) Zoning
- Site Plan Review
- Best Stormwater Management Practices
- Traditional Neighborhood Zoning (TND)
- Upgrading of existing storm water systems
- Riparian corridor protection
- Vegetative buffers
- Non-point source pollution control
- Acquisition of sensitive areas
- Conservation of sensitive areas through easements.
- Linkage of new development to repair of existing storm water systems
- Upgrading of existing sewage treatment plants to tertiary level
- Installation of wetlands retention basins, vegetated swales, vegetative buffers in new and existing neighborhoods.

Development Projected by the year 2000

Severn River Watershed Management Plan

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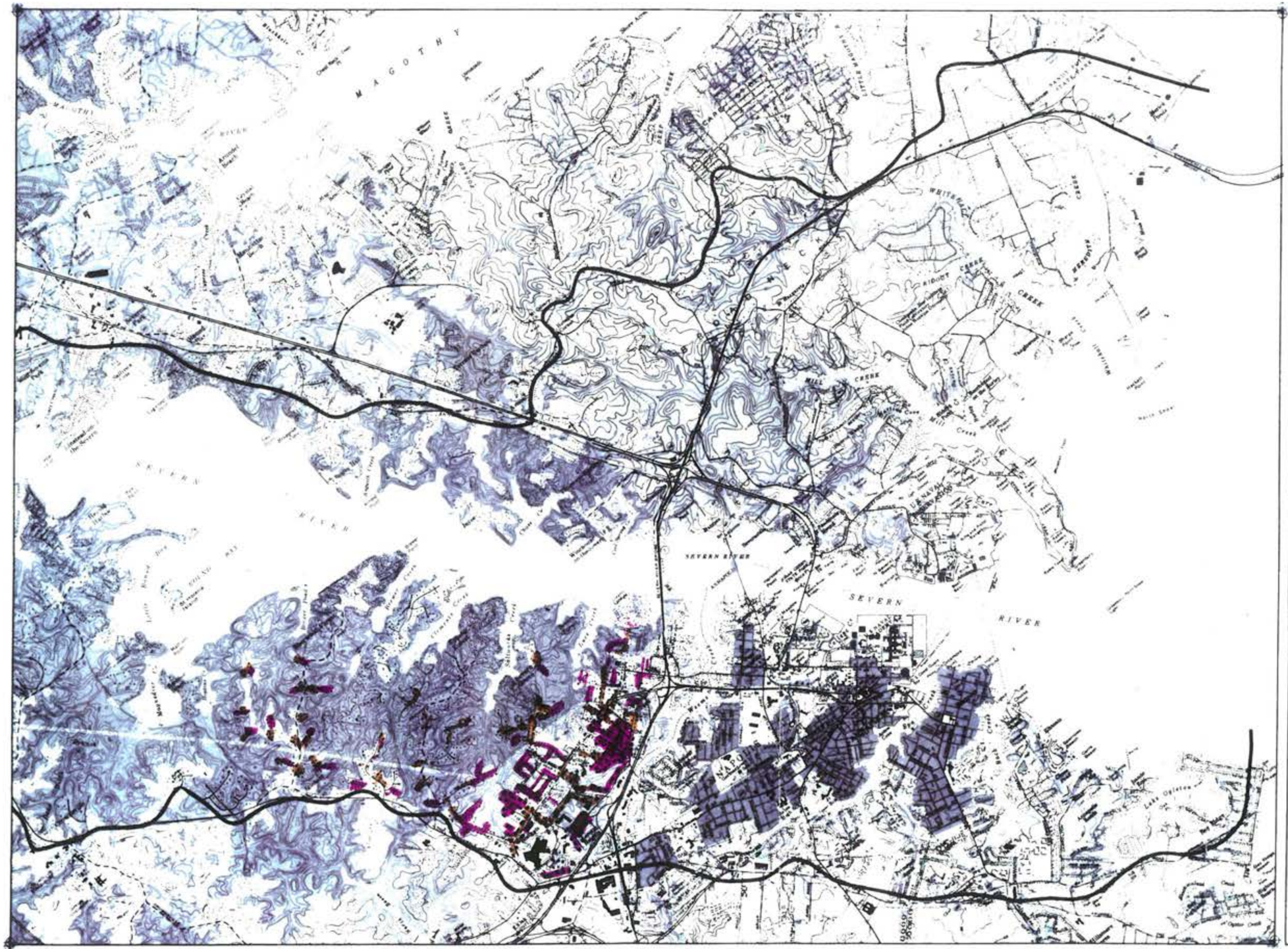

