
ASSESSMENT OF CONDITIONS CONTRIBUTING ACID MINE DRAINAGE TO THE LITTLE NESCOPECK CREEK WATERSHED, LUZERNE COUNTY, PENNSYLVANIA, AND AN ABATEMENT PLAN TO MITIGATE IMPAIRED WATER QUALITY IN THE WATERSHED

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SUSQUEHANNA RIVER BASIN COMMISSION

The Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact* among the states of Maryland, New York, Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to coordinate the planning, conservation, management, utilization, development and control of basin water resources among the public and private sectors.

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INTRODUCTION

The Little Nescopeck Creek, a tributary to Nescopeck Creek, is severely impacted by a water-quality-impaired discharge from the adjacent mined watershed. The natural watersheds have been interconnected by a water-level drainage tunnel, the Jeddo, that was constructed to dewater deep mined coal measures in the Eastern Middle Anthracite Field (Plate 1).

The Jeddo Tunnel drainage system involves four major coal basins: Big Black Creek, Little Black Creek, Cross Creek, and Hazleton. More than a century of subsurface and surface mining activities has left a legacy of physical and chemical contamination of mine water draining the coal field through the tunnel.

The Jeddo Tunnel, which drains over 30 square miles and discharges an average of 80 cubic feet per second (cfs), is one of the largest mine water discharges in the anthracite region (Plate 1). The Little Nescopeck Creek receives all the flow from the tunnel.

The Little Nescopeck Creek is a pristine stream above the tunnel discharge, as is Nescopeck Creek upstream of its confluence with Little Nescopeck Creek. The quality-impaired Little Nescopeck Creek joins Nescopeck Creek, which eventually enters the Susquehanna River near Berwick, Pa.

PURPOSE AND SCOPE

This acid mine drainage (AMD) assessment report and abatement plan addresses factors and conditions relevant to the quality of the Jeddo Tunnel discharge to the Little Nescopeck Creek. A reduction in AMD at the mouth of the Jeddo Tunnel will decrease the negative impact on the Nescopeck Creek, which contains a high level of biological diversity and is classified as a High Quality Cold Water Fishery (HQ-CWF) above the confluence with the Little Nescopeck Creek. This, in turn, will provide a significant benefit downstream to the Susquehanna River.

Consequently, this report will focus on the area in the Eastern Middle Anthracite Field draining to the Jeddo Tunnel. Long-term records, as well as ongoing and recently-collected data, were used to characterize the quality of the Jeddo Tunnel discharge, identify surface water infiltration points, refine the hydrologic budget and develop a strategy for restoration.

The principal objectives of this report are to: (1) present feasible and applicable abatement measures that would eliminate or mitigate conditions and factors that contribute AMD to the Little Nescopeck Creek through the Jeddo Tunnel; and (2) prioritize remediation options based on the greatest potential environmental benefit.

STUDY PROCEDURES

To complete the Little Nescopeck Creek Watershed Assessment and Management Plan, the Susquehanna River Basin Commission (SRBC) and its subcontractor, Wildlands Conservancy (the Conservancy), have partnered with Pa. Department of Environmental Protection, Pottsville District Office, District Mining Operations (Pa. DEP-Pottsville), Pa. DEP, Bureau of Abandoned Mine Reclamation (Pa. DEP-BAMR), Pa. DEP, Bureau of Mining and Reclamation (Pa. DEP-BMR), Pa. DEP's Citizens Water Quality Monitoring Program, U.S. Geological Survey (USGS), Friends of the Nescopeck, Bloomsburg University, Wilkes University, Kings College, and Pennsylvania State University—Hazleton Campus.

The various team members were responsible for different aspects of data collection and analysis. Pa. DEP-BMR funded the reinstrumentation of the USGS flow gage at the mouth of the Jeddo Tunnel and the collection and analysis of water quality samples at the gage and other locations. The Conservancy conducted water quality monitoring and a stream subsidence survey. In particular, field reconnaissance conducted by the Conservancy documented hydrologic features and problems, including the source and destination of storm water, sewage, and local runoff within the Jeddo system and possible source or sources of "blackwater" events. Global positioning system (GPS) technology for accurate location data and geographic information system (GIS) analysis of hydrologic features was subcontracted through Wilkes University. SRBC used USGS streamflow data, available local precipitation data, estimated areas draining to the tunnel, and flow measurements of larger surface flows to develop a rudimentary hydrologic budget. This, in turn, provided Pa. DEP and the Conservancy the information necessary to prepare a management plan.

