CASSELMAN RIVER WATERSHED PLAN FOR pH REMEDIATION

JANUARY 2011

Creation of this watershed plan was a cooperative effort by:

Maryland Department of the Environment

Land Management Administration

Mining Program

Abandoned Mine Lands Division

and

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Water Quality Protection

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TMDL Implementation Division

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LIST OF ABBREVIATIONS:

AMD	Acid Mind Drainage
AML	Abandoned Mine Land
AMLD	MDE Abandoned Mine Lands Division
ANC	Acid Neutralization Capability
BIBI	Benthic Index of Biotic Integrity
BMP	Best Management Practice
CEP	Casselman Eastern Portion
COCW	Crab Orchard Creek Watershed
COMAR	Code of Maryland Regulations
CVI	Canaan Valley Institute
CWA	Clean Water Act
DNRF	MD Department of Natural Resources Inland Fisheries
DOC	Dissolved Organic Carbon
EBJTV	Eastern Brook Trout Joint Venture
GIS	Geographic Information System
gpm	gallons per minute
LA	Load Allocations
LLB	Limestone Leach Beds
MACS	Maryland Agricultural Water Quality Cost-Share
MBSS	Maryland Biological Stream Survey
MBTA	Maryland Brook Trout Alliance
MDAS	Mining Data Analysis System
MDE	Maryland Department of the Environment
mg/L	milligrams per liter
MSC	Main Stem Casselman
NBC-1	North Branch Casselman - Headwaters
NBC-2	North Branch Casselman - Mainstem
NPS	Non-Point Source
NRCS	Natural Resources Conservation Service
OLC	Oxic Limestone Channels
RAPs	Reducing and Alkalinity Producing systems
RC&D	Western MD Resource, Conservation and Development Council, Inc.
TMDLs	Total Maximum Daily Loads
tpy	tons per year
UMAL	University of MD Center for Environmental Science - Appalachian Laboratories
USEPA	United States Environmental Protection Agency
USOSM	United States Office of Surface Mining
WLA	Waste Load Allocations
WRP	Watershed Restoration Plan
WVDNR	West Virginia Department of Natural Resources
YRWO	Youghiogheny River Watershed Organization

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1. Introduction

The Casselman River Watershed (Casselman), located in Garrett County, Maryland flows from its headwaters near the Savage River state forest to the state line with Pennsylvania. The Casselman flows north, and lies within the Monongahela River watershed, a part of the Ohio River drainage basin. The main river is approximately 20 miles in length from the headwaters in the North Branch to the Maryland/ Pennsylvania line. In 1996, the Casselman River (MD Segment 05020204) was placed on Maryland's 303(d) list for low pH impairment. A Total Maximum Daily Load (TMDL) for pH was developed and approved for the Casselman River watershed in 2008. The Casselman is a high quality mountain stream noted for its populations of endangered species such as Brook Trout, Stonecats, and Hellbenders in its less impaired reaches. The tributaries of the Casselman that have pH impairment have shown a significant reduction in the native brook trout population. This plan will incorporate phased mitigation strategies to eliminate pH impairments associated with acid mine drainage (AMD) from abandoned mine lands (AML) or episodic atmospheric deposition and to monitor the effects of mitigation efforts on biological communities.

Purpose

The purpose of this document is to provide a comprehensive Watershed Restoration Plan (WRP) for the Casselman River with respect to Non-Point Sources (NPS) of acidity. The watershed receives acid loads from both abandoned mine land (AML) discharges and episodic atmospheric deposition. The intent of this project is to establish a comprehensive, holistic approach toward assessment and eventual pollution abatement and mitigation of the existing water quality problems. The WRP will provide a framework for future efforts by the Maryland Department of the Environment (MDE) Abandoned Mine Lands Division (AMLD), formerly called Bureau of Mines (BOM), for prioritizing and coordinating restoration/planning activities with citizens as well as federal and local agencies.

This WRP will serve as a working template/framework to guide future mitigation/planning and monitoring efforts and will assist in setting mitigation priorities. Phased priority identification of sources and solutions will assist stakeholders with planning and performing more efficiently when restoring and identifying NPS outfalls and related impacts providing the means for more efficient use of already limited funding.

Objectives

The primary objectives of this plan was to identify major NPS discharges within the Casselman River watershed, obtain existing analytical/physical data associated with the discharges, and develop a working Geographic Information System (GIS) database of the data collected.

The second objective was to incorporate elements of prioritization studies conducted by the Canaan Valley Institute (CVI) in 2008 to generate a priority list of impaired stream segments for which general mitigation strategies would be developed. Since funding may not be available to mitigate or address every problem, approaching them in a phased manner would eliminate those problems that require more time to develop access or relationships with the associated stakeholders in order to place effective mitigation projects in those impaired segments.

- During Phase I, pH management measures will be implemented in ten priority stream segments located on state owned land due to ease of access and permission. Pre and post implementation water quality and biological community sampling will be conducted to evaluate the effectiveness of management measures used. An outreach campaign will begin to contact private stakeholders in order to secure access and participation with implementation of phase II. It is anticipated that phase I will require approximately five years to complete.

- Phase II will include additional implementation of pH mitigation measures to address remaining impairments located on private lands. Additional water quality and biological community sampling will be conducted to evaluate the effectiveness of mitigation measures installed during both phases of implementation. It is anticipated that phase II will require an additional five years to gather the necessary permissions, access and implementation funding.

- During Phase III, post reclamation water quality and biological assessments will be used to evaluate success in meeting water quality improvement goals. If it is determined that the technologies, or locations of mitigation projects, failed to meet water quality goals, this phase will be a contingency plan to address alternative methods to meet water quality standards.

The third objective of this plan is to demonstrate that the WRP strategy will restore the Casselman River and its tributaries to support their designated uses and to remove the watershed from the Maryland 303(d) list of impaired waters.

Limitations of the WRP

This plan is based on data generated as a result of previous studies within the watershed. In addition, this assessment focused on the main impairments of the streams within the watershed, namely acid mine drainage from abandoned mine lands and atmospheric deposition. As such, water quality parameters evaluated were generally limited to pH, metals and flow. The biological community will be monitored periodically for reactions to mitigation efforts, but is not a primary component of this WRP. Although portions of the Casselman River flow through Pennsylvania, this document addresses only the portion that flows through Maryland.

2. Watershed Characterization

The Casselman River Watershed lies in the Appalachian Plateau Province, which is characterized by rugged, well-dissected landscape with dendritic drainage pattern. Elevations in the province range from 1000'-3000'. The watershed includes 170 stream miles and occupies an area of approximately 66 square miles or 42,375 acres. **(Figure 1)** For the purposes of this plan, the watershed was divided into 6 subwatersheds to coincide with a 2004 Acid Mine Drainage Analysis. (Davis 2004)

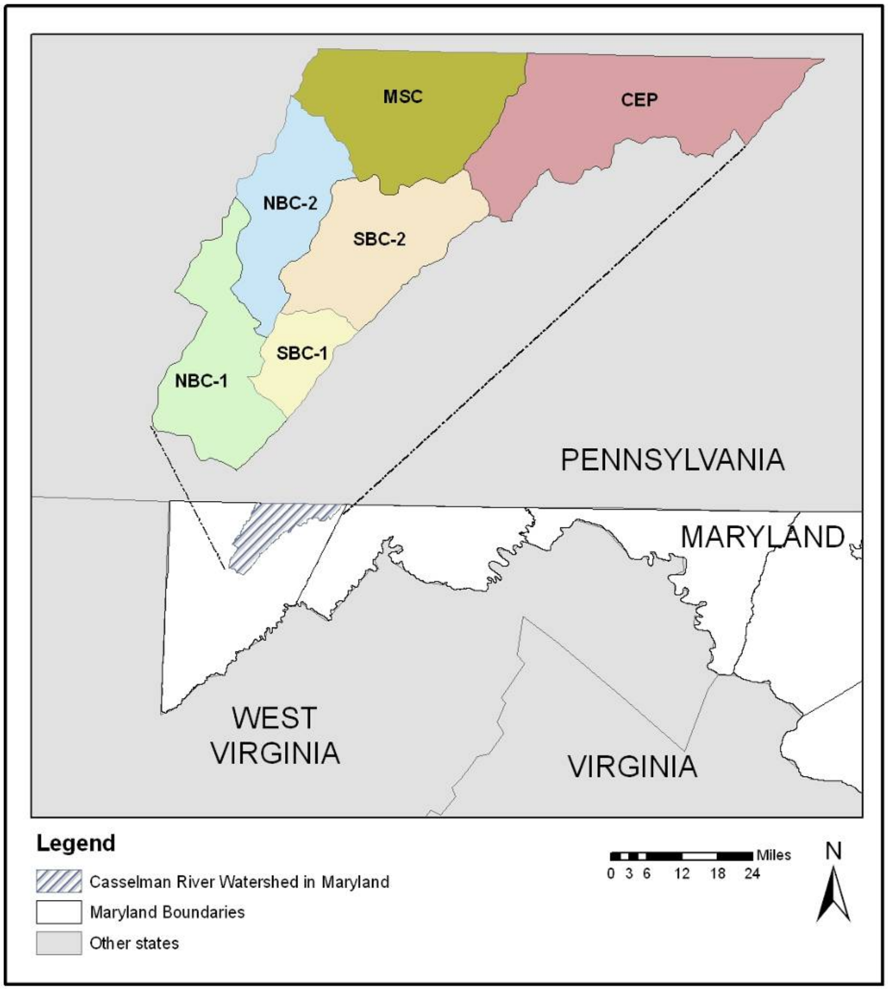

Figure 1 - Overview of Casselman River Watershed

CEP = Casselman Eastern Portion. This section does not have any substantial mining within its boundaries. Meadow Run, Wolf Swamp, Red Run, and Piney Creek (which feeds Piney Reservoir, a water reservoir for the town of Frostburg, MD) are all a part of this sub-watershed.
MSC = Main Stem Casselman River to the Pennsylvania border. Included in this sub-watershed are Spiker Run, Little Shade Run, Big Shade Run, Slaughbaugh Run, Crab Run, Schoolhouse Run, and several unnamed tributaries to the Mainstem Casselman.
NBC-1 = Headwaters of the NB Casselman which includes Cunningham Swamp, and several unnamed tributaries to the NB Casselman.
NBC-2 = Lower reaches of the NB Casselman up to the confluence with the SB Casselman. Tributaries located within this portion include Alexander Run, Tarn Kiln Run, and several unnamed tributaries to the river.
SBC-1 = Headwaters of the SB Casselman which includes a few unnamed tributaries.
SBC-2 = Lower reaches of the SB Casselman up to the confluence with the NB Casselman. Tributaries located within this portion include Little Laurel Run and Big Laurel Run, along with a few unnamed tributaries.

Low, rolling hills and wetlands best describes the terrain of most of the Casselman River Basin in Maryland, particularly throughout the southern and eastern extents. A high plateau in the northwest portion of the basin supports the largest development, which includes low density residential, industrial, and high intensity agriculture. Development in the northwest ends abruptly as a high plateau descends to the wide valley of the Casselman River. The remainder of the basin contains sparse roadside residences and large low intensity agriculture (BSID 2009). **(Figure 2)**

Table 1. Casselman Land Use

Coverage Type	Acreage	Percent Coverage
Agriculture	16758.46	19
Urban	3521.09	9
Forest	172059.97	71
Water	992.90	1

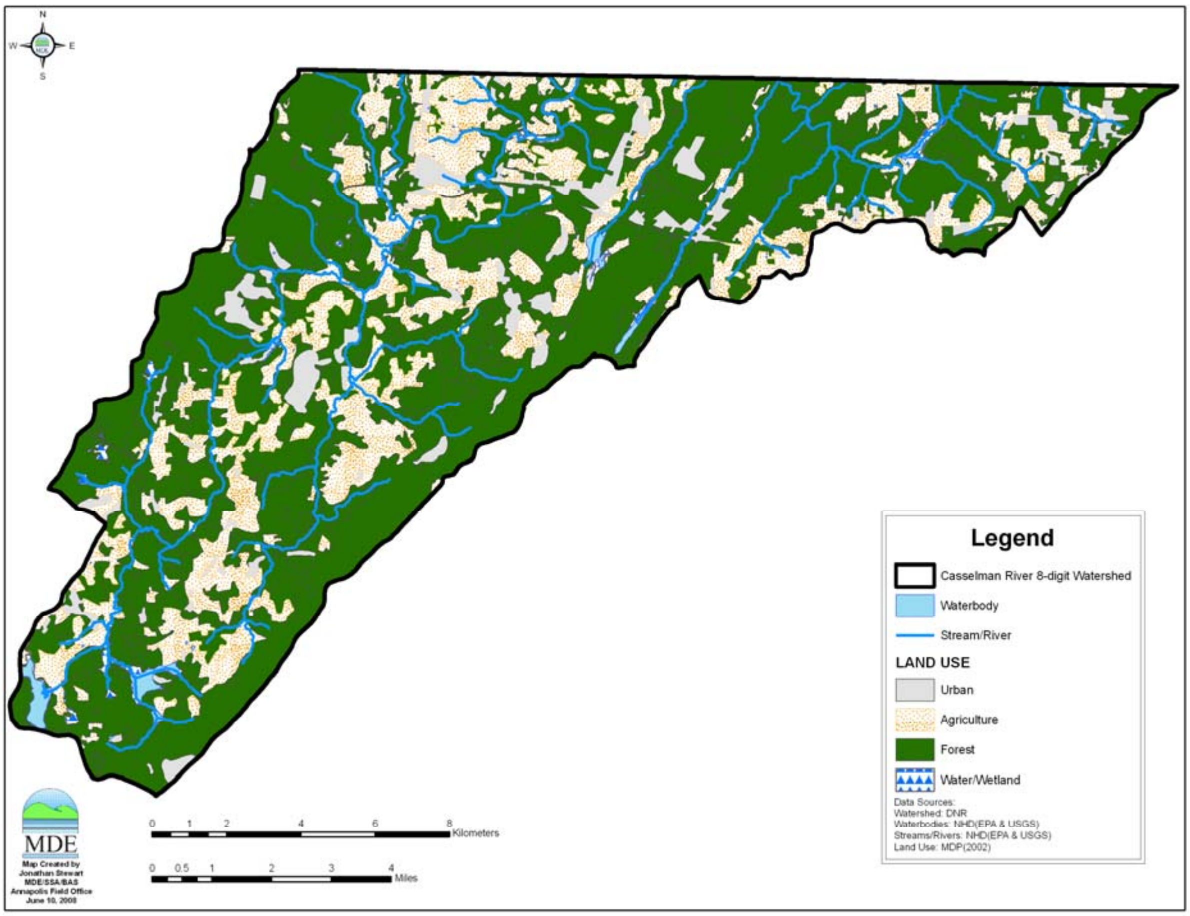

Figure 2. Land Use Map of Casselman (BSID 2009)

The Casselman originates from wetlands along the southern watershed boundary which is bordered by the intersection of Meadow Mountain to the east and Negro Mountain to the west. A North Branch (to the west) and a South Branch (to the east) flow northward nearly parallel to each other and converge mid-basin to form the Casselman mainstem. Maryland Route 495, which transects the basin, roughly divides the North and South Branch drainage areas. The South Branch Casselman is a small stream with few significant tributaries and is predominantly forested.

The Casselman mainstem is a slow moving, meandering river with areas of wide shallow riffles. The North and South Branches contribute nearly equal flows to the Casselman mainstem. The North Branch drainage area includes the southwest quarter of the Casselman watershed, as well as the entire southern boundary. The valley in the southern portion of the drainage contains many wetlands due to its low topography. Land in the area is generally undeveloped, containing sparse residences and occasional fields of hay or row crops. Recreational use is important, as the basin contains portions of the Savage River State Forest and the Pleasant Valley Recreational Center. The predominant population center in the Casselman is Grantsville with a population of 619 (U.S. Census Bureau 2010). Other towns in the watershed include Jennings and Foxtown.

2.1 Geology

Formations Descriptions (BOM 2004) (Figure 3)

Pc – Conemaugh Formation – Includes the rocks between the base of the Pittsburgh coal and the top of the Upper Freeport coal; consists of two unnamed members which are separated by the Barton coal; both members are gray and brown claystone, shale, siltstone, and sandstone, with several coal beds; lower members also contains redbeds and fossiliferous marine shales; thichness 825 to 925 feet.

Pap – Allegheny Formation – Interbedded sandstone, siltstone, claystone, shale, and coal beds; Upper Freeport coal at top; where present, Brookville coal defines base; thickness 275 feet in northeast, increases to 325 feet in south and west.

Pottsville Formation – Interbedded sandstone, siltstone, claystone, shale and coal beds; conglomeratic orthoquartzite and protoquartzite at base; thickness 60 feet in northeast, increases to 440 feet in the south. The Pottsville/Allgheny Formations contain rock formations known to produce AMD when exposed to oxygen and water, which could result in the production of slightly acidic naturally occurring stream water quality.

Mmc – Mauch Chunk Formation – Red and green shale, reddish-purple mudstone, and red, green, brown, and gray thin-bedded and cross-bedded sandstones; thickness 500 feet in west, increases to about 800 feet in east.

Dch – "Chemung" Formation – Predominately marine beds characterized by gray to olive-green greywacke, siltstone, and shale; thickness ranges from 2000 to 3000 feet.

- Parkhead Sandstone – gray to olive-green sandy shale, conglomerate sandstone, and greywacke; present in Washington County, identification uncertain in the west; thickness averages 400 feet
- Brallier Formation – Medium to dark gray, laminated shale and siltstone; weathers to light olive-gray; grain size coarsens upward, thickness about 2000 feet in west, about 1,700 in east.
- Harrell Shale – Dark gray laminated shale, absent in east where Brallier lies directly on Mahantango, Tully Limestone lies near base in west, in subsurface of Garrett County; total thickness in west 140 to 300 feet.

NOTE: "Chemung", Parkhead, Brallier, and Harrell Formations formerly designated as Jennings Formation..

Hydrologic Soils

The Natural Resources Conservation Service (NRCS) has defined four hydrologic soil groups providing a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils (Group D) that are poorly drained have the lowest infiltration rates with the highest amount of runoff, while sandy soils (Group A) that are well drained have high infiltration rates, with little runoff. The Casselman River watershed mostly consists of C soils. Group C soils typically have slow infiltration rates. Most soils in this classification include a layer that impedes downward water movement and/or have a moderately fine-to-fine texture (BSID 2009). In the southern headwaters of the North Branch, Group D soil underlies wetlands known as Cunningham Swamp and The Glades. These bog wetlands tend to produce acidic water due to the presence of tannic acids which may be responsible for natural pH impairments under low flow conditions. **(Figure 4)**

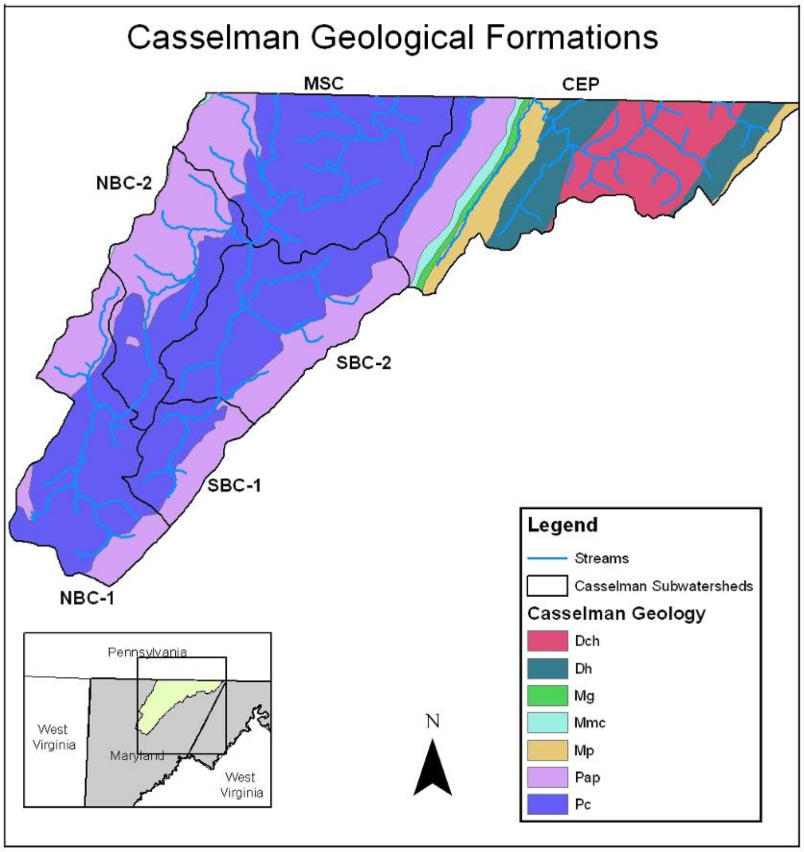

Figure 3. Geology of the Casselman River Watershed

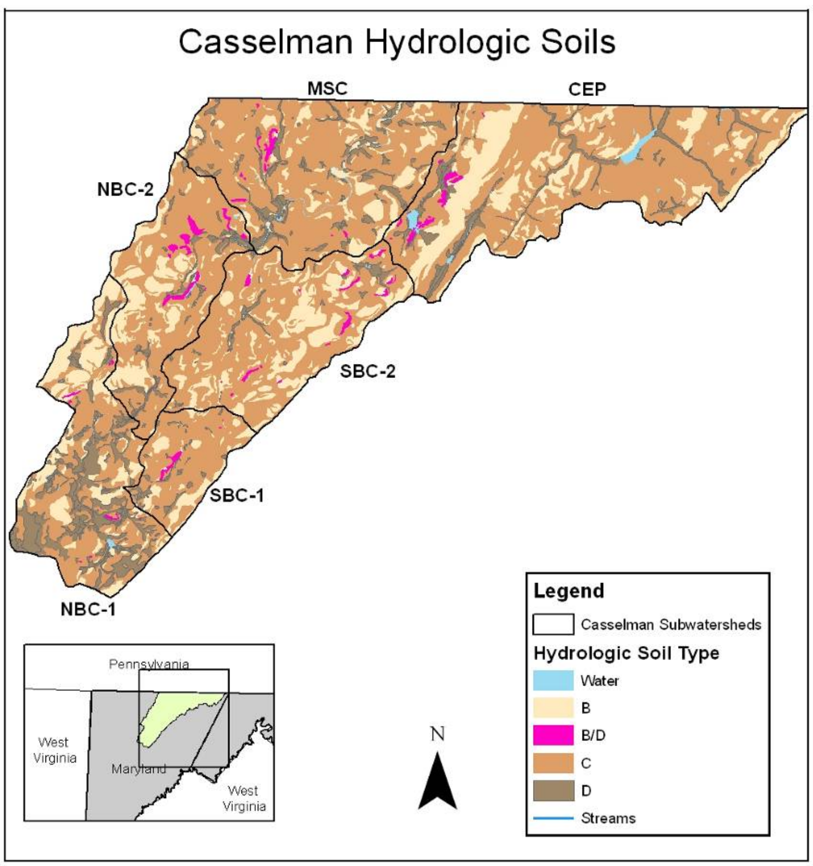

Figure 4. Distribution of Hydrologic soils

2.2 Historical Background

Numerous coal seams of varying quality and quantity exist within the Casselman watershed. Coal mining activities in the watershed began in the middle 1800s as local deep mines provided coal to power a steam-driven sawmill. Production peaked during World War I and World War II. After World War II, strip mining replaced deep mining and has continued to a much lesser extent than in surrounding coal basins. **(Figure 5)** A large portion of abandoned mine land in this watershed has been reclaimed between 1984 and 2003. **(Table 2)**

Table 2. List of Completed Abandoned Mine Land Reclamation Projects

ABANDONED MINE LAND PROJECT	YEAR COMPLETED	ACRES RECLAIMED	TOTAL PROJECT COST $
Grantsville Dump Reclamation		25.5	135,130
Davies		12	50,363
Merrill		6.9	69,836
Amish Road Reclamation	1984	32.0	199,905
Merrill Reclamation Project	1984	8.0	11,957
Buckel Pit Reclamation	1985	12.0	41,500
Casselman Deep Mine	1985	1.0	2,665
Meadow Lake Reclamation	1985	32.0	92,500
Meadow Run Reclamation - Markowitz Tract	1985	10.0	11,957
Foxtown Road / Negro Mtn.	1986	10.0	14,957
Alleghany Mining Special Rec - Bittinger	1986	3.8	6,000
Jennings Deep Mine Reclamation	1986	1.0	29,865
Austin Kelly AMLR -Phase II	1986	10.0	28,000
Austin Kelly AMLR -Phase 1	1986	22.0	21,997
Action Mining Special Reclamation	1986	1.0	2,500
Amish Road /Tarkiln Run Reclamation	1986	30.0	233,864
Foxtown Road Reclamation	1987	18.0	22,750
Delta/Yoder AMLR	1988	8.5	27,700
Sugar Point AMLR	1988	50.0	959,00
Austin/Kelly AMLR- Phase III	1990	3.0	37,591
Durst Road AMLR	1992	38.0	178,623
Ternent AMLR	1993	28.0	110,169
Meadow Run AMLR	1994	32.0	242,624
Little Meadows AMLR	1999	66.0	298,793
Chestnut Ridge AMLR	2000	20.0	97,908
Bear Hill Road AMLR Reclamation	2003	2.0	78135
Totals		482.7	$2,048,248

The 2000 census found that mining does not employ anyone in the watershed's largest town, Grantsville. Today, watershed residents are employed in a number of different sectors including retail, manufacturing, construction, and transportation. The per capita income in 2000 was $15,625 and the median family income was $35,000 (United States Census Bureau 2010). There are numerous existing and potential stakeholders in the watershed, e.g., farmers, foresters, hunters, fisherman and outdoor enthusiasts, local and state agencies, environmental groups, and local industry. This may change for the 2010 census, but that data is not yet available at this level of detail to the public.