Recommended Development Pattern 2020

Weems-Hopkins Creek Subsection

Projected development pattern under modified landuse regulations and likely future development trends.

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Development Projected by the year 2000

Development Projected by the year 2020

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North

Severn River Watershed Management Plan

Typical Existing Conditions

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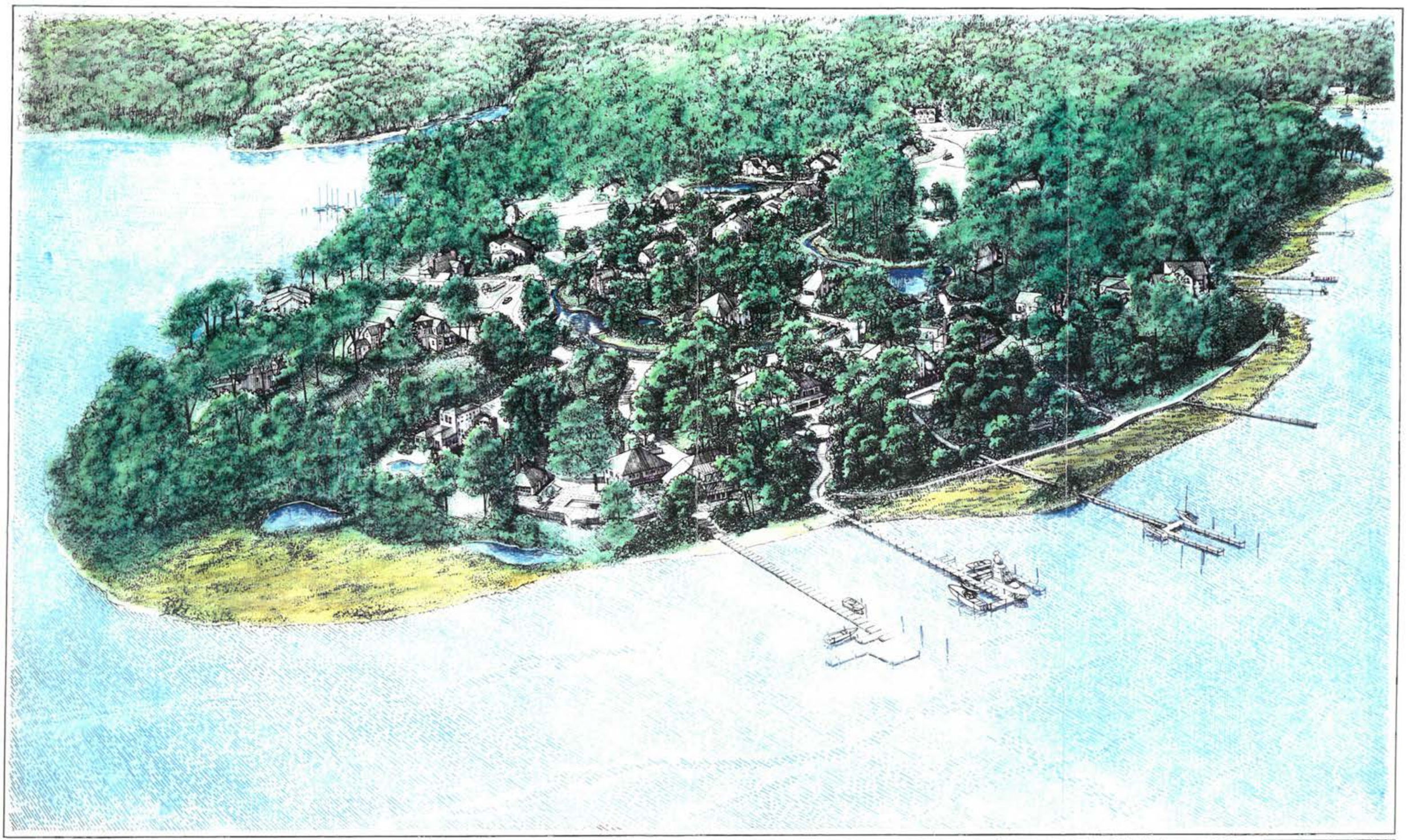