However, during project coordination and planning sessions, the need for additional work tasks was identified. These tasks include additional data collection and analysis of the Jeddo Tunnel discharge, completed by the USGS under separate funding arrangement; and additional data collection and analysis relating to enhancements of the hydrologic budget completed by SRBC (Ballaron, 1999; Hollowell, 1999).

Global Positioning System (GPS) Procedure

Reference maps include USGS 7.5-minute quadrangles of the study area and associated Pa. DEP-BAMR overlays to identify features associated with the strip and deep mine areas. Aerial photography flown on May 9, 1995, at a scale of 1 inch equals 1,600 feet, served as a visual guide of current morphology and also was used to plot documented surface features. The surface features identified were correctly positioned into a real-world coordinate system using GPS technology.

All GPS positions were collected using the Pathfinder Basic Plus unit furnished by Trimble Navigation. The points collected in the field were stored as "rover files" that were transferred and processed in the PFINDER software package (a product of Trimble Navigation). Each rover file was differentially corrected against Wilkes University's base station data files, resulting in a position accuracy of 2 to 5 meters (6.5 to 16.4 feet). The information recorded in the files was entered into Excel spreadsheets that describe the attributes of each individual position.

Corrected files were sorted and grouped within a specific category, and eventually were exported as GIS files. The GIS files were built into coverages using ARC/INFO[1] software. Each position was built as a point feature, with the exception of stream channels that were built as line features. ARC/INFO also was used to join the default attribute tables to database files in Excel. Attribute tables are designed to present all data associated with the feature type, but currently contain only location. Additional data could be entered into attribute tables in the future.

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[1] ARC/INFO is a registered trademark of Environmental Systems Research Institute, Inc.

MINING TECHNIQUES AND AMD RESPONSES

Impact of Coal Mine Drainage

Most of the AMD discharging to the Little Nescopeck Creek Basin through the Jeddo Tunnel is from abandoned underground mine workings. These subsurface mines were developed by driving entryways ("shafts," "slopes," "drifts," or "tunnels") into coal-bearing rock units. The type of entry depends on the slope and location of the coal seam. A shaft mine is driven vertically down to reach coal-bearing formations when coal is not exposed at the surface. Coal mined by this method is often below the ground-water table.

Slopes are entries driven downward at an angle necessary to intercept a coal seam. A drift entry is usually driven to the rise or dip of an outcropping of coal that tilts slightly from the horizontal. In the Jeddo Tunnel drainage system, "tunnels" or large haulageways were driven with a slight rise (to provide inexpensive gravity drainage) into many coal seams that dip downward or below the coal basin. While coal was being removed from the mine, infiltrating ground water was removed by gravity drainage and pumping. Active shaft and slope mines are usually pumped to avoid inundation of recoverable coal.

Many tunnel mines are a major and continuing source of AMD in the basin. When abandoned, they discharge poor quality water that shows little improvement with time. The Jeddo Tunnel discharge has shown some water quality improvement since the mines in the system were abandoned in 1961. The discharge, however, is still very acidic and negatively impacts the Little Nescopeck Creek.

Surface mines are usually extensive strip mine operations that use draglines and front-end loaders for overburden and coal removal. The created strip pits are drained by gravity or by pumping. Currently, regulations require that steps be taken to divert surface water from the mine workings.

In areas previously disturbed by strip mining, runoff may be trapped in abandoned or improperly restored strip pits. These strip mine pools contain high concentrations of dissolved constituents and are reservoirs of potential pollution. During rainfall periods, they may overflow and release concentrated "slugs" of impaired-quality water, severely polluting the receiving stream.

Water from impoundments can infiltrate slowly through the bottom and sides of the pool into the ground-water system to emerge as AMD at an outfall. This impaired-quality water, and water seeping into and through deep mine workings, add high concentrations of dissolved solids to deep mine flows.

Pollution is associated with cast coal refuse piles from the abandoned mining operations. Refuse piles were spread over large areas; some were designed to be disposal areas and others were caused by spillage when transporting the material to disposal areas. Often this waste material contains minerals that yield high concentrations of acid and dissolved constituents available for leaching during rainfall periods.

