Final Report

Metals and pH TMDLs for the Stony River Watershed, West Virginia

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1.0 Problem Understanding

The Stony River is in northeastern West Virginia in the Appalachian Plateau physiographic province. The drainage area of the Stony River watershed is approximately 58.8 square miles (37,653 acres), as shown in Figure 1-1. From its headwaters at the Tucker and Grant county line, the Stony River flows in a generally northerly direction through Grant County for approximately 18 miles to its confluence with the North Branch of the Potomac River at the West Virginia and Maryland state line. Two reservoirs are located in the Stony River watershed. Stony River Reservoir (about 430 acres), in the headwaters portion of the watershed, is owned by Westvaco Corporation. Mount Storm Lake (about 1,150 acres) is further downstream and is operated by Dominion Virginia Power Company.

The watershed is almost entirely in Grant County and contains active surface and deep mining operations. The watershed is rural; the only town, Mount Storm, is in the lower part of the basin.

Six segments of the Stony River have been included on West Virginia's 1996 and 1998 Section 303(d) list due to metals, pH, and/or ammonia impairments (see Table 1-1, Figure 1-2). These listed waterbodies include two segments of the main stem of the Stony River and four additional stream segments in the watershed. The metals (total iron, aluminum, and manganese), pH, and/or ammonia impairments have been attributed to acid mine drainage (AMD) and possible acid mine drainage treatment. Before the implementation of the West Virginia Surface Coal Mining and Reclamation Act (WVSCMRA) and the Surface Mining Control and Reclamation Act (SMCRA), little consideration was given to the environmental degradation that resulted from these activities. Currently, the quality of the Stony River and its tributaries are being negatively affected by acidic drainage from mines that were abandoned before the WVSCMRA and SMRCA.

AMD occurs when surface and subsurface water percolates through coal-bearing minerals containing high concentrations of pyrite and marcasite, which are crystalline forms of iron sulfide (FeS_2). It is the chemical reactions of the pyrite that generate acidity 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 (Fe^{2+}) and hydrogen (H^+) ions. It is these H^+ ions that cause the acidity.
- The intermediate reaction with the dissolved Fe^{2+} ions generates a precipitate, ferric hydroxide [$Fe(OH)_3$], and releases H^+ ions, thereby causing more acidity.
- A third reaction occurs between the pyrite and the generated ferric (Fe^{3+}) ions contained in the ferric hydroxide precipitate, where more hydrogen ions (increasing acidity) are released as well as Fe^{2+} ions, which enter the reaction cycle.

The EPA's *Water Quality Planning and Management Regulations* (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waters that are exceeding water quality standards. The objective of this study was to develop TMDLs for the impaired waterbodies in the Stony River watershed.

This report presents pH and metals TMDLs for each of the six impaired stream segments in the Stony

River watershed. Evaluation of recent and historical data has shown that the un-ionized ammonia impairment in the Stony River no longer exists and TMDL development for that pollutant is not necessary. These impairment will be addressed in the development of the West Virginia 2002 Section 303(d) List. Additional information regarding the un-ionized ammonia impairment is provided in Appendix E.

To develop the TMDLs and other pertinent watershed and waterbody information, the watershed was divided into two regions (Figure 1-2). These regions represent hydrologic units. Each region was further divided into subwatersheds (24 total for the entire Stony River watershed) for modeling purposes. The two regions and their respective subwatersheds provide a good basis for georeferencing pertinent source information and monitoring data, and presenting TMDLs. This information is presented in Appendices A-1 and A-2 of this report. The information in Appendix A-1 and A-2 corresponds to regions 1 and 2, respectively.

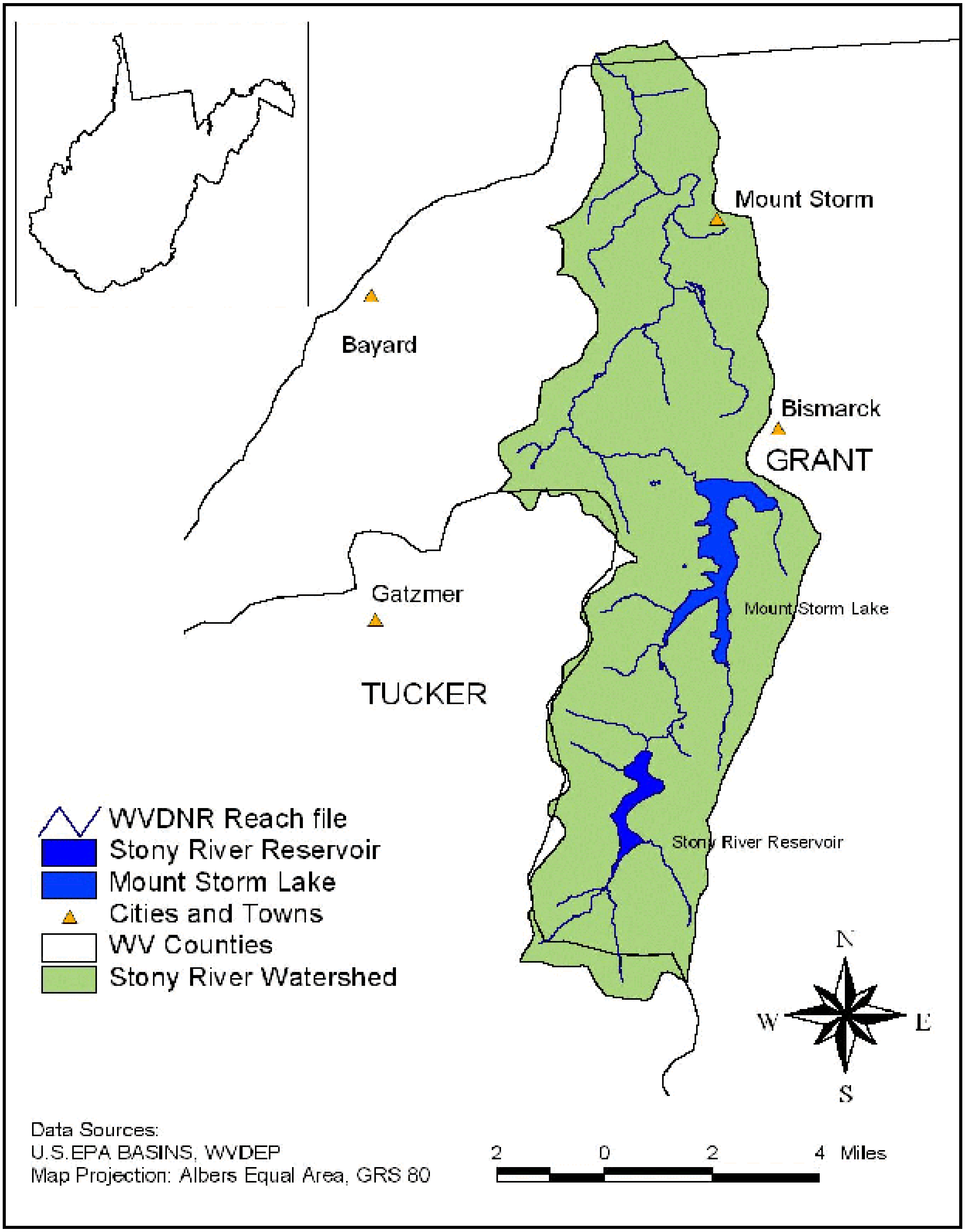

Figure 1-1. Location of the Stony River watershed

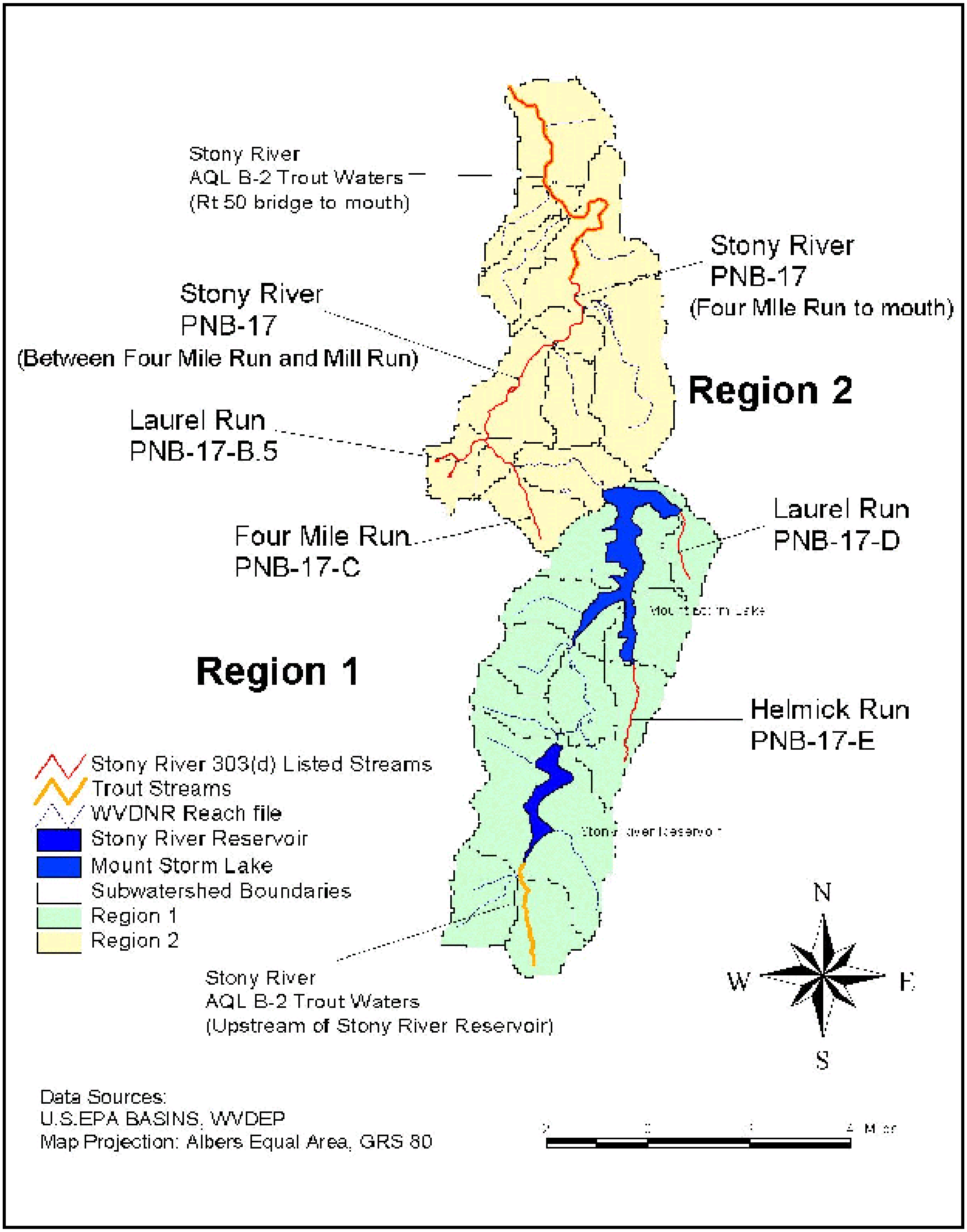

Figure 1-2. Stony River watershed and its two regions

Table 1-1. Section 303(d) listed waterbodies and corresponding information

Stream Name	Stream Code	Miles Affected	Use Affected	Pollutant(s) of Concern	Source	Year[a]
Stony River	PNB-17	4.69	Aquatic Life (B1)	pH, Un-ionized Ammonia	Mine Drainage	1998
Stony River	PNB-17	11.87	Aquatic Life (B1, B2)[b]	Metals	Mine Drainage	1998
Laurel Run	PNB-17-B.5	1.42	Aquatic Life (B1)	pH	Mine Drainage	1998
Fourmile Run	PNB-17-C	1.52	Aquatic Life (B1)	pH, Metals	Mine Drainage	1998
Laurel Run	PNB-17-D	1.37	Aquatic Life (B1)	pH, Metals	Mine Drainage	1998
Helmick Run	PNB-17-E	0.95	Aquatic Life (B1)	pH, Metals	Mine Drainage	1998

[a] - Stony River was listed as a single segment on the 1996 303(d) list.

[b] - Stony River (from Route 50 bridge to mouth) has been designated as having an Aquatic Life use of B-2 - Propagation and maintenance of fish and other aquatic life, trout fishery stream.

2.0 Water Quality Standards

West Virginia's Requirements Governing Water Quality Standards (WV WQS, 2000) have defined water quality criteria for surface waters as a numeric constituent concentration or a narrative statement representing a quality of water that supports a designated use or uses of the waterbody. Total aluminum, iron, manganese, ammonia and pH are given numeric criteria under the Aquatic Life use designation categories (Table 2-1). All listed waterbodies in the Stony River watershed have been designated as having a Human Health use and an Aquatic Life use of Category B1-Propagation and maintenance of fish and other aquatic life, warm water fishery stream. The lower portion of theStony River (from the Route 50 bridge to mouth) has been designated as a Category B2-Propagation and maintenance of fish and other aquatic life, trout fishery stream (WVDEP, 1996 and 1998).

Table 2-1. Water quality standards applicable the Stony River watershed.

POLLUTANT	USE DESIGNATION				
	Aquatic Life				Human Health
	B1, B4		B2		A[c]
	Acute [a]	Chronic [b]	Acute [a]	Chronic [b]	
Aluminum, Total (µg/L)	750	-	750	-	-
Iron, Total (mg/L)	-	1.5	-	0.5	1.5
Manganese, Total (mg/L)	-	-	-	-	1.0
Unionized Ammonia (ug/L)[d]	50	50	50	50	
pH	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0

Note: B1 = warm water fishery streams, B4 = wetlands, B2 = trout waters, A = public water supply
[a] One hour average concentration not to be exceeded more than once every 3 years on average.
[b] Four-day average concentration not to be exceeded more than once every 3 years on average.
[c] Not to exceed.
[d] Unionized ammonia = (1.2*total ammonia-N)/(1+10$^{(pka-pH)}$) where pka=0.0902+2730(273.2+T) and T=temperature in degrees Celcius (°C).
Source: WVWQS, 1999.

3.0 Source Assessment

This section examines and identifies the potential sources of aluminum, ammonia, iron, and manganese in the Stony River watershed. The following sections identify potential sources and to characterize the relationship between point and nonpoint source discharges and in-stream response at monitoring stations.

3.1 Data Inventory

A wide range of data and information were used in the development of these TMDLs. The categories of data used include physiographic data that describe the physical conditions of the watershed, environmental monitoring data that identify potential pollutant sources and their contribution, and in-stream water quality monitoring data. Additional water quality monitoring data gathered by non-governmental groups were obtained through the West Virginia Department of Environmental Protection (WVDEP). Table 3-1 shows the various data types and data sources used in these TMDLs.

Table 3-1. Inventory of data and information used to develop the Stony watershed TMDLs

Data Category	Description	Data Source(s)
Watershed Physiographic Data	Land Use (Gap 2000)	USGS
	Abandoned Mining Coverage	WVDEP OMR
	Stream Reach Coverage	USGS, WVDEP, WVDNR
	Weather Information	National Climatic Data Center
Environmental Monitoring Data	Daily Mean Discharge Data	USGS
	NPDES Data	WVDEP OMR, PCS
	Discharge Monitoring Report Data	WVDEP
	Abandoned Mine Loading Data	WVDEP OMR
	303(d) Listed Water Bodies	WVDEP
	Water Quality Monitoring Data	EPA STORET, WVDEP OWR
	Article 3 In-stream monitoring data	WVDEP OWR, WVDEP OMR
	Historical Mining Maps	WV Geological and Economic Survey

3.2 Stream Flow Data

There is one U.S.Geological Survey (USGS) flow gage in the Stony River watershed, station 01595200. Flow data from this station were used to support flow analysis for the watershed. Table 3-2 presents a summary of the flow data available for this location.

Table 3-2. Summary of flow data available for USGS station 01595200

Station	Location	Start Date	End Date	Flow (cfs)		
				Min	Mean	Max
01595200	Stony R Near Mount Storm, WV	10/1/61	9/30/00	1.3	97.8	9,880

3.3 Point Source Data

To characterize the contributing point sources in the Stony River watershed, the point sources were classified into two major categories: permitted nonmining point sources and permitted mining point sources.

3.3.1 Permitted Nonmining Point Sources

Data regarding nonmining point sources were retrieved from EPA's Permit Compliance System (PCS) and WVDEP. There are nine nonmining point sources in the Stony River watershed, and none of the facilities have metal or ammonia limits in their permits. The nonmining permitted facilities are shown in Table 3-3.

Table 3-3. Nonmining permitted facilities located in the Stony River watershed

NPDES Permit	Facility Name	Issue date	Expire Date	Facility Type	Status	Permit Type
WVG550455	Mount Storm Village	1993/12/24	2003/12/03	Sewage General	Renewed	Sewage
WVG550690	Union Educational	1994/06/14	2003/12/03	Sewage General	Renewed	Sewage
WVG550793	Mount Storm Ind. Park	1995/11/10	2003/12/03	Sewage General	Renewed	Sewage
WVG610172	Allegheny Wood Products #2	1993/11/01	2004/02/10	Storm Water Industrial (Gp)	Renewed	Industrial
WV0005525	Mount Storm Power Station	1997/10/21	2001/10/20	Individual	Renewed	Industrial
WV0074934	Water Treatment Plant, Mountain Top PSD	1992/10/27	1997/10/26	Individual	Extended	Industrial
WV0110256	Life of Station Ash Disposal	1994/07/29	1999/07/28	Solid Waste Landfill	Extended	Industrial
WV0077461	Flyash Disposal	2000/06/26	2005/06/25	Solid Waste Landfill	New	Industrial

3.3.2 Permitted Mining Point Sources

Untreated mining related point source discharges from deep, surface, and other mines typically have low pH values and contain high concentrations of metals (iron, aluminum, and manganese). Consequently, mining related activities are commonly issued discharge permits for these parameters. A spatial coverage of the mining permit data was provided by West Virginia's Office of Mining and Reclamation (OMR). The coverage includes both active and inactive mining facilities, which are classified by type of mine and facility status. The mines are classified into eight different categories: coal surface mine, coal underground mine, haulroad, coal preparation plant, coal reprocessing, prospective mine, quarry, and other. The haulroad and prospective mine categories represent mining access roads and potential coal mining areas, respectively. The permits were also classified into seven categories describing the status of each permitted discharge. OMR provided a brief description regarding classification and associated potential impact on water quality. Mining types and status descriptions are shown in Table 3-4.

Table 3-4. Classification of mining permit type and status

Type of Mining	Status Code	Description
- Coal Surface Mine - Coal Underground Mine - Haulroad - Coal Preparation Plant - Coal Reprocessing - Prospective Mine - Quarry - Other	Completely Released	Completely reclaimed, revegetated; should not be any associated water quality problems
	Phase II Released	Sediment and ponding are gone, partially revegetated, very little water quality impact
	Phase I Released	Regraded and reseeded: initial phase of the reclamation process; could potentially impact water quality
	Renewed	Active mining facility, assumed to be discharging according to the permit limits
	New	Newly issued permit; could be currently active or inactive; assumed to be discharging according to permit limits
	Inactive	Currently inactive; could become active anytime; assumed to be discharging according to discharge limits
	Revoked	Bond forfeited; forfeiture may be caused by poor water quality; highest impact to water quality

Coal mining operations typically have permits for concentrations of total iron, total manganese, total nonfilterable solids, and pH. They are also required to list total aluminum discharges. There are a total of 24 mining discharge permits in the Stony River watershed, 18 of which are active. A complete listing of mining permits in the Stony River watershed is provided in Appendix B.