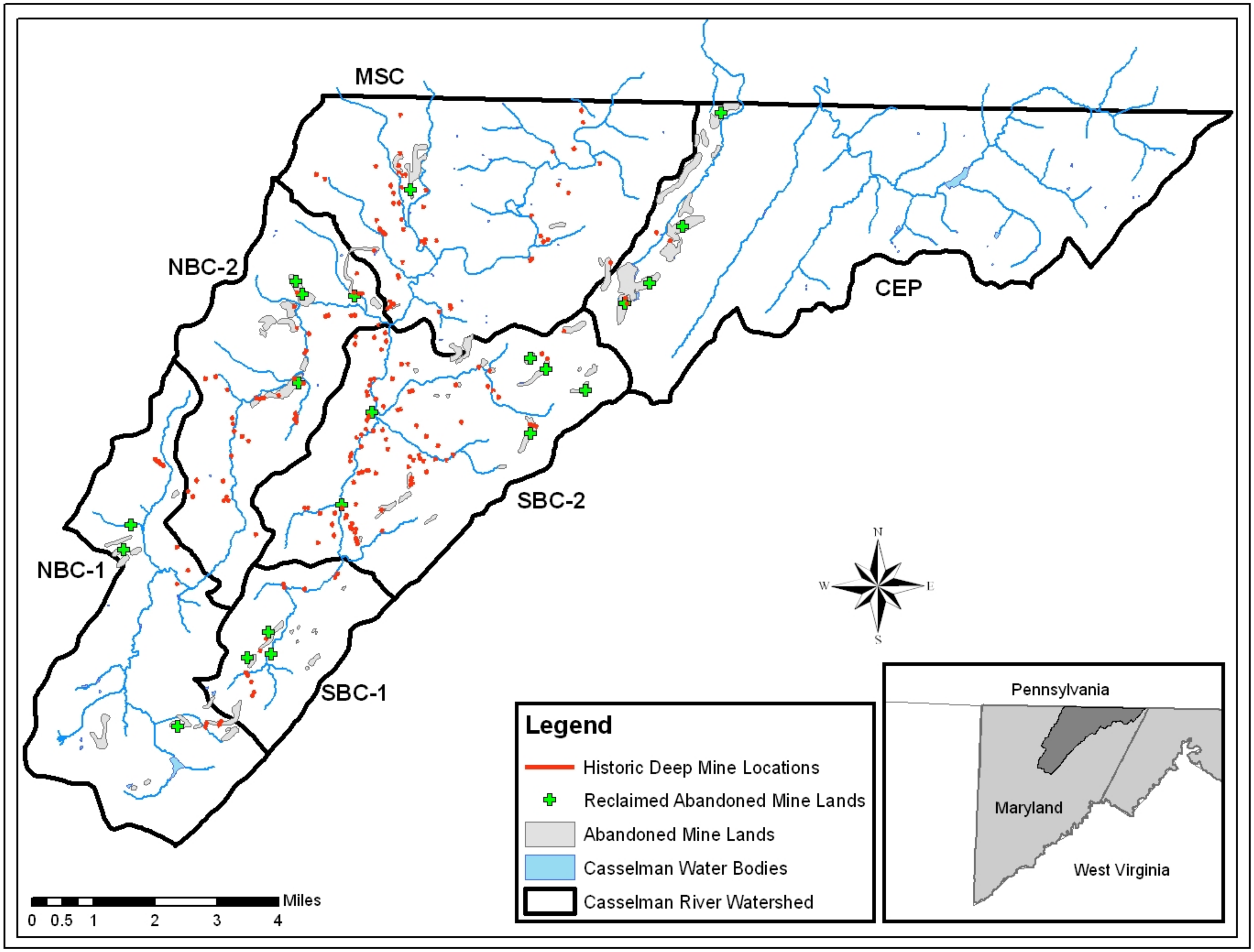

Figure 5. Historical Mining Activities in Casselman River Watershed

2.3 Current Mining in the Casselman Watershed

In September 2009, a new deep mine permit was issued by the Maryland Department of the Environment Bureau of Mines. The permit is for a 2940.8 acre underground coal mine which would discharge into the North Branch of the Casselman River (Figure 6). The mine will run underneath the Casselman mainstem, the North Branch, the South Branch along with several other tributaries of the Casselman including Spiker Run and Big Laurel Run.

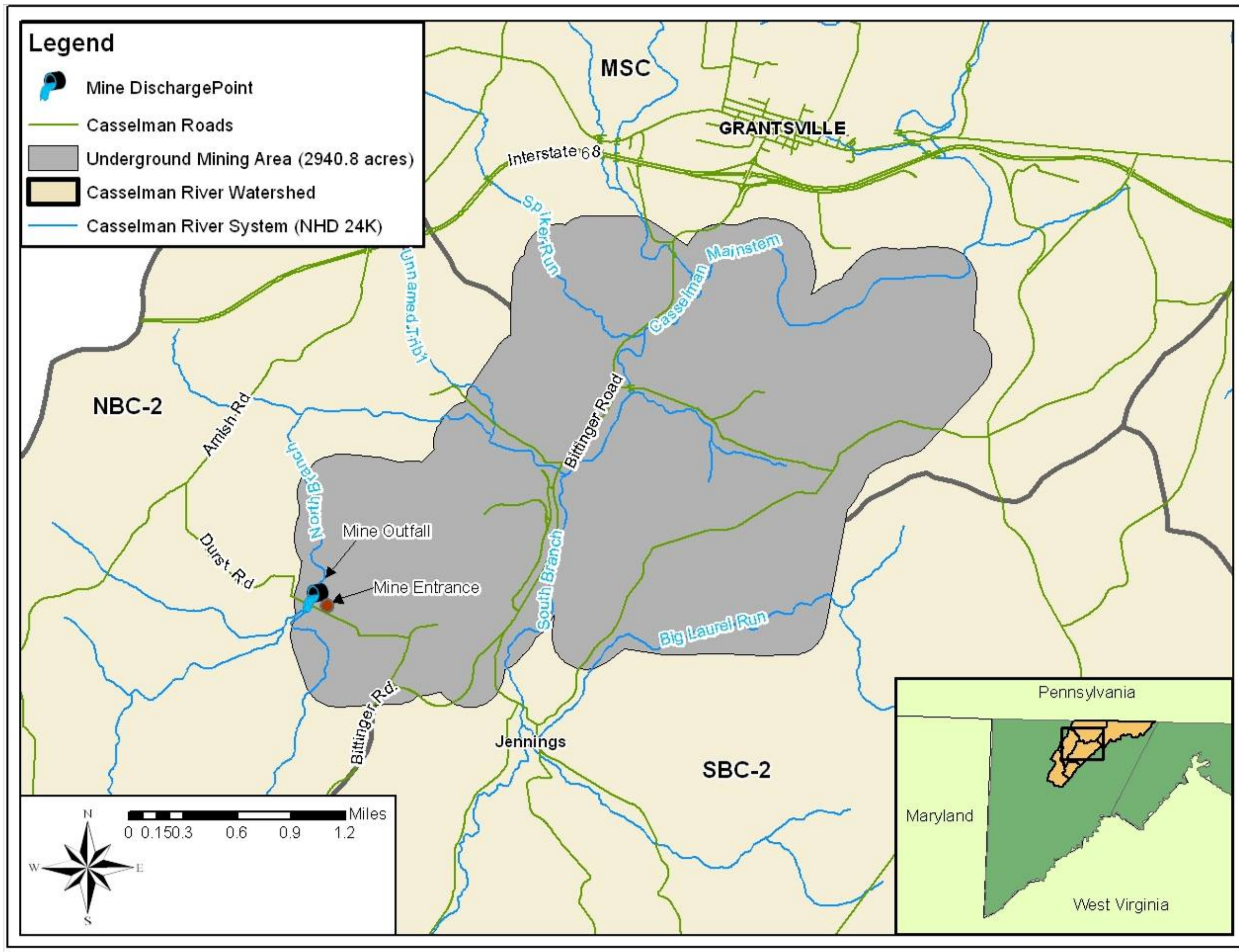

Figure 6. New Casselmand Deep Coal Mine Location

As of November 2010, activities for the mine have begun at the surface, including construction of access ramps and treatment ponds. As of February 2011, deep mining has not begun, but is expected to begin in the spring of calendar year 2011. Along with the current mining permit, a groundwater extraction permit and a National Pollutant Discharge Elimination System (NPDES) permit was issued for surface stormwater and mining effluent. Permits issued by MDE specifically address pH impairment and require that an automated control system be installed that would cease discharge of wastewater should it fall outside of COMAR pH standards. (MDESW 2009) A copy of the NPDES permit has been included as **Appendix D**.

3. Water Quality

3.1 TMDL Summary

The Casselman River is included as part of the Western Maryland low pH Total Maximum Daily Loads (TMDLs). Reduction goals in the TMDL were calculated using the Mining Data Analysis System (MDAS) to represent the source-response linkage for pH. MDAS is a comprehensive data management and modeling system capable of representing loads from nonpoint and point sources in the watershed and simulating in-stream processes. The model manipulates concentrations of pH influencing parameters (iron, aluminum, ammonia, nitrogen, nitrate and sulfate) to estimate pH and develops reductions in these parameters that it determines would lead to the achievement of TMDL pH endpoints.

TMDLs and source allocations were developed on a subwatershed basis for each of the impaired watersheds in Table 3. TMDL allocations include the Load Allocations (LA) for nonpoint sources and the Waste Load Allocations (WLA) for point sources. A top-down methodology was followed to develop these TMDLs and allocate loads to sources. Headwaters were analyzed first because their loadings affect downstream water quality. Loading contributions were reduced from applicable sources to these waterbodies until pH criteria were met. The loading contributions of unimpaired headwaters and the reduced loadings for impaired headwaters were then routed through downstream waterbodies. Using this method, contributions from all sources were weighted equitably, and pH criteria were achieved throughout the system. Reductions in sources affecting impaired headwaters ultimately led to improvements downstream and effectively decreased necessary loading reductions from downstream sources. (TMDL 2008)

Allocations were assigned so that pH did not fall below the water quality standard of 6.5. The model was run for the period of December 1, 2004, through November 30, 2005. This produced daily loads that were then summed over the year to create the annual loads. Note that the atmospheric deposition contribution of some parameters is expected to increase in the model area on the basis of the CAIR model; thus, some TMDL conditions are greater than baseline conditions. (TMDL 2008)

The result of the modeling process was to produce a baseline condition demonstrating model derived low pH impaired streams. TMDL endpoints represent the water quality targets used to quantify TMDLs and their individual components. The water quality criteria for pH allow no values below 6.5 or above 8.5.

3.2 Water Quality Standards

Maryland water quality standards consist of two components that are relevant here: (1) designated and existing uses **(Figure 6)**; and (2) narrative or numeric water quality criteria necessary to support those uses. **(Table 3)** Furthermore, water quality standards serve the purpose of protecting public health, enhancing the quality of water, and protecting aquatic resources. Maryland's water quality standards require that water quality in the six impaired subwatersheds support their designated uses.

Portions of the Casselman River are in Pennsylvania. Maryland and Pennsylvania water quality standards for parameters included in the MDAS model are presented in Table 1-3, as are EPA's national recommended water quality criteria. (TMDL 2008) Segments of the Casselman watershed covered by this plan are on the 2008 303(d) list for AMD-related pollutants as well as atmospheric deposition. In Table 3, it shows that Maryland does not currently have standards for the parameters included in the MDAS model and is a contributing factor for selecting pH standards as the end point for this WRP.

Table 3. Applicable Water Quality Standards for all Casselman Designated Uses

Parameter	Maryland[a]		Pennsylvania[b]		EPA[c]	
	Value	Comment	Value	Comment	Value	Comment
Acidity	--		--		--	
Alkalinity	--		20 mg/L as $CaCO_3$		20 mg/L	
Aluminum	--		750 μg/L		750 μg/L 87 μg/L	Freshwater maximum concentration at pH 6.5–9.0 Freshwater continuous concentration at pH 6.5–9.0
Ammonia Nitrogen	--		--	Varies based on pH	--	Varies based on pH and temperature
Iron	--		1.5 mg/L 0.3 mg/L	30-day average total recoverable Dissolved	1.0 mg/L 0.3 mg/L	Freshwater continuous concentration Human health for consumption of water and organism
Nitrate	--		10 mg/L as N	Nitrate + Nitrite	10 mg/L	Human health for consumption of water and organism
pH	6.5–8.5		6.0–9.0		6.5–9.0 5.0–9.0	Freshwater continuous range Human health for consumption of water and organism
Sulfate	--		250 mg/L		--	
Non-Tidal Biological Integrity[d]	<20% of stream miles degraded		Based upon Maryland Biological Stream Survey sampling and its Index of Biotic Integrity for both Benthic and Fish Communities.			

Notes: (Source – TMDL, 2008)
[a] COMAR 2005
[b] PADEP 2006
[c] USEPA 2006
[d] Maryland Department of the Environment (MDE) 2008

3.3 Water Quality Objectives and Goals

This watershed is on the 303(d) list as impaired by pH, therefore this WRP will focus on meeting pH water quality standards established in the Code of Maryland Regulations (COMAR), no less than 6.5 and no greater than 8.5, through the increase in net alkalinity (mg $CaCO_3$ /l) and not the reduction of intermediary chemicals used in the TMDL MDAS Model. This approach is approved in the TMDL under "Section 6 – Reasonable Assurance":

TMDL Implementation – Reasonable Assurance

Section 303(d) of the Clean Water Act (CWA) and EPA regulations require reasonable assurance that TMDLs will be implemented. TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Western Maryland TMDLs identify the necessary overall load reductions for those pollutants causing use impairments and distributes those reduction goals to the appropriate sources. Reaching the reduction goals established by these TMDLs will occur only through changes in current land use practices, including the mitigation of AMD and the implementation of the Clean Air Interstate Rule (CAIR). Although the derived TMDLs are based on best professional judgment using current data in the calibrated model*, **meeting these TMDLs might not be necessary if alternative mitigation and future monitoring prove that pH is being corrected without reducing these parameters**.* (TMDL 2008)

The use of a net alkalinity pH focused approach has been documented in an accepted A-I watershed plan for the Crab Orchard Creek Watershed (COCW) in Tennessee. The COCW watershed plan was featured in an USEPA document titled "The Best Watershed-Based Plans in the Nation." (Scozzafava 2006)
This end goal of this plan is to raise pH and satisfy TMDL endpoints while improving the health of ecological communities in the watershed, addressing both the impairment for which the watershed is on the Maryland 303(d) list of impaired waters while protecting both natural resources and biological communities. EPA approval of this approach is documented in **Appendix A**.

3.4 Designated Uses

All stream segments in the Casselman watershed should, at a minimum, be fishable and swimmable, and should be clean enough to contain healthy communities of indigenous aquatic species. The federal Clean Water Act (CWA) and state regulations have determined a set of interlinked water quality goals. COMAR designated uses for the streams in the Casselman watershed include: **(Figure 6)**

Use I Waters: Water Contact Recreation and Protection of Nontidal Warmwater Aquatic Life
Use I-P Waters: Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply
Use III Waters: Nontidal Cold Water – Natural Trout Waters
Use IV Waters: Recreational Trout Waters

The mainstem of the Casselman River is designated as use IV—Recreational Trout Waters (COMAR 26.08.02.08S(5)). Broad Ford Run and its tributaries are designated as Use I-P—Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life, and Public Water Supply (COMAR 26.08.02.08S(1)(a)) and the South Branch Casselman Use III – Natural Trout Waters (COMAR 26.08.02.08S(3)(a)). All remaining tributaries not listed are designated as Use I – Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life (COMAR 26.08.02.07A). The numeric criteria for pH for all the above designated uses requires that pH values not be less than 6.5 or greater than 8.5 (COMAR 26.08.02.03-3(B)(1), (E)(2)(a), (F)(4) and (G)(1)).

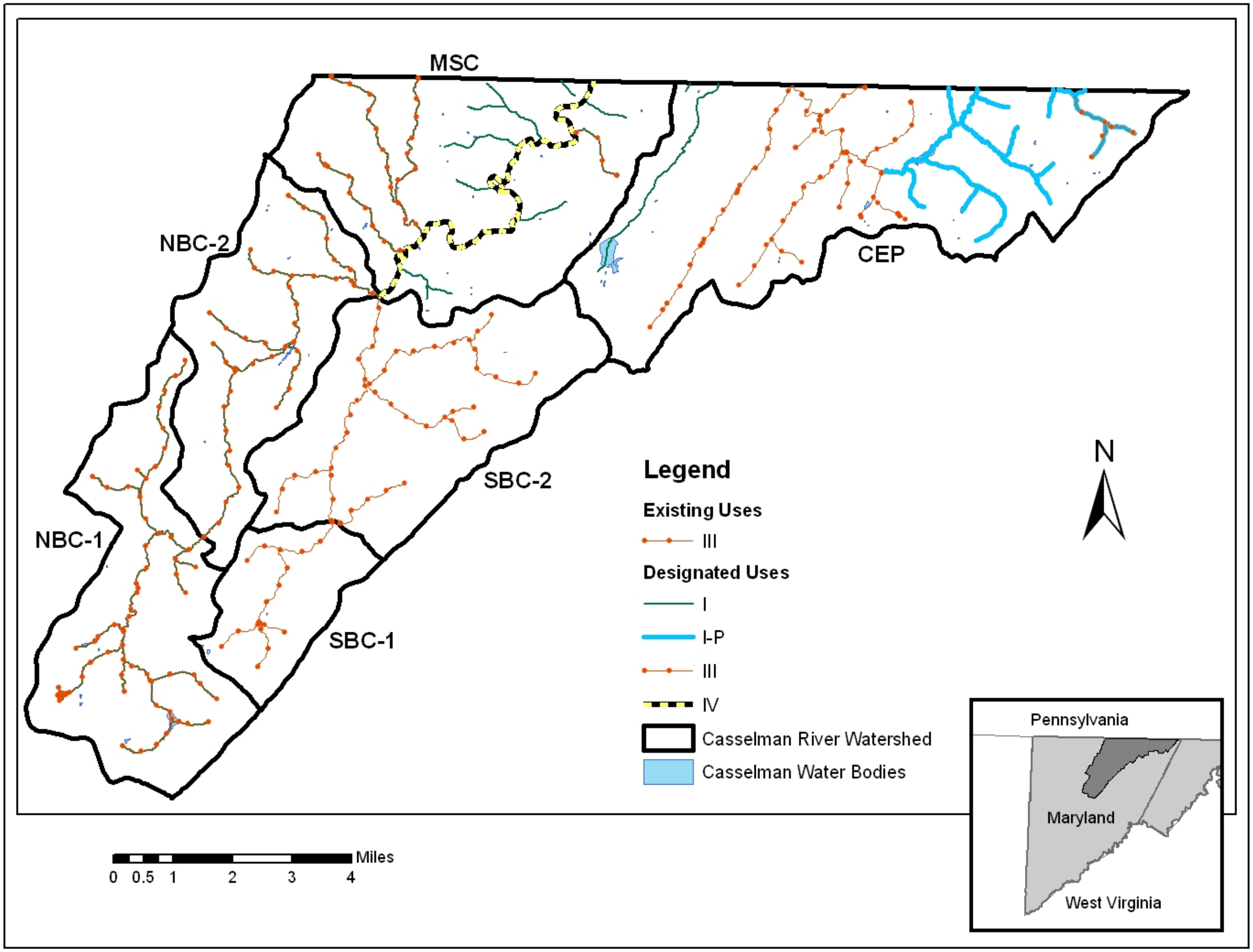

Figure 7. Casselman River Watershed Stream Designations

3.3 Recent Studies

3.3.1 Acidity

3.3.1a 2004 MDE AMLD Study

Recent studies of the comprehensive water quality and biological health of the watershed were commissioned in 2004 by the MDE Bureau of Mines, now the Abandoned Mine Lands Division (AMLD). The goal of the study was to obtain up to date chemical and biological data for the portion of the Casselman watershed that lies in Maryland. The study results serve two key purposes; 1) to identify pre-law abandoned mine drainage problems and 2) document baseline environmental conditions prior to efforts to restore the water quality and native species in impaired stream segments throughout the Casselman River Watershed.

In 2004 the University of Maryland Center for Environmental Science - Appalachian Lab (UMAL) conducted an extensive biological and MDE AMLD carried out an intensive water chemistry assessment of the entire Casselman watershed. In order to show impairments more efficiently, the watershed was divided into six separate subwatersheds for data analysis and description of impacts. Within the Maryland portion of the Casselman River watershed, 93.4 out of 170 stream miles (55%) were assessed for low pH. Of the 103 separate water sampling sites, a total of 39 sites exhibited pH impairments of less than 6.40 or greater that 8.5. (Davis 2004)

During high flow, pH impairments affected 21.6 stream miles with an additional 27.5 miles projected to be impaired: thirty-eight (38) sites were observed to have a pH of less than 6.4 (none greater than 8.5); twenty-one (21) were suspected impairment due to mining, eight (8) sites warranted further investigation into the cause of impairment, and nine (9) sites were suspected to be impaired due to the underlying geology and/or flushing events. During low flow pH impairments affected 26.1 stream miles with an additional 17.2 miles projected to be impaired: twenty-two (22) sites exhibited pH values less than 6.4 or greater than 8.5; twelve (12) suspected impairments due to mining, four (4) sites warranting further investigation as to the cause of impairment, five (5) sites suspected to be impaired due to the underlying geology and/or flushing events, and one (1) site with a pH of 9.22 most likely due to the Grantsville sewage treatment facility located upstream from the site. (Davis 2004)

A priority ranking for impairment severity was developed for each subwatershed. This rating was based upon three (3) factors:

1) The total of suspected AMD impaired sites and the sites that will warrant further investigation in each subwatershed
2) The total impaired low flow and high flow sampling sites, and
3) The number of 90% acid producers (AMD versus geologic suspected cause) in both the low flow and high flow sites.

