Baltimore County WRE Technical Memo - A
Existing Water Quality Conditions

This technical memo is the first of three technical memos created to address the stormwater requirements of the Water Resources Element as detailed in HB 1141.The technical memos include:

- Technical Memo A – Existing Water Quality Conditions: a summary of existing water quality data, use designations, high quality waters (Tier II) and trout analysis, impairment listings, and Total Maximum Daily Load (TMDL) development status.
- Technical Memo B – Pollutant Loading Analysis: an analysis of current and projected future phosphorus and nitrogen pollutant loads based on project population increases in 25 Water Quality Planning Areas (WQPAs). Three scenarios were analyzed for effect on future pollutant loadings, Scenario 1 – Development As Is, Scenario 2 - All Development within the Urban-Rural Demarcation Line, and Scenario 3 – All Redevelopment. In addition, cost of meeting nutrient TMDLs is addressed.
- Technical Memo C – Impervious Cover Analysis: an analysis of the changes in impervious cover as a result of future population growth.

This technical memo is divided into four sections. Section A.1 will be a short section on Use Class designations and their relation to water quality standards. Section A.2 will focus the Tier II (high quality waters) and trout resources, as indicators of better than average waters in need of extra protection to maintain their status. Section A.3 will discuss the opposite end of the spectrum with a discussion of impaired water listings and the status of the development of Total Maximum Daily Loads to address the water quality impairments. Section A.4 will summarize various data available on chemical and biological parameters.

A.1 Use Designations and Water Quality Standards

Designated uses define an intended human and aquatic life goal for a water body. It takes into account what is considered the attainable use for the water body, for protection of aquatic communities and wildlife, use as a public water supply, and human uses, such as, recreation, agriculture, industry, and navigation. Water quality standards have been developed to protect the Use class designations.

A.1.1 Use Class Designations

Every stream, lake, reservoir, and tidal water body in Maryland has been assigned a Use designation. The Use designation is linked to specific water quality standards that will enable the Use of the water body to be met. A listing of the Use designations follows:

- Use I: Water contact recreation, and protection of nontidal warmwater aquatic life.
- Use II: Support of estuarine and marine aquatic life and shell fish harvesting (not all subcategories apply to each tidal water segment)

    - Shellfish harvesting subcategory
    - Seasonal migratory fish spawning and nursery subcategory (Chesapeake Bay only)
    - Seasonal shallow-water submerged aquatic vegetation subcategory (Chesapeake Bay only)
    - Open-water fish and shellfish subcategory (Chesapeake Bay only)
    - Seasonal deep-water fish and shellfish subcategory (Chesapeake Bay only)
    - Seasonal deep-channel refuge use (Chesapeake Bay only)

- Use III: Nontidal cold water – usually considered natural trout waters
- Use IV: Recreational trout waters – waters are stocked with trout

The letter "P" may follow any of the Use designations, if the surface waters are used for public water supply. There may be a mix of Use classes within a single 8-digit watershed, for example, Gwynns Falls has Use I, Use III, and Use IV designations depending on the subwatershed.

The tidal water subcategories under the Use II designation are relatively new, having been included in the 2003 Maryland Triennial Review of Water Quality Standards. In the same review, tidal water segments were created for the first time. For each tidal water segment some or all of the subcategories apply, and each subcategory has specific criteria and times of applicability. Table A-1 provides additional information on the tidal water subcategories.

Table A-1: Use II Subcategories*

Designated Use	What is Protected	Habitats and Locations
1. Migratory Fish Spawning and Nursery	Migratory fish including striped bass, perch, shad, herring and sturgeon during the late winter/spring spawning and nursery season.	In tidal freshwater to low-salinity habitats. This habitat zone is primarily found in the upper reaches of many Bay tidal rivers and creeks and the upper mainstem Chesapeake Bay.
2. Shallow Water – Submerged Aquatic Vegetation	Underwater bay grasses and the many fish and crab species that depend on this shallow-water habitat.	Shallow waters with grass beds near the shoreline.
3. Open-Water Fish and Shellfish	Water quality in the surface water habitats to protect diverse populations of sportfish, including striped bass, bluefish, mackerel and seatrout, bait fish such as menhaden and silversides, as well as the shortnose sturgeon, and endangered species.	Species within tidal creeks, rivers, embayments and the mainstem Chesapeake Bay year-round.

4. Deep-Water Fish and Shellfish	The many bottom-feeding fish, crabs and oysters, and other important species such as the bay anchovy.	Living resources inhabiting the deeper transitional water column and bottom habitats between the well-mixed surface waters and the very deep channels during the summer months. The deep-water designated use recognizes that low dissolved oxygen conditions prevail during the summer due to a water density gradient (pycnocline) formed by temperature and salinity that reduces re-oxygenation of waters below the upper portion of the gradient.
5. Deep-Channel Seasonal Refuge	Bottom sediment-dwelling worms and small clams which provide food for bottom-feeding fish and crabs in the very deep channel in summer.	Deep-channel designated use recognizes that low dissolved oxygen conditions prevail in the deepest portions of this habitat zone and will naturally have very low to no oxygen during the summer.

*Source - http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/wqstandards/faqs.asp

In addition to the Use II subcategories that apply to tidal waters, the salinity range exhibited by a tidal water segment influences the water quality standards that apply. There are four tidal salinity designations. The designations are as follows:

- Tidal Fresh - salinity range 0 – 0.5 parts per thousand (ppt). These areas are at the extreme reach of tidal influence. They are typically not designated as a tidal segment.
- Oligohaline (OH) – salinity range 0.5 – 5 ppt. These areas are typically in the upper portion of an estuary. The designation for a tidal segment will have an OH as part of the designation. Five of the seven tidal segments adjacent to Baltimore County are oligohaline.
- Mesohaline (MH) – salinity range 5 – 18 ppt. These areas are typically in the middle portion of an estuary. The designation for the tidal segment will have an MH as part of the designation. Two of the seven tidal segments adjacent to Baltimore County are mesohaline.
- Polyhaline – salinity 18 – 30 ppt. These areas are typically in the lower portion of an estuary, where the ocean and estuary meet. There are no polyhaline segments adjacent to Baltimore County.

Table A-2 presents the Use Class Designations for Baltimore County streams and tidal water segments. When there is more than one designation in a watershed, the specific subwatersheds are listed. The 2009 Triennial Review of Water Quality proposed some Use class changes. Both the current Use class and the proposed Use Class are listed. For the tidal water segments the Use II subcategory is listed by number. The numbers correspond to the subcategory number in Table A-1. The stream Use classes are displayed in Figure A-1, while the tidal water Use classes are displayed in Figure A-2.

Table A-2: Use Class Designations

Watershed/Tidal Water Segment	Use Designation
Deer Creek	Use III – P
Prettyboy Reservoir	Use III – P
Loch Raven Reservoir - above the reservoir - the reservoir itself	 Use III – P Use I – P Proposed in 2009 Triennial Review
Lower Gunpowder Falls - Long Green Run and all tributaries - Sweathouse Branch and all tributaries - Lower Gunpowder Falls and remaining tribs	 Use III Use III Use I Mainstem proposed Use IV in Triennial Review
Little Gunpowder Falls	Use III
Bird River - Whitemarsh Run and all tributaries	 Use IV
Middle River	Use I
Gunpowder River	Use I
Liberty Reservoir - Norris Run and all tributaries - Cooks Branch and all tributaries - Keyers Run and all tributaries - Locust Run and all tributaries - Glen Falls Run and all tributaries	 Use III – P Use III – P Use III – P Use III – P Use III – P
Patapsco River - Brice Run and tributaries - Rest of Baltimore County Patapsco River	 Use III Use I
Gwynns Falls - Red Run and all tributaries - Gwynns Falls above Reisterstown Road - Dead Run and all tributaries - Rest of Gwynns Falls	 Use III Use III Use IV Use I Mainstem proposed Use IV in Triennial Review
Jones Falls - Jones Falls and all tributaries above Lake Roland - Rest of Baltimore County Jones Falls	 Use III Use IV
Back River - Herring Run and all tributaries - Stemmers Run and all tributaries - Remaining tributaries	 Use IV Use IV Use I
Baltimore Harbor	Use I
Tidal Water Segments	
GUNOH2	Use II – 1, 2, 3
GUNOH1	Use II – 1, 2, 3
MIDOH	Use II – 1, 2, 3
CB2OH	Use II – 1, 2, 3
BACOH	Use II – 1, 2, 3
PATMH	Use II – 1, 2, 3, 4, 5
CB3MH	Use II – 1, 2, 3, 4, 5

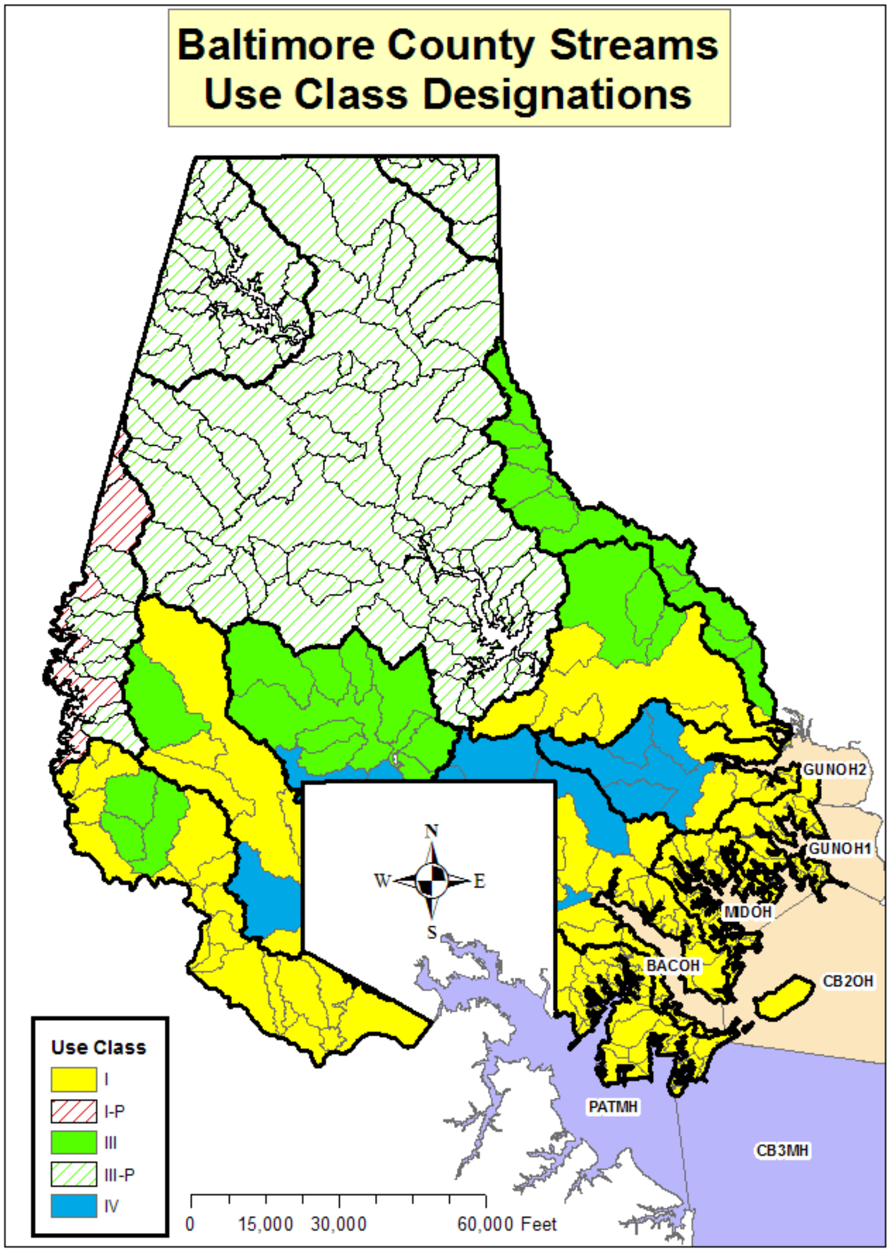


Figure A-1: Baltimore County Stream Use Class Designations

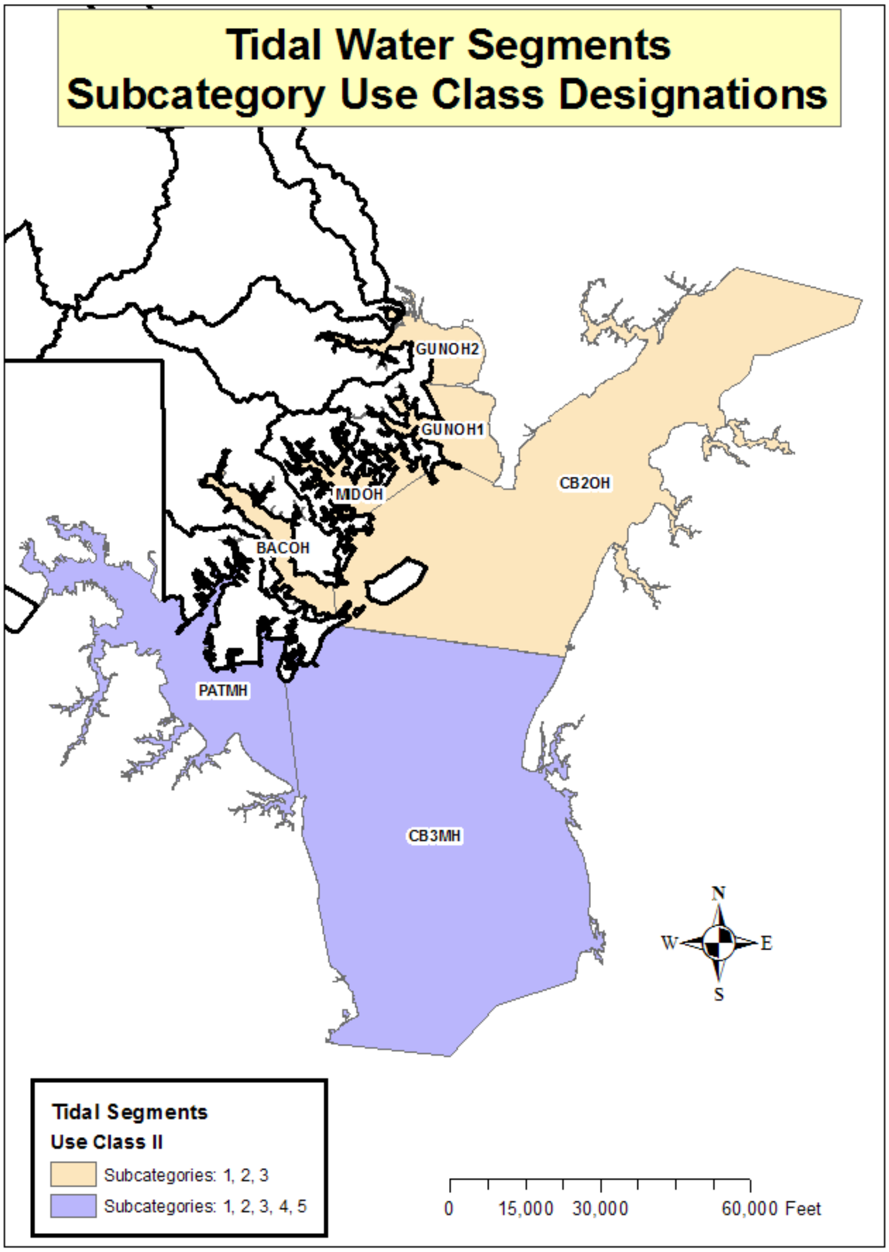


Figure A-2: Baltimore County Tidal Water Segment Use Class Designations

A.1.2 Water Quality Standards

Water quality standards are expressed through numeric criteria that set the minimum water quality needed to meet the designated use. Where specific numeric criteria are not available, then narrative criteria apply. Numeric criteria have been developed for numerous substances to protect both aquatic life and human health. These criteria typically apply to all use designations. The specific chemical water quality criteria will not be presented here, but can be found at:
http://www.dsd.state.md.us/comar/subtitle_chapters/26_Chapters.aspx

There are two note worthy areas where more stringent standards are applied to the temperature and dissolved oxygen criteria. Use III – nontidal coldwater streams set a maximum temperature of 68°F (20°C) and the dissolved oxygen must have a daily average of not less than 6 mg/l. Use IV – recreation trout streams may not exceed 75°F (23.9°C).

The WRE is expressly concerned with nutrient pollution. At this time, there are no standards for nitrogen or phosphorus concentrations in streams, reservoirs, or tidal waters. Instead, the excess level of nitrogen and phosphorus are inferred through effects on the chlorophyll *a*, dissolved oxygen, and water clarity. Dissolved oxygen standards for stream use classes were described above. The tidal waters Use II subcategories have somewhat more complicated dissolved oxygen standards based on instantaneous measures, 7-day means, and 30-day means, that vary by subcategory and applicable time periods. Table A-3 summarizes the tidal water dissolved oxygen criteria for each subcategory.

Table A-3: Tidal Water Dissolved Oxygen Criteria

Use II Subcategory	Dissolved Oxygen Criteria	Applicable Time Period
Migratory Fish Spawning and Nursery	7 day mean >= 6 mg $liter^{-1}$ (1) Instantaneous minimum >= 5 mg $liter^{-1}$	February 1 - May 31
Shallow Water – Submerged Aquatic Vegetation	30 day mean of >=5.5 mg/l in low salinity; 5 mg/l in high salinity 7 day mean of >= 4 mg/l Instantaneous minimum of >= 3.2 mg/l	Year-round
Open-Water Fish and Shellfish	30 day mean of >=5.5 mg/l in low salinity; 5 mg/l in high salinity 7 day mean of >= 4 mg/l Instantaneous minimum of >= 3.2 mg/l	Year-round
Deep-Water Seasonal Fish and Shellfish	30 day mean of >= 3 mg/l 1 day mean of >= 2.3 mg/l Instantaneous minimum of >= 1.7 mg/l	June 1 - September 30
Deep-Channel Seasonal Refuge	Instantaneous minimum of >= 1 mg/l	June 1 - September 30

The water clarity criteria relate to the Use II subcategory Shallow Water – Submerged Aquatic Vegetation (SAV) and are based on the percentage of light that passes through water. These criteria vary based on the salinity regime of the tidal water body and depth criteria established for each tidal segment. These criteria are only applicable during the SAV growing season April 1 through October 1. Table A-4 presents the criteria related to water clarity.

Table A-4: Water Clarity Criteria as Secchi Depth

Salinity Regime	Water Clarity Criteria as Percent Light through Water	Water Clarity Criteria Application Depths (meters)				Seasonal Application
		0.5	1.0	1.5	2.0	
		Secchi Depth Equivalents for Criteria Application Depth				
Tidal Fresh	13%	0.4	0.7	1.1	1.4	Apri1 1 to October 1
Oligohaline	13%	0.4	0.7	1.1	1.4	Apri1 1 to October 1
Mesohaline	22%	0.5	1.0	1.4	1.9	Apri1 1 to October 1

[1]Based on application of the formula PLW = 100exp($-K_d Z$), the appropriate PLW criterion value and the selected application depth (Z) are inserted and the equation is solved for K_d. The generated K_d value is then converted to Secchi depth (in meters) using the conversion factor K_d = 1.45/Secchi depth.

The Maryland Department of the Environment has developed target SAV acreage goals as criteria based on the analysis of the Chesapeake Bay Program of historic SAV distribution. These target SAV acreages are now criteria, where acreages below the target result in the tidal water segment being considered impaired. Table A-5 presents the acreage of SAV required for each tidal water segment and the application depth for water clarity.

Table A-5: Tidal Segment SAV Acreage Requirements and Application Secchi Depth

Tidal Segment Designation	SAV Acres	Secchi Application Depth (meters)
GUNOH2	572	2.0
GUNOH1	1,860	0.5
MIDOH	879	2.0
CB2OH	705	0.5
BACOH - Proposed in 2009 Triennial Review	340	0.5
PATMH	389	1.0
CB3MH	1,370	0.5

A.2 High Quality Waters – Tier II Waters and Trout Resources

Typically, high quality waters and trout resources co-occur, but not invariably so. In some cases, due to the Tier II listing criteria, and the distribution of the monitoring points, sites with trout are not listed as Tier II. Some of these sites may be listed in future years as the monitoring distribution expands. Baltimore County believes that both Tier II waters and trout resources should be afforded the same degree of protection.

A.2.1 Tier II Waters

The waters of the state of Maryland are divided into three tiers, as follows:

- Tier I – These waters must meet the minimum water quality standards, support balanced aquatic communities, and support contact recreation. This often referred to as "fishable – swimmable".
- Tier II – These waters are better than the minimum specified for the designated use. These waters may be designated based on any water quality standard, but in current practice, they are designated based on benthic macroinvertebrate and fish community sampling conducted by the Maryland Department of Natural Resources, Maryland Biological Stream Survey

(MBSS) program. Tier II waters meet the anti-degradation requirements of the federal Clean Water Act.

- Tier III – these waters are called an Outstanding National Resource Water (ONRW). These waters would require even greater degrees of protection. Currently, Maryland has no designated Tier III waters.

In practice, any water not designated as Tier II is assumed to be Tier I waters. As part of the Maryland Triennial Review of Water Quality Standards, Tier II waters are listed. To date, Baltimore County has 20 stream segments that are listed as Tier II waters. The segments occur in six of the fourteen 8-digit watersheds that are present in whole or in part in Baltimore County. Table A-6 displays the Tier II water designations, the watershed and subwatershed in which each segment occurs, the length of stream designated as Tier II in feet and miles, and the drainage area above the designated segment along with the total drainage area of Tier II segments in the watershed. Also displayed is the percentage of the watershed drainage area that flows to Tier II waters. Figure A-2 displays the Tier II segments and the drainage areas throughout the county.

Table A-6: Tier II Waters – Stream Length and Drainage Areas

Watershed	Subwatershed	Stream Length (ft)	Stream Length (mi.)	Segment DA (acres)	Watershed Tier II DA (acres)	% Watershed – Tier II
Deer Creek	Deer Creek	11,240	2.13	2,671	2,671	100%*
Prettyboy Reservoir	Gunpowder Falls	3,463	0.66	2,148	3,779	14.6%
	Peggys Run I	3,505	0.66	1,631		
	Peggys Run II	13,438	2.55	752		
Loch Raven Reservoir	Beetree Run	9,015	1.71	5,151	62,328	44.7%
	Little Falls	5,489	2.04	26,669		
	Blackrock Run	8,417	1.59	7,117		
	Delaware Run	4,409	0.84	7,568		
	First Mine Branch	15,500	2.94	2,115		
	Indian Run	4,784	0.91	2,454		
	Western Run	9,658	1.83	26,430		
Little Gunpowder Falls	Mainstem I	8,310	1.57	8,069	13,457	78.1%
	Mainstem II	10,604	2.01	13,457		
	Mainstem III	10,336	1.96	11,764		
Liberty Reservoir	Timber Run	10,947	2.07	608	4,150	23.6%
	Cooks Branch I	10,741	2.03	786		
	Cooks Branch II	1,323	.25	1,718		
	Keyser Run	15,552	2.95	1,006		
	Glen Falls Run	8,926	1.69	1,426		
Gwynns Falls	Red Run	9,228	1.75	3,631	3,631	12.7%
	Totals	**174,885**	**33.12**		**90,016**	**23.1%**

* Tier II stream segments in Harford County encompass all of the Deer Creek drainage area in Baltimore County

Overall, 23% of Baltimore County drains to Tier II waters. The watershed percentages range from 100% of Deer Creek (due to Tier II waters designation down stream in Harford County) to 0% in the Bird River, Gunpowder River, Middle River, Patapsco River, Back River, and Baltimore Harbor watersheds.

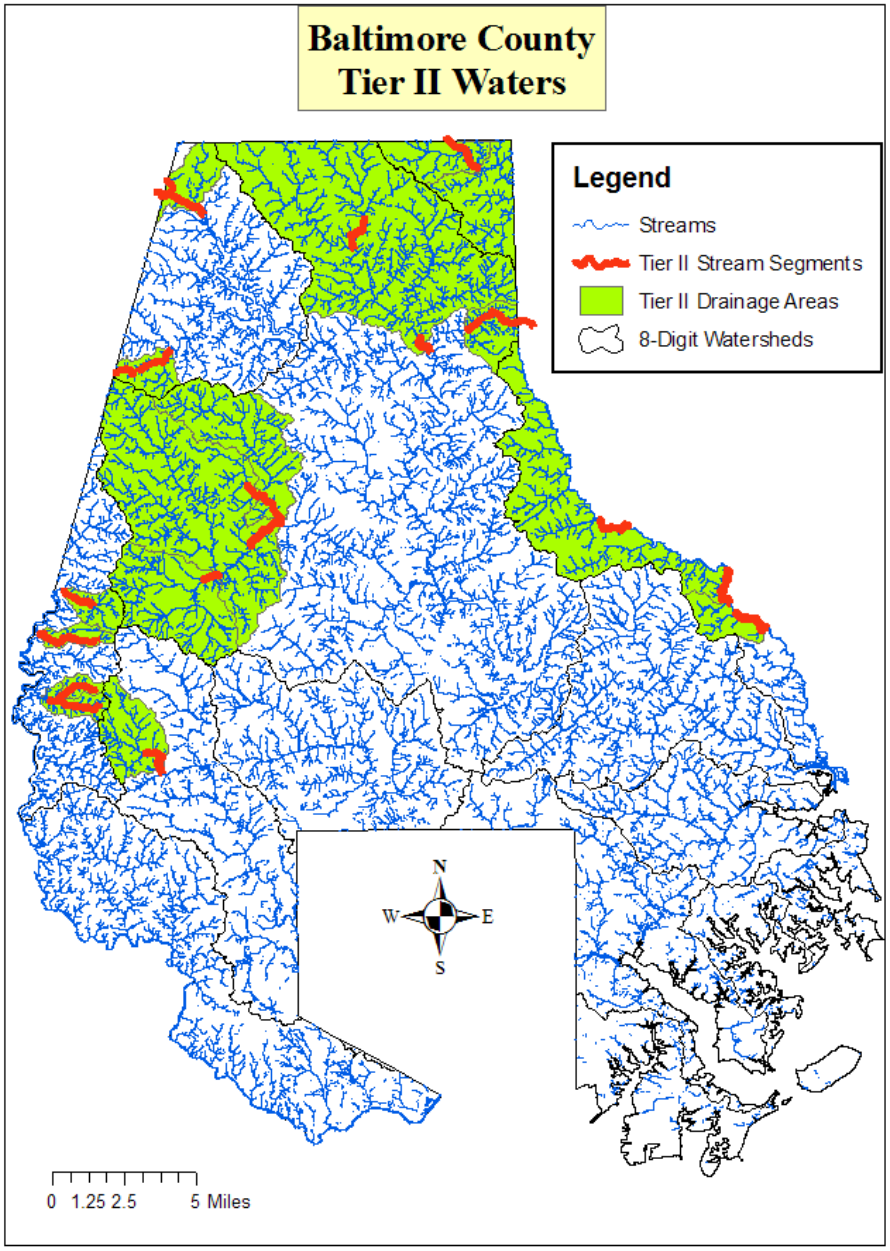


Figure A-2: Baltimore County Tier II Segments and Their Associated Drainage Areas

The specific regulations related to Tier II waters are extracted from COMAR 26.08.02.04 and are presented below:

26.08.02.04 – 1(B)

"General: An applicant for proposed amendments to county plans or discharge permits for discharge to Tier II waters that will result in a new, or an increased, permitted annual discharge of pollutants and a potential impact to water quality, shall evaluate alternatives or eliminate or reduce discharges or impacts. If impacts are unavoidable, an applicant shall prepare and document a social and economic justification. The Department shall determine, through a public process, whether these discharges can be justified."

26.08.02.04 – 1(F)(1) – (3)

"(1) Permits. Before submitting an application for a new discharge permit or major modification of an existing discharge permit (for example, expansion), the discharger or applicant shall determine whether the receiving body is Tier II or, a Tier II determination is pending, by consulting the list of Tier II waters."

(2) Water and Sewer Plans (County Plans). As part of its continuing planning process, the Department shall review proposed amendments to county plans for any new or major modifications to discharges to Tier II bodies of water. If a proposed amendment to a County Plan results in a new discharge or a major modification of an existing discharge to a Tier II water body, the applicant shall perform a Tier II antidegradation review.

(3) Exemptions. The requirements to perform a Tier II antidegradation review does not apply to individual discharges of treated sanitary wastewater of less than 5,000 gallons per day, if all of the existing and current uses continue to be met."

26.08.02.04 – 1(G)

"(1) If a Tier II antidegradation review is required, the applicant shall provide an analysis of reasonable alternatives that do not require direct discharge to a Tier II water body (no-discharge alternative). The analysis shall include cost data and estimates to determine the cost effectiveness of the alternatives.

(2) If a cost effective alternative to direct discharge is reasonable, the alternative is required as a condition of the discharge permit or amendment to the county plan.

(3) If the Department determines that the alternatives that do not require direct discharge to a Tier II water body are not cost effective, the applicant shall:

> (a) Provide the Department with plans to configure or structure the discharge to minimize the use of the assimilative capacity of the water body, which is the difference between the water quality at the time the water body was designated as Tier II (baseline) and the water quality criterion, and
>
> (b) If an impact cannot be avoided, or no assimilative capacity remains as described in G(3)(a) of this regulation, provide the Department with a social and economic justification for permitting limited degradation of the water quality.

(4) An applicant shall update an antidegradation review when applying for a new permit or major modification to an existing permit."

26.08.02.04 – 1 - L

(1) Components of the social and economic justification (SEJ) may vary depending on factors including, but not limited to, the extent and duration of the impact from the proposed discharge and the existing uses of the water body.

(2) The economic analyses shall include impacts that result from treatment beyond the costs to meet technology-based or water quality-based requirements.

(3) The economic analysis shall address the cost of maintaining high water quality in Tier II waters and the economic benefit of maintaining Tier II waters.

(4) The economic analysis shall determine whether the costs of the pollution controls needed to maintain the Tier II water would limit growth or development in the watershed including the Tier II waters."

A.2.2 Trout Resources

Trout resources include the native brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*) and the introduced brown trout (*Salmo trutta*). Brown trout is generally more aggressive and, when present, often drive brook trout to headwater areas where the habitat is suboptimal for brown trout. Brook trout are also more sensitive to changes in impervious cover in a drainage area due the effects of impervious cover on temperature, stream flows with habitat alterations, changes in stream chemistry. Brook trout are typically not found in streams that have drainage areas with impervious cover greater than 3%. Brown trout are a little more tolerant and may be found in drainage areas with impervious cover up to 10%.

Maryland Department of Natural Resources conducts game fish assessments throughout the state of Maryland. The results of these assessments for brook and brown trout are tabulated in Table A-7 and displayed in Figure A-3.

Table A-7: Number of Sites with Trout by Watershed

Watershed	Brook Trout Only	Brown Trout Only	Brook and Brown Trout	Total Sites by Watershed
Deer Creek		1		**1**
Prettyboy Reservoir	10	1		**11**
Loch Raven Reservoir	10	15	14	**39**
Lower Gunpowder Falls		1		**1**
Little Gunpowder Falls	1			**1**
Liberty Reservoir	1	1		**2**
Gwynns Falls		1	1	**2**
Jones Falls		3	1	**4**
Total Sites	**22**	**23**	**16**	**61**

There are a total of 61 sites with trout present throughout Baltimore County. The majority of the sites (64%) are in the Loch Raven Reservoir watershed. The Prettyboy Reservoir watershed has the second most sites (18%), but has 45% of the sites with brook trout only.

Only eight of the fourteen 8-digit watersheds have trout present, with the highly urban and coastal plain watersheds (Back River, Patapsco River, Baltimore Harbor, Middle River, Gunpowder River, and Bird River) lacking trout. Gwynns Falls, a highly urban watershed, does have trout present in the upper portion of the watershed. This is also the only urban watershed that has Tier II waters.

Trout may have a wider distribution than indicated by this data. Many streams have not been assessed for the presence of trout.

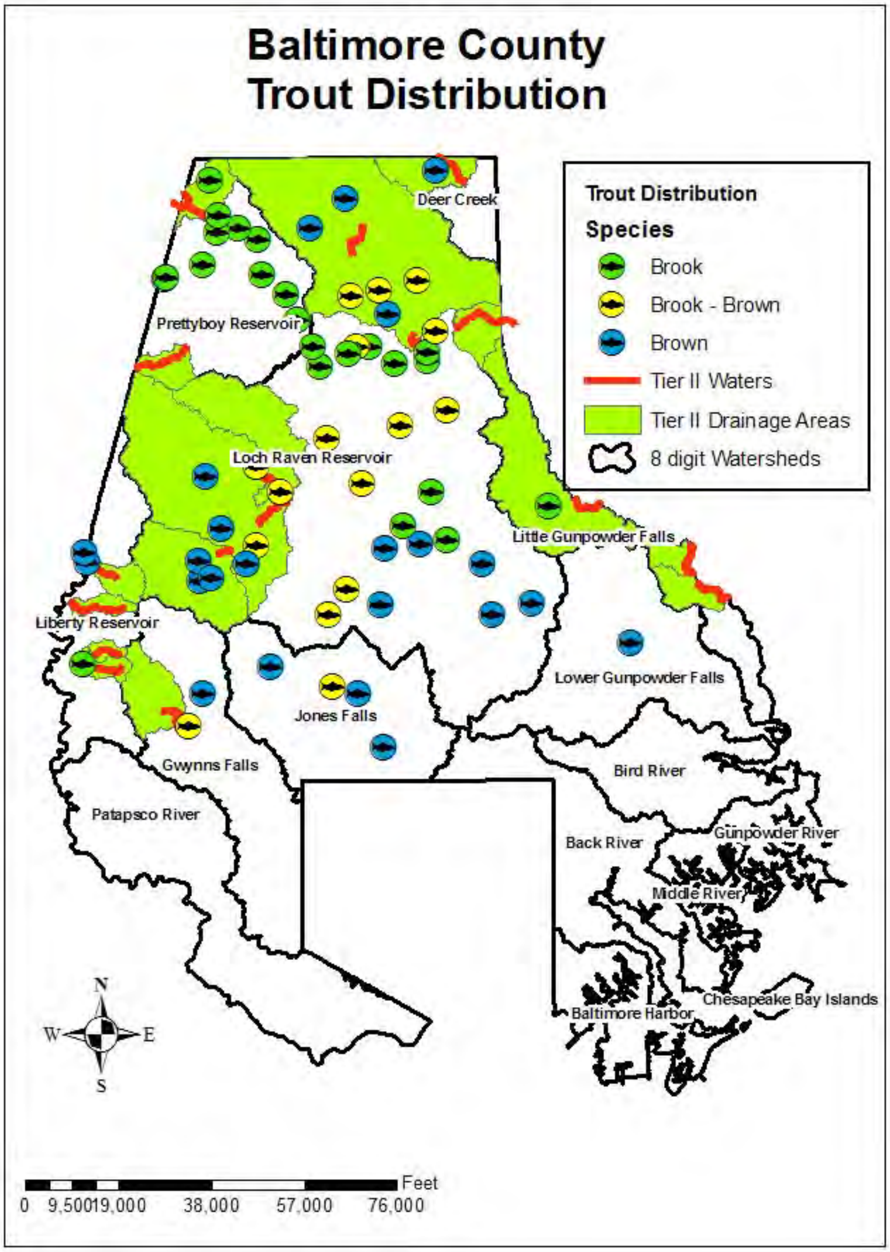


Figure A-3: The Location of Trout Resources in Relation to Tier II Segments and Their Drainage Areas

A.3 Water Impairments and Total Maximum Daily Loads (TMDLs)

The state of Maryland produces a biennial Integrated Report of Surface Water Quality. The integrated report replaces the previously separate reports prepared for Sections 303(d), 305(b), and 314 of the Clean Water Act. The latest report was prepared in 2008. This report assesses water quality of surface waters in Maryland and places them in one of five categories:

- Category 1: water bodies that meet all water quality standards and no used is threatened.
- Category 2: water bodies meeting some water quality standards but with insufficient data and information to determine if other water quality standards are being met.
- Category 3: insufficient data and information available to determine if any water quality standard is being attained.
- Category 4: one or more water quality standards are impaired or threatened, but a TMDL is not required or has already been established.
- Category 5: water body is impaired, does not attain the water quality standard, and a TMDL or other acceptable pollutant abatement initiative is required. This is the part of the list historically known as the 303(d) list.

The category 5 listing requires that action be taken to address the listing. Action may take two forms: submittal of a Total Maximum Daily Load (TMDL) or submittal of a Water Quality Analysis (WQA). TMDLs are developed when a given substance or stressor is exceeding water quality standards. WQAs are developed when supplemental data indicate the water body is meeting water quality standards for that substance. The impairment listing and TMDL status are shown in Table A-8 and Figure A-4.

Nutrient impairments are currently undergoing a revision. In most cases, the streams within a watershed are not impaired by nutrients, but the receiving waters (reservoirs and tidal water segments) are the impaired water bodies. TMDLs for nutrients require reductions within the watershed in order to meet water quality standards in the receiving water body. Thus, the three drinking water reservoirs and the tidal water segments are all impaired by nutrients. In the case of the reservoirs, only phosphorus is the impairing substance. Changes in nitrogen have minimal effect on the water quality standards within the reservoirs.

Two 8-digit watersheds in Baltimore County, Deer Creek and Little Gunpowder Falls, are not impaired by any substance. Three 8-digit watersheds, Bird River, Gunpowder River, and Middle River, are not impaired by nutrients, bacteria, sediment, or toxics, but there is insufficient information to determine if the biological community in the streams is impaired. The balance of the watersheds, and all of the tidal water segments, are impaired by at least one substance and usually more.

Table A-8: Watershed and Tidal Segment Impairment Listings and TMDLs Completed

Watershed / Tidal Segment	Nutrients	Bacteria	Sediment	Biological Community	Toxics
Deer Creek	Not Impaired	Not Impaired	Not Impaired	Not Impaired	Not Impaired
Prettyboy Reservoir	TMDL – P	TMDL - Pending	Not Impaired	Not Impaired	TMDL - Mercury
Loch Raven Reservoir	TMDL – P	TMDL – Pending	TMDL	Impaired	TMDL - Mercury
Lower Gunpowder Falls	Impaired	Not Impaired	Not Impaired	Impaired	Not Impaired
Little Gunpowder Falls	Not Impaired*	Not Impaired	Not Impaired	Not Impaired	Not Impaired
Bird River	Not Impaired	Not Impaired	Not Impaired	Insufficient Information	Not Impaired
Gunpowder River	Not Impaired	Not Impaired	Not Impaired	Insufficient Information	Not Impaired
Middle River	Not Impaired	Not Impaired	Not Impaired	Insufficient Information	Not Impaired
Liberty Reservoir	Impaired	TMDL – Pending	Impaired	Impaired	TMDL – Mercury – Pending
Patapsco River	TMDL – P, N#	TMDL – Pending	TMDL – Pending	Impaired	Impaired – PCBs
Gwynns Falls	TMDL – P, N#	TMDL	TMDL – Pending	Impaired	Not Impaired
Jones Falls	TMDL – P, N#	TMDL	TMDL – Pending	Impaired	TMDL – Chlordane – Lake Roland Impaired - PCBs
Back River	TMDL – P, N#	TMDL – Herring Run	Not Impaired	Impaired	Not Impaired
Baltimore Harbor	TMDL – P, N#	Not Impaired	Not Impaired	Impaired	Not Impaired
GUNOH2	Impaired	Not Impaired	Not Impaired	Not Impaired	Impaired – PCBs
GUNOH1	Impaired	Not Impaired	Not Impaired	Not Impaired	Impaired – PCBs
MIDOH	Impaired	Not Impaired	Impaired	Not Impaired	Impaired – PCBs
CB2OH	Impaired	Not Impaired	Not Impaired	Not Impaired	Not Impaired
BACOH	TMDL – P, N	Not Impaired	Impaired	Insufficient Information	TMDL – Chlordane Impaired – PCBs
PATMH	TMDL – P, N	Not Impaired	Impaired	Impaired	TMDL – Chlordane Impaired – PCBs
CB3MH	Impaired	Not Impaired	Impaired	Impaired	Not Impaired

* A Water Quality Analysis for nutrients in Little Gunpowder Falls was submitted to EPA in January 2009, acceptance pending.
# The TMDL for nutrients is based on the receiving tidal water body. WQAs have been submitted for nutrients for Patapsco River, Gwynns Falls, and Jones Falls.

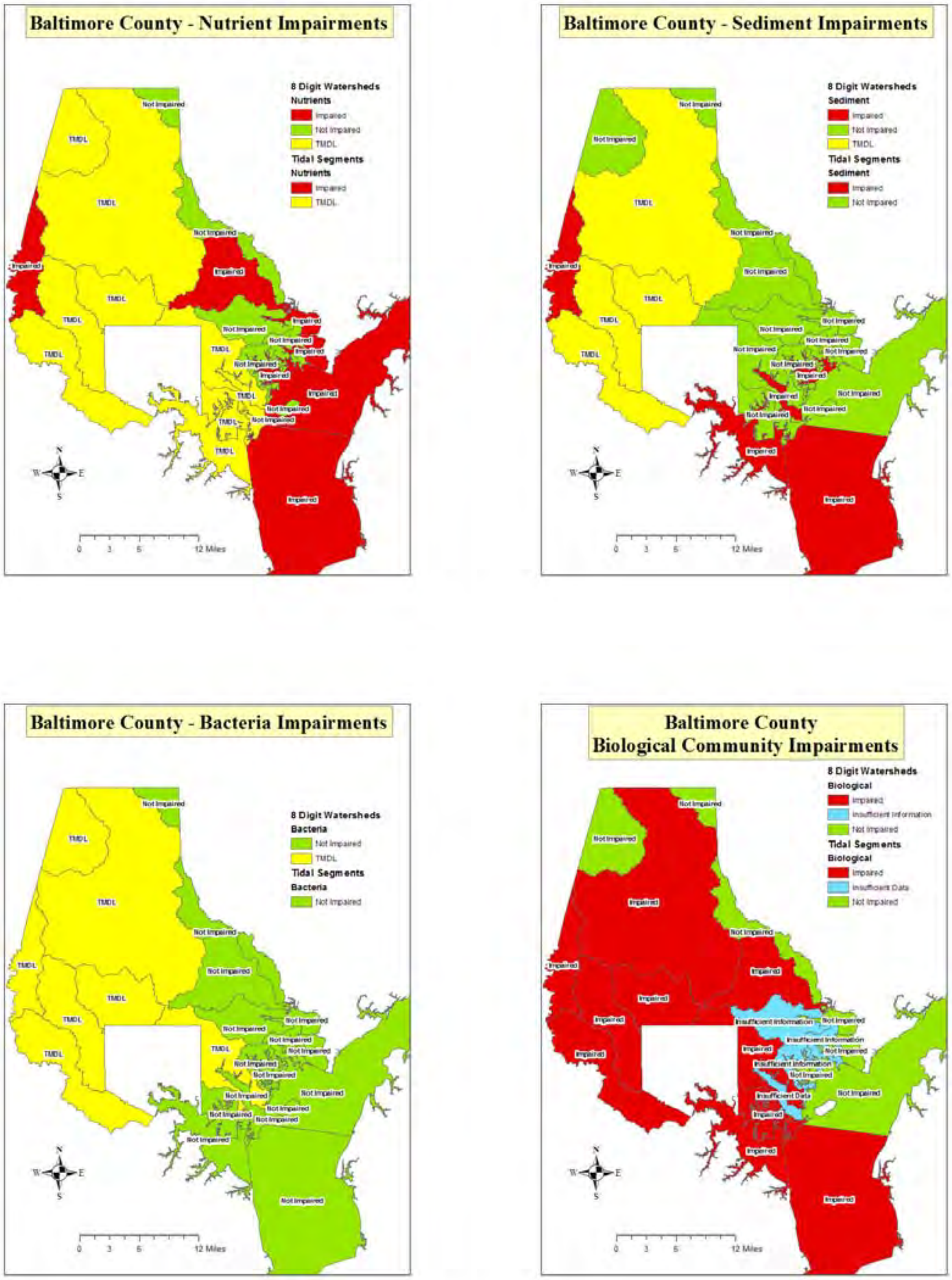


Figure A-5: Watershed and Tidal Segment Impairment Status for Nutrients, Sediment, Bacteria, and Biological Community

A.4 Existing Water Quality Data Analysis

This section provides a brief presentation on existing water quality. The information on the Baltimore County monitoring programs (Section A.4.1) is derived from the Baltimore County 2009 NPDES Annual Report.

A.4.1 Baltimore County Monitoring Programs

Baltimore County has developed an integrated monitoring program to meet regulatory and non-regulatory program requirements, support watershed planning efforts, and to assess the effectiveness of restoration. Chemical, physical and biological components of stream systems are monitored. These components are monitored for regulatory programs that include: the National Pollutant Discharge Elimination System (NPDES) – Municipal Stormwater Discharge Permit Program, the Total Maximum Daily Load (TMDL) Program, and stream restoration permit requirements. The non-regulatory programs include the Chesapeake Bay Tributary Strategy Program, Coastal Zone Management, and the Reservoir Management Program.

The nontidal monitoring programs provide information on the existing condition of stream water quality and channel stability, biological resources, and help determine trends over time. A brief description of each monitoring program element is provided below. The tidal monitoring programs provide information on water quality and Submerged Aquatic Vegetation (SAV) distribution in select locations.

Summary information is presented on the Baltimore County Baseflow Monitoring Program (A.4.1.1), the Recreational Waters Monitoring Program (A.4.1.2), Random Point Monitoring Program (A.4.1.3), and Submerged Aquatic Vegetation Monitoring (A.4.1.4)

A.4.1.1 County Baseflow Monitoring Program

Building on prior baseflow monitoring efforts, the current Baseflow Monitoring Program was initiated in 2003. Baseflows are monitored in the Patapsco/Back River Basin in odd-numbered years, while the Gunpowder Basin/Deer Creek are monitored in the even-numbered years. In 2007, because of staff time constraints, Tier 1 and Tier 2 sites were created. The Tier 1 sites are regular sampling sites. Tier 2 are sites that were removed from sampling, but will be picked back up if there is a Small Watershed Action Plan (SWAP) or other project in that area. There are 31 Tier 1, and 9 Tier 2 sites in the Patapsco Back River Basin. There are 53 Tier 1 and 22 Tier 2 sites in the Gunpowder Basin/Deer Creek. The points were chosen to maximize the number of subwatersheds monitored.

The target number of baseflow samples is eight samples per year at each site. The actual number sampled will vary depending on weather conditions, staffing and other duties. The standard set of monitored pollutants includes (TSS, TS, TKN, Nitrate/Nitrite, Total Phosphorus, Ortho-phosphorus, Cadmium, Copper, Lead, Zinc, BOD, COD, Chlorides, Sodium, Hardness, Magnesium and Calcium) as well as temperature and pH determined in *situ*. Discharge measurements are taken during each sample collection. A minimum of three days of dry weather is required prior to monitoring of baseflow.

The design will allow determination of ambient water quality for major portions of each watershed. The two-year sampling cycle will allow an analysis of baseflow water quality trends for the pollutant parameters analyzed.

Two map displays showing the Total Nitrogen and Total Phosphorus mean concentrations are shown in Figures A-6 and A-7 on the following two pages and in Table A-9. The information is displayed based on the following rating system:

Condition	Nitrogen Concentration (mg/L)	Phosphorus Concentration (mg/L)
Baseline	< 1.0	< 0.010
Moderately Elevated	1.0 – 2.0	0.010 – 0.020
Elevated	2.0 – 3.0	0.020 – 0.030
High	3.0 – 4.0	0.030 – 0.040
Very High	> 4.0	> 0.040

Table A-9: Mean Total Nitrogen and Total Phosphorus by Watershed

Watershed	Total Nitrogen (mg/L)	Total Nitrogen Condition	Total Phosphorus (mg/L)	Total Phosphorus Condition
Deer Creek	3.78	High	0.049	Very High
Prettyboy	3.49	High	0.020	Moderately Elevated
Loch Raven	2.49	Elevated	0.024	Elevated
Lower Gunpowder	2.40	Elevated	0.037	High
Little Gunpowder	2.72	Elevated	0.021	Moderately Elevated
Bird River	1.05	Moderately Elevated	0.033	High
Gunpowder River	NA*		NA*	
Middle River	NA*		NA*	
Liberty Reservoir	1.86	Moderately Elevated	0.066	Very High
Patapsco River	1.44	Moderately Elevated	0.037	High
Gwynns Falls	1.73	Moderately Elevated	0.040	Very High
Jones Falls	1.70	Moderately Elevated	0.053	Very High
Back River	1.76	Moderately Elevated	0.043	Very High
Baltimore Harbor	NA*		NA*	

*NA – Baseflow monitoring not conducted due to limited stream miles

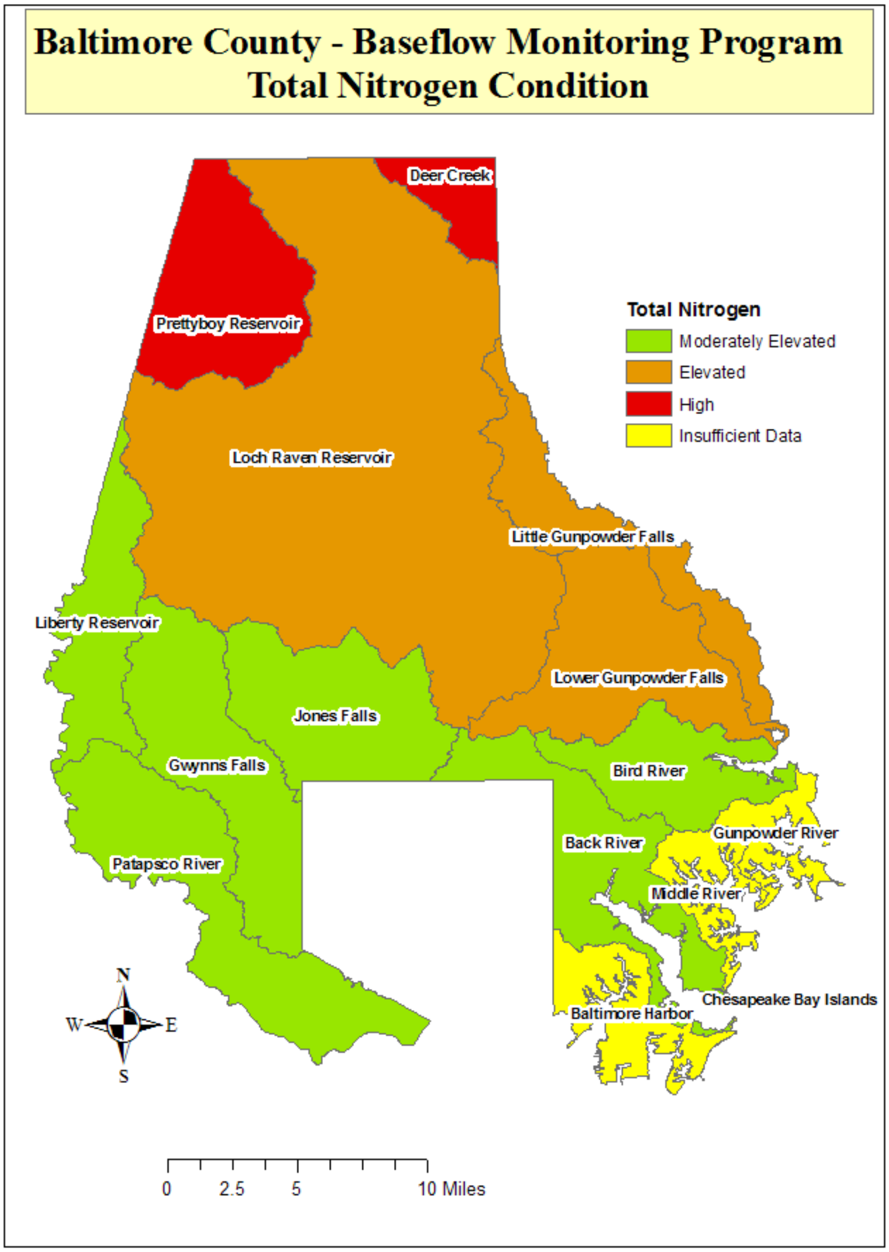


Figure A-6: Baseflow Total Nitrogen Mean Concentrations for Baltimore County 8-Digit Watersheds

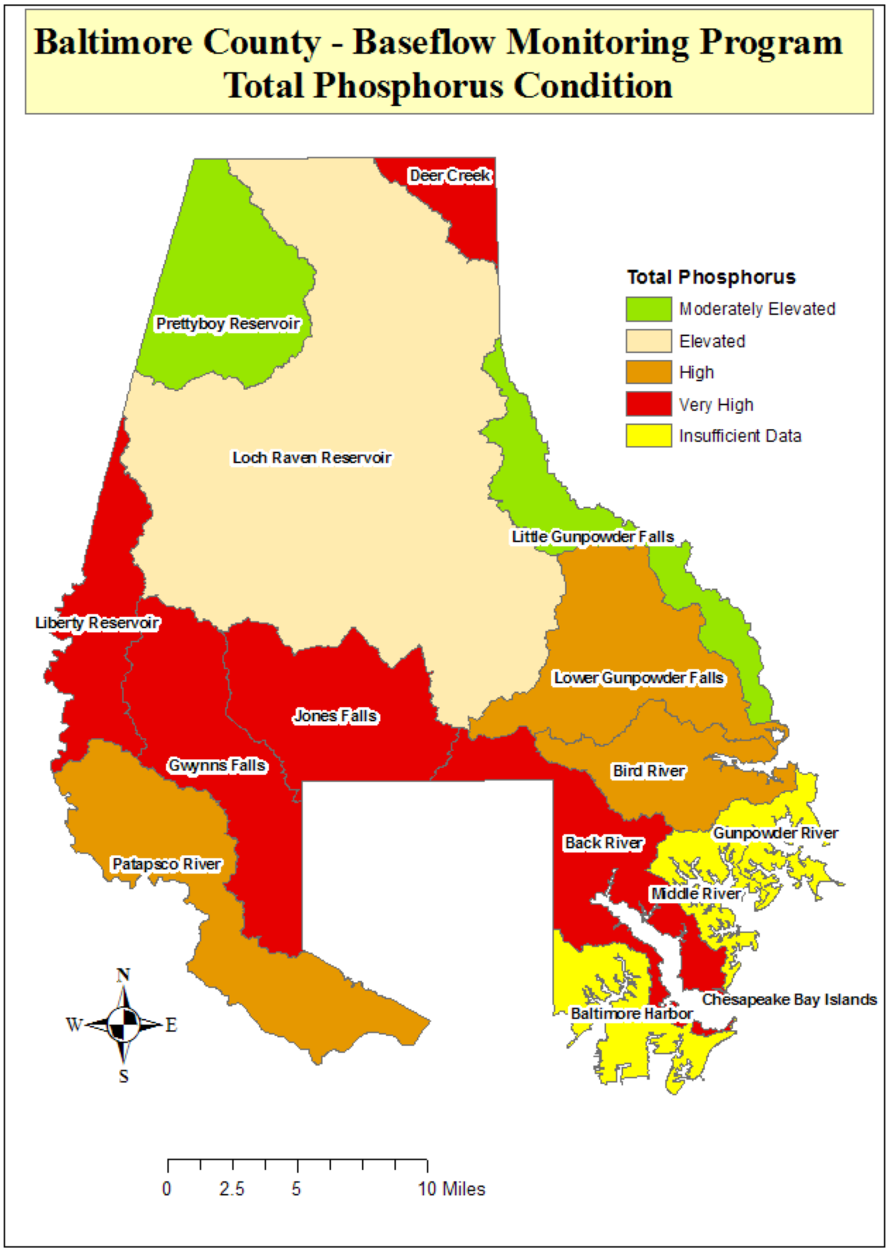


Figure A-7: Baseflow Total Phosphorus Mean Concentrations Baltimore County 8-Digit Watersheds

As can be seen from Figure A-6, the highest concentrations of Total Nitrogen predominate in the northern portions of the County, these watersheds are predominately in agriculture and rural residential land uses. These increased Total Nitrogen concentrations may be the result of agricultural activities, septic system inputs, or a combination. The upper Gwynns Falls, a predominately urban area shows high values of Total Nitrogen, as well as one sub-watershed in the Back River (not shown in figure or table).

The distribution of Total Phosphorus concentrations conversely shows the highest concentrations in the predominately urban areas, with several notable exceptions, including upper Lower Gunpowder Falls, and the rural portions of the Liberty Reservoir and Loch Raven watersheds. The majority of Total Phosphorus is delivered during storm events, associated with sediment. Thus, the concentrations measured in baseflow sampling are much lower than during storm event sampling. The elevated concentrations in the urban areas are likely the result of increases in orthophosphate, which occurs in a dissolved form. The source is currently not known, but may be associated with sewage and various industrial processes. The elevated and very high concentrations in rural areas may be associated with animal operations where livestock have access to the stream.

A.4.1.2 County Recreational Waters Monitoring Program

Baltimore County has had a tidal recreational water-monitoring program since 1970. Early bacteriological sampling was conducted on a monthly basis between Labor Day and Memorial Day for fecal coliform. Since 2000, and the advent of the US EPA Beach Act, tidal water sampling has been conducted bi-weekly by boat for the indicator organism Enterococci. The sampling season has been extended to cover the period of April through November (weather permitting). Multiple bacteriological samples are taken in ten zones representing areas of heavy recreational use with four single grab samples taken in less utilized areas. In addition, beach sampling also utilizing Enterococci is conducted at three permitted beach locations, on a basis alternate to recreational water sampling.

Individual sample results are recorded, as well as the Geometric Mean of multiple sample zones. The water quality threshold for Entercocci is 35 MPN (geomean) for public safety and water contact only in association with a known or suspected sewage overflow. Thirty-five (35) MPN is otherwise used for comparison purposes to make general characterizations of open water. The results of the bacteriological sampling can be viewed at: http://www.baltimorecountymd.gov/Agencies/environment/watersampling/results.html.

Special sampling is also conducted to support environmental/public health evaluations after severe storm events or sanitary sewage overflows.

Starting in 2002, chemical sampling of surface waters was initiated at locations designed to represent major county tidal basins. This sampling takes place during the recreational water-sampling run and has recently been expanded to ten locations. The codes for those locations are noted on the Beach, Beach Area, and Recreational Water Sampling Locations map (Figure A-8).

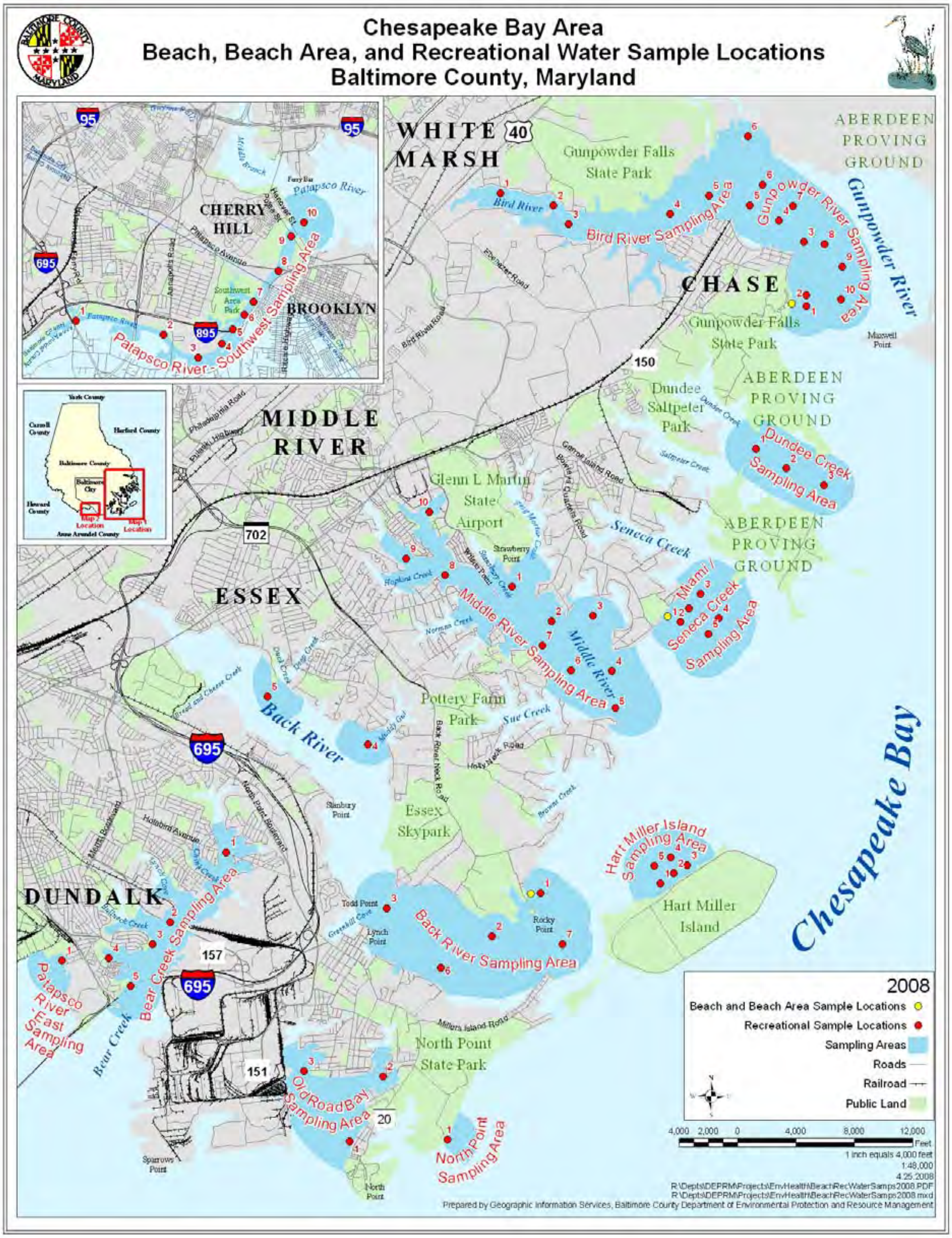


Figure A-8: Tidal Waters Monitoring Site Locations.

The nitrogen and phosphorus data for the tidal water segments was summarized over the entire span of monitoring. The results are displayed in Table A-10 and Figures A-9 (nitrogen) and A-10 (phosphorus). As with the baseflow monitoring, nitrogen and phosphorus condition was determined for each segment based on the mean concentration. The rating system was changed to reflect differences in tidal oligiohaline and mesohaline concentrations. The tidal water nutrient condition was rated based on the rating system below.

Condition	Nitrogen Concentration (mg/L)	Phosphorus Concentration (mg/L)
Low	< 0.75	< 0.050
Moderately Elevated	0.75 – 1.0	0.050 – 0.075
Elevated	1.0 – 2.0	0.075 – 0.100
High	> 2.0	> 0.100

Table A-10: Tidal Water Segment Nitrogen and Phosphorus Concentrations and Condition

Tidal Segment	Total Nitrogen (mg/L)	Total Nitrogen Condition	Total Phosphorus (mg/L)	Total Phosphorus Condition
GUNOH1	0.58	Low	0.050	Low
GUNOH2	0.95	Moderately Elevated	0.081	Elevated
MIDOH	0.71	Low	0.055	Moderately Elevated
CB2MH	0.88	Moderately Elevated	0.053	Moderately Elevated
BACOH	2.25	High	0.179	High
PATMH	1.14	Elevated	0.076	Elevated
CB3MH	NA	Insufficient Data	NA	Insufficient Data

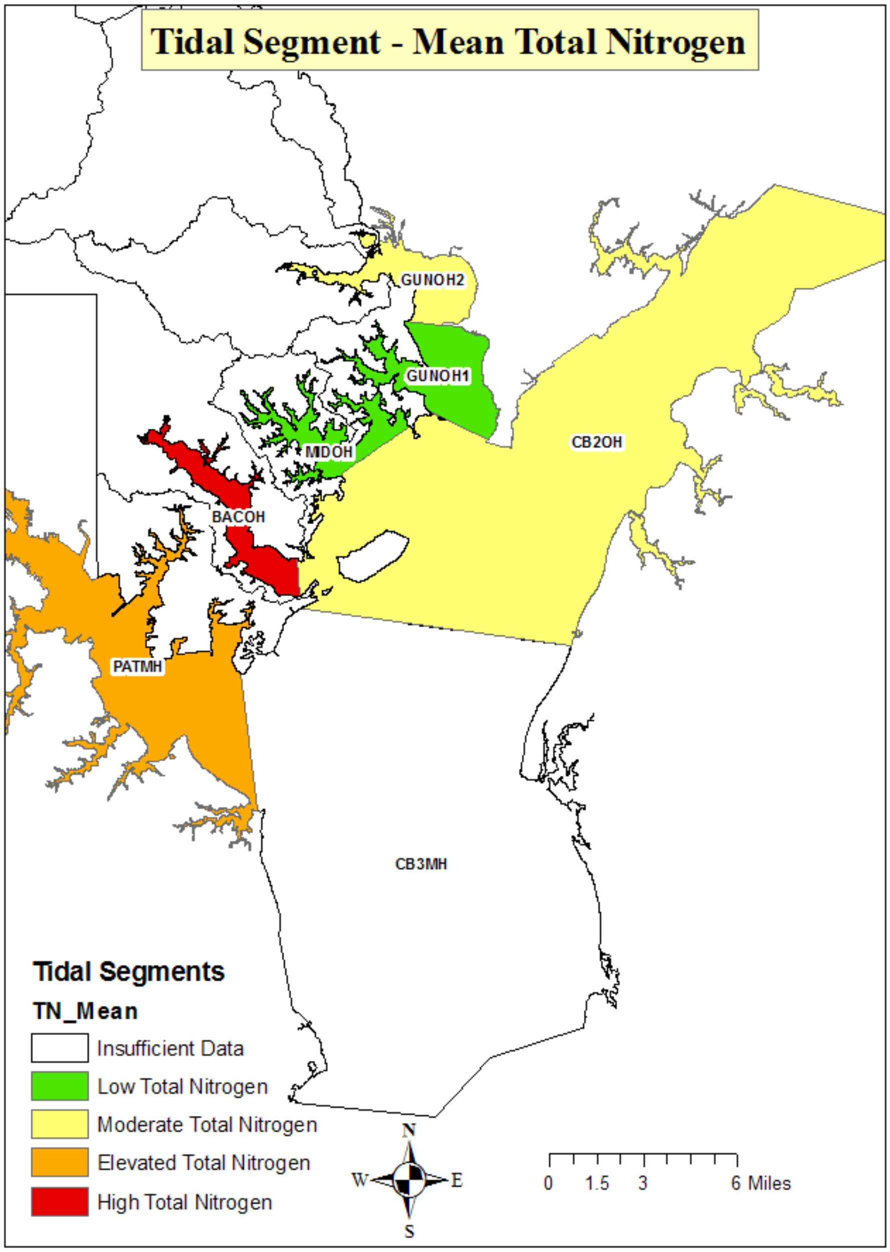


Figure A-9: Tidal Water Segment Nitrogen Condition

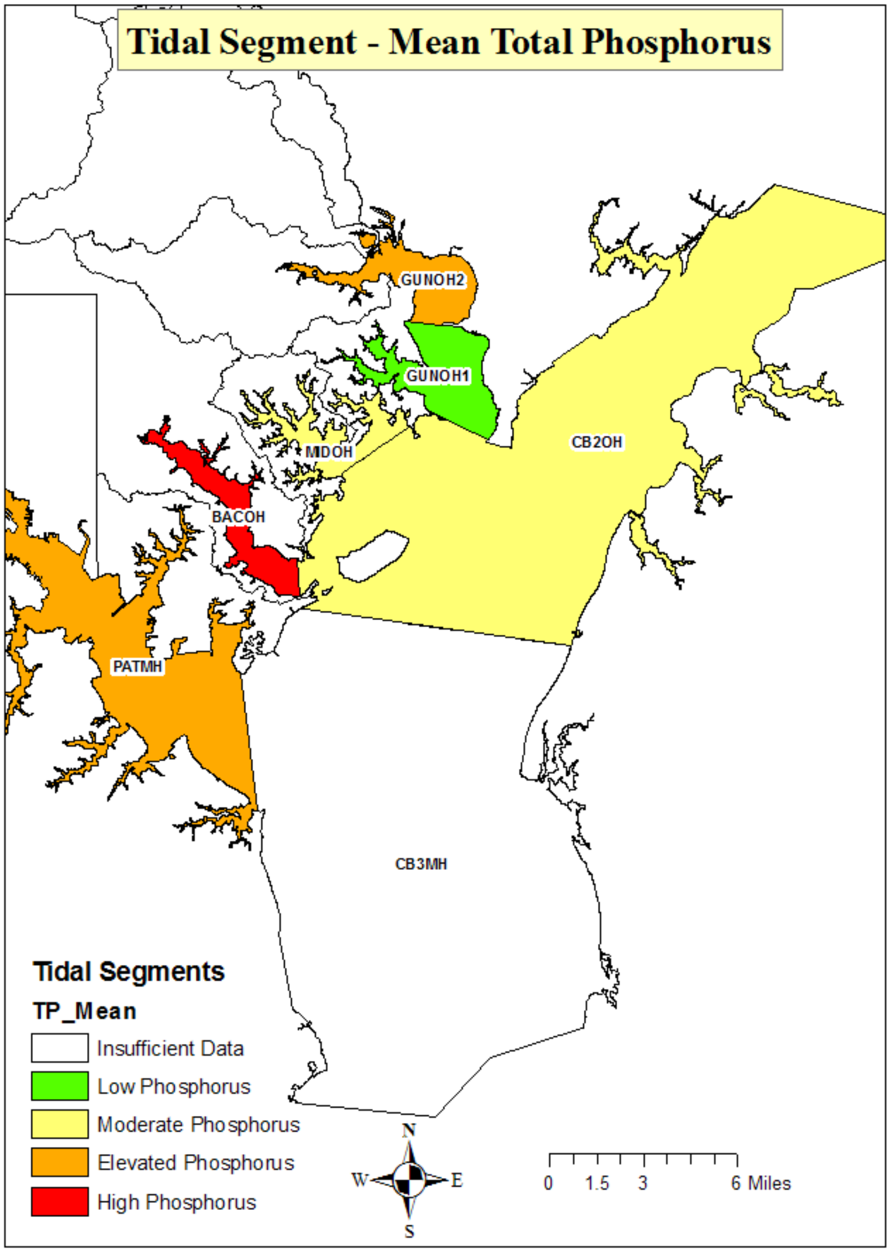


Figure A-10: Tidal Water Phosphorus Condition

The Back River (BACOH) tidal segment is high for both nitrogen and phosphorus. The Back River WWTP, which is due for an upgrade to Enhanced Nutrient Removal (ENR) in 2014, is the largest source of nitrogen and phosphorus in the drainage area. Baltimore Harbor (PATMH) tidal segment is moderately elevated for both nitrogen and phosphorus.

There are a number of point sources within the drainage area, with Patapsco WWTP being the largest point source. It is currently under design for ENR. PATMH tidal segment also has significant nutrient sources from the watersheds that drain into the harbor. Much of the source from the watersheds is derived from urban land uses.

A.4.1.3 County Biological Monitoring Program – Random Point Program

The County adopted Maryland Biological Stream Survey (MBSS) methodologies in 2003, which has allowed for direct comparisons with state generated data. This has expanded upon the available data for assessing county waters. Probabilistic monitoring (randomly selected monitoring sites) has allowed statistically valid statements regarding the state of the waters.

The County has contracted a consultant to perform the probabilistic monitoring. Each year a different basin is sampled, with the Patapsco/Back River Basin (Liberty Reservoir, Patapsco River, Gwynns Falls, Jones Falls, and Back River) monitored in odd years and the Gunpowder River Basin and Deer Creek watersheds (Deer Creek, Prettyboy Reservoir, Loch Raven Reservoir, Lower Gunpowder, Little Gunpowder, and Bird River) monitored in the even years. Three watersheds are not assessed using the Biological Probabilistic Monitoring Program (Baltimore Harbor, Middle River, and Gunpowder River) due to the limited miles of free flowing streams in the watersheds.

One hundred sites are selected at random for each year's sampling effort. The contractor samples these 100 sites during the spring index period, March 1 to April 30, for macroinvertebrates using the MBSS protocols. These samples are sub-sampled to 100 organisms and identified to genus or the lowest possible taxonomic level. A Benthic Index of Biotic Integrity (BIBI) is calculated. The BIBI describes the biological condition of the streams in the County. In 2006, a subset of previously sampled random sites was selected to serve as sentinel sites. The sites were located towards the base of major subwatersheds. Eighteen sentinel sites were selected in the Patapsco/Back River basin, and thirteen sentinel sites were selected in the Gunpowder/Deer Creek basin. The sentinel sites will be used to monitor biological condition over a range of watershed and stream conditions.

The current BIBI uses six metrics; what they measure and the expected response to stressors are displayed in Table A-11.

Table A-11: BIBI Metrics

BIBI Metric	Metric Measure	Expected Response
Number of Taxa	Species Richness	Decrease
Number of EPT	Species Richness	Decrease
Number of Ephemeroptera	Species Richness	Decrease
Percent Intolerant to Urban	Tolerance/Intolerance	Decrease
Percent Chironomidae	Taxonomic Composition	Increase
Percent Clingers	Habit	Decrease

Table A-12 shows the results by watershed, as the percentage of sites within each BIBI range, for the entire six-year probabilistic data set. The Patapsco/Back River Basin data show an improvement in biological condition. Sites within the Good and Fair categories increased from 15% in 2003 to 44% in 2007. Liberty Reservoir had all 20 sampled sites in the Fair and Good categories in 2007. As in 2005, Jones Falls had the next highest percentage of sites in the Fair and Good categories (46%).

The 2004 and 2006 sampling results for the Gunpowder Basin/Deer Creek watersheds indicated a decrease in water quality. In 2004, 79% of sites were in the Fair and Good categories, while in 2008 only 62% of sites rated Fair and Good. The biological condition of streams in the Gunpowder River/Deer Creek watersheds continues to be better than in Patapsco/Back River. Gunpowder River/Deer Creek streams had higher percentages of sites rated Fair and Good, and Patapsco/Back River had higher percentages of streams rated Very Poor and Poor. This is likely a reflection of higher population density and greater development pressure in Patapsco/Back River. However, over the entire county for the 6-year sampling period, the percentages of streams rated Fair and Good (47%) is roughly equal to percentage rated Very Poor and Poor (53%).

Table A-12: BIBI Score Distribution by Watershed (% by Category)

Watershed	N	1.00-1.99 Very Poor	2.00-2.99 Poor	3.00-3.99 Fair	4.00-5.00 Good
Patapsco/Back River Basin – Sampled in 2003					
Liberty Reservoir	10	10	50	30	10
Patapsco River	13	54	46	0	0
Gwynns Falls	30	43	53	3	0
Jones Falls	32	38	31	25	6
Back River	15	87	13	0	0
2003 Total/%	**100**	**46**	**39**	**12**	**3**
Gunpowder River Basin/Deer Creek – Sampled in 2004					
Deer Creek	3	0	33	67	0
Prettyboy Reservoir	7	0	14	43	43
Loch Raven Res.	67	6	9	43	42
Lower Gunpowder	7	29	43	29	0
Little Gunpowder	6	0	0	50	50
Bird River	2	50	50	0	0
2004 Total/%	**92**	**8**	**13**	**42**	**37**
Patapsco/Back River Basin – Sampled in 2005					
Liberty Reservoir	22	5	32	41	23
Patapsco River	21	29	43	24	4
Gwynns Falls	22	18	68	14	0
Jones Falls	23	17	30	48	4
Back River	12	58	42	0	0
2005 Total/%	**100**	**22**	**43**	**28**	**7**
Gunpowder River Basin/Deer Creek – Sampled in 2006					
Deer Creek	13	8	8	31	53
Prettyboy Reservoir	17	0	30	35	35
Loch Raven Res.	44	7	16	57	20
Lower Gunpowder	17	30	35	35	0
Little Gunpowder	4	0	25	25	50
Bird River	5	80	20	0	0
2006 Total/%	**100**	**13**	**21**	**42**	**24**
Patapsco/Back River Basin – Sampled in 2007					
Liberty Reservoir	20	0	0	30	70
Patapsco River	24	33	33	17	17
Gwynns Falls	26	12	54	19	15
Jones Falls	28	29	25	25	21
Back River	19	84	11	5	0
2007 Total/%	**117**	**30**	**26**	**20**	**24**
Gunpowder River Basin/Deer Creek – Sampled in 2008					
Deer Creek	12	17	17	33	33
Prettyboy Reservoir	13	0	8	38	54
Loch Raven Res.	47	4	9	23	64
Lower Gunpowder	12	58	17	8	17
Little Gunpowder	11	0	0	64	36
Bird River	5	100	0	0	0
2008 Total/%	**100**	**30**	**8**	**28**	**34**
All Years County Total/%	***509***	***24***	***29***	***28***	***19***

Using the MBSS methodology to determine impairment listing for aquatic biological condition, the condition of each watershed was determined for each sampling year. The results are displayed for all sampling years in Table A-13, along with an estimate of the percent of stream miles that are biologically impaired. Figure A-11 shows the impairment status for sampling years 2007 and 2008.

Table A-13: Watershed Biological Condition Using Percent Stream Mile Method

Watershed	Sites Degraded	N	% Stream Miles With Possible Degradation	CL_{Lower} (%)	CL_{Upper} (%)	Category
2003 Sampling Year						
Liberty	6	10	**60**	35	81	Impaired
Patapsco River	13	13	**100**	84	100	Impaired
Gwynns Falls	29	30	**97**	88	99	Impaired
Jones Falls	22	32	**69**	56	80	Impaired
Back River	15	15	**100**	86	100	Impaired
2004 Sampling Year						
Deer Creek	1	3	**33**	3	80	Inconclusive
Prettyboy	1	7	**14**	1	45	Attaining
Loch Raven	10	67	**15**	9	22	Attaining
Lower Gunpowder	5	7	**71**	40	92	Impaired
Little Gunpowder	0	6	**0**	0	32	Attaining
Bird River	2	2	**100**	32	100	Impaired
2005 Sampling Year						
Liberty	8	22	**36**	22	52	Impaired
Patapsco River	15	21	**71**	55	84	Impaired
Gwynns Falls	19	22	**86**	72	95	Impaired
Jones Falls	11	23	**48**	33	63	Impaired
Back River	12	12	**100**	83	100	Impaired
2006 Sampling Year						
Deer Creek	2	13	**15**	4	36	Attaining
Prettyboy	5	17	**29**	15	48	Impaired
Loch Raven	10	44	**23**	15	33	Impaired
Lower Gunpowder	11	17	**65**	46	80	Impaired
Little Gunpowder	1	4	**25**	3	68	Inconclusive
Bird River	5	5	**100**	63	100	Impaired
2007 Sampling Year						
Liberty	0	20	**0**	0	11	Attaining
Patapsco River	16	24	**67**	52	80	Impaired
Gwynns Falls	17	26	**65**	51	78	Impaired
Jones Falls	15	28	**54**	40	67	Impaired
Back River	18	19	**95**	81	99	Impaired
2008 Sampling Year						
Deer Creek	4	12	**33**	15	56	Impaired
Prettyboy	1	13	**8**	1	27	Attaining
Loch Raven	6	47	**13**	7	21	Attaining
Lower Gunpowder	9	12	**75**	52	90	Impaired
Little Gunpowder	0	11	**0**	0	19	Attaining
Bird River	5	5	**100**	63	100	Impaired

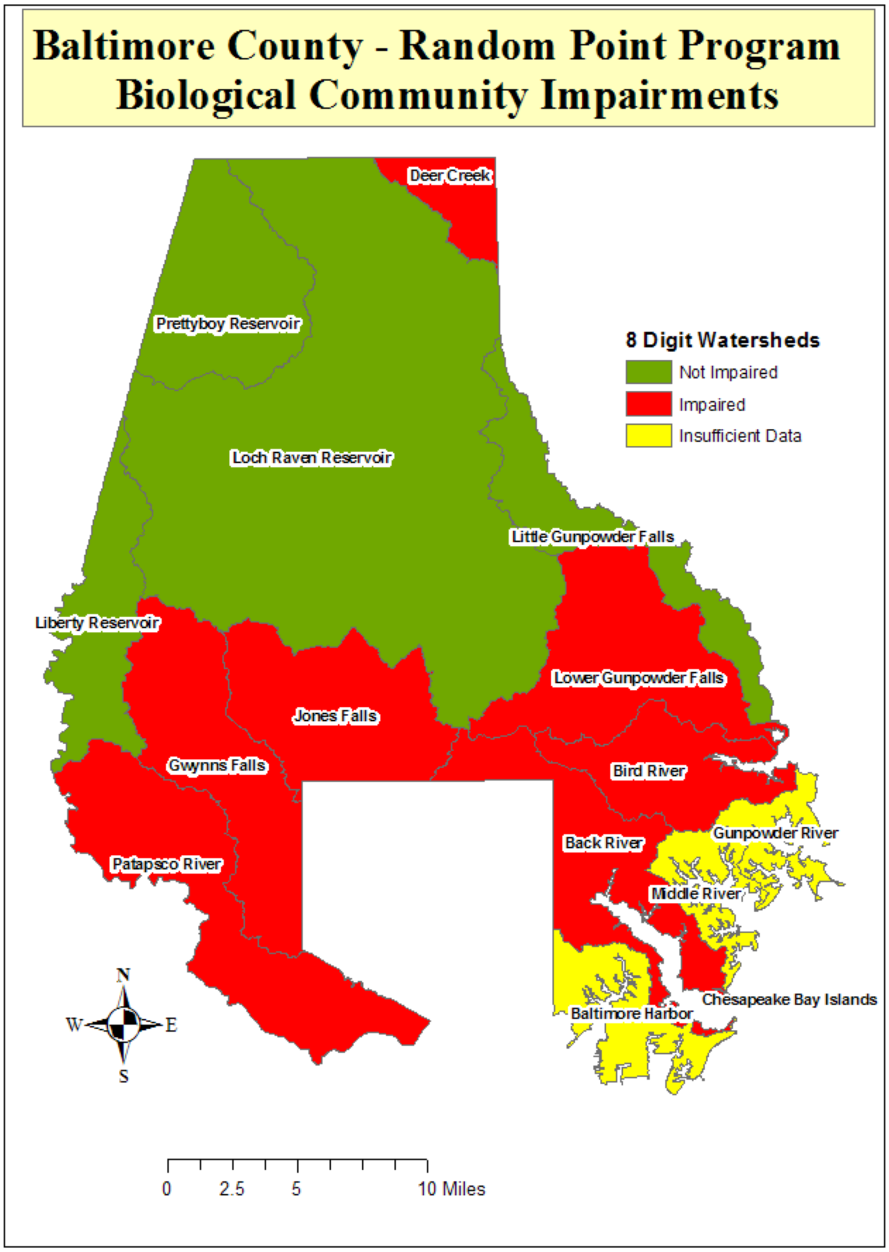


Figure A-11: Biological Community Impairment Status

Figures A-12 and A-13 show the means and one standard deviation of the mean BIBI scores for each watershed between 2003 and 2008. The mean scores for Liberty, Patapsco, and Gwynns increased over the period. Watersheds in the Gunpowder River and Deer Creek basins were stable.

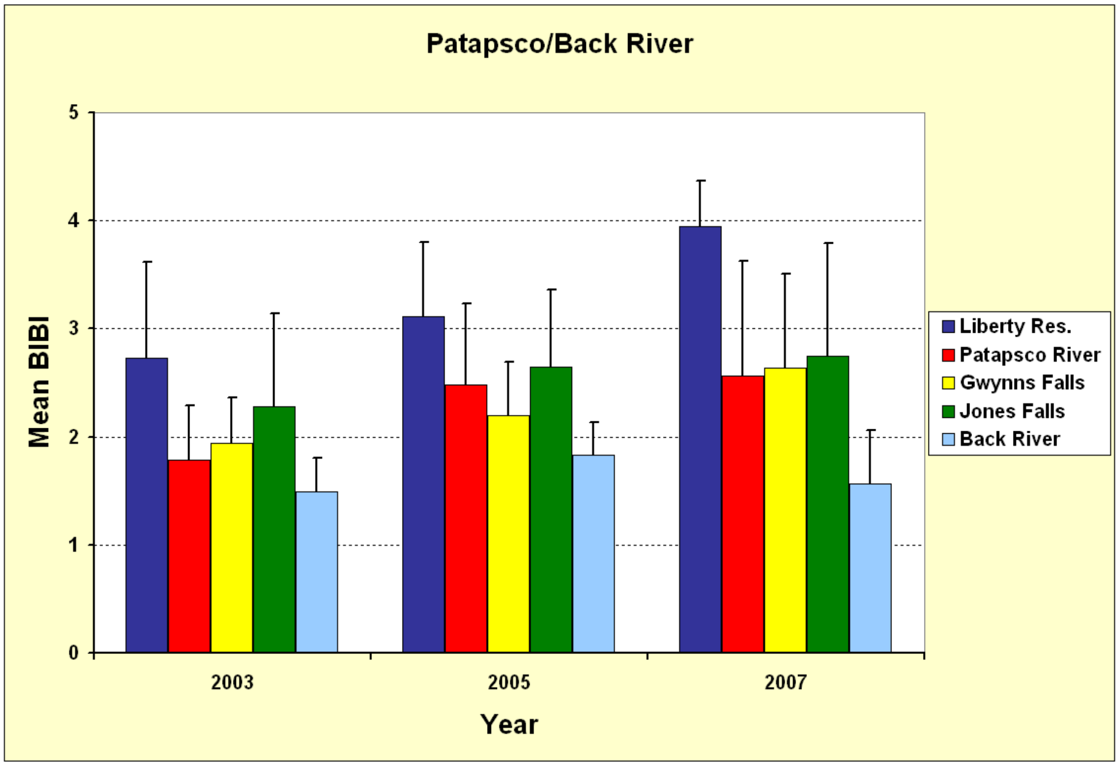


Figure A-12: Means and One Standard Deviation of BIBI Scores for Patapsco/Back River Watersheds Between 2003 and 2007.