3.4 Nonpoint Sources

Acid mine drainage (AMD) typically produces low pH and high metals concentrations in surface and subsurface water in areas where mining activities are or once were present. A number of abandoned mining activities have been identified in the Stony River watershed. Because these activities can contribute significant amounts of AMD, nonpoint source contributions were grouped for assessment into two separate categories: abandoned mine lands (AML) and other nonpoint sources. Figure 3-1 presents a schematic of the potential sources in the Stony River watershed.

3.4.1 Abandoned Mine Lands (AML)

Historical surface and deep mining activities in the Stony River watershed have resulted in several AML sites producing AMD flows (WVDEP, 1985). Data regarding AML sites in the Stony watershed were compiled from spatial coverages provided by OMR and the *West Virginia Acid Mine Drainage Study in the North Branch Potomac River Basin* (WVDNR, 1974). The AML sites were classified into three categories:

1. High walls: unexcavated face of exposed overburden and coal from surface and underground mining activities.
2. Disturbed land: disturbed land from both surface and underground mining activities.
3. Abandoned mines: abandoned surface and underground mines.

Additional qualitative data were retrieved from OMR Problem Area Data Sheets (PADS). Information regarding the locations of the most critical sources, abandoned mines, is presented in Table 2 in Appendices A-1 and A-2.

3.4.2 Other Nonpoint Sources

The predominant land uses in the Stony River watershed were identified based on the USGS's GAP2000 land use data (representative of the mid-1990s). According to the GAP2000 data, the major land uses in the watershed are forest land, which constitutes approximately 66 percent of the watershed area and agricultural land, which makes up 13 percent of the watershed area. In addition to forest land and agricultural land uses, other land uses that might contribute nonpoint source metals loads to the receiving streams include barren and urban land. The land use distribution for the Stony River watershed is presented in Figure 3-2.

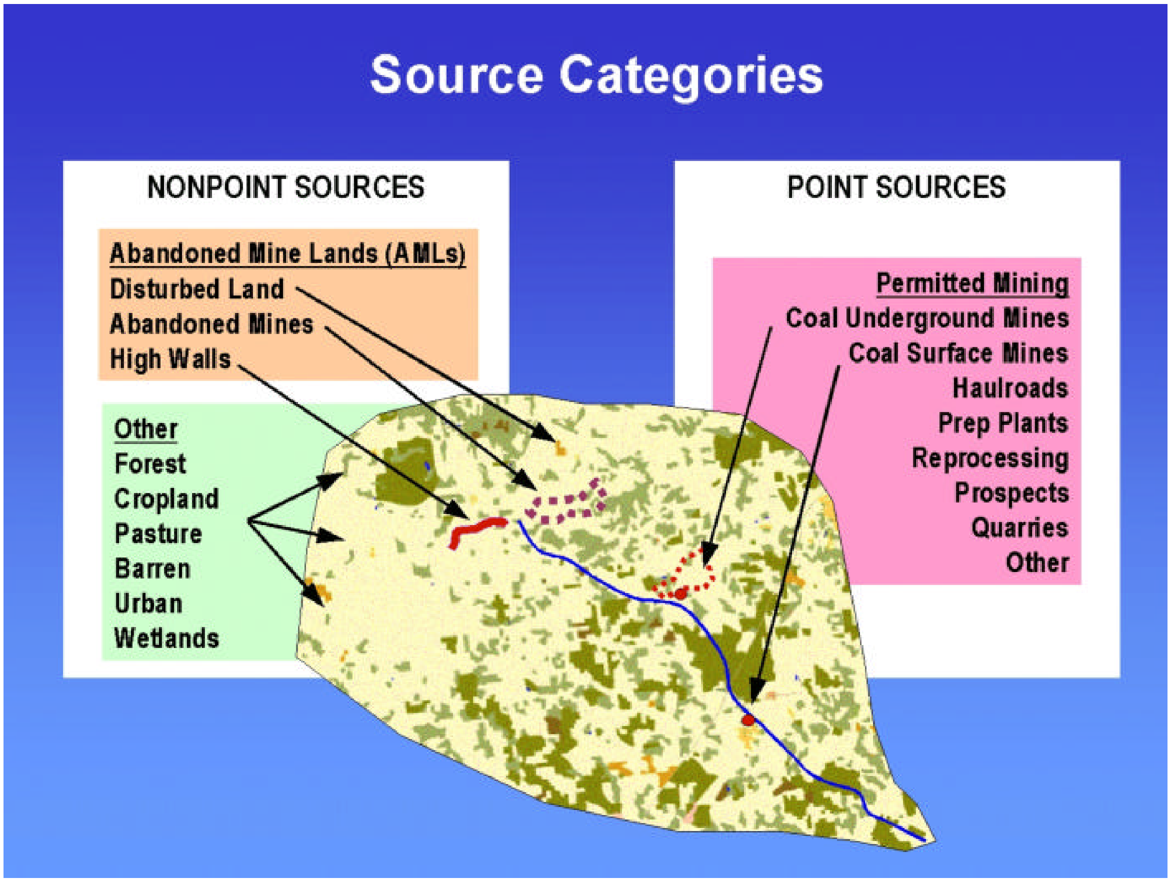

Figure 3-1. Potential sources contributing to impairments in the Stony River watershed

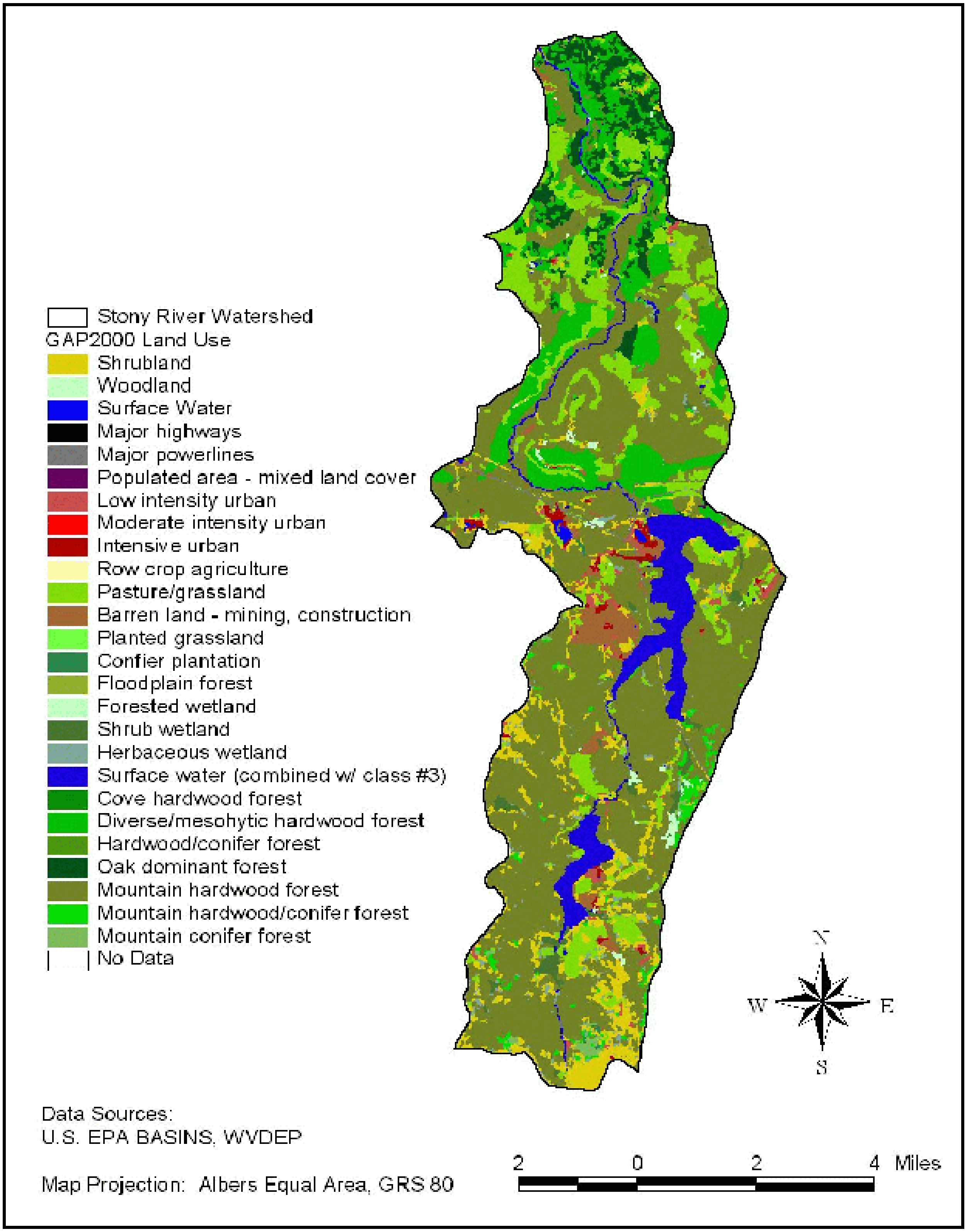

Figure 3-2. Land use distribution in the Stony River watershed

4.0 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 the evaluation of management options that will achieve the desired source load reductions. The link can be established through a number of techniques, ranging from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. The objective of this section is to present the approach taken to develop the linkage between sources and in-stream response for TMDL development in the Stony River watershed.

4.1 Model Framework Selection

Selecting the appropriate approach or modeling technique required considering the following:

- Expression of water quality criteria
- Dominant processes
- Scale of analysis

The relevant criteria for metals and pH were presented in Section 2. Numeric criteria, such as those applicable here, require evaluation of magnitude, frequency, and duration. For metals, the West Virginia criteria are expressed as total metals. This dictates that the methodology predict the total metals concentration in the water column of the receiving water. Thresholds of a numeric measure are evaluated for frequency of exceedance (e.g., not to exceed more than once every 3 years on average). Acute standards typically require evaluation over short time periods, and violations may occur under variable flow conditions. Chronic criteria require the evaluation of the response over a 4-day averaging period. The approach or modeling technique must permit representation of in-stream concentrations under a variety of flow conditions in order to evaluate critical periods for comparison to chronic and acute criteria.

The approach must also consider the dominant processes regarding pollutant loadings and in-stream fate. For the Stony River watershed, primary sources contributing to metals and pH impairments include an array of nonpoint or diffuse sources, as well as discrete point sources/permitted discharges. Loading processes for nonpoint sources or land-based activities are typically rainfall-driven and thus relate to surface runoff and subsurface discharge to a stream. Permitted discharges may or may not be dependent on rainfall; however, they are controlled by permit limits. Because they are a land-based activity, permitted mining discharges are precipitation-driven.

Key in-stream factors that must be considered include routing of flow, dilution, and transport of total metals. In the stream systems of the Stony River watershed, the primary physical driving process is the transport of total metals by diffusion and advection in the flow. Significant chemical processes are the speciation and precipitation of metals followed by sediment adsorption/desorption and reduction-oxidation reactions related to the precipitation reactions.

Scale of analysis and waterbody type must also be considered in the selection of the overall approach. The approach should have the capability to evaluate watersheds at multiple scales, particularly those of a few hundred acres in size. The listed waters in the Stony River watershed range from small streams to the main stem of the river. Selection of scale should be sensitive to the locations of key features, such as abandoned mines and point source discharges. At the larger watershed scale, land areas are lumped into subwatersheds for practical representation of the system, commensurate with the available data. Occasionally, site specific and localized acute problems may require more detailed segmentation or definition of detailed modeling grids.

Based on the considerations described previously, analysis of the monitoring data, review of the literature, and past pH and metals modeling experience, the Mining Data Analysis System (MDAS) was applied to represent the source-response linkage in the Stony River watershed. The MDAS is a comprehensive data management and modeling system that is capable of representing loading from nonpoint and point sources in the Stony River Watershed and simulating in-stream processes.

4.2 Mining Data Analysis System (MDAS) Overview

The MDAS is a system designed to support TMDL development for areas affected by AMD. The system integrates the following:

- Graphical interface
- Data storage and management system
- Dynamic watershed model
- Data analysis/postprocessing system

The graphical interface supports basic geographic information system (GIS) functions, including electronic geographic data importation and manipulation. Key data sets include stream networks, land use, flow and water quality monitoring station locations, weather station locations, and permitted facility locations. The data storage and management system functions as a database and supports storage of all data pertinent to TMDL development, including water quality observations, flow observations, and permitted facility DMRs, as well as stream and watershed characteristics used for modeling. The system also includes functions for inventorying the data sets. The Dynamic Watershed Model, also referred to as the Hydrological Simulation Program C++ (HSPC), simulates nonpoint source flow and pollutant loading as well as in-stream flow and pollutant transport, and it is capable of representing time-variable point source contributions. The data analysis/postprocessing system conducts correlation and statistical analyses and enables the user to plot model results and observation data.

The most critical component of the MDAS to TMDL development is the HSPC model because it provides the linkage between source contributions and in-stream response. The HSPC is a comprehensive watershed model used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and in-stream water quality. It can simulate flow, sediment, metals, nutrients, pesticides, and other conventional pollutants, as well as temperature and pH for pervious and impervious lands and waterbodies. The HSPC is essentially a re-coded C++ version of selected Hydrologic Simulation Program FORTRAN (HSPF) modules. HSPC's algorithms are identical to those in HSPF. Table 4-1 presents the modules from HSPF used in HSPC. Refer to the *Hydrologic Simulation Program FORTRAN User's Manual for Release 11* (Bicknell et al., 1996) for a more detailed discussion of simulated processes and model parameters.

Table 4-1. Modules from HSPF[a] converted to HSPC

RCHRES Modules	HYDR	Simulates hydraulic behavior
	CONS	Simulates conservative constituents
	HTRCH	Simulates heat exchange and water
	SEDTRN	Simulates behavior of inorganic sediment
	GQUAL	Simulates behavior of a generalized quality constituent
	PHCARB	Simulates pH, carbon dioxide, total inorganic carbon, and alkalinity
PQUAL and IQUAL Modules	PWATER	Simulates water budget for a pervious land segment
	SEDMNT	Simulates production and removal of sediment
	PWTGAS	Estimates water temperature and dissolved gas concentrations
	IQUAL	Uses simple relationships with solids and water yield
	PQUAL	Simple relationships with sediment and water yield

[a] Source: Bicknell et al., 1996.

4.3 Model Configuration

The MDAS was configured for the Stony River watershed, and the HSPC model was used to simulate the watershed as a series of hydrologically connected subwatersheds. Configuration of the model involved subdivision of the Stony River Watershed into modeling units, followed by continuous simulation of flow and water quality for these units using meteorological, land use, point source loading, and stream data. The specific pollutants that were simulated were total aluminum, total iron, total manganese, and pH. This section describes the configuration process and key components of the model in greater detail.

4.3.1 Watershed Subdivision

To represent watershed loadings and resulting concentrations of metals in the Stony River, the watershed was divided into 24 subwastersheds. These subwatersheds are presented in Figure 4-2 and in Figure 1 of Appendices A-1 and A-2, and they represent hydrologic boundaries.

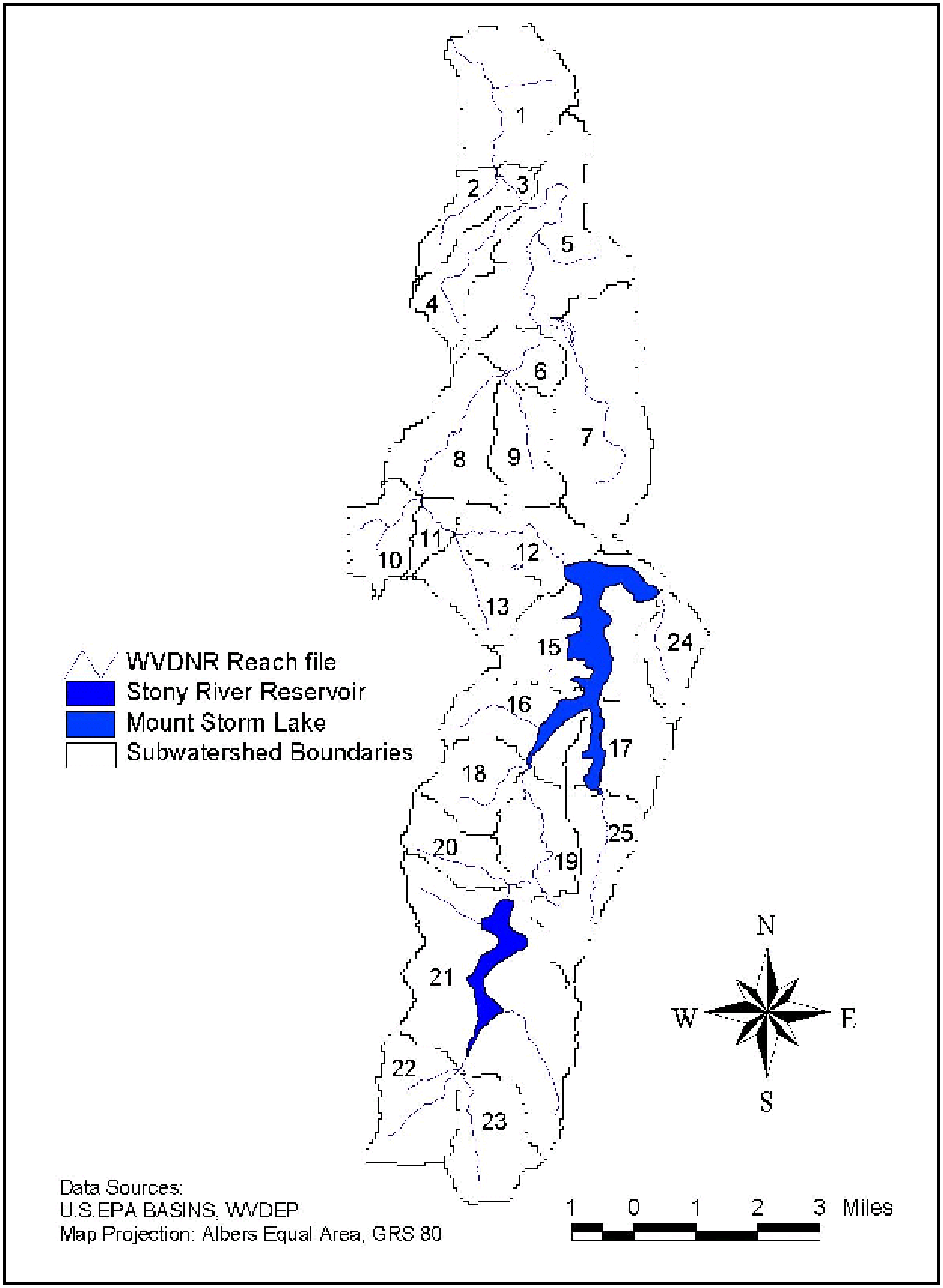

Figure 4-1. Stony River watershed's subwatersheds

The division was based on elevation data (7.5-minute Digital Elevation Model [DEM] from USGS), stream connectivity (from USGS's National Hydrography Dataset [NHD] stream coverage), and locations of monitoring stations.