EASTERN MIDDLE ANTHRACITE FIELD

The Eastern Middle Anthracite Field, the smallest of the four major anthracite fields of northeastern Pennsylvania, is situated in Luzerne, Carbon, Schuylkill, and Columbia Counties (Figure 1). Its maximum length is 26 miles, and its maximum width is 10 miles. Coal-bearing rocks underlie approximately 30 square miles. Most of the Eastern Middle field occupies a high plateau centered near Hazleton City. The highest elevations (1,600 to 1,800 feet) occur on the steep escarpments bordering the plateau and along several northeast-southwest trending ridges that have local relief of 200 to 300 feet.

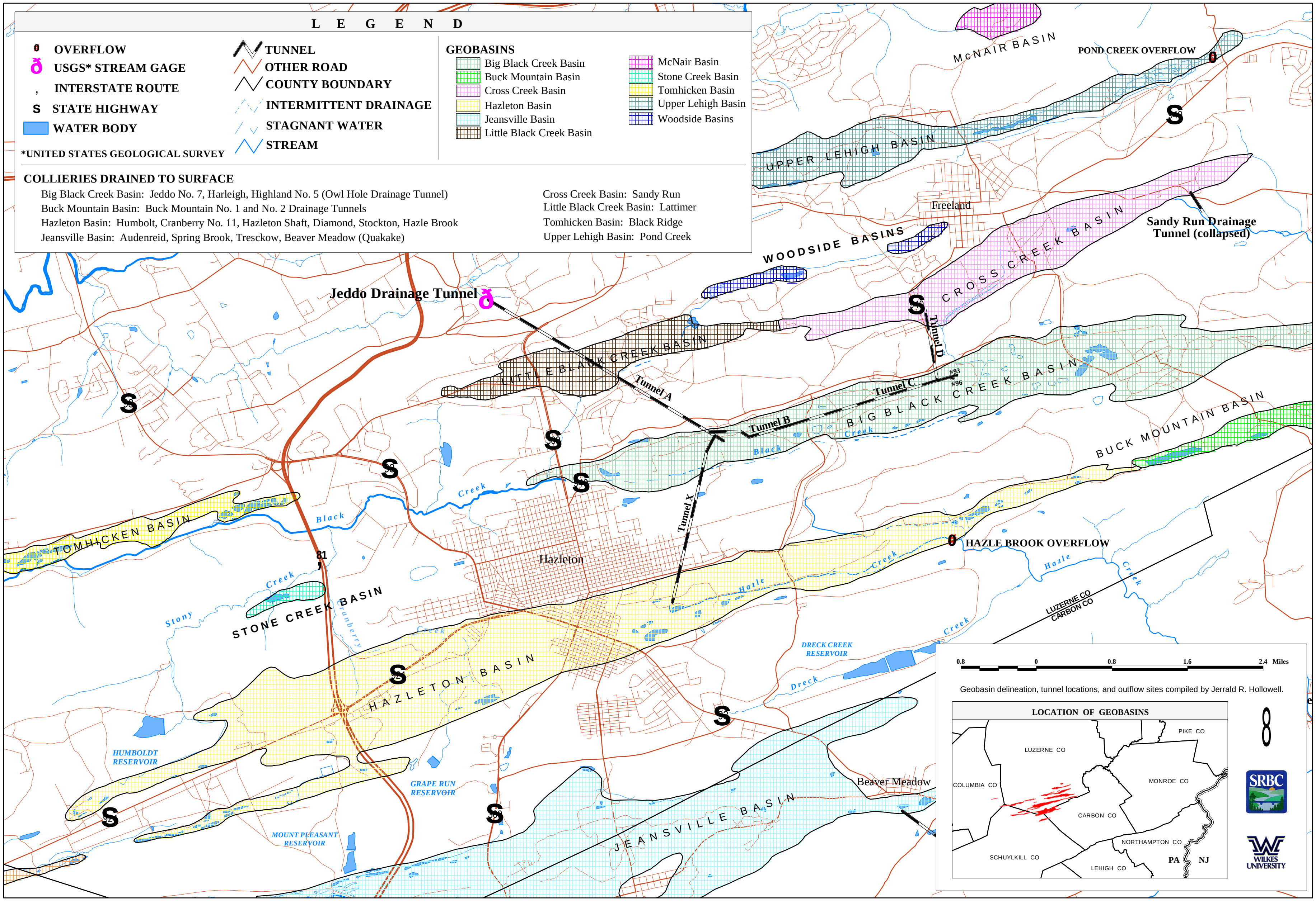

Figure 1. Jeddo Tunnel Coal Basins in the Vicinity of Hazleton and Jeddo Tunnel Complex