Severn River Watershed Management Plan

Recommended Environmental Remediation

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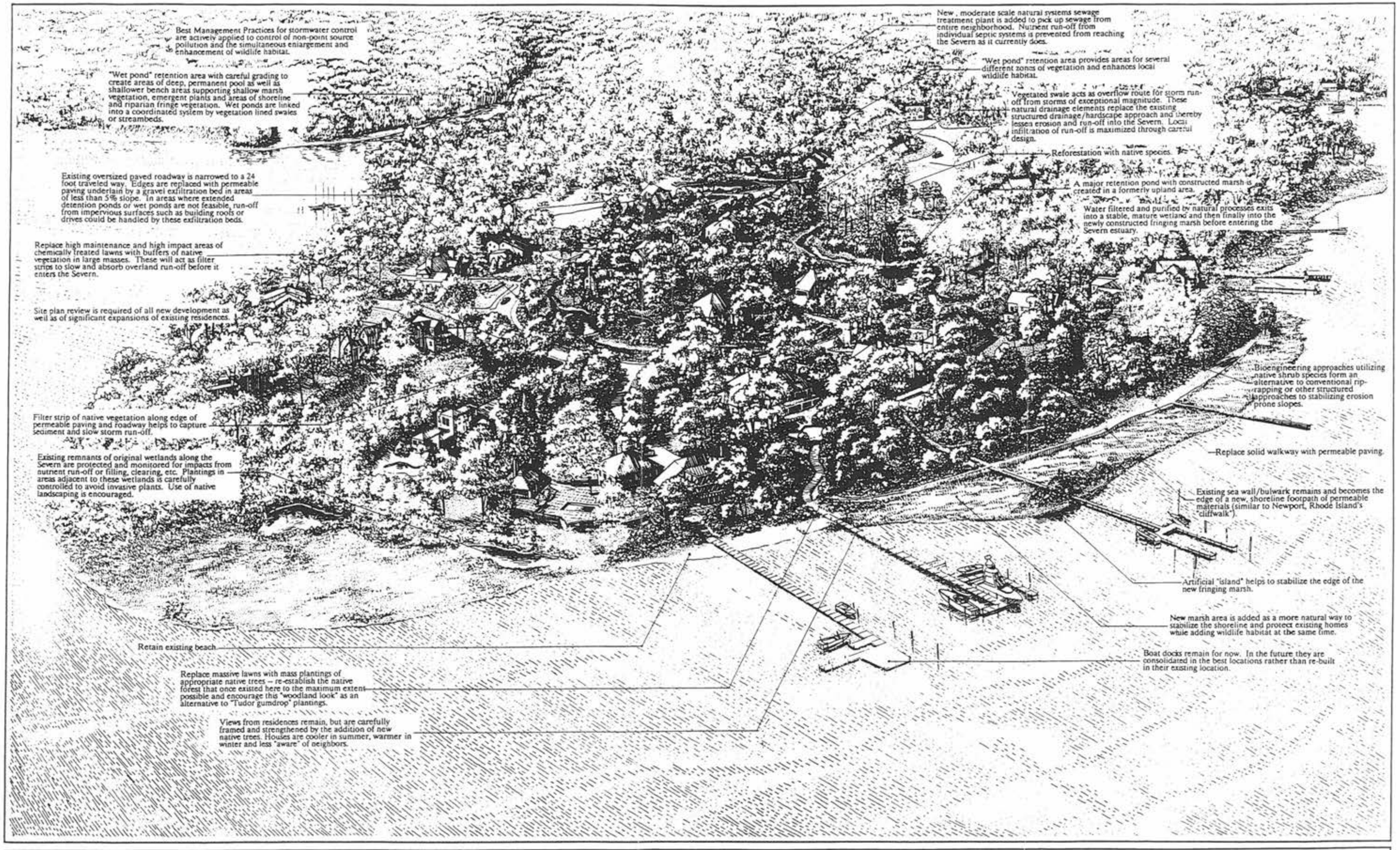