4.3.2 Meteorological Data

Meteorological data are a critical component of the watershed model. Appropriate representation of precipitation, wind speed, potential evapotranspiration, cloud cover, temperature, and dewpoint are required to develop a valid model. Meteorological data from a number of sources were accessed in an effort to develop the most representative dataset for the Stony River watershed.

In general, hourly precipitation data are recommended for nonpoint source modeling. Therefore, only weather stations with hourly recorded data were considered in developing a representative dataset. Long-term hourly precipitation data available from three National Climatic Data Center (NCDC) weather stations located near the watershed were used:

- Elkins WSO Airport,
- Moorefield 1 SSE, and
- Terra Alta No 1.

Meteorological data for the remaining required parameters were available from the Elkins WSO Airport station. These data were applied based on subwatershed location relative to the weather stations.

4.3.3 Nonpoint Source Representation

Abandoned Mine Lands (AML)

To represent AMLs as nonpoint sources, the AML categories were represented as three unique land use categories: high walls, disturbed land, and abandoned mines. The abandoned mines represent either discharge from abandoned deep mines or seeping and leaching from other abandoned mine sites. The forested area land use (described later in the Other Nonpoint Sources section) was reduced to account for the three additional land uses.

Other Nonpoint Sources

The GAP2000 land use categories were grouped into nine land use categories that best describe the watershed conditions and dominant source categories. The nine land uses represent nonpoint sources, which include barren land, cropland, forest, pasture, strip mining/quarries/gravel pits, urban impervious, urban pervious, water, and wetlands. The land use grouping is shown in Table 4-2.

Table 4-2. Model land use grouping

Model Category	GAP2000 Category
Barren	Barren Land, Mining and Construction
Crop land	Row Crops Agriculture
	Small Grains
Forest	Shrubland
	Woodland
	Conifer Plantation
	Floodplain Forest
	Cove Hardwood Forest
	Diverse/Mesophytic Hardwood Forest
	Hardwood/Conifer Forest
	Oak Dominant Forest
	Mountain Hardwood Forest
	Mountain Hardwood/Conifer Forest
	Mountain Conifer Forest
Pasture	Power Lines
	Pasture/Grassland
	Planted Grassland
Strip Mining	Quarries/Strip Mines/Gravel Pits
Urban Impervious	Roads
	Populated Areas
	Light Intensity Urban
	Moderate Intensity Urban
	Intensive Urban
Urban Pervious	Roads
	Populated Areas
	Light Intensity Urban
	Moderate Intensity Urban
	Intensive Urban
Water	Surface Water
Wetlands	Forested Wetland
	Shrub Wetland
	Herbaceous Wetland

This land use coverage provided the basis for estimating and distributing total aluminum, iron, and manganese loadings associated with conventional land uses.

4.3.4 Point Sources Representation

Permitted Nonmining Point Sources

Nonmining point source permits in the Stony River watershed do not include iron, aluminum, or manganese limits. Therefore, the nonmining facilities were not considered in the modeling effort.

Permitted Mining Point Sources

The permitted mining point sources were introduced as nine unique land use categories based on the type of mine and the current status of the mine. Phase II and Completely Released permitted facilities were not modeled because reclamation of these mines is complete or nearly complete and they are assumed to have little potential water quality impact (WVDEP, 2000a). Table 4-3 shows the land uses representing current active mines that were modeled.

Table 4-3. Model nonpoint source representation of different permitted mines

Type and status of active mine	Land use representation
Active deep mines	ADM
New/inactive deep mines	IADM
Phase I released deep mine s	PIDM
Revoked deep mines	RDM
Active/inactive/revoked surface mines	ASM
Other mines (other, haulroad, prospect, quarry)	Other
Phase 1 released surface mines	PIRS
Revoked surface mines	RSM
Revoked other mines	ROM

To account for the additional deep mine land use categories that were not categorized in the GAP2000 land use coverage (ADM, IADM, RDM and PIDM), the area of each permitted deep mine was subtracted from the forested land use area. The remaining additional land use categories (ASM, PIRS, RSM, ROM, and Other) were subtracted from the strip mine land use areas. The size of each mine was assumed to be equivalent to the surface disturbed area. The land use distribution is summarized in Tables 4-4 and 4-5.

Point sources were represented differently, depending on the stage of modeling for TMDL development. The two major stages, which are described in more detail later in this section and in Section 5, are the calibration condition and the allocation conditions.

Table 4-4. Modeled land use distribution for region 1 (acres)

	Subwatersheds										
Land Use Name	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
ADM	11	0	0	0	0	0	0	0	0	0	0
AML	0	0	0	0	0	0	0	0	0	0	0
ASM	14	0	0	32	353	82	982	0	64	0	384
Cropland	0	0	0	0	0	0	0	0	0	0	0
Disturb	0	0	0	0	0	0	0	0	0	0	0
Forest	984	895	1,130	967	682	690	2,446	1,379	1,185	574	862
Highwall	3	0	0	0	0	0	0	0	0	7	0
IADM	0	0	0	0	0	0	0	0	0	0	0
IASM	0	0	0	0	0	0	0	0	0	0	0
Other	8	10	0	9	17	14	39	0	0	0	11
Pasture	382	49	32	23	115	78	533	15	42	128	106
PIDM	0	0	0	0	0	0	0	0	0	0	0
PIRS	0	0	0	0	0	0	0	0	0	0	0
RDM	0	0	0	0	0	0	0	0	0	0	0
ROM	0	0	0	0	0	0	0	0	0	0	0
RSM	0	0	0	0	0	0	0	0	0	0	0
Strip Mining	212	292	3	0	0	0	0	3	0	49	0
Urban Impervious	136	34	0	0	5	10	86	7	11	32	3
Urban Pervious	136	34	0	0	5	10	86	7	11	32	3
Water	815	209	218	3	37	2	489	0	16	8	2
Wetlands	41	8	5	10	78	23	271	94	93	68	148
Total Area (acres)	**2,741**	**1,531**	**1,388**	**1,044**	**1,293**	**908**	**4,932**	**1,504**	**1,423**	**900**	**1,518**

Table 4-5. Modeled land use distribution in for region 2 (acres)

	Subwatersheds												
Land Use Name	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
ADM	0	0	0	0	0	0	0	0	0	1	0	152	217
AML	0	0	0	0	0	0	0	0	0	0	0	0	0
ASM	0	0	0	1	0	0	91	125	29	7	12	174	228
Cropland	0	0	0	0	0	0	0	3	0	0	0	0	0
Disturb	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest	1,846	451	144	494	1,853	525	2,286	1,358	883	725	352	645	444
Highwall	4	0	5	0	1	0	0	0	0	0	0	0	0
IADM	0	0	0	0	0	0	0	0	0	0	0	0	0
IASM	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	6	4	50	0	0	3
Pasture	281	206	31	383	830	123	705	244	222	24	28	159	84
PIDM	0	0	0	0	0	0	0	0	0	0	0	0	0
PIRS	0	0	0	0	0	0	0	0	0	0	0	0	0
RDM	0	0	0	0	0	0	0	0	0	0	0	0	0
ROM	0	0	0	0	0	0	0	0	0	0	0	0	0
RSM	0	0	0	0	0	0	0	0	0	0	0	0	0
Strip Mining	19	0	0	7	8	0	19	0	0	16	0	0	0
Urban Impervious	0	3	0	8	13	0	5	3	0	21	3	37	76
Urban Pervious	0	3	0	8	13	0	5	3	0	21	3	37	76
Water	58	8	11	11	78	11	19	47	0	15	13	133	44
Wetlands	8	15	0	19	26	0	58	3	2	24	3	18	16
Total Area (acre)	**2,217**	**687**	**192**	**932**	**2,822**	**659**	**3,189**	**1,793**	**1,140**	**905**	**414**	**1,356**	**1,189**

Calibration Condition

For matching model results to historical data, which is described in more detail in the Model Calibration section, it was necessary to represent the existing point sources using available historical data. Discharges that were issued permits after the calibration period were not considered during the calibration process. The DMR data include monthly averages and maximums for flow, pH, total aluminum, total iron, and total manganese. The monthly average metals concentrations were multiplied by the discharge flows to estimate average loadings for these point sources.

In most cases, DMRs were insufficient to support representation in the model. For these situations, permitted point sources were represented by the following approach. When DMR data were available for point sources in a region, the average flow and monthly average concentrations for point sources throughout that particular region were used to estimate the point source loadings. In cases where there were no available DMR data within a region, the average point source flow from the entire Stony River watershed and the permitted average concentrations were used to estimate the loadings for the point sources. Parameters affecting pollutant concentrations from these mines were adjusted to be consistent with typical discharge characteristics from similar mining activities or to match site-specific in-stream monitoring data.

Allocation Conditions

Modeling for allocation conditions required running multiple scenarios, including a baseline scenario and multiple allocation scenarios. This process is further explained in Section 5. For the allocation conditions, all permitted mining facilities were represented using precipitation-driven nonpoint source processes in the model. Under this nonpoint source representation, flow was estimated in a manner similar to other nonpoint sources in the watershed (based on precipitation and hydrologic properties). This approach is consistent with OMR’s estimation that discharges from most surface mines and some deep mines are precipitation-driven (WVDEP, 2000b). Flow was typically present at all times, and it increased during storm events. The metals concentrations were assigned based on permit limits for the baseline condition modeling and based on required reductions to achieve in-stream TMDL endpoints for the allocation scenarios.

Mining discharge permits have either technology-based or water quality-based limits. Average Monthly Average Limit concentrations for technology-based limits are 3.0 mg/L and 2.0 mg/L for total iron and manganese, respectively, with a “report only” limit for total aluminum. Permitted discharges with water quality-based limits must meet in-stream water quality criteria at end-of-pipe. Point sources were assigned concentrations based on the appropriate limits. For discharges that are technology-based, the waste load concentration for aluminum was assumed to be 4.3 mg/L.

4.3.5 Stream Representation

Modeling subwatersheds and calibrating hydrologic and water quality model components required routing flow and pollutants through streams. Each subwatershed was represented with a single stream. Stream segments were identified using EPA's RF3 stream coverage.

To route flow and pollutants, development of rating curves was required. Rating curves were developed for each stream using Manning's equation and representative stream data. Required stream data include slope; Manning's roughness coefficient; and stream dimensions, including mean and channel widths and depths. Manning's roughness coefficient was assumed to be 0.05 for all streams (representative of mountain streams). Slopes were calculated based on digital elevation model (DEM) data and stream lengths measured from the RF3 stream coverage. Stream dimensions were estimated using regression curves that relate upstream drainage area to stream dimensions (Rosgen, 1996).

4.3.6 Hydrologic Representation

Hydrologic processes were represented in the HSPC using algorithms from the PWATER (water budget simulation for pervious land segments) and IWATER (water budget simulation for impervious land segments) modules of HSPF (Bicknell et al., 1996). Parameters associated with infiltration, groundwater flow, and overland flow were designated during model calibration.

Each of the two reservoirs (Stony River Reservoir and Mount Storm Lake) was represented by a single model cell with trapezoidal cross section. In HSPC the lake outflow can be controlled by both spillway and orifice dimensions to simulate managed flow conditions. The lake hydraulic parameters, such as dam height, spillway width, diameter of orifice, and location of orifice, were specified based on information provided by WVDEP and Dominion Virginia Power Company. A simple first-order decay for pollutants is implemented in the model to simulate the net loss of pollutants due to decay and settling in the reservoirs.

4.3.7 Pollutant Representation

In addition to flow, three pollutants were modeled with the HSPC:

- Total aluminum
- Total iron
- Total manganese

The loading contributions of these pollutants from different nonpoint sources were represented in the HSPC using the PQUAL (simulation of quality constituents for pervious land segments) and IQUAL (simulation of quality constituents for impervious land segments) modules in HSPF (Bicknell et al., 1996). Pollutant transport was represented in the streams using the GQUAL (simulation of behavior of a generalized quality constituent) module. The calibrated dataset represents existing conditions. Values for the pollutant representation were refined through the water quality calibration process.

4.4 Model Calibration

After the model was configured, calibration was performed at multiple locations throughout the Stony River watershed. Calibration is the adjustment or fine-tuning of modeling parameters to reproduce observations. Model calibration focused on two main areas: hydrology and water quality. Upon completion of the calibration at selected locations, a calibrated dataset containing parameter values for modeled sources and pollutants was developed. This dataset was applied to areas for which calibration data were not available.

A significant amount of time-varying monitoring data were necessary to calibrate the model. Available monitoring data in the watershed were identified and assessed for application to calibration (Tables 3a, 3b, and 3c in Appendices A-1 and A-2). Only monitoring stations with data representing a range of hydrologic conditions, source types, and pollutants were selected. The locations selected for calibration are presented in Figure 4-2.

4.4.1 Hydrology Calibration

Hydrology was the first model component calibrated. Ideally, the hydrology calibration involved a comparison of model results to in-stream flow observations at selected locations and the subsequent adjustment of hydrologic parameters. Key considerations included the overall water balance, the high-flow/low-flow distribution, storm flows, and seasonal variation.

Historical flow data with extended periods of record were limited to one location with daily flow monitoring data (refer to Table 3-2). As a result, the model hydrology could be calibrated only at that one location. The station was USGS station 01595200 on the Stony River near Mt. Storm, West Virginia. To represent a range of hydrologic conditions, the model was calibrated for the individual year 1989. Flow-frequency curves, temporal comparisons (daily and monthly), and comparisons of high flows and low flows were developed to support calibration. The calibration involved adjustment of infiltration, subsurface storage, evapotranspiration, surface runoff, and interception storage parameters. Table 4-6 shows the comparison of simulated versus observed flow for the year 1989.

Table 4-6. Hydrology calibration: comparison of simulated and observed flow for 1989

Simulated versus Observed Flow	Percent Error	Recommended Criterion
Error in total volume	**2.46**	+/- 10%
Error in 50% lowest flows	**-2.68**	+/- 10%
Error in 10% highest flows	**0.40**	+/- 15%
Seasonal volume error - Summer	**4.43**	+/- 30%
Seasonal volume error - Fall	**15.86**	+/- 30%
Seasonal volume error - Winter	**3.05**	+/- 30%
Seasonal volume error - Spring	**-9.93**	+/- 30%
Error in storm volumes	**9.45**	+/- 20%

Error in summer storm volumes	**15.60**	+/- 50%

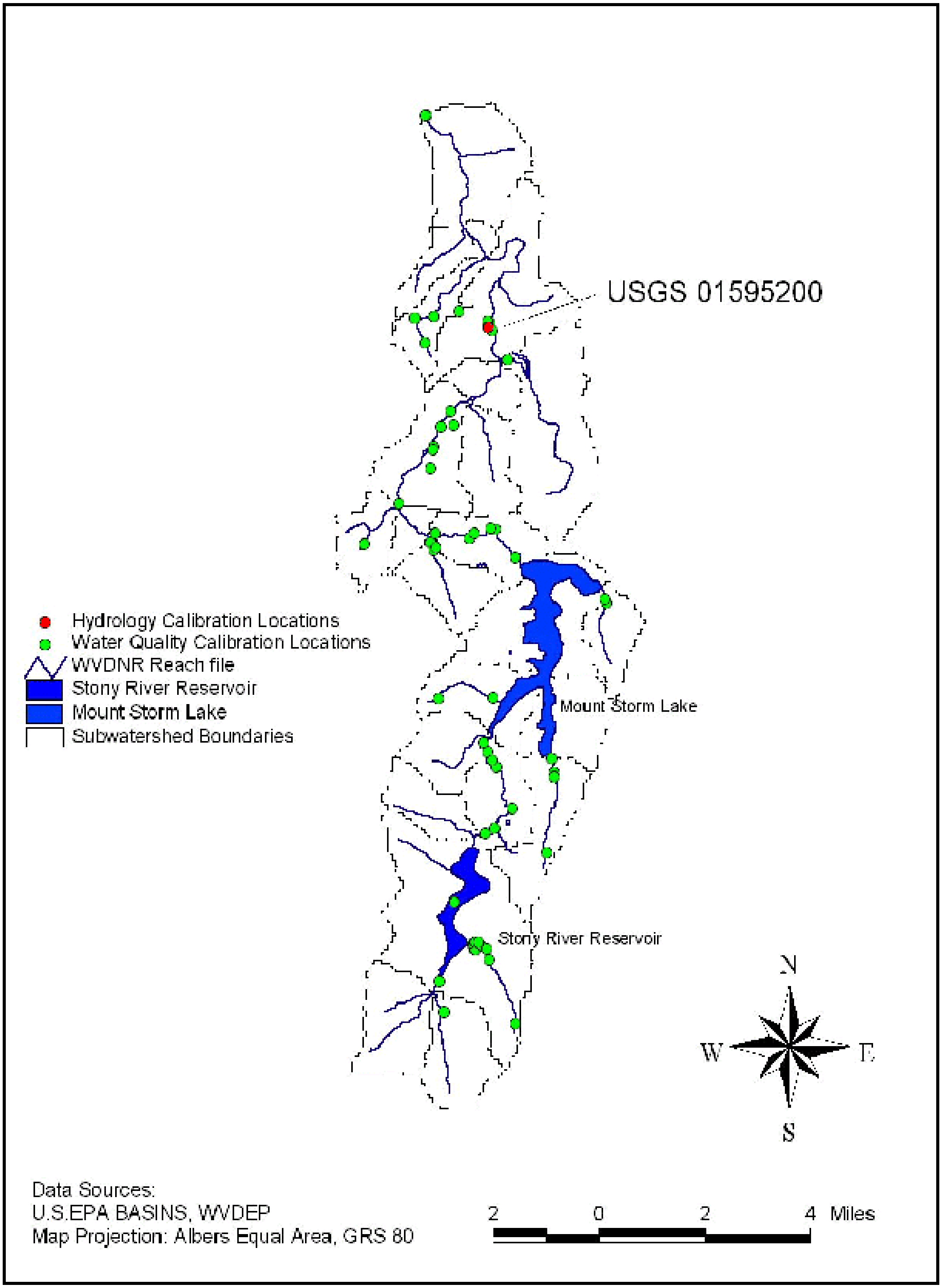

Figure 4-2. Calibration locations used in modeling

After adjusting the appropriate parameters within acceptable ranges, good correlations were found between model results and observed data for the comparisons made. Flow-frequency curves and temporal analyses are presented in Appendix C.

Parameter values were validated for an independent, extended time period (between 1988 and 1998) after calibrating parameters at the stations. Validation involved comparing model results and flow observations without further adjusting the parameters. The validation comparisons also showed a good correlation between modeled and observed data. Refer to Appendix C for validation results.

4.4.2 Water Quality Calibration

After hydrology had been sufficiently calibrated, water quality calibration was performed. Modeled versus observed in-stream concentrations were directly compared during model calibration. The water quality calibration consisted of executing the watershed model, comparing water quality time series output to available water quality observation data, and adjusting water quality parameters within a reasonable range.

