Total Maximum Daily Loads of Iron and Aluminum for the Upper North Branch Potomac River Watershed, Garrett County, Maryland

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Acronyms and Abbreviations

µg/L	micrograms per liter
Al	aluminum
AMD	acid mine drainage
AML	abandoned mine lands
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
BOM	Bureau of Mines
CAIR	Clean Air Interstate Rule
CFR	Code of Federal Regulations
cfs	cubic feet per second
CO_2	carbon dioxide
COMAR	Code of Maryland Regulations
COOP	Cooperative Observer Network
CWA	Clean Water Act
DMR	discharge monitoring report
EPA	U.S. Environmental Protection Agency
Fe	iron
$Fe(OH)_3$	ferric hydroxide
Fe^{+2}	ferrous iron
Fe^{+3}	ferric iron
FeS_2	iron sulfide
FA	future allocation
GIS	geographical information system
H^+	hydrogen ion
HSPF	Hydrologic Simulation Program FORTRAN
LA	load allocation
MDAS	Mining Data Analysis System
MDE	Maryland Department of the Environment
MDOT	Maryland Department of Transportation
mgd	million gallons per day
mg/L	milligrams per liter
MOS	margin of safety
NCDC	NOAA's National Climatic Data Center
NH_4^+	ionized ammonia
NLCD	National Land Cover Dataset
NOAA	National Oceanic and Atmospheric Administration
NO_3	nitrate
NPDES	National Pollutant Discharge Elimination System
NPS / PS	nonpoint sources / point sources
SMCRA	Surface Mining Control and Reclamation Act
SO_4	sulfate
STATSGO	State Soil Geographic Database
STORET	STOrage and RETrieval water quality database (EPA)
TMDL	Total Maximum Daily Load
UNBPR	Upper North Branch Potomac River
UNT	unnamed tributary
USGS	U.S. Geological Survey
WBAN	Weather Bureau Army-Navy
WLA	wasteload allocation
WQA	Water Quality Analysis

Executive Summary

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes Total Maximum Daily Loads (TMDLs) for iron and aluminum in the Upper North Branch Potomac River watershed (8-digit assessment unit MD-02141005). Section 303(d) of the Clean Water Act and the EPA's implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is required to either establish a TMDL of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate via a water quality analysis (WQA) that water quality standards are being met (CFR 2009; USEPA 1991).

The Maryland Department of the Environment (MDE) has identified the waters of the Upper North Branch Potomac River, located in Garrett County, as impaired by metals (1996 listing); metals – aluminum, iron, manganese (2008 listings); sediments (1996 listing); nutrients (1996 listing); low pH (1996 listing); and impacts to biological communities (2002/2004 listing). A WQA to address the 1996 metals listing was developed by MDE and approved by EPA in 2006. The WQA determined that a TMDL for metals in the entire Upper North Branch Potomac River 8-digit watershed was not necessary to achieve water quality standards, but, as explained below, impairments were identified in certain tributaries and a portion of the river's mainstem. This TMDL document addresses the listings for aluminum and iron in the specified areas of the watershed. A TMDL for sediment was approved by EPA in 2007. A TMDL to address the listing for low pH was approved by EPA in 2008. The listings for manganese and impacts to biological communities will be addressed separately at a future date.

Streams in the Upper North Branch Potomac River watershed were monitored in May 2004 and October 2005 for metals impairments. A total of 19 stations were sampled with two samples collected at each station. Analysis of the monitoring data showed that the aquatic life criteria for aluminum (Al), and iron (Fe) are being met in the Upper North Branch Potomac River watershed, except for the following tributaries where exceedances of Al and Fe criteria were found: Sand Run (12-digit assessment unit MD-021410050040), Laurel Run (MD-021410050039), and Three Forks Run (MD-021410050048). Exceedances of Fe were also found at four stations along the Upper North Branch Potomac River mainstem above Jennings Randolph Lake (MDE 2006b).

MDE concluded that the major sources of metal contamination in the study area are found in the tributaries and not in the watershed directly feeding the Upper North Branch Potomac River. On the basis of the analysis of the monitoring results and impairment listing methodologies applied by MDE, the tributaries in the Upper North Branch Potomac River with two exceedances—Laurel Run (Fe) and Three Forks Run (Fe and Al)—are not attaining the aquatic life uses and were listed under Category 5 of the *2008 Integrated Report of Surface Water Quality in Maryland* (Integrated Report) (MDE 2008) as impaired and requiring TMDLs. The tributaries with only one exceedance—Sand Run (Fe) and Laurel Run (Al)—had insufficient data to determine if aquatic life uses are attained. These tributaries and the North Branch Potomac River mainstem above Jennings Randolph Lake were listed under Category 3 (waterbodies having insufficient data or information to determine impairment status) of the Integrated Report. Additional data collected in 2008 for this study demonstrate that aquatic life criteria in the subwatersheds listed with insufficient data are not being met, with the exception of Sand Run, which is meeting water quality standards for iron. Therefore, TMDLs of iron and aluminum have been developed in this document for the Category 3 areas confirmed in this analysis as not attaining aquatic life uses, as well as for the listed Category 5 subwatersheds. Additionally, a WQA included in this report will be used to support a revision of the iron listing for Sand Run from Category 3 to Category 2 (waterbodies meeting some [in this case iron-related] water quality standards, but with insufficient data to assess all impairments) when MDE proposes the revision of the Integrated Report. Table ES-1 presents the Integrated Report listings and summarizes the project type.

Table ES-1. 2008 Integrated Report Metals Listings for waterbodies in the TMDL area

8-digit basin name	8-digit assess-ment unit	12-digit basin name and applicable assessment unit(s)	Substance	Current listing category	Listing year	New data demonstrates impairment	Project type
Upper North Branch Potomac River	MD-02141005	Laurel Run MD-021410050039	Al	3	2008	Yes	TMDL
			Fe	5		Yes	TMDL
		Three Forks Run MD-021410050048	Al	5	2008	Yes	TMDL
			Fe	5		Yes	TMDL
		Sand Run MD-021410050040	Fe	3	2008	No	WQA
		Mainstem upstream of Jennings Randolph Run MD-021410050042 MD-021410050044 MD-021410050047	Fe	3	2008	Yes	TMDL

The water quality goal of these TMDLs is to support the designated uses for the watershed. The Upper North Branch Potomac River mainstem is designated as Use I-P—*Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life, and Public Water Supply* (Code of Maryland Regulations [COMAR] 26.08.02.08R(1)(a)). All other tributaries of the Upper North Branch Potomac River are designated Use III-P, *Nontidal Cold Water and Public Water Supply* (COMAR 26.08.02.08 (R)(4)). Maryland does not specify numeric criteria for Fe or Al. For the purposes of this TMDL, the State has adopted EPA's aquatic life non-priority pollutant criteria for Fe and Al. In a Maryland WQA for metals in the Upper North Branch Potomac River, approved by EPA in 2006, West Virginia's chronic criteria for dissolved Al were applied. This was done because West Virginia assigned different numeric criteria to designated uses comparable to Maryland's Use I and III waters. The current West Virginia criterion for Al, as refined in 2007, is now consistent with the EPA criterion applied in this TMDL. Table ES-2 provides the numeric criteria for Fe and Al and the applicable designated uses.

Table ES-2. Applicable metals water quality criteria

Metal	Applicable criteria	Criteria value (µg/L)[a]
Fe[b,d]	Freshwater aquatic life—chronic	1,000
Al[c,d]		87

[a] µg/L = micrograms per liter
[b] Fe (total) chronic freshwater aquatic criterion for all waters (USEPA 2006)
[c] Al (dissolved) chronic freshwater aquatic criterion for all waters (USEPA 2006)
[d] Criteria based on 4-day average and not to be exceeded more than once every 3 years.

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody, and may include a future allocation (FA) component. The TMDL components are illustrated using the following equation: $\text{TMDL} = \Sigma\, WLAs + \Sigma\, LAs + MOS + FA$.

In TMDL development, allowable loadings from pollutant sources are determined, the sum of which amounts to a cumulative TMDL threshold, thus providing a quantitative basis for establishing water quality-based controls. To address metal impairments, metal species (Fe and Al) were reduced in the model simulation to meet the applicable water quality criteria.

For this TMDL, the Mining Data Analysis System (MDAS) was used to represent the source-response linkage for metals in the Maryland portion of the watershed. 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 MDAS model simulation covered a multiyear period that inherently accounts for seasonal variation—a required component of TMDLs. Continuous simulation represents both hydrologic and source loading variability seasonally. In addition, the model takes critical conditions into account through dynamic model simulation (i.e., using the model to predict conditions over a long period of time that represents wet, dry, and average flow periods).

The configuration of MDAS for the development of metals TMDLs in the Upper North Branch Potomac River watershed is a continuation of a previous pH TMDL study for the area. For the previous study, MDAS was set up to simulate the loading of constituents affecting pH in watershed streams, including Fe and Al.[1] Model development for these TMDLs used the pH model as a platform to which additional modifications were made to address the conditions of the metal impairments, including loadings from the West Virginia portion of the watershed, simulating water quality in the Upper North Branch Potomac River mainstem, and extending the modeling period.

The Upper North Branch Potomac River watershed receives flow and loadings from Maryland and West Virginia. Flow and loadings from the Maryland portions were generated by MDAS. Flow and loadings generated by the West Virginia portion were estimated using a combination of methods. Portions of the loadings from West Virginia were obtained through existing metals TMDLs developed using MDAS. The model simulation time series for these watersheds were included as boundary conditions to the Maryland MDAS model.

The total allowable TMDL loading was determined by reducing baseline loadings. WLAs were assigned to three permitted facilities that discharge to waters in the Upper North Branch Potomac River watershed. An explicit five percent MOS and ten percent FA was subtracted from the total TMDL. The LAs include background loadings and nonpoint sources such as acid mine drainage (AMD). Summaries of annual TMDLs of Fe and Al for the Upper North Branch Potomac River subwatersheds are presented in Tables ES-3 and ES-4. The loadings reported in these tables are the edge of stream loadings for the contributing watershed area. These tables also present the percent reduction of each parameter between the baseline and TMDL loadings. Daily maximum loads are presented in full in Section 5 (Tables 5-3 and 5-4) of this report. Maryland reserves the right to revise these allocations provided that the allocations are consistent with the achievement of water quality standards.

Section 303(d) of the CWA and EPA regulations require reasonable assurance that TMDLs will be implemented. TMDLs quantify the pollutant load that can be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Upper North Branch Potomac River 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 remediation of AMD and implementing the Clean Air Interstate Rule (CAIR) that will reduce acid deposition and therefore metals released into the environment.

[1] A copy of the pH TMDL document for the study area is located at http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/TMDL_Final_W_MD_pH.asp (Accessed May 2009.)

Table ES-3. Summary of Annual Fe TMDLs for Lower North Branch Potomac Watershed

Watershed	Allocation point	Load	Iron (lb/yr) Baseline	TMDL	% reduction
Laurel Run	Unnamed Tributary (UNT) to Laurel Run	NPS/LA	46,196	11,839	74.4
		PS/WLA	0	0	0.0
		MOS	--	696	--
		FA	--	1,393	--
		Total	46,196	13,929	69.8
	Direct contributions	NPS/LA	772,785	81,277	89.5
		PS/WLA	865	865	0.0
		MOS	--	4,832	--
		FA	--	9,664	--
		Total	773,650	96,637	87.5
	Entire watershed	**NPS/LA**	**818,980**	**93,116**	**88.6**
		PS/WLA	**865**	**865**	**0.0**
		MOS	**--**	**5,528**	**--**
		FA	**--**	**11,057**	**--**
		Total	**819,845**	**110,566**	**86.5**
Three Forks Run	Right Prong Three Forks Run	NPS/LA	33,154	2,818	91.5
		PS/WLA	0.46	0.46	0.0
		MOS	--	166	--
		FA	--	332	--
		Total	33,155	3,316	90.0
	Left Prong Three Forks Run	NPS/LA	37,625	21,747	42.2
		PS/WLA	0.00	0.00	0.0
		MOS	--	1,279	--
		FA	--	2,558	--
		Total	37,625	25,585	32.0
	Direct contributions	NPS/LA	339,464	57,816	83.0
		PS/WLA	0.23	0.23	0.0
		MOS	--	3,401	--
		FA	--	6,802	--
		Total	339,464	68,019	80.0
	Entire watershed	**NPS/LA**	**410,243**	**82,381**	**79.9**
		PS/WLA	**0.69**	**0.69**	**0.0**
		MOS	**--**	**4,846**	**--**
		FA	**--**	**9,692**	**--**
		Total	**410,243**	**96,919**	**76.4**

Watershed	Allocation point	Load	Iron (lb/yr)		
			Baseline	TMDL	% reduction
Upper North Branch Potomac River upstream of Jennings Randolph Lake	Direct contributions	NPS/LA	47,910	40,723	15.0
		PS/WLA	0	0	0.0
		MOS	--	2,395	--
		FA	--	4,791	--
		Total	47,910	47,910	0.0
	Tributary contributions	NPS/LA	1,658,731	537,446	67.6
		PS/WLA	21,752	21,752	0.0
		MOS	--	32,894	--
		FA	--	65,788	--
		Total	1,680,483	657,880	60.9
	Entire MD portion	**NPS/LA**	**1,706,641**	**578,169**	**66.1**
		PS/WLA	**21,752**	**21,752**	**0.0**
		MOS	**--**	**35,289**	**--**
		FA	**--**	**70,579**	**--**
		Total	**1,728,393**	**705,789**	**59.2**
	Upstream Load from WV		2,146,595[a]	1,830,771[b]	14.7
	Entire watershed		**3,874,989**	**2,536,561**	**34.5**

[a] This baseline load represents a conversion of delivered loads, as calculated in the West Virginia TMDL, into edge-of-stream loads that are comparable to those derived for Maryland in this TMDL. The West Virginia baseline load also includes contributions from West Virginia subwatersheds for which no TMDLs have been developed. (See Appendix C for details.)
[b] Upstream load allocation to West Virginia determined as necessary to meet water quality standards in the Maryland portion of the watershed.

Table ES-4. Summary of Annual Al TMDLs for Lower North Branch Potomac Watershed

Watershed	Allocation point	Load	Aluminum (lb/yr) Baseline	TMDL	% reduction
Laurel Run	Unnamed Tributary (UNT) to Laurel Run	NPS/LA	41,792	1,927	95.4
		PS/WLA	0	0	0.0
		MOS	--	113	--
		FA	--	227	--
		Total	41,792	2,267	94.6
	Direct contributions	NPS/LA	331,672	98,281	70.4
		PS/WLA	0	0	0.0
		MOS	--	5,781	--
		FA	--	11,563	--
		Total	331,672	115,625	65.1
	Entire watershed	**NPS/LA**	**373,464**	**100,209**	**73.2**
		PS/WLA	**0**	**0**	**0.0**
		MOS	**--**	**5,895**	**--**
		FA	**--**	**11,789**	**--**
		Total	**373,464**	**117,893**	**68.4**
Three Forks Run	Right Prong Three Forks Run	NPS/LA	26,903	3,280	87.8
		PS/WLA	0	0	0.0
		MOS	--	193	--
		FA	--	386	--
		Total	26,903	3,858	85.7
	Left Prong Three Forks Run	NPS/LA	12,315	1,576	87.2
		PS/WLA	0	0	0.0
		MOS	--	93	--
		FA	--	185	--
		Total	12,315	1,854	84.9
	Direct contributions	NPS/LA	259,329	22,443	91.3
		PS/WLA	0	0	0.0
		MOS	--	1,320	--
		FA	--	2,640	--
		Total	259,329	26,404	89.8
	Entire watershed	**NPS/LA**	**298,547**	**27,299**	**90.9**
		PS/WLA	**0**	**0**	**0.0**
		MOS	**--**	**1,606**	**--**
		FA	**--**	**3,212**	**--**
		Total	**298,547**	**32,116**	**89.2**

1 INTRODUCTION AND BACKGROUND

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes Total Maximum Daily Loads (TMDLs) for iron and aluminum in the Upper North Branch Potomac River watershed (8-digit assessment unit MD-02141005). Section 303(d) of the Clean Water Act and the EPA's implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is required to either establish a TMDL of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate via a water quality analysis (WQA) that water quality standards are being met. A TMDL must also account for seasonal variations and critical conditions, and provide a protective margin of safety (MOS) to account for uncertainty (CFR 2009; USEPA 1991).

The Maryland Department of the Environment (MDE) has identified the waters of the Upper North Branch Potomac River, located in Garrett County, as impaired by metals (1996 listing); metals – aluminum, iron, manganese (2008 listings); sediments (1996 listing); nutrients (1996 listing); low pH (1996 listing); and impacts to biological communities (2002/2004 listing). A WQA to address the 1996 metals listing was developed by MDE and approved by EPA in 2006. The WQA determined that a TMDL for metals in the entire Upper North Branch Potomac River 8-digit watershed was not necessary to achieve water quality standards, but, as explained below, impairments were identified in certain tributaries and a portion of the river's mainstem. This TMDL document addresses the listings for aluminum and iron in the specified areas of the watershed. A TMDL for sediment was approved by EPA in 2007. A TMDL to address the listing for low pH was approved by EPA in 2008. The listings for manganese and impacts to biological communities will be addressed separately at a future date.

Streams in the Upper North Branch Potomac River watershed were monitored in May 2004 and October 2005 for metals impairments. A total of 19 stations were sampled with two samples collected at each station. Analysis of the monitoring data showed that the aquatic life criteria and designated uses for aluminum (Al), and iron (Fe) are being met in the Upper North Branch Potomac River watershed, except for the following tributaries where exceedances of aluminum (Al) and iron (Fe) criteria were found: Sand Run (12-digit assessment unit MD-021410050040), Laurel Run (MD-021410050039), and Three Forks Run (MD-021410050048). Exceedances of Fe were also found at four stations along the Upper North Branch Potomac River mainstem above Jennings Randolph Lake (MDE 2006b).

MDE concluded that the major sources of metal contamination in the study area are found in the tributaries and not in the watershed directly feeding the Upper North Branch Potomac River. On the basis of the analysis of the monitoring results and impairment listing methodologies applied by MDE, the tributaries in the Upper North Branch Potomac River with two exceedances—Laurel Run (Fe) and Three Forks Run (Fe and Al)—were listed under Category 5 of the *2008 Integrated Report of Surface Water Quality in Maryland* (Integrated Report) as impaired and requiring TMDLs. The tributaries with only one exceedance—Sand Run (Fe) and Laurel Run (Al)—had insufficient data to determine if an impairment exists. These tributaries and the North Branch Potomac River mainstem above Jennings Randolph Lake were listed under Category 3 (waterbodies having insufficient data or information to determine impairment status) of the Integrated Report (MDE 2008). Additional data collected in 2008 for this study demonstrate that aquatic life criteria in the subwatersheds listed with insufficient data are not being met, with the exception of Sand Run, which is meeting water quality standards for iron. Table 1-1 and Figure 1-1 present the Integrated Report listings and impaired stream segments, respectively.

Table 1-1. 2008 Integrated Report Metals Listings for waterbodies in the TMDL area

8-digit basin name	8-digit assess-ment unit	12-digit basin name and applicable assessment unit(s)	Substance	Current listing category	Listing year	New data demonstrates impairment
Upper North Branch Potomac River	MD-02141005	Laurel Run MD-021410050039	Al	3	2008	Yes
			Fe	5		Yes
		Three Forks Run MD-021410050048	Al	5	2008	Yes
			Fe	5		Yes
		Sand Run MD-021410050040	Fe	3	2008	No
		Mainstem upstream of Jennings Randolph Run MD-021410050042 MD-021410050044 MD-021410050047	Fe	3	2008	Yes

Metals known to cause toxicity in aquatic life and humans are generally defined as the metallic elements from periodic table groups IIA through VIA, including Fe and Al. At trace levels, many of these elements are necessary to support life. However, at elevated levels they become toxic, can build up in biological systems, and become harmful to aquatic life. Elevated levels of Al and Fe are proven to cause toxicity in aquatic life.

The Upper North Branch of the Potomac River flows along the southern edge of Maryland and drains portions of Maryland and West Virginia. Historically, the watershed was extensively mined. Over time, these mining operations have been discontinued, leaving behind areas of abandoned mine land (AML). Without remediation, the AMLs release acid mine drainage (AMD) to the watershed causing elevated levels of metals and acidity in streams. This TMDL report addresses the aluminum and iron impairments in the Upper North Branch Potomac River watershed.

