3.0 Source Assessment

This section examines and identifies the potential sources of aluminum, iron, and manganese in the Elk River watershed. A wide range of data was used to identify potential sources and to characterize the relationship between point and nonpoint source discharges and instream response at monitoring stations. Sources of lead and zinc in the watershed were not identified in the assessment process detailed below.

3.1 Data Inventory

Data and information from various sources were used in the development of TMDLs for the impaired streams in the Elk River watershed. The categories of data used include physiographic data that describe the physical conditions of the watershed and environmental monitoring data that identify potential pollutant sources and their contribution. Table 3-1 shows the various data types used to develop TMDLs.

Table 3-1. Inventory of data and information used to develop Elk River watershed TMDLs

Data Category	Description	Data Source(s)
Watershed Physiographic Data	Land Use (GAP2000)	USGS
	Abandoned Mining Coverage	WVDEP OMR
	Soil data (STATSGO)	USDA, NRCS
	Stream Reach Coverage	USGS, WVDEP DWR
	Weather Information	National Climatic Data Center
	Oil and Gas Operations Coverage	WVDEP OOG
	Paved and Unpaved Roads	WVDOT, USDOT
	Timber Harvest Data	USDA, US Forest Serice
Environmental Monitoring Data	NPDES Data	WVDEP OMR, WVDEP DWR
	Discharge Monitoring Report Data	WVDEP OMR
	Abandoned Mine Land Data	WVDEP OMR, WVDEP DWR
	Section 303(d) Listed Waters	WVDEP DWR
	Water Quality Monitoring Data for 598 Sampling Stations	EPA STORET, WVDEP DWR

3.2 Stream Flow Data

There are 18 USGS flow gages in the Elk River watershed, as well as one flow gage station operated by the National Weather Service. Flow data from 12 of these USGS gages were used to support flow analyses for the watershed. Table 3-2 shows the12 flow gaging stations with available records of flow data and the corresponding period of record for each. These 12 stations were used because they were the only stations which include sufficient long-term records to characterize the stream flow in the watershed.

Table 3-2. Flow analysis for the Elk River watershed

Station	Stream Name	Start Date	End Date	Min (cfs)	Mean (cfs)	Max (cfs)
03195600	Granny Creek at Sutton, WV	06/01/1967	09/30/1977	0.03	9.33	281.00
03197000	Elk River at Queen Shoals, WV	10/01/1928	09/30/1998	0.30	2090.64	58100.00
03196800	Elk River at Clay, WV	10/01/1958	09/30/1978	1.80	1925.24	32100.00
03195100	Right Fork Holly River at Guardian, WV	10/01/1985	09/30/1987	0.03	98.15	1670.00
03195500	Elk River at Sutton, WV	10/01/1938	09/30/1993	0.40	1145.52	20400.00
03195000	Elk River at Centralia, WV	10/01/1934	09/30/1963	1.30	664.64	14700.00
03194700	Elk River below Webster Springs, WV	09/20/1985	09/30/1998	4.90	709.09	15200.00
03196600	Elk River near Frametown, WV	10/01/1994	09/30/1995	82.00	1109.64	10000.00
03196500	Birch River at Herold, WV	10/01/1978	09/30/1984	1.80	242.14	5630.00
03197440	Left Hand Creek near Clendenin, WV	01/24/1974	02/14/1975	0.91	31.46	202.00
03193830	Gilmer Run near Marlinton, WV	06/12/1968	09/30/1977	0.01	3.83	153.00
03195250	Left Fork Holly River near Replete, WV	10/01/1985	09/30/1987	0.03	124.82	2020.00

3.3 Point Sources

In order to characterize the contributing point sources in the Elk watershed, the point sources were classified into two major categories: permitted non-mining 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 a total of 143 nonmining point sources in the Elk River watershed. Three of these facilities are permitted to discharge one or more of the listed pollutants to the Elk River watershed. The three facilities are listed in Table 3-3 along with the pollutants they are permitted to discharge. The discharges from these nonmining point sources are required to be within a pH range of 6 to 9, inclusive.