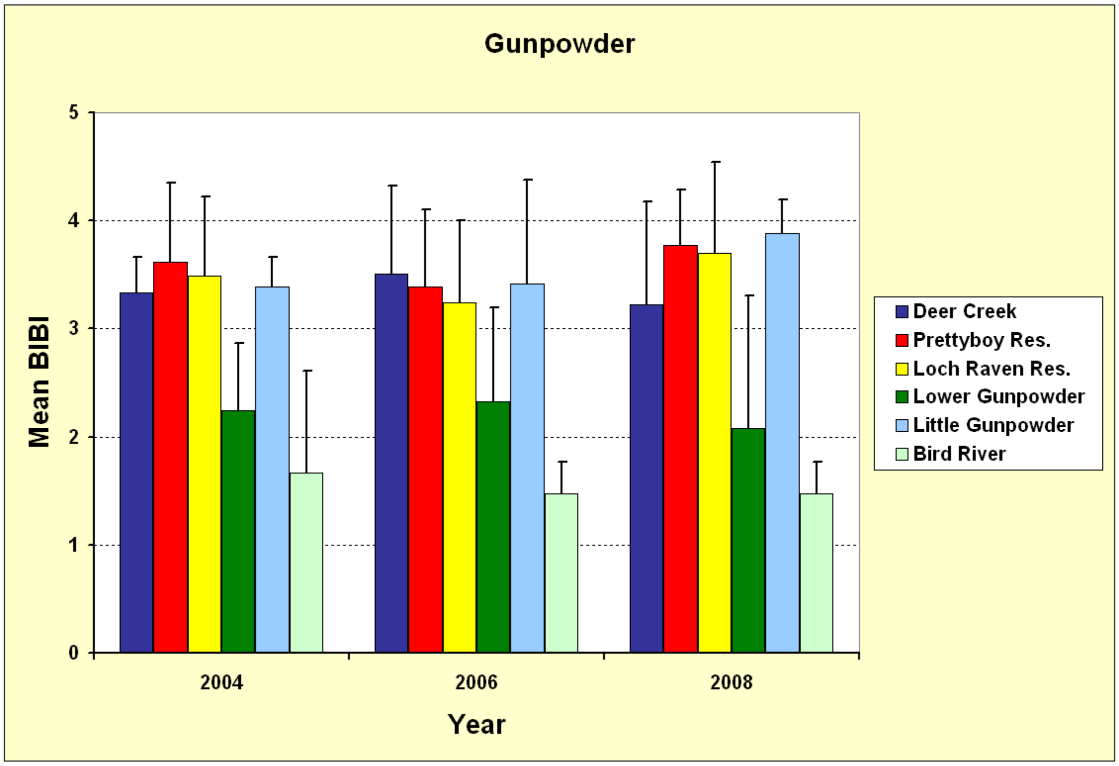


Figure A-13: Means and One Standard Deviation of BIBI Scores for Gunpowder Falls/Deer Creek Watersheds Between 2004 and 2008.

A.4.1.4 County Biological Monitoring Program – Submerged Aquatic Vegetation (SAV) Program

Baltimore County has conducted Submerged Aquatic Vegetation monitoring since 1989 on certain waterways. With the advent of water quality standards for submerged aquatic vegetation, reporting on the monitoring results commenced in the 2006 NPDES Annual Report. During the 2003 Water Quality Standards Triennial Review, Maryland Department of the Environment adopted standards for tidal water submerged aquatic vegetation and water clarity, among other standards also adopted. The standards are based on water quality segments that are derived from the Chesapeake Bay Program model. There are a total of seven segments in Baltimore County tidal waters. Three of the segments (MIDOH, GUNOH1, and BACOH) are entirely within Baltimore County. Four other segments have tidal waters that extend to other jurisdictions. Two of these segments (CB2OH and CB3MH) are Chesapeake Bay mainstem segments and extend to the eastern shore of Maryland. The Chesapeake Bay Program draft document *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries 2006 Addendum* provides guidance on assessing the attainment of the SAV acreage criteria. The document states “the shallow-water bay grass designated use is considered in attainment if there are sufficient acres of SAV observed within the segment or there are enough acres of shallow-water habitat meeting the applicable water clarity criteria to support restoration of the desired acres of SAV for that segment.” The recommended procedure is to use the **single best year SAV acreage** based on the most recent three-year period of available data. The criteria may also be met by attaining water clarity acres for the most recent three-year period of available data. The water clarity depth varies by tidal segment (see Table 9-13). Water clarity data is currently not collected in Baltimore County, so only the SAV acreage will be used.

The 2009 Triennial Review of Water Quality Standards proposed several changes that affect the SAV criteria. First, the tidal segment BACOH, which covers tidal Back River, has had a change in the target SAV acreage goal from 0 to 340 acres. Secondly, credit for meeting water clarity standards in areas with no SAV have changed from an acre by acre basis to 2.5 acres per acre basis. In other words, using Back River as an example, if no SAV were present in Back River, water clarity standards would have to be met for 850 acres (340 acres SAV goal X 2.5).

Baltimore County monitors SAV distributions in the spring and summer of each year in accordance with the US Fish and Wildlife methodologies. There are currently 29 waterways in the County that are monitored. In order to assess the total acres of yearly coverage for the creeks surveyed, the data for the spring and summer were analyzed for overlap in SAV distribution between the two seasons. The total SAV coverage for each year is calculated by the following formula:

$$\textbf{Total SAV}_{acres} = (\textbf{Spring SAV}_{acres} - \textbf{Overlap}_{acres}) + (\textbf{Summer}_{acres}\textbf{ SAV} - \textbf{Overlap}_{acres}) + \textbf{Overlap}_{acres}$$

To estimate the progress in meeting the SAV goal for each tidal segment the Total SAV_{acres} are divided by the SAV goal for that segment. Only two of the seven segments are totally within Baltimore County jurisdiction, and therefore can be assessed for SAV criteria attainment. However, these two segments are not entirely surveyed for SAV coverage and so, like the other five segments, this analysis will only provide a conservative estimate of SAV criteria attainment.

Table A-14 presents the SAV water quality standard for each segment and the results of the last three years of SAV monitoring. The yellow highlighted water quality segments lie entirely within Baltimore County. The red highlighted cells are the highest percent attainment for each water quality segment based on the last three years of data.

Table A-14: SAV Standards and Baltimore County SAV Monitoring Results (2006-2008)

Water Quality Segment	SAV Goal (Acres)	Water Clarity Depth (m)	2006		2007		2008	
			Acres	% of Goal	Acres	% of Goal	Acres	% of Goal
MIDOH	879	2.0	234	26.7	240.7	27.3	518.0	58.9
GUNOH1	1,860	0.5	**	**	**	**	**	**
GUNOH2	572	2.0	84	14.7	194.4	33.9	187.7	32.8
BACOH	340	0.5	5	1.5	6.3	1.9	0	0
PATMH	389	1.0	5	1.3	9.0	2.3	6.1	1.6
CB2OH	705	0.5	152	21.6	133.8	19.0	197.9	28.1
CB3MH	1,370	0.5	55	4.0	44.3	3.2	77.4	5.6
Total SAV Acres	**6,115**		**535.0**		**628.5**		**987.1**	

** No monitoring conducted by Baltimore County in this segment.

The Middle River segment (MIDOH) has consistently the highest acreage of SAV coverage each year. In 2004, Middle River attained 54.9% of the SAV criteria. 2008 saw a resurgence of SAV in Middle River with a total of 518 acres representing ~59% of the goal. Back River has the least amount of SAV coverage over the three-year period and is far from meeting the new draft criteria of 340 acres of SAV coverage. Overall, the SAV coverage has increased in each of the last three years of monitoring, with almost 1,000 acres of coverage in 2008. Since not all of the county tidal waters are monitored through this program, the numbers represent a conservative estimate of progress in meeting the SAV goals. The Gunpowder segment (GUNOH1) is not monitored by Baltimore County.

Figure A-14 displays the trends in SAV coverage over 20 years of monitoring. The figure displays the percent of the area survey that was covered by SAV. As can be seen from the figure, there is a generally an increasing trend in the percent of the area surveyed that is covered by SAV from a low in 1989 of 0.37% to a high of 27.4% in 2008. While there is a certain degree of variability, possibly related to climatic events (record wet year in 2003 with reduced % coverage) the overall trend is improved coverage.

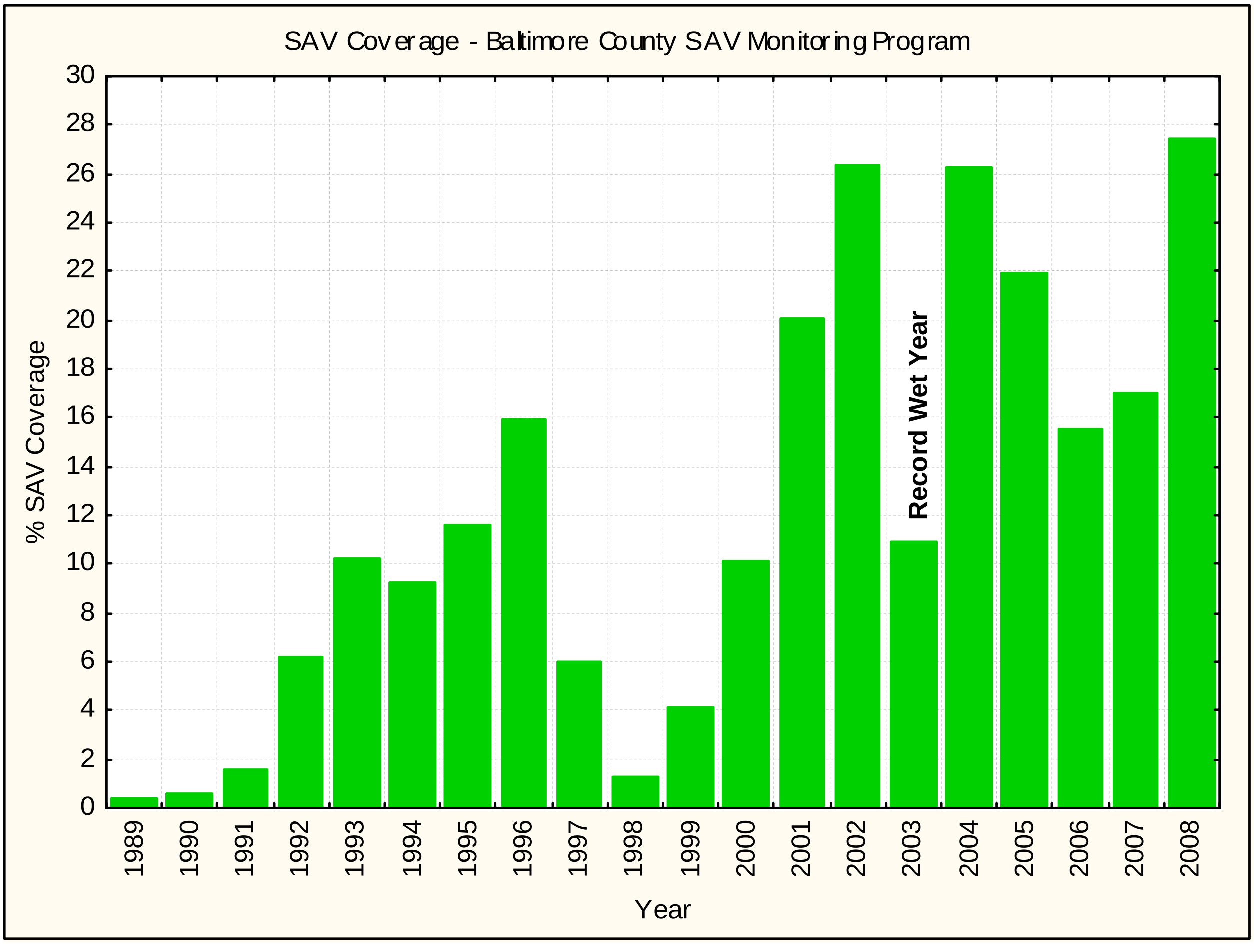


Figure A-14: Baltimore County SAV Monitoring Program – Trends in % Coverage

A.4.2 State and Federal Assessments

The *2008 Integrated Report of Surface Water Quality in Maryland* (MDE 2008) provided a new listing methodology for nontidal stream biological impairment. The methodology can be found in the document at: http://www.mde.state.md.us/assets/document/2008_IR_Parts_A_thru_E(1).pdf. Table A-15 is the Baltimore County portion of Table 6 of the MDE document that relevant to Baltimore County. The table provides information on the passage or failure of the watershed in support of the aquatic biological community. Failure results in an impairment listing (see previous Section A.3). The table also provides an estimate of the % of stream miles that are degraded. The same methodology was used in the analysis of the county collected biological community data above. Only three of the 8-digit watersheds (Deer Creek, Prettyboy Reservoir, and Little Gunpowder Falls) were determined to not be impaired. Three watersheds were inconclusive (Bird River, Gunpowder River, and Middle River) due to limited or no data. The balance of the 8-digit watersheds were considered to be impaired.

The data can be compared to the biological information collected by the County (Table A-13). While there is consistency in the assessment for eleven of the watersheds, three watersheds had opposite results:

Watershed	State	County
Deer Creek	Pass	Fail
Loch Raven Reservoir	Fail	Pass
Liberty Reservoir	Fail	Pass

This could be due to different sampling years. Baltimore County sampling over the sampling period provided different results on impairment and the number of impaired stream miles for each of the three watersheds.

Table A-15: Biological Assessment of Baltimore County 8-Digit Watersheds

Watershed	8-digit	Final Status	% Stream Degraded	% (LCL)	% (UCL)	% Difference from Reference	Total Sites	Sites Degraded
Deer Creek	2120202	Pass	11%	5%	19%	1%	46	5
Prettyboy	2130806	Pass	16%	6%	32%	6%	19	3
Loch Raven	2130805	Fail	27%	18%	37%	17%	45	12
Lower Gunpowder	2130802	Fail	54%	33%	74%	44%	13	7
Little Gunpowder Falls	2130804	Pass	15%	7%	27%	5%	27	4
Bird River	2130803	Inc.	100%	32%	100%	90%	2	2
Gunpowder River	2130801	N=0						
Middle River	2130807	N=0						
Liberty Reservoir	2130907	Fail	22%	16%	29%	12%	77	17
Patapsco River	2130906	Fail	61%	48%	72%	51%	33	20
Gwynns Falls	2130905	Fail	79%	65%	88%	69%	28	22
Jones Falls	2130904	Fail	36%	22%	52%	26%	22	8
Back River	2130901	Fail	100%	90%	100%	90%	21	21
Baltimore Harbor	2130903	Fail	69%	55%	81%	59%	26	18

Maryland Department of Natural Resources periodically prepares summary reports on water quality for the Tributary Strategy Basins. The latest reports were in 2007 and covered the 1985 – 2005 data.

Maryland Tributary Strategy Upper Western Shore Basin Summary Report for 1985-2005 Data (DNR 2007) can be found at:
http://dnr.maryland.gov/bay/pdfs/UWSBasinSum8505FINAL07.pdf

Maryland Tributary Strategy Patapsco/Back Rivers Basin Summary Report for 1985-2005 Data (DNR 2007) can be found at:
http://dnr.maryland.gov/bay/pdfs/PatBackBasinSum8505FINAL07.pdf

The findings of these reports are briefly summarized in Table A-16.

Table A-16: Summary of Basin Reports

	Upper Western Shore	**Patapsco/ Back River**
Modeled Nitrogen Loading	Down 0.98 million #s, 45% of the tributary goal	Down 10.7 million #s, 65% of the tributary goal
Modeled Phosphorus Loading	Down 0.12 million #s, 70% of the tributary goal	Down 8.5 million #s, 93% of the tributary goal
Modeled Sediment Loading	Down 19,000 tons, 46% of tributary goal	Down 9,000 tons, 41% of tributary goal

Non-tidal nitrogen	Fair to poor	Fair to good
Non-tidal phosphorus	Fair to good	No report
Tidal nitrogen	Fair to good	Poor
Tidal phosphorus	Good and improving	Poor
Summer bottom Dissolve Oxygen	Good	Poor
Algal Abundance	Middle River – Fair Gunpowder River - Good	Poor
SAV	Middle River and Gunpowder River close to acreage goal	Small amount of acreage
Tidal benthic community	Good but limited sampling	Degraded or severely degraded

The federal Environmental Protection Agency (EPA) – Chesapeake Bay Program periodically assesses the Chesapeake Bay health and the progess made in reducing nutrients. The following three figures were obtained from the Chesapeake Bay Program website: http://www.chesapeakebay.net/status_reducingpollution.aspx?menuitem=19691

Figure A-14 shows the progress made in reducing nitrogen pollution, Figure A-15 shows progress made in reducing phosphorus, and Figure A-16 shows progress made in reducing sediment. The scale of the mapping has all of Baltimore County, with the exception of Deer Creek in the Maryland Western Shore basin. This mapping units include parts of adjacent jurisdictions. Mapping unit 7 is the unit that contains Baltimore County. The data is current to 2007. The data from these maps is summarized in Table A-17.

Table A-17: Summary of Pollutant Reduction Progress – Chesapeake Bay Program

	Percent Responsibility	Percent Goal Achieved
Nitrogen	10.97%	61 – 80%
Phosphorus	7.83%	81 – 100%
Sediment	3.77%	41 – 60%

As can be seen by these maps and the table above, significant progress has been made in achieving nitrogen and phosphorus reductions, while additional effort is needed for sediment reduction.

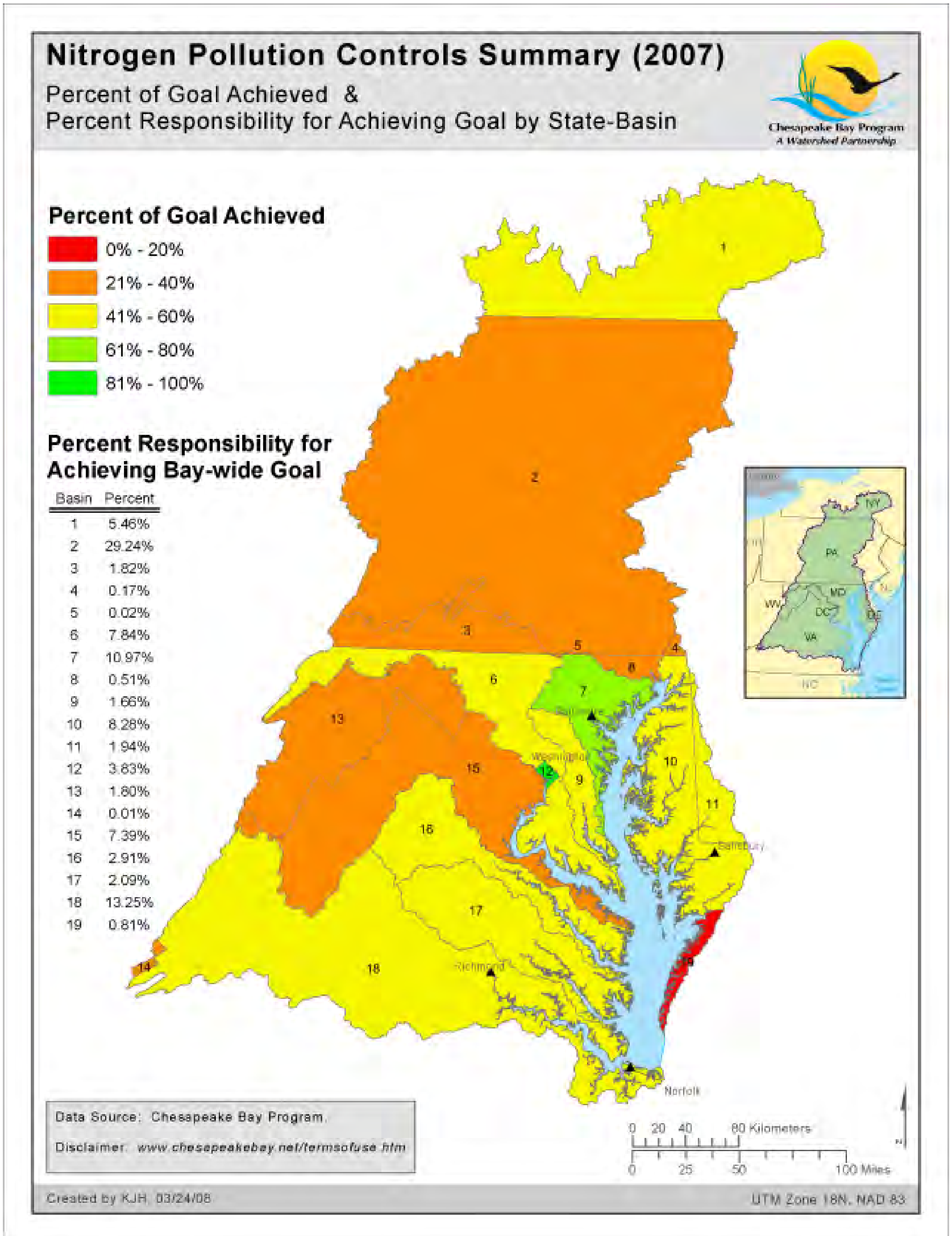


Figure A-14: Progress Made in Reducing Nitrogen Pollution

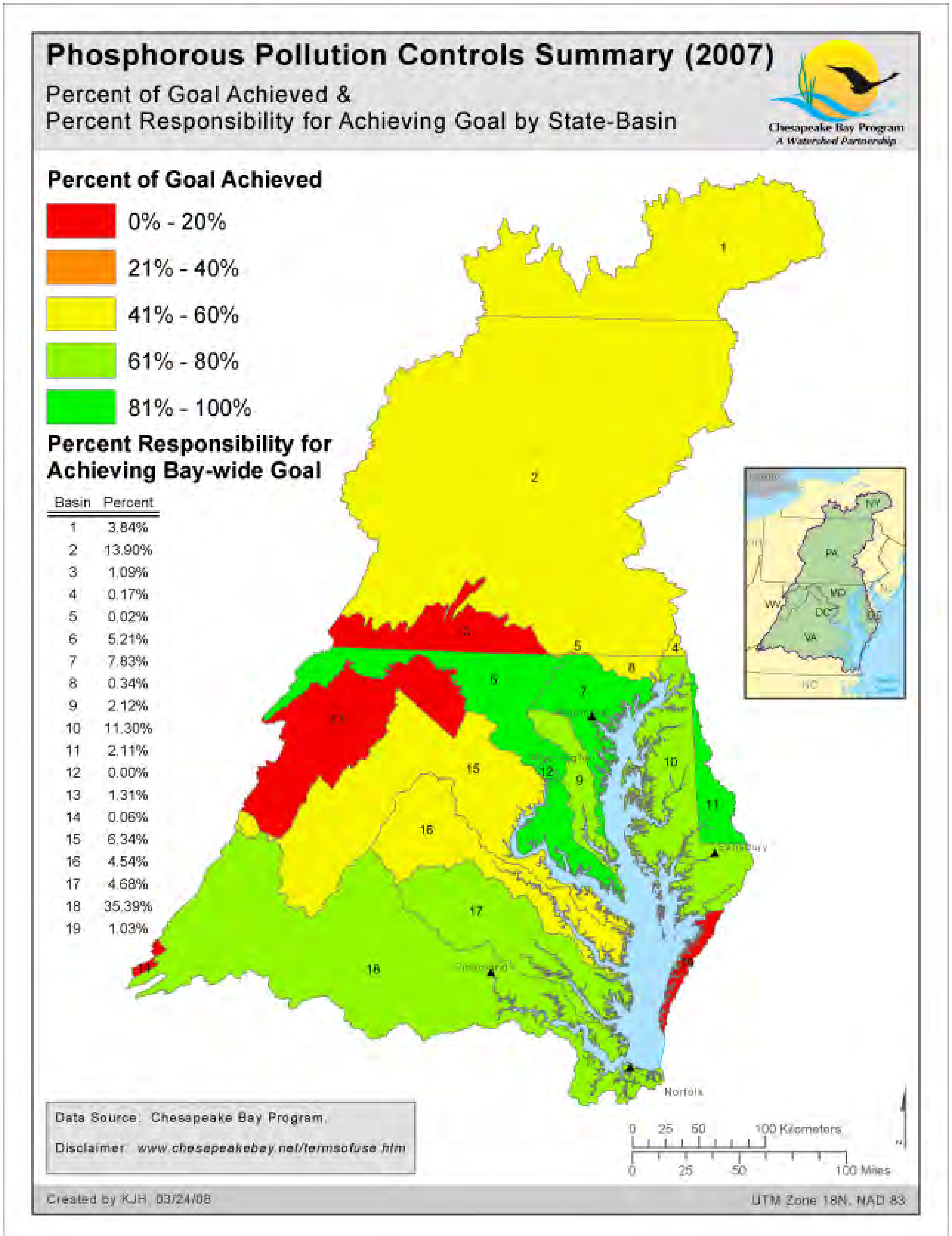


Figure A-15: Progress Made in Reducing Phosphorus Pollution

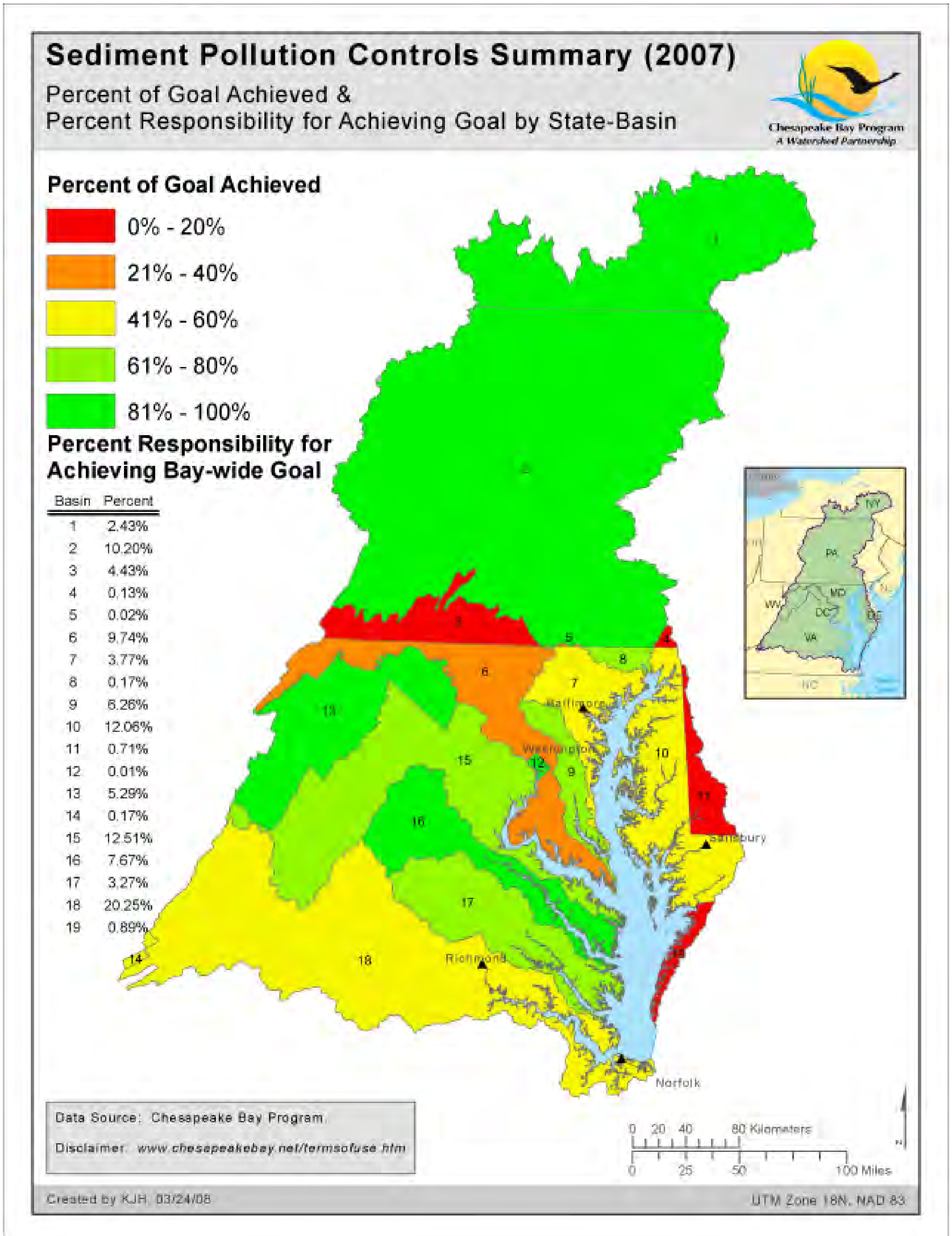


Figure A-16: Progress Made in Reducing Sediment Pollution

The University of Maryland and partners has been providing a bay report card since 2006. This report card is based on data collected by many organizations as indicated in the acknowledgement below:

Acknowledgements

The data and methods underpinning this report card represent the collective effort of many individuals and organizations working within the Chesapeake Bay scientific and management community. The following organizations are acknowledged for their significant contributions to the development of the report card: Chesapeake Bay Program, University of Maryland Center for Environmental Science, National Oceanic and Atmospheric Administration, Maryland Department of Natural Resources, Virginia Department of Environmental Quality, Virginia Institute of Marine Science, Versar Incorporated, US Environmental Protection Agency, Maryland Department of the Environment, Interstate Commission on the Potomac River Basin, Old Dominion University, and Morgan State University.

While acknowledging the critical role of these organizations in generating, analyzing, and reviewing the data, the Integration and Application Network, University of Maryland Center for Environmental Science and EcoCheck (NOAA-UMCES Partnership) are responsible for the report card release.

A total of eight indictors are used in the development of the Bay Health Report Card. Figure A-17 below shows the report card for 2006, 2007, and 2008. More information on the indicators can be found at: http://www.eco-check.org/reportcard/chesapeake/2008/

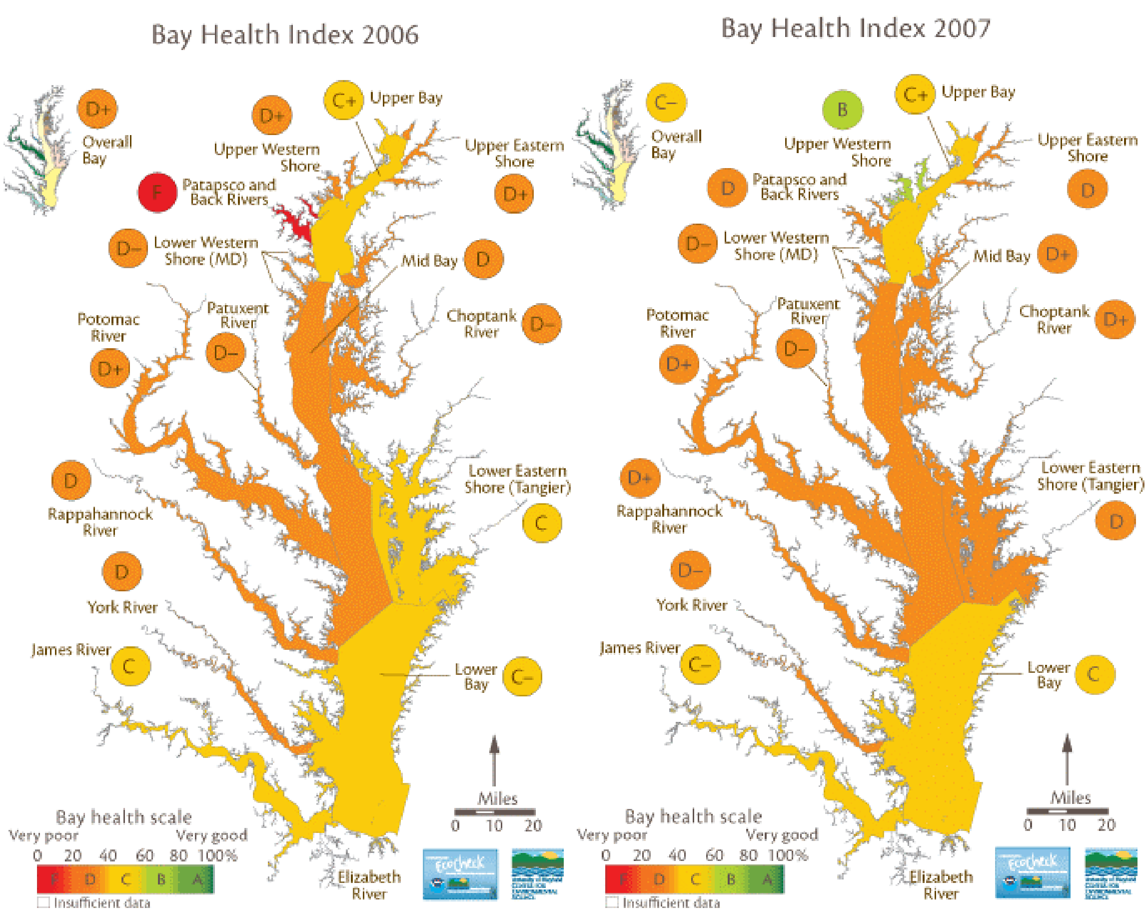


Figure A-17: Bay Report Card

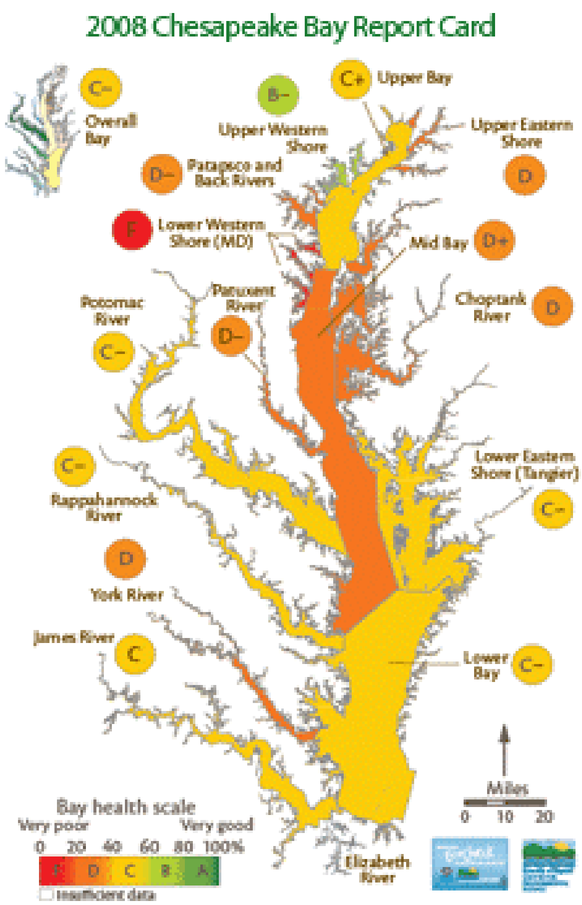


Figure A-17: Bay Report Card (continued)

The report card indicates that the Patapsco/Back River basin has improved only slightly from an F in 2006 to a D- in 2008. The Upper Western Shore basin improved from a D+ in 2006 to a B in 2007 and degraded slightly to a B- in 2008. In both cases there has been recent improvement based on the indicators used compared to the base year of 2006.

Brief summaries of the two basins were provided by the Report Card; these are shown below.

Patapsco and Back Rivers: 2008

Poor ecosystem health. Water quality scores over the past 20 years have been consistently poor, showing no signs of improving.

- *Water quality:* In 2008, both water clarity and chlorophyll *a* scored a 0% (conditions over the year never exceeded the threshold levels). This scoring is consistent with the poor to very poor scores for all water quality indicators over the past 20 years. The dissolved oxygen score in 2008 was 59%, the second lowest score in the bay.

- *Biotic indicators:* In 2008, the benthic community condition declined from unusually good conditions in 2007. Benthic and phytoplankton community condition tend to vary greatly between years. Aquatic grass distribution has remained very poor (0 to 11%) since 1989, with the exception of a short two-year period (2004 and 2005), when the score increased to 72%.

Upper Western Shore: 2008

Moderate-good ecosystem health--highest ranked region. Large improvement in benthic community condition and aquatic grasses in the past two years.

- *Water quality:* In 2008, and the past 6 years, the dissolved oxygen score has remained 100%. Dissolved oxygen scores over the past 20 years have ranged between 88 to 100% (good to very good.). In contrast, water clarity tends to be poor to very poor. In 2008, the water clarity score was only 5%, the lowest score since the wet conditions in 2003.
- *Biotic indicators:* In 2008, the aquatic grass and benthic community scores improved for the second year in a row, leading to the second highest Biotic Index score on record. Biotic indicators (aquatic grasses and benthic community) scores tend to vary between years. No phytoplankton community monitoring is conducted in this region.

Appendix A: Trout Locations in Baltimore County

Watershed	Subwatershd	Species
Deer Creek	Little Deer Creek	Brown
Prettyboy Reservoir Watershed	Unnamed Tributary to Prettyboy	Brook
	Frog Hollow Run	Brook
	Unnamed Tributary to Prettyboy	Brook
	Graves Run	Brown
	Indian Run	Brook
	Poplar Run	Brook
	Unnamed Tributary to Prettyboy	Brook
	Unnamed Tributary to Prettyboy	Brook
	Unnamed Tributary to Prettyboy	Brook
	Silver Run	Brook
	Walker Run	Brook
Loch Raven Reservoir	Fitzhugh Run	Brown
	Dulaney Valley Branch	Brown
	Overshot Run	Brown
	Greene Branch	Brook
	Gunpowder Falls	Brown
	Quail Run	Brook
	Carroll Branch	Brook
	Piney Creek	Brook – Brown
	Buffalo Run	Brook – Brown
	Unnamed Tributary to Gunpowder Falls	Brook – Brown
	Charles Run	Brook – Brown
	Panther Branch	Brook
	Unnamed Tributary to Gunpowder Falls	Brook
	Unnamed Tributary to Gunpowder Falls	Brook – Brown
	Mingo Branch	Brook
	Bush Cabin Branch	Brook
	Unnamed Tributary to Gunpowder Falls	Brook
	Western Run	Brown
	Beaver Dam Run	Brook – Brown
	Goodwin Run	Brown
	Baisman Run	Brook – Brown
	Blackrock Run	Brook – Brown
	Indian Run	Brook – Brown
	Deadman Run	Brook – Brown
	Waterspout Run	Brown
	Piney Run	Brown
	McGill Run	Brown
	Delaware Run	Brown
	Slade Run	Brown
	Councilmans Run	Brown
	Little Falls	Brown
	Little Falls	Brown
	Unnamed Tributary to Little Falls	Brook
	Unnamed Tributary to Little Falls	Brook
	First Mine Branch	Brook – Brown

	Third Mine Branch	Brook – Brown
	Fourth Mine Branch	Brook – Brown
	Owl Branch	Brook - Brown
	Bee Tree Run	Brown
Lower Gunpowder Falls	Long Green Creek	Brown
Little Gunpowder Falls	Sawmill Branch	Brook
Liberty	Timber/Cooks Run	Brook
	Unnamed Tributary to Liberty	Brown
Gwynns Falls	Gwynns Falls	Brown
	Red Run	Brook - Brown
Jones Falls	Jones Falls Mainstem	Brown
	Deep Run	Brown
	Dipping Pond Run	Brook – Brown
	Jones Falls North Branch	Brown

Baltimore County WRE Technical Memo - B
Pollutant Loading Analysis

The guidance document, *The Water Resources Element: Planning for Water Supply and Wastewater and Stormwater Management*, (MDP 2007) states:

> "The Stormwater Assessment component of the WRE is intended to inform the land use planning process by evaluating suitable receiving waters and land areas to include appropriate stormwater management treatment. It is also intended to ensure that the land use planning process is used as an effective nonpoint source pollution management instrument. This, in conjunction with the management of point source pollution, will help a jurisdiction achieve and maintain its water quality standards."

In order to assess the impacts of current and future development on water quality, Baltimore County has taken the approach of conducting the pollutant loading analysis on each of the Maryland designated 8-digit watersheds located entirely, or in part, within Baltimore County. The rationale for this approach is based on how the state of Maryland lists water quality impaired waters. Beginning with the 2008 Integrated Assessment (MDE 2008), and the change in how biological community impairments were listed, all watershed impairments are listed on the 8-digit scale, or by tidal water segment. To further link the analysis to the land use plan, the analysis split those watersheds that intersected the Urban-Rural Demarcation Line (URDL). This line essentially determines our Priority Funding Area (PFA), with all land inside the URDL designated as Smart Growth Areas.

Table B-1 indicates the pollutant loading analysis areas (designated as Water Quality Planning Areas (WQPA) and the acreages associated with each, while Figure B-1 shows the distribution of watersheds and the URDL. A total of 25 WQPAs were assessed for nitrogen and phosphorus pollutant loads.

Table B-1: Water Quality Planning Areas

Watershed	8-Digit Watershed Number	Tributary Strategy Segment	URDL	Acres
Deer Creek	02-13-02-02	Upper Western Shore	Outside (Rural)	7,173
Prettyboy Reservoir	02-13-08-06	Upper Western Shore	Outside (Rural)	25,548
Loch Raven Reservoir	02-13-08-05	Upper Western Shore	Outside (Rural)	126,747
Loch Raven Reservoir	02-13-08-05	Upper Western Shore	Inside (Urban)	12,826
Lower Gunpowder Falls	02-13-08-02	Upper Western Shore	Outside (Rural)	20,425
Lower Gunpowder Falls	02-13-08-02	Upper Western Shore	Inside (Urban)	9,044
Little Gunpowder Falls	02-13-08-04	Upper Western Shore	Outside (Rural)	17,275
Bird River	02-13-08-03	Upper Western Shore	Outside (Rural)	2,826
Bird River	02-13-08-03	Upper Western Shore	Inside (Urban)	13,582
Gunpowder River	02-13-08-01	Upper Western Shore	Outside (Rural)	3,627
Gunpowder River	02-13-08-01	Upper Western Shore	Inside (Urban)	2,232
Middle River	02-13-08-07	Upper Western Shore	Outside (Rural)	1,241
Middle River	02-13-08-07	Upper Western Shore	Inside (Urban)	5,225
Liberty Reservoir	02-13-09-07	Patapsco/Back River	Outside (Rural)	16,960
Liberty Reservoir	02-13-09-07	Patapsco/Back River	Inside (Urban)	542
Patapsco River	02-13-09-06	Patapsco/Back River	Outside (Rural)	18,231

Patapsco River	02-13-09-06	Patapsco/Back River	Inside (Urban)	15,348
Gwynns Falls	02-13-09-05	Patapsco/Back River	Outside (Rural)	1,861
Gwynns Falls	02-13-09-05	Patapsco/Back River	Inside (Urban)	26,793
Jones Falls	02-13-09-04	Patapsco/Back River	Outside (Rural)	12,015
Jones Falls	02-13-09-04	Patapsco/Back River	Inside (Urban)	13,918
Back River	02-13-09-01	Patapsco/Back River	Outside (Rural)	2,266
Back River	02-13-09-01	Patapsco/Back River	Inside (Urban)	20,847
Baltimore Harbor	02-13-09-03	Patapsco/Back River	Outside (Rural)	1,041
Baltimore Harbor	02-13-09-03	Patapsco/Back River	Inside (Urban)	10,346
		Total Rural Acres (outside URDL)		**257,236**
		Total Urban Acres (inside URDL)		**130,703**
		Total Acres		**387,939**

As part of the triennial review of water quality standards in 2005, Maryland Department of the Environment added tidal water quality standards and designated tidal water segments. Baltimore County's streams discharge to seven different tidal water segments. These segments and the associated surface area are displayed in Table B-2 and Figure B-2. The analysis will consider the amount of nitrogen and phosphorus delivered to each tidal water segment from Baltimore County. Included in the analysis of the amount of nitrogen and phosphorus delivered to the tidal water segments will be the effects of the three drinking water reservoirs with respect to both treatment and amount of water delivered downstream.

Table B-2: Baltimore County Tidal Water Segments, Surface Area, Contribution Watersheds and Upstream Tidal Segments

Tidal Segment Designation	Surface (acres)	Contributing Watersheds
GUNOH2	4,600	Prettyboy Reservoir Loch Raven Reservoir Lower Gunpowder Falls Little Gunpowder Falls Bird River
GUNOH1	5,775	GUNOH2 and all watersheds that drain to GUNOH2 Portions of the Gunpowder River (Dundee Creek and Saltperter Creek)
MIDOH	3,977	Middle River Portions of the Gunpowder River (Seneca Creek)
CB2OH	67,723	GUNOH1 and all contributing watersheds to GUNOH1 MIDOH and Middle River Watershed BACOH and Back River Watershed Portions of Harford and Kent Counties
BACOH	3,947	Back River
PATMH	22,986	Liberty Reservoir Patapsco River Gwynns Falls Jones Falls Baltimore Harbor Direct Portions of Anne Arundel County
CB3MH	91,087	CB2OH and all contributing watersheds and tidal segments PATMH and all contributing watersheds Portions of Kent and Anne Arundel Counties

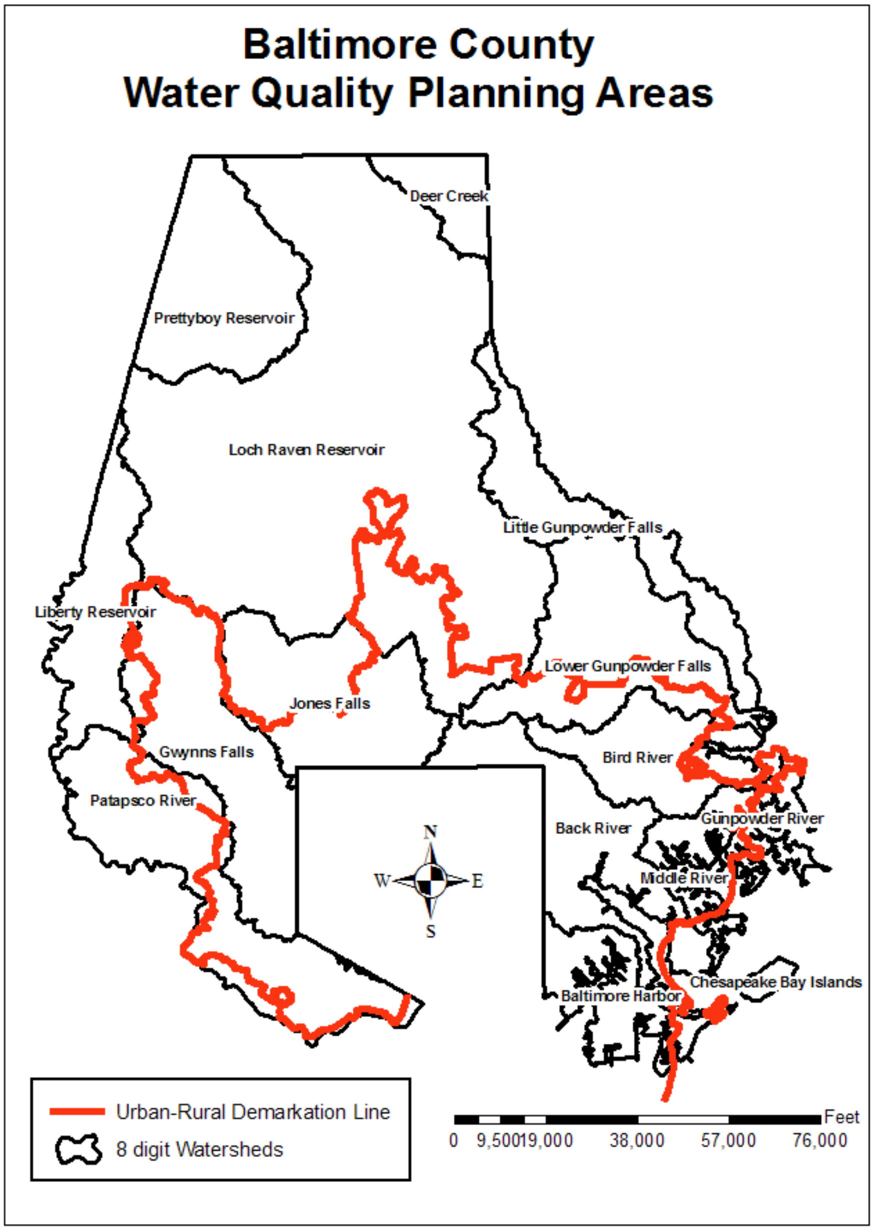


Figure B-1: Water Quality Planning Areas

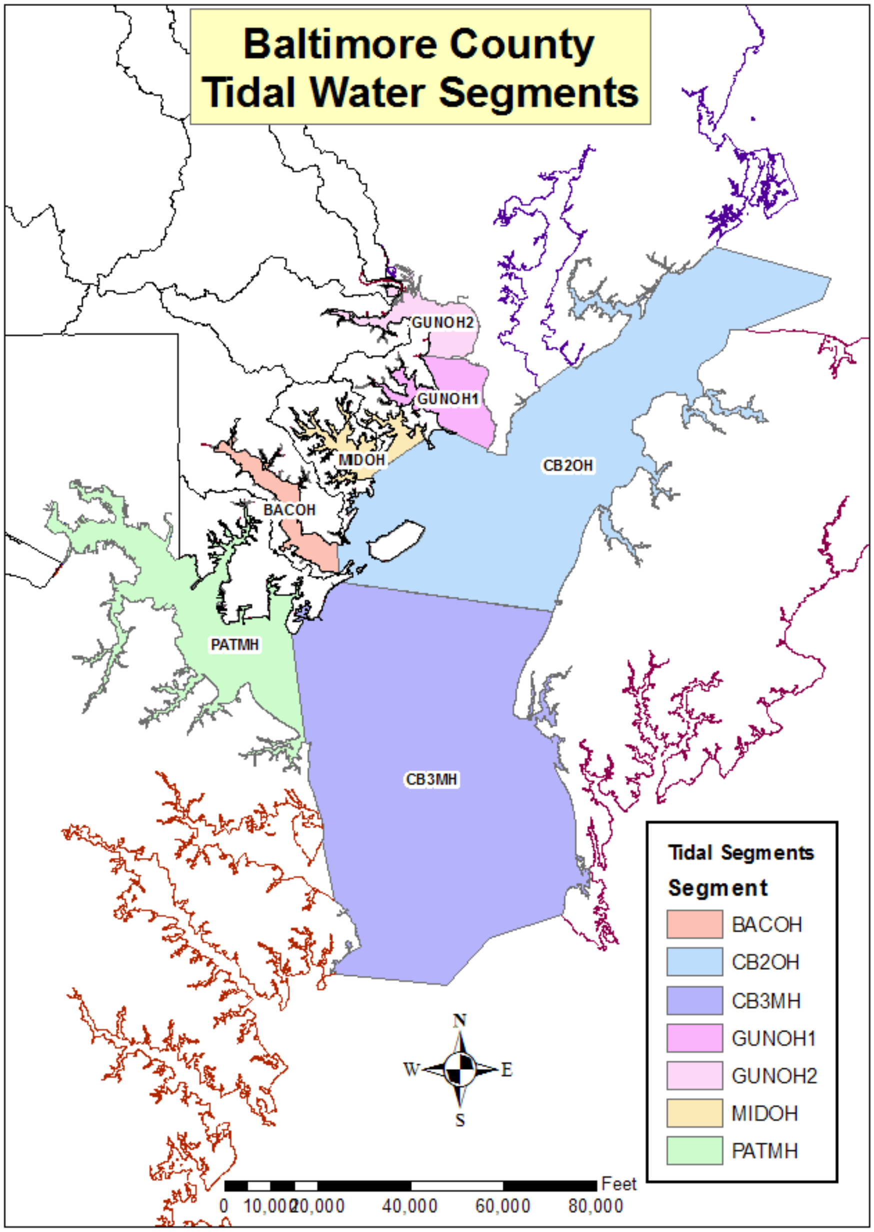


Figure B-2: Baltimore County Tidal Water Segments

B.1 Data Sources

In order to look at future nitrogen and phosphorus pollutant loading rates and impervious cover due to changes in land use, Baltimore County took the approach of looking at recent historical changes in development and the effect those changes had on pollutant loads and impervious cover. The data that Baltimore County had available to conduct this analysis were:

GIS Data:
MDE 8-digit Watersheds
Baltimore County Urban Rural Demarcation Line (URDL)
1997 Maryland Department of Planning (MDP) Land Use Land Cover
2002 MDP Land Use Land Cover
1995 - 1997 Baltimore County planimetric data
    Transportation layer (roads, parking lots, driveways >200 feet)
    Buildings layer
2005 Baltimore County planimetric data
    Transportation layer (roads, parking lots, driveways >200 feet)
    Buildings layer (residential, commercial, and industrial buildings, garages)
1995, 1996, 1997 & 1998 Baltimore County Orthophotography ("1997")
2005 Baltimore County Orthophotography
Stormwater Facilities Drainage Areas
Facilities Geodatabase:
    Facility Use Codes
    Residential Dwelling Unit Tally (custom query)
    Geocoding Services (address point and street centerline)
Redevelopment Projects
Subdivisions (S_List)
1990 US Census Tracts
2005 Transportation Analysis Zones
2008 Maryland Department of Planning Development Capacity Analysis

Tabular Data:
Bay Restoration Fund Billing Table, April 2008
Baltimore County DEPRM Septic System Permits Database
Baltimore County Master Water & Sewerage Plan: Inventory of small sewage treatment facilities
1997 Census Tract Population Estimates
2005 – 2035 Transportation Analysis Zone Population Forecasts (Round 7B)

These data permit analysis in the changes in land use, pollutant loads, impervious cover, and population between the time periods of 1997 and 2005 with some modification of both the 1997 and 2002 MDP Land Use layers. The ultimate objective is to calculate the changes in land use, pollutant loads, and impervious cover per person. This information, along with future population growth projections, is used to determine future pollutant loads and impervious cover changes for each WQPA. Three initial scenarios were used to calculate future pollutant loads and impervious cover:

- Scenario 1: Future development patterns continue based on past development patterns with Environmental Site Design applied.
- Scenario 2: Future development is directed entirely to areas within the URDL.

- Scenario 3: Future development is directed entirely to redevelopment sites. There are four subcategories of redevelopment:
  - a) Future redevelopment follows the recent pattern of redevelopment with some sites gaining residential units and some sites losing residential development. This subcategory is designated as “high” due to the need for a larger amount of land to handle the projected population increase.
  - b) Future redevelopment follows the pattern of higher density development, with only those recent sites resulting in an increase in residential units used in the analysis. This subcategory is designated as “low” due to the need for a smaller amount of land to handle the projected population increase.
  - c) Future redevelopment follows the recent pattern of redevelopment and includes parks as part of the redevelopment scenario. The parks can be used in addressing urban water quality through the incorporation of retrofits in the park design. This subcategory is designated as “high/park”.
  - d) Future redevelopment results in higher density residential units and includes parks as part of the redevelopment scenario, as above. This subcategory is designated as “low/park”.

The ultimate objective is to find the land use growth plan that results in a “no net increase” in pollutant loads and, if possible, to develop a land use growth plan that results in water quality improvement. To this end, the nutrient reduction requirements set out in the various TMDLs will be analyzed to determine the most cost effective approach.

B.2 Methodology

B.2.1 Loading rates

The pollutant loading rates for nitrogen and phosphorus were derived from two sources, the technical guidance provided by Maryland Department of the Environment (MDE) entitled *User’s Guide for Nutrient Load Analysis Spreadsheet in Support of the Water Resources Element* (MDE 2008) and the Chesapeake Bay Program – Watershed Model Phase 5.3.

The MDE technical guidance provided loading rates for Baltimore County based on three basins, Western Shore (above the fall line), Western Shore (below the fall line), and Susquehanna (above the fall line). These loading rates are based on the Chesapeake Bay Program - Watershed Model Phase 4.3 and include the full implementation of the Maryland Tributary Strategy for nutrient reduction, thereby eliminating the need to consider nutrient controls. For consideration of the impacts related to urban development, particularly in relation to green field and redevelopment scenarios Baltimore County determined that the urban loading rates without the implementation of urban BMPs would best serve the intent of Water Resources Element in looking at future development scenarios that will result in a no net increase in nutrient loading rates due to future development and restoration actions needed to reduce loads to meet water quality standards where TMDLs have already been developed. Thus, the final model for developing nutrient loads was a hybrid between the MDE guidance document for loading rates for all non-urban land uses, and the segment specific nutrient loading rates for urban land uses.

The Chesapeake Bay Program (CBP) Watershed Model Phase 5.2 provides loading rates by model segment with the urban land uses divided into “low density pervious urban”, “high density pervious urban”, “low density impervious urban”, and “high density impervious urban”. For Baltimore County there are no differences in the urban loading rates across the county (personal communication, Jing Wu, Chesapeake Bay Program). The loading rates applied to each watershed, the MDE segment and the CBP segment used in the pollutant loading analysis are displayed in Table B-3 for nitrogen and Table B-4 for phosphorus. These tables condense some of the MDP land use classifications since the loading rates did not differ between the use classes, for example forest. See Table B-6 under Land Use Calculations below for the correspondence between the MDP land use classification and the WRE land use classification.

Table B-3: Nitrogen Per Acre Pollutant Rate, MDE Segment and CBP Segment

	Deer Creek	Prettyboy Loch Raven Lower Gunpowder Little Gunpowder Falls Gwynns Falls Jones Falls Liberty Patapsco River	Bird River Gunpowder River Middle River Back River Baltimore Harbor
MDE Seg	Sus	Above Fall Line	Below Fall Line
CBP Seg	140	480	860
Low Density Impervious Urban	14.10	14.10	14.10
Low Density Pervious Urban	7.24	7.24	7.24
High Density Impervious Urban	14.10	14.10	14.10
High Density Pervious Urban	7.25	7.25	7.25
Crop	12.23	16.55	13.54
Pasture	8.42	7.35	5.64
Livestock	15.62	24.87	19.68
Forest	2.36	1.41	1.29
Water	10.61	10.05	10
Bare soil	8.42	7.35	5.64

Table B-4: Phosphorus Per Acre Pollutant Rate, MDE Segment and CBP Segment

	Deer Creek	Prettyboy Loch Raven Lower Gunpowder Little Gunpowder Falls Gwynns Falls Jones Falls Liberty Patapsco River	Bird River Gunpowder River Middle River Back River Baltimore Harbor
MDE Seg	Sus	Above Fall Line	Below Fall Line
CBP Seg	140	480	860
Low Density Impervious Urban	2.26	2.26	2.26
Low Density Pervious Urban	0.427	0.427	0.427
High Density Impervious Urban	2.26	2.26	2.26
High Density Pervious Urban	0.431	0.431	0.431
Crop	0.85	0.72	0.69
Pasture	0.44	0.73	0.66

Livestock	1.60	1.18	0.99
Forest	0.03	0.02	0.02
Water	0.57	0.57	0.57
Bare soil	0.44	0.73	0.66

B.2.2 Modification of 2002 MDP land use to 2005 land use

Figure B-3 presents an analysis diagram for the Land Use analyses described in sections B.2.2 through B.2.4. A legend for this and similar diagrams is presented in Figure B-4.

A 2005 Land Use Land Cover feature class was compiled by modifying the 2002 MDP Land Use Land Cover to reflect the 2005 land use in Baltimore County. The modification used the Subdivision GIS feature class (S_list). S_list stores the areal extent of development projects submitted for approval in Baltimore County, and includes useful attributes and status for each project.

Using 2005 aerials overlain by S_list and 2002 MDP Land Use, each S_list feature was visually inspected to determine if development had actually occurred on the site between the date represented in the 2002 MDP Land Use and when the 2005 aerials were flown. If a discrepancy was found, the 2002 MDP Land Use Land Cover was modified to reflect the change (i.e. if the 2002 MDP Land Use layer showed cropland, but the aerial showed medium density residential development, the 2002 MDP layer was changed to reflect the change in land use).

In the course of implementing this procedure, it was noted that the MDP land use designation Low Density Residential (code 11) contained a significant amount of forest cover. This is a semantic incompatibility between the categories employed in the MDP Land Use Land Cover and the Chesapeake Bay Program Watershed Model pollutant loading rates. It was determined that in order to obtain a more accurate representation of pollutant loading in Baltimore County, the low density residential category had to be decomposed into land cover components compatible with the CBP Watershed Model.

Figure B-3

Baltimore County Water Resource Element Data Analysis Diagrams
1997 to 2005 Land Use Land Cover Change Analysis

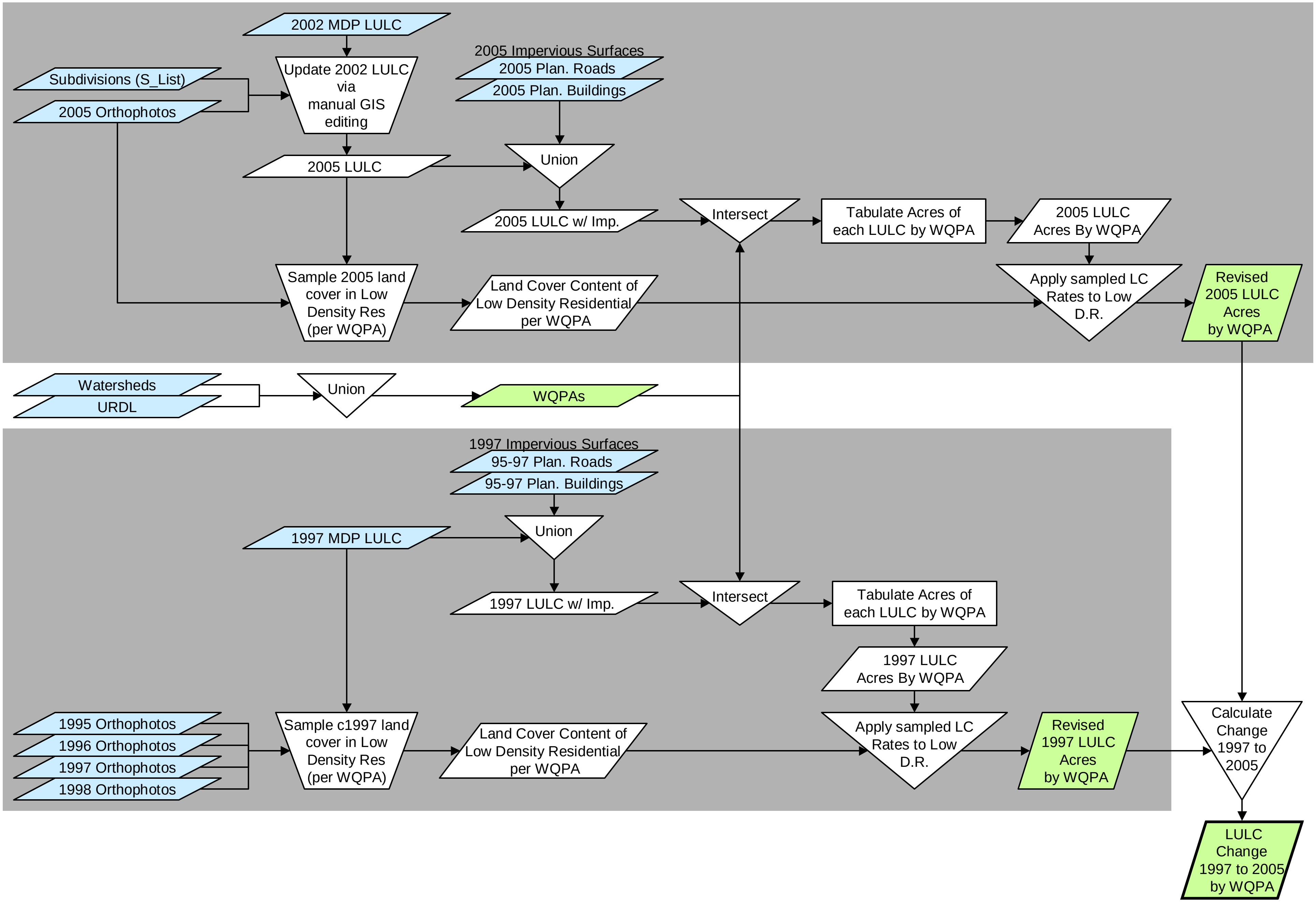
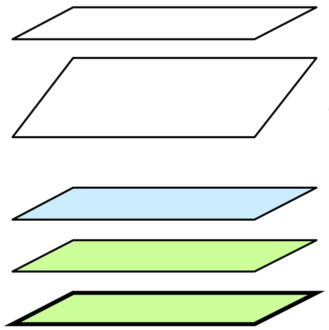


Figure B-4

Baltimore County Water Resource Element Data Analysis Diagrams Legend

Data Inputs and Outputs



GIS Feature Class / Layer

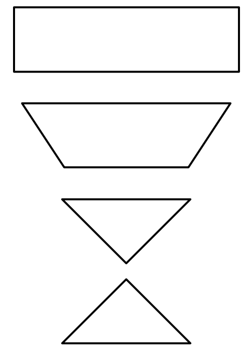
Tabular / Spreadsheet Data

Input Source Data

Results (as output and as input)

Final Results of Analysis

Processes



Automated Process

Manual Process

Process that Merges Inputs into a Single Output

Process that Extracts a Subset of the Input

Definitions of Selected Abbreviations

BRF	Bay Restoration Fund billing file
Calc.	Calculate
Dev. Cap.	Development Capacity
Diff.	Difference (arithmetic: subtraction)
Imp.	Impervious surfaces
LULC	Land Use Land Cover
NHC	New Housing Capacity (from development capacity analysis)
Plan.	Planimetric: two-dimensional representation
Pop.	Population
Res.	Residential
TAZ	Transportation Analysis Zone: Areas used to forecast population, for the primary purpose of transportation planning, but applicable to other population forecasting needs.
URDL	Urban Rural Demarcation Line
WQPAs	Water Quality Planning Areas: MDE's 8-digit watersheds, intersected with the Baltimore County Urban-Rural Demarcation Line (URDL).

Definitions of Selected Processes

Intersect	A topological overlay of GIS layers returning only the portions of features which share an area with features from all input datasets. Output features are given the tabular attributes of all the overlapping ("intersecting") features. Analogous to a Venn Diagram intersection.
Union	A topological overlay of GIS layers returning all overlapping and non-overlapping features. Overlapping features are treated as in the Intersect process.
Spatial Join	A tabular join operation in which the shared key relating the tables is spatial co-location: the attributes from a source feature are joined to a target feature if the features overlap in geographic space.
Join	A tabular database join: records from a source table are joined to target records if the records share a key attribute value.
Address Geocoding	A GIS operation for converting street addresses into spatial data that can be displayed as features on a map, by referencing address information from a street or facilities layer.

B.2.3 Low Density Residential Modifications

Low density residential category from MDP data is very heterogeneous with respect to land cover (Table B-5): in some parts of the county, the land cover in low density residential areas is mostly agriculture, or mostly forest, or mostly urban. To obtain results closer to the true conditions in the county, low-density residential pervious cover was analyzed using orthophotographs and random sampling methods to determine the land cover composition of low density residential in each WQPA for each year of the analysis (1997 and 2005). The results of this were fed back into the table, producing the final table.

Table B-5: Orthophotograph Interpretation Derived Land Cover Decomposition of 1997 and 2005 MDP Low Density Residential Polygons: Summary Statistics for WQPAs in Baltimore County, Maryland. (Note the large ranges)

Land Cover	Maximum	Minimum	Range
Cropland	30.8%	0.0%	30.8%
Forest	54.5%	12.2%	42.3%
Pasture	11.6%	0.0%	11.6%
Urban Impervious	23.3%	0.8%	22.5%
Urban Pervious	78.1%	36.6%	41.5%

A point sampling method was chosen to save time (compared to comprehensive manual delineation of land cover features). ESRI ArcGIS 9.2 was used to generate random points for evaluating land cover of low density residential polygons: the CreateRandomPoints command was used to generate one randomly located point for every two acres in each low density residential polygon. A pilot area evaluation showed that one point for every two acres is the maximum point density required to produce reasonable accuracy. A separate land cover analysis was performed for each WQPA. All low density residential polygons intersecting the WQPA were selected. One polygon was selected from this set at random, and all points inside that polygon were evaluated against orthophotography to determine land cover. Land cover categories derived from the orthophoto interpretation were: Forest and Wetlands, Cropland, Pasture, Lawn, and Other urban cover (driveways, structures, etc). Lawn was reclassified into urban pervious, and other urban cover was reclassified into urban impervious.

After each polygon was completed, tallies were recorded in Excel, where formulas calculated a 95% confidence error margin, the Chi squared statistic comparing the most recent results with the prior iteration's results, and a chart displayed the land cover proportions as a function of points sampled. Additional polygons were sampled at random until all the points in the WQPA were evaluated, or the 95% confidence error margin fell below 5% for all land covers detected, the Chi squared statistic remained above 80% for several polygons in a row, and the land cover proportions remained relatively constant from polygon to polygon. This process was performed once using 2005 orthophotographs, and once using the 1995 – 1998 orthophotography set (different overlapping subsections of the county were flown in 1995, 1996, 1997, and 1998. Where 1997 orthophotography does not exist, photography from the closest year available was used.)

The land use data for each WQPA was modified for 1997 and 2005 land use using this procedure. These results were then used to calculate the pollutant loads by land use category for each WQPA and each year.

B.2.4 Land Use Calculations

ESRI ArcGIS 9.2 was used to reclassify MDP LULC features into WRE LC categories, and to overlay the planimetric roads and buildings with the LC layer (converting urban to urban pervious and urban impervious). Table B-6 indicates the how the land use classifications were condensed.

Table B-6: Reclassification of MDP Land Use Land Cover to WRE Land Cover Categories.

MDP Land Use/Land Cover	WRE Land Cover
11 Low Density Residential	Urban * #
12 Medium Density Residential	Urban *
13 High Density Residential	Urban *
14 Commercial	Urban *
15 Industrial	Urban *
16 Institutional	Urban *
17 Extractive	Urban *
18 Open Urban	Urban *
21 Cropland	Cropland
22 Pasture	Pasture
23 Orchards/vineyards/horticulture	Pasture
24 Feeding Operations	Livestock Feeding Operations
25 Row and Garden Crops	Cropland
241 Feeding Operations	Livestock Feeding Operations
242 Agricultural Buildings	Pasture
41 Deciduous Forest	Forest and Wetlands
42 Evergreen Forest	Forest and Wetlands
43 Mixed Forest	Forest and Wetlands
44 Brush	Forest and Wetlands
50 Water	Water
60 Wetlands	Forest and Wetlands
73 Bare Ground	Bare Ground
80 Transportation	Urban *

* Split into pervious urban and impervious urban
# Pervious areas were broken into constituent land covers

The original 1997 MDP and the 2005 land use data were overlain by the WQPA data layer to derive the WRE land use classification distribution for the two years under consideration.   The land use for each WQPA was adjusted by the results of the low-density land use analysis to yield the final acreages used in the pollutant load calculations.

B.2.5 Population Change Analysis, 1997 – 2005

B.2.5.1 General Description of Method

The analyses described here are the result of development and prototyping done specifically for the Water Resource Element. The analysis integrated many data sources, several of which were new to DEPRM staff. For these reasons, evaluation of intermediate results during the analysis was critical. Therefore, the method was developed and implemented primarily through interactive command line geoprocessing in ArcGIS 9.2.

Copious notes were retained detailing the ArcGIS commands and other steps in the analysis, allowing both diagnosis and repair of quality problems and repetition of the analysis. Results of GIS analyses were copied into Microsoft Excel spreadsheets for some simple final calculations and for integration and presentation of results.

A geographic distribution method was required to estimate population for WQPAs. This is due to the fact that the geographic reporting areas (Transportation Analysis Zones (TAZ) and Census Tracts) do not share boundaries with the WQPAs (Figure B-5). Of 342 TAZs in Baltimore County, 192 are split by WQPA boundaries. Of the 195 Census Tracts, 119 are split by WQPA boundaries.

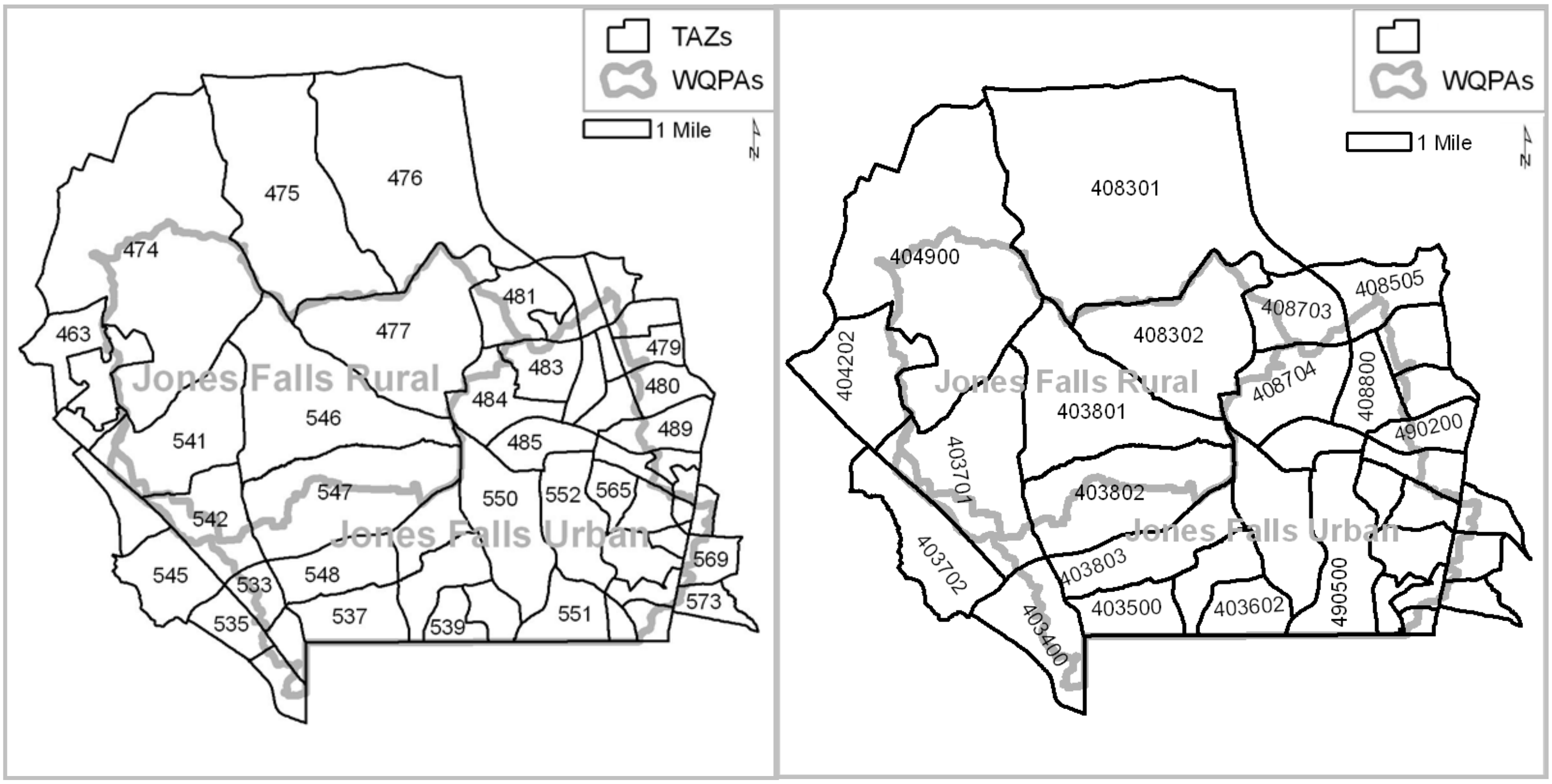


Figure B-5: Boundaries of WQPAs Used in the WRE do not Coincide with Boundaries of TAZs or Census Tracts, Necessitating Distribution of Population Data from TAZ and Tracts to WQPA Geographies.

Simple areal interpolation methods (eg, Plane and Rogerson 1994, p.351) were considered, but rejected due to concerns about errors caused by variation in population densities and development capacities within TAZs and Census Tracts. A method based on household count methods (eg, Plane and Rogerson 1994, p.142) was deemed more appropriate given the requirements of the analysis and availability of appropriate data.

This household method distributes the estimated household population of an area evenly among all the residential facilities present in the area. The population of a different area can then be calculated by summing the population of all residential facilities present in the different area. Group quarters population is assigned directly to the appropriate group quarters facility. A hypothetical example is worked for demonstration purposes in Figure B-6. The method can be represented mathematically with the following equation (1):

$$P_w = GQP_w + \sum_{j \in \{T\}} \sum_{i \in \{F \cap w\}} \left(h_{ijw} \, (HHP_j \, / \, H_j \,) \right) \qquad (1)$$

Where:

P_w	=	Total Population of WQPA 'w'		
GQP_w	=	Group Quarters Population of WQPA 'w'		
T	=	Set of all Census Tracts in Baltimore County with property:		
		HHP	=	total household population
F	=	Set of all Residential Facilities in Baltimore County with properties:		
		w	=	WQPA 'w' the facility exists within
		t	=	Census Tract 't' the facility exists within
		h	=	number of households at the facility
h_{ijw}	=	Number of Households at Facility 'i' in Tract 'j' and WQPA 'w'		
HHP_j	=	Total Household Population of Census Tract 'j' in set T		
H_j	=	Number of Households at Facilities in Census Tract 'j'		

Figure B-6: Simple Demonstration of Household Method for Distribution of Population Data from Tracts or TAZs to WQPAs.

Tract j	Household Pop in Tract HHP_j	Households in Tract H_j	Mean Household Size in Tract HHP_j / H_j
A	160	71	160 / 71 = 2.25
B	20	7	20 / 7 = 2.86

WQPA w	Tract j	Tract x WQPA fragment jw	Households in Tract x WQPA $\sum_i h_{ijw}$	Household Pop in Tract x WQPA $\sum_i h_{ijw} * (HHP_j/H_j)$	Household Pop in WQPA $\sum_j \sum_i (h_{ijw} (HHP_j / H_j))$
North Run	A	North Run, A	27	27*2.25 = 60.75	
North Run	B	North Run, B	3	3*2.86 = 8.58	
North Run					60.75 + 8.58 = **69.33**
East Run	A	East Run, A	50	50*2.25 = 112.5	
East Run	B	East Run, B	4	4*2.86 = 11.44	
East Run					112.5 + 11.44 = **123.94**

B.2.5.2 Detailed Description of Method Implementation

Figure B-7 presents an analysis diagram for the population change analysis described in this section.

The Baltimore County Facilities Geodatabase was queried to determine the number of residential dwelling units present at each facility (address) point. We assumed one household per residential dwelling unit. This facilities data represented conditions in 2008, but we required conditions in 2005 and 1997. Planimetric building feature classes were available for 2005 and 1995-1997 ground condition dates. Facility points which intersect planimetric buildings were assumed to exist at the date of the planimetric feature class. Facility points not intersecting buildings were assumed to be newly constructed between the planimetric date and 2008, and were excluded from the analysis. A redevelopment feature class was available from the Office of Planning, and included attributes for number of dwelling units present before and after redevelopment. Each redevelopment occuring between the planimetric date and 2008 was reviewed, and the facilties dwelling unit data adjusted accordingly. Facility dwelling unit points were added to represent demolished dwelling units present in 1997 or 2005. The result was facilty dwelling unit feature classes for 1997 and 2005.

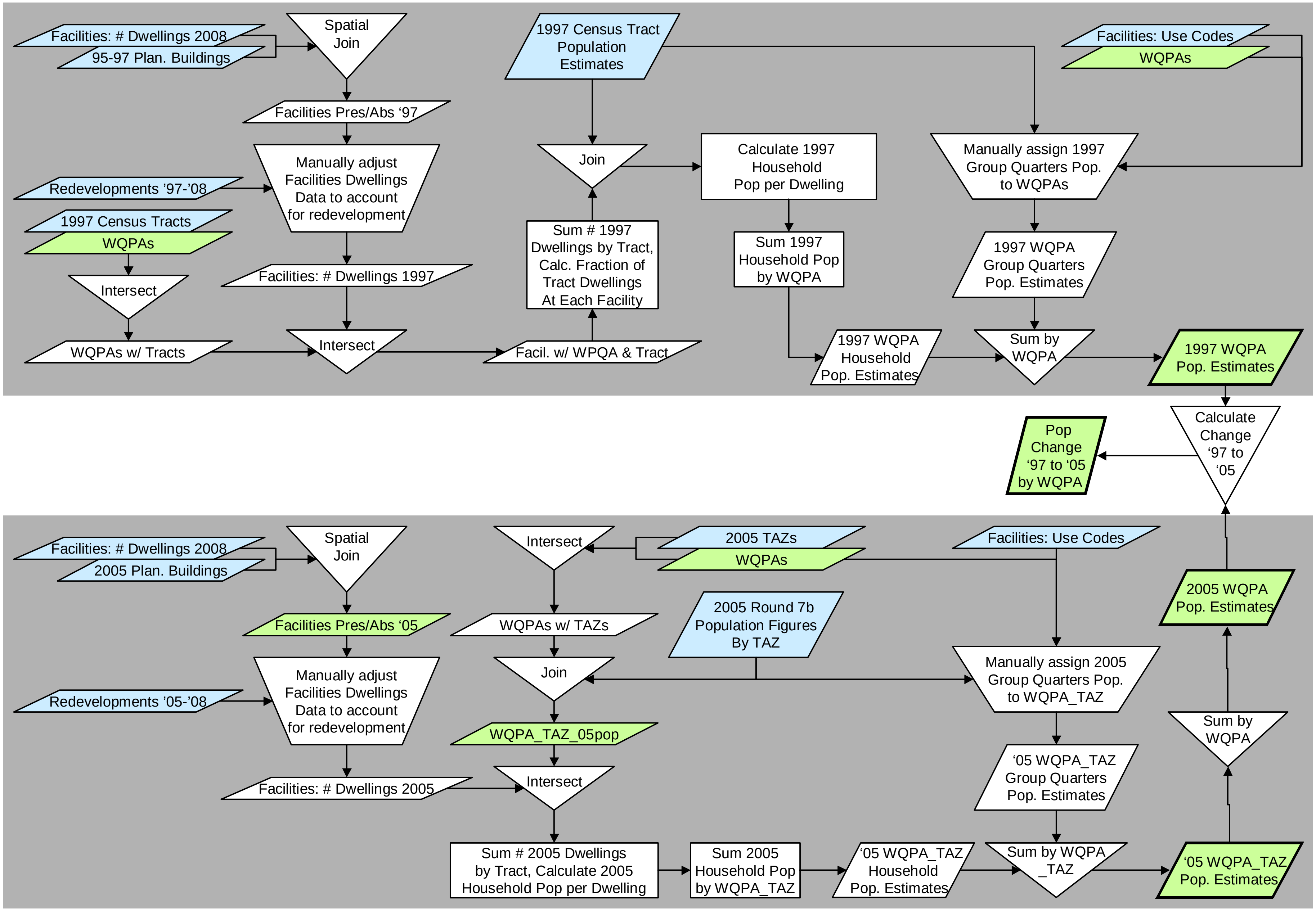
The 1997 population estimates by census tract from Census 1990 were provided by the Office of Planning for allocating population by WQPA. The Census Tracts were intersected with the WQPAs and the 1997 facility dwelling unit feature class. This created facility points attributed with number of dwelling units, WQPA, and Tract. The sum total of dwelling units per Tract was calculated, and the fraction of total Tract households present at each facility point calculated. 1997 tract population estimates were joined to the facility points, and the tract household population was multiplied by the faction of tract households present at each facility point, yielding the household population at each facility point. Household population was summed across all facilities by WQPA.

1997 estimated group quarters populations were assigned to WQPAs, using the facilities use code attributes as a guide when tracts were split into multiple WQPAs. When facilities in one tract had group quarters use codes and fell in different WQPAs, the group quarters population was split among the WQPAs according to the proportion of observed group quarters facilities in each WQPA in the tract.

WQPA group quarters and household population estimates were summed to total population estimates. This process was repeated, using Round 7B population for 2005 Transportation Analysis Zones (TAZs). The Round 7B population for 2005 by TAZ was provided by Office of Planning, for use in this regional planning report. Change from 1997 to 2005 was calculated by subtracting the 1997 population from the 2005 population.