The approach taken to calibrate water quality focused on matching trends identified during the water quality analysis. Daily average in-stream concentration from the model was compared directly to observed data. Observed data were obtained from EPA's STORET database as well as from three additional groups collecting water quality data in the Stony River watershed_ the Stream Restoration Group, the Special Reclamation Group, and the mining industry. Each group's data were obtained through WVDEP. The objective was to best simulate water quality during low flow, mean flow, and storm peaks at representative water quality monitoring stations. Representative stations were selected based on both location (distributed throughout the Stony River watershed) and source type. These stations were typically West Virginia DEP monitoring stations. Results of the water quality calibration are presented in Appendix C.

5.0 Allocation Analysis

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$TMDL = \Sigma WLAs + \Sigma LAs + MOS$$

To develop aluminum, iron, manganese, and pH TMDLs for each of the waterbodies in the Stony River watershed listed on the West Virginia 303(d) list, the following approach was taken:

- Define TMDL endpoints.
- Simulate baseline conditions.
- Assess source loading alternatives.
- Determine the TMDL and source allocations.

5.1 TMDL Endpoints

TMDL endpoints represent the in-stream water quality targets used in quantifying TMDLs and their individual components. Different TMDL endpoints are necessary for each impairment type (aluminum, iron, manganese, and pH). West Virginia's numeric water quality criteria for aluminum, ammonia, iron, manganese, and pH (identified in Section 2) and an explicit and implicit margin of safety (MOS) were used to identify endpoints for TMDL development.

5.1.1 Aluminum, Iron, and Manganese

The TMDL endpoint for aluminum was selected as 712.5 ug/L (based on the 750 ug/L criterion for aquatic life minus a 5 percent MOS). The endpoint for iron was selected either as 0.475 mg/L (based on the 0.5 mg/L criterion for aquatic life-trout waters minus a 5 percent MOS) or 1.425 mg/L (based on the 1.5 mg/L criterion for aquatic life minus a 5 percent MOS). The endpoint for manganese was selected as 0.95 mg/L (based on the 1.0 mg/L criterion for human health minus a 5 percent MOS).

Components of the TMDLs for aluminum, iron, and manganese are presented in terms of mass per time in this report.

5.1.2 pH

The water quality criterion for pH requires it to be above 6 and below 9 (inclusive). In the case of acid mine drainage, pH is not a good indicator of the acidity in a waterbody and can be a misleading characteristic. Water with near-neutral pH (~7) but containing elevated concentrations of dissolved ferrous (Fe^{2+}) ions can become acidic after oxidation and precipitation of the iron (PADEP, 2000). Therefore, a more practical approach to meeting the water standards for pH is to use the concentration of metal ions as a surrogate for pH. Through reducing in-stream metals (namely aluminum and iron) to meet water quality criteria (or TMDL endpoints), it is assumed that the pH will result in meeting the water quality standards. This assumption is based on the application of MINTEQA2, a geochemical equilibrium speciation model, to aqueous systems representative of waterbodies in the Stony River watershed. By inputting into the model the dissolved concentrations of metals, a pH value can be predicted. Refer to Appendix D for a more detailed description of the modeling.

5.1.3 Margin of Safety

An implicit MOS was included in TMDL development through application of a dynamic model for simulating daily loading over a wide range of hydrologic and environmental conditions, and through the use of conservative assumptions in model calibration and scenario development. In addition to this implicit margin of safety, a 5 percent explicit MOS was used to account for the differences between modeled and monitored data. Long-term water quality monitoring data were used for model calibration. Although these data represented actual conditions, they were not continuous time series and might not have captured the full range of in-stream conditions that occurred during the simulation period. The explicit 5 percent MOS also accounts for those cases where monitoring data might not have captured the full range of in-stream conditions.

5.2 Baseline Conditions

The calibrated model provided the basis for performing the allocation analysis. The first step in this analysis involved simulation of baseline conditions. Baseline conditions represent existing nonpoint source loading conditions and permitted point source discharge conditions. The baseline conditions allow for an evaluation of in-stream water quality under the "worst currently allowable" scenario.

The model was run for baseline conditions for the period January 1, 1987, through December 31, 1992. Predicted in-stream concentrations of aluminum, iron, and manganese for the impaired waterbodies in the Stony River watershed were compared directly to the TMDL endpoints. This comparison allowed evaluation of the expected magnitude and frequency of exceedances under a range of hydrologic and environmental conditions, including dry periods, wet periods, and average periods.

Permitted conditions for mines were represented using precipitation-driven flow estimations and the metals concentrations presented in Table 5-1.

Table 5-1. Metals concentrations used in representing permitted conditions for mines

Pollutant	Technology-based Permits	Water Quality-based Permits
Aluminum, total	4.3 mg/L (assumed for "report only")	0.75 mg/L
Iron, total	3.2 mg/L	1.5 mg/L, 0.5 mg/L (trout waters)
Manganese, total	2.0 mg/L	1.0 mg/L

5.3 Source Loading Alternatives

Simulation of baseline conditions provided the basis for evaluating each stream's response to variations in source contributions under virtually all conditions. This sensitivity analysis gave insight into the dominant sources and how potential decreases in loads would affect in-stream metals concentrations. For example, loading contributions from abandoned mines, permitted facilities, and other nonpoint sources were individually adjusted and in-stream concentrations were observed.

Multiple scenarios were run for the impaired waterbodies. Successful scenarios were those that achieved the TMDL endpoints under all conditions for aluminum, iron, and manganese (through comparison of model results for the 1987 through 1992 modeling period). Exceedances for aluminum and iron were allowed once every 3 years. The averaging period was taken into consideration during these assessments (e.g., a 4-day average was used for iron). In general, loads contributed by abandoned mines and revoked mines were reduced first because they generally had the greatest impact on in-stream concentrations. If additional load reductions were required to meet the TMDL endpoints, reductions were made in point source (permitted) contributions.

5.4 TMDLs and Source Allocations

A top-down methodology was followed to develop the TMDLs and allocate loads to sources. Impaired headwaters were analyzed first because their impact frequently had a profound effect on downstream water quality. Loading contributions were reduced from applicable sources for these waterbodies, and TMDLs were developed. Model results from the selected successful scenarios were then routed through downstream waterbodies. Therefore, when TMDLs were developed for downstream impaired waterbodies, upstream contributions were representing conditions meeting water quality criteria. Using this method, contributions from all sources were weighted equitably. In some situations, reductions in sources affecting unimpaired headwaters were required in order to meet downstream water quality criteria. In other situations, reductions in sources affecting impaired headwaters ultimately led to improvements far downstream. This effectually decreased required loading reductions from many potential downstream sources.

The following general methodology was used when allocating to sources for the Stony River TMDL:

- For watersheds with AMLs but no point sources, AMLs were reduced until in-stream water quality criteria were met.

- For watersheds with AMLs and point sources, point sources were set at permit limits and AMLs were subsequently reduced. AMLs were reduced (and point sources were not reduced) until in-stream water quality criteria were met. If further reduction was required, reductions were made from revoked mines until in-stream water quality criteria were met. If further reduction was required once AMLs and revoked mines were reduced, point source discharge limits were reduced. When reductions were maximized for AMLs, the resulting contribution was considered to be equivalent to background levels.

- For watersheds with point sources but no AMLs, point sources were set at permit limits and subsequently reduced until in-stream water quality criteria were met. Point sources were not reduced below in-stream water quality criteria. If further reduction was required, the additional loading was assigned to an unknown source category.

The TMDLs for the Stony River Watershed were determined on a subwatershed basis.

5.4.1 Wasteload Allocations (WLAs)

Waste load allocations (WLAs) were made for all permitted facilities except for those with a Completely Released or Phase 2 Released classification. For TMDL purposes these point sources were assumed to be compliant with water quality criteria because they were assumed to have little potential water quality impact. Loading from revoked permitted facilities was assumed to be a nonpoint source contribution based on the absence of a permittee.

The WLAs for aluminum, iron, and manganese (for each permit) are presented in Tables 4a, 4b, and 4c in Appendices A-1 and A-2. The WLAs are presented as annual loads, in terms of pounds per year and as constant concentrations equivalent to permit limits . They are presented on an annual basis (as an average annual load), because they were developed to meet TMDL endpoints under a range of conditions observed throughout the year. Using the WLAs presented, permit limits can be derived using EPA's *Technical Support Document for Water Quality-based Toxics Control* (USEPA, 1991) to find the monthly average discharge concentration. The ranges are as follows: Al: 0.75-4.3mg/L, Fe:1.5 -3.0 mg/L, Mn: 1.0-2.0 mg/L.

5.4.2 Load Allocations (LAs)

Load allocations (LAs) were made for the dominant source categories, as follows:

- Abandoned mine lands (including abandoned mines (deep), high walls, and disturbed areas), strip mines (areas represented in the land use coverage, but not accounted for by permits or AMLs).
- Other nonpoint sources (urban, agricultural, and forested land contributions).
- Revoked permits (loading from revoked permitted facilities).

The LAs for aluminum, iron, and manganese are presented in Tables 5a, 5b, and 5c in Appendices A-1 and A-2. The LAs are presented as annual loads, in terms of pounds per year. They are presented on an annual basis (as an average annual load) because they were developed to meet TMDL endpoints under a range of conditions observed throughout the year. Tables 5-2, 5-3, and 5-4 present the sum of LAs and sum of WLAs for aluminum, iron, and manganese, respectively, for each of the 303(d) listed segments.

5.4.3 pH Modeling Results

As described in section 5.1.2, aluminum, iron, and manganese concentrations were input into MINTEQA2 to simulate various scenarios, including conditions with metals concentrations meeting water quality standards and conditions in proximity to mining activities. MINTEQA2 was run twice using the two different iron standards for aquatic life and trout waters. Based on the inputs (described in more detail in Appendix D), pH was estimated to be 7.48 for the aquatic life iron standard of 1.5 mg/L and 7.53 for the trout waters iron standard of 0.5 mg/L. For the scenario representative of mining areas, typical in-stream metals concentrations were used, and pH was estimated to be 4.38. Results from MINTEQA2 imply that pH will meet the West Virginia pH criteria of above 6 and below 9 (inclusive) if metals concentrations meet water quality criteria.

5.4.4 Seasonal Variation

A TMDL must consider seasonal variation in the derivation of the allocation. By using continuous simulation (modeling over a period of several years), seasonal hydrologic and source loading variability was inherently considered. The metals concentrations simulated on a daily time step by the model were compared to TMDL endpoints. An allocation that would meet these endpoints throughout the year was developed.

Table 5-2. Load and waste load allocations for aluminum

Region	Stream Name	List ID	TMDL (lb/yr)	∑ LAs (lb/yr)	∑ WLAs (lb/yr)	MOS (lb/yr)
2	Four Mile Run	PNB-17-C	3,348	2,078	1,110	159
2	Laurel Run	PNB-17-B.5	2,176	1,498	574	104
2	Stony River	PNB-17	18,890	15,363	2,628	900
1	Helmick Run	PNB-17-E	4,231	2,087	1,943	201
1	Laurel Run	PNB-17-D	22,266	2,430	18,775	1,060

Table 5-3. Load and waste load allocations for iron

Region	Stream Name	List ID	TMDL (lb/yr)	∑ LAs (lb/yr)	∑ WLAs (lb/yr)	MOS (lb/yr)
2	Four Mile Run	PNB-17-C	7,781	4,886	2,525	371
2	Laurel Run	PNB-17-B.5	5,274	4,419	604	251
2	Stony River	PNB-17	22,214	19,147	2,009	1,058
1	Helmick Run	PNB-17-E	7,373	2,817	4,205	351
1	Laurel Run	PNB-17-D	19,742	4,446	14,356	940

Table 5-4. Load and waste load allocations for manganese

Region	Stream Name	List ID	TMDL (lb/yr)	∑ LAs (lb/yr)	∑ WLAs (lb/yr)	MOS (lb/yr
2	Four Mile Run	PNB-17-C	4,495	2,395	1,886	214
2	Laurel Run	PNB-17-B.5	2,542	2,047	374	121
2	Stony River	PNB-17	12,384	10,546	1,249	590
1	Helmick Run	PNB-17-E	4,544	1,545	2,783	216
1	Laurel Run	PNB-17-D	14,850	5,219	8,923	707

5.4.5 Future Growth

This TMDL does not include specific future growth allocations to each subwatershed. Because of the general allocation philosophy used in this TMDL, such allocations would be made at the expense of active mining point sources in the watershed. However, the absence of specific future growth allocations does not prohibit new mining in the watershed. Future growth could occur in the watershed under the following scenarios:

1. A new facility could be permitted anywhere in the watershed, provided that effluent limitations are based on the achievement of water quality standards end-of-pipe for the pollutants of concern in the TMDL.

2. Remining could occur without a specific allocation to the new permittee, provided that the requirements of existing state remining regulations are achieved. Remining activities are viewed as a partial nonpoint source load reduction from abandoned mine lands.

3. Reclamation and release of existing permits could provide an opportunity for future growth provided that permit release is conditioned on achieving discharge quality better than the wasteload allocation prescribed by the TMDL.

West Virginia may revise the TMDL, with approval from EPA, to reallocate the distribution of loads to accommodate future growth. It is also possible that the TMDL might be refined in the future through remodeling. Such refinement might incorporate new information and/or redistribute pollutant loads. Trading might provide an additional opportunity for future growth, contingent on the state's development of a statewide or watershed-based trading program.

5.4.6 Remining and Water Quality Trading

This TMDL neither prohibits nor authorizes trading in the Stony River watershed. Both the WVDEP and EPA generally endorse the concept of trading and recognize that it might become an effective tool for TMDL implementation. However, significant regulatory framework development is necessary before large-scale trading in West Virginia may be realized. EPA will cooperate with WVDEP in its development of a statewide or watershed-based trading program. Further, EPA supports program development assisted by a consensus-based stakeholder process.

Before the development of a formal trading program, it is conceivable that the regulation of specific point source-to-point source trades might be feasible under the framework of the NPDES program. EPA commits to cooperate with the WVDEP to facilitate such trades if opportunities arise and are proven to be environmentally beneficial.

6.0 Reasonable Assurance

Two primary programs that provide reasonable assurance for maintenance and improvement of water quality in the watershed are in effect. The WVDEP's efforts to reclaim abandoned mine lands, coupled with its duties and responsibilities for issuing NPDES permits, will be the focal points in water quality improvement.

Additional opportunities for water quality improvement are both ongoing and anticipated. Historically, a great deal of research into mine drainage has been conducted by scientists at West Virginia University, the West Virginia Division of Natural Resources, the United States Office of Surface Mining, the National Mine Land Reclamation Center, the National Environmental Training Laboratory and many other agencies and individuals. Funding from EPA's 319 Grant program has been used extensively to remedy mine drainage impacts. These many activities are expected to continue and result in water quality improvement.

6.1 Reclamation

Two distinct units of the WVDEP reclaim land and water resources affected by abandoned mines. The Office of Abandoned Mine Lands and Reclamation remedies eligible sites under Title IV of the Surface Mining Control and Reclamation Act of 1977. The Office of Mining and Reclamation's Special Reclamation Program remedies sites where operating permits and bonds have been revoked. Funding of the Office of Abandoned Mine Lands and Reclamation is derived from a federal tax on coal producers. The Special Reclamation Program is funded by the Special Reclamation Fund, which has primary sources of income from civil penalties, forfeited bonds, and a 3-cent per ton fee on all coal produced.

A description of the operating procedures and accomplishments of each program follows.

6.1.1 Office of Abandoned Mine Lands and Reclamation

Title IV of the Surface Mining Control and Reclamation Act (Public Law 95-87) is designed to help reclaim and restore coal mine areas abandoned prior to August 3, 1977, throughout the country. The AML Program supplements existing state programs and allows the state of West Virginia to correct many abandoned mine-related problems that would otherwise not be addressed.

The major purpose of the AML Program is to reclaim and restore abandoned mine areas so as to protect the health, safety, and general welfare of the public and the environment.
The AML Program corrects abandoned mine-related problems in accordance with the prioritization process specified in Public Law 95-87, Section 403 (a), 1-3.
Priorities:

- <u>Priority 1</u> : The protection of public health, safety, general welfare, and property from extreme danger of adverse effects related to coal mining practices.

- Priority 2: The protection of public health, safety, and general welfare from adverse effects related to coal mining practices.
- Priority 3: The restoration of the environment, including the land and water resources that were degraded by adverse effects related to coal mining practices. This restoration involves the conservation and development of soil, water (not channelization), woodland, fish and wildlife, recreational resources, and agricultural productivity.

Priority 1 and 2 problem areas include unsafe refuse piles, treacherous highwalls, pollution of domestic water supplies from mine drainage, mine fires, subsidence, and other abandoned mine-related problems.

The AML Program is now also focused on Priority 3 problem areas and on treating and abating water quality problems associated with abandoned mine lands, but it is not required by law or any statutory authority to do so. By recognizing the need to protect and, in many cases, improve the quality of the state's water resources from the impacts of mine drainage pollution from abandoned coal mines, coordinated efforts are now being employed to deal with this nonpoint source pollution problem.

Although OAML&R has been actively involved in the successful remediation of mine drainage pollution, inadequate funding and the lack of cost-effective mine drainage pollution treatment and abatement technologies have limited water quality improvement efforts. In 1990 the Surface Mining Control and Reclamation Act was amended to include a provision allowing states and tribes to establish an Acid Mine Drainage Treatment and Abatement Program and Fund. States and tribes may set aside up to 10 percent of their annual grant to begin to address abandoned polluted coal mine drainage problems. Money from the Acid Mine Drainage Treatment and Abatement Fund can be used to clean up mine drainage pollution at sites where mining ceased before August 3, 1977, and where no continuing reclamation responsibility can be determined. To qualify and be eligible, qualified hydrologic units or watersheds must be identified and water quality must adversely affect biological resources. A plan must be prepared and presented to the Natural Resources Conservation Service for review and the Office of Surface Mining for approval. Plans that include the most cost-effective treatment and abatement alternatives, the greatest down-stream benefits to the ecosystem, and diverse cooperators and stakeholders, will be the highest priority for approval.

AML&R has created an Acid Mine Drainage Abatement Policy to guide efforts in treating and abating mine drainage pollution. The Policy acts to guide the expenditure of funds to achieve the maximum amount of mine drainage pollution treatment within the boundaries imposed by budgetary and statutory constraints. The goal is to utilize existing technologies and practical economic considerations to maximize the amount of treatment for dollars expended.

The policy includes a holistic watershed characterization and remediation procedure known as the Holistic Watershed Approach Protocol. The Protocol involves diverse stakeholders in the establishing various sampling networks and subsequently generating water quality data that focus remediation efforts. The Protocol is first used to subdivide the watershed into focus areas. More specific data are then generated to allow identification of the most feasible pollution sources to address and the best available pollution abatement technology to apply. The Protocol also includes the establishment of post-construction sampling networks to assess the impacts of remediation efforts. The Protocol is iteratively implemented until all focus areas have been addressed and all feasible pollution abatement technologies have been applied.

6.1.2 Special Reclamation Group

When notice of permit revocation is received from the Director, a liability estimate is completed within 60 days of the revocation. The liability estimate notes any special health and safety characteristics of the site and calculates the cost to complete reclamation according to the permit reclamation plan. At sites where acid mine drainage is present, the permit is flagged for water quality characterization and a priority index assigned.

The reclamation plan at all sites includes the application of the best professional judgment to address the site-specific problems, including acid mine drainage. Any change or modification to the permit reclamation plan is done by or under the supervision of a Registered Professional Engineer. All construction requires application of best management practices to ensure quality work and protect the environment.

