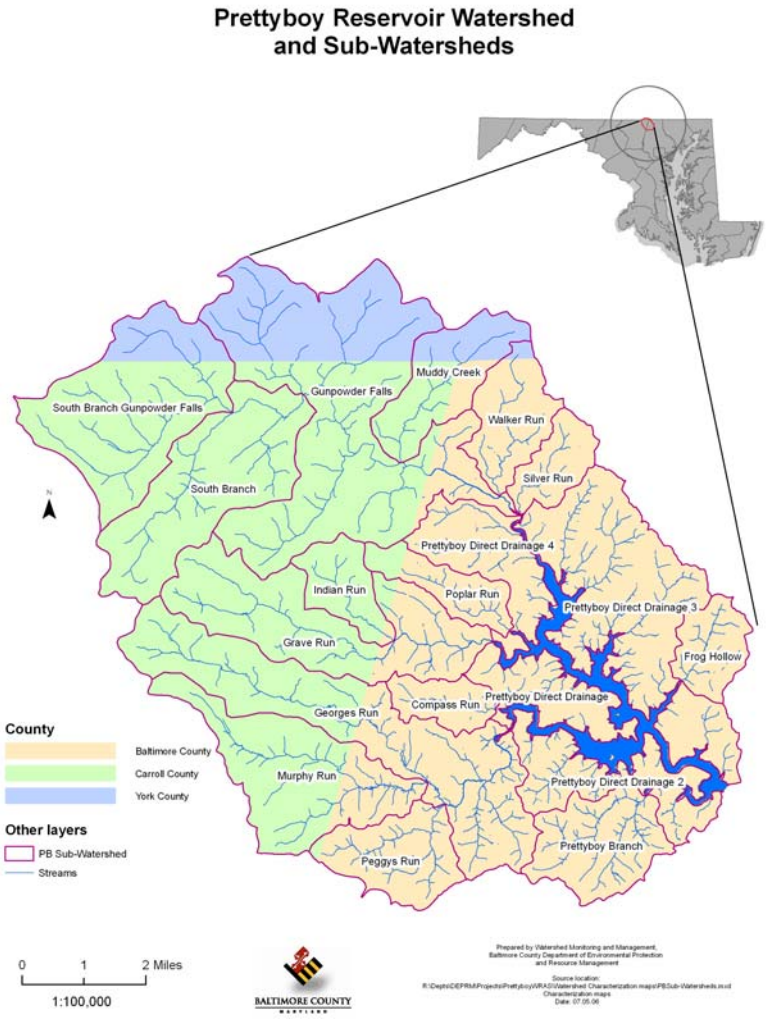
Prettyboy Reservoir Watershed Characterization Report



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Department of Environmental Protection and Resource Management

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CHAPTER 1

INTRODUCTION

1.1 Purpose of the Characterization

The Prettyboy Reservoir Watershed Characterization Report is intended to summarize information on geomorphological, hydrological, and biological factors that may affect water quality and other natural resources and the condition of the natural resources. In addition, the report identifies and assesses the human impact on the watershed, the management framework within which this activity takes place, and finally identifies restoration and preservation strategies and actions to achieve watershed goals. The information presented in this report, along with information provided by the Prettyboy Synoptic Survey, Benthic Community Assessment, the Biological Stream Survey, the Baltimore County Prettyboy Stream Corridor Assessment, the Carroll County Stream Corridor Assessment, and the Prettyboy Stream Stability Assessment will be used as the basis for the formulation of the Prettyboy Reservoir Watershed Action Strategy. This characterization report has two main objectives:

- Summarize watershed information relevant to natural resources and impacts on natural resources, and
- To describe the condition of the natural resources within the watershed.

1.2 Location and Scale of Analysis

The Prettyboy Reservoir watershed is located in the Gunpowder River Basin in the Piedmont region of Maryland. The watershed contains the headwaters of the Gunpowder Basin with portions of the watershed in Carroll County, Baltimore County, Maryland and York County, Pennsylvania (Figure 1-1). Table 1-1 displays the distribution of acreage between the three jurisdictions, while Figure 1-2 depicts the location of the subwatersheds within the Prettyboy Reservoir watershed.

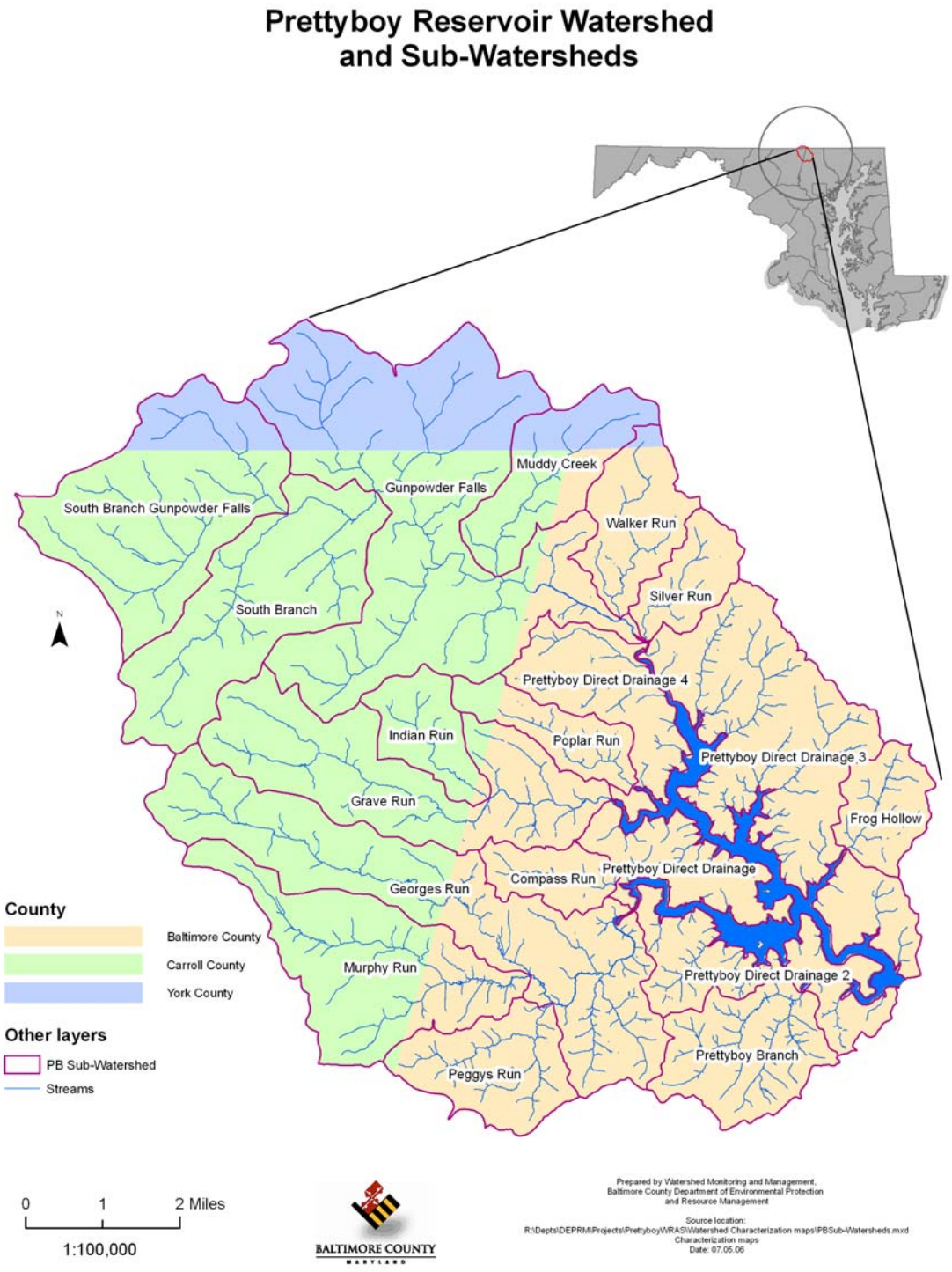

Figure 1-1: Prettyboy Reservoir Watershed Location in Maryland and Distribution Between the Three Counties.

Table 1-1: Distribution of Prettyboy Reservoir Watershed Acreage

County	Land		Water		Total	
	Acres	%	Acres	%	Acres	%
Carroll	21,069	42.5	0	0	21,069	41.2
Baltimore	24,022	48.4	1,516	100	25,538	49.9
York	4,538	9.1	0	0	4,538	8.9
Watershed Total	***49,629***	***100***	***1,516***	***100***	***51,145***	***100***

The analysis presented in this report was conducted at a variety of landscape scales in addition to an analysis of the entire watershed. The two additional scales used were the Maryland Department of Natural Resources (DNR) 12-digit watershed scale and the subwatershed scale. The DNR 12-digit scale is important since biological listing of impairment is presented at that scale and the analyses conducted by the Maryland Biological Stream Survey (MBSS) are at that scale. The subwatershed scale provides information on smaller drainage areas that are often the focus of intense restoration and preservation efforts, and the effect of these efforts may be more easily monitored at that level. Table 1-2 presents the labels used at the various scales and their relationship to one another. Figure 1-2 presents the various levels of scale used in the analysis.

Table 1-2: Prettyboy Reservoir (Basin No. 02130806) – DNR 12-digit and Subwatershed Scales

DNR 12-digit Scale	Subwatershed Scale	Acres
0313	Compass Run	768
	Poplar Run	982
	Silver Run	868
	Frog Hollow	975
	Prettyboy Branch	1,927
	Prettyboy Direct Drainage 1	1,300
	Prettyboy Direct Drainage 2	1,821
	Prettyboy Direct Drainage 3	4,906
	Prettyboy Direct Drainage 4	1,711
0313 Total Acres		**15,258**
0314	Georges Run	5,357
	Murphy Run	3,333
	Peggys Run	1,679
0314 Total Acres		**10,369**
0315	Grave Run	3,896
	Indian Run	1,012
0315 Total Acres		**4,908**
0316	Gunpowder Falls	8,035
	Muddy Creek	1,791
	Walker Run	1,444
0316 Total Acres		**11,270**
0317	South Branch	3,643
	South Branch Gunpowder Falls	4,193
0317 Total Acres		**7,836**
Prettyboy Total		**49,341**

As Table 1-2 indicates there are five DNR 12-digit watersheds in the Prettyboy Reservoir watershed and 19 separate subwatersheds identified for this report.

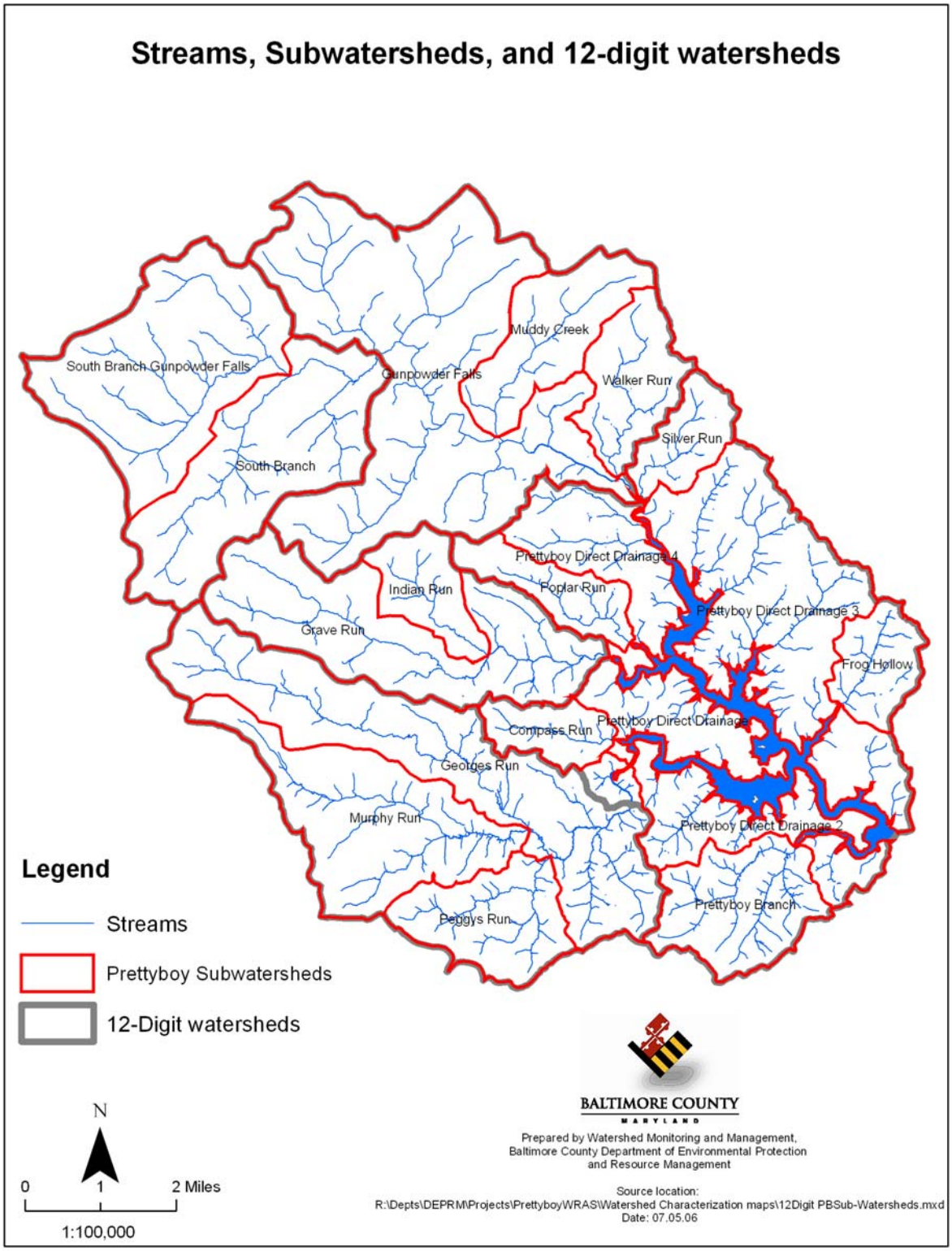

Figure 1-2: Maryland Department of Natural Resources 12-digit watersheds and subwatersheds within the Prettyboy Reservoir watershed.

1.3 Report Organization

This report is organized in six chapters. Chapter 1 presents an overview of the characterization report and a general location and acreage distribution among the three local jurisdictions.

Chapter 2 presents information on landscape characteristics that may have an effect on natural resources. Included in this chapter are some characteristics that are considered natural resources in their own right, such as, geology and soils. Data is presented on land use, impervious cover, population density, and a number of human modifications to the landscape that affect water quality.

Chapter 3 focuses on water quality and water quantity, and it relates the landscape characteristics to the potential for degradation or protection.

Chapter 4 summarizes the information on the living resources and habitat within the Prettyboy Reservoir watershed, including water-related resources, as well as terrestrial living resources (forest, wildlife).

Chapter 5 summarizes protection and restoration strategies, including activities that have taken place to date, and their effects on meeting the goals identified by the Prettyboy Reservoir WRAS Steering Committee.

CHAPTER 2

LANDSCAPE AND LAND USE

2.1 Introduction

The physical aspects of a watershed provide the background and context for the associated biological and hydrological processes, as well as for the development that takes place on the land at the hands of man. In this chapter, we will describe both the natural physical context and the human use and present state of the land in the Prettyboy Reservoir watershed. This will provide the basis for later chapters on water quality, living resources, restoration, and management.

The Prettyboy Reservoir watershed lies entirely within the Piedmont Region of Maryland and Pennsylvania. The natural Piedmont landscape is characterized by rolling hills, extensive forests, thick soils on deeply weathered crystalline bedrock, and abundant forest litter that minimizes overland flow. Much of the Piedmont, including the Prettyboy Reservoir watershed, was transformed by settlement starting in the 18th Century. Virgin forests were cleared for agriculture, and agricultural land use rose steadily until peaking around the beginning of the late 20th Century. In the 20th Century, residential development increased in the Prettyboy Reservoir watershed, especially in the Carroll County portion of the watershed. Two towns, Hampstead and Manchester, are located in the Carroll County portion of the Prettyboy watershed. The county and towns have adopted a growth plan whereby the towns are designated for growth, called Community Planning Areas, while the remaining portions of the county are less developed. The growth in the Hampstead and Manchester areas is by design and guided by the planning process.

This chapter will be presented in two parts: the first will document the natural background state of the natural resources of the basin, and the second will describe the present state of the landscape as it is now, after several centuries of human modification.

2.2 The Natural Landscape

The natural landscape includes many factors that provide the background context and foundation for land use. Among the factors are the physiographic province, the underlying geology and the surface soils, the climate that effects the formation and erosion of soils, the stream drainage system, and the forest and wetland cover.

2.2.1 Climate

The climate of the region can be characterized as a humid continental climate, with four distinct seasons modified by the proximity of the Chesapeake Bay and Atlantic Ocean (DEPRM, 2000). Rainfall is evenly distributed through all months of the year, with most months averaging between 3.0 and 3.5 inches per month. Storms in the fall, winter, and early spring tend to be of longer duration and lesser intensity than summer storms, which are often convective in nature with scattered high-intensity storm cells. The average annual rainfall, as measured at the Westminster Police barracks, is ~44 inches per year. The average annual snowfall is approximately 21 inches, with the majority of accumulation in December, January, and February.

The climate of a region affects the rate and form of soil formation and erosion patterns, and, by interacting with the underlying geology, influences the stream drainage network pattern and the resulting topography. Climate also affects the distribution and composition of the flora and fauna of the aquatic and terrestrial ecosystems.

2.2.2 Physiogeographic Province and Topography

2.2.2.1 Location and watershed delineation

The Prettyboy Reservoir watershed lies entirely within the Piedmont Physiographic Province. The highest point of the watershed, located at Beecher Hill in York County, is 1,087 feet in elevation. The lowest point in the watershed is located at the dam spillway, which is 520 feet in elevation. The Piedmont Physiographic Province is characterized by rolling hills of varying steepness dissected by streams that occur in dendritic drainage patterns.

All points of land are contained in nested watersheds based on water drainage patterns. Maryland divides its waters into 138, 8-digit watersheds, a scale finer than the USGS 8-digit hydrologic unit codes. Maryland's 8-digit watersheds contain, on average, 75 square miles. The Prettyboy watershed is an average-sized 8-digit watershed that contains about 49,640 acres, or 77.5 square miles. For some purposes, these watersheds are further divided into 12-digit subwatersheds, which, in Maryland, average 8 square miles. Prettyboy watershed contains five 12-digit watersheds, which are further divided into 19 subwatersheds. These subwatersheds are shown and labeled in Figure 2-1. The 12-digit watersheds are also shown; they are usually referred to by a 4-digit code, which represents the last 4 digits of their full 12-digit name. In this report, we will report many results at both the 12-digit and subwatershed levels.

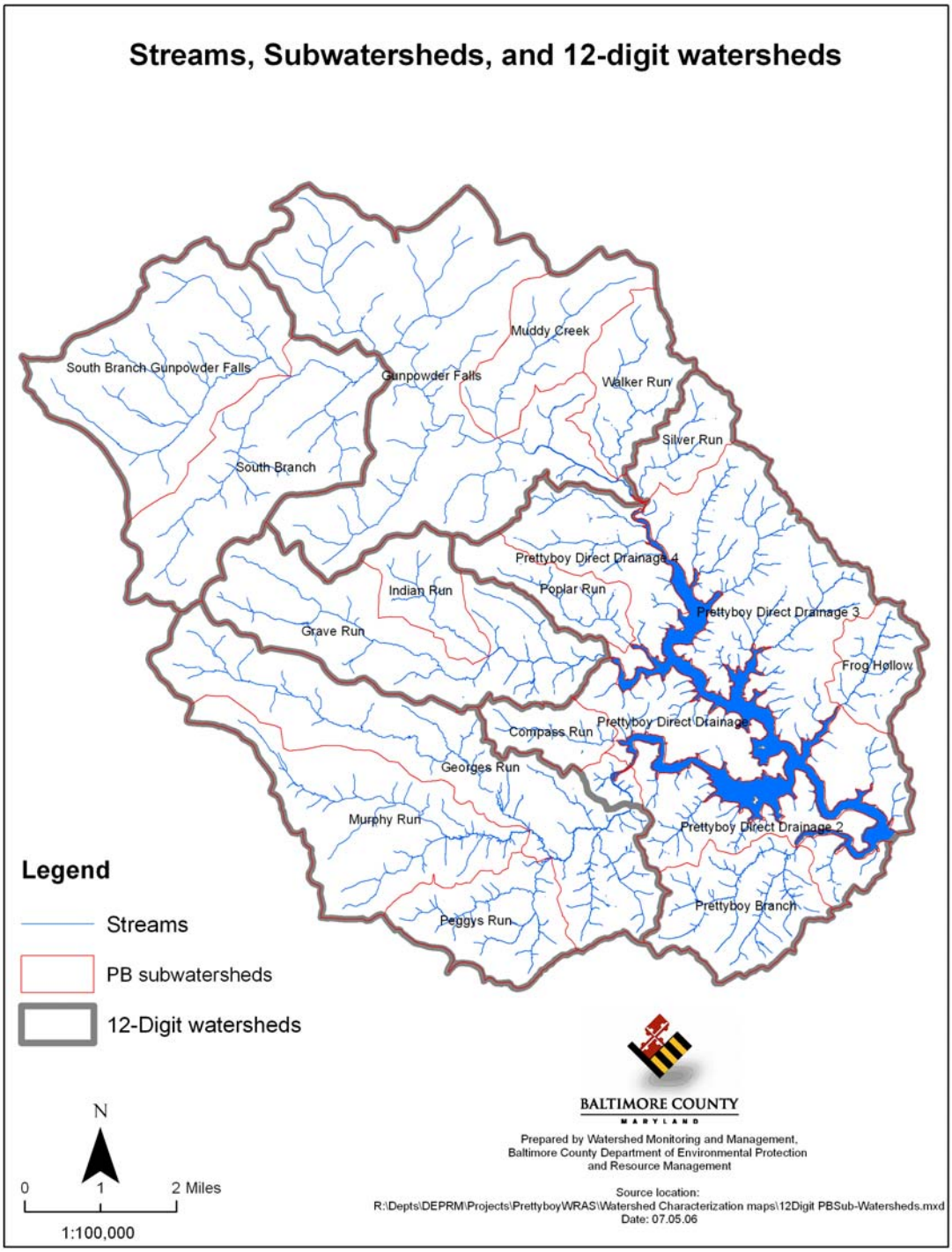

Figure 2-1. Subwatersheds and 12-digit watersheds of Prettyboy

2.2.2.2 Topography

The shape of the land, including its steepness and degree of concavity, affect surface water flows and soil erosion, as well as the suitability for development. The Piedmont Region is characterized by rolling hills of varying steepness. Steep slopes are more prone to overland flow

and soil erosion, and therefore have a greater potential for generation of pollutants. For this project the slopes were determined based on the soil data and divided into three categories: low slopes (0- 8 %), medium slopes (8 %- 15 %), and high slopes (>15 %). Table 2-1 displays the results, in percentage of the area in each category, by 12-digit watershed and subwatershed.

Table 2-1: Prettyboy Reservoir Subwatershed Slope Categories (%)

DNR 12-digit Scale	Subwatershed	Slope Category		
		Low	Medium	High
0313	Compass Run	19	54	28
	Poplar Run	21	48	31
	Silver Run	18	44	38
	Frog Hollow	11	55	34
	Prettyboy Branch	56	20	24
	Prettyboy Direct Drainage 1	37	29	34
	Prettyboy Direct Drainage 2	38	32	30
	Prettyboy Direct Drainage 3	30	39	32
	Prettyboy Direct Drainage 4	23	47	30
0313 Total		**31**	**38**	**31**
0314	Georges Run	20	49	31
	Murphy Run	16	53	30
	Peggys Run	14	56	29
0314 Total		**18**	**52**	**31**
0315	Grave Run	21	42	37
	Indian Run	18	45	37
0315 Total		**20**	**43**	**37**
0316	Gunpowder Falls	32	38	29
	Muddy Creek	31	41	31
	Walker Run	25	47	29
0316 Total		**31**	**40**	**29**
0317	South Branch	25	42	32
	South Branch Gunpowder Falls	18	41	40
0317 Total		**22**	**41**	**36**
Prettyboy Reservoir Watershed Total		***25***	***43***	***32***

The South Branch Gunpowder Falls subwatershed contains the highest proportion of steep (high) slopes (40% of the area), with Silver Run (38%), Grave Run (37%), and Indian Run (37%) just behind. These subwatersheds contain relatively broken topography, making them more prone to erosion, depending on soil type and land cover. Conversely, Prettyboy Branch (24%) has the smallest proportion of steep slopes. This subwatershed is composed of mainly flat land with 56% low slopes and 20% medium slopes. This flatness makes the land less prone to erosion depending on the soil types and land cover.

Figure 2-2 displays the distribution of the topographic slope categories throughout the Prettyboy Reservoir watershed.

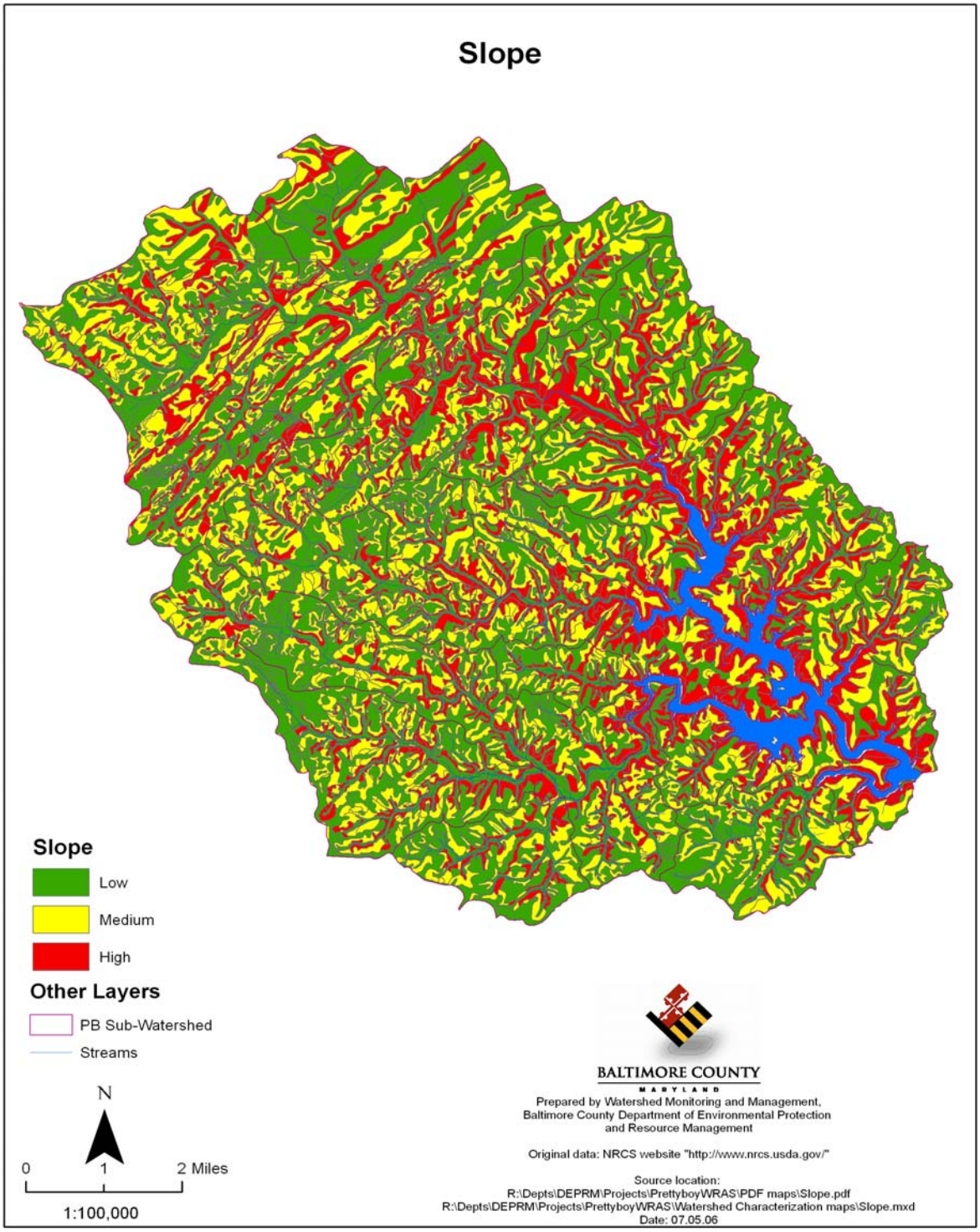

Figure 2-2. Prettyboy Reservoir Watershed Topography

2.2.3 Geology

The geological formations of the Prettyboy Reservoir watershed are shown in Figure 2-3. These formations affect the chemical composition of surface and groundwater, as well as the recharge rate to groundwater and wells. They are also key to soil formation. As such, the geology is closely correlated with water quality in pristine systems, and affects the buffering of pollution to stream systems in developed areas.

The metamorphic rock that underlies the Prettyboy watershed and much of the Piedmont consists mainly of crystalline schists and gneiss with smaller areas of marble. In general, the schist and gneiss formations have relatively low infiltration rates, giving them lower groundwater recharge rates and less vulnerability to contamination.

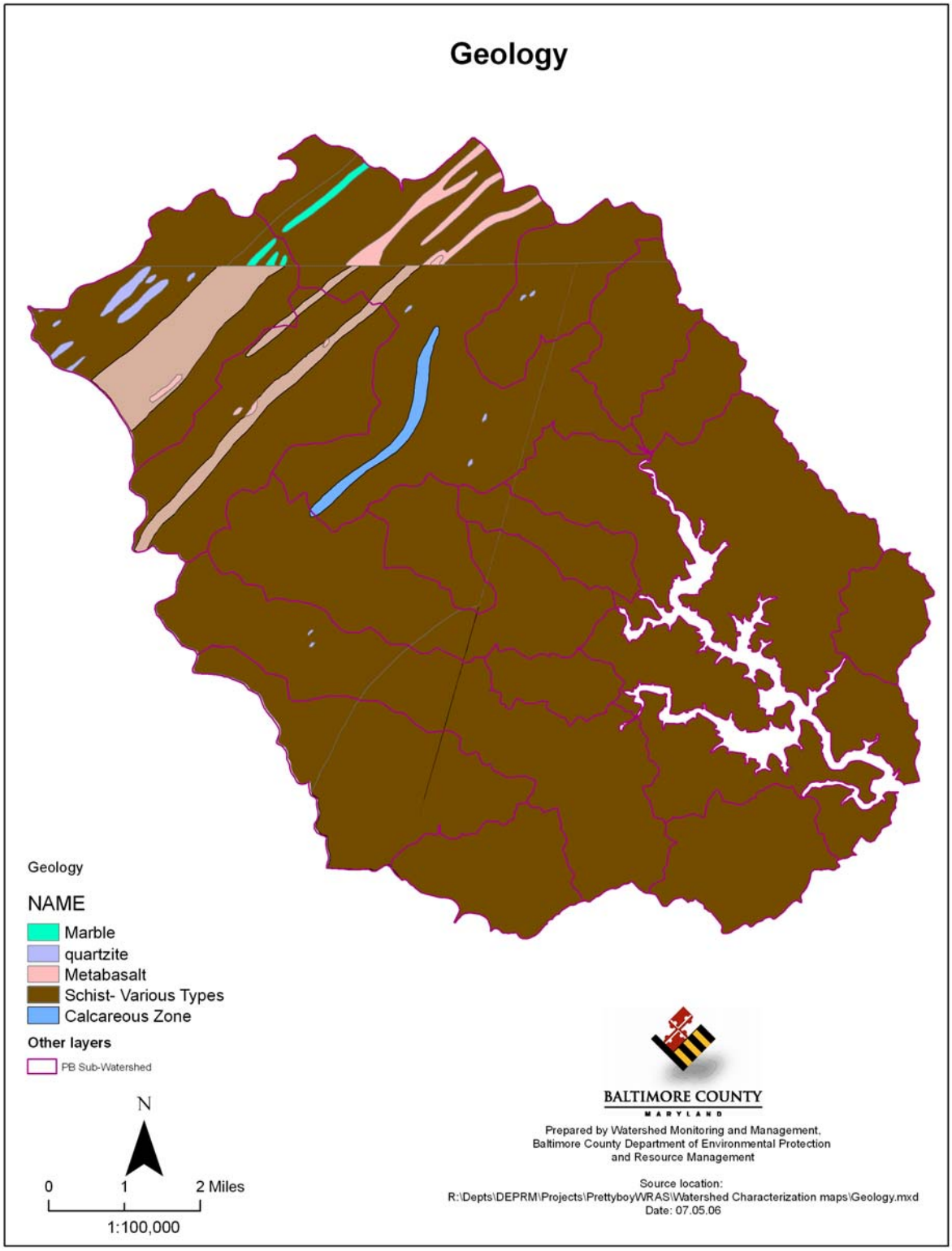

Figure 2-3. Prettyboy Reservoir Watershed Geology

2.2.4 Soils

Soil type and moisture conditions greatly affect how land may be used and the potential for vegetation and habitat on the land. Soil conditions are also one determining factor for water quality and quantity in streams and rivers. Soils are an important factor to consider in targeting projects aimed at improving water quality or habitat.

Piedmont soils are developed from highly metamorphosed schist, gneiss, and granite. Chester and Manor soils are common in the Piedmont from Pennsylvania to North Carolina, including the Prettyboy Watershed (Costa, 1975). Local soil conditions vary greatly from site to site.

2.2.4.1 Hydrologic Soil Groups

The Natural Resource Conservation Service (USDA) classifies soils into four Hydrologic Soil Groups (HSG) based on the soil's runoff potential. Runoff potential is the opposite of infiltration capacity; soils with high infiltration capacity will have low runoff potential, and vice versa. The four Hydrologic Soils Groups are A, B, C and D, where A's generally have the smallest runoff potential and D's the greatest. Soils with low runoff potential will be less prone to erosion, and their higher infiltration rates result in faster flow-through of precipitation to groundwater.