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Recommended Environmental Remediation

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Appendix D: Public Meetings Summary

Severn River Public Meetings

The Severn River Commission (SRC), in response to the Maryland Tributary Strategy Program, has initiated efforts to develop a comprehensive Watershed Management Plan for the Severn River. The SRC completed the first phase of this effort, a watershed study called "Living with the Severn River, A Management Study for the Severn River", which defines current impacts and general recommendations to protect the resources of the Severn River Watershed.

The Severn River Commission met with local citizen organizations and distributed informational brochures to initiate public participation efforts in the planning process. The meetings were conducted to educate the public regarding current Commission activities and to gain input from the residents of the Severn River watershed and concerned individuals regarding issues raised and recommendations proposed in the study.

Throughout October 1994 - February 1995, presentations were made to umbrella citizen groups including: General's Highway Association, Severn River Association, Annapolis City Council, Severna Park Council, Citizens Advisory Committee of the Chesapeake Executive Council (CAC) and Odenton Improvement Association. Table 1 summarizes the general topic areas discussed at these public meetings. Following is a brief discussion of the key issues and viewpoints of the community groups put forth as a result of the participatory efforts.

Role of SRC

The presentations provided the opportunity to educate the public regarding the role of the Severn River Commission and the current status of the Severn River Watershed Management efforts. Overall there was favorable interest in and support for the SRC's efforts.

Community Awareness

Throughout all of the presentations participants expressed interest in learning more about the efforts of SRC. They indicated a continued need for education and a better definition of the public's role in protecting the watershed.

Table 1. Summary of Topics Discussed at Public Meetings.

SUBJECT	CAC [1]	ACC [2]	GHA [3]	SRA [4]	SPC [5]	OIA [6]
Role of SRC				◘	◘	
Existing Regulations		◘	◘	◘	◘	
Further Assessment of Exist. Regs.			◘	◘	◘	
Future Regulatory Initiatives	◘		◘		◘	◘
Develop Specific Guidelines					◘	
Involvement in Regulatory Process				◘	◘	
Local Govern/Agencies Support	◘					◘
Community Projects	◘		◘	◘		◘
Public Access				◘	◘	
Community Awareness Efforts		◘		◘		
Expand Stakeholders	◘					
Support SRC /Offer Assistance		◘	◘	◘	◘	

[1] Citizens Advisory Committee of the Chesapeake Executive Council (CAC)
[2] Annapolis City Council
[3] General's Highway Association
[4] Severn River Association
[5] Severna Park Council
[6] Odenton Improvement Association

Existing Regulations

Participants acknowledged the effectiveness of existing regulations (i.e. Critical Area legislation), but recommended further efforts to educate the public concerning the components of these regulations. Participants stated that many problems, particularly those affecting individual homeowners, stem from misunderstanding the regulatory requirements and procedures. Also, these misunderstandings place more focus on the cumbersome and economic aspects of the regulations and not enough focus on their environmental value.

Concerns were raised that some of the existing regulations actually provide disincentives for what they are actually attempting to achieve. For example, with the existing process resulting from the Forest Conservation Act, it is often less expensive for a developer to pay a reforestation fee than to actually reforest an area. Questions were raised if the existing regulations are really doing what we want them to do. Perhaps some of the existing development requirements are excessive or providing more negative effects rather than beneficial ones, such as excessive road widths within subdivision design standards.