Prioritization of bond forfeiture sites is consistent with the criteria used in the Abandoned Mine Land and Reclamation (AML&R) program. The criteria, as described below, have been used successfully for many years on abandoned mine areas with similar characteristics to bond forfeiture sites.

Priority	Description
1.	The highest priority sites are those that entail protection of public health, safety, general welfare, and property from extreme danger. There are relatively few of these types of bond forfeiture sites; however, they are unquestionably first order priorities and receive a ranking of 1.
2.	Second order priority sites are those where public health, safety, welfare, and property values are judged to be threatened. Examples include sites with a high potential for landslides or flooding or the presence of dangerous highwalls, derelict buildings or other structures.
3a.	Third order priorities comprise the bulk of bond forfeiture sites.Therefore, this ranking level is sub-divided into smaller groupings. The first sub-group is sites that are causing or have a high potential for causing off-site environmental damage to the land and water resources. Such off-site damage would most likely be from heavy erosion, or high loadings of acid mine drainage.

3b. The second subgroup would include sites that are of a lower priority but are in close geographic proximity to first or second priority sites. It is more efficient and cost-effective to "cluster" projects where possible.

3c. The third subgroup includes sites near high-use public recreation areas and major thoroughfares.

3d. The fourth subgroup includes sites that are nearly fully reclaimed by the operator and require only monitoring of vegetative growth or other parameters. Sites that have a real potential for re-permitting by another operator or reclamation by a third party will also be placed in this subgroup.

Reclamation construction contracts occur by submission of a detailed Project Requisition to the State Purchasing Division. All state purchasing policies and procedures are applicable and the contract is awarded to the lowest qualified bidder. Special Reclamation personnel perform inspection and contract management activities through the life of the contract. When all reclamation work is satisfactorily completed, a 1-year contract warranty period begins to ensure adequate vegetative growth and drainage system operation. Upon completion of the contract warranty period and recommendation of the Regional Supervisor, the permit status is classified as "Completed." Completed status removes the liability of the forfeited site and terminates WVDEP jurisdiction and responsibility as a Phase III bond release.

At the sites with significant and high-priority AMD, treatment operations are conducted to the extent of available funding, pursuant to the authority granted in 22-3-11(g) of the West Virginia Surface Coal Mining and Reclamation Act. That regulation limits the annual expenditure of funds for designing, constructing, and maintaining water treatment systems to 25 percent of the annual amount of the fees collected.

6.2 Permitting

NPDES permits in the watershed will be issued, reissued, or modified by the Office of Water Resources in close cooperation with the Office of Mining and Reclamation. Because offices have adjusted permitting schedules to accommodate the state's Watershed Management Framework, implementation of TMDL requirements at existing facilities will generally occur at the time of scheduled permit reissuance. Permits for existing facilities in the Stony River watershed are scheduled to be reissued in 2002.

7.0 Monitoring Plan

Follow-up monitoring of the Stony River watershed is recommended. Future monitoring can be used to evaluate water quality conditions and changes or trends in water quality conditions and could contribute to an improved understanding of the source loading behavior. The following monitoring activities are recommended for this TMDL:

- WVDEP should continue monitoring the impaired segments of the Stony River (tributaries) via its established Watershed Management monitoring approach in 2002, 2007, and beyond.

- WVDEP should continue monitoring in advance of, during, and after installation of reclamation activities affecting water quality at abandoned mine sites.

- WVDEP should consider additional stations and more frequent sampling of water quality in the impaired reaches, and continue to encourage participation by active watershed organizations.

- WVDEP should emphasize the use of proper quality assurance and quality control (QA/QC) protocols to avoid potential sample contamination during water sample collection and transfer.

8.0 Public Participation

EPA's policy is that there must be full and meaningful public participation in the TMDL development process. Each state must, therefore, provide for public participation consistent with its own continuing planning process and public participation requirements. As a result, it is the intent of the WVDEP to solicit public input by providing opportunities for public comment and review of the draft TMDLs. The public meetings pertaining to the Stony River watershed occurred as follows:

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Appendix A

Stony River Watershed Data and TMDLs

Appendix A is divided into three separate sections. Each section provides information for a different region of the Stony River watershed. The map on the following page (Figure A) presents the watershed's two regions. Numeric designation for each Appendix A section corresponds to the same numerically identified region of the Stoney River watershed (e.g., Appendix A-1 corresponds to region 1 of the Stony River watershed).

The structure and content of the appendices are as follows:

- **Figure 1**—presents a map of the region, including impaired waterbodies, RF3 stream segments, and subwatersheds used in the model. The subwatershed IDs provide a basis for presenting information in the subsequent tables.

- **Table 1**—lists each impaired waterbody, its corresponding impairment and use designation, all subwatersheds in the region that drain into the impaired waterbody (contributing SWS), and any other regions that drain into the impaired waterbody (contributing regions). Use designations are presented in Section 2 of the main report.

- **Table 2**—lists the subwatersheds in the region that are assumed to contain abandoned mines. These abandoned mines refer to seeps, deep mines, and leaching. They do not include highwall locations or disturbed areas.

- **Tables 3a, 3b, and 3c**—summarize water quality data for water quality monitoring stations in the region. Each table summarizes data for a different metal (aluminum, iron, and manganese). Data are summarized by subwatershed (SWS), and the summary includes average, minimum, and maximum observed values, as well as the total number of observations (count) and the start and end date of sampling.

- **Tables 4a, 4b, and 4c**—present baseline and allocation information for permitted mine point sources in the region and future growth allocations. Tables a through c present information for different metals. The information is presented by mine permit for each subwatershed. Baseline loads (in lbs/yr) are presented for each mine. The baseline load represents the load estimated under baseline conditions, assuming a constant permitted concentration. This load represents the monthly average permitted discharge (based on existing permit limits) and does **not** necessarily represent current conditions. This load is presented for comparative purposes. Allocation loads (in lb/yr) and allocation concentrations (in mg/L) are also presented for each mine. The allocation load represents the WLA. The allocation concentration represents the constant concentration that will meet the water quality criteria for all conditions. Using the WLAs presented, permit limits can be derived using EPA's *Technical Support Document for Water Quality-based Toxics Control* (USEPA, 1991) to find the monthly average discharge concentration.

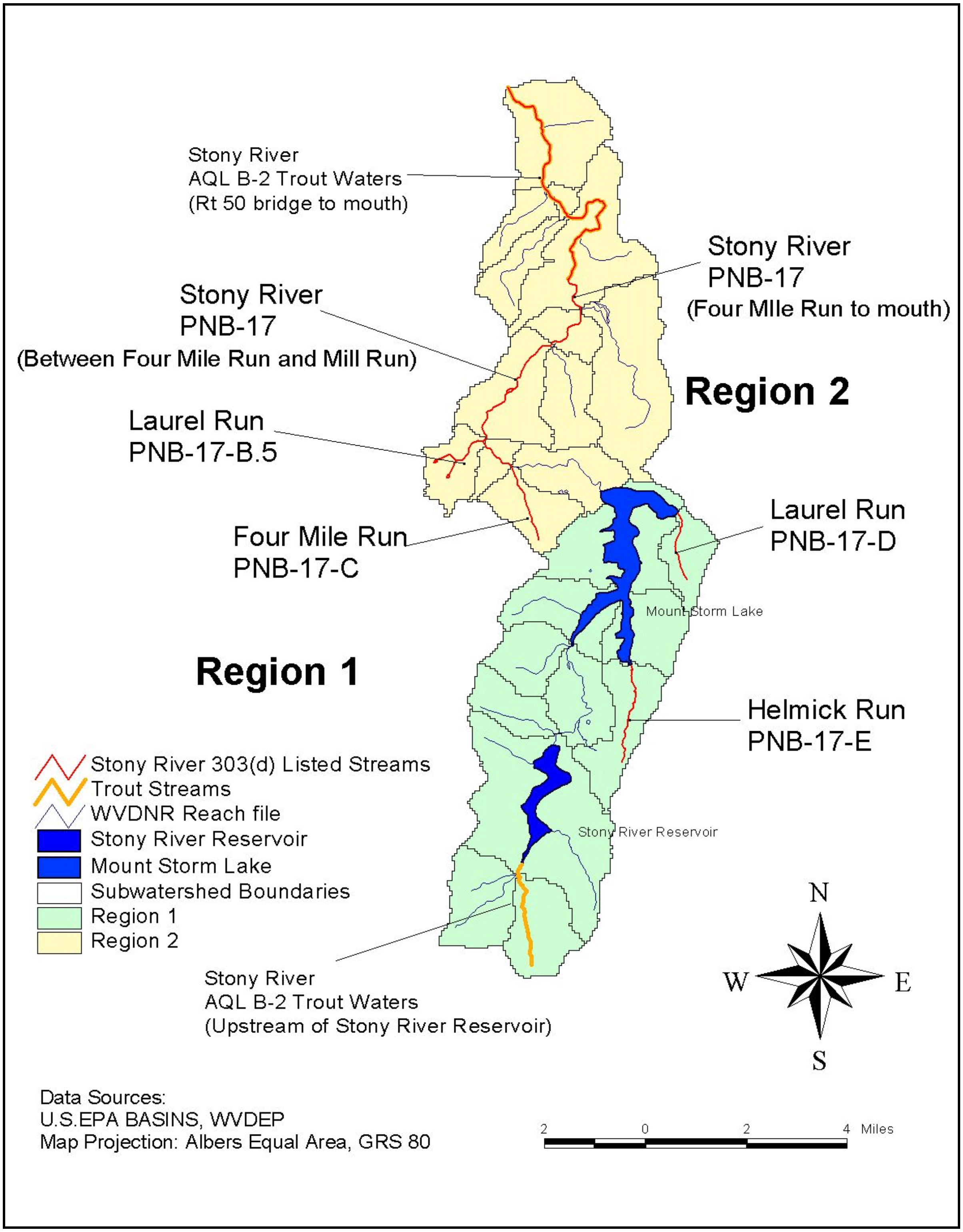


Figure A. Stony River watershed and its two regions

- **Tables 5a, 5b, and 5c**—present baseline and allocation information for nonpoint sources in the region. Each table presents information for a different metal. Baseline and allocation loads (in lb/yr) are presented by subwatershed for the following nonpoint source categories: AML, other nonpoint sources, and revoked mines. The AML category represents highwalls, disturbed land, strip mines, and abandoned mines. The other nonpoint source category represents contributions from forest, pasture, cropland, urban (impervious and pervious), wetlands, and barren land. The revoked mines category represents the loading contribution from revoked mines. The baseline loads presented represent nonpoint source contributions under existing conditions. The allocation loads represent the LAs for individual categories. A column entitled "Requires Reduction" is also included to conveniently identify subwatersheds that require nonpoint source load reductions to meet water quality criteria.

Appendix A-1

Region 1

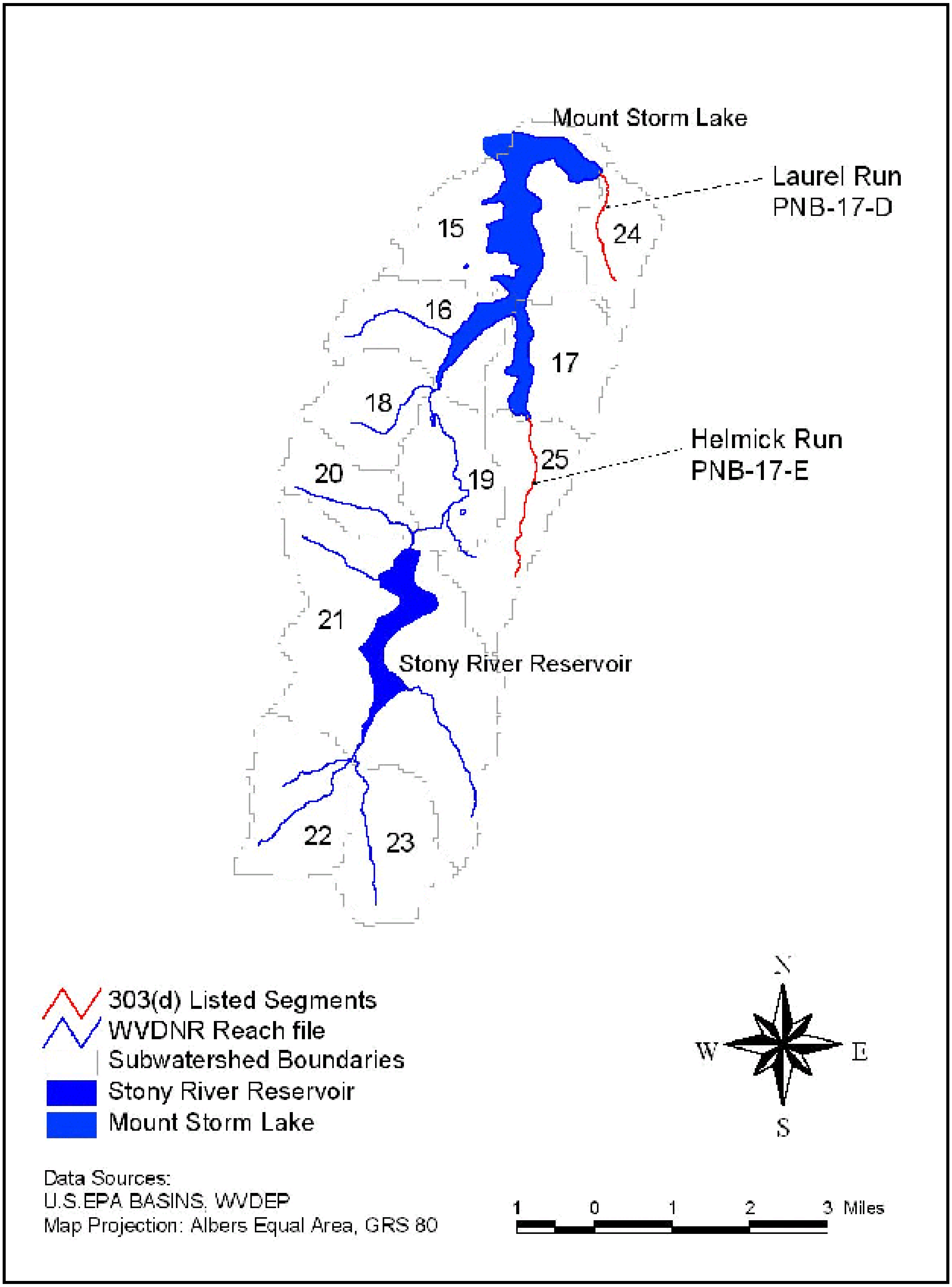


Figure . Region 1- Stony River watershed

Table 1. Impaired waterbodies in Region 1

Stream Name	Stream Code	Pollutant	Contributing SWS	Contributing Regions	Aquatic Life
Stony River, above Stony River Reservoir (SRR)	PNB-17	pH, Metals, unionized ammonia	23	NA	T
Stony River SRR and Mt. Storm Lake	PNB-17	pH, Metals, unionized ammonia	19,21,22,23	NA	W
Helmick Run	PNB-17-E	pH, Metals	25	NA	W
Laurel Run	PNB-17-D	pH, Metals	24	NA	W

T = Aquatic Life Trout Waters
W = Warm Water Fishery

Table 2. Locations of abandoned mines (seep, deep mine, and/or leaching)

SWS
15
24

Table 3a. Water quality data for aluminum

SWS	WQ station	Avg (ug/L)	Min (ug/L)	Max (ug/L)	Count	Start Date	End Date
21	01595135	135	120	150	2	6/12/84	9/19/84
21	01595140	360	360	360	1	6/12/84	6/12/84
21	390640079181501	1500	1500	1500	1	6/12/84	6/12/84
21	390640079181502	50000	50000	50000	1	9/19/84	9/19/84
24	PNB-17-O	4800	4800	4800	1	8/19/97	8/19/97
25	PNB-17-E	180	180	180	1	8/19/97	8/19/97

Table 3b. Water quality data for iron

SWS	WQ station	Avg (ug/L)	Min (ug/L)	Max (ug/L)	Count	Start Date	End Date
19	001 Below	0.51	0.25	1.03	22	6/10/96	12/4/00
19	002 Above	0.53	0.24	1.53	22	1/6/00	12/4/00
19	S-1	0.66	0.37	1.86	10	6/10/96	9/5/00
19	S-2	0.66	0.29	1.53	11	6/10/96	12/4/00
19	S-3	1.42	0.07	16.80	20	12/11/95	12/4/00
21	001 Below	0.51	0.25	1.03	22	6/10/96	12/4/00
21	01595135	280.00	280.00	280.00	2	6/12/84	9/19/84
21	01595140	740.00	740.00	740.00	1	6/12/84	6/12/84
21	390640079181501	1700.00	1700.00	1700.00	1	6/12/84	6/12/84
21	390640079181502	130000.00	130000.00	130000.00	1	9/19/84	9/19/84
21	S-3	1.42	0.07	16.80	20	12/11/95	12/4/00
21	S-4	1.16	0.28	4.59	21	12/11/95	12/4/00
21	S-6	0.75	0.12	8.01	52	12/11/95	12/4/00
21	S-7	1.08	0.40	3.38	10	6/10/96	9/5/00
21	SWM 1 Above	4.74	0.15	32.00	11	9/11/96	6/6/00
21	SWM 4 Below	1.90	0.12	12.34	14	9/11/96	12/4/00
23	002 Above	0.53	0.24	1.53	22	1/6/00	12/4/00

24	PNB-17-O	1800.00	1800.00	1800.00	1	8/19/97	8/19/97
25	PNB-17-E	720.00	720.00	720.00	1	8/19/97	8/19/97
25	S-4	1.16	0.28	4.59	21	12/11/95	12/4/00
25	S-5	2.26	0.26	11.00	9	3/1/99	12/4/00

Table 3c. Water quality data for manganese

SWS	WQ station	Avg (ug/L)	Min (ug/L)	Max (ug/L)	Count	Start Date	End Date
19	001 Below	0.22	0.05	1.07	22	6/10/96	12/4/00
19	002 Above	0.22	0.03	1.10	22	1/6/00	12/4/00
19	S-1	0.46	0.20	1.07	10	6/10/96	9/5/00
19	S-2	0.44	0.16	1.10	11	6/10/96	12/4/00
19	S-3	0.10	0.05	0.43	20	12/11/95	12/4/00
21	001 Below	0.22	0.05	1.07	22	6/10/96	12/4/00
21	01595135	45.00	40.00	50.00	2	6/12/84	9/19/84
21	01595140	3400.00	3400.00	3400.00	1	6/12/84	6/12/84
21	390640079181501	550.00	550.00	550.00	1	6/12/84	6/12/84
21	390640079181502	29000.00	29000.00	29000.00	1	9/19/84	9/19/84
21	S-3	0.10	0.05	0.43	20	12/11/95	12/4/00
21	S-4	2.46	0.06	6.88	21	12/11/95	12/4/00
21	S-6	0.09	0.01	0.41	52	12/11/95	12/4/00
21	S-7	2.66	0.33	11.00	10	6/10/96	9/5/00
21	SWM 1 Above	0.28	0.03	1.83	11	9/11/96	6/6/00
21	SWM 4 Below	0.17	0.05	1.08	14	9/11/96	12/4/00
23	002 Above	0.22	0.03	1.10	22	1/6/00	12/4/00
24	PNB-17-O	2200.00	2200.00	2200.00	1	8/19/97	8/19/97
25	PNB-17-E	900.00	900.00	900.00	1	8/19/97	8/19/97
25	S-4	2.46	0.06	6.88	21	12/11/95	12/4/00
25	S-5	0.35	0.07	1.03	9	3/1/99	12/4/00