Details of the hydrological soils classification can be found in 'Urban Hydrology for Small Watersheds' published by the Engineering Division of the Natural Resource Conservation Service, United States Department of Agriculture, Technical Release–55.

> **Group A** is composed of sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well-to excessively drained sands or gravels and have a high rate of water transmission.
>
> **Group B** is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures.
>
> **Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water, and the soils have moderately fine to fine structure.
>
> **Group D** soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This Hydrologic Soil Group (HSG) has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils lying over nearly impervious material.

Hydrologic soil group information was obtained for only the Maryland portion of the watershed. The data are summarized in Figure 2-4 and Table 2-2. Areas with group C or D soils can be targeted for conservation practices, since they are the most vulnerable to high runoff. No subwatershed or 12-digit watershed has over 10% of its area in soils with the highest runoff potential, group D. As can be seen from Figure 2-4 most C and D soils are associated with the stream systems. Two subwatersheds, Frog Hollow and Peggys Run, have over 10% of their area in group C soils, making them more vulnerable to increased runoff from storm events. In general, group B soils, with moderate runoff potential, predominate in the Prettyboy Reservoir watershed.

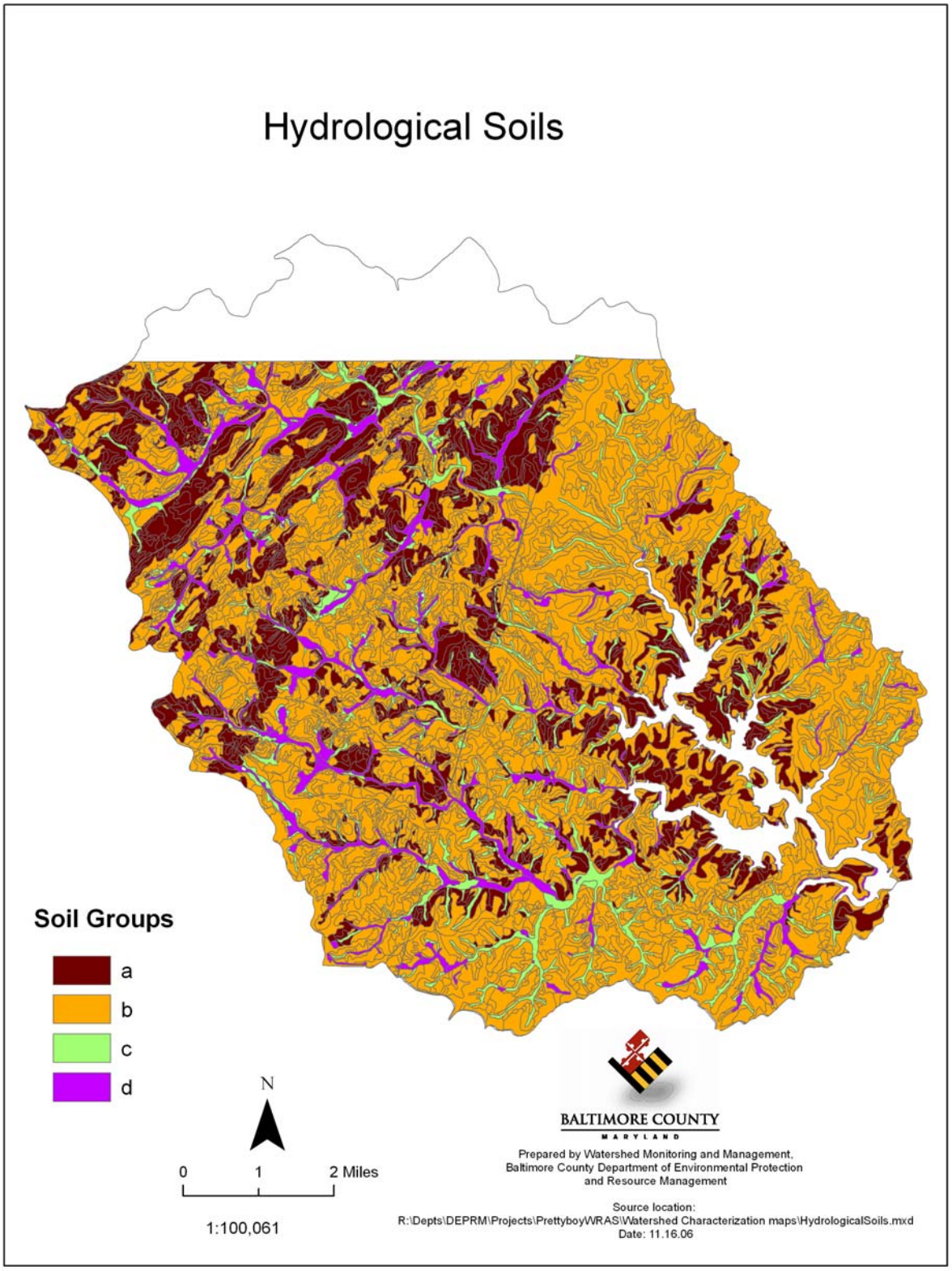

Figure 2-4. Prettyboy Reservoir Watershed - Hydrological Soil Groups

Table 2-2: Prettyboy Reservoir Subwatershed Hydrologic Soil Group Categories (%)

DNR 12-digit Scale	Subwatershed Scale	Hydrologic Soil Group %			
		A	B	C	D
0313	Compass Run	6	79	8	7
	Poplar Run	0	90	7	3
	Silver Run	17	71	5	7
	Frog Hollow	1	78	13	8
	Prettyboy Branch	48	47	2	3
	Prettyboy Direct Drainage 1	30	62	4	3
	Prettyboy Direct Drainage 2	26	67	5	2
	Prettyboy Direct Drainage 3	16	74	6	5
	Prettyboy Direct Drainage 4	10	84	2	5
0313 Total		**20**	**60**	**5**	**4**
0314	Georges Run	20	63	8	9
	Murphy Run	13	71	7	8
	Peggys Run	1	83	12	5
0314 Total		**15**	**69**	**9**	**8**
0315	Grave Run	26	62	6	7
	Indian Run	24	64	3	9
0315 Total		**25**	**62**	**5**	**7**
0316	Gunpowder Falls	27	60	7	6
	Muddy Creek	54	35	4	7
	Walker Run	1	91	8	0
0316 Total		**26**	**62**	**7**	**5**
0317	South Branch	37	49	5	9
	South Branch Gunpowder Falls	43	43	5	9
0317 Total		**40**	**46**	**5**	**9**
Prettyboy Watershed Total		***24***	***64***	***6***	***6***

2.2.4.2 Soil Erodibility

The erodibility of the soil is its intrinsic susceptibility to erosion. It is one factor (known as the K factor) in the Universal Soil Loss Equation, which estimates the rate of erosion at an actual site. Erodibility is based on the physical and chemical properties of the soil, which determine how strongly soil particles cohere with one another. Figure 2-5 shows soil erodibility in the Prettyboy Reservoir watershed, and Table 2-3 is the summary by subwatershed. Low erodibility is defined as a K factor <0.24, medium is K between 0.24 and 0.32, and high is K>0.32. These classes are based on groupings in the data that resulted in three classes. They also represent the breaks used in the Baltimore County *Steep Slopes and Erodible Soils Analysis* for determining riparian buffer widths. They are not the same as Maryland Department of Natural Resources (MDNR) or Maryland Department of Planning (MDP) categories, but overlap with them.

The subwatersheds with the highest values for erodibility offer the greatest potential for interventions addressing soil conservation, such as the Conservation Reserve Enhancement Program and riparian buffer forestation. Best management practices concerned with keeping topsoil in place would be ideal for implementation in these watersheds. This indicator would be useful when combined with additional information about cropland, slope steepness, and distance to streams, as this would indicate areas where one best management practice--retirement of highly erodible land--would be most useful. High values for this indicator also raise warning

flags about other, more urban activities near streams, such as road construction or utility placements.

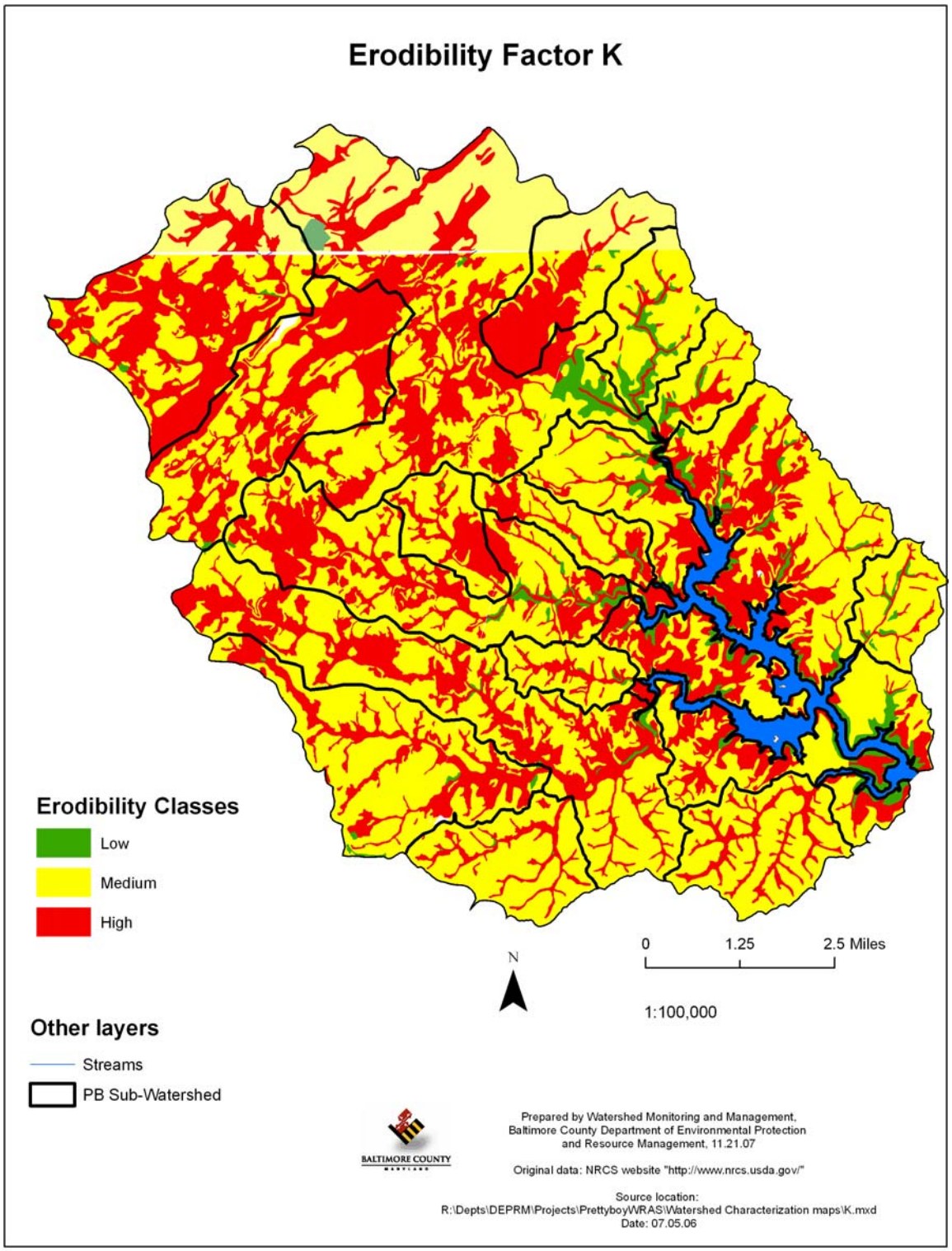

Figure 2-5. Soil Erodibility based on the K factor

Overall, the Prettyboy Reservoir watershed has very little soil of low erodibility, meaning a large proportion of the watershed's soils are prone to at least moderate erosion. The medium and high erodibility classes are well represented, with 61% and 36% respectively. Three sub-watersheds have over 50% highly erodible soils: Prettyboy Direct Drainage 1 (52%), on the west side of the reservoir; South Branch (52%); and South Branch Gunpowder Falls (53%). These would rate as priority subwatersheds for maintaining protective land cover.

Table 2-3: Prettyboy Reservoir Subwatershed Soil Erodibility Categories (%)

DNR 12-digit Scale	Subwatershed Scale	Soil Erodibility Category		
		Low 0-.24	Medium .25-.32	High >.32
0313	Compass Run	1	77	22
	Frog Hollow	5	85	10
	Poplar Run	2	68	30
	Prettyboy Branch	0	78	22
	Prettyboy Direct Drainage 1	9	39	52
	Prettyboy Direct Drainage 2	10	53	37
	Prettyboy Direct Drainage 3	7	58	34
	Prettyboy Direct Drainage 4	7	66	27
	Silver Run	6	76	18
0313 Total		**6**	**64**	**30**
0314	Georges Run	1	62	38
	Murphy Run	1	70	29
	Peggys Run	0	83	17
0314 Total		**1**	**68**	**32**
0315	Grave Run	3	57	40
	Indian Run	0	61	38
0315 Total		**3**	**58**	**40**
0316	Gunpowder Falls	4	61	35
	Muddy Creek	1	56	44
	Walker Run	14	78	8
0316 Total		**5**	**63**	**33**
0317	South Branch	1	47	52
	South Branch Gunpowder Falls	1	46	53
0317 Total		**1**	**47**	**52**
Prettyboy Reservoir Watershed Total		***3***	***61***	***36***

2.2.4.3 Prime Farmlands

Figure 2-6 and Table 2-4 show prime agricultural land and hydric soils. Prime farmland is land that has the best combination of physical and chemical characteristics for agricultural production. Baltimore and other counties use the highest 3 (out of 8) soil capability classifications, as defined by the Natural Resources Conservation Service, to designate their prime farmlands. The figure shows the lands that fall in these soil classes for the entire watershed.

Hydric soils occur where an anaerobic environment (one devoid of oxygen) caused by soil saturation continues for long periods during the growing season, making them largely unsuited for agriculture and other uses. If hydric soils are drained, they can be converted to agriculture, and some hydric soils occur on land classified as prime farmland.

Of the 49,640 acres in Prettyboy Reservoir watershed, over 30,000 acres (61%) are classified as prime agricultural land. At the subwatershed level, Walker's Run, Peggy's Run, and Prettyboy Branch all exhibit very high fertility with at least ¾ of their area in prime farmland. At the other end of the scale, Prettyboy Direct Drainage 1 contains only 25% prime agricultural land, significantly below the next lowest subwatershed.

A total of 5,550 acres are on hydric soils, of which 2,870 are considered to be on prime agricultural land. Hydric soils suggest where wetlands are located presently or were located historically. Where they are being cultivated, these areas may represent habitat restoration opportunities. Wetlands and hydric soils will be discussed in further detail below.

Table 2-4: Prime Farmlands and Hydric Soils

DNR 12-digit	Subwatershed	Prime Farmland (ac)	Prime Farmland (%)	Prime Farmland w/hydric soils (ac)	Prime Farmland w/hydric soils (%)	Other hydric soils (ac)	Other hydric soils (%)
0313	Compass Run	534	69	6	0.7	108	14.0
	Frog Hollow	723	74	24	2.4	73	7.5
	Poplar Run	683	70	44	4.5	72	7.4
	Prettyboy Branch	1,517	79	58	3.0	350	18.1
	Prettyboy Direct Drainage 1	326	25	1	0.1	37	2.9
	Prettyboy Direct Drainage 2	838	46	0	0.0	99	5.4
	Prettyboy Direct Drainage 3	2,432	50	99	2.0	253	5.1
	Prettyboy Direct Drainage 4	1,052	61	34	2.0	123	7.2
	Silver Run	614	71	31	3.5	22	2.6
0313 Total		**8,720**	**57**	**297**	**1.9**	**1,137**	**7.4**
0314	Georges Run	3,504	65	435	8.1	473	8.8
	Murphy Run	2,270	68	326	9.8	172	5.2
	Peggys Run	1,358	81	115	6.8	157	9.3
0314 Total		**7,133**	**69**	**877**	**8.5**	**802**	**7.7**
0315	Grave Run	2,344	60	327	8.4	161	4.1
	Indian Run	556	55	51	5.0	69	6.9
0315 Total		**2,900**	**59**	**377**	**7.7**	**230**	**4.7**
0316	Gunpowder Falls	4,827	60	499	6.2	164	2.0
	Muddy Creek	1,135	63	97	5.4	21	1.2
	Walker Run	1,083	75	67	4.7	41	2.8
0316 Total		**7,045**	**63**	**663**	**5.9**	**226**	**2.0**
0317	South Branch	1,923	53	306	8.4	187	5.1
	South Branch Gunpowder Falls	2,339	56	350	8.3	99	2.4
0317 Total		**4,262**	**54**	**656**	**8.4**	**285**	**3.6**
Prettyboy Reservoir Watershed Total		***30,060***	***61***	***2,870***	***5.8***	***2,680***	***5.4***

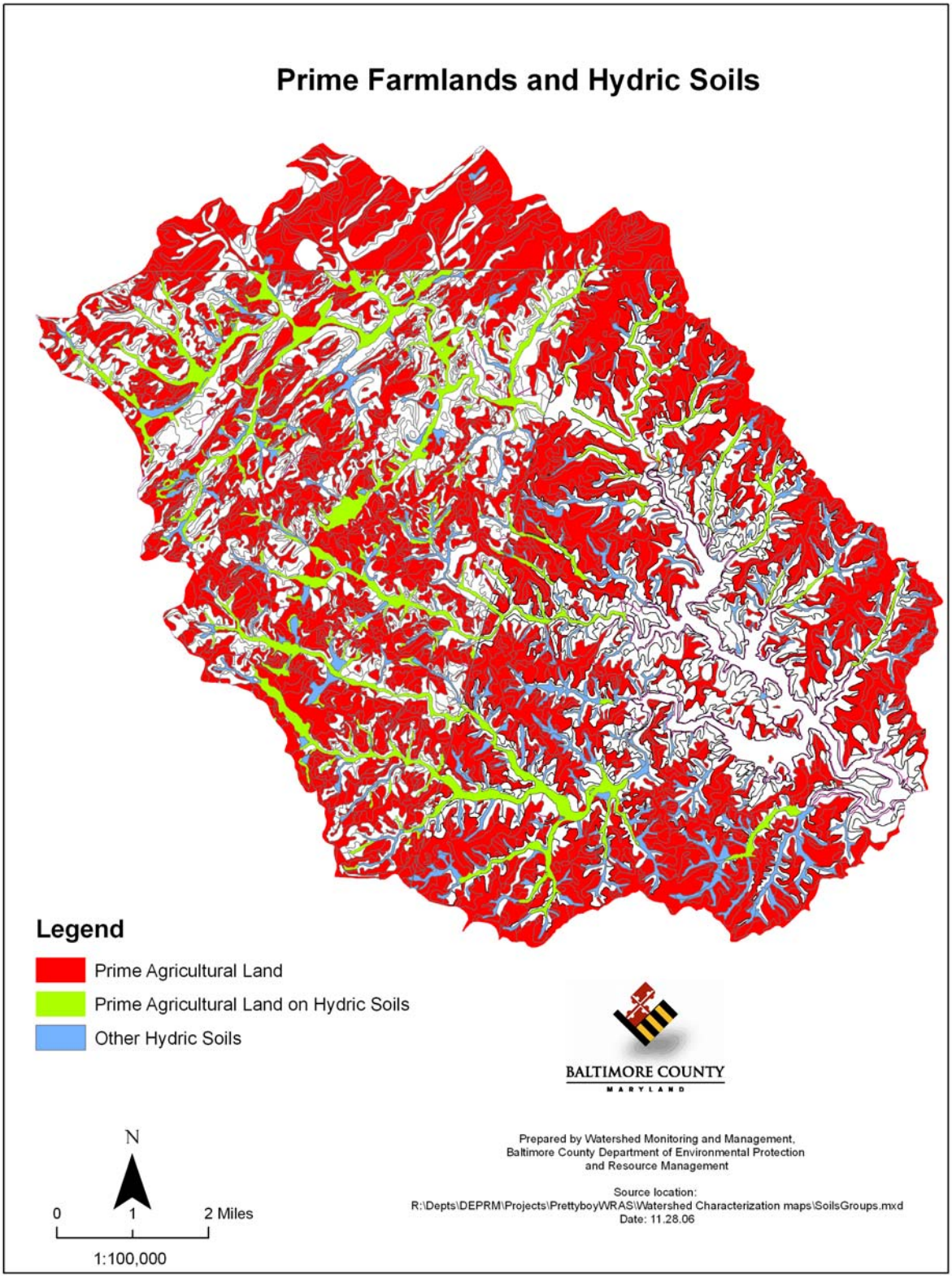

Figure 2-6. Prime Farmlands

2.2.5 Forest

The entire Chesapeake watershed, including the Prettyboy Reservoir watershed, consisted overwhelmingly of old-growth forest at the time of European settlement. Forest cover provides the greatest protection among land cover types for the quality of the soil and water. In pristine systems, forest and soils co-evolve, and in turn shape the hydrological cycle; these systems operate within a natural range of variability, assuring healthy habitat and water quality. In human-impacted systems, forest cover still provides many of these benefits, and can help protect water quality if judiciously conserved.

This section will discuss both forest cover and the "Green Infrastructure" model developed by Maryland Department of Natural Resources for prioritizing a network of forest hubs and connecting corridors.

2.2.5.1 Forest Cover

While the forest area has been greatly reduced in the Prettyboy Reservoir watershed since European settlement, it still remains relatively high, compared to the many more urbanized watersheds in the region. Intact and healthy forests provide many ecological, aesthetic, and recreational benefits. While all of the original old-growth forest cover in the Prettyboy Watershed was removed at one time or another, large areas have regrown into mature or secondary succession forests. Much of this forest area is protected, most notably around the reservoir. Large forest blocks provide greater ecological benefits than small blocks. Forest interior dwelling species (FIDS), for example, require large blocks of forest habitat with relatively little fragmentation or human impact (MDNR 2003). FIDS habitat is a forest block at least 50 acres, in size with the forest edge at least 300 feet away.

In order to have a comprehensive map of forests, all forested stands in the Maryland portion of the watershed were digitized (aerial images of York County were not available). Among other benefits, this information allows planners and managers to refine their analysis of land use and focus on specific areas for preservation or restoration.

Figure 2-7 shows all forested stands in the MD portion of the Prettyboy Reservoir watershed. Large forests blocks greater than 50 acres are also shown. Within these large blocks, interior forest, defined to be at least 300 feet from the edge of the forest, is also shown.

In addition to providing habitat for terrestrial communities, forest is the least polluting of the land uses in the region. Healthy forest holds soil in place and conserves nutrients. Forest reduces runoff and protects streams from erosion. The forest landscape position is important in regards to water quality, with riparian forest and forest cover on highly erodible lands providing greater water quality benefits. Riparian forest helps moderate water temperatures, which help support coldwater fisheries. In addition, riparian forest provides the natural input of food and energy to the stream systems that is typical for streams in this region.

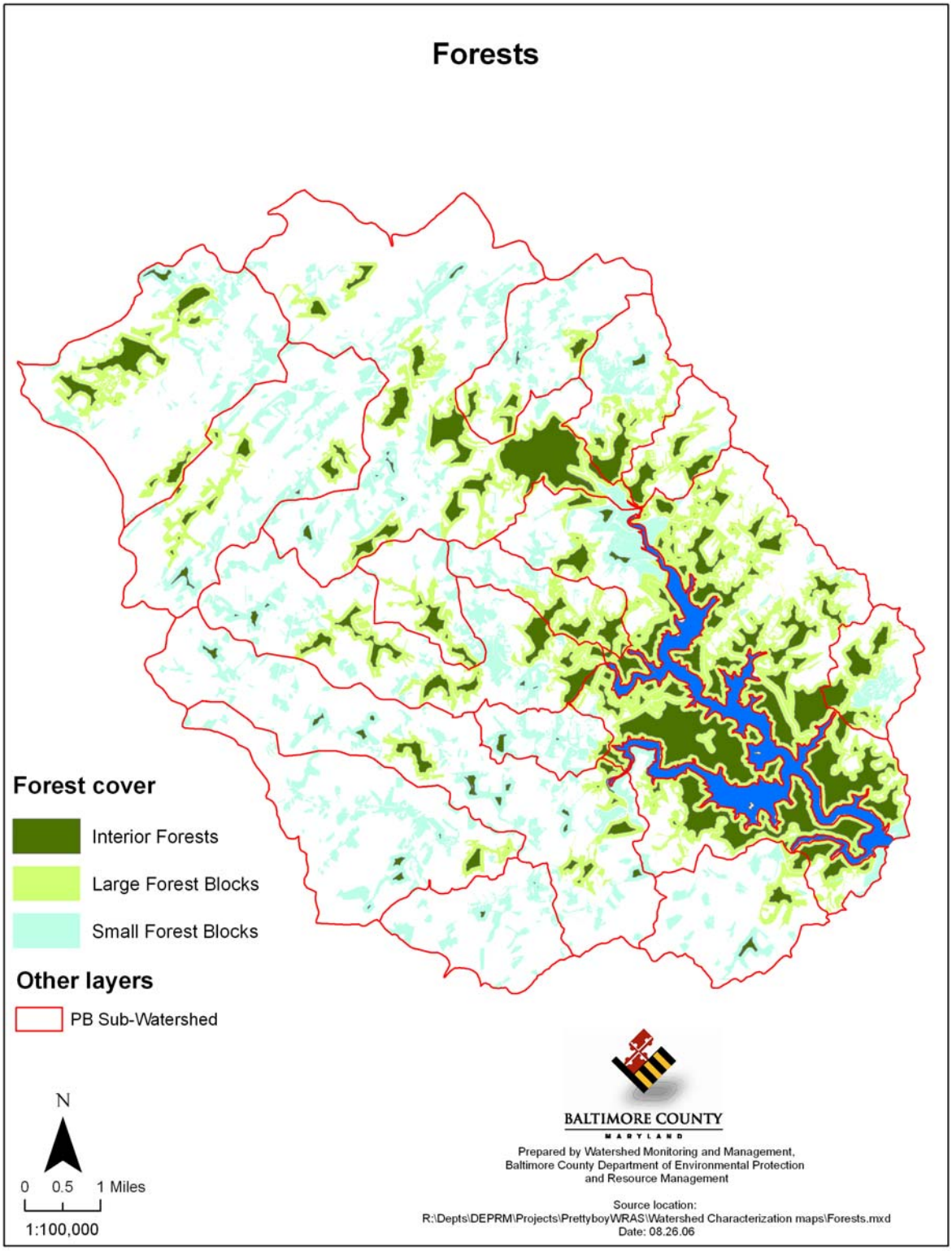

Figure 2-7. Forest Cover in the Prettyboy Reservoir Watershed

Figure 2-7 and Table 2-5 show that Maryland's portion of the Prettyboy watershed contains 19,364 acres of forest, of which 12,716 acres are in large blocks. Of the large forest blocks, 3,880 acres are in interior forest and thus provide habitat for the FIDS. The subwatersheds with the greatest forested area are Gunpowder Falls and Prettyboy Direct Drainage 3. Prettyboy Direct Drainage 2 and Gunpowder Falls contain the greatest areas in large forest blocks and interior forests. These areas are a potential priority for preservation, and analysis later in this chapter will show how much of this forest cover is protected.

Table 2-5: Prettyboy Reservoir Subwatershed Forested Area

DNR 12-digit Scale	Subwatershed Scale	Total Acres	Forested Acres	% Forested	Acres of Large Forest Blocks	Acres of Interior Forest
0313	Compass Run	768	315	41	37	16
	Frog Hollow	975	476	49	361	129
	Poplar Run	982	488	50	376	85
	Prettyboy Branch	867	327	38	188	42
	Prettyboy Direct Drainage 1	1,927	423	22	1,149	521
	Prettyboy Direct Drainage 2	1,300	1,159	89	1,078	367
	Prettyboy Direct Drainage 3	1,821	1,181	65	3,029	859
	Prettyboy Direct Drainage 4	4,906	3,148	64	630	139
	Silver Run	1,711	1,031	60	308	82
0313 Total		**15,257**	**8,548**	**56**	**7,156**	**2,240**
0314	Georges Run	5,357	1,346	25	404	112
	Murphy Run	3,333	681	20	97	26
	Peggys Run	1,679	293	17	0	0
0314 Total		**10,469**	**2,320**	**22**	**501**	**138**
0315	Grave Run	3,896	1,580	41	851	228
	Indian Run	1,012	381	38	240	43
0315 Total		**4,908**	**1,961**	**40**	**1,091**	**271**
0316	Gunpowder Falls	8,032	3,065	38	2,096	817
	Muddy Creek	1,782	578	32	303	55
	Walker Run	1,440	620	43	384	98
0316 Total		**11,254**	**4,263**	**38**	**2,783**	**970**
0317	South Branch	3,643	992	27	400	55
	South Branch Gunpowder Falls	4,190	1,278	31	785	202
0317 Total		**7,833**	**2,270**	**29**	**1,185**	**257**
Prettyboy Reservoir Watershed Total		***46,620***	***19,364***	***41***	***12,716***	***3,880***

Prettyboy Branch, Georges Run, Murphy Run, Peggys Run, and South Branch all contain less than 30% forest cover, with Peggys Run the lowest at 17%. The 12-digit watershed containing Georges Run, Murphy Run, and Peggys Run is the least forested at 22%. These areas provide ample opportunity for potential forest restoration.

While data calculated from GIS layers and land cover maps are useful, they should not be taken as the last word on conditions on the ground. Recent developments may have changed conditions, or areas placed within a category by GIS may miss or gloss over the complexity in the field. For example, within the forested acres and interior forest of Prettyboy Reservoir watershed there are many acres of pine plantations that may not fill all the ecological functions

of natural deciduous forest cover. While we focus here on conditions within Prettyboy, it is critical to also compare the condition of the Prettyboy Reservoir watershed as a whole to other 8 digit watersheds in Central Maryland. The forests (and other natural resources) in Prettyboy provide value to the residents and ecology of the entire region, where forest cover has diminished substantially in recent decades from development pressure. In this regard, the Prettyboy Reservoir watershed as a whole, and its remaining forest cover, may have high regional priority for preservation.

2.2.5.2 Green Infrastructure

MDNR has mapped a Statewide network of ecologically important lands across the State called "Green Infrastructure". This network is comprised of large blocks of important natural resource lands called hubs and corridors that connect the hubs. These areas are primarily large blocks of contiguous forest but also include wetlands and other naturally vegetated lands. These lands provide significant environmental benefits, such as cleaning the air, filtering and cooling water, and storing and cycling nutrients.

The Green Infrastructure assessment map differs from the forest interior assessment presented earlier in that forest interior areas are more numerous and more widely distributed because the forest interior size threshold is lower.

DNR has mapped a network of ecologically important lands, comprised of hubs and linking corridors, using several of the GIS data layers used to develop other indicators. Hubs contain one or more of the following:

- Areas containing sensitive plant or animal species;
- Large blocks of contiguous interior forest (at least 250 contiguous acres, plus the 300 foot transition zone);
- Wetland complexes with at least 250 acres of unmodified wetlands;
- Streams or rivers with aquatic species of concern, rare coldwater or blackwater ecosystems, or important to anadromous fish, and their associated riparian forest and wetlands; and
- Conservation areas already protected by public (primarily DNR or the federal government) and private organizations like The Nature Conservancy or Maryland Ornithological Society.

This "Green Infrastructure" provides the bulk of the state's natural support system. Forest provide ecosystem services, such as cleaning the air, filtering and cooling water, storing and cycling nutrients, conserving and generating soils, pollinating crops and other plants, regulating climate, protecting areas against storm and flood damage, and maintaining hydrologic function. For more information on the Green Infrastructure identification project, see www.dnr.maryland.gov/greenways/.

Protection of Green Infrastructure lands may be addressed through various existing programs, including Rural Legacy, Program Open Space, conservation easements and other similar programs. Within Program Open Space, the Green Print program helps to target funds to protect Green Infrastructure areas.

Figure 2-8 shows the Green Infrastructure in the Prettyboy Reservoir watershed as identified by DNR. The natural vegetation area in the Green Infrastructure hubs within the Prettyboy

Reservoir watershed totals about 9,140 acres. Most of this natural area is forest in large hubs. The main hub includes the Baltimore City-owned property around the reservoir.

The corridors connecting the Green Infrastructure hubs are characterized by long, narrow, discontinuous areas of natural vegetation that total about 4,000 acres. These natural areas are fragmented by land uses like agriculture and development.