Figure B-7

Baltimore County Water Resource Element Data Analysis Diagrams
1997 and 2005 Population Estimation and Change Analysis



B.2.6 Population Forecast Analysis, 2020 and 2035

B.2.6.1 General Description of Method

The Round 7B population forecasts by TAZ were provided by Office of Planning, for use in this regional planning report. Forecasts were available at 5 year increments. To assign population forecasts to WQPAs, simple areal interpolation was rejected (see section B.2.5). We desired a mechanistic method, analogous to the household estimation method described in section B.2.5: the method would model population growth mechanisms to allocate population forecasts to smaller geographies which could be summed to WQPA geographies.

Vital statistics and migration data are not available for small geographies within a jurisdiction, preventing the use of a demographic mechanism model. Therefore, the commonly used dwelling unit and development capacity method were applied for allocating 2020 and 2035 forecast population to WQPAs. The Maryland Department of Planning has used such a method for distributing forecast population increases to parcel geographies, using parcel-level assessments of development capacity (MDP, 2009). The parcel level population forecasts are then summed to whatever target geographies are of interest. This method assumes new homes are constructed on existing parcels within a forecast area (TAZs in this case) and occupied with average-sized households until one of two conditions are met: (A) the forecast population increase for the forecast area is reached, or (B) the development capacity of parcels in the forecast area is exhausted. If condition (B) is met, parcels adjacent to the forecast area are assigned the excess forecast population until the forecast population is reached.

This "spill-over" effect, and the assumption that development capacities are fixed during the 10 and 25 year planning windows considered here, were deemed unrealistic for Baltimore County's present conditions: TAZ population forecasts already consider development capacity, rezoning opportunities occur every 4 years in Baltimore County, and moreover, the County is emphasizing redevelopment and dense, transit-oriented development as mechanisms for accommodating population growth. Therefore, while current development capacity can be used to indicate which parcels are most likely to be developed, and provide comparative amounts of development likely on each parcel, it should not be treated as a hard constraint on how much development can occur on each parcel. On this logic, we chose to use MDP's development capacity data to indicate where future development was most likely to occur, but did not constrain population growth to MDP's estimated development capacity.

Additionally, MDP's development capacity data is not suitable for assigning populations to inside and outside the URDL. Redevelopment cannot be anticipated by MDP's methods, and therefore more population is assigned to parcels with 'green field' development opportunities. Green field opportunities are greater outside the URDL, and redevelopment opportunities are greater inside the URDL. Therefore, using MDP's development capacity data would create population projections biased by overprediction outside the URDL, and underprediction inside the URDL. It was decided than an expert system, based on our professional knowledge of Baltimore County's current growth management objectives, planning goals, and supported by data on the County's past performance, would be preferable for allocating projections to inside and outside the

URDL. The County's current plans are to maintain the URDL growth boundary, and focus population increases inside the URDL. The County has been successful in these objectives in the past, with the proportion of citizens residing inside/outside the URDL consistently near 90%/10% during the past 15 years. We decided that the best projection method is to assume the County's growth management mechanisms and plans will continue with the same efficacy demonstrated in the past, and the proportion inside/outside the URDL will not change between 2005 and 2035.

Our final population projection method used MDP's data to mechanistically assign projected population increases to watersheds, and the projected population in each watershed was assigned to inside and outside the URDL using the same proportions observed in the 2005 population estimates (see section B.2.5.).

In addition to population growth, the Round 7B forecasts incorporate known population losses, typically associated with the closing of group quarters facilities. These losses were removed from the forecasts, and distributed to the WQPA containing the particular group quarters facilities.

B.2.6.2 Detailed Description of Method Implementation

Figure B-9 presents an analysis diagram for the population change analysis described in this section.

MDP provided us with parcel centroids, attributed with the results of MDP's 2008 development capacity and growth projection model. We made use of the New Household Capacity (NHC) field.

Known population losses between 2005 and 2010 (due to the closing of group quarters facilities) were subtracted from the Round 7B population forecasts, creating forecast population gains to 2020 and 2035. These two forecast dates were processed separately, using the same method. Using a GIS, population gains were joined to WQPAs intersected with TAZs. The MDP Development Capacity Analysis parcel centroids were assigned WQPAs and TAZs using a spatial join.

Total NHC per TAZ was calculated by summing NHC from all parcel centroids in each TAZ. For each TAZ, the Round 7B forecast population gain was divided by the total NCH, creating population gain per NHC. For each of MDP's parcel centroids, the population gain per NHC was multiplied by the NHC for that parcel, creating forecasted population gain per parcel centroid. These forecast population gains were then summed to watersheds. Some manual corrections were needed to account for MDP centroids falling outside the WQPAs, and for TAZs with 0 NHC. The watershed population gains were assigned to the urban and rural WQPAs by multiplying the total watershed population gain by the proportion of the 2005 watershed population in the respective urban and rural WQPAs (see section B.2.5).

Known population losses were assigned to WQPAs by locating the facilities closed and noting the WQPA the facility was located in. These population losses were subtracted from the forecast population gains to create the WQPA forecast population changes, which were in turn added to the 2005 WQPA population estimates (section B.2.5) to produce 2020 and 2035 population forecasts for WQPAs.

A hypothetical example of our method is worked for demonstration purposes in figure B-8. The method can be represented mathematically with the following equation (2):

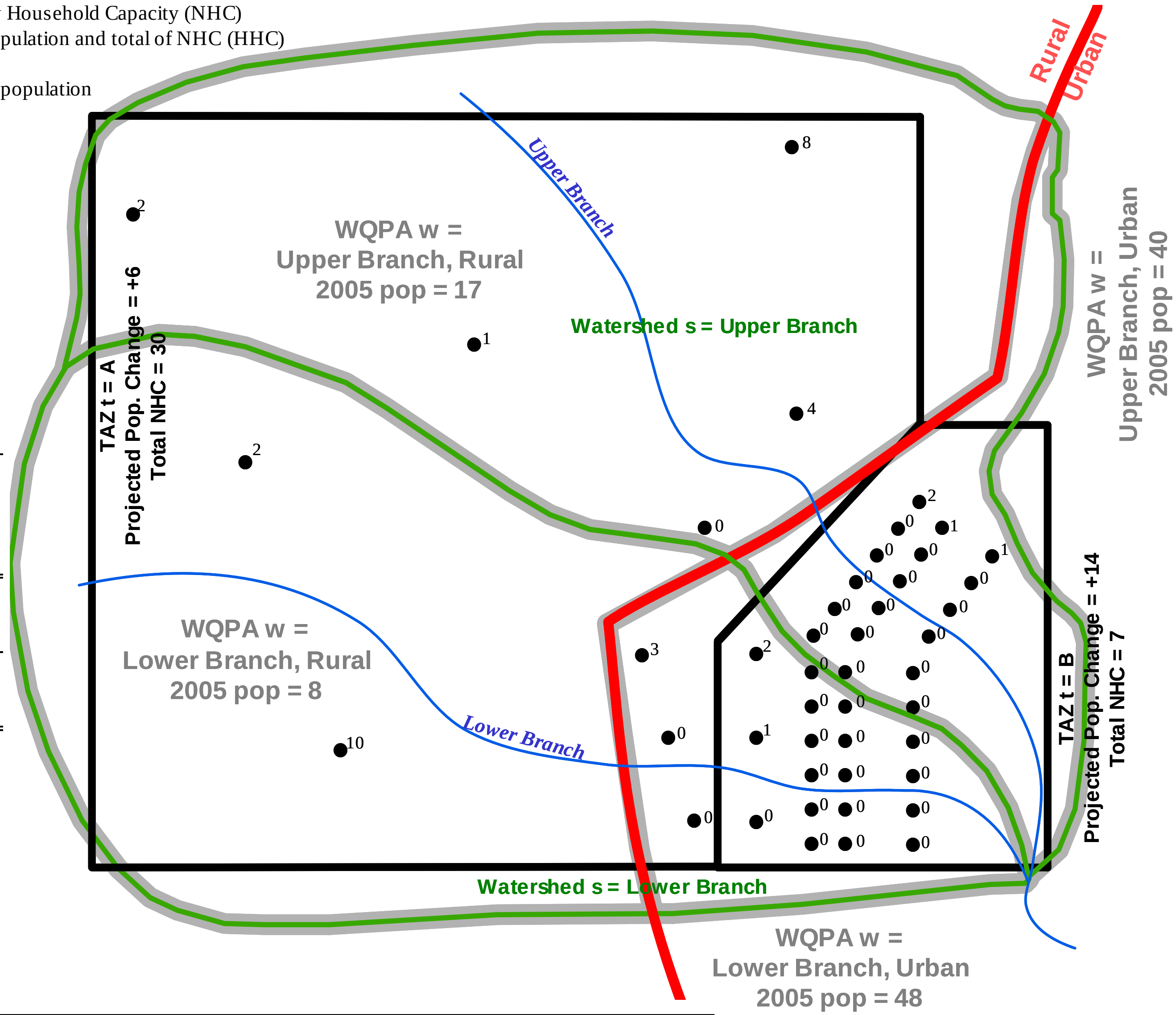
$$P_{w,t+1} = P_{w,t} - L_w + R_{w:s,t} \sum_{j \in \{T\}} \sum_{i \in \{C \cap s\}} \left(NHC_{ij} \left(\Delta P_j / HHC_j \right) \right) \qquad (2)$$

Where:

w	=	WQPA of interest
s	=	MDE 8-digit Watershed which WQPA 'w' belongs to
$P_{w,t+1}$	=	Population of WQPA 'w' at forecast year 't+1'
$P_{w,t}$	=	Population of WQPA 'w' at base year 't'
L_w	=	Known population losses in WQPA 'w'
$R_{w:s,t}$	=	Ratio of population of WQPA 'w' to population of watershed 's', at base year 't'
T	=	Set of all TAZs in Baltimore County with property: ΔP = Forecast change in population
C	=	Set of all Parcel Centroids in Baltimore County with properties: s = Watershed the parcel centroid exists within t = TAZ the parcel centroid exists within NHC = MDP's New Household Capacity
NHC_{ijs}	=	NHC at Parcel 'i' in TAZ 'j' and Watershed 's'
ΔP_j	=	Projected change in population for TAZ 'j' in set T
HHC_j	=	Total NHC for all Parcels in TAZ 'j'

Figure B-8: Si mple demonstration of development capacity and expert system method for distribution of projected population data from TAZs to WQPAs.

Black Dots = parcel centroids, labeled with MDP's New Household Capacity (NHC)
Black Lines = TAZ, labeled with projected change in population and total of NHC (HHC)
Red Lines = Urban Rural Demarcation Line (URDL)
Green Lines = watershed boundaries, labeled with 2005 population
Blue Lines = streams



TAZ t	Total NHC for Parcels in TAZ HHC_j	Projected Pop. Change in TAZ ΔP_j	Proj. Pop Change per NHC in TAZ $\Delta P_j / HHC_j$
A	30	6	6 / 30 = 0.2
B	7	14	14 / 7 = 2.0

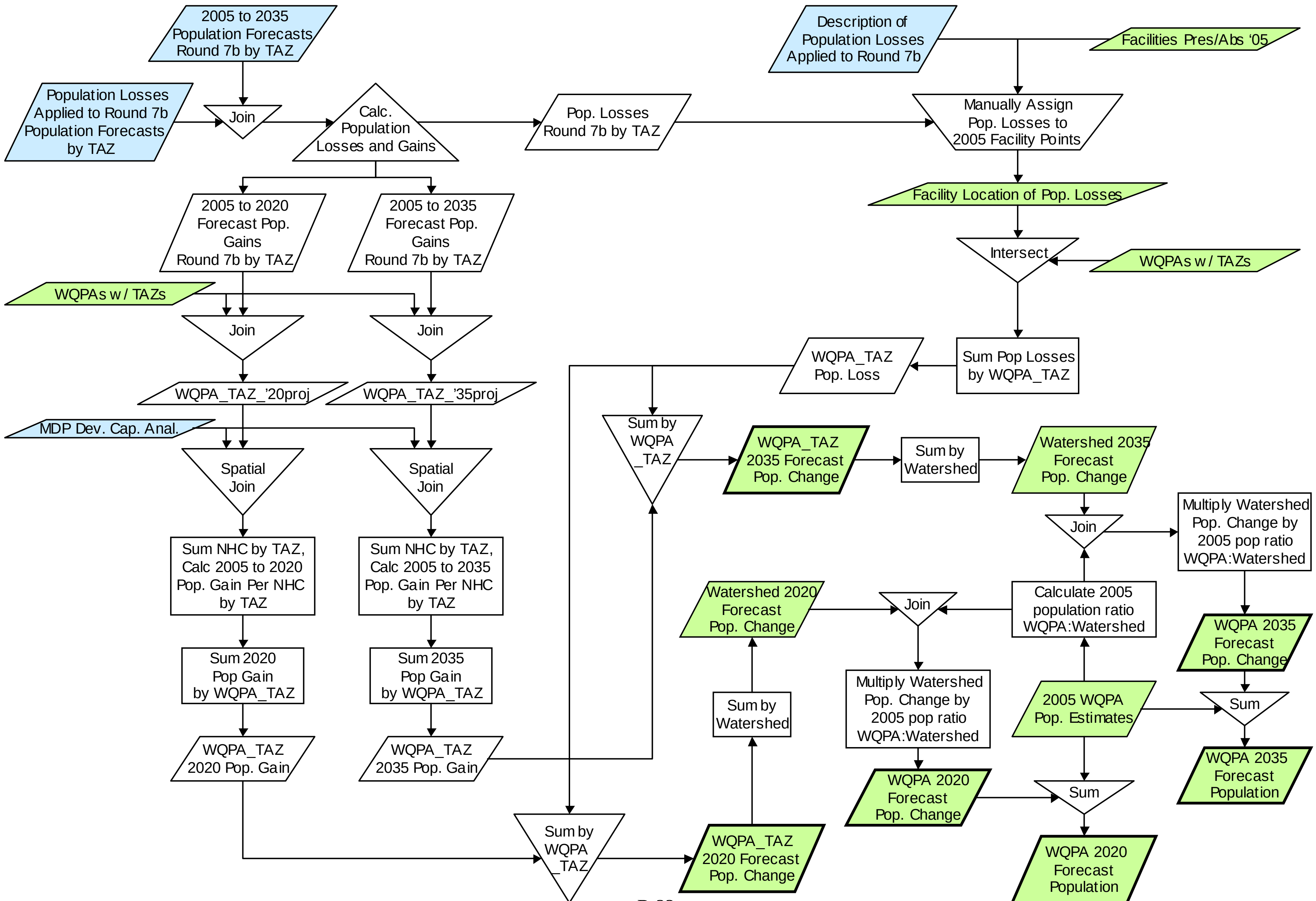
TAZ x Watershed fragment js	Total NHC in TAZ x WQPA NHC_{ij}	Projected Pop Change in TAZ x WQPA $\sum_i NHC_{ij} (\Delta P_j / HHC_j)$
Upper Branch, A	15	15 * 0.2 = **3**
Upper Branch, B	4	4 * 2.0 = **8**
Lower Branch, A	15	15 * 0.2 = **3**
Lower Branch, B	3	3 * 2.0 = **6**

Watershed s	Projected Pop Change in Watershed $\sum_j \sum_i NHC_{ij} (\Delta P_j / HHC_j)$	2005 Pop in Watershed
Upper Branch	3 + 8 = **11**	57
Lower Branch	3 + 6 = **9**	56

URDL	WQPA w	2005 Pop in WQPA $P_{w,t}$	Ratio of 2005 WQPA:Watershed $R_{w:s,t}$	Projected Pop Change in WQPA $R_{w:s,t} \sum_j \sum_i NHC_{ij} (\Delta P_j / HHC_j)$	Projected Pop at Time t+1 $P_{w,t} + R_{w:s,t} \sum_j \sum_i NHC_{ij} (\Delta P_j / HHC_j)$
Rural	Upper Branch, Rural	17	17 / 57 = **0.298**	0.298 * 11 = **3.278**	17 + 3.278 = **20.278**
Urban	Upper Branch, Urban	40	40 / 57 = **0.702**	0.702 * 11 = **7.722**	40 + 7.722 = **47.722**
Rural	Lower Branch, Rural	8	8 / 56 = **0.143**	0.143 * 9 = **1.287**	8 + 1.287 = **9.287**
Urban	Lower Branch, Urban	48	48 / 56 = **0.857**	0.857 * 9 = **7.713**	48 + 7.713 = **55.713**

Figure B-9

Baltimore County Water Resource Element Data Analysis Diagrams
2020 and 2035 Population Forecasts by WQPA



B.2.6.3 Redevelopment Population Analysis Methodology

In order to estimate the effects of redevelop relative to population changes and the ability of redevelopment to absorb future population increases, a methodology based on the number of units pre and post redevelopment was developed. The initial assumption was that all units prior to redevelopment were fully occupied and all units post redevelopment would be fully occupied. The average household size by tenure (owner occupied and renter-occupied units) was calculated based on the census block group from the 2000 Census where the redevelopment project is located for both the pre and post redevelopment population for the project. Subsequent to the initial analysis, information on the occupancy rates for the various projects was obtained. This information was used to adjust the initial pre-redevelopment population size for each project. Where information was not available for a particular project the average occupancy rate was used.

The final estimates of the pre and post redevelopment population sizes were then used to calculate the amount of acreage needed per person for each of the four redevelopment scenarios.

B.2.7 Septic System Distribution and Loading Rate Analysis

B.2.7.1 General Description of Method

To forecast nitrogen loading to surface waters, demand for public water service, and use of public sanitary sewer treatment plants, the number of persons on septic systems had to be estimated for 2005, and forecast to 2020 and 2035.

Septic systems and wells have been installed in Baltimore County since the 17th century. No single authoritative census for well and septic systems exists. As a general rule, no facilities outside the County's Metropolitan Water and Sewer district (URDL) have public water and sewer service. However, for a variety of reasons ranging from landowner choice to the cost of extending service, many dwellings inside the URDL utilize private wells and septic systems.

The best source for comprehensive septic and sewer information was deemed to be the Bay Restoration Fund billing file. This billing file includes every tax account in the County, and assigns each account record to the public sewer or private septic fund. By geocoding the address of each account record, it was possible to estimate the proportion of facilities in each WQPA using well and septic systems.

To forecast changes in the number of septic system users to 2020 and 2035, we considered each WQPA x TAZ geography and estimated the likelihood that existing septic system users would convert to public sewer, and the likelihood that new development would use septic or public sewer systems. These likelihoods were estimated by an expert panel (Kevin Koepenick, Dave Thomas, Rob Hirsch, and Bruce Seeley) and applied to the existing population on septic, and the forecast for new population in each WQPA x TAZ geography.

For institutional septic system load, DEPRM's ground water management section maintains a list of Large Institutional septic systems found in the Master Water & Sewerage Plan, named inventory of small sewage treatment facilities. Other institutional septic systems were deemed unimportant to the analysis, due to their small volume of discharge. We assume that no change in Large Institutional septic system load will occur.

Conversion of population on septic, and gallons per day (GPD) discharged to Large Institutional septic systems, into nitrogen loads was guided by MDP's guidance document.

B.2.7.2 Detailed Description of Method Implementation: 2005 Septic Load

Figures B-10 and B-11 present analysis diagrams for the septic system distribution and loading rate analyses described in this section.

The Bay Restoration Fund billing file (BRF) was geocoded to facility and street centerline locations, creating a GIS feature class for septic and sewered facilities. These were assigned to WQPAs and TAZs with 2005 population figures using an ArcGIS Intersect command. Residential facilities were selected, and the count of facilities on septic and sewer made for each WQPA x TAZ. From these counts, the proportion of residential facilities on septic systems was calculated for each WQPA x TAZ area. Due to errors in the BRF and geocoding result, some WQPAs located outside the URDL were assigned proportions on septic less than 100%. The proportion was set to 100% for these WQPAs.

For each WQPA x TAZ, the proportion of residential facilities on septic was multiplied by the 2005 population, returning the residential population on septic per WQPA x TAZ, which was summed up to WQPA. The nitrogen load from this septic system population was estimated using the MDP guidance document equation (3):

$$\text{Household Load} = 9.5 \text{ lbs N/person/year} * 0.4 / 365 \text{ days/year}$$

$$= 0.010411 \text{ lbs N/day/person} * \text{household population} \quad (3)$$

Large Institutional Septic Systems (LISS), from the inventory of small sewage treatment facilities, were geocoded in the same manner as the BRF. LISS were assigned to WQPAs using an intersect command, and the GPD summed to WQPA. The nitrogen load from these LISS was estimated using the MDP guidance document equation (4):

$$\text{Institutional load} = \text{MGD} * 40 \text{ mg N/L} * 3{,}785{,}000 \text{ L/MG} * 1/453592.37 \text{ lb/mg} * 0.4$$

$$= 0.000133512 \text{ lbs N/day/GPD} * \text{GPD} \quad (4)$$

Total 2005 Nitrogen load from septic systems was calculated as the sum of residential and LISS loads.

B.2.7.3 Detailed Description of Method Implementation: 2020 and 2035 Septic Load

To forecast the 2020 and 2035 septic system loads, the likelihoods described in section B.2.7 were joined to WQPA x TAZ feature classes. Because our final population forecasts were made at the WQPA geographies (and not TAZ geographies), we had to change the geography of the likelihoods described earlier from WQPA x TAZ to WQPAs. We used an areal interpolation method to make this change: each likelihood value was multiplied by the area of its WQPA x TAZ geography, these were summed to WQPAs, and then divided by the total area of the WQPA.

The WQPA likelihoods were joined to the WQPA forecast population changes to 2020 and 2035. The new population on sewer in each WQPA x TAZ was calculated as the (new population added) * (likelihood that new population is on sewer).

The population converting from septic to sewer was calculated by first joining the 2005 population on septic systems to the WQPA likelihoods. The population converting from septic to sewer by 2020 and 2035 in each WQPA x TAZ was calculated as (2005 population on septic) * (likelihood a household would switch to sewer).

A third segment of the population had sewer service in 2005, and will remain on sewer service through 2020 and 2035. We assumed that this population will remain constant, and it was calculated by subtracting the 2005 septic population from the 2005 total population by WQPA.

Total population on sewer service in 2020 and 2035 was calculated by summing the three quantities described above: new population on sewer + conversion from septic population + remain on sewer population.

To estimate population on septic in each WQPA in 2020 and 2035, the population on sewer (see above) was subtracted from the total population.

Figure B-10

Baltimore County Water Resource Element Data Analysis Diagrams
2005 Estimation of Population on Septic Systems and Septic System Nitrogen Load

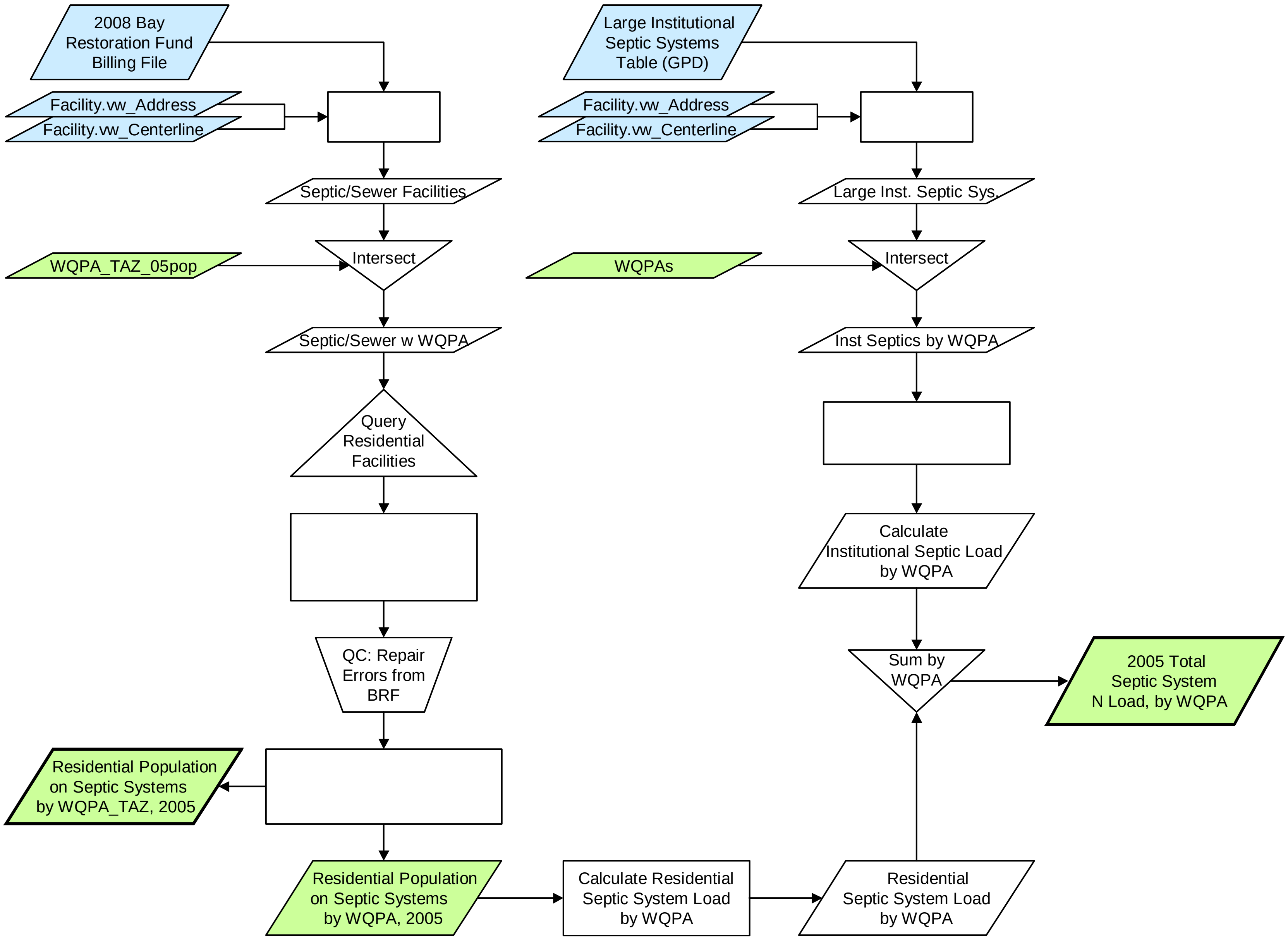
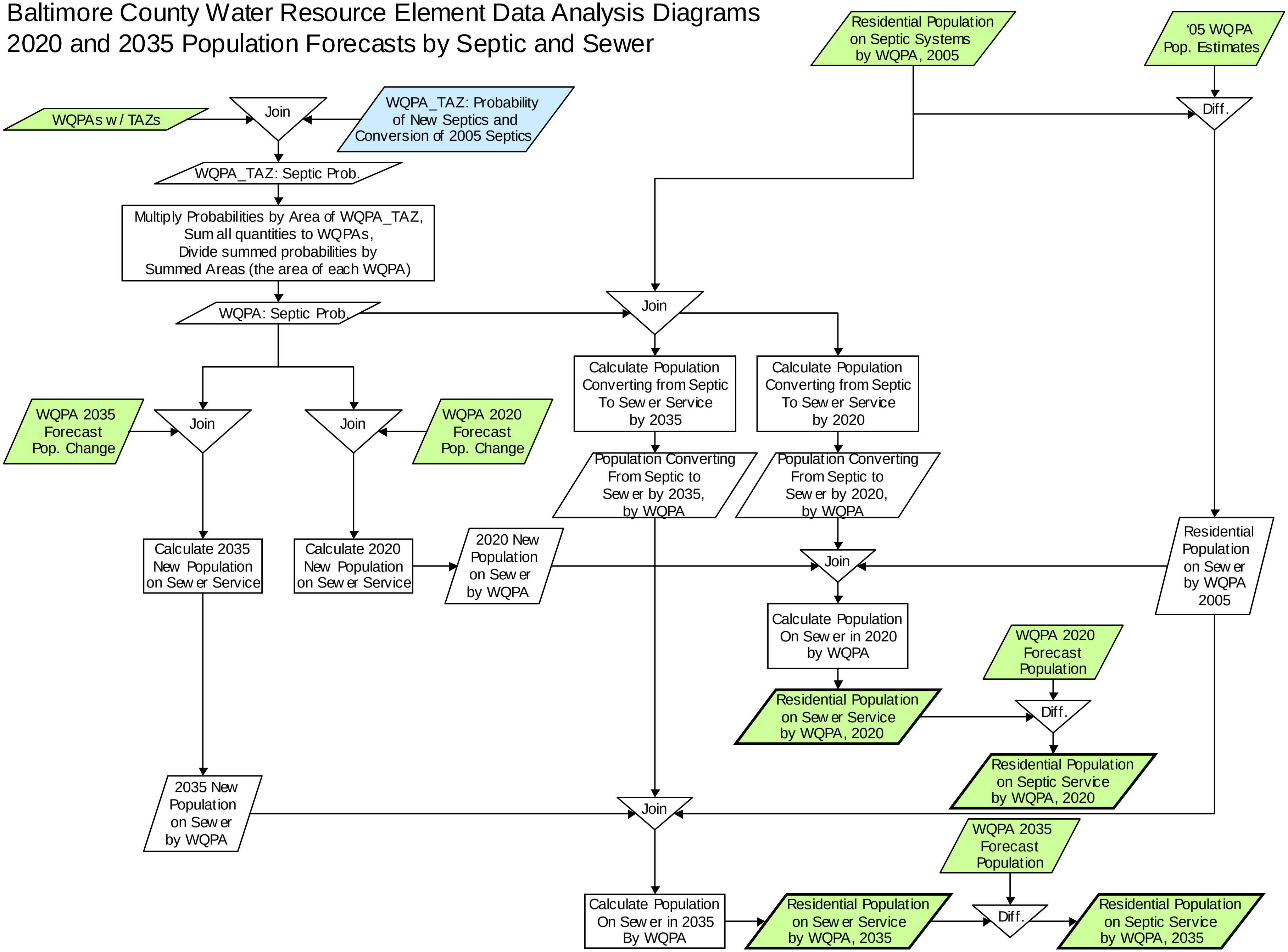


Figure B-11

Baltimore County Water Resource Element Data Analysis Diagrams
2020 and 2035 Population Forecasts by Septic and Sewer



B.2.8 Pollutant Load Calculations

The pollutant load calculations were conducted for each WQPA using the formula:

$$PL = \sum_{n}^{1} acres(LU_1) * \#/acre(LU_1) + acres(LU_2) * \#/acre(LU_2) \ldots acres(LU_n) * \#/acre(LU_n) \qquad (5)$$

Where:

PL	=	Pollutant Load (either nitrogen or phosphorus)
$LU_{1\text{-}n}$	=	Land Use (each land use type – see Table B-6)
$\#/acre(LU_{1\text{-}n})$	=	Pounds per acre loading for each land use type (see Table B-3 for nitrogen and Table B-4 for phosphorus)

The pollutant loads were calculated for both 1997 and 2005. The difference between the two time periods represented the pollutant load changes that resulted from the land use change that occurred in each WQPA, this was calculated for each land use type. The septic system load contribution for each time period was added into the calculations for nitrogen. Changes between the two time periods represent the growth in the nitrogen load due to the installation of septic systems.

B.2.9 Urban Best Management Practice and Water Quality Restoration Analysis

In order to account for implementation of urban best management (BMP) practices and water quality restoration efforts on nitrogen and phosphorus loads a series of analyses was conducted as detailed below. The results for 1997 and 2005 are based on the actual implementation.

Future requirements for stormwater management applied to development were used to predict the reduction in the increase in urban pollutant loads. The Chesapeake Bay Program uses a reduction factor of 50% for nitrogen and 60% for phosphorus when a site uses Environmental Site Design criteria. Thus, all future projected increases in urban nitrogen and phosphorus loads as a result of development were reduced by 50% for nitrogen and 60% for phosphorus.

The restoration components were grouped into three types; 1) traditional Capital Improvement projects, 2) reforestation, and 3) street sweeping, storm drain cleaning and citizen based restoration. To project future implementation of water quality restoration, it was assumed that the rate of implementation would stay the same as in the 1997 – 2005 time period. In order to adjust the rates for the difference in time periods (1997-2005, eight years vs. 2005-2020 and 2020-2035) the rates were annualized based on the existing implementation rate and multiplied by fifteen to account for the projected rates. Since the traditional Capital Improvements and reforestation are cumulative, each corresponding time period included the pollutant reduction for the time period, plus the cumulative rate for the previous time period. Street sweeping and storm drain cleaning practices are not cumulative, so the rates included are for only a single year. The watershed association citizen based restoration actions are cumulative, but with the limited data available, and the lack of ability to control and predict future actions the reductions associated with these actions were included with the street sweeping and storm drain cleaning numbers.

B.2.9.1 Urban Best Management Practices

The stormwater management database and the use of the 1997 aerials were used to determine when each completed stormwater management facility was built. The facilities were placed into two time period categories, pre 1997 and post 1997. The drainage areas of built facilities were delineated in GIS by importing the stormwater facility drawing that showed the drainage area. After registering each drawing in the GIS, the drainage area was traced. The resulting data layer was overlain by the 2005 land use data layer (see above on modification of the 2002 MDP land use layer) to determine the land use within each stormwater facility drainage area. The nitrogen and phosphorus pollutant loads for each drainage area were determined, using the methodology detailed for the WQPA pollutant load determination (B.2.7). The pollutant load reduction efficiency is dependant on the type of facility installed. Table B-7 details the pollutant load efficiencies used in the calculation of the pollutant load reduction from the installation of urban BMPs. These numbers were derived from the Chesapeake Bay Program - http://archive.chesapeakebay.net/pubs/NPS_BMP_Tables_011806.pdf

Table B-7: Percent Removal Efficiency of BMPs

BMP	Pollutants		
	TSS	TP	TN
Detention Facilities	10	10	5
Extended Detention Facilities	60	20	30
Wet Ponds	80	50	30
Infiltration Practices	90	70	50
Filtration Practices	85	60	40

Detention Facilities = Detention Pond and Hydrodynamic Devices (DP, OGS, and UGS)
Extended Detention Facilities = Extended Detention Ponds (EDSD, EDSW, ED)
Wet Ponds and Wetlands = Wet Pond and Shallow Marsh (WP and SM)
Infiltration Practices = Infiltration Trench and Infiltration Basins (IB, IT and ITWQC), Porous Paving (PP), and Dry Wells (DW)
Filtration Practices = Sand filters and Bioretention Facilities (SF, BIO)

Using the pollutant load calculated for each stormwater management facility drainage area and the appropriate reduction efficiency based on the facility type, the pounds of nitrogen and phosphorus reduction were calculated. Finally, the location of each facility was used to place the results in the appropriate WQPA for the calculation of pollutant load reductions.

B.2.9.2 Capital Improvement Water Quality Restoration Projects

The calculation of pollutant load reductions due to stream restoration were based on the re-analysis of the Spring Branch data presented in the NPDES 2006 Annual Report, which resulted in the following pollutant load reduction estimates:

- Total Nitrogen – 0.202 pounds per linear foot of stream restoration
- Total Phosphorus – 0.0107 pounds per linear foot of stream restoration
- Total Suspended Solids – 3.58 pound per linear foot of stream restoration

The calculation simply becomes the length of the stream restoration project in feet, times the pounds of pollutant reduced per linear foot of restoration.

To obtain nutrient reduction numbers associated with shoreline enhancement projects, it must be determined how much sediment the project is theoretically preventing from entering a waterway. To calculate an estimate of annual erosion at a given shoreline site, the equation

$$V = LEB \qquad (6)$$

Where,

V = volume eroded
L = length of shoreline
E = erosion rate in feet per year
B = bank height

This equation yields a volume expressed in cubic feet per year. Cubic feet are converted to pounds using a soil bulk density of 93.6 lb/ft^3. Pounds are then converted to tons using a factor of 0.0005. Lengths of shoreline and bank heights are taken from engineering and project plans prepared by consultants for Baltimore County. The erosion rates used are from the Department of Natural Resources website, http://shorelines.dnr.state.md.us

Nitrogen and phosphorus loading rates for shorelines are taken from *'Eroding Bank Nutrient Verification Study for the Lower Chesapeake Bay'* (p. 44), published February 1992. The mean total N and total P loading concentrations in the study are 0.73 lb/ton and 0.48 lb/ton respectively.

Pollutant load reductions from stormwater management facility retrofits (new facility) and conversions (modification of an existing facility) were determined using the method detailed under Urban Best Management Practices above.

B.2.9.3 Street Sweeping and Storm Drain Cleaning Programs

In the fall of 2005, a study was initiated on the pollutant removal effectiveness of street sweeping and storm drain cleaning. This study was funded by the Chesapeake Bay Program and led by the Center for Watershed Protection and UMBC. Both Baltimore County and Baltimore City were partners in this research effort. Baltimore County specifically looked at the storm drain cleaning portion of the study by measuring monthly accumulation rates for 100 inlets in coastal plain commercial/industrial and residential, and piedmont commercial/industrial and residential. Baltimore County conducting sampling and chemical analysis of the material from a subset of the inlets. The results from this study are used to estimate pollutant load reductions from street sweeping and storm drain cleaning activities.

The composition of 16 inlets sampled in spring and fall of 2006 was divided into three categories; sediment, leaves (organic matter), and trash. The weight and volume of each component was determined for each inlet sampled. In the spring, sediment accounted for 63.5%, leaves 28.8% and trash 7.7% of the material accumulated in the inlets. In the fall, sediment accounted for 61.3%, leaves 31.0%, and trash 7.7% of the material accumulated in the inlets. An ANOVA based on a 2 x 2 x 2 factorial design (land use, physiographic province, sampling round) was conducted. This analysis found no significant differences between the design factors. The average bulk density for the spring was 330.7 pounds/cubic yard of material and for the fall 331.4 pounds/cubic yard of material. The following formula was used to determine kilograms of material per cubic yard:

331 pounds/cubic yard x 0.45 kilograms/pound = 148.95 kilograms/cubic yard (7)

The derived kilograms/cubic yard was then multiplied by the total cubic yards of material removed from each watershed in 2008 to determine the total kilograms of material removed. These results were then multiplied by the average concentrations for each pollutant to determine the milligrams of pollutant removed. The concentrations used were 1,825.92 mg/kg total nitrogen and 707.95 mg/kg total phosphorus. Finally, the milligrams of pollutant were back calculated for pounds of pollutant removed.

B.2.9.4 Reforestation Projects

Baltimore County's reforestation program plants trees on public and private land, in stream buffers and open areas. Nutrient reductions associated with buffer plantings are obtained using the sum of a reduction efficiency and a land use change. A reduction efficiency of 25% for nitrogen and 50% for phosphorus is applied to 4X the area planted for nitrogen and 2X the area planted for phosphorus. The land use change is from pervious urban nutrient load to forested nutrient load, using loading rates from the Phase 4.3 Chesapeake Bay Program Model. Open area plantings (non-buffer) simply use this land use change to calculate load reductions (see Chesapeake Bay Program link on p.30).

B.2.9.5 Citizen Based Watershed Association Water Quality Improvement Projects

Many of the activities that local watershed groups and their volunteers engage in have nitrogen and phosphorus reducing capabilities. Using loading rates and reduction efficiencies from the Phase 4.3 Chesapeake Bay Program Watershed Model, the following Best Management Practices (BMPs) yield nutrient reduction numbers:

- Downspout Disconnection and Rain Barrels - Rooftop acres disconnected is estimated and the loading rate for impervious surface associated with the geographical area is applied to this acreage. At this point in time, these two BMPs are classified as an infiltration practice and the total nitrogen and total phosphorus reduction efficiencies, 50% and 70% respectively, are applied to the estimated load.

- Rain Gardens - Rain gardens drain specific areas of pervious and/or impervious surface. Using nutrient loads based on these two land use types, and applying infiltration reduction efficiencies to these loads, nutrient reduction numbers for rain gardens can be determined.

- Stream Buffer Tree Plantings - Nutrient reductions associated with buffer plantings are obtained using the sum of a reduction efficiency plus a land use change. A reduction efficiency of 25% for nitrogen and 50% for phosphorus is applied to 4X the area planted for nitrogen and 2X the area planted for phosphorus. The land use change from pervious to forest is calculated using the respective loading rates for nitrogen and phosphorus per acre for these land use types. The difference between these figures represents the reduction per year in the associated nutrient.

- Street Tree/Open Space Plantings - Here the land use conversion from pervious acres to forest acres described above is used to determine nutrient reduction.

B.2.10 Future Conditions Projections

In order to determine the future land use and pollutant load conditions, the changes in land use between 1997 and 2005 were divided by the change in population for each WQPA. This resulted in a per acre change for each individual added to the planning area during the time period. The results could be positive or negative acreages for each individual.

Two future time periods were selected for the analysis, 2020 and 2035. The 2020 time period represents the period of time when the next Comprehensive Plan would be updated, while the 2035 time period represents the longest period for which population projections are available. The population projections were divided among the various WQPAs as described above. The future land use for each WQPA was then calculated using the following formula:

$$LU_{i\text{-}n}\ \text{Future} = LU_{i\text{-}n}\ \text{Change/individual} \times \text{projected population change} \qquad (8)$$

Where :

$LU_{i\text{-}n}$ = Each discrete land use (i-n) used in the analysis

$LU_{i\text{-}n}$ Change/individual = The change in acres of land use per population change between 1997 and 2005

Two screening analyses were performed based on the results of this analysis. First, if the population change in the 1997 – 2005 time period was negative, the results of the change/individual were replaced by the average for the respective type of WQPA, either rural or urban, and either Upper Western Shore or Patapsco/Back River. Thus, for example, the negative population change in the Gunpowder River rural WQPA resulted in replacing the land use changes in the Gunpowder rural WQPA with the overall Upper Western Shore rural land use changes per person. This resulted in always having an increase in urban land uses for future population growth.

The second screening analysis was conducted on the results of the projected future land use distribution for each WQPA based on the calculations using formula 8. Because there were negative changes in land uses based the population growth between 1997 and 2005 (cropland for example), it was possible to end up with negative acres for a particular land use. In order to correct for this a number of decision rules were developed and are detailed below:

- Agriculture
    - Negative acres of livestock feeding were subtracted from pasture, if this resulted in negative pasture acres, the remaining acres were subtracted from cropland
    - Negative acres of pasture were subtracted from cropland
    - Negative acres of cropland were subtracted from pasture
    - If all of the agriculture uses summed resulted in negative acres, the remaining negative acres were subtracted from forest.
- Water, Bare Soil, and Forest
    - Negative acres of water and/or bare soil were subtracted from forest
    - Any remaining negative acres of agricultural uses after subtraction from forest were subtracted from bare soil.
- Urban
    - If, after the application of all of the above, there remained negative acres, the acres were added to urban pervious. This occurred in only one WQPA, Gwynns Falls – rural.

The first screening process resulted in what was labeled as 2020 Land Use Calculated and 2035 Land Use Calculated. The second screening process resulted in what was labeled as 2020 Land Use Adjusted and 2035 Land Use Adjusted.

The future pollutant loads were calculated using the 2020 Land Use Adjusted and the 2035 Land Use Adjusted and formula 5 above. As indicated above, in order to assess the implementation of urban BMPs based on the new requirements for urban stormwater management applied to development, the increased urban nitrogen and phosphorus loads were reduced by 50% for nitrogen and 60% for phosphorus. Future water quality restoration projects were also calculated as detailed above.

B.2.11 Downstream Pollutant Load Contributions from Baltimore County Reservoirs – Calculation Methods

In order to account for the reduction in downstream pollutant load contributions from the reservoir watersheds, an analysis of the amount of water flowing over the dams was conducted. Using data from the U.S. Geological Survey gages listed in Table B-8, annual water volume (in gallons) flowing past each gage was determined. To account for ungaged flow, an area weighted average annual flow per acre was calculated for each reservoir watershed. This annual average flow per acre was multiplied by the ungaged acres in each reservoir watershed to determine the flow into the reservoir. Direct precipitation input to each reservoir was determined by multiplying the annual inches of rainfall by the acres of reservoir surface and then converted to gallons. The total of the gaged water input, the ungaged water input, and the direct precipitation input represented the total volume of water entering each reservoir.

Table B-8: USGS Gages Used to Determine Annual Water Inputs to the Reservoirs

Gage Number	SubWatershed	Reservoir	Drainage Area	Years of Analysis	# of Years
1581810	Gunpowder Falls	Prettyboy	17,280	2000-2007	8
1581830	Graves Run	Prettyboy	4,915	2000-2007	8
1581870	Georges Run	Prettyboy	10,112	2000-2007	8
	Un-gaged	Prettyboy	17,332		8
1582500	Gunpowder Falls	Loch Raven	51,255	1995-2007*	10
1583500	Western Run	Loch Raven	38,272	1995-2007*	10
1583600	Beaverdam Run	Loch Raven	13,376	1995-2007*	10
	Un-gaged	Loch Raven	34,358		10
1586000	NB Patapsco	Liberty	36,224	1995-2007	13
1586210	Beaver Run	Liberty	8,960	1995-2007	13
1586610	Morgan Run	Liberty	17,920	1995-2007	13
	Un-gaged	Liberty	39,265		13

* The years 2003-2005 were excluded from the analysis due to repairs to the Loch Raven dam, which effected flows over the dam.

Data on daily reservoir height was obtained from Baltimore City, Reservoir Office. The volume of water flowing over the dam was calculated by the following formula using data in Table B-8, the dam elevation, and spillway length.

$$Q = CLH^{3/2} \qquad (9)$$

Where; Q = Discharge in cubic feet per second

C = A constant that includes, Reynolds number (inertial force), Weber number (surface tension), and other factors that effect flow. For this analysis a number of 3.1 was used, which is appropriate for broad-crested weirs.

L = Length of spillway

H = Height over the dam (Brater and King 1976)

An annual flow over the dam was calculated and expressed as the percentage of the inputs into each reservoir. The average percentage of flow over each dam was calculated by two methods; the simple overall yearly average, and by the total accumulated input to each reservoir divided by the total calculated overflow. The second method yielded a higher percentage of overflow. To provide a conservative estimate (higher) of pollutant loads contributed downstream, the higher percentage of overflow calculated by the second method was used.

B.2.12 All Development Within the URDL Scenario Methods

For this scenario, all of the population growth was forced into the urban portion of each watershed. In cases of all rural watersheds (Deer Creek, Prettyboy Reservoir watershed, and Little Gunpowder Falls), the population was moved to the nearest urban watershed (Deer Creek and Prettyboy into Loch Raven urban, and Little Gunpowder Falls into Lower Gunpowder Falls). The land use and pollutant load changes for 2020 and 2035 were then recalculated. All future population growth was assigned to the public water and sewer. This resulted in no changes in the rural pollutant loads or septic system loads for 2020 and 2035.

B.2.13 Redevelopment Scenario Methods

In order to assess the pollutant loading effects of redevelopment, recent and current redevelopment projects were analyzed for pollutant loads prior to redevelopment and pollutant loads post redevelopment. A total of seven projects were analyzed. Pollutant loads and load reductions were calculated using the methods detailed above. The pre and post redevelopment nitrogen and phosphorus loads were compared on an overall reduction basis. One redevelopment project was the conversion into a park, with a retrofit that treated 190 acres of previously untreated urban stormwater. This project was also analyzed for pollutant load reductions. A second set of pollutant load reductions were calculated using the seven projects above and the park project.

The ability of redevelopment projects to absorb population was calculated in two separate fashions. All projects identified that clearly had prior and post number of units were used in the first set of calculations. In some cases, there was a decrease in the number of units during redevelopment. The overall average increase in units was calculated and divided by the acreage of redevelopment to determine the acreage of land redeveloped per unit. This was converted into population by assuming an average of 2 people per unit (the acreage per unit divided by two). The second method used a subset of redevelopment projects that had a positive increase in the number of units. The acreage per person increase was then calculated in the same fashion as the total data set.

The results of this analysis was the development of four scenarios:

- High – used the entire data set to derive acres of redevelopment needed per person and only the seven redevelopment projects for the pollutant load calculations.

- Low – used the subset of data that had only positive change in the number of units and only the seven redevelopment projects for the pollutant load calculations.
- High/Park – used the entire data set to derive acres of redevelopment needed per person and included the pollutant reduction associated with the park redevelopment project.
- Low/Park – used the subset of data that had only positive change in the number of units and included the pollutant load reduction associated with the park redevelopment project.

B.2.13 Cost Analysis

A cost analysis was performed to compare the potential cost of remediation for any increase in phosphorus or nitrogen as a result of development, and to provide an estimate of the cost to meet TMDL reductions for nitrogen and phosphorus. The cost analysis was based on the Baltimore County Waterway Improvement Program restoration actions. For this analysis it was assumed that future restoration actions would incorporate the same types of restoration activities (shoreline enhancement, water quality retrofits, stream restoration) and in the same relative proportion as has occurred to date. The restoration nitrogen and phosphorus reductions were calculated, along with the cost of the restoration. From this data, the cost per pound of removal for nitrogen and phosphorus was derived. This cost was then applied to any changes in the pounds of nitrogen and phosphorus as a result of future development for each of the scenarios developed. It was also applied to the remaining pounds of removal of nitrogen and phosphorus needed to meet an overall reduction of 15% from urban loads. The reduction needed was calculated based on the 1997 urban nitrogen and phosphorus loads after accounting for reductions due to the installation of best management practices that occurred prior to 1997. This benchmark time period was used as the baseline, since each nutrient TMDL developed to date has used a 1994-1997 modeling time period, and the 1997 MOP land use to determine the nutrient load reduction requirements.

Even though nutrient TMDLs have not been developed for every watershed in Baltimore County, the entire county urban load was used in the calculations. This provides for a margin of safety (MOS) in the load reductions and addresses the uncertainty due to the future TMDL for the Chesapeake Bay.

B.3 Results

The combined County results will be presented here for land use changes and pollutant load changes. The changes for the Maryland Tributary Strategy Basins and the individual watersheds are presented in Appendix A. Population changes are presented by watershed and Tributary Strategy Basin in Section B.3.1. The results for each scenario are in the following Sections:

- B.3.2 - Population growth is handled by development as usual,
- B.3.3 - Population growth is forced inside the URDL
- B.3.4 - Population growth is handled through 100% redevelopment.

Section B.3.5 will summarize the results from the three scenarios and provide a cost analysis for meeting any increase in the nitrogen and phosphorus pollutant loads resulting from future development, and a calculation of the cost for meeting the nutrient TMDLs based on the current restoration progress. The final section (B.3.6) will present the analysis results of the downstream pollutant loadings to the tidal water segments, taking into account the effects of the three drinking water reservoirs.

B.3.1 Population Change

The projected changes in population were determined for two time periods, 2020 and 2035. The results are displayed by watershed, and inside or outside the URDL in Table B-9 for the Upper Western Shore Tributary Basin, and B-10 for the Patapsco/Back River Tributary Basin. Also displayed is the population change from 1997 to 2005. Overall, the population growth of Baltimore County is projected to decrease over the two projected periods relative to the 1997-2005 time frame. In the eight year period from 1997 – 2005, population increased by ~67,000. Projections show that in the fifteen years from 2005 – 2020 population will increase by ~58,000, and in the fifteen year period from 2020 – 2035, the increase will be ~18,000. Approximately two-thirds of the growth is projected to be in the Patapsco/Back River Basin. Approximately 11 percent of the growth is projected to occur in the rural areas. Figure B-12 graphically displays the projected population changes for all of Baltimore County during the time period under consideration.

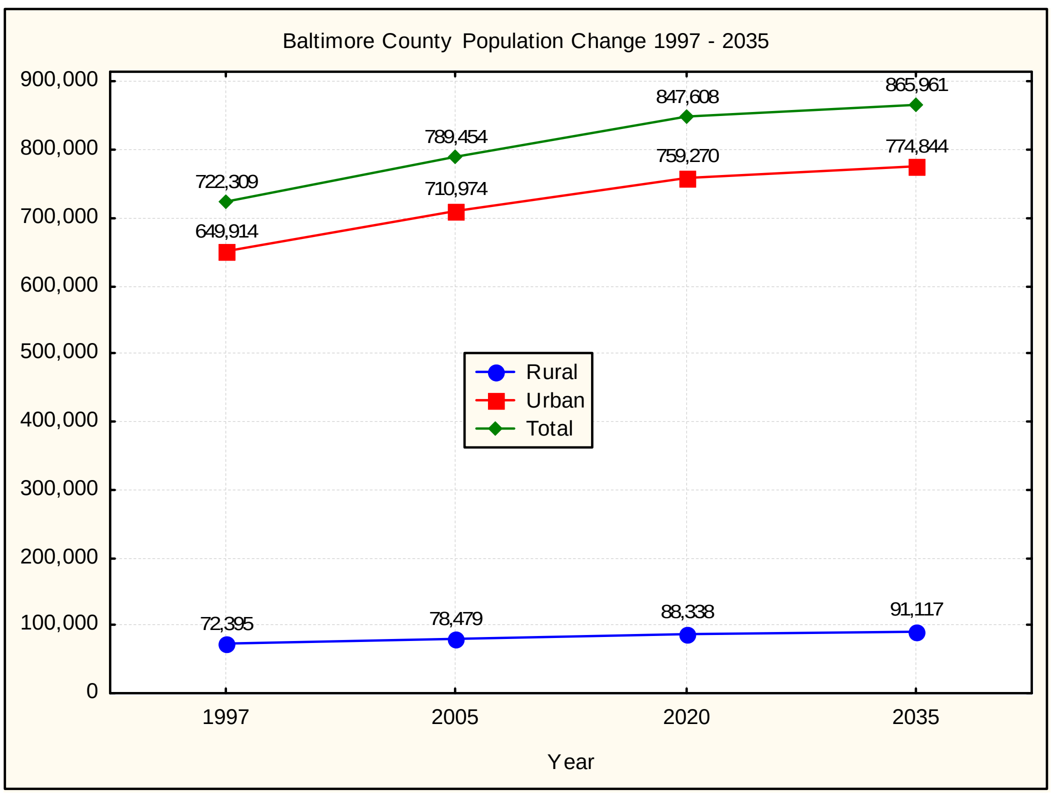


Figure B-12: Baltimore County Projected Population Changes 1997-2035.

Table B-9: Population Changes – Upper Western Shore

8-Digit Watershed	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Deer Creek	1,450	-	1,450	1,502	-	1,502	1,575	-	1,575	1,604	-	1,604
Prettyboy Reservoir	4,001	-	4,001	3,975	-	3,795	4,430	-	4,430	4,520	-	4,520
Loch Raven Res.	31,350	50,894	82,244	35,502	56,620	92,122	38,833	61,932	100,765	39,770	63,426	103,196
Lower Gunpowder	7,171	38,897	46,068	7,611	43,556	51,167	8,030	45,953	53,983	8,190	46,871	55,061
Little Gunpowder	6,905	-	6,905	7,353	-	7,353	7,867	-	7,867	8,056	-	8,056
Bird River	1,294	48,678	49,972	1,310	55,891	57,201	1,481	63,202	64,683	1,525	65,048	66,573
Gunpowder River	852	8,012	8,864	728	7,850	8,578	767	8,268	9,035	781	8,425	9,208
Middle River	1,321	27,381	28,702	1,433	25,702	27,135	1,541	27,643	29,184	1,570	28,163	29,733
Total	**54,344**	**173,862**	**228,206**	**57,414**	**189,619**	**249,033**	**64,524**	**206,998**	**271,522**	**66,016**	**211,933**	**277,949**
Deer Creek – Population changes				52	-	52	73	-	73	29	-	29
Prettyboy Reservoir – Population changes				-26	-	-26	455	-	455	90	-	90
Loch Raven Res. – Population changes				4,152	5,726	9,878	3,331	5,312	8,643	937	1,494	2,431
Lower Gunpowder – Population changes				440	4,659	5,099	419	2,397	2,816	160	918	1,078
Little Gunpowder – Population changes				448	-	448	514	-	514	189	-	189
Bird River – Population changes				16	7,213	7,229	171	7,311	7,482	43	1,847	1,890
Gunpowder River – Population changes				-124	-162	-286	39	418	457	15	156	171
Middle River – Population changes				112	-1,679	-1,567	108	1,941	2,049	29	520	549
Upper Western Shore Total Population Change				**5,070**	**15,757**	**20,827**	**5,110**	**17,379**	**22,489**	**1,492**	**4,935**	**6,427**

Table B-10: Population Changes – Patapsco/Back River Basin and Sum of All of Baltimore County

8-Digit Watershed	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Liberty Res.	4,330	367	4,697	4,776	1,792	6,568	5,308	1,991	7,299	5,513	2,069	7,582
Patapsco River	4,833	86,452	91,285	5,410	96,468	101,878	5,689	101,434	107,123	5,830	103,958	109,788
Gwynns Falls	1,299	150,575	151,874	1,368	174,855	176,223	1,501	191,907	193,408	1,531	195,688	197,219
Jones Falls	7,196	53,524	60,720	7,094	58,836	65,930	7,579	62,859	70,438	7,722	64,044	71,766
Back River	351	127,660	128,011	383	132,388	132,771	397	137,058	137,455	404	139,710	140,114
Baltimore Harbor	15	57,475	57,490	13	57016	57,029	14	60,327	60,341	14	61,506	61,520
Total	**18,024**	**476,053**	**494,077**	**19,044**	**521,355**	**540,399**	**20,487**	**555,577**	**576,064**	**21,015**	**566,974**	**587,989**
Liberty Res. – Population changes				446	1,425	1,871	532	199	731	206	77	283
Patapsco River – Population changes				577	10,016	10,593	279	4,966	5,245	142	2,523	2,655
Gwynns Falls – Population changes				69	24,280	24,349	133	17,052	17,185	30	3,781	3,811
Jones Falls – Population changes				-102	5,312	5,210	485	4,023	4,508	143	1,185	1,328
Back River – Population changes				32	4,728	4,760	14	4,670	4,684	8	2,651	2,659
Baltimore Harbor – Population changes				-2	-459	-461	1	3,311	3,312	0	1,179	1,179
Patapsco/Bck River Total Population Change				**1,020**	**45,302**	**46,322**	**1,443**	**34,222**	**35,665**	**528**	**11,397**	**11,925**
Balt. Co. Totals	72,395	649,914	722,309	78,479	710,974	789,454	88,338	759,270	847,608	91,117	774,844	865,961
Total Baltimore County Population Change				***6,085***	***61,060***	***67,145***	***6,553***	***51,601***	***58,154***	***2,020***	***15,574***	***18,352***

B.3.2 Land Use Change and Pollutant Load Change – Development As Is

The analysis of the land use change between 1997 and 2005 is presented in Appendix A for each of the fourteen 8-digits watersheds in Baltimore County and the Maryland Tributary Basins. Table B-11 presents the results for the results for all of Baltimore County. In each case the results are split between the rural (outside the URDL) and the urban (inside the URDL) portions of the county. Figure B-13 displays the land use distribution and changes for areas outside the URDL, inside the URDL, and the entire county.

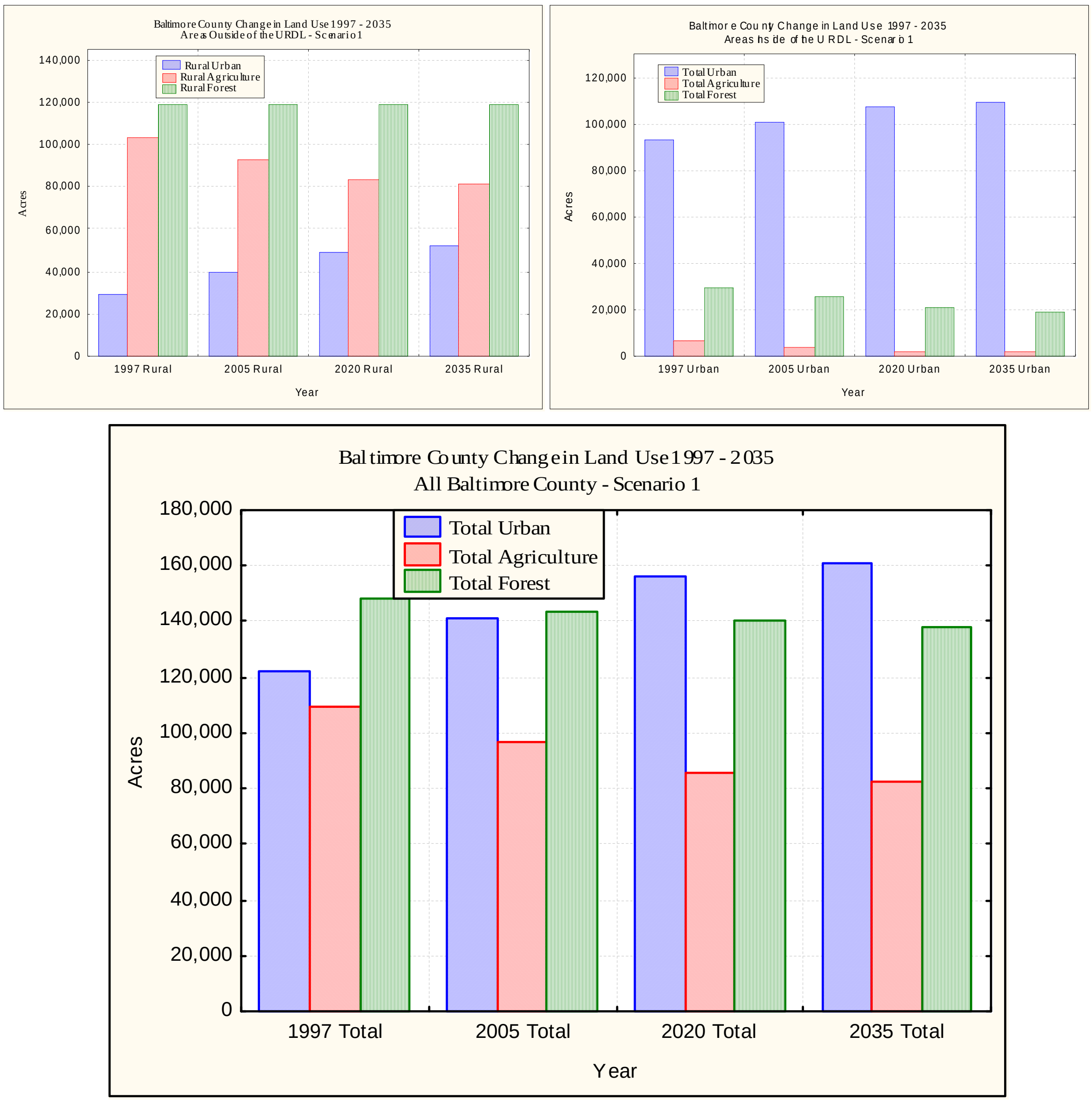


Figure B-13: Changes in Land use Distribution from 1997-2035 for the Rural Areas, Urban Areas, and the Entire County.

As can be seen from this figure, both the rural and the urban areas experienced growth in urban land use at the expense of agricultural and forestland uses. In the rural area the loss of agricultural land was greater than forest loss. In the urban areas, where little agriculture remains, forest loss was greater compared to the rural areas.

Table B-11: Scenario 1 - Land Use Changes – All Baltimore County

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	4,525	26,698	31,223	5,761	30,850	36,612	6,810	34,553	41,363	7,169	35,870	43,040
Pervious Urban - HD	4,648	56,860	61,508	16,587	61,394	77,981	27,138	63,265	90,404	30,382	63,550	93,932
Pervious Urban - LD	19,975	9,681	29,656	17,612	8,854	26,466	14,971	9,276	24,247	14,344	9,732	24,076
Cropland	83,376	5,220	88,596	70,602	2,976	73,578	57,959	1,634	59,593	53,968	1,444	55,412
Pasture	19,607	1,183	20,790	22,183	870	23,053	25,561	460	26,021	26,683	400	27,083
Livestock Feeding	450	0	450	382	0	382	347	0	347	337	0	337
Forest	118,799	29,762	148,561	118,456	25,229	143,684	118,884	21,238	140,122	118,819	19,450	138,269
Water	5,251	632	5,883	5,012	144	5,156	4,930	39	4,969	4,907	32	4,939
Bare Soil	626	647	1,273	660	365	1,026	657	218	875	648	204	852
Total	**257,256**	**130,683**	**387,939**	**257,256**	**130,683**	**387,938**	**257,258**	**130,683**	**387,940**	**257,258**	**130,682**	**387,940**
Total Urban	29,148	93,239	122,387	39,961	101,098	141,059	48,919	107,094	156,013	51,985	109,152	161,048
Total Agriculture	103,432	6,403	109,835	93,168	3,846	97,014	83,867	2,093	85,961	80,988	1,844	82,832
Total Forest	118,799	29,762	148,561	118,456	25,229	143,684	118,884	21,238	140,122	118,819	19,450	138,269
% Urban	11.3%	71.3%	31.5%	15.5%	77.4%	36.4%	**19.0%**	**82.0%**	**40.2%**	**20.2%**	**83.5%**	**41.5%**
% Agriculture	40.2%	4.9%	28.3%	36.2%	2.9%	25.0%	**32.6%**	**1.6%**	**22.2%**	**31.5%**	**1.4%**	**21.4%**
% Forest	46.2%	22.8%	38.3%	46.0%	19.3%	37.0%	**46.2%**	**16.3%**	**36.1%**	**46.2%**	**14.9%**	**35.6%**
Change in Urban from previous time period				**10,813**	**7,859**	**18,673**	**8,958**	**5,996**	**14,954**	**2,976**	**2,058**	**5,034**
Change in Agriculture from previous time period				**-10,265**	**-2,557**	**-12,822**	**-9,300**	**-1,753**	**-11,053**	**-2,879**	**-249**	**-3,128**
Change in Forest from previous time period				**-344**	**-4,534**	**-4,877**	**429**	**-3,991**	**-3,562**	**-65**	**-1,788**	**-1,853**

Phosphorus and nitrogen pollutant load changes are presented in Figures B-14 and B-15, and in Tables B-12 and B-13. Three conditions are presented in the graphs; changes in nitrogen and phosphorus over the time period with no BMPs, changes with implementation of BMPs, and changes over time with implementation of BMPs and restoration. Also indicated are the phosphorus and nitrogen load caps for a 15% load reduction and a 36% load reduction scenario.

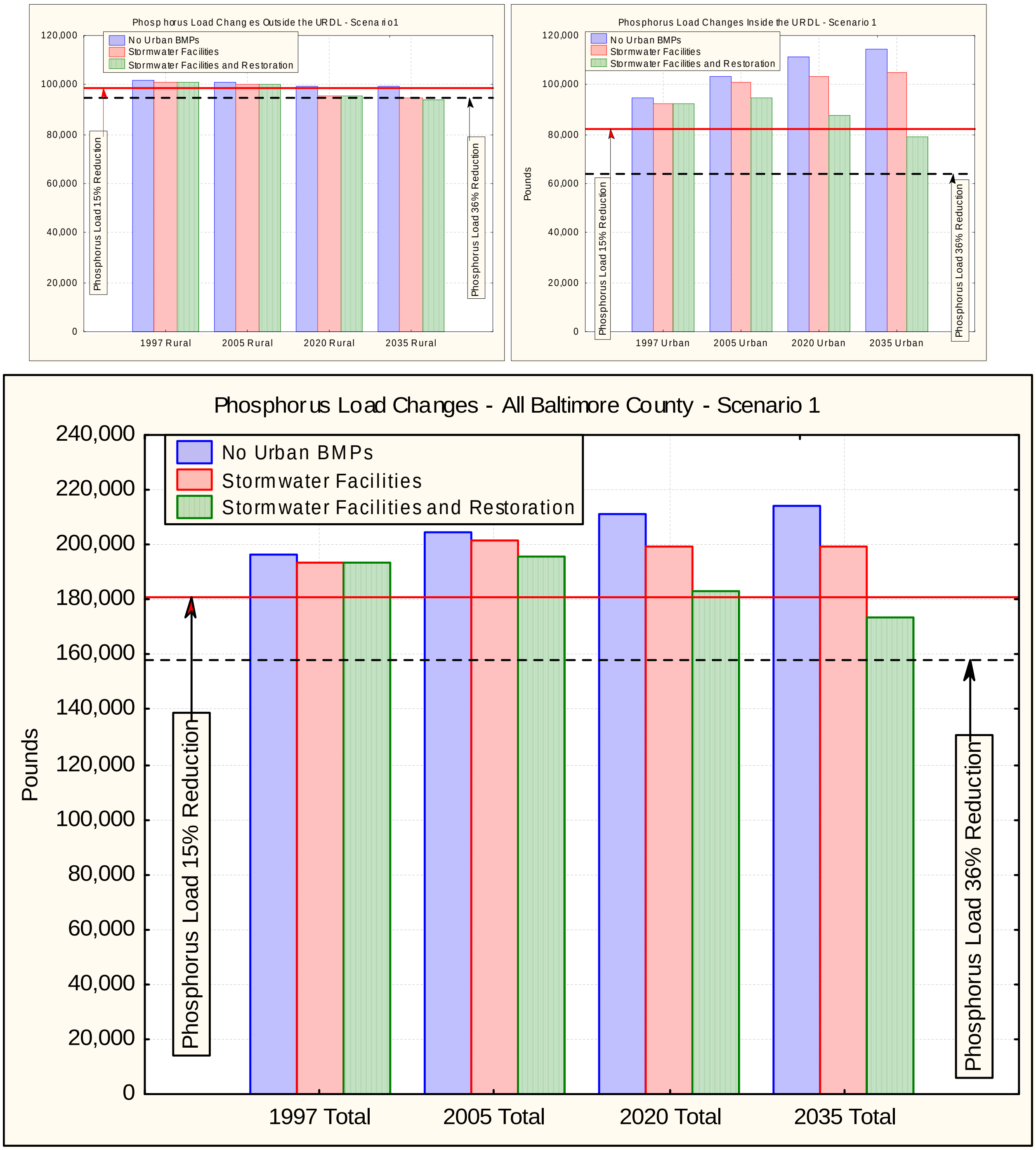
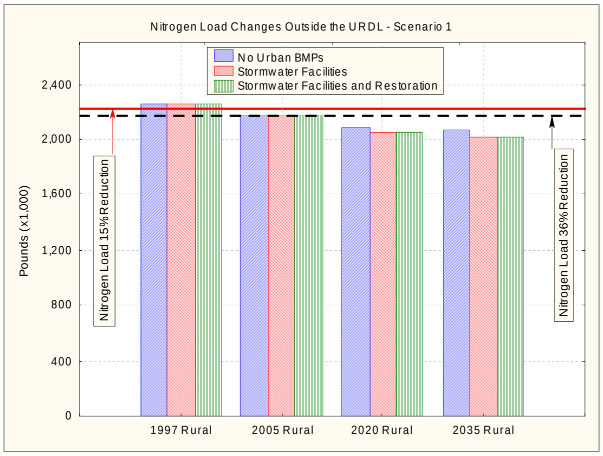
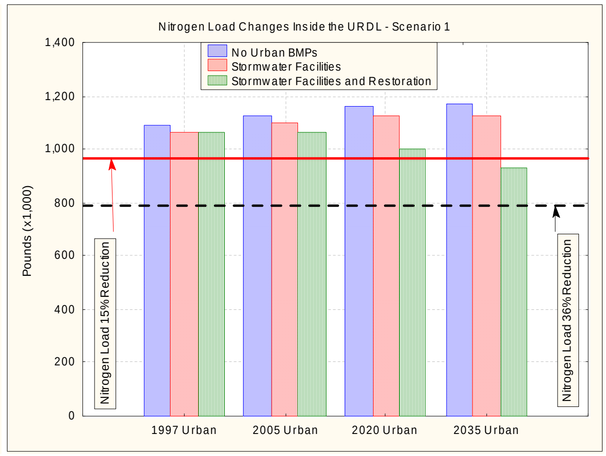


Figure B-14: Scenario 1 - Phosphorus Load Changes and Effects of BMPs and Restoration in Rural Areas, Urban Areas, and All of Baltimore County.

Table B-12: Scenario 1 - Phosphorus Load Changes – All of Baltimore County

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	20,759	88,977	109,736	27,690	99,963	127,653	33,480	109,318	142,797	35,423	112,612	148,035
Agriculture	75,144	4,541	79,686	67,551	2,727	70,278	60,601	1,481	62,082	58,426	1,305	59,731
Forest	2,400	595	2,995	2,394	505	2,899	2,405	425	2,830	2,405	389	2,794
Water	2,993	360	3,353	2,852	84	2,936	2,810	22	2,832	2,797	18	2,815
Bare Soil	457	445	902	471	260	731	468	155	623	461	149	608
Total	**101,753**	**94,919**	**196,672**	**100,963**	**103,532**	**204,495**	**99,763**	**111,402**	**211,165**	**99,512**	**114,470**	**213,982**
Change in Urban from previous time period				6,931	10,986	17,917	5,789	9,355	15,144	1,943	3,294	5,237
Change in Agriculture from previous time period				-7,593	-1,814	-9,408	-6,950	-1,246	-8,196	-2,175	-177	-2,351
Changes in Forest from previous time period				-5	-91	-96	11	-80	-69	0	-36	-36
Total Change from previous time period				**-790**	**8,614**	**7,823**	**-1,200**	**7,870**	**6,670**	**-252**	**3,068**	**2,817**
Urban BMPs	-384	-2,553	-2,937	-408	-2,211	-2,620	-3,882	-7,824	-11,706	-5,048	-9,801	-14,849
CIP Restoration	0	0	0	0	-4,410	-4,410	0	-13,860	-13,860	0	-23,310	-23,310
Reforestation	0	0	0	-32	-32	-63	-79	-79	-158	-126	-126	-253
Other Reductions	0	0	0	-27	-2,012	-2,039	-27	-2,241	-2,268	-27	-2,241	-2,268
Total Reductions	**-384**	**-2,553**	**-2,937**	**-467**	**-8,665**	**-9,132**	**-3,988**	**-24,004**	**-27,992**	**-5,201**	**-35,479**	**-40,679**
Total with Urban BMPs	101,369	92,365	193,735	100,555	101,321	201,875	95,882	103,577	199,459	94,464	104,669	199,133
Total With Urban BMPs and Restoration	101,369	92,365	193,735	100,496	94,867	195,363	95,776	87,397	183,173	94,311	78,992	173,302





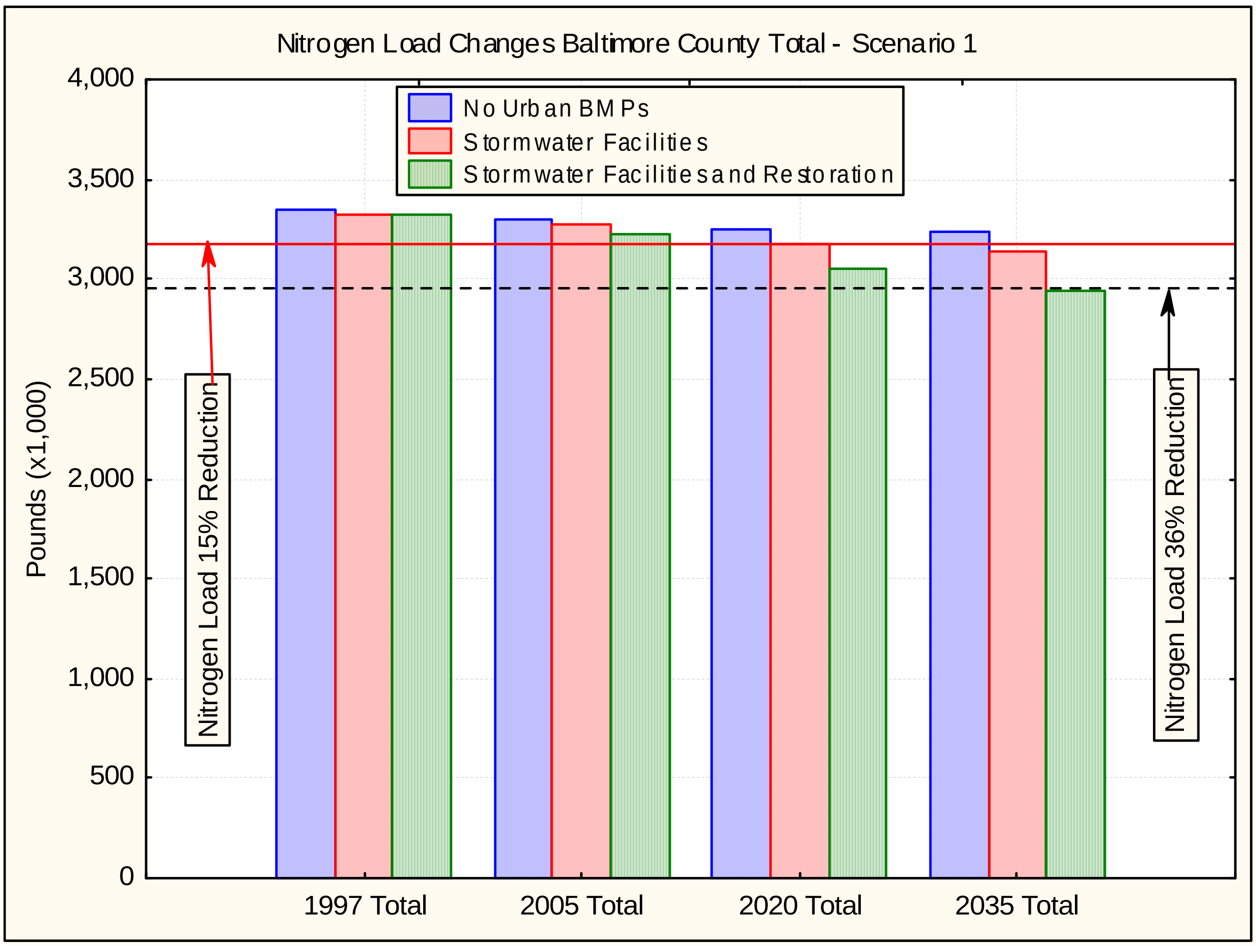


Figure B-15: Scenario 1 - Nitrogen Load Changes and Effects of BMPs and Restoration in Rural Areas, Urban Areas, and All of Baltimore County.

Table B-13: Scenario 1 - Nitrogen Load Changes – All of Baltimore County (pounds x 1,000)

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	242.1	858.8	1,100.9	329.0	944.2	1,273.2	401.2	1,013.0	1,414.2	425.2	1,037.0	1,462.2
Agriculture	1,514.2	88.1	1,602.3	1,323.4	50.8	1,374.2	1,143.9	27.4	1,171.3	1,088.2	24.1	1,112.2
Forest	168.8	40.5	209.3	168.5	34.3	202.8	169.4	28.8	198.2	169.4	26.4	195.8
Other	57.4	10.4	67.8	55.0	3.9	58.8	54.1	1.9	56.0	53.8	1.8	55.6
Septic	272.4	89.4	361.8	300.3	90.4	390.7	323.8	87.3	411.1	330.7	83.4	414.1
Total	**2,255.0**	**1,087.1**	**3,342.1**	**2,176.2**	**1,123.4**	**3,299.7**	**2,092.3**	**1,158.5**	**3,250.8**	**2,067.2**	**1,172.6**	**3,239.8**
Change in Urban from previous time period				86.9	85.4	172.3	72.2	68.8	141.0	24.0	23.9	48.0
Changes in Septic from previous time period				27.9	1.0	28.9	23.4	-3.0	20.4	7.0	-4.0	3.0
Change in Agriculture from previous time period				-190.8	-37.3	-228.2	-179.4	-23.4	-202.9	-55.9	-3.3	-59.1
Changes in forest from previous time period				-.0.3	-6.3	-6.6	0.8	-5.4	-4.6	-0.0	-2.4	-2.4
Total Change from previous time period				**-78.7**	**36.3**	**-42.4**	**-83.9**	**35.1**	**-48.8**	**-25.2**	**14.1**	**-11.0**
Urban BMPs	-3.8	-20.4	-24.3	-5.0	-22.6	-27.6	-39.1	-36.5	-75.5	-51.1	-48.4	-99.5
CIP Restoration	0	0	0	0	-35.4	-35.4	0	-111.2	-111.2	0	-187.0	-187.0
Reforestation	0	0	0	-0.5	-0.5	-0.9	-1.1	-1.1	-2.3	-1.8	-1.8	-3.6
Other Reductions	0	0	0	-0.1	-6.1	-6.2	-0.1	-7.7	-7.8	-.0.1	-7.7	-7.8
Total Reductions	**-3.8**	**-20.4**	**-24.3**	**-5.5**	**-64.5**	**-70.0**	**-40.3**	**-156.5**	**-196.7**	**-53.0**	**-245.0**	**-297.9**
Total with Urban BMPs	2,251.2	1,066.6	3,317.8	2,171.2	1,100.9	3,272.1	2,053.3	1,122.0	3,175.3	2,016.1	1,124.2	3,140.3
Total With Urban BMPs and Restoration	2,251.2	1,066.6	3,317.8	2,170.7	1,058.9	3,229.6	2,052.1	1,002.0	3,054.1	2,014.2	927.7	2,941.9

As can be seen from Figure B-14 and Table B-12, the phosphorus loads increase over time due to additional development to accommodate the projected population growth. The application of Best Management Practices (BMPs) through the use of Environmental Site Design (ESD) reduces those load increases. With the continued implementation of restoration projects, reforestation projects, street sweeping, storm drain cleaning, and citizen based restoration, the overall phosphorus load will be reduced 20,433 pounds by 2035 relative to the 1997 phosphorus load. This reduction is sufficient to meet the 15% phosphorus reduction required by existing TMDLs, but will not meet the anticipated 36% reduction that may be required to meet the Chesapeake Bay Nutrient TMDL. Neither of the reduction goals would be met by 2020.

Nitrogen would also see a decrease under Scenario 1 (Figure B-15 and Table B-13). This is the result of conversion of land uses, such as cropland, that have a higher nitrogen loading than urban pervious cover. Cropland was also converted to pasture in the 1997-2005 time frame and this conversion was projected to continue in the 2020 and 2035 time frames. Pasture also has lower nitrogen loadings than cropland. This effect of land use conversion coupled with the implementation of ESD in the 2020 and 2035 time frame and continued implementation of restoration projects results in an overall nitrogen reduction of sufficient magnitude to meet a 15% countywide nitrogen by 2020, but not the 36% reduction from urban land uses projected to be the requirement for the Chesapeake Bay Nutrient TMDL.

B.3.3 Land Use and Pollutant Load Changes – All Future Development Inside the URDL

The second scenario directs all future development inside the URDL. This results in no changes in rural land use, and therefore no changes in the rural phosphorus or nitrogen loads. This scenario will result in a greater land use change within the URDL and subsequently, a higher potential for increased phosphorus and nitrogen loading. To offset that change most of the restoration and pollutant load reduction programs to address urban loads have been directed inside the URDL. Figure B-16 and Table B-14 display the land use changes that result from this scenario.

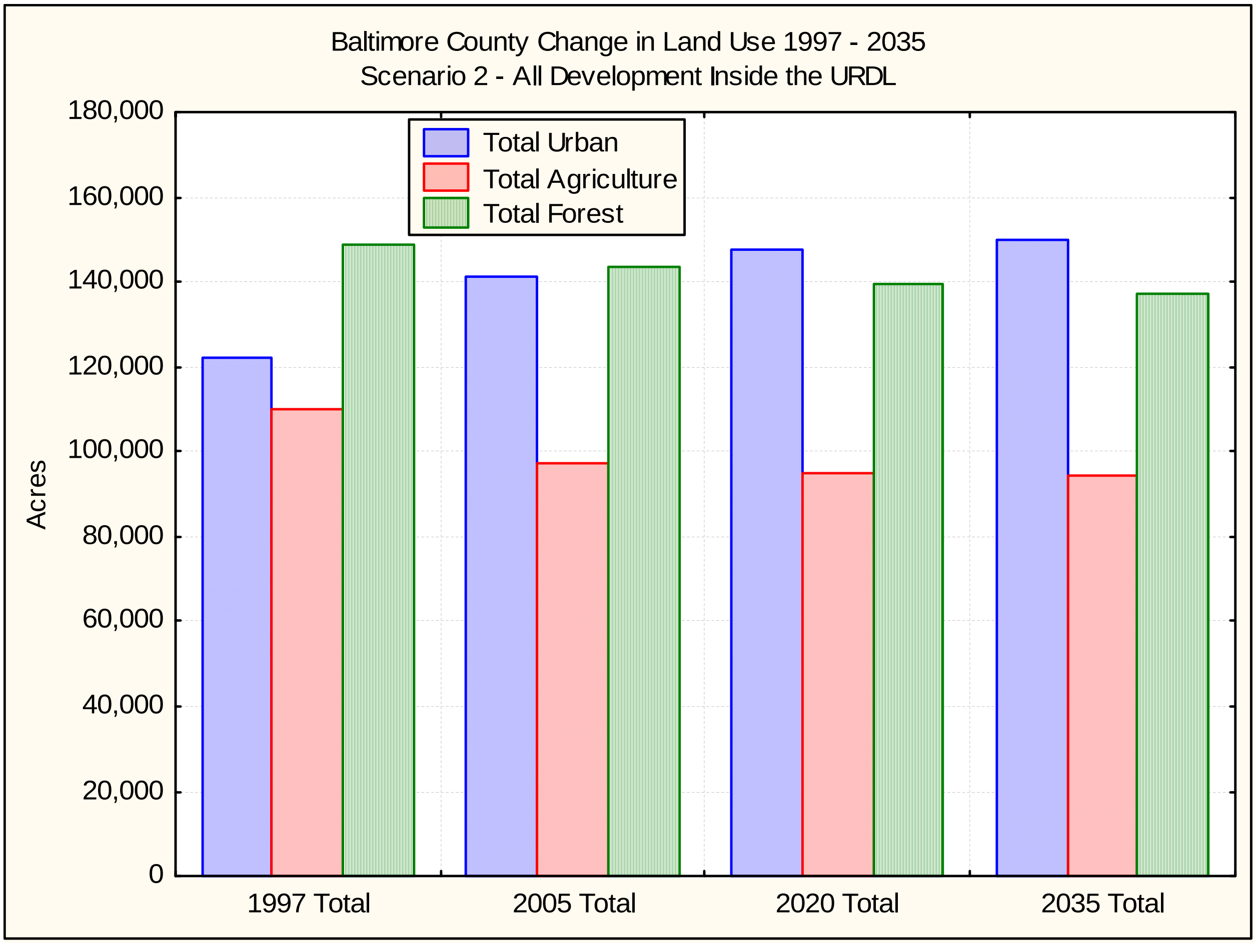


Figure B-16: Land Use Change Between 1997-2035 with all Development within the URDL in the 2005-2035 Time Frame

Over all, this scenario would result in less land use change in the 2005 - 2035 time period. By forcing all development inside the URDL, ~12,000 acres of agricultural and ~1,100 acres of forestland would be saved. For the same population growth over the 2005 – 2035 time period, ~11,100 less acres of land would be converted to urban land use.