1.1 Watershed Description

The model area includes the mainstem of the Upper North Branch Potomac River and its tributaries downstream to the Savage River confluence. This area represents the upstream reaches of the North Branch and the contributing drainage area includes portions of Garrett County in Maryland and Preston, Tucker, Grant, and Mineral Counties in West Virginia. Downstream of the study area, the North Branch of the Potomac flows along the southern edge of Maryland until the river reaches the Chesapeake Bay. Figure 1-1 shows the location of the watershed. For the purposes of these TMDLs, this portion of the river is considered entirely in Maryland.

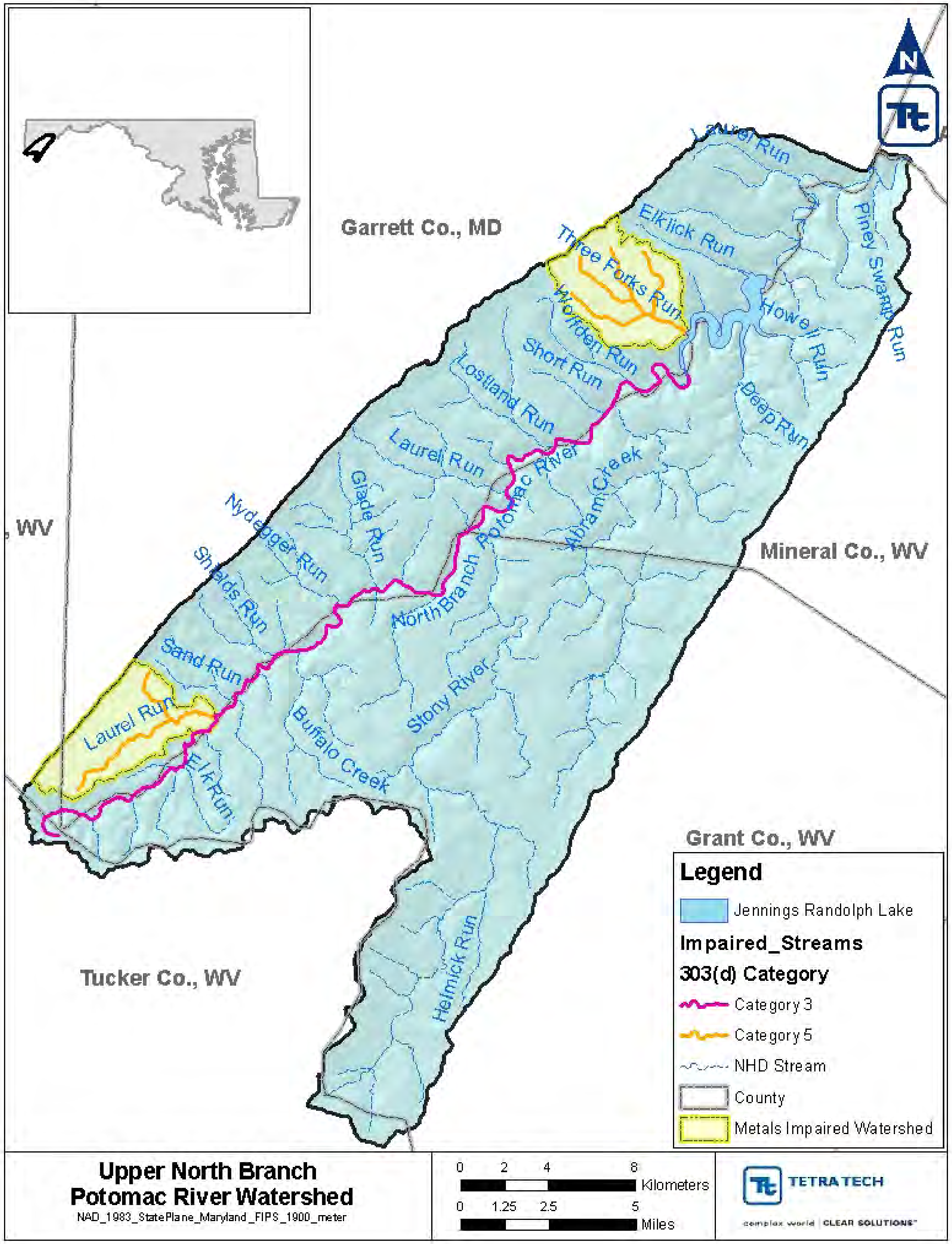

Figure 1-1. Location of the UNBPR watershed and impaired stream segments

1.2 History of Mining in Western Maryland

Coal mining has occurred in western Maryland since the early 1700s. Coal was discovered in the North Branch Potomac River watershed in 1736, with commercial development beginning in 1738 in the Georges Creek coal field (Salstrom 1994). Deep mine production peaked in the early 1900s. Coal mining in Maryland peaked at 5.5 million tons in 1907 but usually averaged 4 to 5 million tons annually (USDOI 2006). Deep mines in the area produced AMD when water was pumped from the mines and discharged to the streams. AMD was also an issue after the closure of deep mines because they filled with water. Underground mining declined in Maryland after 1945, with 91 percent of the mines being surface mines in 1977 (USDOI 2006). In the 1980s, production fluctuated between 3 and 4.5 million tons annually (USDOI 2006). In the western Maryland watersheds, mining is now confined to the southeast and northwest portions of the panhandle including the Upper North Branch Potomac River watershed.

Beginning in the 1960s, several studies showed the effects that coal mining and the resulting AMD had on the North Branch Potomac River watershed. These publications and reports document the biological status of the watershed up to 1990. Studies documented the severe effect AMD has had on the water quality by causing chronically low pH (Clark 1969; Lauby 1966–1968; Mason et al. 1976; Skelly and Loy, Inc. 1976). Other studies documented the effects AMD has had on fish and benthic communities in the North Branch Potomac River watershed. Davis (1973) sampled several stations with no fish as well as no measurable alkalinity, low pH, and high Fe; acidity; sulfates; and conductivity. Staubitz (1981) and Staubitz and Sobashinski (1983) sampled the North Branch watershed's streamflow, water quality, and biological data. All stations affected by AMD had very poor benthic populations, and many stations in the watershed had low pH as a result of AMD. Hendricks et al. (1984), Lebo (1983), and the Morgan Mining and Environmental Consultants report (1994) all found few to no fish at many of their sampling stations and poor benthic macroinvertebrate populations. At the stations that did have fish or benthic populations, the diversity of species was low.

2 WATER QUALITY DESCRIPTION

2.1 Water Quality Problem Statement

MDE has identified AMD as the primary cause of metals loading impairments in the Upper North Branch Potomac River watershed. AMD typically produces low pH and high metals concentrations in surface and subsurface water in areas where mining activities are or once were present. AMD occurs when surface and subsurface water percolates through coal-bearing minerals containing large amounts of pyrite and marcasite, which are crystalline forms of iron sulfide (FeS_2). Common chemical reactions involving pyrite generate acidity and metals concentrations in water. A synopsis of these reactions is as follows (Stumm and Morgan 1996):

- Exposure of pyrite to air and water causes the oxidation of pyrite.
- The sulfur component of pyrite is oxidized, releasing dissolved ferrous iron (Fe^{+2}) and hydrogen (H^+) ions. These hydrogen ions cause the acidity.
- The intermediate reaction with the dissolved Fe^{+2} ions generates a precipitate, ferric hydroxide [$Fe(OH)_3$], and releases hydrogen ions, thereby causing more acidity.
- A third reaction occurs between the pyrite and the generated ferric iron (Fe^{+3}) ions contained in the $Fe(OH)_3$ precipitate, where more hydrogen ions (increasing acidity) are released as well as Fe^{+2} ions, which enter the reaction cycle.

Acid rain is produced when atmospheric moisture reacts with gases to form sulfuric acid and nitric acids. These gases are primarily formed from nitrogen dioxides and sulfur dioxide, which enter the atmosphere through exhaust and smoke from burning fossil fuels such as gas, oil, and coal. Acid rain crosses political and watershed boundaries and can originate out of state.

Low pH in a waterbody leads to acidic conditions. A pH of less than 5 is considered to be harmful to most stream biota (USEPA 1999).

Metals concentrations in streams (e.g., aluminum) can also become toxic to fish when stream water and runoff entering the stream is acidic (USEPA 1999). Metal impaired segments in the Upper North Branch Potomac River include listings for Al and Fe. Elevated concentrations of dissolved Al are often observed in acidified waters. This is a result of the increased solubility of aluminum hydroxides and aluminosilicates as water pH decreases (Drever 1988).

2.2 Water Quality Standards

Applicable Maryland water quality standards consist of two components: (1) designated uses, and (2) narrative or numeric water quality criteria necessary to support such uses. Furthermore, water quality standards serve the purpose of protecting public health, enhancing the quality of water, and protecting aquatic resources.

The Upper North Branch Potomac River mainstem is designated as Use I-P, *Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life, and Public Water Supply* (Code of Maryland Regulations [COMAR] 26.08.02.08R(1)(a)). All tributaries to the mainstem are designated as Use III-P, Nontidal Cold Water and Public Water Supply (COMAR 26.08.02.08 (R)(4)). Maryland does not specify numeric criteria for Fe or Al. For the purposes of this TMDL, the State has adopted EPA's aquatic life non-priority pollutant criteria for Fe and Al. In a Maryland WQA for metals in the Upper North Branch Potomac River, approved by EPA in 2006, West Virginia's chronic criteria for dissolved Al were applied.

This was done because West Virginia assigned different numeric criteria to designated uses comparable to Maryland's Use I and III waters. The current West Virginia criterion for Al, as refined in 2007, is now consistent with the EPA criterion applied in this TMDL. The listings addressed in this TMDL were established on the basis of the WQA's findings (see Section 2.3 below). The applicable water quality criteria are presented in Table 2-1.

Table 2-1. Applicable metals water quality criteria

Metal	Applicable criteria	Criteria value (µg/L)[a]
Fe[b,d]	Freshwater aquatic life—chronic	1,000
Al[c,d]		87

[a] µg/L = micrograms per liter
[b] Fe (total) chronic freshwater aquatic criterion for all waters (USEPA 2006)
[c] Al (dissolved) chronic freshwater aquatic criterion for all waters (USEPA 2006)
[d] Criteria based on 4-day average and not to be exceeded more than once every 3 years.

2.3 Water Quality Characterization and Impairment

A WQA to address the 1996 metals listing was developed by MDE and approved by EPA in 2006. The WQA determined that a TMDL for metals in the entire Upper North Branch Potomac River 8-digit watershed was not necessary to achieve water quality standards, but, as explained below, impairments were identified in certain tributaries and a portion of the river's mainstem.

Streams in the Upper North Branch Potomac River watershed were monitored in May 2004 and October 2005 for metals impairments. A total of 19 stations were sampled with two samples collected at each station. Analysis of the monitoring data showed that the aquatic life criteria for aluminum (Al) and iron (Fe) are being met in the Upper North Branch Potomac River watershed, except for the following tributaries where exceedances of Al and Fe criteria were found: Sand Run (12-digit basin 021410050040), Laurel Run (021410050039), and Three Forks Run (021410050048). Exceedances of Fe were also found at four stations along the Upper North Branch Potomac River mainstem above Jennings Randolph Lake (MDE 2006b).

MDE defines a waterbody as impaired by a chemical contaminant in the water column when greater than 10% of the samples, with a minimum of ten samples collected over a three-year period, exceed the applicable criteria (USEPA 1997). If there are less than 10 samples for a given area, MDE may interpret the data and determine if aquatic life uses are attained by considering a number of factors, including the magnitude of the criteria exceedance and number of criteria exceeded. In addition, current EPA guidelines suggest that a waterbody is not fully use-supporting when more than one exceedance of the acute or chronic water quality criterion occurs over a three-year period (USEPA 2002). On the basis of the analysis of the monitoring results and impairment listing methodologies applied by MDE, the tributaries in the Upper North Branch Potomac River with two exceedances—Laurel Run (Fe) and Three Forks Run (Fe and Al)—were listed under Category 5 of the Integrated Report as not attaining aquatic life uses and requiring TMDLs. Even though less than ten samples were collected, the percentage of sample exceedances would be greater than 10% if sufficient data were available. The tributaries with only one exceedance—Sand Run (Fe) and Laurel Run (Al)—had insufficient data to determine if aquatic life uses are attained. These tributaries and the North Branch Potomac River mainstem above Jennings Randolph Lake were listed under Category 3 (waterbodies having insufficient data or information to determine impairment status) of the Integrated Report (MDE 2008).

Additional data collected in 2008 for the Category 3 listings in Laurel Run (Al) and mainstem of the Upper North Branch Potomac River (Fe) establish that 7 of 14 (50%) and 8 of 32 (25%) samples, respectively, exceed the aquatic life chronic criteria, providing sufficient information to determine that these stream segments are not attaining aquatic life uses and therefore require TMDLs. For the Category 3 listing in Sand Run (Fe), only one of eight samples exceeds the aquatic life chronic criteria. Even though less than ten samples have been collected, the six most recent samples collected in 2008 did not exceed the criterion and the single exceedance from 2004 was not significantly greater than the criterion. Therefore, the analysis of the most recent data provided in this report, indicating that Sand Run is not impaired for Fe, will be used to support a revision of the iron listing for Sand Run from Category 3 to Category 2 (waterbodies meeting some [in this case iron-related] water quality standards, but with insufficient data to assess all impairments) when MDE proposes the revision of the Integrated Report. Table 2-2 summarizes the Fe and Al exceedance data for each waterbody listing. An evaluation of the water quality concentration data and criteria is found in Table A-5 of Appendix A.

Table 2-2. Summary of metal exceedances from the 2004/2005 and 2008 monitoring studies

Watershed	Year	Station	Fe (total) exceedances	Al (dissolved) exceedances
Laurel Run	2008	LNB0014	4/6	1/6
	2008	ULF0003	2/6	5/6
	2004/2005	UNB-4	2/2	1/2
		Total	**8/14 (57%)**	**7/14 (50%)**
Sand Run	2008	SAD0004	0/6	-
	2004/2005	UNB-6	1/2	-
		Total	**1/8**	**-**
Three Forks Run	2008	RTF0005	5/6	0/6
	2008	TFR0016	6/6	4/6
	2008	TFR0021	0/6	3/6
	2008	ZWT0000	1/6	1/6
	2004/2005	UNB-21	2/2	2/2
		Total	**14/27 (52%)**	**10/26 (39%)**
UNBPR	2008	POTOMAC-1 ALT	0/6	-
	2008	SITE 1	0/6	-
	2008	SITE 17	0/6	-
	2008	SITE 9	3/6	-
	2004/2005	UNB-9	2/2	-
	2004/2005	UNB-13	1/2	-
	2004/2005	UNB-17	1/2	-
	2004/2005	UNB-20	1/2	-
		Total	**8/32 (25%)**	**-**

3 DATA INVENTORY AND ANALYSIS

3.1 Data Inventory

Table 3-1 outlines key data sets compiled for this project. The data sets include geographical and political information, such as county boundaries and land uses, and in-stream monitoring data, such as water quality and flow. Descriptions of the data sets that were used in model development are provided in Sections 3.1.1 through 3.1.8.

Table 3-1. Data sets compiled for the UNBPR watershed

Data type	Information sources
Reservoir boundaries and stream network	BASINS[a], USGS[b] 7.5 minute Quads, MDE
Land use	MDE; USGS 2001 NLCD[c]
Soils	STATSGO[d]
Watershed boundaries	USGS Hydrologic Unit Boundaries (8-digit), MDE
Topographic relief and elevation data	USGS 7.5 minute Quads, Digital Elevation Models from BASINS
Surface geology	Maryland Geological Survey
Active and abandoned mine locations	MDE
Flow data and locations	USGS
Meteorological data and locations[e]	National Oceanic and Atmospheric Administration – National Climatic Data Center (NOAA–NCDC), Maryland Department of Transportation (MDOT), West Virginia Department of Transportation
Water quality data and locations	MDE, STORET[f]
NPDES[g] permitted facilities and locations	Permit Compliance System, MDE

Notes:
[a] BASINS (Better Assessment Science Integrating Point and Nonpoint Sources)
[b] U.S. Geological Survey
[c] NLCD (National Land Cover Dataset)
[d] STATSGO (State Soil Geographic database)
[e] Precipitation, dry-bulb [air] temperature, dew point temperature, wind speed, cloud cover.
[f] EPA's STOage and RETrival database
[g] NPDES (National Pollutant Discharge Elimination System) permit limits, design flow, DMR data

3.1.1 Hydrology and Topography

The U.S. Geological Survey (USGS) online database (NWISWeb) contains six stations that have daily flow data for the modeling period in the TMDL watersheds (USGS 2005). These stations are shown in Figure 3-1 and listed in Table 3-2.

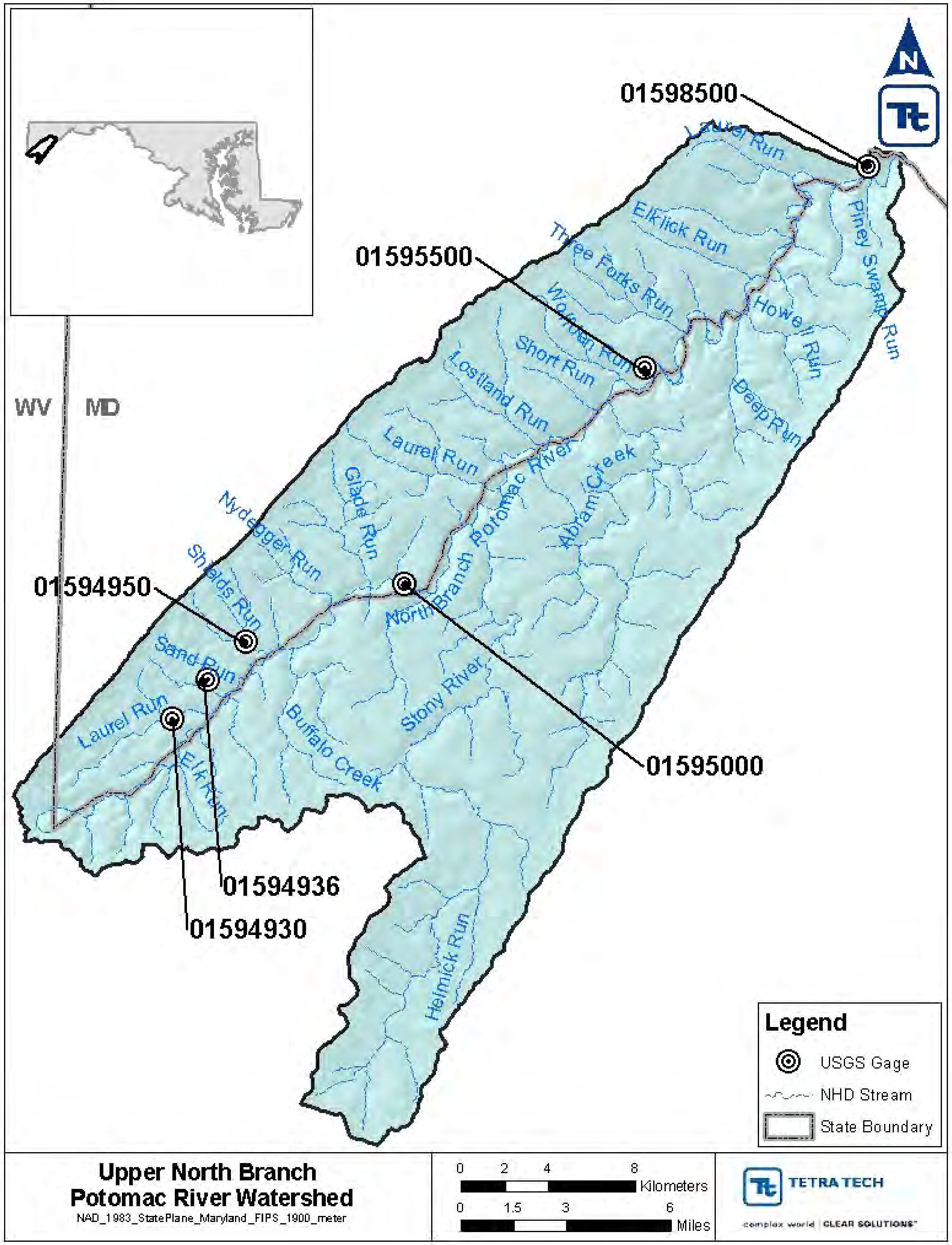

Figure 3-1. USGS gages in the UNBPR watershed

Table 3-2. Three USGS gaging stations with daily flow data

Station	Station name	Drainage area (square miles)	Start date	End date	Percent complete*
01594930	Laurel Run at Dobbin Road near Wilson, Maryland	8.23	5/1/1980	9/30/2004	100%
01594936	North Fork Sand Run near Wilson, Maryland	1.91	5/1/1980	9/30/2007	100%
01594950	McMillan F near Fort Pendleton, Maryland	2.3	5/1/1980	9/30/2008	100%
01595000	North Branch Potomac River at Steyer, Maryland	73.1	1/1/1990	5/1/2009	100%
01595500	North Branch Potomac River at Kitzmiller, Maryland	225	10/1/2003	5/1/2009	100%
01598500	North Branch Potomac River at Luke, Maryland	406	1/1/1990	5/1/2009	100%

*Note that the percent complete was calculated for the period of record used in the watershed model, not the entire period of record for each USGS gage.