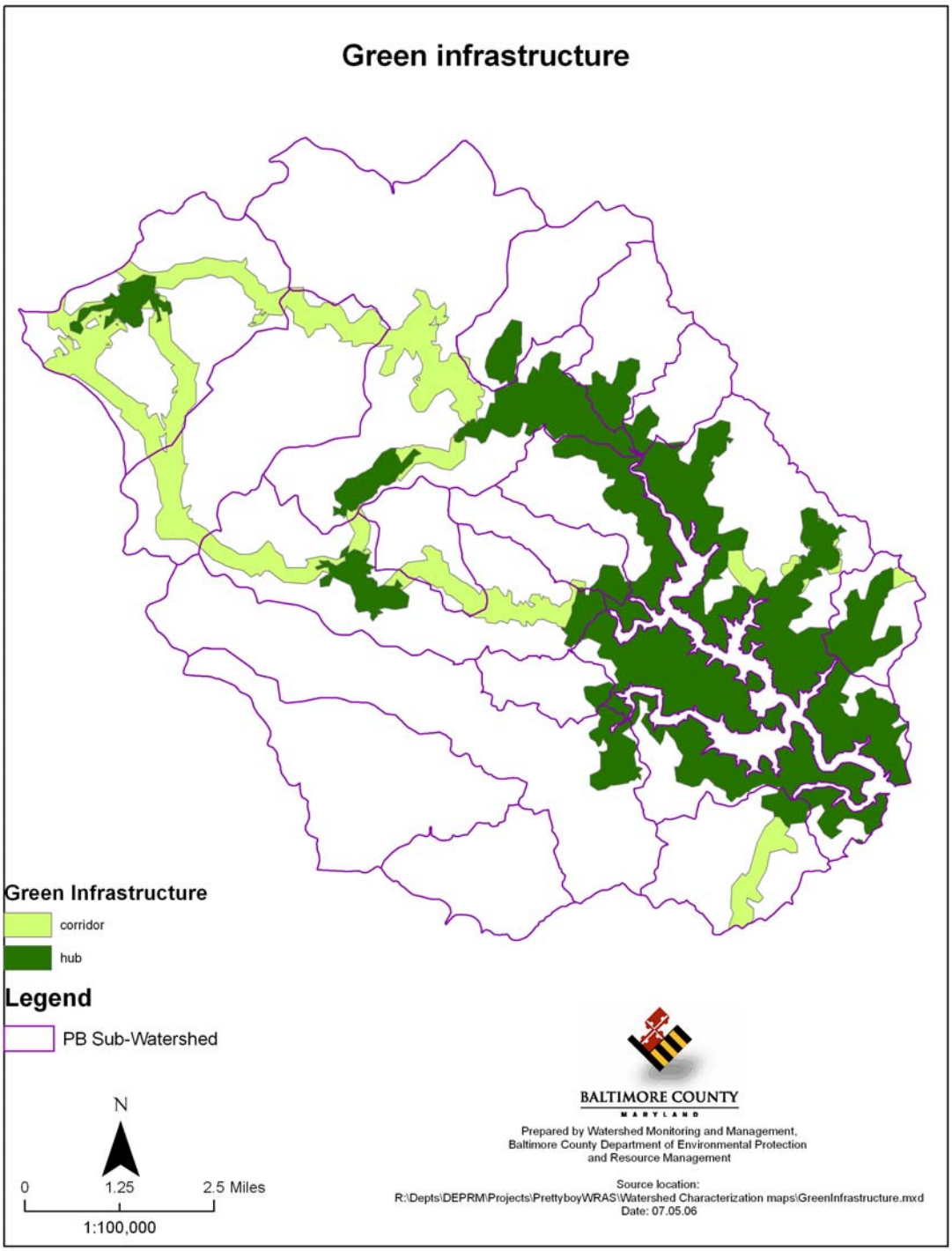

Figure 2-8. Green Infrastructure

The Green Infrastructure provides the model for where reforestation will provide benefits for terrestrial communities through the expansion of existing hubs and connecting corridors.

2.2.6 Wetlands

Wetlands improve water quality by their natural filtering capability and their nutrient uptake and transformation. They also provide downstream flood protection by absorbing storm waters and slowly releasing them after the storm event.

The US Army Corps of Engineers and the US Environmental Protection Agency define wetlands as follows (EPA Office of Wetlands, Oceans and Watersheds web site):
"Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." Wetlands in the Piedmont Province are generally less abundant compared to Maryland's Western and Eastern Shore areas (on the Coastal Plain Province), due to greater topographic relief, regional geology, lower groundwater table and lack of tidal influence. The majority of Prettyboy reservoir watershed wetlands are associated with low-lying areas around streams or with the reservoir itself.

There are two main sources of information on wetlands in the State of Maryland: the National Wetlands Inventory (NWI), which covers the entire country; and the MDNR, which has mapped wetlands for the state. Because wetland classifications were carried out by two different agencies at two different scales, their results can differ significantly. DNR's estimates are based on larger-scale images, and may contain wetlands that are not contained on the NWI maps. Estimates of wetland acreage in the Prettyboy Reservoir watershed are presented in Table 2-6.

In the Prettyboy Reservoir watershed, wetlands historically occupied a much larger extent than they do presently. The MD Clean Water Action Plan estimates that 892 wetland acres have been lost historically. In this watershed, hydric soils that indicate wetlands tend to be associated with streams, but many are no longer wetlands. Many of these hydric soils are currently in agricultural land use, having been artificially drained or turned into pasture.

As mentioned earlier, the DNR classification estimated 48 wetland acres being farmed in the watershed. These areas are often ideal locations for wetland restoration. The Baltimore County Soil Conservation District and Carroll Soil Conservation District, familiar with the local farms, may have knowledge of landowners interested in restoring wetlands on their property.

The MDE report entitled *Priority Wetland Restoration and Preservation Sites* further assesses wetland restoration priorities. The document presents a comprehensive compilation of numerous resource inventories and management plans on wetlands, their surrounding environment and conditions, and management and restoration recommendations. It also presents priorities for restoration and identifies sites and practices that are most suitable for both voluntary restoration and mitigation projects throughout Maryland.

MDE tracks all regulated nontidal wetland activity in Maryland, including regulated wetland impacts and gains. Based on data for the time period of January 1, 1991 through December 31, 2004, for this watershed, there has been a slight loss (0.12 ac.) in wetlands (Walbeck, 2005).

Table 2-6: Prettyboy Reservoir Watershed Wetland Estimates, Acres

DNR 12-digit	Subwatershed	NWI-estimated (entire watershed)		DNR-estimated (MD only)	
		Acres	%	Acres	%
0313	Compass Run	3	0.4	10	1.3
	Frog Hollow	10	1.1	10	1.0
	Poplar Run	3	0.3	18	1.9
	Silver Run	51	2.6	20	1.0
	Prettyboy Branch	34	2.6	49	3.7
	Prettyboy Direct Drainage 1	51	2.8	61	3.4
	Prettyboy Direct Drainage 2	39	0.8	45	0.9
	Prettyboy Direct Drainage 3	30	1.7	42	2.5
	Prettyboy Direct Drainage 4	4	0.5	13	1.5
0313 Total		**224**	**1.5**	**269**	**1.8**
0314	Georges Run	72	1.3	77	1.4
	Murphy Run	17	0.5	74	2.2
	Peggys Run	4	0.3	8	0.5
0314 Total		**93**	**0.9**	**159**	**1.5**
0315	Grave Run	50	1.3	73	1.9
	Indian Run	8	0.8	11	1.1
0315 Total		**58**	**1.2**	**84**	**1.7**
0316	Gunpowder Falls	89	1.1	78	1.5
	Muddy Creek	16	0.9	34	3.1
	Walker Run	7	0.5	14	1.0
0316 Total		**112**	**1.0**	**126**	**1.7**
0317	South Branch	69	1.9	76	2.1
	South Branch Gunpowder Falls	72	1.7	38	1.1
0317 Total		**141**	**1.8**	**114**	**1.6**
Prettyboy Reservoir Watershed Total		***627***	***1.3***	***752***	***1.7***

Figure 2-9 shows the mapped wetlands using the NWI classification, and covers the entire watershed. Nontidal Wetlands of Special State Concern will be covered in Chapter 4 of this report, Living Resources and Habitat.

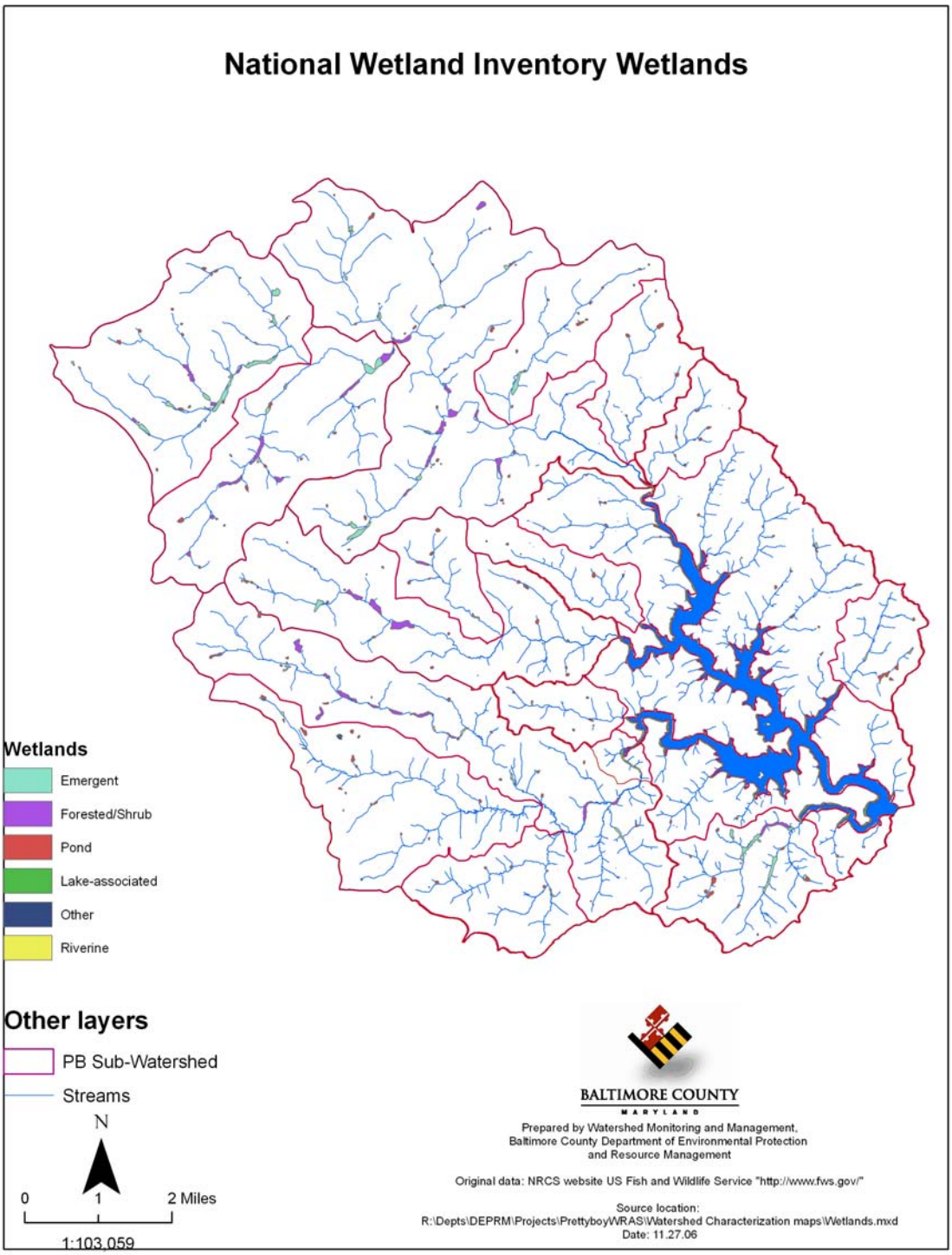

Figure 2-9. Prettyboy Reservoir Watershed Wetlands

2.2.7 Stream Systems

Stream systems are a watershed's circulatory system, and the most visible attribute of the hydrological cycle. Streams are the flowing surface waters, and are distinct from both

groundwater and standing surface water (such as lakes), though they are connected with both of them. The stream system is an intrinsic part of the landscape, and closely reflects conditions on the land. Streams are a fundamental natural resource, with myriad benefits for plants, animals, and humans. Maintaining a healthy stream system is a priority for many individuals and organizations, and requires ensuring that stream flows and water quality closely mimic the conditions found in unimpacted watersheds.

2.2.7.1 Stream System Characteristics

The Prettyboy Reservoir watershed contains approximately 314 miles of perennial streams, all of which drain into the Prettyboy Reservoir. The reservoir is an artificial impoundment that was created by damming the main stem of the Gunpowder River. The dam was built in 1933.

The Prettyboy Reservoir watershed is classified as an 8-digit watershed by the State of Maryland. In turn, it is separated into five 12-digit watersheds and further into 19 'subwatersheds'. Figure 2-10 shows the stream network and the 12-digit and sub-watersheds. Table 2-7 shows the stream mileage and density by subwatershed. Because different scales were used for each county's digitized stream layer, these data should be interpreted with caution.

Baltimore County DEPRM has further classified its streams into orders. A first-order stream is a stream with no tributaries; a stream becomes second-order where two first-order tributaries come together, and so on. Table 2-7 summarizes the percentages of Baltimore County's streams in each of 3 groups of stream orders.

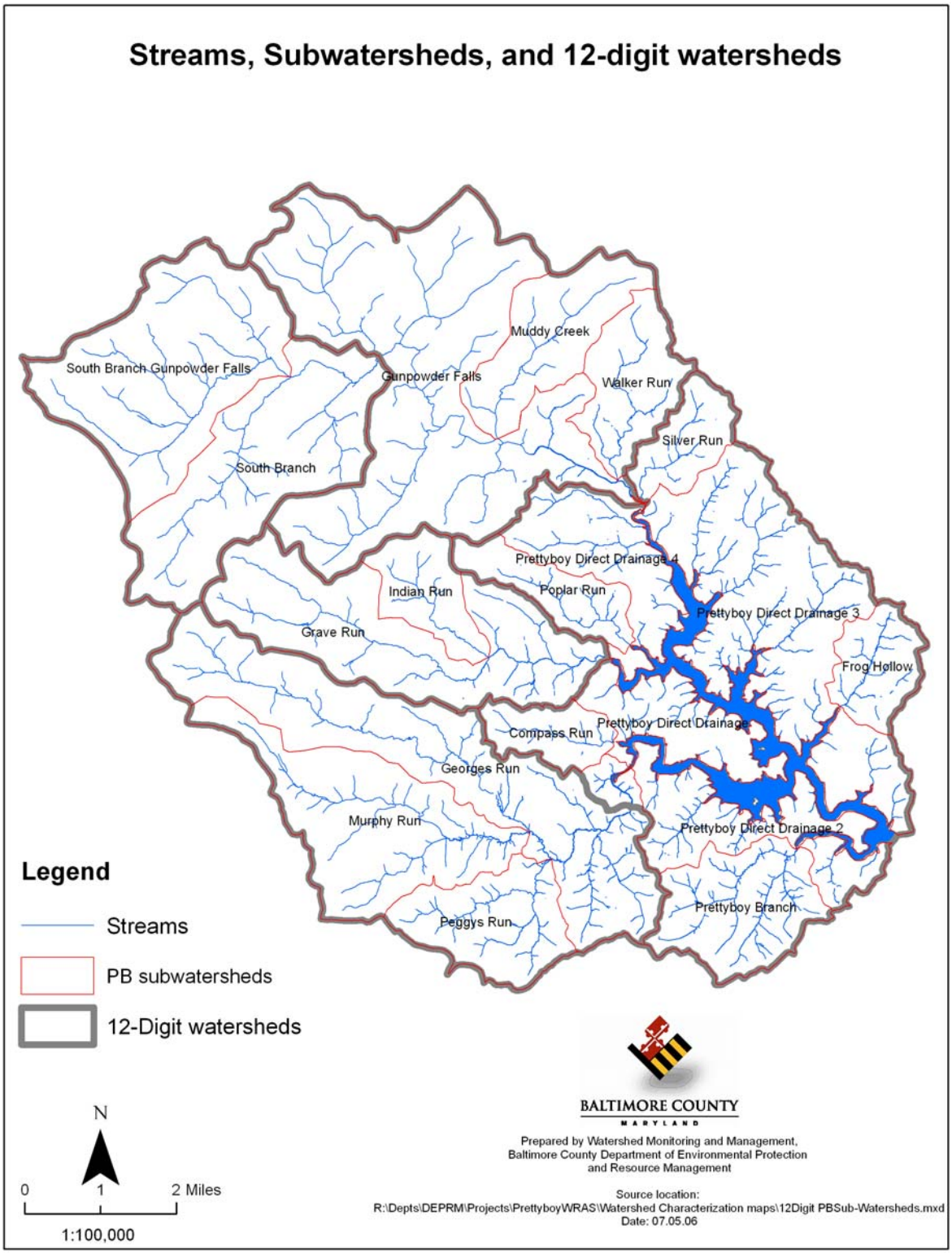

Figure 2-10. Prettyboy Reservoir Watershed Streams and Subwatersheds

Table 2-7: Prettyboy Reservoir Subwatershed Streams Mileage and Density

DNR 12-digit Scale	Subwatershed Scale	Entire Watershed		Baltimore County Portion only		
		Stream Miles	Stream Miles/Sq. Mile	% 1st Order	% 2nd Order	% 3rd Order and Higher
0313	Compass Run	4.6	3.8	45	28	27
	Frog Hollow	7.9	5.2	45	34	21
	Poplar Run	6.1	4.0	31	55	15
	Prettyboy Branch	23.4	7.8	45	30	25
	Prettyboy Direct Drainage 1	12.8	6.3	89	11	1
	Prettyboy Direct Drainage 2	19.0	6.7	67	26	6
	Prettyboy Direct Drainage 3	39.6	5.2	59	25	16
	Prettyboy Direct Drainage 4	15.6	5.8	36	50	14
	Silver Run	6.4	4.7	40	32	28
0313 Total		**135.4**	**5.7**			
0314	Georges Run	41.1	4.9	38	18	44
	Murphy Run	20.0	3.8	45	4	51
	Peggys Run	13.3	5.1	50	36	14
0314 Total		**74.4**	**4.6**			
0315	Grave Run	22.0	3.6	39	11	51
	Indian Run	4.1	2.6	0	0	100
0315 Total		**26.2**	**3.4**			
0316	Gunpowder Falls	36.2	2.9	21	15	64
	Muddy Creek	7.4	2.7	100	0	0
	Walker Run	9.6	4.3	35	39	26
0316 Total		**53.2**	**3.0**			
0317	South Branch	16.0	2.5			
	South Branch Gunpowder Falls	9.6	2.4			
0317 Total		**25.7**	**2.1**			
Prettyboy Watershed Total		***314.5***				

2.2.7.2 Stream Riparian Buffers

Forested buffer areas along streams play a crucial role in increasing water quality, reducing surface runoff, stabilizing stream banks, trapping sediment, mitigating floods, and providing the required habitat for all types of stream life, including fish. Tree roots capture and remove pollutants, including excess nutrients from shallow flowing water, and their structure helps prevent erosion and slow down water flow, thereby reducing sediment load and the risk of flooding. Shading from the tree canopy provides the cooler water temperatures necessary for much stream life, especially cold-water species like trout. In smaller streams, such as those surveyed, terrestrial plant material falling into the stream is the primary source of plant food for stream life. Tree leaves provide seasonal food, in the form of leaves and plant parts for stream life at the base of the food chain, while fallen tree branches and trunks provide a more consistent, slow-release food source throughout the year. Tree roots and snags also provide important habitat for fish and other aquatic species. Maintaining healthy streams and forest buffers are important to reducing the nutrient and sediment loadings to the reservoirs and other sensitive waters. When stream buffers are converted from forests to agriculture or to open residential development, many of these benefits are lost, and the stream health declines.

The vegetative condition of the riparian buffer based on 100 feet of buffer on either side of the stream was analyzed by subwatershed. Two conditions were identified, either forested or not forested. Figure 2-11 shows the results of the buffer analysis in the Maryland portion of the watershed. Data was not available for the Pennsylvania portion of the watershed.

Table 2-8 displays the acres of forested buffer, unforested buffer, total buffer acres, and the percent of the 100 foot buffer (on each side of the stream) that is forested.

Table 2-8: Prettyboy Reservoir Subwatershed Riparian Buffer Condition

DNR 12-Digit	Subwatershed	Forested BufferAcres	Unforested Buffer Acres	Total Buffer Acres	% Forested
0313	Compass Run	50.9	32.5	83.4	61.0
	Frog Hollow	105.2	28.6	133.8	78.6
	Poplar Run	78.6	35.0	113.6	69.2
	Prettyboy Branch	136.9	208.2	345.1	39.7
	Prettyboy Direct Drainage 1	114.1	11.4	125.5	90.9
	Prettyboy Direct Drainage 2	175.4	60.6	236.0	74.3
	Prettyboy Direct Drainage 3	542.7	110.3	653.0	83.1
	Prettyboy Direct Drainage 4	132.2	76.4	208.6	63.4
	Silver Run	52.8	40.2	93.0	56.8
0313 Total		**1,388.8**	**603.2**	**1992.0**	**69.7**
0314	Georges Run	325.5	402.5	728.0	44.7
	Murphy Run	150.5	230.8	381.3	39.5
	Peggys Run	65.0	167.5	232.5	28.0
0314 Total		**541**	**800.8**	**1,341.8**	**40.3**
0315	Grave Run	234.7	170.0	404.7	58.0
	Indian Run	67.8	32.5	100.3	67.6
0315 Total		**302.5**	**202.5**	**505.0**	**59.9**
0316	Gunpowder Falls	295.9	262.3	558.2	53.0
	Muddy Creek	46.6	64.4	111.0	42.0
	Walker Run	96.9	44.2	141.1	68.7
0316 Total		**439.4**	**370.9**	**810.3**	**54.2**
0317	South Branch	132.8	194.2	327.0	40.6
	South Branch Gunpowder Falls	88.8	236.0	324.8	27.3
0317 Total		**221.6**	**430.2**	**651.8**	**34.0**
Prettyboy Watershed Total		***2,892.7***	***2,407.6***	***5,300.9***	***54.6***

The percentage of the riparian buffer that is forested ranges from a high of 90.9% (Prettyboy Direct Drainage 1 to a low of 27.3% (South Branch Gunpowder Falls). The area to the north of the Prettyboy Reservoir generally had higher percentages of forested buffer, while the area to the south and west of the reservoir had lower percentages of forested buffer.

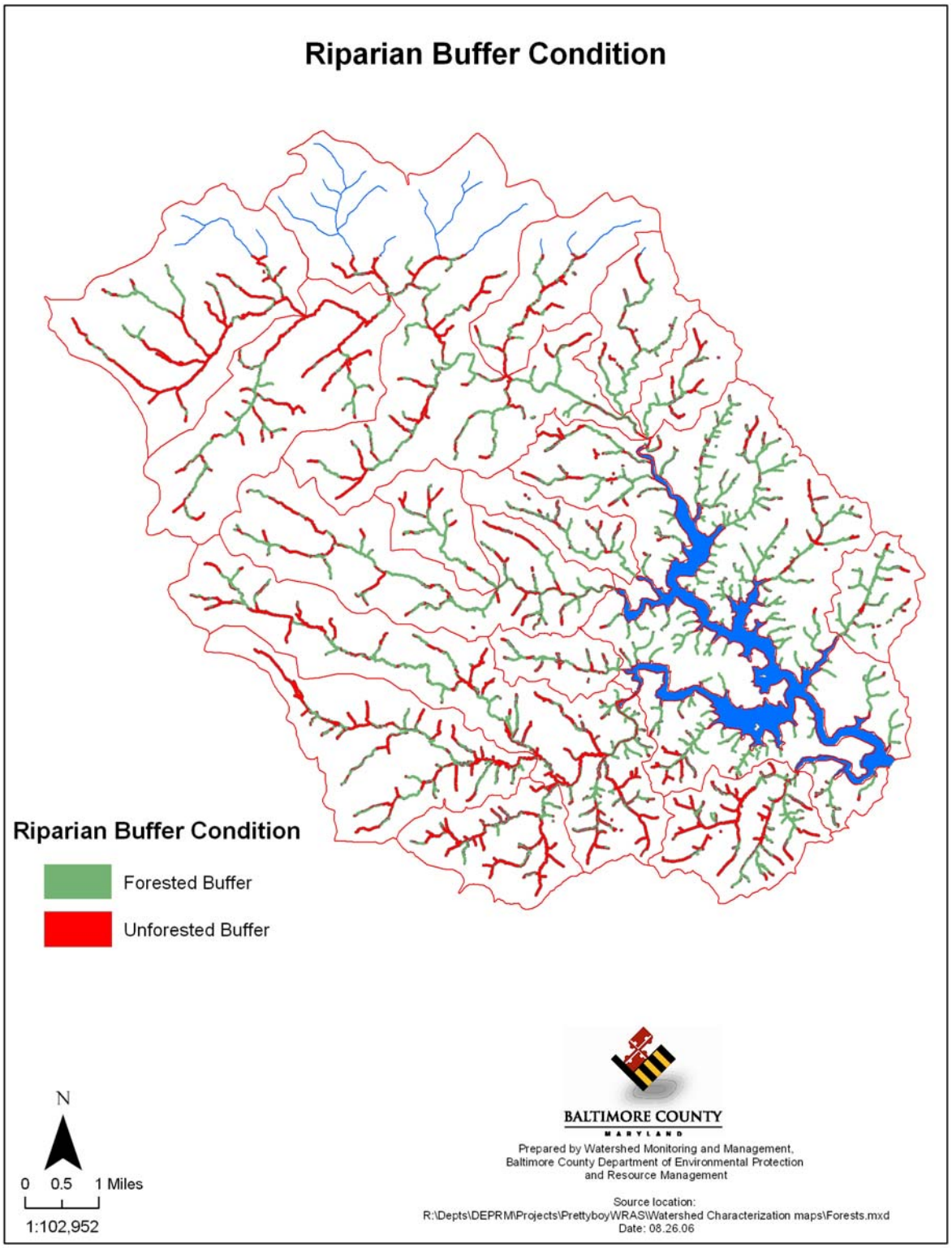

Figure 2-11. Riparian Buffer Condition

2.3 The Human Modified Landscape

The natural landscape has been modified for human use over time. The intensity of this modification has increased, starting with the colonization of Maryland in the 1600s. This modification has resulted in environmental impacts to both the terrestrial and aquatic ecosystems. This section will provide a characterization of the human modified landscape and will explain how that modification is associated with impacts on the natural ecosystem. The characterization will progress from the general characteristics of land use and land cover to specific human impacts including impervious cover, drinking water and wastewater, storm water systems, discharge permits, zoning, and build-out analysis.

2.3.1 Land Use and Land Cover

Based on MDP 2002 GIS land use data, the Baltimore County portion of the Prettyboy Reservoir watershed has 1,502 acres of open water (Prettyboy Reservoir) and 24,102 acres of land. The land acres are divided as follows: urban 2,563 acres (11%), agriculture 9,854 acres (41%), forest 11,632 acres (48%), wetlands 48 acres (<1%) and barren land 6 acres (<1%). Since estimates of wetland acreage based on this MDP data are often underestimated, DNR wetland estimates, as presented earlier in this document, should be used instead.

In comparison, the Carroll County portion of the watershed has 5 acres of open water and 20,816 acres of land. The land acres are divided as follows: urban 4,374 acres (21%), agriculture 11,121 acres (53%), and forest 5,320 acres (26%).

Prettyboy Reservoir is owned by the Baltimore City Department of Public Works. It is surrounded by a park, allows fishing (including fish stocking), and has a boat launch. The Prettyboy Reservoir serves as a holding water reservoir that supplements the capacity of Loch Raven reservoir. Loch Raven reservoir in turn supplies water to Baltimore City and four adjacent counties (Baltimore, Harford, Anne Arundel, and Howard). Gunpowder Falls State Park is located along the stream valleys of Big and Little Gunpowder Falls.

Since the reservoirs Loch Raven and Prettyboy supply water to the city and surrounding jurisdictions, during the dry season these reservoirs reduce the water flow into the Big Gunpowder, negatively impacting the aquatic resources and recreational opportunities on the river (DNR, 1983). The impact of reduced dry-weather water flows from the Prettyboy Reservoir is reduced through cold-water release from the middle depth of the reservoir to support the downstream trout populations.

Land use has pronounced impacts on water quality and habitat. A forested watershed diminishes erosion, absorbs nutrients and slows the flow of water into streams. Agricultural land, if not properly managed, can cause substantial increases in nutrients and coliform bacteria in streams. Roads, parking areas, and roofs are collectively called impervious surface. Impervious surfaces block the natural seepage of rain into the ground. Unlike many natural surfaces, impervious surfaces typically concentrate stormwater runoff, accelerate flow rates, and direct stormwater to the nearest stream. This can cause bank erosion and destruction of in-stream and riparian habitat. Watersheds with small amounts of impervious surface tend to have better water quality in local streams than watersheds with greater amounts of impervious surface.

The map of land use in the Maryland portion of Prettyboy Reservoir watershed is presented in Figure 2-12 and the data are summarized in Table 2-9. Because this information comes from the MD Department of Planning (MDP), no data are shown for Pennsylvania. Additionally, the

classifications for Baltimore and Carroll Counties were done separately, accounting for the apparent incongruity of land use between the two counties. The data are based on the MDP 2002 land use GIS data layer.

Table 2-9: Prettyboy Reservoir Watershed Land Use (Excluding York County)

DNR 12-digit Scale	Subwatershed Scale	Low Density Residential	All Other Urban	Cropland	All Other Agriculture	Forest and Wetlands
0313	Compass Run	25%	0%	46%	4%	25%
	Poplar Run	20%	0%	19%	20%	41%
	Silver Run	3%	0%	44%	9%	44%
	Frog Hollow	19%	0%	26%	6%	48%
	Prettyboy Branch	8%	0%	56%	14%	21%
	Prettyboy Direct Drainage 1	3%	0%	1%	2%	94%
	Prettyboy Direct Drainage 2	10%	0%	24%	1%	66%
	Prettyboy Direct Drainage 3	6%	0%	23%	4%	66%
	Prettyboy Direct Drainage 4	4%	0%	30%	8%	58%
0313 Total		**9%**	**0%**	**28%**	**7%**	**56%**
0314	Georges Run	11%	5%	50%	12%	22%
	Murphy Run	20%	10%	43%	5%	22%
	Peggys Run	5%	0%	72%	8%	13%
0314 Total		**13%**	**6%**	**51%**	**9%**	**20%**
0315	Grave Run	11%	1%	32%	20%	36%
	Indian Run	10%	0%	1%	61%	28%
0315 Total		**11%**	**1%**	**25%**	**29%**	**35%**
0316	Gunpowder Falls	10%	1%	38%	13%	37%
	Muddy Creek	8%	0%	51%	9%	32%
	Walker Run	10%	0%	43%	0%	46%
0316 Total		**10%**	**1%**	**41%**	**10%**	**38%**
0317	South Branch	15%	5%	48%	8%	23%
	South Branch Gunpowder Falls	10%	2%	48%	12%	28%
0317 Total		**13%**	**3%**	**48%**	**10%**	**26%**
Prettyboy Watershed Percentages		***11%***	***2%***	***39%***	***11%***	***38%***

Urban/suburban development accounts for 13% of the land use in the Maryland portion of the Prettyboy Reservoir watershed, with the majority (11%) in low-density residential land use (>1 acre). MDP identifies 50% of the Prettyboy Reservoir watershed as agricultural land uses. Cropland accounts for 39%, while pasture, orchards, and farm facilities cover 11%. Forest is the second largest land cover with 38%.

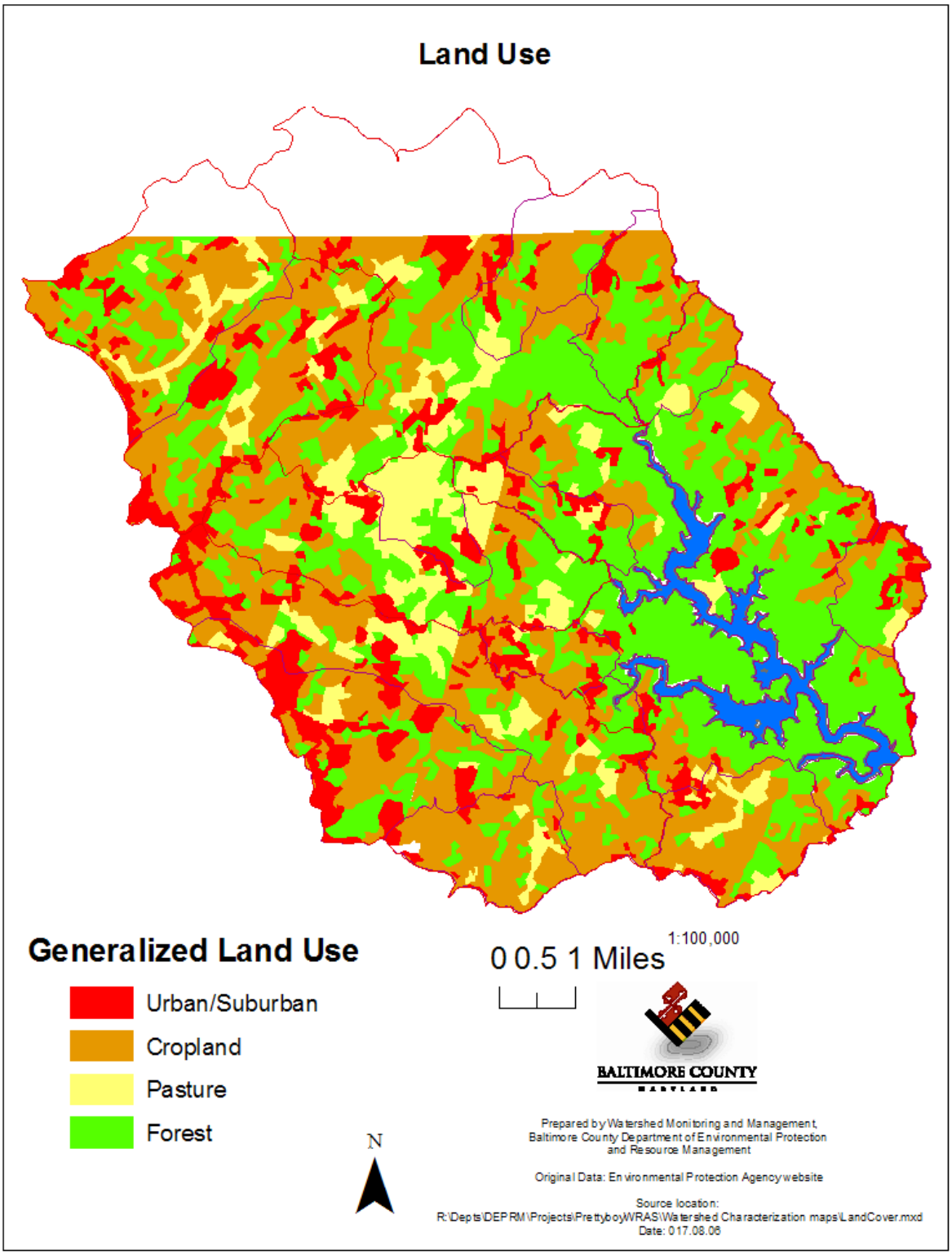

Figure 2-12. Land Use in the Maryland Portion of the Prettyboy Reservoir watershed.