Table 3-3. Nonmining point source facilities discharging to the Elk River watershed

NPDES ID	Facility Name	Permitted Pollutant Discharged
WV0002631	Columbia Gas Transmission	Iron
WV0072249	Appalachian Timber Services	Iron
WV0080900	Elk Pinch PSD	Aluminum, lead, zinc

3.3.2 Permitted Mining Point Sources

Mining-related point source discharges, from deep mines, surface mines, and other mining activities, if untreated, 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 the West Virginia 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 7 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; in 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 on water quality

Coal mining operations and sandstone quarries typically have permits limiting total iron, total manganese, total nonfilterable residue, and pH. They are also required to monitor for total aluminum discharges. However, limestone quarries do not have permits for discharge concentrations of total iron, total manganese, total nonfilterable residue, and aluminum discharges. There are a total of 256 mining discharge permits in the Elk River watershed. A complete list is provided in Appendix B.

3.4 Nonpoint Sources

In addition to point sources, nonpoint sources might also contribute to water quality impairments in the Elk River watershed. Nonpoint sources represent contributions from diffuse, nonpermitted sources. Based on the identification of a number of abandoned mining activities in the Elk River watershed, abandoned mine lands (AML) represent a critical nonpoint source. Abandoned mines can contribute significant amounts of acid mine drainage (AMD), which produces low pH and high metals concentrations in surface and subsurface water in areas where mining activities are or once were present.

AMD occurs when surface and subsurface water percolates through coal-bearing minerals containing high concentrations of pyrite and marcasite, which are crystalline forms of iron sulfide (FeS_2). It is these chemical reactions of the pyrite that generate acidity in water. A synopsis of these reaction is as follows: Exposure of pyrite to air and water causes the oxidation of pyrite. The sulfur component of pyrite is oxidized releasing dissolved ferrous (Fe^{2+}) ions and also 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 also releases more H^+ ions, thereby causing more acidity. Another reaction is one between the pyrite and generated ferric (Fe^{3+}) ions, in which more acidity (H^+) is released as well as Fe^{2+} ions, which then can enter the reaction cycle (Stumm and Morgan, 1996).

Sediment produced from land-based activities is another potential source of high metal contamination in the Elk River watershed. region 3. West Virginia is composed of two basic geologic areas: the western two-thirds has relatively flat-lying rocks and the eastern one-third has folded and faulted rocks. The Appalachian Plateau Province is located in the west and the Valley and Ridge Province in the east, separated by the Allegheny Front. The oldest formation, the Catoctin Formation (late Precambrian), is found in the eastern part of the state, with younger formations (Paleozoic) in the west. Quaternary alluvium overlays much of the formations.

The Appalachian Plateau, composed mostly of Pennsylvanian and Permian strata, is where much of the minable coal is located. The rocks of the Pennsylvanian System are widely exposed at the surface, having been extensively mined for coal and drilled extensively for oil and gas. Lower and Middle Pennsylvanian rocks that are exposed in the east-central part of the state (Kanawha, Clay, and western Roan counties) consist primarily of sandstone with clayey sediments and coal found in the subsurface. From east to west, shale and coal are commonly exposed in the younger Pennsylvanian formations (Watts et al., 1994).

The Lower Pocahontas basin is in the southern part of the state and is the older of two sedimentary basins in West Virginia. Alternating units of sandstone, shale, limestone, and coal of the Kanawha, New River, and Pocahontas Formations are found in the sediments in the Pocahontas basin. The Dunkard basin, the northern sedimentary basin, overlaps the Pocahontas basin in central West Virginia (Calhoun, Gilmer, Kanawha, and Roan counties). Sediments of the Dunkard basin consist of sandstone and shale from the Conemaugh Formation with small amounts of coal from the Monongahela and Dunkard Groups.

Watts et al. (1994) identified clays derived from shale units within the drainage basins as the primary source of high aluminum concentrations instream sediments. In addition, correlation coefficients indicate that iron and manganese are associated with aluminum as a result of precipitated iron oxides and oxyhydroxides in the streambeds (Watts et al., 1994).