Elevations in the Upper North Branch Potomac River watershed range from approximately 905 feet to over 4,000 feet, with an average elevation of 2,689 feet. Topographic information was obtained from Digital Elevation Models from EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) (USEPA 2004) and USGS topographic maps.

3.1.2 Climate

Weather data was available for the study area from two sources—the Maryland Department of Transportation (MDOT) and the National Oceanic and Atmospheric Administration (NOAA). MDOT collects daily weather data throughout the state as part of its Local Traveler Information Program. NOAA collects weather data from numerous regional climate stations. NOAA's National Climatic Data Center (NCDC) stores and distributes weather data gathered by the Cooperative Observer Network (COOP) throughout the United States and from Weather Bureau Army-Navy (WBAN) airways stations. The COOP stations record hourly or daily rainfall data, while the WBAN stations record hourly rainfall plus additional hourly data.

Identifying the best weather data for this modeling effort was based on several factors including geographic coverage, data record, and data completeness. Four stations were used for this TMDL study, based mainly on geographic location. Other nearby weather stations had more complete data sets, but they were not considered representative of the watershed because they were on opposite sides of the surrounding mountains and most likely had different rainfall patterns. Information on the selected hourly and daily MDOT, COOP, and WBAN stations is presented in Figure 3-2. Table 3-3 provides statistics regarding the period of record and the completeness of records expressed as percentages of reported data corresponding to the stations' period of record.

Data for dry bulb air temperature, wind speed, solar radiation, cloud cover, and dew point temperature data were required in addition to hourly precipitation and evapotranspiration. Precipitation, wind speed, temperature, dew point temperature and cloud cover data were taken directly from the NOAA WBAN station 13729, MDOT, and MD8065 weather gage. Solar radiation was calculated using the Hamon equation (Hamon 1961) using latitude (to determine the hours of sunshine) and cloud cover. Potential evapotranspiration was calculated using the Penman method (Penman 1948). The Penman equation uses air temperature, wind speed, solar radiation, and dew point temperature to compute pan evaporation. An additional conversion factor of 0.8 for winter and 1.0 for summer was applied to estimate potential evapotranspiration. This conversion factor is used to represent the influence of vegetative cover on the land surface.

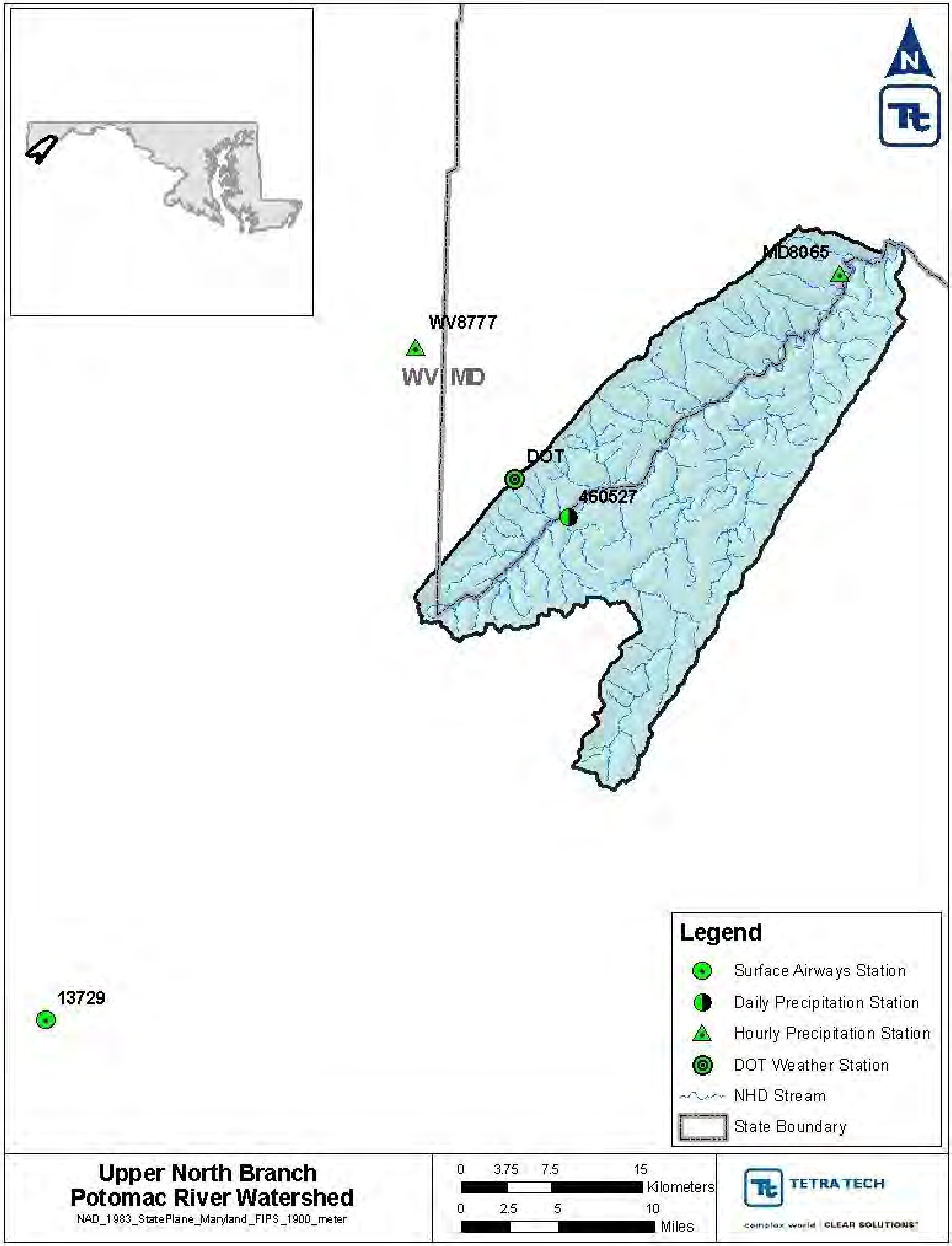

Figure 3-2. Climate stations used in the UNBPR watershed model

Table 3-3. Available meteorological data

Station ID	Station name	Start date	End date	Data type
MD8065	Savage River Dam	1/1/1990	3/1/2008	Precipitation
460527	Bayard	1/1/1990	12/31/2008	Precipitation
WV8777	Terra Alta No 1	1/1/1978	12/31/2008	Precipitation
MDOT	DOT at US 50	9/1/2003	12/31/2008	Precipitation, wind, Dew point temperature, temperature
13729	Elkins - Randolph Co Airport	7/1/1996	12/31/2008	Dew point temperature (Celsius)
		1/1/1980	12/31/2008	Dew point temperature (Fahrenheit)
		1/1/1980	12/31/2008	Relative humidity
		7/1/1996	12/31/2008	Dry-bulb temperature (Celsius)
		1/1/1980	12/31/2008	Dry-bulb temperature (Fahrenheit)
		1/1/1980	12/31/2008	Wet-bulb temperature (Fahrenheit)
		1/1/1980	12/31/2008	Cloud cover
		1/1/1980	12/31/2008	Windspeed and direction

3.1.3 Water Quality Data

Water quality data for the Upper North Branch Potomac River watershed were provided by MDE. MDE data sets include results from monitoring conducted in 2005 and 2008 and from the October 2004 to May 2005 special study (MDE 2006b) that prompted the initial metal impairment listings. Additional data for areas in West Virginia were obtained from EPA's STORET database (USEPA 2005a). Table 3-4 presents the available water quality data sets and the availability of the corresponding location data, flow data, data range, and parameters. Figure 3-3 shows the locations of the water quality stations. The data sets contain many parameters including total and dissolved Al and Fe. Water quality data are summarized in Appendix A.

Table 3-4. Water quality monitoring data sets

Source file	No. of stations	Percent of stations with flow	Period of record	Parameters
WV UNB STORET	110	18	8/5/1997–11/29/2006	Diss. Al, Fe, Zn; Total Al, Cu, Fe, Mn, Zn; Hardness
MDE UNBPR Metals 2004–2005	19	0	October 2004 May 2005	Diss. Al, Cu, Cd, Pb, Zn, As, Ni, Cr, Se, Ag; Total Fe; Mn
MDE 2005	259	0	3/28/2005–4/21/2005 9/19/2005–11/3/2005	Diss. Fe; Total Fe, Al; Hardness
MDE 2008	16	0	4/3/2008–10/22/2008	Diss. Fe, Al, Mn; Total Fe, Al, Mn; Hardness

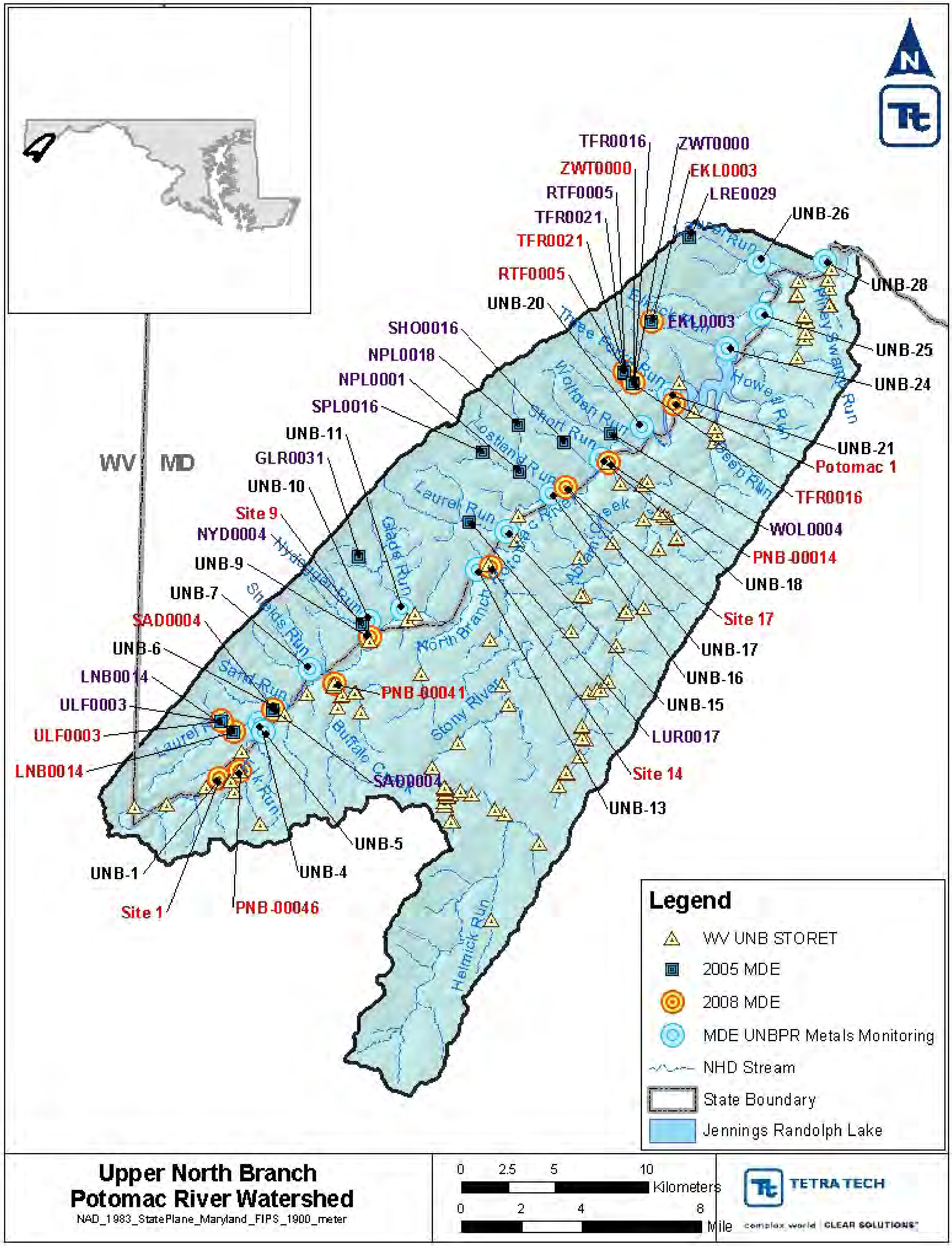

Figure 3-3. Water quality stations in the UNBPR watershed

3.1.4 Land Use Data

Land use data for Maryland were obtained from the Maryland Department of Planning. These data represent the most detailed locally developed land use data available and are suited for the development of the watershed model. The 2001 National Land Cover Dataset (NLCD) developed by the USGS were selected to represent the land use of the West Virginia portion of the watershed on the basis of considerations of land use classification simplicity. The more general land use classifications provided in the 2001 NLCD were determined to be the most appropriate for developing the index watershed approach. The selected land use data sets have similar, but not identical, land cover classification systems. Because the land use loadings from the West Virginia portion of the watershed will be developed separately from the Maryland portion, it was not necessary to reconcile the two.

For the purposes of watershed model development, the detailed MDE classifications were grouped into seven categories (Table 3-5). Tables 3-6 and 3-7 present the final land use classifications and the area of each land use in the watershed. The dominant land use in the watersheds is forest (78 percent) followed by agriculture (11 percent). Mining land use covers 5 percent of the study area, while urban land use accounts for less than 4 percent. Figure 3-4 presents the land use coverage for the watershed.

Table 3-5. Land use reclassifications from the Maryland Department of Planning data set

Detailed land use description	Land use group	Detailed land use description	Land use group
Agricultural breeding building	Agriculture	High-density residential	Urban
Agriculture	Agriculture	Industrial	Urban
Bare exposed rock	Barren	Institutional	Urban
Bare ground	Barren	Low-density residential	Urban
Barren land	Barren	Medium-density residential	Urban
Beaches	Barren	Mixed forest	Forest
Brush	Forest	Open urban land	Urban
Commercial—retail and wholesale services	Urban	Orchards/vineyards/ horticulture	Agriculture
Cropland	Agriculture	Pasture	Agriculture
Deciduous forest	Forest	Row and garden crops	Agriculture
Evergreen forest	Forest	Transportation	Urban
Extractive-surface mines/quarries/pits	Mining	Urban built-up	Urban
Feeding operations	Agriculture	Water	Water
Forest	Forest	Wetlands	Wetlands

Table 3-6. Land use areas used for the Maryland portion of the UNBPR watershed

Detailed land use description	Model land use group	Area (acres)	Area (square miles)	Percent land use
Cropland	Agriculture	5,385	8.41	8.01%
Pasture	Agriculture	4,819	7.53	7.16%
	Agriculture subtotal	**10,204**	**15.94**	**15.17%**
Bare ground	Barren	352	0.55	0.52%
	Barren subtotal	**352**	**0.55**	**0.52%**
Brush	Forest	1,703	2.66	2.53%
Deciduous forest	Forest	42,974	67.15	63.89%
Evergreen forest	Forest	2,233	3.49	3.32%
Mixed forest	Forest	2,950	4.61	4.39%
	Forest subtotal	**49,860**	**77.91**	**74.13%**

Detailed land use description	Model land use group	Area (acres)	Area (square miles)	Percent land use
Extractive-surface mines/quarries/pits	Mining	4,232	6.61	6.29%
	Mining subtotal	**4,232**	**6.61**	**6.29%**
Commercial - retail and wholesale services	Urban	32	0.05	0.05%
High-density residential	Urban	16	0.03	0.02%
Industrial	Urban	28	0.04	0.04%
Institutional	Urban	32	0.05	0.05%
Low-density residential	Urban	1,768	2.76	2.63%
Medium-density residential	Urban	259	0.40	0.38%
	Urban subtotal	**2,136**	**3.34**	**3.18%**
Water	Water	425	0.66	0.63%
	Water subtotal	**425**	**0.66**	**0.63%**
Wetlands	Wetlands	53	0.08	0.08%
	Wetlands subtotal	**53**	**0.08**	**0.08%**
Total		**67,210**	**105**	**100%**

Table 3-7. Land use areas used for the West Virginia portion of the UNBPR watershed

Detailed land use description	Model land use group	Area (acres)	Area (square miles)	Percent land use
Cultivated crops	Agriculture	269	0.42	0.23%
Pasture/hay	Agriculture	9,642	15.07	8.09%
	Agriculture subtotal	**9,911**	**15.49**	**8.31**%
Barren land	Barren	4,926	7.70	4.13%
	Barren subtotal	**4,926**	**7.70**	**4.13**%
Deciduous forest	Forest	90,706	141.73	76.07%
Evergreen forest	Forest	3,958	6.18	3.32%
Mixed forest	Forest	1,762	2.75	1.48%
	Forest subtotal	**96,426**	**150.67**	**80.87%**
Developed, high intensity	Urban	20	0.03	0.02%
Developed, low intensity	Urban	220	0.34	0.18%
Developed, medium intensity	Urban	106	0.17	0.09%
Developed, open space	Urban	3,880	6.06	3.25%
	Urban subtotal	**4,227**	**6.60**	**3.54%**
Open water	Water	2,826	4.42	2.37%
	Water subtotal	**2,826**	**4.42**	**2.37%**
Emergent herbaceous wetlands	Wetlands	137	0.21	0.12%
Woody wetlands	Wetlands	781	1.22	0.65%
	Wetlands subtotal	**918**	**1.43**	**0.77%**
Total		**119,234**	**186**	**100%**

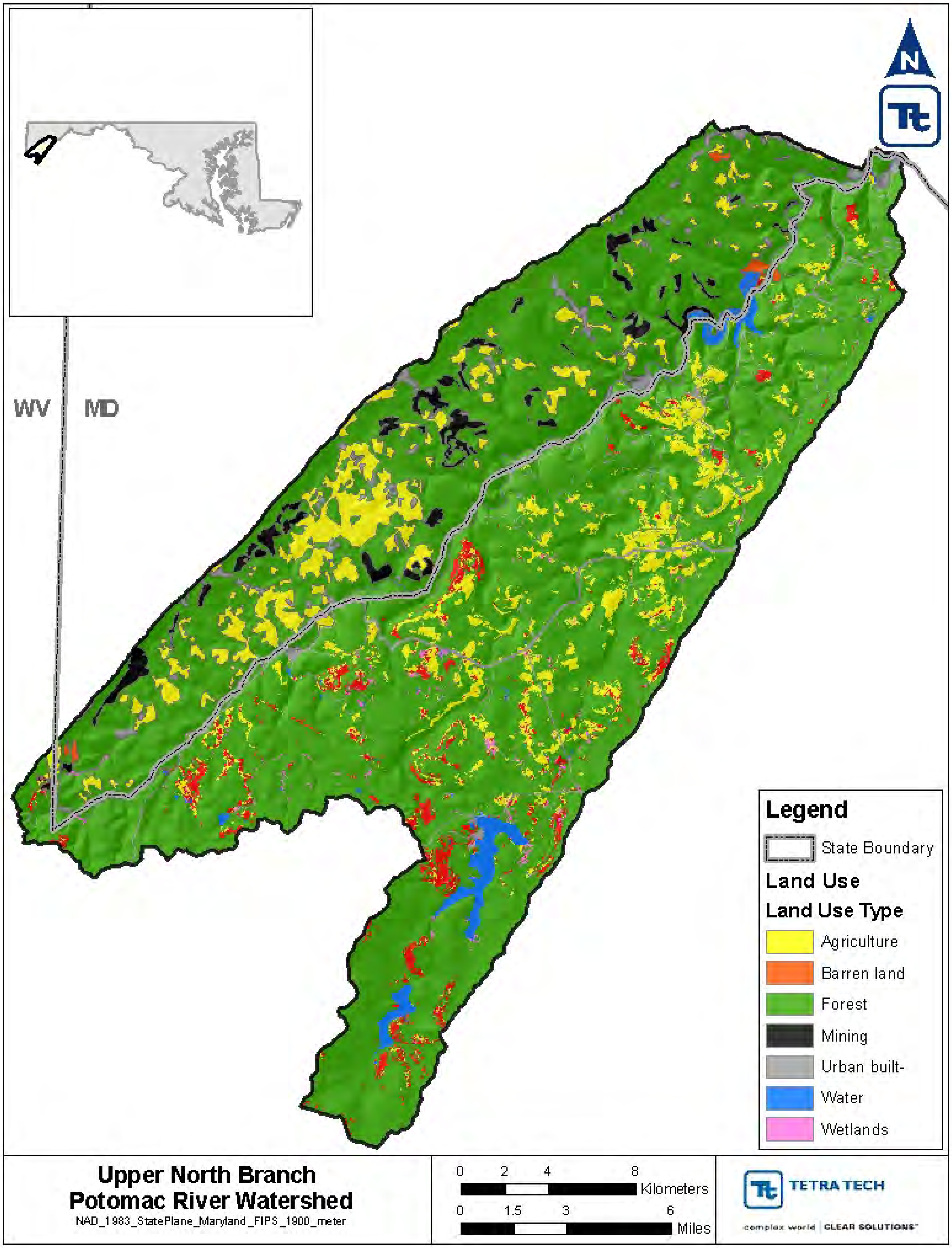

Figure 3-4. Land use in the UNBPR watershed

3.1.5 Soils and Geology

The Natural Resources Conservation Service 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. Data for the watershed were obtained from BASINS, which contains information from the State Soil Geographic database (STATSGO) and are presented in Figure 3-5. The majority of the Upper North Branch Potomac River watershed consists of B soils. There are small portions of C soils and even smaller portions of D soils in the watershed.