Bedrock Stratigraphy

Bedrock units exposed within, and directly adjacent to, the Eastern Middle field range from the Late Mississippian Mauch Chunk Formation to the Middle to Late Pennsylvanian Llewellyn Formation (Table 1). All rocks are apparently of non-marine origin and represent terrigenous sediments shed from intermittently uplifted "southeastern" highlands during an early phase of the North American-African plate collision that culminated in the Alleghanian orogeny (Inners, 1988).

The Mauch Chunk Formation consists of at least 3,000 feet of interbedded sandstones, siltstones, mudstones, and conglomerates that are characterized by a dominant red coloration. Members at the top and bottom of the formation are coarser grained and contain numerous non-red sandstone and conglomerate units. The middle member, approximately 1,500 feet thick, contains the fine-grained red beds that are most typical of the Mauch Chunk (Inners, 1988). Most of the Mauch Chunk is composed of fining-upward alluvial cycles that apparently formed on a broad upper deltaic plain.

The Pottsville Formation in the Eastern Middle field is predominantly thick-bedded, light gray, oligomictic quartzose conglomerates that total 250 to 300 feet in thickness. While all three members—the Tumbling Run, Schuylkill, and Sharp Mountain—are recognized in the Southern and Western Middle fields, the darker-gray Tumbling Run Member disappears to the north and northeast (Inners, 1988). Throughout the remainder of the Eastern Middle field, "white" quartz conglomerate typical of the Schuylkill-Sharp Mountain Members disconformably overlies the upper member of the Mauch Chunk. The Pottsville conglomerates represent the deposits of a great system of braided rivers that debouched from the "southeastern" highlands at a time of plate impact and subsequent uplift (Inners, 1988). One or two coal beds (the Alpha and/or the Little Buck Mountain) occur in the finer-grained upper part of the Pottsville.

The Llewellyn Formation is about 1,500 feet thick and contains all of the major coal beds of the Eastern Middle field. Aside from its numerous anthracite seams, it consists predominantly of interbedded, dark-gray, carbonaceous sandstones (and some conglomerates), siltstones, claystones, and shales that are often arranged in fining-upward cycles, 50 to 60 feet thick (Inners, 1988). The Llewellyn contains an abundance of pyrite and siderite, attesting to a predominance of reducing and acidic conditions during deposition and diagenesis. Pyrite occurs interstitially in many of the coarser-grained sandstones adjacent to the anthracite seams, in stringers and blebs within the coal beds, and as large "sulfur balls" in claystone and siltstone seatrocks. The sediments that form the Llewellyn Formation were deposited on an alluvial plain in which short periods of high-energy fluvial deposition alternated with relatively longer periods of quiescent, swampy conditions (Inners, 1988).

Structure

The geologic structure of the coal field is typical of the geology in the anthracite region. The Eastern Middle field lies in the east-central part of the great structural depression in the Appalachian fold belt that forms the Pennsylvania Anthracite region. The coal-bearing areas of the Eastern Middle field consist of numerous relatively shallow, elongate, 2nd-order synclines that lie mainly on the crestal area of the Selinsgrove-Shade Mountain anticlinorium (Inners, 1988). These synclines are commonly chevron-shaped and complexly faulted, and the intervening anticlines are more open. The major structural fold in the field is the Hazleton basin, whose axis parallels the major regional folds trending northeast to southwest. The basin becomes broader and shallower in the eastern and western margins.

Faults are minor structural features in this area; most are small wedge faults that transect one or more beds and have displacements of three feet (1 meter) or less. Joints are developed in all lithologies, but are particularly well-expressed in sandstones and siltstones. Dominant joint sets strike either northwest-southeast or northeast-southwest (Nasilowski and Owen, 1998).