Nonpoint source contributions were grouped for assessment into three separate categories: AML, sediment sources, and other nonpoint sources. Figure 3-1 presents a schematic of potential sources in the Elk River watershed. The land use distribution for the Elk watershed is presented in Figure 3-2.

3.4.1 Abandoned Mine Lands (AML)

Historically, there have been both surface and deep mining activities in the Elk River watershed, and consequently numerous AML sites that produce AMD flows remain. Data regarding AML sites in the Elk River watershed were compiled from spatial coverages provided by WVDEP OMR. The AML sites were classified into three categories:

High walls: the face of exposed overburden and coal in an open cut of a surface coal mining activity or for entry to underground mining activities

Disturbed land: disturbed land associated to both surface and underground mining activities

Abandoned mines: abandoned surface and underground mines

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

3.4.2 Sediment Sources

Based on the review of existing literature, sediment was identified as a potential source of high metals concentrations in the Elk River watershed. Visual observations by WVDEP in April 2001 indicated that the impaired segment of the main stem exhibited a high level of siltation. However, increased siltation was not observed in the upstream impaired segments (Buffalo Creek, Morris Creek, Left Fork Morris Creek and Pheasant Run). Water quality data from 42 stations on the impaired main stem and 25 stations on the upstream segments were evaluated to determine whether a relationship between total metals and total suspended solids (TSS) concentrations exists. The results of these analyses are presented in Appendix C.

For the Elk River main stem, results of a comparison of the water quality data for total aluminum, total iron, and total manganese concentrations showed that concentrations appeared to closely follow suspended solids concentrations, increasing as flow increased (Figures C-1 through C-4). Regression analysis indicated that a good linear relationship exists between total aluminum, total iron, and total manganese and sediment concentrations during the 30 percent highest flows (Figures C-7 through C-9). However, dissolved iron and manganese concentrations are shown to decrease during high-flow events and increase during periods of low flow (Figures C-5 and C-6). The increase in metals concentrations during high flow, the linear relationship between metals and total suspended solids, and the decrease in dissolved metals concentrations during high flow indicate that sediment is a significant contributor to the high metals concentrations in the impaired main stem of the Elk River. Therefore, potential sources of sediment must be considered in the development of metals TMDLs for the main stem segment.

Similar analyses were performed using water quality data from the upstream impaired segments to determine whether land-based nonpoint sources were significant sources of metals in these watersheds. Higher total metals concentrations were shown to occur during low-flow conditions for each stream (Figures C-10 and C-11). These data confirm WVDEP observations in April 2001 regarding instream siltation and suggest that land-based activities are not significant contributors of metals, as has been shown for the Elk River mainstem. AMD and other sources are likely the primary sources of metals in these streams.

In the Elk River watershed, land-based nonpoint sources of sediment include abandoned and active mine areas, forestry operations, oil and gas operations, unpaved roads, agricultural land uses, barren land, and forestland. Because sediment transport is considered to be a primary source of metals in the main stem segment of the Elk River, reductions in sediment loading will be required to meet instream metals criteria. Reductions in sediment loading from these areas will be based on the sediment transport characteristics of each of these nonpoint source categories. High-sediment-yield areas include disturbed lands such as unpaved roads, forest harvest areas and access roads, oil and gas operations, agricultural land, barren land, and active mine areas. Mature forestland and other undisturbed areas have the lowest sediment yield and therefore have the lowest impact on receiving waters. A conceptual representation of sediment loading from nonpoint sources relative to the natural or undisturbed forest condition is presented in Table 3-5. To spatially represent land-based nonpoint sources in the Elk River watershed, the GAP2000 land use coverage for each subwatershed was updated to include paved and unpaved road areas, forest harvest areas, oil and gas operations, and mining areas.

Table 3-5. Sediment source characterization

	Sediment Contribution			Time Scale of impact on receiving water body	
Sources	**High**	**Medium**	**Low**	**Long**	**Short**
Forest (undisturbed)[a]			X	NA	NA
Forest operations	X				X
Access roads in forest	X			X	
Agriculture		X		X	
Oil and gas drilling		X			X
Oil and gas access road	X			X	
Mining (abandoned)		X		X	
Mining (active)			X	X	
Construction	X				X
Roadway construction	X				X
Paved roads and highways			X	X	
Unpaved roads	X			X	
Point sources (permitted)			X	X	

[a] Undisturbed forest condition is the reference level condition.