Participants recommended that some of the existing regulations be evaluated for their effectiveness and modified as necessary. In particular, participants expressed concern regarding the limited protection and lack of teeth provided by the current State Wild and Scenic River regulations. For example, the Patuxent River (not designated a WSR) has more protection than the Severn River as a result of the

development and implementation of the Patuxent River Policy Plan. Assessment and restructuring of the WSR legislation could provide enhanced protection for the valuable resources of the Severn River.

Finally, participants recommended future regulatory recommendations tie into the existing regulations and programs where possible. For example, the Greenscape Program and the Public Urban Land Trust within the city of Annapolis would coincide with some of the recommendations put forth in the study.

Future Regulatory Initiatives

Future steps planned by the SRC in the watershed management process were discussed. Participants recommended that the first step in the process be the development of more detailed legislative initiatives, and that community groups could provide more specific input and/or support. The question was raised if the SRC had plans to assess the potential impact on the tax base resulting from some of its preliminary recommendations, for example, lost tax revenues associated with TDR or PDR. Others questioned SRC's future plans for water quality monitoring. It was suggested that existing water quality monitoring information be consolidated, as much of the data has not yet been evaluated.

Some participants expressed concern that the report was too land focused. The point was raised that we need to address regulations pertaining to water-based issues in the efforts to protect the river.

Several comments focused on coordinating SRC's watershed management efforts with ongoing local and state government planning efforts. For example, there was support of SRC's involvement in the development of the Anne Arundel County General Development Plan and comprehensive rezoning. There was also recognition of the value of county and state government agencies' support of the recommendations put forth by the SRC. Comments were made focusing on the value of communications and coordination of efforts regarding future development between agencies and organizations for the effective management of the resources of the Severn River watershed.

Expand the Stakeholders

Members of the Citizens Advisory Committee of the Chesapeake Executive Council recommended increased communications with homebuilders associations and utilities, such as BGE. The cooperation of the SRC, local citizen organizations, homebuilders associations, and utilities could provide a strong constituency and supportive framework for implementing recommendations. A "unified" backing of specific legislative recommendations would increase chances for adoption of the recommended legislation and polices by the governmental agencies

Access to the River

Most individuals were opposed to the idea of increased public access to the Severn River. The concern appeared to be based on increased use (or overuse) of the Severn River. Citizens were interested if the SRC had identified specific locations for public access. A previous survey of residents in Severna Park demonstrated little enthusiasm and a degree of community opposition to the concept of increased public access points. There was generally the feeling that the Severn River already has too many access points.

Community Projects

The citizen groups expressed significant interest in the concept of community-based mitigation projects. The community projects provide a key method to gain the support of the communities and draw them into the watershed management efforts. Currently, many communities are afraid to take on remedial projects. Various groups stated the need for technical and financial assistance in order to implement such projects.

Suggestions focused on providing incentives, such as potential funding sources, and eliminating disincentives which result from the complexities of existing regulations. Many communities and individuals are afraid to take on remedial projects due to potential costs and problems that arise from the existing regulations. The County beautification funds were suggested as a potential funding source for community projects. Others suggested that the community projects would make perfect boy scouts projects. The Severn River Association offered to provide technical assistance to community groups desiring to implement remedial projects. If homeowner groups provide locations and potential types of projects, members of the SRA can provide technical expertise and suggestions for potential funding sources.

Support for SRC Efforts

Specific suggestions were put forth by several of the citizen groups to assist the efforts of the SRC. These included:

- The Generals Highway Association would be willing to help disseminate information regarding existing regulations to help educate the public about current requirements, restrictions, etc.

- The Severn River Association offers to support the efforts of SRC and assist in identifying specific community projects. We need to keep the momentum going and coordinate our efforts with those of the tributary strategies.

- The Severna Park Council would like to meet SRC's challenge of providing input and support for establishing regulatory measures to address future development. The Severna Park Council has previous experience with legislative issues and could provide guidance.

- The Annapolis City Council commended the results of the completed work and appreciates the efforts of SRC. The City participated in the funding of Phase I and would like to participate in future phases.