Results of this study are located in Section 4.1 below.

3.3.1b 2005 TMDL Study

The 2005 water quality study was used as a baseline to determine impaired stream segments and their potential sources. This study was conducted independently of the MDE AMLD study and was conducted in March 2005 – November 2005. It collected the following parameters: acidity, alkalinity, acid neutralizing capacity, chloride, dissolved iron, dissolved organic carbon, hardness, total aluminum, total iron, nitrate, pH, and sulfate. Results of the water quality assessment determined sources of impairment by the methods listed below: (Source TMDL 2008)

- Assuming baseflow conditions, there is most likely no major source of acidification if the acid neutralizing capacity (ANC) of the stream is greater than 200 µeq/L.

- If agriculture represents greater than 50 percent of the drainage area for the monitoring location and the nitrogen nitrate (NO_3-N) level is greater than 100 μeq/L (≈ 14 mg/L), there is a strong probability that agriculture is the major influence in stream acidification.
- If sulfate levels are greater than 500 μeq/L (≈ 24 mg/L), the primary acidification source is most likely AMD.
- If sulfate is greater than 300 μeq/L (≈ 14 mg/L), there is the potential that the stream can be affected by both AMD and atmospheric deposition.
- If conductivity is greater than 80–100 μS/cm, the stream is considered AMD-influenced.
- If the levels of organic ions are greater than the levels of nitrate and sulfate, there is the potential that the stream is acidified by organic acids.
- If the concentration of dissolved organic carbon (DOC) is greater than 8 mg/L, the stream could be influenced by organic sources and atmospheric deposition.
- Finally, stream water quality can be broken into three levels of acidification depending on the levels of ANC:
    - Low (ANC > 50 and ≤ 200 μeq/L): This level has episodic acidification, especially during high intensity storm events, and occasionally long-duration storms.
    - Very Low (ANC > 0 and ≤ 50 μeq/L): This level has chronic acidification where small acid inputs would drive the stream below 0 μeq/L.
    - Acidic (ANC ≤ 0 μeq/L): These streams have a baseflow ANC that remains below 0 μeq/L.

Results of the 2005 study are detailed in **Table 4** in Section 4.1 below.

3.3.2 Biological Studies

The Maryland Biological Stream Survey (MBSS) conducted by MD DNR has been collecting fish and benthic samples in the Casselman River watershed since 1994 as part of their effort to catalog the stream habitat and ecological health of non-tidal freshwater streams and rivers within Maryland. The MBSS data was further analyzed by the Maryland Department of the Environment (MDE) to determine the causes of biological impairment and the results show biological communities in the Casselman River Watershed are likely degraded due to acidity related stressors as well as stressed by inorganic pollutants (i.e., chlorides and conductivity). (BSID 2009)

Additional Benthic and Fish sampling was conducted during the 2004 MD AMLD study with results similar to the MBSS sampling. DNR-Fisheries group is conducting an ongoing study to monitor Brook Trout populations in the Casselman River. All sampling was conducted using a distinct Index of Biotic Integrity (IBI) for both fish and benthic communities detailed in the MBSS Sampling Manual. (Stranko et al. 2010)

3.3.3 Implementation Targeting Studies

The Canaan Valley Institute (CVI) conducted a targeting study using information from the 2004 MD AMLD study that incorporate a weighting scheme to target projects which would address acidic waters in areas with the greatest potential to provide a more rapid biological response in an effort to restore native brook trout habitat and populations. After an initial list of projects were selected from the previous criteria, CVI was asked to develop a separate site location targeting scheme to determine which areas had accessibility available to properly implement limestone leach beds and limestone sand dumps. One concern of the CVI partners in developing these targeting schemas was the difficulties associated with trying to gain access and long-term partnerships with private land owners. A list of the prioritized project sites is included in section 5.1 below.

4. Non-point Source Inventory (Criterion A)

Acid impaired waters in the Casselman have been identified by several efforts over the past decade and include potential AMD impairments as well as atmospheric deposition in smaller headwater tributaries. Source assessments determined from the TMDL survey **(Table 4)** are provided along with the 2004 characterization identifying those impaired waters contributing 90% of the acidity within the watershed (90% producers) during low flow **(Table 6)** and high flow events. **(Table 7)**

4.1 TMDL Source Assessment

Streams in the Casselman subwatersheds were monitored in the spring and fall of 2005 to determine the acid load and pH during different seasons for the Western Maryland pH TMDL. MDE analyzed the monitoring results following the impairment characterization method summarized in section 3.1.1b; the results are listed in **Table 4**. Spatial distributions of the sites are presented in **Figures 7 through 17**.

Table 4. List of Impaired Sampling Sites from the TMDL and modeled baseline pH minimum, median and maximum

Station code	Sub-watershed	Stream segment	pH source assessment	pH Min	pH Med	pH Max
WM-135	CEP	MDW0008 Meadow Run	AMD and acidic deposition	5.54	6.52	6.86
WM-137	SBC2	LLR0024 Little Laurel Run	Chronic acidification	4.22	5.26	5.61
WM-138	MSC	SPI0018 Spiker Run	Episodic acidification	5.57	6.95	7.78
WM-141	SBC2	LLR0009 Little Laurel Run	Episodic acidification	4.67	6.37	6.61
WM-142	NBC1	NBC0072 North Branch Casselman	AMD and acidic deposition	4.41	6.69	7.50
WM-143	SBC1	SCA0067 South Branch Casselman	AMD	5.21	6.47	6.82
WM-144	NBC2	ALE0011 Alexander Run	Chronic acidification	4.20	5.17	5.55
WM-145	NBC1	NBC0090 North Branch Casselman	AMD and acidic deposition	4.23	6.60	7.67
WM-146	NBC2	TAR0003 Tarkiln Run	AMD and acidic deposition	4.25	5.31	5.63
WM-147	NBC1	PLE0008 Pleasant Valley Run	AMD and acidic deposition	4.75	6.84	7.88
WM-148	NBC1	NBC0106 North Branch Casselman	AMD and acidic deposition	4.26	6.87	7.73
WM-149	NBC1	ZWN0003 Unnamed trib to NB Casselman	Chronic acidification	4.85	6.92	8.07
WM-151	NBC1	UNA0015 Unnamed trib to NB Casselman	Chronic acidification	4.36	5.32	6.16
WM-155	MSC	LSR0015 Little Shade Run	Chronic acidification	4.25	5.20	5.53

Notes: Source (TMDL 2008)

4.2 Acid Impairments Identified by the 2004 MD AMLD Commissioned Study (Davis 2004)

4.2.1 NBC-1 Watershed

The NBC1 subwatershed produced 75% of the acid loading problems under low flow and 25.6% under high flow conditions.

Low Flow Impairments (Figure 7)

As part of the 2004 study, low pH impairments at sites C-12, C-13, C-14, C-15, and C-39 are likely the result of untreated AMD. Low pH values measured at sites C-1and C-4 are likely the result of the presence of bog wetlands (Cunningham Swamp and The Glades). Sites C-13, and C-15 are 90% producers of acidity during both high and low flow.

High Flow Impairments (Figure 8)

Low pH impairments during high flow conditions in the northern unnamed tributary containing sites C-12, C-13, C-14, C-15, and C-39 are likely the result of AMD. Two other sites exhibited low pH impairments only during high flow conditions, sites C-5 and C-108. C-5 is one of the 90% acid producing sites in the Maryland portion of the Casselman River Watershed during high flow, and both sites are in proximity to abandoned deep mines. These mines may flow and/or flush themselves out during high flows, which could be the reason there was no measurable effect during low flow.

Low pH values measured at sites C-1and C-4 are likely the result of the presence of bog wetlands (Cunningham Swamp and The Glades). This slightly acidic water quality also occurred downstream of wetlands at sites C-3 and C-6 and are likely the result of naturally occurring flushing of the underlying geology and the upstream wetlands. The pH impairment measured at site C-38 in the NB Casselman is probably related to the problems further upstream.

4.2.2 NBC-2 Watershed

The third-most pH impaired sub-watershed is NBC-2, with pH impairments varying between high and low flow. In this subwatershed, there is a decrease in the overall water quality, especially pH, during high flow conditions.

Low Flow Impairments (Figure 9)

Three streams in this portion were found to exhibit pH impairments (C-16, 22, and 27) during low flow conditions. Two unnamed tributaries (C-16 pH with a value of 5.62, and C-27 pH with a value of 6.26) may be the result of the underlying Allegheny/Pottsville Formation, but could also be slightly affected by the presence of abandoned mines along these streams. The Alexander Run, site C-22, had a pH value of 4.56 during low flow studies and is one of the 90% acid producers during high flow conditions, suggesting that this stream is impaired year round. There are no known abandoned mines close to the stream, but the pH impairment levels indicate that natural geology, acid rain or AMD are affecting the stream quality.

High Flow Impairments (Figure 10)

Eight streams segments were found to exhibit pH impairment (Sites C-16, C-17, C-22, C-23, C-24, C-25, C-27, and C-29) when compared with only three sites during low flow. Two unnamed tributaries (sites C-16 pH of 4.48 and C-27 pH of 5.03) showed a decrease in stream water quality during high flow conditions, which are most likely the effects of flushing of impaired water into the stream. Four other stream sections showed pH impairment during high flow conditions. Site C-17 and site C-29 are impaired, but only during the high flow conditions. Site C-29 is one of the 90% acid producers, however underlying geology is the most likely cause. Sites C-24 and C-25 exhibit year round pH impairment.

4.2.3 SBC-1 Watershed

The pH-impaired sites in SBC-1 rank as significant contributors of the 90% acid producers in the Maryland portion of the Casselman River.

Low Flow Impairments (Figure 11)

Only one headwater stream indicated slight pH impairment (C-40) during low flow conditions. This headwater also shows pH impairment during high flow as well.

High Flow Impairments (Figure 12)

The water quality decreased in pH value low to high flow and an additional three sites downstream (C-41, C-42, and C-43) are impaired during high flow and it is likely the decreased pH values are the result of flushing of abandoned deep mines in the area. Another small unnamed tributary showed a decrease in pH during high flow. Water quality collected at Site C-53 indicates that this site is a 90% producer of acid in the Maryland portion of the Casselman watershed during high flow. However, with no known abandoned mine features in the area, the decrease in pH during high flow appears to be due to natural flushing of the regional geology or the impact of acid rain.

4.2.4 SBC-2 Watershed

Sub-watershed SBC-2 exhibited the most mine-related problems during both high and low flows. There are numerous pH-impaired streams in this subwatershed section.

Low Flow Impairments (Figure 13)

Sites C-64, C-68, C-71, and C-72 showed low pH during low flow and all are located in close proximity to abandoned mine lands, some of which have discharging portals. Site C-68 was prioritized as one of the 90% producers of acidity in the Casselman River watershed. It is not known if sample sites C-56, C-59, C-65 and C-104 are influenced by the underlying geology, or the result of abandoned mine lands that have not yet been located.

High Flow Impairments (Figure 14)

Sites C-64 and C-68 rank as two of the 90% producers of acidity in the Casselman watershed during high flow. Sample sites C-56 and C-59 are impaired under both low and high flow conditions. Site C-56 is one of the 90% acid producers during high flow. Site C-73 is severely degraded during high flow and is located adjacent to abandoned mines, one with a discharging portal. Two additional sites exhibited low pH values during high flow. Site C-8, which is located downstream from Sites C-71 and 72, is one of the high flow 90% acid producers and has abandoned mines located just upstream from it. Site C-74, in an unnamed tributary, also exhibited a decrease in pH, but it is likely that natural conditions are the cause. Only one site showed an improvement to pH during high flow, C-104.

4.2.5 MSC Watershed

Low and High Flow Impairments (Figures 15 and 16)

There are three pH impairments in this sub-watershed during low flow (C-30, C-32 and C-100). Shade Run site C-32 and unnamed tributary site C-30 are impaired for low pH during low and high flow conditions. Both sites lay in the Allegheny/Pottsville geologic formation and are downstream from abandoned mine portals. They are likely impaired from the underlying geology and possibly untreated AMD. Site C-100 has a high pH during low flow conditions, but is improved during high flow conditions. The elevated pH value is most likely the result of its location in the main stem of the Casselman River downstream from the Grantsville sewage processing facility.

4.2.6 CEP Watershed

Low Flow Impairments (Figure 17)

This watershed was not mapped for high flow conditions despite the presence of the single pH impaired site, which appears to be the result of the underlying geology (Allegheny/Pottsville Formation) and flushing of the stream during high flow events. There were no identifiable AMD impairments in this subwatershed.

Summary

Based upon the pH impairment review and analysis, the top three priority sub-watersheds are in order of high to low priority: SBC-2, NBC-1 and NBC-2. Sub-watershed SBC-2 exhibits the most suspected mine related problems during both high and low flows. All of SBC-2's problems are found in tributaries to the South Branch Casselman River. Every main tributary on the eastern portion of the South Branch Casselman (Big Laurel Run, Little Laurel Run, and numerous unnamed tributaries) also exhibits some pH impairments during both high and low flows. Although the Allegheny/Pottsville Formation comes in contact with the headwaters of these streams, there are numerous abandoned mines adjacent to most of the streams, some with discharging portals. Both Big Laurel Run and Little Laurel Run have a fish IBI value of very poor. Further investigation of this sub-watershed should be conducted and treatment plan be developed for each of the impaired subwatersheds.

Table 5. Sub-watershed Impairment Ranking** (Davis 2004)

Sub-watershed	Suspected AMD Impaired Sites	Sites warranting further investigation	Sites with suspected geologic influence	Total Number of Impaired Sites	Total of Potential Mine Sites	Impairment Ranking*
NBC-1	5	3	4	12	8	4
NBC-2	4	3	1	8	7	3
SBC-1	4	0	1	5	4	2
SBC-2	7	2	2	11	9	5
MSC	1	0	1	2	1	1
CEP	0	0	1	1	0	0
Total	21	8	10	39	29	

*Ranking of suspected AMD and further investigations (Rating of 5-0; 5 = highest priority)

**Sites impaired during both high and low flows counted only once

Table 6. 90% Producers of pH Impairment under Low Flow Conditions (Davis 2004)

Sub	Site	Lab pH	Flow (gpm)	Acid (mg/L)	Acid Load	Alkalinity (mg/L)	Alkalinity Load	Net Acidity	Percent	% Problem	Daily Net Loading Lbs/day	Annual Loading Lbs/yr	Annual Loading Tns/yr	Total Annual Tons
NBC1*	C-13	4.76	652.00	26.4	206.82	0.0	0.00	206.82	47.71		206.82	75,489	37.74	
NBC1*	C-14	4.94	260.00	27.9	87.16	2.2	6.87	80.29	18.52		80.29	29,306	14.65	
NBC1*	C-15	4.29	373.00	8.4	37.65	0.0	0.00	37.65	8.69	74.92	37.65	13,742	6.87	59.26
NBC2	C-39	6.18	186.00	15.1	33.75	4.2	9.39	24.36	5.62	5.62	24.36	8,891	4.4	4.4
SBC2	C-68	5.99	465.00	12.2	68.16	3.8	21.23	46.93	10.83	10.83	46.93	17,129	8.56	8.56
Low Flow Totals					**433.54**		**37.49**	**396.05**		**91.37**	**391.05**	**144,557**		**72.22**

Note: The 90% producers of acidity are calculated by subtracting the total daily loadings of alkalinity from the total daily loadings of acidity [loadings formula = acid mg/L (8.34410^6)*1440*flow in gpm]. (BOM 2004)

*NBC1 subwatershed produced 75% of the acid loading problems under low flow and 25.6% under high flow conditions. Location of any proposed BMPs requires obtaining private landowner permission. Addressing pH issues in the Casselman must include restoration of this subwatershed to be effective.

Table 7. 90% Producers of pH Impairment under High Flow Conditions (Davis 2004)

Sub	Site	Lab pH	Flow (gpm)	Acid (mg/L)	Acid Load	Alkalinity mg/L	Alkalinity Load	Net Acidity	Percent	% Problem	Daily Net Loading Lbs/day	Annual Loading Lbs/yr	Annual Loading Tns/yr	Total Annual Tons
NBC1*	C-04	5.16	5287.00	7.6	482.79	3.3	209.63	273.16	4.07		273.16	99703	49.85	
NBC1*	C-05	5.08	1193.95	13.6	195.10	3.8	54.51	140.59	2.10		140.59	51,315	25.65	
NBC1*	C-13	4.54	10011.95	9.6	1154.85	0.0	0.00	1154.8	17.21		1154.80	421,502	210.75	
NBC1*	C-15	4.16	867.72	14.2	148.05	0.0	0.00	148.05	2.21	25.59%	148.05	54,038	27.01	313.26
NBC2	C-22	4.56	961.37	21.2	244.89	0.0	0.00	244.89	3.65		244.89	89,385	44.69	
NBC2	C-29	5.19	1667.00	14.0	280.41	4.0	80.12	200.30	2.99		200.30	73,110	36.55	
NBC2	C-32	5.02	2495.00	11.7	350.75	4.0	119.91	230.83	3.44	10.08%	230.83	84,253	42.12	123.36
SBC1	C-40	4.42	1223.14	21.8	320.38	0.0	0.00	320.38	4.78		320.38	116,939	58.46	
SBC1	C-41	5.03	1947.36	20.8	486.68	12.4	290.14	196.55	2.93		196.55	71,741	35.87	
SBC1	C-42	5.01	1300.00	24.4	381.13	10.0	156.20	224.93	3.35		224.93	82,099	41.04	
SBC1	C-43	5.44	8073.24	16.4	1590.85	10.0	970.03	620.82	9.25		620.82	226,599	113.29	
SBC1	C-53	5.34	3722.70	19.2	858.81	10.2	456.24	402.57	6.00	26.31%	402.57	146,938	73.46	322.12
SBC2	C-56	4.38	1842.83	13.4	296.71	0.0	0.00	296.71	4.42		296.71	108,299	54.14	
SBC2	C-64	4.33	7142.03	12.6	1081.26	0.0	0.00	1081.2	16.12		1081.2	394,638	197.31	
SBC2	C-68	5.13	4207.00	6.8	343.73	0.7	35.38	308.35	4.60		308.35	112,548	56.27	
SBC2	C-81	5.51	4530.00	7.4	402.78	3.2	174.17	228.60	3.41	28.55%	228.60	83,439	41.71	349.43
					8619.17		2546.33	6072.73	90.53		**6072.73**	**2,216,546**		**1108.17**

Note: The 90% producers of acidity are calculated by subtracting the total daily loadings of alkalinity from the total daily loadings of acidity [loadings formula = acid mg/L (8.34410^6)*1440*flow in gpm]. (BOM 2004)

*NBC1 subwatershed produced 75% of the acid loading problems under low flow and 25.6% under high flow conditions. Location of any proposed BMPs requires obtaining private landowner permission. Addressing pH issues in the Casselman must include restoration of this subwatershed to be effective