Table B14: Scenario 2 - Land Use Changes – All Development Inside the URDL– All Baltimore County

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	4,525	26,698	31,223	5,761	30,850	36,612	5,761	34,894	40,655	5,761	36,315	42,077
Pervious Urban HD	4,648	56,860	61,508	16,587	61,394	77,981	16,587	63,785	80,373	16,587	64,231	80,818
Pervious Urban LD	19,975	9,681	29,656	17,612	8,854	26,466	17,612	9,037	26,649	17,612	9,423	27,035
Cropland	83,376	5,220	88,596	70,602	2,976	73,578	70,602	1,531	72,133	70,602	1,297	71,899
Pasture	19,607	1,183	20,790	22,183	870	23,053	22,183	473	22,656	22,183	448	22,631
Livestock Feeding	450	0	450	382	0	382	382	0	382	382	0	382
Forest	118,799	29,762	148,561	118,456	25,229	143,684	118,456	20,696	139,152	118,456	18,713	137,169
Water	5,251	632	5,883	5,012	144	5,156	5,012	35	5,047	5,012	30	5,041
Bare Soil	626	647	1,273	660	365	1,026	660	231	891	660	226	886
Total	**257,256**	**130,683**	**387,939**	**257,256**	**130,683**	**387,938**	**257,256**	**130,682**	**387,939**	**257,256**	**130,682**	**387,939**
Total Urban	29,148	93,239	122,387	39,961	101,098	141,059	39,961	107,620	147,581	39,961	109,989	149,930
Total Agriculture	103,432	6,403	109,835	93,168	3,846	97,014	93,168	2,004	95,172	93,168	1,745	94,913
Total Forest	118,799	29,762	148,561	118,456	25,229	143,684	118,456	20,766	139,210	118,456	18,713	137,169
% Urban	11.3%	71.3%	31.5%	15.5%	77.4%	36.4%	15.5%	**82.3%**	**38.0%**	**15.5%**	**84.1%**	**38.6%**
% Agriculture	40.2%	4.9%	28.3%	36.2%	2.9%	25.0%	36.2%	**1.5%**	**24.5%**	**36.2%**	**1.3%**	**24.5%**
% Forest	46.2%	22.8%	38.3%	46.0%	19.3%	37.0%	46.0%	**15.9%**	**35.9%**	**46.0%**	**14.3%**	**35.4%**
Change in Urban from previous time period				**10,813**	**7,859**	**18,673**	**0**	**6,618**	**6,618**	**0**	**2,253**	**2,253**
Change in Agriculture from previous time period				**-10,265**	**-2,557**	**-12,822**	**0**	**-1,842**	**-1,842**	**0**	**-259**	**-259**
Change in Forest from previous time period				**-344**	**-4,534**	**-4,877**	**0**	**-4,533**	**-4,533**	**0**	**-1,983**	**-1,983**

The results for the phosphorus and nitrogen pollutant loading analysis for Scenario 2 are presented in Figures B-17 and B-18, and Tables B-15 and B-16, for phosphorus and nitrogen respectively.

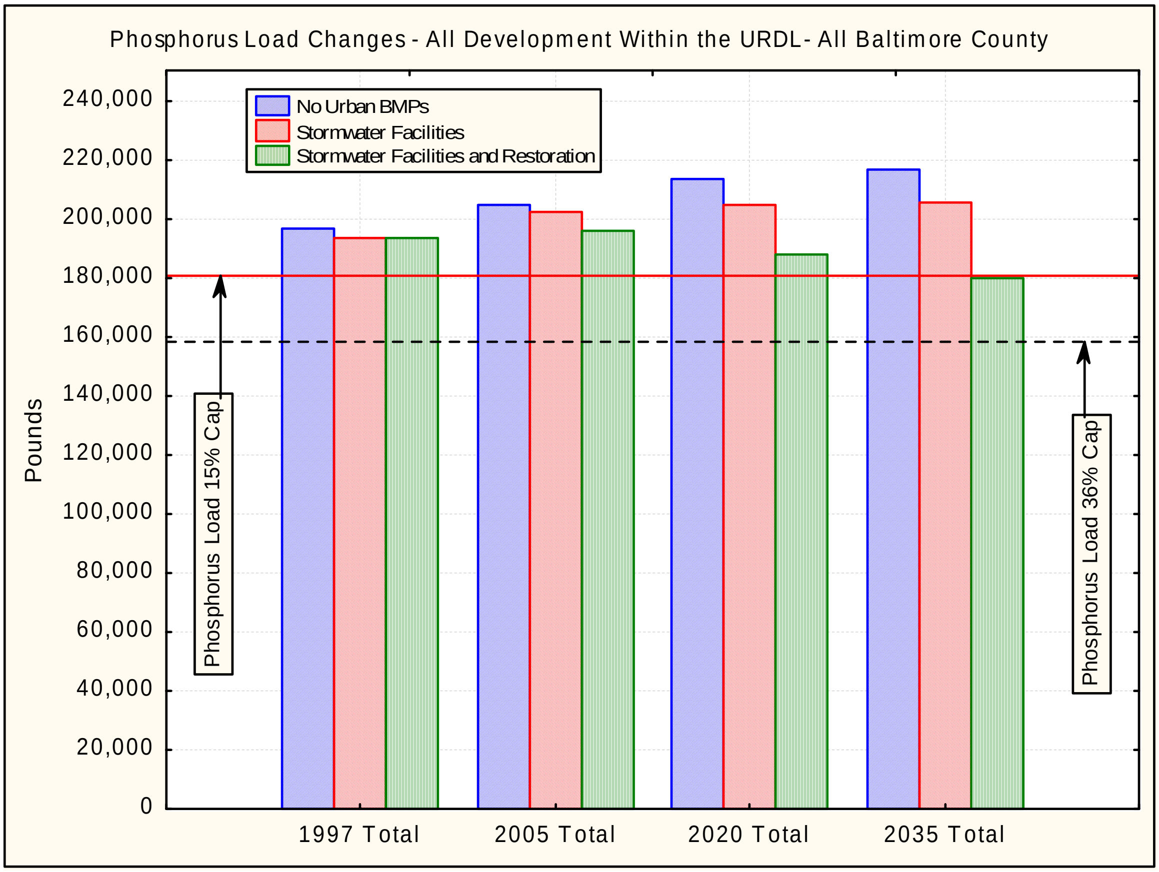


Figure B-17: Scenario 2 - Phosphorus Load Changes and Effects of BMPs and Restoration - All of Baltimore County.

Table B-15: Scenario 2 - Phosphorus Load Changes – All Development Inside the URDL – All Baltimore County

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	20,759	88,977	109,736	27,690	99,963	127,653	27,690	110,211	137,901	27,690	113,779	141,470
Agriculture	75,144	4,541	79,686	67,551	2,727	70,278	67,551	1,418	68,969	67,551	1,234	68,785
Forest	2,400	595	2,995	2,394	505	2,899	2,394	414	2,808	2,394	377	2,769
Water	2,993	360	3,353	2,852	84	2,936	2,852	20	2,877	2,852	17	2,884
Bare Soil	457	445	902	471	260	731	471	165	636	471	162	633
Total	**101,753**	**94,919**	**196,672**	**100,963**	**103,532**	**204,495**	**100,963**	**112,227**	**213,190**	**100,963**	**115,567**	**216,530**
Change in Urban from previous time period				6,931	10,986	17,917	0	10,248	10,248	0	3,569	3,569
Change in Agriculture from previous time period				-7,593	-1,814	-9,408	0	-1,309	-1,309	0	-184	-184
Changes in Forest from previous time period				-5	-91	-96	0	-91	-91	0	-40	-40
Total Change from previous time period				**-790**	**8,614**	**7,823**	**0**	**8,695**	**8,695**	**0**	**3,339**	**3,339**
Urban BMPs	-384	-2,553	-2,937	-408	-2,211	-2,620	-408	-2,553	-8,768	-408	-10,501	-10,910
CIP Restoration	0	0	0	0	-4,410	-4,410	0	-13,860	-13,860	0	-23,310	-23,310
Reforestation	0	0	0	-32	-32	-63	-79	-79	-158	-126	-126	-253
Other Reductions	0	0	0	-27	-2,012	-2,039	-27	-2,241	-2,268	-27	-2,241	-2,268
Total Reductions	**-384**	**-2,553**	**-2,937**	**-467**	**-8,665**	**-9,132**	**-514**	**-24,540**	**-25,054**	**-562**	**-36,179**	**-36,740**
Total with Urban BMPs	101,369	92,365	193,735	100,555	101,321	201,875	100,555	103,867	204,422	100,555	105,065	205,620
Total With Urban BMPs and Restoration	101,369	92,365	193,735	100,496	94,867	195,363	100,449	87,687	188,136	100,402	79,388	179,789

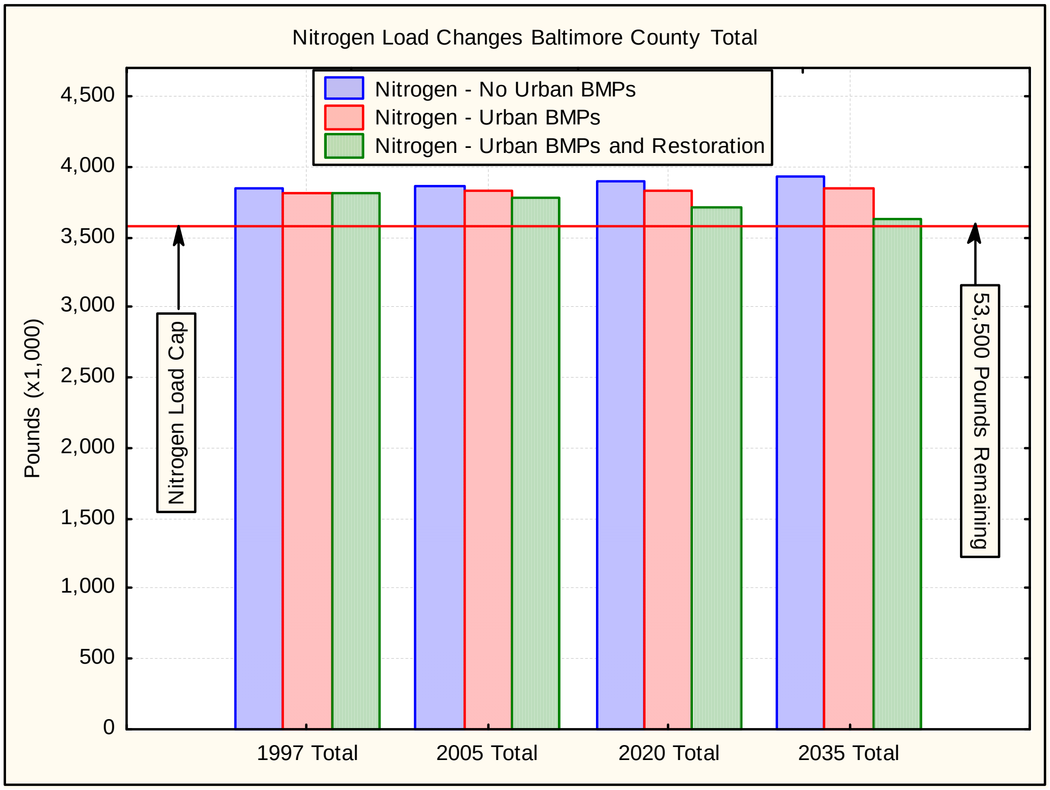


Figure B-18: Scenario 2 - Nitrogen Load Changes and effects of BMPs and Restoration - all of Baltimore County.

Table B-16: Scenario 2 - Nitrogen Load Changes – All Development Within the URDL – All Baltimore County (pounds x 1,000)

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	242.1	858.8	1,100.9	329.0	944.2	1,273.2	329.0	1,019.9	1,348.9	329.0	1,045.9	1,374.9
Agriculture	1,514.2	88.1	1,602.3	1,323.4	50.8	1,374.2	1,323.4	25.8	1,349.2	1,323.4	22.1	1,345.4
Forest	168.8	40.5	209.3	168.5	34.3	202.8	168.5	28.1	196.6	168.5	25.4	193.9
Other	57.4	10.4	67.8	55.0	3.9	58.8	55.0	2.0	57.0	55.0	1.9	56.8
Septic	272.4	89.4	361.8	300.3	90.4	390.7	300.3	87.3	387.7	300.3	83.4	383.7
Total	**2,255.0**	**1,087.1**	**3,342.1**	**2,176.2**	**1,123.4**	**3,299.7**	**2,176.2**	**1,63.1**	**3,339.3**	**2,176.2**	**1,178.7**	**3,354.9**
Change in Urban from previous time period				86.9	85.4	172.3	0	75.7	75.7	0	26.1	26.1
Changes in Septic from previous time period				27.9	1.0	28.9	0	-3.0	-3.0	0	-4.0	-4.0
Change in Agriculture from previous time period				-190.8	-37.3	-228.2	0	-25.0	-25.0	0	-3.7	-3.7
Changes in Forest from previous time period				-.0.3	-6.3	-6.6	0	-6.1	-6.1	0	-2.7	-2.7
Total Change from previous time period				**-78.7**	**36.3**	**-42.4**	**0**	**39.6**	**39.6**	**0**	**15.6**	**15.6**
Urban BMPs	-3.8	-20.5	-24.3	-5.0	-22.6	-27.6	-5.0	-40.1	-45.1	-5.0	-53.1	-58.1
CIP Restoration	0	0	0	0	-35.4	-35.4	0	-111.2	-111.2	0	-187.0	-187.0
Reforestation	0	0	0	-0.5	-0.5	-0.9	-1.1	-1.1	-2.3	-1.8	-1.8	-3.6
Other Reductions	0	0	0	-0.1	-6.1	-6.2	-0.1	-7.7	-7.8	-0.1	-7.7	-7.8
Total Reductions	**-3.8**	**-20.5**	**-24.3**	**-5.5**	**-64.5**	**-70.0**	**-11.7**	**-193.3**	**-205.0**	**-14.6**	**-282.0**	**-296.5**
Total with Urban BMPs	2,251.2	1,066.6	3,317.8	2,171.2	1,100.9	3,272.1	2,171.2	1,123.0	3,294.2	2,171.2	1,125.6	3,293.8
Total With Urban BMPs and Restoration	2,251.2	1,066.6	3,317.8	2,170.7	1,058.9	3,229.6	2,170.0	1,003.0	3,173.0	2,169.3	929.0	3,098.4

Implementation of Scenario 2, all development inside the URDL, would result in an increase in the total phosphorus load (~6,500 pounds) relative to development spread throughout the county. The nitrogen load would also increase (~156,500 pounds) under scenario 2. The differences explained by the fewer acres of agriculture (higher nitrogen and phosphorus loading rates) being converted to pervious urban land (lower nitrogen and phosphorus loading rates) when all of the development is inside the URDL.

B.3.4 Land Use and Pollutant Load Changes – All Future Development as Redevelopment

This scenario looked at the effect of placing all future development in the 2005 – 2035 time period in already developed lands. In order to determine how effective this scenario would be, existing redevelopment projects were analyzed for changes in pollutant loads and in the number of dwelling units. With this scenario, there will be no changes in land use, other than from urban pervious to urban impervious. The 2005 pollutant loads serve as the baseline loads.

Table B-17 presents the results of the analysis of nine redevelopment projects. One of those projects (Village of Tall Trees) was a redevelopment project that converted an apartment complex into a park. The remaining eight projects were redevelopment projects that removed either existing residential land use or commercial land use, and replaced them with new residential units. In the case of the Palisades redevelopment project, a mix of commercial and residential units is being constructed.

Table B-17: Nitrogen and Phosphorus Pollutant Load Reductions Due to Redevelopment

Waterview	71.8	23.6	26.9	681.8	384.5	74.0	42.5
The Quarter Phase I	5.9	2.0	3.9	56.2	51.7	6.2	5.5
Timothy House	1.9	0.6	0.9	18.0	19.4	1.9	2.3
Valleys of Towson	1.2	0.4	0.8	11.7	13.8	1.3	1.8
Palisades	1.7	1.2	1.4	20.5	21.3	3.0	3.2
Towson Prominade	5.4	3.8	3.4	65.3	35.0	9.3	2.9
Dulaney Cresent	3.4	1.0	2.4	41.3	31.6	5.9	3.3
Miramar	102.6	27.7	43.6	836.2	748.3	89.1	85.4
Village of Tall Trees*	34.5	10.2	4.3	320.0	-485.6	33.5	-48.7
	219.1	**70.5**	**87.6**	**2,050.9**	**820.0**	**244.2**	**98.2**
%Change		**~22% Increase**		**~59% Reduction**		**~ 55% Reduction**	

* Stormwater retrofit addressed 190 acres of off site drainage + a stream restoration project

The redevelopment of the eight projects analyzed resulted in an increase in impervious cover of 38%, but a reduction of the nitrogen load by 25% and the phosphorus load by 23%. When the Village of Tall Trees redevelopment project is added in, the impervious cover increase is reduced to 22%, and the nitrogen load reduction was increased to 59%, and the phosphorus load reduction was increased to 55%. Clearly, a mix of redevelopment projects that provide citizen amenities, such as parks, if strategically located, can greatly increase the ability to reduce nitrogen and phosphorus pollutant loads.

The ability of redevelopment to absorb population was analyzed with a larger set of redevelopment projects, some of which are in the early planning stages and did not have stormwater plans available as yet. A total of 11 redevelopment projects were used in the initial analysis with the results displayed in Table B-18.

Table B-18: Redevelopment – Analysis of Ability to Absorb Population – All Data

Project	Acres	Pre Redevelopment Population	Post Redevelopment Population	Difference
Towson Promenade	5.4	0	629	629
Hampton Apartments	6.6	80	186	106
Waterview	71.8	1,847	459	-1,388
Palisades	1.7	0	558	558
The Quarter	14.5	340	1,494	1,154
Miramar	77.7	2,476	2,164	-312
Kingsley Park	13.1	622	440	-182
Owings Mills Town Center	1.7	0	743	743
Global View	6.2	0	437	437
Towson Manor	9.7	49	280	231
Yorkway PUD	11.7	228	135	-93
Total Units	**220.1**	**5,642**	**7,525**	**1,883**
Acres Per Person		**.117**		

As can be seen from Table B-18, four of the redevelopment projects result in a decrease in the number of residential units. These four redevelopment projects, typically were a change from multifamily units to either single family, or mixed single family/townhouse communities. Overall, there was an increase of 1,883 people associated with the 220.1 acres of redevelopment.

In order to assess different redevelopment patterns, a subset of projects from Table B-18 that had a positive change in the number of residential units were selected and the analysis was repeated. These projects typically did not result in a change in residential housing unit type. The results are displayed in Table B-19.

Table B-19: Redevelopment – Analysis of Ability to Absorb Population – Multi-unit Developments

Project	Acres	Pre Redevelopment Population	Post Redevelopment Population	Difference
Towson Promenade	5.4	0	629	629
Hampton Apartments	6.6	80	186	106
Palisades	1.7	0	558	558
The Quarter	14.5	340	1,494	1,154
Owings Mills Town Center	1.7	0	743	743
Global View	6.2	0	437	437
Towson Manor	9.7	49	280	231
Total Units	**45.8**	**469**	**4,327**	**3,858**
Acres Per Person		**.012**		

This analysis indicated that only .012 acres of redevelopment are necessary for each person added to the population, which is a considerable reduction compared to the previous analysis. In order to incorporate the effects of redevelopment of existing urban to parks, the analysis was conducted with the acreage of park redevelopment projects added in both redevelopment scenarios. This resulted in four redevelopment scenarios with differing acreage needs and differing pollutant load reduction factors. The characteristics of the four redevelopment scenarios are displayed in Table B-20.

Table B-20: Redevelopment Scenarios - Characteristics

Scenario	Designation	Acres/Person	% Phosphorus Reduction	% Nitrogen Reduction
High Redevelopment	3a	.117	23%	25%
Low Redevelopment	3b	.012	23%	25%
High Redevelopment with Parks	3c	.135	55%	59%
Low Redevelopment with Parks	3d	.021	55%	59%

Based on the projected population increases for 2020 and 2035 and the redevelopment acres calculated for each of the four redevelopment scenarios, an estimated amount of redevelopment acreage was calculated. The results are displayed in Table B-21.

Table B-21: Redevelopment Acres Needed for Projected Population Increases

	Acres/Person	2020	2035	Total
Population Increase		58,154	18,352	**76,506**
Acres Redevelopment High	.117	7,095	2,147	**9,242**
Acres Redevelopment Low	.012	698	220	**918**
Acres Redevelopment High with Parks	.135	7,851	2,478	**10,329**
Acres Redevelopment Low with Parks	.021	1,221	385	**1,606**

The number of redevelopment acres needed ranged from a low of 918 acres to a high of 10,329 acres over the 30-year time frame from 2005 – 2035. Based on the urban acreage within the URDL in 2005, it would require redevelopment of 10.2% of the urban land to achieve the high redevelopment with parks acreage needed to accommodate all of the population growth anticipated by 2035.

In order to assess if sufficient acreage is available for redevelopment, the Baltimore County planning staff have identified, in general, potential areas and road corridors that may be suitable for redevelopment. The potential redevelopment acreage was divided by watershed and assessed against the acreage determined to be needed for each redevelopment scenario. The results for redevelopment scenarios 3a and 3b are displayed in Table B-22, while the results for 3c and 3d are displayed in Table B-23.

Table B-22: Analysis of Redevelopment Potential Versus Redevelopment Needs – No Park Retrofit

Watershed	Available acres	Acres Needed 2020		Acres Needed 2035		Deficit/Excess	
		High – 3a	Low – 3b	High – 3a	Low – 3b	High – 3a	Low – 3b
Loch Raven	793	1,173	110	298	31	-578	652
Lower Gunpowder	529	390	40	148	15	-9	474
Bird River	1,612	875	90	221	23	515	1,500
Gunpowder River	15	53	5	20	2	-58	7
Middle River	774	240	25	64	7	470	743
Liberty Reservoir	89	86	9	33	3	-30	77
Patapsco	1,830	614	63	312	32	905	1,735
Gwynns Falls	2,565	2,011	206	446	46	108	2,313
Jones Falls	720	527	54	155	16	37	650

Back River	3,014	548	56	311	32	2,155	2,926
Baltimore Harbor	1,191	388	40	138	14	666	1,137
Totals	**13,132**	**6,905**	**698**	**2,146**	**220**	**4,181**	**12,214**

Table B-23: Analysis of Redevelopment Potential Versus Redevelopment Needs – Park Retrofits

Watershed	Available acres	Acres Needed 2020		Acres Needed 2035		Deficit/Excess	
		High – 3c	Low – 3d	High – 3c	Low – 3d	High – 3c	Low – 3d
Loch Raven	793	1,238	193	344	54	-789	547
Lower Gunpowder	529	450	70	171	27	-92	432
Bird River	1,612	1,010	157	255	40	347	1,415
Gunpowder River	15	62	10	23	4	-70	2
Middle River	774	277	43	74	12	423	719
Liberty Reservoir	89	99	15	38	6	-48	68
Patapsco	1,830	708	110	360	56	762	1,664
Gwynns Falls	2,565	2,320	361	514	80	-269	2,124
Jones Falls	720	609	95	179	28	-68	597
Back River	3,014	632	98	359	56	2,023	2,860
Baltimore Harbor	1,191	447	70	159	25	585	1,097
Totals	**13,132**	**7,852**	**1,221**	**2,476**	**385**	**2,804**	**11,525**

An estimated 13,132 acres are potentially available for redevelopment. None of the redevelopment scenarios exceed the potential acreage available on a countywide basis. However, when assessed at the watershed level a number of watersheds do not have sufficient identified redevelopment acreage to support the anticipated population growth for scenarios 3a and 3c, particularly the Loch Raven Reservoir watershed. This will necessitate attempting to encourage population growth where sufficient acreage is available, or selecting a redevelopment scenario (3b or 3d) that would provide sufficient acreage, or a combination of both.

The land use changes that occur with the redevelopment scenarios are limited to conversions between urban impervious and urban pervious. To provide a conservative estimate of the pollutant load reduction effects of redevelopment, it was assumed that the phosphorus and nitrogen pollutant loads associated with land use change will not occur as in Scenarios 1 and 2 (i.e. the only effect will be the result of stormwater treatment). There will be a pollutant load decrease due to the installation of various stormwater control practices as part of the redevelopment requirements. Using the pollutant load reductions determined from the analysis of existing redevelopment projects (Table B-17) the pollutant load reduction for each of the redevelopment scenarios was determined for phosphorus and nitrogen. The results of this analysis are presented in Table B-24.

Table B-24: Pollutant Load Reductions (Pounds) Achieved by the Four Redevelopment Scenarios

2005 nitrogen loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	6,905	69,401	17,350	2.146	21,901	5,475
Low – 3b	25%	698	7,118	1,780	220	2,246	562
High/Parks – 3c	59%	7,852	80,078	47,246	2,476	25,271	14,910
Low/Parks – 3d	59%	1,221	12,457	7,349	385	3,931	2,319
2005 phosphorus loading –1.22	**Reduction %**						
High	23%	6,905	8,301	1,909	2.146	2,620	602
Low	23%	698	851	196	220	269	62
High/Parks	55%	7,852	9,578	5,268	2,476	3,023	1,662

Low/Parks	55%	1,221	1,490	819	385	470	259

Scenario 3c results in the largest decrease in pollutant loads for both nitrogen and phosphorus, while scenario 3b results in the lowest reductions. This is due to the larger acreage needed for the 3c scenario, which would result in a greater acreage covered by stormwater management BMPs.

In order to look at future phosphorus and nitrogen loadings, the 2005 nutrient loads with urban BMPs and restoration were used as the baseline. There would be no future growth in the nutrient loads, as there would be no land use change with an all redevelopment scenario. Future loads are determined by subtracting the loads addressed by restoration efforts in each of the two time periods (2005 – 2020 and 2020 – 2035) and then by subtracting the load reductions due to the four redevelopment scenarios (Table B-24). The results are displayed in Table B-25 for phosphorus and in Table B-26 for nitrogen. Also, displayed are the TMDL caps based on a 15% and a 36% reduction for urban nutrient loads, with loads below the 15% reduction caps highlighted. The loads displayed are total loads.

Table B-25: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	180,652	158,224	193,735	195,363	184,036	165,124
Low – 3b	180,652	158,224	193,735	195,363	185,749	174,925
High/Parks – 3c	180,652	158,224	193,735	195,363	180,677	163,444
Low/Parks – 3d	180,652	158,224	193,735	195,363	185,126	174,085

Table B-26: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	3,180,599	2,954,512	3,317,811	3,229,619	3,133,502	3,050,852
Low – 3b	3,180,599	2,954,512	3,317,811	3,229,619	3,149,073	3,071,337
High/Parks – 3c	3,180,599	2,954,512	3,317,811	3,229,619	3,070,774	3,011,522
Low/Parks – 3d	3,180,599	2,954,512	3,317,811	3,229,619	3,138,396	3,064,009

All of the redevelopment scenarios would result in meeting the 15% reduction for phosphorus in the 2020 – 2035 time frame and the 15% reduction for nitrogen in the 2005 - 2020 timeframe. Scenario 3c provides the most nutrient reduction. None of the redevelopment scenarios would meet the 36% nutrient reduction target.

B.3.5 Scenario Comparison

This section will provide an overall comparison of the six scenarios that have been developed. The comparison will be on the effect of the various scenarios on nitrogen and phosphorus loads in relation to the loading caps. The loads reflect both the stormwater management installation and implementation of restoration projects. The comparison for phosphorus is presented in Table B-27, while the comparison for nitrogen is presented in Table B-28.

Table B-27: All Land Uses - Phosphorus Load Changes (pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	180,652	158,224	193,735	195,363	183,173	2,521	24,949	173,302	**-7,350**	15,078
Scenario 2 – All Development within URDL	180,652	158,224	193,735	195,363	188,136	7,484	29,912	179,789	**-863**	21,565
Scenario 3a – All Redevelopment – High	180,652	158,224	193,735	195,363	184,036	3,384	25,812	165,124	**-15,528**	6,900
Scenario 3b – All Redevelopment – Low	180,652	158,224	193,735	195,363	185,749	5,097	27,525	174,925	**-5,727**	16,701
Scenario 3c – All Redevelopment – High/Parks	180,652	158,224	193,735	195,363	180,677	25	22,453	163,444	**-17,208**	5,220
Scenario 3d – All Redevelopment – Low/Parks	180,652	158,224	193,735	195,363	185,126	4,474	26,902	174,085	**-6,567**	15,861

The TMDL cap for phosphorus based on local TMDLs that call for a 15% urban phosphorus load reduction is 180,652 pounds annually. The Chesapeake Bay TMDL may have a phosphorus reduction requirement of 36%. This cap would be 158,224 pounds annually. These numbers represents both the poundage that we achieve through the implementation of restoration projects, but also a cap for future development. Any increase in loads due to development must be addressed through a load reduction program. The changes in the phosphorus load result from the conversion of land from one type to another (Scenarios 1 and 2), the implementation of urban best management practices to control those loads in future development (all scenarios), and the ability of restoration projects to reduce the loads (all scenarios). In the case of phosphorus, change from any land use to urban impervious will result in an increase in the load based on the loading rates per acre (Table B-4), however, change in land use to pervious urban from agricultural operations will result in a decrease in the phosphorus load. Even though future stormwater management will incorporate Environmental Site Design (ESD), the Chesapeake Bay Program has only assigned a 60% reduction efficiency for phosphorus. Therefore, any increase in the urban development footprint will result in an increase in the phosphorus pollutant load.

The model indicated that an increase (1,628 pounds) in the phosphorus load occurred in the 1997 – 2005 time frame, despite all of the restoration work that has been completed in Baltimore County in that time period (6,512 pounds removed). During that time period, stormwater management requirements evolved. Until 2000, large lot subdivisions were exempt from stormwater management with the exception of the roads serving the subdivisions. In addition, the types of facilities constructed, while an improvement over the dry ponds that were typical of the 1980’s, were still less efficient at pollutant removal than the types that are currently being implemented.

Scenarios 1 and 2 both represent a change in the development footprint, and therefore a change in the phosphorus pollutant loads. In both the 2005 – 2020 and the 2020 - 2035 time frames there is a decrease in the phosphorus load. This accounted for the increased pollutant removal efficiency through the use of ESD, and the continued implementation of restoration projects. Restoration during this time period is able to overcome the increase in the phosphorus pollutant load due to development. However, the additional reductions necessary to meet the phosphorus TMDL are substantial for both the 15% and the 36% reduction targets by 2020. The 15% phosphorus reduction could be met in the 2035 timeframe, but substantial reductions would be necessary to meet the 36% phosphorus reduction.

The redevelopment scenarios will result in no land use changes in the future and, therefore no increase in the phosphorus pollutant load from land use change. The outcome for all four redevelopment scenarios is a greater decrease in the phosphorus pollutant load than for Scenario 2. Only redevelopment scenario 3c will result in a greater decrease in phosphorus than Scenario 1. Three of the scenarios will not reduce phosphorus enough to meet the 15% phosphorus TMDL reduction requirements. The fourth (3c) will reduce phosphorus almost to the 15% level by 2020. The 3c redevelopment scenario requires the redeveloping ~ 10% of the existing 2005 urban land within the URDL.

All of the Scenarios would meet the 15% phosphorus reduction by 2035, but would require additional reductions to meet the 36% phosphorus reduction target. During this time frame two of the redevelopment scenarios (3a and 3c) perform better than either Scenario 1 or 2.

Table B-28: All Land Uses Nitrogen Load Changes (x1,000 pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	**Above 15 % Cap**	**Above 36 % Cap**	**Load**	**Above 15 % Cap**	**Above 36 % Cap**
Scenario 1 – Development As Is	3,180.6	2,954.5	3,317.8	3,229.6	3,054.1	**-126.5**	99.6	2,941.9	**-238.7**	**-12.6**
Scenario 2 – All Development within URDL	3,180.6	2,954.5	3,317.8	3,229.6	3,173.0	**-7.6**	218.5	3,098.4	**-82.2**	143.9
Scenario 3a – All Redevelopment – High	3,180.6	2,954.5	3,317.8	3,229.6	3,133.5	**-47.1**	179.0	3,050.9	**-129.7**	96.4
Scenario 3b – All Redevelopment – Low	3,180.6	2,954.5	3,317.8	3,229.6	3,149.1	**-31.5**	194.6	3,071.3	**-109.3**	116.8
Scenario 3c – All Redevelopment – High/Parks	3,180.6	2,954.5	3,317.8	3,229.6	3,070.8	**-109.8**	116.3	3,011.5	**-169.1**	57.0
Scenario 3d – All Redevelopment – Low/Parks	3,180.6	2,954.5	3,317.8	3,229.6	3,138.4	**-42.2**	183.9	3,064.0	**-116.6**	109.5

For nitrogen, the conversion of other land uses to urban land, particularly cropland, can result in a decrease in the nitrogen pollutant load (Table B-3). So, the response of nitrogen to development is different than phosphorus. This is bourn out by Table B-28 above, where Scenario 1 and 2 result in a decrease in the nitrogen loads to the point where it is below the TMDL 15% cap by 2020. All of the redevelopment scenarios also result in a nitrogen load decrease large enough to meet the TMDL 15% reduction requirement by 2020.

The 36% nitrogen reduction target is harder to meet, with no scenario meeting the target by 2020 and only Scenario 1 meeting the target by 2035. Scenario 1 would result in a greater loss of agriculture and forest land uses, which would be contrary to county policy to of preserving agriculture and forest.

Figures B-19 and B-20 display the comparison graphically for phosphorus and nitrogen, respectively.

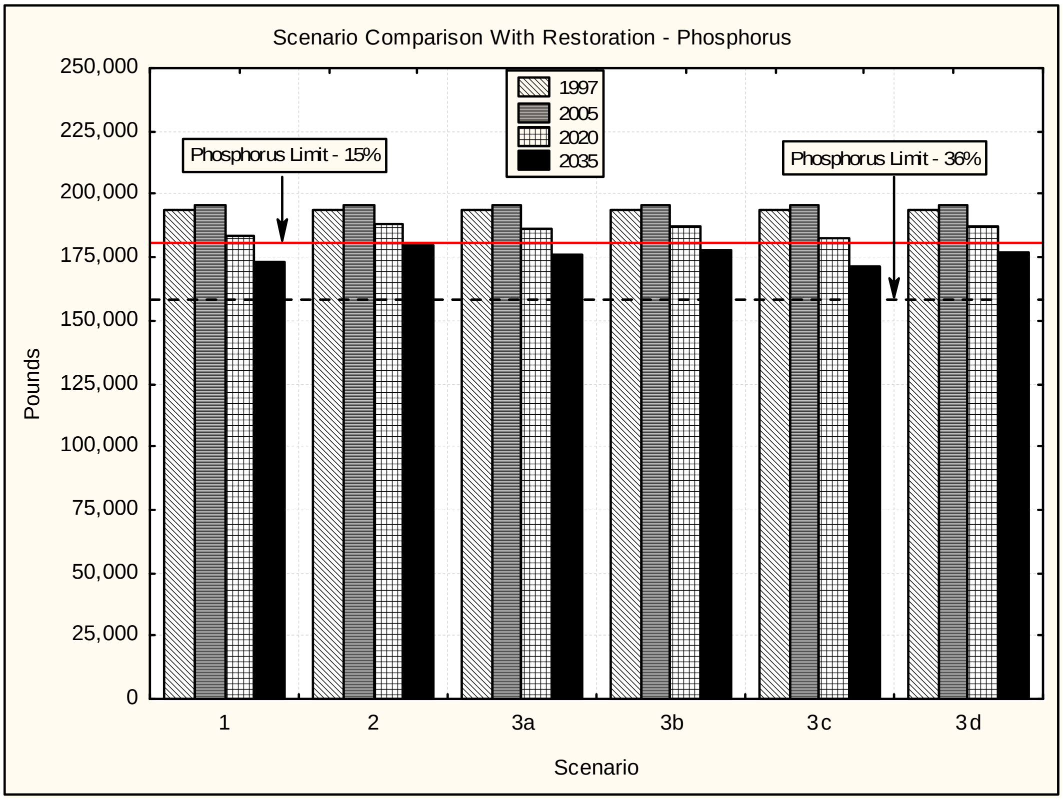


Figure B-19: Scenario Comparison for Phosphorus.

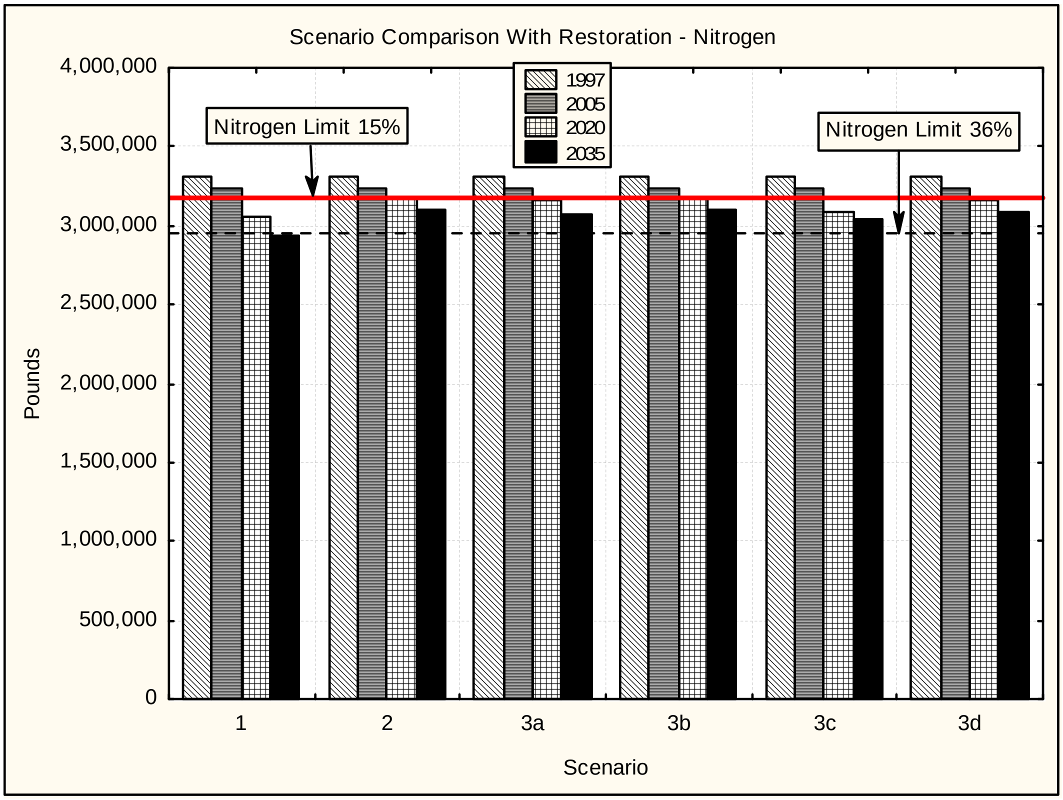


Figure B-20: Scenario Comparison for Nitrogen.

An analysis of past restoration capital projects was conducted, in order to determine the potential future cost of addressing nutrient load increases from future development, and to determine potential costs for restoration to address the urban stormwater portion of nutrient TMDLs. The capital program includes a number of restoration project types, including stream restoration, conversion of existing stormwater management facilities for greater nutrient reductions, installation of new stormwater management facilities, and shoreline erosion control projects. Using the data in the Baltimore County 2009 Annual NPDES Report, a cost per pound of removal for nitrogen and for phosphorus was determined. The analysis determined that it cost, on average, $1,108 per pound of nitrogen removed and $8,889 per pound of phosphorus removed.

To determine the phosphorus load change for each time period without the effects of restoration, the data in Tables B-12 and B-15 were used for Scenarios 1 and 2, respectively. The total load with urban BMPs (second line from the bottom) for each time period was subtracted from the subsequent time period to derive the phosphorus load change due to development. For the redevelopment scenarios, there was no land use change, so the load reductions derived from Table B-24 were used. The first time period 1997 – 2005 was the same for all scenarios and represents development that has already been completed. Any load gain from this time period will have to be addressed in order to meet the TMDL goal. The results of this cost analysis for phosphorus are shown in Table B-29. The last column represents the total cost of addressing the phosphorus loads generated from 1997 through 2035.

Table B-29: Phosphorus Load Changes Due to Development and Cost ($ x 1,000)

						Cost	Total Change #s	Total Cost
Scenario 1 – Development As Is	8,141	$53,372	-2,417*	-$21,485	-326*	-$2,898	5,398*	$47,983
Scenario 2 – All Development within URDL	8,141	$53,372	2,547*	$22,640	1,198*	$10,649	11,885*	$105,646
Scenario 3a – All Redevelopment – High	8,141	$53,372	-1,909	-$16,969	-602	-$5,351	5,630	$50,045
Scenario 3b – All Redevelopment – Low	8,141	$53,372	-196	-$1,742	-62	-$551	7,883	$70,072
Scenario 3c – All Redevelopment – High/Parks	8,141	$53,372	-5,268	-$46,827	-1,662	-$14,774	1,211	$10,765
Scenario 3d – All Redevelopment – Low/Parks	8,141	$53,372	-819	-$7,280	-259	-$2,302	7,063	$62,783

* Includes decreases that resulted from land use changes

Placing future development within the URDL (Scenario 2) will have the highest cost (~$106 million) for addressing the increases in phosphorus. Redevelopment scenario 3c provides the most benefit, with only a $10 million cost to address the phosphorus load due to all development that has occurred since 1997.

The same calculations were performed for nitrogen to determine the cost of addressing increased (or decreased) nitrogen loads due to development over the 1997 – 2035 time period. The results are presented in Table B-30.

All of the six scenarios resulted in a decreased nitrogen load, and therefore a decrease in cost over the 1997 – 2005 time frame. As discussed previously, the decreased nitrogen loads for Scenario 1 are a result of conversion of agricultural lands with higher per acre nitrogen loading rates compared to urban land uses. While this is a desirable result for decreases in nitrogen loads, it conflicts with County initiatives for agricultural preservation, and ignores other potential impacts to streams associated with increased runoff and a suite of other pollutants associated with urban development. While Scenario 2 results in an increase in nitrogen loads for the future, the reduction in nitrogen loads in the 1997 – 2005 time period offsets the increases. All of the redevelopment scenarios result in a decrease in the nitrogen load, with 3c having the highest decrease.

Table 30: Nitrogen Load Changes (#s) and Cost ($ x 1,000)

								Total Cost
Scenario 1 – Development As Is	-45,737*	-$50,677	-88,796*	-$96,773	-25,056*	-$35024	-177,534	**-$109,151**
Scenario 2 – All Development within URDL	-45,737*	-$50,677	22,111*	$24,499	2,572*	$2,850	-21,055	**-$23,329**
Scenario 3a – All Redevelopment – High	-45,737*	-$50,677	-17,350	-$19,224	-5,475	-$6,066	-68,562	**-$75,967**
Scenario 3b – All Redevelopment – Low	-45,737*	-$50,677	-1,780	-$1,972	-562	-$623	-48,079	**-$53,272**
Scenario 3c – All Redevelopment – High/Parks	-45,737*	-$50,677	-47,246	-$52,349	-14,910	-$16,520	-107,893	**-$119,545**
Scenario 3d – All Redevelopment – Low/Parks	-45,737*	-$50,677	-7,349	-$8,143	-2,319	-$2,569	-55,405	**-$61,389**

* Includes decreases that resulted from land use changes

In addition to the cap on phosphorus and nitrogen pollutant loads, there is a requirement to reduce the pollutant loads down to the cap. The urban phosphorus load reduction of 15% of the 1997 load equals a total of 16,020 pounds of phosphorus, while a 36% reduction equals a total of 38,448 pounds of phosphorus. The urban nitrogen load reduction of 15% of the 1997 load equals a total of 161,491 pounds of reductions and a 36% reduction equals 387,577 pound of nitrogen reduction. In this analysis, reductions from other land uses are not a concern, as the assumption made in the loading analysis is that all of the tributary strategies have been incorporated.

Baltimore County has been implementing restoration projects for 20 years. In order to estimate progress made to date, and progress projected in the future, an analysis of the pollutant load reductions has been conducted using the methods detailed in Section B.2.8. Using the actual data on pollutant load reductions for the time period 1997 –2005, the future reductions were calculated based on the assumption that the restoration pace would remain the same. Using the scenario comparison for phosphorus displayed in Table B-27, the additional capital dollars needed above the current restoration funding was calculated for both a 15% reduction and a 36% reduction of phosphorus. The results are displayed in Table B-31. The same analysis was conducted for nitrogen based on the scenario comparison results in Table B-28, with the results displayed in Table B-32. For nitrogen the 15% reduction will be met by all scenarios, therefore additional capital dollars above current funding are not needed to meet a 15% nitrogen reduction target.

Table B-31: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets

Cost/Pound $8,889	TMDL 15 % Cap	TMDL 36 % Cap	Pounds			Costs (x 1,000)			
			2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	180,652	158,224	183,173	2,521	24,949	$22,409	$221,772	$2,241	$22,177
Scenario 2 – All Development within URDL	180,652	158,224	188,136	7,484	29,912	$66,525	$265,888	$6,653	$26,589
Scenario 3a – All Redevelopment – High	180,652	158,224	184,036	3,384	25,812	$30,080	$229,443	$3,008	$22,944
Scenario 3b – All Redevelopment – Low	180,652	158,224	185,749	5,097	27,525	$45,307	$244,670	$4,531	$24,467
Scenario 3c – All Redevelopment – High/Parks	180,652	158,224	180,677	25	22,453	$222	$199,585	$22	$19,958
Scenario 3d – All Redevelopment – Low/Parks	180,652	158,224	185,126	4,474	26,902	$39,769	$239,132	$3,977	$23,913

Table B-32: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets

Cost/Pound $1,108	TMDL 15 % Cap	TMDL 36 % Cap	Pounds (x 1,000)			Costs (x 1,000)			
			2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	3,180.6	2,954.5	3,054.1	**-126.5**	99.6	$0	$110,357	$0	$11,036
Scenario 2 – All Development within URDL	3,180.6	2,954.5	3,173.0	**-7.6**	218.5	$0	$242,098	$0	$24,210
Scenario 3a – All Redevelopment – High	3,180.6	2,954.5	3,133.5	**-47.1**	179.0	$0	$198,332	$0	$19,833
Scenario 3b – All Redevelopment – Low	3,180.6	2,954.5	3,149.1	**-31.5**	194.6	$0	$215,617	$0	$21,562
Scenario 3c – All Redevelopment – High/Parks	3,180.6	2,954.5	3,070.8	**-109.8**	116.3	$0	$128,860	$0	$12,886
Scenario 3d – All Redevelopment – Low/Parks	3,180.6	2,954.5	3,138.4	**-42.2**	183.9	$0	$203,761	$0	$20,376

As can be seen from Table B-31 and Table B-32, a significant increase in funding would be required to meet a 36% nutrient reduction target for either phosphorus or nitrogen. The lowest estimate would be an additional $20 million annually, based on the redevelopment scenario 3c (phosphorus), while the highest is $26.5 million annually based on Scenario 2. The 15% nutrient reduction target is easier to meet, with all scenarios not requiring any additional capital restoration funding over the existing funding for nitrogen reduction. The 15% phosphorus reduction can be met with little additional capital funds if all future development to absorb the projected population increase is conducted in accordance with Redevelopment Scenario 3c. If development continues as it has in the past, an additional $2.2 million annual funding would be required over the existing capital restoration budget.

B.3.6 Downstream Pollutant Load Delivery

In order to account for the effects of the reservoirs on the Baltimore County contribution to the tidal water segments, an analysis was conducted on the percent of water flowing over each of the three dams. The methodology is described in section B.2.10. For the Prettyboy Reservoir, the flow over the dam was 19.9%, Liberty 18.1% and for Loch Raven 37.1% of the water flowing into the respective reservoir. The downstream pollutant loads were reduced by using these percentages and further reduced due to the treatment effects of the reservoir itself. The reduction values for wet ponds were used. For phosphorus this value is 50% and for nitrogen the value is 30%. Since flow from the Prettyboy Reservoir flows through the Loch Raven Reservoir an additional reduction for Prettyboy pollutant loads was applied. The formulas for the three reservoirs were:

Prettyboy pollutant load delivered to tidal waters:

$$PL_D \text{ (N or P)} = PL_Y * .3_{PBTE} * .199_{PBF} * .3_{LRTE} * .371_{LRF} \quad (10)$$

Where,

PL_D	=	Pollutant load delivered to tidal waters
PL_Y	=	Pollutant load for each analysis year (1997, 2005, 2020, 2035)
$.3_{PBTE}$	=	Prettyboy reservoir treatment effect for nitrogen (substitute .5 for phosphorus)
$.199_{PBF}$	=	Average proportion of water input that flows over the dam for Prettyboy Reservoir
$.3_{LRTE}$	=	Loch Raven reservoir treatment effect for nitrogen (substitute .5 for phosphorus)
$.371_{LRF}$	=	Average proportion of water input that flows over the dam for Loch Raven Reservoir

Loch Raven pollutant load delivered to tidal waters:

$$PL_D \text{ (N or P)} = PL_Y * .3_{LRTE} * .371_{LRF} \quad (11)$$

Where,

PL_D	=	Pollutant load delivered to tidal waters
PL_Y	=	Pollutant load for each analysis year (1997, 2005, 2020, 2035)
$.3_{LRTE}$	=	Loch Raven reservoir treatment effect for nitrogen (substitute .5 for phosphorus)
$.371_{LRF}$	=	Average proportion of water input that flows over the dam for Loch Raven Reservoir

Liberty pollutant load delivered to tidal waters:

$$PL_D \text{ (N or P)} = PL_Y * .3_{LiRTE} * .181_{LiRF} \quad (12)$$

Where,

PL_D	=	Pollutant load delivered to tidal waters

PL_Y	=	Pollutant load for each analysis year (1997, 2005, 2020, 2035)
$.3_{LiRTE}$	=	Liberty reservoir treatment effect for nitrogen (substitute .5 for phosphorus)
$.181_{LiRF}$	=	Average proportion of water input that flows over the dam for Liberty Reservoir

The contributing watersheds, and in some cases tidal waters, were determined for each of the seven tidal water segments that border Baltimore County. In addition, the contribution of air deposition to the phosphorus and nitrogen loads were calculated based on the acres of tidal water surface and a loading factor of 0.57 pounds per acre for phosphorus, and 10.5 pounds per acre for nitrogen (see Table B-3 and B-4 for loading rates for water). The results are displayed in Tables B-33 and B-34, for phosphorus and nitrogen, respectively. Where there are other contributing counties or up-stream segments these are designated in the tables, but loads are not calculated. Similarly, point source load calculations have not been included in the table. The results represent the Baltimore County urban, agriculture, and forest load contributions, along with air deposition for each tidal segment. The data are based on Scenario 1 – Development As Is, results include the pollutant reduction resulting from installation of urban Best Management Practices and the implementation of various restoration practices (stream restoration, shoreline erosion control, stormwater retrofits and conversions, reforestation, street sweeping and storm drain cleaning, and citizen based restoration).

Table B-33: Tidal Segment Phosphorus Loadings

Tidal Segment Designation	Contributing Watersheds	1997	2005	2020	2035
GUNOH2	Prettyboy Reservoir	181	175	169	168
	Loch Raven Reservoir	11,386	11,100	10,481	10,205
	Lower Gunpowder Falls	13,769	14,350	13,911	13,410
	Little Gunpowder Falls	7,774	7,724	7,437	7,332
	Bird River	8,115	8,890	8,060	7,038
	Air Deposition on Tidal Waters	2,622	2,622	2,622	2,622
	Portions of Harford County				
	GUNOH2 Total Phosphorus Load	**43,847**	**44,861**	**42,680**	**40,775**
GUNOH1	GUNOH2 and all watersheds that drain to GUNOH2	43,847	44,861	42,680	40,775
	Portions of the Gunpowder River (Dundee Creek and Saltpeter Creek)	1,177	1,313	1,252	1,193
	Air Deposition on Tidal Waters	3,292	3,292	3,292	3,292
	Portions of Harford County				
	GUNOH1 Total Phosphorus Load	**48,316**	**49,466**	**47,224**	**45,260**
MIDOH	Middle River	4,139	3,806	2,617	1,284
	Portions of the Gunpowder River (Seneca Creek)	294	328	313	298
	Air Deposition on Tidal Waters	2,267	2,267	2,267	2,267
	MIDOH Total Phosphorus Load	**6,700**	**6,401**	**5,197**	**3,849**
BACOH	Back River	16,434	16,058	13,404	10,601
	Air Deposition on Tidal Waters	2,250	2,250	2,250	2,250
	BACOH Total Phosphorus Load	**18,684**	**18,308**	**15,654**	**12,851**

CB2OH	GUNOH1 and all contributing watersheds to GUNOH1	48,316	49,466	47,224	45,260
	MIDOH and Middle River Watershed	6,700	6,401	5,197	3,849
	BACOH and Back River Watershed	18,684	18,308	15,654	12,851
	Air Deposition on Tidal Waters	38,602	38,602	38,602	38,602
	Portions of Harford, Kent Counties and Upstream flows from Susquehanna River				
	CB2OH Total Phosphorus Load	**112,302**	**112,777**	**106,677**	**100,562**
PATMH	Liberty Reservoir	564	572	547	537
	Patapsco River	16,048	18,083	17,983	17,846
	Gwynns Falls	19,932	21,469	21,464	21,429
	Jones Falls	15,166	15,108	14,179	13,611
	Baltimore Harbor Direct	9,615	8,997	7,802	6,385
	Air Deposition on Tidal Waters	13,102	13,102	13,102	13,102
	Portions of Anne Arundel County and Baltimore City				
	PATMH Total Phosphorus Load	**74,427**	**77,331**	**75,077**	**72,910**
CB3MH	CB2OH and all contributing watersheds and tidal segments	112,302	112,777	106,677	100,562
	PATMH and all contributing watersheds	74,427	77,331	75,077	72,910
	Air Deposition on Tidal Waters	51,920	51,920	51,920	51,920
	Portions of Harford, Kent Counties and Upstream flows from Susquehanna River				
	CB3MH Total Phosphorus Load	**238,649**	**242,028**	**233,674**	**225,392**

Table B-34: Tidal Segment Nitrogen Loadings

Tidal Segment Designation	**Contributing Watersheds**	**1997**	**2005**	**2020**	**2035**
GUNOH2	Prettyboy Reservoir	1,462	1,395	1,324	1,311
	Loch Raven Reservoir	144,087	137,757	130,571	127,341
	Lower Gunpowder Falls	266,464	253,683	232,399	217,172
	Little Gunpowder Falls	170,659	158,063	143,052	137,374
	Bird River	112,823	109,459	93,459	75,714
	Air Deposition on Tidal Waters	48,300	48,300	48,300	48,300
	Portions of Harford County				
	GUNOH2 Total Nitrogen Load	**743,795**	**708,657**	**649,105**	**607,212**
GUNOH1	GUNOH2 and all watersheds that drain to GUNOH2	743,795	708,657	649,105	607,212
	Portions of the Gunpowder River (Dundee Creek and Saltpeter	20,952	21,297	20,206	19,294
	Creek)	60,638	60,638	60,638	60,638
	Air Deposition on Tidal Waters				
	Portions of Harford County				
	GUNOH1 Total Nitrogen Load	**825,385**	**790,592**	**729,949**	**687,144**
MIDOH	Middle River	46,067	46,355	44,246	40,350
	Portions of the Gunpowder River (Seneca Creek)	5,238	5,324	5,052	4,823
	Air Deposition on Tidal Waters	41,759	41,759	41,759	41,759
	MIDOH Total Nitrogen Load	**93,064**	**93,438**	**91,057**	**86,932**
BACOH	Back River	171,271	170,675	161,687	151,054
	Air Deposition on Tidal Waters	41,444	41,444	41,444	41,444
	BACOH Total Nitrogen Load	**212,715**	**212,119**	**203,131**	**192,498**

CB2OH	GUNOH1 and all contributing watersheds to GUNOH1	825,385	790,592	729,949	687,144
	MIDOH and Middle River Watershed	93,064	93,438	91,057	86,932
	BACOH and Back River Watershed	212,715	212,119	203,131	192,498
	Air Deposition on Tidal Waters	711,092	791,092	791,092	791,092
	Portions of Harford, Kent Counties and Upstream flows from Susquehanna River				
	CB2OH Total Nitrogen Load	**1,842,256**	**1,887,241**	**1,815,229**	**1,757,666**
PATMH	Liberty Reservoir	7,635	7,474	7,093	6,940
	Patapsco River	239,736	260,156	258,977	255,886
	Gwynns Falls	241,769	243,233	241,498	239,306
	Jones Falls	224,991	220,038	206,412	196,604
	Baltimore Harbor Direct	96,552	92,748	86,929	80,322
	Air Deposition on Tidal Waters	241,353	241,353	241,353	241,353
	Portions of Anne Arundel County and Baltimore City				
	PATMH Total Nitrogen Load	**1,052,036**	**1,065,002**	**1,042,262**	**1,020,411**
CB3MH	CB2OH and all contributing watersheds and tidal segments	1,842,256	1,887,241	1,815,229	1,727,666
	PATMH and all contributing watersheds	1,052,036	1,065,002	1,042,262	1,020,411
	Air Deposition on Tidal Waters	956,414	956,414	956,414	956,414
	Portions of Harford, Kent Counties and Upstream flows from Susquehanna River				
	CB3MH Total Nitrogen Load	**3,850,706**	**3,908,657**	**3,813,905**	**3,704,491**

B.4 Future Improvements

The pollutant loading analysis is dependant on the resolution of the data that is input into the analysis. In order to improve future Water Resource Element analysis, a number of improvements are recommended, including:

- Improve the land use GIS data layer. The Maryland Department of Planning land use data layer resolution is limited, particularly in reference to low density residential. While modifications of the low density residential land use were made for the purposes of this analysis, greater accuracy in the land use classification will result in removing some of the variability and uncertainty in the analysis.
- Develop better techniques to track population changes by Water Quality Planning Area. This is crucial to forecasting land use changes.
- Use Chesapeake Bay Watershed Model 5.3 pollutant loadings by segment for all land uses. The current analysis assumes that all the agricultural and forest BMPs have been installed in accordance with the Tributary Strategies. This results in an under estimation of the actual pollutant loads.
- Develop a better tracking system for redevelopment and revitalization projects.

- Develop a better assessment of the pollutant load reduction benefits of redevelopment, particularly as the new 2007 stormwater regulations are applied to redevelopment.
- Refine the restoration analysis and needs based on project type and cost per pound of removal.

Baltimore County WRE Technical Memo – B
Appendix A: Results for Tributary Strategy Basins and 8-Digit Watersheds

This appendix will provide the results of the pollutant loading analysis for the two Maryland Tributary Strategy Basins (Section A.1) and the fourteen 8-digit watersheds (Section A.2). The land use, phosphorus and nitrogen loading results from each scenario will be presented. Each scenario will include the effect of stormwater management on urban nutrient reduction, and basin or watershed specific nutrient load reductions from restoration practices. Future stormwater management is based on implementation of Environmental Site Design (ESD) practices for Scenarios 1 and 2, while the redevelopment scenarios pollutant load reduction is based on recent redevelopment projects within Baltimore County. The restoration progress is based on actual restoration that has taken place in the basin or watershed and projected forward on an annualized basis.

The scenarios will be compared with a 15% and a 36% urban phosphorus and nitrogen reduction. The 15% reduction is based on local Total Maximum Daily Load (TMDL) results for some of the watersheds within Baltimore County and the "assurances of implementation" section of the TMDL, which applies a 15% nutrient reduction from urban stormwater sources to meet the TMDL reduction requirements. The 36% reduction is based on a potential reduction requirement from urban stormwater sources needed to meet the Chesapeake Bay TMDL that is currently in development. The final urban reduction requirement for the Chesapeake Bay may be different and has the potential to vary by watershed. A cost analysis based on expenditures of the capital program, and pounds of phosphorus and nitrogen removed is included in each section. The cost analysis indicates additional capital expenditures needed for each basin and watershed to meet the 15% and 36% nutrient reduction targets by 2020.

A.1 Maryland Tributary Strategy Basins

The state of Maryland has designated ten (10) Tributary Strategy Basins in response to the Chesapeake Bay efforts to reduce nutrients and sediment delivery to the Bay. Baltimore County has a portion of the drainage area of two of the Tributary Strategy Basins. The Upper Western Shore Tributary Strategy Basin contains the Gunpowder Basin with seven 8-digit watersheds in Baltimore County, and Deer Creek in the Susquehanna Basin. The Upper Western Shore Basin also includes drainage from Carroll, Harford, and Cecil Counties. The Patapsco/Back River Tributary Strategy Basin contains six 8-digit watersheds in Baltimore County. The Patapsco/Back River Basin includes drainage from Carroll, Howard, and Anne Arundel Counties, and all of Baltimore City. Only the Baltimore County portion of each basin is included in this analysis.

A.1.1 Upper Western Shore

The Upper Western Shore Tributary Basin is composed of parts of Cecil, Carroll, and Baltimore Counties, along with all of Harford County. In Baltimore County it includes the seven 8-digit watersheds in the Gunpowder River Basin and Deer Creek in the Susquehanna River Basin. All tables and graphs are presented after the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-1 for each 8-digit watershed and in total. The data is displayed as population in the rural section of each watershed (outside the Urban-Rural Demarcation Line, or URDL) and as population in the urban section (inside the URDL).

The majority of the population in 2005 was located within the urban areas (76.1%) and is projected to maintain approximately the same proportion. There will be a slight increase to 76.2% in the urban area. The population growth is expected to slow in later time periods. The annual growth rate will decrease from ~2,600 per year in the 1997 – 2005 time period to ~1,500 and ~425 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively.

The Upper Western Shore Tributary Basin contains 63.9% of the land in Baltimore County and 31.5% of the population. In the future the percent of the population located in the Upper Western Shore is expected to increase slightly to 32.1%.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-2. An additional 10,254 acres of urban land will be developed during the 2005 – 2035 time frame, almost all at the expense of agricultural land. Forest land is projected to be virtually unchanged, although the distribution of forest land will change with additional forest acres in the rural areas and decrease in the urban area. The overall percentage of urban land will increase from 22.9% in 2005 to 27.1% in 2035. The Baltimore County portion of the Upper Western Shore Tributary Basin is projected to remain primarily rural.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-3 and A-4, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in a decrease in phosphorus by 2,414 pounds by 2035 relative to 1997. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 5,729 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 13,750 pounds. Through 2005, restoration activities have achieved 2,423 pounds of reduction, or ~42.3% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 time frame due to development (1,434 pounds), progress toward meeting the 15% reduction target was only 989 pounds or only 17.3%.

Nitrogen pollutant loads (Table A-4) showed an overall decrease from 1997 – 2035. The increase in the urban nitrogen load was more than offset by the decrease in agricultural nitrogen loads. When coupled with Environmental Site Design, which will further decrease nitrogen loads for new development by 50%, a total decrease in nitrogen load of 166,165 pounds by 2020 and >198,000 pounds by 2035 results. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 60,896 pounds of urban nitrogen. A 36% urban nitrogen reduction that may be required by the Chesapeake Bay TMDL would require the reduction of 146,150 pounds of nitrogen. The both the 15% and 36% nitrogen reduction targets can be met by 2020 in the Upper Western Shore Tributary Basin through the Scenario 1 land use change, implementation of ESD, and restoration efforts. Restoration efforts through 2005 have resulted in a reduction of 22,855 pounds of nitrogen. Overall, implementation of stormwater management, restoration efforts, and land use changes through 2005 have resulted in meeting 61.7% or a 15% reduction goal.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the population would be served by public water and sewer.

Table A-5 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development (3,469 acres versus 10,254) compared to Scenario 1, but most of the land use change would come at the expense of forest. This Scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land uses.

Tables A-6 and A-7 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 time frame, as those changes are based on development activities that have already occurred. Because the land use change involves mainly conversion for forest to urban land use, the phosphorus load will increase by 1,222 pounds in the 2005 – 2020 time frame, even with ESD. The cost to address this additional phosphorus load created through development would be ~$10.9 million.

Nitrogen under this scenario would also increase by 3,476 pounds, requiring an additional $3.5 million to address the development load.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-8 presents the number of acres needed to absorb the projected population increase in the Upper Western Shore Tributary Basin, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 3,723 acres of land for potential redevelopment identified. This provides sufficient acreage to meet the redevelopment needs of all the redevelopment scenarios with the exception of Scenario 3c, where an additional 181 acres of urban land would need to be identified. The amount of redevelopment needed ranged from 2% to 13% of the urban land within the URDL.

Table A-9 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most amount of phosphorus and nitrogen removal. Table A-10 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. All redevelopment scenarios would be able to meet the 15% phosphorus reduction by 2020, while none of the redevelopment scenarios would meet the 36% phosphorus reduction by 2035. Table A-11 displays the same information for nitrogen. This table shows that the 15% reduction of nitrogen was already met by 2005 (development that has already occurred has reduced nitrogen by at least 15% in the 1997 – 2005 time frame, much of the reduction was through land use conversion and restoration efforts). All redevelopment scenarios can meet the 36% nitrogen reduction by 2020.

Scenario Comparisons

Tables A-12 and A-13 show the comparison of all scenarios considered in the Upper Western Shore Basin for phosphorus and nitrogen, respectively. The only scenario that would not meet the 15% phosphorus reduction by 2020 is Scenario 2 – All Development Inside the URDL. None of the scenarios would meet a 36% phosphorus reduction by 2020, but one (Scenarios 1) would meet that reduction target by 2035. All Scenarios would meet the 15% reduction target for nitrogen by 2020, in fact these reduction targets have already been met in 2005. The 36% nitrogen reduction target would be met by 2020 by all scenarios with the exception of Scenario 2.

Cost of Meeting Nutrient TMDLs by 2020

In order to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, the information in Tables A-12 and A-13 was used. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used in Table A-12 for phosphorus and A-13 for nitrogen. Based the capital program expenditures in the 1997 – 2005 time frame and the pounds of phosphorus and nitrogen removed through capital project implementation; a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are displayed in Table A-14 for phosphorus and Table A-15 for nitrogen. For the Upper Western Shore, only Scenario 2 would require additional capital expenditure to meet a 15% phosphorus reduction ($662,000 per year would be required). To meet a 36% phosphorus reduction by 2020, all scenarios would require additional capital funding. The additional funding would range from $4-7.8 million per year depending on the scenario. All Scenarios would meet both a 15% and a 36% reduction of urban nitrogen by 2020.

Table A-1: Population Changes – Upper Western Shore

Deer Creek	1,450	-	1,450	1,502	-	1,502	1,575	-	1,575	1,604	-	1,604
Prettyboy Reservoir	4,001	-	4,001	3,975	-	3,795	4,430	-	4,430	4,520	-	4,520
Loch Raven Reservoir	31,350	50,894	82,244	35,502	56,620	92,122	38,833	61,932	100,765	39,770	63,426	103,196
Lower Gunpowder	7,171	38,897	46,068	7,611	43,556	51,167	8,030	45,953	53,983	8,190	46,871	55,061
Little Gunpowder	6,905	-	6,905	7,353	-	7,353	7,867	-	7,867	8,056	-	8,056
Bird River	1,294	48,678	49,972	1,310	55,891	57,201	1,481	63,202	64,683	1,525	65,048	66,573
Gunpowder River	852	8,012	8,864	728	7,850	8,578	767	8,268	9,035	781	8,425	9,206
Middle River	1,321	27,381	28,702	1,433	25,702	27,135	1,541	27,643	29,184	1,570	28,163	29,733
				23.9%	**76.1%**		**23.8%**	**76.2%**		**23.8%**	**76.2%**	
Deer Creek – Population changes				52	-	52	73	-	73	29	-	29
Prettyboy Reservoir – Population changes				-26	-	-26	455	-	455	90	-	90
Loch Raven Res. – Population changes				4,152	5,726	9,878	3,331	5,312	8,643	937	1,494	2,431
Lower Gunpowder – Population changes				440	4,659	5,099	419	2,397	2,816	160	918	1,078
Little Gunpowder – Population changes				448	-	448	514	-	514	189	-	189
Bird River – Population changes				16	7,213	7,229	171	7,311	7,482	43	1,847	1,890
Gunpowder River – Population changes				-124	-162	-286	39	418	457	15	156	171
Middle River – Population changes				112	-1,679	-1,567	108	1,941	2,049	29	520	549
Upper Western Shore Total Population Change				**5,070**	**15,757**	**20,827**	**5,110**	**17,379**	**22,489**	**1,492**	**4,935**	**6,427**
Percent Distribution				**24.3%**	**76.1%**		**22.7%**	**77.3%**		**23.2%**	**76.2%**	

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Table A-2: Scenario 1 - Land Use Changes (Acres) – Upper Western Shore Tributary Basin

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	3,244	7,122	10,366	3,956	8,596	12,552	4,663	9,924	14,587	4,887	10,292	15,179
Pervious Urban HD	2,435	15,559	17,994	10,135	17,786	27,921	17,256	19,445	36,702	19,395	19,884	39,279
Pervious Urban LD	14,892	4,250	19,142	13,091	3,234	16,325	11,032	2,472	13,505	10,344	2,280	12,624
Cropland	73,059	2,799	75,857	61,718	2,060	63,778	50,948	1,504	52,453	47,612	1,348	48,961
Pasture	16,166	395	16,561	19,508	360	19,868	23,084	369	23,453	24,321	402	24,723
Livestock Feeding	427	0	427	382	0	382	347	0	347	337	0	337
Forest	90,507	12,438	102,945	91,981	10,664	102,644	93,462	8,995	102,457	93,904	8,499	102,403
Water	3,888	190	4,078	3,684	22	3,706	3,631	11	3,641	3,615	9	3,624
Bare Soil	243	156	399	408	186	594	438	187	629	447	194	641
Total	**204,861**	**42,908**	**247,769**	**204,861**	**42,908**	**247,769**	**204,862**	**42,908**	**247,770**	**204,863**	**42,908**	**247,770**
Total Urban	20,572	26,931	47,502	27,181	29,616	56,798	32,952	31,842	64,794	34,626	32,456	67,082
Total Agriculture	89,651	3,194	92,845	81,608	2,420	84,028	74,379	1,873	76,252	72,271	1,750	74,021
Total Forest	90,507	12,438	102,945	91,981	10,664	102,645	93,462	8,995	102,457	93,904	8,499	102,403
% Urban	10.0%	62.8%	19.2%	13.3%	69.0%	22.9%	**16.1%**	**74.2%**	**26.6%**	**16.9%**	**75.6%**	**27.1%**
% Agriculture	43.8%	7.4%	37.5%	39.8%	5.6%	33.9%	**36.3%**	**4.4%**	**30.3%**	**35.3%**	**4.1%**	**29.9%**
% Forest	44.2%	29.0%	41.5%	44.9%	24.9%	41.4%	**45.6%**	**21.0%**	**41.5%**	**45.8%**	**19.8%**	**41.3%**
Change in Urban from previous time period				**6,609**	**2,686**	**9,295**	**5,770**	**2,226**	**7,996**	**1,674**	**614**	**2,288**
Change In Agriculture from previous time period				**-8,044**	**-773**	**-8,817**	**-7,228**	**-547**	**-7,775**	**-2,109**	**-123**	**-2,232**
Change in Forest from previous time period				**1,474**	**-1,774**	**-301**	**1,482**	**-1,669**	**-187**	**441**	**-496**	**-55**

Table A-3: Scenario 1 - Phosphorus Load Changes (Pounds)– Upper Western Shore

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	14,741	24,615	39,356	18,898	28,474	47,372	22,686	31,865	54,552	23,821	32,803	56,624
Agriculture	65,195	2,235	67,430	59,219	1,701	60,920	53,763	1,322	55,085	52,144	1,237	53,381
Forest	1,834	249	2,083	1,865	213	2,078	1,897	180	2,077	1,906	170	2,076
Water	2,216	108	2,325	2,100	12	2,112	2,069	6	2,075	2,061	5	2,066
Bare Soil	178	103	281	287	129	416	308	133	442	315	139	453
Total	**84,164**	**27,311**	**111,475**	**82,368**	**30,530**	**112,898**	**80,724**	**33,506**	**114,230**	**80,247**	**34,354**	**114,601**
Change in Urban from previous time period				4,157	3,859	8,016	3,788	3,391	7,179	1,134	938	2,073
Change in Agriculture from previous time period				-5,976	-534	-6,510	-5,456	-379	-5,835	-1,619	-85	-1,704
Change in Forest from previous time period				31	-35	-4	32	-33	-2	10	-10	0
Total Change from previous time period				**-1,795**	**3,219**	**1,423**	**-1,645**	**2,977**	**1,332**	**-447**	**848**	**371**
Urban BMPs	-303	-858	-1,161	-294	-856	-1,161	-2,567	-2,891	-5,457	-3,248	-3,453	-6,701
CIP Restoration	0	0	0	0	-1,809	-1,809	0	-5,684	-5,684	0	-9,560	-9,560
Reforestation	0	0	0	-18	-18	-36	-45	-45	-89	-72	-72	-143
Other Reductions	0	0	0	-27	-551	-578	-27	-678	-705	-27	-678	-705
Total Reductions	**-303**	**-858**	**-1,161**	**-339**	**-3,234**	**-3,573**	**-2,639**	**-9,298**	**-11,936**	**-3,346**	**-13,763**	**-17,109**
Total with Urban BMPs	83,861	26,454	110,314	82,074	29,674	111,748	78,157	30,616	108,773	76,999	30,901	107,900
Total With Urban BMPs and Restoration	83,861	26,454	110,314	82,029	27,296	109,326	78,085	24,209	102,294	76,900	20,591	97,492

Table A-4: Scenario 1 - Nitrogen Load Changes – Upper Western Shore (Pounds x 1,000)

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	171.2	244.0	415.2	224.0	273.6	497.6	270.7	298.8	569.5	284.4	305.8	590.1
Agriculture	1,319.4	43.4	1,362.8	1,158.5	32.4	1,190.9	1,011.5	24.5	1,036.1	967.3	22.5	989.9
Forest	129.2	16.7	145.9	131.5	14.3	145.8	133.8	12.1	145.9	134.5	11.4	145.9
Other	40.9	2.8	43.7	39.8	1.4	41.2	39.4	1.4	40.8	39.3	1.5	40.8
Septic	208.8	35.7	244.5	228.5	36.3	264.8	246.9	35.8	282.7	252.1	34.4	286.5
Total	**1,869.6**	**342.6**	**2,212.1**	**1,782.3**	**358.0**	**2,140.3**	**1,702.3**	**372.7**	**2,075.0**	**967.3**	**375.6**	**2,053.3**
Change in Urban from previous time period				52.8	29.6	82.4	46.7	25.2	71.9	13.7	7.0	20.7
Change in Septic from previous time period				19.7	0.6	20.3	18.3	-0.5	17.9	5.2	-1.4	3.8
Change in Agriculture from previous time period				-161.0	-11.0	-171.9	-147.0	-7.9	-154.9	-44.1	-2.0	-46.2
Change in Forest from previous time period				2.3	-2.4	-0.1	2.3	-2.2	0.1	0.7	-0.7	0.0
Total Change from previous time period				**-87.3**	**15.4**	**-71.8**	**-80.0**	**14.7**	**-65.3**	**-24.7**	**2.9**	**-21.7**
Urban BMPs	-3.0	-6.3	-9.2	-3.5	-8.8	-12.3	-26.9	-21.4	-48.3	-33.7	-24.9	-58.6
CIP Restoration	0	0	0	0	-20.6	-21.7	0	-64.9	-64.9	0	-109.1	-109.1
Reforestation	0	0	0	-0.3	-0.3	-2.4	-0.6	-0.6	-1.3	-1.0	-1.0	-2.0
Other Reductions	0	0	0	-.1	-1.6	-1.2	-.1	-2.5	-2.6	-.1	-2.5	-2.6
Total Reductions	**-3.0**	**-6.3**	**-9.2**	**-3.9**	**-31.3**	**-35.2**	**-27.6**	**-89.4**	**-117.0**	**-34.8**	**-137.6**	**-172.4**
Total with Urban BMPs	1,866.6	336.3	2,202.9	1,778.8	349.2	2,128.0	1,675.4	351.3	2,027.0	1,643.9	350.7	1,994.7
Total With Urban BMPs and Restoration	1,866.6	336.3	2,202.9	1,778.4	326.7	2,105.1	1,674.7	283.2	1,957.9	1,642.9	238.0	1,880.9

Table A-5: Scenario 2 – Future Land Use Changes (Acres) – Upper Western Shore

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	3,956	8,596	12,552	3,956	10,217	14,173	3,956	10,670	14,626
Urban Pervious HD	10,135	17,786	27,921	10,135	19,858	29,993	10,135	20,418	30,553
Urban Pervious LD	13,091	3,234	16,325	13,091	2,255	15,345	13,091	1,997	15,087
Cropland	61,718	2,060	63,778	61,718	1,440	63,158	61,718	1,261	62,979
Pasture	19,508	360	19,867	19,508	403	19,910	19,508	448	19,956
Livestock Feeding	382	0	382	382	0	382	382	0	382
Forest	91,981	10,664	102,644	91,981	8,521	100,502	91,981	7,886	99,867
Water	3,684	22	3,705	3,684	9	3,693	3,684	9	3,693
Bare Soil	408	186	594	408	204	612	408	217	625
Total	**204,861**	**42,908**	**247,769**	**204,861**	**42,908**	**247,769**	**204,861**	**42,908**	**247,769**
Total Urban	27,181	29,616	56,797	27,181	32,330	59,512	27,181	33,085	60,266
Total Agriculture	81,608	2,420	84,028	81,608	1,843	83,450	81,608	1,710	83,317
Total Forest	91,981	10,664	102,644	91,981	8,521	100,502	91,981	7,886	99,867
% Urban	13.3%	69.0%	22.9%	13.3%	75.3%	24.0%	13.3%	77.1%	24.3%
% Agriculture	39.8%	5.6%	33.9%	39.8%	4.3%	33.7%	39.8%	4.0%	33.6%
% Forest	44.9%	24.9%	41.4%	44.9%	19.9%	10.6%	44.9%	18.4%	40.3%
Change in Urban from previous period				**0**	**2,714**	**2,714**	**0**	**755**	**755**
Change in Agricultural from previous period				**0**	**-578**	**-578**	**0**	**-133**	**-133**
Change in Forest from previous period				**0**	**-2,142**	**-2,142**	**0**	**-635**	**-635**

Table A-6: Scenario 2 – Phosphorus Load Changes (Pounds) – Upper Western Shore

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	18,898	28,474	47,372	18,898	32,613	51,511	18,898	33,768	52,666
Agriculture	59,219	1,701	60,920	59,219	1,301	60,520	59,219	1,209	60,428
Forest	1,865	213	2,078	1,865	170	2,035	1,865	158	2,023
Water	2,100	12	2,112	2,100	5	2,105	2,100	5	2,105
Bare Soil	286	129	416	286	146	432	286	156	443
Total	**82,368**	**30,530**	**112,898**	**82,368**	**34,235**	**116,603**	**82,368**	**35,295**	**117,664**
Change in Urban from previous period				0	4,139	4,139	0	1,155	1,155
Change in Agricultural from previous period				0	-400	-400	0	-92	-92
Change in Forest from previous period				0	-43	-43	0	-13	-13
Total Phosphorus Change				**0**	**3,705**	**3,705**	**0**	**1,061**	**1,061**
Urban BMPs	-294	-856	-1,150	-294	-3,339	-3,633	-294	-4,032	-4,326
CIP Restoration	0	-1,809	-1,809	0	-5,684	-5,684	0	-9,560	-9,560
Reforestation	-18	-18	-36	-45	-45	-89	-72	-72	-143
Other Reductions	-27	-551	-578	-27	-678	-705	-27	-678	-705
Total	**-339**	**-3,234**	**-3,573**	**-366**	**-9,746**	**-10,112**	**-393**	**-14,342**	**-14,734**
Total with Urban BMPs	82,074	29,674	111,748	82,074	30,896	112,970	82,074	31,263	113,338
Total with Urban BMPs and Restoration	82,029	27,296	109,326	82,003	24,489	106,491	81,976	20,954	102,930

Table A-7: Scenario 2 – Nitrogen Load Changes (Pounds) – Upper Western Shore

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	224,031	273,570	497,601	224,031	304,362	528,393	224,031	312,939	536,970
Agriculture	1,158,487	32,429	1,190,916	1,158,487	23,783	1,182,270	1,158,487	21,479	1,179,966
Forest	131,484	14,288	145,772	131,484	11,398	142,882	131,484	10,538	142,022
Water	37,031	217	37,248	37,031	89	37,120	37,026	95	37,121
Bare Soil	2,724	1,205	3,929	2,726	1,418	4,143	2,726	1,533	4,259
Septic	228,529	36,290	264,819	228,529	35,822	264,350	228,529	34,430	262,959
Total	**1,782,281**	**357,999**	**2,140,281**	**1,782,281**	**376,872**	**2,159,153**	**1,782,281**	**381,015**	**2,163,297**
Change in Urban from previous period				0	30,792	30,792	0	8,577	8,577
Change in Septic from previous period				0	-469	-469	0	-1,391	-1,391
Change in Agricultural from previous period				0	-8,646	-8,646	0	-2,304	-2,304
Change in Forest from previous period				0	-2,890	-2,890	0	-859	-859
Total Change				**0**	**18,872**	**18,872**	**0**	**4,143**	**4,143**
Urban BMPs	-3,527	-8,768	-12,295	-3,527	-24,164	-27,691	-3,527	-28,453	-31,979
CIP Restoration	0	-20,648	-20,648	0	-64,893	-64,893	0	-109,139	-109,139
Reforestation	-255	-255	-511	-638	-638	-1,277	-1,021	-1,021	-2,043
Other Reductions	-70	-1,627	-1,697	-70	-2,524	-2,594	-70	-2,524	-2,594
Total	**-3,852**	**-31,298**	**-35,150**	**-4,235**	**-92,220**	**-96,455**	**-4,618**	**-141,137**	**-145,755**
Total with Urban BMPs	1,778,755	349,231	2,127,986	1,778,755	352,708	2,131,462	1,778,755	352,563	2,131,317
Total with Urban BMPs and Restoration	1,778,429	326,701	2,105,131	1,778,046	284,652	2,062,699	1,777,663	239,879	2,017,542

Table A-8: Acres of Redevelopment Needed to Meet Upper Western Shore Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	2,631	752	3,383	3,723	340	11.4 %
3b	270	77	347	3,723	3,376	1.2%
3c	3,036	868	3,904	3,723	-181	13.2%
3d	472	135	607	3,723	3,116	2.0 %

Table A-9: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 nitrogen loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	2,631	26,838	6,710	752	7,670	1,917
Low – 3b	25%	270	2,753	688	77	787	197
High/Parks – 3c	59%	3,036	30,967	18,271	868	8,850	5,221
Low/Parks – 3d	59%	472	4,817	2,842	135	1,377	812
2005 phosphorus loading –1.22	**Reduction %**						
High	23%	2,631	3,210	738	752	917	211
Low	23%	270	329	76	77	94	22
High/Parks	55%	3,036	3,704	2,037	868	1,059	582
Low/Parks	55%	472	576	317	135	165	91

Table A-10: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	105,746	97,725	110,314	109,326	104,531	100,391
Low – 3b	105,746	97,725	110,314	109,326	105,194	101,243
High/Parks – 3c	105,746	97,725	110,314	109,326	103,232	98,721
Low/Parks – 3d	105,746	97,725	110,314	109,326	104,953	100,933

Table A-11: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	2,151,217	2,065,963	2,202,876	2,105,131	2,052,513	2,005,583
Low – 3b	2,151,217	2,065,963	2,202,876	2,105,131	2,058,534	2,013,326
High/Parks – 3c	2,151,217	2,065,963	2,202,876	2,105,131	2,040,951	1,990,718
Low/Parks – 3d	2,151,217	2,065,963	2,202,876	2,105,131	2,056,380	2,010,556

Table A-12: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	105,746	97,725	110,314	109,326	102,294	-3,452	4,569	97,492	-8,254	-233
Scenario 2 – All Development within URDL	105,746	97,725	110,314	109,326	106,491	745	8,766	102,930	-2,816	5,205
Scenario 3a – All Redevelopment – High	105,746	97,725	110,314	109,326	104,887	-1,215	6,806	97,213	-5,355	2,666
Scenario 3b – All Redevelopment – Low	105,746	97,725	110,314	109,326	105,549	-552	7,469	100,917	-4,503	3,518
Scenario 3c – All Redevelopment – High/Parks	105,746	97,725	110,314	109,326	103,588	-2,514	5,507	96,578	-7,025	996
Scenario 3d – All Redevelopment – Low/Parks	105,746	97,725	110,314	109,326	105,308	-793	7,228	100,599	-4,813	3,208

Table A-13: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	2,151,217	2,065,963	2,202,876	2,105,131	1,957,942	-193,275	-108,021	1,880,894	-270,323	-185,069
Scenario 2 – All Development within URDL	2,151,217	2,065,963	2,202,876	2,105,131	2,062,699	-88,518	-3,264	2,017,542	-133,675	-48,421
Scenario 3a – All Redevelop-ment – High	2,151,217	2,065,963	2,202,876	2,105,131	2,052,513	-98,704	-13,450	2,005,583	-145,634	-60,380
Scenario 3b – All Redevelop-ment – Low	2,151,217	2,065,963	2,202,876	2,105,131	2,058,534	-92,683	-7,429	2,013,326	-137,891	-52,637
Scenario 3c – All Redevelop-ment – High/Parks	2,151,217	2,065,963	2,202,876	2,105,131	2,028,255	-110,266	-25,012	1,990,718	-160,499	-75,245
Scenario 3d – All Redevelop-ment – Low/Parks	2,151,217	2,065,963	2,202,876	2,105,131	2,054,405	-94,837	-9,583	2,010,556	-140,661	-55,407

Table A-14: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	105,746	97,725	102,294	-3,452	4,569	$0	$40,614	$0	$4,061
Scenario 2 – All Development within URDL	180,652	158,224	106,491	745	8,766	$6,622	$77,921	$662	$7,792
Scenario 3a – All Redevelopment – High	180,652	158,224	104,887	-1,215	6,806	$0	$60,499	$0	$6,050
Scenario 3b – All Redevelopment – Low	180,652	158,224	105,549	-552	7,469	$0	$66,392	$0	$6,639
Scenario 3c – All Redevelopment – High/Parks	180,652	158,224	103,588	-2,514	5,507	$0	$48,952	$0	$4,895
Scenario 3d – All Redevelopment – Low/Parks	180,652	158,224	105,308	-793	7,228	$0	$64,250	$0	$6,425

Table A-15: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds (x 1,000)		Pounds (x 1,000)			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	2,151	2,065	1,958	-193	-108	$0	$0	$0	$0
Scenario 2 – All Development within URDL	2,151	2,065	2,063	-88	-3	$0	$0	$0	$0
Scenario 3a – All Redevelopment – High	2,151	2,065	2,052	-99	-13	$0	$0	$0	$0
Scenario 3b – All Redevelopment – Low	2,151	2,065	2,059	-93	-7	$0	$0	$0	$0
Scenario 3c – All Redevelopment – High/Parks	2,151	2,065	2,028	-123	-38	$0	$0	$0	$0
Scenario 3d – All Redevelopment – Low/Parks	2,151	2,065	2,054	-97	-12	$0	$0	$0	$0

A.1.2 Patapsco/Back River

The Patapsco/Back River Tributary Basin is composed of parts of Carroll, Howard, Anne Arundel, and Baltimore County, and all of Baltimore City. In Baltimore County it includes parts of six 8-digit watersheds of the Patapsco River Basin.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-16 for each 8-digit watershed, and in total. The data are displayed as population in the rural section of each watershed (outside the Urban-Rural Demarcation Line, or URDL) and as population in the urban section (inside the URDL).