The TMDL watershed is in the Appalachian Plateaus Physiographic Province. The Appalachian Plateau is characterized by gently folded sedimentary rocks, such as sandstone, shale, and siltstone.

Surface geology of the area consists of the Mauch Chunk Formation, Monongahela Formation, Pottsville Formation, Allegheny Formation, and Conemaugh Formation. Four of these formations contain significant coal-bearing layers: the Monongahela Formation (Waynesburg and Pittsburgh coals), the Conemaugh Formation (Upper Freeport and Barton coals), and the Pottsville and Allegheny Formations (Upper Freeport and Brookville coals). Figure 3-6 presents the surface geology of the watershed.

3.1.6 Historical Mining Data

Historical mining activities are an important consideration when developing metals TMDLs. The study area contains numerous mining activities, but information on past activities is difficult to obtain because many operations did not keep thorough records. Many of these mines were in place before mining regulations came into place. The Maryland Bureau of Mines (BOM) provided information on mine drainage sources associated with non-permitted discharges (i.e., “pre-law” mines) such as seeps, portals, sediment ponds, and pits for the Maryland portion of the watershed (Figure 2-7). This information was plotted, and each location was assigned to its corresponding subwatershed in the model area. In all, 59 mine seeps were included as model inputs for the Maryland portions of the entire model area, including non-impaired reaches that flowed to impaired reaches. Few of the locations had concentration or flow data associated with them. In addition, Figure 3-7 shows areas of historical mining activities.

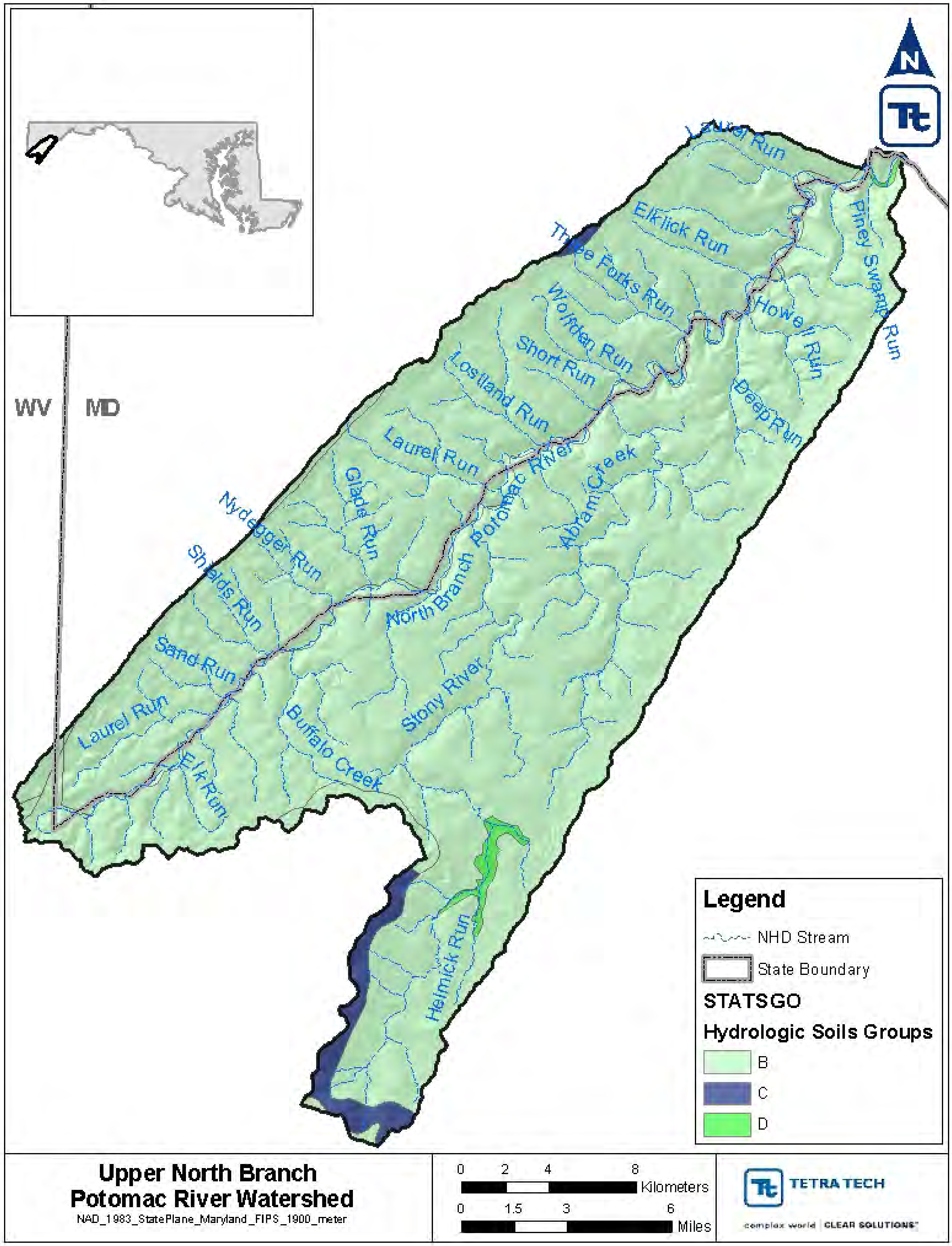

Figure 3-5. Hydrologic soil groups in the UNBPR watershed

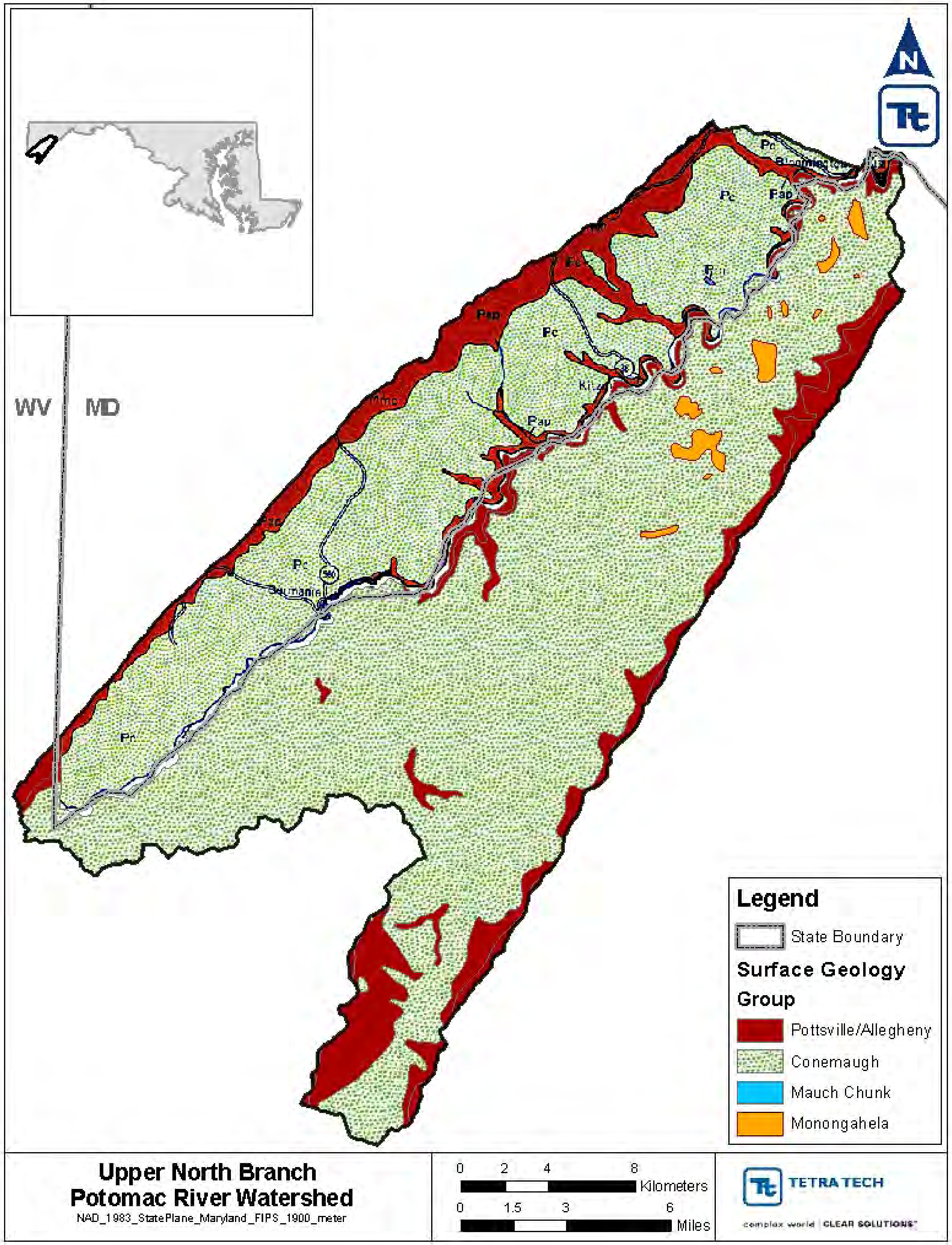

Figure 3-6. Surface geology in the UNBPR watershed

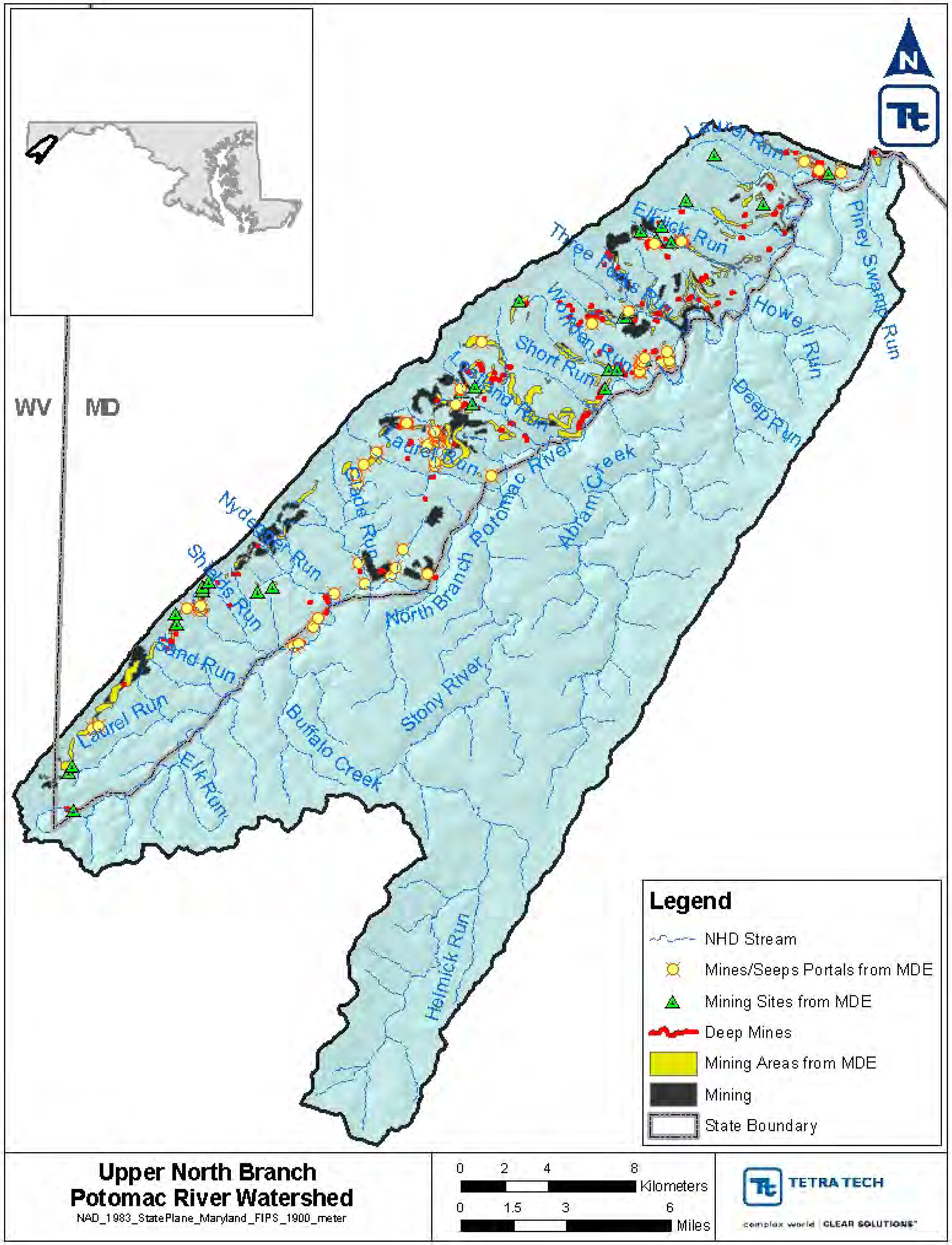

Figure 3-7. Maryland mining activities in the UNBPR watershed

3.1.7 Point Source Data

A point source, according to 40 CFR 122.3, is any discernible, confined, and discrete conveyance, including any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, and vessel or other floating craft from which pollutants are or could be discharged. The National Pollutant Discharge Elimination System (NPDES) program, established under CWA sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources. A search of EPA's Permit Compliance System database (USEPA 2005b) found several mining-related, industrial, and municipal NPDES permits, which were included in the TMDL development for the Upper North Branch Potomac River watershed. A complete list of the permits and outlets is provided in Table 3-8. Figure 3-8 illustrates the extent of the mining NPDES outlets in the watershed.

Table 3-8. Permitted facilities included in the western Maryland watershed model

Permit number	Outfall	Facility name	Permit flow (mgd)[a]	Total Fe (mg/L)[a]	
				Monthly avg.	Daily max
MD0055182	001	Mettiki Coal, LLC	0	3.0	6.0
	002		5.627	1.0	2.5
	003		0.110151	3.0	6.0
	005		0	3.0	6.0
	006		0	3.0	6.0
	007		0	3.0	6.0
	008		0.063762	3.0	6.0
	009		0.065958	3.0	6.0
	010		0	3.0	6.0
	012		0.094657	3.0	6.0
MD0060933	001	Bloomington WWTP	0.05	n/a	n/a
MD0060941	001	Town Of Kitzmiller WWTP	0.04	n/a	n/a
MD0060950	001	Gorman WWTP	0.0085	n/a	n/a
MD0068811	001	Backbone Mountain, LLC -Mine#1 Oakland	0.16421	3.0	6.0
	002		0.000628	3.0	6.0
MDG851722	001	Buffalo Coal Company - Kempton Job Oakland	0.001	3.0	6.0
	004		0.001	3.0	6.0
	005		0.001	3.0	6.0
MDG852173	002	Wolf Run Mining Company - Steyer Deep Mine	0	3.0	6.0
MDG852905	001	G & S Coal Company-Manor Hill Mine Swanton	0.0002	3.0	6.0
	002		0.0002	3.0	6.0
	003		0.0002	3.0	6.0
	004		0.0002	3.0	6.0
MDG859602	000	Mettiki Coal Corp. - C-Mine	0.001	3.0	6.0
MDG859605	001	Patriot Mining Company - Vindex/Douglas Mine	0.0001	3.0	6.0
MDG859613	001	Vindex Energy Corporation - Island Tract Mine	0.00005	3.0	6.0
	002		0.000025	3.0	6.0
	003		0	3.0	6.0
	004		0	3.0	6.0
MDG859615	001	LAOC Corporation - Paugh Tract Mine	0	3.0	6.0
MDG859622	001	WPO Inc. - Table Rock Mine	0.0002	3.0	6.0

[a] mgd = million gallons per day; mg/L = milligrams per liter.

3.1.7.1 Mining NPDES Permits

The Surface Mining Control and Reclamation Act of 1977 (SMCRA, Public Law 95-87) and its subsequent revisions were enacted to establish a nationwide program to protect the beneficial uses of land and water resources, protect public health and safety from the adverse effects of current surface coal mining operations, and promote the reclamation of mined areas left without adequate reclamation before August 3, 1977. The SMCRA requires a permit for developing new, previously mined, or abandoned sites for the purpose of surface mining. Permittees are required to post a performance bond that will be sufficient to ensure the completion of reclamation requirements by a regulatory authority if the applicant forfeits its permit. Mines that ceased operations before the effective date of SMCRA (often called *pre-law* mines) are not subject to the requirements of SMCRA.

SMCRA Title IV is designed to provide assistance for the reclamation and restoration of abandoned mines, while Title V states that any surface coal mining operations are required to meet all applicable performance standards. Some general performance standards include the following:

- Restoring the land affected to a condition capable of supporting the uses that it was capable of supporting before any mining
- Backfilling and compacting (to ensure stability or to prevent leaching of toxic materials) to restore the approximate original contour of the land, including all highwalls
- Minimizing disturbances to the hydrologic balance and to the quality and quantity of water in surface water and groundwater systems both during and after surface coal mining operations and during reclamation by avoiding acid or other toxic mine drainage

Untreated coal mining-related point source discharges from deep, surface, and other mines typically have low pH values (that is, they are acidic) and contain high concentrations of metals (e.g., Fe and Al). Coal mining-related activities are commonly issued NPDES discharge permits that contain effluent limits for total Fe, total Mn, nonfilterable residue, and pH. Many permits also include effluent monitoring requirements for total Al.

3.1.7.2 NPDES Regulated Stormwater

The model applied in the TMDL analysis estimates Fe and Al pollutant loadings from the urban land use within the Upper North Branch Potomac River watershed. Within Maryland, MDE estimates pollutant loadings from regulated stormwater sources based on urban land use within a watershed. This methodology assumes certain relationships between specific Maryland Department of Planning (MDP) urban land use classifications and various categories of NPDES regulated stormwater sources, whereby the identification of these sources determines what portion of the urban land use is considered regulated (MDE 2009).

The Maryland portion of the Upper North Branch Potomac River watershed is located in Garrett County, which is not regulated under a NPDES Phase I or II jurisdictional municipal separate storm sewer system (MS4) permit. There are also no other additional jurisdictional Phase II MS4s (i.e, Phase II municipalities) within the watershed. Furthermore, since the State Highway Administration's (SHA) MS4 permit applies only to SHA owned areas within Phase I MS4 jurisdictions, SHA owned areas within the watershed are not regulated for stormwater runoff. Thus, the only NPDES regulated stormwater runoff in the watershed includes Fe and Al pollutant loadings from: state and federal general MS4s, industrial facilities, and construction sites, collectively termed "Other NPDES Regulated Stormwater" (MDE 2009).

State and federal general MS4s, industrial facilities, and construction sites were the only regulated stormwater sources identified within the watershed (i.e., the only urban land use areas considered to be regulated are those associated with MDP industrial and institutional land use classifications) (MDE 2009). However, these areas comprise a relatively small percentage of the total watershed area (60 acres or 0.09%), the Fe and Al loadings from these areas are considered to be insignificant. At this point, desegregation of these loads is not practical, and for the purposes of this analysis, no regulated stormwater Fe and Al loads have been characterized. Instead, these loads are included as part of the overall watershed nonpoint source load. Additionally the pollutants for which this TMDL is being developed are not included in the list of priority pollutants that are regulated under NPDES stormwater permits.