2.3.2 Land use adjacent to streams

Figure 2-13 shows the general land use adjacent to the streams in the Prettyboy Reservoir watershed using GIS. This method of assessing land use at the stream's edge can be used in the absence of field data collected by stream corridor assessment. The data are summarized in Table 2-10. The categories of low-density residential, other urban, cropland, other agricultural land use, and forest and wetlands were used for this analysis.

Forested riparian buffers provide many ecological functions and environmental services. Among the services are reduction of nutrients and sediment pollution through filtering, uptake, and providing carbon sources for denitrification. Ecologically, the riparian forest provides the food source for the stream macroinvertebrates that in turn support the fish community. In addition, the riparian forest provides valuable habitat both for the terrestrial community and the aquatic community.

Table 2- 10: Land Use in the 100 Foot Riparian Buffer – Acres (%)

DNR 12-digit Scale	Subwatershed Scale	Low Density Residential	All Other Urban	Cropland	All Other Agriculture	Forest and Wetlands	Total
0313	Compass Run	9 (11)	0 (0)	29 (35)	3 (4)	42 (51)	83
	Poplar Run	8 (7)	0 (0)	27 (24)	10 (9)	68 (60)	113
	Silver Run	0 (0)	0 (0)	48 (45)	9 (8)	50 (47)	107
	Frog Hollow	8 (6)	0 (0)	17 (13)	1 (1)	109 (81)	135
	Prettyboy Branch	9 (3)	0 (0)	158 (46)	63 (18)	114 (33)	344
	Prettyboy Direct Drainage 1	3 (2)	0 (0)	1 (1)	2 (1)	119 (95)	125
	Prettyboy Direct Drainage 2	18 (7)	0 (0)	117 (45)	2 (1)	126 (48)	263
	Prettyboy Direct Drainage 3	18 (2)	0 (0)	383 (40)	36 (4)	520 (54)	955
	Prettyboy Direct Drainage 4	4 (2)	0 (0)	110 (40)	19 (7)	139 (51)	272
0313 Total		**77 (3)**	**0 (0)**	**890 (38)**	**145 (6)**	**1,287 (53)**	**2,397**
0314	Georges Run	27 (4)	9 (1)	282 (39)	118 (16)	293 (40)	729
	Murphy Run	53 (14)	28 (7)	101 (27)	21 (6)	178 (47)	381
	Peggys Run	0 (0)	0 (0)	134 (59)	35 (15)	60 (26)	229
0314 Total		**80 (6)**	**37(3)**	**517 (39)**	**174 (13)**	**531 (40)**	**1,339**
0315	Grave Run	5 (1)	1 (0)	88 (22)	71 (18)	241 (59)	406
	Indian Run	1 (1)	0 (0)	0 (0)	47 (47)	52 (52)	100
0315 Total		**6 (1)**	**1 (0)**	**88 (17)**	**118 (23)**	**293 (58)**	**506**
0316	Gunpowder Falls	18 (3)	1 (0)	149 (27)	105 (19)	271 (50)	544
	Muddy Creek	6 (5)	0 (0)	54 (48)	13 (12)	39 (35)	112
	Walker Run	0 (0)	0 (0)	87 (46)	0 (0)	101 (54)	188
0316 Total		**24 (3)**	**1 (0)**	**290 (34)**	**118 (14)**	**411 (49)**	**844**
0317	South Branch	30 (9)	2 (1)	120 (36)	52 (16)	131 (39)	335
	South Branch Gunpowder Falls	5 (2)	6 (2)	99 (30)	127 (38)	100 (30)	337
0317 Total		**32 (5)**	**8 (1)**	**219 (33)**	**179 (27)**	**231 (34)**	**672**
Prettyboy Reservoir WatershedTotals		***222 (4)***	***47 (1)***	***2,041(35)***	***734 (13)***	***2,752(48)***	***5,796***

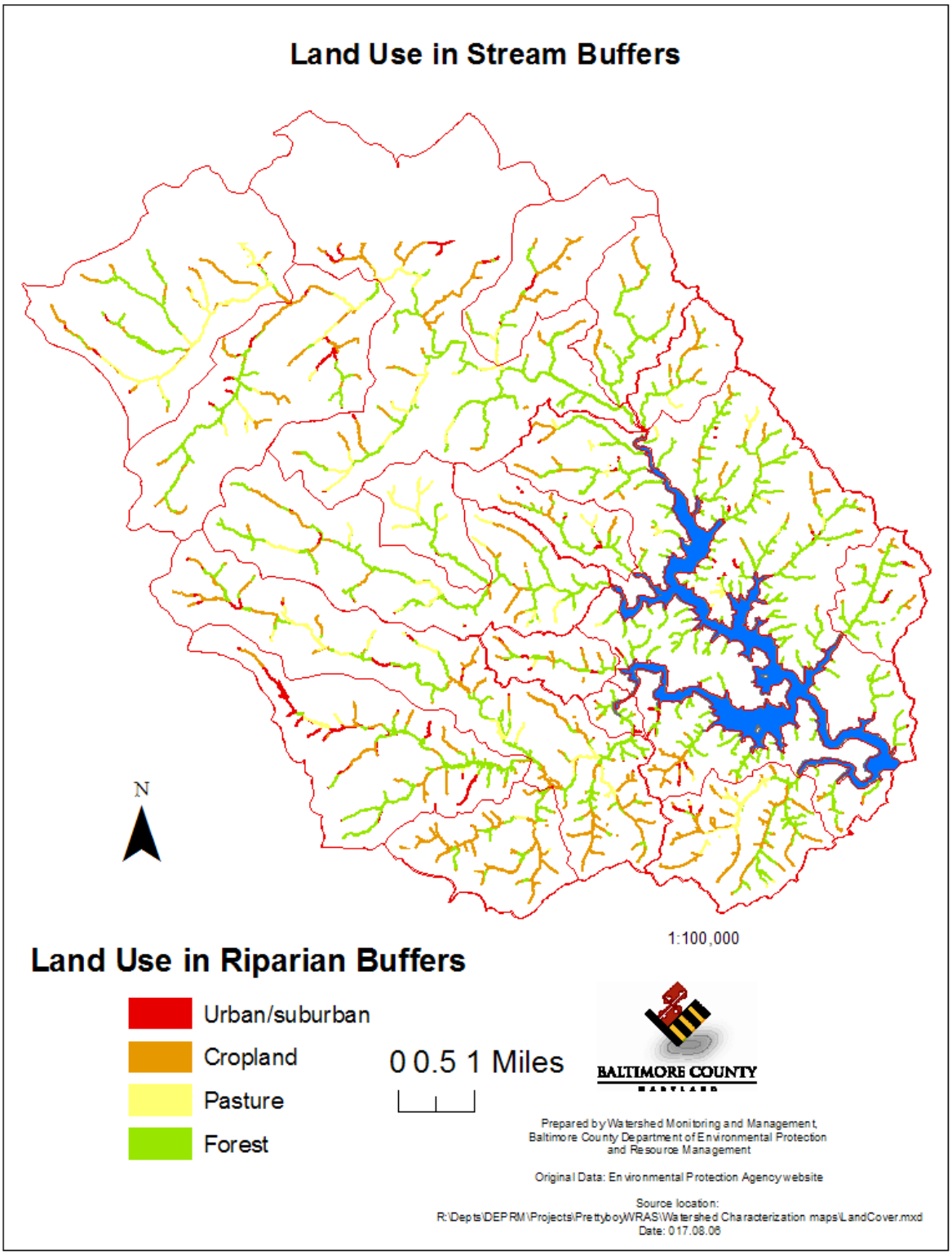

Figure 2-13: Land Use Within the 100 Foot Riparian Buffer

Of the 5,796 acres of riparian buffer, 48% are either forested or in wetland land cover. Urban development has 269 acres of riparian buffer that is not forested, while agriculture has a total of 2,775 acres of unforested riparian buffer. This unforested acreage represents an opportunity for restoration, particularly the urban acres. Reforestation of riparian buffers on cropland (2,041 acres), while desirable, has the potential for negative impacts on agricultural production due to shading of croplands, drawdown of the water table, and providing a haven for pests, including deer.

2.3.3 Impervious Surfaces

Roads, parking areas, roofs and other human constructions are collectively called impervious surfaces. Impervious surfaces block the natural seepage of rain into the ground. Unlike many natural surfaces, impervious surfaces typically concentrate stormwater runoff, accelerate flow rates and direct stormwater to the nearest stream. Watersheds with small amounts of impervious surface tend to have better water quality in local streams than watersheds with greater amounts of impervious surface. Some aquatic species, e.g. brook trout, tend to disappear when the proportion of impervious area in the watershed reaches some threshold level. While this level varies by species, it can be quite low. For example, brook trout decline when the impervious cover reaches 0.5-3% of the total watershed area and are completely extinguished when it reaches 3-5%; the exact level of impervious area that can be tolerated depends partly on the watershed, and remains a topic of discussion among fisheries experts. Other species, e.g. macro-invertebrates, are also negatively impacted by increases in the impervious area, though the pertinent knowledge is often incomplete.

To derive estimates of impervious surface acreages in Prettyboy, two methods were used. First, Baltimore County has digitized the entire 'footprint' of impervious surfaces by interpreting aerial photographs from 1997. This gives a highly accurate estimation for Baltimore County in that year. Since this footprint does not exist for the other portions of the watershed (Carroll and York Counties), a second method using land use categories was used. Because land use correlates closely with the area of impervious surface, the ratios of impervious to total area for each land use category can be assumed to be constant throughout the watershed. We estimated these ratios based on the impervious footprint of Baltimore County, and then applied them to Carroll County. Because land use classification was not available for York County, impervious surface could only be estimated using this method for the MD portion of the watershed.

Because certain land uses that occur in the Prettyboy Reservoir watershed are not represented in the Baltimore County portion of the watershed, or are present only to a very limited extent, a ratio of impervious to total acreage could not be derived for them. Instead, the broadly similar Loch Raven watershed, where these land uses are present, was used to derive the pertinent percentages.

The percentages derived from this analysis were then applied to the land uses in the Carroll County portion of the Prettyboy Reservoir watershed to estimate the impervious area for the MD portion of the watershed. The estimated percent impervious by land use type and the impervious acres in Carroll County are presented in Table 2-11.

Table 2-11: Impervious Surface Estimates for Carroll County

Land Use Code	Land Use Description	% Impervious	Acres	Acres Impervious
11	Low Density Residential	6.5	2,978	193.6
12	Medium Density Residential	12.0	612	73.4
13	High Density Residential	29.8	60	17.9

Land Use Code	Land Use Description	% Impervious	Acres	Acres Impervious
14	Commercial	37.9	90	34.2
16	Institutional	26.1	39	10.2
18	Open Urban	7.1	180	12.8
21	Cropland	2.2	8,325	183.1
22	Pasture	2.4	3,322	79.7
41 – 44	Forest	1.0	5,371	53.5
241	Ag Buildings	16.4	52	8.5
242	Ag Operations	16.4	27	4.4
Carroll County Total			**21,056**	**671.3**

Table 2-12 shows the impervious cover and the calculated percent impervious by subwatershed for the Maryland portion of the Prettyboy Reservoir watershed. The total amount of impervious surface in the MD portion of the watershed is estimated to be 1,241 acres or 2.5% of the watershed area. Compared to more urban watersheds in Baltimore County, this is a relatively low level of imperviousness, but in terms of sensitive species, such as brook trout the level of imperviousness is either approaching the survival threshold or has already exceeded that level.

Table 2-12: Estimated Impervious Surface in the Maryland portion of the watershed

DNR 12-digit Scale	Subwatershed Scale	Acres	Percent Impervious	Acres Impervious
0313	Compass Run	768	3.0	23.0
	Poplar Run	982	2.5	24.6
	Silver Run	867	2.6	22.5
	Frog Hollow	975	2.3	22.4
	Prettyboy Branch	1,927	1.0	19.3
	Prettyboy Direct Drainage 1	1,300	1.8	23.4
	Prettyboy Direct Drainage 2	1,821	1.7	31.0
	Prettyboy Direct Drainage 3	4,906	1.7	83.4
	Prettyboy Direct Drainage 4	1,711	1.8	30.8
0313 Total		**15,257**	**1.9**	**289.9**
0314	Georges Run	5,357	3.2	171.4
	Murphy Run	3,333	4.2	140.0
	Peggys Run	1,679	2.4	40.3
0314 Total		**10,369**	**3.4**	**352.5**
0315	Grave Run	3,896	2.4	93.5
	Indian Run	1,012	2.4	24.3
0315 Total		**4,908**	**2.4**	**117.8**
0316	Gunpowder Falls	8,032	2.4	192.8
	Muddy Creek	1,782	2.2	39.2
	Walker Run	1,460	2.1	30.7
0316 Total		**11,274**	**2.3**	**259.3**
0317	South Branch	3,643	3.3	120.2
	South Branch Gunpowder Falls	4,190	2.7	113.1
0317 Total		**7,833**	**3.0**	**235.0**
Prettyboy Watershed Total		**49,641**	**2.5**	**1,241**

2.3.4 Drinking Water

Drinking water is a fundamental need for human development. Drinking water can be supplied by either public distribution systems or by wells associated with individual developed properties.

Having an adequate supply of drinking water is essential to supporting the human population and livestock in a given area.

2.3.4.1 Public Water Supply

The Prettyboy Reservoir serves as a holding reservoir for the public drinking water system managed by Baltimore City, which systemwide supplies drinking water for 1.8 million people. None of the water from the Prettyboy Reservoir serves residents of the Prettyboy Reservoir watershed. Within Carroll County, public drinking water is supplied by the towns of Hampstead and Manchester, located on the southwestern ridge that represents the topographic watershed divide. This water is derived from community wells located in the Prettyboy, Patapsco, and Double Pipe watersheds, where it is treated and then piped throughout the towns. Hampstead provides water to about 6,300 residents and Manchester provides water to about 4,400 residents.

Environmental impacts associated with a public supply of water include the potential for residential development at higher densities with the resulting impacts associated with impervious cover (see 2.3.2) and the potential for leaks from the system. Leaks from public water supply systems introduce chlorine into the local aquatic systems, potentially resulting in the death of aquatic organisms. In addition, major leaks may cause erosion and introduction sediment into the stream channels, which may bury aquatic benthic communities and degrade habitat.

2.3.4.2 Private Well Supply

The majority of property owners in the Prettyboy Reservoir Watershed derive their drinking water from private wells on their individual lots. The geology underlying the Prettyboy Reservoir watershed consists mainly of crystalline metamorphic rock (2.2.3). The water in these wells is derived exclusively from an unconfined aquifer where surface water passes down through overlying soil and into the bedrock fractures that are assessed by the wells' bore hole. The source of the water is, therefore, locally derived and impacts on the water quality will be associated with local factors. This is in contrast to wells that draw their water from confined aquifers, where the source of the water may be located many miles from where it is used.

Water quality in domestic wells on individual properties is influenced by and dependent on, activities onsite, and on adjacent properties, that may introduce contaminants to the unconfined aquifer supplying the wells. Some wells sampled in Baltimore County portion of the watershed have higher levels of nitrate than normal (see subsection 3.3.3.2). The federal limit for nitrates in drinking water is 10 mg/L. Levels above this have been associated with what is called the blue baby syndrome (methemoglobinemia). In this disorder nitrates inhibit the ability of the hemoglobin molecule to carry oxygen to the organs of the body. Pregnant women and infants under the age of six months must not sonsume water with high levels of nitrates.

2.3.5 Wastewater

Wastewater created through human use must be treated and disposed. This may be accomplished in two ways, either through on-site individual wastewater treatment systems (septic systems) or through public conveyance to a municipal wastewater treatment plant. Residential wastewater consists of all of the water that is typically used by residents, including wash water, bathing water, human waste, and any other rinse water (paint brush, floor washing, etc). Industrial operations must also dispose of any water used as part of their operation. Depending on the operation, the water could contain any number of contaminants, including

metals, organic compounds, detergents, and other synthetic compounds. All of these wastes have the potential to harm the natural environment.

2.3.5.1 On-Site Wastewater Disposal Systems

On-site wastewater disposal systems are the main type of wastewater treatment in the Prettyboy Reservoir watershed. There are ~1,500 septic systems in the Baltimore County portion of the watershed and ~2,600 on-site wastewater disposal systems in the Carroll County portion. Properly functioning on-site wastewater disposal systems provide treatment for virtually all of the phosphorus, but they leak nitrogen in the form of nitrates. Depending on the location of the system, some of the nitrates may either be reduced or eliminated through denitrification as the groundwater passes through riparian buffers, particularly forested riparian buffers. Failing systems can result in increased contamination of the aquatic environment and groundwater resources through increased releases of nitrogen, phosphorus, and other chemicals. They can also result in increased bacterial contamination of the waterways and have the potential for human health concerns.

2.3.5.2 Public Sewers

A public sewer system conveys wastewater from individual residences or businesses to a facility that treats the wastewater prior to discharge. The system itself consists of the building sewer and cleanouts on individually owned properties. The individual landowner is responsible for the maintenance of this part of the system. The part of the system that is in the public right-of-way is owned and maintained by the local government. The public system consists of the gravity piping system, access manholes, pumping stations, and force mains.

Environmental impacts associated with the public sewer system are usually the result of sewage overflows. These overflows usually result from blockages within the sewage system, pumping station failures, infiltration or exfiltration of sewage effluent due to sewer line deterioration/failure. The environmental impacts themselves include high Biological Oxygen Demand, nutrients, bacteria, and turbidity.

2.3.5.3 Waste Water Treatment Facilities

In the Prettyboy Reservoir watershed there is only one municipal wastewater treatment plant (WWTP). This WWTP treats sanitary sewer effluent from the Town of Manchester and from April 1 through November 30 uses spray irrigation on the land for treatment in the headwaters of Georges Run. The design flow for the Manchester WWTP is .5 million gallons per day. The portion of the Prettyboy Reservoir watershed that is within the Town of Hampstead is served by sanitary sewer that discharge to the Hampstead WWTP, which in turn discharges to the Piney Run stream in the Loch Raven Reservoir watershed.

The spray irrigation and subsequent growth of vegetation provides for uptake of nutrients. The natural filtering ability of the soil results in the removal or attenuation of many constituents of sanitary sewer effluent. The Maryland Department of the Environment has estimated during the course of the development of a Total Maximum Daily Load (TMDL) for phosphorus that the Manchester WWTP contributes only 0.8% of the total annual phosphorus load in the Prettyboy Reservoir watershed with the majority coming from non-point sources.

2.3.6 Stormwater

Stormwater consists of the surface and shallow subsurface water that runs off during and immediately after storm events. Impervious surfaces placed in a watershed increase the amount of runoff that makes its way to the streams. Soil characteristics and slope as well as the amount and intensity of rainfall affect the amount of runoff water,. Stormwater can carry pollutants from impervious surfaces and agricultural operations into the streams. The increase in the amount of runoff due to impervious surfaces (high) and agricultural operations (moderate) typically results in stream erosion that destroys natural habitat and impairs natural ecological function of the stream.

2.3.6.1 Storm Drainage System

The storm drainage system consists of either curb and gutter, with associated inlets and piping system, or drainage swales. The function of either system is to remove water quickly from roadways to prevent flooding and other potentially hazardous situations. However, the environmental impact from the two types of systems is different. The curb and gutter system with inlets, piping and storm drain outfalls removes water quickly from impervious surfaces and routes that water to low spots in the topography, usually directly to the nearest stream. This type of system delivers not only increased volumes of water, but untreated pollutants associated with impervious surfaces. Drainage swales (road side ditches) do not move the water as efficiently as curb and gutter systems. Therefore, the water is slowed somewhat prior to entering the stream. The drainage swales also allow some infiltration into the soil, thus reducing the amount of water eventually delivered. The infiltration and the slower movement of water also provide some filtering of pollutants. The majority of the storm drainage systems within the Prettyboy Reservoir watershed fall into the drainage swale category.

2.3.6.2 Stormwater Management Facilities

Starting in the mid-1980s, stormwater management was required by Maryland Department of the Environment for new development to control the quantity of runoff. Within that initial set of regulations was an exemption for large-lot subdivisions (>2 acres). Large-lot subdivisions only had to provide stormwater management for roads. The State's stormwater management regulations evolved from the initial requirement for control of water quantity to including water quality control in the early 1990s. In 2000 a new stormwater design manual was released by MDE requiring additional water quality and quantity controls along with stormwater management for large-lot subdivisions.

There is a variety of types of stormwater management facilities that have different pollutant removal capabilities. The initial dry pond design for water quantity management has the lowest pollutant-removal efficiency, while those facilities that infiltrate or otherwise filter the water have among the highest pollutant-removal capabilities.

Figure 2-14 and Table 2-13 document the stormwater management facilities present in the Maryland portion of the watershed. Because these facilities are managed primarily by the counties, they are separated along these lines. The facility type, subwatershed location, and drainage area to the facility, if known, is displayed in Table 2-13.

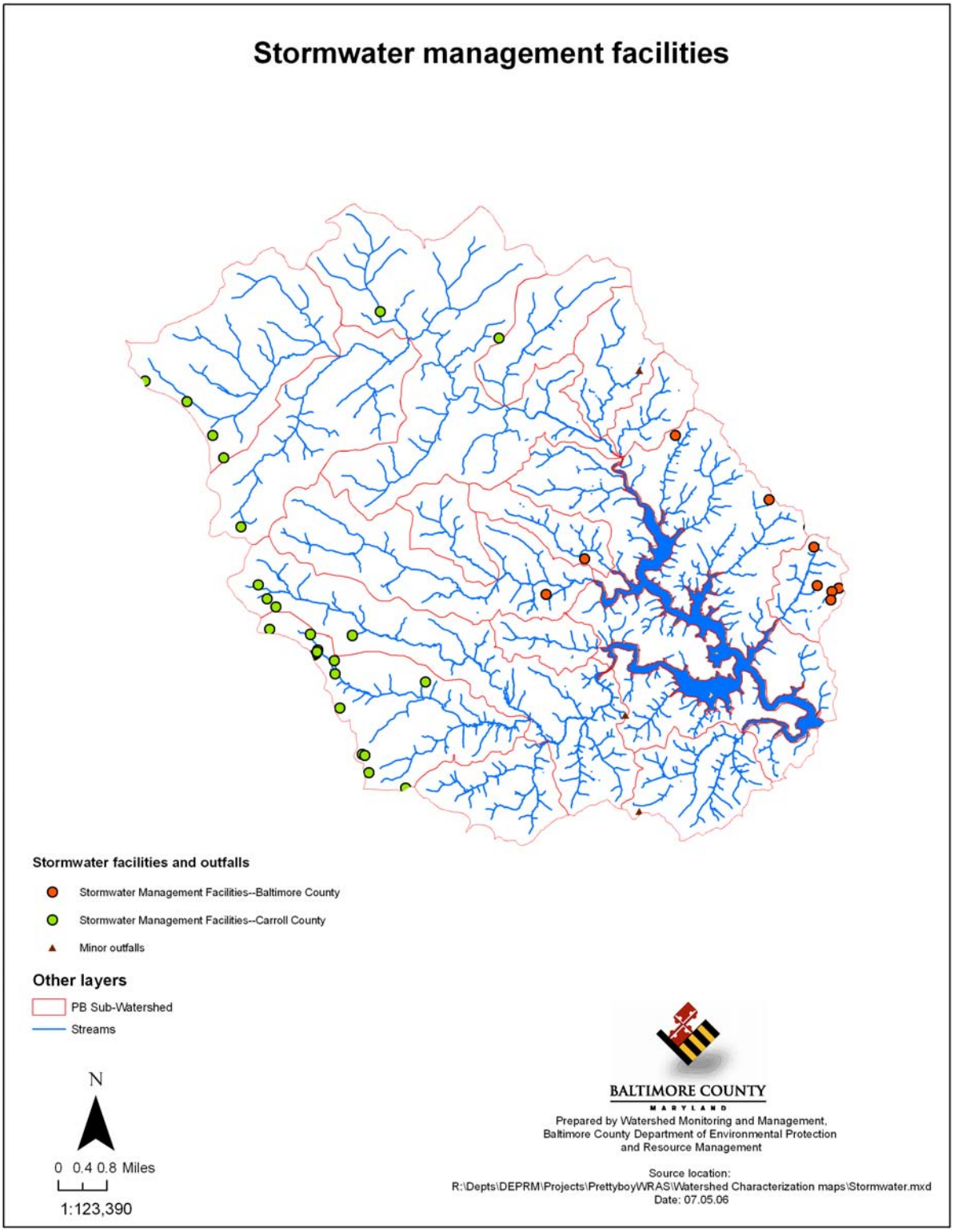

Figure 2-14. Stormwater Management

Table 2-13: Stormwater Management Facilities, Maryland

Baltimore County		
Subwatershed	**Type of Facility**	**Drainage Area (acres)**
Frog Hollow	Extended Detention Pond	12.00
Frog Hollow	Infiltration Trench	13.21
Frog Hollow	Extended Detention Pond	8.75
Frog Hollow	Extended Detention	9.00
Frog Hollow	Extended Detention	0.40
Frog Hollow	Swale	1.00
Grave Run	Extended Detention W/WQ Device	5.89
Direct Drainage 3	Sand Filter for WQ	13.48
Direct Drainage 3	Underground Sand Filter	0.52
Poplar Run	Pocket Sand Filter	3.60
Carroll County		
George's Run	Retention #1	27.76
George's Run	Dry-Infiltration Basins (2)	4.88
George's Run	WQ. Infiltration Trench	0.10
George's Run	Pond and Sand Filter (2 Facilities)	15.00
Gunpowder Falls	Infiltration Trench	1.46
Gunpowder Falls	Sand Filter	0.1
Murphy Run	Infiltration/Detention	12.2
Murphy Run	Retention #2	29.68
Murphy Run	Retention #3	30.20
Murphy Run	Dry-Detention Pond	5.33
Murphy Run	Wet-Infiltration Basin	1.42
Murphy Run	Infiltration Trench	0.62
Murphy Run	Dry-Detention	29.70
Murphy Run	Infiltration Basin	5.18
Murphy Run	Infiltration Detention Basin	23.03
Murphy Run	Dry Detention	1.44
Murphy Run	Infiltration Trench	0.62
Murphy Run	WQ. RV. UD Sone &Bioretention	29.70
Murphy Run	Shallow Marsh	5.18
Murphy Run	Filtration Basin	23.03
South Branch	Filtration/Detention	1.44
South Branch Gunpowder Falls	Shallow Marsh	0.45
South Branch Gunpowder Falls	Dry-Infiltration Trenches	2.54
South Branch Gunpowder Falls	Water Quality Filtration	20.05
South Branch Gunpowder Falls	Filtration Basin U. D.	0.50

An examination of Figure 2-14 indicates that the majority of stormwater management facilities in Carroll County are along the southern edge of the watershed. A total of 27 facilities are represented. These facilities, for the most part, are within the town boundaries of Manchester or Hampstead. Within Baltimore County, Figure 2-14 shows that 8 of the 10 facilities are located along the northern border of the watershed. These facilities serve residential developments along Middletown Road.

Table 2-13 reveals that the majority of the stormwater facilities are the types that are already providing the highest pollutant-removal efficiencies. Therefore, there is limited opportunity for converting existing stormwater facilities to more efficient designs.

2.3.7 NPDES Permits

Facilities that discharge municipal or industrial wastewater, or which conduct activities that can contribute pollutants to a waterway, are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit. Table 2-14 displays information on the ten permits that exist within the Prettyboy Reservoir watershed. One of the permits is for the Manchester WWTP, and two are stormwater discharge permits for the towns of Hampstead and Manchester. Two are commercial swimming pool discharge permits, one is for a commercial facility septic system, and the balance are associated with industrial stormwater discharges. This is a relatively small number of permits (there are over 500 in effect throughout Baltimore and Carroll Counties) and is reflective of the largely rural nature of the Prettyboy Reservoir watershed.

Table 2-14: NPDES Permits in Prettyboy Reservoir Watershed

Permit holder	Type of Permit	Subwatershed
Manchester Wastewater Treatment Plant	2G—Surface with spray option	Georges Run
J.C. Wilhelm, Inc	5SW—General Industrial Stormwater	Georges Run
Town of Manchester Municipal Separate Storm Sewer System Discharge Permit	6G—General (Municipal)	Georg's Run
Martin Construction, Inc	3—Industrial Groundwater	South Branch Gunpowder Falls
River Valley Ranch	4—Domestic Groundwater	Muddy Creek
River Valley Ranch	5—General (Swimming pool)	Muddy Creek
Baltimore County Bureau of Highways—Shop 4-2	5SW—General Industrial Stormwater	Direct Drainage 3
Lions Club Pool	5—General (Swimming pool)	Grave Run
Town of Hampstead Municipal Separate Storm Sewer System Discharge Permit	6G—General (Municipal)	Murphy Run

2.3.8 Zoning, Build-Out, and Priority Funding Areas

"Zoning is the legal mechanism by which county government is able, for the sake of protecting the public health, safety, morals, and/or general welfare, to limit an owner's right to use privately-owned land." (Baltimore County Office of Planning, 2003). Zoning therefore controls the development patterns that occur over time. Each of the three local jurisdictions (Baltimore County, Carroll County, and York County) have independently developed the zoning codes that are in place in the Prettyboy Reservoir watershed. The current zoning enacted by the three Counties is displayed in Figure 2-15. As can be seen from this figure, the majority (62.3%) of the zoning in the Prettyboy Reservoir watershed is for agricultural uses.

Build-out is the analysis of the number of residential units that could be built in a given area, based on the current zoning. Build-out looks at the existing development and, based on the density (allowable housing units), attempts to determine how many more residential units can be built in the future. This analysis is conducted to estimate the potential future impacts due to urban development.

Priority Funding Areas (PFAs) are existing communities and places where local governments want State funding to support future growth. The Priority Funding Areas concept is an out growth of the Marlyand 1997 "Smart Growth" Areas Act. In the Prettyboy Reservoir watershed, PFAs occur in Carroll County only.

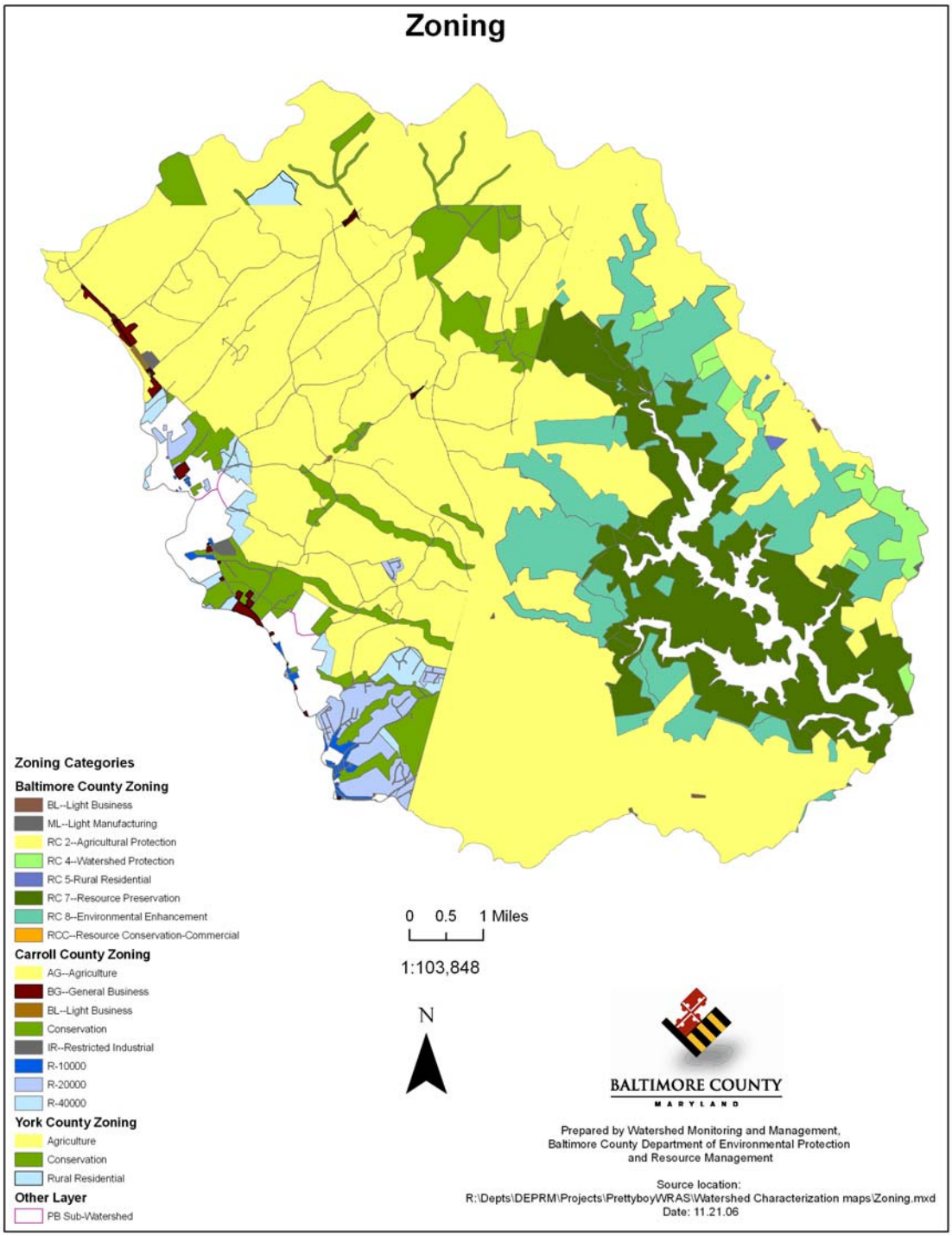

Figure 2-15. Zoning in the Prettyboy Reservoir watershed

Each local jurisdiction's zoning and build-out will be discussed separately.