Table 4a. Aluminum baseline conditions and allocations (WLAs) for permitted mining point sources

SWS	PERMIT ID	Baseline(lb/yr)	Allocation(lb/yr)	Allocation (mg/L)
15	h049900	119	119	4.30
15	s200186	259	259	4.30
15	u013983	223	223	4.30
16	h049900	149	149	4.30
18	h049900	134	107	3.44
18	s005280	593	356	2.58
19	h049900	253	203	3.44
19	s005280	3,446	2,757	3.44
19	s010084	2,779	2,223	3.44
19	s201300	315	252	3.44
20	h049900	209	63	1.29
20	s005280	1,501	450	1.29
20	s005380	19	6	1.29

SWS	PERMIT ID	Baseline(lb/yr)	Allocation(lb/yr)	Allocation (mg/L)
21	h049900	581	581	4.30
21	s005380	6,737	6,737	4.30
21	s010084	9,458	9,458	4.30
21	s201187	1,980	1,980	4.30
21	s201300	19	19	4.30
25	h049900	164	164	4.30
25	s010084	3,983	996	1.08
25	s201300	3,131	783	1.08

Table 4b. Iron baseline conditions and allocations (WLAs) for permitted mining point sources

SWS	Permit ID	Baseline (lb/yr)	Allocation(lb/yr)	Allocation (mg/L)
15	h049900	94	94	3.20
15	s200186	198	198	3.20
15	u013983	169	169	3.20
16	h049900	118	118	3.20
18	h049900	106	106	3.20
18	s005280	453	453	3.20
19	h049900	200	200	3.20
19	s005280	2,632	2,632	3.20
19	s010084	2,123	2,123	3.20
19	s201300	241	241	3.20
20	h049900	165	165	3.20
20	s005280	1,146	1,089	3.04
20	s005380	14	13	3.04
21	h049900	459	459	3.20
21	s005380	5,146	5,146	3.20
21	s010084	7,224	7,224	3.20
21	s201187	1,513	1,513	3.20
21	s201300	14	14	3.20
25	h049900	129	129	3.20
25	s010084	3,043	2,282	2.40
25	s201300	2,392	1,794	2.40

Table 4c. Manganese baseline conditions and allocations (WLAs) for permitted mining point sources

SWS	Permit ID	Baseline (lb/yr)	Allocation(lb/yr)	Allocation (mg/L)
15	h049900	58	58	2.00
15	s200186	123	123	2.00
15	u013983	105	105	2.00
16	h049900	73	73	2.00
18	h049900	66	66	2.00
18	s005280	282	282	2.00
19	h049900	124	124	2.00
19	s005280	1,636	1,636	2.00
19	s010084	1,320	1,320	2.00
19	s201300	150	150	2.00
20	h049900	102	102	2.00

SWS	Permit ID	Baseline (lb/yr)	Allocation(lb/yr)	Allocation (mg/L)
20	s005280	713	713	2.00
20	s005380	9	9	2.00
21	h049900	284	284	2.00
21	s005380	3,199	3,199	2.00
21	s010084	4,491	4,491	2.00
21	s201187	940	940	2.00
21	s201300	9	9	2.00
25	h049900	80	80	2.00
25	s010084	1,891	1,513	1.60
25	s201300	1,487	1,189	1.60

Table 5a. Aluminum baseline conditions and allocations (LAs) for nonpoint sources

	AML		Nonpoint		Revoked Mine		
SWS	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	Requires Reduction
15	2,621	2,621	3,337	3,337	0	0	
16	0	0	2,360	2,360	0	0	
17	0	0	2,214	2,214	0	0	
18	0	0	1,890	1,890	0	0	
19	3,069	61	2,300	2,300	0	0	x
20	0	0	1,925	1,925	0	0	
21	0	0	4,513	4,513	0	0	
22	0	0	1,806	1,806	0	0	
23	0	0	1,635	1,635	0	0	
24	28,223	282	2,148	2,148	0	0	x
25	2,439	49	2,038	2,038	0	0	x

Table 5b. Iron baseline conditions and allocations (LAs) for nonpoint sources

	AML		Nonpoint		Revoked Mine		
SWS	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	Requires Reduction
15	1,313	1,313	4,324	4,324	0	0	
16	0	0	3,047	3,047	0	0	
17	0	0	2,881	2,881	0	0	
18	0	0	2,459	2,459	0	0	
19	10,144	9,129	3,455	3,455	0	0	x
20	0	0	2,902	2,902	0	0	
21	0	0	8,169	8,169	0	0	
22	0	0	3,648	3,648	0	0	
23	0	0	2,106	2,106	0	0	
24	10,638	851	3,595	3,595	0	0	x
25	8,788	176	2,641	2,641	0	0	x

Table 5c. Manganese baseline conditions and allocations (LAs) for nonpoint sources

SWS	AML		Nonpoint		Revoked Mine		Requires Reduction
	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	
15	875	875	2,306	2,306	0	0	
16	0	0	1,589	1,589	0	0	
17	0	0	1,541	1,541	0	0	
18	0	0	1,314	1,314	0	0	
19	4,777	4,777	2,462	2,462	0	0	
20	0	0	1,974	1,974	0	0	
21	0	0	2,290	2,290	0	0	
22	0	0	777	777	0	0	
23	0	0	724	724	0	0	
24	17,444	2,617	2,603	2,603	0	0	x
25	7,628	153	1,393	1,393	0	0	x

Appendix A-2

Region 2

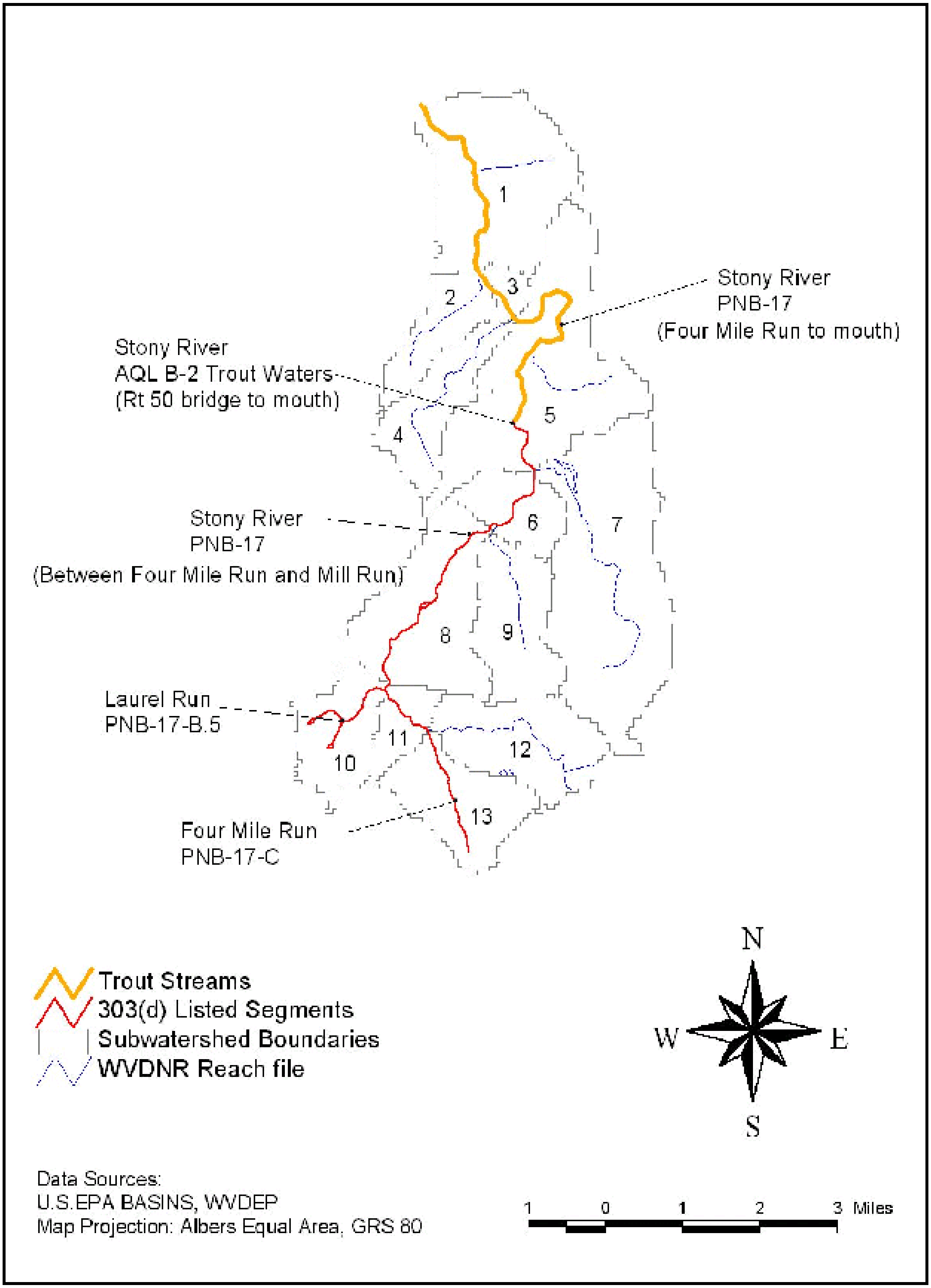


Figure 1. Region 2- Stony River watershed

Table 1. Impaired waterbodies in Region 2

Stream Name	Stream Code	Pollutant	Contributing SWS	Contributing Regions	Aquatic Life
Stony River, Mt. Storm Lake to mouth	PNB-17	pH, Metals, unionized ammonia	1,2,3,4,5,6,7,8,9, 10,11,12,13	1	T, W
Four Mile Run	PNB-17-C	pH, Metals	13	NA	W

T = Aquatic Life Trout Waters
W = Warm Water Fishery

Table 2. Locations of abandoned mines (seep, deep mine, and/or leaching)

SWS
1
3
5

Table 3a. Water quality data for aluminum

SWS	WQ station	Avg (ug/L)	Min (ug/L)	Max (ug/L)	Count	Start Date	End Date
4	01595201	670.00	670.00	670.00	1	6/12/84	6/12/84
4	01595202	100.00	100.00	100.00	1	6/12/84	6/12/84
4	01595203	100.00	100.00	100.00	1	6/12/84	6/12/84
4	391606079170801	670.00	670.00	670.00	1	6/12/84	6/12/84
4	391629079165201	100.00	100.00	100.00	1	6/12/84	6/12/84
4	PNB-18	50.00	50.00	50.00	1	8/13/97	8/13/97
5	550554	748.65	25.00	7000.00	224	6/17/74	7/18/93
5	PNB-17-{06.9}	37.50	25.00	50.00	2	8/13/97	8/13/97
7	PNB-17-B	37.50	25.00	50.00	2	8/13/97	8/13/97
8	PNB-17-{09.6}	37.50	25.00	50.00	2	8/12/97	8/12/97
10	PNB-17-B.5	1000.00	1000.00	1000.00	2	8/12/97	8/12/97
12	550891	198.35	25.00	460.00	124	4/22/86	7/20/92
12	550935	7078.84	170.00	20000.00	86	4/21/88	2/17/93
13	550934	12381.82	1700.00	66000.00	88	2/3/88	7/20/92
13	PNB-17-C	2800.00	2800.00	2800.00	2	8/19/97	8/19/97

Table 3b. Water quality data for iron

SWS	WQ station	Avg (ug/L)	Min (ug/L)	Max (ug/L)	Count	Start Date	End Date
4	01595201	1900.00	1900.00	1900.00	1	6/12/84	6/12/84
4	01595202	5800.00	5800.00	5800.00	1	6/12/84	6/12/84
4	01595203	3500.00	3500.00	3500.00	1	6/12/84	6/12/84
4	391606079170801	1900.00	1900.00	1900.00	1	6/12/84	6/12/84
4	391629079165201	3500.00	3500.00	3500.00	1	6/12/84	6/12/84
4	PNB-18	260.00	260.00	260.00	1	8/13/97	8/13/97
5	01595200	4059.44	270.00	11000.00	18	4/18/79	8/26/81
5	391610079154539	4422.22	1700.00	8500.00	9	4/18/79	9/9/80
5	550554	922.99	0.03	20404.00	236	6/17/74	7/18/93
5	PNB-17-{06.9}	25.01	0.03	50.00	2	8/13/97	8/13/97

SWS	WQ station	Avg (ug/L)	Min (ug/L)	Max (ug/L)	Count	Start Date	End Date
7	PNB-17-B	60.05	0.10	120.00	2	8/13/97	8/13/97
8	391410079172801	420.00	320.00	520.00	2	6/6/84	8/28/84
8	391446079165001	505.00	370.00	640.00	2	6/6/84	8/28/84
8	PNB-17-{09.6}	25.01	0.03	50.00	2	8/12/97	8/12/97
10	PNB-17-B.5	65.05	0.10	130.00	2	8/12/97	8/12/97
10	WTS #1	0.88	0.17	2.26	12	6/9/97	12/5/00
12	550891	206.10	0.01	1680.00	124	4/22/86	7/20/92
12	550935	290.63	0.04	4300.00	86	4/21/88	2/17/93
13	550934	21018.15	0.60	327000.00	88	2/3/88	7/20/92
13	PNB-17-C	3653.50	7.00	7300.00	2	8/19/97	8/19/97

Table 3c. Water quality data for manganese

SWS	WQ station	Avg (ug/L)	Min (ug/L)	Max (ug/L)	Count	Start Date	End Date
4	01595201	120.00	120.00	120.00	1	6/12/84	6/12/84
4	01595202	3100.00	3100.00	3100.00	1	6/12/84	6/12/84
4	01595203	570.00	570.00	570.00	1	6/12/84	6/12/84
4	391606079170801	120.00	120.00	120.00	1	6/12/84	6/12/84
4	391629079165201	570.00	570.00	570.00	1	6/12/84	6/12/84
4	PNB-18	20.00	20.00	20.00	1	8/13/97	8/13/97
5	01595200	1278.33	470.00	2900.00	18	4/18/79	8/26/81
5	391610079154539	946.67	470.00	2000.00	9	4/18/79	9/9/80
5	550554	370.79	0.00	2424.00	235	6/17/74	7/18/93
5	PNB-17-{06.9}	14.52	0.03	29.00	2	8/13/97	8/13/97
7	PNB-17-B	24.53	0.05	49.00	2	8/13/97	8/13/97
8	391410079172801	35.00	30.00	40.00	2	6/6/84	8/28/84
8	391446079165001	2050.00	1900.00	2200.00	2	6/6/84	8/28/84
8	PNB-17-{09.6}	90.10	0.20	180.00	2	8/12/97	8/12/97
10	PNB-17-B.5	650.65	1.30	1300.00	2	8/12/97	8/12/97
10	WTS #1	1.89	0.19	5.94	12	6/9/97	12/5/00
12	550891	117.44	0.02	520.00	124	4/22/86	7/20/92
12	550935	996.67	0.03	6500.00	86	4/21/88	2/17/93
13	550934	3788.79	0.10	52000.00	88	2/3/88	7/20/92
13	PNB-17-C	2352.35	4.70	4700.00	2	8/19/97	8/19/97

Table 4a. Aluminum baseline conditions and allocations (WLAs) for permitted mining point sources

SWS	PERMIT ID	Baseline(lb/yr)	Allocation(lb/yr)	Allocation (mg/L)
4	s200392	19	19	4.30
8	o001181	89	89	4.30
8	s012579	514	514	4.30
8	s200896	1,802	1,802	4.30
9	o001181	60	46	3.31
9	s012579	537	414	3.31
10	o004084	119	89	3.23
10	o009683	611	458	3.23
10	o009783	15	11	3.23

SWS	PERMIT ID	Baseline(lb/yr)	Allocation(lb/yr)	Allocation (mg/L)
10	u003885	20	15	3.23
11	s012579	19	19	4.30
11	s101091	204	204	4.30
12	s012579	278	278	4.30
12	u013983	3,080	3,080	4.30
13	h049900	45	11	1.08
13	u013983	4,397	1,099	1.08

Table 4b. Iron baseline conditions and allocations (WLAs) for permitted mining point sources

SWS	Permit ID	Baseline (lb/yr)	Allocation(lb/yr)	Allocation (mg/L)
4	s200392	14	14	3.20
8	o001181	71	71	3.20
8	s012579	392	392	3.20
8	s200896	1,377	1,377	3.20
9	o001181	47	47	3.20
9	s012579	410	410	3.20
10	o004084	94	94	3.20
10	o009683	483	483	3.20
10	o009783	12	12	3.20
10	u003885	15	15	3.20
11	s012579	14	14	3.20
11	s101091	155	155	3.20
12	s012579	212	212	3.20
12	u013983	2,333	2,333	3.20
13	h049900	35	26	2.40
13	u013983	3,331	2,498	2.40

Table 4c. Manganese baseline conditions and allocations (WLAs) for permitted mining point sources

SWS	Permit ID	Baseline (lb/yr)	Allocation(lb/yr)	Allocation (mg/L)
4	s200392	9	9	2.00
8	o001181	44	44	2.00
8	s012579	244	244	2.00
8	s200896	856	856	2.00
9	o001181	29	29	2.00
9	s012579	255	255	2.00
10	o004084	58	58	2.00
10	o009683	299	299	2.00
10	o009783	7	7	2.00
10	u003885	10	10	2.00
11	s012579	9	9	2.00
11	s101091	97	97	2.00
12	s012579	132	132	2.00
12	u013983	1,453	1,453	2.00
13	h049900	22	20	1.80
13	u013983	2,074	1,866	1.80

Table 5a. Aluminum baseline conditions and allocations (LAs) for nonpoint sources

SWS	AML		Nonpoint		Revoked Mine		Requires Reduction
	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	
1	7	7	4,081	4,081	0	0	
2	0	0	1,286	1,286	0	0	
3	9	9	333	333	0	0	
4	0	0	1,740	1,740	0	0	
5	1,281	1,281	5,198	5,198	0	0	
6	0	0	1,231	1,231	0	0	
7	0	0	5,833	5,833	0	0	
8	0	0	2,490	2,490	0	0	
9	0	0	2,104	2,104	0	0	
10	126	3	1,496	1,496	0	0	x
11	0	0	733	733	0	0	
12	10,519	7,889	1,652	1,652	0	0	x
13	42,975	859	1,219	1,219	0	0	x

Table 5b. Iron baseline conditions and allocations (LAs) for nonpoint sources

SWS	AML		Nonpoint		Revoked Mine		Requires Reduction
	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	
1	9	9	5,312	5,312	0	0	
2	0	0	1,675	1,675	0	0	
3	11	11	433	433	0	0	
4	0	0	2,265	2,265	0	0	
5	642	642	6,769	6,769	0	0	
6	0	0	1,604	1,604	0	0	
7	0	0	7,591	7,591	0	0	
8	0	0	3,414	3,414	0	0	
9	0	0	2,740	2,740	0	0	
10	7,071	2,475	1,944	1,944	0	0	x
11	0	0	954	954	0	0	
12	10,519	10,519	2,149	2,149	0	0	
13	165,019	3,300	1,586	1,586	0	0	x