3.4.3 Other Nonpoint Sources

In addition to land uses that contribute metals through sediment loading, urban lands can contribute nonpoint source metals loads to the receiving streams through the washoff of metals that build up in industrial areas and other urban areas due to human activities. Urban lands in the Elk River watershed include paved roads, populated areas, and high-, moderate-, and light-intensity urban areas.

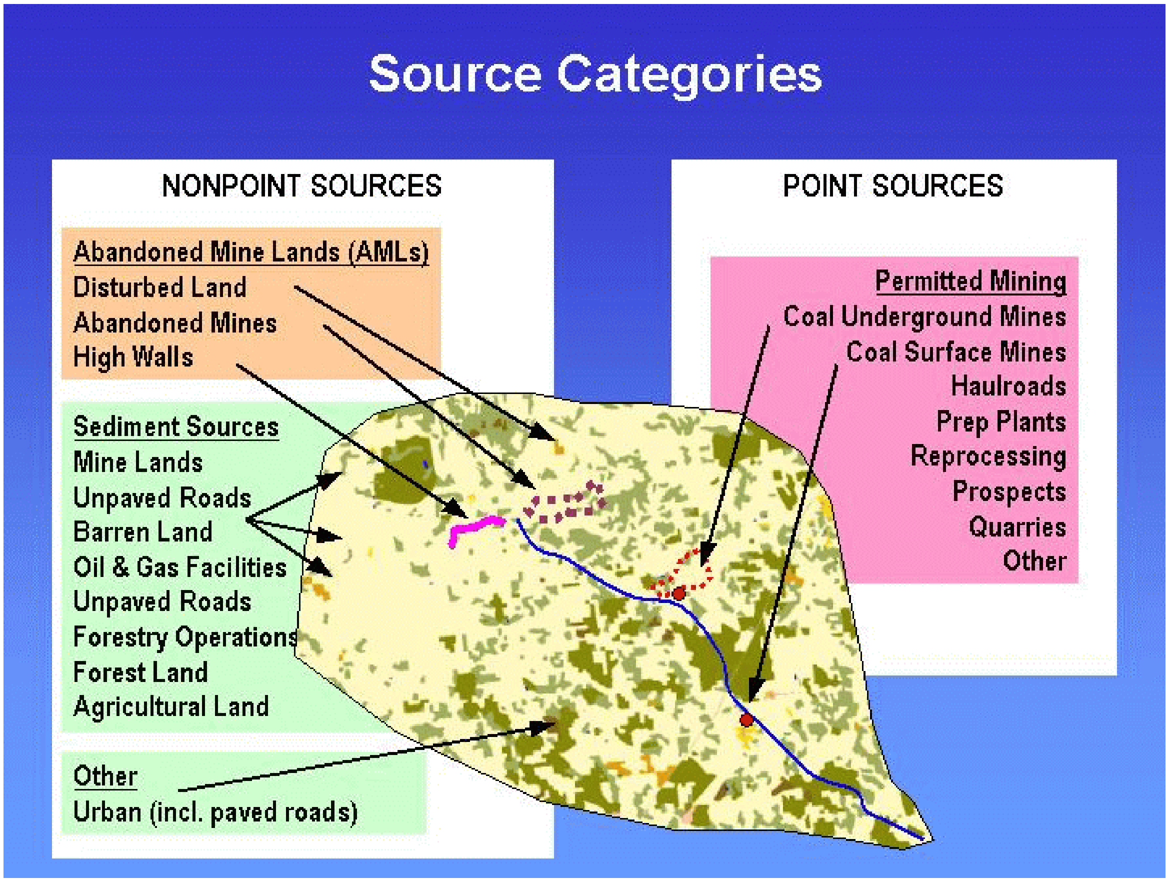

Figure 3-1. Potential sources contributing to impairments in the Elk River watershed