In conclusion, the discussion at the public meetings reflected overall support for the recommendations and efforts put forth by the Severn River Commission. Responses and interests primarily focused upon the implementation of community projects, review of existing regulations, and development of specific regulatory recommendations to address existing problems affecting the resources of the Severn River. There was acknowledgment of the need for cooperative efforts between local citizen groups, government agencies and other organizations in order to protect the valuable resources of the Severn River watershed.

References

Athanas, C. and C. Stevenson. 1991. *The Use of Artificial Wetlands in Treating Stormwater Runoff.* Prepared for the Sediment and Stormwater Administration. Maryland Department of the Environment.

Athanas, C. 1986. *Wetland Basins for Stormwater Treatment: Analysis and Guidelines.* Prepared for the Water Resources Administration. Maryland Department of Natural Resources.

Betchel, T.J. and B.J. Copeland. 1970. "Fish Species Diversity Indicies as Indicators of Pollution in Galveston Bay, Texas." *Contributions in Marine Science* 15:103-132.

CH2M Hill, 1980, *Severn Run Watershed Management Study.*

Carmichael, J.T., B.M. Richardson, M. Roberts and S.J. Jordan. 1992. *Fish Assemblages and Dissolved Oxygen Trends in Eight Chesapeake Bay Tributaries During the Summers of 1989 - 1991: A Data Report.* Maryland Department of Natural Resources, Chesapeake Bay Research and Monitoring Division.

Curtis, Meosotis C. 1991. *The Anne Arundel County Instream Monitoring Program, Heavy Metals, 1987-89.* Anne Arundel County Office of Planning and Zoning Environmental Division.

Davison, Todd A. and Rucker, Colby B. 1988. *Gems of the Severn,* Severn River Commission.

Dewberry and Davis. 1989. *Toxicity of Sediments from BMP Ponds.* Prepared for Northern Virginia Planning District Commission.

Dillaha, T. A., J. H. Sherrard, and D. Lee. 1989. "Long-Term Effectiveness of Vegetative Filter Strips." *Water Environment and Technology.* November 1989, pp. 419 -421.

Driscoll, E. D. 1983. *Performance of Detention Basins for Control of Urban Runoff Quality.* Presented at the 1983 International Symposium on Urban Hydrology, Hydraulics and Sediment Control. Lexington, Kentucky. 42 pp.

Engineering Technologies Associates, Inc. No Date. *Weems Creek Watershed Study, Phase II.*

Galli, F. J. 1992. *Analysis of the Performance and Longevity of Urban BMPs installed in Prince George County, Maryland.* Prepared for the Department of Environmental Resources. Prince George's County, Maryland.

Galli, F. J. and L. Herson. 1988. *Montgomery County Anacostia Watershed Retrofit Inventory.* Anacostia Restoration Team.

Galli, F. J. and L. Herson. 1989. *Prince George's County Anacostia Watershed Restoration Inventory.* Anacostia Restoration Team.

Galli, F. J. 1991. *Thermal Impacts Associated With Urbanization and Stormwater BMPs in Maryland.* Anacostia Restoration Team. Prepared for Maryland Dept. of the Environment.

Gore, A. 1992. *Earth in the Balance: Ecology and the Human Spirit*, New York, Houghton Mifflin Company.

Greenhorne and O'Mara, Inc. 1985. *Management Plan for the Weems Creek Watershed.*

Greenhorn and O'Mara, Inc. 1985. *Weems Creek Watershed Study.*

Groffman, P. M., A. J. Gold, T. P. Husband, R. C. Simmons, and W. R. Eddleman. *Final Report: Narragansett Bay Project. An Investigation into Multiple Uses of Vegetated Buffer Strips.* University of Rhode Island. 150 pp.

Horton, T., W.M. Eichbaum. 1991. *Turning the Tide: Saving the Chesapeake Bay.* Island Press, Washington DC.

Huppman, L. Reed, 1992. *Weems Creek Restoration Study.* Biohabitats, Inc.

Huppman, L. Reed, 1990. *State Highways Administration, Weems Creek Analysis.* Biohabitats, Inc.

Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yant and I.J. Schlosser. 1986. *Assessing Biological Integrity in Running Waters: A Method and its Rationale.* Illinois Natural History Survey, Special Publication No.5.

Kumble, P. 1991. *Management Measures for Coastal Urban Nonpoint Source Pollution Control.* Anacostia Restoration Team. Prepared for U.S. EPA Nonpoint Source Branch.

Limburg, K.E. and R.E. Schmidt. 1990. "Patterns of Fish Spawning in Hudson River Tributaries: Response to and Urban Gradient?" *Ecology* 71(4):1238-1245.

Livingston, E. H. 1989. The Use of Wetlands for Urban Stormwater Management. (in): *"Design of Urban Runoff Quality Controls."* L. A. Roesner, B. Urbonas and M,. B. Sonnen, eds. American Society of Civil Engineers. New York, New York.

Metropolitan Washington Council of Governments (MWCOG). 1992. *Watershed Restoration Source Book.* Anacostia Restoration Team. Department of Environmental Programs. Washington, DC.

Metropolitan Washington Council of Governments (MWCOG). 1983. *Final Report: Pollutant Removal Capability of Urban Best Management Practices in the Washington Metropolitan Area.* Prepared for the U.S. Environmental Protection Agency.

Oberts, G. L., P.J. Wotzka and J.A. Hartsoe. 1989. *The Water Quality Performance of Select Urban Runoff Treatment Systems.* Prepared for the Legislative Commission on Minnesota Resources. Metropolitan Council. St. Paul, Minnesota.

Occoquan Watershed Monitoring Laboratory and George Mason University. Department of Biology. 1990. *Final Project Report: The Evaluation of a Created Wetland as an Urban Best Management Practice.* Prepared for the Northern Virginia Soil and Water Conservation District.

Maryland Department of the Environment. 1991. *Stormwater Management Infiltration Practices in Maryland: A Second Survey.* Sediment and Stormwater Administration.

Maryland Department of the Environment. 1986. *Maintenance of Stormwater Management Facilities: A Departmental Summary.* Sediment and Stormwater. Administration.

Maryland Department of Natural Resources, Scenic and Wild Rivers Program. 1983. *Maryland Scenic Rivers: The Severn.*

Occoquan Watershed Monitoring Laboratory (OWML). 1986. *An Evaluation of the Performance of Porous Pavement for Stormwater Quality Control.* Davis Foundation. Northern Virginia Water Control Board.

Office of Planning and Zoning, Anne Arundel County, Maryland, July 1992, *Quick Stats, 1992, Population and Household Forecasts: 1980 To 2020 and 1990* Census Summary By Census Tract."

Office of Planning and Zoning, Anne Arundel County, Maryland, *Master Water and Sewerage Plan,* 1992 Update.

Office of Planning and Zoning, Anne Arundel County, Maryland, 1992, *Draft Parole Urban Design Plan.*

Office of Planning and Zoning, Anne Arundel County, Maryland, 1990, *1990 Census Data.*

Office of Planning and Zoning, Anne Arundel County, Maryland, 1992, *Quick Stats, 1992, Population and Household Forecasts: 1980 to 2020 and 1990* Census Summary By Census Tract.

Office of Planning and Zoning, Anne Arundel County, Maryland, 1992, *Major Statistics Forecasts To 2020, Population, Housing, Income and Employment.*

Office of Planning and Zoning, Anne Arundel County, Maryland, *Critical Area Development Guidelines.*

Office of Planning and Zoning, Anne Arundel County, Maryland, 1988, *Critical Area Program.*

Office of Planning and Zoning, Anne Arundel County, Maryland, 1978, *General Development Plan,* Addendum - 1986.

Office of Planning and Zoning, Anne Arundel County, Maryland, 1991. *General Development Plan for Anne Arundel County Maryland.*

Office of Planning and Zoning, Anne Arundel County, Maryland, 1988, *Instream and Estuarine Water Quality Monitoring,* Fall, 1991.