Table 1. **Generalized Description of Bedrock Units** *(from Inners, 1988)*

System	Geologic Unit	Thickness (feet)	Dominant Lithologies
Pennsylvania	Llewellyn Formation	1,500	Interbedded conglomerate, sandstone, shale, claystone and coal
	Pottsville Formation		
	Sharp Mountain. Member	100 – 500	Quartzitic conglomerate and sandstone; minor shale, claystone and coal
	Schuylkill Member	100	
	Tumbling Run Member	0-125	
Mississippian	Mauch Chunk Formation		
	Upper Member	500-600	Gray conglomerate and red mudstone
	Middle Member	2,000	Red sandstone and mudstone
	Lower Member	500	Gray sandstone and red mudstone
	Pocono Formation	600-650	Quartzitic sandstone
Mississippian-Devonian	Spechty Kopf Formation	0-500	Quartzitic sandstone
Devonian	Catskill Formation		
	Duncannon Member	1,100	Interbedded red and gray sandstone, shale, and siltstone
	Sherman Creek Member	2,500	
	Irish Valley Member	1,800-2,000	
	Trimmers Rock Formation	2,500	Siltstone, shale, and sandstone
	Harrell Formation	100	Grayish-black shale
	Mahantango Formation		
	Tully Member	50-60	Argillaceous limestone and shale
	Lower Member	1,100-1,200	Shale, locally fossiliferous
	Marceilus Formation	300	Grayish-black shale
	Onondaga Formation	50-175	Shale and limestone
	Old Port Formation	150	Limestone, shale and chert
Devonian-Silurian	Keyser Formation	125	Limestone, nodular and fossiliferous, in part
Silurian	Tonoloway Formation	200	Laminated limestone
	Willis Creek Formation	600-700	Calcareous shale and limestone
	Bloomsburg Formation	500	Red mudstone and siltstone
	Mifflintown Formation	200	Limestone and shale
	Keefer Formation	40	Quartzitic sandstone
	Rose Hill Formation		
	Upper Member	120	Shale, limestone, and sandstone; locally hematitic
	Centre Member	60	
	Lower Member	720	
	Tuscarora Formation	350	Quartzitic sandstone

Anthracite

According to Ash and others (1949), the area covered by anthracite measures in this field is approximately 33 square miles. The synclinal coal basins are relatively long and narrow, and separated by broad areas immediately underlain by members of the Pottsville conglomerate, which contains no anthracite. The anthracite measures are discontinuous because the crests of the anticlines have been eroded away.

Only the Hazleton and Jeansville basins exceed a depth of 1,000 feet to the bottom coal. In the other basins, the lowest minable coal lies well above sea level and could be completely mined out by open pit methods under the proper economic conditions.

The major coal beds of the Eastern Middle field are shown in Figure 2. The Mammoth and Buck Mountain, in that order, were the most productive. Production from the other seams has been relatively less, both because of their usual lesser thickness and somewhat poorer quality, and because of the limited extent of outcrop of the beds above the Mammoth. The Mammoth bed in the Eastern Middle field generally consists of a single bed that averages about 30 feet in thickness but has up to three splits in some basins. The Buck Mountain (No. 5) is mined in all the basins and averages about 5 feet of good coal; however, in many places the “Buck” consists of two splits 10 to 20 feet apart (Inners, 1988).

Hydrology

The Eastern Middle Anthracite Field consists mainly of comparatively small, discontinuous coal basins, most of which lie above the natural drainage system of nearby watersheds. Coal beds in the Eastern Middle field have been extensively mined since the early 1800s.

The subsurface is a maze of collapsed gangways, tunnels, and chambers that interconnect the Buck Mountain, Gamma, Wharton, three splits of the Mammoth Vein, and numerous other beds of lesser thickness and poor quality coal. The surface also has been extensively disturbed by previously unregulated surface mining operations and is presently scarred with open abandoned pits, spoil piles, and refuse banks. These abandoned deep and surface mining operations have destroyed the natural surface-water and ground-water systems within the mining area. The open pits and fractured strata allow all surface water, not controlled at the surface, to infiltrate into the deep mine workings. The quality of this water has been greatly affected through contact with acid-producing minerals present in the coal and associated rock exposed to infiltrating water.

The Eastern Middle field is mostly drained to the surface by the drainage tunnels and surface outfalls listed in Table 2. Underground mine workings are flooded below the elevation of drainage tunnels. The water in some mine workings is confined by barrier pillars or collapsed areas, and drains through boreholes in the barrier pillars to other mines or overflows at the surface.