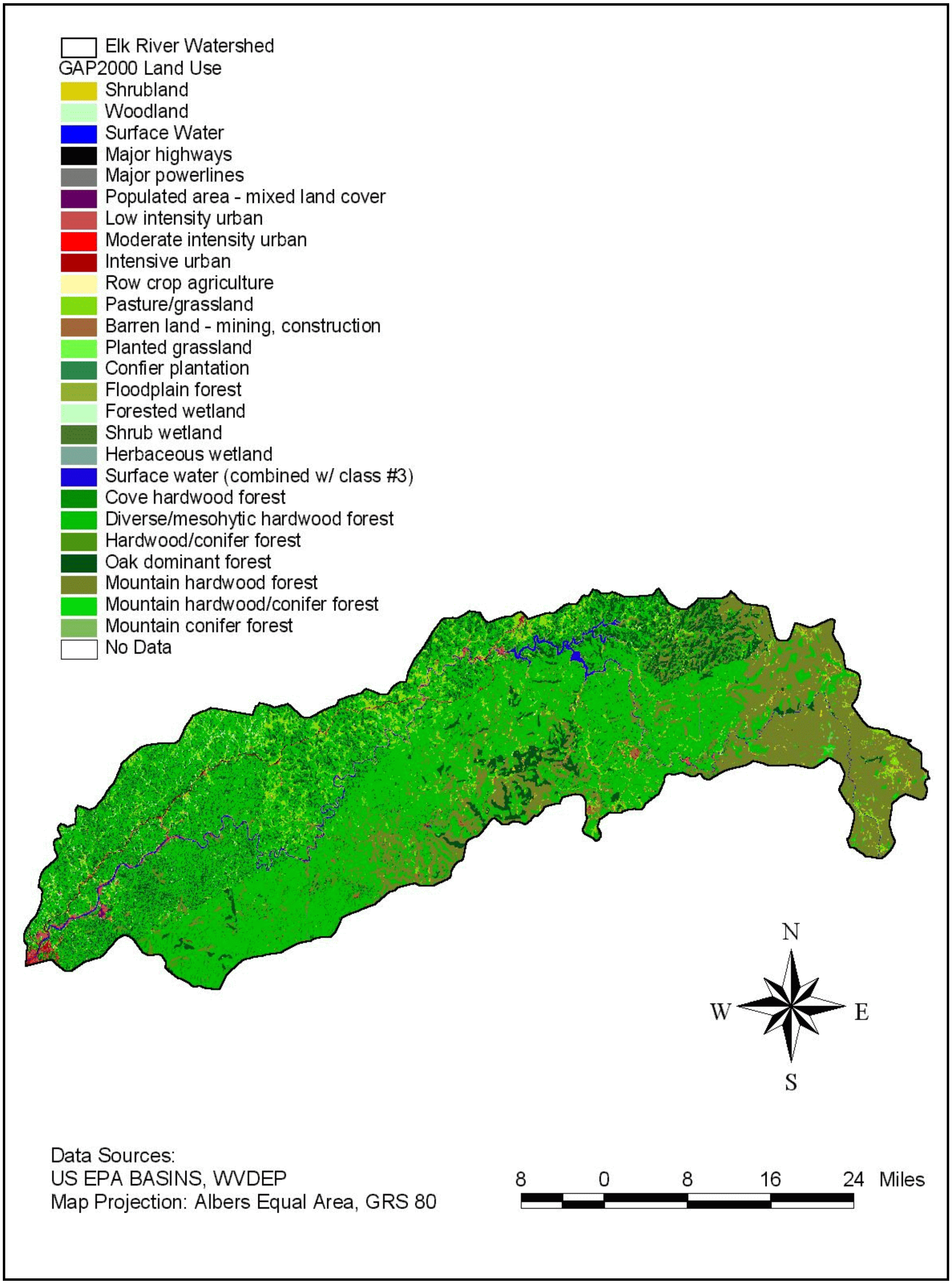

Figure 3-2. Land use distribution in the Elk River watershed