Office of Planning and Zoning, Watershed Management Program, Anne Arundel County, Maryland, 1990, *Critical Area Program - Habitat Assessment Manual.*

Office of Planning and Zoning, Watershed Management Program, Anne Arundel County, Maryland, 1989, *Anne Arundel County Instream Water Quality Monitoring Program,* April 1987 - December 1988, Weems Creek."

Office of Planning and Zoning, Watershed Management Program, Anne Arundel County. *Citizen Volunteer Water Quality Monitoring Program,* Weems Creek Monitoring Data Analysis, March, 1987 to November, 1987."

Office of Planning and Zoning, Anne Arundel County, Maryland *Forests, Woodlands and Trees - Preservation and Protection During the Development Process*, Bill No. 13-90.

Office of Planning and Zoning, Anne Arundel County, Maryland *Floodplain Management, Sediment Control and Stormwater Management*, Article 21 .

Redman/Johnson Associates, Ltd. 1987. *Land Preservation, Recreation and Open Space Plan - Anne Arundel County.*

Severn River Commission, 1987. *1985-86 Report to the Anne Arundel County Council and the Annapolis City Council.*

Severn River Commission, October 1989, *Definition of the Severn River Watershed, Report and Recommendations.*

Severn River Commission, 1989. *1987-88 Report to the Anne Arundel County Council and the Annapolis City Council.*

Severn River Commission, 1993. *1991-92 Report to the Anne Arundel County Council and the Annapolis City Council.*

Severn River Commission, 1991. *1989/1990 Biennial Report.*

Severn River Commission, 1986. *Severn River Natural Areas of Highest Priority for Preservation.*

Schueler, T. R., F. J. Galli, L. Herson, P. Kumble and D. Shepp. 1991. *Developing Effective BMP Systems for Urban Watersheds.* Urban Nonpoint Workshops. New Orleans, Louisiana. January 27-29, 1991.

Schueler, T. R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practices.* Metropolitan Washington Council of Governments. 213 pp. + appendices.

Schueler, T. R. 1991. *Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Governments.* Proceedings of the National Conference Integration of Stormwater and Local Nonpoint Source Issues. Northern Illinois Planning Commission. pp. 25 - 36.

Schueler, T. R. and M. Helfrich. 1988. Design of Extended Detention Wet Pond Systems. (in): *Design of Urban Runoff Controls.* L. Roessner and B. Urbonas, eds. American Society of Civil Engineering. New York, New York. pp. 180 -200.

Schueler, T. R., P. A. Kumble and M. A. Heraty. 1992. A Current *Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone.* Anacostia Restoration Team, Metropolitan Washington Council of Governments. Publication #92705. Washington, DC. .

Schueler, T. R. 1992. *Design of Stormwater Pond Systems.* Metropolitan Washington Council of Governments. Washington, DC.

Troung, H. V. 1989. *The Sand Filter Water Quality Structure.* District of Columbia. Environmental Regulation Administration.

Weems Creek Conservancy, Maryland Department of Natural Resources, Land Planning Services, Wild and Scenic Rivers Program, United States Department of the Interior, National Park Service, Mid-Atlantic Regional Office, Division of Natural Resource Planning. 1982. *A Greenway Strategy for Weems Creek.*

Wiegand, C. W., W. C. Chittenden, and T. R. Schueler. 1986. Cost of Urban Runoff Controls. (in): *"Urban Runoff Quality : Impact and Quality*

Enhancement Technology." B. Urbonas and L. Roesner, eds. American Society of Civil Engineers. pp. 366 - 380.

Wotzka, L. and G. Oberts. 1988. *"The Water Quality Performance of a Detention Basin Wetland Treatment System in an Urban Area. Nonpoint Source Pollution: Economy, Policy, Management and Appropriate Technology."* American Water Resources Association.

Wu, J. S., B. Holman and J. Dorney. 1988. Water Quality Study on Urban Wet Detention Ponds. (in): *"Design of Urban Runoff Quality Controls."* L. A. Roesner, B. Urbonas and M. B. Sonnen, eds. American Society of Civil Engineers. New York, New York. pp. 280 - 289.