3.1.8 Nonpoint Source Data

Nonpoint sources of pollutants are diffuse, nonpermitted sources, such as acidic deposition. They most often result from precipitation-driven runoff. Historical unpermitted mining lands are the main source of nonpoint source pollution that contributes to the high metals concentrations in the Upper North Branch Potomac River. Mining was described in Section 3.1.7. In addition, acidic conditions in overland and subsurface flows affect chemical reactions between soils and water that can increase certain metals concentrations, particularly Al and Fe.

The majority of the acid deposition occurs in the eastern United States. In March 2005, EPA issued the Clean Air Interstate Rule (CAIR), which places caps on emissions for sulfur dioxide and nitrogen dioxides for the eastern United States. It is expected that CAIR will reduce sulfur dioxide emissions by more than 70 percent and nitrogen oxides emissions by more than 60 percent from the 2003 emission levels (USEPA 2005c).[2] Because the pollution is highly mobile in the atmosphere, reductions based on CAIR in West Virginia, Ohio, and Pennsylvania will likely improve the quality of precipitation in the TMDL watersheds.

Atmospheric deposition occurs by two main methods: wet and dry. Wet deposition occurs through rain, fog, and snow. Dry deposition occurs from gases and particles. Dry deposition accounts for approximately half of the atmospheric deposition acidity (USEPA 2005d). Particles and gases from dry deposition can be washed from trees, roofs, and other surfaces by precipitation after it is deposited and washed into streams. Winds blow the particles and gases contributing to acid deposition over long distances, including political boundaries, such as state boundaries. The primary pollutants from atmospheric deposition are sulfur dioxide and nitrogen oxides. The majority of sulfur dioxides (two-thirds) and one-fourth of nitrogen oxides are from fossil fuel burning electric power generating plants (USEPA 2005d).

Atmospheric deposition data were obtained from EPA's Office of Air Quality Planning and Standards at Research Triangle Park, North Carolina. The data are a result of air quality modeling in support of CAIR. The data include actual concentrations of sulfate and nitrogen oxides in wet and dry deposition for 2001 and projected 2020 concentrations. For the technical information on these data, see the *Technical Support Document for the Final Clean Air Interstate Rule—Air Quality Modeling* (USEPA 2005e).

[2] CAIR was successfully challenged and EPA is expected to revise the rule on the basis of a Supreme Court ruling. The original rule remains in effect until a revision is approved, and is therefore used in this TMDL. Should a future revision of the rule result in a change to the projected deposition rates, this change will be addressed through appropriate revision of the TMDL. Please see www.epa.gov/cair for more information.

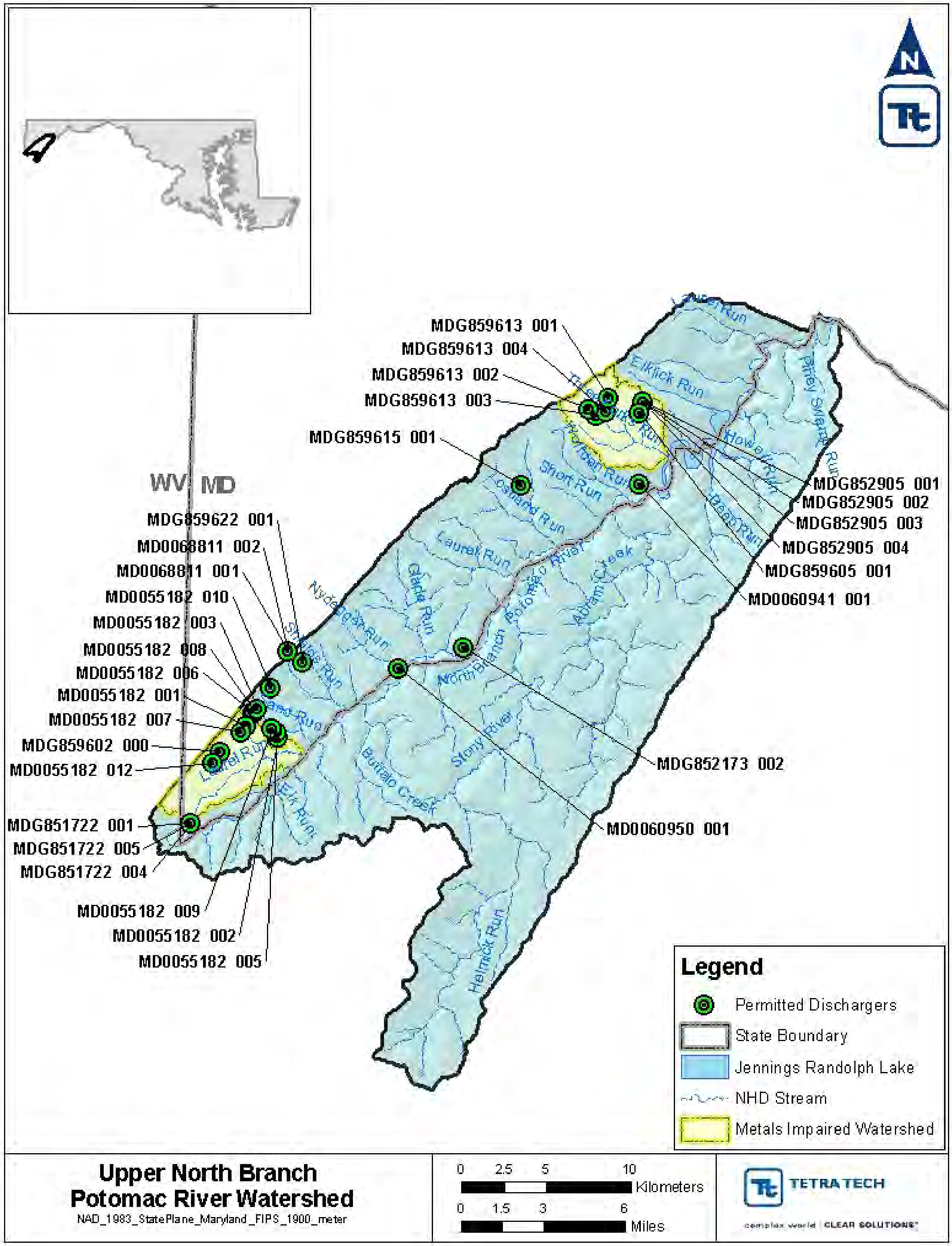

Figure 3-8. NPDES permitted facilities in the UNBPR watershed

4 TECHNICAL APPROACH

Establishing the relationship between the in-stream water quality targets and source loadings is a critical component of TMDL development. It allows for evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. This section presents the approach taken to develop the linkage between sources and in-stream response for TMDL development in the Upper North Branch Potomac River.

A watershed model is a useful tool for providing a quantitative linkage between sources and in-stream response. It is essentially a series of algorithms applied to watershed characteristics and meteorological data to simulate naturally occurring, land-based processes over an extended period, including hydrology and pollutant transport. Many watershed models are also capable of simulating in-stream processes using the land-based and subsurface calculations as input. Once a model has been adequately set up and calibrated for a watershed, it can be used to quantify the existing loading of pollutants from subwatersheds or from land use categories, and it can be used to assess the impacts of a variety of hypothetical scenarios.

The following technical factors were critical to selecting an appropriate watershed model:

- The model should be able to address the pollutants of concern (e.g., metals).
- The model should be able to simulate processes and constituents that influence metals concentrations, including pH levels and sulfate.
- The model should be able to simulate chemical processes and interactions in the surface and subsurface environments because the cumulative effect of these two environments and chemical/biological reactions will affect in-stream metals concentrations in areas impacted by AMD.
- The model should be able to address a watershed with primarily rural land uses.
- The model should provide adequate time-step estimation of flow and not oversimplify storm events to provide accurate representation of rainfall events/snowmelt and resulting peak runoff.
- The model should be capable of simulating various pollutant transport mechanisms (e.g., groundwater contributions, sheet flow).
- The model should include an acceptable snowmelt routine.

Using the above considerations, the Mining Data Analysis System (MDAS) was selected for modeling the Upper North Branch Potomac River. MDAS integrates a geographical information system (GIS), comprehensive data storage and management capabilities, Hydrologic Simulation Program FORTRAN (HSPF) algorithms, and a data analysis/post-processing system. MDAS's algorithms are identical to a subset of those in the HSPF model and was developed for mining-related TMDL development in EPA Region 3. A brief overview of the HSPF model is provided below, and a detailed discussion of HSPF-simulated processes and model parameters is available in the HSPF User's Manual (Bicknell et al. 1997).

HSPF is a comprehensive watershed and receiving water quality modeling framework that was originally developed in the mid-1970s. During the past several years, it has been used to develop hundreds of EPA-approved TMDLs, and it is generally considered the most advanced hydrologic and watershed loading model available. The hydrologic portion of HSPF is based on the Stanford Watershed Model (Crawford and Linsley 1966), which was one of the pioneering watershed models developed in the 1960s. The HSPF framework is developed in a modular fashion with many different components that can be assembled in different ways, depending on the objectives of the individual project.

HSPF includes three major modules:

- PERLND for simulating watershed processes on pervious land areas
- IMPLND for simulating processes on impervious land areas
- RCHRES for simulating processes in streams and vertically mixed lakes

All three modules include many subroutines that calculate the various hydrologic and water quality processes in the watershed. Many options are available for both simplified and complex process formulations. Spatially, the watershed is divided into a series of subwatersheds representing the drainage areas that contribute to each of the stream reaches. These subwatersheds are then further subdivided into segments representing different land uses. For the developed areas, the land use segments are further divided into the pervious (PERLND) and impervious (IMPLND) fractions. The stream network (RCHRES) links the surface runoff and groundwater flow contributions from each of the land segments and subbasins and routes them through the waterbodies using storage routing techniques. The stream model includes precipitation and evaporation from the water surfaces, as well as flow contributions from the watershed, tributaries, and upstream stream reaches. Flow withdrawals can also be accommodated. The stream network is constructed to represent all the major tributary streams, as well as different portions of stream reaches where significant changes in water quality occur.

Like the watershed components, several options are available for simulating water quality in the receiving waters. The simpler options calculate transport through the waterways and represent all transformations and removal processes using simple, first-order decay approaches. The framework is flexible and allows different combinations of constituents to be modeled depending on data availability and the objectives of the study.

5 MDAS Model Development

5.1 Model Configuration

Configuration of the model considered the following major components, which collectively enable the model to estimate flow and pollutant loadings:

- Watershed subdivision, which provides the basis for spatial representation of sources and transporting water and metals throughout the watershed,
- Stream representation, which characterizes the stream channels used to convey water and metals throughout the watershed
- Land use representation, which provides the basis for representing land-based sources
- Meteorological data, which is the driver for hydrologic processes in the watershed
- Hydrologic and pollutant representation, which characterizes spatially- and temporally-variable aspects of hydrologic and water quality prediction throughout the watershed and in the streams and rivers
- Boundary conditions, which are used to represent conditions where the model is not used (i.e., to represent pollutant loadings from the West Virginia portion of the watershed)

MDAS configuration for developing metals TMDLs in the Upper North Branch Potomac River watershed is based on a previous pH TMDL study for the area.[3] For the previous study, MDAS was set up to simulate the loading of constituents affecting pH in streams, including but not limited to Fe and Al. Model development for the current TMDLs used the pH model as a platform. Additional modifications were made to address considerations for the metals of interest, including representation of contributions from the West Virginia portion of the watershed, simulation of water quality in the Upper North Branch Potomac River mainstem, and extension of the model simulation time period. The MDAS pH model was configured for tributary subwatersheds in Maryland only.

5.1.1 Watershed Subdivision

Watershed subdivision refers to the subdivision of the entire watershed into smaller, discrete subwatersheds for modeling and analysis. MDAS calculates watershed processes with for each of these independent, hydrologically-connected subwatersheds and then transports flow and metals throughout their connecting streams and rivers. Only the Maryland portion of the watershed was subdivided for modeling. The West Virginia portion of the study area was represented as a boundary condition.

Watershed subdivision was based primarily on the stream network and topographic variability and secondarily on the locations of flow and water quality monitoring stations to facilitate model calibration. Using this method, 69 subwatersheds were defined for the Maryland portion of the watershed (Figure 5-1).

5.1.2 Stream Representation

Each delineated subwatershed in the MDAS model was conceptually represented with a single stream assumed to be a completely mixed, one-dimensional segment with a constant cross-section. The National Hydrography Dataset stream reach network was used to determine the representative stream length for

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[3] The previously developed pH TMDL document is at http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/TMDL_Final_W_MD_pH.asp (Accessed May 2009)

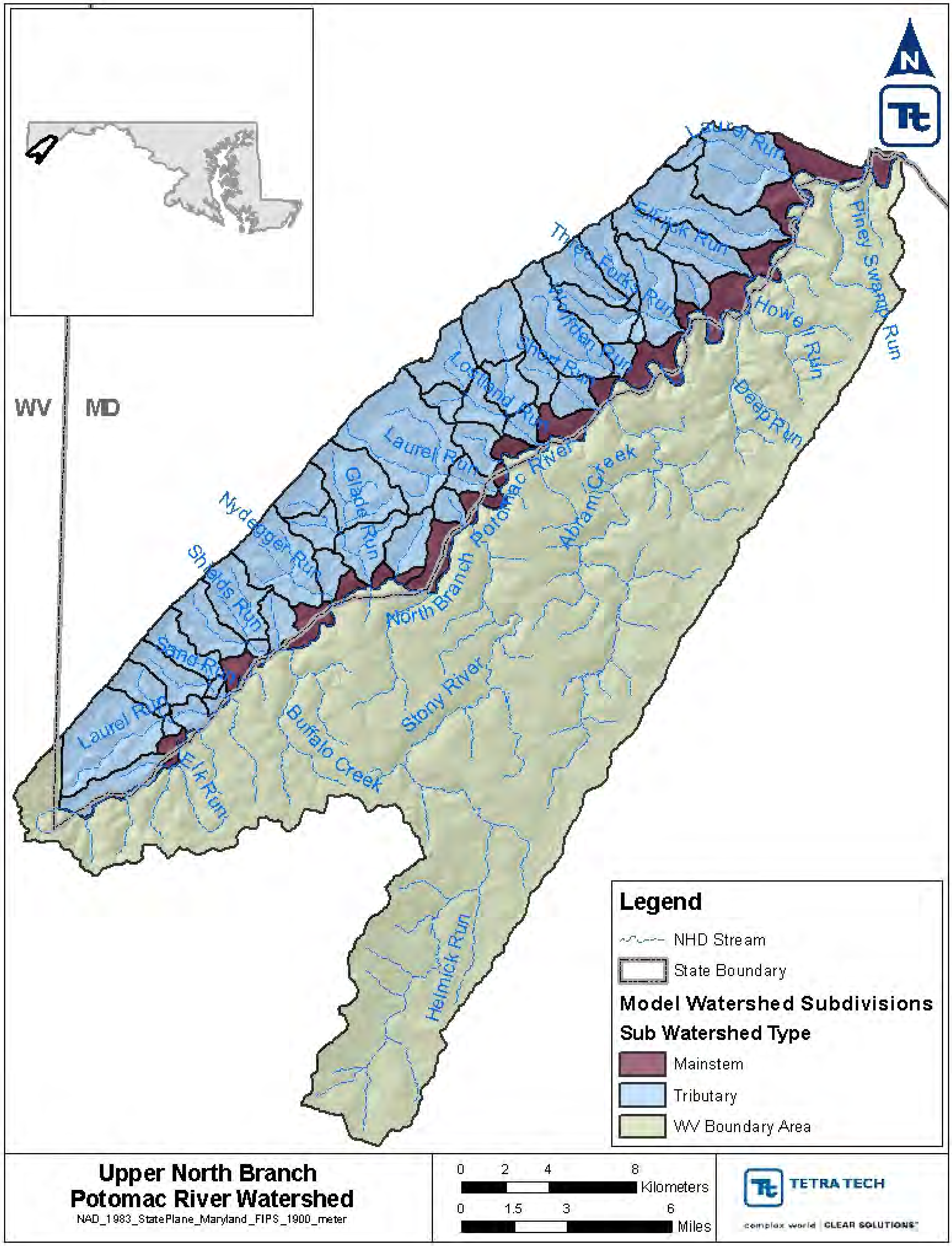

Figure 5-1. Watershed delineation for the UNBPR watershed MDAS model

each subwatershed. The stream lengths were used along with the 30-meter National Elevation Dataset to calculate reach slope.

A representative trapezoidal geometry was assumed for the stream, and mean stream depth and channel width were estimated using regression curves that relate upstream drainage area to stream dimensions (Rosgen 1996). Rating curves consisted of a representative depth-outflow-volume-surface area relationship. An estimated Manning's roughness coefficient of 0.035 was applied to each representative stream reach using typical literature values for natural streams (Chapra 1997).

5.1.3 Land Use Representation

MDAS requires a basis for distributing hydrologic and pollutant loading parameters. This is necessary to appropriately represent hydrologic variability throughout the watershed, which is influenced by land surface and subsurface characteristics. It is also necessary to represent variability in pollutant loading, which is highly related to land practices (and sources). Land use typically represents the primary unit for computing both water quantity and quality. In addition to the need for land use data in computing water quantity and quality, nonpoint source management decisions are also frequently based on land use-related activity at the subwatershed level. Therefore, it is important to have a detailed land use representation with classifications that are meaningful for load allocation.

Existing land use and land cover in the Maryland portion of the watershed were determined from information provided by MDE. The land use data for the West Virginia portion of the watershed were obtained from a variety of sources depending on the area and method used to develop the boundary condition time series representing metals loadings to the Upper North Branch Potomac River mainstem. For more information on land use information, see Section 3.1.4.

5.1.4 Meteorological Representation

Hydrologic processes are time varying and depend on changes in environmental conditions such as precipitation, temperature, and wind speed. As a result, meteorological data are a critical component of watershed models. Meteorological conditions are the driving force for nonpoint source transport processes in watershed modeling. Generally, the finer the spatial and temporal resolution available for meteorology, the more representative the simulation of associated watershed processes will be. At a minimum, precipitation and potential evapotranspiration are required as forcing functions for most watershed models. For the Upper North Branch Potomac River where the snowfall and snowmelt processes are a significant factor in watershed-wide hydrology, additional data were required for snow simulation. These data included temperature, dew point temperature, wind speed, and solar radiation.

Available precipitation data for a station are not always 100 percent complete. An effort was made to select weather stations with a high level of completeness—above 90 percent. However, precipitation stations often contain intervals of accumulated, missing, or deleted data.[4] In these circumstances, rainfall patching must be performed. Patching was conducted using the *normal-ratio method*, which estimates a missing rainfall record with a weighted average from surrounding stations with similar rainfall patterns. Accumulated, missing, and deleted data records were repaired using hourly rainfall patterns at nearby stations with unimpaired data.

After reviewing the available weather data, it was concluded that there were four adequate precipitation gages for the watersheds: Savage River Dam (MD8065), Bayard (460527), Terra Alta No 1 (WV8777), and MDOT (US50 at Table Rock Road).

[4] Accumulated data represent cumulative precipitation over several hours, but the exact hourly distribution of the data is unknown.

Data from these gages were used to develop an input file with hourly time-series data from January 1999 through September 2008. An hourly time step for weather data was required to properly reflect diurnal temperature changes (and the resulting influence on whether precipitation was modeled as rainfall or snow) and provide adequate resolution for rainfall/runoff intensity to drive erosion and water quality processes during storms or snowmelt events.

5.1.5 Hydrologic and Pollutant Representation

5.1.5.1 Soils

Hydrologic soils group data for the TMDL watersheds were obtained from the STATSGO database. The data were summarized using the major hydrologic group in the surface layers of the map unit. The distribution of hydrologic soil type throughout the Maryland portion of the watershed is relatively uniform, with the vast majority of the area characterized as B soils. Therefore, hydrology characteristics throughout the watershed were represented accordingly with hydrology parameters varying only by land cover classification.

5.1.5.2 Point Sources

Point source contributions of flow and total Fe were incorporated into the model. Data were obtained from EPA's Permit Compliance System database (Section 3.1.7). Monthly flow and pollutant concentrations obtained from discharge monitoring reports were used when available (Table 5-1).