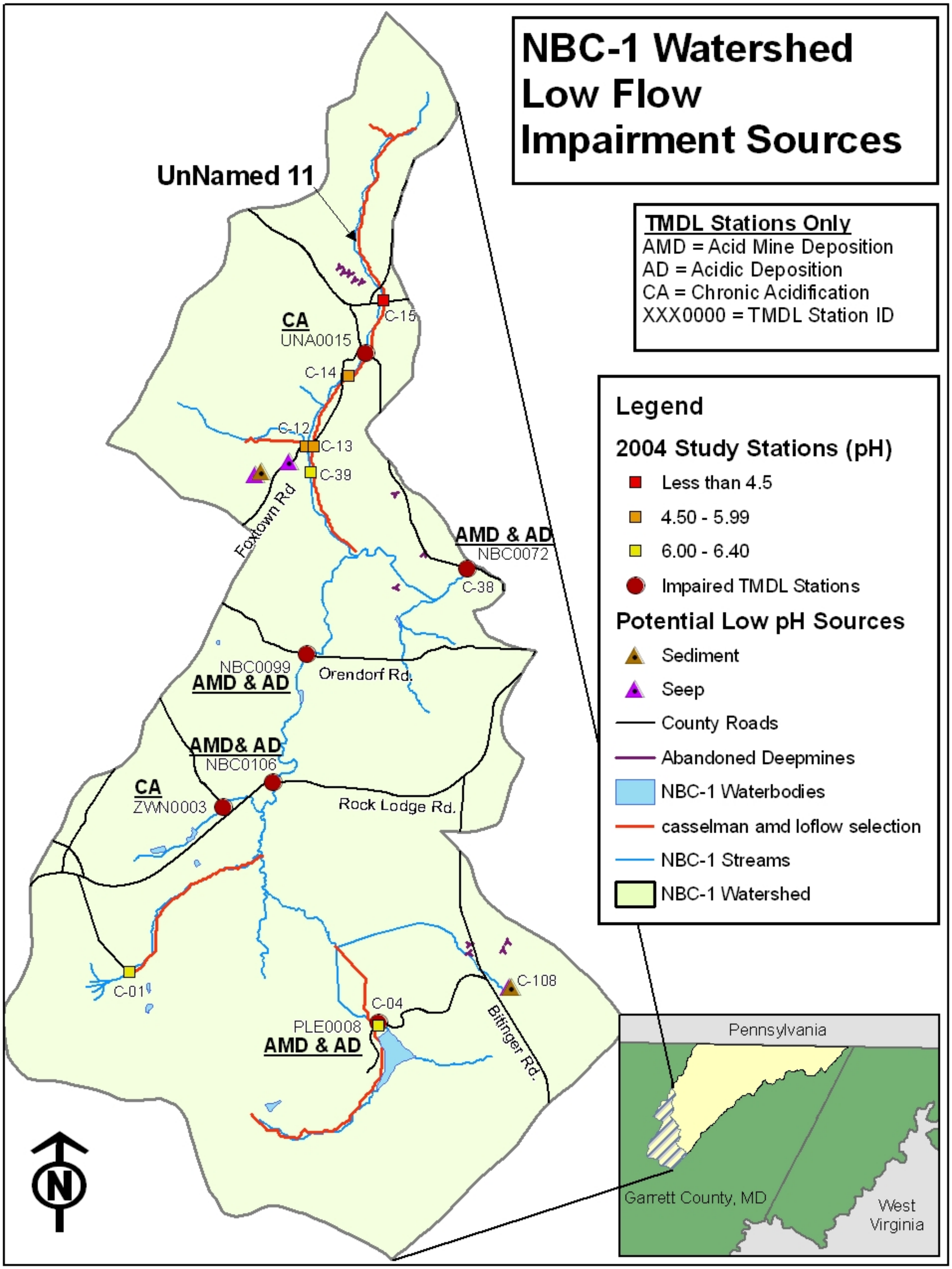

Figure 8. NBC-1 Watershed Low Flow Impairment Sources

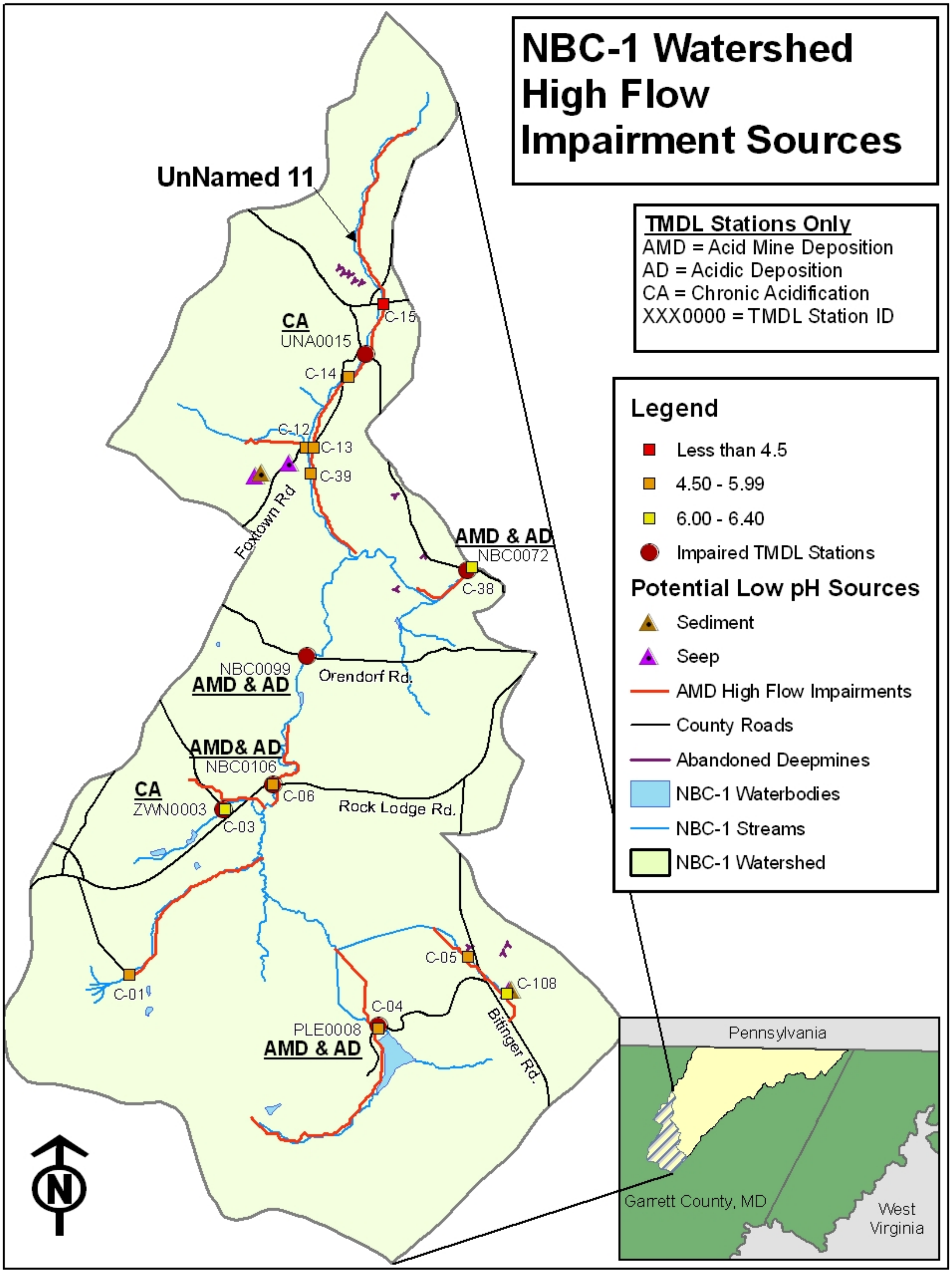

Figure 9. NBC-1 Watershed High Flow Impairment Source

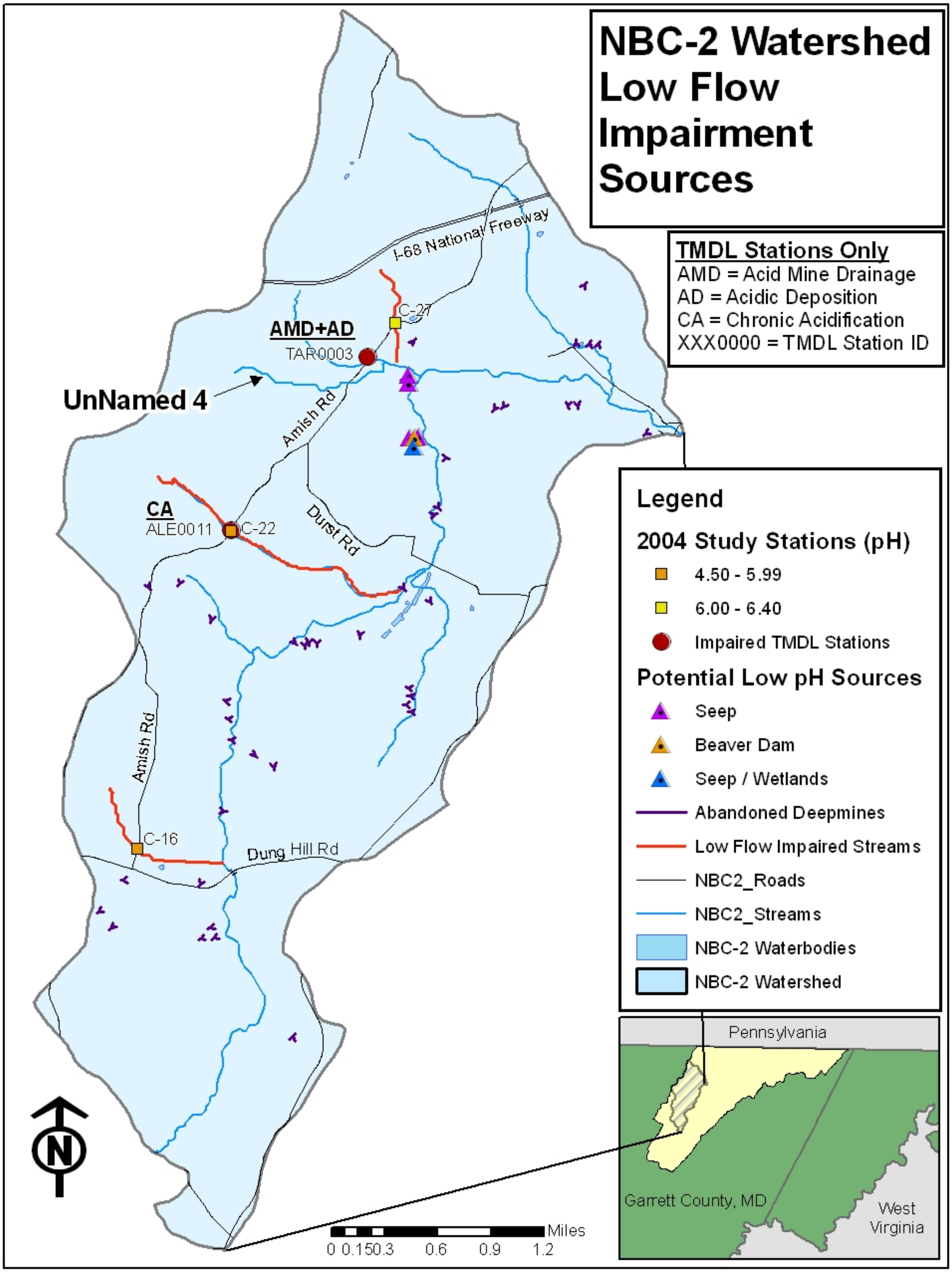

Figure 10. NBC-2 Watershed Low Flow Impairment Sources

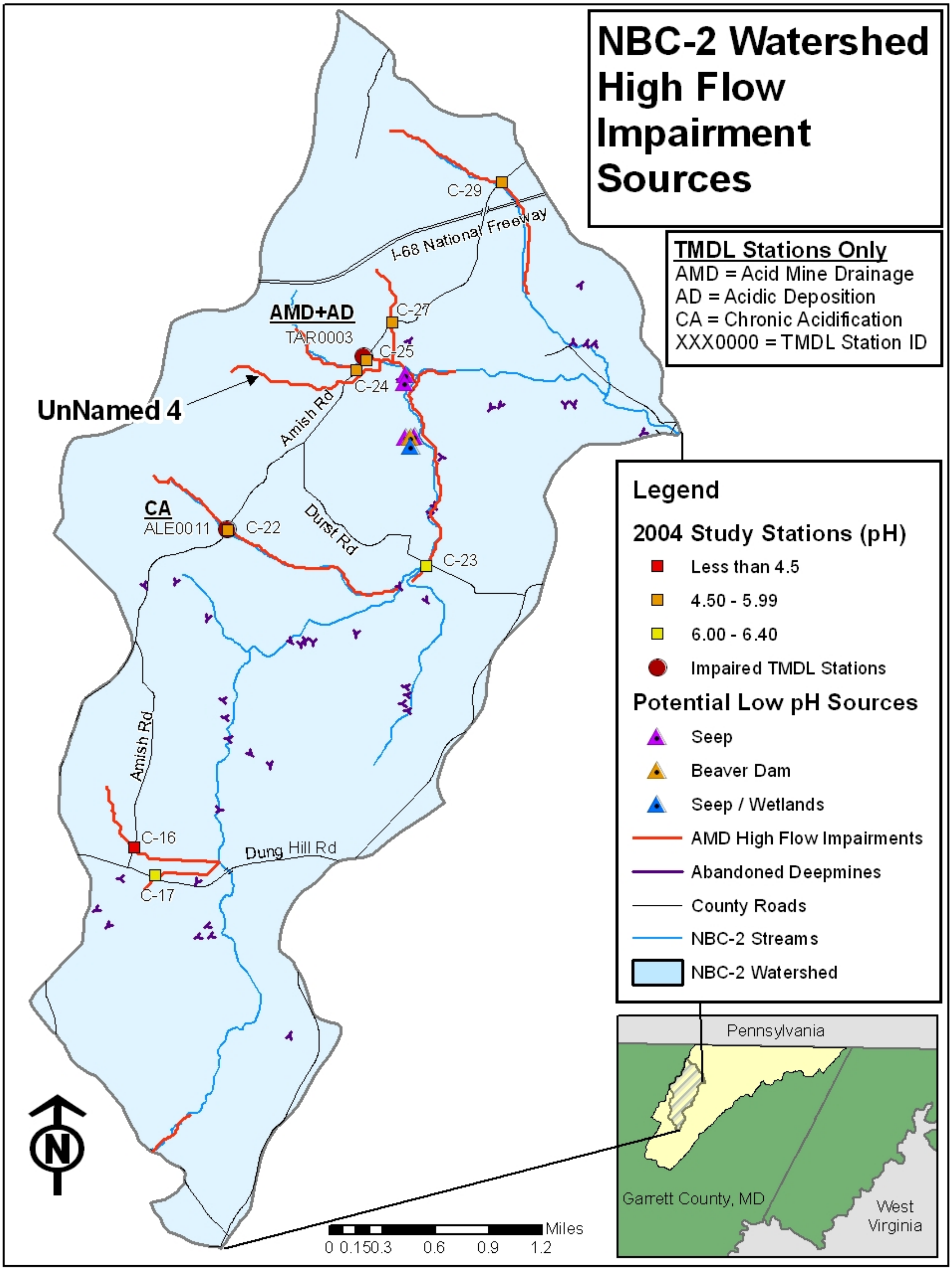

Figure 11. NBC-2 Watershed High Flow Impairment Sources

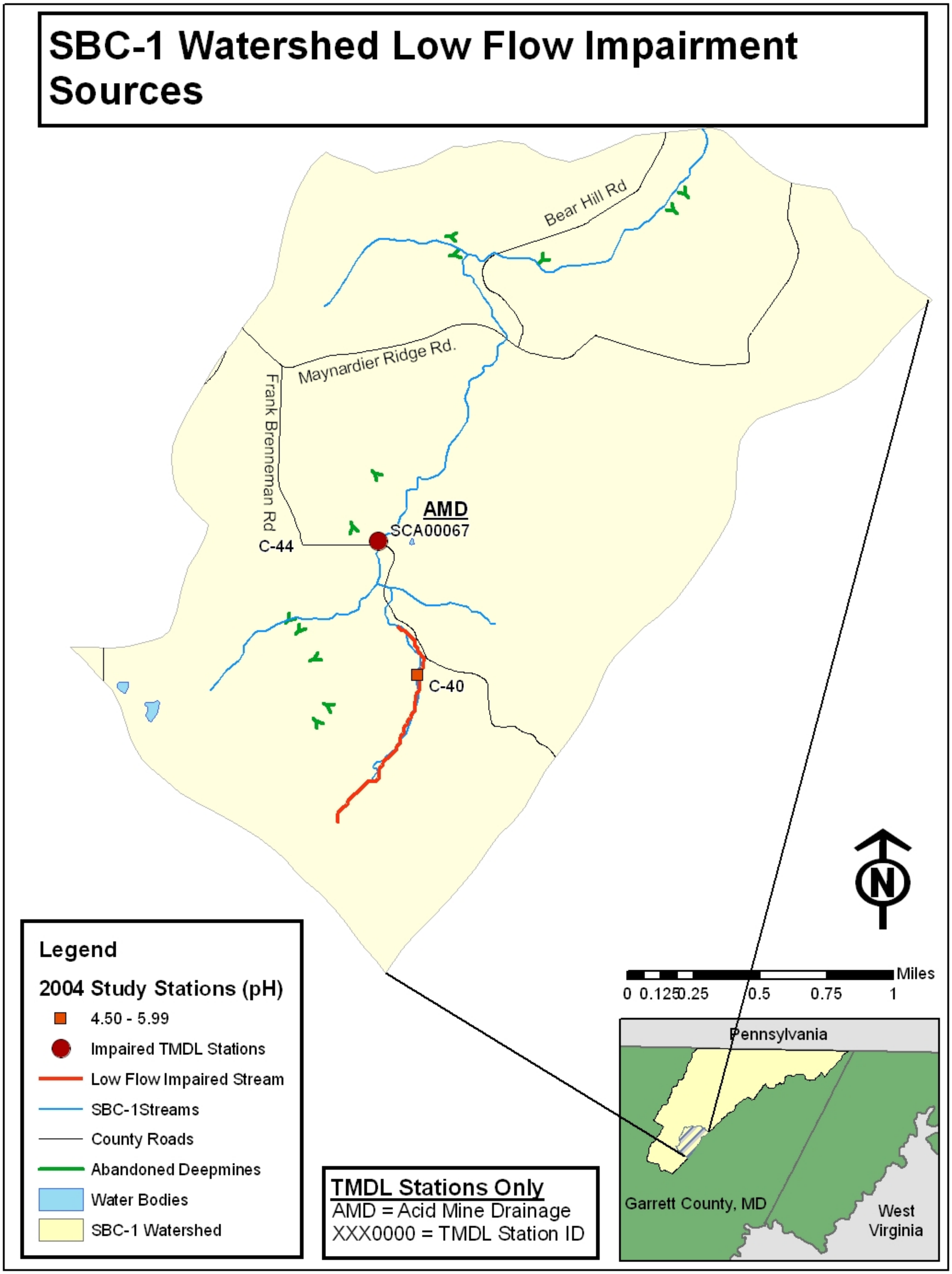

Figure 12. SBC-1 Watershed Low Flow Impairment Sources

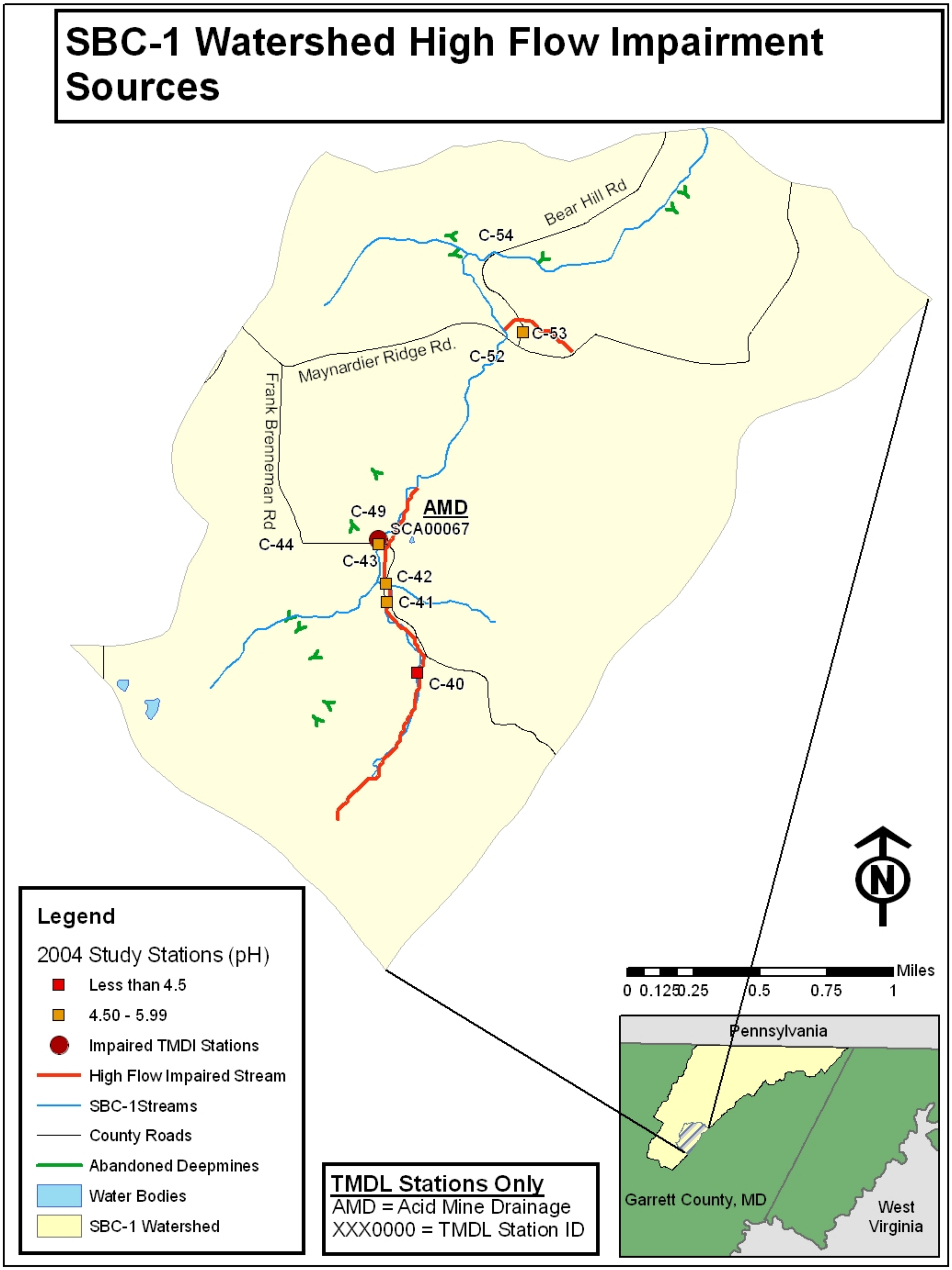

Figure 13. SBC-1 Watersged High Flow Impairment Sources

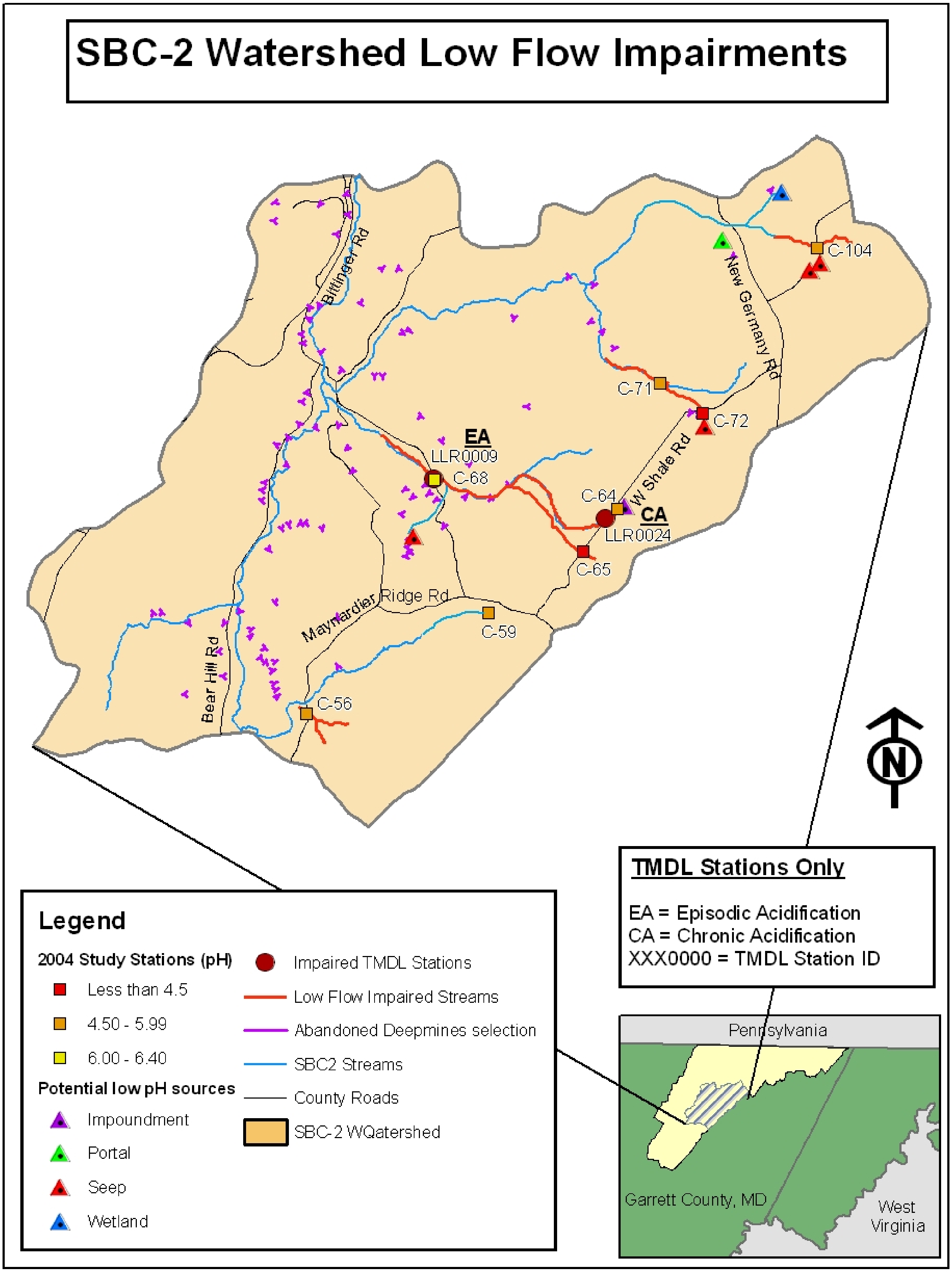

Figure 14. SBC-2 Watershed Low Flow Impairment Sources

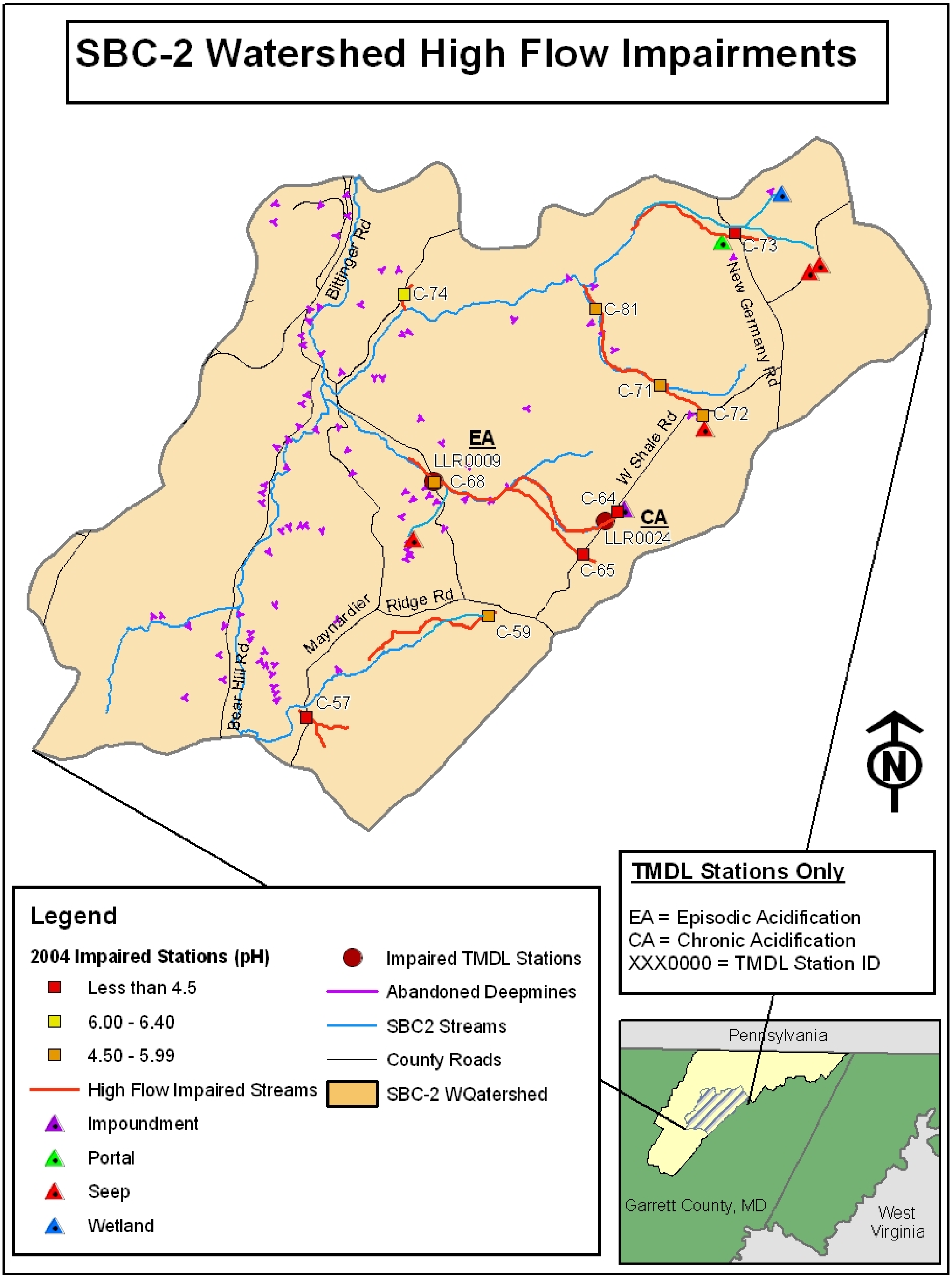

Figure 15. SBC-2 Watershed High Flow Impairment Sources

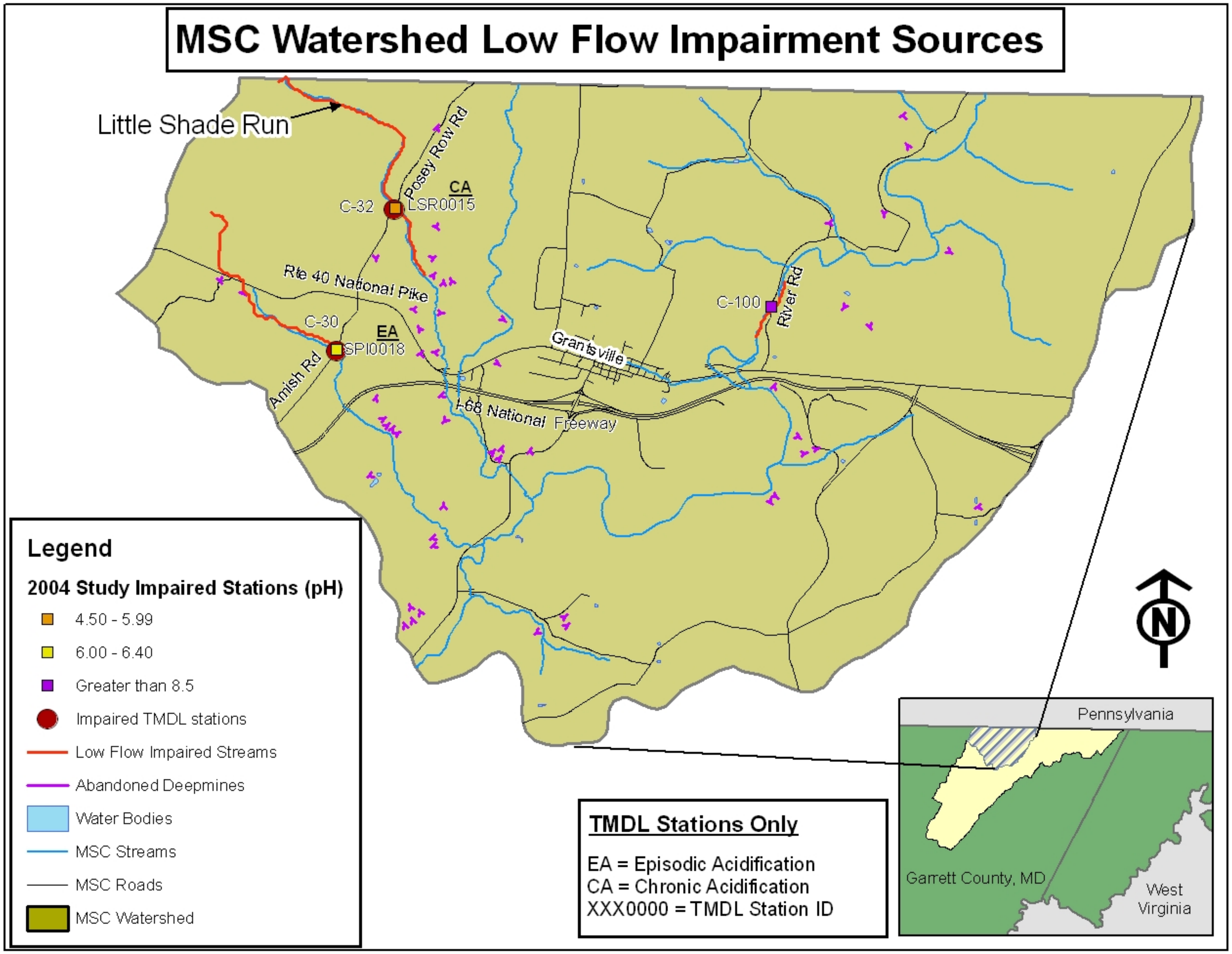

Figure 16. MSC Watershed Low Flow Impairments

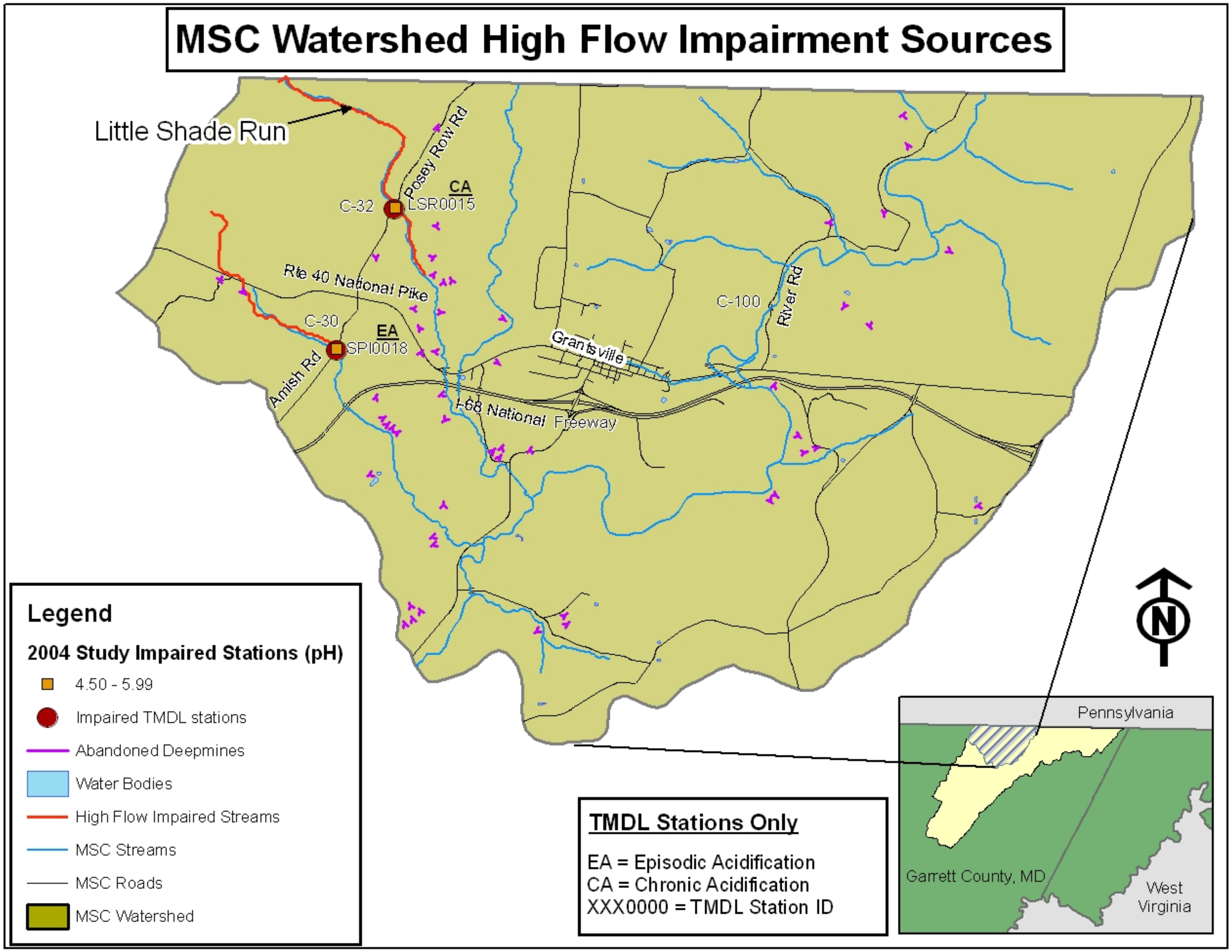

Figure 17. MSC Watershed High Flow Impairments

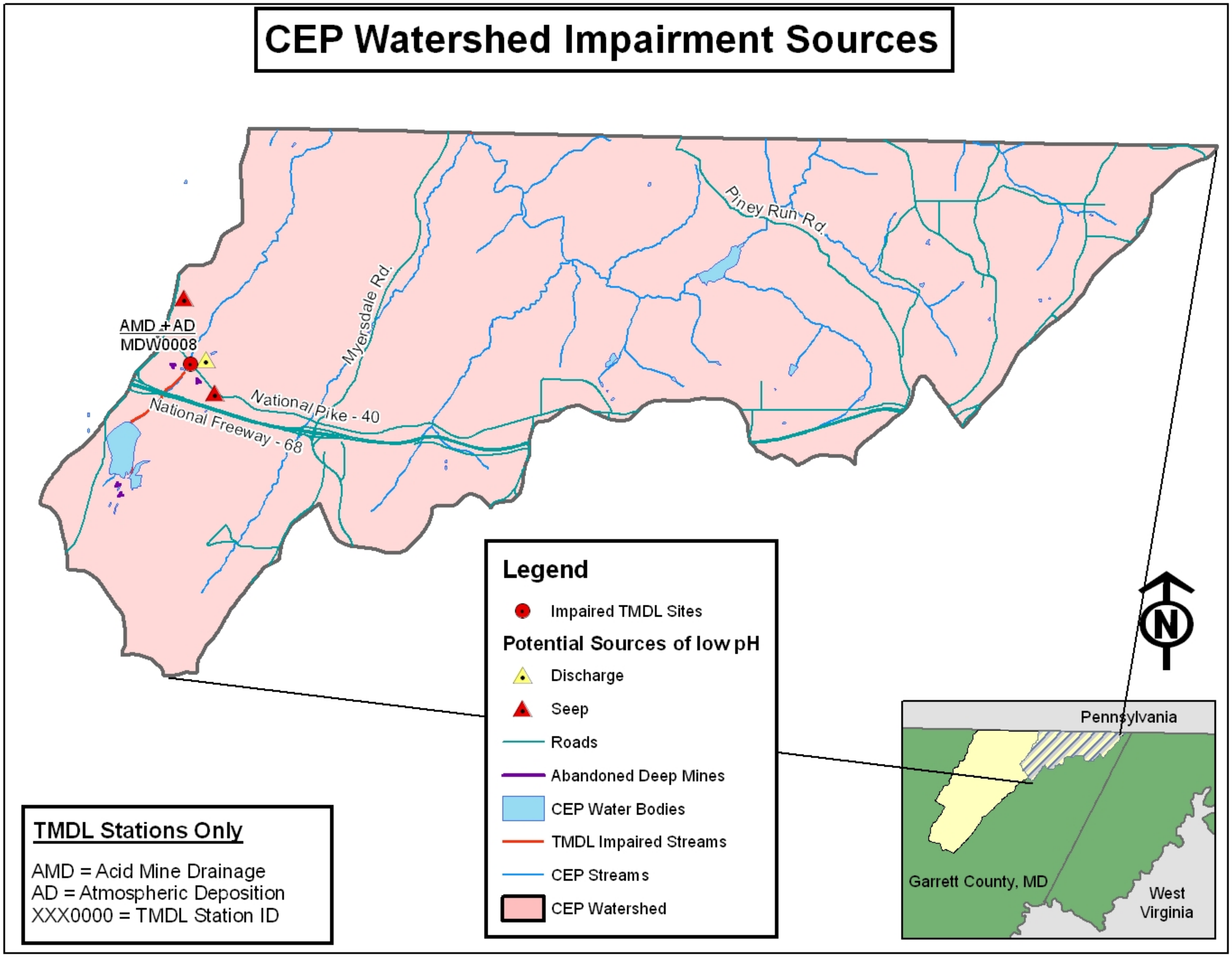

Figure 18. CEP Low Flow pH Impairment

5. Non-point Source Management (Criterion B)

Due to the number and distribution of pH impairments in the Casselman, MD Abandoned Mine Lands Division has decided to implement treatment projects in a three phase approach which considers the amount of acid load to the individual streams, the load contributed by these streams to the main stems of all branches of the Casselman, site suitability for project size, accessibility to the site for implementation and treatment technologies selected for each stream.

5.1 Low pH Treatment Stream Selection

5.1.1 – Phase I

Building on the 2004 AMD study, the Canaan Valley Institute (CVI) was contracted by the Youghiogheny River Watershed Organization (YRWO) to conduct a collaborative study with the MDE AMLD, and the Maryland Department of Natural Resources, Inland Fisheries (DNRF) to prioritize projects for AMD and atmospheric deposition mitigation with the primary goal of rehabilitating brook trout habitat the Casselman Watershed. Fifteen tributaries were ranked from 1 through 14 (2 sites tied at 11th). The ranked project sites contain priorities for adequate natural flow, ease of access, suitable topography, as well as enough area on State land to contain each proposed system (this criteria was established in response to prior experience of the difficulties of obtaining private landowner permission in this area of Maryland and to provide for more rapid implementation). Eleven sites met these critical siting criteria for the proposed mitigation technologies in four of the six subwatersheds. (MSC, NBC-2, SBC-1 and SBC-2) Additional mitigation systems are being planned for construction on private land and will be reviewed and ranked under phase II at a future date (Miller, 2007).

“Where to add the limestone depends on treatment objectives and road access. For example, a dump truck delivering limestone sand may weigh as much as 30 tons and require bridges rated for such heavy loads. Smaller trucks may be used to ferry limestone sand into less accessible areas, and helicopters could be used to reach more remote areas. Wherever the limestone is placed, the site should have sufficient flow and stream gradient to carry sand downstream.” (Schmidt, 2002)

In May 2008, MDE AMLD personnel scouted the CVI prioritized tributaries and collected GPS locations, photographs, and pH readings. Eleven (11) sites were selected for low impact, low maintenance limestone treatment systems (sand dumps and limestone leach beds). These systems will add the needed alkalinity loading to the pH impacted tributaries so that the TMDL pH standards are achieved. These sites will effectively treat over 13 miles of severely impaired tributaries in the Casselman watershed.

Site choice was based on several metrics 1) prioritization of stream for mitigation, 2) access and ease of constructing low impact, low maintenance projects, and 3) the decision to locate all systems on the state-managed Savage River State Forest Lands. The primary reason for this decision was because obtaining right of entry from landowners has delayed projects in the past. DNR owns the lands proposed and has agreed to work with MDE staff as a supporting agency.

The selection of these sites coincides with the results from the 2005 TMDL study and therefore many of the sites selected in phase I immediately address TMDL impairments as well. Those TMDL sites not addressed in phase I will become priority sites in phase II. The selected sites are listed in **Table 8** below and identified in **Figure 18** on page 30.

Table 8. List of Project Areas

Project Area	BMP Location	Subwatershed	CVI Rank	BMP #
CR Project Area 1	Spiker Run	MSC	3	1
CR Project Area 2	Unnamed 1	NBC2	13	2
	Unnamed 2	NBC2	11	3
	Tarkiln Run	NBC2	8	4
	Alexander Run	NBC2	6	5
CR Project Area 3	Mainstem	SBC1	NR	6
	Unnamed 12	SBC1	12	7
CR Project Area 4	Unnamed 8a, 10	SBC2	11	8
	Unnamed 6	SBC2	9	9
	Unnamed 5	SBC2	7	10
	Big Laurel Run	SBC2	1	11

5.1.2 – Phase II

Several ranked sites were incorporated directly into Phase II due to access issues or private ownership in potential implementation areas. These sites are Little Shade Run (**Figure 15**), UnNamed 11 (**Figure 7**), and UnNamed 4 (**Figure 10**). They will be reviewed in phase II to determine if further consideration is warranted or feasible. Acidity identified at site C-4, one of the high flow 90% acid producers in the Maryland portion of the Casselman watershed, will need further investigation due to identification of non-anthropogenic environmental factors, Cunningham Swamp, as the potential primary source of acid loads.

5.2 Potential Treatment Technologies (Criterion C)

The following list describes in depth the various measures that may be used to control AMD. Numbers in parentheses following the name of the method indicate the potential load reductions when the method is used correctly and in the proper situation. (Pavlick, et. al 2005)