Plate 2 is a composite USGS topographic map of the area showing the location of the outfalls listed in Table 2 and the coal basins’ approximate surficial contact with the lowest mined bed. Also designated are approximate surface projections of underground mine tunnel systems that drain to the surface. Included in Appendix A are detailed maps showing principal mine outfalls in the Hazleton area of the Eastern Middle Anthracite Field and their water quality characteristics.

There are thirteen functional mine drainage tunnels in the Eastern Middle field that were specifically driven to dewater the mine workings. This drainage system was most successful in the Eastern Middle field because of the comparable elevation of the drainage tunnel discharge to the receiving streams.

The most extensive constructed gravity-drainage system in the Eastern Middle field is the Jeddo Tunnel. Much has been written about this extraordinary engineering feat, the eventual success of dewatering approximately 13 square miles of coal basins, and more recently, the environmental impact. The other discharges, each smaller, yield a comparatively minor amount of water.

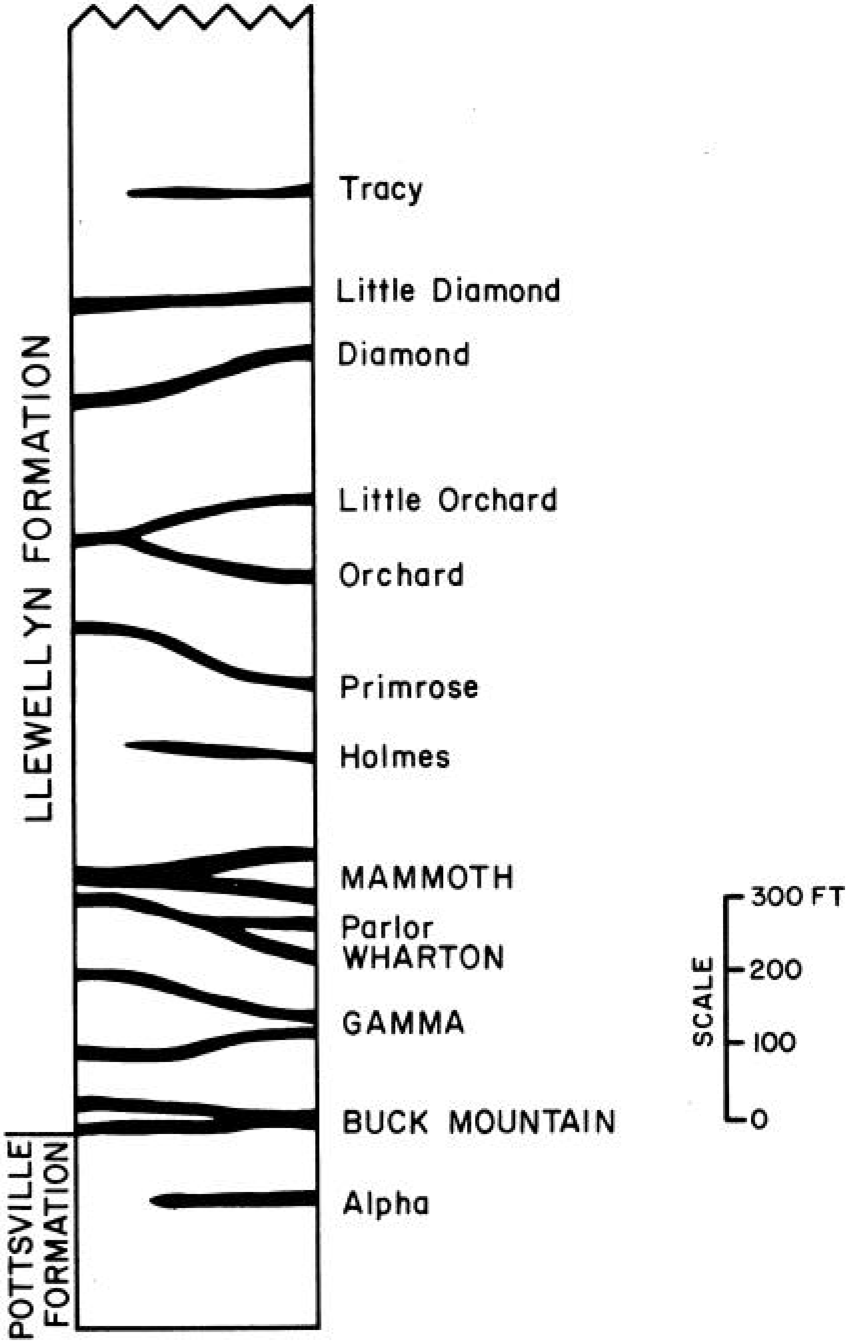

Figure 2. Coal Beds of the Eastern Middle Field *(from Inners, 1988)*

Table 2. Mine Drainage Tunnels and Outflows in the Eastern Middle Anthracite Field *(Wood, 1996)*