Table 5-1. Modeled permitted flow and concentrations

NPDES No.	Outfall	Flow (cfs)	Average monthly iron limit (mg/L)
MD0055182	001	n/a[b]	3.0
MD0055182	002	8.706768169	1.0
MD0055182	003	0.170428822	3.0
MD0055182	005	n/a	3.0
MD0055182	006	n/a	3.0
MD0055182	007	n/a	3.0
MD0055182	008	0.098654415	3.0
MD0055182	009	0.10205213	3.0
MD0055182	010	n/a	3.0
MD0055182	012	0.146456055	3.0
MD0060933	001	0.07736145	n/a
MD0060941	001	0.06188916	n/a
MD0060950	001	0.013151447	n/a
MD0068811	001	0.254070474	3.0
MD0068811	002	0.00097166	3.0
MDG851722	001	0.001547229	3.0
MDG851722	004	0.001547229	3.0
MDG851722	005	0.001547229	3.0
MDG852173	002	n/a	3.0
MDG852905	001	0.000309446	3.0
MDG852905	002	0.000309446	3.0
MDG852905	003	0.000309446	3.0

NPDES No.	Outfall	Flow (cfs)	Average monthly iron limit (mg/L)
MDG852905	004	0.000309446	3.0
MDG859602	000	0.001547229	3.0
MDG859605	001	0.000154723	3.0
MDG859613	001	7.73615E-05	3.0
MDG859613	002	3.86807E-05	3.0
MDG859613	003	n/a	3.0
MDG859613	004	n/a	3.0
MDG859615	001	n/a	3.0
MDG859622	001	0.000309446	3.0

[a] cfs = cubic feet per second
[b] n/a = not available

5.1.5.3 Nonpoint Source Representation

Nonpoint source contributions of Fe and Al were represented in the model through a number of mechanisms. Contributions were land use dependent and represented through surface, interflow, and groundwater outflows by concentrations. These concentrations were initially based on literature values and then calibrated to correspond to observed concentrations (Section 5.2.2). In addition to the land use-based contributions, specific contributions were also included in the model for atmospheric deposition and mine seepage.

Atmospheric deposition was represented by two different pathways in the model: dry deposition and wet deposition. Both pathways were represented similarly for land uses and included contributions for nitrate (NO_3), ammonium (NH_4^+), sulfate (SO_4). Dry-weather deposition was represented using a constant load over time (weight/area/time). Wet deposition was represented by associating a specified concentration with precipitation data in the model. Data for both types of deposition were obtained from EPA's Office of Air Quality Planning and Standards at Research Triangle Park, North Carolina. The data are a result of air quality modeling in support of CAIR. The data include concentrations of sulfate and nitrogen oxides in wet and dry deposition. For additional information on these data, see the *Technical Support Document for the Final Clean Air Interstate Rule—Air Quality Modeling* (USEPA 2005e).

Dry and wet deposition was represented for two time periods in the model. The year 2001 was used to represent current conditions for calibration. Predicted levels for 2020 were used in the model to represent TMDL conditions. These levels are reflective of the CAIR reducing emissions to the 2020 estimated levels. Table 5-2 presents both 2001 levels and predicted 2020 levels.

Table 5-2. Modeled atmospheric deposition concentrations and fluxes

2001												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Dry deposition (gram/acre-day)												
NH_4	0.29	0.28	0.51	0.80	0.88	1.00	0.86	0.56	0.69	0.64	0.47	0.45
NO_3	0.18	0.18	0.27	0.17	0.05	0.03	0.02	0.04	0.02	0.06	0.12	0.11
SO_4	30.40	26.39	29.08	20.63	35.82	43.54	34.36	43.11	38.91	35.30	27.59	39.89
Wet deposition (mg/L)												
NH_4	0.15	0.10	0.21	0.28	0.35	0.28	0.11	0.11	0.09	0.08	0.12	0.17
NO_3	1.11	0.96	1.32	1.16	1.34	1.22	0.69	0.54	0.47	0.43	0.95	1.85
SO_4	1.14	1.44	1.58	2.47	4.18	4.17	2.16	1.93	1.31	0.85	1.39	2.43

2020												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Dry deposition (gram/acre-day)												
NH_4	0.40	0.42	0.62	1.08	1.22	1.55	1.22	0.63	1.05	0.96	0.71	0.59
NO_3	0.17	0.18	0.23	0.17	0.04	0.02	0.01	0.01	0.01	0.05	0.10	0.10
SO_4	10.51	8.83	9.38	5.82	9.13	8.92	7.96	7.27	9.41	9.74	8.25	12.43
Wet deposition (mg/L)												
NH_4	0.16	0.10	0.22	0.28	0.35	0.27	0.11	0.11	0.08	0.08	0.12	0.17
NO_3	0.72	0.57	0.79	0.61	0.57	0.49	0.26	0.21	0.21	0.19	0.44	1.85
SO_4	0.63	0.73	0.97	1.34	1.90	1.58	0.86	0.81	0.59	0.47	0.79	1.26

Mine seepage was modeled as a constant input (flow and concentration) at specific, known, abandoned mine locations. Pollutants in the mine seepage included Fe, Al, and SO_4. Mine seepage locations were available through MDE and are shown in Figure 3-7, labeled as “Mine seeps/portals from MDE.” Table 5-3 presents the flow and chemical data that were used for these seeps and portals. Flow and chemical data were not provided for most sites, so median values of the available data were used and are highlighted in Table 5-3.

Table 5-3. Flow and chemical data for mine seeps and portals used in the model

Mine seep or portal	Flow (cfs)	Fe (mg/L)	Al (mg/L)	SO_4 (mg/L)
GO-01-P1	0.0067	15.0	12.0	761.5
GO-01-P2	0.0111	15.0	12.0	761.5
GO-01-P3	0.0111	15.0	12.0	761.5
GO-01-P4	0.0011	15.0	12.0	761.5
GO-01-P5	0.0022	15.0	12.0	761.5
GO-01-P7	0.0891	15.0	12.0	761.5
GO-01-P8	0.0111	15.0	12.0	761.5
GO-01-P9	0.0011	15.0	12.0	761.5
GO-01-S1	0.0334	24.0	4.9	635.9
GO-02-P1	0.0045	15.0	12.0	761.5
GO-02-P2	0.0465	15.0	12.0	761.5
GO-03-P3	0.0022	15.0	12.0	761.5
GO-03-P6	0.0022	15.0	12.0	761.5
GO-03-P7	0.0067	15.0	12.0	761.5
GO-04-P1	0.0045	15.0	12.0	761.5
GO-04-P2	0.0011	15.0	12.0	761.5
GO-04-P4	0.0022	15.0	12.0	761.5
GO-04-P6	0.0223	15.0	12.0	761.5
GO-04-P7	0.0465	4.0	2.0	131.0
GO-04-P8	0.0334	0.0	2.0	168.0
GO-05-P1	0.0022	15.0	12.0	761.5
GO-08-S1	0.0290	24.0	4.9	635.9
GO-09-P1	0.0011	15.0	12.0	761.5
GO-09-P2	0.0156	15.0	12.0	761.5
GO-12-P1	0.0022	15.0	12.0	761.5
GO-12-P2	0.0067	15.0	12.0	761.5

Mine seep or portal	Flow (cfs)	Fe (mg/L)	Al (mg/L)	SO_4 (mg/L)
GO-12-P4	0.0067	15.0	12.0	761.5
GO-13-P1	0.0022	15.0	12.0	761.5
KZ-01-P10	0.0111	15.0	12.0	761.5
KZ-01-P13	0.0022	15.0	12.0	761.5
KZ-01-P14	0.0334	15.0	12.0	761.5
KZ-01-P15	0.0022	15.0	12.0	761.5
KZ-01-P16	0.0011	15.0	12.0	761.5
KZ-01-P3	0.0465	15.0	12.0	761.5
KZ-01-P4	0.0465	15.0	12.0	761.5
KZ-01-P6	0.0465	15.0	12.0	761.5
KZ-01-P7	0.0067	15.0	64.0	1395.0
KZ-01-P8	0.0011	15.0	12.0	761.5
KZ-01-P9	0.0011	15.0	12.0	761.5
KZ-01-S1	0.0290	24.0	4.9	635.9
P-03-S1	0.0290	24.0	4.9	635.9
P-10-S1	0.0045	24.0	4.9	635.9
P-13-P1	0.0334	15.0	12.0	761.5
P-22-P1	0.0465	15.0	12.0	761.5
P-22-P2	0.0465	15.0	12.0	761.5
P-26-S1	0.0045	0.0	5.0	339.0
P-29-S1	0.0011	24.0	4.9	635.9
P-29-S2	0.0011	24.0	4.9	635.9
P-29-S3	0.0011	24.0	4.9	635.9
P-31-S1	0.0067	24.0	4.9	635.9
P-35-S1	0.0290	24.0	4.9	635.9
P-54-P1	0.0465	15.0	12.0	761.5
P-88-P1	0.0334	15.0	12.0	761.5
P-88-P2	0.0465	15.0	12.0	761.5
P-89-S1	0.0290	24.0	4.9	635.9

Note: Highlighted values are averages for either seeps or portals.

5.1.6 West Virginia Boundary Condition

The Upper North Branch Potomac River watershed includes areas in Maryland and West Virginia. An updated MDAS watershed model was developed for only the Maryland portion of the watershed. The Stony River subwatersheds and *Group B* subwatersheds (Elk Run, Buffalo Creek, Abram Creek, Piney Swamp Run, and Montgomery Run) have existing metals TMDLs developed using MDAS (Figure 5-2).[5] The previous West Virginia MDAS models were updated with recent climatological data from 1999 through 2008. Loadings from these models were represented as discrete inputs/boundary conditions into the Upper North Branch Potomac River watershed model. The remainder of the West Virginia portion of the study area was represented using an index-watershed approach. For a full explanation of this process, see Appendix C.

[5] The TMDL documents discussing model development for these areas are at http://www.wvdep.org/Docs/3006_StonyRiver_TMDL.pdf (Accessed May 2009) and http://www.wvdep.org/Docs/12421_NBP_Final_TMDL_Report_2_13_07.pdf (Accessed May 2009)

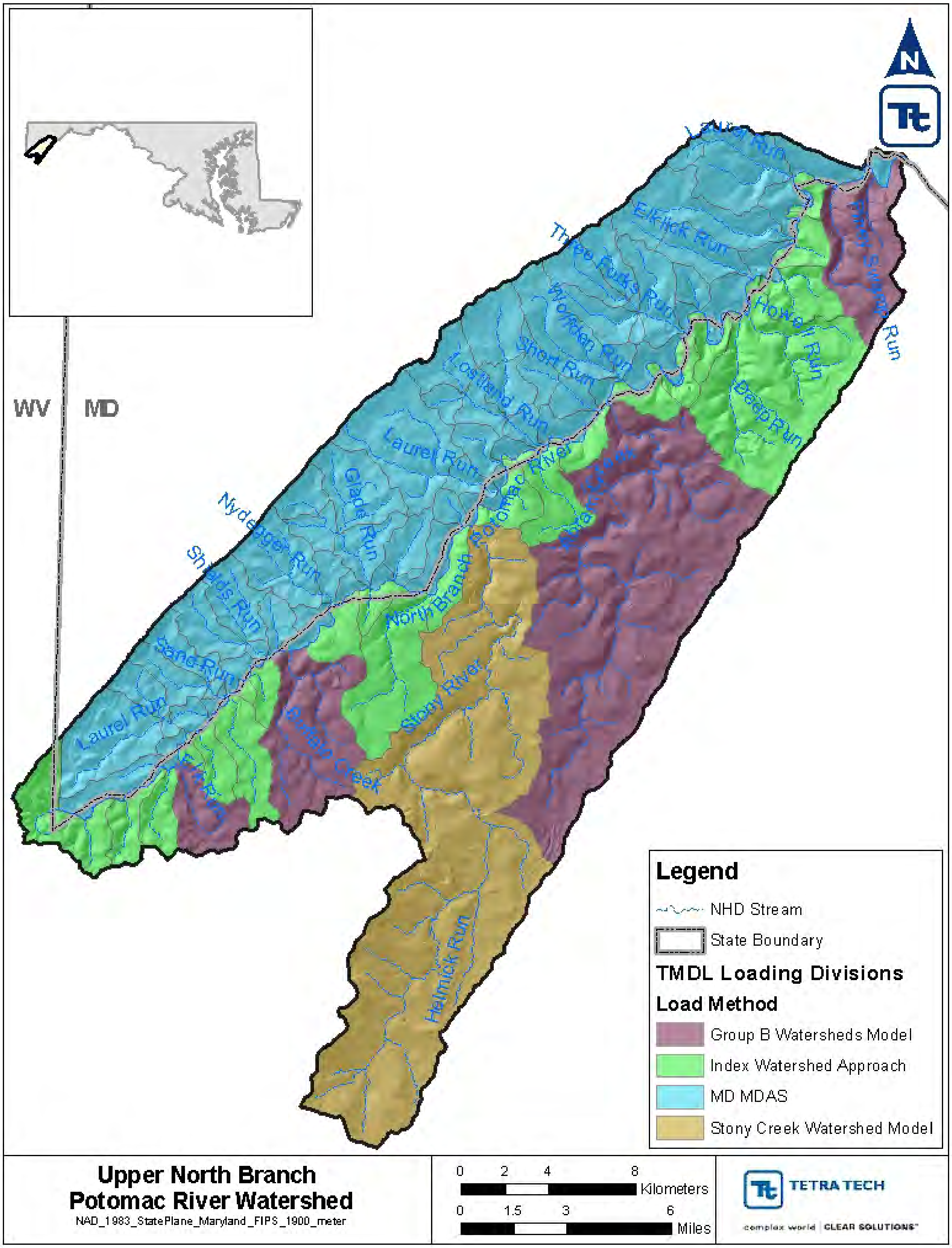

Figure 5-2. Boundary condition areas for the UNBPR watershed MDAS model

5.2 Calibration and Validation

After initially configuring the watershed model, model calibration and validation for hydrology and water quality were performed. Calibration refers to adjusting or fine-tuning modeling parameters to reproduce observations. Previous calibrations associated with the pH TMDL model, described in Section 4, served as the starting point for the current calibrations. Validation was performed for different monitoring stations without further adjusting the calibration parameters, in order to ensure that the model accurately represents other locations in the watershed. After completing the calibration and validation at selected locations, a calibrated data set containing parameter values for each modeled land use and soil type was obtained.

5.2.1 Hydrology Calibration and Validation

Hydrologic calibration was performed after the initial model setup. For MDAS, calibration is an iterative procedure of parameter evaluation and refinement as a result of comparing simulated and observed values of interest. It is required for parameters that cannot be deterministically and uniquely evaluated from topographic, climatic, physical, and chemical characteristics of the watershed and compounds of interest. Calibration was based on several years of simulation to evaluate parameters under a variety of climatic conditions. The calibration procedure resulted in parameter values that produce the best overall agreement between simulated and observed flows throughout the calibration period.

Five USGS flow-gaging stations were used for MDAS hydrology calibration and validation (Figure 3-1). These stations are listed in Table 3-2, with periods of record and measures of completeness. Table 5-4 lists the USGS flow stations and their associated calibration and validation periods. The calibration years were selected after examining annual precipitation variability and the availability of observation data. The periods were determined to represent a range of hydrologic conditions including low-, mean-, and high-flow conditions. Calibration for these conditions is necessary to ensure that the model accurately predicts a range of conditions over the entire simulation period.

Table 5-4. USGS gaging station calibration and validation time periods

Station	Station name	Calibration time period	Validation time period
01594930	Laurel Run at Dobbin Road near Wilson, Maryland		01/2000–09/2004
01594936	North Fork Sand Run near Wilson, Maryland	01/2000–12/2003	12/2004–09/2007
01594950	McMillan F near Fort Pendleton, Maryland	01/2000–12/2003	01/2004–12/2008
01595000	North Branch Potomac River at Steyer, Maryland		01/2000–12/2008
01595500	North Branch Potomac River at Kitzmiller, Maryland		01/2004–12/2008

During calibration, parameters influencing the simulation of runoff, infiltration, and evapotranspiration were adjusted on the basis of land use and soil type. Modeling parameters were varied to keep with observed temporal trends and soil and land cover characteristics. Guidelines identified in the BASINS Technical Note 6 (USEPA 2000) were followed as closely as possible.

Key considerations in the hydrology calibration included the overall water balance, the high-flow and low-flow distribution, storm-flow volumes and timing, and seasonal variation. At least three criteria for goodness of fit were used for calibration: volumetric comparison, graphical comparison, and the relative error method. The calculation of runoff volumes at various time scales (e.g., daily, monthly) provides an assessment of the model's ability to accurately simulate the water budget.

Stations USGS 01594936 and USGS 01594950 showed the best correlation between predictions and monitoring data. Result plots and tables are included in Appendix B. Discrepancies can largely be explained by differences in measured precipitation data (used in the model) and the actual precipitation that fell in the watershed. The weather stations that were used in the model often contained localized storm events that did not occur over the entire watershed, thus creating peaks in the modeled results that were not present in the observed data. Likewise, the model did not predict storms at other times because the precipitation data did not include events that might have occurred in the watershed. These types of discrepancies are common and acceptable in watershed modeling applications. Overall, the calibration and validation results demonstrate that the model accurately predicts hydrology. It should be noted that the model generally under-predicted winter flows and over-predicted summer flows.

5.2.2 Water Quality Calibration and Validation

After hydrology was sufficiently calibrated, water quality calibration was performed. The water quality calibration consisted of running the watershed model, comparing water quality output to available water quality observation data, and adjusting pollutant loading and in-stream water quality parameters within a reasonable range. Parameters influencing the simulation of water quality were adjusted by land use and soil type. Calibration and validation were conducted for Fe and Al. Recent data (2005 and 2008) were used for the calibration process to ensure that current conditions were simulated.

The relevant water quality constituents were calibrated and validated using monitoring data from 21 water quality stations. Calibration stations were selected on the basis of the amount of data available and age of the data (where recent data were preferable). The calibration year(s) were selected using available data.

Chemical species were calibrated by adjusting the subsurface chemical reaction parameters and background concentrations. Specific parameters included precipitation rates, metal dissolution constants, base saturation percentage, Al solubility constant, carbon dioxide (CO_2) pressure, and the Al selectivity constant. Many of these parameters had been calibrated during previous modeling (MDE 2007), and thus required only minor modifications. Fe and Al were simulated through in-stream chemical reaction models in MDAS.

An example of an Fe calibration plot is shown in Figure 5-3. Model calibration and validation results for all parameters are presented in Appendices D and E. Modeled metals concentrations were generally within the observed range. In some situations, they were outside the range, but this is justifiable and to be expected since monitoring data do not necessarily cover the range of potential conditions (i.e., that don't necessarily capture all events – extreme or otherwise).

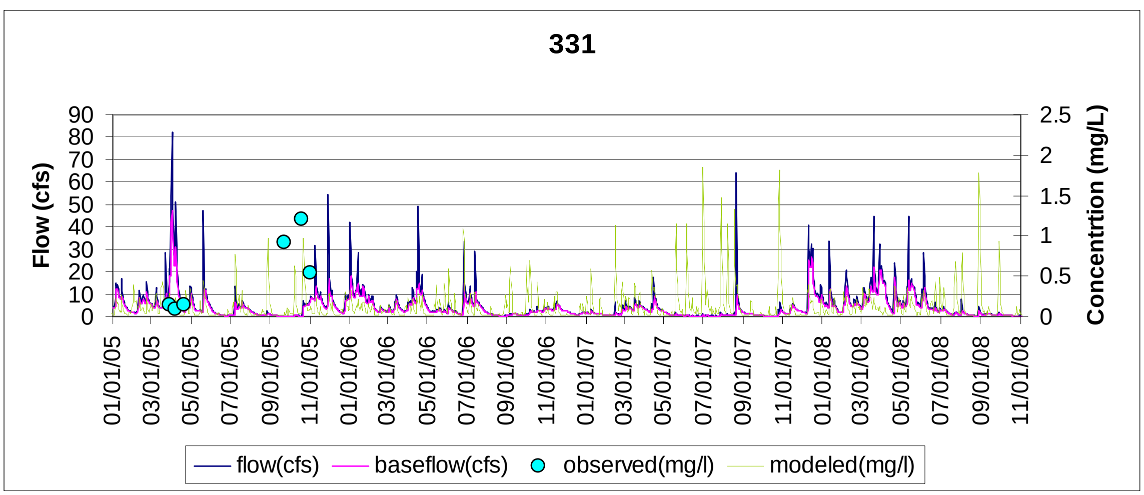

Figure 5-3. Iron calibration at station NPL0018

Several watersheds had Fe or Al concentrations that were either lower than observed data or higher than observed data. Further investigation is needed in these watersheds. For example, if the modeled Fe concentrations were too low but the pH and the other parameters were fairly well represented, it could mean there is a local source of Fe that had not been identified (and thus generally not represented in the model). Similarly, if modeled Fe or Al (the hallmarks of AMD) are abpve observed levels and modeled pH is reasonable, the watershed might have a greater acid-neutralizing capability than calibrated for, or there could be an acid-neutralizing source. Additionally, in watersheds where pH predictions reasonably match observations and Fe or Al are modeled below observed levels, there might be an additional source of acidity not represented in the model.