5.2.1 Passive pH treatment

- **Reducing and Alkalinity Producing Systems (RAPSs) (25 g acidity/m^2).** In these systems, also known as "successive alkalinity producing systems" and "vertical flow ponds," water encounters two or more treatment cells in series. First, water passes through organic material to deplete dissolved oxygen. Several helpful reactions take place in the anoxic environment. First, bacteria reduce sulfate in an alkalinity producing reaction. Second, ferric iron, which comes into contact with pyrite, should reoxidize the sulfur and turn to ferrous iron. In a second cell, the anoxic solution comes into contact with limestone. H^+ acidity is neutralized through contact with the limestone. Additional alkalinity dissolves into the water as well. Iron does not armor the limestone because it is the ferrous form. Water then runs through the aeration and settling pond, in which ferrous iron oxidizes and then precipitates out of solution as ferric hydroxide. The acidity released in this process is neutralized by the alkalinity that has accumulated in the solution.
- **Sulfate-reducing bioreactors (40 g acidity/m^2).** These systems also consist of organic matter and limestone, but in sulfate-reducing bioreactors, the materials are all mixed in a single cell. Some of the organic material included is of a coarser nature, such as sawdust or woodchips. Reactions in these systems are similar to those in RAPSs: compost eliminates oxygen, and drives the iron and sulfur to reduced forms. The coarser organic matter may serve to protect hydraulic conductivity and may retain metals as various organic complexes.
- **Oxic (or Open) limestone channels (30%).** Research to estimate the efficacy of OLCs is active. OLCs have the advantage that continually moving water may erode any armoring from limestone, and that water flow should remove precipitates from OLCs so that they do not interfere with acid neutralization. In practice, the efficacy of OLCs may suffer because they are too short, most limestone may be placed so as to react with water only at high flows, and fluctuating water levels enhance armoring. Recent research suggests that the acid neutralization that takes place in OLCs is actually greater than can be accounted for by limestone dissolution.

- **Limestone leachbeds (50%).** Leach beds are plots constructed and filled with varying sizes of limestone. Acidic water from AMD passes through the limestone slowly dissolving it, and as a result, alkalinity is added to the stream water. Limestone leachbeds are most effective when water has a pH of 3 or less, and when water retention times are short (~90 minutes). The low pH promotes rapid limestone dissolution, but the short retention time prevents armoring. Water alkalinity in such an open structure can reach 75 mg/L and can buffer streams against acidity introductions downstream.
- **Limestone Sand Dumps.** Limestone sand is dumped at the bank of a stream and gradually washes into the stream. Most of the limestone sand dissolves in the water, increasing alkalinity, while some becomes assimilated into the streambed adding longer term alakalinity. Periodic replenishing of the limestone sand is required as it dissipates.
- **Steel slag leachbeds (addition of alkalinity).** Steel slag leachbeds are not exposed to acidic waters. Rather, circumneutral feed water passes through these leachbeds, and that water is then mixed with impaired waters to reduce its acidity drastically.
- **Compost wetlands (wide range).** Constructed wetlands can serve multiple functions in AMD treatment. Wide areas of exposure to the atmosphere allow metals in solution to oxidize. Slower waters allow precipitates to fall out of suspension. Anaerobic zones in sediments allow for sulfate reduction, which consumes acidity. Inclusion of limestone in the substrate provides an additional alkalinity source and helps maintain conditions that support sulfate reduction.
- **Grouting (50%).** Setting up grout walls or curtains in deep mines has great potential to solve AMD problems. Ideally, such barriers may serve to keep water from entering mines and interacting with acid-forming materials. They must be constructed carefully so as not to build water pressures near a weak point and to avoid blowouts. Also, fractures in bedrock always allow some water into mines, even if flows are eliminated. A grouting project at Winding Ridge, near Friendsville, MD, decreased acidity by 50% (MPPRP, 2000).

5.2.2 Active AMD treatment

- **Treating (100+%).** A variety of active treatment methods exist for AMD. One of a number of alkaline chemicals can be mixed with the polluted water. The mixture may then be aerated and is finally passed through ponds allowing metal hydroxides to settle out as sludge.

5.3 Technology Selection

Acid load mitigation has high initial construction and operating costs, particularly using active systems like dosers. Based on an economic report compiled to describe the program in 2008, ten active dosers in three Maryland watersheds were installed at a cost of $2.2 million with annual operating costs of $351,000 for lime dosing materials, weekly maintenance and water sample collection and analysis. Also by 2008, there were 22 “passive” mitigation systems in five watersheds installed at cost of $3.4 million with annual operating costs of $130,000 for maintenance, water sample collection and analysis. Since 1993, active dosers have removed approximately 31 million pounds of acidity compared to the 5 million pounds removed by passive systems since 1995 (CTL, 2008).

Treatment systems for each site were also chosen based on the assumption that Section 319 funds will continue to be limited to funding capital costs, not operations and maintenance. Therefore treatment options are limited to land reclamation and passive systems that do not require substantial ongoing operations and maintenance.