2.3.8.1 Zoning and Build Out in Baltimore County

Baltimore County's portion of the Prettyboy Reservoir watershed contains more than 25,500 acres or about 50% of the total watershed area. Watershed land use/land cover are dominated by the Prettyboy Reservoir and the surrounding forested reservation owned by the City of Baltimore, and by a mosaic of mostly agricultural and low-density residential development. Characteristics described herein are derived from analysis of recent cadastral (property boundary) data and tax assessment data (through Spring 2006), as well as 2000 and 2004 zoning data, 2002 aerial photography, and digitized forest cover from 1995-1997 aerial photography.

Land Use and Tax Assessment of Parcels

Overall, Baltimore County's portion of the Prettyboy Reservoir watershed is comprised of about 14,360 acres of agriculturally-assessed parcels, (the predominant assessment class) at 56.2% of the watershed area. Residentially-assessed parcels total 4,610 acres or 18.0% of the watershed area. The remaining 6,576 acres or 25.8% of the watershed includes the expansive publicly-owned reservoir properties and small amounts of commercial, industrial, and other tax-exempt land. In Figure 2-16, the location of agriculturally- and residentially-assessed parcels in the Baltimore County portion is presented.

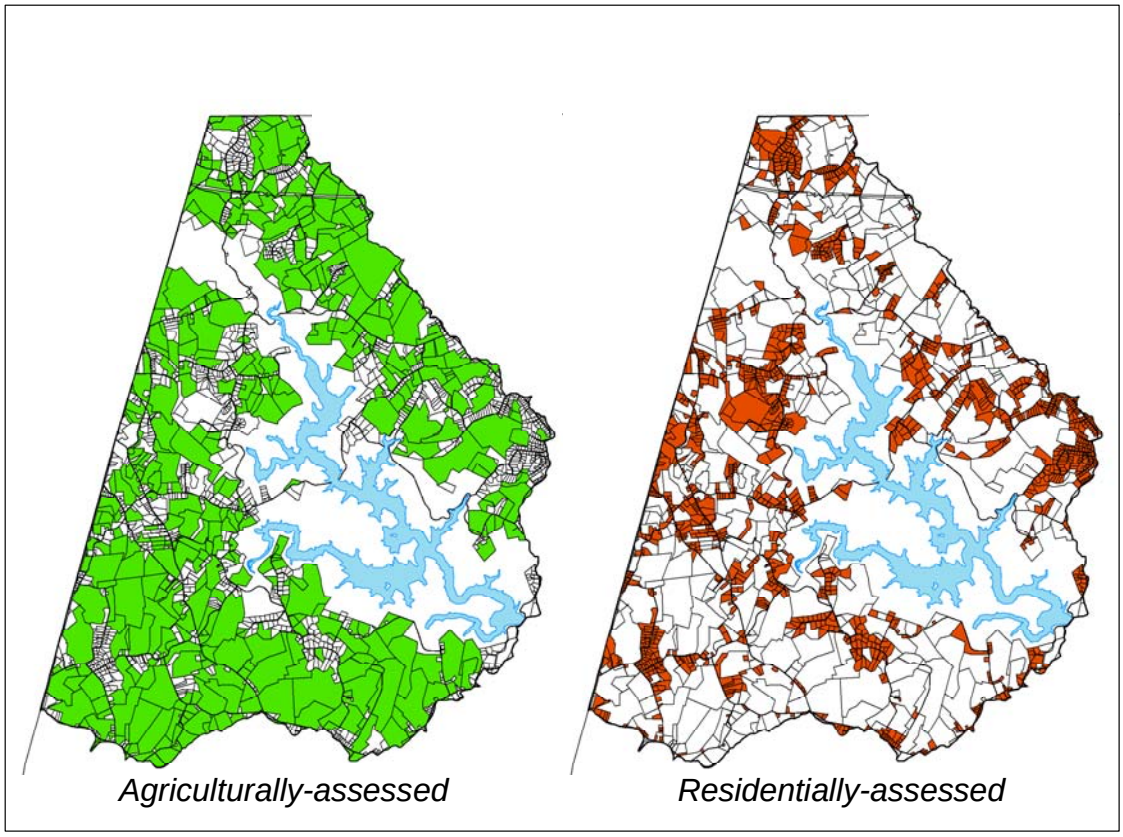

Figure 2-16: Agriculturally and Residentially Assessed Parcels in the Baltimore County Portion of the Prettyboy Reservoir Watershed

Historical Residential Development

Although the earliest farms and houses were established in the watershed in the late 1700's and land continued to be subdivided well before the construction of the reservoir in the early 1930's, the majority of existing residential units were constructed since the 1960's, due primarily to the

relative remoteness of the watershed, compared to the urban core of the County. Of the 1,567 existing houses built on land currently assessed for agriculture and residential uses, 1,283 or 82% are located on residentially-assessed parcels, and the remaining 284 or 18% are located on agriculturally-assessed parcels. Improved residentially-assessed parcels comprise only 3,720 acres or 25% of the 14,650 acres of improved parcels. Improved agriculturally-assessed parcels include larger farmsteads and crop, pasture, and forested areas. Only 319 or 20% of the total number of existing houses were built before 1950, including 169 on residentially-assessed parcels and 150 on agriculturally-assessed parcels. And of those 319, 180 or 56% were built between 1851 and 1900, considerably more than the number of houses built before 1850 or between 1900 and 1950. After 1950, the number of improved residential parcels increased rapidly until 1980, after which the pace of residential development declined, despite continuing thereafter at a significant pace.

In Table 2-15, the number of improved parcels is presented by multi-year increments, as well as the cumulative number of improved parcels. As discussed below, watershed zoning has influenced residential development trends in that lot sizes have generally increased over the years. The acreage of improved parcels and cumulative acreage converted are also presented in Table 2-15.

Table 2-15: Number and Acreage of Improved Parcels in the Prettyboy Reservoir Watershed

Years	Number of Improved Parcels				Improved RES Acres	
	RES	AGR	TOTAL	CUMUL	TOTAL	CUMUL
2001-2005	99	16	115	1,567	314.1	3,721.8
1996-2000	90	13	103	1,452	279.1	3,407.7
1991-1995	118	11	129	1,349	433.7	3,128.6
1986-1990	194	18	212	1,220	586.2	2,694.9
1981-1985	84	12	96	1,008	223.9	2,108.7
1976-1980	212	20	232	912	508.0	1,884.8
1971-1975	124	22	146	680	409.4	1,376.8
1966-1970	65	9	74	534	179.6	967.4
1961-1965	48	4	52	460	107.7	787.8
1956-1960	45	5	50	408	76.5	680.1
1951-1955	35	4	39	358	47.1	603.6
1946-1950	15	-	15	319	23.6	556.5
1941-1945	13	4	17	304	50.0	532.9
1936-1940	7	1	8	287	17.9	482.9
1831-1935	6	-	6	279	12.4	465.0
1926-1930	5	3	8	273	16.8	452.6
1921-1925	4	5	9	265	8.7	435.8
1916-1920	2	2	4	256	6.3	427.1
1901-1915	19	29	48	252	60.6	420.8
1851-1900	89	91	180	204	329.5	360.2
1801-1850	8	12	20	24	25.2	30.7
< 1800	1	3	4	4	5.5	5.5
Total	**1,283**	**284**	**1,567**		**3,721.8**	

Watershed Zoning

The Baltimore County portion of the Prettyboy Reservoir watershed is zoned extensively for Resource Conservation. Resource Conservation zoning is intended to protect the rural nature of the watershed. Table 2-16 provides a description of the Resource Conservation zoning

categories found in the Prettyboy Reservoir watershed, their purposes and the allowable residential densities.

Table 2-16: Baltimore County Resource Conservation Zoning Applicable to Prettyboy Reservoir Watershed

Zoning Category	Purpose	Density	Acres/Unit
RC 2	Foster and protect agriculture		50
RC 4	Protect drinking water	0.2	5
RC 5	Provide rural residential development	0.667	1
RC 7	Protect cultural, historical, recreational, and environmental resources	0.04	25
RC 8	Protect forests, reservoir watersheds, and extensive natural areas	.1 - .04	10 - 25

Baltimore County has a Comprehensive Rezoning cycle of four years. Within the Prettyboy Reservoir watershed, this has resulted in considerable down-zoning (less residential density) over the last several cycles. Figure 2-17 shows the changes in zoning between 2000 and 2004. Table 2-16 provides a breakdown of the zoning acres by zoning category and subwatershed after the 2004 Comprehensive Rezoning cycle.

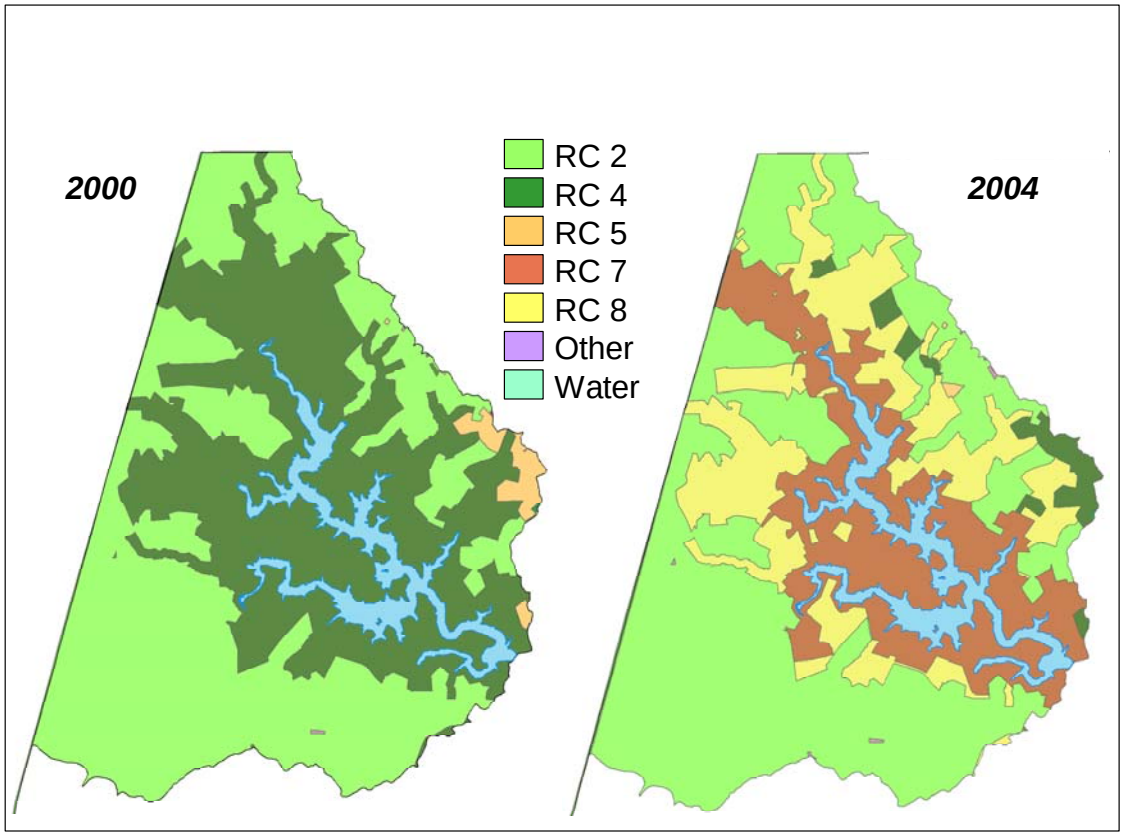

Figure 2-17: Prettyboy Reservoir Watershed Resource Conservation Zoning, 2000 and 2004

As can be seen from Table 2-17, there is a small amount of business local (BL) and light manufacturing (ML) totaling 17 acres throughout the Baltimore County portion of the watershed. The majority of the zoning (53%) is for agricultural protection (RC2). RC 7 accounts for approximately 23% of the land area in the Baltimore County portion of the Prettyboy Reservoir watershed. This zoning category has a very low density of one residential unit per 25 acres. As can be noted from Figure 2-15, most of the RC 7 zoned land is adjacent to the reservoir. This

land is owned by Baltimore City and will not be developed. RC8 zoning covers ~21% of the land and is located adjacent to the city-owned land and along stream valleys. Prior to the 2004 Comprehensive Rezoning cycle, most of this land was zoned as RC4. The RC8 zoning has a sliding density scale, based on the size of the parcel to be developed, as show below:

Number of Acres in Parcel	Number of Lots
1 to 10	1
10 to 30	2
30 to 50	3
51 acres or more	25 acres/lot

Table 2-17: Baltimore County Zoning (acres)

DNR 12-digit Scale	Subwatershed Scale	Zoning Category						
		BL	ML	RC 2	RC 4	RC 5	RC 7	RC 8
0313	Compass Run	0	0	494	0	0	20	254
	Frog Hollow	0	4	212	337	0	67	354
	Poplar Run	0	0	313	0	0	38	427
	Prettyboy Branch	6	0	1,748	0	0	53	120
	Prettyboy Direct Drainage 1	0	0	0	0	0	1,157	143
	Prettyboy Direct Drainage 2	0	0	480	0	0	961	380
	Prettyboy Direct Drainage 3	7	0	1,538	260	25	1,796	1,281
	Prettyboy Direct Drainage 4	0	0	805	0	0	609	289
	Silver Run	0	0	228	50	0	27	562
	0313 Total	**13**	**4**	**5,820**	**651**	**25**	**4,728**	**3,818**
0314	Georges Run	4	0	2,538	0	0	219	116
	Murphy Run	0	0	797	0	0	0	0
	Peggys Run	0	0	1,638	0	0	0	0
	0314 Total	**0**	**0**	**4,973**	**0**	**0**	**219**	**116**
0315	Grave Run	0	0	525	0	0	54	672
	Indian Run	0	0	43	0	0	0	0
	0315 Total	**0**	**0**	**568**	**0**	**0**	**54**	**672**
0316	Gunpowder Falls	0	0	233	0	0	492	23
	Muddy Creek	0	0	255	0	0	0	0
	Walker Run	0	0	824	44	0	86	417
	0316 Total	**0**	**0**	**1,312**	**44**	**0**	**578**	**440**
	Baltimore County Prettyboy Total	***13***	***4***	***12,669***	***695***	***25***	***5,586***	***5,041***

Watershed Build-Out

The watershed build out analysis for Baltimore County was conducted using the zoning data layer and the parcel tax assessment data layer to identify improved properties. The maximum legal density was used to assess the number of potential new residential units for properties that have already been improved, (but are below full density) and for un-improved properties. The Baltimore-City owned land was excluded from the analysis, as these lands will not be developed.

Table 2-18 presents the number of improved parcels and vacant parcels by zoning category. Table 2-19 presents the estimated build-out potential for the Baltimore County portion of the Prettyboy Reservoir watershed.

Table 2-18:Number and Acreage of Improved and Vacant Parcels by Zoning Category (2004)

	Improved Parcels					
Zone	**Number**			**Acres**		
	Residential	**Agricultural**	**Total**	**Residential**	**Agricultural**	**Total**
RC 2	771	187	958	2,141	7,269	9,410
RC 4	200	10	210	392	550	942
RC 5	-	1	1	-	3	3
RC 7	66	21	87	340	1,057	1,397
RC 8	248	63	311	862	1,763	2,625
Non-RC	6	2	8	8	266	274
Total	**1,291**	**284**	**1,575**	**3,743**	**10,908**	**14,651**
	Vacant Parcels					
Zone	**Number**			**Acres**		
	Residential	**Agricultural**	**Total**	**Residential**	**Agricultural**	**Total**
RC 2	120	94	214	340	2,108	2,448
RC 4	36	6	42	75	214	289
RC 5	1	-	1	1	-	1
RC 7	12	6	18	64	313	377
RC 8	65	29	94	387	621	1,008
Non-RC	2	3	5	1	194	195
Total	**236**	**138**	**374**	**868**	**3,450**	**4,318**

As can be seen from Table 2-18, the number of improved parcels accounts for ~80% of the available parcels and ~77% of the available acreage. Since the improved lots may not be developed to full density, there is the potential for further subdivision. This is reflected in Table 2-18 by the number of potential lots from improved parcels.

Based on this analysis, a total of 953 new residential lots (558 + 395) can potentially be developed. This represents a potential for a 63% increase in the total number of improved residential lots over the existing number of improved lots (1,567 Table 2-14). Sixty percent of the potential improved lots occur in the RC2 category for agricultural protection, with only 411 potential residential lots derived from the other four resource conservation categories. Based on the Baltimore County Annual NPDES Reports, an average of 29 new building permits have been issued in the Prettyboy Reservoir watershed during each of the preceding three years (2004-2006).

Table 2-19: Estimated Potential Buildout (Baltimore County)

	Number of New Lots from Improved Parcels			Number of New Lots from Vacant Parcels		
Zone	**Residential**	**Agricultural**	**Total**	**Residential**	**Agricultural**	**Total**
RC 2	196	193	389	89	93	182
RC 4	8	96	104	37	40	77
RC 5	-	-	-	-	-	-
RC 7	-	10	10	10	8	18
RC 8	7	48	55	64	54	118
Total	**211**	**347**	**558**	**200**	**195**	**395**

2.3.7.2 Zoning and Build-Out in Carroll County

The Carroll County zoning distribution for the Prettyboy watershed is presented in Table 2-20. Approximately 77% of the land is zoned for agricultural conservation. The second largest

category is Conservation residential (1 unit per 3 acres) at ~14% of the total land. The balance is higher density residential and commercial. The later zoning is associated with outlying areas of the towns of Manchester and Hampstead (Figure 2-13, above).

Table 2-20: Carroll County Zoning (acres)

DNR 12-digit Scale	Subwatershed Scale	Zoning Category							
		Agricultural	General Business	Local Business	Conservation (1 home per 3 acres)	Restricted Industrial	R-10000 Urban (1 home per 1/4 acre)	R-20000—Suburban (1 home per 1/2 acre)	R-40000 (1 home per acre)
0313	Poplar Run	202	0	0	0	0	0	0	0
	Prettyboy Direct Drainage 4	8	0	0	0	0	0	0	0
	0313 Total	**210**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0314	Georges Run	1,291	7	0	495	32	17	2	95
	Murphy Run	281	48	1	632	0	101	673	261
	Peggys Run	0	0	0	0	0	0	35	0
	0314 Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0315	Grave Run	2,129	0	1	255	0	0	30	110
	Indian Run	914	0	0	38	0	0	0	0
	0315 Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0316	Gunpowder Falls	3,216	15	2	1,035	0	0	0	0
	Muddy Creek	798	0	0	50	0	0	0	0
	0316 Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0317	South Branch	2,793	17	0	190	0	6	94	87
	South Branch Gunpowder Falls	3,165	78	15	2	21	0	0	18
	0317 Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Carroll County Prettyboy Total	***14,797***	***165***	***19***	***2,697***	***53***	***124***	***834***	***571***

Build-out

According to data from the MD Department of Taxation and Assessment, there are a total of 5,177 land parcels in the Carroll County portion of the Prettyboy watershed. Of these, an estimated 4,091 have built residences, as of 2006; (using the assumption that an assessed improved value of $30,000 or greater means there is a residence on the property). For a simple build-out scenario, the 228 zoning polygons in the Carroll County portion of the watershed were divided into parcels, based on zoning category. To do this, the acreage of each of these polygons was calculated and then divided by the lot size allowed for that category. Not all the estimated 4,091 residences are on parcels that have been built up to the level of their zoning. To account for this, the maximum allowed density for the improved lots was used to calculate the overall density, and then the number of improved lots was subtracted to obtain the potential build-out for the improved parcels. For unimproved parcels, the acreage for each zoning category was determined and multiplied by the maximum density allowed for to that zoning category.

2.3.7.3 Zoning and Build Out in York County

The general zoning categories for the York County portion of the Prettyboy Reservoir watershed and the associated acreage are presented in Table 2-21. Approximately 88% of the acreage is zoned for agricultural conservation, with only 3% zoned for rural residential.

Table 2-21: York County zoning (acres)

DNR 12-digit Scale	Subwatershed Scale	Zoning Category		
		Agriculture	Conservation	Rural Residential
0316	Gunpowder Falls	2,737	183	14
	Muddy Creek	666	0	0
	Walker Run	71	0	0
	0316 Total	**3,474**	**183**	**14**
0317	South Branch Gunpowder Falls	497	221	131
	York County Prettyboy Total	***3,971***	***404***	***145***

A build-out analysis is not available for York County at this time.

2.3.7.4 Priority Funding Areas

The Maryland Planning Act and Smart Growth Initiatives required local jurisdictions to map specified growth areas where State infrastructure dollars would be targeted. These growth areas are referred to as Priority Funding Areas (PFA). In the Prettyboy Reservoir Watershed, PFA's occur in Carroll County only. Portions of the Manchester and Hampstead PFA's overlap the watershed. In addition, within Carroll County's rural portion of the watershed are several Rural Villages that are designated as PFA's. The Rural Villages are the focal areas for social, employment and commercial activity in the rural area. These villages have specific, designated PFA boundaries.

CHAPTER 3

WATER QUALITY

3.1 Introduction

Maryland and Pennsylvania water quality standards address the federal requirements "to restore and maintain the chemical, physical and biological integrity of the Nation's waters" (Clean Water Act, Section 101). Standards have been established to support beneficial uses such as fishing, aquatic life, water contact recreation, boating, drinking water supply, and terrestrial wildlife that depend on water. The state has adopted standards that must be met by the streams in the Prettyboy watershed and for Prettyboy Reservoir itself. Local ongoing monitoring efforts are aimed in part at documenting which streams do or do not meet the legal standards. While there is a certain amount of chemical monitoring data for the Prettyboy watershed, it is limited in extent. In particular there is limited information on water quality associated with storm events.

This chapter presents data related to designated uses (Section 3.2), existing water quality data (non-point source 3.3 and point source 3.4), flow data (3.5), and current listings of water quality impairment (3.6). The data will be utilized to prioritize restoration and preservation actions (Chapter 5) among the subwatersheds in the Prettyboy watershed.

3.2 Designated Uses

Streams and other water bodies in Maryland and all other states are each assigned a "designated use". Maryland's water uses are recorded in the Code of Maryland Regulations (COMAR) 26.08.02.08. A water body's designated use refers to the anticipated uses and aquatic life protections. The designated uses are associated with sets of specific water quality criteria necessary to support the uses. Together, the designated uses and the criteria are commonly referred to as "Water Quality Standards".

In the Prettyboy Reservoir watershed, the Use III-P designation, (Natural Trout Waters) Nontidal Cold Water and Public Water Supply, is applied to the entire Maryland portion of the watershed. Pennsylvania also assigns designated uses to its bodies of water, though the use categories differ somewhat from those of Maryland. Pennsylvania's portion of the Prettyboy Reservoir watershed is designated as WWF, Warm Water Fishes (Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat). These several designations are presented in Figure 3-1.

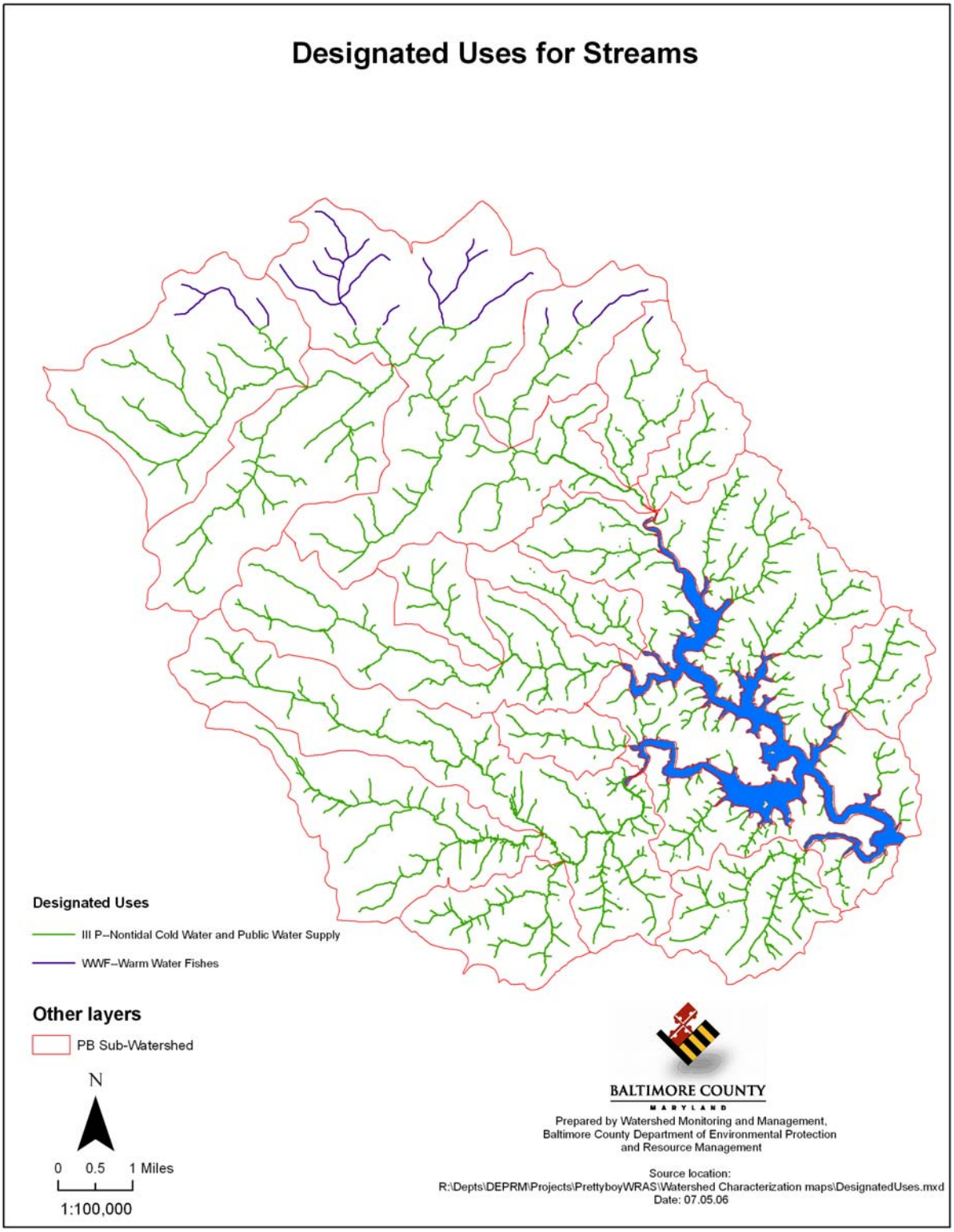

Figure 3-1: Designated uses for Prettyboy Reservoir Watershed streams.

As the Designated Use category indicates, Prettyboy Reservoir is used as a source of public drinking water. Prettyboy Reservoir is one of the three reservoirs in the system that supplies drinking water for approximately 1.8 million people in Baltimore City and the five surrounding counties. Prettyboy Reservoir serves as a holding reservoir for the Loch Raven Reservoir. As such, drinking water is not directly withdrawn from the Prettyboy Reservoir, but is released to replenish the water in Loch Raven Reservoir. Homes, farms, and businesses within the Prettyboy Reservoir watershed do not draw their water from the reservoir, but are served by wells that depend on groundwater or by small municipal water systems in Hampstead and Manchester.

3.3 Water Quality Data

Chemical water quality data have been collected over the years through a number of programs run by various State and local agencies, in addition to the specific data collected in support of the Prettyboy Watershed Restoration Action Strategy (WRAS). The results of the recent synoptic survey collected to support the Prettyboy WRAS are presented in 3.3.1. The State CORE/Trend data for the single site maintained in the Prettyboy Reservoir watershed is discussed in 3.3.2. Both Baltimore County (3.3.3) and Baltimore City (3.3.4) also conduct chemical water quality monitoring programs within the Prettyboy Reservoir watershed. While the County program is limited to the tributary streams, the City program includes in-lake monitoring.

3.3.1 Synoptic Survey Results

A synoptic survey was performed by Maryland Department of the Environment in the spring of 2005, in support of the Prettyboy Watershed Restoration Action Strategy. A total of 68 sites throughout the watershed were each sampled one time during the spring of 2005. The full report can be found at:
http://dnrweb.dnr.state.md.us/download/bays/pbres_synoptic.pdf.

Only a brief summary of the primary findings, will be included here.

Each site was sampled for nitrate/nitrite and orthophosphorus concentrations. In addition, discharge (flow) measurements, conductivity, temperature, dissolved oxygen, and pH were monitored *in situ* at the time of sample collection. The drainage area to the sampling point was determined in hectares. The discharge measurements in conjunction with the nutrient concentrations were used to calculate a yield in kilograms/hectare/day ((flow x concentration/) = load delivered). A daily load was determined since only one sample per site was collected. Extrapolating one sample over an annual period could produce erroneous results since the concentration and discharge will vary on an annual basis. The results should only be used for a comparison to benchmark standards and as a relative comparison between sites.

The results indicated that pH, temperature, and dissolved oxygen were within acceptable ranges. The nutrient data was assessed based on both the concentration and the yield at each monitoring location in comparison with the criteria in Table 3-1.

Table 3-1: Nutrient Ranges and Rating (adapted from Table 1, MDE 2006)

Rating	NO2+NO3 Concentration mg/L	NO2+NO3 Yield Kg/ha/day	PO4 Concentration mg/l	PO4 Yield Kg/ha/day
Baseline	<1	<.01	<.005	<.0005
Moderate	1 to 3	.01 to .02	.005 to .01	.005 to .001
High	3 to 5	.02 to .03	.01 to .015	.001 to .002
Escessive	>5	>.03	>.015	>.002

The observed nitrate/nitrite concentrations at the 68 sites ranged from baseline to excessive. The nitrate/nitrite yields were generally high to excessive with three sites exhibiting baseline concentrations. The distribution of the nitrate/nitrite concentrations is presented in Figure 3-2. MDE compared the results to seven other nutrient synoptic surveys and found that Prettyboy Reservoir watershed had the highest nitrate/nitrite (4.41 mg/L) mean concentration.

Conversely, the orthophosphorus concentrations were found to be mostly in the baseline to moderate range with only a few in the high (3 sites) or excessive (2 sites) range, and the orthophosphorus yields were all in the baseline range. Conductivity was noted as being high in four of the subwatersheds, generally located along the southern portion of the watershed adjacent to the towns of Manchester and Hampstead. The increase in conductivity could be associated with the usage of road salt in those areas.

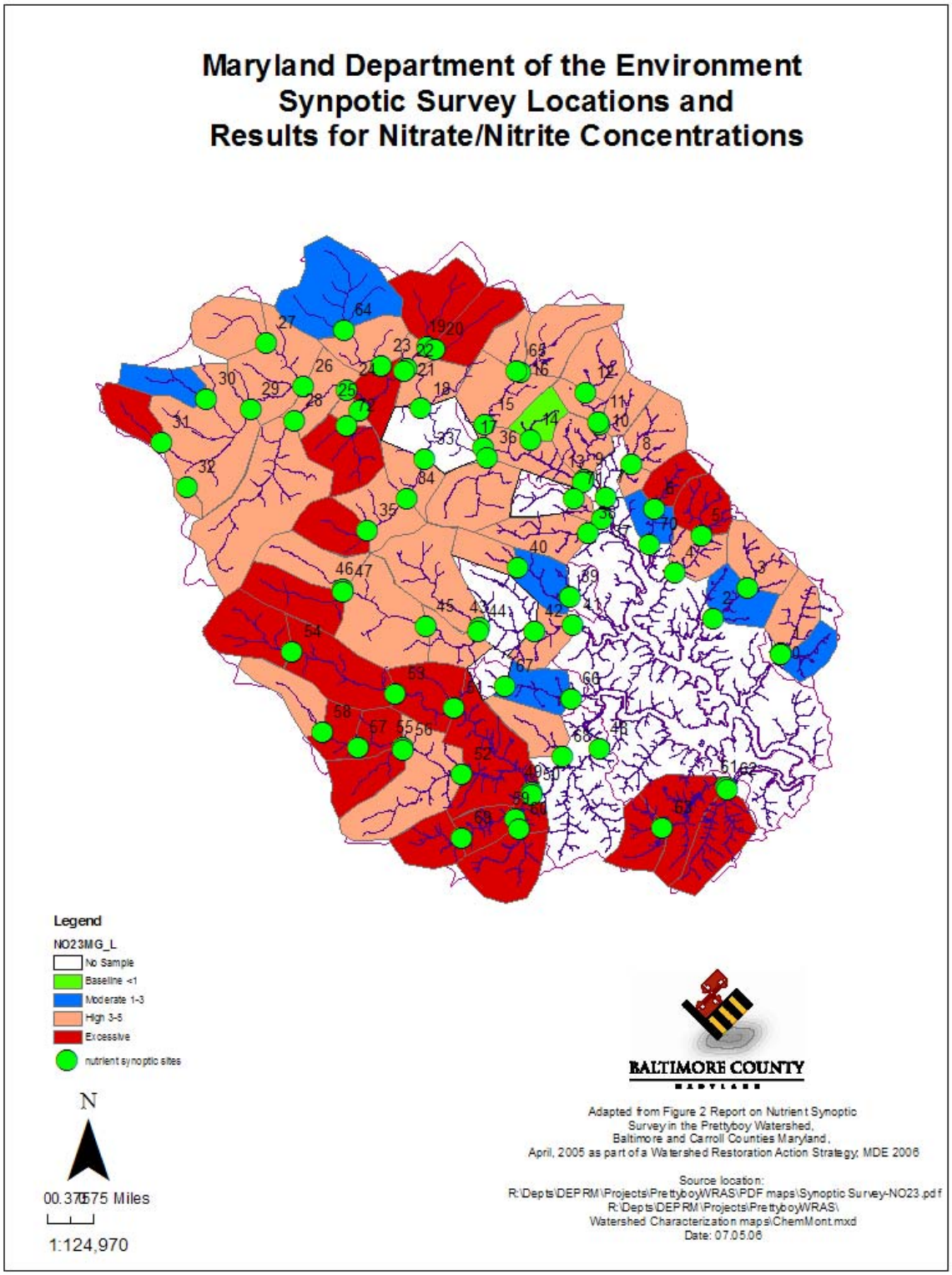

Figure 3-2: Nitrate/Nitrite Concentrations Found During the MDE Synoptic Survey (adapted from Figure 2, MDE 2006)

The data from the 68 sites were analyzed based on the 19 subwatersheds within the Prettyboy Reservoir watershed. The mean concentrations for nitrogen and phosphorus for each subwatershed was calculated on the basis of area weighting using the following formula:

Mean Pollutant Concentration = $(PC_{1\text{-}i} * Area_{1\text{-}i}) / (Area_1 + Area_2 \ldots.. + Area_i)$, where

PC = Pollutant Concentration for each drainage in the subwatershed,
Area = The drainage area associated with each pollutant concentration measure.