Table 5c. Manganese baseline conditions and allocations (LAs) for nonpoint sources

SWS	AML		Nonpoint		Revoked Mine		Requires Reduction
	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	
1	4	4	2,844	2,844	0	0	
2	0	0	900	900	0	0	
3	5	5	232	232	0	0	
4	0	0	1,218	1,218	0	0	

SWS	AML		Nonpoint		Revoked Mine		Requires Reduction
	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	Baseline (lb/yr)	Allocation (lb/yr)	
5	428	428	3,637	3,637	0	0	
6	0	0	861	861	0	0	
7	0	0	4,068	4,068	0	0	
8	0	0	2,022	2,022	0	0	
9	0	0	1,471	1,471	0	0	
10	50,246	1,005	1,042	1,042	0	0	x
11	0	0	512	512	0	0	
12	49,050	12,263	1,381	1,381	0	0	x
13	76,501	1,530	865	865	0	0	x

Appendix B

Mining Permits in the Stony Watershed

Permit ID	NPDES ID	Mine Type	Status	Bonded Area[a] (acres)	Original Area[b] (acres)	Facility Name[c]	NPDES Status	County	Inspector
h049900	WV0068471	Haulroad	Renewed, Active	44	44	Buffalo Coal Company, Inc.			
o001181	WV1010417	Other	Renewed, Active	12	12	Vindex Energy Corporation			
o004084	WV0060372	Other	Renewed, Active	23	23	Buffalo Coal Company, Inc.			
o009683	WV0060372	Other	Renewed, Active	52	52	Buffalo Coal Company, Inc.			
o009783	WV0060372	Other	Renewed, Active	101	101	Buffalo Coal Company, Inc.			
s003284	WV0068209	Coal Surface Mine	Renewed, Active	170	170	Buffalo Coal Company, Inc.			
s005280	WV0051403	Coal Surface Mine	Extended, Active	191	191	Buffalo Coal Company, Inc.			
s005380	WV0051381	Coal Surface Mine	Extended, Active	375	375	Buffalo Coal Company, Inc.			
s005684	WV0068233	Coal Surface Mine	Completely Released	47	47	New Allegheny, Inc.			
s010084	WV0068471	Coal Surface Mine	Renewed, Active	934	934	Buffalo Coal Company, Inc.			
s010184	WV0068535	Coal Surface Mine	Completely Released	20	20	New Allegheny, Inc.			
s012579	WV0048526	Coal Surface Mine	Renewed, Active	182	182	Vindex Energy Corporation			
u013983	WV0093556	Coal Underground	Renewed, Active	344	344	Laurel Run Mining Company			
s024774	WV0036781	Coal Surface Mine	Completely Released	134	134	New Allegheny, Inc.			
u204786	WV0064475	Coal Underground	Extended, Active	27	27	Double H Mining Co., Inc.			
s205786	WV0098591	Coal Surface Mine	Phase 2 Released	120	120	Rostosky Mining			
s200186	WV0098744	Coal Surface Mine	Extended, Active	425	425	Buffalo Coal Company, Inc.			
s201187	WV1003429	Coal Surface Mine	Renewed, Active	107	107	Buffalo Coal Company, Inc.			
s101091	WV1010417	Coal Surface Mine	Renewed, Active	65	65	Vindex Energy Corporation			
s200896	WV1013998	Coal Surface Mine	Completely Released	421	421	Juliana Mining Company, Inc.			
o201596	WV1014030	Other	Renewed, Active	33	33	Buffalo Coal Company, Inc.			
s201195	WV1014030	Coal Surface Mine	Renewed, Active	187	187	Buffalo Coal Company, Inc.			
s200388	WV0098167	Coal Surface Mine	Remining, Inactive	354	354	Buffalo Coal Company, Inc.			

[a] Current Area - Surface disturbed area of permitted mines (June 2000.)

[b] Original Area - Surface disturbed area when mining permit was originally issued.

[c] Facility Name can represent either the permittee or the operator.

Appendix C

Hydrology and Water Quality Calibration and Validation Results

Hydrology Calibration

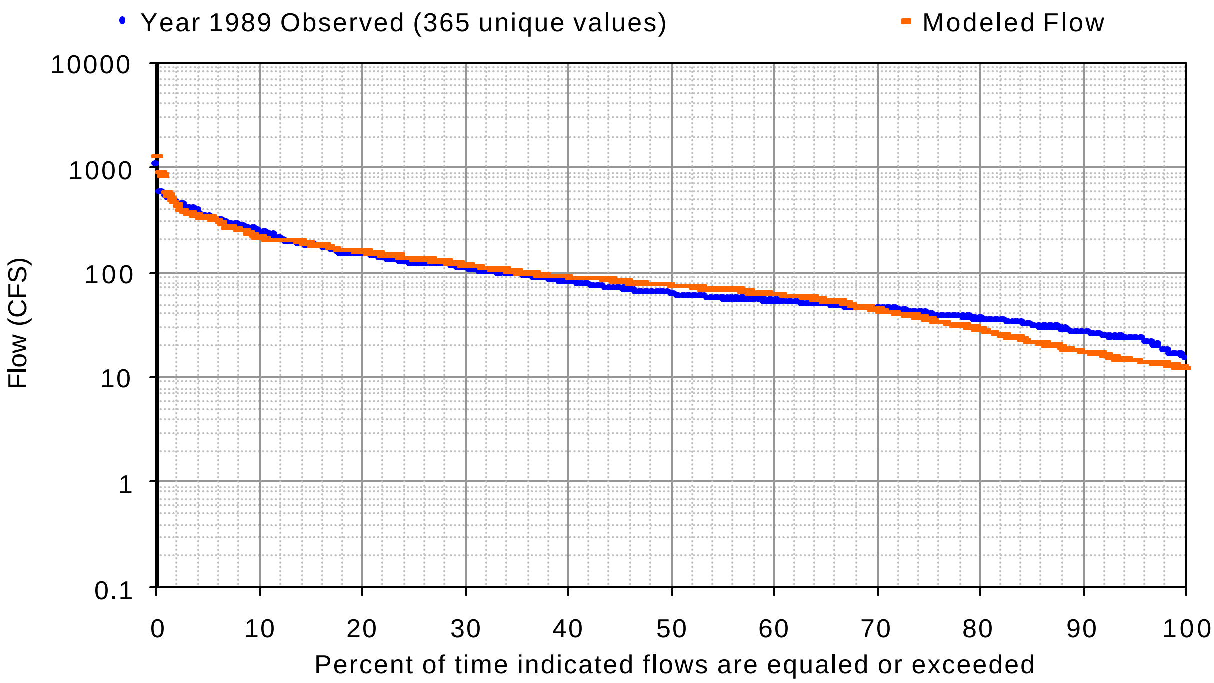


Figure C-1. Stony River (USGS 01595200) flow-frequency curve for year 1989

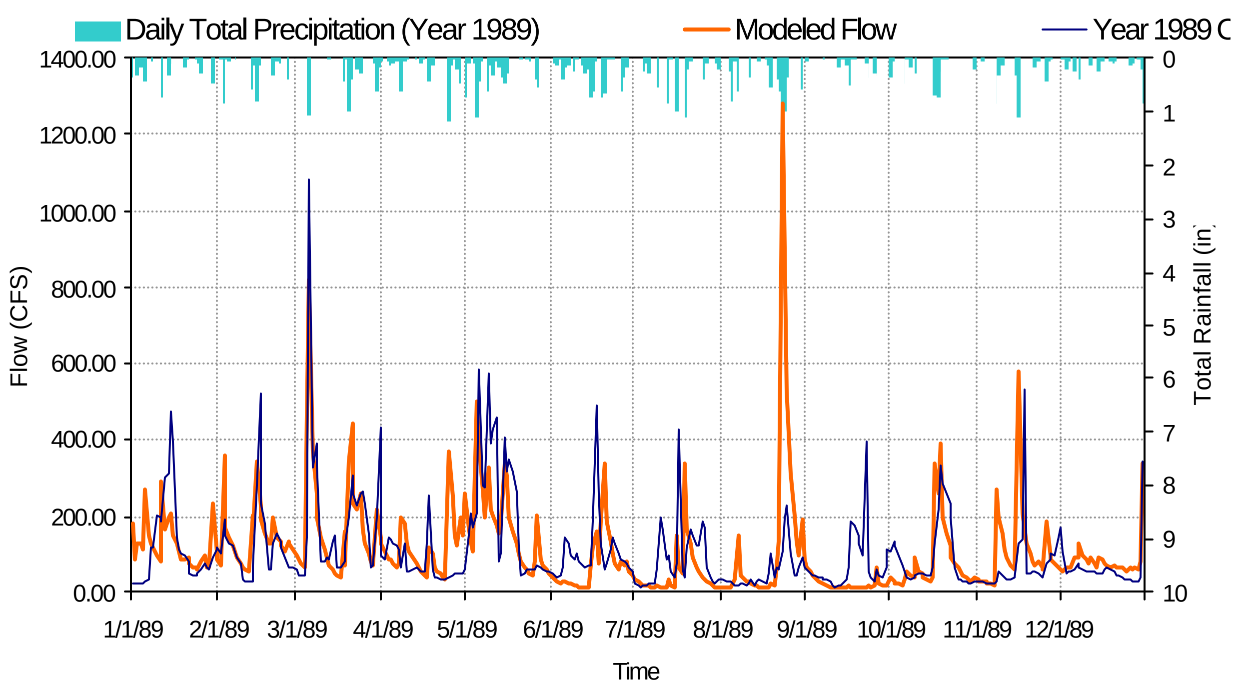


Figure C-2. Temporal calibration results for Stony River (USGS 01595200) for year 1989

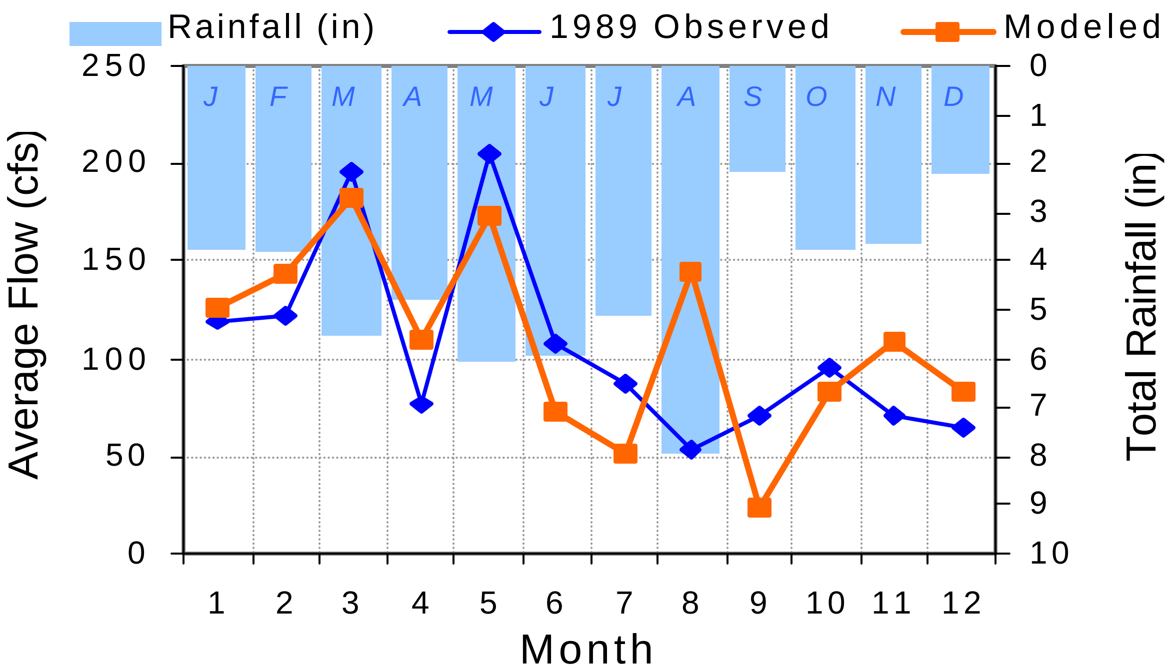


Figure C-3. Temporal calibration results for Stony River (USGS 01595200) for year 1989