The majority of the population in 2005 was located within the urban areas (96.5%) and is projected to maintain approximately the same proportion. The Patapsco/Back River Tributary Basin is projected to receive ~62% of the future population growth. The annual growth rate will decrease from ~5,800 per year in the 1997 – 2005 time period to ~2,400 and ~800 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Patapsco/Back River Tributary Basin contains 36.1% of the land in Baltimore County and 68.5% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-17. An additional 9,704 acres of urban land will be developed during the 2005 – 2035 time frame, at the expense of agricultural land and forest land. Forest land is projected to decrease by 5,200 acres and agriculture is projected to decrease by 4,200 acres. The overall percentage of urban land will increase from 60.1% in 2005 to 67.0% in 2035. The Baltimore County portion of the Patapsco/Back River Tributary Basin is projected to continue to urbanize.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-18 and A-19, respectively. These tables represent the results of Scenario 1 –

development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in an increase in phosphorus by 7,812 pounds by 2035 relative to 1997. Much of this increase (6,706 pounds) has already occurred due to development in the 1997 – 2005 time frame. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 10,291 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 24,697 pounds. Through 2005 restoration activities have achieved 4,090 pounds of reduction, or ~17% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 time frame due to development (6,706 pounds), progress toward meeting the 15% reduction target is negative with a 2,616 increase in the phosphorus load.

Nitrogen pollutant loads (Table A-19) also showed an overall increase (20,667 pounds) from 1997 – 2035, even with implementation of Environmental Site Design. The increase in nitrogen occurred in the 1997 – 2005 time frame, with slight decreases in the nitrogen load during future development. The continued implementation of capital restoration projects results in a total decrease in nitrogen load of 52,457 pounds by 2020 and 84,620 pounds by 2035 results. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 100,595 pounds of urban nitrogen. A 36% urban nitrogen reduction that may be required by the Chesapeake Bay TMDL would require the reduction of 241,428 pounds of nitrogen. The 15% reduction cannot be met by 2020 in the Patapsco/Back River Tributary Basin through the Scenario 1 land use change, implementation of ESD, and restoration efforts. Restoration efforts through 2005 have resulted in a reduction of 19,600 pounds of nitrogen. Urban development in the Patapsco/Back River Tributary Basin during the same time period resulted in an increase of the nitrogen load by 29,200 pounds. When coupled with the capital restoration, there was an overall increase in the nitrogen load of 9,600 pounds of nitrogen. As with phosphorus, progress toward meeting the nitrogen reduction goal is negative.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the new population would be served by public water and sewer.

Table A-20 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development compared to Scenario 1 (5,402 acres versus 9,704 acres), but most of the land use change would come at the expense of forest (-3,738 acres). There would be fewer acres of forest loss compared to Scenario 1 (3,738 acres versus 5,200 acres). This Scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land uses.

Tables A-21 and A-22 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 timeframe, as those changes are based on development activities that have already occurred. Because the land use change involves mainly conversion for forest to urban land use, the phosphorus load will increase by 1,325 pounds in the 2005 – 2020 timeframe, even with ESD. The cost to address this additional phosphorus load created through development would be ~$11.8 million.

Nitrogen under this scenario would decrease by 1,681 pounds, and would no additional funds to address the development load.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-23 presents the number of acres needed to absorb the projected population increase in the Patapsco/Back River Tributary Basin, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 9,409 acres of land for potential redevelopment identified. This provides sufficient acreage to meet the redevelopment needs of all the redevelopment scenarios. The amount of redevelopment needed ranged from 0.8% to 8.6% of the urban land.

Table A-24 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most amount of phosphorus and nitrogen removal. Table A-25 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. None of the redevelopment scenarios would be able to meet the 15% phosphorus reduction by 2020. However, all of the redevelopment scenarios would meet the 15% phosphorus reduction target by 2035. None of the redevelopment scenarios would be able to meet the 36% phosphorus reduction by 2035. Table A-26 displays the same information for nitrogen. This table shows that only redevelopment scenario 3c would be able to meet the 15% reduction for nitrogen by 2020. The other three redevelopment scenarios would not meet the 15% reduction in either the 2020 or the 2035 timeframes. None of the scenarios would be able to meet the 36% nitrogen reduction target.

Scenario Comparisons

Tables A-27 and A-28 show the comparison of all scenarios considered in the Patapsco/Back River Tributary Basin for phosphorus and nitrogen, respectively. None of the scenarios would meet a 15% phosphorus reduction by 2020. All of the redevelopment scenarios would meet the 15% phosphorus reduction target by 2035, but not Scenario 1 or Scenario 2. None of the scenarios would meet a 36% phosphorus reduction by 2035. None of the scenarios would meet the 15% reduction target for nitrogen by 2020, and only redevelopment Scenario 3c would meet the 15% nitrogen reduction target in 2035.

Cost of Meeting Nutrient TMDLs by 2020

In order to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, the information in Tables A-27 and A-28 was used. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used in Table A-27 for phosphorus and A-28 for nitrogen. Based the capital program expenditures in the 1997 – 2005 timeframe and the pounds of phosphorus and nitrogen removed through capital project implementation; a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results of this analysis are displayed in Table A-29 for phosphorus and A-30 for nitrogen. For the Patapsco/Back River Tributary Basin, all of the scenarios would require additional capital expenditure to meet a 15% phosphorus reduction by 2020. The additional capital expenditure would range from $1.9 million (Scenario 3c) to $6.0 million (Scenario 2) per year. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $14.7 to $18.8 million. To meet the 15% nitrogen reduction target by 2020 would require additional annual funding in the range of $3.7 million (Scenario 3c) to $6.7 million (Scenario 2). To meet the 36% nitrogen reduction target by 2020 the range in additional annual funding would be $19.2 - $22.3 million.

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Table A-16: Population Changes – Patapsco/Back River Basin

Liberty Reservoir	4,330	367	4,697	4,776	1,792	6,568	5,308	1,991	7,299	5,513	2,069	7,582
Patapsco River	4,833	86,452	91,285	5,410	96,468	101,878	5,689	100,434	107,123	5,830	103,958	109,788
Gwynns Falls	1,299	150,575	151,874	1,368	174,855	176,223	1,501	191,907	193,408	1,531	195,688	197,219
Jones Falls	7,196	53,524	60,720	7,094	58,836	65,930	7,579	62,589	70,438	7,722	64,044	71,766
Back River	351	127,660	128,011	383	132,388	132,771	397	137,455	137,455	404	139,710	140,114
Baltimore Harbor	15	57,475	57,490	13	57,016	57,029	14	60,327	60,341	14	61,506	61,520
				3.5%	**96.5%**		**3.6%**	**96.4%**		**3.6%**	**96.4%**	
Liberty Reservoir – Population changes				446	1,425	1,871	532	199	731	206	87	283
Patapsco River – Population changes				577	10,016	10,593	279	4,966	5,245	142	2,223	2,655
Gwynns Falls – Population changes				69	24,280	24,349	133	17,052	17,185	30	3,781	3,811
Jones Falls – Population changes				-102	5,312	5,210	485	4,023	4,508	143	1,185	1,328
Back River – Population changes				32	4,728	4,760	14	4,670	4,684	8	2,651	2,659
Baltimore Harbor – Population changes				-2	-459	-461	1	3,311	3,312	0	1,179	1,179
Patapsco/Back River Total Population Change				**1,020**	**45,302**	**46,322**	**1,443**	**34,222**	**35,665**	**528**	**11,397**	**11,925**
Percent Distribution				**2.2%**	**97.3%**		**4.0%**	**96.0%**		**4.4%**	**95.6%**	

Table A-17: Scenario 1 - Land Use Changes (Acres) – Patapsco/Back River Tributary Strategy Basin

Land Use	1997 – Actual			2005 – Actual			2020 – Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	1,281	19,576	20,857	1,805	22,254	24,059	2,147	24,629	26,776	2,283	25,578	27,861
Pervious Urban HD	2,213	41,301	43,514	6,453	43,608	50,061	9,882	43,820	53,702	10,987	43,666	54,653
Pervious Urban LD	5,082	5,431	10,513	4,522	5,620	10,142	3,938	6,803	10,742	4,000	7,452	11,452
Cropland	10,317	2,421	12,739	8,885	915	9,800	7,011	129	7,140	6,355	94	6,499
Pasture	3,441	788	4,229	2,675	511	3,186	2,477	91	2,568	2,362	0	2,362
Livestock Feeding	23	0	23	0	0	0	0	0	0	0	0	0
Forest	28.292	17,334	45,616	26,475	14,565	41,040	25,422	12,243	37,665	24,916	10,951	35,867
Water	1,364	442	1,805	1,328	123	1,450	1,299	29	1,328	1,291	23	1,315
Bare Soil	383	491	874	253	179	432	218	30	249	201	10	211
Total	**52,395**	**87,775**	**140,170**	**52,395**	**87,775**	**140,170**	**52,395**	**87,774**	**140,170**	**52,395**	**87,774**	**140,170**
Total Urban	8,576	66,308	74,884	12,780	71,482	84,262	15,967	75,252	91,220	17,269	76,696	93,966
Total Agriculture	13,781	3,209	16,990	11,560	1,426	12,986	9,488	220	9,708	8,718	94	8,811
Total Forest	28,292	17,324	45,616	26,475	14,565	41,040	25,422	12,243	37,665	24,916	10,951	35,867
% Urban	16.4%	75.5%	53.4%	24.4%	81.4%	60.1%	**30.5%**	**85.7%**	**65.1%**	**33.0%**	**87.4%**	**67.0%**
% Agriculture	26.3%	3.7%	12.1%	22.1%	1.6%	9.3%	**18.1%**	**0.3%**	**6.9%**	**16.6%**	**0.1%**	**6.3%**
% Forest	54.0%	19.7%	32.5%	50.5%	16.6%	29.3%	**48.5%**	**13.9%**	**26.9%**	**47.6%**	**12.5%**	**25.6%**
Change in Urban from previous time period				**4,204**	**5,174**	**9,377**	**3,188**	**3,770**	**6,958**	**1,302**	**1,444**	**2,746**
Change in Agriculture from previous time period				**-2,221**	**-1,783**	**-4,004**	**-2,072**	**-1,206**	**-3,278**	**-771**	**-126**	**-897**
Change in Forest from previous time period				**-1,817**	**-2,760**	**-4,577**	**-1,053**	**-2,322**	**-3,375**	**-506**	**-1,292**	**-1,798**

Table A-18: Scenario 1 - Phosphorus Load Changes (Pounds) – Patapsco/Back River Tributary Basin – Baltimore County

Land Use	1997 – Actual			2005 – Actual			2020 – Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	6,018	64,362	70,380	8,792	71,489	80,281	10,793	77,453	88,246	11,602	79,809	91,411
Agriculture	9,949	2,306	12,255	8,332	1,026	9,358	6,838	159	6,997	6,282	68	6,349
Forest	566	346	912	529	291	821	508	245	753	498	219	717
Water	777	252	1,029	757	70	827	741	16	757	736	13	749
Bare Soil	279	341	621	184	126	311	159	22	182	147	7	154
Total	**17,590**	**67,607**	**85,197**	**18,595**	**73,002**	**91,597**	**19,040**	**77,895**	**96,935**	**19,265**	**80,116**	**99,381**
Change in Urban from previous time period				2,774	7,127	9,901	2,001	5,964	7,965	809	2,356	3,165
Change in Agriculture from previous time period				-1,617	-1,280	-2,897	-1,494	-867	-2,361	-556	-92	-648
Change in Forest from previous time period				-36	-55	-92	-21	-46	-67	-10	-26	-36
Total Change from previous time period				**1,005**	**5,395**	**6,400**	**445**	**4,893**	**5,338**	**225**	**2,221**	**2,446**
Urban BMPs	-81	-1,696	1,777	-114	-1,356	-1,470	-1,315	-4,934	-6,249	-1,800	-6,348	-8,148
CIP Restoration	0	0	0	0	-2,601	-2,601	0	-8,176	-8,176	0	-13,750	-13,750
Reforestation	0	0	0	-14	-14	-27	-34	-34	-68	-55	-55	-109
Other Reductions	0	0	0	0	-1,461	-1,461	0	-1,563	-1,563	0	-1,563	-1,563
Total Reductions	**-81**	**-1,696**	**1,777**	**-128**	**-5,431**	**-5,559**	**-1,349**	**-14,707**	**-16,056**	**-1,855**	**-21,715**	**-23,570**
Total with Urban BMPs	17,509	65,912	83,421	18,480	71,647	90,127	17,725	72,961	90,686	17,465	73,768	91,233
Total With Urban BMPs and Restoration	17,509	65,912	83,421	18,467	67,571	86,038	17,691	63,189	80,879	17,410	58,401	75,811

Table A-19: Scenario 1 - Nitrogen Load Changes (Pounds x 1,000)– Patapsco/Back River Tributary Basin

Land Use	1997 – Actual			2005 – Actual			2020 – Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	70.9	614.9	685.7	105.0	670.6	775.6	130.4	714.2	844.7	140.8	731.2	872.0
Agriculture	194.8	44.7	239.5	164.9	18.4	183.2	132.4	2.8	135.2	120.7	1.6	122.3
Forest	39.6	23.8	63.5	37.1	20.0	57.0	35.6	16.8	52.4	34.9	15.0	49.9
Other	16.5	7.6	24.1	15.2	2.4	17.6	14.7	0.5	15.2	14.5	0.3	14.8
Septic	63.6	53.6	117.2	71.8	54.1	125.9	76.9	51.5	128.4	78.7	49.0	127.6
Total	**385.4**	**744.6**	**1,130.0**	**393.9**	**765.4**	**1,159.4**	**390.0**	**785.8**	**1,175.9**	**389.5**	**797.0**	**1,186.5**
Change in Urban from previous time period				34.1	55.9	89.9	25.5	43.6	69.0	10.3	17.0	27.3
Change in Septic from previous time period				8.2	0.4	8.6	5.1	-2.5	2.6	1.7	-2.5	-0.8
Change in Agriculture from previous time period				-29.9	-26.4	-56.2	-32.5	-15.5	-48.0	-11.7	-1.2	-12.9
Change in Forest from previous time period				-2.6	-3.9	-6.4	-4.2	-3.2	-4.7	-0.7	-1.8	-2.5
Total Change from previous time period				**8.5**	**20.9**	**29.4**	**-3.9**	**20.4**	**16.5**	**-0.5**	**11.2**	**10.7**
Urban BMPs	-0.8	-14.2	-15.0	-1.5	-13.8	-15.3	-14.2	-35.6	-49.8	-19.4	-44.1	-63.5
CIP Restoration	0	0	0	0	-14.7	-14.7	0	-46.3	-46.3	0	-77.9	-77.9
Reforestation	0	0	0	-0.2	-0.2	-0.4	-0.5	-0.5	-1.0	-0.8	-0.8	-1.6
Other Reductions	0	0	0	0	-4.5	-4.5	0	-5.2	-5.2	0	-5.2	-5.2
Total Reductions	**-0.8**	**-14.2**	**-15.0**	**-1.6**	**-33.2**	**-34.9**	**-14.7**	**-87.6**	**-102.3**	**-20.2**	**-127.9**	**-148.1**
Total with Urban BMPs	384.6	730.4	1,114.9	392.4	751.6	1,144.1	375.8	750.2	1,126.1	370.1	753.0	1,123.1
Total With Urban BMPs and Restoration	384.6	730.4	1,114.9	392.3	732.2	1,124.5	375.3	698.3	1,073.6	369.3	669.1	1,038.4

Table A-20: Scenario 2 – Future Land Use Changes (Acres) – Patapsco/Back River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	1,805	22,254	24,059	1,805	24,677	26,482	1,805	25,645	27,450
Urban Pervious HD	6,453	43,608	50,061	6,453	43,927	50,379	6,453	43,813	50,265
Urban Pervious LD	4,522	5,620	10,142	4,522	6,782	11,304	4,522	7,426	11,948
Cropland	8,885	915	9,800	8,885	90	8,975	8,885	36	8,920
Pasture	2,675	511	3,186	2,675	71	2,746	2,675	0	2,675
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	26,475	14,565	41,040	26,475	12,175	38,649	26,475	10,827	37,302
Water	1,328	123	1,450	1,328	26	1,354	1,328	20	1,348
Bare Soil	253	179	432	253	26	279	253	8	261
Total	**52,395**	**87,775**	**140,170**	**52,395**	**87,774**	**140,170**	**52,395**	**87,774**	**140,170**
Total Urban	12,780	71,482	84,262	12,780	75,386	88,166	12,780	76,884	89,664
Total Agriculture	11,560	1,426	12,986	11,560	161	11,721	11,560	36	11,596
Total Forest	26,475	14,565	41,040	26,475	12,175	38,649	26,475	10,827	37,302
% Urban	24.4%	81.4%	60.1%	24.4%	85.9%	62.9%	24.4%	87.6%	64.0%
% Agriculture	22.1%	1.6%	9.3%	22.1%	0.2%	8.4%	22.1%	0.0%	8.3%
% Forest	50.5%	16.6%	29.3%	50.5%	13.9%	27.6%	50.5%	12.3%	26.6%
Change in Urban Land Use from previous period				**0**	**3,904**	**3,904**	**0**	**1,498**	**1,498**
Change in Agricultural Land Use from previous period				**0**	**-1,265**	**-1,265**	**0**	**-126**	**-126**
Change in Forest Land Use from previous period				**0**	**-2,390**	**-2,390**	**0**	**-1,348**	**-1,348**

Table A-21: Scenario 2 – Phosphorus Load Changes (Pounds) – Patapsco/Back River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	8,792	71,489	80,281	8,792	77,598	86,390	8,792	80,012	88,804
Agriculture	8,332	1,026	9,358	8,332	117	8,449	8,332	26	8,357
Forest	529	291	821	529	243	773	529	217	746
Water	757	72	827	757	15	772	757	11	768
Bare Soil	184	126	311	184	19	204	184	6	190
Total	**18,595**	**73,002**	**91,597**	**18,595**	**77,992**	**96,587**	**18,595**	**80,271**	**98,866**
Change in Urban from previous period				0	6,109	6,109	0	2,414	2,414
Change in Agricultural from previous period				0	-909	-909	0	-91	-91
Change in Forest from previous period				0	-48	-48	0	-27	-27
Total Change				**0**	**4,990**	**4,990**	**0**	**2,279**	**2,279**
Urban BMPs	-114	-1,356	-1,470	-114	-5,021	-5,135	-114	-6,469	-6,584
CIP Restoration	0	-2,601	-2,601	0	-8,176	-8,176	0	-13,750	-13,750
Reforestation	-14	-14	-27	-34	-34	-68	-55	-55	-109
Other Reductions	0	-1,461	-1,461	0	-1,563	-1,563	0	-1,563	-1,563
Total	**-128**	**-5,431**	**-5,559**	**-148**	**-14,794**	**-14,942**	**-169**	**-21,837**	**-22,006**
Total with Urban BMPs	18,480	71,647	90,127	18,480	72,971	91,452	18,480	73,802	92,282
Total with Urban BMPs and Restoration	18,467	67,571	86,038	18,446	63,199	81,645	18,426	58,434	76,860

Table A-22: Scenario 2 – Nitrogen Load Changes (Pounds) – Patapsco/Back River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	104,976	670,628	775,604	104,976	715,514	820,490	104,976	733,000	837,976
Agriculture	164,887	18,353	183,240	164,887	2,018	166,905	164,887	588	165,476
Forest	37,037	19,977	57,014	37,054	16,692	53,745	37,054	14,857	51,911
Water	13,258	1,260	14,518	13,345	265	13,610	13,345	202	13,547
Bare Soil	1,856	1,250	3,106	1,856	195	2,051	1,856	61	1,917
Septic	71,812	54,062	125,873	71,812	51,520	123,332	71,812	48,955	120,767
Total	**393,930**	**765,442**	**1,159,372**	**393,930**	**786,203**	**1,180,133**	**393,930**	**797,664**	**1,191,594**
Change in Urban from previous period				0	44,886	44,886	0	17,487	17,487
Change in Septic from previous period				0	-2,542	-2,542	0	-2,564	-2,564
Change in Agricultural from previous period				0	-16,335	-16,335	0	-1,430	-1,430
Change in Forest from previous period				0	-3,271	-3,271	0	-1,834	-1,834
Total Change				**0**	**20,762**	**20,762**	**0**	**11,460**	**11,460**
Urban BMPs	-1,484	-13,800	-15,284	-1,484	-36.243	-37.727	-1,484	-44.986	-46.471
CIP Restoration	0	-14,736	-14,736	0	-46,313	-46,313	0	-77,891	-77,891
Reforestation	-195	-195	-391	-488	-488	-976	-781	-781	-1,562
Other Reductions	0	-4,472	-4,472	0	-5,168	-5,168	0	-5,168	-5,168
Total	**-1,680**	**-33,203**	**-34,883**	**-1,972**	**-88,212**	**-90,184**	**-2,265**	**-128,825**	**-131,091**
Total with Urban BMPs	392,446	751,642	1,144,087	392,446	749,960	1,142,406	392,446	752,677	1,145,123
Total with Urban BMPs and Restoration	392,250	732,238	1,124,489	391,958	697,991	1,089,949	391,665	668,838	1,060,503

Table A-23: Acres of Redevelopment Needed to Meet Patapsco/Back River Basin Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	4,173	1,395	**5,568**	9,409	3,841	7.5 %
3b	428	143	**571**	9,409	8,838	0.8%
3c	4,815	1,610	**6,425**	9,409	2,984	8.6%
3d	749	250	**999**	9,409	8,410	1.3%

Table A-24: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 Nitrogen Loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	4,173	69,401	17,350	1,395	21,901	5,475
Low – 3b	25%	428	7,118	1,780	143	2,246	562
High/Parks – 3c	59%	4,815	80,078	47,246	1,610	25,271	14,910
Low/Parks – 3d	59%	749	12,457	7,349	250	3,931	2,319
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	4,173	8,301	1,909	1,395	2,620	602
Low	23%	428	851	196	143	269	62
High/Parks	55%	4,815	9,578	5,268	1,610	3,023	1,662
Low/Parks	55%	749	1,490	819	250	470	259

Table A-25: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	74,907	60,500	83,421	86,038	79,149	73,142
Low – 3b	74,907	60,500	83,421	86,038	80,200	74,544
High/Parks – 3c	74,907	60,500	83,421	86,038	77,089	70,394
Low/Parks – 3d	74,907	60,500	83,421	86,038	79,817	74,034

Table A-26: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	1,029,382	888,549	1,114,934	1,124,489	1,080,990	1,045,269
Low – 3b	1,029,382	888,549	1,114,934	1,124,489	1,090,539	1,058,011
High/Parks – 3c	1,029,382	888,549	1,114,934	1,124,489	1,062,655	1,020,804
Low/Parks – 3d	1,029,382	888,549	1,114,934	1,124,489	1,087,123	1,053,453

Table A-27: All Land Uses - Phosphorus Load Changes (pounds) – Scenario Comparison (Pounds)

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	74,907	60,500	83,421	86,038	80,879	5,972	20,379	75,811	904	15,311
Scenario 2 – All Development within URDL	74,907	60,500	83,421	86,038	81,645	6,738	21,145	76,860	1,953	16,360
Scenario 3a – All Redevelopment – High	74,907	60,500	83,421	86,038	79,149	4,242	18,649	67,912	-1,765	12,642
Scenario 3b – All Redevelopment – Low	74,907	60,500	83,421	86,038	80,200	5,293	19,700	74,008	-363	14,044
Scenario 3c – All Redevelopment – High/Parks	74,907	60,500	83,421	86,038	77,089	2,182	16,589	66,867	-4,513	9,894
Scenario 3d – All Redevelopment – Low/Parks	74,907	60,500	83,421	86,038	79,817	4,910	19,317	73,485	-873	13,534

Table A-28: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	1,029,382	888,549	1,114,934	1,124,489	1,073,593	44,211	185,044	1,038,442	9,060	149,893
Scenario 2 – All Development within URDL	1,029,382	888,549	1,114,934	1,124,489	1,089,949	60,567	201,400	1,060,503	31,121	171,954
Scenario 3a – All Redevelop-ment – High	1,029,382	888,549	1,114,934	1,124,489	1,080,990	51,608	192,441	1,045,269	15,887	156,720
Scenario 3b – All Redevelop-ment – Low	1,029,382	888,549	1,114,934	1,124,489	1,090,539	61,157	201,990	1,058,011	28,629	169,462
Scenario 3c – All Redevelop-ment – High/Parks	1,029,382	888,549	1,114,934	1,124,489	1,042,520	33,273	174,106	1,020,804	-8,578	132,255
Scenario 3d – All Redevelop-ment – Low/Parks	1,029,382	888,549	1,114,934	1,124,489	1,083,991	57,741	198,574	1,053,453	24,071	164,904

Table A-29: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	74,907	60,500	80,879	5,972	20,379	$53,085	$181,149	$5,309	$18,115
Scenario 2 – All Development within URDL	74,907	60,500	81,645	6,738	21,145	$59,894	$187,958	$5,989	$18,796
Scenario 3a – All Redevelopment – High	74,907	60,500	79,149	4,242	18,649	$37,707	$165,771	$3,771	$16,577
Scenario 3b – All Redevelopment – Low	74,907	60,500	80,200	5,293	19,700	$47,049	$175,113	$4,705	$17,511
Scenario 3c – All Redevelopment – High/Parks	74,907	60,500	77,089	2,182	16,589	$19,396	$147,460	$1,940	$14,746
Scenario 3d – All Redevelopment – Low/Parks	74,907	60,500	79,817	4,910	19,317	$43,645	$171,709	$4,364	$17,171

Table A-30: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds (x 1,000)		Pounds (x 1,000)			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	1,029	889	1,074	44	185	$48,986	$205,029	$4,899	$20,503
Scenario 2 – All Development within URDL	1,029	889	1,090	60	201	$67,108	$223,151	$6,711	$22,315
Scenario 3a – All Redevelopment – High	1,029	889	1,081	52	192	$57,182	$213,225	$5,718	$21,322
Scenario 3b – All Redevelopment – Low	1,029	889	1,091	61	202	$67,762	$223,805	$6,776	$22,380
Scenario 3c – All Redevelopment – High/Parks	1,029	889	1,043	13	154	$36,866	$192,909	$3,687	$19,291
Scenario 3d – All Redevelopment – Low/Parks	1,029	889	1,084	55	195	$63,977	$220,020	$6,398	$22,002

A.2 Eight Digit Watersheds

There are a total of fourteen 8-digit watersheds with a portion or all of their drainages in Baltimore County. Eight of these 8-digit watersheds occur in the Upper Western Shore Tributary Basin and will be discussed first, followed by the six 8-digit watersheds that occur in the Patapsco/Back River Tributary Basin.

A.2.1 Deer Creek

Deer Creek is located in the northeastern portion of Baltimore County. The headwaters of Deer Creek originate in Pennsylvania; it receives drainage from 7,173 acres in Baltimore County, and then flows into Harford County, ultimately discharging to the Susquehanna River. All of the Deer Creek watershed is outside the URDL, therefore only Scenario 1 is applicable. Scenario 2 – All Development Within the URDL and the redevelopment scenarios would result in no change from 2005.

Table A-31 above indicates that population growth between 1997 and 2005 added 52 additional people over the eight-year period. The projected growth is 73 and 29 additional people between 2005 – 2020 and 2020 – 2035 timeframes, respectively.

Table A-31: Deer Creek Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	1,450	-	1,450	-	-	-
2005	1,502	-	1,502	52	-	52
2020	1,575	-	1,575	73	-	73
2035	1,604	-	1,604	29	-	29

Table A-32 presents the land use change between 1997 and 2005 along with the projected change between 2005 – 2020 and between 2020 – 2035 using Scenario 1 – Development As Is.

Table A-32: Scenario 1 - Deer Creek – Land Use Changes (Acres)

Land Use Category	1997 Actual	2005 Actual	2020 Projected	2035 Projected
Urban Impervious	53	94	151	174
Urban Pervious HD	48	176	356	427
Urban Pervious LD	246	247	249	249
Cropland	3,846	3,148	2,169	1,780
Pasture	619	981	1,490	1,692
Livestock Feeding	0	0	0	0
Forest	2,361	2,520	2,744	2,833
Water	0	7	16	20
Bare Ground	0	0	0	0
Totals	**7,173**	**7,173**	**7,173**	**7,173**
Total Urban	347	517	755	850
Total Agriculture	4,465	4,129	3,659	3,492
Total Forest	2,361	2,521	2,744	2,833
% Urban	4.8%	7.2%	10.5%	11.8%
% Agriculture	62.2%	57.6%	51.0%	48.7%
% Forest	32.9%	35.1%	38.2%	39.5%
Change in Urban from previous period		**170**	**239**	**95**
Change in Agriculture from previous period		**-335**	**-471**	**-187**
Change in Forest from previous period		**159**	**223**	**89**

Both urban land use and forest are calculated to increase at the expense of agriculture. The percentage of urban land use is projected to more than double from 4.8% to 11.8%. Based on the development pattern in the 1997 – 2005 time period, approximately 3.25 acres of land was developed for each individual that was added to the population of the watershed.

The changes in phosphorus and nitrogen loads are displayed in Tables A-33 and A-34, respectively. Due to the land use change from agriculture to urban land and to forested land, both the phosphorus and nitrogen loads decrease as the result of land use change. Future implementation of ESD would result in further decreases. There have been no restoration projects implemented in the Deer Creek watershed.

Table A-33: Scenario 1 - Deer Creek – Phosphorus Loads (Pounds)

Urban	245	393	601	683
Agriculture	3,541	3,108	2,499	2,257
Forest	71	76	82	85
Water	0	4	9	11
Bare Soil	0	0	0	0
Change in Urban from previous time period		148	208	83
Change in Agriculture from previous time period		-434	-609	-242
Change in Forest from previous time period		5	7	3
Urban BMPs	0	0	-125	-125
CIP Restoration	0	0	0	0
Reforestation	0	0	0	0
Other Reductions	0	0	0	0
Total with Urban BMPs	3,857	3,580	3,066	2,862
Total with Urban BMPs and Restoration	3,857	3,580	3,066	2,862

Table A-34: Scenario 1 - Deer Creek – Nitrogen Loads (Pounds)

	1997 Actual	2005 Actual	2020 Projected	2035 Projected
Urban	2,871	4,383	6,507	7,350
Agriculture	52,246	46,764	39,068	36,011
Forest	5,573	5,948	6,474	6,685
Other	0	66	171	211
Septic	5,291	5,706	5,983	6,093
Total	**65,981**	**62,808**	**58,205**	**57,351**
Change in Urban from previous time period		1,513	2,123	844
Change in Septic from previous time period		415	277	110
Change in Agriculture from previous time period		-5,482	-7,696	-3,057
Change in Forest from previous time period		376	527	210
Total Change from previous time period		**-3,113**	**-4,662**	**-1,854**
Urban BMPs	0	0	-1,062	-1,483
CIP Restoration	0	0	0	0
Reforestation	0	0	0	0
Other Reductions	0	-2	-2	-2
Total Reductions	**0**	**-2**	**-1,164**	**-1,485**
Total with Urban BMPs	65,981	62,868	57,144	54,867
Total with Urban BMPs and Restoration	65,981	62,866	57,142	54,865

Due to the land use changes from agriculture to urban land and forest land, Deer Creek watershed met both the 15% and 36% reduction targets for phosphorus and nitrogen in 2005.

A.2.2 Prettyboy Reservoir Watershed

The Prettyboy Reservoir watershed is located in the northwestern portion of Baltimore County. The headwaters of the Prettyboy Reservoir watershed originate in Pennsylvania, and flow through Carroll County before entering Baltimore County. A total of 25,548 acres of the Prettyboy Reservoir watershed occur in Baltimore County. All of Prettyboy Reservoir watershed is outside the URDL, therefore only Scenario 1 is applicable in this watershed.

Scenario 2 – All Development Within the URDL and the redevelopment scenarios would result in no change from 2005.

Table A-35 below indicates that there was a population decrease between 1997 and 2005. This may be an artifact of the way population change was determined (see main body of Technical Memo B for methods). The mean change in land use per person for the rural portion of the Gunpowder Basin was used to project the effects of future population growth. The projected growth is 455 and 90 additional people between 2005 – 2020 and 2020 – 2035 timeframes, respectively.

Table A-35: Prettyboy Reservoir Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	4,001	-	4,001	-	-	-
2005	3,975	-	3,975	-26	-	-26
2020	4,430	-	4,430	455	-	455
2035	4,520	-	4,520	90	-	90

Table A-36 presents the land use change between 1997 and 2005 along with the projected changed between 2005 – 2020 and between 2020 – 2035 using Scenario 1 – Development As Is.

Table A-36: Prettyboy Reservoir Watershed – Land Use Changes (Acres)

Land Use Category	1997 Actual	2005 Actual	2020 Projected	2035 Projected
Urban Impervious	234	247	311	323
Urban Pervious HD	14	578	1,269	1,406
Urban Pervious LD	857	959	797	765
Cropland	9,258	8,109	7,091	6,889
Pasture	1,573	1,839	2,135	2,193
Livestock Feeding	0	0	0	0
Forest	12,104	12,309	12,441	12,468
Water	1,499	1,501	1,483	1,479
Bare Ground	9	6	20	23
Totals	**25,548**	**25,548**	**25,548**	**25,548**
Total Urban	1,105	1,784	2,377	2,495
Total Agriculture	10,831	9,948	9,226	9,083
Total Forest	12,104	12,309	12,441	12,479
% Urban	4.3%	7.0%	9.3%	9.8%
% Agriculture	42.4%	38.9%	36.1%	35.6%
% Forest	47.4%	48.2%	48.7%	48.8%
Change in Urban from previous period		**680**	**593**	**117**
Change in Agriculture from previous period		**-884**	**-722**	**-143**
Change in Forest from previous period		**206**	**132**	**26**

Both urban land use and forest are calculated to increase at the expense of agriculture. The percentage of urban land use is projected to more than double from 4.3% to 9.8%.

The changes in phosphorus and nitrogen loads are displayed in Tables A-37 and A-38, respectively. Due to the land use change from agriculture to urban land and to forested land, both the phosphorus and nitrogen loads decrease as the result of land use change. Future implementation of ESD would result in further decreases. There have been no restoration projects implemented in the Prettyboy Reservoir watershed.

Table A-37: Prettyboy Reservoir Watershed – Phosphorus Loads (Pounds)

Urban	900	1,217	1,590	1,664
Agriculture	7,814	7,181	6,664	6,562
Forest	242	246	249	249
Water	855	856	845	843
Bare Soil	7	4	15	17
Change in Urban from previous time period		317	373	74
Change in Agriculture from previous time period		-634	-517	-102
Change in Forest from previous time period		-4	3	1
Urban BMPs	-7	-5	-229	-273
CIP Restoration	0	0	0	0
Reforestation	0	0	0	0
Other Reductions	0	0	0	0
Total with Urban BMPs	9,811	9,499	9,134	9,062
Total with Urban BMPs and Restoration	9,811	9,499	9,134	9,062

Table A-38: Prettyboy Reservoir Watershed – Nitrogen Loads (Pounds)

	1997 Actual	2005 Actual	2020 Projected	2035 Projected
Urban	9,599	14,617	19,356	20,294
Agriculture	164,786	147,713	133,044	130,142
Forest	17,066	17,356	17,542	17,579
Other	15,135	15,131	15,055	172
Septic	13,589	15,106	16,835	17,177
Total	**220,176**	**209,923**	**201,832**	**200,232**
Change in Urban from previous time period		5,017	4,739	937
Change in Septic from previous time period		1,517	1,729	342
Change in Agriculture from previous time period		-17,073	-14,669	-2,902
Change in Forest from previous time period		290	187	37
Total Change from previous time period		**-10,253**	**-8,091**	**-1,600**
Urban BMPs	-73	-53	-2,423	-2,892
CIP Restoration	0	0	0	0
Reforestation	0	0	0	0
Other Reductions	0	0	0	0
Total Reductions	**-73**	**-53**	**-2,423**	**-2,892**
Total with Urban BMPs	220,102	209,870	199,409	197,340
Total with Urban BMPs and Restoration	220,102	209,870	199,409	197,340

Due to the land use changes from agriculture to urban land and forest land, the Prettyboy Reservoir watershed met the 15% urban reduction targets for phosphorus and nitrogen in 2005. The 36% nitrogen reduction target was met in 2005, but the 36% phosphorus reduction target was short by 2.6 pounds. A TMDL has been developed for the Prettyboy Reservoir, indicating that a 54% reduction in phosphorus is necessary to meet water quality standards in the reservoir. Modeled changes in nitrogen indicated that reductions in nitrogen would have limited effect on reservoir water quality. The urban phosphorus sources were allocated a 15% reduction in the TMDL.

A.2.3 Loch Raven Reservoir Watershed

The Loch Raven Reservoir watershed is composed of parts of Carroll and Harford Counties, and York County, Pennsylvania. The majority of this watershed is located in north central portion of Baltimore County. The Prettyboy Reservoir watershed is upstream of the Loch Raven watershed and supplies water to the stream system either through cold-water releases or flow over the dam. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-39. The data is displayed as population in the rural section of the watershed (outside the Urban-Rural Demarcation Line, or URDL) and as population in the urban section of the watershed (inside the URDL).

The majority of the population in 2005 was located within the urban portion of the watershed (61.5%) and is projected to maintain approximately the same proportion. However, the urban section of the watershed comprises only 9.2% of the land area in the watershed. The Loch Raven Reservoir watershed is projected to receive ~14.5% of the future population growth. The annual growth rate will decrease from ~1,225 per year in the 1997 – 2005 time period to ~576 and ~160 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Loch Raven Reservoir watershed contains 36% of the land in Baltimore County and 11.7% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-40. An additional 5,569 acres of urban land will be developed during the 2005 – 2035 timeframe, primarily at the expense of agricultural land. Forest land is projected to gain a small amount of acreage and agriculture is projected to decrease by 6,250 acres. The overall percentage of urban land will increase from 19.7% in 2005 to 23.7% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-41 and A-42, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in a decrease in phosphorus by 3,915 pounds by 2035 relative to 1997. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 2,635 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 6,324 pounds. Through 2005 restoration activities have achieved 654 pounds of reduction, or ~25% of the 15% reduction goal. Because of the decrease in the phosphorus loads in the 1997 – 2005 timeframe due to development with stormwater management (887 pounds), progress toward meeting the 15% reduction target is 58%.

Nitrogen pollutant loads (Table A-42) also showed an overall decrease from 1997 – 2035. The decrease is a result of decreased loads due to land use changes, implementation of Environmental Site Design, and continued implementation of capital restoration projects. This results in a total decrease in nitrogen load of 121,500 pounds by 2020 and 150,500 pounds by 2035 results. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 28,266 pounds of urban nitrogen. A 36% urban nitrogen reduction that may be required by the Chesapeake Bay TMDL would require the reduction of 67,837 pounds of nitrogen. The 15% and the 36% urban nitrogen reductions were met by 2005. Restoration efforts through 2005 have resulted in a reduction of 7,112 pounds of nitrogen. Combined with the nitrogen reduction effects of land use change, and implementation of stormwater management, nitrogen reductions are currently adequate to meet the 15% and 36% reduction targets.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the new population would be served by public water and sewer.

Table A-43 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development compared to Scenario 1 (1,113 acres versus 5,569 acres), but most of the land use change would come at the expense of forest. This Scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land uses.

Tables A-44 and A-45 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 timeframe, as those changes are based on development activities that have already occurred. Because the land use change involves mainly conversion from forest to urban land use, the phosphorus load will increase by 462 pounds in the 2005 – 2020 timeframe, even with ESD. The cost to address this additional phosphorus load created through development would be ~$4.1 million.

Nitrogen under this scenario would also increase by 3,461 pounds, and would also require ~$3.8 million to address the development load.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-46 presents the number of acres needed to absorb the projected population increase in the Loch Raven Reservoir watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 793 acres of land for potential redevelopment identified. This provides sufficient acreage to meet the redevelopment for scenarios 3b and 3d, but falls short of the acreage needed for scenarios 3a and 3c. The amount of redevelopment needed ranged from 1.4% to 15.2% of the urban land.

Table A-47 presents the phosphorus and nitrogen loads projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most amount of phosphorus and nitrogen removal. Table A-48 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. All of the redevelopment scenarios would be able to meet the 15% phosphorus reduction by 2020. None of the scenarios would meet a 36% urban phosphorus reduction even in the 2035 timeframe. Table A-49 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen was already met by 2005 and the 36% urban nitrogen reduction would be met by 2020.

Scenario Comparisons

Tables A-50 and A-51 show the comparison of all scenarios considered in the Loch Raven Reservoir watershed for phosphorus and nitrogen, respectively. All of the scenarios, with the exception of Scenario 2 would meet a 15% phosphorus reduction by 2020. None of the scenarios would meet a 36% phosphorus reduction by 2035. All of the scenarios have already met the 15% reduction target for urban nitrogen and all are projected to meet the 36% urban nitrogen reduction target by 2020.

Cost of Meeting Nutrient TMDLs by 2020

In order to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, the information in Tables A-50 and A-51 was used. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used in Table A-50 for phosphorus and A-51 for nitrogen. Based the capital program expenditures in the 1997 – 2005 timeframe and the pounds of phosphorus and nitrogen removed through capital project implementation, a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are displayed in Table A-52 for phosphorus and A-53 for nitrogen. For the Loch Raven Reservoir watershed, only Scenario 2 would require additional capital expenditures to meet a 15% urban phosphorus reduction by 2020. The additional capital expenditure for Scenario 2 would be only $66,000 per year. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $0.8 to $3.3 million. To meet the 15% or the 36% urban nitrogen reduction target by 2020 would require no additional capital funding.

Table A-39: Loch Raven Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	31,350	50,984	82,334	-	-	-
2005	35,502	56,620	92,122	4,152	5,726	9,788
2020	38,833	61,932	100,765	3,331	5,312	8,643
2035	39,770	63,426	103,196	937	1,494	2,431

Table A-40: Land Use Changes (Acres) – Loch Raven Reservoir Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	1,942	2,755	4,697	2,280	3,073	5,352	2,551	3,368	5,918	2,627	3,451	6,077
Pervious Urban HD	1,215	5,378	6,593	6,238	5,822	12,059	10,267	6,234	16,501	11,400	6,349	17,750
Pervious Urban LD	9,087	1,758	10,845	8,516	1,540	10,056	18,057	1,338	9,395	7,928	1,281	9,209
Cropland	46,564	74	46,638	39,914	21	39,935	34,578	0	34,578	33,077	0	33,077
Pasture	10,314	88	10,403	10,985	35	11,020	11,523	0	11,523	11,675	0	11,675
Livestock Feeding	109	0	109	62	0	62	25	0	25	14	0	14
Forest	55,226	2,747	57,974	56,488	2,328	58,815	57,500	1,884	59,384	57,784	1,744	59,529
Water	2,101	15	2,116	2,081	8	2,089	2,064	2	2,067	2,060	0	2,060
Bare Soil	188	10	198	185	0	185	182	0	182	181	0	181
Total	**126,747**	**12,826**	**139,573**	**126,747**	**12,826**	**139,573**	**126,747**	**12,826**	**139,573**	**126,747**	**12,826**	**139,573**
Total Urban	12,245	9,891	22,135	17,033	10,435	27,468	20,875	10,939	31,814	21,955	11,081	33,037
Total Agriculture	56,988	162	57,150	50,961	55	51,017	46,126	0	46,126	44,766	0	44,766
Total Forest	55,226	2,747	57,974	56,488	2,328	58,815	57,500	1,884	59,384	57,784	1,744	59,529
% Urban	9.7%	77.1%	15.9%	13.4%	81.4%	19.7%	16.5%	85.3%	22.8%	17.3%	86.4%	23.7%
% Agriculture	45.0%	1.3%	40.9%	40.2%	0.4%	36.6%	36.4%	0.0%	33.0%	35.3%	0.0%	32.1%
% Forest	43.6%	21.4%	41.5%	44.6%	18.1%	42.1%	45.4%	14.7%	42.5%	45.6%	13.6%	42.7%
Change in Urban from previous time period				**4,788**	**544**	**5,332**	**3,842**	**505**	**4,346**	**1,081**	**142**	**1,223**
Change in Agriculture from previous time period				**-6,026**	**-107**	**-6,133**	**-4,835**	**-55**	**-4,890**	**-1,360**	**0**	**-1,360**
Change in Forest from previous time period				**1,261**	**-420**	**842**	**1,012**	**-443**	**569**	**285**	**-140**	**144**

Table A-41: Phosphorus Load Changes (Pounds) – Loch Raven Reservoir Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	8,792	9,295	18,087	11,477	10,111	21,588	13,630	10,869	24,499	14,236	11,082	25,318
Agriculture	41,184	118	41,302	36,831	40	36,871	33,338	0	33,338	32,355	0	32,335
Forest	1,105	55	1,159	1,130	47	1,176	1,150	38	1,188	1,156	35	1,191
Water	1,198	9	1,206	1,186	5	1,191	1,177	1	1,178	1,174	0	1,174
Bare Soil	137	8	145	135	0	135	133	0	133	132	0	132
Total	**52,416**	**9,484**	**61,900**	**50,785**	**10,203**	**60,691**	**49,427**	**10,908**	**60,335**	**49,053**	**11,117**	**60,170**
Change in Urban from previous time period				2,684	817	3,501	2,153	758	2,911	606	213	819
Change in Agriculture from previous time period				-4,354	-77	-4,431	-3,493	-40	-3,533	-983	0	-983
Changes in Forest from previous time period				25	-8	17	20	-9	11	6	-3	3
Total Change from previous time period				**-1,658**	**719**	**-939**	**-1,330**	**705**	**-625**	**-374**	**209**	**-165**
Urban BMPs	-123	-397	-520	-204	-265	-469	-1,496	-719	-2,215	-1,859	-847	-2,707
CIP Restoration	0	0	0	0	-373	-373	0	-1,173	-1,173	0	-1,973	-1,973
Reforestation	0	0	0	-12	-12	-22	-29	-29	-57	-46	-46	-92
Other Reductions	0	0	0	0	-258	-258	0	-385	-385	0	-385	-385
Total Reductions	**-123**	**-397**	**-520**	**-215**	**-908**	**-1,123**	**-1,525**	**-2,306**	**-3,831**	**-1,905**	**-3,251**	**-5,156**
Total with Urban BMPs	52,293	9,086	61,379	50,554	9,938	60,492	47,931	10,188	58,120	47,194	10,270	57,464
Total With Urban BMPs and Restoration	52,293	9,086	61,379	50,542	9,925	59,838	47,903	8,602	56,504	47,148	7,886	55,014

Table A-42: Nitrogen Load Changes (Pounds x 1,000) – Loch Raven Reservoir Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	102.0	90.6	192.5	139.0	96.7	235.7	168.7	102.4	271.1	177.1	104.0	281.1
Agriculture	849.2	1.9	851.0	742.9	0.6	743.5	657.6	0.0	657.6	633.6	0.0	633.6
Forest	77.9	3.9	81.7	79.6	3.3	82.9	81.1	2.7	83.7	81.5	2.5	83.9
Other	22.5	0.2	22.7	22.3	0.3	22.5	22.1	0.0	22.1	22.0	0.0	22.0
Septic	131.8	18.8	150.7	146.6	19.1	165.7	159.2	19.5	178.7	162.8	18.9	181.7
Total	**1,183.4**	**115.3**	**1,298.7**	**1,130.4**	**119.7**	**1,250.1**	**1,088.7**	**124.5**	**1,213.2**	**1,077.0**	**125.4**	**1,202.4**
Change in Urban from previous time period				37.0	6.1	43.2	29.7	5.7	35.4	8.4	1.6	10.0
Change in Septic from previous time period				14.8	0.3	15.0	12.7	0.4	13.0	3.6	-0.5	3.0
Change in Agriculture from previous time period				-106.3	-1.3	-107.5	-85.3	-0.6	-85.9	-24.0	0.0	-24.0
Change in Forest from previous time period				1.8	-0.6	1.2	1.4	-0.6	0.8	0.4	-0.2	0.2
Total Change from previous time period				**-53.0**	**4.4**	**-18.6**	**-41.7**	**4.8**	**-36.9**	**-11.7**	**0.8**	**-10.9**
Urban BMPs	-1.5	-2.6	-4.1	-2.7	-2.6	-5.3	-17.5	-5.5	-23.0	-21.7	-6.3	-28.0
CIP Restoration	0.0	0.0	0.0	0.0	-5.9	-5.9	0.0	-18.6	-18.6	0.0	-31.3	-31.3
Reforestation	0.0	0.0	0.0	-0.2	-0.2	-0.3	-0.4	-0.4	-0.8	-0.7	-0.7	-1.3
Other Reductions	0.0	0.0	0.0	0.0	-0.9	-0.9	0.0	-1.8	-1.8	0.0	-1.8	-1.8
Total Reductions	**-1.5**	**-2.6**	**-4.1**	**-2.8**	**-9.6**	**-12.4**	**-17.9**	**-26.2**	**-44.2**	**-22.4**	**-40.0**	**-62.3**
Total with Urban BMPs	1,181.8	112.7	1,294.6	1,127.7	117.1	1,244.8	1,071.2	119.0	1,190.2	1,055.3	119.1	1,174.4
Total With Urban BMPs and Restoration	1,181.8	112.7	1,294.6	1,1127.5	110.2	1,237.7	1,070.8	98.3	1,169.1	1,054.6	85.4	1,140.0

Table A-43: Scenario 2 – Future Land Use Changes (Acres) – Loch Raven Reservoir (done)

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	2,280	3,073	5,352	2,280	3,582	5,861	2,280	3,723	6,003
Urban Pervious HD	6,238	5,822	12,059	6,238	6,533	12,771	6,238	6,731	12,968
Urban Pervious LD	8,516	1,540	10,056	8,516	1,191	9,707	8,516	1,094	9,610
Cropland	39,914	21	39,935	39,914	0	39,914	39,914	0	39,914
Pasture	10,985	35	11,020	10,985	0	10,985	10,985	0	10,985
Livestock Feeding	62	0	62	62	0	62	62	0	62
Forest	56,488	2,328	58,815	56,488	1,520	58,007	56,488	1,278	57,765
Water	2,081	8	2,089	2,081	0	2,081	2,081	0	2,081
Bare Soil	185	0	185	185	0	185	185	0	185
Total	**126,747**	**12,826**	**139,573**	**126,747**	**12,826**	**139,573**	**126,747**	**12,826**	**139,573**
Total Urban	17,033	10,435	27,468	17,033	11,306	28,339	17,033	11,548	28,581
Total Agriculture	50,961	55	51,017	50,961	0	50,961	50,961	0	50,961
Total Forest	56,488	2,328	58,815	56,488	1,520	58,007	56,488	1,278	57,765
% Urban	13.4%	81.4%	19.7%	13.4%	88.2%	20.3%	13.4%	90.0%	20.5%
% Agriculture	40.2%	0.4%	36.6%	40.2%	0.0%	36.5%	40.2%	0.0%	36.5%
% Forest	44.6%	18.1%	42.1%	44.6%	11.8%	41.6%	44.6%	10.0%	41.4%
Change in Urban Land Use from previous period				**0**	**871**	**871**	**0**	**242**	**242**
Change in Agricultural Land Use from previous period				**0**	**-55**	**-55**	**0**	**0**	**0**
Change in Forest Land Use from previous period				**0**	**-808**	**-808**	**0**	**-242**	**-242**

Table A-44: Scenario 2 – Phosphorus Load Changes (Pounds) – Loch Raven Reservoir

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	11,477	10,111	21,588	11,477	11,419	22,896	11,477	11,783	23,260
Agriculture	36,831	40	36,871	36,831	0	36,831	36,831	0	36,831
Forest	1,130	47	1,176	1,130	30	1,160	1,130	26	1,155
Water	1,186	5	1,191	1,186	0	1,186	1,186	0	1,186
Bare Soil	135	0	135	135	0	135	135	0	135
Total	**50,758**	**10,203**	**60,961**	**50,758**	**11,450**	**62,208**	**50,758**	**11,809**	**62,566**
Change in Urban from previous period				0	1,308	1,308	0	364	364
Change in Agricultural from previous period				0	-40	-40	0	0	0
Change in Forest from previous period				0	-16	-16	0	-5	-5
Total Change				**0**	**1,247**	**1,247**	**0**	**359**	**359**
Urban BMPs	-204	-265	-469	-204	-1,050	-1,254	-204	-1,268	-1,472
CIP Restoration	0	-373	-373	0	-1,173	-1,173	0	-1,973	-1,973
Reforestation	-12	-12	-23	-29	-29	-57	-46	-46	-92
Other Reductions	0	-258	-258	0	-358	-358	0	-385	-385
Total	**-214**	**-908**	**-1,123**	**-233**	**-2,636**	**-2,869**	**-250**	**-3,672**	**-2,450**
Total with Urban BMPs	50,554	9,938	60,492	50,554	10,400	60,954	50,554	10,541	61,095
Total with Urban BMPs and Restoration	50,542	9,295	59,838	50,525	8,813	59,339	50,508	8,137	58,645

Table A-45: Scenario 2 – Nitrogen Load Changes (Pounds) – Loch Raven Reservoir

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	139,020	96,685	235,705	139,020	106,493	245,513	139,020	109,220	248,240
Agriculture	742,863	597	743,460	742,863	0	742,863	742,863	0	742,863
Forest	79,648	3,282	82,929	79,648	2,143	81,790	79,648	1,801	81,449
Other	22,269	84	22,353	22,269	0	22,269	22,269	0	22,269
Septic	146,584	19,094	165,678	146,584	19,471	166,054	146,584	18,934	165,517
Total	**1,130,382**	**119,743**	**1,250,125**	**1,130,382**	**128,107**	**1,258,489**	**1,130,382**	**167,184**	**1,396,157**
Change in Urban from previous period				0	9,808	9,808	0	2,727	2,727
Change in Septic from previous period				0	377	377	0	-537	-537
Change in Agricultural from previous period				0	-597	-597	0	0	0
Change in Forest from previous period				0	-1,139	-1,139	0	-342	-342
Total Change				**0**	**8,364**	**8,364**	**0**	**1,848**	**1,848**
Urban BMPs	-2,672	-2,634	-5,306	-2,672	-7,538	-10,210	-2,672	-8,901	-11,573
CIP Restoration	0	-5,914	-5,914	0	-18,586	-18,586	0	-31,258	-21,258
Reforestation	-164	-164	-327	-409	-409	-819	-655	-655	-1,310
Other Reductions	0	-871	-871	0	-1,768	-1,768	0	-1,768	-1,768
Total	**-2,835**	**-9,582**	**-12,418**	**-3,081**	**-28,301**	**-31,362**	**-3,327**	**-42,582**	**-45,909**
Total with Urban BMPs	1,127,711	117,109	1,244,819	1,127,711	120,569	1,248,280	1,127,711	121,054	1,248,764
Total with Urban BMPs and Restoration	1,127,547	110,160	1,237,707	1,127,301	99,806	1,227,107	1,127,056	87,373	1,214,428

Table A-46: Acres of Redevelopment Needed to Meet Loch Raven Watershed Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	1,073	298	1,371	793	-578	13.1 %
3b	110	31	143	793	650	1.4%
3c	1,238	344	1,582	793	-789	15.2%
3d	193	54	247	793	546	2.4 %

Table A-47: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 Nitrogen Loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	1,073	10,945	2,736	298	3,043	761
Low – 3b	25%	110	1,123	281	31	312	78
High/Parks – 3c	59%	1,238	12,628	7,451	344	3,511	2,072
Low/Parks – 3d	59%	193	1,964	1,159	54	546	322
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	1,073	1,309	301	298	364	84
Low	23%	110	134	31	31	37	9
High/Parks	55%	1,238	1,510	831	344	420	231
Low/Parks	55%	193	235	129	54	65	36

Table A-48: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	59,265	55,576	61,900	60,961	58,575	57,657
Low – 3b	59,265	55,576	61,900	60,961	58,846	58,003
High/Parks – 3c	59,265	55,576	61,900	60,961	58,046	56,981
Low/Parks – 3d	59,265	55,576	61,900	60,961	58,747	57,877

Table A-49: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	1,270,431	1,230,860	1,298,697	1,250,125	1,220,911	1,206,987
Low – 3b	1,270,431	1,230,860	1,298,697	1,250,125	1,223,366	1,210,125
High/Parks – 3c	1,270,431	1,230,860	1,298,697	1,250,125	1,216,196	1,200,961
Low/Parks – 3d	1,270,431	1,230,860	1,298,697	1,250,125	1,222,488	1,209,002

Table A-50: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	59,265	55,576	61,900	60,961	56,504	-2,761	928	55,014	-4,251	-562
Scenario 2 – All Development within URDL	59,265	55,576	61,900	60,961	59,339	74	3,763	58,645	-620	3,069
Scenario 3a – All Redevelopment – High	59,265	55,576	61,900	60,961	58,575	-690	2,999	57,657	-1,608	2,081
Scenario 3b – All Redevelopment – Low	59,265	55,576	61,900	60,961	58,846	-419	3,270	58,003	-1,262	2,427
Scenario 3c – All Redevelopment – High/Parks	59,265	55,576	61,900	60,961	58,046	-1,219	2,470	56,981	-2,284	1,405
Scenario 3d – All Redevelopment – Low/Parks	59,265	55,576	61,900	60,961	58,747	-518	3,171	57,877	-1,388	2,301

Table A-51: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	1,270,431	1,230,860	1,298,697	1,250,125	1,169,061	-101,370	-61,799	1,140,044	-130,387	-90,816
Scenario 2 – All Development within URDL	1,270,431	1,230,860	1,298,697	1,250,125	1,227,107	-43,324	-3,753	1,214,428	-56,003	-16,432
Scenario 3a – All Redevelopmen t – High	1,270,431	1,230,860	1,298,697	1,250,125	1,220,911	-49,520	-9,949	1,206,987	-63,444	-23,873
Scenario 3b – All Redevelopmen t – Low	1,270,431	1,230,860	1,298,697	1,250,125	1,223,366	-47,065	-7,494	1,210,125	-60,306	-20,735
Scenario 3c – All Redevelopmen t – High/Parks	1,270,431	1,230,860	1,298,697	1,250,125	1,216,196	-54,235	-14,664	1,200,961	-69,470	-29,899
Scenario 3d – All Redevelopmen t – Low/Parks	1,270,431	1,230,860	1,298,697	1,250,125	1,222,488	-47,943	-8,372	1,209,002	-61,429	-21,858

Table A-52: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	59,265	55,576	56,504	-2,761	928	$0	$0	$8,249	$825
Scenario 2 – All Development within URDL	59,265	55,576	59,339	74	3,763	$658	$66	$33,449	$3,345
Scenario 3a – All Redevelopment – High	59,265	55,576	58,575	-690	2,999	$0	$0	$26,658	$2,666
Scenario 3b – All Redevelopment – Low	59,265	55,576	58,846	-419	3,270	$0	$0	$29,067	$2,907
Scenario 3c – All Redevelopment – High/Parks	59,265	55,576	58,046	-1,219	2,470	$0	$0	$21,956	$2,196
Scenario 3d – All Redevelopment – Low/Parks	59,265	55,576	58,747	-518	3,171	$0	$0	$28,187	$2,819

Table A-53: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	1,270,431	1,230,860	1,169,061	-101,370	-61,799	$0	$0	$0	$0
Scenario 2 – All Development within URDL	1,270,431	1,230,860	1,227,107	-43,324	-3,753	$0	$0	$0	$0
Scenario 3a – All Redevelopment – High	1,270,431	1,230,860	1,220,911	-49,520	-9,949	$0	$0	$0	$0
Scenario 3b – All Redevelopment – Low	1,270,431	1,230,860	1,223,366	-47,065	-7,494	$0	$0	$0	$0
Scenario 3c – All Redevelopment – High/Parks	1,270,431	1,230,860	1,216,196	-54,235	-14,664	$0	$0	$0	$0
Scenario 3d – All Redevelopment – Low/Parks	1,270,431	1,230,860	1,222,488	-47,943	-8,372	$0	$0	$0	$0

A.2.4 Lower Gunpowder Falls

The Lower Gunpowder Falls watershed is located entirely in Baltimore County in the east central portion of the county. The Prettyboy Reservoir and Loch Raven watersheds are located upstream of the Lower Gunpowder Falls. The Lower Gunpowder Falls in turn discharges to the tidal water segment GUNOH. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-54. The data is displayed as population in the rural section of the watershed (outside the Urban-Rural Demarcation Line, or URDL) and as population in the urban section of the watershed (inside the URDL).

The majority of the population in 2005 was located within the urban portion of the watershed (85.1%) and is projected to maintain approximately the same proportion. However, the urban section of the watershed comprises 31% of the land area in the watershed. The Lower Gunpowder Falls watershed is projected to receive ~5.1% of the future population growth. The annual growth rate will decrease from ~630 per year in the 1997 – 2005 time period to ~190 and ~70 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Lower Gunpowder Falls watershed contains 7.6% of the land in Baltimore County and 6.5% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-55. An additional 1,037 acres of urban land will be developed during the 2005 – 2035 timeframe, at the expense of agricultural land and forest land. Forest land is projected to lose 633 acres and agriculture is projected to decrease by 444 acres. The overall percentage of urban land will increase from 31.9% in 2005 to 35.4% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-56 and A-57, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in an increase in phosphorus by 1,106 pounds by 2035 compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 987 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 2,368 pounds. Through 2005, restoration activities have achieved 387 pounds of reduction, or ~39% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 timeframe due to development with stormwater management (968 pounds), progress toward meeting the 15% reduction target is negative, with a net gain of 581 pounds of phosphorus. A total reduction of 1,568 pounds of urban phosphorus by 2020 is now needed to meet the 15% reduction target and 2,949 pounds is needed to meet a 36% reduction.

Nitrogen pollutant loads (Table A-57) showed an overall decrease from 1997 – 2035. The decrease is a result of decreased loads due to land use changes, implementation of Environmental Site Design, and continued implementation of capital restoration projects. This results in a total decrease in nitrogen load of 34,100 pounds by 2020, and 49,300 pounds by 2035. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 10,616 pounds of urban nitrogen. A 36% urban nitrogen reduction that may be required by the Chesapeake Bay TMDL would require the reduction of 25,478 pounds of nitrogen. The 15% reduction was met by 2005 and the 36% urban nitrogen reduction will be met by 2020. Restoration efforts through 2005 have resulted in a reduction of 7,112 pounds of nitrogen. Combined with the nitrogen reduction effects of land use change and implementation of stormwater management, nitrogen reductions are currently adequate to meet the 15% and 36% reduction targets.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the new population would be served by public water and sewer.

Table A-58 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development (345 acres) compared to Scenario 1 and fewer acres of forest (-340 acres) and agricultural land (-97) would be lost between 2005 and 2035. This Scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land.

Tables A-59 and A-60 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 timeframe, as those changes are based on development activities that have already occurred. Because the land use change involves mainly conversion for forest to urban land use, the phosphorus load will increase by 166 pounds in the 2005 – 2020 timeframe, even with ESD. The cost to address this additional phosphorus load created through development would be ~$1.5 million.

Nitrogen under this scenario would decrease by 995 pounds, and would require no additional fund to address the development load.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-61 presents the number of acres needed to absorb the projected population increase in the Loch Raven Reservoir watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 529 acres of land for potential redevelopment identified. This provides sufficient acreage to meet the redevelopment for scenarios 3b and 3d, but falls short of the acreage needed for scenarios 3a and 3c. The amount of redevelopment needed ranged from 0.9% to 10.5% of the urban land.

Table A-62 presents the phosphorus and nitrogen loads projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most amount of phosphorus and nitrogen removal. Table A-63 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. None of the redevelopment scenarios would be able to meet the 15% urban phosphorus reduction by 2020, although 3c would meet the 15% phosphorus reduction by 2035. None of the scenarios would meet a 36% urban phosphorus reduction even in the 2035 timeframe. Table A-64 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen was already met by 2005 and the 36% urban nitrogen reduction would be met by 2020, with the exception of redevelopment scenario 3b.

Scenario Comparisons

Tables A-65 and A-66 show the comparison of all scenarios considered in the Lower Gunpowder Falls watershed for phosphorus and nitrogen, respectively. None of the scenarios would meet a 15% phosphorus reduction by 2020, and only two (3a and 3c) would meet the 15% phosphorus reduction by 2035. None of the scenarios would meet a 36% phosphorus reduction by 2035. All of the scenarios have already met the 15% reduction target for urban nitrogen and all but two (Scenario 2 and Redevelopment Scenario 3b) are projected to meet the 36% urban nitrogen reduction target by 2020.

Cost of Meeting Nutrient TMDLs by 2020

In order to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, the information in Tables A-65 and A-66 was used. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used from Table A-65 for phosphorus and A-67 for nitrogen. Based on the capital program expenditures in the 1997 – 2005 timeframe and the pounds of phosphorus and nitrogen removed through capital project implementation, a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are displayed in Table A-67 for phosphorus and A-68 for nitrogen. For the Lower Gunpowder Falls watershed, all scenarios would require additional capital expenditures to meet a 15% urban phosphorus reduction by 2020. The additional capital expenditure ranges from $427,000 (3c) to $842,000 (2) per year. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $1.7 to $2.1

million. To meet the 15% or the 36% urban nitrogen reduction target by 2020 would require no additional capital funding.

Table A-54: Lower Gunpowder Falls Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	7,171	38,897	46,068	-	-	-
2005	7,611	43,556	51,167	440	4,659	5,099
2020	8,030	45,953	53,983	419	2,397	2,816
2035	8,190	46,871	55,061	160	918	1,078

Table A-55: Scenario 1 - Land Use Changes (Acres) – Lower Gunpowder Falls Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	452	1,297	1,749	568	1,543	2,110	677	1,669	2,346	719	1,717	2,436
Pervious Urban HD	277	3,043	3,321	1,240	3,469	4,709	2,156	3,688	5,844	2,506	3,772	6,278
Pervious Urban LD	2,133	1,239	3,371	1,654	918	2,571	1,197	753	1,950	1,.23	689	1,712
Cropland	6,643	898	7,541	5,161	631	5,792	3,749	493	4,243	3,210	441	3,651
Pasture	1,449	113	1,561	2,647	282	2,929	3,789	369	4,158	4,225	402	4,627
Livestock Feeding	265	0	265	264	0	264	263	0	263	263	0	263
Forest	9,082	2,449	11,530	8,787	2,104	10,891	8,507	1,927	10,434	8,400	1,859	10,259
Water	91	5	96	61	7	68	32	8	40	21	9	30
Bare Soil	33	0	33	43	90	134	53	137	190	57	155	212
Total	**20,425**	**9,044**	**29,468**	**20,425**	**9,044**	**29,468**	**20,425**	**9,044**	**29,468**	**20,425**	**9,044**	**29,468**
Total Urban	2,862	5,579	8,441	3,461	5,929	9,390	4,031	6,110	10,140	4,248	6,179	10,427
Total Agriculture	8,357	1,011	9,367	8,072	913	8,985	7,802	862	8,664	7,698	843	8,541
Total Forest	9,082	2,449	11,530	8,787	2,104	10,891	8,507	1,927	10,434	8,400	1,859	10,259
% Urban	14.0%	61.7%	28.6%	16.9%	65.6%	31.9%	19.7%	67.6%	34.4%	20.8%	68.2%	35.4%
% Agriculture	40.9%	11.2%	31.8%	39.5%	10.1%	30.5%	38.2%	9.5%	29.4%	37.7%	9.3%	29.0%
% Forest	44.5%	27.1%	39.1%	43.0%	23.3%	37.0%	41.7%	21.3%	35.4%	41.1%	20.6%	34.8%
Change in Urban from previous time period				**598**	**350**	**949**	**570**	**180**	**750**	**218**	**69**	**287**
Change in Agriculture from previous time period				**-284**	**-98**	**-382**	**-271**	**-50**	**-321**	**-103**	**-19**	**-123**
Change in Forest from previous time period				**-294**	**-345**	**-639**	**-280**	**-177**	**-458**	**-107**	**-68**	**-175**

Table A-56: Phosphorus Load Changes (Pounds) – Lower Gunpowder Falls Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	2,052	4,772	6,824	2,523	5,373	7,896	2,971	5,683	8,654	3,142	5,801	8,943
Agriculture	6,153	729	6,882	5,960	660	6,620	5,776	624	6,401	5,706	611	6,317
Forest	182	49	231	176	42	218	170	39	209	168	37	205
Water	52	3	55	35	4	39	18	5	23	12	5	17
Bare Soil	24	0	24	32	66	98	39	100	139	42	113	154
Total	**8,463**	**5,553**	**14,016**	**8,725**	**6,145**	**14,870**	**8,975**	**6,450**	**15,425**	**9,070**	**6,567**	**15,637**
Change in Urban from previous time period				471	601	1,072	448	309	758	171	118	290
Change in Agriculture from previous time period				-193	-69	--262	-184	-35	-219	-70	-14	-84
Change in Forest from previous time period				-6	-7	-13	-6	-4	-9	-2	-1	-3
Total Change from previous time period				**262**	**592**	**855**	**250**	**305**	**554**	**95**	**117**	**212**
Urban BMPs	-81	-166	-247	-22	-111	-133	-291	-297	-588	-394	-368	-762
CIP Restoration	0	0	0	0	-251	-251	0	-790	-790	0	-1,329	-1,329
Reforestation	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-2
Other Reductions	0	0	0	0	-135	-135	0	-135	-135	0	-135	-135
Total Reductions	**-81**	**-166**	**-247**	**-22**	**-498**	**-520**	**-192**	**-1,222**	**-1,514**	**-395**	**-1,833**	**-2,227**
Total with Urban BMPs	8,382	5,387	13,769	8,703	6,034	14,737	8,683	6,154	14,837	8,676	6,199	14,875
Total With Urban BMPs and Restoration	8,382	5,387	13,769	8,702	5,648	14,350	8,683	5,228	13,911	8,675	4,734	13,409

Table A-57: Nitrogen Load Changes (Pounds) – Lower Gunpowder Falls Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	23,830	49,321	73,151	28,962	53,546	82,508	33,850	55,719	89,569	35,717	56,552	92,268
Agriculture	127,179	15,690	142,869	111,439	12,510	123,950	96,450	10,875	107,325	90,727	10,248	100,975
Forest	12,805	3,453	16,258	12,390	2,967	15,357	11,995	2,716	14,711	11,844	2,621	14,465
Other	1,154	54	1,208	928	739	1,667	713	1,091	1,804	630	1,226	1,857
Septic	27,290	7,567	35,357	29,213	7,775	36,988	30,679	7,400	38,079	31,204	7,017	38,221
Total	**192,759**	**76,084**	**268,843**	**182,933**	**77,536**	**260,469**	**173,687**	**77,802**	**251,489**	**170,121**	**77,664**	**247,786**
Change in Urban from previous time period				5,133	4,225	9,357	4,888	2,174	7,061	1,866	832	2,699
Change in Septic from previous time period				1,423	207	1,630	1,466	-374	1,092	525	-383	142
Change in Agriculture from previous time period				-15,740	-3,179	-18,919	-14,989	-1,636	-16,625	-5,724	-626	-6,350
Change in Forest from previous time period				-415	-486	-901	-395	-250	-645	-151	-96	-247
Total Change from previous time period				**-9,826**	**1,452**	**-8,374**	**-9,246**	**266**	**-8,980**	**-3,566**	**-138**	**-3,704**
Urban BMPs	-904	-1,474	-2,378	-297	-1,391	-1,688	-2,741	-2,478	-5,219	-3,674	-2,894	-6,568
CIP Restoration	0	0	0	0	-4,743	-4,743	0	-14,907	-14,907	0	-25,070	-25,070
Reforestation	0	0	0	-4	-4	-7	-9	-9	-18	-15	-15	-29
Other Reductions	0	0	0	0	-348	-348	0	-348	-348	0	-348	-348
Total Reductions	**-904**	**-1,474**	**-2,378**	**-301**	**-6,486**	**-6,786**	**-2,750**	**-17,742**	**-20,492**	**-3,689**	**-28,327**	**-32,016**
Total with Urban BMPs	191,855	74,610	266,464	182,636	76,145	258,781	170,947	75,324	246,271	166,447	74,770	241,218
Total With Urban BMPs and Restoration	191,855	74,610	266,464	182,632	71,050	253,683	170,937	60,060	230,998	166,433	49,337	215,770

Table A-58: Scenario 2 – Future Land Use Changes (Acres) – Lower Gunpowder Falls

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	568	1,543	2,110	568	1,718	2,286	568	1,785	2,352
Urban Pervious HD	1,240	3,469	4,709	1,240	3,774	5,013	1,240	3,889	5,129
Urban Pervious LD	1,654	918	2,571	1,654	688	2,342	1,654	601	2,255
Cropland	5,161	631	5,792	5,161	440	5,601	5,161	367	5,528
Pasture	2,647	282	2,929	2,647	403	3,050	2,647	448	3,096
Livestock Feeding	264	0	264	264	0	264	264	0	264
Forest	8,787	2,104	10,891	8,787	1,858	10,645	8,787	1,764	10,551
Water	61	7	68	61	9	70	61	9	70
Bare Soil	43	90	134	43	155	198	43	180	223
Total	**20,425**	**9,044**	**29,468**	**20,425**	**9,044**	**29,468**	**20,425**	**9,044**	**29,468**
Total Urban	3,461	5,929	9,390	3,461	6,180	9,641	3,461	6,275	9,736
Total Agriculture	8,072	913	8,985	8,072	842	8,915	8,072	816	8,888
Total Forest	8,787	2,104	10,891	8,787	1,858	10,645	8,787	1,764	10,551
% Urban	16.9%	65.6%	31.9%	16.9%	68.3%	32.7%	16.9%	69.4%	33.0%
% Agriculture	39.5%	10.1%	30.5%	39.5%	9.3%	30.3%	39.5%	9.0%	30.2%
% Forest	43.0%	23.3%	37.0%	43.0%	20.5%	36.1%	43.0%	19.5%	35.8%
Change in Urban Land Use from previous period				**0**	**250**	**250**	**0**	**95**	**95**
Change in Agricultural Land Use from previous period				**0**	**-70**	**-70**	**0**	**-27**	**-27**
Change in Forest Land Use from previous period				**0**	**-246**	**-246**	**0**	**-94**	**-94**

Table A-59: Scenario 2 – Phosphorus Load Changes (Pounds) – Lower Gunpowder Falls

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	2,523	5,373	7,896	2,523	5,803	8,326	2,523	5,966	8,490
Agriculture	5,960	660	6,620	5960	611	6,571	5,960	592	6,552
Forest	176	42	218	176	37	213	176	35	211
Water	35	4	39	35	5	40	35	5	40
Bare Soil	32	66	98	32	113	145	32	131	163
Total	**8,725**	**6,145**	**14,871**	**8,725**	**6,559**	**15,294**	**8,725**	**6,730**	**15,455**
Change in Urban from previous period				0	430	430	0	163	163
Change in Agricultural from previous period				0	-49	-49	0	-19	-19
Change in Forest from previous period				0	-5	-5	0	-2	-2
Total Change from previous period				**0**	**423**	**423**	**0**	**161**	**161**
Urban BMPs	-22	-111	-133	-22	-369	-391	-22	-467	-489
CIP Restoration	0	-251	-251	0	-790	-790	0	-1,329	-1,329
Reforestation	0	0	-1	-1	-1	-1	-1	-1	-1
Other Reductions	0	-135	-135	0	-135	-135	0	-135	-135
Total	**-22**	**-498**	**-520**	**-23**	**-1,295**	**-1,318**	**-23**	**-1,935**	**-1,955**
Total with Urban BMPs	8,703	6,034	14,737	8,703	6,200	14,903	8,703	6,263	14,966
Total with Urban BMPs and Restoration	8,702	5,648	14,350	8,702	5,274	13,976	8,702	4,798	13,500

Table A-60: Scenario 2 – Nitrogen Load Changes (Pounds) – Lower Gunpowder Falls

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	28,962	53,546	82,508	28,962	56,565	85,528	28,962	57,714	86,676
Agriculture	111,439	12,510	123,950	111,439	10,238	121,678	111,439	9,374	120,813
Forest	12,390	2,967	15,357	12,390	2,619	15,009	12,390	2,487	14,877
Water	609	75	684	609	89	699	609	95	704
Bare Soil	319	664	983	319	1,139	1,458	319	1,320	1,639
Septic	29,213	7,775	36,988	29,213	7,400	36,613	29,213	7,017	28,233
Total	**182,933**	**77,536**	**260,469**	**182,933**	**78,051**	**260,984**	**182,933**	**78,007**	**260,940**
Change in Urban from previous period				0	3,020	3,020	0	1,149	1,149
Change in Septic load from previous period				0	-374	-374	0	-383	-383
Change in Agricultural from previous period				0	-2,272	-2,272	0	-865	-865
Change in Forest from previous period				0	-347	-347	0	-132	-132
Total Change from previous period				**0**	**515**	**515**	**0**	**-44**	**-44**
Urban BMPs	-297	-1,391	-1,688	-297	-2,901	-3,198	-297	-3,475	-3,772
CIP Restoration	0	-4,743	-4,743	0	-14,907	-14,907	0	-25,070	-25,070
Reforestation	-4	-4	-7	-9	-9	-18	-15	-15	-29
Other Reductions	0	-348	-348	0	-348	-348	0	-348	-348
Total	**-301**	**-6,486**	**-6,786**	**-306**	**-18,165**	**-18,471**	**-312**	**-28,908**	**-29,220**
Total with Urban BMPs	182,636	76,145	258,781	182,636	75,150	257,786	182,636	74,531	257,167
Total with Urban BMPs and Restoration	182,632	71,050	253,683	182,627	59,887	242,513	182,621	49,099	231,720

Table A-61: Acres of Redevelopment Needed to Meet Lower Gunpowder Falls Watershed Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	390	148	**538**	529	-9	9.1%
3b	40	15	**55**	529	474	0.9%
3c	450	171	**621**	529	-92	10.5%
3d	70	27	**97**	529	432	1.6 %

Table A-62: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 Nitrogen Loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	390	3,974	994	148	1,512	378
Low – 3b	25%	40	408	102	15	155	39
High/Parks – 3c	59%	450	4,585	2,705	171	1,745	1,029
Low/Parks – 3d	59%	70	713	421	27	271	160
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	390	475	109	148	181	42
Low	23%	40	49	11	15	19	4
High/Parks	55%	450	548	302	171	209	115
Low/Parks	55%	70	85	47	27	32	18

Table A-63: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	13,029	11,648	13,769	14,350	13,701	13,120
Low – 3b	13,029	11,648	13,769	14,350	13,800	13,256
High/Parks – 3c	13,029	11,648	13,769	14,350	13,509	12,855
Low/Parks – 3d	13,029	11,648	13,769	14,350	13,764	13,207

Table A-64: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	258,227	243,365	266,464	253,683	242,515	231,962
Low – 3b	258,227	243,365	266,464	253,683	243,406	233,193
High/Parks – 3c	258,227	243,365	266,464	253,683	240,803	229,599
Low/Parks – 3d	258,227	243,365	266,464	253,683	243,087	232,753

Table A-65: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	13,029	11,648	13,769	14,350	13,911	882	2,263	13,409	380	1,761
Scenario 2 – All Development within URDL	13,029	11,648	13,769	14,350	13,976	947	2,328	13,500	471	1,852
Scenario 3a – All Redevelopment – High	13,029	11,648	13,769	14,350	13,701	672	2,053	13,120	91	1,472
Scenario 3b – All Redevelopment – Low	13,029	11,648	13,769	14,350	13,800	771	2,152	13,256	227	1,608
Scenario 3c – All Redevelopment – High/Parks	13,029	11,648	13,769	14,350	13,509	480	1,861	12,855	-174	1,207
Scenario 3d – All Redevelopment – Low/Parks	13,029	11,648	13,769	14,350	13,764	735	2,116	13,207	178	1,559

Table A-66: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	258,227	243,365	266,464	253,683	230,998	-27,229	-12,367	215,770	-42,457	-27,595
Scenario 2 – All Development within URDL	258,227	243,365	266,464	253,683	242,513	-15,714	-852	231,720	-26,507	-11,645
Scenario 3a – All Redevelopment – High	258,227	243,365	266,464	253,683	242,515	-15,712	-850	231,962	-26,265	-11,403
Scenario 3b – All Redevelopment – Low	258,227	243,365	266,464	253,683	243,406	-14,821	41	233,193	-25,034	-10,172
Scenario 3c – All Redevelopment – High/Parks	258,227	243,365	266,464	253,683	240,803	-17,424	-2,562	229,599	-28,628	-13,766
Scenario 3d – All Redevelopment – Low/Parks	258,227	243,365	266,464	253,683	243,087	-15,140	-278	232,753	-25,474	-10,612

Table A-67: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	13,029	11,648	13,911	882	2,263	$7,840	$20,116	$784	$2,012
Scenario 2 – All Development within URDL	13,029	11,648	13,976	947	2,328	$8,418	$20,694	$842	$2,069
Scenario 3a – All Redevelopment – High	13,029	11,648	13,701	672	2,053	$5,973	$18,249	$597	$1,825
Scenario 3b – All Redevelopment – Low	13,029	11,648	13,800	771	2,152	$6,853	$19,129	$685	$1,913
Scenario 3c – All Redevelopment – High/Parks	13,029	11,648	13,509	480	1,861	$4,267	$16,542	$427	$1,654
Scenario 3d – All Redevelopment – Low/Parks	13,029	11,648	13,764	735	2,116	$6,533	$18,809	$653	$1,881

Table A-68: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	258,227	243,365	230,998	-27,229	-12,367	$0	$0	$0	$0
Scenario 2 – All Development within URDL	258,227	243,365	242,513	-15,714	-852	$0	$0	$0	$0
Scenario 3a – All Redevelopment – High	258,227	243,365	242,515	-15,712	-850	$0	$0	$0	$0
Scenario 3b – All Redevelopment – Low	258,227	243,365	243,406	-14,821	41	$0	$45	$0	$5
Scenario 3c – All Redevelopment – High/Parks	258,227	243,365	240,803	-17,424	-2,562	$0	$0	$0	$0
Scenario 3d – All Redevelopment – Low/Parks	258,227	243,365	243,087	-15,140	-278	$0	$0	$0	$0

A.2.5 Little Gunpowder Falls

The Little Gunpowder Falls watershed is located in the east central portion of Baltimore County. The watershed is split between Baltimore County and Harford County with the mainstem serving as the dividing line between the two jurisdictions. The Little Gunpowder Falls discharges to the tidal water segment GUNOH. The entire Little Gunpowder Falls watershed is outside the URDL, therefore only Scenario 1 is applicable. Scenario 2 – All Development Within the URDL and the redevelopment scenarios would result in no change from 2005.