5.3 Assumptions and Limitations

The goal of the modeling calibration was to determine a set of parameters that best describe hydrologic and water quality processes in the Upper North Branch Potomac River watersheds. Using the best available data, model output was evaluated at representative calibration gages. The MDAS model is considered to be calibrated to the available data. Imprecision in the model output is present, expected, and is primarily governed by uncertainty associated with the model inputs. Some uncertainties with the inputs were corrected during the calibration process (i.e., infiltration rates, interception capacity). Others simply appear as unexplained variance between the modeled and observed data. Model uncertainty is difficult to quantify because it changes as temporal and spatial conditions vary. The remainder of this section outlines the model inputs and limitations most likely to cause uncertainty with the model output.

Weather gages are a likely source of model uncertainty. Only four precipitation gages were available for the modeling analysis, and they were responsible for generating precipitation data for 292 square miles. In addition, the climate station used for climate data (e.g., temperature, cloud cover) was outside the watershed. The lack of weather gages significantly increases model uncertainty in terms of amount and timing of water flowing through the system. Lack of weather gages particularly increases model uncertainty during storm events (timing and volume of water).

Point source discharges have the potential to affect flow and water quality in a stream. The MDAS model can account for these sources by using time-series inputs of flow and concentrations. However, most point sources report data only monthly (or less frequently), and data were interpolated to provide daily model input. In other cases, very little information is available about the point sources, and best professional judgment was used to estimate flow, timing, or outfall location. Point source uncertainties have the greatest potential to affect model output during low-flow events, when point sources make up a larger percentage of the pollutant load.

Mining information for the model is limited. Few mine seep data are available. The flow information for these seeps were labeled as estimated. The values used for the model are considered assumptions. If more data are obtained and contributions are found to be more significant than current estimates, mine seeps might have an effect on modeled metals concentrations. In addition, land area was subtracted from forest land use and added to the mining land use on the basis of observed concentrations. This assumed that on the basis of monitoring data, additional mine lands/seeps were present in the watersheds, though they have not yet been identified.

Each MDAS/HSPF model is driven by the basic physiographic characteristics that make up a watershed—land use, soils, slopes, and geology (Section 3.1). Therefore, physiographic data must be accurate and complete for each subwatershed. Potential uncertainties were introduced into the model because several of these physiographic characteristics were simplified to facilitate modeling. In addition, physiographic characteristics change over time and are not necessarily represented by the available data and the chosen calibration period. However, this process most likely does not introduce much modeling uncertainty when compared to the other potential sources of uncertainty.

Atmospheric deposition was based on a regional model and predicted values. It was assumed to contribute at a constant rate (for dry deposition) and a constant concentration (for wet deposition) over multiple years and the entire watershed. Atmospheric deposition did not have a large influence on the model.

For load allocations (LAs), the CO_2 pressure was adjusted at a number of locations because CO_2 is created by respiration and the decay of organic matter. For acidic streams with pH levels as low as 4.4, these processes do not occur. With improved pH levels, these processes are likely to occur, thus changing the CO_2 pressure to values reflective of less impaired watersheds.

The following is a list of the major limitations and assumptions in the MDAS model for predicting pH:

- No explicit AMD chemical reactions are incorporated.
- Chemical reactions are based on an equilibrium concept, with no kinetic considerations.
- Nitrogen transformations are assumed to be a first-order reaction.
- Sulfate adsorption to soil particles is assumed to be linear.
- Generated soil CO_2 follows a seasonal sine curve.

5.4 Baseline Model Results

The calibrated and validated model was run for a *baseline* condition. This condition was essentially the starting point for TMDL analysis. For the baseline condition, permit flows and permit limits were included in the model instead of observed DMR flows and concentrations. (Permit information is provided in Table 3-9.) By using these permit values, the total potential loading from a point source is included in the model. The model was run for the period of March 1, 2007, through February 29, 2008, which was determined to have a 12-month average flow closest to the overall average flow at USGS gages 0159500 and 0159550 on the mainstem of the North Branch of the Potomac River. This produced daily loads that were then summed over the year to create the annual loads, which are presented in Table 5-5 and subsequent tables.

Tables 5-5 and 5-6 present existing (before TMDL reductions) total daily loads per watershed, annual loads per watershed, and loads from mine seeps. Table 5-5 presents the total existing modeled loads for the model year for Fe and Al at each station. The loadings reported in these tables are the edge of stream loadings for the contributing watershed area. Table 5-6 presents the existing yearly loads of Fe and Al from mine seeps and portals in the impaired watersheds using information presented in Table 5-3.

Table 5-5. Modeled baseline Fe and Al yearly loads

Watershed	Allocation point	Iron (lb/yr)	Aluminum (lb/yr)
Laurel Run	UNT to Laurel Run	46,196	41,792
	Direct contributions	773,650	331,672
	Entire watershed	**819,845**	**373,464**
Three Forks Run	Right Prong Three Forks Run	33,155	26,903
	Left Prong Three Forks Run	37,625	12,315
	Direct contributions	339,464	259,329
	Entire watershed	**410,243**	**298,547**
UNBPR	WV Contributions	2,146,595	--
	Direct contributions	47,910	--
	Tributary contributions	1,680,483	--
	Entire watershed	**3,874,989**	--

Table 5-6. Baseline yearly loads from mine seeps and portals

Watershed	Stream segment	Mine seep or portal	Fe (lb/yr)	Al (lb/yr)
Laurel Run	Entire watershed	P-03-S1	1,371	280
Three Forks Run	Entire watershed	P-54-P1	1,374	1,099
UNBRP	Above Jennings Randolph Lake	GO-01-P1	197	--
UNBRP	Above Jennings Randolph Lake	GO-01-P2	329	--
UNBRP	Above Jennings Randolph Lake	GO-01-P3	329	--
UNBRP	Above Jennings Randolph Lake	GO-01-P4	33	--
UNBRP	Above Jennings Randolph Lake	GO-01-P5	66	--
UNBRP	Above Jennings Randolph Lake	GO-01-P7	2,632	--
UNBRP	Above Jennings Randolph Lake	GO-01-P8	329	--
UNBRP	Above Jennings Randolph Lake	GO-01-P9	33	--
UNBRP	Above Jennings Randolph Lake	GO-01-S1	1,579	--
UNBRP	Above Jennings Randolph Lake	GO-02-P1	132	--
UNBRP	Above Jennings Randolph Lake	GO-02-P2	1,374	--
UNBRP	Above Jennings Randolph Lake	GO-03-P3	66	--
UNBRP	Above Jennings Randolph Lake	GO-03-P6	66	--
UNBRP	Above Jennings Randolph Lake	GO-03-P7	197	--
UNBRP	Above Jennings Randolph Lake	GO-04-P1	132	--
UNBRP	Above Jennings Randolph Lake	GO-04-P2	33	--
UNBRP	Above Jennings Randolph Lake	GO-04-P4	66	--
UNBRP	Above Jennings Randolph Lake	GO-04-P6	658	--
UNBRP	Above Jennings Randolph Lake	GO-04-P7	366	--
UNBRP	Above Jennings Randolph Lake	GO-04-P8	66	--
UNBRP	Above Jennings Randolph Lake	GO-05-P1	66	--
UNBRP	Above Jennings Randolph Lake	GO-08-S1	1,371	--
UNBRP	Above Jennings Randolph Lake	GO-09-P1	33	--
UNBRP	Above Jennings Randolph Lake	GO-09-P2	461	--
UNBRP	Above Jennings Randolph Lake	GO-12-P1	66	--
UNBRP	Above Jennings Randolph Lake	GO-12-P2	197	--
UNBRP	Above Jennings Randolph Lake	GO-12-P4	197	--
UNBRP	Above Jennings Randolph Lake	GO-13-P1	66	--

Watershed	Stream segment	Mine seep or portal	Fe (lb/yr)	Al (lb/yr)
UNBRP	Above Jennings Randolph Lake	KZ-01-P10	329	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P13	66	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P14	987	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P15	66	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P16	33	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P3	1,374	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P4	1,374	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P6	1,374	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P7	197	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P8	33	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P9	33	--
UNBRP	Above Jennings Randolph Lake	KZ-01-S1	1,371	--
UNBRP	Above Jennings Randolph Lake	P-10-S1	211	--
UNBRP	Above Jennings Randolph Lake	P-13-P1	987	--
UNBRP	Above Jennings Randolph Lake	P-22-P1	1,374	--
UNBRP	Above Jennings Randolph Lake	P-22-P2	1,374	--
UNBRP	Above Jennings Randolph Lake	P-26-S1	9	--
UNBRP	Above Jennings Randolph Lake	P-29-S1	53	--
UNBRP	Above Jennings Randolph Lake	P-29-S2	53	--
UNBRP	Above Jennings Randolph Lake	P-29-S3	53	--
UNBRP	Above Jennings Randolph Lake	P-31-S1	316	--
UNBRP	Above Jennings Randolph Lake	P-35-S1	1,371	--
UNBRP	Above Jennings Randolph Lake	P-89-S1	1,371	--
UNBRP	Above Jennings Randolph Lake	P-88-P1	987	--
UNBRP	Above Jennings Randolph Lake	P-88-P2	1,374	--

6 Allocation Analysis

A TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody while still achieving water quality standards or goals. It is composed of the sum of individual wasteload allocations (WLAs) for point sources and LAs for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody, and may include a future allocation (FA) component. Conceptually, this definition is represented by the following equation:

$$\text{TMDL} = \Sigma WLAs + \Sigma LAs + MOS + FA$$

In TMDL development, allowable loadings from each pollutant source are summed to a cumulative TMDL threshold, thus providing a quantitative basis for establishing water quality-based controls. TMDLs can be expressed as a mass loading (e.g., grams of pollutant per year) or as a concentration, in accordance with 40 CFR 130.2(l). The state reserves the right to revise these allocations, provided that the allocations are consistent with the achievement of water quality standards.

6.1 TMDL Endpoints

TMDL endpoints represent the water quality targets used to quantify TMDLs and their individual components. The water quality criteria for metals are presented in Table 2-2.

6.2 Critical Conditions and Seasonal Variations

Federal regulations (40 CFR 130.7(c)(1)) require that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is vulnerable. Critical conditions are the set of environmental conditions, which, if met, will ensure the attainment of objectives for all other conditions. Nonpoint source loading is typically precipitation-driven. In-stream impacts tend to occur during wet-weather and storm events that cause surface runoff to carry pollutants to waterbodies. During dry periods, little or no land-based runoff occurs, and elevated in-stream pollutant levels could be due to point sources. Because of the presence of both point and nonpoint sources in the watershed, both high-flow and low-flow periods were taken into account during TMDL development. This was accomplished through dynamic model simulation (i.e., using the model to predict conditions over a long period of time that represents wet-, dry-, and average-flow periods).

The TMDL must also consider seasonal variation. MDAS model simulation for a multiyear period inherently accounts for seasonal variation. Continuous simulation represents both hydrologic and source loading variability seasonally. The constituent concentrations simulated on a daily time step by the model were compared to the TMDL endpoints. Allocations that met these endpoints throughout the modeling period were developed and are presented in Section 6.3.

6.3 TMDLs and Allocations

For the load reduction simulation (TMDL simulation), the model was run similar to the baseline condition described in Section 5.4. The TMDL simulation also included permit flows and permit limits included in the model instead of observed DMR flows and concentrations.

TMDLs and source allocations were developed on a subwatershed basis for each of the impaired reaches listed in Table 2-1. TMDL allocations include the LAs for nonpoint sources and the WLAs 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 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 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.

The WLA in this TMDL only applies to general and industrial permits for mining operations. A WLA for NPDES regulated stormwater has not been characterized as part of this analysis since the majority of the urban land use within the watershed constitutes unregulated stormwater runoff, and the Fe and Al loadings from the portion of the MDP urban land use that is considered regulated is relatively insignificant (see Section 3.1.7). Therefore, any Fe and Al loads associated with the regulated portion of the urban land use are included within the LA.

Sections 6.3.1, 6.3.2, and 6.3.3 describe WLAs, LAs, and the MOS and FA components, respectively. The model was run for the period of March 1, 2007, through February 29, 2008, which was determined to have a 12-month average flow closest to the overall average flow at USGS gages 0159500 and 0159550 on the mainstem of the North Branch Potomac River. This produced daily loads that were then summed to create the annual loads, which are presented in Table 6-1 and 6-2. The loadings reported in these tables are the edge of stream loadings for the contributing watershed area. These tables also present the percent reduction of each parameter between the baseline and TMDL loadings. Figure 6-1 presents a delineation of the allocation points contributing subwatersheds.

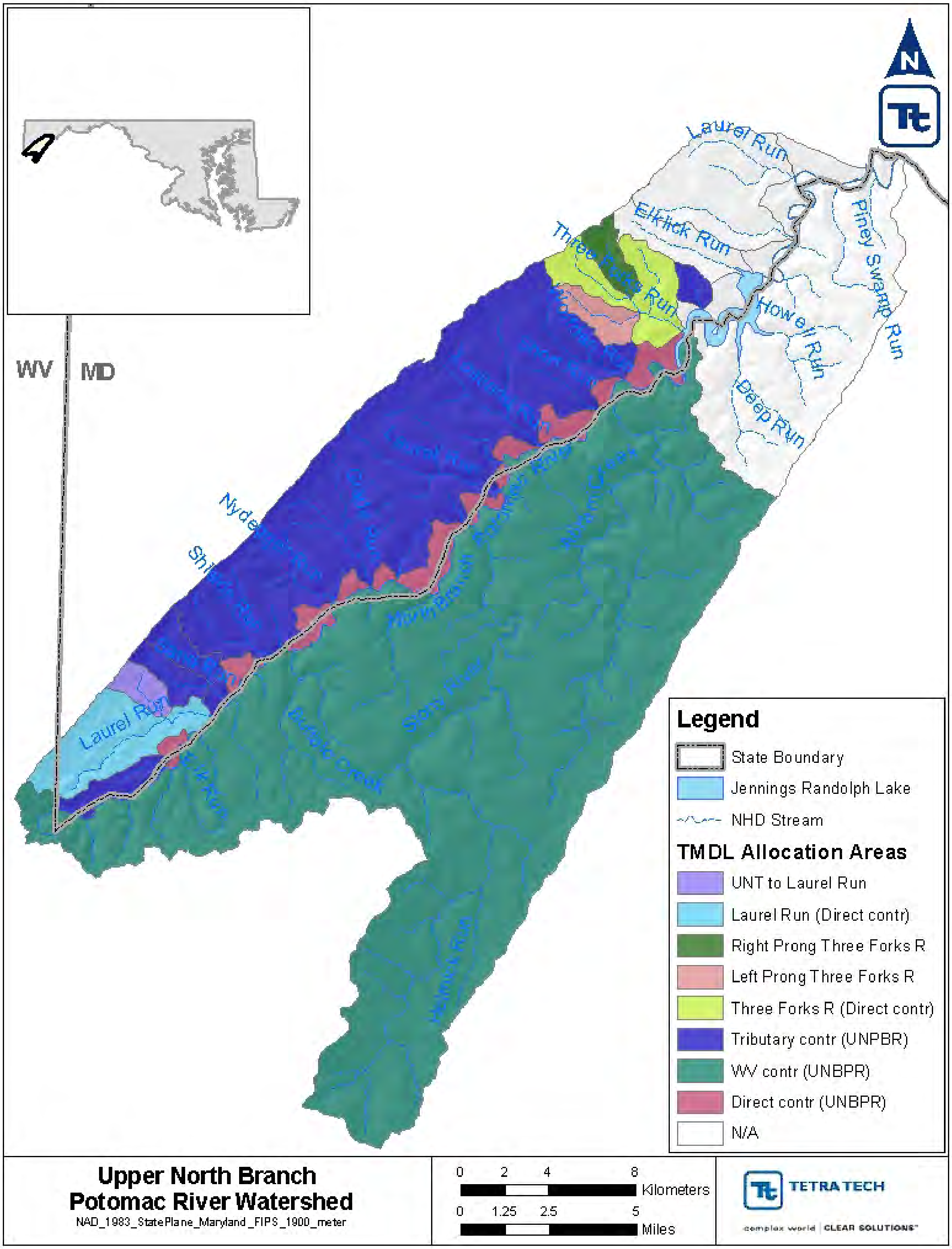

Figure 6-1. TMDL allocation areas

Table 6-1. Summary of Annual Fe TMDLs for Lower North Branch Potomac Watershed

Watershed	Allocation point	Load	Iron (lb/yr) Baseline	TMDL	% reduction
Laurel Run	Unnamed Tributary (UNT) to Laurel Run	NPS/LA	46,196	11,839	74.4
		PS/WLA	0	0	0.0
		MOS	--	696	--
		FA	--	1,393	--
		Total	46,196	13,929	69.8
	Direct contributions	NPS/LA	772,785	81,277	89.5
		PS/WLA	865	865	0.0
		MOS	--	4,832	--
		FA	--	9,664	--
		Total	773,650	96,637	87.5
	Entire watershed	**NPS/LA**	**818,980**	**93,116**	**88.6**
		PS/WLA	**865**	**865**	**0.0**
		MOS	**--**	**5,528**	**--**
		FA	**--**	**11,057**	**--**
		Total	**819,845**	**110,566**	**86.5**
Three Forks Run	Right Prong Three Forks Run	NPS/LA	33,154	2,818	91.5
		PS/WLA	0.46	0.46	0.0
		MOS	--	166	--
		FA	--	332	--
		Total	33,155	3,316	90.0
	Left Prong Three Forks Run	NPS/LA	37,625	21,747	42.2
		PS/WLA	0.00	0.00	0.0
		MOS	--	1,279	--
		FA	--	2,558	--
		Total	37,625	25,585	32.0
	Direct contributions	NPS/LA	339,464	57,816	83.0
		PS/WLA	0.23	0.23	0.0
		MOS	--	3,401	--
		FA	--	6,802	--
		Total	339,464	68,019	80.0
	Entire watershed	**NPS/LA**	**410,243**	**82,381**	**79.9**
		PS/WLA	**0.69**	**0.69**	**0.0**
		MOS	**--**	**4,846**	**--**
		FA	**--**	**9,692**	**--**
		Total	**410,243**	**96,919**	**76.4**

Watershed	Allocation point	Load	Iron (lb/yr) Baseline	TMDL	% reduction
Upper North Branch Potomac River upstream of Jennings Randolph Lake	Direct contributions	NPS/LA	47,910	40,723	15.0
		PS/WLA	0	0	0.0
		MOS	--	2,395	--
		FA	--	4,791	--
		Total	47,910	47,910	0.0
	Tributary contributions	NPS/LA	1,658,731	537,446	67.6
		PS/WLA	21,752	21,752	0.0
		MOS	--	32,894	--
		FA	--	65,788	--
		Total	1,680,483	657,880	60.9
	Entire MD portion	**NPS/LA**	**1,706,641**	**578,169**	**66.1**
		PS/WLA	**21,752**	**21,752**	**0.0**
		MOS	**--**	**35,289**	**--**
		FA	**--**	**70,579**	**--**
		Total	**1,728,393**	**705,789**	**59.2**
	Upstream Load from WV		2,146,595[a]	1,830,771[b]	14.7
	Entire watershed		**3,874,989**	**2,536,561**	**34.5**

[a] This baseline load represents a conversion of delivered loads, as calculated in the West Virginia TMDL, into edge-of-stream loads that are comparable to those derived for Maryland in this TMDL. The West Virginia baseline load also includes contributions from West Virginia subwatersheds for which no TMDLs have been developed. (See Appendix C for details.)
[b] Upstream load allocation to West Virginia determined as necessary to meet water quality standards in the Maryland portion of the watershed.

One way to express loads is through load duration curves. Figure 6-2 is an example of a curve for Fe for Three Forks Run. Points at the lower end of the curve plot (0 through 10 percent) represent high-flow conditions where only 0 through 10 percent of the flow exceeds the plotted point. Conversely, points on the high end of the plot (90 to 100 percent) represent low-flow conditions. The load duration curve shows the calculation of the TMDL at any flow rather than at a single, critical flow. The official TMDL number is reported as a single number, but the curve is provided to demonstrate the value of the acceptable load at any flow. Tables 6-3 and 6-4 present the maximum daily load by flow percentile range for Al and Fe. The loadings reported in these tables are the edge of stream loadings for the contributing watershed area. Appendix F presents additional daily statistics and load duration curves by flow percentile range for each segment.