The results of this analysis are presented in Table 3-2 and in Figures 3.3 and 3.4. The table includes the resulting "rating category" designation based on the ranges given in Table 3-1.

Table 3-2: Synoptic Survey Average Nutrient Concentrations

Subwatershed	Monitoring Sites	Mean PO4	Rating Category	Mean NO2/NO3	Rating Category
Compass Run	1	.0050	Baseline	2.99	Moderate
Poplar Run	2	.0036	Baseline	2.62	Moderate
Silver Run	2	.0055	Moderate	4.12	High
Frog Hollow	2	.0038	Baseline	3.00	High
Prettyboy Branch	3	.0090	Moderate	6.45	Excessive
Prettyboy Direct Drainage 1	0	NA	NA	NA	NA
Prettyboy Direct Drainage 2	0	NA	NA	NA	NA
Prettyboy Direct Drainage 3	6	.0062	Moderate	3.78	High
Prettyboy Direct Drainage 4	0	NA	NA	NA	NA
Georges Run	4	.0058	Moderate	6.07	Excessive
Murphy Run	5	.0038	Baseline	5.10	Excessive
Peggys Run	4	.0082	Moderate	6.55	Excessive
Grave Run	5	.0041	Baseline	4.69	High
Indian Run	1	.0040	Baseline	3.79	High
Gunpowder Falls	12	.0064	Moderate	3.83	High
Muddy Creek	3	.0072	Moderate	3.32	High
Walker Run	4	.0056	Moderate	3.59	High
South Branch	5	.0043	Baseline	4.12	High
South Branch Gunpowder Falls	6	.0046	Baseline	3.84	High

Three subwatersheds (Prettyboy Direct Drainage 1, 2, and 4) had no synoptic survey sampling sites. This was due to the remoteness of the streams within these subwatersheds. The orthophosphorus concentrations were in the baseline (8 subwatersheds) to moderate (8 subwatersheds) range. Figure 3-3 indicates that the moderate subwatersheds were distributed along the northern and southern portions of the watershed, with the central subwatersheds in the baseline category.

For nitrate/nitrite concentrations, four subwatersheds were in the excessive category, two in the moderate category, and the balance (10) in the high category. Figure 3-4 clearly indicates that the excessive concentration subwatersheds are distributed along the southern portion of the Prettyboy Reservoir watershed, east of the Route 30 corridor.

While the synoptic data suggest that nitrate/nitrite nitrogen may be the impairing nutrient, the model run for the Prettyboy Reservoir TMDL indicates that phosphorus is the limiting nutrient for algae growth in the reservoir, and thus is the nutrient that needs to be reduced to meet the water quality standards for the reservoir. In general, most of the phosphorus is

delivered to the reservoir during storm events. Since the synoptic survey is conducted during dry weather the bulk of the phosphorus load may be missed. There is limited wet weather data collected in the Prettyboy Reservoir watershed. The nitrates while not a threat to the reservoir, they are potentially harmful for livestock and wildlife that obtain their drinking water from the streams.

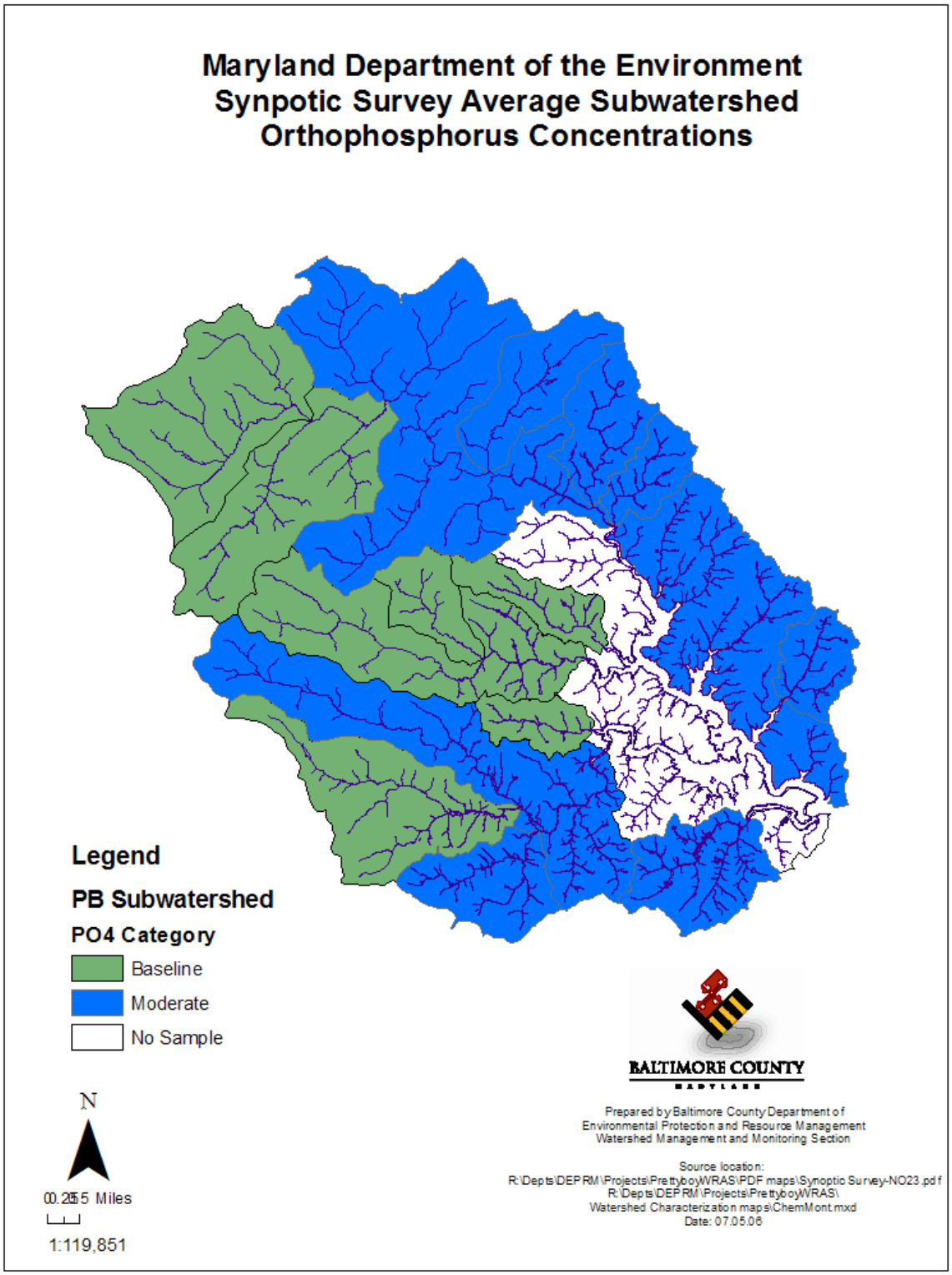

Figure 3-3: Average Subwatershed Orthophosphorus Concentrations based on the MDE Synoptic Survey

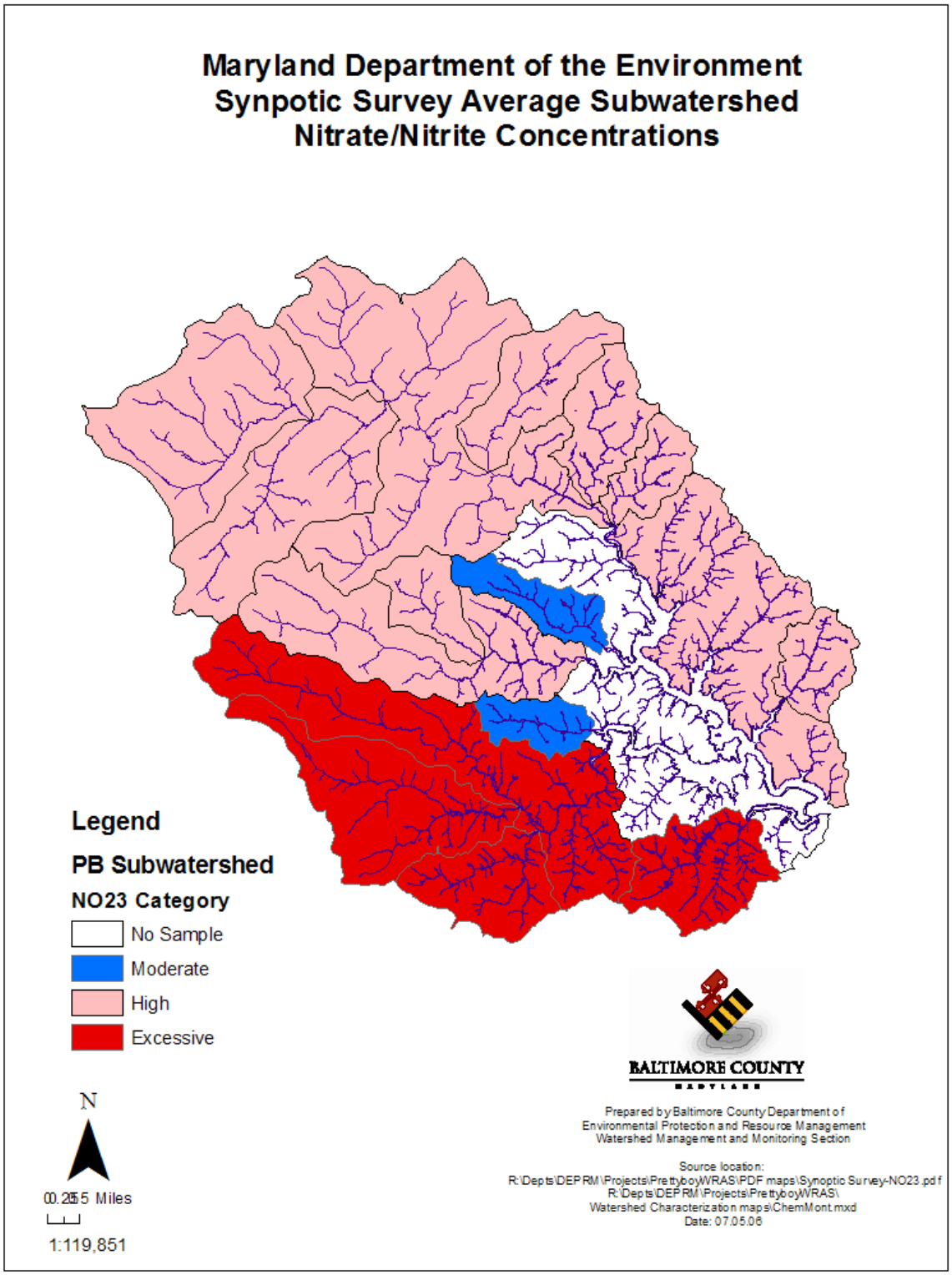

Figure 3-4: Average Subwatershed Nitrate/Nitrite Concentrations based on the MDE Synoptic Survey

3.3.2 CORE/Trend Site Data

Maryland Department of Natural Resources (DNR) conducts an ambient fixed station water quality monitoring program (Core/Trend) to assess statewide water quality status and trends. The 54 sampling locations are distributed throughout the state, with particular attention to the Potomac River. One of the sites is located upstream of Prettyboy Reservoir.

Determination of status is based upon the median concentration of a given parameter at one station for the most recent three years (2002-2004), compared to a "benchmark" data set of all measured concentrations in the nontidal Core/Trends database for all sites in Maryland from 1986-1996. To determine the cut-off values, the benchmark data are divided into thirds so the lower third cut-off value is at the 33rd percentile and the cut-off for the middle third is at the 67th percentile. Trends are a measure of how the system has been changing over time. More information on the assessment methods and details on each parameter are available on the MDNR site: http://www.dnr.state.md.us/streams/status_trend/index.html

Station GUN0476 is on the Gunpowder River at Gunpowder Road above Prettyboy Reservoir). Monthly water chemistry samples are taken from the bridge at Gunpowder Road. A USGS gage, funded by Baltimore City, was installed in 2000. The data and the discussion of the data presented below has been derived from the DNR Core/Trend website.

Table 3-3 presents the median concentration at this one station from 2002-2004. The median concentration of TN (total nitrogen) was high and no trend was evident. TKN, the reduced nitrogen compound of TN, decreased since 1986 and NO23 (nitrate/nitrite nitrogen, the oxidized nitrogen component of TN) did not. The median concentration of TP was low and has decreased since 1986. Total alkalinity was in the mid-percentile range and has increased since 1986. pH was high and exhibited no trend. Total alkalinity and conductivity were not correlated but both increased. Conductivity was low at GUN0476 relative to the benchmark data set.

In general, this data set is in agreement with the recent synoptic survey. What is most notable about this data set is that total phosphorus, the nutrient of concern, for the reservoir TMDL has decreased 36% since 1986. The high nitrate concentration noted in the synoptic survey is also found with this data set.

Table 3-3: Core/Trend Site GUN0476 Gunpowder - Baltimore County – Data Summary (adapted from DNR)

Water Quality Parameter	Median Concentration 2002-2004	Percentile Range	Linear Trend 1986-2004	% Change
Nitrogen Parameters				
Ammonium NH4	0.014 mg/L	(Lower)	Significant Zero	0
Total Kjeldahl Nitrogen TKN	0.346 mg/L	(Middle)	Decreasing	-26.8
Nitrate NO3	2.68 mg/L	(Upper)	NS	2.6
Nitrite NO2	0.01 mg/L	(Lower)	Decreasing	-28.8
Nitrate + Nitrite NO23	2.69 mg/L	(Upper)	NS	3
Total nitrogen TN	3.1	(Upper)	NS	-2.9
Phosphorus Parameters				
Total phosphorus TP	0.03mg/L	(Lower)	Decreasing	-36.3
Orthophosphate PO4	0.014 mg/L	(Middle)	NS	-12.7
Other Parameters				
Chlorophyll a	1.60 µg/L	(Lower)	NS	-4.6

Water Quality Parameter	Median Concentration 2002-2004	Percentile Range	Linear Trend 1986-2004	% Change
Conductivity	177.5 mhos/cm	(Lower)	Increasing	33
Dissolved Oxygen	10.65 mg/L	(Upper)	Decreasing	-5.5
pH	7.8	(Upper)	NS	0
Total Alkalinity	36 mg/L	(Middle)	Increasing	31.7
Total organic carbon	1.98 mg/L	(Lower)	NS	23.6
Total suspended solids	4 mg/L	(Lower)	NS	0
Turbidity	4.2 NTU	(Lower)	Decreasing	-24.9
Water temperature	12.6° C	(Lower)	NS	-8.3

NS = not significant
( ) = indicates where station median concentration falls within benchmark data set concentration percentile

3.3.3 Baltimore County Data

Baltimore County Department of Environmental Protection and Resource Management operates a Baseflow Monitoring Program that samples the Gunpowder Basin in even-numbered years. There are five sites located in the Prettyboy Reservoir watershed (Figure 3-5). The average data from these stations (2004 & 2006) are presented in a later subsection. In addition, for the preparation of the Prettyboy Reservoir Watershed Action Strategy, a subset (16 of the 68 sites) on the synoptic survey sites sampled by Maryland Department of the Environment were sampled multiple times between the spring of 2005 and the spring 2006 to provide additional data for prioritization of nutrient problem areas. The County also conducts periodic groundwater studies that include wells within the Baltimore County portion of the Prettyboy Reservoir watershed (see Subsection 3.3.3.2). Figure 3-5 shows the locations of the Baltimore County monitoring sites, the USGS gage locations, and Baltimore City in-lake and tributary monitoring sites.

3.3.3.1 Surface Water Data

Continued synoptic survey data: The continued monitoring of the subset of the Maryland Department of the Environment's synoptic survey sites resulted in an additional two to five samples at each of the sixteen sites monitored. In some cases, the site was downstream from two sites. These data were analyzed for nitrate/nitrite nitrogen and total phosphorus mean concentrations. The category definitions in Table 3-1 were used to determine the status (baseline through excessive) of the drainage areas monitored. The data are not strictly comparable for phosphorus, since the rating system is based on orthophosphorus concentrations, but applied to total phosphorus in this comparison. Figure 3-6 displays the results for nitrate/nitrite nitrogen and the results for each site are displayed in Table 3-4, along with the synoptic survey results for comparison.

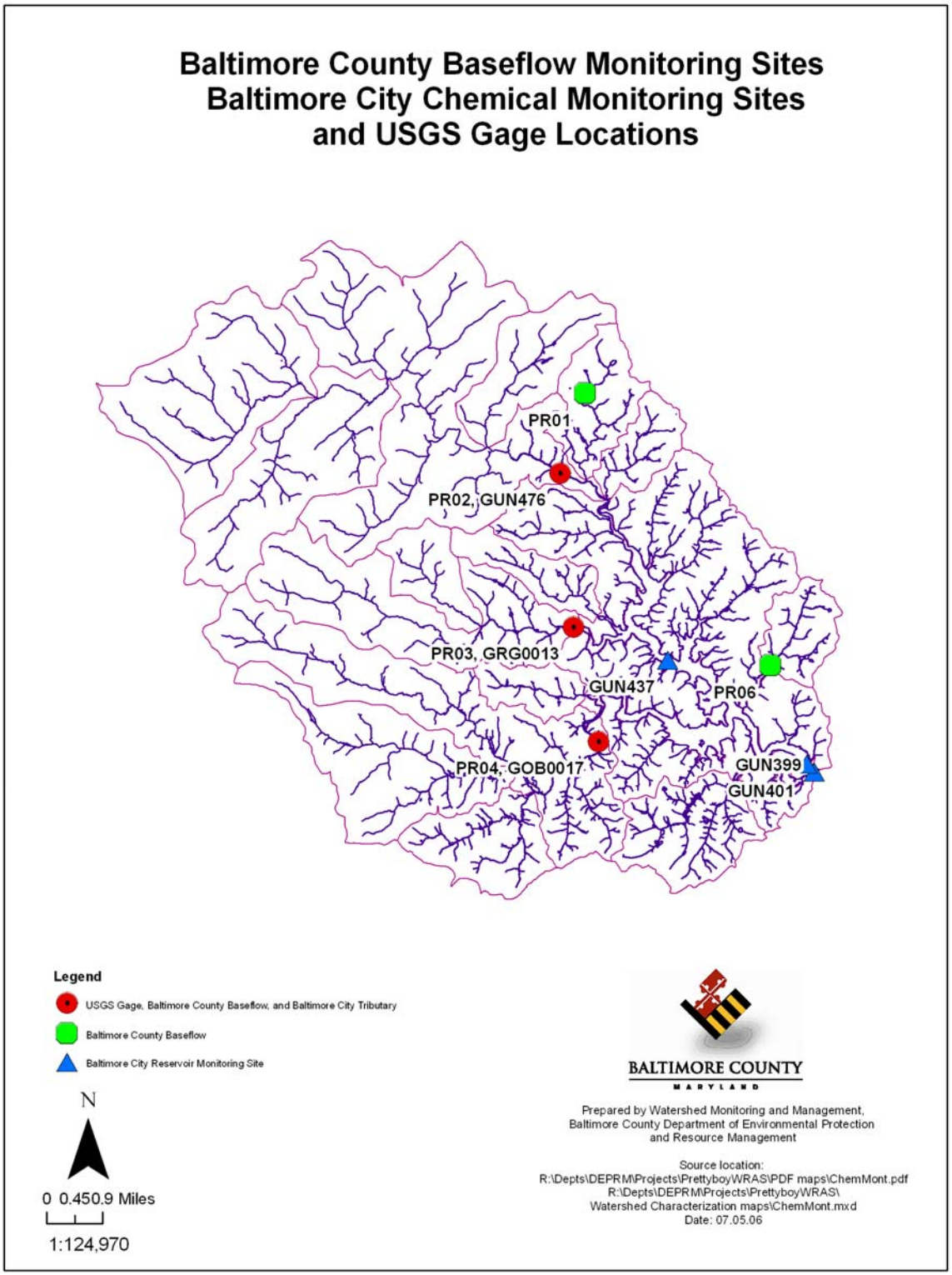

Figure 3-5: Locations of Baltimore County Baseflow Monitoring Sites, USGS gages, and Baltimore City Monitoring Sites.

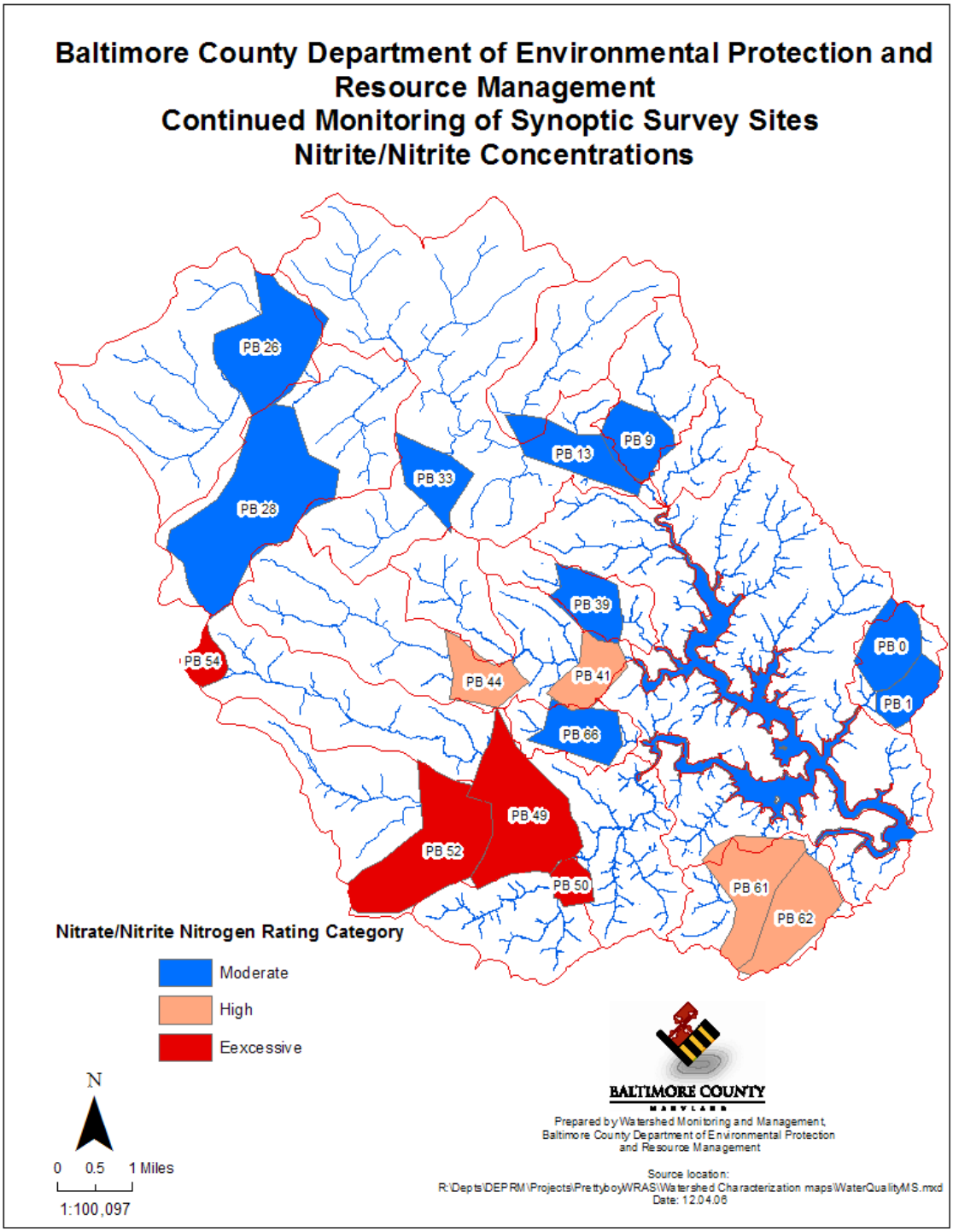

Figure 3-6: Continued Monitoring of Synoptic Survey Sites Results

In general, the continued synoptic survey replicated the results from the one-time survey, except that the mean concentrations were lower generally for nitrate/nitrite concentrations. This would be expected, based on the observed annual cycle in nitrate/nitrite concentrations, with the highest concentrations in the spring. The greater discrepancy at

some sites can be explained by the differing dates that the replicate sampling was performed. Comparison of Figures 3-2 and 3-6 indicates that the excessive nitrate/nitrite concentrations are limited to the southern portion of the watershed. Some of the watersheds, which were previously considered in the high range for nitrate/nitrite nitrogen (in Figure 3-2) are considered to be in the "moderate" range for nitrate/nitrite based on the Baltimore County continued monitoring data (Figure 3-6).

Table 3-4: Continued Synoptic Survey Results by Site (Monitoring by Baltimore County)

Station	Nitrate/Nitrite mg/L	Synoptic Survey NO_3	Total Phosphorus mg/L	Synoptic Survey PO_4
PB0/1	2.61	3.17/2.74	.013	.003/.005
PB9/13	2.73	3.01/3.54	.015	.005/.007
PB26	2.98	3.63	.018	.007
PB28	2.51	3.41	.018	.003
PB33	2.78	3.62	.013	.005
PB39	1.40	2.28	.015	.004
PB41	3.05	3.95	.012	.003
PB44	3.76	3.79	.012	.004
PB49	5.22	5.52	.013	.005
PB50	5.41	5.99	.025	.008
PB52	5.04	4.92	.013	.004
PB54	6.64	7.47	.035	.003
PB61/62	3.69	5.71/5.32	.037	.008/.006
PB66	2.36	2.99	.014	.005

Applying the orthophosphorus (PO_4) rating system to total phosphorus data resulted in all the sites falling in the excessive or the high range. However, orthophosphorus is only a portion of the total phosphorus concentration, so the rating system used in the synoptic survey is not applicable. Instead of using the rating system, the concentrations are displayed in Figure 3-7 based on natural breaks in the data (breaks are based on clumping of the data). Three areas clearly stand out as having higher concentrations of total phosphorus, two in Prettyboy Branch (PB61/PB62) and one in the headwaters of Georges Run (PB 54). The Manchester Waste Water Treatment Plant (WWTP) uses spray irrigation upstream of the sampling location.

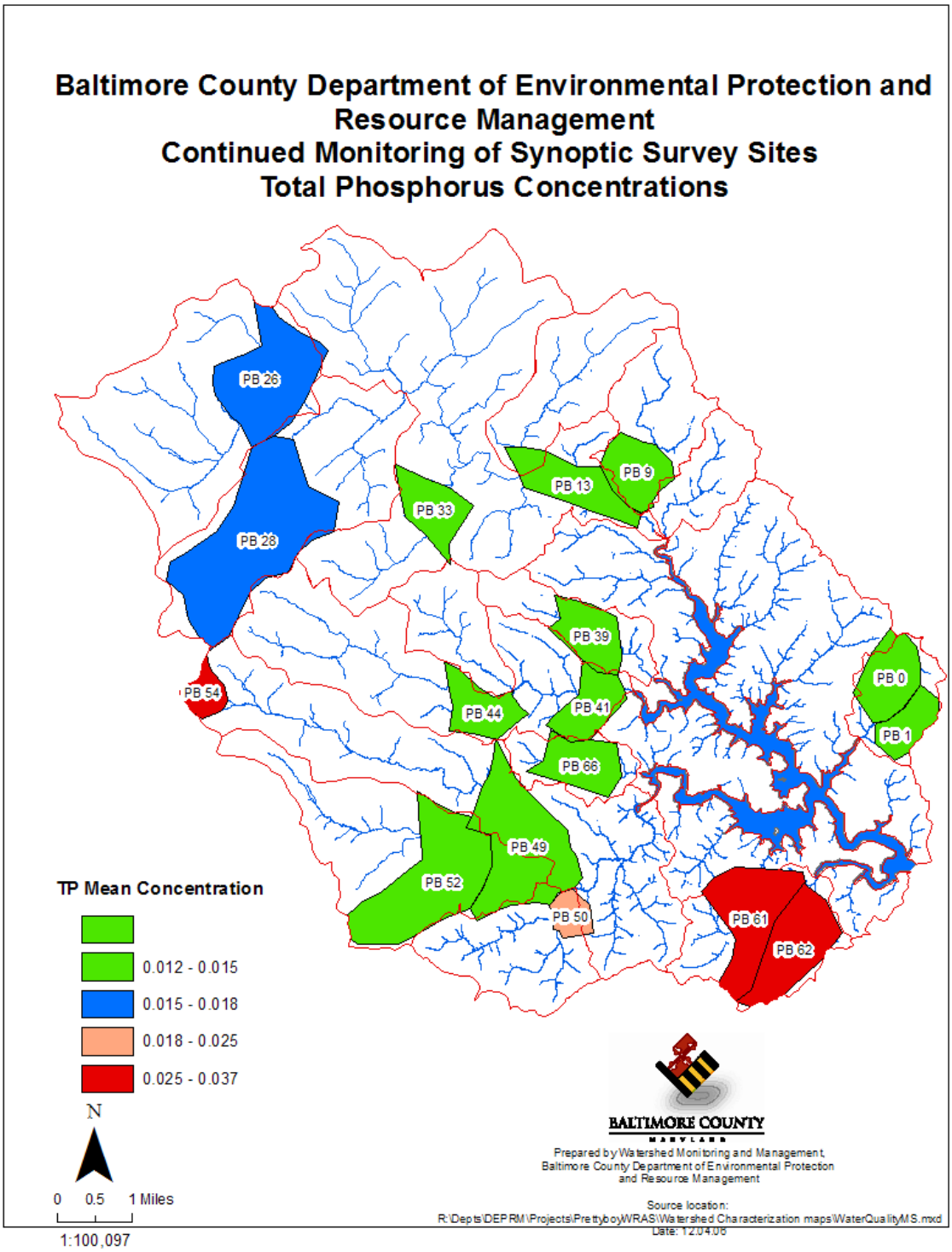

Figure 3-7: Total Phosphorus Mean Concentrations Based on Natural Breaks.

Baltimore County Baseflow Monitoring Program: Baltimore County conducts a baseflow monitoring program that targets the Gunpowder River Basin in even-numbered years. Five sites are located in the Prettyboy Reservoir watershed and sampled three to eight times per

year, based on weather patterns and availability of staff. Sample results are available for 2004 and 2006. Table 3-5 presents the average nutrient concentrations at each site.

Table 3-5: Baltimore County Prettyboy Reservoir Baseflow Monitoring Sites Means (mg/L)

Site	Watershed	TKN	NO_2/NO_3	TN	TP
PR01	Walker Run	0.22	2.74	2.95	0.030
PR02	Gunpowder River	0.16	2.61	2.77	0.017
PR03	Grave Run	0.12	3.14	3.24	0.017
PR04	Georges Run	0.21	4.53	4.74	0.016
PR06	Frog Hollow	0.14	2.30	2.42	0.019

3.3.3.2 Ground Water Data

Baltimore County has conducted two rounds of groundwater sampling, based on randomly selected wells throughout the County. The first round of sampling occurred in 1994-1996, with 112 wells and springs being sampled. Thirteen of those sites were in the Prettyboy Reservoir watershed. The second round of sampling occurred in 2000-2001 and was a re-sampling of 46 wells and 3 springs sampled during the first round. There were six wells in the Prettyboy Reservoir watershed re-sampled in 2000-2001. General findings included the fact that while pesticides were found, none exceeded their Maximum Contaminant Level (MCL). The types and ranges of pesticide concentrations changed little between 1994-96 and 2000-01. The wells were analyzed for nitrate/nitrite these results are presented in Table 3-6. The wells with two concentrations in the 1994-1996 results column reflect sampling at two different time periods during the sampling round. The results over 5 mg/L are bolded.

Table 3-6: Ground Water Study Nitrate/Nitrite Results (mg/L)

Well Name	Land Use	Subwatershed	1994-1996 Nitrate/Nitrite (mg/L)	2000-2001 Nitrate/Nitrite (mg/L)
BA Ab 51	Ag	Walker Run	**8.20/8.5**	**8.4**
BA Ab 52	Res	Poplar Run	**8.50**	Not Sampled
BA Bb 136	Ag	Grave Run	4.90	**5.0**
BA Bb 139	Res	Prettyboy Direct Drainage	0.62	Not Sampled
BA Bb 140	Ag	Prettyboy Direct Drainage	2.80	3.5
BA Bb 141	Forest	Georges Run	2.8/<.050	Not Sampled
BA Bb 143	Ag	Peggy's Run	**7.50**	**9.4**
BA Bb 147	Forest	Murphys Run	0.12	Not Sampled
BA Bb 148	Ag	Prettyboy Direct Drainage	**9.10**	Not Sampled
BA Bb 151	Ag	Peggy's Run	**9.00**	**5.9**
BA Bc 267	Ag	Prettyboy Branch	**8.5/11.0**	**10**
BA Bc 268	Ag	Prettyboy Direct Drainage	2.90	Not Sampled
BA Bc 274	Ag	Prettyboy Branch	4.70	Not Sampled

The nitrate/nitrite results indicate that in certain wells there are problems with nitrate/nitrite concentrations. In the 1994-1996 sampling period, 46% of the wells had nitrate/nitrite concentrations in excess of 5 mg/L, with five of the wells approaching the EPA drinking water limit of 10 mg/L. Only one of the six wells sampled in the 2000-2001 time period showed a decrease in relation to the earlier sampling period.