Table A-69 below indicates that the population grew by 448 new residents between 1997 and 2005. The projected growth is 514 and 189 additional people between 2005 – 2020 and 2020 – 2035 timeframes, respectively.

Table A-69: Little Gunpowder Falls Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	6,905	-	6,905	-	-	-
2005	7,353	-	7,353	448	-	448
2020	7,867	-	7,867	514	-	514
2035	8,056	-	8,056	189	-	189

Table A-70 presents the land use change between 1997 and 2005 along with the projected changed between 2005 – 2020 and between 2020 – 2035 using Scenario 1 – Development As Is.

Table A-70: Little Gunpowder Falls Watershed – Land Use Changes (Acres)

Land Use Category	1997 Actual	2005 Actual	2020 Projected	2035 projected
Urban Impervious	403	538	693	750
Urban Pervious HD	166	996	1,950	2,300
Urban Pervious LD	2,233	1,446	544	212
Cropland	5,700	4,310	2,716	2,130
Pasture	2,198	3,031	3,987	4,338
Livestock Feeding	54	56	59	60
Forest	6,474	6,847	7,275	7,432
Water	35	35	35	35
Bare Ground	13	15	17	18
Totals	**17,275**	**17,275**	**17,275**	**17,275**
Total Urban	2,801	2,981	3,186	3,262
Total Agriculture	7,952	7,397	6,762	6,528
Total Forest	6,474	6,847	7,275	7,432
% Urban	16.2%	17.3%	18.4%	18.9%
% Agriculture	46.0%	42.8%	39.1%	37.8%
% Forest	37.5%	39.6%	42.1%	43.0%
Change in Urban from previous period		**179**	**206**	**76**
Change in Agriculture from previous period		**-554**	**-637**	**-234**
Change in Forest from previous period		**373**	**428**	**157**

Both urban land use and forest are calculated to increase at the expense of agriculture. The percentage of urban land use is projected grow from 16.2% to 18.9%.

The changes in phosphorus and nitrogen loads are displayed in Tables A-71 and A-72, respectively. Due to the land use change from agriculture to urban land and to forested land, both the phosphorus and nitrogen loads decrease as the result of land use change. Future implementation of ESD would result in further decreases. There have been no restoration projects implemented in the Little Gunpowder Falls watershed, other than street sweeping and inlet cleaning.

Table A-71: Little Gunpowder Falls Watershed – Phosphorus Loads (Pounds)

Urban	1,935	2,262	2,638	2,776
Agriculture	5,772	5,382	4,935	4,771
Forest	129	137	145	149
Water	20	20	20	20
Bare Soil	10	11	13	13
Change in Urban from previous time period		327	375	138
Change in Agriculture from previous time period		-390	-447	-164
Change in Forest from previous time period		7	9	3
Urban BMPs	-92	-63	-288	-371
CIP Restoration	0	0	0	0
Reforestation	0	0	0	0
Other Reductions	0	-26	-26	-26
Total with Urban BMPs	7,774	7,750	7,463	7,358
Total with Urban BMPs and Restoration	7,774	7,724	7,437	7,332

Table A-72: Little Gunpowder Falls Watershed – Nitrogen Loads (Pounds)

	1997 Actual	**2005 Actual**	**2020 Projected**	**2035 Projected**
Urban	23,047	25,279	27,840	28,782
Agriculture	111,824	95,007	75,714	68,619
Forest	9,128	9,654	10,258	10,479
Other	448	462	478	484
Septic	26,679	28,233	30,187	30,905
Total	**171,126**	**158,636**	**144,476**	**139,269**
Change in Urban from previous time period		2,232	2,561	942
Change in Septic from previous time period		1,555	1,953	718
Change in Agriculture from previous time period		-16,816	-19,294	-7,074
Change in Forest from previous time period		526	603	222
Total Change from previous time period		**-12,489**	**-14,160**	**-5,207**
Urban BMPs	-466	-505	-1,785	-2,256
CIP Restoration	0	0	0	0
Reforestation	0	0	0	0
Other Reductions	0	-68	-68	-68
Total Reductions	**-466**	**-573**	**-1,853**	**-2,324**
Total with Urban BMPs	170,659	158,131	142,691	137,013
Total with Urban BMPs and Restoration	170,659	158,063	142,623	136,945

Due to the land use changes from agriculture to urban land and forest land, the Little Gunpowder Falls watershed met the 15% and the 36% urban reduction target nitrogen in 2005. The 15% urban phosphorus load reduction was not met in 2005, but would be met in 2020 if development continues as is. An additional 234 pounds of phosphorus would need to be reduced to meet the 36% urban phosphorus reduction target by 2020. The capital cost associated with this additional reduction would be $2.1 million.

A.2.6 Bird River

The Bird River watershed is located entirely in Baltimore County in the east central portion of the county. The Bird River watershed discharges to the tidal water segment GUNOH. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-73. The data is displayed as population in the rural section of the watershed (outside the Urban-Rural Demarcation Line, or URDL) and urban section (inside the URDL).

The majority of the population in 2005 was located within the urban portion of the watershed (97.7%) and is projected to maintain approximately the same proportion. The urban section of the watershed comprises 82.8% of the land area in the watershed. The Bird River watershed is projected to receive ~12.3% of the future population growth. The annual growth rate will decrease from ~900 per year in the 1997 – 2005 time period to ~500 and ~125 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Bird River watershed contains 4.2% of the land in Baltimore County and 7.2% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-74. An additional 1,706 acres of urban land will be developed during the 2005 – 2035 timeframe, at the expense of agricultural land and forest land. Forest land is projected to lose 828 acres and agriculture is projected to decrease by 815 acres. The overall percentage of urban land will increase from 51.3% in 2005 to 61.7% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-75 and A-76, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in an increase in phosphorus by 1,713 pounds by 2035 compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 934 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 2,243 pounds. Through 2005, restoration activities have achieved 615 pounds of reduction, or ~66% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 timeframe due to development with stormwater management (1,390 pounds), progress toward meeting the 15% reduction target is negative, with a net gain of 775 pounds of phosphorus. A total reduction of 1,709 pounds of urban phosphorus by 2020 is now needed to meet the 15% reduction target and 3,018 pounds is needed to meet a 36% reduction.

Nitrogen pollutant loads (Table A-76) showed an overall increase (4,115 pounds) from 1997 – 2035, even with the implementation of Environmental Site Design. Continued implementation of capital restoration projects results in a decrease in nitrogen load of 24,628 pounds by 2020 and 41,224 pounds by 2035. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 9,600 pounds of urban nitrogen. A 36% urban nitrogen reduction that may be required by the Chesapeake Bay TMDL would require the reduction of 23,040 pounds of nitrogen. While there will be an increase in the nitrogen load due to development, if restoration efforts are continued at the same rate as in the past the 15% urban nitrogen reduction will be met by 2020, and the 36% urban nitrogen reduction will be met by 2035.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the new population would be served by public water and sewer.

Table A-77 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development (1,459 acres versus 1,706) compared to Scenario 1 and fewer acres of agricultural land (-487) would be lost between 2005 and 2035. A greater amount of forest (-903 acres) would be lost under Scenario 2 compared to Scenario 1. This Scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land.

Tables A-78 and A-79 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 timeframe, as those changes are based on development activities that have already occurred. Because the land use change involves mainly conversion for forest to urban land use, the phosphorus load will increase by 396 pounds in the 2005 – 2020 timeframe, even with ESD. The cost to address this additional phosphorus load created through development would be ~$3.5 million.

Nitrogen under this scenario would increase by 42 pounds. However, due to restoration activities, nitrogen would still meet the 15% urban nitrogen reduction target by 2020, but would be ~775 pounds shy of meeting the 36% urban nitrogen reduction target.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-80 presents the number of acres needed to absorb the projected population increase in the Bird River watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 1,612 acres of land for potential redevelopment identified. This provides sufficient acreage to meet all the land acreage requirements of the redevelopment scenarios. The amount of redevelopment needed ranged from 1.4% to 15.8% of the urban land.

Table A-81 presents the phosphorus and nitrogen loads projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most amount of phosphorus and nitrogen removal. Table A-82 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. Only redevelopment scenario 3c would be able to meet the 15% urban phosphorus reduction by 2020, although all would meet the 15% phosphorus reduction by 2035. Scenario 3c would meet a 36% urban phosphorus reduction in the 2035 time frame. Table A-83 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen would be met by 2020 for all redevelopment scenarios and the 36% urban nitrogen reduction would be met by 2020 for redevelopment scenarios 3a and 3c.

Scenario Comparisons

Tables A-84 and A-85 show the comparison of all scenarios considered in the Bird River watershed for phosphorus and nitrogen, respectively. Only scenario 3c would meet a 15% phosphorus reduction by 2020, but all would meet the 15% phosphorus reduction by 2035. Two of the scenarios (3a and 3c) would meet a 36% phosphorus reduction by 2035. All of the scenarios would meet the 15% reduction target for urban nitrogen by 2020, and two (3a and 3c) are projected to meet the 36% urban nitrogen reduction target by 2020. All of the scenarios would meet the 36% nitrogen reduction target by 2035.

Cost of Meeting Nutrient TMDLs by 2020

In order to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, the information in Tables A-84 and A-85 was used. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used from Table A-84 for phosphorus and A-85 for nitrogen. Based the capital program expenditures in the 1997 – 2005 timeframe and the pounds of phosphorus and nitrogen removed through capital project implementation, a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are displayed in Table A-86 for phosphorus and A-87 for nitrogen. For the Bird River watershed, all scenarios, except 3c, would require additional capital expenditures to meet a 15% urban phosphorus reduction by 2020. The additional capital expenditure ranges from $117,000 (3a) to $688,000 (2) per year. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $0.9 to $1.9 million. To meet the 15% urban nitrogen reduction target by 2020 would require no additional capital funding. To meet the 36% urban nitrogen reduction target, no additional funding would be needed for 3a and 3c. The balance of the scenarios would need additional funding in the range of $86,000 to $576,000 per year.

Table A-73: Bird River Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	1,294	48,678	49,972	-	-	-
2005	1,310	55,891	57,201	16	7,213	7,229
2020	1,481	63,202	64,683	171	7,311	7,482
2035	1,525	65,048	66,573	43	1,847	1,890

Table A-74: Land Use Changes (Acres) – Bird River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	57	1,745	1,802	77	2,422	2,499	101	3,108	3,209	107	3,281	3,388
Pervious Urban HD	253	4,185	4,438	201	4,913	5,114	461	5,651	6,112	526	5,838	6,364
Pervious Urban LD	194	949	1,143	144	668	812	56184	382	465	68	310	378
Cropland	619	1,639	2,257	613	1,331	1,944	230	980	1,211	134	884	1,018
Pasture	13	96	108	24	29	53	135	0	135	163	0	163
Livestock Feeding	0	0	0	0	0	0	0	0	0	0	0	0
Forest	1,662	4,797	6,458	1,609	4,117	5,726	1,652	3,414	5,066	1,662	3,235	4,898
Water	30	26	56	0	6	6	0	0	0	0	0	0
Bare Soil	0	145	145	159	96	255	164	46	210	166	33	199
Total	**2,826**	**13,582**	**16,408**	**2,827**	**13,581**	**16,408**	**2,827**	**13,581**	**16,408**	**2,827**	**13,581**	**16,408**
Total Urban	504	6,879	7,383	422	8,003	8,425	645	9,141	9,786	701	9,429	10,130
Total Agriculture	631	1,734	2,366	637	1,360	1,997	366	980	1,346	297	884	1,182
Total Forest	1,662	4,797	6,458	1,609	4,117	5,726	1,652	3,414	5,066	1,662	3,235	4,898
% Urban	17.8%	50.7%	45.0%	14.9%	58.9%	51.3%	**22.8%**	**67.3%**	**59.6%**	**24.8%**	**69.4%**	**61.7%**
% Agriculture	22.3%	12.8%	14.4%	22.5%	10.0%	12.2%	**12.9%**	**7.2%**	**8.2%**	**10.5%**	**6.5%**	**7.2%**
% Forest	58.8%	35.3%	39.4%	56.9%	30.3%	34.9%	**58.4%**	**25.1%**	**30.9%**	**58.8%**	**23.8%**	**29.8%**
Change in Urban from previous time period				**-82**	**1,124**	**1,041**	**223**	**1,139**	**1,362**	**56**	**288**	**344**
Change in Agriculture from previous time period				**6**	**-375**	**-369**	**-271**	**-380**	**-651**	**-68**	**-96**	**-164**
Change in Forest from previous time period				**-53**	**-679**	**-732**	**43**	**-703**	**-660**	**11**	**-179**	**-168**

Table A-75: Phosphorus Load Changes (Pounds) – Bird River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	320	6,153	6,474	322	7,877	8,199	462	9,623	10,085	497	10,064	10,562
Agriculture	435	1,194	1,629	439	937	1,376	248	676	925	200	610	810
Forest	33	96	229	32	82	115	33	68	101	33	65	98
Water	17	15	32	0	3	3	0	0	0	0	0	0
Bare Soil	0	96	96	105	63	169	108	30	139	109	22	131
Total	**805**	**7,554**	**8,359**	**898**	**8,963**	**9,861**	**852**	**10,398**	**11,250**	**840**	**10,761**	**11,601**
Change in Urban from previous time period				2	1,723	1,725	140	1,747	1,887	35	441	477
Change in Agriculture from previous time period				4	-256	--253	-191	-261	-452	-48	-66	-114
Change in Forest from previous time period				-1	-14	-15	0	-14	-13	0	-4	-3
Total Change from previous time period				**92**	**1,409**	**1,501**	**-46**	**1,435**	**1,389**	**-12**	**363**	**352**
Urban BMPs	0	-244	-244	0	-355	-355	-84	-1,403	-1,487	-105	-1,668	-1,773
CIP Restoration	0	0	0	0	-506	-506	0	-1,590	-1,590	0	-2,674	-2,674
Reforestation	0	0	0	-1	-1	-2	-3	-3	-6	-5	-5	-9
Other Reductions	0	0	0	0	-107	-107	0	-107	-107	0	-107	-107
Total Reductions	**-0**	**-244**	**-244**	**-1**	**-969**	**-971**	**-87**	**-3,103**	**-3,190**	**-110**	**-4,484**	**-4,564**
Total with Urban BMPs	805	7,310	8,115	898	8,608	9,505	768	8,995	9,762	735	9,093	9,828
Total With Urban BMPs and Restoration	805	7,310	8,115	896	7,994	8,890	765	7,295	8,060	730	6,307	7,038

Table A-76: Nitrogen Load Changes (Pounds) – Bird River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	4,041	61,821	65,862	3,585	74,604	78,190	5,366	87,562	92,928	5,814	90,835	96,649
Agriculture	8,447	22,729	31,176	8,433	18,187	26,621	3,882	13,272	17,153	2,737	11,973	14,710
Forest	2,143	6,188	8,331	2,075	5,311	7,387	2,131	4,404	6,535	2,145	4,173	6,318
Other	297	1,079	1,336	895	598	1,494	927	258	1,185	934	187	1,121
Septic	2,445	5,496	7,940	2,492	5,543	8,035	2,733	5,266	7,999	2,725	4,988	7,713
Total	**17,373**	**97,312**	**114,685**	**17,481**	**104,244**	**121,725**	**15,038**	**110,761**	**125,800**	**14,355**	**112,157**	**126,512**
Change in Urban from previous time period				-455	12,783	12,328	1,781	12,957	14,738	448	3,273	3,721
Change in Septic from previous time period				47	47	95	241	-277	-36	-8	-277	-285
Change in Agriculture from previous time period				-14	-4,542	-4,555	-4,552	-4,916	-9,467	-1,145	-1,299	-2,443
Change in Forest from previous time period				-69	-887	-994	55	-907	-852	14	-231	-217
Total Change from previous time period				**108**	**6,932**	**7,041**	**-2,443**	**6,517**	**4,074**	**-683**	**1,395**	**712**
Urban BMPs	0	-1,861	-1,861	0	-3,728	-3,728	-891	-10,207	-11,097	-1,115	-11,843	-12,958
CIP Restoration	0	0	0	0	-7,723	-7,723	0	-24,271	-24,271	0	-40,820	-40,820
Reforestation	0	0	0	-16	-16	-32	-40	-40	-80	-64	-64	-128
Other Reductions	0	0	0	0	-276	-276	0	-276	-276	0	-276	-276
Total Reductions	**0**	**-1,861**	**-1,861**	**-16**	**-11,743**	**-11,759**	**-931**	**-34,794**	**-35,725**	**-1,179**	**-53,004**	**-54,182**
Total with Urban BMPs	17,373	95,451	112,823	17,481	100,516	117,997	14,148	100,516	117,997	14,148	100,555	114,702
Total With Urban BMPs and Restoration	17,373	95,451	112,823	17,465	92,501	109,967	14,108	75,967	90,075	13,176	59,153	72,329

Table A-77: Scenario 2 – Future Land Use Changes (Acres) – Bird River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	77	2,422	2,499	77	3,124	3,201	77	3,302	3,378
Urban Pervious HD	201	4,913	5,114	201	5,669	5,869	201	5,859	6,060
Urban Pervious LD	144	668	812	144	375	520	144	301	446
Cropland	613	1,331	1,944	613	971	1,584	613	873	1,486
Pasture	24	29	53	24	0	24	24	0	24
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	1,609	4,117	5,726	1,609	3,398	5,006	1,609	3,214	4,823
Water	0	6	6	0	0	0	0	0	0
Bare Soil	159	96	255	159	45	203	159	32	190
Total	**2,827**	**13,581**	**16,408**	**2,827**	**13,581**	**16,408**	**2,827**	**13,581**	**16,408**
Total Urban	422	8,003	8,425	422	9,168	9,590	422	9,462	9,884
Total Agriculture	637	1,360	1,997	637	971	1,608	637	873	1,510
Total Forest	1,609	4,117	5,726	1,609	3,398	5,006	1,609	3,214	4,823
% Urban	14.9%	58.9%	51.3%	14.9%	67.5%	58.4%	14.9%	69.7%	60.2%
% Agriculture	22.5%	10.0%	12.2%	22.5%	7.2%	9.8%	22.5%	6.4%	9.2%
% Forest	56.9%	30.3%	34.9%	56.9%	25.0%	30.5%	56.9%	23.7%	29.4%
Change in Urban Land Use from previous period				**0**	**1,165**	**1,165**	**0**	**294**	**294**
Change in Agricultural Land Use from previous period				**0**	**-389**	**-389**	**0**	**-98**	**-98**
Change in Forest Land Use from previous period				**0**	**-720**	**-720**	**0**	**-183**	**-183**

Table A-78: Scenario 2 – Phosphorus Load Changes (Pounds) – Bird River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	322	5,474	8,199	322	7,061	9,986	322	10,116	10,437
Agriculture	439	937	1,376	439	670	1,109	439	602	1,041
Forest	32	82	115	32	68	100	32	64	96
Water	0	3	3	0	0	0	0	0	0
Bare Soil	105	63	168	105	29	134	105	21	126
Total	**898**	**8,963**	**9,861**	**898**	**10,432**	**11,329**	**898**	**10,116**	**11,701**
Change in Urban from previous period				0	1,787	1,787	0	452	452
Change in Agricultural from previous period				0	-267	-267	0	-68	-68
Change in Forest from previous period				0	-14	-14	0	-4	-4
Total Change				**0**	**1,469**	**1,469**	**0**	**372**	**372**
Urban BMPs	0	-355	-355	0	-1,428	-1,428	0	-1,699	-1,699
CIP Restoration	0	-506	-506	0	-1,590	-1,590	0	-2,674	-2,674
Reforestation	-1	-1	-2	-3	-3	-6	-5	-5	-9
Other Reductions	0	-107	-107	0	-107	-107	0	-107	-107
Total	**-1**	**-969**	**-970**	**-3**	**-3,128**	**-3,130**	**-5**	**-4,484**	**-4,489**
Total with Urban BMPs	898	8,608	9,505	898	9,004	9,901	898	9,104	10,002
Total with Urban BMPs and Restoration	896	7,994	8,890	893	7,304	8,199	893	6,319	7,212

Table A-79: Scenario 2 – Nitrogen Load Changes (Pounds) – Bird River

Land Use	2005 Rural	2005 Urban	2005 Total	2020 Rural	2020 Urban	2020 Total	2035 Rural	2035 Urban	2035 Total
Urban	3,585	74,604	78,190	3,585	87,865	91,450	3,585	91,214	94,800
Agriculture	8,433	18,187	26,621	8,433	13,152	21,585	8,433	11,823	20,256
Forest	2,075	5,311	7,387	2,075	4,383	6,458	2,075	4,146	6,222
Water	0	58	58	0	0	0	0	0	0
Bare Soil	895	540	1,436	895	251	1,147	895	179	1,074
Septic	2,492	5,543	8,035	2,492	5,266	7,757	2,492	4,988	7,480
Total	**17,481**	**104,244**	**121,725**	**17,481**	**110,916**	**128,397**	**17,481**	**112,350**	**129,831**
Change in Urban from previous period				0	13,260	13,260	0	3,350	3,350
Change in Septic from previous period				0	-277	-277	0	-277	-277
Change in Agricultural from previous period				0	-5,036	-5,036	0	-1,329	-1,329
Change in Forest from previous period				0	-928	-928	0	-236	-236
Total Change				**0**	**6,672**	**6,672**	**0**	**1,434**	**1,434**
Urban BMPs	0	-3,728	-3,728	0	-10,358	-10,358	0	-12,033	-12,033
CIP Restoration	0	-7,723	-7,723	0	-24,271	-24,271	0	40,820	40,820
Reforestation	-16	-16	-32	-40	-40	-80	-64	-64	-128
Other Reductions	0	-276	-276	0	-276	-276	0	-276	-276
Total	**-16**	**-11,743**	**-11,759**	**-40**	**-34,946**	**-34,986**	**-64**	**-53,193**	**-53,258**
Total with Urban BMPs	17,481	100,516	117,997	17,481	100,558	118,039	17,481	100,317	117,798
Total with Urban BMPs and Restoration	17,465	92,501	109,967	17,441	75,970	93,412	17,417	59,157	76,574

Table A-80: Acres of Redevelopment Needed to Meet Bird River Watershed Projected Population Growth

Scenario	Acres Needed 2020	Acres Needed 2035	Acres Needed Total	Acres Available	Difference Total	% Redevelopment
3a	875	221	**1,096**	1,612	515	13.7%
3b	90	23	**113**	1,612	1,500	1.4%
3c	1,010	255	**1,265**	1,612	347	15.8%
3d	157	40	**197**	1,612	1,415	2.5 %

Table A-81: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 Nitrogen Loading – 10.2	**Reduction %**	**2020 Acres**	**2020 Load**	**2020 Reduction**	**2035 Acres**	**2035 Load**	**2035 Reduction**
High – 3a	25%	875	8,929	2,232	221	2,256	564
Low – 3b	25%	90	916	229	23	231	58
High/Parks – 3c	59%	1,010	10,303	6,079	255	2,603	1,535
Low/Parks – 3d	59%	157	1,603	946	40	405	239
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	875	1,068	246	221	270	62
Low	23%	90	110	25	23	28	6
High/Parks	55%	1,010	1,232	678	255	311	171
Low/Parks	55%	157	192	105	40	48	27

Table A-82: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	7,425	6,117	8,115	8,890	7,557	6,407
Low – 3b	7,425	6,117	8,115	8,890	7,777	6,683
High/Parks – 3c	7,425	6,117	8,115	8,890	7,125	5,866
Low/Parks – 3d	7,425	6,117	8,115	8,890	7,697	6,583

Table A-83: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	105,085	91,645	112,823	109,967	91,137	73,977
Low – 3b	105,085	91,645	112,823	109,967	93,141	76,486
High/Parks – 3c	105,085	91,645	112,823	109,967	87,291	69,159
Low/Parks – 3d	105,085	91,645	112,823	109,967	92,424	75,588

Table A-84: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	7,425	6,117	8,115	8,890	8,060	635	1,943	7,038	-387	921
Scenario 2 – All Development within URDL	7,425	6,117	8,115	8,890	8,199	774	2,082	7,212	-213	1,095
Scenario 3a – All Redevelopment – High	7,425	6,117	8,115	8,890	7,557	132	1,440	6,407	-1,018	290
Scenario 3b – All Redevelopment – Low	7,425	6,117	8,115	8,890	7,777	352	1,660	6,683	-742	566
Scenario 3c – All Redevelopment – High/Parks	7,425	6,117	8,115	8,890	7,125	-300	1,008	5,866	-1,559	-251
Scenario 3d – All Redevelopment – Low/Parks	7,425	6,117	8,115	8,890	7,697	272	1,580	6,583	-842	466

Table A-85: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	105,085	91,645	112,823	109,967	90,075	-11,626	1,814	72,329	-32,756	-19,316
Scenario 2 – All Development within URDL	105,085	91,645	112,823	109,967	93,412	-8,240	5,200	76,574	-28,511	-15,071
Scenario 3a – All Redevelop-ment – High	105,085	91,645	112,823	109,967	91,137	-13,948	-508	73,977	-31,108	-17,668
Scenario 3b – All Redevelop-ment – Low	105,085	91,645	112,823	109,967	93,141	-11,944	1,496	76,486	-28,599	-15,159
Scenario 3c – All Re-development – High/Parks	105,085	91,645	112,823	109,967	87,291	-17,794	-4,354	69,159	-35,926	-22,486
Scenario 3d – All Re-development – Low/Parks	105,085	91,645	112,823	109,967	92,424	-12,661	779	75,588	-29,497	-16,057

Table A-86: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	7,425	6,117	8,060	635	1,943	$5,645	$17,271	$564	$1,727
Scenario 2 – All Development within URDL	7,425	6,117	8,199	774	2,082	$6,880	$18,507	$688	$1,851
Scenario 3a – All Redevelopment – High	7,425	6,117	7,557	132	1,440	$1,173	$12,800	$117	$1,280
Scenario 3b – All Redevelopment – Low	7,425	6,117	7,777	352	1,660	$3,129	$14,756	$313	$1,476
Scenario 3c – All Redevelopment – High/Parks	7,425	6,117	7,125	-300	1,008	$0	$8,960	$0	$896
Scenario 3d – All Redevelopment – Low/Parks	7,425	6,117	7,697	272	1,580	$2,418	$14,045	$242	$1,404

Table A-87: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	105,085	91,645	90,075	-11,626	1,814	$0	$2,010	$0	$201
Scenario 2 – All Development within URDL	105,085	91,645	93,412	-8,240	5,200	$0	$5,762	$0	$576
Scenario 3a – All Redevelopment – High	105,085	91,645	91,137	-13,948	-508	$0	$0	$0	$0
Scenario 3b – All Redevelopment – Low	105,085	91,645	93,141	-11,944	1,496	$0	$1,658	$0	$166
Scenario 3c – All Redevelopment – High/Parks	105,085	91,645	87,291	-17,794	-4,354	$0	$0	$0	$0
Scenario 3d – All Redevelopment – Low/Parks	105,085	91,645	92,424	-12,661	779	$0	$863	$0	$86

A.2.7 Gunpowder River

The Gunpowder watershed is located entirely in Baltimore County on the eastern side. The Gunpowder River watershed discharges to the tidal water segment GUNOH and MIDOH. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-88. The data is displayed as population in the rural section of the watershed (outside the Urban-Rural Demarcation Line, or URDL) and urban section (inside the URDL).

The majority of the population in 2005 was located within the urban portion of the watershed (91.5%) and is projected to maintain approximately the same proportion. The urban section of the watershed comprises 38.1% of the land area in the watershed. The Gunpowder River watershed is projected to receive less than 1.0% of the future population growth. The population growth in the 1997 – 2005 timeframe was negative (loss of 285 residents). This may be due to errors in the population estimate due to the small size of the watershed (<6,000 acres) or to the acquisition by the County of an apartment complex for redevelopment purposes. The annual growth rate is projected to be small at ~30 and ~11 new residents per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Gunpowder River watershed contains 1.5% of the land in Baltimore County and 1.1% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-89. An additional 168 acres of urban land will be developed during the 2005 – 2035 timeframe, at the expense of agricultural land and forestland. Forestland is projected to lose 57 acres and agriculture is projected to decrease by 113 acres. The overall percentage of urban land will increase from 32.7% in 2005 to 35.6% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-90 and A-91, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in an increase in phosphorus of 213 pounds by 2035, compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 157 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 377 pounds. Through 2005, restoration activities have achieved 48 pounds of reduction, or ~31% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 timeframe due to development with stormwater management (218 pounds), progress toward meeting the 15% reduction target is negative, with a net gain of 170 pounds of phosphorus. A total reduction of 327 pounds of urban phosphorus by 2020 is now needed to meet the 15% reduction target, and 547 pounds is needed to meet a 36% reduction.

Nitrogen pollutant loads (Table A-91) indicated an overall decrease (-161 pounds) from 1997 – 2035. The decrease is a result of land use changes and implementation of Environmental Site Design. Continued implementation of capital restoration projects through 2020 will result in a total net decrease in nitrogen load of 932 pounds by 2020, and a decrease of 2,073 pounds by 2035. A 15% urban nitrogen load reduction (1,785 pounds of nitrogen) is required to meet the existing nutrient TMDL. A 36% urban nitrogen reduction, that may be required by the Chesapeake Bay TMDL, would require the reduction of 4,283 pounds of nitrogen. The 15% reduction can be met by 2035. Restoration efforts through 2005 have resulted in a reduction of 417 pounds of nitrogen. The combined nitrogen reduction efforts of land use change, implementation of stormwater management, and restoration efforts are not currently adequate to meet the 15% and 36% reduction targets by 2020.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the population would be served by public water and sewer.

Table A-92 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development (107 acres versus 168 acres) compared to Scenario 1 and fewer acres of agricultural land (-30 acres versus 113 acres) would be lost between 2005 and 2035. A greater amount of forest (-77 acres versus 57 acres) would be lost under Scenario 2 compared to Scenario 1. This Scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land.

Tables A-93 and A-94 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 timeframe, as those changes are based on development activities that have already occurred. Because the land use change involves mainly conversion from forest to urban land use, the phosphorus load will increase by 29 pounds in the 2005 – 2020 timeframe, even with ESD. The cost to address this additional phosphorus load created through development would be ~$0.3 million.

Nitrogen under this scenario would also decrease by 43 pounds in the 2005 – 2020 timeframe.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-95 presents the number of acres needed to absorb the projected population increase in the Gunpowder River watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are only 15 acres of land identified for potential redevelopment. This provides sufficient acreage to meet all the land acreage requirements for redevelopment scenarios 3b and 3d, but is far short of the needs for scenarios 3a and 3c. The amount of redevelopment needed ranged from 0.5% to 6.4% of the urban land.

Table A-96 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most phosphorus and nitrogen removal. Table A-97 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. None of the redevelopment scenarios would be able to meet the 15% urban phosphorus reduction by 2020 or by 2035. Table A-98 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen cannot be met by either the 2020 or the 2035 timeframes.

Scenario Comparisons

Tables A-99 and A-100 show the comparison of all scenarios considered in the Gunpowder River watershed for phosphorus and nitrogen, respectively. None of the scenarios would meet a 15% phosphorus reduction by 2020 or by 2035. Scenario 3c comes closest to meeting the 15% urban phosphorus reduction target. None of the scenarios would meet the 15% reduction target for urban nitrogen by 2020, and only Scenario 1 would meet the 15% reduction target by 2035. None of the scenarios would meet the 36% nitrogen reduction target by 2035.

Cost of Meeting Nutrient TMDLs by 2020

In order to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, the information in Tables A-99 and A-100 was used. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used from Table A-99 for phosphorus and A-100 for nitrogen. Based the capital program expenditures in the 1997 – 2005 timeframe and the pounds of phosphorus and nitrogen removed through capital project implementation, a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are presented in Table A-101 for phosphorus and Table A-102 for nitrogen. For the Gunpowder River watershed, all scenarios would require additional capital expenditures to meet a 15% urban phosphorus reduction by 2020. The additional capital expenditure ranges from $176,000 (3c) to $238,000 (2) per year. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $372,000 to $434,000. Additional funding in the range of $57,000 (1) to $144,000 (2) would be required to meet the 15% urban nitrogen reduction target by 2020. To meet the 36% urban nitrogen reduction target, additional funding would be needed for the range of $357,000 to $447,000 per year.

Table A-88: Gunpowder River Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	852	8,012	8,864	-	-	-
2005	728	7,850	8,578	-124	-162	-286
2020	767	8,268	9,035	39	418	457
2035	781	8,425	9,206	15	156	171

Table A-89: Land Use Changes (Acres) – Gunpowder River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	50	196	246	78	270	348	83	309	393	85	334	409
Pervious Urban HD	248	801	1,049	458	1,043	1,501	517	1,097	1,614	540	1,109	1,649
Pervious Urban LD	59	74	132	47	22	69	33	0	33	28	0	28
Cropland	221 0	166	386	215	51	267	128	31	159	95	23	118
Pasture	0	0	0	0	0	0	25	0	25	35	0	35
Livestock Feeding	0	0	0	0	0	0	0	0	0	0	0	0
Forest	2,965	945	3,909	2,828	846	3,674	2,838	794	3,632	2,842	775	3,617
Water	85	52	137	0	0	0	0	0	0	0	0	0
Bare Soil	0	0	0	0	0	0	1	1	2	2	1	3
Total	**3,627**	**2,232**	**5,859**	**3,627**	**2,232**	**5,859**	**3,627**	**2,232**	**5,859**	**3,627**	**2,232**	**5,859**
Total Urban	357	1,070	1,427	583	1,335	1,918	634	1,406	2,040	654	1,432	2,086
Total Agriculture	220	166	386	215	52	267	153	31	184	134	23	153
Total Forest	2,965	945	3,909	2,828	846	3,674	2,838	794	3,632	2,842	775	3,617
% Urban	9.8%	47.9%	24.4%	16.1%	59.8%	32.7%	**27.5%**	**63.0%**	**34.8%**	**18.0%**	**64.2%**	**35.6%**
% Agriculture	6.1%	7.4%	6.6%	5.9%	2.3%	4.6%	**4.2%**	**1.4%**	**3.1%**	**3.6%**	**1.0%**	**2.6%**
% Forest	81.7%	42.3%	66.7%	78.0%	37.9%	62.7%	**78.3%**	**35.6%**	**62.0%**	**78.4%**	**34.7%**	**61.7%**
Change in Urban from previous time period				**227**	**265**	**491**	**51**	**71**	**122**	**20**	**27**	**46**
Change in Agriculture from previous time period				**-5**	**-114**	**-119**	**-62**	**-21**	**-82**	**-24**	**-8**	**-31**
Change in Forest from previous time period				**-136**	**-99**	**-235**	**10**	**-52**	**-42**	**4**	**-19**	**-15**

Table A-90: Phosphorus Load Changes (Pounds) – Gunpowder River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	244	819	1,486	394	1,069	1,463	426	1,171	1,597	438	1,210	1,648
Agriculture	152	114	266	149	36	184	105	21	126	88	16	104
Forest	59	19	78	57	17	73	57	16	73	57	16	72
Water	48	29	78	0	0	0	0	0	0	0	0	0
Bare Soil	0	0	0	0	0	0	1	1	1	1	1	2
Total	**504**	**982**	**1,486**	**599**	**1,122**	**1,720**	**588**	**1,209**	**1,798**	**584**	**1,242**	**1,826**
Change in Urban from previous time period				149	250	399	32	102	134	12	38	50
Change in Agriculture from previous time period				-4	-79	-82	-43	-14	-58	-17	-5	-22
Change in Forest from previous time period				-3	-2	-5	0	-1	-1	0	0	0
Total Change from previous time period				**95**	**140**	**234**	**-10**	**88**	**77**	**-4**	**33**	**29**
Urban BMPs	0	-16	-16	0	-31	-31	-19	-92	-112	-27	-115	-142
CIP Restoration	0	0	0	0	-28	-28	0	-88	-88	0	-147	-147
Reforestation	0	0	0	-4	-4	-9	-11	-11	-21	-17	-17	-34
Other Reductions	0	0	0	0	-12	-12	0	-12	-12	0	-12	-12
Total Reductions	**-0**	**-16**	**-16**	**-4**	**-75**	**-79**	**-30**	**-203**	**-232**	**-44**	**-292**	**-335**
Total with Urban BMPs	504	966	1,471	599	1,091	1,689	569	1,117	1,686	558	1,127	1,684
Total With Urban BMPs and Restoration	504	966	1,471	594	1,046	1,641	558	1,007	1,565	541	950	1,491

Table A-91: Nitrogen Load Changes (Pounds) – Gunpowder River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	2,925	9,100	12,025	4,761	11,526	16,287	5,167	12,311	17,478	5,323	12,603	17,927
Agriculture	2,985	2,243	5,229	2,916	697	3,613	1,877	419	2,297	1,478	315	1,794
Forest	3,824	1,219	5,043	3,648	1,091	4,740	3,661	1,025	4,686	3,666	1,000	4,666
Other	849	516	1,365	0	0	0	7	5	12	10	6	16
Septic	647	2,009	2,655	647	2,009	2,655	684	1,908	2,592	685	1,808	2,493
Total	**11,231**	**15,087**	**26,317**	**11,971**	**15,323**	**27,294**	**11,396**	**15,667**	**27,064**	**11,162**	**15,733**	**26,895**
Change in Urban from previous time period				1,836	2,426	4,262	406	785	1,191	156	293	449
Changs in Septic from previous time period				0	0	0	37	-100	-63	1	-100	-99
Change in Agriculture from previous time period				-69	-1,546	-1,616	-1,038	-278	-1,316	-399	-104	-503
Change in Forest from previous time period				-176	-127	-303	13	-66	-54	5	-25	-20
Total Change from previous time period				**741**	**236**	**977**	**-575**	**345**	**-231**	**-234**	**66**	**-168**
Urban BMPs	0	-127	-127	0	-257	-257	-203	-649	-853	-281	-796	-1,077
CIP Restoration	0	0	0	0	-264	-264	0	-829	-829	0	-1,395	-1,395
Reforestation	0	0	0	-61	-61	-122	-152	-152	-304	-243	-243	-487
Other Reductions	0	0	0	0	-31	-31	0	-31	-31	0	-31	-31
Total Reductions	**0**	**-127**	**-127**	**-61**	**-613**	**-674**	**-355**	**-1,622**	**-2,017**	**-525**	**-2,465**	**-2,990**
Total with Urban BMPs	11,231	14,960	26,190	11,971	15,066	27,037	11,193	15,018	26,211	10,881	14,937	25,818
Total With Urban BMPs and Restoration	11,231	14,960	26,190	11,910	14,710	26,620	11,041	14,006	25,047	10,638	13,268	23,906

Table A-92: Scenario 2 – Future Land Use Changes (Acres) – Gunpowder River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	78	270	348	78	313	391	78	329	407
Urban Pervious HD	505	1,065	1,570	505	1,100	1,605	505	1,113	1,618
Urban Pervious LD									
Cropland	215	51	267	215	29	244	215	21	236
Pasture	0	0	0	0	0	0	0	0	0
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	2,828	846	3,674	2,828	790	3,618	2,828	769	3,597
Water	0	0	0	0	0	0	0	0	0
Bare Soil	0	0	0	0	1	1	0	1	1
Total	**3,627**	**2,232**	**5,859**	**3,627**	**2,232**	**5,859**	**3,627**	**2,232**	**5,859**
Total Urban	583	1,335	1,918	583	1,413	1,996	583	1,442	2,025
Total Agriculture	215	51	267	215	29	244	215	21	236
Total Forest	2,828	846	3,674	2,828	790	3,618	2,828	769	3,597
% Urban	16.1%	59.8%	32.7%	16.1%	63.3%	34.1%	16.1%	64.6%	34.6%
% Agriculture	5.9%	2.3%	4.6%	5.9%	1.3%	4.2%	5.9%	0.9%	4.0%
% Forest	78.0%	37.9%	62.7%	78.0%	35.4%	61.8%	78.0%	34.4%	61.4%
Change in Urban Land Use from previous period				**0**	**78**	**78**	**0**	**29**	**29**
Change in Agricultural Land Use from previous eriod				**0**	**-22**	**-22**	**0**	**-8**	**-8**
Change in Forest Land Use from previous period				**0**	**-56**	**-56**	**0**	**-21**	**-21**

Table A-93: Scenario 2 – Phosphorus Load Changes (Pounds) – Gunpowder River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	394	1,069	1,463	394	1,181	1,575	394	1,223	1,616
Agriculture	149	36	184	149	20	169	149	14	163
Forest	57	17	73	57	16	72	57	15	72
Water	0	0	0	0	0	0	0	0	0
Bare Soil	0	0	0	0	1	1	0	1	1
Total	**599**	**1,122**	**1,720**	**599**	**1,217**	**1,816**	**599**	**1,253**	**1,852**
Change in Urban from previous period				0	112	112	0	42	42
Change in Agricultural from previous period				0	-15	-15	0	-6	-6
Change in Forest from previous period				0	-1	-1	0	0	0
Total Change				**0**	**96**	**96**	**0**	**36**	**36**
Urban BMPs	0	-31	-31	0	-98	-98	0	-123	-123
CIP Restoration	0	-28	-28	0	-88	-88	0	-147	-147
Reforestation	-4	-4	-9	-11	-11	-21	-17	-17	-34
Other Reductions	0	-12	-12	0	-12	-12	0	-12	-12
Total	**-4**	**-75**	**-79**	**-11**	**-208**	**-219**	**-17**	**-299**	**-317**
Total with Urban BMPs	599	1,091	1,689	599	1,119	1,718	599	1,130	1,729
Total with Urban BMPs and Restoration	594	1,046	1,641	588	1,009	1,597	582	954	1,535

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Table A-94: Scenario 2 – Nitrogen Load Changes (Pounds) – Gunpowder River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	4,761	11,526	16,287	4,761	12,384	17,145	4,761	12,705	17,466
Agriculture	2,916	697	3,613	2,916	393	3,309	2,916	283	3,198
Forest	3,648	1,091	4,740	3,648	1,019	4,667	3,648	991	4,640
Water	0	0	0	0	0	0	0	0	0
Bare Soil	0	0	0	0	5	5	0	7	7
Septic	647	2,009	2,655	647	1,908	2,555	647	1,808	2,454
Total	**11,971**	**15,323**	**27,294**	**11,971**	**15,709**	**27,680**	**11,971**	**15,794**	**27,765**
Change in Urban from previous period				0	858	858	0	321	321
Change in Septic from previous period				0	-100	-100	0	-100	-100
Change in Agricultural from previous period				0	-304	-304	0	-111	-111
Change in Forest from previous period				0	-73	-73	0	-27	-27
Total Change				**0**	**386**	**386**	**0**	**85**	**85**
Urban BMPs	0	-257	-257	0	-686	-686	0	-847	-847
CIP Restoration	0	-264	-264	0	-829	-829	0	-1,395	-1,395
Reforestation	-61	-61	-122	-152	-152	304	-243	-243	-487
Other Reductions	0	-31	-31	0	-31	-31	0	-31	-31
Total	**-61**	**-613**	**-674**	**-152**	**-1,698**	**-1,851**	**-243**	**-2,516**	**-2,759**
Total with Urban BMPs	11,971	15,066	27,037	11,971	15,023	26,994	11,971	14,947	26,918
Total with Urban BMPs and Restoration	11,910	14,710	26,620	11,819	14,011	25,830	11,728	13,278	25,006

Table A-95: Acres of Redevelopment Needed to Meet Gunpowder River Watershed Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	53	20	**73**	15	-58	5.5%
3b	5	2	**7**	15	7	0.5%
3c	62	23	**85**	15	-70	6.4%
3d	10	4	**14**	15	2	1.0%

Table A-96: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 Nitrogen Loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	53	545	136	20	204	51
Low – 3b	25%	5	56	14	2	21	5
High/Parks – 3c	59%	62	629	371	23	235	139
Low/Parks – 3d	59%	10	98	58	4	37	22
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	53	65	15	20	24	6
Low	23%	5	7	2	2	3	1
High/Parks	55%	62	75	41	23	28	15
Low/Parks	55%	10	12	6	4	4	2

Table A-97: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	1,329	1,109	1,471	1,641	1,553	1,475
Low – 3b	1,329	1,109	1,471	1,641	1,567	1,494
High/Parks – 3c	1,329	1,109	1,471	1,641	1,527	1,439
Low/Parks – 3d	1,329	1,109	1,471	1,641	1,562	1,487

Table A-98: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	24,533	22,024	26,190	26,620	25,736	24,937
Low – 3b	24,533	22,024	26,190	26,620	25,859	25,105
High/Parks – 3c	24,533	22,024	26,190	26,620	25,501	24,614
Low/Parks – 3d	24,533	22,024	26,190	26,620	25,815	25,045

Table A-99: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	1,329	1,109	1,471	1,641	1,565	236	456	1,491	162	382
Scenario 2 – All Development within URDL	1,329	1,109	1,471	1,641	1,597	268	488	1,535	206	426
Scenario 3a – All Redevelopment – High	1,329	1,109	1,471	1,641	1,553	225	445	1,475	146	367
Scenario 3b – All Redevelopment – Low	1,329	1,109	1,471	1,641	1,567	238	458	1,494	165	385
Scenario 3c – All Redevelopment – High/Parks	1,329	1,109	1,471	1,641	1,527	198	418	1,439	110	330
Scenario 3d – All Redevelopment – Low/Parks	1,329	1,109	1,471	1,641	1,562	233	453	1,487	158	378

Table A-100: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	24,533	22,024	26,190	26,620	25,047	514	3,023	23,906	-627	1,882
Scenario 2 – All Development within URDL	24,533	22,024	26,190	26,620	25,830	1,297	3,806	25,006	473	2,982
Scenario 3a – All Redevelop-ment – High	24,533	22,024	26,190	26,620	25,736	1,204	3,702	24,937	405	2,903
Scenario 3b – All Redevelop-ment – Low	24,533	22,024	26,190	26,620	25,859	1,326	3,835	25,105	573	3,071
Scenario 3c – All Re-development – High/Parks	24,533	22,024	26,190	26,620	25,501	969	3,467	24,614	82	2,580
Scenario 3d – All Re-development – Low/Parks	24,533	22,024	26,190	26,620	25,815	1,282	3,781	25,045	513	3,011

Table A-101: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	1,329	1,109	1,565	236	456	$2,098	$4,053	$210	$405
Scenario 2 – All Development within URDL	1,329	1,109	1,597	268	488	$2,382	$4,338	$238	$434
Scenario 3a – All Redevelopment – High	1,329	1,109	1,553	225	445	$1,996	$3,952	$200	$395
Scenario 3b – All Redevelopment – Low	1,329	1,109	1,567	238	458	$2,115	$4,072	$212	$407
Scenario 3c – All Redevelopment – High/Parks	1,329	1,109	1,527	198	418	$1,761	$3,718	$176	$372
Scenario 3d – All Redevelopment – Low/Parks	1,329	1,109	1,562	233	453	$2,072	$4,028	$207	$403

Table A-102: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	24,533	22,024	25,047	514	3,023	$570	$3,349	$57	$335
Scenario 2 – All Development within URDL	24,533	22,024	25,830	1,297	3,806	$1,437	$4,217	$144	$422
Scenario 3a – All Redevelopment – High	24,533	22,024	25,736	1,204	3,702	$1,334	$4,102	$133	$410
Scenario 3b – All Redevelopment – Low	24,533	22,024	25,859	1,326	3,835	$1,469	$4,238	$147	$424
Scenario 3c – All Redevelopment – High/Parks	24,533	22,024	25,501	969	3,467	$1,073	$3,842	$107	$384
Scenario 3d – All Redevelopment – Low/Parks	24,533	22,024	25,815	1,282	3,781	$1,421	$4,189	$142	$419

A.2.8 Middle River

The Middle River watershed is located entirely in eastern Baltimore County. The Middle River watershed discharges to the tidal water segment GUNOH and MIDOH. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-103. The data is displayed as population in the rural section of the watershed (outside the Urban-Rural Demarcation Line, or URDL) and urban section (inside the URDL).

The majority of the population in 2005 was located within the urban portion of the watershed (94.7%) and is projected to maintain approximately the same proportion. The urban section of the watershed comprises 80.8% of the land area in the watershed. The Middle River watershed is projected to receive less than 3.4% of the future population growth. The population growth in the 1997 – 2005 timeframe was negative (loss of 1,568 residents). This may be due to errors in the population estimate due to the small size of the watershed (<6,500 acres) or to the acquisition by the County of several housing complexes for redevelopment purposes. The redevelopment had not occurred prior to 2005. The annual growth rate is projected to be ~137 and ~37 new residents per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Middle River watershed contains 1.7% of the land in Baltimore County and 3.4% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-104. An additional 480 acres of urban land will be developed during the 2005 – 2035 timeframe, mainly at the expense of forestland. Forestland is projected to lose 493 acres and agriculture is projected to increase by 8 acres. The overall percentage of urban land will increase from 66.8% in 2005 to 74.2% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-105 and A-106, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in an increase in phosphorus of 628 pounds by 2035, compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 569 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 1,365 pounds. Through 2005, restoration activities have achieved 691 pounds of reduction, or ~121% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 time frame due to development with stormwater management (358 pounds), progress toward meeting the 15% reduction target is at 333 pounds of phosphorus (53.8% of goal). A total reduction of an additional 236 pounds of urban phosphorus by 2020 is now needed to meet the 15% reduction target, and 998 pounds is needed to meet a 36% reduction. With continued implementation of capital restoration projects the 15% urban phosphorus goal can be met by 2020.

Nitrogen pollutant loads (Table A-106) indicated an overall increase from 1997 – 2035 (5,068 pounds). The increase is a result of land use changes (forest to urban pervious and urban impervious, even with implementation of Environmental Site Design. With the continued implementation of capital restoration projects a total decrease in nitrogen load of 1,822 pounds by 2020, and 5,517 pounds by 2035 results. A 15% urban nitrogen load reduction to meet the existing nutrient TMDL requires a 5,383 pounds reduction. A 36% urban nitrogen reduction, that may be required by the Chesapeake Bay TMDL, would require the reduction of 12,919 pounds of nitrogen. The 15% reduction can be met by 2035. Restoration efforts through 2005 have resulted in a reduction of 6,456 pounds of nitrogen or 120% or the 15% urban nitrogen reduction goal. However, with of 2,415 pounds of nitrogen due to development in the 1997 – 2005 timeframe, the actual progress is only 3,841 pounds of nitrogen reduced or 71.4% of the goal. The combined nitrogen reduction effects of land use change, implementation of stormwater management, and restoration efforts are not currently adequate to meet the 15% and 36% reduction targets, mainly due to the increased urban loads resulting from conversion of forest to urban land in this watershed.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the new population would be served by public water and sewer.

Table A-107 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development (443 acres versus 480 acres) compared to Scenario 1 and fewer acres of forestland (-407 acres versus 493 acres) would be lost between 2005 and 2035. A greater amount of agricultural land (-41 acres versus +8 acres) would be lost under Scenario 2 compared to Scenario 1. This Scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, but would eliminate all agricultural land within the URDL.

Tables A-108 and A-109 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 timeframe, as those changes are based on development activities that have already occurred. Because the land use change involves mainly conversion of forest to urban land use, the phosphorus load will increase by 169 pounds in the 2005 – 2020 timeframe, even with ESD. The cost to address this additional phosphorus load created through development would be ~$1.5 million.

Nitrogen under this scenario would also increase by 1,012 pounds, and would require ~$1.0 million to address.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-110 presents the number of acres needed to absorb the projected population increase in the Middle River watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 744 acres of land identified for potential redevelopment. This provides sufficient acreage to meet all the land acreage requirements for all of the redevelopment scenarios. The amount of redevelopment needed ranged from 0.8% to 7.8% of the urban land.

Table A-111 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most phosphorus and nitrogen removal. Table A-112 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. All of the redevelopment scenarios would be able to meet the 15% and the 36% urban phosphorus reduction by 2020. Table A-113 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen can only be met by redevelopment scenario 3c 2020. All of the redevelopment scenarios could meet the 15% urban nitrogen reduction target by 2035. The 36% urban nitrogen reduction could not be met by any of the redevelopment scenarios for either timeframe.

Scenario Comparisons

Tables A-114 and A-115 show the comparison of all scenarios considered in the Middle River watershed for phosphorus and nitrogen, respectively. All of the scenarios would meet a 15% and a 36% phosphorus reduction by 2020. Only scenario 3c would meet the 15% reduction target for urban nitrogen by 2020. All Scenarios would meet the 15% reduction target by 2035. None of the scenarios would meet the 36% nitrogen reduction target by 2035.

Cost of Meeting Nutrient TMDLs by 2020

Information in Tables A-114 and A-115 was used to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets. The results are presented from Table A-114 for phosphorus and A-115 for nitrogen. Based the capital program expenditures in the 1997 – 2005 timeframe and the pounds of phosphorus and nitrogen removed through capital project implementation, a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are displayed in Table A-116 for phosphorus and A-117 for nitrogen. For the Middle River watershed, none of the scenarios would require additional capital expenditures to meet a 15% or 36% urban phosphorus reduction by 2020. To meet the 15% urban nitrogen reduction target by 2020 would require additional funding for all scenarios, except 3c. The additional funding would range from $56,000 (3a) to $297,000 (1). To meet the 36% urban nitrogen reduction target, additional funding would be needed for the range of $775,000 to $1,132,000 per year.

Table A-103: Middle River Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	1,321	27,381	28,702	-	-	-
2005	1,433	25,702	27,135	112	-1,679	-1,567
2020	1,541	27,643	29,184	108	1,941	2,049
2035	1,570	28,163	29,733	29	520	549

Table A-104: Scenario 1 - Land Use Changes (Acres) – Middle River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	55	1,128	1,183	76	1,289	1,364	96	1,470	1,566	102	1,519	1,621
Pervious Urban HD	213	2,153	2,366	247	2,539	2,787	281	2,775	3,057	290	2,815	3,105
Pervious Urban LD	84	230	315	78	87	165	71	0	71	70	0	70
Cropland	208	23	230	248	26	274	286	0	286	297	0	297
Pasture	0	98	98	0	15	15	0	0	0	0	0	0
Livestock Feeding	0	0	0	0	0	0	0	0	0	0	0	0
Forest	634	1,501	2,134	592	1,269	1,861	506	975	1,481	482	886	1,368
Water	48	92	140	0	0	0	0	0	0	0	0	0
Bare Soil	0	0	0	0	0	0	0	4	4	0	5	5
Total	**1,241**	**5,225**	**6,465**	**1,241**	**5,225**	**6,465**	**1,241**	**5,225**	**6,465**	**1,241**	**5,225**	**6,465**
Total Urban	352	3,512	3,863	401	3,915	4,316	449	4,246	4,694	461	4,334	4,796
Total Agriculture	208	121	328	247	41	289	286	0	286	297	0	297
Total Forest	634	1,501	2,134	592	1,269	1,861	506	975	1,481	482	886	1,368
% Urban	28.4%	67.2%	59.8%	32.3%	74.9%	66.8%	**36.2%**	**81.3%**	**72.6%**	**37.2%**	**83.0%**	**74.2%**
% Agriculture	16.7%	2.3%	5.1%	19.9%	0.8%	4.5%	**23.1%**	**0.0%**	**4.4%**	**23.9%**	**0.0%**	**4.6%**
% Forest	51.1%	28.7%	33.0%	47.7%	24.3%	28.8%	**40.8%**	**18.7%**	**22.9%**	**38.9%**	**17.0%**	**21.2%**
Change in Urban from previous time period				**49**	**403**	**453**	**48**	**331**	**379**	**13**	**89**	**101**
Change in Agriculture from previous time period				**40**	**-80**	**-40**	**39**	**-41**	**-2**	**10**	**0**	**10**
Change in Forest from previous time period				**-41**	**-232**	**-273**	**-87**	**-294**	**-380**	**-23**	**-90**	**-113**

Table A-105: Scenario 1 - Phosphorus Load Changes (Pounds) – Middle River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	251	3,576	3,827	311	4,044	4,355	369	4,519	4,888	384	4,646	5,031
Agriculture	143	80	224	171	28	199	198	0	198	205	0	205
Forest	13	30	43	12	25	37	10	20	30	10	18	27
Water	27	53	80	0	0	0	0	0	0	0	0	0
Bare Soil	0	0	0	0	0	0	0	2	2	0	3	3
Total	**434**	**3,739**	**4,173**	**493**	**4,097**	**4,591**	**577**	**4,541**	**5,117**	**599**	**4,667**	**5,266**
Change in Urban from previous time period				60	468	528	58	475	533	16	127	143
Change in Agriculture from previous time period				28	-52	-25	27	-28	-1	7	0	7
Change in Forest from previous time period				-1	-5	-5	-2	-6	-8	0	-2	-2
Total Change from previous time period				**59**	**358**	**417**	**83**	**444**	**527**	**22**	**126**	**148**
Urban BMPs	0	-34	-34	0	-94	-94	-35	-379	-414	-44	-455	-499
CIP Restoration	0	0	0	0	-650	-650	0	-2,044	-2,044	0	-3,437	-3,437
Reforestation	0	0	0	-1	-1	-2	-2	-2	-4	-3	-3	-6
Other Reductions	0	0	0	0	-39	-39	0	-39	-39	0	-39	-39
Total Reductions	**-0**	**-34**	**-34**	**-1**	**-784**	**-785**	**-37**	**-2,463**	**-2,500**	**-47**	**-3,934**	**-3,982**
Total with Urban BMPs	434	3,705	4,139	493	4,003	4,497	542	4,162	4,704	555	4,212	4,767
Total With Urban BMPs and Restoration	504	966	1,471	493	3,313	3,806	540	2,078	2,617	552	733	1,284

Table A-106: Scenario 1 - Nitrogen Load Changes (Pounds) – Middle River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	2,924	33,183	36,107	3,424	37,209	40,633	3,910	40,853	44,762	4,040	41,828	45,869
Agriculture	2,811	858	3,669	3,351	437	3,788	3,876	0	3,876	4,018	0	4,018
Forest	817	1,936	2,753	764	1,637	2,401	652	1,258	1,911	622	1,143	1,765
Other	475	922	1,397	0	0	0	0	21	21	0	27	27
Septic	529	1,833	2,362	548	1,870	2,419	521	1,777	2,298	493	1,683	2,177
Total	**7,557**	**38,183**	**36,107**	**8,087**	**41,154**	**49,240**	**8,959**	**43,909**	**52,868**	**9,174**	**44,828**	**53,855**
Change in Urban from previous time period				500	4,026	4,525	486	3,644	4,130	131	976	1,106
Change in Septic from previous time period				540	-421	119	-27	-94	-121	-27	-94	-121
Change in Agriculture from previous time period				-53	-299	-352	526	-437	88	141	0	141
Change in Forest from previous time period				19	38	57	-112	-379	-490	-30	-116	-146
Total Change from previous time period				**530**	**2,422**	**2,951**	**873**	**2,755**	**3,628**	**214**	**772**	**987**
Urban BMPs	0	-222	-222	0	-758	-758	-243	-2,580	-2,823	-308	-3,068	-3,376
CIP Restoration	0	0	0	0	2,005	2,005	0	6,300	-6,300	0	10,596	10,596
Reforestation	0	0	0	-11	-11	-22	-28	-28	-55	-44	-44	-89
Other Reductions	0	0	0	0	-101	-101	0	-101	-101	0	-101	-101
Total Reductions	**0**	**-222**	**-222**	**-11**	**-2,874**	**-2,886**	**-271**	**-9,008**	**-9,279**	**-353**	**-13,808**	**-14,161**
Total with Urban BMPs	7,557	38,510	46,067	8,087	40,396	48,482	8,716	41,329	50,046	8,865	41,614	50,479
Total With Urban BMPs and Restoration	7,557	38,510	46,067	8,076	38,279	46,355	8,689	34,901	43,589	8,821	30,873	39,694

Table A-107: Scenario 2 – Future Land Use Changes (Acres) – Middle River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	76	1,289	1,364	76	1,480	1,556	76	1,532	1,607
Urban Pervious HD	247	2,539	2,787	247	2,784	3,031	247	2,826	3,073
Urban Pervious LD	78	87	165	78	0	78	78	0	78
Cropland	247	26	274	247	0	247	247	0	247
Pasture	0	15	15	0	0	0	0	0	0
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	592	1,269	1,861	592	957	1,549	592	862	1,454
Water	0	0	0	0	0	0	0	0	0
Bare Soil	0	0	0	0	4	4	0	5	5
Total	**1,241**	**5,225**	**6,465**	**1,241**	**5,225**	**6,465**	**1,241**	**5,225**	**6,465**
Total Urban	401	3,915	4,316	401	4,264	4,665	401	4,358	4,758
Total Agriculture	247	41	289	247	0	247	247	0	247
Total Forest	592	1,269	1,861	592	957	1,549	592	862	1,454
% Urban	32.3%	74.9%	66.8%	32.3%	81.6%	72.2%	32.3%	83.4%	73.6%
% Agriculture	19.9%	0.8%	4.5%	19.9%	0.0%	3.8%	19.9%	0.0%	3.8%
% Forest	47.7%	24.3%	28.8%	47.7%	18.3%	24.0%	47.7%	16.5%	22.5%
Change in Urban Land Use from previous period				**0**	**349**	**349**	**0**	**94**	**94**
Change in Agricultural Land Use from previous period				**0**	**-41**	**-41**	**0**	**0**	**0**
Change in Forest Land Use from previous period				**0**	**-312**	**-312**	**0**	**-95**	**-95**

Table A-108: Scenario 2 – Phosphorus Load Changes (Pounds) – Middle River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	311	4,044	4,355	311	4,545	4,856	311	4,680	4,991
Agriculture	171	28	199	171	0	171	171	0	171
Forest	12	25	37	12	19	31	12	17	29
Water	0	0	0	0	0	0	0	0	0
Bare Soil	0	0	0	0	3	3	0	3	3
Total	**493**	**4,097**	**4,591**	**493**	**4,567**	**5,061**	**493**	**4,700**	**5,194**
Change in Urban from previous period				0	502	502	0	134	134
Change in Agricultural from previous period				0	-28	-28	0	0	0
Change in Forest from previous period				0	-6	-6	0	-2	-2
Total Change				**0**	**470**	**470**	**0**	**133**	**133**
Urban BMPs	0	-94	-94	0	-395	-395	.0	-475	-475
CIP Restoration	0	-650	-650	0	-2,044	-2,044	0	-3,437	-3,437
Reforestation	-1	-1	-2	-2	-2	-4	-3	-3	-6
Other Reductions	0	-39	-39	0	-39	-39	0	-39	-39
Total	**-1**	**-784**	**-785**	**-2**	**-2,479**	**-2,491**	**-3**	**-3,955**	**-3,958**
Total with Urban BMPs	493	4,003	4,497	493	4,173	4,666	493	4,225	4,719
Total with Urban BMPs and Restoration	493	3,313	3,806	492	2,088	2,579	490	746	1,236

Table A-109: Scenario 2 – Nitrogen Load Changes (Pounds) – Middle River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	3,424	37,209	40,633	3,424	41,055	44,479	3,424	42,086	45,509
Agriculture	3,351	437	3,788	3,351	0	3,351	3,351	0	3,351
Forest	764	1,637	2,401	764	1,234	1,998	764	1,112	1,876
Other	0	0	0	0	22	22	0	28	28
Septic	548	1,870	2,419	548	1,777	2,325	548	1,683	2,232
Total	**8,087**	**41,154**	**49,240**	**8,087**	**44,089**	**52,175**	**8,087**	**44,909**	**52,996**
Change in Urban from previous period				0	3,846	3,846	0	1,030	1,030
Change in Septic				0	-94	-94	0	-94	-94
Change in Agricultural from previous period				0	-437	-437	0	0	0
Change in Forest from previous period				0	-403	-403	0	-122	-122
Total Change				**0**	**2,935**	**2,935**	**0**	**821**	**821**
Urban BMPs	0	-758	-758	0	-2,681	-2,681	0	-3,196	-3,196
CIP Restoration	0	-2,005	-2,005	0	-6,300	-6,300	0	-10,596	-10,596
Reforestation	-11	-11	-22	-28	-28	-55	-44	-44	-89
Other Reductions	0	-101	-101	0	-101	-101	0	-101	-101
Total	**-11**	**-2,874**	**-2,886**	**-28**	**-9,110**	**-9,137**	**-44**	**-13,937**	**-13,981**
Total with Urban BMPs	8,087	40,396	48,482	8,087	41,408	49,494	8,087	41,713	49,800
Total with Urban BMPs and Restoration	8,076	38,279	46,355	8,059	34,979	43,038	8,042	30,973	39,015

Table A-110: Acres of Redevelopment Needed to Meet Middle River Watershed Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	240	64	**304**	744	470	7.8%
3b	25	7	**32**	744	743	0.8%
3c	277	74	**351**	744	423	9.0%
3d	43	12	**55**	744	719	1.4%

Table A-111: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 Nitrogen Loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	240	2,445	611	64	655	164
Low – 3b	25%	25	251	63	7	67	17
High/Parks – 3c	59%	277	2,821	1,665	74	756	446
Low/Parks – 3d	59%	43	439	259	12	118	69
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	240	292	67	64	78	18
Low	23%	25	30	7	7	8	2
High/Parks	55%	277	337	186	74	90	50
Low/Parks	55%	43	52	29	12	14	8

Table A-112: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	3,604	2,808	4,139	3,806	2,343	929
Low – 3b	3,604	2,808	4,139	3,806	2,403	1,006
High/Parks – 3c	3,604	2,808	4,139	3,806	2,225	779
Low/Parks – 3d	3,604	2,808	4,139	3,806	2,381	978

Table A-113: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	40,906	33,370	46,067	46,355	41,415	36,922
Low – 3b	40,906	33,370	46,067	46,355	41,963	37,618
High/Parks – 3c	40,906	33,370	46,067	46,355	40,361	35,587
Low/Parks – 3d	40,906	33,370	46,067	46,355	41,767	37,369

Table A-114: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	3,604	2,808	4,139	3,806	2,617	-987	-191	1,284	-2,320	-1,524
Scenario 2 – All Development within URDL	3,604	2,808	4,139	3,806	2,579	-1,025	-229	1,236	-2,368	-1,572
Scenario 3a – All Redevelopment – High	3,604	2,808	4,139	3,806	2,343	-1,261	-465	929	-2,675	-1,878
Scenario 3b – All Redevelopment – Low	3,604	2,808	4,139	3,806	2,403	-1,201	-404	1,006	-2,598	-1,802
Scenario 3c – All Redevelopment – High/Parks	3,604	2,808	4,139	3,806	2,225	-1,379	-583	779	-2,825	-2,028
Scenario 3d – All Redevelopment – Low/Parks	3,604	2,808	4,139	3,806	2,381	-1,223	-426	978	-2,626	-1,830

Table A-115: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	40,906	33,370	46,067	46,355	43,589	2,683	10,219	39,694	-1,212	6,324
Scenario 2 – All Development within URDL	40,906	33,370	46,067	46,355	43,038	2,132	9,668	39,015	-1,891	5,645
Scenario 3a – All Redevelopment – High	40,906	33,370	46,067	46,355	41,415	509	8,045	36,922	-3,984	3,552
Scenario 3b – All Redevelopment – Low	40,906	33,370	46,067	46,355	41,963	1,057	8,593	37,618	-3,288	4,248
Scenario 3c – All Redevelopment – High/Parks	40,906	33,370	46,067	46,355	40,361	-545	6,991	35,587	-5,319	2,217
Scenario 3d – All Redevelopment – Low/Parks	40,906	33,370	46,067	46,355	41,767	861	8,397	37,369	-3,537	3,999

Table A-116: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	3,604	2,808	2,617	-987	-191	$0	$0	$0	$0
Scenario 2 – All Development within URDL	3,604	2,808	2,579	-1,025	-229	$0	$0	$0	$0
Scenario 3a – All Redevelopment – High	3,604	2,808	2,343	-1,261	-465	$0	$0	$0	$0
Scenario 3b – All Redevelopment – Low	3,604	2,808	2,403	-1,201	-404	$0	$0	$0	$0
Scenario 3c – All Redevelopment – High/Parks	3,604	2,808	2,225	-1,379	-583	$0	$0	$0	$0
Scenario 3d – All Redevelopment – Low/Parks	3,604	2,808	2,381	-1,223	-426	$0	$0	$0	$0

Table A-117: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	40,906	33,370	43,589	2,683	10,219	$2,973	$11,323	$297	$1,132
Scenario 2 – All Development within URDL	40,906	33,370	43,038	2,132	9,668	$2,362	$10,712	$236	$1,071
Scenario 3a – All Redevelopment – High	40,906	33,370	41,415	509	8,045	$564	$8,914	$56	$891
Scenario 3b – All Redevelopment – Low	40,906	33,370	41,963	1,057	8,593	$1,172	$9,521	$117	$952
Scenario 3c – All Redevelopment – High/Parks	40,906	33,370	40,361	-545	6,991	$0	$7,746	$0	$775
Scenario 3d – All Redevelopment – Low/Parks	40,906	33,370	41,767	861	8,397	$954	$9,304	$95	$930

A.2.9 Liberty Reservoir Watershed

The Liberty Reservoir watershed is located along the western border of Baltimore County with a majority of the watershed in Carroll County (83.3%). Liberty Reservoir, along with the Loch Raven Reservoir/Prettyboy Reservoir system, provides drinking water for the Baltimore metropolitan area. The Liberty Reservoir watershed provides flow downstream to the Lower North Branch of the Patapsco River, when sufficiently full to release water over the dam. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-118. The data is displayed as population in the rural section of the watershed (outside the Urban-Rural Demarcation Line, or URDL) and urban section (inside the URDL).

The majority of the population in 2005 was located within the rural portion of the watershed (72.7%) and is projected to maintain approximately the same proportion. The rural section of the watershed comprises 96.9% of the land area in the watershed. The Liberty Reservoir watershed is projected to receive ~1.3% of the future population growth. The annual growth rate will decrease from ~234 per year in the 1997 – 2005 time period to ~49 and ~19 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Liberty Reservoir watershed contains 4.5% of the land in Baltimore County and 0.8% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-119. An additional 1,489 acres of urban land will be developed during the 2005 – 2035 timeframe, at the expense of agricultural land and forest land. Forest land is projected to lose 258 acres and agriculture is projected to decrease by 1,107 acres. The overall percentage of urban land will increase from 16.1% in 2005 to 24.0% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-120 and A-121, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in a decrease in phosphorus of 275 pounds by 2035, compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 215 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 517 pounds. Through 2005, restoration activities have achieved 11 pounds of reduction, or ~5% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 timeframe due to development with stormwater management (106 pounds), progress toward meeting the 15% reduction target is negative with a net gain of 95 pounds of phosphorus. A total reduction of 310 pounds of urban phosphorus by 2020 is now needed to meet the 15% reduction target, and 612 pounds is needed to meet a 36% reduction.

Nitrogen pollutant loads (Table A-121) showed an overall decrease from 1997 – 2035. The decrease is a result of land use changes and implementation of Environmental Site Design. This results in a total decrease in nitrogen load of 9,945 pounds by 2020, and 12,756 pounds by 2035 results. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 2,417 pounds. A 36% urban nitrogen reduction, that may be required by the Chesapeake Bay TMDL, would require the reduction of 5,800 pounds of nitrogen. The 15% reduction was met by 2005, and the 36% urban nitrogen reduction will be met by 2020. Restoration efforts through 2005 have resulted in a reduction of 33 pounds of nitrogen. Combined with the nitrogen reduction effects of land use change and implementation of stormwater management, nitrogen reductions are currently adequate to meet the 15% and 36% reduction targets.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the new population would be served by public water and sewer.

Table A-122 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development (55 acres versus 1,489 acres) compared to Scenario 1. Fewer acres of agricultural land (49 acres versus 1,107 acres) and fewer acres of forest land (6 acres versus 258 acres) would be lost between 2005 and 2035. This Scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land.

Tables A-123 and A-124 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 timeframe, as those changes are based on development activities that have already occurred. The land use change involves mainly conversion from agriculture to urban land use and with the implementation of ESD, the phosphorus load is projected to decrease by 7 pounds in the 2005 – 2020 timeframe. With continued implementation of restoration projects the phosphorus load will decrease by an additional 11 pounds.

Nitrogen under this scenario would also decrease by 479 pounds. With restoration activities, nitrogen would meet the 15% urban nitrogen reduction target by 2020, but would be ~300 pounds shy of meeting the 36% urban nitrogen reduction target.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-125 presents the number of acres needed to absorb the projected population increase in the Liberty Reservoir watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 89 acres of land identified for potential redevelopment. This provides sufficient acreage to meet all the land acreage requirements of redevelopment scenarios 3b and 3d, but is insufficient to meet the acreage requirements of scenarios 3a and 3c. The amount of redevelopment needed ranged from 4.0% to 45.7% of the urban land.

Table A-126 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most amount of phosphorus and nitrogen removal. Table A-127 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. None of the redevelopment scenarios would be able to meet the 15% urban phosphorus reduction by 2020 or by 2035. Table A-128 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen was already met by 2005, but none of the redevelopment scenarios would meet the 36% urban nitrogen reduction target.

Scenario Comparisons

Tables A-129 and A-130 show the comparison of all scenarios considered in the Liberty Reservoir watershed for phosphorus and nitrogen, respectively. None of the scenarios would meet a 15% phosphorus reduction by 2020, and only Scenario 1 would meet the 15% phosphorus reduction by 2035. All of the scenarios met the 15% reduction target for urban nitrogen in 2005, and only Scenario 1 is projected to meet the 36% urban nitrogen reduction target by 2020.

Cost of Meeting Nutrient TMDLs by 2020

Information in Tables A-129 and A-130 was used to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used from Table A-129 for phosphorus and A-130 for nitrogen. Based the capital program expenditures in the 1997 – 2005 timeframe and the pounds of phosphorus and nitrogen removed through capital project implementation, a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are displayed in Table A-131 for phosphorus and Table A-132 for nitrogen. For the Liberty Reservoir watershed, all scenarios would require additional capital expenditures to meet a 15% urban phosphorus reduction by 2020. The additional capital expenditure ranges from $28,000 (1) to $269,000 (3b) per year. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $295,000 to $532,000. No additional capital funding would be required to meet the 15% urban nitrogen reduction target by 2020 for any scenario. To meet the 36% urban nitrogen reduction target, no additional funding would be needed for Scenario 1. The balance of the scenarios would need additional funding in the range of $229,000 to $304,000 per year.

Table A-118: Liberty Reservoir Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	4,330	367	4,697	-	-	-
2005	4,776	1,792	6,568	446	1,425	1,871
2020	5,308	1,991	7,299	532	199	731
2035	5,513	2,069	7,582	206	77	283

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	295	45	340	452	79	531	639	84	723	712	86	798
Pervious Urban HD	239	133	372	1,491	99	1,590	2,868	94	2,962	3,179	92	3,271
Pervious Urban LD	1,152	45	1,197	573	122	696	0	133	133	0	137	137
Cropland	4,459	79	4,538	3,820	49	3,868	3,057	39	3,095	2,761	35	2,796
Pasture	726	43	769	728	0	728	702	0	702	693	0	693
Livestock Feeding	23	0	23	0	0	0	0	0	0	0	0	0
Forest	8,754	199	8,953	8,659	195	8,854	8,473	194	8,668	8,402	194	8,596
Water	1,251	0	1,251	1,236	0	1,236	1,219	0	1,219	1,212	0	1,215
Bare Soil	60	0	60	0	0	0	0	0	0	0	0	0
Total	**16,958**	**544**	**17,502**	**16,958**	**544**	**17,503**	**16,958**	**544**	**17,503**	**16,958**	**544**	**17,503**
Total Urban	1,686	223	1,909	2,516	300	2,817	3,507	311	3,818	3,890	315	4,206
Total Agriculture	5,208	122	5,330	4,547	49	4,596	3,759	39	3,798	3,454	35	3,489
Total Forest	8,754	199	8,953	8,659	195	8,854	8,473	194	8,668	8,402	194	8,596
% Urban	9.9%	41.0%	10.9%	14.8%	55.2%	16.1%	**20.7%**	**57.2%**	**21.8%**	**22.9%**	**58.0%**	**24.0%**
% Agriculture	30.7%	22.4%	30.5%	26.8%	9.0%	26.3%	**22.2%**	**7.1%**	**21.7%**	**20.4%**	**6.4%**	**19.9%**
% Forest	51.6%	36.4%	51.2%	51.1%	35.6%	50.6%	**50.0%**	**35.7%**	**49.5%**	**49.5%**	**35.7%**	**49.1%**
Change in Urban from previous time period				**830**	**77**	**908**	**990**	**11**	**1,101**	**384**	**4**	**388**
Change in Agriculture from previous time period				**-661**	**-73**	**-734**	**-788**	**-10**	**-798**	**-305**	**-4**	**-309**
Change in Forest from previous time period				**-96**	**-4**	**-100**	**-185**	**-1**	**-186**	**-72**	**0**	**-72**

Table A-120: Scenario 1 - Phosphorus Load Changes (Pounds) – Liberty Reservoir Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	1,262	179	1,441	1,909	274	2,183	2,681	287	2,968	2,979	292	3,271
Agriculture	3,767	88	3,855	3,281	35	3,316	2,714	28	2,741	2,494	25	2,519
Forest	175	4	179	173	4	177	169	4	173	168	4	172
Water	713	0	713	705	0	705	695	0	695	691	0	691
Bare Soil	44	0	44	0	0	0	0	0	0	0	0	0
Total	**5,961**	**271**	**6,231**	**6,068**	**313**	**6,381**	**6,259**	**319**	**6,578**	**6,332**	**321**	**6,653**
Change in Urban from previous time period				647	95	743	772	13	785	298	5	303
Change in Agriculture from previous time period				-486	-53	-539	-568	-7	-575	-220	-3	-223
Change in Forest from previous time period				-2	0	-2	-4	0	-4	-1	0	-1
Total Change from previous time period				**108**	**42**	**150**	**191**	**6**	**196**	**73**	**2**	**75**
Urban BMPs	-4	0	-5	-27	-21	-48	-490	-29	-519	-669	-32	-701
CIP Restoration	0	0	0	0	0	0	0	0	0	0	0	0
Reforestation	0	0	0	0	0	0	-1	-1	-1	-1	-1	-2
Other Reductions	0	0	0	0	-11	-11	0	-11	-11	0	-11	-11
Total Reductions	**-4**	**0**	**-5**	**-27**	**-32**	**-59**	**-491**	**-40**	**-531**	**-670**	**-44**	**-713**
Total with Urban BMPs	5,956	270	6,227	6,041	292	6,333	5,769	290	6,059	5,663	290	5,952
Total With Urban BMPs and Restoration	5,956	270	6,227	6,041	281	6,322	5,768	279	6,047	5,662	278	5,940

Table A-121: Scenario 1 - Nitrogen Load Changes (Pounds) – Liberty Reservoir Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	14,234	1,926	16,160	21,336	2,720	24,055	29,805	2,831	32,636	33,082	2,874	35,956
Agriculture	79,696	1,625	81,321	68,562	807	69,369	55,753	638	56,391	50,792	573	51,365
Forest	12,343	281	12,624	12,209	275	12,484	11,947	274	12,221	11,846	274	12,120
Other	13,007	0	13,007	12,424	0	12,424	12,251	0	12,251	12,184	0	12,184
Septic	16,393	1,158	17,551	18,711	1,177	19,888	20,731	1,118	21,849	21,513	1,059	22,572
Total	**135,674**	**4,989**	**140,663**	**133,241**	**4,979**	**138,220**	**130,487**	**4,861**	**135,348**	**129,418**	**4,779**	**134,197**
Change in Urban from previous time period				7,101	794	7,895	8,469	111	8,580	3,277	43	3,320
Changs in Septic from previous time period				2,318	19	2,337	2,020	-59	1,961	782	-59	723
Change in Agriculture from previous time period				-11,134	,818	-11,952	-12,810	-169	-12,979	-4,960	-65	-5,026
Change in Forest from previous time period				-135	-6	-141	-261	-1	-262	-101	0	-101
Total Change from previous time period				**-2,433**	**-11**	**-2,443**	**-2,754**	**-118**	**-2,872**	**-1,069**	**-82**	**-1,151**
Urban BMPs	-42	-6	-48	-339	-209	-549	-4,574	-265	-4,839	-6,212	-286	-6,499
CIP Restoration	0	0	0	0	0	0	0	0	0	0	0	0
Reforestation	0	0	0	-3	-3	-6	-7	-7	-15	-12	-12	-23
Other Reductions	0	0	0	0	-27	-27	0	-27	-27	0	-27	-27
Total Reductions	**-42**	**-6**	**-48**	**-342**	**-239**	**-581**	**-4,581**	**-299**	**-4,880**	**-6,224**	**-325**	**-6,549**
Total with Urban BMPs	135,632	4,983	140,615	132,902	4,769	137,671	125,913	4,596	130,509	123,206	4,493	127,698
Total With Urban BMPs and Restoration	135,632	4,983	140,615	132,899	4,739	137,639	125,906	4,562	130,468	123,194	4,454	127,648

Table A-122: Scenario 2 – Future Land Use Changes Acres) – Liberty Reservoir

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	452	79	531	452	97	549	452	104	556
Urban Pervious HD	1,491	99	1,590	1,491	81	1,572	1,491	74	1,565
Urban Pervious LD	573	122	696	573	162	735	573	177	751
Cropland	3,820	49	3,868	3,820	11	3,831	3,820	0	3,820
Pasture	728	0	728	728	0	728	728	0	728
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	8,659	195	8,854	8,659	193	8,851	8,659	189	8,847
Water	1,236	0	1,236	1,236	0	1,236	1,236	0	1,236
Bare Soil	0	0	0	0	0	0	0	0	0
Total	**16,958**	**544**	**17,503**	**16,958**	**544**	**17,503**	**16,958**	**544**	**17,503**
Total Urban	2,516	300	2,817	2,516	340	2,857	2,516	355	2,872
Total Agriculture	4,547	49	4,596	4,547	11	4,558	4,547	0	4,547
Total Forest	8,659	195	8,854	8,659	193	8,851	8,659	189	8,847
% Urban	14.8%	55.2%	16.1%	14.8%	62.5%	16.3%	14.8%	65.3%	16.4%
% Agriculture	26.8%	9.0%	26.3%	26.8%	2.1%	26.0%	26.8%	0.0%	26.0%
% Forest	51.1%	35.8%	50.6%	51.1%	35.4%	50.6%	51.1%	34.7%	50.5%
Change in Urban Land Use from previous period				**0**	**40**	**40**	**0**	**15**	**15**
Change in Agricultural Land Use from previous period				**0**	**-38**	**-38**	**0**	**-11**	**-11**
Change in Forest Land Use from previous period				**0**	**-2**	**-2**	**0**	**-4**	**-4**

Table A-123: Scenario 2 – Phosphorus Load Changes (Pounds) – Liberty Reservoir

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	1,909	274	2,183	1,909	323	2,232	1,909	342	2,251
Agriculture	3,281	35	3,316	3,281	8	3,289	3,281	0	3,281
Forest	173	4	177	173	4	177	173	4	177
Water	705	0	705	705	0	705	705	0	705
Bare Soil	0	0	0	0	0	0	0	0	0
Total	**6,068**	**313**	**6,381**	**6,068**	**335**	**6,403**	**6,068**	**346**	**6,414**
Change in Urban from previous period				0	49	49	0	19	19
Change in Agricultural from previous period				0	-27	-27	0	-8	-8
Change in Forest from previous period				0	0	0	0	0	0
Total Change				**0**	**22**	**22**	**0**	**11**	**11**
Urban BMPs	-27	-21	-48	-27	-50	-77	-27	-61	-89
CIP Restoration	0	0	0	0	0	0	0	0	0
Reforestation	0	0	0	-1	-1	-1	-1	-1	-2
Other Reductions	0	-11	-11	0	-11	-11	0	-11	-11
Total	**-27**	**-32**	**-59**	**-28**	**-61**	**-89**	**-28**	**-73**	**-101**
Total with Urban BMPs	6,041	292	6,333	6,041	285	6,326	6,041	284	6,325
Total with Urban BMPs and Restoration	6,041	281	6,322	6,041	273	6,314	6,040	273	6,313

Table A-124: Scenario 2 – Nitrogen Load Changes (Pounds) – Liberty Reservoir

Land Use	2005 Rural	2005 Urban	2005 Total	2020 Rural	2020 Urban	2020 Total	2035 Rural	2035 Urban	2035 Total
Urban	21,336	2,720	24,055	21,336	3,127	24,463	21,336	3,285	24,620
Agriculture	68,562	807	69,369	68,562	186	68,748	68,562	0	68,562
Forest	12,209	275	12,484	12,209	272	12,480	12,209	266	12,475
Other	12,424	0	12,424	12,424	0	12,424	12,424	0	12,424
Septic	18,711	1,177	19,888	18,711	1,118	19,829	18,711	1,059	19,770
Total	**133,241**	**4,979**	**138,220**	**133,241**	**4,703**	**137,944**	**133,241**	**4,610**	**137,851**
Change in Urban from previous period				0	407	407	0	158	158
Change in Septic				0	-59	-59	0	-59	-59
Change in Agricultural from previous period				0	-621	-621	0	-186	-186
Change in Forest from previous period				0	-3	-3	0	-6	-6
Total Change				**0**	**-276**	**-276**	**0**	**-93**	**-93**
Urban BMPs	-339	-209	-549	-339	-413	-752	-339	-492	-831
CIP Restoration	0	0	0	0	0	0	0	0	0
Reforestation	-3	-3	-6	-7	-7	-15	-12	-12	-23
Other Reductions	0	-27	-27	0	-27	-27	0	-27	-27
Total	**-342**	**-239**	**-581**	**-346**	**-447**	**-794**	**-351**	**-531**	**-881**
Total with Urban BMPs	132,902	4,769	137,671	132,902	4,290	137,192	132,902	4,118	137,020
Total with Urban BMPs and Restoration	132,899	4,739	137,639	132,895	4,225	137,150	132,891	4,079	136,970

Table A-125: Acres of Redevelopment Needed to Meet Liberty Reservoir Watershed Projected Population Growth

Scenario	Acres Needed 2020	Acres Needed 2035	Acres Needed Total	Acres Available	Difference Total	% Redevelopment
3a	86	33	**119**	89	-30	39.7%
3b	9	3	**12**	89	77	4.0%
3c	99	38	**137**	89	-48	45.7%
3d	15	6	**21**	89	68	7.0%

Table A-126: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 Nitrogen Loading – 10.2	Reduction %	2020 Acres	2020 Load	2020 Reduction	2035 Acres	2035 Load	2035 Reduction
High – 3a	25%	86	872	218	33	338	84
Low – 3b	25%	9	89	22	3	35	9
High/Parks – 3c	59%	99	1,007	594	38	390	230
Low/Parks – 3d	59%	15	157	92	6	61	36
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	86	104	24	33	40	9
Low	23%	9	11	2	3	4	1
High/Parks	55%	99	120	66	38	47	26
Low/Parks	55%	15	19	10	6	7	4

Table A-127: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	6,016	5,715	6,227	6,322	6,297	6,288
Low – 3b	6,016	5,715	6,227	6,322	6,319	6,317
High/Parks – 3c	6,016	5,715	6,227	6,322	6,255	6,229
Low/Parks – 3d	6,016	5,715	6,227	6,322	6,311	6,307

Table A-128: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	138,247	134,863	140,615	137,639	137,412	137,319
Low – 3b	138,247	134,863	140,615	137,639	137,607	137,590
High/Parks – 3c	138,247	134,863	140,615	137,639	137,036	136,797
Low/Parks – 3d	138,247	134,863	140,615	137,639	137,537	137,493

Table A-129: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	6,016	5,715	6,227	6,322	6,047	31	332	5,940	-76	225
Scenario 2 – All Development within URDL	6,016	5,715	6,227	6,322	6,314	298	599	6,313	297	598
Scenario 3a – All Redevelopment – High	6,016	5,715	6,227	6,322	6,297	281	583	6,288	272	573
Scenario 3b – All Redevelopment – Low	6,016	5,715	6,227	6,322	6,319	303	604	6,317	301	603
Scenario 3c – All Redevelopment – High/Parks	6,016	5,715	6,227	6,322	6,255	239	540	6,229	213	514
Scenario 3d – All Redevelopment – Low/Parks	6,016	5,715	6,227	6,322	6,311	295	597	6,307	291	592

Table A-130: All Land Uses - Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	138,247	134,863	140,615	137,639	130,468	-7,779	-4,395	127,648	-10,599	-7,215
Scenario 2 – All Development within URDL	138,247	134,863	140,615	137,639	137,150	-1,097	2,287	136,970	-1,277	2,107
Scenario 3a – All Redevelopment – High	138,247	134,863	140,615	137,639	137,412	-835	2,549	137,319	-928	2,455
Scenario 3b – All Redevelopment – Low	138,247	134,863	140,615	137,639	137,607	-639	2,744	137,590	-657	2,727
Scenario 3c – All Redevelopment – High/Parks	138,247	134,863	140,615	137,639	137,036	-1,211	1,173	136,797	-1,449	1,934
Scenario 3d – All Redevelopment – Low/Parks	138,247	134,863	140,615	137,639	137,537	-709	2,674	137,493	-754	2,630

Table A-131: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	6,016	5,715	130,468	-7,619	-4,235	$276	$2,951	$28	$295
Scenario 2 – All Development within URDL	6,016	5,715	137,150	-902	2,482	$2,649	$5,325	$265	$532
Scenario 3a – All Redevelopment – High	6,016	5,715	6,297	281	582	$2,501	$5,181	$250	$518
Scenario 3b – All Redevelopment – Low	6,016	5,715	6,319	303	604	$2,693	$5,373	$269	$537
Scenario 3c – All Redevelopment – High/Parks	6,016	5,715	6,255	239	540	$2,126	$4,806	$213	$481
Scenario 3d – All Redevelopment – Low/Parks	6,016	5,715	6,311	295	596	$2,623	$5,303	$262	$530

Table A-132: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	138,247	134,863	130,468	-7,779	-4,395	$0	$0	$0	$0
Scenario 2 – All Development within URDL	138,247	134,863	137,150	-1,097	2,287	$0	$2,287	$0	$229
Scenario 3a – All Redevelopment – High	138,247	134,863	137,412	-835	2,549	$0	$2,824	$0	$282
Scenario 3b – All Redevelopment – Low	138,247	134,863	137,607	-639	2,744	$0	$3,041	$0	$304
Scenario 3c – All Redevelopment – High/Parks	138,247	134,863	137,036	-1,211	1,173	$0	$2,408	$0	$241
Scenario 3d – All Redevelopment – Low/Parks	138,247	134,863	137,537	-709	2,674	$0	$2,963	$0	$296

A.2.10 Patapsco River – Lower North Branch

A portion of the Patapsco River watershed is located in southwestern Baltimore County. Parts of the watershed are in Carroll, Howard and Anne Arundel Counties. The river mainstem forms the jurisdictional boundary between Baltimore County and the other three counties. The Patapsco River watershed discharges to the tidal water segment PATMH. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-133. The data is displayed as population in the rural section of the watershed (outside the Urban-Rural Demarcation Line, or URDL) and urban section (inside the URDL).