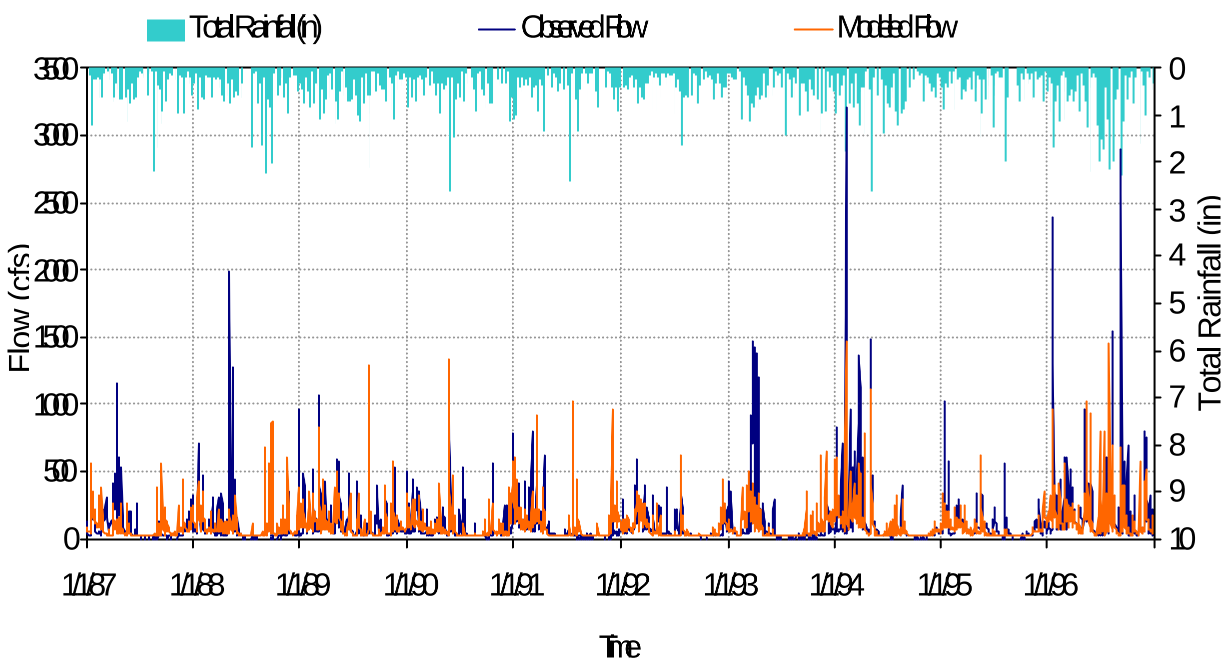


Figure C-4. Stony River (USGS 01595200) validation

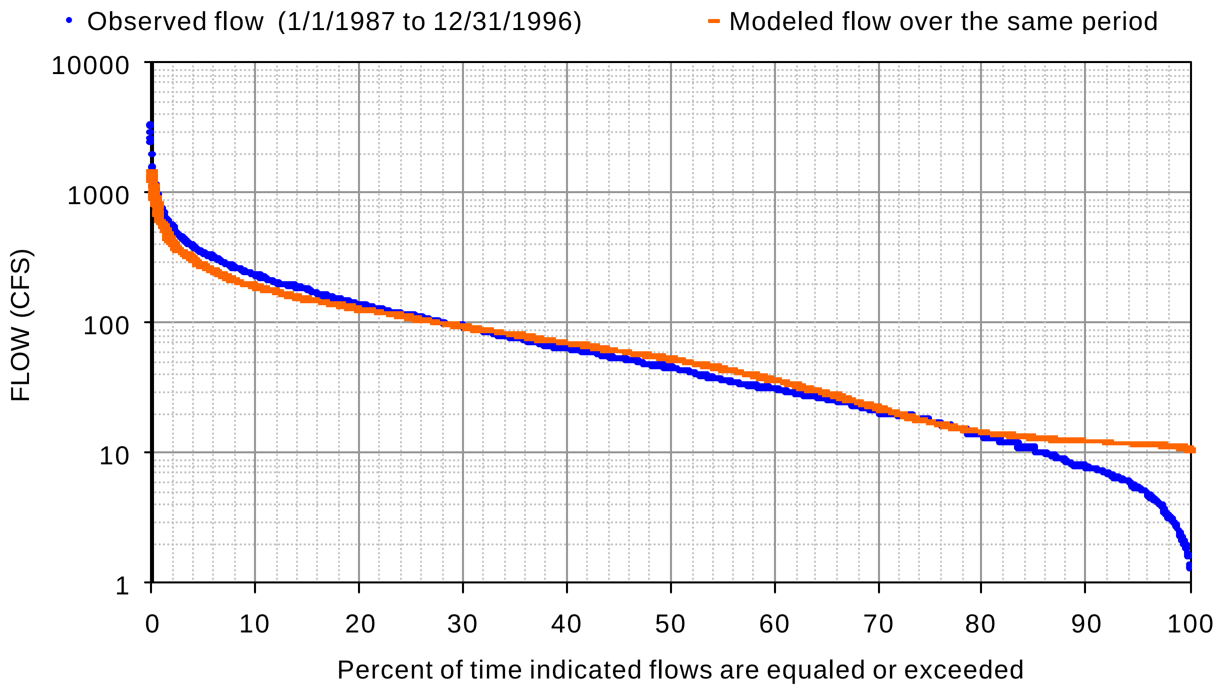


Figure C-5. Stony River (USGS 01595200) flow-frequency validation

Water Quality Calibration

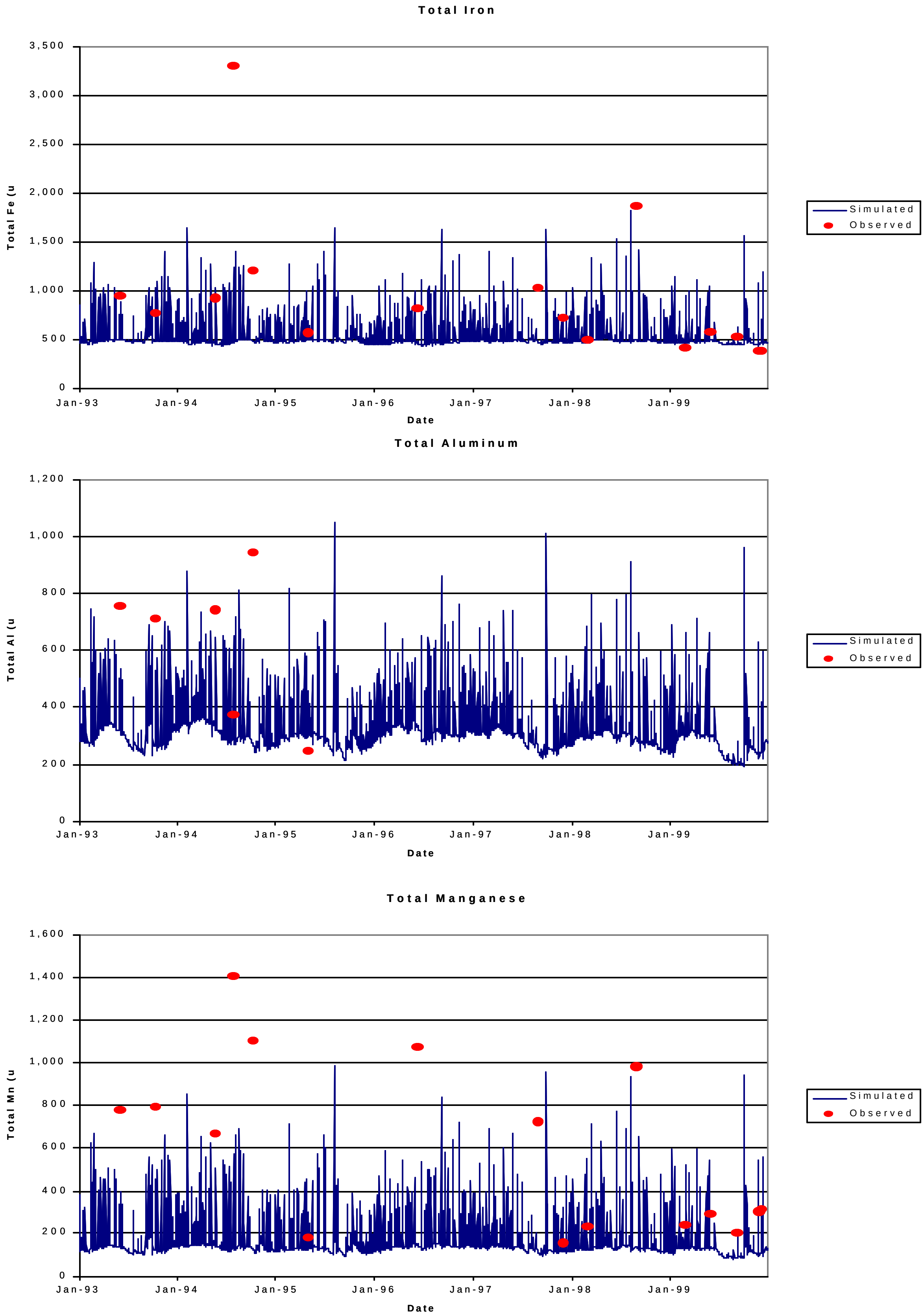


Figure C-6. Water quality calibration at Stony River above Mount Storm Lake

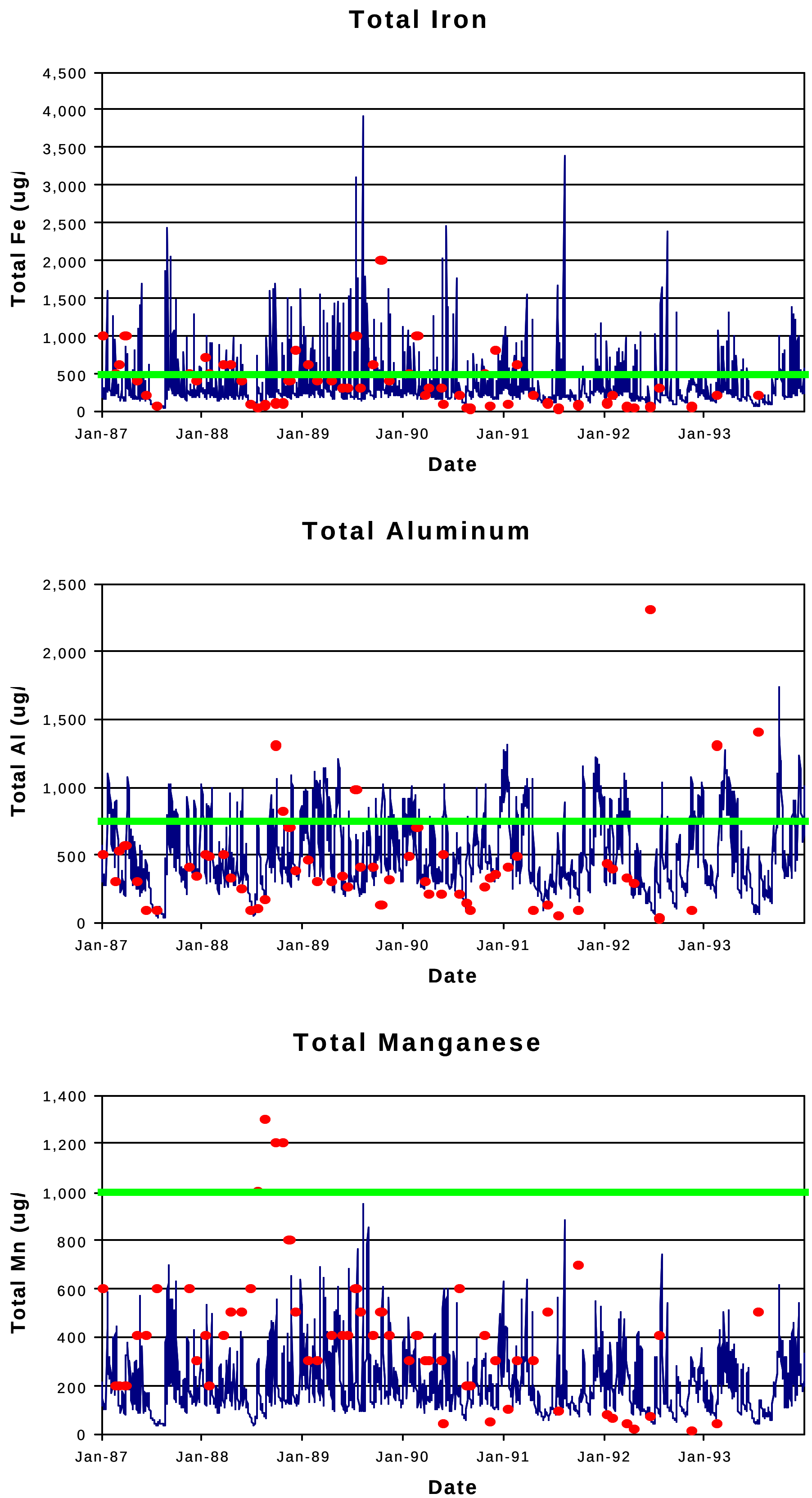


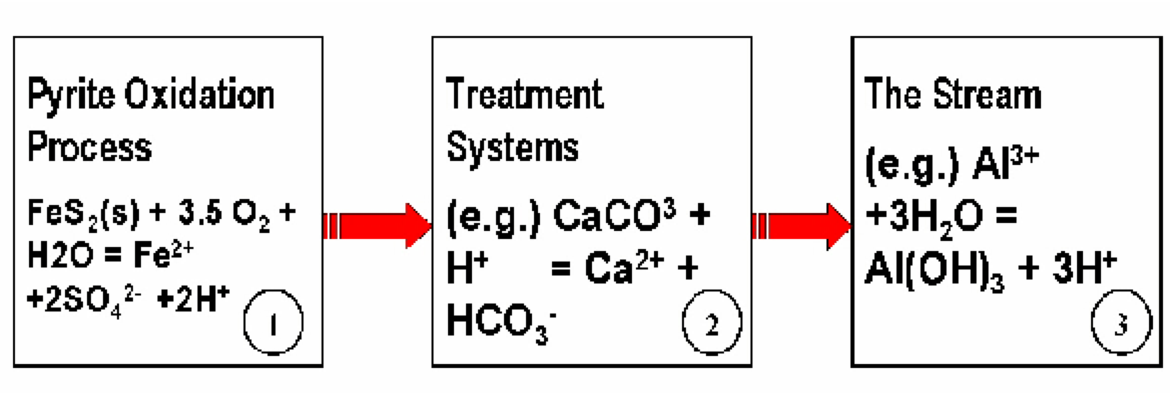
Figure C-7. Water Quality Calibration at Stony River near Route 50 (550554)

Appendix D

Modeling pH for TMDL Development

Overview

Streams affected by acid mine drainage often exhibit high metals concentrations (specifically for iron [Fe], aluminum [Al], and manganese [Mn]) along with low pH. The relationship between these metals and pH provides justification for using metals TMDLs as a surrogate for a separate pH TMDL calculation. The following figure shows three representative physical components that are critical to establishing this relationship.



Note: Several major ions compose the water chemistry of a stream. The cations are usually Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, and H^{+}, and the anions consist of HCO_3^{-}, CO_3^{2-}, NO_3^{-}, Cl^{-}, SO_4^{2-}, and OH^{-} (Stumm and Morgan, 1996).

Component 1 describes the beginning oxidation process of pyrite (FeS_2) resulting from its exposure to H_2O and O_2. This process is common in mining areas. The kinetics of pyrite oxidation processes are also affected by bacteria (Thiobacillus ferrooxidans), pH, pyrite surface area, crystallinity, and temperature (PADEP, 2000). The overall stoichiometric reaction of the pyrite oxidation process is as follows:

$$FeS_2(s) + 3.75\ O_2 + 3.5\ H_2O \longrightarrow Fe(OH)_3\ (s) + 2SO_4^{2-}\ + 4H+$$

Lower pH and higher metals concentrations from Component 1 should be treated effectively with applicable systems.

Component 2 presents an example chemical reaction occurring within a mining treatment system. Examples of treatment systems include wetlands, successive alkalinity-producing systems, and open limestone channels. Carbonate and other bases (e.g., hydroxide) created in treatment systems consume hydrogen ions produced by pyrite oxidation and hydrolysis of metals, thereby increasing pH. The increased pH of the solution will precipitate metals as metal hydroxides. Treatment systems may not necessarily work properly, however, because the removal rate of metals, and therefore the attenuation of pH depends on chemical constituents of the inflow, the age of the systems, and physical characteristics of the systems such as flow rate and detention rate (West Virginia University Extension Service, 2000).

It is assumed that implementing TMDLs in the Stony River watershed for aluminum, iron, and manganese will result in in-stream metals concentrations meeting the water quality criteria. This assumes that treatment systems are implemented properly and effectively increase pH in order to precipitate and thus lower metals concentrations.

After treatment, the focus shifts to Component 3 and the relationship between metals concentrations and pH in the stream. The chemical process that needs to be considered is the hydrolysis reaction of metals in the stream. Component 3 presents an example of this reaction. To estimate pH resulting from chemical reactions occurring in the stream, MINTEQA2 (a geochemical equilibrium speciation model for dilute aqueous systems) was used.

MINTEQA2 Application

MINTEQA2 is an EPA geochemical equilibrium speciation model capable of computing equilibrium aqueous speciation, adsorption, gas phase partitioning, solid phase saturation states, and precipitation-dissolution of metals in an environmental or lab setting. The model includes an extensive database of reliable thermodynamic data. The MINTEQA2 model was run using the following inputs:

Species	Input Values (mg/L)
Ca	43.2
Mg	14.5
Na [(a)]	6.3
K [(a)]	2.3
Cl [(a)]	7.8
SO_4	86.6
Fe [(b)]	1.5 and 0.5
Al [(b)]	0.75
Mn [(b)]	1.0
Alkalinity	11.3 (as $CaCO_3$)

[a] source: Livingstone (1963)
[b] allowable maximum concentrations (TMDL endpoints)

Input values for Fe, Al, and Mn were based on TMDL endpoints (maximum allowable limits). The alkalinity value was based on average in-stream concentrations for rivers relatively unimpacted by mining activities in the Stony River watershed. Mean observation values were used for the remaining ions requiring input for MINTEQA2. Where observation data were not available, literature values were used for the chemical species. Additionally, the model was set to equilibrium with atmospheric CO_2. Based on the inputs presented, the resultant equilibrium pH was estimated to be **7.48** using the aquatic life standard (1.5 mg/L total Fe) and **7.53** using the trout waters standard (0.5 mg/L total Fe).

The model was also run using typical in-stream metals concentrations found in the vicinity of mining activities (10 mg/L for total Fe, 10 mg/L for Al, 5 mg/L for Mn, and 3 mg/L as $CaCO_3$ for alkalinity). These inputs resulted in an equilibrium pH of **4.38**.

Results from MINTEQA2 imply that pH will be within the West Virginia criterion of above 6 and below 9, provided that in-stream metals concentrations simultaneously meet applicable water quality criteria.

Assumptions

The conclusions presented above assume that TMDLs are implemented properly, so that metals concentrations from point and nonpoint sources result in the streams meeting metals criteria (implying that pH from these sources has already been increased in order to decrease metals). Additional assumptions (and facts) considered in this process are as follows:

Iron (Fe)

Ferric iron was selected as total iron based on the assumption that the stream will be in equilibrium with the atmospheric oxygen. Because iron exhibits oxidized and reduced states, the redox part of the iron reactions might need to be considered. The reduced state of iron, ferrous iron, can be oxidized to ferric iron through abiotic and biotic oxidation processes in the stream. The first process refers to oxidation by increasing the dissolved oxygen because of the mixing of flow. The other process is oxidation by microbial activity in acidic conditions on bedrock (Mcknight and Bencala, 1990). Photoreduction of hydrous oxides also can increase the dissolved ferrous form. This reaction could increase pH of the stream followed by oxidation and hydrolysis reactions of ferrous iron (Mcknight, Kimball and Bencala, 1988). Since water quality data are limited, the concentration of total Fe was assumed to be constant at 1.5 mg/L, and it was assumed that total Fe increase by photoreduction would be negligent. (This assumption could ignore pH changes during daytime.)

Sodium (Na), Potassium (K), and Chloride (Cl)

The concentration of Na, K, and Cl can be higher in streams affected by acid mine drainage. These ions are conservative and are not reactive in natural water, however, so it is likely that the pH of the stream would not be affected.

Calcium (Ca), Magnesium (Mg)

These ions may have higher concentrations than the values used for the modeling in this study due to the dissolution of minerals under acidic conditions and the reactions within treatment systems. Increasing the concentrations of these ions in the stream, however, could result in more complex forms with sulfate in the treatment system and in the river. This should not affect pH.

Manganese (Mn)

Manganese oxide (MnO_2) can have a redox reaction with ferrous iron and produce ferric iron (Evangelou, 1998). This ferric iron can go through a hydrolysis reaction and produce hydrogen ions, thereby decreasing pH.

Biological Activities $\longleftrightarrow$

Biological activities such as photosynthesis, respiration, and aerobic decay can influence the pH of localized areas in the stream. Biological reactions such as the following:

$$CO_2 + H_2O \qquad\qquad 1/6\ C_6H_{12}O_6 + O_2$$

will assimilate CO_2 during photosynthesis and produce CO_2 during respiration or aerobic decay. Reducing CO_2 levels will increase the pH and increasing CO_2 levels will lower the pH of the water (Langmuir, 1997). It is possible that as a result of these biological activities, the pH standards might be violated even though metals concentrations are below in-stream water quality standards.

Kinetic Considerations

The kinetic aspect of metal reactions in the stream is an important factor that also needs to be considered. For example, Fe and Mn can be oxidized very rapidly if the pH of the solution is 7.5 to 8.5; otherwise, the oxidization process is much slower (Evangelou, 1995). Having a violation of metals concentrations but no pH violation might be a result of the kinetic aspect of the reactions.

Appendix E

Un-ionized Ammonia Impairments in the Stony River Watershed

Problem Understanding and Conclusions

The main stem of the Stony River (stream code: PNB-17) was listed as impaired on West Virginia's 1996 and 1998 303(d) lists due to metals, pH, and un-ionized ammonia impairments. Un-ionized ammonia data collected from stations located on the main stem of the Stony River are shown in Figure E-1. There were 3 exceedances (station 550934) of the water quality criteria for unionized ammonia out of 308 total observations (1 percent violation rate). Treatment of permitted mine discharge with anhydrous ammonia during this time period is believed to have caused the noted exceedances. Evaluation of recent and historical data suggests that the un-ionized ammonia impairment on the Stony River main stem no longer exists and TMDL development for this pollutant is not necessary. This impairment will be addressed in the development of the West Virginia 2002 303(d) list.

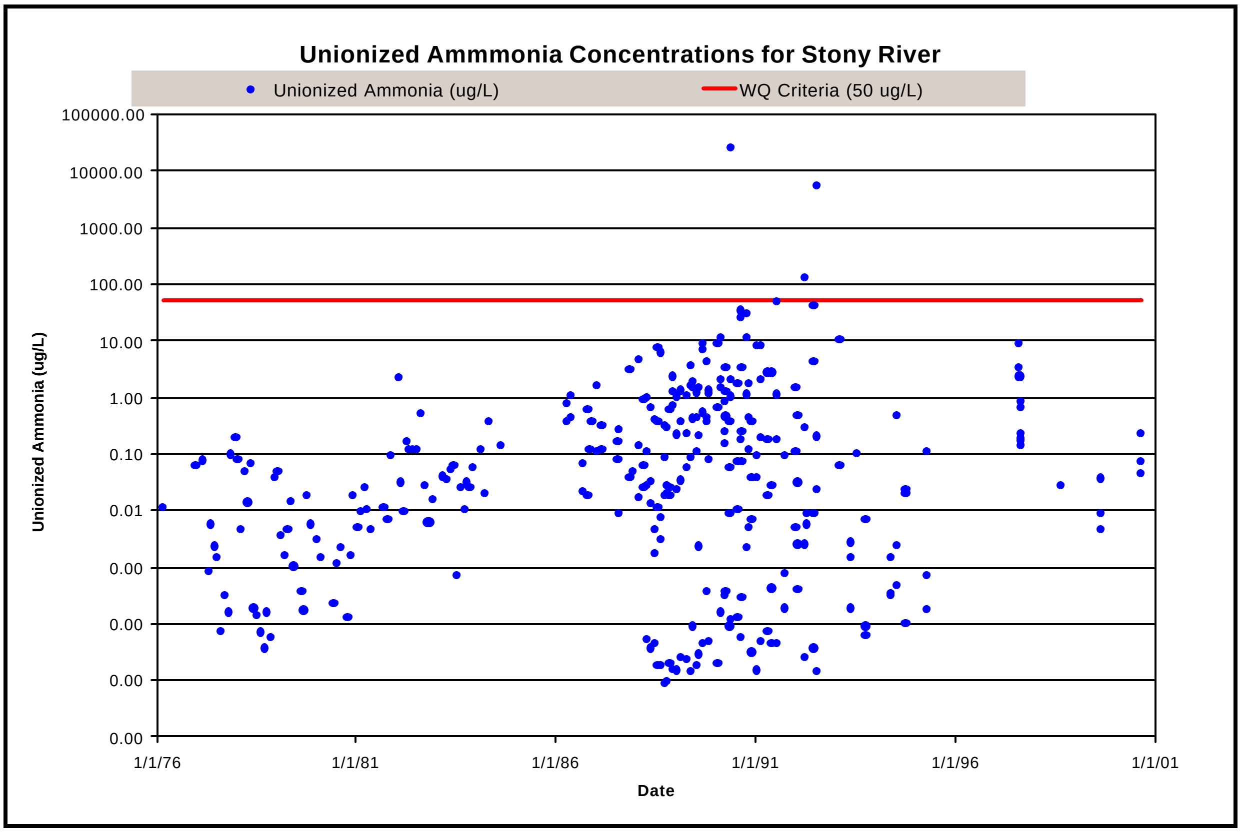


Figure E-1. Historical unionized ammonia concentrations for Stony River (using ammonia nitrogen)