For acid load mitigation a passive treatment system can be chosen and sized based on the presence of direct inputs, water chemistry and flow data. Based on the limited presence of direct discharge portals and seeps, the passive water treatment systems for the sources that have been studied in the Casselman are the alkalinity producing technologies of limestone sand dumps and leach beds. The choice of limestone sand dumps and leach beds as treatment systems was made because they will be low maintenance, low cost, and low impact systems that will be able to mitigate the current acid load within the Casselman River watershed. As part of a contingency plan, small active dosers have been proposed in the event that passive systems can not adequately mitigate acid loads in all streams identified in the 2004 and 2005 studies.

Limestone Sand Dumps

Sand dumping is proposed at selected sites to add needed alkalinity in the upper portion of several tributaries of the North and South branches of the Casselman River. Limestone leach beds were preferred because of their longevity, low capital cost and low operations and maintenance costs; where topography prohibits leach beds or makes them prohibitively expensive, sand dumps were considered the preferred option.

Limestone Leach Beds

Limestone leach beds (LLB) consist of a pond constructed to receive water that has little or no alkalinity or dissolved metals (Black et al. 1999). The pond is filled with limestone, and designed with a retention time of at least 12 hours to allow maximum interaction between acidic water and limestone without armoring.

Active Limestone Dosers (contingency plan)

During Phase I and Phase II of the plan, passive technologies will be evaluated for their effectiveness at reducing acidity levels in the various stream reaches. Active lime dosers may be implemented as part of Phase III.

The location of specific technologies being deployed during phase I, along with their association to impaired stream reaches, is summarized in **Table 9** and **Figure 19**.

Table 9. Eleven Proposed BMPs (in the four project areas)

BMP#	Project Area	Subwaterhed	Road Locations	BMP Locations	Proposed BMP	Sampling Location #	Associated TMDL Station
1	Area 1	MSC	Route 40	Spiker Run	Sand Dump and Leach Bed	C30u*	SPI0018
2	Area 2	NBC-2	Amish Road	Unnamed Tributary 1	Sand Dump and Leach Bed	C28	None
3	Area 2	NBC-2	Amish Road	Unnamed Tributary 2	Leach Beds(3), Sand Dumps(1)	C27	TAR0003
4	Area 2	NBC-2	Amish Road	Tarkiln Run	Sand Dump	C25	TAR0003
5	Area 2	NBC-2	Amish Road	Alexander Run	Sand Dump	C22	ALE0011
6	Area 3	SBC-1	Bear Hill Road	SB Casselman Mainstem	Sand Dump and Leach Bed	C52	SCA0031
7	Area 3	SBC-1	Maynardier Ridge Road	Unnamed Tributary 12	Leach Bed	C53	SCA0031
8	Area 4	SBC-2	Maynardier Ridge Road	Unnamed Tributaries 8a & 10	Sand Dump	C56	SCA0031
9	Area 4	SBC-2	West Shale Road	Unnamed Tributary 6	Sand Dump	C65	LLR0024 / LLR009
10	Area 4	SBC-2	West Shale Road	Unnamed Tributary 5	Sand Dump	C64	LLR0024 / LLR010
11	Area 4	SBC-2	West Shale Road	Big Laurel Run Headwaters	Leach Bed	C72	BIL0006

Notes:
Upstream of 2004 C30 station*
Need Survey indicates survey not completed to date.

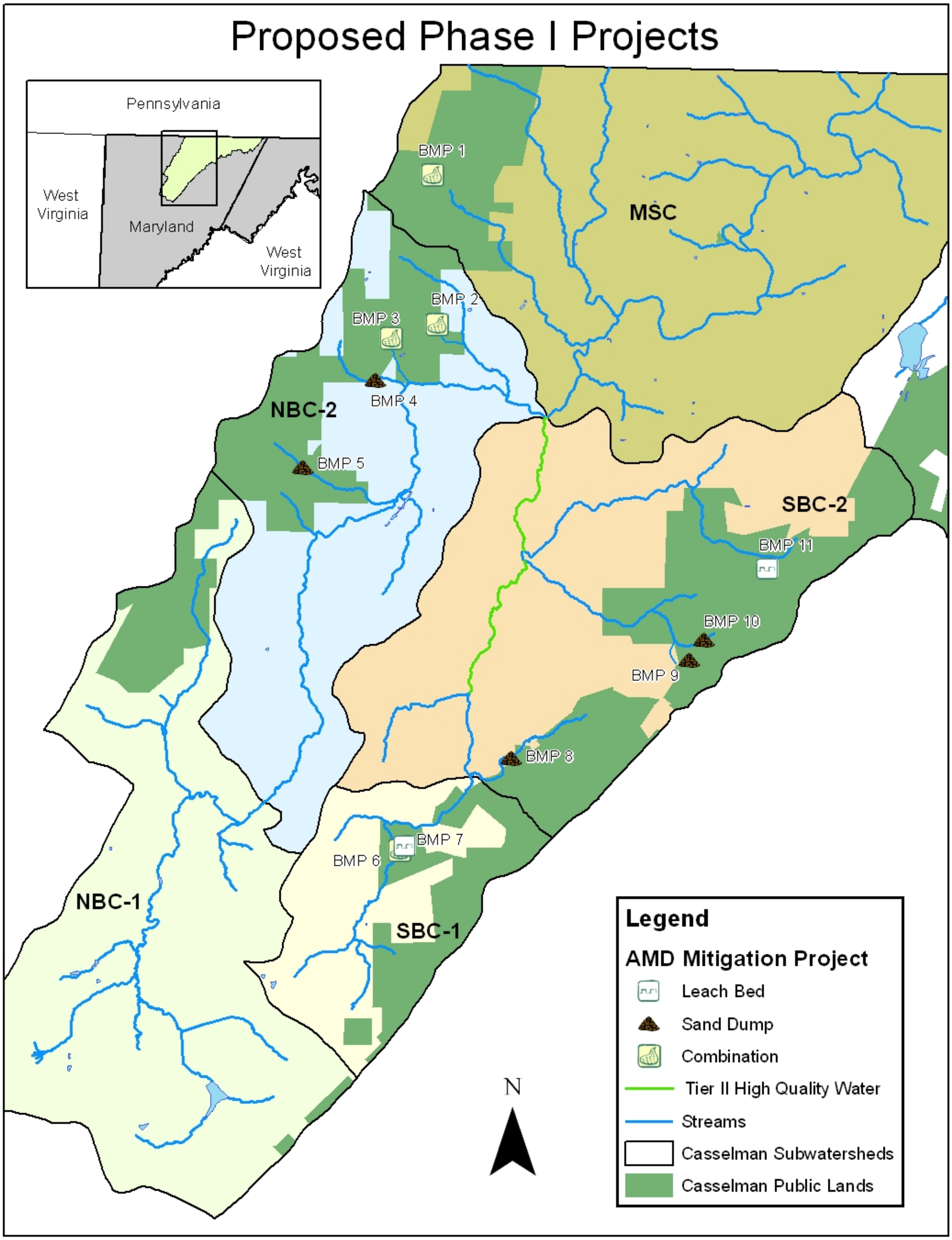

Figure 19. Location of Phase I Priorities and Proposed BMPs

5.3.1 Load Reduction Post Implementation

In the summer of 2010, MD AMLD collected water samples from three of the impacted reaches in the Casselman River watershed: Alexander Run, Big Laurel Run, and Unnamed Tributary 8b. The samples were sent to UMAL to analyze the amount of added $CaCO_3$ (limestone) needed to achieve COMAR pH values (6.5 – 8.5) and to determine the amount of time it takes for that volume of $CaCO_3$ to dissolve from limestone sands. The results of the titration show that pH standards in all three streams can be reached with the addition of between 14 and 24 mg/L of $CaCO_3$ in the form of limestone. The data from the laboratory titrations is presented in **Table 11** and **Figures 20-22** below.

In addition to the titrations, UMAL conducted limestone sand leaching experiments to determine the dissolution rates of the sand as well as the amount of residence time needed to neutralize the acid loads using this technology. The results show that after approximately 1.6 hours pH values were between 7.00 and 7.99 in all the stream samples taken. At these dissolution rates, it can be inferred that in approximately one hour of direct contact, pH values were close to COMAR lower standard of 6.5. In the short term, the amount of direct contact between sands and water flowing within impaired streams will be short, however as time and high flow events distribute the sand downstream, that contact time is greatly extended. This analysis shows that it is possible to achieve successful mitigation levels using the limestone sand technology. Results are summarized in **Table 11 and Figures 23-25** below.

MDE AMLD proposes to use the following procedure to reach the pH values shown in the tables below. The first part is to calculate existing acid loads using the data collected from previous sampling events and then assume a 1:1 relationship in tons acid to tons limestone in a worst case scenario (i.e. high flow and high acid loads). For example, at the Amish Road North site, the highest recorded flow is 1667 gallons per minute (gpm) at high flow and the acid concentration can be as high as 16.4 milligrams per liter (mg/L). Using a loading calculation of 0.01202 x concentration (mg/l) x flow (gpm) = load in pounds per day it was determined that 60 tons per year (tpy) of acid was being discharged into this stream. Therefore it would require 60 tpy of limestone sand to mitigate the acid load.

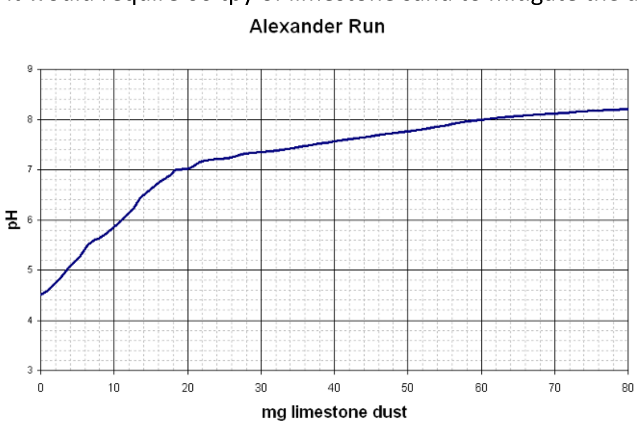

Figure 20. Titration Graph for Alexander Run

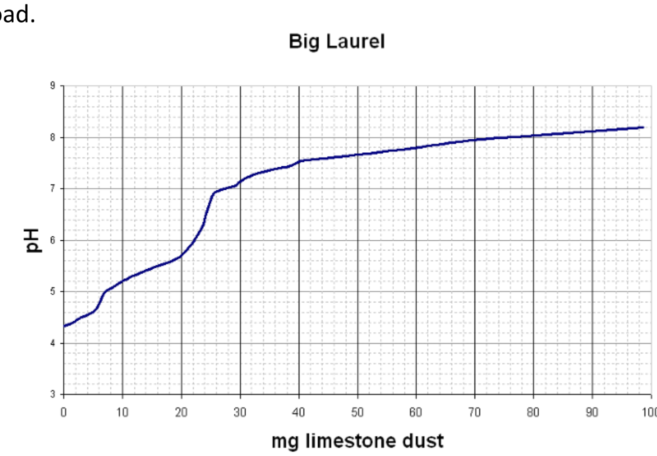

Figure 21. Titration Graph for Big Laurel Run

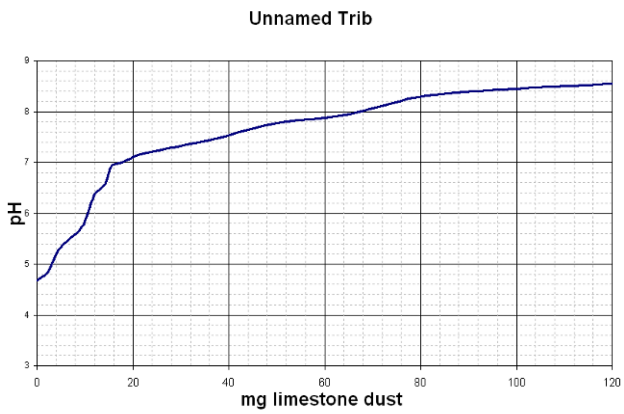

Figure 22. Titration Graph for Unnamed Trib 8

Table 10. Results of laboratory pH reaction analysis

Alexander Run			Big Laurel Run			Unnamed Tributary 8b		
limestone (mg)	sum total	pH	limestone (mg)	sum total	pH	limestone (mg)	sum total	pH
0	0	4.51	0	0	4.34	0	0	4.68
1.4	1.4	4.65	1.8	1.8	4.41	2.2	2.2	4.83
1.1	2.5	4.82	1.2	3	4.5	1.2	3.4	5.07
0.8	3.3	4.96	2.1	5.1	4.615	0.9	4.3	5.27
1.7	5	5.22	1.2	6.3	4.84	1.6	5.9	5.43
1.7	6.7	5.53	0.6	6.9	4.98	1.4	7.3	5.54
1.5	8.2	5.66	1.3	8.2	5.08	1.3	8.6	5.63
1.2	9.4	5.8	2	10.2	5.21	1.3	9.9	5.83
1.5	10.9	5.97	2.6	12.8	5.35	1.5	11.4	6.23
1.5	12.4	6.19	1.3	14.1	5.42	0.9	12.3	6.42
1	13.4	6.41	2.3	16.4	5.51	1.8	14.1	6.56
1.2	14.6	6.58	2.4	18.8	5.62	1.3	15.4	6.91
1.3	15.9	6.72	1.6	20.4	5.74	2.4	17.8	7
1.8	17.7	6.9	2.9	23.3	6.2	1.6	19.4	7.08
0.5	18.2	6.98	1.4	24.7	6.71	1.7	21.1	7.14
1.6	19.8	7.02	1.2	25.9	6.94	2.7	23.8	7.2
0.7	20.5	7.05	3	28.9	7.05	7.3	31.1	7.35
1.1	21.6	7.16	1.2	30.1	7.14	6.8	37.9	7.48
1.6	23.2	7.2	1.7	31.8	7.25	7.4	45.3	7.67
1.4	24.6	7.22	2	33.8	7.32	6.9	52.2	7.81
1.3	25.9	7.25	2.2	36	7.39	11.2	63.4	7.92
2	27.9	7.32	1.5	37.5	7.42	16.1	79.5	8.28
5	32.9	7.39	0.8	38.3	7.44	14.2	93.7	8.41
7.1	40	7.57	2	40.3	7.55	29	122.7	8.56
12.8	52.8	7.83	2.5	42.8	7.58			
6.2	59	7.97	2.7	45.5	7.605			
8.8	67.8	8.1	13.9	59.4	7.79			
16.3	84.1	8.25	11.9	71.3	7.965			
			27.3	98.6	8.2			

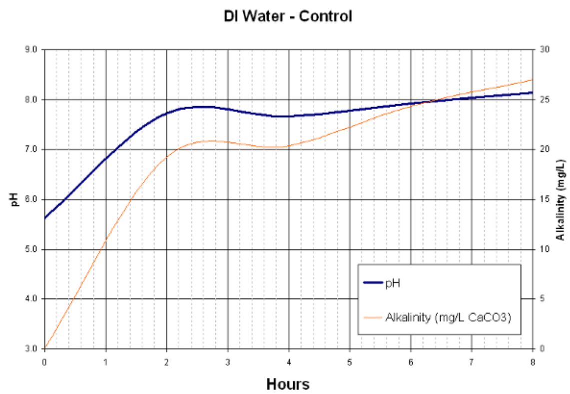

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Figure 23. Control Leaching Results

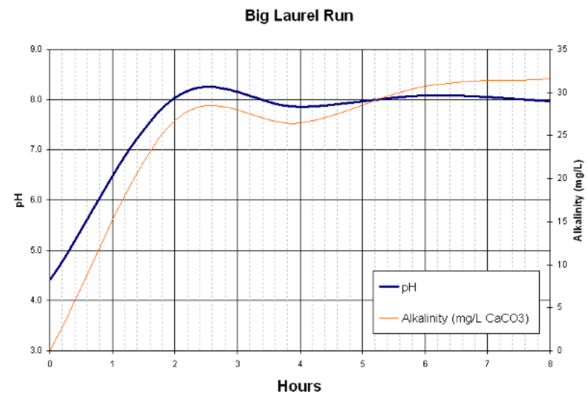

Figure 25. Big Laurel Run Leaching Results

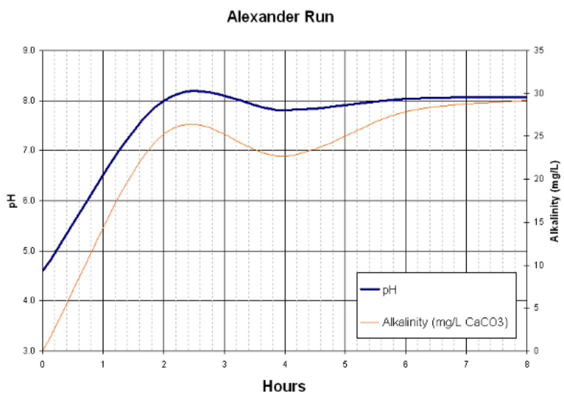

Figure 24. Alexander Run Leaching Results

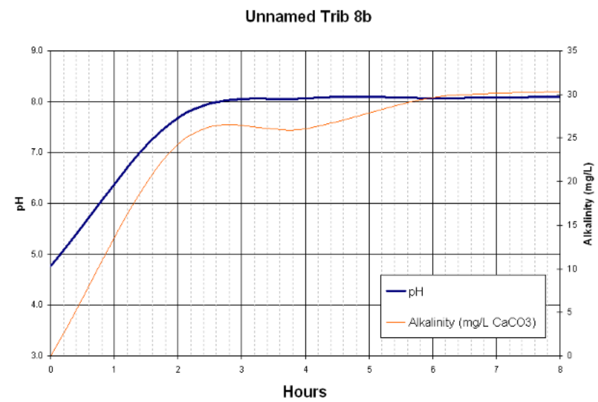

Figure 26. Unnamed Trib8 Leaching Results

Table 11. Limestone Sand Leaching Results

Medium	Conductance (µS/cm)	pH	Alkalinity (mg/L CaCO3)
DI Water - 0 hours	0.888	5.62	0.1
DI Water - 2 hours	376.6	7.72	19.2
DI Water - 4 hours	610.4	7.66	20.4
DI Water - 6 hours	439.5	7.92	24.3
DI Water - 8 hours	297	8.14	27.0
Alex Run - 0 hours	35.6	4.59	0.0
Alex Run - 2 hours	255.4	7.99	25.3
Alex Run - 4 hours	908.1	7.81	22.7
Alex Run - 6 hours	344.8	8.04	27.9
Alex Run - 8 hours	331.7	8.06	29.2
Big Laurel Run - 0 hours	38.9	4.40	0.0
Big Laurel Run - 2 hours	365.9	8.04	26.7
Big Laurel Run - 4 hours	797.9	7.85	26.5
Big Laurel Run - 6 hours	390.7	8.08	30.7
Big Laurel Run - 8 hours	368.9	7.97	31.6
Unnamed Trib. - 0 hours	26	4.77	0.0
Unnamed Trib. - 2 hours	272.5	7.68	24.3
Unnamed Trib. - 4 hours	670.2	8.07	26.0
Unnamed Trib. - 6 hours	302.5	8.06	29.6
Unnamed Trib. - 8 hours	343	8.10	30.3

Table 12. Phase 1 Project Expected Results

BMP#	Sub	Impaired TMDL Segment	TMDL pH Low Impairment	Impaired 2004 Station	2004 pH sample	Flow (GPM)	Acid Load (mg/L)	Acid Load (lbs/day)	Alkalinity Present (mg/L)	Alkalinity Load (mg/L)	Alkalinity Needed (mg/L)	Alkalinity Needed (lbs/day)	pH Result Expected
1	MSC	SPI0018	5.57	C30u*	5.89	889	98.3	1050.1	38.5	411.40	59.77	638.69	6.5-7.0
2	NBC-2	None	X	C28	6.65	177	0.0	0.0	15.3	32.55	0.00	0.00	6.5-7.0
3	NBC-2	TAR0003	4.25	C27	5.03	153	12.8	23.5	2.4	4.41	10.40	19.13	6.5-7.0
4	NBC-2	TAR0003	4.25	C25	5.03	565	10.6	72.0	2.6	17.66	22.88	155.39	6.5-7.0
5	NBC-2	ALE0011	4.20	C22	4.56	961.37	21.2	245.0	0.0	0.00	16.00	184.89	6.5-7.0
6	SBC-1	None	X	C52	6.62	10099	0.3	36.4	16.8	2039.35	0.00	0.00	6.5-7.0
7	SBC-1	None	X	C53	5.34	3722.7	19.2	859.1	10.2	456.42	35.95	1608.82	6.5-7.0
8	SBC-2	None	X	C56	4.38	1842.83	13.4	296.8	0.0	0.00	15.00	332.26	6.5-7.0
9	SBC-2	LLR0009	4.67	C65	4.31	150.00	11.7	21.1	0.0	0.00	11.70	21.10	6.5-7.0
10	SBC-2	LLR0024	4.22	C64	4.33	7142.03	12.6	1081.7	0.0	0.00	30.29	2600.18	6.5-7.0
11	SBC-2	None	X	C72	4.86	102.50	13.4	16.5	3.0	3.70	25.00	30.80	6.5-7.0

Table 13. Phase II & III TMDL segments

Sub	Impaired TMDL Segment	TMDL pH Impairment	Impaired 2004 Station	2004 pH Impairment	Flow (GPM)	Acid Load (mg/L)	Acid Load (lbs/day)	Alkalinity Present (mg/L)	Alkalinity Load (mg/L)	Alkalinity Needed (mg/L)	Alkalinity Needed (lbs/day)	pH Result Expected
CEP	MDW0008	5.54	C-91*	7.39	1664.00	0.0	0.0	68.6	1372.09	0	0.00	NA
			C-92*	6.66	NA	6.4	NA	7.2	NA	NA	NA	NA
NBC1	NBC0072	4.41	C-38	6.34	NA	10.2	NA	15.7	NA	NA	NA	NA
SBC1	SCA0067	5.21	C-43	5.44	8073.24	16.4	1591.5	10.0	970.40	NA	NA	NA
NBC1	NBC0090	4.23	No Site**	NA	NA	4.4	NA	14.7	NA	NA	NA	NA
NBC1	PLE0008	4.75	C-04	5.16	5287.00	7.6	483.0	3.3	209.71	NA	NA	NA
NBC1	NBC0106	4.26	C-06	5.97	NA	8.2	NA	4.8	NA	NA	NA	NA
NBC1	ZWN0003	4.85	C-03	6.03	2835.75	5.6	190.9	8.9	303.36	NA	NA	NA
NBC1	UNA0015	4.36	C-14	4.56	123.00	12.0	17.7	0.0	0.00	NA	NA	NA
MSC	LSR0015	4.25	C-32	5.02	2495.00	350.8	10519.0	119.9	3596.09	NA	NA	NA

The titrations from the three streams were applied to the remaining Phase I project sites to determine the alkalinity needed to buffer each system to result in a pH value of 6.5 – 7.0. A multiplier was developed from each of the titrations to determine how much $CaCO_3$ mg/L is needed to buffer 1 mg/L of acid. The remaining Ca from 2004 water chemistry samples at each site was then used to determine the potential similarity of stream response to added $CaCO_3$. Stations C27, C28, C30 &C65 resembled Alexander Run, which had a correlation of 1:0.8 (1 mg/L neutralized by 0.8 mg/L $CaCO_3$). Stations C25, C52, C53 & C64 resembled Big Laure Run with a 1:2.4 relation. Phase II & III sites will be analyzed during phase I using independent titrations.