The majority of the population in 2005 was located within the urban portion of the watershed (94.7%) and is projected to maintain approximately the same proportion. The urban section of the watershed comprises 45.7% of the land area in the watershed. The Patapsco River watershed is projected to receive ~10.3% of the future population growth. The annual growth rate will decrease from ~1,325 per year in the 1997 – 2005 time period to ~350 and ~180 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Patapsco River watershed contains 8.7% of the land in Baltimore County and 12.9% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-134. An additional 3,549 acres of urban land will be developed during the 2005 – 2035 timeframe, at the expense of agricultural land and forest land. Forest land is projected to lose 2,631 acres and agriculture is projected to decrease by 836 acres. The overall percentage of urban land will increase from 53.8% in 2005 to 64.4% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-135 and A-136, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in an increase in phosphorus of 2,729 pounds by 2035, compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 1,760 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 4,223 pounds. Through 2005, restoration activities have achieved 395 pounds of reduction, or ~22% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 timeframe due to development with stormwater management (2,430 pounds), progress toward meeting the 15% reduction target is negative, with a net gain of 2,030 pounds of phosphorus. A total of reduction of 3,790 pounds of urban phosphorus by 2020 is now needed to meet the 15% reduction target, and 6,253 pounds is needed to meet a 36% reduction.

Nitrogen pollutant loads (Table A-136) showed a projected overall increase (25,465 pounds) from 1997 – 2035. The increase is a result of land use changes, with implementation of Environmental Site Design moderating the effects. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 17,615 pounds. A 36% urban nitrogen reduction, that may be required by the Chesapeake Bay TMDL, would require the reduction of 42,275 pounds of nitrogen. Restoration efforts through 2005 have resulted in a reduction of 2,385 pounds of nitrogen or ~13.5% of the urban nitrogen reduction goal. Development in the 1997 – 2005 timeframe added an additional 22,805 pounds of nitrogen, negating the gains made through restoration. In order to meet the 15% urban nitrogen reduction, a total of 38,035 pounds of nitrogen now need to be removed, and to meet a 36% reduction, 62,695 pounds of nitrogen is needed.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the new population would be served by public water and sewer.

Table A-137 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development (1,642 acres versus 3,579 acres) compared to Scenario 1. Fewer acres of agricultural land (-162 acres versus 832 acres) would be lost and fewer acres of forest (-1,423 versus 2,631 acres) would be lost between 2005 and 2035 compared to Scenario 1. This scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land.

Tables A-138 and A-139 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 timeframe, as those changes are based on development activities that have already occurred. Because the land use change involves mainly conversion for forest to urban land use, the phosphorus load will increase by 268 pounds in the 2005 – 2020 timeframe, even with ESD. The cost to address this additional phosphorus load created through development would be ~$2.4 million.

Nitrogen under this scenario would also increase by 1,273 pounds, and would require $1.4 million to address the development load. Even with restoration activities, the nitrogen reduction targets for a 15% and a 36% nitrogen will not be met by 2020.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-140 presents the number of acres needed to absorb the projected population increase in the Patapsco River watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 1,830 acres of land identified for potential redevelopment. This provides sufficient acreage to meet all the land acreage requirements of the redevelopment scenarios. The amount of redevelopment needed ranged from 0.7% to 8.1% of the urban land.

Table A-141 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most phosphorus and nitrogen removal. Table A-142 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. None of the redevelopment scenarios would be able to meet the 15% urban phosphorus reduction by 2020 or by 2035. Table A-143 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen would not be met by 2020, or by 2035, for all redevelopment scenarios.

Scenario Comparisons

Tables A-143 and A-145 show the comparison of all scenarios considered in the Patapsco River watershed for phosphorus and nitrogen, respectively. None of the scenarios would meet a 15%

phosphorus reduction by 2020 or by 2035. None of the scenarios would meet the 15% reduction target for urban nitrogen by 2020 or by 2035. For both phosphorus and nitrogen, Scenario 3c would result in the least amount of pollutant above the 15% reduction target.

Cost of Meeting Nutrient TMDLs by 2020

Information in Tables A-143 and A-144 was used to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used from Table A-143 for phosphorus and A-144 for nitrogen. Based on the capital program expenditures in the 1997 – 2005 timeframe and the pounds of phosphorus and nitrogen removed through capital project implementation, a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are displayed in Table A-145 for phosphorus and A-146 for nitrogen. For the Patapsco River watershed to meet a 15% urban phosphorus reduction by 2020, all scenarios would require additional capital expenditures in the range of $2.4 million (3c) to $3.1 million (2) per year. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $4.6 to $5.3 million. To meet the 15% urban nitrogen reduction target by 2020 would require additional capital funding in the range of $3.1 million (3c) to $3.7 million (2). To meet the 36% urban nitrogen reduction target need additional funding in the range of $5.8 million to $6.4 million per year would be needed.

Table A-133: Patapsco River Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	4,833	86,452	91,285	-	-	-
2005	5,410	96,468	101,878	577	10,016	10,593
2020	5,689	101,434	107,123	279	4,966	5,245
2035	5,830	103,958	109,788	142	2,523	2,665

Table A-134: Scenario 1 - Land Use Changes – Patapsco (Acres) – Lower North Branch Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	216	3,255	3,471	395	3,823	4,218	482	4,104	4,586	526	4,247	4,773
Pervious Urban HD	744	6,875	7,619	2,833	8,707	11,540	3,843	9,615	13,458	4,357	10,076	14,434
Pervious Urban LD	1,117	1,039	2,156	1,619	682	2,302	1,862	506	2,368	1,986	416	2,402
Cropland	2,741	285	3,026	2,339	52	2,391	2,144	0	2,144	2,045	0	2,045
Pasture	1,919	147	2,066	1,397	110	1,508	1,145	29	1,174	1,017	0	1,017
Livestock Feeding	0	0	0	0	0	0	0	0	0	0	0	0
Forest	11,087	3,677	14,764	9,315	1,940	11,255	8,458	1,079	9,537	8,022	602	8,624
Water	85	0	85	80	0	80	78	0	78	77	0	77
Bare Soil	323	70	393	253	34	286	218	16	235	201	7	208
Total	**18,231**	**15,348**	**33,580**	**18,231**	**15,348**	**33,580**	**18,231**	**15,348**	**33,580**	**18,231**	**15,348**	**33,580**
Total Urban	2,076	11,170	13,246	4,848	13,212	18,060	6,188	14,225	20,412	6,870	14,739	21,609
Total Agriculture	4,660	432	5,092	3,736	162	3,898	3,289	29	3,318	3,062	0	3,062
Total Forest	11,087	3,677	14,764	9,315	1,940	11,255	8,458	1,079	9,537	8,022	602	8,624
% Urban	11.4%	72.8%	39.4%	26.6%	86.1%	53.8%	**33.9%**	**92.7%**	**60.8%**	**37.7%**	**96.0%**	**64.4%**
% Agriculture	25.6%	2.8%	15.2%	20.5%	1.1%	11.6%	**18.0%**	**0.2%**	**9.9%**	**16.8%**	**0.0%**	**9.1%**
% Forest	60.8%	24.0%	44.0%	51.1%	12.6%	33.5%	**46.4%**	**7.0%**	**28.4%**	**44.0%**	**3.9%**	**25.7%**
Change in Urban from previous time period				**2,771**	**2,042**	**4,813**	**1,340**	**1,013**	**2,353**	**682**	**514**	**1,196**
Change in Agriculture from previous time period				**-924**	**-269**	**-1,193**	**-447**	**-134**	**-580**	**-227**	**-29**	**-256**
Change in Forest from previous time period				**-1,772**	**-1,737**	**-3,509**	**-857**	**-861**	**-1,718**	**-436**	**-477**	**-913**

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Table A=135: Scenario 1 - Phosphorus Load Changes (Pounds) – Patapsco River – Lower North Branch Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	1,286	10,764	12,049	2,806	12,683	15,489	3,541	13,635	17,176	3,916	14,118	18,034
Agriculture	3,374	312	3,687	2,704	118	2,822	2,380	21	2,401	2,215	0	2,215
Forest	222	74	295	186	39	225	169	22	191	150	12	172
Water	48	0	48	46	0	46	44	0	44	44	0	44
Bare Soil	236	51	287	184	25	209	159	12	171	147	5	152
Total	**5,116**	**11,201**	**16,366**	**5,926**	**12,865**	**18,791**	**6,294**	**13,689**	**19,983**	**6,481**	**14,135**	**20,617**
Change in Urban from previous time period				1,521	1,919	3,440	735	952	1,687	374	783	858
Change in Agriculture from previous time period				-670	-194	-865	-324	-97	-421	-165	-21	-186
Change in Forest from previous time period				-35	-35	-70	-17	-17	-34	-9	-10	-18
Total Change from previous time period				**761**	**1,664**	**2,425**	**368**	**824**	**1,192**	**187**	**446**	**634**
Urban BMPs	-23	-295	-318	-55	-258	-313	-496	-829	-1,325	-720	-1,119	-1,839
CIP Restoration	0	0	0	0	-108	-108	0	-341	-341	0	-573	-573
Reforestation	0	0	0	-8	-8	-16	-20	-20	-40	-32	-32	-63
Other Reductions	0	0	0	0	-271	-271	0	-295	-295	0	-295	-295
Total Reductions	**-23**	**-295**	**-318**	**-62**	**-645**	**-708**	**-516**	**-1,485**	**-2,000**	**-752**	**-2,019**	**-2,771**
Total with Urban BMPs	5,142	10,906	16,048	5,872	12,607	18,478	5,798	12,860	18,659	5,761	13,016	18,777
Total With Urban BMPs and Restoration	5,142	10,906	16,048	5,864	12,219	18,083	5,779	12,204	17,983	5,729	12,116	17,846

Table A-136: Scenario 1 - Nitrogen Load Changes (Pounds) – Patapsco River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	16,523	103,269	119,792	37,839	121,965	159,804	48,146	131,235	179,380	53,392	135,944	189,335
Agriculture	59,466	5,795	65,261	48,976	1,672	50,648	43,903	212	44,115	41,321	0	41,321
Forest	15,633	5,185	20,818	13,134	2,736	15,870	11,926	1,521	13,447	11,311	849	12,160
Other	3,228	513	3,741	2,661	249	2,910	2,387	118	2,505	2,248	52	2,300
Septic	16,531	15,954	32,485	20,376	16,010	36,386	21,120	15,325	36,445	21,430	14,617	36,047
Total	**111,381**	**130,716**	**242,097**	**122,985**	**142,633**	**265,618**	**127,482**	**148,411**	**275,893**	**129,702**	**151,944**	**281,164**
Change in Urban from previous time period				21,316	18,696	40,012	10,307	9,269	19,576	5,246	4,709	9,955
Changs in Septic from previous time period				3,845	-264	3,902	744	-685	59	310	-708	-398
Change in Agriculture from previous time period				-10,491	-4,123	-14,613	-5,073	-1,461	-6,533	-2,582	-212	-2,793
Change in Forest from previous time period				-2,499	-2,499	-4,948	-1,208	-1,214	-2,423	-615	-672	-1,287
Total Change from previous time period				**11,605**	**11,917**	**23,521**	**4,496**	**5,778**	**10,275**	**2,220**	**3,051**	**5,271**
Urban BMPs	-256	-2,104	-2,361	-749	-2,328	-3,077	-5,902	-6,963	-12,866	-8,525	-9,318	-17,843
CIP Restoration	0	0	0	0	-1,421	-1,421	0	-4,467	-4,467	0	-7,512	-7,512
Reforestation	0	0	0	-113	-113	-226	-283	-283	-566	-453	-453	-906
Other Reductions	0	0	0	0	-737	-737	0	-898	-898	0	-898	-898
Total Reductions	**-256**	**-2,104**	**-2,361**	**-862**	**-4,600**	**-5,462**	**-6,185**	**-12,611**	**-18,796**	**-8,978**	**-18,181**	**-27,159**
Total with Urban BMPs	111,124	128,611	239,736	122,236	140,304	262,541	121,579	141,448	263,027	121,176	142,144	263,321
Total With Urban BMPs and Restoration	111,124	128,611	239,736	122,123	238,033	260,156	121,296	135,800	257,097	120,724	133,281	254,005

Table A-137: Scenario 2 – Future Land Use Changes (Acres) – Patapsco River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	395	3,823	4,218	395	4,120	4,515	395	4,271	4,666
Urban Pervious HD	2,833	8,707	11,540	2,833	9,666	12,499	2,833	10,153	12,986
Urban Pervious LD	1,619	682	2,302	1,619	496	2,114	1,619	401	2,020
Cropland	2,339	52	2,391	2,339	0	2,338	2,339	0	2,339
Pasture	1,397	110	1,508	1,397	21	1,418	1,397	0	1,397
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	9,315	1,940	11,255	9,315	1,031	10,345	9,315	518	9,833
Water	80	0	80	80	0	80	80	0	80
Bare Soil	253	34	286	253	15	267	253	6	258
Total	**18,231**	**15,348**	**33,580**	**18,231**	**15,348**	**33,580**	**18,231**	**15,348**	**33,580**
Total Urban	4,848	13,212	18,060	4,848	14,281	19,129	4,848	14,825	19,673
Total Agriculture	3,736	162	3,898	3,736	21	3,757	3,736	0	3,736
Total Forest	9,315	1,940	11,255	9,315	1,031	10,346	9,315	518	9,833
% Urban	26.6%	86.1%	53.8%	26.6%	93.0%	57.0%	26.6%	96.6%	58.6%
% Agriculture	20.5%	1.1%	11.6%	20.5%	0.1%	11.2%	20.5%	0.0%	11.1%
% Forest	51.1%	12.6%	33.5%	51.1%	6.7%	30.8%	51.1%	3.4%	29.3%
Change in Urban Land Use from previous period				**0**	**1,069**	**1,069**	**0**	**543**	**543**
Change in Agricultural Land Use from previous period				**0**	**-141**	**-141**	**0**	**-21**	**-21**
Change in Forest Land Use from previous period				**0**	**-910**	**-910**	**0**	**-513**	**-513**

Table A138: Scenario 2 – Phosphorus Load Changes (Pounds) – Patapsco River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	2,806	12,683	15,489	2,806	13,688	16,494	2,806	14,199	17,005
Agriculture	2,704	118	2,822	2,704	16	2,719	2,704	0	2,704
Forest	186	39	225	186	21	207	186	10	197
Water	46	0	46	46	0	46	46	0	46
Bare Soil	184	25	209	184	11	195	184	4	188
Total	5,926	12,865	18,791	5,926	13,735	19,662	5,926	14,213	20,140
Change in Urban from previous period				0	1,005	1,005	0	511	511
Change in Agricultural from previous period				0	-102	-102	0	-16	-16
Change in Forest from previous period				0	-18	-18	0	-10	-10
Total				0	871	871	0	478	478
Urban BMPs	-55	-258	-313	-55	-861	-916	-55	-1,168	-1,222
CIP Restoration	0	-108	-108	0	-341	-341	0	-573	-573
Reforestation	-8	-8	-16	-20	-20	-40	-32	-32	-63
Other Reductions	0	-271	-271	0	-295	-295	0	-295	-295
Total	-62	-645	-708	-74	-1,517	-1,591	-86	-2,068	-2.154
Total with Urban BMPs	5,872	12,607	18,478	5,872	12,874	18,746	5,872	13,046	18,918
Total with Urban BMPs and Restoration	5,864	12,219	18,083	5,852	12,219	18,071	5,840	12,146	17,986

Table A-139: Scenario 2 – Nitrogen Load Changes (Pounds) – Patapsco River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	37,839	121,965	159,804	37,839	131,755	169,594	37,839	136,730	174,568
Agriculture	48,976	1,672	50,648	48,976	156	49,132	48,976	0	48,976
Forest	13,134	2,736	15,870	13,134	1,453	14,587	13,134	731	13,865
Other	2,661	249	2,910	2,661	111	2,772	2,661	41	2,702
Septic	20,376	16,010	36,386	20,376	15,325	35,701	20,376	14,617	34,992
Total	**122,985**	**142,633**	**265,618**	**122,985**	**148,801**	**271,786**	**122,985**	**152,118**	**275,103**
Change in Urban from previous period				0	9,790	9,790	0	4,974	4,974
Change in Septic from previous period				0	-685	-685	0	-708	-708
Change in Agricultural from previous period				0	-1,516	-1,516	0	-156	-156
Change in Forest from previous period				0	-1,282	-1,282	0	-723	-723
Total Change				**0**	**6,168**	**6,168**	**0**	**3,317**	**3,317**
Urban BMPs	-749	-2,328	-3,077	-749	-7,244	-7,972	-749	-9,711	-10,460
CIP Restoration	0	-1,421	-1,421	0	-4,467	-4,467	0	-7,512	-7,512
Reforestation	-113	-113	-226	-283	-283	-566	-453	-453	-906
Other Reductions	0	-737	-737	0	-898	-898	0	-898	-898
Total	**-862**	**-4,600**	**-5,462**	**-1,032**	**-12,871**	**-13,903**	**-1,202**	**-18,574**	**-19,775**
Total with Urban BMPs	122,236	140,304	262,541	122,236	141,578	263,814	122,236	142,407	264,644
Total with Urban BMPs and Restoration	122,123	138,033	260,156	121,953	135,930	257,883	121,784	133,544	255,328

Table A-140: Acres of Redevelopment Needed to Meet Patapsco River Watershed Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	614	312	**926**	1,830	904	7.0%
3b	63	32	**96**	1,830	1,734	0.7%
3c	708	360	**1,068**	1,830	762	8.1%
3d	110	56	**166**	1,830	1,664	1.3%

Table A-141: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 Nitrogen Loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	614	6,259	1,565	312	3,180	795
Low – 3b	25%	63	642	160	32	326	82
High/Parks – 3c	59%	708	7,222	4,261	360	3,670	2,165
Low/Parks – 3d	59%	110	1,123	663	56	571	337
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	614	749	172	312	380	87
Low	23%	63	77	18	32	39	9
High/Parks	55%	708	864	475	360	439	241
Low/Parks	55%	110	134	74	56	68	38

Table A-142: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	14,607	12,143	16,048	18,083	17,631	17,287
Low – 3b	14,607	12,143	16,048	18,083	17,785	17,520
High/Parks – 3c	14,607	12,143	16,048	18,083	17,328	16,830
Low/Parks – 3d	14,607	12,143	16,048	18,083	17,729	17,435

Table A-143: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	224,482	199,821	239,739	260,156	255,045	250,865
Low – 3b	224,482	199,821	239,739	260,156	256,450	252,983
High/Parks – 3c	224,482	199,821	239,739	260,156	252,349	246,799
Low/Parks – 3d	224,482	199,821	239,739	260,156	255,947	252,225

Table A-144: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	14,607	12,143	16,048	6,322	17,983	3,376	5,840	17,846	3,239	5,703
Scenario 2 – All Development within URDL	14,607	12,143	16,048	6,322	18,071	3,464	5,928	17,986	3,379	5,843
Scenario 3a – All Redevelopment – High	14,607	12,143	16,048	6,322	17,631	3,024	5,488	17,287	2,680	5,144
Scenario 3b – All Redevelopment – Low	14,607	12,143	16,048	6,322	17,785	3,179	5,642	17,520	2,913	5,377
Scenario 3c – All Redevelopment – High/Parks	14,607	12,143	16,048	6,322	17,328	2,721	5,185	16,830	2,223	4,687
Scenario 3d – All Redevelopment – Low/Parks	14,607	12,143	16,048	6,322	17,729	3,122	5,586	17,435	2,829	5,292

Table A-145: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	224,482	199,821	239,739	260,156	257,097	32,615	57,276	254,005	29,523	54,184
Scenario 2 – All Development within URDL	224,482	199,821	239,739	260,156	257,883	33,401	58,062	255,328	30,846	55,507
Scenario 3a – All Redevelopment – High	224,482	199,821	239,739	260,156	255,045	30,563	55,224	250,865	26,383	51,044
Scenario 3b – All Redevelopment – Low	224,482	199,821	239,739	260,156	256,450	31,968	56,628	252,983	28,501	53,162
Scenario 3c – All Redevelopment – High/Parks	224,482	199,821	239,739	260,156	252,349	27,867	52,528	246,799	22,317	46,978
Scenario 3d – All Redevelopment – Low/Parks	224,482	199,821	239,739	260,156	255,947	31,465	56,126	252,225	27,744	52,404

Table A-146: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	14,607	12,143	17,983	3,376	5,840	$30,009	$51,912	$3,001	$5,191
Scenario 2 – All Development within URDL	14,607	12,143	18,071	3,464	5,928	$30,791	$52,694	$3,079	$5,269
Scenario 3a – All Redevelopment – High	14,607	12,143	17,631	3,024	5,488	$26,880	$48,779	$2,688	$4,878
Scenario 3b – All Redevelopment – Low	14,607	12,143	17,785	3,179	5,642	$28,254	$50,152	$2,825	$5,015
Scenario 3c – All Redevelopment – High/Parks	14,607	12,143	17,328	2,721	5,185	$24,188	$46,086	$2,419	$4,609
Scenario 3d – All Redevelopment – Low/Parks	14,607	12,143	17,729	3,122	5,586	$27,754	$49,652	$2,775	$4,965

Table A-147: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	224,482	199,821	257,097	32,615	57,276	$36,137	$63,462	$3,614	$6,346
Scenario 2 – All Development within URDL	224,482	199,821	257,883	33,401	58,062	$37,008	$64,333	$3,701	$6,433
Scenario 3a – All Redevelopment – High	224,482	199,821	255,045	30,563	55,224	$33,864	$61,188	$3,386	$6,119
Scenario 3b – All Redevelopment – Low	224,482	199,821	256,450	31,968	56,628	$35,420	$62,744	$3,542	$6,274
Scenario 3c – All Redevelopment – High/Parks	224,482	199,821	252,349	27,867	52,528	$30,877	$58,201	$3,088	$5,820
Scenario 3d – All Redevelopment – Low/Parks	224,482	199,821	255,947	31,465	56,126	$34,864	$62,188	$3,486	$6,168

A.2.11 Gwynns Falls

The Gwynns Falls watershed is located entirely in western Baltimore County. The Gwynns Falls watershed discharges to Baltimore City, and subsequently to tidal water segment PATMH. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-148. The data is displayed as

population in the rural section of the watershed (outside the Urban-Rural Demarcation Line, or URDL) and urban section (inside the URDL).

The majority of the population in 2005 was located within the urban portion of the watershed (99.2%) and is projected to maintain approximately the same proportion. The urban section of the watershed comprises 93.5% of the land area in the watershed. The Gwynns Falls watershed is projected to receive ~27.4% of the future population growth. The annual growth rate will decrease from ~3,050 per year in the 1997 – 2005 time period to ~1,150 and ~250 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Gwynns Falls watershed contains 7.4% of the land in Baltimore County and 22.3% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-149. An additional 1,950 acres of urban land will be developed during the 2005 – 2035 timeframe, at the expense of agricultural land and forest land. Forest land is projected to lose 963 acres and agriculture is projected to decrease by 937 acres. The overall percentage of urban land will increase from 76.6 % in 2005 to 83.4% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-150 and A-151, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in an increase in phosphorus of 2,382 pounds by 2035, compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 2,733 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 6,559 pounds. Through 2005, restoration activities have achieved 594 pounds of reduction, or ~22% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 timeframe due to development with stormwater management (1,537 pounds), progress toward meeting the 15% reduction target is negative, with a net gain of 775 pounds of phosphorus. A total reduction of 4,270 pounds of urban phosphorus by 2020 is now needed to meet the 15% reduction target, and 8,096 pounds is needed to meet a 36% reduction.

Nitrogen pollutant loads (Table A-151) also showed an increase from 1997 – 2035 when land use change and implementation of ESD is considered. A total increase in nitrogen load of 4,323 pounds by 2020, and 3,964 pounds by 2035 results. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 26,521 pounds of urban nitrogen. A 36% urban nitrogen reduction, that may be required by the Chesapeake Bay TMDL, would require the reduction of 63,650 pounds of nitrogen. Restoration efforts through 2005 have resulted in a reduction of 2,761 pounds of nitrogen. Progress toward meeting the 15% reduction goal was only 10.4%. Development in the 1997-2005 timeframe resulted in an increase of 4,225 pounds of nitrogen resulting in a net increase of nitrogen (1,464 pounds). Current restoration efforts are inadequate to meet either the 15% or the 36% nitrogen or phosphorus in the 2020 or the 2035 timeframes.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the new population would be served by public water and sewer.

Table A-152 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development (1,615 acres versus 1,950 acres) compared to Scenario 1 and fewer acres of agricultural land (-775 acres versus –937 acres) would be lost between 2005 and 2035. A smaller amount of forest (-788 acres versus -963 acres) would also be lost under Scenario 2 compared to Scenario 1. This scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land.

Tables A-153 and A-154 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 timeframe, as those changes are based on development activities that have already occurred. Because the land use change involves a combination of conversion for forest and agriculture to urban land use, the phosphorus load will increase by only 172 pounds in the 2005 – 2020 timeframe. This is slightly more than the increase in phosphorus load in Scenario 1. The cost to address this additional phosphorus load created through development would be ~$1.5 million.

Nitrogen under this scenario would decrease by 4,412 pounds in the 2005 – 2020 timeframe.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-155 presents the number of acres needed to absorb the projected population increase in the Gwynns Falls watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 2,565 acres of land identified for potential redevelopment. This provides sufficient acreage to meet all the land acreage requirements of the redevelopment scenarios, with the exception of Scenario 3c. The amount of redevelopment needed ranged from 1.2% to 11.5% of the urban land.

Table A-156 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most phosphorus and nitrogen removal. Table A-157 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. None of the redevelopment scenarios would be able to meet the 15% urban phosphorus reduction by 2020 or by 2035. Table A-158 displays the same information for nitrogen. This table shows that the 15% reduction and the 36% reduction for nitrogen would not be met by 2020, or by 2035, for any of the redevelopment scenarios.

Scenario Comparisons

Tables A-159 and A-160 show the comparison of all scenarios considered in the Gwynns Falls watershed for phosphorus and nitrogen, respectively. None of the scenarios would meet a 15% or 36% phosphorus reduction by 2020 or by 2035. Scenario 3c would reduce phosphorus the most. None of the scenarios would meet the 15% or the 36% reduction target for urban nitrogen by 2020 or by 2035.

Cost of Meeting Nutrient TMDLs by 2020

Information in Tables A-159 and A-160 was used to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used from Table A-159 for phosphorus and A-160 for nitrogen. Based the capital program expenditures in the 1997 – 2005 timeframe and the pounds of phosphorus and nitrogen removed through capital project implementation, a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are displayed in Table A-161 for phosphorus and Table A-162 for nitrogen. For the Gwynns Falls watershed, all scenarios would require additional capital expenditures to meet a 15% urban phosphorus reduction by 2020 in the range of $1.6 million (3c) to $3.1 million (2) per year. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $5.0 to $6.5 million. To meet the 15% urban nitrogen reduction target by 2020 would require additional capital funding for all scenarios, ranging from $0.6 (3a) million to $2.1 million (3b). To meet the 36% nitrogen reduction target the range in additional funding would be $4.7 million to $6.1 million per year.

Table A-148: Gwynns Falls Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	1,299	150,575	151,874	-	-	-
2005	1,368	174,855	176,223	69	24,280	24,349
2020	1,501	191,907	193,408	133	17,052	17,185
2035	1,531	195,688	197,219	30	3,781	3,811

Table A-149: Scenario 1 - Land Use Changes (Acres) – Gwynns Falls Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Impervious Urban	88	5,608	5,696	102	6,602	6,704	128	7,301	7,428	133	7,456	7,589
Pervious Urban HD	46	12,626	12,671	275	13,614	13,890	718	14,309	15,027	818	14,463	15,281
Pervious Urban LD	405	1,174	1,579	309	1,058	1,367	124	977	1,101	82	959	1,041
Cropland	241	1,373	1,614	171	449	620	35	0	35	04	0	4
Pasture	25	436	461	27	326	353	31	49	80	032	0	32
Livestock Feeding	0	0	0	0	0	0	0	0	0	0	0	0
Forest	1,056	5,458	6,514	977	4,689	5,666	825	4,146	4,971	791	3,913	4,704
Water	0	13	13	0	3	4	0	0	0	0	0	0
Bare Soil	0	106	106	0	51	51	0	12	12	0	3	3
Total	**1,861**	**26,793**	**28,654**	**1,861**	**26,793**	**28,654**	**1,861**	**26,793**	**28,654**	**1,861**	**26,793**	**28,654**
Total Urban	539	19,408	19,946	686	21,275	21,961	970	22,586	23,556	1,034	22,877	23,911
Total Agriculture	266	1,809	2,075	198	775	973	66	49	115	37	0	37
Total Forest	1,056	5,458	6,514	977	4,689	5,666	825	4,146	4,971	791	3,913	4,704
% Urban	28.9%	72.4%	69.6%	36.9%	79.4%	76.6%	**52.1%**	**84.3%**	**82.2%**	**55.5%**	**85.4%**	**83.4%**
% Agriculture	14.3%	6.8%	7.2%	10.6%	2.9%	3.4%	**3.6%**	**0.2%**	**0.4%**	**2.0%**	**0.0%**	**0.1%**
% Forest	56.8%	20.4%	22.7%	52.5%	17.5%	19.8%	**44.3%**	**15.5%**	**17.3%**	**42.5%**	**14.6%**	**16.4%**
Change in Urban from previous time period				**147**	**1,867**	**2,014**	**284**	**1,311**	**1,595**	**64**	**291**	**355**
Change in Agriculture from previous time period				**-68**	**-1,034**	**-1,102**	**-132**	**-726**	**-858**	**-30**	**-49**	**-79**
Change in Forest from previous time period				**-79**	**-768**	**-847**	**-152**	**-543**	**-695**	**-34**	**-233**	**-268**

Table A-150: Scenario 1 - Phosphorus Load Changes (Pounds) – Gwynns Falls Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	392	18,617	19,009	480	21,241	21,721	651	23,211	23,735	689	23,492	24,182
Agriculture	192	1,307	1,499	143	561	704	48	36	84	27	0	27
Forest	21	109	130	20	94	113	17	83	99	16	78	94
Water	0	7	7	0	2	2	0	0	0	0	0	0
Bare Soil	0	77	77	0	37	37	0	9	9	0	2	2
Total	**605**	**20,118**	**20,723**	**643**	**21,935**	**22,578**	**715**	**23,211**	**23,735**	**732**	**23,573**	**24,305**
Change in Urban from previous time period				88	2,624	2,712	171	1,843	2,013	38	409	447
Change in Agriculture from previous time period				-49	-746	-795	-95	-526	-620	-21	-36	-57
Change in Forest from previous time period				-2	-15	-17	-3	-11	-14	-1	-5	-5
Total Change from previous time period				**38**	**1,817**	**2,712**	**73**	**1,276**	**1,349**	**16**	**362**	**378**
Urban BMPs	-9	-782	-791	-10	-505	-515	-112	-1,610	-1,723	-135	-1,856	-1,991
CIP Restoration	0	0	0	0	-67	-67	0	-212	-212	0	-357	-357
Reforestation	0	0	0	0	0	-1	-1	-1	-2	-1	-1	-2
Other Reductions	0	0	0	0	-526	-526	0	-526	-526	0	-526	-526
Total Reductions	**-9**	**-782**	**-791**	**-10**	**-1,099**	**-1,109**	**-113**	**-2,349**	**-2,462**	**-136**	**-2,739**	**-2,876**
Total with Urban BMPs	596	19,336	19,932	633	21,430	22,063	603	21,600	22,204	597	21,717	22,314
Total With Urban BMPs and Restoration	596	19,336	19,932	633	20,836	21,469	602	20,861	21,464	595	20,833	21,429

Table A-151: Scenario 1 - Nitrogen Load Changes (Pounds) – Gwynns Falls Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	4,505	179,109	183,614	5,665	199,459	205,124	7,902	213,751	221,653	8,407	216,920	225,326
Agriculture	4,175	25,927	30,102	3,025	9,829	12,853	808	359	1,167	308	0	308
Forest	1,489	7,695	9,184	1,378	6,612	7,990	1,163	5,846	7,010	1,115	5,517	6,632
Other	0	907	907	0	405	405	0	86	86	0	23	23
Septic	4,780	19,989	24,769	5,129	20,168	25,297	5,636	19,160	24,795	5,748	18,151	23,899
Total	**14,949**	**233,629**	**248,577**	**15,197**	**236,473**	**251,669**	**15,509**	**239,201**	**254,711**	**15,578**	**240,611**	**256,189**
Change in Urban from previous time period				1,161	20,350	21,510	2,237	14,292	16,529	505	3,169	3,674
Change in Septic from previous time period				349	179	528	507	-1,008	-501	112	-1,008	-896
Change in Agriculture from previous time period				-1,150	-16,099	-17,249	-2,217	-9,470	-11,687	-500	-359	-859
Changes in Forest from previous time period				-111	-1,084	-1,195	-214	-766	-980	-48	-329	-377
Total Change from previous time period				**248**	**2,844**	**3,092**	**313**	**2,728**	**3,041**	**69**	**1,409**	**1,478**
Urban BMPs	-77	-6,732	-6,809	-76	-5,599	-5,675	-1,195	-12,745	-13,940	-1,447	-14,330	-15,776
CIP Restoration	0	0	0	0	-849	-849	0	-2,669	-2,669	0	-4,489	-4,489
Reforestation	0	0	0	-4	-4	-9	-11	-11	-22	-18	-18	-35
Other Reductions	0	0	0	0	-1,903	-1,903	0	-1,903	-1,903	0	-1,903	-1,903
Total Reductions	**-77**	**-6,732**	**-6,809**	**-81**	**-8,356**	**-8,436**	**-1,206**	**-17,328**	**-18,534**	**-1,464**	**-20,739**	**-18,534**
Total with Urban BMPs	14,872	226,897	241,769	15,120	230,874	245,994	14,315	226,456	240,771	14,131	226,281	240,412
Total With Urban BMPs and Restoration	14,872	226,897	241,769	15,116	228,117	243,233	14,304	221,873	236,177	14,114	219,872	233,985

Table A-152: Scenario 2 – Future Land Use Changes (Acres) – Gwynns Falls

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	102	6,602	6,704	102	7,306	7,407	102	7,462	7,564
Urban Pervious HD	275	13,614	13,890	275	14,314	14,589	275	14,469	14,745
Urban Pervious LD	309	1,058	1,367	309	976	1,284	309	958	1,267
Cropland	171	449	620	171	0	170	171	0	171
Pasture	27	326	353	27	43	70	27	0	27
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	977	4,689	5,666	977	4,142	5,119	977	3,901	4,878
Water	0	3	3	0	0	0	0	0	0
Bare Soil	0	51	51	0	11	11	0	3	3
Total	1,861	26,793	28,654	1,861	26,793	28,654	1,861	26,793	28,654
Total Urban	686	21,275	21,961	686	22,597	23,282	686	22,890	23,575
Total Agriculture	198	775	973	198	43	241	198	0	198
Total Forest	977	4,689	5,666	977	4,142	5,119	977	3,901	4,878
% Urban	36.9%	79.4%	76.6%	36.9%	84.3%	81.3%	36.9%	85.4%	82.3%
% Agriculture	10.6%	2.9%	3.4%	10.6%	0.2%	0.8%	10.6%	0.0%	0.7%
% Forest	52.5%	17.5%	19.8%	52.5%	15.5%	17.9%	52.5%	14.6%	17.0%
Change in Urban Land Use from previous period				**0**	**1,322**	**1,322**	**0**	**293**	**293**
Change in Agricultural Land Use from previous period				**0**	**-732**	**-732**	**0**	**-43**	**-43**
Change in Forest Land Use from previous period				**0**	**-547**	**-547**	**0**	**-241**	**-241**

Table A-153: Scenario 2 – Phosphorus Load Changes (Pounds) – Gwynns Falls

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	480	21,241	21,721	480	23,098	23,578	480	23,510	23,990
Agriculture	143	561	704	143	31	174	143	0	143
Forest	20	94	113	20	83	102	20	78	98
Water	0	2	2	0	0	0	0	0	0
Bare Soil	0	37	37	0	8	8	0	2	2
Total	**643**	**21,935**	**22,578**	**643**	**23,221**	**23,863**	**643**	**23,590**	**24,233**
Change in Urban from previous period				0	1,857	1,857	0	412	412
Change in Agricultural from previous period				0	-530	-530	0	-31	-31
Change in Forest from previous period				0	-11	-11	0	-5	-5
Total				**0**	**1,286**	**1,286**	**0**	**369**	**369**
Urban BMPs	-10	-505	-515	-10	-1,619	-1,629	-10	-1,866	-1,876
CIP Restoration	0	-67	-67	0	-212	-212	0	-357	-357
Reforestation	0	0	-1	-1	-1	-2	-1	-1	-2
Other Reductions	0	-526	-526	0	-526	-526	0	-526	-526
Total	**-10**	**-1,099**	**-1,109**	**-11**	**-2,358**	**-2,369**	**-11**	**-2,750**	**-2,761**
Total with Urban BMPs	633	21,430	22,063	633	21,602	22,235	633	21,724	22,357
Total with Urban BMPs and Restoration	633	20,836	21,469	632	20,863	21,495	632	20,840	21,472

Table A-154: Scenario 2 – Nitrogen Load Changes (Pounds) – Gwynns Falls

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	5,665	199,459	205,124	5,665	213,862	219,527	5,665	217,056	222,721
Agriculture	3,025	9,829	12,853	3,025	317	3,342	3,025	0	3,025
Forest	1,378	6,612	7,990	1,378	5,840	7,218	1,378	5,500	6,878
Other	0	405	405	0	84	84	0	20	20
Septic	5,129	20,168	25,297	5,129	19,160	24,288	5,129	18,151	23,280
Total	**15,197**	**236,473**	**251,669**	**15,197**	**239,263**	**254,459**	**15,197**	**240,727**	**255,924**
Change in Urban from previous period				0	14,403	14,403	0	3,194	3,194
Change in Septic from previous period				0	-1,008	-1,008	0	-1,008	-1,008
Change in Agricultural from previous period				0	-9,512	-9,512	0	-317	-317
Change in Forest from previous period				0	-772	-772	0	-340	-340
Total Change				**0**	**2,790**	**2,790**	**0**	**1,465**	**1,465**
Urban BMPs	-76	-5,599	-5,675	-76	-12,398	-12,877	-76	-14,398	-14,474
CIP Restoration	0	-849	-849	0	-2,669	-2,669	0	-4,489	-4,489
Reforestation	-4	-4	-9	-11	-11	-22	-18	-18	-35
Other Reductions	0	-1,903	-1,903	0	-1,903	-1,903	0	-1,903	-1,903
Total	**-81**	**-8,356**	**-8,436**	**-87**	**-17,384**	**-17,471**	**-94**	**-20,807**	**-20,901**
Total with Urban BMPs	15,120	230,874	245,994	15,120	226,462	241,582	15,120	226,330	241,450
Total with Urban BMPs and Restoration	15,116	228,117	243,233	15,110	221,879	236,989	15,103	219,920	235,023

Table A-155: Acres of Redevelopment Needed to Meet Gwynns Falls Watershed Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	2,011	446	**2,457**	2,565	108	11.5%
3b	206	46	**252**	2,565	2,313	1.2%
3c	2,320	514	**2,834**	2,565	-269	8.1%
3d	361	80	**441**	2,565	2,124	13.3%

Table A-156: Phosphorus and Nitrogen Removal from Redevelopment Through 2020 (Pounds)

2005 Nitrogen Loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	2,011	20,509	5,127	446	4,548	1,137
Low – 3b	25%	206	2,103	526	46	466	117
High/Parks – 3c	59%	2,320	23,664	13,962	514	5,248	3,096
Low/Parks – 3d	59%	361	3,681	2,172	80	816	482
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	2,011	2,453	564	446	544	125
Low	23%	206	252	58	46	56	13
High/Parks	55%	2,320	2,830	1,557	514	628	345
Low/Parks	55%	361	440	242	80	98	54

Table A-157: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	17,990	14,164	19,932	21,469	20,759	20,489
Low – 3b	17,990	14,164	19,932	21,469	21,265	21,107
High/Parks – 3c	17,990	14,164	19,932	21,469	19,767	19,276
Low/Parks – 3d	17,990	14,164	19,932	21,469	21,081	20,882

Table A-158: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	222,056	184,927	241,769	243,233	236,273	233,303
Low – 3b	222,056	184,927	241,769	243,233	240,874	238,925
High/Parks – 3c	222,056	184,927	241,769	243,233	227,439	222,509
Low/Parks – 3d	222,056	184,927	241,769	243,233	239,228	236,914

Table A-159: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	17,990	14,164	19,932	21,469	21,464	3,474	7,300	21,429	3,439	7,265
Scenario 2 – All Development within URDL	17,990	14,164	19,932	21,469	21,495	3,505	7,331	21,472	3,482	7,307
Scenario 3a – All Redevelopment – High	17,990	14,164	19,932	21,469	20,759	2,769	6,595	20,489	2,499	6,324
Scenario 3b – All Redevelopment – Low	17,990	14,164	19,932	21,469	21,265	3,275	7,101	21,107	3,117	6,943
Scenario 3c – All Redevelopment – High/Parks	17,990	14,164	19,932	21,469	19,767	1,777	5,602	19,276	1,286	5,112
Scenario 3d – All Redevelopment – Low/Parks	17,990	14,164	19,932	21,469	21,081	3,091	6,917	20,882	2,892	6,718

Table A-160: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	222,056	184,927	241,769	243,233	236,177	14,121	51,250	233,985	11,929	49,058
Scenario 2 – All Development within URDL	222,056	184,927	241,769	243,233	236,989	14,933	52,062	235,023	12,967	50,096
Scenario 3a – All Redevelopment – High	222,056	184,927	241,769	243,233	236,273	14,217	51,346	233,303	11,247	48,376
Scenario 3b – All Redevelopment – Low	222,056	184,927	241,769	243,233	240,874	18,818	55,947	238,925	16,868	53,997
Scenario 3c – All Redevelopment – High/Parks	222,056	184,927	241,769	243,233	227,439	5,382	42,511	222,509	453	37,582
Scenario 3d – All Redevelopment – Low/Parks	222,056	184,927	241,769	243,233	239,228	17,172	54,301	236,914	14,857	51,986

Table A-161: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	17,990	14,164	21,464	3,474	7,300	$30,880	$64,888	$3,088	$6,489
Scenario 2 – All Development within URDL	17,990	14,164	21,495	3,505	7,331	$31,155	$65,163	$3,156	$6,516
Scenario 3a – All Redevelopment – High	17,990	14,164	20,759	2,769	6,595	$24,614	$58,622	$2,461	$5,862
Scenario 3b – All Redevelopment – Low	17,990	14,164	21,265	3,275	7,101	$29,115	$63,123	$2,912	$6,312
Scenario 3c – All Redevelopment – High/Parks	17,990	14,164	19,767	1,777	5,602	$15,792	$49,800	$1,579	$4,980
Scenario 3d – All Redevelopment – Low/Parks	17,990	14,164	21,081	3,091	6,917	$27,477	$61,485	$2,748	$6,149

Table A-162: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	224,482	199,821	236,177	14,121	51,250	$15,646	$56,785	$1,565	$5,679
Scenario 2 – All Development within URDL	224,482	199,821	236,989	14,933	52,062	$16,546	$57,685	$1,655	$5,768
Scenario 3a – All Redevelopment – High	224,482	199,821	236,273	14,217	51,346	$15,752	$56,891	$1,575	$5,689
Scenario 3b – All Redevelopment – Low	224,482	199,821	240,874	18,818	55,947	$20,850	$61,989	$2,085	$6,199
Scenario 3c – All Redevelopment – High/Parks	224,482	199,821	227,439	5,382	42,511	$5,963	$47,103	$596	$4,710
Scenario 3d – All Redevelopment – Low/Parks	224,482	199,821	239,228	17,172	54,301	$19,027	$60,166	$1,903	$6,017

A.2.12 Jones Falls

The Jones Falls watershed is located the central part of Baltimore County. The Jones Falls watershed discharges to Lake Roland and subsequently to Baltimore City and ultimately to the tidal water segment PATMH. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-163. The data is displayed as

population in the rural section of the watershed (outside the Urban-Rural Demarcation Line (URDL)) and urban section (inside the URDL).

The majority of the population in 2005 was located within the urban portion of the watershed (89.2%) and is projected to maintain approximately the same proportion. The urban section of the watershed comprises 53.6% of the land area in the watershed. The Jones Falls watershed is projected to receive ~7.6% of the future population growth. The annual growth rate will decrease from ~650 per year in the 1997 – 2005 time period to ~300 and ~90 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Jones Falls watershed contains 6.7% of the land in Baltimore County and 8.4% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-164. An additional 1,103 acres of urban land will be developed during the 2005 – 2035 time frame, mainly at the expense of agricultural land. Forest land is projected to gain 62 acres and agriculture is projected to decrease by 1,108 acres. The overall percentage of urban land will increase from 57.6% in 2005 to 61.9% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-165 and A-166, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in a decrease in phosphorus by 213 pounds by 2035 compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 1,858 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 4,458 pounds. Through 2005 restoration activities have achieved 360 pounds of reduction, or ~19% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 time frame due to development with stormwater management (303 pounds), progress toward meeting the 15% reduction target is 57 pounds of phosphorus or ~3% of the 15% phosphorus reduction target.

Nitrogen pollutant loads (Table A-166) showed an overall decrease of 11,333 pounds from 1997 – 2035. The decrease is a result of decreased loads due to land use changes and implementation of Environmental Site Design. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 18,697 pounds of urban nitrogen. A 36% urban nitrogen reduction that may be required by the Chesapeake Bay TMDL would require the reduction of 44,872 pounds of nitrogen. Restoration efforts through 2005 have resulted in a reduction of 3,548 pounds of nitrogen. Combined with the nitrogen reduction effects of land use change and implementation of stormwater management between 1997 and 2005 (reduction of 1,405 pounds of nitrogen) a total nitrogen load reduction of 4,953 pounds of nitrogen have been realized, or ~26% of the target for a 15% urban nitrogen reduction. Continued implementation of restoration projects combined with land use changes and implementation of ESD will result in meeting the 15 urban nitrogen reduction target by 2020, but not the 36% reduction target.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the population would be served by public water and sewer.

Table A-167 shows the results of the analysis for land use change. In this scenario, there would be fewer acres of new urban land development (425 acres versus 1,103 acres) compared to Scenario 1 and fewer acres of agricultural land (220 acres versus 1,108 acres) would be lost between 2005 and 2035. A greater amount of forest (145 acres versus a gain of 62 acres) would be lost under Scenario 2 compared to Scenario 1. This Scenario would help in protecting the high quality natural resources that occur mainly in the rural areas, and would help in preserving agricultural land uses.

Tables A-168 and A-169 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 time frame, as those changes are based on development activities that have already occurred. Because the land use changes involves both conversion of forest and agriculture to urban land use, the phosphorus load will remain approximately the same with only a 26 pound decrease in the 2005 – 2020 time frame. Nitrogen under this scenario would also decrease slightly (1,845 pounds). Neither the phosphorus nor the nitrogen 15% or 36% urban load reductions would be met in the 2020 timeframe with this scenario.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-170 presents the number of acres needed to absorb the projected population increase in the Jones Falls watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 720 acres of land for potential redevelopment identified. This provides sufficient acreage to meet all the land acreage requirements of the redevelopment scenarios, with the exception of scenario 3c. The amount of redevelopment needed ranged from 0.7% to 7.4% of the urban land.

Table A-171 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most amount of phosphorus and nitrogen removal. Table A-172 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. None of the redevelopment scenarios would be able to meet the 15% urban phosphorus reduction by 2020, and only redevelopment scenario 3c would meet the 15% phosphorus reduction by 2035. Table A-173 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen would not be met by 2020 for any redevelopment scenario, but all would meet the 15% urban nitrogen reduction target by 2035. None of the redevelopment scenarios would meet the 36% urban nitrogen reduction target.

Scenario Comparisons

Tables A-174 and A-175 show the comparison of all scenarios considered in the Jones Falls watershed for phosphorus and nitrogen, respectively. None of the scenarios would meet a 15% phosphorus reduction by 2020, and only Scenario 3c would meet the 15% phosphorus reduction by 2035. Only Scenario 1 would meet would meet the 15% reduction target for urban nitrogen by 2020. All scenarios would meet the 15% reduction target for urban nitrogen by 2035. None of the scenarios are projected to meet the 36% urban nitrogen reduction target by 2020 or by 2035.

Cost of Meeting Nutrient TMDLs by 2020

In order to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, the information in Tables A-174 and A-175 was used. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used from Table A-174 for phosphorus and A-175 for nitrogen. Based the capital program expenditures in the 1997 – 2005 time frame and the pounds of phosphorus and nitrogen removed through capital project implementation; a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are displayed in Table A-176 for phosphorus and A-177 for nitrogen. For the Jones Falls watershed, all scenarios would require additional capital expenditures to meet a 15% urban phosphorus reduction by 2020. The additional capital expenditure ranges from $507,000 (3c) to $856,000 (3b) per year. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $2.7 to $3.2 million. To meet the 15% urban nitrogen reduction target by 2020 would require no additional capital funding for scenario 1. The balance of the scenarios would require additional annual funding in the range of $65,000 to $455,000. To meet the 36% urban nitrogen reduction target all scenarios would need additional funding in the range of $2.2 million to $3.4 million per year.

Table A-163: Jones Falls Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	7,196	53,524	60,720	-	-	-
2005	7,094	58,836	65,930	-102	5,312	5,210
2020	7,579	62,859	70,438	485	4,023	4,508
2035	7,722	64,044	71,766	143	1,185	1,328

Table A-164: Scenario 1 - Land Use Changes (Acres) – Jones Falls Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Impervious Urban	656	2,956	3,612	826	3,081	3,907	865	3,176	4,041	877	3,204	4,081
Pervious Urban HD	872	4,707	5,579	1,510	5,438	6,948	2,097	5,991	8,088	2,270	6,154	8,424
Pervious Urban LD	2,378	2,560	4,938	1,994	2,091	4,084	1,927	1,735	3,662	1,907	1,631	3,538
Cropland	2,268	309	2,577	1,954	185	2,138	1,177	91	1,267	948	59	1,011
Pasture	771	147	918	519	71	590	592	13	1605	614	0	610
Livestock Feeding	0	0	0	0	0	0	0	0	0	0	0	0
Forest	5,081	3,084	8,165	5,224	2,961	8,185	5,369	2,869	8,237	5,411	2,835	8,247
Water	0	73	73	0	48	48	0	29	29	0	23	23
Bare Soil	0	70	70	0	32	32	0	3	3	0	0	0
Total	**12,027**	**13,906**	**25,933**	**12,027**	**13,906**	**25,933**	**12,027**	**13,906**	**25,933**	**12,027**	**13,906**	**25,933**
Total Urban	3,907	10,223	14,130	4,330	10,610	14,940	4,889	10,903	15,792	5,054	10,989	16,043
Total Agriculture	3,039	456	3,495	2,473	256	2,728	1,769	104	1,873	1,561	59	1,621
Total Forest	5,081	3,084	8,165	5,224	2,961	8,185	5,369	2,869	8,237	5,411	2,835	8,247
% Urban	32.5%	73.5%	54.5%	36.0%	76.3%	57.6%	**40.7%**	**78.4%**	**60.9%**	**42.0%**	**79.0%**	**61.9%**
% Agriculture	25.3%	3.3%	13.5%	20.6%	1.8%	10.5%	**14.7%**	**0.7%**	**7.2%**	**13.0%**	**0.4%**	**6.2%**
% Forest	42.2%	22.2%	31.5%	43.4%	21.3%	31.6%	**44.6%**	**20.6%**	**31.8%**	**45.0%**	**20.4%**	**31.8%**
Change in Urban from previous time period				**423**	**387**	**810**	**559**	**293**	**852**	**165**	**86**	**251**
Change in Agriculture from previous time period				**-566**	**-200**	**-767**	**-704**	**-152**	**-856**	**-208**	**-45**	**-252**
Change in Forest from previous time period				**143**	**-122**	**21**	**145**	**-93**	**52**	**43**	**-33**	**10**

Table A-165: Scenario 1 - Phosphorus Load Changes (Pounds) – Jones Falls Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	2,875	9,803	12,677	3,368	10,200	13,568	3,682	10,501	14,183	3,774	10,589	14,364
Agriculture	2,196	330	2,526	1,786	185	1,970	1,279	75	1,354	1,130	43	1,173
Forest	102	62	163	104	59	164	107	57	165	108	57	165
Water	0	42	42	0	27	27	0	16	16	0	13	13
Bare Soil	0	51	51	0	23	23	0	2	2	0	0	0
Total	**5,172**	**10,287**	**15,459**	**5,258**	**10,494**	**15,753**	**5,069**	**10,651**	**15,720**	**5,013**	**10,702**	**15,715**
Change in Urban from previous time period				494	397	891	314	301	614	92	89	181
Change in Agriculture from previous time period				-410	-145	-555	-506	-110	+616	-149	-32	-182
Changes in Forest from previous time period				3	-2	0	3	-2	1	1	-1	0
Total Change from previous Time period				**87**	**207**	**294**	**-190**	**157**	**-33**	**-56**	**50**	**-5**
Urban BMPs	-44	-250	-294	-23	-262	-285	-211	-443	-654	-266	-496	-762
CIP Restoration	0	0	0	0	-208	-208	0	-654	-654	0	-1,100	-1,100
Reforestation	0	0	0	-3	-3	-6	-7	-7	-14	-11	-11	-22
Other Reductions	0	0	0	0	-146	-146	0	-219	-219	0	-219	-219
Total Reductions	**-44**	**-250**	**-294**	**-26**	**-619**	**-645**	**-218**	**-1,323**	**-1,541**	**-278**	**-1,827**	**-2,104**
Total with Urban BMPs	5,128	10,037	15,165	5,236	10,232	15,468	4,858	10,209	15,066	4,747	10,206	14,952
Total With Urban BMPs and Restoration	5,128	10,037	15,165	5,233	9,875	15,108	4,851	9,328	14,179	4,735	8,875	13,610

Table A-166: Scenario 1 - Nitrogen Load Changes (Pounds) – Jones Falls Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	32,795	94,342	127,137	37,027	98,006	135,033	41,353	100,780	142,134	42,629	101,598	144,226
Agriculture	43,203	6,192	49,395	36,149	3,577	39,726	23,828	1,597	25,425	20,195	980	21,175
Forest	7,164	4,348	11,512	7,366	4,175	11,541	7,570	4,045	11,615	7,630	3,998	11,628
Other	0	1,252	1,252	0	715	715	0	308	308	0	232	232
Septic	25,751	12,436	38,187	27,428	12,597	40,025	29,271	12,013	41,285	29,814	11,430	41,244
Total	**108,912**	**118,571**	**227,483**	**107,970**	**119,070**	**227,040**	**102,022**	**118,743**	**202,766**	**100,268**	**118,237**	**218,505**
Change in Urban from previous time period				4,232	3,664	7,896	4,326	2,774	7,101	1,276	817	2,093
Changes in Septic from previous time period				1,677	160	1,838	1,843	-583	1,260	543	-583	-40
Change In Agriculture from previous time period				-7,054	-2,615	-9,668	-12,321	1,980	-14,301	-3,633	-617	-4,250
Changes in Forest from previous time period				185	-156	29	204	-131	73	60	-47	13
Total Change from previous Time period				**-942**	**499**	**-443**	**-5,948**	**-327**	**-6,275**	**-1,754**	**-506**	**-2,260**
Urban BMPs	-459	-2,032	-2,491	-320	-3,134	-3,454	-2,483	-4,521	-7,005	-3,121	-4,930	-8,051
CIP Restoration	0	0	0	0	-2,978	-2,978	0	-9,359	-9,359	0	-15,739	-15,739
Reforestation	0	0	0	-40	-40	-80	-100	-100	-200	-160	-160	-320
Other Reductions	0	0	0	0	-490	-490	0	-994	-994	0	-994	-994
Total Reductions	**-459**	**-2,032**	**-2,491**	**-360**	**-6,642**	**-7,002**	**-2,583**	**-14,974**	**-17,557**	**-3,281**	**-21,823**	**-25,104**
Total with Urban BMPs	108,453	116,539	224,991	107,650	115,936	223,586	99,539	114,222	213,761	97,147	113,307	210,454
Total With Urban BMPs and Restoration	108,453	116,539	224,991	107,610	112,428	220,038	99,439	103,770	203,209	96,987	96,414	193,401

Table A-167: Scenario 2 – Future Land Use Changes (Acres) – Jones Falls

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	826	3,081	3,907	826	3,187	4,013	826	3,218	4,044
Urban Pervious HD	1,510	5,438	6,948	1,510	6,058	7,568	1,510	6,241	7,751
Urban Pervious LD	1,994	2,091	4,084	1,994	1,693	3,686	1,994	1,575	3,569
Cropland	1,954	185	2,138	1,954	79	2,033	1,954	36	1,989
Pasture	519	71	590	519	6	526	519	0	519
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	5,224	2,961	8,185	5,224	2,857	8,081	5,224	2,828	8,040
Water	0	48	48	0	26	26	0	20	20
Bare Soil	0	32	32	0	0	0	0	0	0
Total	**12,027**	**13,906**	**25,933**	**12,027**	**13,906**	**25,933**	**12,027**	**13,918**	**25,933**
Total Urban	4,330	10,610	14,940	4,330	10,938	15,268	4,330	11,034	15,364
Total Agriculture	2,473	256	2,728	2,473	86	2,558	2,473	36	2,508
Total Forest	5,224	2,973	8,185	5,224	2,857	8,081	5,224	2,816	8,040
% Urban	36.0%	76.2%	57.6%	36.0%	78.4%	58.9%	36.0%	79.3%	59.2%
% Agriculture	20.6%	1.8%	10.5%	20.6%	0.6%	9.9%	20.6%	0.3%	9.7%
% Forest	43.4%	21.4%	31.6%	43.4%	20.5%	31.2%	43.4%	20.3%	31.0%
Change in Urban land use from previous period				0	328	328	0	97	97
Change in Agricultural land use from previous period				0	-170	-170	0	-50	-50
Change in Forest land use from previous period				0	-105	-105	0	-40	-40

Table A-168: Scenario 2 – Phosphorus Load Changes (Pounds) – Jones Falls

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	3,368	10,200	13,568	3,368	10,537	13,905	3,368	10,636	14,005
Agriculture	1,786	185	1,970	1,786	62	1,847	1,786	26	1,811
Forest	104	59	164	104	57	162	104	57	161
Water	0	27	27	0	15	15	0	11	11
Bare Soil	0	23	23	0	0	0	0	0	0
Total	**5,285**	**10,494**	**15,753**	**5,285**	**10,671**	**15,929**	**5,285**	**10,730**	**15,988**
Change in Urban from previous period				0	337	337	0	99	99
Change in Agricultural from previous period				0	-123	-123	0	-36	-36
Change in Forest from previous period				0	-2	-2	0	-1	-1
Total Change				**0**	**176**	**176**	**0**	**59**	**59**
Urban BMPs	-23	-262	-285	-23	-464	-487	-23	-524	-547
CIP Restoration	0	-208	-208	0	-654	-654	0	-1,100	-1,100
Reforestation	-3	-3	-6	-7	-7	-14	-11	-11	-194
Other Reductions	0	-146	-146	0	-219	-219	0	-219	-219
Total	**-26**	**-619**	**-645**	**-30**	**-1,345**	**-1,375**	**-34**	**-1,855**	**-1,889**
Total with Urban BMPs	5,236	10,232	15,468	5,236	10,206	15,442	5,236	10,205	15,441
Total with Urban BMPs and Restoration	5,233	9,875	15,108	5,229	9,326	14,555	5,225	8,875	14,099

Table A-169: Scenario 2 – Nitrogen Load Changes (Pounds) – Jones Falls

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	37,027	98,006	135,033	37,027	101,115	138,142	37,027	102,031	139,058
Agriculture	36,149	3,577	39,726	36,149	1,359	37,508	36,149	588	36,737
Forest	7,366	4,175	11,541	7,366	4,028	11,394	7,366	3,971	11,337
Other	0	715	715	0	265	265	0	202	202
Septic	27,428	12,597	40,025	27,428	12,013	39,441	27,428	11,430	38,858
Total	**27,428**	**12,597**	**40,025**	**107,970**	**118,780**	**226,750**	**107,970**	**118,221**	**226,192**
Change in Urban from previous period				0	3,109	3,109	0	916	916
Change in Septic from previous period				0	-583	-583	0	-583	-583
Change in Agricultural from previous period				0	-2,219	-2,219	0	-770	-770
Change in Forest from previous period				0	-148	-148	0	-57	-57
Total Change				**0**	**-290**	**-290**	**0**	**-558**	**-558**
Urban BMPs	-320	-3,134	-3,454	-320	-4,688	-5,009	-320	-5,146	-5,467
CIP Restoration	0	-2,978	-2,978	0	-9,359	-9,359	0	-15,739	-15,739
Reforestation	-40	-40	-80	-100	-100	-200	-160	-160	-320
Other Reductions	0	-490	-490	0	-994	-994	0	-994	-994
Total	**-360**	**-6,642**	**-7,002**	**-420**	**-15,141**	**-15,561**	**-480**	**-22,040**	**-22,520**
Total with Urban BMPs	107,650	115,936	223,586	107,650	114,091	221,741	107,650	113,075	220,725
Total with Urban BMPs and Restoration	107,610	112,428	220,038	107,550	103,639	211,189	107,490	96,182	203,672

Table A-170: Acres of Redevelopment Needed to Meet Jones Falls Watershed Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	527	155	**682**	720	37	6.4%
3b	54	16	**70**	720	650	0.7%
3c	609	179	**788**	720	-68	7.4%
3d	95	28	**123**	720	597	1.2%

Table A-171: Phosphorus and Nitrogen Removal from Redevelopment Through 2020

2005 Nitrogen Loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	527	5,380	1,345	155	1,585	396
Low – 3b	25%	54	552	138	16	163	41
High/Parks – 3c	59%	609	6,208	3,662	179	1,829	1,079
Low/Parks – 3d	59%	95	966	570	28	284	168
2005 Phosphorus Loading –1.22	**Reduction %**						
High	23%	527	643	148	155	190	44
Low	23%	54	66	15	16	19	4
High/Parks	55%	609	742	408	179	219	120
Low/Parks	55%	95	115	64	28	34	19

Table A-172: All Redevelopment Scenarios – Urban Phosphorus Loads (Pounds) Including Restoration Efforts

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	13,602	11,001	15,165	15,108	14,433	13,934
Low – 3b	13,602	11,001	15,165	15,108	14,565	14,106
High/Parks – 3c	13,602	11,001	15,165	15,108	14,172	13,597
Low/Parks – 3d	13,602	11,001	15,165	15,108	14,517	14,044

Table A-173: All Redevelopment Scenarios – Urban Nitrogen Loads (Pounds) Including Restoration Efforts

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	208,786	182,611	224,991	220,038	211,689	204,792
Low – 3b	208,786	182,611	224,991	220,038	212,896	206,354
High/Parks – 3c	208,786	182,611	224,991	220,038	209,371	201,791
Low/Parks – 3d	208,786	182,611	224,991	220,038	212,464	205,795

Table A-174: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	13,602	11,001	15,165	15,108	14,179	577	3,178	13,610	8	2,609
Scenario 2 – All Development within URDL	13,602	11,001	15,165	15,108	14,555	953	3,098	14,099	497	3,098
Scenario 3a – All Redevelopment – High	13,602	11,001	15,165	15,108	14,433	831	3,432	13,934	332	2,933
Scenario 3b – All Redevelopment – Low	13,602	11,001	15,165	15,108	14,565	963	3,564	14,106	504	3,105
Scenario 3c – All Redevelopment – High/Parks	13,602	11,001	15,165	15,108	14,172	570	3,171	13,597	-5	2,596
Scenario 3d – All Redevelopment – Low/Parks	13,602	11,001	15,165	15,108	14,517	915	3,516	14,044	442	3,043

Table A-175: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020 Load	2020 Above 15 % Cap	2020 Above 36 % Cap	2035 Load	2035 Above 15 % Cap	2035 Above 36 % Cap
Scenario 1 – Development As Is	208,786	182,611	224,991	220,038	203,209	-5,577	20,598	193,401	-15,385	10,790
Scenario 2 – All Development within URDL	208,786	182,611	224,991	220,038	211,189	2,403	28,578	203,672	-5,114	21,061
Scenario 3a – All Redevelopment – High	208,786	182,611	224,991	220,038	211,689	2,903	29,078	204,792	-3,994	22,181
Scenario 3b – All Redevelopment – Low	208,786	182,611	224,991	220,038	212,896	4,110	30,285	206,354	-2,432	23,743
Scenario 3c – All Redevelopment – High/Parks	208,786	182,611	224,991	220,038	209,371	585	26,760	201,791	-6,995	19,180
Scenario 3d – All Redevelopment – Low/Parks	208,786	182,611	224,991	220,038	212,464	3,678	29,853	205,795	-2,991	23,184

Table A-176: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds TMDL 15 % Cap	Pounds TMDL 36 % Cap	Pounds 2020 Load	Pounds Above 15% Cap	Pounds Above 36% Cap	Costs (x 1,000) Total CIP Costs 15%	Costs (x 1,000) Total CIP Costs 36%	Costs (x 1,000) Annual CIP Costs 15%	Costs (x 1,000) Annual CIP Costs 36%
Scenario 1 – Development As Is	13,602	11,001	14,179	577	3,178	$5,129	$28,249	$513	$2,825
Scenario 2 – All Development within URDL	13,602	11,001	14,555	953	3,098	$8,471	$27,538	$847	$2,754
Scenario 3a – All Redevelopment – High	13,602	11,001	14,433	831	3,432	$7,387	$30,507	$739	$3,051
Scenario 3b – All Redevelopment – Low	13,602	11,001	14,565	963	3,564	$8,560	$31,680	$856	$3,168
Scenario 3c – All Redevelopment – High/Parks	13,602	11,001	14,172	570	3,171	$5,067	$28,187	$507	$2,819
Scenario 3d – All Redevelopment – Low/Parks	13,602	11,001	14,517	915	3,516	$8,133	$31,254	$813	$3,125

Table A-177: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	208,786	182,611	206,412	-5,577	20,598	-$0	$22,823	-$0	$2,282
Scenario 2 – All Development within URDL	208,786	182,611	211,189	2,403	28,578	$2,663	$31,664	$266	$3,166
Scenario 3a – All Redevelopment – High	208,786	182,611	211,689	2,903	29,078	$3,217	$32,218	$322	$3,222
Scenario 3b – All Redevelopment – Low	208,786	182,611	212,896	4,110	30,285	$4,554	$33,556	$455	$3,356
Scenario 3c – All Redevelopment – High/Parks	208,786	182,611	209,371	585	26,760	$648	$29,650	$65	$2,965
Scenario 3d – All Redevelopment – Low/Parks	208,786	182,611	212,464	3,678	29,853	$4,075	$33,077	$408	$3,308

A.2.13 Back River

The Back River watershed is extends from the south central to the eastern part of Baltimore County. A portion of the watershed lies within Baltimore City. The Back River watershed discharges to the tidal water segment BACOH. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-178. The data is displayed as population in the rural section of the watershed (outside the Urban-Rural Demarcation Line (URDL)) and urban section (inside the URDL).

The majority of the population in 2005 was located within the urban portion of the watershed (99.7%) and is projected to maintain approximately the same proportion. The urban section of the watershed comprises 90.2% of the land area in the watershed. The Back River watershed is projected to receive ~9.6% of the future population growth. The annual growth rate will decrease from ~600 per year in the 1997 – 2005 time period to ~300 and ~125 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Back River watershed contains 6.0% of the land in Baltimore County and 16.8% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-179. An additional 1,067 acres of urban land will be developed during the 2005 – 2035 time frame, at the expense of agricultural land and forest land. Forest land is projected to lose 869 acres and agriculture is projected to decrease by 128 acres. The overall percentage of urban land will increase from 74.0% in 2005 to 78.6% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-180 and A-181, respectively. These tables represent the results of Scenario 1 –

development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in an increase in phosphorus by 2,369 pounds by 2035 compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 2,345 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 5,629 pounds. Through 2005 restoration activities have achieved 1,843 pounds of reduction, or ~79% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 time frame due to development with stormwater management (1,467 pounds), progress toward meeting the 15% reduction target is reduced, with only 376 pounds of phosphorus reduced in the time period or only ~16% of the target.

Nitrogen pollutant loads (Table A-181) showed an increase of 10,629 pounds from 1997 – 2035, when only development with ESD is considered. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 22,359 pounds of urban nitrogen. A 36% urban nitrogen reduction that may be required by the Chesapeake Bay TMDL would require the reduction of 53,662 pounds of nitrogen. Through 2005 restoration activities have achieved 6,931 pounds of nitrogen reduction, or ~31% of the 15% reduction goal. Restoration efforts through 2005 have resulted in a reduction of 7,112 pounds of nitrogen. Because of the increase in the nitrogen loads in the 1997 – 2005 time frame due to development with stormwater management (6,336 pounds), progress toward meeting the 15% reduction target is reduced, with only 595 pounds of phosphorus reduced in the time period or only ~3% of the target.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the population would be served by public water and sewer.

Table A-182 shows the results of the analysis for land use change. In this scenario, there would only be slightly fewer acres of new urban land development (1,052 acres versus 1,067 acres) compared to Scenario 1. There is virtually no difference in the acres of agricultural land impacted and only slightly less impact on the acres of forest lost between 2005 and 2035. This is primarily due to the highly urban nature of the Back River watershed.

Tables A-183 and A-184 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 time frame, as those changes are based on development activities that have already occurred. Because the land use change involves mainly conversion for forest to urban land use, the phosphorus load will increase by 533 pounds in the 2005 – 2020 time frame, even with ESD. The cost to address this additional phosphorus load created through development would be ~$4.7 million.

Nitrogen under this scenario would also increase by 2,198 pounds, and would require $2.4 million to address the development load.

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-185 presents the number of acres needed to absorb the projected population increase in the Back River watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 3,014 acres of land for potential redevelopment identified. This provides sufficient acreage to meet all the land acreage requirements of the redevelopment scenarios. The amount of redevelopment needed ranged from 0.5% to 5.9% of the urban land.

Table A-186 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most amount of phosphorus and nitrogen removal. Table A-187 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. All of the redevelopment scenarios would be able to meet the 15% urban phosphorus reduction by 2020, and all would meet the 36% phosphorus reduction by 2035. Table A-188 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen would not be met by 2020 any of redevelopment scenarios, but all would meet the 15% nitrogen reduction by 2035. None of the redevelopment scenarios would meet the 36% urban nitrogen reduction by 2035.

Scenario Comparisons

Tables A-189 and A-190 show the comparison of all scenarios considered in the Back River watershed for phosphorus and nitrogen, respectively. All of the scenarios would meet a 15% phosphorus reduction by 2020, and all would meet the 36% phosphorus reduction by 2035. None of the scenarios would meet the 15% reduction target for urban nitrogen by 2020, however, they would all meet the 15% reduction by 2035. None of the scenarios would meet the 36% nitrogen reduction target by 2035.

Cost of Meeting Nutrient TMDLs by 2020

In order to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, the information in Tables A-189 and A-190 was used. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used from Table A-189 for phosphorus and A-190 for nitrogen. Based the capital program expenditures in the 1997 – 2005 time frame and the pounds of phosphorus and nitrogen removed through capital project implementation; a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. Results are displayed in Table A-191 for phosphorus and Table A-192 for nitrogen. For the Back River watershed, none of the scenarios would require additional capital expenditures to meet a 15% urban phosphorus reduction by 2020. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $1.2 to $2.0 million. To meet the 15% urban nitrogen reduction target by 2020 would require additional annual capital funding in the range of $208,000 (3c) to $873,000 (2). To meet the 36% urban nitrogen reduction target, the range in additional annual funding would be $3.6 million to $4.3 million.