Groundwater supplies the baseflow to the local perennial streams and may have a residence time of from years to decades. The groundwater results seem to support the surface water results that indicate that Prettyboy Reservoir watershed has elevated

nitrate/nitrite concentrations. The 1994-1996 study concluded, based on the larger data set, that nitrate concentrations are associated with current or former agricultural activity and that septic system effluent has little overall impact on groundwater nitrate.

3.3.4 Baltimore City Data

The Baltimore City Department of Public Works conducts monitoring at six sites in the Prettyboy Reservoir watershed, three at tributary streams and three at in-lake locations (Figure 3-5). The following discussion is derived from the 2000 Action Report for the Reservoir Watersheds (2000). The reservoirs are assessed in terms of eutrophication of the lake waters. Eutrophic lakes have high algal production and in severe condition can cause drinking water treatment problems as well as taste and odor issues. The degree of eutrophication is measured by the amount of chlorophyll a, the concentration of phosphorus, and water turbidity (measured by secchi disk). A chlorophyll a value of 10 ug/l corresponds to the boundary between mesotrophic (moderately impaired) and eutrophic conditions. The threshold for the boundary between mesotrophic and eutrophic conditions for total phosphorus is 26 ug/l, and for secchi disk measurements the boundary between mesotrophic and eutrophic conditions is 1.86 meters. In addition, to the trophic condition measurements, the State of Maryland has established standards for dissolved oxygen at 5 mg/l for surface waters.

3.3.4.1 Tributary Streams

The tributary stream locations are currently monitored during dry-weather periods. The following conclusions were drawn for the tributary streams.

- The data for the Prettyboy Reservoir tributary stations show a decreasing dry-weather total phosphorus trend through 2000.

3.3.4.2 In-Lake Data

The following is the bulleted summary for the Prettyboy Reservoir.

- Prettyboy Reservoir epilimnion (surface layer, from the surface to 30 feet below) samples equaled or exceeded the mesotrophic level for chlorophyll a (10 ug/l) 26.2% of the time.
- Prettyboy Reservoir epilimnion samples were less than the surface water standard for dissolved oxygen (5.0 mg/l) 8.2% of the time. The hypolimnion (bottom layer, greater than 30 feet below the surface) was less than the upper mesotrophic range (1.0 mg/l) 24% of the time.
- Prettyboy Reservoir's epilimnion total phosphorus samples equaled or exceeded the critical value of 26 ug/l 55.5% of the time.
- Prettyboy Reservoir secchi disk measurements were less than the criterion (1.86 m) 7.3% of the time.

The summary information above indicate that the Prettyboy Reservoir is at the borderline between mesotropic and eutrophic conditions. Total phosphorus has the highest exceedance rates for any of the measures of trophic conditions.

3.4 Point Sources

The location of nine NPDES permitted facilities was described in Chapter 2.3.6. Only the Manchester WWTP discharges have monitoring data associated with them. The other eight permits are either general permits or MS4 permits that do not require monitoring.

3.5 US Geological Survey Gage Data

The US Geological Survey (USGS) operates three stream-flow gages within the Prettyboy Reservoir watershed (see Figure 3-5 for locations). The gages are funded through a cooperative agreement between Baltimore City and USGS. Table 3-7 presents the data with regard to these three gages.

Table 3-7: USGS Gage Period of Record, Locations, and Drainage Areas

Gage Number	Gage	Period of Record	Latitude	Longitude	Drainage Area (sq. miles)
01581510	Gunpowder Falls at Hoffmanville	March 2000 to current year	39 41’ 23.3”	76 46’ 53.3”	27.0
01581830	Grave Run near Beckleysville	March 2000 to current year	39 39’ 17.3”	76 46’ 51.3”	7.68
01581870	Georges Run near Beckleyville	March 2000 to current year	39 37’ 32.5”	76 46’ 21.8”	15.8

These gages have been in operation since March 2000. As of this time, an analysis has not been made of the flow distribution at these gages. The USGS is currently analyzing the watershed monitoring programs of Baltimore City, Baltimore County, and Carroll County in an effort to design a coordinated monitoring program for the three jurisdictions that will help to address the questions relating to the three reservoirs. One of the questions relates to the pollutant loads to the reservoirs and trends over time. It is anticipated that one recommendation will be monitoring at the USGS gages during both dry-weather periods and storm events. The maintenance of these gages in the Prettyboy Reservoir watershed, through a cooperative agreement between Baltimore City and USGS, represents an opportunity to obtain critical data in the future.

3.6 303(d) List of Impaired Waters and Total Maximum Daily Load (TMDL)

Some streams and the reservoir itself in the Prettyboy Reservoir watershed WRAS project area do not attain the full extent of their designated uses as defined in Maryland water quality regulations. These areas, known as “impaired waters”, are tracked by MDE under Section 303(d) requirements of the Federal Clean Water Act.

Maryland Department of the Environment uses the 303(d) list of impaired waters to determine the need for establishing Total Maximum Daily Loads (TMDLs). A TMDL is the maximum amount of pollutant a given that a waterbody can assimilate and still meet the standards for its designated use. A waterbody may have multiple impairments and multiple TMDLs to address them. MDE is responsible for establishing TMDLs.

In general, TMDLs have two key parts:

1- Maximum pollutant load that the water can accept while still allowing the waterbody to meet its intended use.

2- Allocation of the maximum pollutant load to point and nonpoint pollutant sources in the watershed.

The list of impairments for waterbodies and any associated total maximum daily loads in the Prettyboy Reservoir watershed are summarized below. More information on the 303(d) list can be found at:
http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/index_new.asp

A new listing of impaired waterbodies will be prepared in 2008. The current impairment listings for the Prettyboy Reservoir watershed include:

- Methylmercury
- Nutrients
- Bacteria
- Biological Community

3.6.1 Methylmercury

The State's 303(d) list in 2002 included listings for mercury contamination for Prettyboy and the other two Baltimore-area reservoirs. The entire Prettyboy watershed was listed. The listings were based on observed mercury content in fish tissue and on a recent change in the EPA methodology for calculating the risk associated with human consumption of contaminated fish. Total Maximum Daily Loads (TMDLs) have been completed for all three reservoirs and submitted to EPA for approval. EPA granted approval in August 2004.

As part of this effort, MDE submitted a TMDL for mercury for Prettyboy Reservoir watershed of 196.6 grams per year. Although TMDLs as originally defined explicitly call for daily loads, many agencies estimate allowable loads on a per-year basis, rather than a daily basis. This load was primarily allocated to "load" or non-point sources (180.9 grams per year). With MDE's preparation of this TMDL, Prettyboy was placed on the Category 4A list for mercury, the list of impaired water bodies for which TMDLs have been completed. Since the primary source of mercury pollution in the watershed is atmospheric deposition from sources outside the watershed (especially from coal-fired electric power generating plants), this characterization and the WRAS will not further address this contaminant. The TMDL for Methylmercury may be viewed at:
http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/TMDL_final_prettyboy_Hg.asp.

3.6.2 Biological

The 2006 303(d) list includes three 12-digit (see Section 4.3) watersheds in the Prettyboy Watershed as being biologically impaired. These listings result from Maryland Biological Stream Survey (MBSS) 2000-2004 data that show one stream in each listed watershed with markedly low indices of fish and/or macro-invertebrate integrity. One 12-digit watershed was listed in 2002, and two others were listed in 2004 under revised listing standards. However, one of these 12-digit watersheds, the Prettyboy Direct Drainage, was apparently incorrectly placed on the impaired list (Poukish, MDE, personal communication), and could be de-listed in the near future.

The current method that MDE uses to list streams for biological impairment allows for entire 12-digit watersheds to be listed based on one sample with low biological integrity (either fish or macro-invertebrates). MDE is considering revising this standard, and works with local authorities to verify if such listings are based on systemic biological problems

associated with particular pollutants, or if there are other causes. In the latter case, the water body could potentially be taken off the impaired list. As part of the revised standard, streams and 12-digit watersheds with only one sample with a low index of biological integrity could be targeted with a more intense monitoring effort to verify if the impaired listing is justified. This may be very appropriate for the subwatersheds in Prettyboy, since the determination of biological impairment was made, in each case, based on a single sample with low biological integrity.

A TMDL has not yet been developed for this impairment in the Prettyboy watershed.

3.6.3 *Nutrients*

The 303(d) list for 1996 included the entire Maryland portion of Prettyboy watershed as being "impaired" due to elevated concentrations of nutrients. While nitrogen levels are elevated in Prettyboy, the primary nutrient of concern is phosphorous, due to its significant connection with chlorophyll a levels in the reservoir.

For the Prettyboy Reservoir Watershed, in 2006 MDE submitted to the EPA a Total Maximum Daily Load for phosphorous of 23,192 pounds per year; this represents a 54% reduction from 1997 levels. This load was allocated as follows: 19,072 pounds were allocated to non-point sources (82%) and 2,940 were allocated to point sources (18%). EPA granted approval of the nutrient TMDL in March of 2007. The TMDL may be viewed at:
http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/TMDL_final_gunpowder_P_sed.asp#TMDL_Prettyboy_Reservoir_Nut.

3.6.4 *Bacteria*

The entire 8-digit Prettyboy watershed was listed in 2002 for impairment due to bacteria. Levels of fecal coliform in 2001 at the Core/Trend site caused the listing. This site is located on the mainstem of the Gunpowder River above the Prettyboy Reservoir at Gunpowder Road. To follow up, MDE carried out more intensive bacterial sampling in 2003-2004, using an updated sampling methodology that focused on E. coli. This data is currently being analyzed by MDE. MDE uses a bacteria source-tracking system, based on antigen resistance, in order to establish the relative proportion of bacteria from various sources. A TMDL has not yet been developed for this impairment in the Prettyboy watershed.

3.7 Summary

Based on the various sampling programs that were summarized above, Prettyboy Reservoir is adversely impacted by nutrients as reflected in seasonally elevated chlorophyll levels and dissolved oxygen impairment in the upper layers of the lake in summer and fall. While the TMDL for nutrients targeted phosphorus for reduction, the high nitrate/nitrite levels represent a potential threat to drinking water wells within the Reservoir watershed and an opportunity to help meet nitrogen reductions for the Chesapeake Bay Program.

CHAPTER 5

RESTORATION AND PRESERVATION

5.1 Introduction

This first portion of this chapter (5.2) briefly reviews the types of restoration practices that are available to address water quality impairments and the practices installed to date in the Prettyboy Reservoir watershed. The second section deals with land preservation and the amount of land preserved to date. The final sections of the chapter discuss different approaches to prioritization (subwatershed, BMP prioritization, and erosion hazard models).

5.2 Best Management Practices

Best management practices (BMP's) are on-the-ground actions that help minimize the delivery of pollutants to waterways from intensively managed lands. BMP's are typically divided into types depending on where they are put in place. Here we distinguish between two broad types: those on agricultural lands and those in developed areas.

5.2.1 Agricultural Best Management Practices

There are a large number of agricultural practices that are used by farmers to minimize soil loss, trap nutrients, and minimize the amounts of nutrients and pesticides used on the land. The Chesapeake Bay Program recognizes many of these agricultural best management practices with specific reduction efficiencies for nitrogen, phosphorus, and sediment assigned to each practice. The efficiencies are currently under review for both the agricultural and urban best management practices. The efficiencies used in the preparation of the Prettyboy Watershed Restoration Action Strategy are those in effect as of 1/12/06 and can be found at the following web address:
http://www.chesapeakebay.net/pubs/waterqualitycriteria/NPS_BMP_Tables_011206.doc

The following description of agricultural best management practices is derived from the Chesapeake Bay Program publication *Best Management Practices (BMP) Basics.*

Agricultural riparian forest buffers are linear wooded areas along rivers, stream and shorelines. Forest buffers help filter nutrients, sediments and other pollutants from runoff, as well as remove nutrients from groundwater. The recommended buffer width for riparian forest buffers (agriculture) is 100 feet, with a 35-foot minimum width required.
Agricultural riparian grass buffers are linear strips of grass or other non-woody vegetation maintained between the edge of fields and streams, rivers or tidal waters that

help filter nutrients, sediment and other pollutant from runoff. The recommended buffer width for riparian forests buffers (agriculture) is 100 feet, with a 35-foot minimum width required.

Agricultural land retirement takes marginal and highly erosive cropland out of production by planting permanent vegetative cover, such as shrubs, grasses, and/or trees. Agricultural agencies have a program to assist farmers in land retirement procedures. Land retired and planted to trees is reported under "Tree Planting".

The tree planting (row crop) BMP includes any tree planting on agricultural lands, except those used to establish riparian forest buffers, targeting lands that are highly erodible or identified as critical resource areas. Tree planting is also called afforestation because it involves growing trees and converting the land use from agricultural to forest. This BMP results in a landuse conversion from row crop to forest. It is assumed that the density of the plantings is sufficient to produce a forest like condition over time.

Nutrient management plan (NMP) implementation refers to a comprehensive plan that describes the optimum use of nutrient inputs to minimize nutrient loss while maintaining crop yield. A NMP details the type, rate, timing, and placement of nutrients for each crop. Soil, plant tissue, manure and/or sludge tests are used to assure optimal application rates. Plans should be revised every 2 to 3 years.

Conservation tillage involves planting and growing crops with minimal disturbance of the surface soil. Conservation tillage requires two components, (a) a minimum 30% residue coverage at the time of planting and (b) a non-inversion tillage method. No-till farming is a form of conservation tillage in which the crop is seeded directly into vegetative cover or crop residue, with little disturbance of the surface soil. Minimum tillage farming involves some disturbance of the soil, but uses tillage equipment that leaves much of the vegetation cover or crop residue on the surface. The overall benefit is to reduce surface soil erosion.

Cereal cover crops reduce erosion and the leaching of nutrients to groundwater by maintaining a vegetative cover on cropland and holding nutrients within the root zone. This practice involves the planting and growing of cereal crops (non-harvested) with minimal disturbance of the surface soil. The crop is seeded directly into vegetative cover or crop residue, with little disturbance of the surface soil. These crops capture or "trap" nitrogen in their tissues as they grow. By timing the springtime cover crop burn or plow-down, the trapped nitrogen can be released and used by the following crop.

Farm conservation plans (SCWQ Plans) are a combination of agronomic, management and engineered practices that protect and improve soil productivity and water quality, and that prevent deterioration of natural resources on all or part of a farm. Plans may be prepared by staff working in conservation districts, natural resource conservation field offices, or a certified private consultant. In all cases, the plan must meet technical standards.

Animal waste management systems are practices designed for proper handling, storage, and utilization of wastes generated from confined animal operations they include a means of collecting, scraping or washing wastes and contaminated runoff from confinement areas into appropriate waste storage structures. Lagoons, ponds, or steel or concrete tanks are used for the treatment and/or storage of liquid wastes. Storage sheds or pits are common

storage structures for solid wastes. Controlling runoff from roofs, feedlots and "loafing" areas are an integral part of these systems.

Stream protection with fencing with off stream watering incorporates both alternative watering and installation of fencing that establishes narrow strips of land along streams to exclude livestock. The fenced areas may be planted with trees or grass, but are typically not wide enough to provide the benefits of buffers. The implementation of stream fencing should substantially limit livestock access to streams, but can allow for the use of limited hardened crossing areas where necessary to accommodate access to additional pastures or for livestock watering.

Off stream watering in pasture without fencing requires the use of alternative drinking water troughs or tanks away from streams. The BMP may also include options to provide shade for livestock away from streams. Limited research has been conducted for this practice that documents changes in livestock behavior resulting in significantly less time spent near streambanks and in streams. The net effectiveness of the practice must reflect partial removal of livestock from near stream areas and relocation of animal waste deposition areas and heavy traffic areas surrounding water sources to more upland locations.

Off stream watering with stream fencing and rotational grazing (pasture) combines stream fencing and alternative watering with cross fencing systems to create paddocks to enable rapid grazing of small areas in sequence. Once an area is intensively grazed of most vegetative matter, the animals are moved to another paddock to enable recovery of the pasture grasses. This BMP is beneficial in removing animals from stream areas, but may be offset by an increased animal stocking rate per acre. This increases the concentration of animal manure per acre and may adversely impact the quality of surface water runoff.

The Maryland Department of Agriculture provided information regarding implementation of agricultural BMPs in the Prettyboy Reservoir watershed in the time period of January 1998 through April 2007. This information pertains only to those practices that were funded by the Maryland Agricultural Water Quality Cost-Share Program (MACS) and does not include practices that may be implemented by individual farmers without a cost-share. Table 5-1 provides a summary of this information.

Table 5-1: Agricultural BMPs Implemented in the Prettyboy Watershed Through the MACS Program

BMP	Extent	Unit	#s N/Unit	#s P/ Unit	#s N/year	# P/Year
Waste Storage Structure	1	ST	531	101	531	101
Conservation Cover	163.4	Acres	4.61	1.13	753	185
Fencing	279.7	Acres	4.53	0.55	1,267	154
Riparian Grass Buffer	5.7	Acres	16.92	1.08	96	6
Riparian Forest Buffer	103.2	Acres	27.28	2.15	2,815	222
Filter Strip	2.3	Acres	16.92	1.08	39	2
Grassed Waterway	10.97	Acres	16.92	1.08	186	12
Roof Runoff Structure	7	NO	69	13	483	91
Nutrient Management Plans	19,709	Acres	3.11	.03	61,295	5,913
SCWQ Plans	18,110	Acres	0.66	0.1	11,953	1,811
2007 Cover Crops	733	Acres	7.48	0.13	6,952	95
Total Nutrient Reductions Implemented					**86,370**	**8,592**

The reduction of 8,592 pounds of Phosphorus represents 31.4% of the 27,340 pounds of Phosphorus reduction needed to meet the Total Maximum Daily Load or approximately 34% of the reduction attributable to agriculture.

5.2.2 Urban Best Management Practices

Urban best management practices include various types of stormwater management, sediment and erosion control, stream restoration, tree planting, and urban residential nutrient management.

The following description of urban best management practices are derived from the Chesapeake Bay Program publication *Best Management Practices (BMP) Basics.*

Stormwater Management Practices:

Wetponds and wetland practices collect and increase the settling of pollutants in the structure and protect downstream channels from frequent storm events. Wetponds retain a permanent pool of water.

Dry detention ponds and hydrodynamic structure practices are used to moderate flows and remain dry between storm events. These are storm water design features that provide a gradual release of water in order to increase the settling of pollutants and protect downstream channels from frequent storm events. A variety of products for these storm water inlets known as swirl separators, or hydrodynamic structures, are modifications of the traditional oil-grit separator and include an internal component that creates a swirling motion as storm water flows through a cylindrical chamber. These designs allow sediment to settle out as storm water moves in this swirling path. Additional compartments or chambers are sometimes present to trap oil and other floatables.

Dry extended-detention ponds are storm water structures that provide a gradual release of a specific volume of water in order to increase the settling of pollutants in the pond and to protect downstream channels from frequent storm events. Dry extended detention ponds are often designed with small pools at the inlet and outlet of the pond. These BMPs can also be used to provide flood control by including additional detention storage above the extended-detention level.

Infiltration practices are used to capture and temporarily store the water quality volume before allowing it to infiltrate into the soil, promoting pollutant treatment and groundwater recharge.

Filtering practices capture and temporarily store the water quality volume and pass it through a filter of sand, organic matter and vegetation, promoting pollutant treatment and groundwater recharge.

Other Urban Best Management Practices

Impervious surface reduction includes practices that reduce the total area of impervious cover as well as features that capture storm water and divert it to pervious areas, subsequently encouraging storm water infiltration.

Stream restoration in urban areas is used to restore an urban stream ecosystem by restoring the natural hydrology and landscape of a stream. Stream restoration in urban areas is used to help improve habitat and water quality conditions in degraded streams.

Typically, streams in need of restoring have watershed conditions that have destabilized the stream channel and eroded stream banks. The objectives for stream restoration in urban areas include, but are not limited to, reducing stream channel erosion, promoting physical channel stability, reducing the transport of pollutants downstream, and working towards a stable habitat with a self-sustaining, diverse aquatic community. Stream restoration activities in urban areas should result in a stable stream channel that experiences no net aggradation or degradation over time.

Erosion and sediment control practices protect water resources from sediment pollution and from increases in runoff associated with land development activities. By retaining soil on-site, sediment and attached nutrients are prevented from leaving disturbed areas and polluting streams.

Urban nutrient management involves the reduction of fertilizer applied to grass lawns and other urban areas. The implementation of urban nutrient management is based on public education and awareness, targeting suburban residences and businesses, with emphasis on reducing excessive fertilizer use.

Mixed open riparian forest buffers are areas of trees usually accompanied by other vegetation, that are adjacent to a body of water and which: maintain the integrity of stream channels; reduce the impact of upland pollution sources by trapping, filtering, and converting sediments, nutrients, and other chemicals; and supply food, cover, and thermal protection to fish and other wildlife. The recommended width for riparian forest buffers (mixed open) is 100 feet with a 35-foot minimum.

Mixed open tree planting includes any tree plantings on any site, except those along rivers and streams, which are considered forested buffers and are treated differently. The definition of tree planting does not include reforestation.

Urban stormwater management has been required in the State of Maryland since 1984. The stormwater management program has evolved over time to include water quality as well as water quantity management. With the introduction of the *Maryland 2000 Design Manual*, large lot subdivisions previously exempt from stormwater management were required to provide stormwater management. The stormwater management facilities within the Prettyboy Reservoir watershed were listed in Chapter 2, Table 2-12. The drainage area to these facilities (317 acres) represents 5.6% of the urban development within the watershed. Utilizing the Chesapeake Bay Program pollutant removal efficiencies for urban stormwater management by facility type, an estimated 82.5 pounds of Phosphorus is removed on an annual basis. This represents ~3% of the phosphorus load coming from developed lands in the watershed.

5.3 Land Preservation

Land preservation complements the implementation of BMP's by insuring that specific non-urban land uses remain intact over time on specific parcels. Here we use the term land preservation to include areas such as parks and watershed protection zones where non-extractive uses predominate, as well as areas that are intensively managed for agriculture. These parcels may be large, such as parks and the city-owned reservoir lands, or small, protecting a single farm. Land preservation reflects societal priorities and decisions to limit urban and residential development, and provides broad benefits. However, while

protected from certain uses, preserved lands may still be intensively used. Therefore, by themselves, they do not assure that certain environmental goals, such as good water quality, will be met. Best management practices must also be used, if such goals are to be met.

5.3.1 Land Preservation to Date

"Protected land" includes any land with some form of long-term limitation on conversion to urban/developed land use. This protection may be in various forms: public ownership for natural resource or low impact recreational intent, private ownership where a third party acquired the development rights or otherwise acquired the right to limit use through the purchase of an easement, etc. The extent of "protection" varies greatly from one situation to the next. Therefore, for some protected land, it may be necessary to explore the details of land protection parcel-by-parcel through the local land records office to determine the true extent of protection.

For purposes of watershed management, an understanding of existing protected lands can provide a starting point in prioritizing potential protection and restoration activities. In some cases, protected lands may provide opportunities for restoration projects because owners of these lands may value natural resource protection or enhancement goals. More information on watershed protection can be found in: *The Practice of Watershed Protection* (Schueler and Holland 2000).

Table 5-2 presents the land preservation data based on type of protection and County. Data were provided by Baltimore County, Carroll County, York County, MDNR and MDP. Some land parcels may be affected by more than one type of protection. For example, government-owned parkland may also have a conservation easement on it. With over 11,000 acres, almost 23% of the area of the entire Prettyboy Reservoir watershed receives one sort of protection or another. Figure 5-1: Protected Areas, shows the status of protected lands in the Prettyboy watershed.

Table 5-2: Protected Lands in Prettyboy Watershed (acres)

Type of Protection	County			Total
	Baltimore	Carroll	York	
Agricultural Preservation Easement	3,081	1,835	645	**5,561**
Public Lands and Parks	5,393	278	0	**5,671**
The Nature Conservancy	0	114	0	**114**
Total	**8,474**	**2,227**	**645**	**11,346**

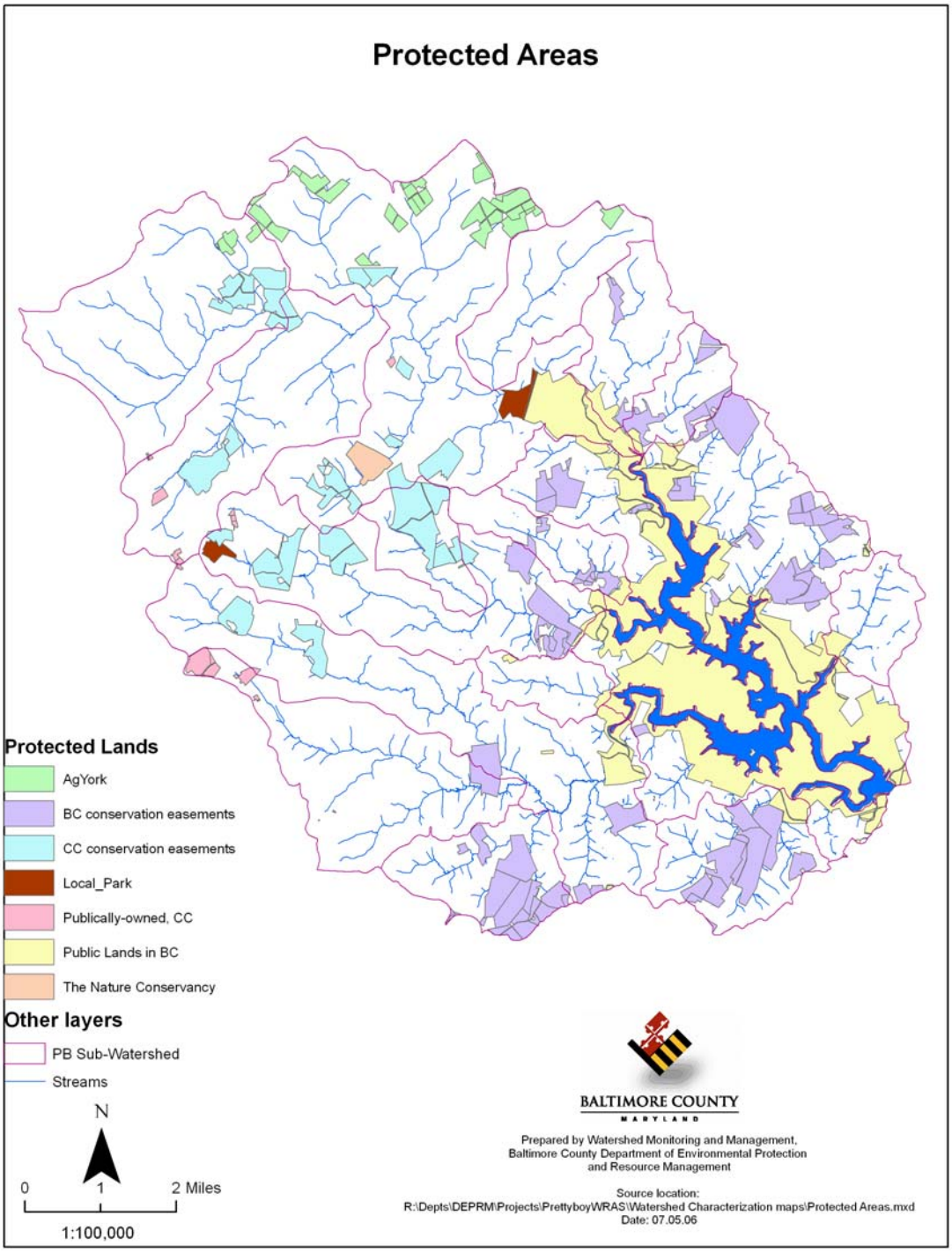

Figure 5-1: Protected Lands in the Prettyboy Reservoir Watershed

5.4 Prioritization

A number of prioritization schemes were developed to help focus efforts on subwatersheds that are more in need of restoration or preservation (5.4.1), project type prioritization (5.4.2), and erosion hazard models (5.4.3).

5.4.1 Subwatershed Prioritization

Using information derived from the water quality assessments, the biological assessments, and the Geographic Information System Analysis, a prioritization scheme was developed to rank the 19 subwatersheds for restoration or preservation. This ranking is intended to provide only a guideline on where to focus efforts. There are other factors that may dictate where restoration and/or preservation efforts actually occur. In addition, there are current efforts underway that focus on certain subwatersheds outside of the ranking scheme developed here. In order to meet the goals for the Prettyboy Reservoir Watershed Restoration Action Strategy, actions will have to take place throughout the watershed.

The following list presents the factors that the steering committee for the WRAS considered important in prioritizing areas to meet WRAS goals. In broad terms, the goals can be met either through restoration actions oriented to degraded sites or preservation actions oriented to relatively intact areas. We examined restoration and preservation options separately, and the factors used in each examination could either differ or overlap significantly, as described below.

Physical/Chemical Factors

- **Size of subwatershed**—larger areas have larger effects on streams and water quality, and are therefore high priorities for both restoration and preservation.
- **Stream Corridor Assessment (SCA) Ranking**—the SCA identifies potential environmental problems along streams; streams with many problems are priorities for restoration, while streams with few problems are priorities for preservation.
- **Phosphorous**—phosphorous, along with nitrogen, is an important nutrient for plant growth, and is applied on farm fields and residential lawns in the form of animal manure or fertilizer; excess phosphorous can enter streams and rivers, where it has a negative impact; streams with high amounts of phosphorous are prioritized for restoration, since targeted restoration efforts can bring these levels down; this factor is given extra weight for restoration, because a Total Maximum Daily Load (TMDL) has been adopted that calls for a 54% reduction in phosphorous entering the Prettyboy Reservoir; as for preservation, streams with low amounts of phosphorous are prioritized, as preserving these areas should insure that phosphorous levels there remain low.
- **Nitrogen**—along with phosphorous, an important nutrient for plant growth that is applied to fields and lawns; nitrogen is also contained in human and animal waste, and enters waterways from septic systems and wastewater treatment plants; like phosphorous, excess amounts of nitrogen in waterways cause negative impacts; as with phosphorous, streams with high concentrations of nitrogen are targeted for restoration, while streams with low concentrations are targeted for preservation
- **Erosion Hazard**—steep areas and certain soils are particularly prone to erosion; such areas are priorities for restoration/reforestation where the trees have been removed, or preservation, if the forest is intact.
- **Erosion Hazard in Stream Buffers**—soil eroded near a stream is much more likely to enter the stream itself and cause negative impacts; areas near streams that are at high risk of erosion are high priorities for restoration and preservation.

Biological Factors

- **Biological Impairment present**—the MD Department of Environment lists watersheds as 'impaired' when they do not meet their official designated uses; biological impairment occurs when fish or aquatic macroinvertebrate communities are not healthy; waters that are not impaired are higher priorities for preservation, while waters that are impaired can benefit from restoration, and are prioritized for such intervention.
- **MBSS Aquatic Species Rankin**g—the MD DNR rates all MD waterways based on their condition and on the presence of rare or threatened aquatic species; streams with rare or threatened species are a priority, both for preservation and restoration.
- **Brook Trout**—this native trout, protected in MD as a Species of Greatest Need of Conservation, is present in some streams in the Prettyboy watershed, and its decline here and throughout MD has raised concern; streams with healthy populations are a priority for preservation, and this factor is given extra weight; for restoration, streams with healthy trout populations also receive priority, as restoring degraded parts of these streams can add habitat where trout are already present.
- **Natural Heritage Ecologically Significant Areas**—the MD DNR tracks rare and threatened animal and plant species, and designates areas where they are present as Ecologically Significant Areas; these areas are prioritized both for restoration and preservation.

Land Use Factors

- **Development**—Where land is developed and covered with roads or buildings, rainfall cannot penetrate the soil and enters streams directly, with negative consequences; areas with large amounts of development are high priorities for restoration and low priorities for preservation.
- **Projected Land Use**—zoning allows for new residential or commercial uses on certain land parcels, and is specific to each county; areas that are expected to grow significantly are high priorities for preservation, especially if they contain environmentally valuable or sensitive areas; projected land use is not a factor in restoration.
- **Area in Public/Protected Ownership**—some land in the Prettyboy watershed is publicly owned; large areas with a significant amount of publicly protected land are ideal candidates for further preservation, as large protected areas bring many environmental benefits; these areas can also be excellent candidates for restoration where they are degraded, and are prioritized as such.
- **Forested Area**—forests have many environmental benefits; areas with high forest cover are priorities for preservation, while areas with low forest cover are priorities for restoration/reforestation.
- **Forests in Stream Buffers**—forests in stream buffers help to take up nutrients and sediment that would otherwise enter streams; areas that have little forest buffer along their streams are high priorities for restoration, while areas with extensive forest buffer are high priorities for preservation.

5.4.1.1 Restoration Subwatershed Prioritization

The criteria for subwatershed restoration ranking are presented in Table 5-3, while the results are presented in Table 5-4 and Figure 5-2.