6. Technical and Financial Assistance/Benefits (Criterion D)

To meet TMDL standards, it will take a combination of federal, state, private and public partnerships to work jointly to provide the desired outcome; restoration of the watershed.

6.1 Technical Assistance Needs and Partners

Technical assistance will be solicited for the following tasks:

- Locating Funding
- Watershed Characterization
- Project site selection
- Project design and engineering
- Project Implementation and management
- Water quality and biological monitoring
- Outreach

6.1.1 Maryland Department of the Environment (MDE)

Two MDE programs have responsibilities associated with watershed plan implementation.

The MDE Land Management Administration (LMA) Abandoned Mine Lands Division (AMLD) is the lead agency for reclamation of abandoned mines including those in the Casselman River watershed. Coordinated funding for the project, sampling and analysis used to characterize impairments in the watershed, rank the projects importance and the implementation effort. They will also manage project implementation, coordinate outreach programs and further sampling to document the effectiveness of projects.

The MDE Science Services Administration (SSA) is lead agency for TMDL development, TMDL implementation, NPS management and water quality planning, water quality impairment tracking and reporting, and water quality monitoring. SSA's Water Quality Protection and Restoration Program assisted in drafting this watershed plan and will assist in coordinating field monitoring. SSA's Field Services Program will conduct monitoring of water quality and biological integrity to measure success mitigation projects and progress toward meeting the TMDL and water quality standards.

6.1.2 Youghiogheny River Watershed Association (YWRA)

The YRWA partnered with AMLD to help provide funding for a contractor to conduct targeting work to help determine priority restoration sites. They will also help to be a source for conducting outreach to the local communities regarding restoration work being done in their areas.

6.1.3 Canaan Valley Institute (CVI)

The Youghiogheny River Watershed Association contracted Canaan Valley Institute (CVI) to work collaboratively with AMLD and DNR-Inland Fisheries (DNR) to conduct Sub-Watershed and Project Prioritization for acid mine drainage (AMD) mitigation and brook trout restoration in the Casselman River Watershed.

6.1.4 Maryland Department of Natural Resources (DNR)

The Inland Fisheries Service program has been monitoring populations of native brook trout in the Casselman for the last 6 years. They will continue to provide sampling efforts for these indicators of biological and water quality of the streams in the watershed.

The Maryland Monitoring and Non-tidal Assessment (MANTA) Division is responsible for assessment of status and trends of biological communities in the non-tidal portions of tributaries in Maryland. They may be asked to provide biological assessments within the watershed that will be used to help determine the success of implemented projects with regards to meeting the requirements to remove the watershed from the 303(d) list of impaired waters.

6.1.5 University of Maryland Center for Environmental Science – Appalachian Labs (UMAL)
UMAL was contracted to provide a detailed assessment of AMD impairments and potential sources within the Casselman watershed. Their efforts have contributed greatly to understanding the nature and extent of pH impairment within the Casselman's tributaries. Future assistance may include sampling for biological communities, both benthic and fish, water quality analysis and habitat assessment.

6.1.6 Other Technical Resources
There exist a multitude of agencies that may help contribute to this project in the future at the local, state and federal level. These partners may provide expertise in AMD mitigation, project design and funding.

6.2 Financial Assistance Needs
6.2.1 Mitigation Project Funding

Implementation costs for AMD projects can be highly variable depending on location of the project, alkalinity addition costs and seasonal loads. For this reason costs presented in **Table 14** are based on previous MDE implementation experience around the state, unless the site name is from another State or "projected":
- Capital cost includes cost related to planning, design and construction. The range of projected capital cost varies depending on the extent of needed road construction, stream crossings and site improvement/stabilization. The range of projected maintenance cost varies depending on the site's need for road maintenance and materials/parts replacement.
- Maintenance cost includes ongoing material costs for BMP operation.
- Operational costs include ongoing labor costs associated with operation and maintenance and on-going monitoring necessary to determine site-specific operational and maintenance needs.

6.2.2 Operation and Maintenance Funding

Treatment of acid mine drainage requires ongoing operation and maintenance to mitigate continuing pollution sources and meet water quality standards in the streams receive the acid mine drainage.

To meet this need, MDE uses the Acid Mine Drainage Abatement and Treatment Account (AMD Account) to pay for operation and maintenance costs associated with acid mine treatment systems in Maryland. The AMD Account, and interest earned by unexpended funds in the AMD Account, is currently used to pay for operation and maintenance of 37 operating acid mine drainage treatment systems, including 11 lime dosers and 26 passive treatment systems(count is current as of 12/3/2010). The AMD Account will also be used to pay for the operation and maintenance costs for the treatment systems that will be implemented consistent with this watershed plan.

Funds in the AMD Account originate from the Federal Abandoned Mine Land Grant (AML Grant) that Maryland receives annually. The AML Grant is provided by the Federal Office of Surface Mining under the Federal Surface Mine Control and Reclamation Act of 1977 (SMCRA). Maryland's AML Grant is $2.7 Million annually through Federal Fiscal Year 2011 and $3 Million annually beginning FFY2012. The AML Grant is funded by a federal "per ton" fee on coal production (31.5 cents for surface mined coal and 11.5 cents on deep mined coal).
The AML Grant is divided into the State Share, Historical Production Share and Minimum Program State make-up Share. The 2006 Amendments to SMCRA allows States to direct 30% of the State Share and Historical Share into the AMD Account.

6.2.3 Monitoring Funding

There are two categories of monitoring costs anticipated by this watershed plan:
- Operational monitoring cost: The cost for staff time for field monitoring and for analytical services will be paid for by the Acid Mine Drainage Abatement and Treatment Account (AMD Account), which is part of the Abandoned Mine Land Grant, and;
- Water quality progress monitoring cost: The cost for staff time for field monitoring and for analytical services for the water quality component of this project will be covered in part by MDE's Targeted Watershed Project, which is funded by the Federal 319(h) Grant.

Table 14. Estimated Project Costs for Phase I Projects*

BMP#	Project Area	BMP Locations	Proposed BMP	Sampling Location #	Capital Costs**	Leach BedAnnual O&M
1	Area 1	Spiker Run	Leach Bed	C30u	$46,900	$3,564
2	Area 2	Unnamed Tributary 1	Sand Dump and Leach Bed	C28	$45,610	$3,564
3	Area 2	Unnamed Tributary 2	Leach Beds(2), Sand Dumps(3)	C27	$305,000	$7,128
4	Area 2	Tarkiln Run	Sand Dump	C25	$8,000	NA
5	Area 2	Alexander Run	Sand Dump	C22	$11,000	NA
6	Area 3	SB Casselman Mainstem	Sand Dump and Leach Bed	C52	$247,000	$3,564
7	Area 3	Unnamed Tributary 12	Leach Bed	C53	$114,300	$3,564
8	Area 4	Unnamed Tributaries 8a & 10	Sand Dumps (2)	C56	$8,000	NA
9	Area 4	Unnamed Tributary 6	Leach Bed and Sand Dump	C65	Need new costs	NA
10	Area 4	Unnamed Tributary 5	Sand Dumps (2)	C64	$6,500	NA
11	Area 4	Big Laurel Run Headwaters	Leach Bed, Sand Dump	C72	$68,000	$3,564

*Estimates are based on 2010 limestone/labor costs and will change according to market values
**Sand Dump Capital Costs include 5 years of O&M/Materials costs

Table 15. Historical Passive Mitigation BMP Costs*

BMP Type	Site/Project Name	Capital Cost $	Maint. Cost $/Yr	Operation $/Yr incl. Monitoring	Reference. Discussion
Aluminator/Pond	Amish Rd I	$ 182,850	$ 3,157	$ 5,395	MDE Sept. 2008.
Aluminator/SAPS/Wetland	Everhart	$ 103,121	$ 2,360	$ 3,488	MDE Sept. 2008.
	Glotfelty	$ 93,861	$ 2,267	$ 3,765	MDE Sept. 2008.
Compost Wetlands	Crellin School	$ 216,200	$ 3,491	$ 4,989	MDE Sept. 2008.
Doser (Aquafix WaterWheel using calcium Oxide)	Wolfden Mine, Shallmar, MD	$ 215,000	$ 31,000		MDE 1/21/2010. Treatment cost/lb 2006 acidity neutralized = $0.123
Grout (alkaline CCB grout to fill mine)	Wolfden Mine, Shallmar, MD	$ 26,700,000			MDE 1/21/2010. Projected cost.
Grout (alkaline CCB grout to fill mine)	Frazee Mine, MD				MDE 1/21/2010
Grout (alkaline CCB grout to fill mine)	Omega Mine, WV				MDE 1/21/2010
Pyrolusite	Jay Rice	$ 153,518	$ 2,864	$ 5,102	MDE Sept. 2008.
	Midlothian School	$ 170,856	$ 3,037	$ 4,165	MDE Sept. 2008.
	Teets	$ 207,500	$ 3,399	$ 5,267	MDE Sept. 2008.
RAPS (ALD/Pond/Wetland)	Interstate 335	$ 112,281	$ 2,451	$ 4,689	MDE Sept. 2008.
	Amish Rd II	$ 183,080	$ 3,159	$ 5,397	MDE Sept. 2008.
RAPS (ALD/Wetland)	Elk Lick 1	$ 31,970	$ 1,648	$ 3,146	MDE Sept. 2008.
RAPS (SAPS)	Coney Cleaners	$ 230,443	$ 3,633	$ 5,871	MDE Sept. 2008.
	Railroad Street	$ 264,500	$ 3,974	$ 6,212	MDE Sept. 2008.
RAPS (SAPS/Steel Slag)	Potomac Hill	$ 218,333	$ 3,512	$ 5,010	MDE Sept. 2008.
	WineBrenner Run	$ 280,945	$ 4,138	$ 5,266	MDE Sept. 2008.
RAPS (SAPS/Steel Slag/Wetland)	Elk Lick II	$ 79,733	$ 2,373	$ 3,501	MDE Sept. 2008.
RAPS (SAPS/Wetland)	Elk Lick III	$ 71,345	$ 2,042	$ 3,540	MDE Sept. 2008.
	Fazenbaker	$ 174,507	$ 3,074	$ 4,942	MDE Sept. 2008.
	Oak Hill I	$ 287,500	$ 4,204	$ 6,072	MDE Sept. 2008.
Steel slag leachbeds	Neff Run II	$ 73,791	$ 2,067	$ 3,934	MDE Sept. 2008.
Sulfate-reducing bioreactors					BMP type mentioned in draft plan but no cost information available – XXX must be fixed

*These costs are being provided as a comparison for BMPs selected and BMPs that may be considered in future Phases of this Watershed Restoration Plan.

Table 16. Funding Sources (Existing/Potential)

Type	Source Name	Strategic Use
Federal	319(h) Grant, Federal Clean Water Act	BMP implementation consistent with an EPA-accepted watershed plan. Also before/after monitoring of BMP implementation.
Federal	Abandoned Mine Land Grant, Federal Surface Mine Control and Reclamation Act	Operation and maintenance of mine reclamation projects. Costs of monitoring associated with operation of mine reclamation projects.
State	Water Quality Revolving Loan	Stream corridor restoration and protection
State	Watershed Cooperative Grant	Watershed planning, stakeholder outreach and education
Local	None	None
Private	Eastern Brook Trout Joint Venture (EBTJV, a Fish Habitat Partnership operating under the National Fish Habitat Action Plan)	EBTJV coordinates efforts that build private and public partnerships to improve brook trout habitat. There is the potential to receive $50,000 towards brook trout habitat improvement.

6.3 Economic Value of Acid Load Mitigation

A 2008 study prepared by CTL Engineering of Morgantown, WV was prepared for the Maryland Department of the Environment Bureau of Mines to determine the value of AMD mitigation/mitigation in the North Branch of the Potomac River. This study found that the Natural Resources Conservation Service (NRCS) estimated that the value of one mile of restored trout stream was worth between $30,835 and $35,270 in the value of 2000 currency. A study of the effect of AMD impaired streams on the houses in the Cheat River, WV watershed showed that houses within a quarter mile of an AMD impaired stream sold for 12.2% less than those outside of that area. (Williamson, et. al. 2007) Another study on the effects to housing prices the West Branch Susquehanna River, PA and found similar results.

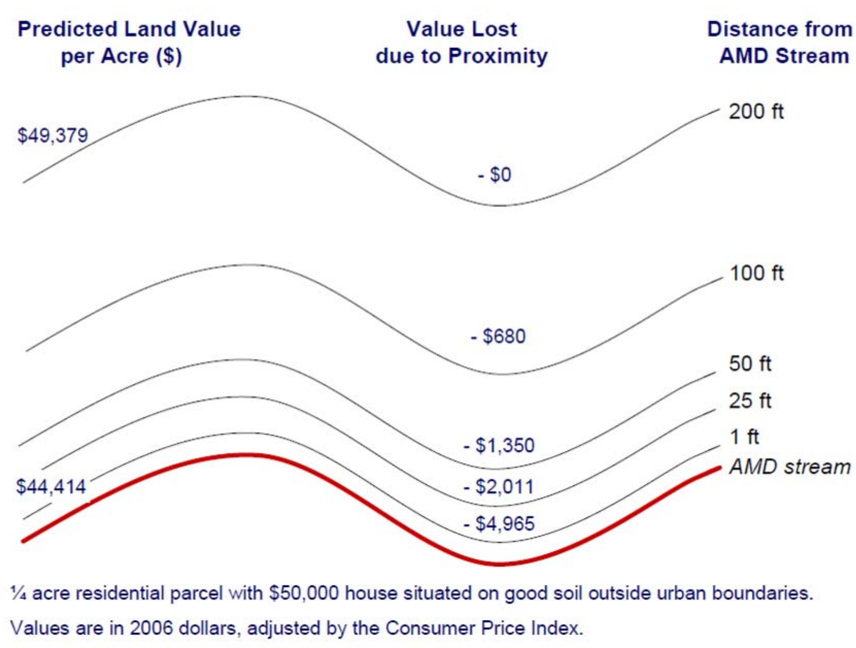

Figure 27. Proximity to AMD stream in relation to property value (Hanson, Wolfe 2007)

“The WVDNR estimates that, in total, the Middle Fork limestone sand project has restored 119 miles of the Middle Fork River and its tributaries. The unit cost of that restoration is thus approximately about $756 per mile per year. This is extremely cost-effective. The WVDNR uses an economic benefit figure of approximately $40,000 per mile per year for restored coldwater streams. At that rate, the benefits of restoring sport fisheries in the Middle Fork watershed exceed $4.75 million annually to the West Virginia economy. The resulting benefit/cost ratio of the Middle Fork project would be about 53 to 1.

By contrast, the Blackwater River project, utilizing the rotary drum and doser methodology, has an annual restoration cost of approximately ten times that amount, even when its $1 million capital construction cost is excluded. Excluding that construction cost, the Blackwater River project’s benefit/cost ratio is about 6 to 1, a figure that is eminently respectable but pales by comparison to that for the limestone sand methodology used in the Middle Fork watershed.” (Brown, 2005)

It is recognized the cost/benefit of remedial activities will vary with degree of impairment caused by AMD, however this example provides relative economics provided by the improvement of AMD impaired waters in other areas.

7. Information, Education and Public Participation (Criteria E)

This section of the plan includes the stakeholder outreach strategy including planning for public meetings, listing of stakeholders identified to date, and education and outreach materials.

Stakeholder Outreach Strategy for the Casselman River Watershed Plan	
Preliminary Outreach and Education 20011-2012	Initiate outreach with key stakeholders focusing on: 1) Landowners potentially affected by watershed plan Phase I, 2) Groups and individuals potentially interested in plan goals, 3) Partner agencies concerned with acid mine drainage remediation or NPS pollution management.
Draft Plan Public Participation 2011-2012	Upon release of the draft watershed plan, input from stakeholders and the public will be gathered and, as appropriate, incorporated as a watershed plan update. A public meeting will be held early 2011 and cooperation with interested groups such as the Youghiogheny River Watershed Association.
Implementation Outreach 2009-2025	For stream segments where BMP implementation is anticipated, "pre-implementation outreach" with landowners and other stakeholders who have a direct stake in BMP implementation will be conducted. Input gathered during pre-implementation outreach will be used to help assess the feasibility of BMP implementation. For key landowners and stakeholders identified during pre-implementation outreach, communication will be continued during BMP implementation as needed to maintain stakeholder support. Post-implementation outreach will be addressed through Annual Progress Reporting and End Phase Assessment.
Annual Progress Reporting	Each year progress will be reported in MDE's NPS Program Annual Report, which is made available to the public via the Internet. Other special reports the may be generated will also be made publicly available.
End Phase Assessments 2015, 2020, 2025	Progress toward meeting milestones will be assessed and findings in the form of watershed plan updates will be made available to the public. Input from stakeholders and the public will be gathered and, as appropriate, may be incorporated into the watershed plan as a plan update. If the assessment findings indicate that the plan should be modified, a plan addendum will be released to the public. Changes in water quality impairment (delisting) will be made public (MDE Internet). Interest in a public meeting will be solicited and, if the solicitation generates interest, a public meeting will be held in cooperation with the Youghiogheny River Watershed Association.

Stakeholders Identified in the Casselman River Watershed, November 2010	
Citizen Groups	Youghiogheny River Watershed Association (YWRA) The YRWA has a vested interest in projects proposed for the Casselman River Watershed. Partnership with this group was critical in funding the Canaan Valley Institute's evaluation of the Casselman River to prioritize AMD mitigation and brook trout habitat restoration projects. It has an active Board, holds public informational meetings 6 times a year and sponsors an annual celebration of the river. Many of the area's lead watershed activists and environmentalist are involved in this group and have an interest in the environmental health of the Youghiogheny River. Information can be distributed through the YRWA network which can collaborate with local universities and schools.
	Eastern Brook Trout Joint Venture (EBTJV) EBTJV's interest involves regional restoration of brook trout habitat and populations. The Casselman River, a major tributary to the Youghiogheny River has been considered a high quality stream that has been noted for its population of native brook trout, *Salvelinus fontinalis*. However, there are identified tributaries that have pH impairment and have shown a significant reduction in the native brook trout population. The MDE AMLD has partnered with the EBTJV to secure funding for some of the project implementation and will continue to develop this relationship to provide outreach through their website and newsletters.
	Maryland Brook Trout Alliance (MBTA) MBTA's interest involves restoration of brook trout habitat and populations in Maryland. The Youghiogheny River watershed has been selected by the MBTA as one of four priority areas for protection of native brook trout. The major goal of the MBTA is to galvanize stakeholders, resource users, and local and state agencies to advance coordinated habitat protection and restoration projects to improve water quality and insure the future of brook trout in the state. They are an active group that is involved with providing information to the public through their website, meetings, and newsletters.
	Potomac Valley Fly Fishers and other groups interested in recreational fisheries (following plan implementation and trout population expansion)
	Interested citizens generally such as farmers, foresters, hunters, fisherman and outdoor enthusiasts, and environmental groups.
Land Owners	Private land owners, State of Maryland, Department of Natural Resources (DNR): - Forest Service - Park Service
Government	Garrett County (various agencies, elected officials)
	DNR: Fisheries Service, Wildlife and Heritage (rare species)
	MDE: mine permitting and abandoned mine reclamation, NPS management, permitting
	Maryland Office of Tourism (following plan implementation and trout population expansion)
	Pennsylvania (state/local): coordination for downstream watershed
	US Dept. Of Interior (mine permitting and oversight)
	US EPA: NPS management
Private Business	Garrett County Chamber of Commerce Coal mining companies

DeFrank's Tour Service (which operates in the MD portion of the Casselman) Others

Education and Outreach Materials

MDE maintains mining-related education and outreach materials on the Internet at:

http://www.mde.state.md.us/programs/Land/mining/Pages/programs/landprograms/mining/index.aspx

Via this link MDE offers a variety of educational programs and support

- Classroom educational programs including lesson plans and educational tools like teacher resources, student research packets and handouts for student groups.
- Links to variety of Federal, State and private educational websites.
- Educational poster (for downloading)
- Link to an educational video produced by Frostburg State University, Maryland.
- Selected information of recent years' outreach activities.
- Descriptions MDE programs related to mining: Abandoned Mine Lands Section, Acid Mine Drainage Abatement Section, and Water Laboratory Section.

8. Implementation Schedule and Milestones (Criteria F/G)

Due to the broad scope of pH impairment mitigation distributed through the Casselman watershed, a phased implementation schedule with milestones and measurable goals is detailed in sections 8.1-8.3. Because of the uncertainty of securing the required funds from a variety of agencies in a short period of time, the schedule, milestones, and measurable goals are divided into five-year phases and no final end date is projected for implementing all of the reductions in this plan.

Many details are provided for Phase 1, which lasts from 2010 through 2015, because these mitigation efforts are more explicit. The schedule, milestones, and goals are designed to expand upon existing efforts within the watershed. Fewer details are provided for in Phase 2 and 3 because of the difficulty to predict the number, location and types of mitigation projects to be funded. These sections will be revisited in future iterations of this WRP.

8.1 Phase I (2010-2015)

Phase I seeks to address those impaired streams with headwaters and acid sources identified on public lands, or right of way, for rapid implementation. During this period, suitable private landowner stakeholders will be identified as potential partners in phase II project implementation on private properties with acid sources.

8.1.1 Secure Implementation Funding

- *Secure funds for reclamation projects***.** Each year of project implementation, MDE AMLD will secure funds to pay capital costs from the 319 program and alternative sources.
- *Secure funds for operations and maintenance***.** AMLD will also ensure that sufficient operations and maintenance funds are spent from a set-aside fund or other potential sources to keep all projects in the watershed functioning properly.

8.1.2 Coordinate Project Design and Materials

<u>August 2010 – March 2011</u>

- *Begin Pre-Implementation Monitoring.* The AMLD has coordinated with the MDE 319 monitoring group to begin pre-implementation monitoring of water quality in accordance with the proposed monitoring strategy. Additional samples may be taken in Spring 2011.
- *Develop specs and site design***.** The MD AMLD will plan and implement projects in the selected phase I project sites to improve existing water quality in the watershed. Preliminary designs for each mitigation measure were developed based upon measured acid and alkalinity loads (tons per year) derived from water quality samples analytical results and leaching experiments. Engineering designs for the leach beds in phase I have been completed and included in **Appendix B.**
- *Permits.* Identify and acquire all the necessary permits to place the proposed measures in non-tidal freshwater streams.
- *Select Contractor/s.* Bid out scope to make sure that the contractors necessary to build leach beds and perform sand dumps are in place.
- *Determine Limestone Source***.** A list of suitable quarries with high quality limestone will be developed. The $CaCO_3$ content of the limestone will be calculated to help determine overall effectiveness of the projects.
- *Develop operations and maintenance plans***.** Once the plan is completed, the AMLD will develop operations and maintenance plans for completed phase I projects, the O&M plan will be an adaptive management plan with regards to the frequency of sand dumps and addition of extra Limestone to leach beds.

<u>5-year goals</u>

- *Reassess the big picture***.** At the end of each year, AMLD and partners will reassess the strategic priorities for AMD and atmospheric deposition mitigation in the watershed. This assessment will be used to track improvements over time and to help plan additional mitigation projects in other sections of the watershed as well as determining operations and maintenance priorities for Phase I and II management measures.
- *Phase II preliminary analysis.* Site selection and initial design of phase II projects will take place in order to prepare for the next 5 year implementation goal. Identify all potential stakeholders for site selection and begin outreach with private land owners for participation in the process.

8.1.3 Install management measures

April 2011 – September 2011

- *Build new projects***.** As funds are secured, new projects will be built. In the short term, the sites selected will be based on available funding, priority assigned by CVI and TMDL impairments.