Table A-178: Back River Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	351	127,660	128,011	-	-	-
2005	383	132,388	132,771	32	4,728	4,760
2020	397	137,058	137,455	14	4,670	4,684
2035	404	139,710	140,114	8	2,651	2,659

Final Draft

Table A-179: Scenario 1 - Land Use Changes (Acres) – Back River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	24	4,852	4,876	29	5,620	5,649	31	6,378	6,410	33	6,809	6,841
Pervious Urban HD	300	10,625	10,925	329	9,476	9,806	342	8,342	8.684	349	7,697	8,046
Pervious Urban LD	30	567	597	27	1,625	11,652	25	2,670	2,696	24	13,264	3,288
Cropland	325	308	633	317	122	440	314	0	314	312	0	312
Pasture	0	15	12	4	3	7	6	0	6	7	0	7
Livestock Feeding	0	0	0	0	0	0	0	0	0	0	0	0
Forest	1,572	4,116	5,688	1,558	3,929	5,487	1,555	3,449	5,004	1,548	3,070	4,618
Water	22	115	137	9	3	12	0	0	0	0	0	0
Bare Soil	0	241	241	0	60	60	0	0	0	0	0	0
Total	**2,274**	**20,839**	**23,113**	**2,274**	**20,839**	**23,113**	**2,274**	**20,839**	**23,113**	**2,274**	**20,839**	**23,113**
Total Urban	355	16,044	16,399	385	16,721	17,107	399	17,390	17,789	406	17,770	18,176
Total Agriculture	325	323	648	321	125	447	320	0	320	319	0	319
Total Forest	1,572	4,116	5,688	1,558	3,929	5,487	1,555	3,449	5,004	1,548	3,070	4,618
% Urban	15.6%	77.0%	71.0%	17.0%	80.2%	74.0%	**17.5%**	**83.4%**	**77.0%**	**17.9%**	**85.3%**	**78.6%**
% Agriculture	14.3%	1.6%	2.8%	14.1%	0.6%	1.9%	**14.1%**	**0.0%**	**1.4%**	**14.0%**	**0.0%**	**1.4%**
% Forest	69.1%	19.8%	24.6%	68.5%	18.9%	23.7%	**68.4%**	**16.6%**	**21.7%**	**68.1%**	**14.7%**	**20.0%**
Change in Urban from previous time period				**31**	**677**	**708**	**13**	**669**	**682**	**7**	**380**	**385**
Change In Agriculture from previous time period				**-4**	**-198**	**-201**	**-2**	**-125**	**-127**	**-1**	**0**	**-1**
Change in Forest from previous time period				**-14**	**-186**	**-201**	**-3**	**-480**	**-483**	**-7**	**-380**	**-386**

Table A-180: Scenario 1 - Phosphorus Load Changes (Pounds) – Back River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	197	15,788	15,984	220	17,479	17,699	229	19,150	19,379	235	20,099	20,333
Agriculture	224	223	447	222	86	308	221	0	221	220	0	220
Forest	21	82	114	31	79	110	31	69	100	31	61	92
Water	12	66	78	5	2	7	0	0	0	0	0	0
Bare Soil	0	159	159	0	40	40	0	0	0	0	0	0
Total	**465**	**16,317**	**16,782**	**477**	**17,686**	**18,163**	**481**	**19,219**	**19,700**	**485**	**20,160**	**20,645**
Change in Urban from previous time period				23	1,692	1,744	10	1,671	1,681	5	949	954
Change In Agriculture from previous time period				-3	-136	-139	-1	-86	-88	-1	0	-1
Changes in Forest From previous time period				0	-4	-7	0	-10	-10	0	-8	-8
Total Change from previous Time period				**12**	**1,369**	**1,381**	**3**	**1,533**	**1,537**	**5**	**941**	**946**
Urban BMPs	0	-349	-349	0	-262	-262	-6	-1,265	-1,271	-9	-1,834	-1,843
CIP Restoration	0	0	0	0	-1,480	-1,480	0	-4,652	-4,652	0	-7,823	-7,823
Reforestation	0	0	0	-2	-2	-4	-5	-5	-9	-7	-7	-15
Other Reductions	0	0	0	0	-359	-359	0	-364	-364	0	-364	-364
Total Reductions	**0**	**-349**	**-349**	**-2**	**-2,103**	**-2,105**	**-10**	**-6,285**	**-6,295**	**-16**	**-10,028**	**-10,045**
Total with Urban BMPs	465	15,968	16,434	477	17,423	17,901	475	17,954	18,429	476	18,326	18,803
Total With Urban BMPs and Restoration	465	15,968	16,434	476	15,583	16,058	470	12,934	13,404	469	10,132	10,601

Table A-181: Scenario 1 -Nitrogen Load Changes (Pounds) – Back River Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	2,736	149,554	152,290	2,995	159,710	162,705	3,105	169,742	172,846	3,167	175,437	178,604
Agriculture	4,402	4,258	8,659	4,320	1,672	5,993	4,286	0	4,286	4,266	0	4,226
Forest	2,028	5,310	7,337	2,010	5,069	7,079	2,006	4,450	6,456	1,998	3,960	5,957
Other	219	2,509	2,728	87	370	457	0	0	0	0	0	0
Septic	107	3,378	3,485	135	3,378	3,513	129	3,209	3,337	122	3,040	3,162
Total	**9,492**	**165,008**	**174,500**	**9,547**	**170,199**	**179,746**	**9,525**	**177,400**	**186,925**	**9,553**	**182,436**	**191,989**
Change in Urban from previous time period				259	10,156	10,415	110	10,032	10,142	63	5,695	5,757
Changes in Septic from previous time period				28	0	28	-7	-169	-176	-7	-169	-176
Change In Agriculture from previous time period				-81	-2,585	-2,667	-35	-1,672	-1,707	-20	0	-20
Changes in Forest From previous time period				-18	-241	-259	-4	-619	-623	-9	-490	-498
Total Change from previous Time period				**55**	**5,191**	**5,246**	**-22**	**7,201**	**7,179**	**28**	**5,036**	**5,064**
Urban BMPs	0	-3,229	-3,229	0	-2,140	-2,140	-55	-7,155	-7,210	-86	-10,003	-10,089
CIP Restoration	0	0	0	0	-5,945	-5,945	0	-18,686	-19,485	0	-31,426	-31,426
Reforestation	0	0	0	-26	-26	-52	-65	-130	-675	-104	-104	-208
Other Reductions	0	0	0	0	-934	-934	0	-965	-965	0	-965	-965
Total Reductions	**0**	**-3,229**	**-3,229**	**-26**	**-9,045**	**-9,071**	**-120**	**-26,871**	**-26,991**	**-190**	**-42,497**	**-42,687**
Total with Urban BMPs	9,492	161,778	171,271	9,547	168,059	177,607	9,470	170,245	179,715	9,467	172,434	181,900
Total With Urban BMPs and Restoration	9,492	161,778	171,271	9,521	161,154	170,675	9,405	150,529	159,935	9,363	139,939	149,302

Table A-182: Scenario 2 – Future Land Use Changes (Acres) – Back River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	29	5,620	5,649	29	6,380	6,410	29	6,812	6,841
Urban Pervious HD	329	9,476	9,806	329	8,338	8,668	329	7,692	8,022
Urban Pervious LD	27	1,625	1,652	27	2,673	2,700	27	3,269	3,295
Cropland	317	122	440	317	0	317	317	0	317
Pasture	4	3	7	4	0	4	4	0	4
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	1,558	3,929	5,487	1,558	3,447	5,005	1,558	3,067	4,624
Water	9	3	12	9	0	9	9	0	9
Bare Soil	0	60	60	0	0	0	0	0	0
Total	**2,274**	**20,839**	**23,113**	**2,274**	**20,839**	**23,113**	**2,274**	**20,839**	**23,113**
Total Urban	385	16,721	17,107	385	17,392	17,778	385	17,773	18,158
Total Agriculture	321	125	447	321	0	321	321	0	321
Total Forest	1,558	3,929	5,487	1,558	3,447	5,005	1,558	3,067	4,624
% Urban	17.0%	80.2%	74.0%	17.0%	83.5%	76.9%	17.0%	85.3%	78.6%
% Agriculture	14.1%	0.6%	1.9%	14.1%	0.0%	1.4%	14.1%	0.0%	1.4%
% Forest	68.5%	18.9%	23.7%	68.5%	16.5%	21.7%	68.5%	14.7%	20.0%
Change in Urban land use from previous period				**0**	**671**	**671**	**0**	**381**	**381**
Change in Agricultural land use from previous period				**0**	**-125**	**-125**	**0**	**0**	**0**
Change in Forest land use from previous period				**0**	**-482**	**-482**	**0**	**-381**	**-381**

Table A-183: Scenario 2 – Phosphorus Load Changes (Pounds) – Back River

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	220	17,479	17,699	220	19,155	19,375	220	20,106	20,326
Agriculture	222	86	308	222	0	222	222	0	222
Forest	31	79	110	31	69	100	31	61	92
Water	5	2	7	5	0	5	5	0	5
Bare Soil	0	40	40	0	0	0	0	0	0
Total	**477**	**17,686**	**18,163**	**477**	**19,224**	**19,701**	**477**	**20,168**	**20,645**
Change in Urban from previous period				0	1,676	1,676	0	951	951
Change in Agricultural from previous period				0	-86	-86	0	0	0
Change in Forest from previous period				0	-10	-10	0	-8	-8
Total Change				**0**	**1,538**	**1,538**	**0**	**944**	**944**
Urban BMPs	0	-262	-262	0	-1,268	-1,268	0	-1,839	-1,839
CIP Restoration	0	-1,480	-1,480	0	-4,652	-4,652	0	-7,823	-7,823
Reforestation	-2	-2	-4	-5	-5	-9	-7	-7	-15
Other Reductions	0	-359	-359	0	-364	-364	0	-364	-364
Total	**-2**	**-2,103**	**-2,105**	**-5**	**-6,288**	**-6,293**	**-7**	**-10,033**	**-10,040**
Total with Urban BMPs	477	17,423	17,901	477	17,956	18,434	477	18,329	18,807
Total with Urban BMPs and Restoration	476	15,583	16,058	473	12,936	13,409	470	10,135	10,605

Table A-184: Scenario 2 – Nitrogen Load Changes (Pounds) – Back River

Land Use	2005 Rural	2005 Urban	2005 Total	2020 Rural	2020 Urban	2020 Total	2035 Rural	2035 Urban	2035 Total
Urban	2,995	159,710	162,705	2,995	169,772	172,767	2,995	175,484	178,479
Agriculture	4,320	1,672	5,993	4,320	0	4,320	4,320	0	4,320
Forest	2,010	5,069	7,079	2,010	4,447	6,457	2,010	3,956	5,966
Other	87	370	457	87	0	87	87	0	87
Septic	135	3,378	3,513	135	3,209	3,344	135	3,040	3,175
Total	**9,547**	**170,199**	**179,746**	**9,547**	**177,428**	**186,975**	**9,547**	**182,479**	**192,027**
Change in Urban from previous period				0	10,062	10,062	0	5,712	5,712
Change in Septic from previous period				0	-169	-169	0	-169	-169
Change in Agricultural from previous period				0	-1,672	-1,672	0	0	0
Change in Forest from previous period				0	-622	-622	0	-491	-491
Total Change				**0**	**7,229**	**7,229**	**0**	**5,052**	**5,052**
Urban BMPs	0	-2,140	-2,140	0	-7,170	-7,170	0	-10,026	-10,026
CIP Restoration	0	-5,945	-5,945	0	-18,686	-18,686	0	-31,426	-31,426
Reforestation	-26	-26	-52	-65	-65	-130	-104	-104	-208
Other Reductions	0	-934	-934	0	-965	-965	0	-965	-965
Total	**-26**	**-9,045**	**-9,071**	**-65**	**-26,886**	**-26,951**	**-104**	**-42,521**	**-42,625**
Total with Urban BMPs	9,547	168,059	177,607	9,547	170,257	179,805	9,547	172,453	182,001
Total with Urban BMPs and Restoration	9,521	161,154	170,675	9,483	150,542	160,024	9,444	139,959	149,402

Table A-185: Acres of Redevelopment Needed to Meet Back River Watershed Projected Population Growth

Scenario	Acres Needed 2020	Acres Needed 2035	Acres Needed Total	Acres Available	Difference Total	% Redevelopment
3a	548	311	**859**	3,014	2,155	5.1%
3b	56	32	**88**	3,014	2,926	0.5%
3c	632	359	**991**	3,014	2,023	5.9%
3d	98	56	**154**	3,014	2,860	0.9%

Table A-186: Phosphorus and Nitrogen Removal from Redevelopment Through 2020

2005 nitrogen loading – 10.2	Reduction %	2020 Acres	2020 Load	2020 Reduction	2035 Acres	2035 Load	2035 Reduction
High – 3a	25%	548	5,590	1,397	311	3,173	793
Low – 3b	25%	56	573	143	32	325	81
High/Parks – 3c	59%	632	6,450	3,805	359	3,661	2,160
Low/Parks – 3d	59%	98	1,003	592	56	570	336
2005 phosphorus loading –1.22	**Reduction %**						
High	23%	548	669	154	311	380	87
Low	23%	56	69	16	32	39	9
High/Parks	55%	632	771	424	359	438	241
Low/Parks	55%	98	120	66	56	68	37

Table A-187: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	14,437	11,153	16,434	16,058	**12,722**	***9,458***
Low – 3b	14,437	11,153	16,434	16,058	**12,860**	***9,674***
High/Parks – 3c	14,437	11,153	16,434	16,058	**12,452**	***9,034***
Low/Parks – 3d	14,437	11,153	16,434	16,058	**12,810**	***9,595***

Table A-188: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts (Pounds)

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	152,141	120,838	171,271	170,675	156,429	**142,817**
Low – 3b	152,141	120,838	171,271	170,675	157,683	**144,783**
High/Parks – 3c	152,141	120,838	171,271	170,675	154,021	**139,042**
Low/Parks – 3d	152,141	120,838	171,271	170,675	157,234	**144,080**

Table A-189: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	14,437	11,153	16,434	16,058	**13,404**	-1,033	2,251	***10,601***	-3,836	-552
Scenario 2 – All Development within URDL	14,437	11,153	16,434	16,058	**13,409**	-1,028	2,256	***10,605***	-3,832	-548
Scenario 3a – All Redevelopment – High	14,437	11,153	16,434	16,058	**12,722**	-1,715	1,569	***9,458***	-4,979	-1,695
Scenario 3b – All Redevelopment – Low	14,437	11,153	16,434	16,058	**12,860**	-1,577	1,707	***9,674***	-4,763	-1,479
Scenario 3c – All Redevelopment – High/Parks	14,437	11,153	16,434	16,058	**12,452**	-1,985	1,299	***9,034***	-5,403	-2,119
Scenario 3d – All Redevelopment – Low/Parks	14,437	11,153	16,434	16,058	**12,810**	-1,627	1,657	***9,595***	-4,842	-1,558

Table A-190: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	152,141	120,838	171,271	170,675	159,935	7,794	39,097	149,302	-2,839	28,464
Scenario 2 – All Development within URDL	152,141	120,838	171,271	170,675	160,024	7,883	39,186	149,402	-2,739	28,564
Scenario 3a – All Redevelopment – High	152,141	120,838	171,271	170,675	156,429	4,288	35,591	**142,817**	-9,324	21,979
Scenario 3b – All Redevelopment – Low	152,141	120,838	171,271	170,675	157,683	5,542	36,845	**144,783**	-7,358	23,945
Scenario 3c – All Redevelopment – High/Parks	152,141	120,838	171,271	170,675	154,021	1,880	33,183	**139,042**	-13,099	18,204
Scenario 3d – All Redevelopment – Low/Parks	152,141	120,838	171,271	170,675	157,234	5,093	36,396	**144,080**	-8,061	23,242

Table A-191: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	Pounds		Pounds			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	14,437	11,153	**13,404**	-1,033	2,251	$0	$20,009	$0	$2,001
Scenario 2 – All Development within URDL	14,437	11,153	**13,409**	-1,028	2,256	$0	$20,054	$0	$2,005
Scenario 3a – All Redevelopment – High	14,437	11,153	**12,722**	-1,715	1,569	$0	$13,947	$0	$1,395
Scenario 3b – All Redevelopment – Low	14,437	11,153	**12,860**	-1,577	1,707	$0	$15,174	$0	$1,517
Scenario 3c – All Redevelopment – High/Parks	14,437	11,153	**12,452**	-1,985	1,299	$0	$11,547	$0	$1,155
Scenario 3d – All Redevelopment – Low/Parks	14,437	11,153	**12,810**	-1,627	1,657	$0	$14,729	$0	$1,473

Table A-192: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	Pounds		Pounds (x 1,000)			Costs (x 1,000)			
	TMDL 15 % Cap	TMDL 36 % Cap	2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	152,141	120,838	159,935	7,794	39,097	$8,636	$864	$43,319	$4,332
Scenario 2 – All Development within URDL	152,141	120,838	160,024	7,883	39,186	$8,734	$873	$43,418	$4,342
Scenario 3a – All Redevelopment – High	152,141	120,838	156,429	4,288	35,591	$4,751	$475	$39,435	$3,943
Scenario 3b – All Redevelopment – Low	152,141	120,838	157,683	5,542	36,845	$6,141	$614	$40,824	$4,082
Scenario 3c – All Redevelopment – High/Parks	152,141	120,838	154,021	1,880	33,183	$2,083	$208	$36,767	$3,677
Scenario 3d – All Redevelopment – Low/Parks	152,141	120,838	157,234	5,093	36,396	$5,643	$564	$40,327	$4,033

A.2.14 Baltimore Harbor

The Baltimore Harbor watershed is located entirely in southeast part of Baltimore County. The Baltimore Harbor watershed discharges to the tidal water segment PATMH. Tables are displayed at the end of the discussion.

Population Change

The population for four time periods (1997, 2005, 2020, and 2035) and changes in the population relative to the previous time period are presented in Table A-193. The data is displayed as

population in the rural section of the watershed (outside the Urban-Rural Demarcation Line (URDL)) and urban section (inside the URDL).

Virtually 100% of the population in 2005 was located within the urban portion of the watershed with only 13 people outside the URDL. Only one additional person is projected to be added in the rural portion of the watershed. The urban section of the watershed comprises 90.8% of the land area in the watershed. The Baltimore Harbor watershed is projected to receive ~5.9% of the future population growth. The annual growth rate was negative in the 1997 – 2005 timeframe. The future growth rate is anticipated to be ~220 and ~80 per year in the 2005 – 2020 and 2020 – 2035 time periods, respectively. The Baltimore Harbor watershed contains 3.0% of the land in Baltimore County and 7.2% of the population.

Scenario 1 – Development As It Is Currently Occurring

The Scenario 1 land use changes that result from the projected population growth are presented in Table A-194. An additional 644 acres of urban land will be developed during the 2005 – 2035 time frame, at the expense of mainly forest and some agricultural land. Forest land is projected to lose 514 acres and agriculture is projected to decrease by 59 acres. The overall percentage of urban land will increase from 82.4% in 2005 to 87.0% in 2035.

The total phosphorus and total nitrogen pollutant loads for the four time periods are presented in Table A-195 and A-196, respectively. These tables represent the results of Scenario 1 – development as it is currently occurring. The combination of implementation of Environmental Site Design for new development and the land use changes resulting from urban development will result in an increase in phosphorus by 820 pounds by 2035 compared to the 1997 phosphorus load. A 15% reduction of the urban phosphorus load to meet existing nutrient TMDLs would require a reduction of 1,380 pounds, while a potential reduction target of 36% for urban phosphorus loads would require a reduction of 3,312 pounds. Through 2005 restoration activities have achieved 886 pounds of phosphorus reduction, or ~108% of the 15% reduction goal. Because of the increase in the phosphorus loads in the 1997 – 2005 time frame due to development with stormwater management (269 pounds), progress toward meeting the 15% reduction target is decreased to 617 pounds of phosphorus or ~75% of the target phosphorus reduction.

Nitrogen pollutant loads (Table A-196) showed an overall increase of 2,725 pounds from 1997 – 2035. A 15% urban nitrogen load reduction to meet existing nutrient TMDL load reductions requires the reduction of 12,987 pounds of urban nitrogen. A 36% urban nitrogen reduction that may be required by the Chesapeake Bay TMDL would require the reduction of 31,168 pounds of nitrogen. Through 2005 restoration activities have achieved 3,941 pounds of nitrogen reduction, or ~30% of the 15% reduction goal. Because of the increase in the nitrogen loads in the 1997 – 2005 time frame due to development with stormwater management (137 pounds), progress toward meeting the 15% reduction target is decreased to 3,804 pounds of phosphorus or ~29% of the target phosphorus reduction.

Scenario 2 – All Development Within the URDL

Scenario 2 would place all of the projected population growth within the URDL. This would result in no future land use changes in the rural areas, and no changes in the septic system loads, as all of the population would be served by public water and sewer. Since the project population growth in the Baltimore Harbor watershed is mainly inside the URDL, with only one person projected to be added outside the URDL, for this watershed Scenario 2 is practically the same as Scenario 1.

Table A-197 shows the results of the analysis for land use change. There would be one fewer acres of new urban land created versus the acres in Scenario 1. The same amount of agricultural land would be lost, and there would be one acre less loss of forest.

Tables A-198 and A-199 display the results of the analysis of phosphorus and nitrogen pollutant load changes, respectively. Only the changes between 2005 – 2020 and 2020 – 2035 are shown. This scenario will not result in any changes in the 1997 – 2005 time frame, as those changes are based on development activities that have already occurred. The results are virtually the same for Scenario 1 and Scenario 2

Scenario 3 - Redevelopment

Four redevelopment scenarios were considered (see main Technical Memo B for methods and countywide results). Each of the four-redevelopment scenarios absorbed all future growth through redevelopment projects of varying intensities, requiring differing acreages. In addition, the pollutant removal efficiency differed between the four-redevelopment scenarios.

Table A-200 presents the number of acres needed to absorb the projected population increase in the Baltimore Harbor watershed, the acres potentially available for redevelopment, and the percentage of the urban land that would have to be redeveloped to absorb the future population. There are 1,191 acres of land for potential redevelopment identified. This provides sufficient acreage to meet all the land acreage requirements of the redevelopment scenarios. The amount of redevelopment needed ranged from 0.6% to 6.5% of the urban land.

Table A-201 presents the phosphorus and nitrogen projected to be removed through implementation of each redevelopment scenario. Scenario 3c would result in the most amount of phosphorus and nitrogen removal. Table A-202 shows the phosphorus removal and the effects of restoration activities in relation to the 15% and 36% TMDL caps for all redevelopment scenarios. All of the redevelopment scenarios would be able to meet the 15% urban phosphorus reduction by 2020, and all would meet the 36% phosphorus reduction by 2035. Table A-203 displays the same information for nitrogen. This table shows that the 15% reduction for nitrogen could be met by 2020 through implementation of redevelopment scenario 3c. None of the other redevelopment scenarios would meet the 15% urban nitrogen reduction by 2020, although all would meet this target by 2035. None of the redevelopment scenarios would meet the 36% urban nitrogen reduction target in either timeframe.

Scenario Comparisons

Tables A-204 and A-205 show the comparison of all scenarios considered in the Baltimore Harbor watershed for phosphorus and nitrogen, respectively. All of the scenarios would meet a 15% phosphorus reduction by 2020, and all would meet a 36% phosphorus reduction by 2035. Only redevelopment scenario 3c would meet the 15% reduction target for urban nitrogen by 2020, although all would meet the 15% reduction target by 2035. None of the scenarios would meet the 36% nitrogen reduction target by 2035.

Cost of Meeting Nutrient TMDLs by 2020

In order to assess the impacts of the various scenarios on future additional county restoration costs to meet a 15% and a 36% nutrient reduction target, the information in Tables A-204 and A-

205 was used. Specifically, the columns containing information on nutrient loads in 2020 and the progress made in meeting the 15% and 36% reduction targets were used from Table A-204 for phosphorus and A-205 for nitrogen. Based the capital program expenditures in the 1997 – 2005 time frame and the pounds of phosphorus and nitrogen removed through capital project implementation; a cost of $8,889 per pound of phosphorus removal, and $1,108 per pound of nitrogen removal was obtained. The results are presented in Table A-206 for phosphorus and in Table A-207 for nitrogen. For the Baltimore Harbor watershed, none of the scenarios would require additional capital expenditures to meet a 15% urban phosphorus reduction by 2020. To meet a 36% phosphorus reduction by 2020, the range in additional annual funding would be $704,000 to $1.3 million. To meet the 15% urban nitrogen reduction target by 2020 would require no additional capital funding for redevelopment scenario 3c. The balance of the scenarios would require additional annual funding in the range of $150,000 to $337,000. To meet the 36% urban nitrogen reduction target additional funding in the range of $1.8 million to $2.4 per year would be required.

Table A-193: Baltimore Harbor Population Change

Year	Population			Change from previous period		
	Rural	Urban	Total	Rural	Urban	Total
1997	15	57,475	57,490	-	-	-
2005	13	57,016	57,029	-2	-459	-461
2020	14	60,327	60,341	1	3,311	3,312
2035	14	61,506	61,520	0	1,179	1,179

Table A-194: Scenario 1 - Land Use Changes (Acres) – Baltimore Harbor Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 - Projected		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Impervious Urban	1	2,859	2,860	1	3,049	3,050	1	3,586	3,588	1	3,778	3,779
Pervious Urban HD	13	6,335	6,347	13	6,274	6,287	14	5,469	5,483	14	5,183	5,197
Pervious Urban LD	0	46	46	0	41	41	0	782	782	0	1,046	1,046
Cropland	283	67	350	285	59	343	285	0	285	285	0	285
Pasture	0	0	0	0	0	0	0	0	0	0	0	0
Livestock Feeding	0	0	0	0	0	0	0	0	0	0	0	0
Forest	741	791	1,532	742	850	1,592	742	505	1,247	742	337	1,078
Water	3	240	246	3	68	71	0	0	2	2	0	2
Bare Soil	0	5	5	0	3	3	0	0	0	0	0	0
Total	**1,044**	**10,343**	**11,387**	**1,044**	**10,343**	**11,387**	**1,044**	**10,343**	**11,387**	**1,044**	**10,343**	**11,387**
Total Urban	14	9,240	9,254	15	9,364	9,378	16	9,838	9,853	16	9,876	9,911
Total Agriculture	283	67	350	285	59	343	285	0	285	285	0	274
Total Forest	741	791	1,532	742	850	1,592	742	505	1,247	742	432	1,165
% Urban	1.3%	89.3%	81.3%	1.4%	90.5%	82.4%	**1.5%**	**95.1%**	**86.5%**	**1.5%**	**95.4%**	**87.0%**
% Agriculture	27.2%	0.7%	3.1%	27.3%	0.6%	3.0%	**27.3%**	**0.0%**	**2.5%**	**27.3%**	**0.0%**	**2.4%**
% Forest	71.2%	7.6%	13.5%	71.1%	8.2%	14.0%	**71.0%**	**4.9%**	**11.0%**	**71.0%**	**4.2%**	**10.2%**
Change in Urban from previous time period				**1**	**123**	**124**	**1**	**474**	**475**	**0**	**169**	**169**
Change In Agriculture from previous time period				**2**	**-9**	**-7**	**0**	**-59**	**-59**	**0**	**0**	**0**
Change in Forest from previous time period				**1**	**59**	**60**	**0**	**-344**	**-345**	**0**	**-169**	**-169**

Table A-195: Scenario 1 - Phosphorus Load Changes (Pounds) – Baltimore Harbor Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	8	9,212	9,219	9	9,611	9,620	9	10,796	10,805	9	11,218	11,227
Agriculture	195	46	242	196	41	237	196	0	196	196	0	196
Forest	15	16	31	15	17	32	15	10	25	15	7	22
Water	3	137	140	2	39	40	1	0	1	1	0	1
Bare Soil	0	3	3	0	2	2	0	0	0	0	0	0
Total	**221**	**9,414**	**9,635**	**222**	**9,710**	**9,931**	**222**	**10,806**	**11,028**	**222**	**11,224**	**11,447**
Change in Urban from previous time period				1	399	400	1	1,185	1,185	0	422	422
Change In Agriculture from previous time period				1	-6	-5	0	-41	-41	0	0	0
Changes in Forest From previous time period				-2	1	1	0	-7	-7	0	-3	-3
Total Change from previous Time period				**0**	**296**	**296**	**0**	**1,096**	**1,097**	**0**	**418**	**418**
Urban BMPs	0	-20	-20	0	-48	-48	0	-758	-759	0	-1,011	-1,012
CIP Restoration	0	0	0	0	-737	-737	0	-2,317	-2,317	0	-3,896	-3,896
Reforestation	0	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-5
Other Reductions	0	0	0	0	-148	-148	0	-148	-148	0	-148	-148
Total Reductions	**0**	**-20**	**-20**	**-1**	**-933**	**-934**	**-2**	**-3,225**	**-3,226**	**-3**	**-5,058**	**-5,061**
Total with Urban BMPs	221	9,393	9,615	222	9,662	9,884	222	10,048	10,269	222	10,213	10,435
Total With Urban BMPs and Restoration	221	9,393	9,615	221	8,776	8,997	220	7,582	7,802	219	6,166	6,385

Table A-196: Scenario 1 - Nitrogen Load Changes (Pounds) – Baltimore Harbor Watershed

Land Use	1997 - Actual			2005 - Actual			2020 - Projected			2035 – Projected		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Urban	106	86,577	86,683	115	88,768	88,882	123	95,880	96,003	123	98,413	98,535
Agriculture	3,834	911	4,745	3,855	795	4,650	3,853	0	3,853	3,853	0	3,853
Forest	957	1,020	1,977	957	1,096	2,053	957	652	1,609	957	434	1,391
Other	61	2,428	2,488	29	698	727	25	0	25	25	0	25
Septic	33	732	765	33	732	765	31	695	727	29	659	688
Total	**3,834**	**91,667**	**96,657**	**4,989**	**92,089**	**97,078**	**4,988**	**97,227**	**102,216**	**4,987**	**99,506**	**104,492**
Change in Urban from previous time period				9	2,191	2,199	8	7,112	7,120	0	2,533	2,533
Changes in Septic from previous time period				0	0	0	-2	-37	-38	-2	-37	-38
Change In Agriculture from previous time period				21	-116	-95	-2	-795	-797	0	0	0
Changes in Forest From pervious time period				1	76	77	-1	-444	-445	0	-218	-218
Total Change from previous Time period				**-1**	**421**	**421**	**-1**	**5,139**	**5,138**	**-2**	**2,278**	**2,277**
Urban BMPs	0	-105	-105	0	-389	-389	-4	-3,945	-3,949	-4	-5,212	-5,216
CIP Restoration	0	0	0	0	-3,542	-3,542	0	-11,134	-11,134	0	-18,725	-18,725
Reforestation	0	0	0	-9	-9	-18	-22	-22	-44	-35	-35	-70
Other Reductions	0	0	0	0	-381	-381	0	-381	-381	0	-381	-381
Total Reductions	**0**	**-105**	**-105**	**-9**	**-4,322**	**-4,330**	**-26**	**-15,482**	**-15,508**	**-39**	**-24,352**	**-24,391**
Total with Urban BMPs	4,990	91,562	96,552	4,989	91,700	96,689	4,984	93,282	98,266	4,983	94,294	99,277
Total With Urban BMPs and Restoration	4,990	91,562	96,552	4,980	87,767	92,748	4,963	81,746	86,708	4,948	75,153	80,101

Table A-197: Scenario 2 – Future Land Use Changes (Acres) – Baltimore Harbor

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban Impervious	1	3,049	3,050	1	3,586	3,588	1	3,778	3,779
Urban Pervious	13	6,274	6,287	13	5,469	5,482	13	5,182	5,196
Cropland	0	41	41	0	783	783	0	1,046	1,046
Pasture	285	59	343	285	0	285	285	0	285
Livestock Feeding	0	0	0	0	0	0	0	0	0
Forest	0	0	0	0	0	0	0	0	0
Water	742	850	1,592	742	505	1,247	742	336	1,079
Bare Soil	3	68	71	3	0	3	3	0	3
Total	**1,044**	**10,343**	**11,387**	**1,044**	**10,343**	**11,387**	**1,044**	**10,343**	**11,387**
Total Urban	15	9,364	9,378	15	9,838	9,852	15	10,007	10,021
Total Agriculture	285	59	343	285	0	285	285	0	285
Total Forest	742	850	1,592	742	505	1,247	742	336	1,079
% Urban	1.4%	90.5%	82.4%	1.4%	95.1%	86.5%	1.4%	96.7%	88.0%
% Agriculture	27.3%	0.6%	3.0%	27.3%	0.0%	2.5%	27.3%	0.0%	2.5%
% Forest	71.1%	8.2%	14.0%	71.1%	4.9%	11.0%	71.1%	3.3%	9.5%
Change in Urban land use from previous period				0	474	474	0	169	169
Change in Agricultural land use from previous period				0	-59	-59	0	0	0
Change in Forest land use from previous period				0	-344	-344	0	-169	-169

Table A-198: Scenario 2 – Phosphorus Load Changes (Pounds) – Baltimore Harbor

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	9	9,611	9,620	9	10,796	10,805	9	11,218	11,227
Agriculture	196	41	237	196	0	196	196	0	196
Forest	15	17	32	15	10	25	15	7	22
Water	2	39	40	2	0	2	2	0	2
Bare Soil	0	2	2	0	0	0	0	0	0
Total	**222**	**9,710**	**9,931**	**222**	**10,806**	**11,028**	**222**	**11,225**	**11,446**
Change in Urban from previous period				0	1,185	1,185	0	422	422
Change in Agricultural from previous period				0	-41	-41	0	0	0
Change in Forest from previous period				0	-7	-7	0	-3	-3
Total Change				**0**	**1,097**	**1,097**	**0**	**418**	**418**
Urban BMPs	0	-48	-48	0	-759	-759	0	-1,012	-1,012
CIP Restoration	0	-737	-737	0	-2,317	-2,317	0	-3,896	-3,896
Reforestation	-1	-1	-1	-2	-2	-2	-3	-3	-5
Other Reductions	0	-148	-148	0	-148	-148	0	-148	-148
Total	**-1**	**-933**	**-933**	**-2**	**-3,225**	**-3,226**	**-3**	**-5,058**	**-5,061**
Total with Urban BMPs	222	9,662	9,884	222	10,048	10,270	222	10,213	10,435
Total with Urban BMPs and Restoration	221	8,776	8,997	220	7,582	7,802	219	6,166	6,386

Table A-199: Scenario 2 – Nitrogen Load Changes (Pounds) – Baltimore Harbor

Land Use	2005			2020			2035		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Urban	115	88,768	88,882	115	95,882	95,997	115	98,415	98,530
Agriculture	3,855	795	4,650	3,855	0	3,855	3,855	0	3,855
Forest	957	1,096	2,053	957	652	1,609	957	434	1,391
Other	29	698	727	29	0	29	29	0	29
Septic	33	732	765	33	695	728	33	659	692
Total	**4,989**	**92,089**	**97,078**	**4,989**	**97,229**	**102,219**	**4,989**	**99,508**	**104,497**
Change in Urban from previous period				0	7,115	7,115	0	2,533	2,533
Change in Septic load from previous period				0	-37	-37	0	-37	-37
Change in Agricultural from previous period				0	-795	-795	0	0	0
Change in Forest from previous period				0	-444	-444	0	-218	-218
Total Change				**0**	**5,141**	**5,141**	**0**	**2,278**	**2,278**
Urban BMPs	0	-389	-389	0	-3,947	-3,947	0	-5,213	-5,213
CIP Restoration	0	-3,542	-3,542	0	-11,134	-11,134	0	-18,725	-18,725
Reforestation	-9	-9	-18	-22	-22	-44	-35	-35	-70
Other Reductions	0	-381	-381	0	-381	-381	0	-381	-381
Total	**-9**	**-4,322**	**-4,330**	**-22**	**-15,483**	**-15,505**	**-35**	**-19,141**	**-19,176**
Total with Urban BMPs	4,989	91,700	96,689	4,989	93,283	98,272	4,989	94,295	99,284
Total with Urban BMPs and Restoration	4,980	87,767	92,748	4,967	81,746	86,714	4,954	75,154	80,108

Table A-200: Acres of Redevelopment Needed to Meet Baltimore Harbor Watershed Projected Population Growth

Scenario	Acres Needed			Acres Available	Difference Total	% Redevelopment
	2020	2035	Total			
3a	388	138	**526**	1,191	666	5.6%
3b	40	14	**54**	1,191	1,137	0.6%
3c	447	159	**606**	1,191	585	6.5%
3d	70	25	**95**	1,191	1,097	1.0%

Table A-201: Phosphorus and Nitrogen Removal from Redevelopment Through 2020

2005 nitrogen loading – 10.2	Reduction %	2020			2035		
		Acres	Load	Reduction	Acres	Load	Reduction
High – 3a	25%	388	3,953	988	138	1,407	352
Low – 3b	25%	40	405	101	14	144	36
High/Parks – 3c	59%	447	4,561	2,691	159	1,623	958
Low/Parks – 3d	59%	70	709	419	25	253	149
2005 phosphorus loading –1.22	**Reduction %**						
High	23%	388	473	109	138	168	39
Low	23%	40	48	11	14	17	4
High/Parks	55%	447	545	300	159	194	107
Low/Parks	55%	70	85	47	25	30	17

Table A-202: All Redevelopment Scenarios – Urban Phosphorus Loads Including Restoration Efforts

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	8,255	6,324	9,615	8,997	**7,307**	***5,687***
Low – 3b	8,255	6,324	9,615	8,997	**7,405**	***5,819***
High/Parks – 3c	8,255	6,324	9,615	8,997	**7,116**	***5,428***
Low/Parks – 3d	8,255	6,324	9,615	8,997	**7,369**	***5,771***

Table A-203: All Redevelopment Scenarios – Urban Nitrogen Loads Including Restoration Efforts

	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020	2035
High – 3a	83,671	65,489	96,552	92,748	84,142	**76,173**
Low – 3b	83,671	65,489	96,552	92,748	85,029	**77,376**
High/Parks – 3c	83,671	65,489	96,552	92,748	**82,440**	**73,865**
Low/Parks – 3d	83,671	65,489	96,552	92,748	84,712	**76,946**

Table A-204: All Land Uses - Phosphorus Load Changes (Pounds) – Scenario Comparison

Scenarios	TMDL 15 % Cap	TMDL 36 % Cap	1997	2005	2020			2035		
					Load	Above 15% Cap	Above 36% Cap	Load	Above 15% Cap	Above 36% Cap
Scenario 1 – Development As Is	8,255	6,324	9,615	8,997	**7,802**	-453	1,478	**6,385**	-1,870	61
Scenario 2 – All Development within URDL	8,255	6,324	9,615	8,997	**7,802**	-453	1,478	**6,386**	-1,869	62
Scenario 3a – All Redevelopment – High	8,255	6,324	9,615	8,997	**7,307**	-948	983	***5,687***	-2,568	-637
Scenario 3b – All Redevelopment – Low	8,255	6,324	9,615	8,997	**7,405**	-850	1,081	***5,819***	-2,436	-505
Scenario 3c – All Redevelopment – High/Parks	8,255	6,324	9,615	8,997	**7,116**	-1,139	792	***5,428***	-2,827	-896
Scenario 3d – All Redevelopment – Low/Parks	8,255	6,324	9,615	8,997	**7,369**	-886	1,045	***5,771***	-2,484	-553

Table A-205: All Land Uses Nitrogen Load Changes (Pounds) – Scenario Comparison

Scenario	TMDL 15 % Cap	TMDL 36 % Cap	1997 Load	2005 Load	2020			2035		
					Load	Above 15 % Cap	Above 36 % Cap	Load	Above 15 % Cap	Above 36 % Cap
Scenario 1 – Development As Is	83,671	65,489	96,552	92,748	86,708	3,037	21,219	**80,101**	-3,570	14,612
Scenario 2 – All Development within URDL	83,671	65,489	96,552	92,748	86,714	3,043	21,225	**80,108**	-3,563	14,619
Scenario 3a – All Redevelopment – High	83,671	65,489	96,552	92,748	84,142	471	18,653	**76,173**	-7,498	10,684
Scenario 3b – All Redevelopment – Low	83,671	65,489	96,552	92,748	85,029	1,358	19,540	**77,376**	-6,295	11,887
Scenario 3c – All Redevelopment – High/Parks	83,671	65,489	96,552	92,748	**82,440**	-1,231	16,951	**73,865**	-9,806	8,376
Scenario 3d – All Redevelopment – Low/Parks	83,671	65,489	96,552	92,748	84,712	1,041	19,223	**76,946**	-6,725	11,457

Table A-206: Additional Capital Dollars Needed to Meet the 15% and 36% Phosphorus Reduction Targets by 2020

Cost/Pound $8,889	TMDL 15 % Cap	TMDL 36 % Cap	Pounds			Costs (x 1,000)			
			2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	8,255	6,324	**7,802**	-453	1,478	$0	$13,138	$0	$1,314
Scenario 2 – All Development within URDL	8,255	6,324	**7,802**	-453	1,478	$0	$13,138	$0	$1,314
Scenario 3a – All Redevelopment – High	8,255	6,324	**7,307**	-948	983	$0	$8,738	$0	$874
Scenario 3b – All Redevelopment – Low	8,255	6,324	**7,405**	-850	1,081	$0	$9,609	$0	$961
Scenario 3c – All Redevelopment – High/Parks	8,255	6,324	**7,116**	-1,139	792	$0	$7,040	$0	$704
Scenario 3d – All Redevelopment – Low/Parks	8,255	6,324	**7,369**	-886	1,045	$0	$9,289	$0	$929

Table A-207: Additional Capital Dollars Needed to Meet the 15% and 36% Nitrogen Reduction Targets by 2020

Cost/Pound $1,108	TMDL 15 % Cap	TMDL 36 % Cap	Pounds (x 1,000)			Costs (x 1,000)			
			2020 Load	Above 15% Cap	Above 36% Cap	Total CIP Costs 15%	Total CIP Costs 36%	Annual CIP Costs 15%	Annual CIP Costs 36%
Scenario 1 – Development As Is	83,671	65,489	86,708	3,037	21,219	$3,365	$23,511	$336	$2,351
Scenario 2 – All Development within URDL	83,671	65,489	86,714	3,043	21,225	$3,372	$23,517	$337	$2,352
Scenario 3a – All Redevelopment – High	83,671	65,489	84,142	471	18,653	$522	$20,668	$52	$2,067
Scenario 3b – All Redevelopment – Low	83,671	65,489	85,029	1,358	19,540	$1,505	$21,650	$150	$2,165
Scenario 3c – All Redevelopment – High/Parks	83,671	65,489	**82,440**	-1,231	16,951	$0	$18,782	$0	$1,878
Scenario 3d – All Redevelopment – Low/Parks	83,671	65,489	84,712	1,041	19,223	$1,153	$21,299	$115	$2,130

Baltimore County WRE Technical Memo - C
Impervious Cover Analysis

The Water Resources Element requires the analysis of impervious surface area changes that will result from future development. Technical Memo B addressed the pollutant loadings due to land use changes and included impervious surfaces as part of that analysis. However, only impervious surfaces associated with urban land use were used in the analysis. In order to incorporate impervious surfaces outside of urban land uses, this separate analysis was performed. Analysis of overall impervious surface changes is critical in assessing the potential impacts to higher quality waters such as, Tier II waters and waters with known trout populations. These high quality waters are discussed in Technical Memo A – Current Water Quality Conditions.

Impervious surfaces are those surfaces that prohibit rain or snow melt from soaking into the ground. They include such things as roads, parking lots, driveways, sidewalks, and roofs. In winter, frozen ground can act as an impervious surface and many urban soils are so compacted that they also can act as an impervious surface. Impervious surface cover is often expressed as a percent cover of a watershed, subwatershed or drainage area and may be called ***total impervious cover***. Additional terms that may be encountered are ***directly connected impervious cover*** and ***effective impervious cover***. These terms refer to impervious cover that drains directly to a storm drain system or water body. Impervious cover that would be excluded from directly connected impervious cover and effective impervious cover would be open section roads with roadside water conveyance through swales, rooftops drainage directed to flow over the ground or to rain barrels, etc.

There are a number of ways to estimate the amount of impervious surface within a watershed, including satellite imagery, land use and associated percentages, and direct measures of roadway, parking lot and building footprints. For this analysis, the direct measure of impervious surfaces was used, based on two time periods of aerial photography and development of planimetric data layers from the aerial photography. The impervious surfaces are expressed as Total Impervious Surface.

C.1 Impervious Surface Impacts on Aquatic Systems

The Center for Watershed Protection has developed an impervious surface model to predict stream quality based on the amount of impervious cover in a drainage area. Stream quality can be a measure of the habitat, the biological community, or the chemical/physical characteristics of the stream. This model is shown graphically in Figure C-1. The model would predict slight impact in drainage areas with less than 10% impervious cover (although trout, particularly brook trout are sensitive to impervious cover >3%). These watersheds would be sensitive in that an increase in impervious cover would result in degradation of stream quality. Watersheds that have an impervious cover between 10% and 25% are impacted and would show signs of degradation. The possibility exists to restore these streams to some semblance of a normally functioning stream. When the impervious cover exceeds 25% the streams are usually damaged with much of the stream either piped or channelized. Management of these streams may focus on the reduction of downstream impacts through pollutant load reduction, but the ability to return the stream to normal functions is remote. Once the impervious cover exceeds 60% in a watershed most of the natural stream system is gone. Again, restoration may focus on protecting downstream resources through pollutant load reduction. In both the damaged and severely damaged streams, an additional restoration goal will be to make the remaining stream system aesethically pleasing and an amenity to the community.

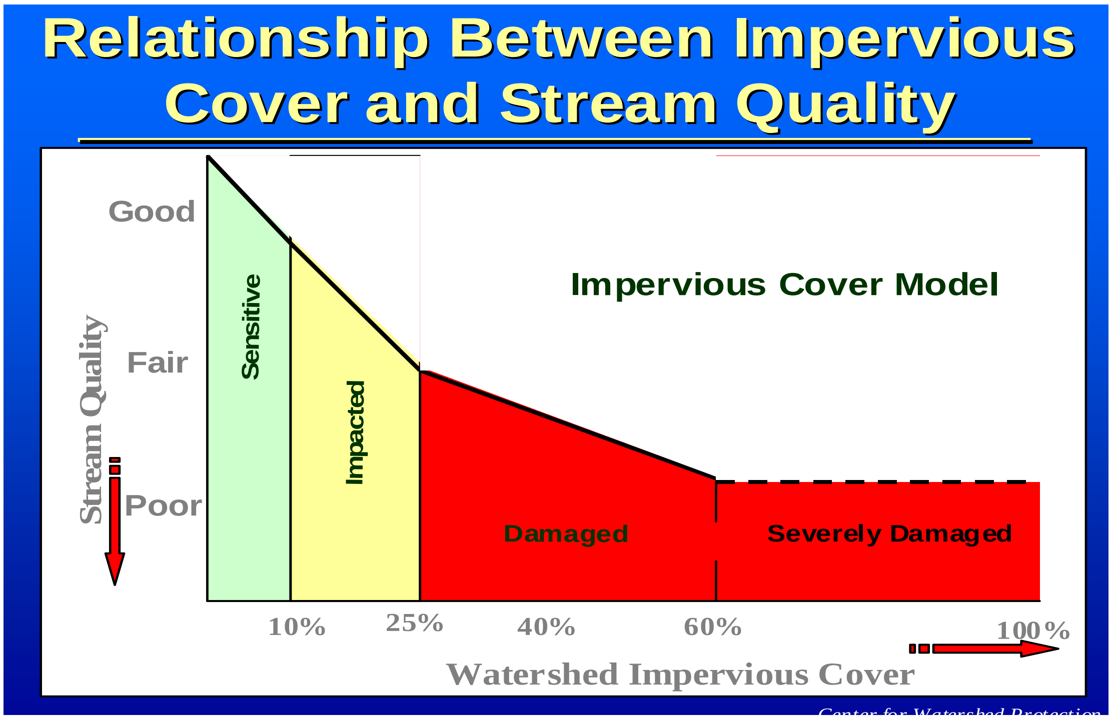

Figure C-1: Center for Watershed Protection Impervious Cover Model Showing the Relationship Between Impervious Cover and Stream Quality.

The following sections look at some of the impacts of impervious surfaces based on local data (Baltimore City and Baltimore County). Examples of habitat destruction, biological impacts and chemical relationships to impervious cover are presented.

C.1.1 Habitat Impacts

Rain that falls on impervious surfaces will not soak into the ground. This rainwater, in urban watersheds, is usually directed to a storm drain system that discharges the water directly into the stream. This results in a greater amount of water in the stream than in a watershed that contains forest cover. This water has a high amount of energy and results in stream erosion that can be seen in urban watersheds. The stream erosion can result in the degradation of stream habitat. The stream habitat are those areas where aquatic organisms live, including the stream bed, banks, leaf litter packs, woody debris and the terrestrial buffer area adjacent to the stream.

C1.2 Biological Impacts

Baltimore County and Baltimore City both conduct biological monitoring, as has been described earlier in the report. Using the data from the Baltimore County biological monitoring program, the relationship between biological condition and percent impervious cover was investigated. The biological condition of a stream is measured by a set of community variables called a Benthic Index of Biological Integrity (BIBI). Figure C-2 shows the relationship between the BIBI stream condition and the percent impervious cover based on the drainage area for each of the 192 biological monitoring sites. A significant negative correlation of r= -0.68 was found between the BIBI and the percent impervious cover.

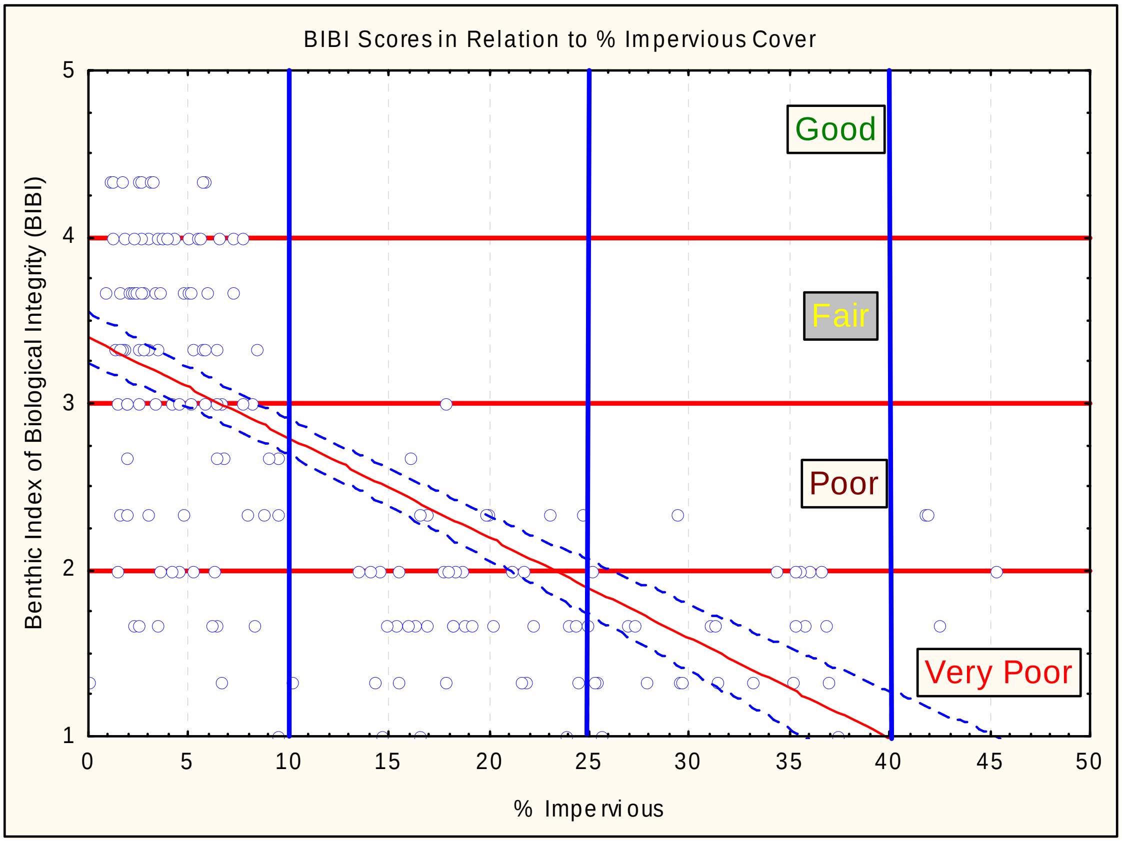

Figure C-2: Patapsco/Back River and Gunpowder River Basin/Deer Creek BIBI Scores and Percent Impervious Cover

Using the Center for Watershed Protection (CWP) impervious cover model, Figure C-2 shows divisions (vertical blue lines) at 10%, 25%, and 40% impervious cover; and the division in the biological condition (horizontal red lines). The CWP impervious cover model indicates that below 10% impervious cover the biological condition is usually good to fair. Between 10% and 25% impervious cover, the biological condition of streams deteriorates to a generally poor condition and above 25% impervious cover, the biology of the stream is severely impacted. As can be seen from Figure C-2, the biological data generally conforms to the predictions of the impervious cover model. There are however, a number of samples that have low impervious cover, but are in poor or very poor biological condition. In order to investigate why that might occur an additional analysis was conducted.

Using the drainage areas derived for each biological monitoring site, Maryland Department of Planning 2002 land use was overlain to determine the percent land use cover for each monitoring site. The land use was generalized to three uses, urban, agriculture, and forest. Figure C-3 shows the results of the application of a quadratic regression analysis to the data. This type of graph is called a ternary graph. It shows the relative proportion of the three generalized land uses on the three axes. The points on the graph represent the land use proportions of the individual monitoring sites.

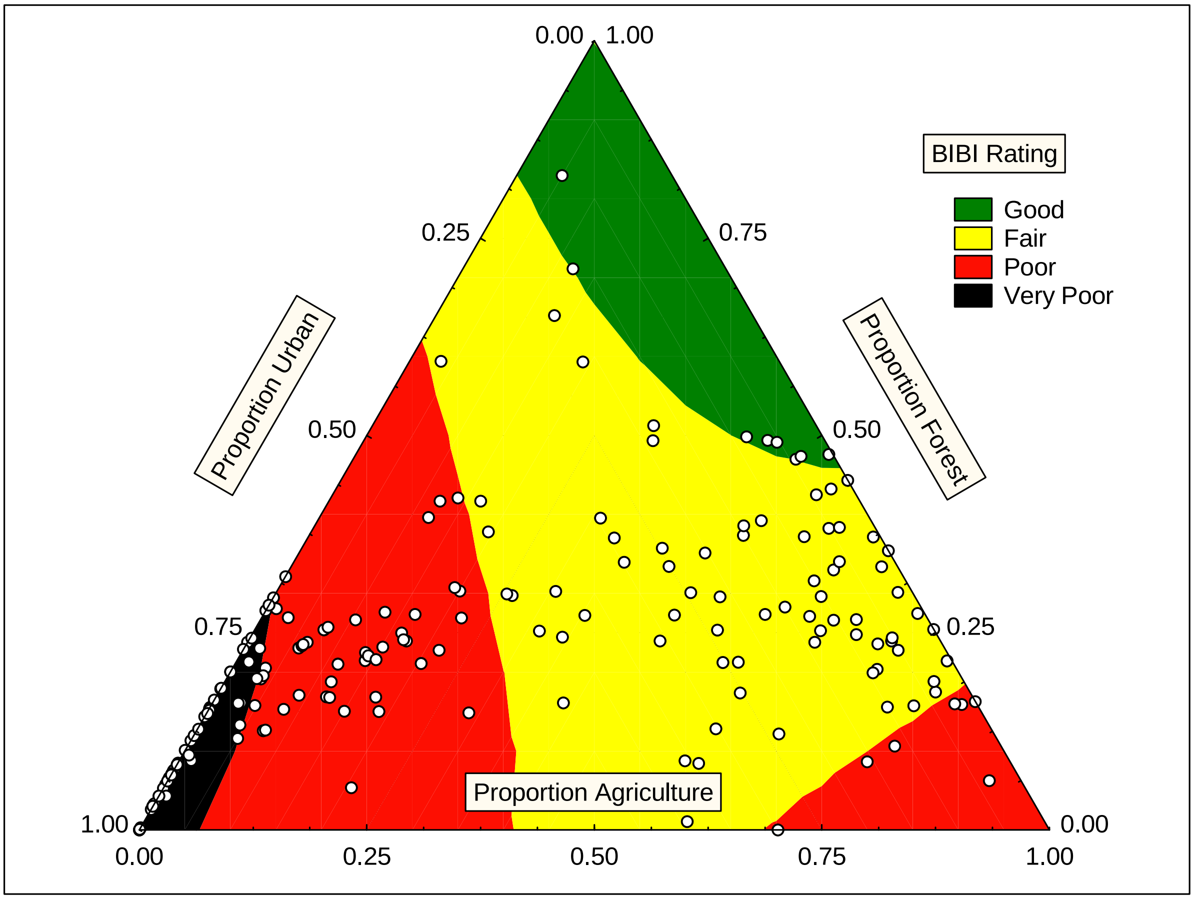

Figure C-3: Ternary Graph Showing the Relationship Between Generalized Land Use and BIBI Scores.

Based on this analysis, high percentages of forest cover will result in good BIBI ratings. Once the proportion of agriculture increases beyond ~55% (bottom axis), the BIBI rating will decrease to fair, and beyond ~80% the BIBI rating will be poor. Urbanization has the effect of reducing the BIBI faster (left axis), with only ~15% urban land use resulting in a reduction of the rating to fair. At ~40% urban land use, the BIBI will drop to poor and at ~70% urban land use the BIBI will be very poor. The bottom axis, which represents zero forest land use, shows an increasing BIBI as the proportion of agriculture land use increases and the urban land use decreases. At about 90% urban land use and 10% agriculture land use the BIBI increases from very poor to poor, and at ~43% urban land use and 57% agriculture land use the BIBI increases from poor to fair. The BIBI decreases again from fair to poor when the proportion of urban land is ~70% and agriculture land use is 30%. Part of this may be an artifact of the land use classification process, where rural subdivisions with forest cover or at least turf cover are classified as urban, but have less impervious cover and less resultant impacts on the stream systems.

From this analysis it can be seen that agricultural land use can account for poor and very poor biological scores, even when the percent impervious cover is low.

C.1.3 Chemical Impacts

The chemistry of a stream will change with increasing urbanization. Both Baltimore City and Baltimore County have stream chemistry monitoring programs. The results presented below are from the Baltimore County Baseflow Monitoring Program, the Baltimore City Reservoir Tributary Monitoring Program, and the Finished Drinking Water Monitoring Program.

As with the biological monitoring program, the drainage areas to the chemical sampling sites were determined and the percentage of impervious cover was calculated based on the foot print method. Data from both Patapsco/Back River Basin and the Gunpowder River Basin/Deer Creek was used in the analysis. A significant relationship was found between the percent impervious cover and four water quality parameters. Select relationships are displayed in Figure C-4, showing the Patapsco/Back River Basin separate from the Gunpowder River Basin.

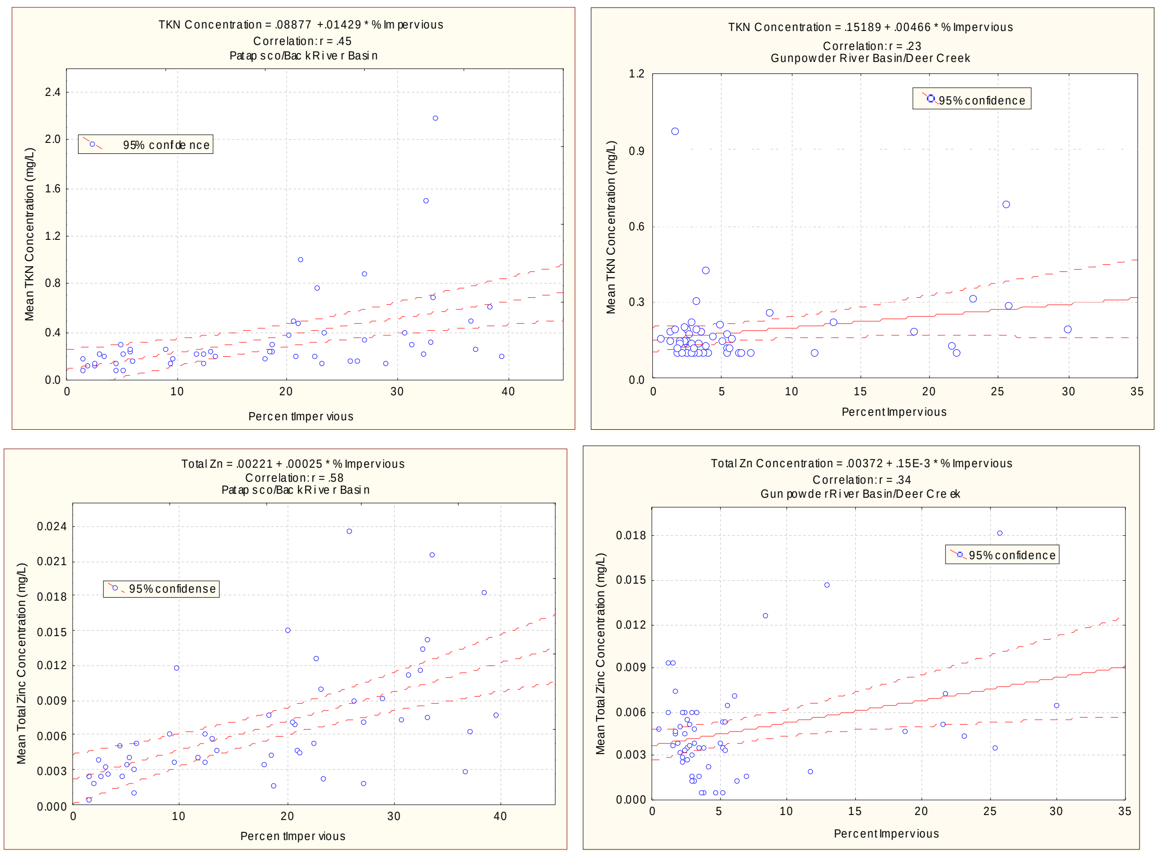

Figure C-4-: Significant Correlations Between Percent Impervious Cover and TKN, Total Zinc, Dissolved Zinc, and Chlorides

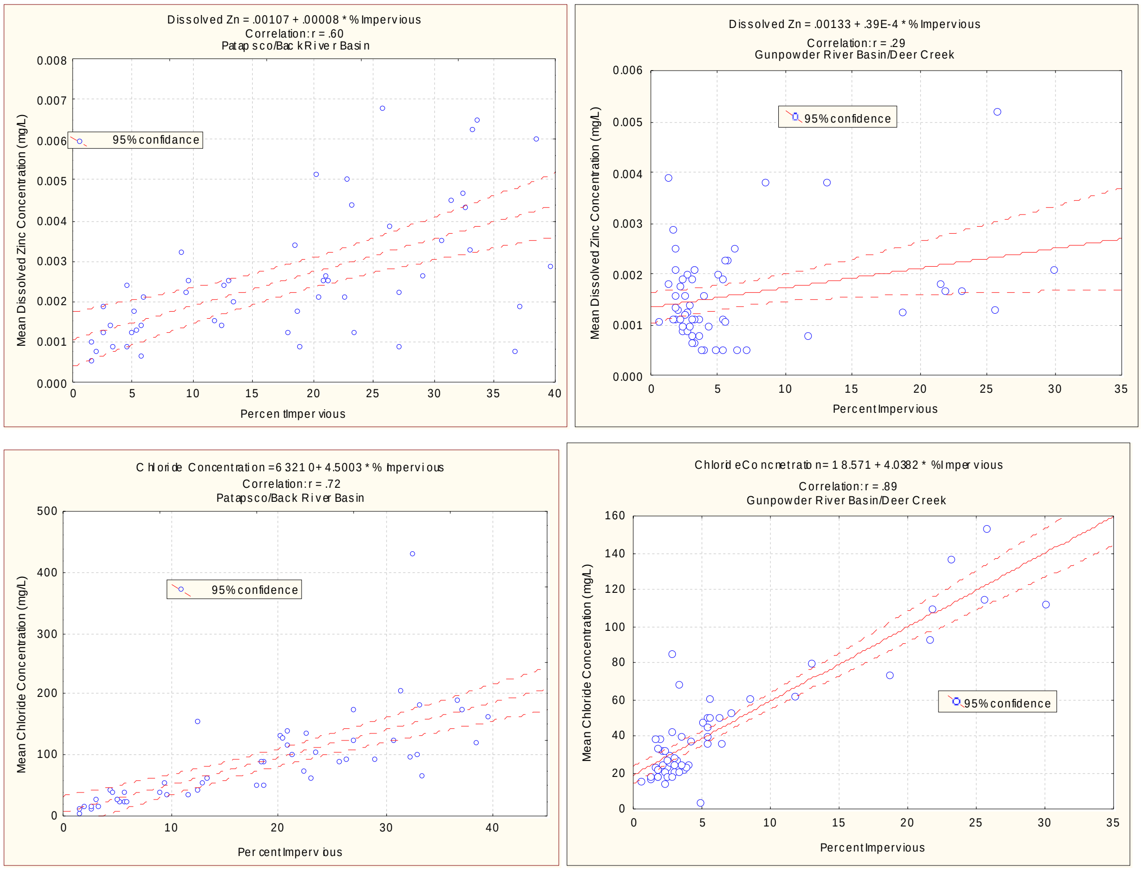

Figure C-4: Significant Correlations Between Percent Impervious Cover and TKN, Total Zinc, Dissolved Zinc, and Chlorides (continued)

As can be seen from Figure C-4, there is a great deal of scatter in the data points, particularly at higher percent impervious cover sites. The relationships are all positive (i.e. pollutant concentrations increase as impervious cover increases) with the exception of nitrate/nitrite nitrogen (not displayed).

C.2 Methods

Baltimore County has developed two GIS data layers for impervious surface coverage based on aerial photography from two different time periods. The initial data layer was based on orthophotography taken in the 1995-1997 timeframe, while the second data layer was based on orthophotography taken in 2005. These data layers do not include sidewalks, or driveways less than 200 feet in length.

Using the Water Quality Planning Areas (WQPAs) developed in Technical Memo B, the impervious surface for each of the 24 planning areas was determined by overlays for the 1997 and the 2005 timeframes. This would permit an analysis for changes in the rural areas of watersheds versus changes in the urban areas of watersheds. Typically, the rural areas contain the majority of Tier II waters (Red Run in Gwynns Falls is an exception) and the majority of known trout populations. These high resource areas are most at risk from impervious cover change.

In order to estimate future impervious cover based on predicted population growth, the change in impervious cover during the 1997 – 2005 timeframe was divided by the change in population during the same time period. The result was an impervious cover acreage/person added to the population. In cases where there was negative population growth, the average for the basin and the appropriate area (rural or urban) was substituted. Impervious cover changes, as a result of future population growth, could then be calculated (See Technical Memo B for details).

As detailed in Technical Memo B, the future population growth was determined for each WQPA and for two time periods, 2020 and 2035. This projected growth was multiplied by the acres of impervious/person to determine the increase in impervious cover for each WQPA. These results are Scenario 1- Development As Is. For Scenario 2 – All Development Within the URDL, the projected rural population growth was placed in the urban portion of the watershed inside the URDL. For watersheds that did not have an urban area (Deer Creek, Prettyboy Reservoir, and Little Gunpowder Falls) the population was placed in the nearest urban area. Both Deer Creek and Prettyboy Reservoir projected populations were placed in the Loch Raven urban area, and the Little Gunpowder Falls projected population growth was placed in the Lower Gunpowder Falls watershed urban area.

C.3 Results

The results are presented for two of the six scenarios developed in Technical Memo B, Scenario 1 – Development As Is, and Scenario 2 – All Development Directed Inside the URDL. The redevelopment Scenarios, 3a – 3d, were not presented as little change in impervious cover is anticipated through redevelopment.

C.3.1 Scenario 1 – Development As Is

The results from the initial impervious cover change analysis of the 1997 – 2005 timeframe are displayed in Tables C-1 and C-2 for the rural and urban areas, respectively. These tables present the total acreage of impervious cover in 1997 and 2005, the difference between the two time periods, an average annual change, the WQPA acreage, the annual impervious cover increase per 1,000 acres, and the acres of impervious cover per new individual added.

The annual impervious cover increase per 1,000 acres provides a means of standardizing the increase in impervious cover and eliminates the effect of WQPA acreage. The seven bolded numbers in the Acres per New Individual column indicate those numbers that had the overall basin average substituted due to negative population change in the 1997 – 2005 timeframe.

Table C-1: Impervious Area Increases by Water Quality Planning Area – Outside the URDL

Watershed	URDL	1997 Impervious	2005 Impervious	Difference	Average Annual Change	WQPA Acres	Annual Impervious Acres per 1,000 acres	Acres per New Individual
Deer Creek	Outside	167.2	193.4	26.2	3.3	7,173	0.46	0.504
Prettyboy	Outside	463.7	528.2	64.5	8.1	25,548	0.32	**0.140**
Loch Raven	Outside	3,440.8	4,044.6	603.8	75.5	126,747	0.60	0.145
Lower Gunpowder Falls	Outside	687.1	834.0	146.9	18.4	20,425	0.90	0.334
Little Gunpowder Falls	Outside	598.6	702.4	103.8	13.0	17,275	0.75	0.232
Bird River	Outside	90.1	118.9	28.8	3.6	2,827	1.27	1.800
Gunpowder River	Outside	122.8	134.5	11.7	1.5	3,627	0.40	**0.140**
Middle River	Outside	83.8	110.7	26.9	3.4	1,241	2.71	0.242
Liberty	Outside	478.6	595.5	116.9	14.6	16,960	0.86	0.262
Patapsco River	Outside	499.7	615.9	116.2	14.5	18,231	0.80	0.209
Gwynns Falls	Outside	83.4	97.8	14.4	1.8	1,861	0.97	0.209
Jones Falls	Outside	655.8	793.1	137.3	17.2	12,015	1.43	**0.514**
Back River	Outside	53.6	60.6	7.0	0.9	2,266	0.39	0.212
Baltimore Harbor	Outside	16.2	19.6	3.4	.4	1,041	0.41	**0.514**
	Totals	**7,441.4**	**8,849.2**	**1407.8**	**176.2**	**257,237**	**0.68**	**0.233**

Table C-2: Impervious Area Increases by Water Quality Planning Area – Inside the URDL

Watershed	URDL	1997 Impervious	2005 Impervious	Difference	Average Annual Change	WQPA Acres	Annual Impervious Acres per 1,000 acres	Acres per New Individual
Loch Raven	Inside	2,836.5	3,159.3	322.8	40.4	12,826	3.15	0.056
Lower Gunpowder Falls	Inside	1,404.2	1,640.4	236.2	29.5	9,044	3.26	0.054
Bird River	Inside	2,035.8	2,717.5	681.7	85.2	13,581	6.27	0.095
Gunpowder River	Inside	223.4	302.0	78.6	9.8	2,232	4.40	**0.094**
Middle River	Inside	1,216.4	1,331.5	115.1	14.4	5,225	2.75	**0.094**
Liberty	Inside	49.4	90.0	40.6	5.2	542	9.36	0.028
Patapsco River	Inside	3,625.4	3,958.3	332.9	41.3	15,349	2.71	0.033
Gwynns Falls	Inside	6,069.1	6,891.8	822.7	102.8	26,793	3.84	0.034
Jones Falls	Inside	2,857.8	3,097.2	239.4	29.9	13,918	2.15	0.045
Back River	Inside	5,202.3	5,785.8	583.5	72.9	20,846	3.50	0.123
Baltimore Harbor	Inside	2,956.8	3,105.2	148.4	18.6	10,346	1.79	**0.059**
	Totals	**28,477.1**	**32,079.0**	**3601.9**	**450.0**	**130,702**	**3.44**	**0.059**

A total of 5,010 acres of impervious cover was added during the 1997 – 2005 timeframe. Seventy-two percent of the increase in impervious cover acreage was inside the URDL. Based on the standardized (acres impervious/1,000 acres) impervious cover increase, the increase inside the URDL was over five times the rate outside the URDL (3.44 versus 0.68). The increase in impervious cover per individual was much lower inside the URDL versus outside (0.059 versus 0.223). Almost a quarter acre of impervious cover was added for every individual added to the population in the rural areas. This is about four times the amount of impervious cover added for every individual inside the URDL.

Using the last column in Tables C-1 and C-2 the future impervious cover for each WQPA was calculated based on the projected population growth for the 2020 and 2035 timeframes. The results of these calculations are presented in Tables C-3 and C-4. The tables present the total acres of impervious cover and the percent impervious cover. In addition, Figure C-5 shows the changes in the percent impervious cover for each watershed for the four time periods. The figure shows the percent impervious for each of the four time periods. The percent impervious is divided into five ranges:

- < 3 %
- 3 % - 5 %
- 5 % - 10 %
- 10 % - 25 %
- > 25 %

These ranges represent increasing stress on the aquatic community. Brook trout are especially sensitive to impervious cover and generally do not occur above 3%. Brown trout are generally limited to <10% impervious cover. Above 25% impervious cover will, in almost all cases, result in a poor to very poor aquatic biological community.

Table C-3: Impervious Area Increases by Water Quality Planning Area – Outside the URDL
Scenario 1 Results

	Acres	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Deer Creek	167	2.3%	193	2.7%	230	3.2%	245	3.4%
Prettyboy	464	1.8%	528	2.1%	592	2.3%	605	2.4%
Loch Raven	3,441	2.7%	4,045	3.2%	4,529	3.6%	4,665	3.7%
Lower Gunpowder Falls	687	3.4%	834	4.1%	974	4.8%	1,027	5.0%
Little Gunpowder Falls	599	3.5%	702	4.1%	821	4.8%	865	5.0%
Bird River	90	3.2%	119	4.2%	427	15.1%	504	17.8%
Gunpowder River	123	3.4%	135	3.7%	140	3.9%	142	3.9%
Middle River	84	6.8%	111	8.9%	137	11.0%	144	11.6%
Liberty	479	2.8%	596	3.5%	735	4.3%	789	4.7%
Patapsco River	500	2.7%	616	3.4%	674	3.7%	704	3.9%
Gwynns Falls	83	4.5%	98	5.3%	126	6.7%	132	7.1%
Jones Falls	656	5.5%	793	6.6%	1,042	8.7%	1,116	9.3%
Back River	54	2.4%	61	2.7%	64	2.8%	65	2.9%
Baltimore Harbor	16	1.6%	20	1.9%	20	1.9%	20	1.9%
Totals	**7,441**	**2.9%**	**8,849**	**3.4%**	**10,511**	**4.0%**	**11,023**	**4.2%**

Table C-4: Impervious Area Increases by Water Quality Planning Area – Inside the URDL
Scenario 1 Results

	Acres	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Loch Raven	2837	22.1%	3,159	24.6%	3,459	27.0%	3,543	27.6%
Lower Gunpowder Falls	1,404	15.5%	1,640	18.1%	1,770	19.6%	1,820	20.1%
Bird River	2,036	15.0%	2,718	20.0%	3,408	25.1%	3,583	26.4%
Gunpowder River	223	10.0%	302	13.5%	341	15.3%	356	15.9%
Middle River	1,216	23.3%	1,332	25.5%	1,513	29.0%	1,562	29.9%
Liberty	49	9.1%	90	16.6%	96	17.6%	98	18.1%
Patapsco River	3,625	23.6%	3,958	25.8%	4,123	26.9%	4,207	27.4%
Gwynns Falls	6,069	22.7%	6,892	25.7%	7,470	27.9%	7,598	28.4%
Jones Falls	2,858	20.5%	3,097	22.3%	3,278	23.6%	3,332	23.9%
Back River	5,202	25.0%	5,786	27.8%	6,362	30.5%	6,689	32.1%
Baltimore Harbor	2,957	28.6%	3,105	30.0%	3,301	31.9%	3,371	32.6%
Totals	**28,477**	**21.8%**	**32,079**	**24.5%**	**35,122**	**26.9%**	**36,090**	**27.6%**

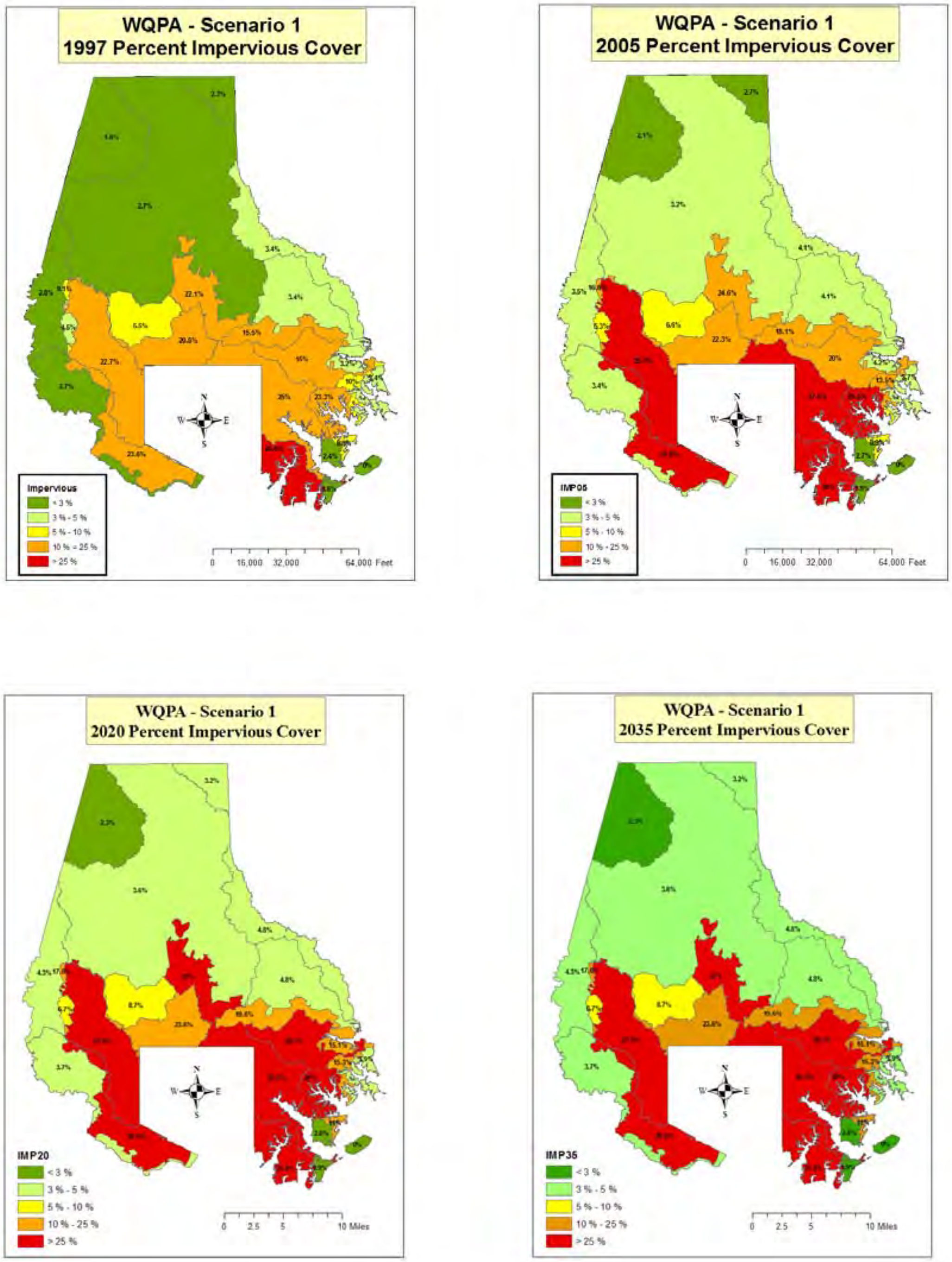

Figure C-5: Impervious Cover Changes - Scenario 1 – Development As Is

In Scenario 1, there will be an increase of ~ 2,200 acres of impervious cover in the rural WQPAs to accommodate the population growth anticipated to occur within these areas. While all of the rural WQPAs are below 10% in 2005, by 2035 two of the areas would be above that percentage. The urban WQPAs total increase in impervious cover would be greater than 4,000 acres (Table C-3 and C-4).

C.3.2 Scenario 2 – All Future Development Within the URDL

Scenario 2 – All Future Development Within the URDL will result in no change in the impervious cover in the rural portions of the watersheds (outside the URDL) after 2005. The urban portions on the other hand will experience an increase relative to the Scenario 1 due to the increased amount of development within the URDL needed to absorb the additional population. Table C-5 presents the results of the Scenario 2 analysis. Only the changes in the urban WQPAs are presented, as there will be no population driven change in the rural WQPAs.

Table C-5: Impervious Area Increases by Water Quality Planning Area – Inside the URDL – Scenario 2 Results

	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Loch Raven	2,837	22.1%	3,159	24.6%	3,676	28.7%	3,820	29.8%
Lower Gunpowder Falls	1,404	15.5%	1,640	18.1%	1,821	20.1%	1,889	20.9%
Bird River	2,036	15.0%	2,718	20.0%	3,425	25.2%	3,603	26.5%
Gunpowder River	223	10.0%	302	13.5%	345	15.4%	361	16.2%
Middle River	1,216	23.3%	1,332	25.5%	1,523	29.2%	1,575	30.1%
Liberty	49	9.1%	90	16.6%	111	20.4%	119	21.9%
Patapsco River	3,625	23.6%	3,958	25.8%	4,133	26.9%	4,221	27.5%
Gwynns Falls	6,069	22.7%	6,892	25.7%	7,474	27.9%	7,603	28.4%
Jones Falls	2,858	20.5%	3,097	22.3%	3,300	23.7%	3,360	24.1%
Back River	5,202	25.0%	5,786	27.8%	6,364	30.5%	6,692	32.1%
Baltimore Harbor	2,957	28.6%	3,105	30.0%	3,301	31.9%	3,371	32.6%
	28,477	**21.8%**	**32,079**	**24.5%**	**35,473**	**27.2%**	**36,614**	**28.0%**

While there would be no increase in the rural WQPAs, the urban WQPAs would add greater than 4,500 acres by 2035 to accommodate the anticipated population increase.

C.3.3 Scenario 1 versus Scenario 2 Comparison

In order to compare the acreage of impervious cover increase between Scenario 1 and Scenario 2, the increase in each of the WQPAs for the years 2020 and 2035 were determined for each period. The difference between Scenario 2 and Scenario 1 was calculated for each WQPA and the total impervious for each watershed, as well as the countywide difference. The results for 2020 are presented in Table C-6 and for 2035 in Table C-7.

Figure C-6 presents a comparison between the two scenarios based on the changes in percentage impervious cover. The figure presents percentage impervious by WQPA for 2020 and 2035.

Table C-6: Impervious Area Increases by Water Quality Planning Area
Scenario 1 versus Scenario 2 Comparison - 2020

Watershed	Scenario 1			Scenario 2			Difference (S2 – S1)		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Deer Creek	230	0	230	193	0	193	-37	0	-37
Prettyboy	592	0	592	528	0	528	-64	0	-64
Loch Raven	4,529	3,459	7,988	4,045	3,676	7,721	-484	218	-267
Lower Gunpowder Falls	974	1,770	2,744	834	1,821	2,655	-140	51	-89
Little Gunpowder Falls	821	0	821	702	0	702	-119	0	-119
Bird River	427	3,408	3,835	119	3,425	3,544	-308	16	-292
Gunpowder River	140	341	481	135	345	479	-5	4	-2
Middle River	137	1,513	1,650	111	1,523	1,634	-26	10	-16
Liberty	735	96	831	596	111	706	-139	15	-124
Patapsco River	674	4,123	4,797	616	4,133	4,749	-58	9	-49
Gwynns Falls	126	7,470	7,595	98	7,474	7,572	-28	5	-23
Jones Falls	1,042	3,278	4,321	793	3,300	4,093	-249	22	-227
Back River	64	6,362	6,426	61	6,363	6,424	-3	2	-1
Baltimore Harbor	20	3,301	3,321	20	3,301	3,321	-1	0	0
Total	**10,374**	**35,138**	**45,633**	**8,849**	**35,526**	**44,322**	**-1,662**	**351**	**-1,311**

Table C-7: Impervious Area Increases by Water Quality Planning Area
Scenario 1 versus Scenario 2 Comparison - 2035

Watershed	Scenario 1			Scenario 2			Difference (S2 – S1)		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Deer Creek	245	0	245	193	0	193	-51	0	-51
Prettyboy	605	0	605	528	0	528	-76	0	-76
Loch Raven	4,665	3,543	8,208	4,045	3,820	7,865	-621	277	-344
Lower Gunpowder Falls	1,027	1,820	2,847	834	1,889	2,723	-193	69	-124
Little Gunpowder Falls	865	0	865	702	0	702	-163	0	-163
Bird River	504	3,583	4,087	119	3,603	3,722	-385	20	-365
Gunpowder River	142	356	498	135	361	495	-8	5	-3
Middle River	144	1,562	1,706	111	1,575	1,685	-33	13	-20
Liberty	789	98	887	596	119	714	-193	21	-172
Patapsco River	704	4,207	4,911	616	4,221	4,837	-88	14	-74
Gwynns Falls	132	7,598	7,730	98	7,603	7,701	-34	6	-28
Jones Falls	1,116	3,332	4,448	793	3,360	4,153	-323	28	-294
Back River	65	6,689	6,755	61	6,692	6,753	-5	3	-2
Baltimore Harbor	20	3,371	3,391	20	3,371	3,390	-1	0	0
Total	**11,023**	**36,090**	**47,181**	**8,849**	**36,614**	**45,464**	**-2,174**	**456**	**-1,718**

By forcing the population growth inside the URDL, there would be ~1,660 acres less impervious cover in the rural areas in 2020, and ~2,275 acres less in 2035. Conversely, the urban WQPAs would have ~350 acres more impervious cover in 2020 and ~450 acres more in 2035. Overall, with the same population growth, Scenario 2 – All Future

Development Within the URDL, would result in ~1,300 acres less impervious countywide in 2020 and ~1,700 acres less impervious cover in 2035. Scenario 3 – Redevelopment Scenario, would result in little change in impervious cover, and therefore, would have ~4,500 impervious cover acres less than Scenario 2, and ~6,250 impervious cover acres less than Scenario 1.

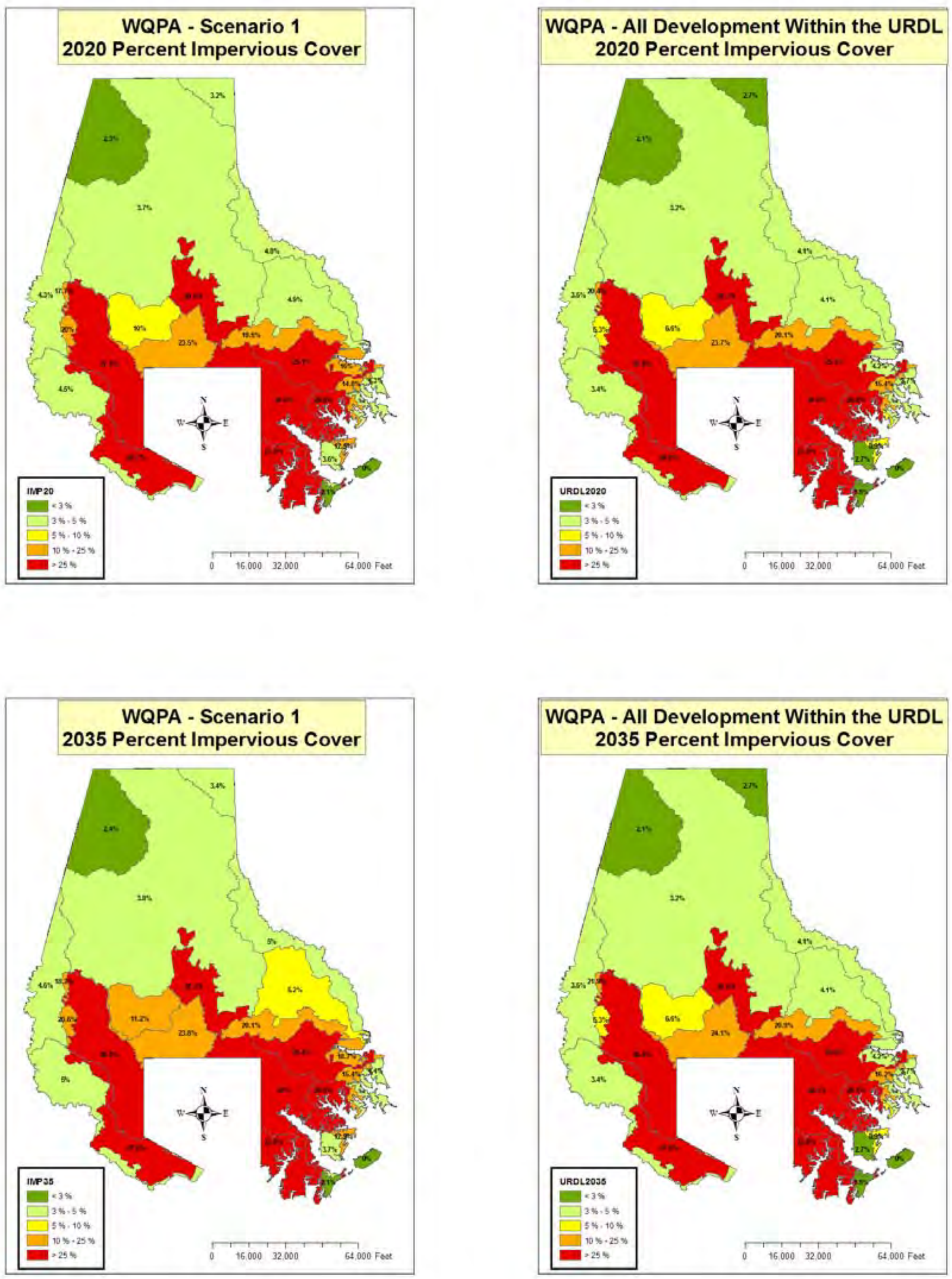

Figure C-6: Impervious Cover Changes – Comparison of Scenario 1 and Scenario 2

C.4 Discussion

In order to preserve our high quality waters, represented by our Tier II waters and the locations of trout resources (Technical Memo A, Section A.2), impervious surfaces should be limited in the rural areas outside the URDL. All of the Tier II waters, with exception of Red Run, are outside the URDL. With the exception of three sites (again Red Run is an exception) all of the locations that have been found to support trout resources are outside the URDL. Both Scenario 2 – All Future Development Inside the URDL, and all of the Scenario 3 – Redevelopment subcategories would limit impervious surface growth in the rural area.