Table 5-3: Subwatershed Restoration Ranking Criteria

Criteria	Criteria Related to Priority	Normalized Score (1-4)	Criteria Weighting
Phosphorus Yield	Higher yield = higher priority	<0.1 kg/H/day=1 0.1-0.3=2 0.3-0.7=3 >0.7=4	2
Nitrogen Yield	Higher yield= higher priority	<0.2kg/H/day=1; 0.2-0.3=2 0.3-0.75=3; >0.75=4	1
Biological Impairment	Y=high priority N=low priority	Y = 4 N= 1	1
MBSS Aquatic Species Ranking	RTE Species Present = higher priority	Cat.1 (aquatic RTE present) = 4 Cat 2 (watch list spp. Present) = 3 Cat.3 (Good Biological Integrity) = 2	1
Brook Trout	Higher trout abundance = higher priority	>1.5 mi & >50/km=4; >1 mi &>25/km=3; Present=2; Absent or no data=1	1
Natural Heritage Ecologically Significant Area	Y=high priority N=low priority	Y = 4 N = 1	1
Erosion Hazard	Higher erosion hazard on ag.land=higher priority	>20% of Land Area in High Erosion Hazard = 4 15-20 = 3 10-15 = 2 <10 = 1	2
Erosion Hazard in Stream Buffers	Higher erosion hazard=higher priority	>30% of buffer acres in High Erosion Hazard = 4 20-30 = 3 15-20 = 2 <15 = 1	2
Forested Area	Higher forested area= lower priority	>50% of subshed area forested=1 40-50%=2 30-40=3 <30=4	1
Forested vs. Unfrosted Stream Buffer Area	Higher forest %=lower priority	<42% of Buffer in Forest = 4 42-52 = 3 52-62 = 2 >62 = 1	1
Stream Corridor Assessment Ranking	Higher problem index= higher priority	>5 problems per mile surveyed=1 3.4-5 = 2 2-3.4 = 3 <2 = 4 No data = 2.5	1
Amount of Public/Protected Ownership	Higher % of public land=higher priority	0%=1; 0-10=2; 10-20=3 ;>20=4	1
Impervious Surface	Higher impervious= higher priority	<2% = 1 2-3 = 2 3-4 = 3 >4 = 4	1
Size of Watershed	Larger subshed=higher priority	<1100 acres=1; 1100-2000=2; 2000-4500=3; >4500=4	1

Table 5-4: Subwatershed Prioritization: Restoration Results

Subwatershed	Phosphorus Yield	Nitrogen Yield	Biological Impairment	MBSS Aquatic Species Ranking	Brook Trout	Natural Heritage Ecologically Significant Area	Erosion Hazard	Erosion Hazard in Stream Buffers	Forested Area	Forested vs. Unfrosted Stream Buffer Area	Stream Corridor Assessment Ranking	Amount of Public/Protected Ownership	Impervious Surface	Size of Watershed	Total Restoration Score	Restoration Rank
313																
Compass Run	2	1	1	4	2	1	6	4	2	3	2	2	2	1	33	17
Frog Hollow	4	2	1	4	2	1	2	6	2	1	2.5	2	2	1	32.5	19
Poplar Run	4	1	1	4	3	4	4	2	2	2	1	2	2	1	33	18
Prettyboy Branch	4	2	4	4	1	1	4	2	4	4	1	2	2	2	37	13
Prettyboy DD 1	5	2.5	1	4	1	1	4	8	1	1	2.5	4	1	2	38	12
Prettyboy DD2	5	2.5	1	4	1	1	4	6	1	1	2.5	4	1	2	36	14
Prettyboy DD 3	6	3	1	4	4	4	6	8	1	1	2.5	4	1	4	49.5	3
Prettyboy DD 4	4	1	1	4	3	1	6	6	1	1	1	4	1	2	36	15
Silver Run	4	2	1	4	4	1	6	8	3	2	1	2	1	1	40	10
314																
Georges Run	6	3	1	2	1	4	6	4	4	4	3	2	3	4	47	4
Murphy Run	6	3	1	2	1	4	4	4	4	3	4	1	4	3	44	6
Peggys Run	6	3	1	2	1	4	4	6	4	4	2	1	2	2	42	7
315																
Grave Run	6	3	1	3	1	4	4	4	2	2	4	2	2	3	41	8
Indian Run	2	1	1	3	3	4	2	6	3	3	4	1	2	1	36	16
316																
Gunpowder Falls	8	4	1	3	4	4	8	4	3	3	1	2	2	4	51	1
Muddy Creek	6	3	1	3	2	4	8	8	3	4	2.5	2	2	2	50.5	2
Walker Run	6	3	1	3	4	4	2	6	2	1	1	2	2	2	39	11
317																
South Branch	6	3	1	2	1	4	8	2	4	4	2.5	1	3	3	44.5	5
South Branch Gunpowder Falls	6	3	1	2	1	4	6	2	3	4	2.5	1	2	3	40.5	9

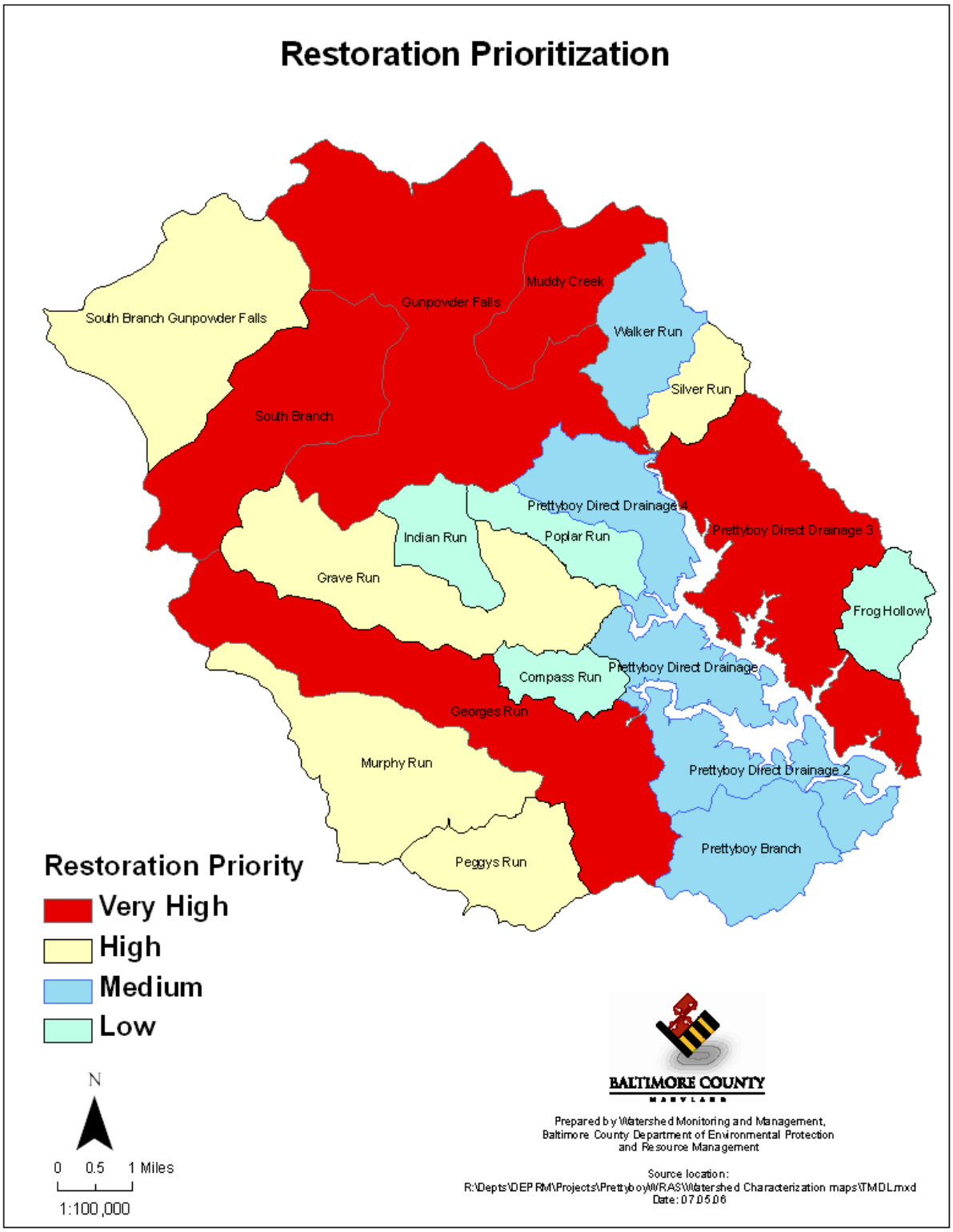

Figure 5-2: Prettyboy Subwatershed Restoration Ranking Results by Quartile.

5.4.1.2 Preservation Subwatershed Prioritization

The criteria for subwatershed preservation ranking are presented in Table 5-5, while the results are presented in Table 5-6 and Figure 5-3.

Table 5-5: Criteria for Subwatershed Prioritization: Preservation Results

Criteria	Criteria Related to Priority	Normalized Score (1-4)	Criteria Weighting
Phosphorus Yield	Higher yield = higher priority	<0.1 kg/H/day = 1 0.1-0.3 = 2 0.3-0.7 = 3 >0.7 = 4	2
Nitrogen Yield	Higher yield = higher priority	<0.2kg/H/day = 1 0.2-0.3 = 2 0.3-0.75=3 >0.75 = 4	1
Biological Impairment	Y = high priority N = low priority	Y = 4 N = 1	1
MBSS Aquatic Species Ranking	RTE Species Present = higher priority	Cat.1 (aquatic RTE present) = 4 Cat 2 (watch list spp. Present) = 3 Cat.3 (Good Biological Integrity) = 2	1
Brook Trout	Higher trout abundance = higher priority	>1.5 mi & >50/km = 4 >1 mi &>25/km = 3 Present = 2 Absent or no data = 1	1
Natural Heritage Ecologically Significant Area	Y= high priority N = low priority	Y = 4 N = 1	1
Erosion Hazard	Higher erosion hazard on ag.land=higher priority	>20% of Land Area in High Erosion Hazard = 4 15-20 = 3 10-15 = 2 <10 = 1	1
Erosion Hazard in Stream Buffers	Higher erosion hazard=higher priority	>30% of buffer acres in High Erosion Hazard = 4 20-30 = 3 15-20 = 2 <15 = 1	1
Forested Area	Higher forested area = higher priority	>50% of subshed area forested=4; 40-50%=3 30-40=2 <30=1	1
Forested vs. Unfrosted Stream Buffer Area	Higher forest %=lower priority	<42% of Buffer in Forest = 1 42-52 = 2 52-62 = 3 >62 = 4	1
Stream Corridor Assessment Ranking	Higher problem index=higher priority	>5 problems per mile surveyed=1 3.4-5 = 2 2-3.4 = 3 <2 = 4 No data = 2.5	1
Amount of Public/Protected Ownership	Higher % of public land= higher priority	0% = 1 0-10 = 2 10-20 = 3 >20 = 4	1
Impervious Surface	Lower impervious= higher priority	<2% = 4 2-3 = 3 3-4 = 2 >4 = 1	1
Size of Watershed	Larger subshed=higher priority	<1100 acres = 1 1100-2000 = 2 2000-4500 = 3 >4500 = 4	1

Table 5-6: Subwatershed Prioritization: Preservation Results

Subwatershed	Phosphorus Yield	Nitrogen Yield	Biological Impairment	MBSS Aquatic Species Ranking	Brook Trout	Natural Heritage Ecologically Significant Area	Erosion Hazard	Erosion Hazard in Stream Buffers	Forested Area	Forested vs. Unfrosted Stream Buffer Area	Stream Corridor Assessment Ranking	Amount of Public/Protected Ownership	Impervious Surface	Size of Watershed	Total Restoration Score	Preservation Rank
313																
Compass Run	1	1	4	4	4	1	3	2	3	2	3	2	3	1	34	14
Frog Hollow	2	2	4	4	4	1	1	3	3	4	2.5	2	3	1	36.5	11
Poplar Run	2	1	4	4	6	4	2	1	3	3	4	2	3	1	40	9
Prettyboy Branch	2	2	1	4	2	1	2	1	1	1	4	2	3	2	28	19
Prettyboy DD 1	2.5	2.5	4	4	2	1	4	4	4	4	2.5	4	4	2	44.5	5
Prettyboy DD2	2.5	2.5	4	4	2	1	4	3	4	4	2.5	4	4	2	43.5	7
Prettyboy DD 3	3	3	4	4	8	4	3	4	4	4	2.5	4	4	4	55.5	1
Prettyboy DD 4	2	1	4	4	6	1	3	3	4	4	4	4	4	2	46	4
Silver Run	2	2	4	4	8	1	3	4	2	3	4	2	4	1	44	6
314																
Georges Run	3	3	4	2	2	4	3	2	1	1	2	2	2	4	35	12
Murphy Run	3	3	4	2	2	4	2	2	1	2	1	1	1	3	31	18
Peggys Run	3	3	4	2	2	4	2	3	1	1	3	1	3	2	34	15
315																
Grave Run	3	3	4	3	2	4	2	2	3	3	1	2	3	3	38	10
Indian Run	1	1	4	3	6	4	1	3	2	2	1	1	3	1	33	17
316																
Gunpowder Falls	4	4	4	3	8	4	4	2	2	2	4	2	3	4	50	2
Muddy Creek	3	3	4	3	4	4	4	4	2	1	2.5	2	3	2	41.5	8
Walker Run	3	3	4	3	8	4	1	3	3	4	4	2	3	2	47	3
317																
South Branch	3	3	4	2	2	4	4	1	1	1	2.5	1	2	3	33.5	16
South Branch Gunpowder Falls	3	3	4	2	2	4	3	1	2	1	2.5	1	3	3	34.5	13

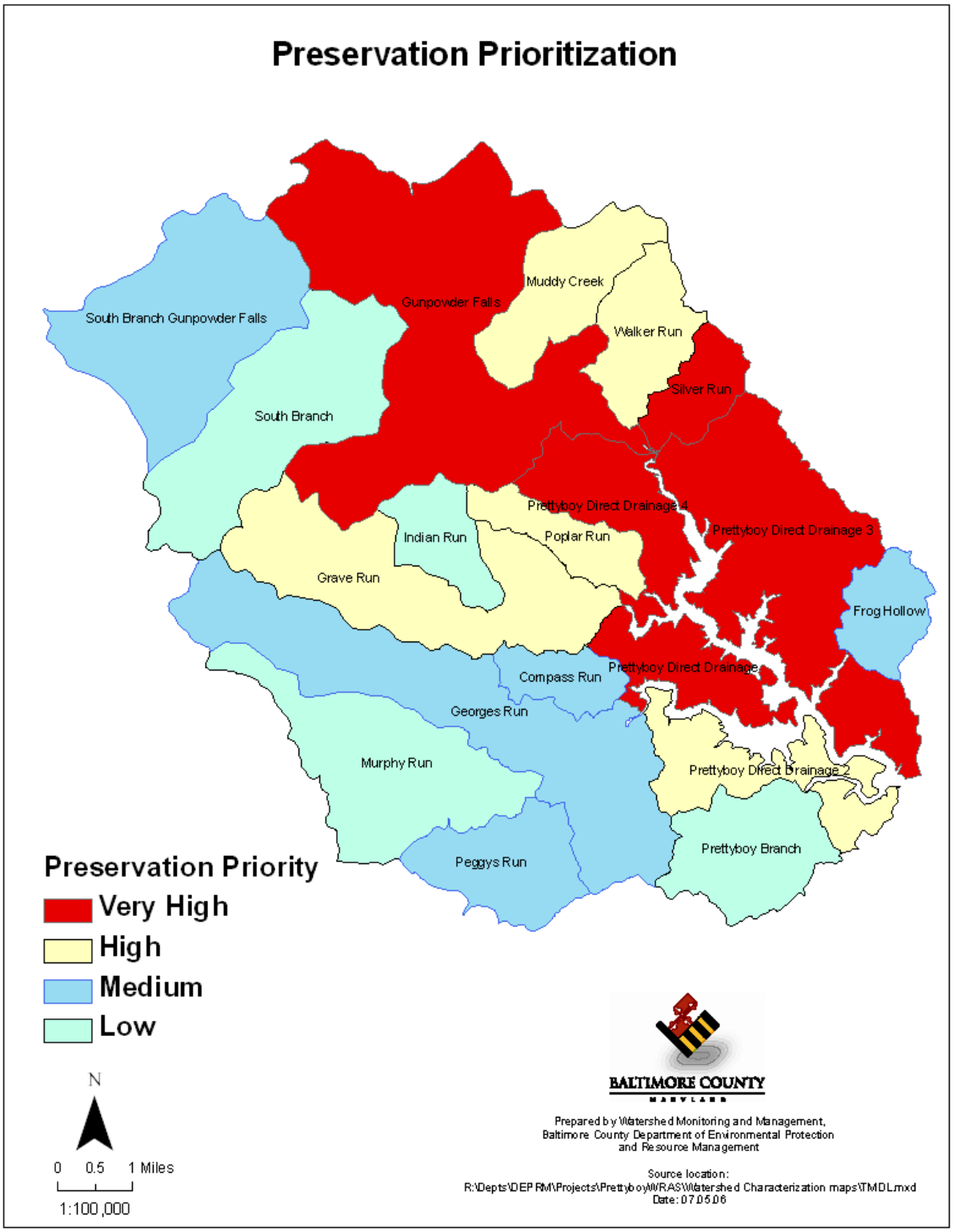

Figure 5-3: Prettyboy Subwatershed Preservation Ranking by Quartile.

5.4.2 Best Management Practices Prioritization

The Prettyboy WRAS Steering Committee and stakeholders have identified 8 goals. There are also four specific water quality objectives (TMDL for Phosphorus, watershed impairment for bacteria, three 12-digit subwatershed impairments for biology, and the Chesapeake Bay Program nitrogen reduction goals) identified through water quality impairments. In order to determine the how the various best management practices relate to the goals and the water quality objectives, a subjective analysis was conducted. The results are displayed in Table 5-7. Below the table are found the designations for the BMP numbers and the description of the goals. The goals are further elaborated in the WRAS document.

Table 5-7: Prettyboy WRAS BMPs and Goals

BMP	TMDL - P	TMDL – Bacteria	TMDL - Biological	CBP - N	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6	Goal 7	Goal 8
Development (Urban)												
1	++	++	+	++	++	++					++	++
2	++			++	++	++					++	++
3	++		++	++	++	++	++	++	++		++	++
4	++		++	++	++	++	++	++	++		++	++
5	++		++	++	++	++	+	++			++	++
6	++			++	++	++	++	++	++		++	++
7				++	++	+					++	+
8		+		++	++	++					++	+
Agriculture												
1	++	+	++	++	++	++	++	++	++	--		++
2	+	+		+	++	++		+		-		++
3	+	+		+	++	++				++		++
4				++	++	++				++		+
5	++	++	+	++	++	++				++		+
6	++	++	+	++	++	++				++		+
7	++		+	+	++	++	+	+	+	-		++
8	++		++	++	++	++	++	++	++	++		++
9	++			++	++	++		++		++		+
10	++			+	++	++				++		+
11	++	++	+	++	++	++				++		+
12	++		++	++	++	++				++		++
13	++	++	+	+	++	++				++		+
Forest												
1	++		++	++	++	++	++	++	++		++	++
Misc.												
1			++			++						++

BMPs	
Development (Urban)	Agriculture
1 – Stormwater Management	1 – Riparian Forest Buffers & Wetland Restoration
2 – Nutrient Management	2 – Riparian Grass Buffers
3 – Riparian Forest Buffers	3 – Conservation Plans
4 – Wetland Restoration	4 – Cover Crops
5 – Stream Restoration	5 – Off stream watering with stream fencing
6 – Tree Planting	6 – Animal Waste Management Systems
7 – Septic Denitrification	7 – Land Retirement
8 – Septic Pumping	8 – Tree Planting
	9 – Nutrient Management Plan
Forest	10 – Continuous No-Till
1 – Forest Harvest Practices	11 – Water Control Structures
	12 – Non-Urban Stream Restoration
Misc.	13 – Horse Pasture Management
1 – Fish Barrier Removal	
Goals	
Goal 1 – Improve and Maintain Clean Water	
Goal 2 – Restore and Maintain Aquatic Biodiversity	
Goal 3 – Support Wildlife Habitat, Recreation, and Aesthetics	
Goal 4 – Restore and Maintain Terrestrial Biodiversity	
Goal 5 – Promote Ecological and Economic Sustainability of Forest	
Goal 6 – Promote Environmentally Sensitive Farming	
Goal 7 – Promote Environmentally Sensitive Development	
Goal 8 – Inter-governmental Commitments	
Relationship Between Goals and BMPs	
+ = BMP supports Goal	
++ = BMP strongly Supports Goal	
- = BMP has a negative impact on Goal	
-- = BMP has a strong negative impact on Goal	

As can be seen from Table 5-7 all BMPs do not address all of the goals. Because goal number 1 is related to water quality in general, almost all BMPs will have a positive effect. When looking at specifically the TMDL for Phosphorus however, those practices that affect nitrogen, only drop out. There are a few negative effects of BMPs related to the goal of promoting environmentally sensitive farming, mainly from an economic impact. We have heard from stakeholders that some practices are less acceptable due to the economic impact. Practices such as forested riparian buffers, grassed buffers, and land retirement take land out of production. Forested riparian buffers may also impact crop yield through shading and/or water uptake, as well as, harboring pests and deer.

The information displayed in Table 5-7, along with the pollutant removal efficiencies for the BMPs, will be used to develop the management scenario for addressing the Phosphorus TMDL.

5.4.3 Erosion Hazard Models

Soil erosion is a natural process that occurs at very low rates on lands occupied by the natural forest vegetation that is native to the Piedmont. However, when this forest cover is reduced or completely removed, the soil becomes more susceptible to erosion. The degree of susceptibility depends on several natural factors, including the force of rainfall, which varies seasonally, the steepness of the land, and the soil's erodibility. Erodibility and steepness were presented in Chapter 2. Additionally, the human-influenced vegetative cover plays a major role. As soil is

exposed during such activities as land clearing for development or plowing to plant crops, it can be transported by overland water flow from storms.

Two erosion hazard models were developed to help target lands for BMPs based on the erodibility and slope of agricultural lands. Because erosion occurs at low background rates on forestland, and because forest is the most protective land cover, these areas have been removed from this analysis. In addition, developed areas were not evaluated for erosion hazard, as they contain significant portions of impervious surface where the soil has been covered and cannot be eroded. Nor were wetlands included in the analysis. One model addresses erosion hazard of all agricultural land surfaces, while the second model is limited to the riparian buffer within 100 feet of streams. In both models, the same criteria were used to determine the erosion hazard category. These criteria are displayed in Table 5-8.

Table 5-8: Erosion Hazard Categories

Erodibility		Slope		
		Low <25%	Medium 15-24%	High >24%
Low	<.25	Low	Low	Midium
Medium	.25 - .32	Low	Medium	High
High	>.32	Medium	High	High

5.4.3.1 Erosion Hazard of Agricultural Lands

Table 5-9 and Figure 5-4 show erosion hazard classes based on present land cover in the Maryland portion of the Prettyboy watershed.

Table 5-9. Erosion Hazard of Maryland Agricultural Lands by Subwatershed (%)

DNR 12-digit Scale	Subwatershed Scale	Agri-cultural Acres	Erosion Hazard %		
			Low	Medium	High
0313	Compass Run	381	40.6	42.5	17.1
	Frog Hollow	314	53.6	37.9	8.3
	Poplar Run	386	25.5	60.2	14.5
	Prettyboy Branch	1,353	33.5	55.4	11.1
	Prettyboy Direct Drainage 1	41	3.5	42.6	54.1
	Prettyboy Direct Drainage 2	448	30.6	48.5	20.9
	Prettyboy Direct Drainage 3	1,330	38.2	45.0	16.7
	Prettyboy Direct Drainage 4	641	34.0	50.5	15.5
	Silver Run	457	40.1	44.1	16.0
	0313 Total	**4,902**	**35.5**	**49.5**	**15.0**
0314	Georges Run	3,328	30.6	53.3	16.0
	Murphy Run	1,565	37.4	49.5	13.1
	Peggys Run	1,348	42.3	45.8	11.9
	0314 Total	**6,241**	**34.8**	**50.7**	**14.4**
0315	Grave Run	2,020	27.0	57.6	15.4
	Indian Run	621	35.3	54.9	9.8
	0315 Total	**2,641**	**28.9**	**56.9**	**14.1**
0316	Gunpowder Falls	2,577	25.1	50.6	24.3
	Muddy Creek	675	24.1	51.2	24.8
	Walker Run	600	47.8	42.4	9.9
	0316 Total	**3,852**	**28.4**	**49.4**	**22.2**
0317	South Branch	2,011	22.6	53.5	24.0

	South Branch Gunpowder Falls	1,981	20.8	65.1	14.1
	0317 Total	**3,992**	**21.7**	**59.2**	**19.1**
Prettyboy Reservoir Watershed Total		***22,077***	***30.7***	***52.5***	***16.8***

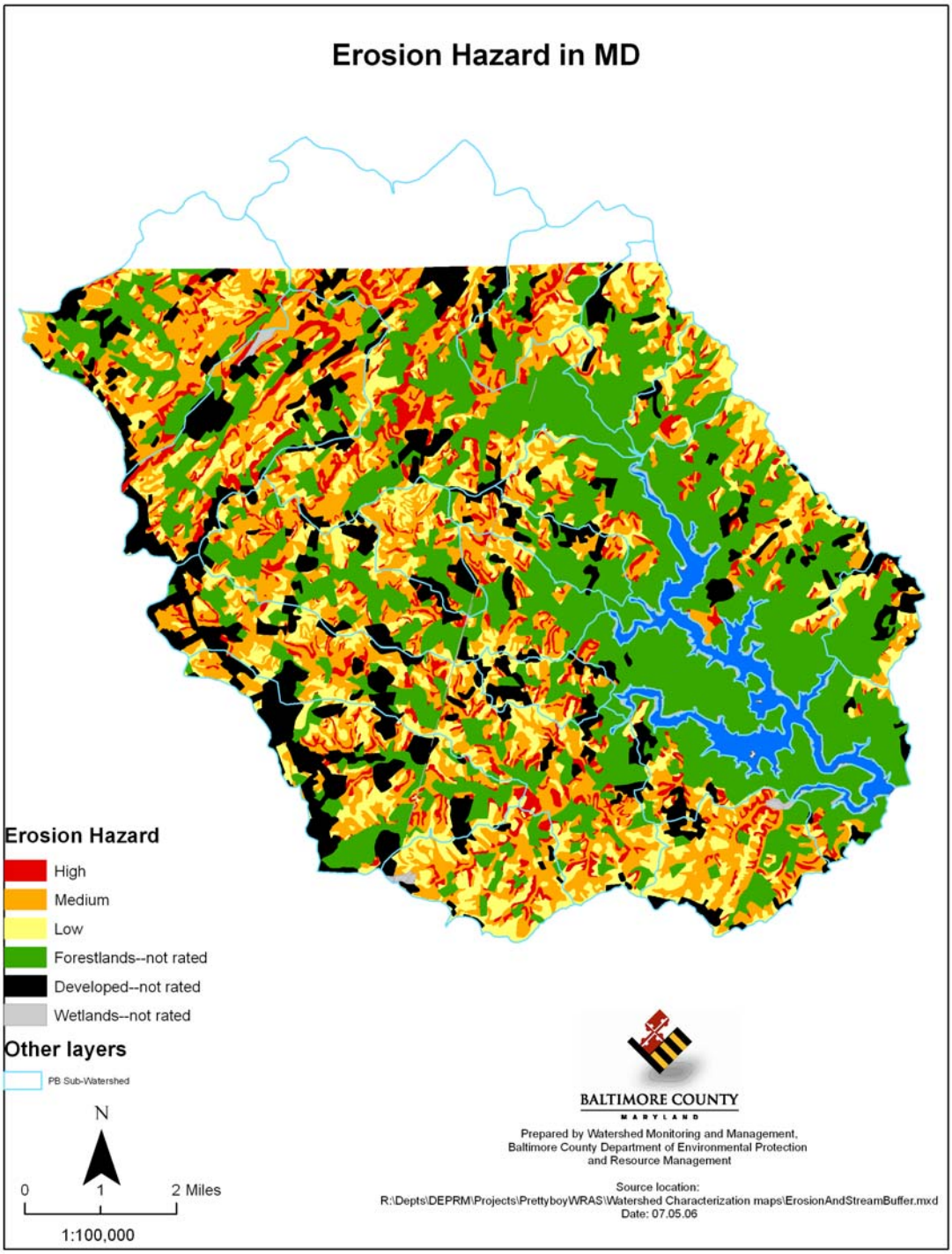

Figure 5-4: Erosion Hazard for Agricultural Land Uses

Prettyboy Direct Drainage 1 has the highest percent high erosion hazard, but only has 41 acres of agricultural land. Four additional subwatersheds (Muddy Creek, Gunpowder Falls, South Branch, and Prettyboy Direct Drainage 2) exceed 20% for the high erosion hazard, all of them with substantial agricultural land use. Overall approximately 3,700 acres of agricultural land use fall in the high erosion hazard category.

5.4.3.2 Land Use Adjacent to Streams

Soil erosion near streams is of particular concern. Soil lost in such areas is typically carried directly to the stream, resulting in higher sedimentation rates that negatively affect ecological conditions. Table 5-10 summarizes the erosion hazard within the 100 foot riparian buffer by subwatershed

5-10: Erosion Hazard in Stream Buffers (%)

DNR 12-digit Scale	Subwatershed Scale	Agri-cultural Acres	Erosion Hazard %		
			Low	Medium	High
0313	Compass Run	32.5	10.5	69.8	19.7
	Frog Hollow	17.4	6.3	66.1	27.6
	Poplar Run	37.3	3.2	83.6	13.1
	Prettyboy Branch	221.3	2.2	85.1	12.7
	Prettyboy Direct Drainage 1	2.8	0.0	53.6	46.4
	Prettyboy Direct Drainage 2	61.3	1.8	69.3	28.9
	Prettyboy Direct Drainage 3	109.8	6.4	61.5	32.1
	Prettyboy Direct Drainage 4	65.4	5.7	71.9	22.5
	Silver Run	43.0	4.2	59.3	36.5
	0313 Total	**590.8**	**4.1**	**74.1**	**21.8**
0314	Georges Run	399.5	1.8	81.0	17.2
	Murphy Run	133.2	3.2	79.5	17.3
	Peggys Run	192.3	3.3	73.5	23.2
	0314 Total	**725.0**	**2.5**	**78.7**	**18.8**
0315	Grave Run	158.9	3.8	77.3	18.8
	Indian Run	47.5	1.5	77.7	20.8
	0315 Total	**206.4**	**3.3**	**77.4**	**19.3**
0316	Gunpowder Falls	250.6	7.3	75.2	17.4
	Muddy Creek	76.6	2.9	53.9	43.2
	Walker Run	40.8	9.1	67.9	23.0
	0316 Total	**368.0**	**6.6**	**70.0**	**23.4**
0317	South Branch	164.4	6.9	84.2	8.9
	South Branch Gunpowder Falls	210.8	6.4	82.3	11.3
	0317 Total	**375.2**	**6.6**	**83.1**	**10.3**
	Prettyboy Reservoir Watershed Total	***2,265.4***	***7.3***	***76.7***	***19.0***

The erosion hazard in stream buffers is presented in Figure 5-5. This map includes the erosion hazard along the streams and does not include the reservoir buffer, which is entirely forested.

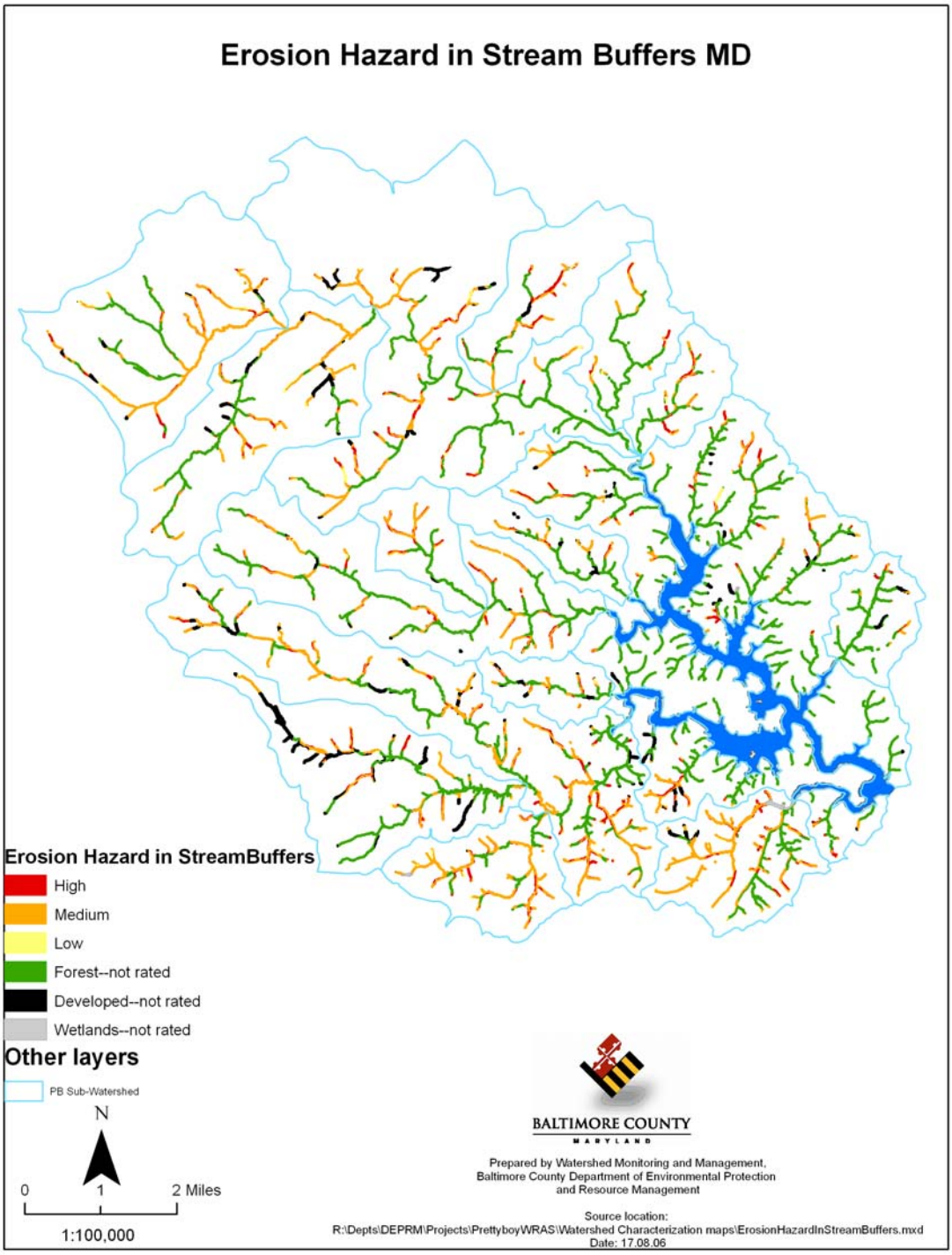

Figure 5-5: Erosion Hazard in Stream buffers.