5-year goals

- *Operate and maintain existing sites.* Look into the potential of using set-aside funds for operations and maintenance of newly installed projects where applicable.
- *Begin monitoring project effectiveness.* Once baseline standards are taken, allow time for the project to begin working and sample at regular intervals to reflect the changes in Low and High flow impairments in accordance with the proposed monitoring strategy.

8.1.4 Measurable goals for Phase I

By the end of Phase I in December 2015, the following measurable goals will be achieved:

- *Project implementation.* pH mitigation projects will have been installed on all impaired streams in Phase I project areas of the Casselman watershed plan. These projects will function well enough that water discharged from these sites meet COMAR based effluent limitations for pH (6.5).
- *Water Quality Monitoring.* Instream water chemistry measurements will show that these tributaries of the Casselman are meeting water quality standards for pH. Measurements in the Casselman mainstem below these projects will also show that it is meeting standards. (6.5 – 8.5)
- *Biological Monitoring.* Biological communities at the end of the five year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.
- *Document Results.* Biological communities at the end of the five year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.
- *Outreach for Phase II.* MD AMLD will have created an inventory of implementation projects with private land owner permissions, preliminary monitoring plan created, preliminary pH mitigations calculations and designs in place. The Casselman Watershed Restoration Plan will need to be evaluated at this time to determine if modifications are warranted in order to continue with the next implementation phase.

8.2 Phase II (2015-2020)

8.2.1 Secure additional funding

- *Secure funds for reclamation projects*. Funding sources will depend on the successful implementation of phase I projects.
- *Investigate other funding sources*. NRCS Public Law 566, State Revolving Loan Fund and US Army Corp of Engineers funds will also be investigated.

8.2.2 Coordinate Project Design and Materials

August 2015 – March 2020

- *Select Mitigation Technologies.* Based on the results of phase I projects assessment, AMLD will decide whether or not to continue with the technologies evaluated in phase I or to use different technologies to address acidity in the phase II operating area.
- *Develop specs and site design*. Secure the personnel and resources needed to accomplish this task.
- *Select Contractor/s.* Bid out scope to make sure that the contractors necessary to build leach beds, sand dumps and slag beds are in place.

5-year goals

- *Modify watershed, operations and maintenance plans*. Make adjustments to the operations and maintenance plan to include needs of phase II projects.
- *Reassess the big picture*. At the end of each year, AMLD and partners will reassess the strategic priorities the phase II operating area. This assessment will be used to track progress over time and to help evaluate the potential for additional mitigation, operations and maintenance priorities for Phase I and II management measures.

8.2.3 Install management measures

- *Install projects*. Secure landowner permissions, permits and establish agreements to operate and maintain mitigation projects.
- *Operate and maintain existing sites.* Continue phase I O&M as well as incorporating the needs of projects in the phase II operating area.
- *Begin monitoring project effectiveness.* Continue to assess phase I and phase II implementation in accordance with the proposed monitoring strategy.

8.2.4 Measurable goals for Phase II

By the end of Phase II in December 2020, the following measurable goals will be achieved:

- pH mitigation projects will have been installed on all impaired streams of the Casselman watershed plan. These projects will function well enough that water discharged from these sites meet technology-based effluent limitations for pH. (6.5)
- *Water Quality Monitoring.* Instream water chemistry measurements will show that all treated tributaries of the Casselman are meeting water quality standards for pH. Measurements in the Casselman mainstem below these projects will also show that it is meeting standards. (6.5 – 8.5)
- *Biological Monitoring.* Biological communities at the end of the five year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.
- *Document Results.* Biological communities at the end of the five year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.

Based upon the results of phase I and phase II, phase III has been developed according with two possible scenarios; phase IIIa assumes that the mitigation measures installed earlier fail to adequately address the acid load in the watershed and phase IIIb assumes that measures are address all or most of the acid load in the watershed and requires no additional mitigation projects.

8.3 Phase IIIa (2020-2025)

This phase was designed as a contingency plan in the event that passive mitigation technologies fail to adequately address the acid load in the Casselman watershed.

8.3.1 Secure additional funding

- *Secure funds for reclamation projects*. Capital costs and long-term O&M funds need to be determined according to whatever grants or alternative funding sources are developed in the future.
- *Secure funds for operations and maintenance*.

8.3.2 Coordinate Project Design and Materials

- *Develop specs and site design*. Select appropriate active dosing equipment, or comparable future technology, to address the size of waters not being adequately mitigated.
- *Determine Limestone Source*.
- *Modify operations and maintenance plans*. Modify plan to accommodate active dosing equipment.
- *Reassess the big picture*. Set new end goals for acid load mitigation and Biological recolonization within previously impaired waters.
- *Select Contractor/s.* Bid out scope to make sure that the contractors necessary to construct doser pads, supply electricity and install equipment.

8.3.3 Install management measures

- *Build new projects*. As funds are secured, new projects will be built. In the short term, the sites selected will be based on available funding and priority assigned by CVI.
- *Operate and maintain existing sites.* Look into the potential of using set-aside funds for operations and maintenance of newly installed projects where applicable.
- *Begin monitoring project effectiveness.* Once baseline standards are taken, allow time for the project to begin working and sample at regular intervals to reflect the changes in Low and High flow impairments.

8.3.4 Measurable goals for Phase IIIa

By the end of Phase III in December 2025, the following measurable goals will be achieved:

- pH mitigation projects will have been installed on all impaired streams in Phase I of the Casselman watershed plan. These projects will function well enough that water discharged from these sites meet technology-based effluent limitations for pH. (6.5)
- *Water Quality Monitoring.* Instream water chemistry measurements will show that all treated tributaries of the Casselman are meeting water quality standards for pH. Measurements in the Casselman mainstem below these projects will also show that it is meeting standards. (6.5-8.5)
- *Biological Monitoring.* Biological communities at the end of the five year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.
- *Document Results.* Biological communities at the end of the five year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.

8.4 Phase IIIb (2020-2025)

8.3.1 Secure additional funding

- *Secure funds for reclamation projects*. Capital costs and long-term O&M funds need to be determined according to whatever grants or alternative funding sources are developed in the future.
- *Secure funds for operations and maintenance*.

8.3.2 Continue Operations and Maintenance

- *Continue sand dumps and replacement of limestone in leach beds*. Follow O&M plan for placement of continued sand dumps to address atmospheric deposition and replacing limestone in leach beds as needed.
- *Select Contractor/s.* Bid out scope to make sure that the contractors necessary to maintain leach beds and sand dumps.

8.3.4 Measurable goals for Phase IIIb

By the end of Phase III in December 2025, the following measurable goals will continue to be achieved:

- pH mitigation projects will have been installed on all impaired streams in Phase I of the Casselman watershed plan. These projects will function well enough that water discharged from these sites meet technology-based effluent limitations for pH.
- *Water Quality Monitoring.* Instream water chemistry measurements will show that all treated tributaries of the Casselman are meeting water quality standards for pH. Measurements in the Casselman mainstem below these projects will also show that it is meeting standards.
- *Biological Monitoring.* Biological communities at the end of the five year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.
- *Document Results.* Biological communities at the end of the five year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.

9. Load Reduction Evaluation (Criterion H)

Overall, success of this watershed plan will be determined by the extent that the Maryland water quality standards for pH are met in previously impaired stream segments of the Casselman River watershed identified in the Western Maryland pH TMDL. In addition, there are other important measures of success to be considered by meeting pH standards across the watershed in supporting more healthy populations of benthic macroinvertebrates and fish. This section presents quantitative and qualitative criteria for gauging progress and success. This section also presents approaches to adaptive management based on both criteria. Results of adaptive management, such as watershed plan updates and addenda, will be made available to the public. When a watershed plan addendum is available for public consideration, an opportunity for a public meeting will be offered (see Section E).

9.1 Stream Segment Criterion for pH

In each stream segment receiving BMP implementation consistent with this watershed plan, the Stream Segment Criterion for pH is to meet the Maryland water quality standard for pH, which is to maintain pH within the 6.5 - 8.5 range. To document that this criterion is met, stream segment monitoring as described in Section I Monitoring will be conducted periodically to measure success in each stream segment following installation of a BMP or group of BMPs.

Interim water quality indicator milestones for Casselman River watershed stream segments:

- 50% meet the pH standard by 2015 (end of Phase I);
- 75% meet the pH standard by 2020 (end of Phase II), and;
- 100% meet the pH standard by 2025 (end of Phase III).

Adaptive management threshold criteria for pH in stream segments that will trigger a watershed plan update or addendum include, but are not limited to:

- Participation of key land owners is a prerequisite for implementation along each stream segment. In order to maximize the rate of watershed plan implementation, the priority order of implementation among stream segments may be changed so that stream segments with willing participation by land owners become the highest priority for implementation. Additionally, if land access permission is withdrawn priorities for implementation may be reconsidered.
- Each time a stream segment pH impairment is remedied, this information will be used to update Maryland's 303(d) list of impaired waters. When Maryland's list of impairments is changed as a result of watershed plan implementation, a watershed plan update will be issued that presents the listing change and implications for the watershed plan.
- If the pH standard is not met in a stream segment where BMPs have been implemented, the BMP(s) will be adjusted to the degree feasible to ensure that the pH standard within that stream segment is met. If appropriate, the watershed plan updates or addenda will present changes that reflect new information and understanding at the stream segment scale.
- If the BMP technology envisioned by this plan (limestone sand dump, etc.) is found to be inappropriate or ineffective at meeting pH standards in a stream segment, then appropriate alternative BMP technologies will be selected and a watershed plan addendum will be issued that presents reasons for the change and, the new direction for watershed plan implementation, and the associated costs.
- If the interim water quality indicator milestones of stream segments (above) are not attained by the target year, then the watershed plan will be modified by adding an addendum that presents reasons that a plan modification is needed and changes to the plan such as revised schedule and milestones.

9.2 Watershed Criteria for pH

For the Casselman River watershed in Maryland, the Watershed Criteria for pH includes two elements: 1) to meet the Maryland water quality standard for pH across the watershed so that the Casselman River Watershed does not appear on Maryland's 303(d) list of impaired waters, and 2) to meet the TMDL for pH for the Casselman River watershed. To meet these criteria, stream segment monitoring and watershed monitoring as described in Section I Monitoring will be conducted and collectively analyzed to measure progress toward meeting these criteria.

Adaptive management threshold criteria for pH for stream segments that will trigger update or modification to this water plan. Plan updates and addenda will be made available to the public. An opportunity for a public meeting will be offered at the end of each watershed plan Phase (see Section E):

- No later than the end of each watershed plan Phase, the findings from the monitoring analysis and other appropriate information will be used to review progress to meeting watershed plan goals and objectives. If this review, finds that watershed plan implementation is not on track to meet the watershed criteria for pH, either a watershed plan update or addendum that represents the findings and implications for the watershed plan will be made available.

9.3 Stream Segment Criterion for Biology

For each stream segment that is 1) receiving BMP implementation proscribed in this watershed plan, and 2) has a biological impairment that both appears on Maryland's 303(d) list of impaired watershed and the source assessment indicates that the impairment is caused by low pH, the Stream Segment Criteria for Biology is to attain a "fair" or "good" Index of Biotic Integrity for benthic macroinvertebrates and fish. After the stream segment meets pH standards, stream segment monitoring for biology as described in Section I will be conducted to measure progress and to document success in meeting this criterion.

Adaptive management threshold criteria for biology for stream segments that will trigger update or modification to this water plan:

- Each time a stream segment biological impairment is remedied, this information will be used to update Maryland's 303(d) list of impaired waters. When Maryland's list of impairments is changed as a result of watershed plan implementation, a watershed plan update will be issued that presents the listing change and implications for the watershed plan.
- If stream biological health does not improve within several years of successful pH mitigation monitoring, additional analysis should be conducted to ascertain if other impairments appear to be limiting improvement. After the analysis is completed, a watershed plan update or an addendum will be made available that presents the findings of the analysis and any changes to the watershed plan that are appropriate as a result.

10. Monitoring (Criterion I)

Baseline historic conditions of water quality in the Casselman River watershed have been thoroughly documented during the 2004 AMD study and the 2005 TMDL study. In order to measure project success, it will require a comprehensive stream monitoring strategy to determine pH levels are being met according to individual designated use of each stream and over the entire Casselman River watershed. MDE Science Services Administration Field Evaluation Division (FED) will be tasked with collecting water quality data prior to and after implementation of acid mitigation projects. In accordance with the proposed implementation schedule, the detailed monitoring schedule will be conducted in a phased approach with emphasis on evaluation of project effectiveness. Biological Integrity will be used in a qualitative manner to determine the effect of the pH reduction on sensitive benthic species in impaired streams, concurrent brook trout inventories are being conducted by DNRF.

10.1 Phase I Monitoring Plan

10.1.1 Water Quality Monitoring

Water quality samples will be collected monthly from 17 stations (**Figure 27**) once a month during July through November 2010 and April through June 2011. Analyses will include Acid Neutralization Capacity (ANC), closed pH, conductivity, iron, manganese, aluminum, calcium, magnesium and sulfate. The University of Maryland, Center for Environmental Science, Appalachian Laboratory will perform all specified analysis in accordance with standard protocols (USEPA 1987, 1999).

In-situ water quality parameters including pH, dissolved oxygen, conductivity, and water temperature will be measured using a handheld Hydrolab® water quality meter and. Stream flow measurements will also be taken at each sample site so that constituent loads can be calculated in the future.

10.1.2 - Benthic Assemblage Monitoring

MDE/SSA FED biologists are responsible for performing field biological sampling, as well as, the laboratory processing and taxonomic identification for all benthic organisms collected at each site. Two benthic sample stations will be established at each pH mitigation site to document biological response over time. Both sample stations will coincide with the water sampling sites as feasible. One benthic station will be established as close to the remediation site as possible, making sure that it is outside any negative influence from the treatment operation. A second site will be established further down stream, preferably below the confluence with the next downstream tributary, in order to document sustained biological effect. Samples will be extracted during the 2011 March/April Maryland Biological Stream Survey (MBSS) Spring Index period. Staff biologists will coordinate as appropriate with the Chemical and Biological Monitoring Division and share personnel and resources as necessary. MBSS techniques and protocols will be followed. The exact site locations for each mitigation site have yet to be determined.

10.1.2a - Field Sampling

All field sampling will be performed under guidance established by the MBSS. The Maryland Biological Stream Survey Sampling Manual, February 2000, will serve as the authority. MBSS methods include qualitative sampling of best available habitats incorporating approximately 20 square feet of substrate within each 75 meter designated station. All samples will be collected from riffle areas, as practical, because this is typically the most productive habitat in stream ecosystems. A 600-micron mesh D-net will be used to trap organisms dislodged from the sample area. The composited sample is condensed in the field with a standard 0.5-micron sieve bucket, placed in a sample jar with appropriate field label, and preserved with alcohol. Each sample is then sub-sampled to approximately 100 individual macroinvertebrates in the laboratory using a random-grid picking/sorting process. Most organisms are identified to genus, if possible, using stereoscopes. Chironomidae are slide-mounted and identified using compound microscopes. Habitat conditions will be assessed using standard MBSS methodology. In-situ water quality parameters will be recorded at each station with a multi-parameter field instrument.

10.1.2b - Laboratory Methods

All benthic macroinvertebrates will be processed and identified through guidance established in the MBSS protocol. The laboratory manual "Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy" Maryland Department of Natural Resources, November 2000, will serve as the basis for analysis of all field samples collected.

10.1.2c - Data Analysis and Report

Each station will be ranked qualitatively according to the protocols established for calculating the Benthic Index of Biological Integrity (BIBI) score (Stribling et al. 1998.), where "good" equals 4.0-5.0, "Fair" equals 3.0-3.9, "Poor" equals 2.0-2.9 and "Very Poor" equals 1.0-1.9. Each BIBI score will be compared against percentage of the best attainable in stream physical habitat in order to assess relationships between habitat and biology. The benthic IBI will be calculated using Non-Coastal Plain metrics. (Mercurio et al. 1999)

10.1.2d - Habit Assessment

Habitat conditions will be assessed using standard MBSS methodology targeting riffle/run prevalent streams. This methodology involves the field observations of eight parameters, including: instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, riffle/run quality, embeddedness, shading, and Trash Rating. Each category contains a maximum value of twenty and overall habitat will be rated as a percentage of the best possible score. There are four categories, Excellent 76-100, Good 51-75, Fair 26-50, and poor 0-25. (Stranko et at. 2010)

10.1.3 – BMP Calibration Monitoring

Sampling conducted throughout the duration of Phase I will be used to monitor and adjust sand dump frequencies as well as the flow of water through leach beds to achieve the TMDL endpoints.

10.2 Phase II Monitoring Plan

The second phase of monitoring will be a modified continuation of the Phase I plan to evaluate long-term effects and an adjustment to the number of sites selected for Phase II of implementation. The monitoring plan will need to be revised and adjusted according to any trends observed from the Phase I mitigation projects yet maintain the integrity of the data collected during Phase I and Phase II.

This phase of the monitoring plan should start to be revised in the fourth year of Phase I to create a seamless transition between the two phases and include baseline monitoring in new project areas, as well as continued monitoring of Phase I project areas. Frequency and number of sites depend upon the success of projects implemented.

10.3 Phase III Monitoring Plan

The third phase of monitoring will include a modified continuation of the Phase II plan to evaluate long-term effects and an adjustment to the types of monitoring and number of sites selected for Phase III observance or implementation. The monitoring plan will need to be revised and adjusted according to any trends observed from the Phase I and Phase II mitigation projects. Revision of the monitoring plan for this phase is entirely dependent upon results from the previous phases of implementation and monitoring, but will need to provide consistency with efforts made during those periods.

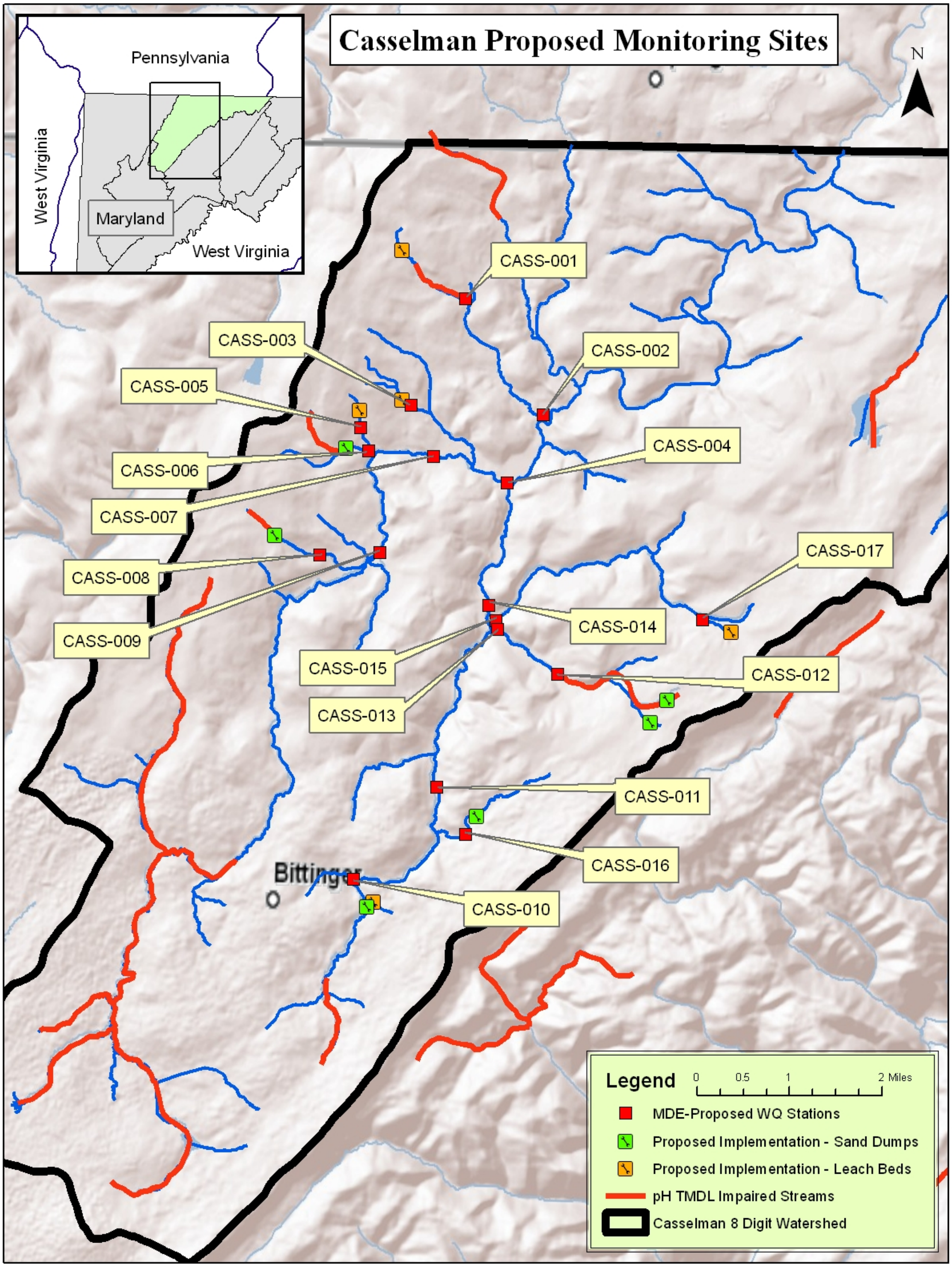

Figure 28. Phase I Monitoring Locations

10.4 NPDES Permit Monitoring Plan

A new Nation Pollutant Discharge Elimination System discharge permit (NPDES 2010) was issued in 2010 for a new deep coal mine that will discharge into the North Branch Casselmen at a point north of Durst Rd (**Figure 6**). The permit focuses on two separate sources of wastewater; underground coal mine drainage and storm water runoff. Each source has different monitoring and constituents regulated by the permit. A summary table detailing the required monitoring for effluent is listed below (**Table 16**) and includes those parameters for which a permit limitation exists (i.e. Daily maximum concentration or flow).

Table 17. NPDES permit effluent limitations

Discharge Source	Parameter	Loading		Concentration			Units	Sampling Freqency
		Monthly Avg	Daily Max	Minimum	Monthly Avg	Daily Max		
Mine Drainage	Flow	Report*	0.144				mgd	Continuous
	Total Suspended Solids				30	45	mg/L	2/week
	Total Iron				3.0	6.0	mg/L	2/week
	Total Manganese				2.0	4.0	mg/L	2/week
	Temperature Difference				0	Report	°F	1/hour
	Acute Toxicity					<1.0	TUa	1/quarter
	pH*			6.5		8.5		Continuous
Storm Water	Flow	Report	Report				gpd	1/month
	Total Suspended Solids				30	45	mg/L	1/month
	Total Iron				3.0	6.0	mg/L	1/month
	Total Manganese				2.0	4.0	mg/L	1/month
	Settleable Solids					0.5	ml/L	1/month
	Temperature Difference					0	°F	1/hour
	pH			6.5		8.5		1/week

*pH sampling must be collected by an automated sampling machine capable of stopping any discharge into the receiving water if concentrations below minimum or above maximum are detected.

Additional parameters not directly related to MD NPDES pollutants are to be collected for potential use in future decision making or when national or state standards are developed, or to confirm the levels that were previously reported or considered. These parameters included: total cadmium, total copper, total lead, total mercury, total nickel, total selenium, total silver, total zinc, dissolved cadmium, dissolved copper, dissolved lead, dissolved mercury, dissolved nickel, dissolved selenium, dissolved silver, dissolved zinc, total hardness, specific conductivity, total dissolved solids, sulfates, chlorides, bicarbonate, magnesium, calcium, potassium and sodium.

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(Appendices provided separately)