Table 6-2. Summary of Annual Al TMDLs for Lower North Branch Potomac Watershed

Watershed	Allocation point	Load	Aluminum (lb/yr) Baseline	TMDL	% reduction
Laurel Run	Unnamed Tributary (UNT) to Laurel Run	NPS/LA	41,792	1,927	95.4
		PS/WLA	0	0	0.0
		MOS	--	113	--
		FA	--	227	--
		Total	41,792	2,267	94.6
	Direct contributions	NPS/LA	331,672	98,281	70.4
		PS/WLA	0	0	0.0
		MOS	--	5,781	--
		FA	--	11,563	--
		Total	331,672	115,625	65.1
	Entire watershed	**NPS/LA**	**373,464**	**100,209**	**73.2**
		PS/WLA	**0**	**0**	**0.0**
		MOS	**--**	**5,895**	**--**
		FA	**--**	**11,789**	**--**
		Total	**373,464**	**117,893**	**68.4**
Three Forks Run	Right Prong Three Forks Run	NPS/LA	26,903	3,280	87.8
		PS/WLA	0	0	0.0
		MOS	--	193	--
		FA	--	386	--
		Total	26,903	3,858	85.7
	Left Prong Three Forks Run	NPS/LA	12,315	1,576	87.2
		PS/WLA	0	0	0.0
		MOS	--	93	--
		FA	--	185	--
		Total	12,315	1,854	84.9
	Direct contributions	NPS/LA	259,329	22,443	91.3
		PS/WLA	0	0	0.0
		MOS	--	1,320	--
		FA	--	2,640	--
		Total	259,329	26,404	89.8
	Entire watershed	**NPS/LA**	**298,547**	**27,299**	**90.9**
		PS/WLA	**0**	**0**	**0.0**
		MOS	**--**	**1,606**	**--**
		FA	**--**	**3,212**	**--**
		Total	**298,547**	**32,116**	**89.2**

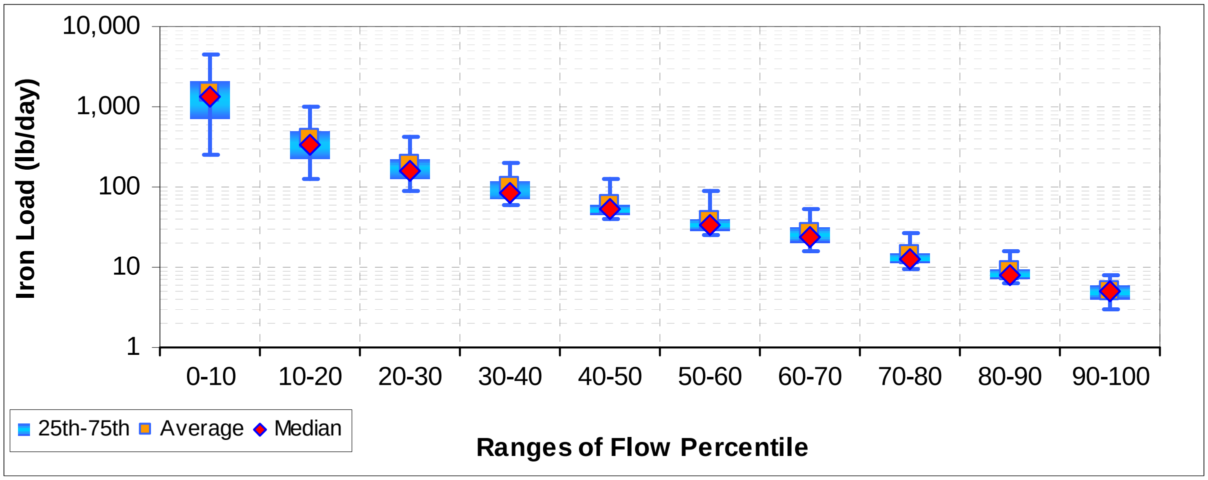

Figure 6-2. Fe loads by flow percentile for Three Forks Run (entire watershed)

Table 6-3. TMDL maximum daily Al loads by flow percentile range (lb/d)

Watershed	Allocation point	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
	UNT to Laurel Run	44.69	13.27	9.56	6.19	4.44	3.39	2.37	1.94	1.54	1.26
	Direct contributions	4,952.77	507.07	635.09	352.02	316.75	143.55	118.29	74.00	65.65	47.75
Laurel Run	Entire watershed	4,995.85	520.19	638.51	355.83	320.15	145.85	120.11	86.83	66.86	48.88
	Right Prong Three Forks Run	158.70	34.16	23.00	23.70	13.33	9.56	5.99	2.05	0.73	0.22
	Left Prong Three Forks Run	80.06	14.77	11.37	5.30	5.92	3.11	1.97	0.90	0.44	0.10
	Direct contributions	1,332.86	236.82	136.87	89.47	43.28	17.61	10.97	5.34	4.31	1.74
Three Forks Run	Entire watershed[a]	1,571.62	274.12	165.22	64.33	47.24	30.15	16.87	7.91	3.92	1.37

Table 6-4. TMDL maximum daily Fe loads by flow percentile range (lb/d)

Watershed	Allocation point	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
	UNT to Laurel Run	180.77	89.91	72.64	48.40	34.70	24.35	18.94	14.99	11.97	10.20
	Direct contributions	4,800.84	436.48	622.67	348.79	285.85	112.45	116.60	69.50	62.76	47.07
Laurel Run	Entire watershed	4,981.62	525.04	639.66	374.91	306.89	134.47	130.62	89.91	72.41	55.97
	Right Prong Three Forks Run	130.33	31.42	21.17	21.16	12.32	9.17	5.80	2.00	0.66	0.23
	Left Prong Three Forks Run	664.68	188.41	105.70	64.51	51.21	35.50	24.26	12.72	8.76	5.07
	Direct contributions	3,584.05	877.58	333.59	257.10	122.27	56.64	34.72	21.47	5.87	2.74
Three Forks Run	Entire watershed	4,345.55	1,028.83	421.97	203.61	129.02	90.49	52.81	27.12	15.86	8.09
	WV contributions	35,367	21,945	14,012	10,405	7,516	3,824	3,845	2,781	2,266	1,998
	Direct contributions	1,410	390	218	270	127	103	70	52	30	14
	Tributary contributions	22,265	5,462	2,914	2,700	1,366	1,153	557	507	205	136
UNBPR	Entire watershed	66,040	35,632	22,993	13,524	9,226	4,735	5,135	3,101	2,488	2,151

6.3.1 Wasteload Allocations

Federal regulations (40 CFR 130.7) require that TMDLs include individual WLAs for each point source. On the basis of the types of activities and the minimal flow of the discharges, these permitted non-mining sources are believed to be negligible. Under these TMDLs, minor discharges are assumed to operate under their current permit limits and are assigned WLAs that allow them to discharge at their current permit limits. Table 6-5 presents the WLAs for each point source. It was assumed that if a parameter limit was not in the permit, the present discharge levels were not adversely affecting the stream.

Table 6-5. WLAs for permitted facilities upstream of impaired segments

NPDES permit number	Permittee	Outlet	Water-shed	Allocation point	Baseline iron (lb/yr)	TMDL iron (lb/yr)	Baseline iron (lb/d)	TMDL iron (lb/d)	% reduction iron
MD0055182	Mettiki Coal, LLC Oakland	001	Laurel Run	UNT to Laurel Run	--	--	--	--	--
		002	Sand Run	South Fork	17,141	17,141	46.96	46.96	0
		003	Sand Run	South Fork	1,007	1,007	2.758	2.758	0
		005	Sand Run	South Fork	--	--	--	--	--
		006	Sand Run	South Fork	--	--	--	--	--
		007	Laurel Run	UNT to Laurel Run	--	--	--	--	--
		008	Sand Run	South Fork	583	583	1.596	1.596	0
		009	Sand Run	South Fork	603	603	1.651	1.651	0
		010	Sand Run	North Fork	--	--	--	--	--
		012	Laurel Run	Direct contributions	865	865	2.370	2.370	0
MD0060933	Bloomington WWTP	001	UNBPR	Direct contributions	--	--	--	--	--
MD0060941	Town Of Kitzmiller WWTP	001	UNBPR	Direct contributions	--	--	--	--	--
MD0060950	Gorman WWTP	001	UNBPR	Direct contributions	--	--	--	--	--
MD0068811	Backbone Mountain, LLC-Mine#1 Oakland	001	UNBPR	Tributary contributions	1,501	1,501	4.111	4.111	0
		002	UNBPR	Tributary contributions	5.74	5.74	0.01572	0.01572	0
MDG851722	Buffalo Coal Company - Kempton Job Oakland	001	UNBPR	Tributary contributions	9.14	9.14	0.02504	0.02504	0
		004	UNBPR	Tributary contributions	9.14	9.14	0.02504	0.02504	0
		005	UNBPR	Tributary contributions	9.14	9.14	0.02504	0.02504	0
MDG852173	Wolf Run Mining Company - Steyer Deep Mine	002	UNBPR	Direct contributions	--	--	--	--	--
MDG852905	G & S Coal Company-Manor Hill Mine Swanton	001	UNBPR	Tributary contributions	1.83	1.83	0.00501	0.00501	0
		002	UNBPR	Tributary contributions	1.83	1.83	0.00501	0.00501	0
		003	UNBPR	Tributary contributions	1.83	1.83	0.00501	0.00501	0
		004	UNBPR	Tributary contributions	1.83	1.83	0.00501	0.00501	0

NPDES permit number	Permittee	Outlet	Water-shed	Allocation point	Baseline iron (lb/yr)	TMDL iron (lb/yr)	Baseline iron (lb/d)	TMDL iron (lb/d)	% reduction iron
MDG859602	Mettiki Coal Corp. - C-Mine		UNBPR	Tributary contributions	9.14	9.14	0.02504	0.02504	0
MDG859605	Patriot Mining Co. – Vindex/ Douglas Mine	001	UNBPR	Tributary contributions	0.91	0.91	0.00250	0.00250	0
MDG859613	Vindex Energy Corporation - Island Tract Mine	001	Three Forks Run	Right Prong	0.46	0.46	0.00125	0.00125	0
		002	Three Forks Run	Direct contributions	0.23	0.23	0.00063	0.00063	0
		003	Three Forks Run	Direct contributions	--	--	--	--	--
		004	Three Forks Run	Direct contributions	--	--	--	--	--
MDG859615	LAOC Corporation - Paugh Tract Mine	001	UNBPR	Tributary contributions	--	--	--	--	--
MDG859622	Wpo Inc. - Table Rock Mine	001	UNBPR	Tributary contributions	1.83	1.83	0.00501	0.00501	0

6.3.2 Load Allocations

The LA is that portion of the TMDL that is assigned to nonpoint sources. LAs were first applied to loads from known mining seeps, and portals were reduced. If further reductions were required, the loads from other nonpoint sources were reduced. These loads were applied to the whole watershed and not a specific nonpoint source or land use.

Table 6-6 presents total annual LAs at the monitoring locations as the stream leaves the watershed. The loads in Table 6-6 include background concentration and are the edge of stream loadings for the contributing watershed area. These loads also include loads from mine seeps, which are presented in Table 6-7. These loads represent a 99 percent reduction in flow and pollutant concentration levels for the mine seeps.

Table 6-6. LAs for Fe and Al

Watershed	Allocation point	Fe (lb/yr)	Al (lb/yr)
Laurel Run	UNT to Laurel Run	11,839	1,927
	Direct contributions	81,277	98,281
	Entire watershed	**93,116**	**100,209**
Three Forks Run	Right Prong Three Forks Run	2,818	3,280
	Left Prong Three Forks Run	21,747	1,576
	Direct contributions	57,816	22,443
	Entire watershed	**82,381**	**27,299**
UNBPR	WV contributions	84,337	--
	Direct contributions	40,723	--
	Tributary contributions	537,446	--
	Entire watershed	**662,507**	--

Table 6-7. Yearly loads from mine seeps and portals

Watershed	Stream segment	Mine seep or portal	Fe (lb/yr)	Al (lb/yr)	Fe (lb/d)	Al (lb/d)
Laurel Run	Entire watershed	P-03-S1	13.71	2.80	0.0376	0.0077
Three Forks Run	Entire watershed	P-54-P1	13.74	10.99	0.0376	0.0301
UNBRP	Above Jennings Randolph Lake	GO-01-P1	1.97	--	0.0054	--
UNBRP	Above Jennings Randolph Lake	GO-01-P2	3.29	--	0.0090	--
UNBRP	Above Jennings Randolph Lake	GO-01-P3	3.29	--	0.0090	--
UNBRP	Above Jennings Randolph Lake	GO-01-P4	0.33	--	0.0009	--
UNBRP	Above Jennings Randolph Lake	GO-01-P5	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	GO-01-P7	26.32	--	0.0721	--
UNBRP	Above Jennings Randolph Lake	GO-01-P8	3.29	--	0.0090	--
UNBRP	Above Jennings Randolph Lake	GO-01-P9	0.33	--	0.0009	--
UNBRP	Above Jennings Randolph Lake	GO-01-S1	15.79	--	0.0433	--
UNBRP	Above Jennings Randolph Lake	GO-02-P1	1.32	--	0.0036	--
UNBRP	Above Jennings Randolph Lake	GO-02-P2	13.74	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	GO-03-P3	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	GO-03-P6	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	GO-03-P7	1.97	--	0.0054	--
UNBRP	Above Jennings Randolph Lake	GO-04-P1	1.32	--	0.0036	--
UNBRP	Above Jennings Randolph Lake	GO-04-P2	0.33	--	0.0009	--
UNBRP	Above Jennings Randolph Lake	GO-04-P4	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	GO-04-P6	6.58	--	0.0180	--
UNBRP	Above Jennings Randolph Lake	GO-04-P7	3.66	--	0.0100	--
UNBRP	Above Jennings Randolph Lake	GO-04-P8	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	GO-05-P1	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	GO-08-S1	13.71	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	GO-09-P1	0.33	--	0.0009	--
UNBRP	Above Jennings Randolph Lake	GO-09-P2	4.61	--	0.0126	--
UNBRP	Above Jennings Randolph Lake	GO-12-P1	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	GO-12-P2	1.97	--	0.0054	--
UNBRP	Above Jennings Randolph Lake	GO-12-P4	1.97	--	0.0054	--
UNBRP	Above Jennings Randolph Lake	GO-13-P1	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P10	3.29	--	0.0090	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P13	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P14	9.87	--	0.0270	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P15	0.66	--	0.0018	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P16	0.33	--	0.0009	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P3	13.74	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P4	13.74	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P6	13.74	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P7	1.97	--	0.0054	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P8	0.33	--	0.0009	--
UNBRP	Above Jennings Randolph Lake	KZ-01-P9	0.33	--	0.0009	--
UNBRP	Above Jennings Randolph Lake	KZ-01-S1	13.71	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	P-10-S1	2.11	--	0.0058	--
UNBRP	Above Jennings Randolph Lake	P-13-P1	9.87	--	0.0270	--
UNBRP	Above Jennings Randolph Lake	P-22-P1	13.74	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	P-22-P2	13.74	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	P-26-S1	0.09	--	0.0002	--

Watershed	Stream segment	Mine seep or portal	Fe (lb/yr)	Al (lb/yr)	Fe (lb/d)	Al (lb/d)
UNBRP	Above Jennings Randolph Lake	P-29-S1	0.53	--	0.0014	--
UNBRP	Above Jennings Randolph Lake	P-29-S2	0.53	--	0.0014	--
UNBRP	Above Jennings Randolph Lake	P-29-S3	0.53	--	0.0014	--
UNBRP	Above Jennings Randolph Lake	P-31-S1	3.16	--	0.0087	--
UNBRP	Above Jennings Randolph Lake	P-35-S1	13.71	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	P-89-S1	13.71	--	0.0376	--
UNBRP	Above Jennings Randolph Lake	P-88-P1	9.87	--	0.0270	--
UNBRP	Above Jennings Randolph Lake	P-88-P2	13.74	--	0.0376	--

6.3.3 Margin of Safety and Future Allocation

The MOS is the portion of the pollutant loading reserved to account for uncertainty in the TMDL development process. There are two ways to incorporate the MOS (USEPA 1991): (1) implicitly by using conservative model assumptions to develop allocations, or (2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For this TMDL, a 5 percent explicit MOS was used to account for uncertainty in the modeling process. The MOS loadings are presented in Tables 6-1 and 6-2.

While the MOS is an allocation for scientific uncertainly, the FA is an allocation for growth. Ten percent of the load was allocated for FA in the area covered by the TMDL. This growth includes future urban developments, including point sources, coal mining areas, agriculture, and other nonpoint sources. The FA could also be used for sources not accounted for or unknown and, therefore, not otherwise included in the TMDL. The FA loadings are presented in Tables 6-1 and 6-2.

6.3.4 Loadings from West Virginia

As described in Appendix C, loads from previous West Virginia Fe TMDLs were included in the model. No reductions to these established TMDLs were made. Table 6-1 presents the established Fe TMDLs for portions of the watershed. The entire upstream West Virginia portion of the watershed is allocated 1,830,771 lb/yr (5,015.8 lb/d) and represents upstream loadings.

7 REASONABLE ASSURANCE

Section 303(d) of the CWA and EPA regulations require reasonable assurance that TMDLs will be implemented. TMDLs quantify the pollutant load that can be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Upper North Branch Potomac River 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 remediation of AMD and implementing the CAIR, which will reduce acid deposition and therefore metals released into the environment.

The Surface Mining Control and Reclamation Act of 1977 (SMCRA, Public Law 95-87) and its subsequent revisions were enacted to establish a nationwide program to protect the beneficial uses of land and water resources, protect public health and safety from the adverse effects of current surface coal mining operations, and promote the reclamation of mined areas left without adequate reclamation before August 3, 1977. The SMCRA requires a permit for developing new, previously mined, or abandoned sites for the purpose of surface mining. Permittees are required to post a performance bond that will be sufficient to ensure the completion of reclamation requirements by a regulatory authority if the applicant forfeits its permit. Mines that ceased operations before the effective date of SMCRA (often called *pre-law* mines) are not subject to the requirements of SMCRA.

The Maryland Bureau of Mines (BOM) is responsible for protecting the environment from potential impacts from active mining and promoting the restoration of AMLs and water resources. In issuing new or updated permits in the TMDL area, BOM will ensure that permit limits will not adversely affect the pH in impaired waters. BOM also reclaims AMLs. These lands are prioritized on the basis of health, safety, and environmental impacts. Within the BOM, the Acid Mine Drainage Abatement Section’s mission is to improve the state’s waters that are impaired by AMD from abandoned coal mines. This is an ongoing process that is limited by the amount of funding available and can be aided by partnerships with industries, watershed groups, other government agencies, and other interested parties.

The West Virginia Department of Environmental Protection (WVDEP) has developed two TMDLs for metals impairments in the West Virginia portion of the Upper North Branch Potomac River basin. Reasonable assurance for maintenance and improvement of water quality in the affected watershed rests primarily with three separate programs. Two of these programs are wholly within WVDEP, and the third program is a cooperative effort involving many state and federal agencies. Within WVDEP, the programs involved in the effort include the NPDES Permitting Program and the Abandoned Mine Lands Program. In addition, WVDEP is involved with the West Virginia Watershed Management Network/Watershed Management Framework, which includes many state and federal agencies dealing with the protection and restoration of water resources. The framework process allows the resources of many entities to focus on the protection or restoration of water quality in selected streams.

Individuals or local watershed groups interested in improving conditions in the watersheds are strongly encouraged to review funding sources available through MDE and other state and federal agencies. Numerous state programs, including CWA section 319 programs, are available. Other Maryland programs include the Small Creeks and Estuaries Restoration Program and the State Revolving Loan Fund. For more information, see http://www.mde.state.md.us/AboutMDE/grants/index.asp (MDE 2006a).

There are several installed and operating AMD treatment systems in the western Maryland watersheds, as well as pending systems that are being designed and planned for construction in the next few years (Table 7-1).

Table 7-1. AMD treatment systems installed or pending installation in western Maryland watersheds

Treatment type	System designation	Design	Year operational
Active	Kitzmiller	Aquafix waterwheel doser	1993
Active	Gorman	Pumpkonsult slurry doser	1994
Active	Laurel Run	Pumpkonsult slurry doser	1994
Active	Lost Land Run	Boxholm bucket doser	1994
Passive	Elk Lick I	Ald / wetland	1995
Active	Vindex	Aquafix waterwheel doser	1996
Passive	Elk Lick II	Saps / steel slag / wetlands	1999
Active	Kempton Air Shaft	Aquafix waterwheel doser	2000
Passive	Elk Lick III	Saps / wetlands	2001
Active	Shallmar	Aquafix waterwheel doser	2006

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