Coal Basins	Tunnel/ Overflow[1]	Latitude	Longitude	Receiving Stream	Flow in April 1975 (cfs)
Roberts Run	Gowen	40°56’54”	76°10’47”	Black Creek	6.6
West Black Creek	Derringer	40°56’48”	76°10’43”	Black Creek	8.8
Green Mountain	Oneida No. 3	40°55’06”	76°08’50”	Tomhicken Creek	9.1
Green Mountain	Oneida No. 1	40°55’32”	76°07’25”	Tomhicken Creek	6.4
Green Mountain	Catawissa	40°54’39”	76°03’59”	Catawissa Creek	0.8
Green Mountain	Green Mountain	40°43’52’	76°04’03”	Catawissa Creek	2.1
Jeansville	Audenreid	40° 53’52”	96°03’59”	Catawissa Creek	19.0
Little Black Creek, Big Black Creek, Cross Creek, and Hazleton	Jeddo Tunnel	41°00’09”	75°59’38”	Little Nescopeck	65.0
Jeansville	Beaver Meadow[2]	40°55’09”	75°54’07”	Wetzel Creek	20.0
Hazleton	Hazle Brook	40°58’08”	75°53’52”	Hazle Creek	1.5
Buck Mountain	No. 1 Tunnel	40°58’53”	75°48’49”	Buck Mountain Creek	1.7
Buck Mountain	No. 2 Tunnel	40°58’51”	75°49’27”	Buck Mountain Creek	0.1
Big Black Creek	Owl Hole	40°00’02”	75°49’11”	Sandy Run	4.5
Cross Creek	Sandy Run	41°00’58”	75°50’55”	Sandy Run	2.3
Upper Lehigh	Pond Creek	41°02’29”	75°50’44”	Sandy Run	13.0
Silver Brook	Silver Brook	40°52’24”	76°00’12”	Little Schuylkill	4.2

[1] Overflows listed include Hazle Brook, Pond Creek, and Silver Brook.
[2] Beaver Meadow Tunnel is locally known as Quakake Tunnel.

Most of the Eastern Middle Anthracite Field drains westward to the Susquehanna River. The eastern-most basins drain to the Lehigh River. The drainage divide is approximately along a line between Freeland, to the north, and Weatherly, to the south. An expression of this divide on the surface is a broadening of the coal basins. This is shown by a broadening of Cross Creek and Big Black Creek Basins and an easterly pinching out of the Hazleton and Jeansville Basins.

Infiltration of precipitation, seepage from stream channels, and ground-water discharge are principal sources of water to the drainage tunnels. Both underground and surface mining, with associated subsidence, create surface catchment basins, fractured rock strata, and artificial ponding that increase the amount of water discharged by the tunnel. To reduce mine water drainage from the Eastern Middle field, measures will have to be taken to control water from entering at the surface.

Chemical Characteristics

The water discharges from the mine drainage tunnels in the Eastern Middle Anthracite Field are predominately acidic. Highest pH levels are 4.8, with 9 of the 16 discharges measuring less than 4.0.

The plots of loads in Hollowell (1999) show that alkalinity is minimal for discharges from the eastern-most basins. Although alkalinity is not high for the western and central basins, the plots suggest some buffering sources are present. This could include the presence of minor carbonate strata or cementing in the clastic rocks. Because of the complexity of sedimentation in the northern Appalachians, the distribution of coal and intervening sediments that influence mine water quality are poorly described in the literature.

The source strata associated with the alkalinity are below the Buck Vein (Hollowell, 1999). In addition, the source strata are common to those basins discharging water with some alkalinity and having a mine-to-surface drainage tunnel elevation below 1,290 feet. These basins are indicated on Plate 1.

Even though some alkalinity is available to the Eastern Middle Anthracite Field, it is inadequate to neutralize the acidic discharges from the field. The loads are flow-related with the higher flows carrying the greater loads. The loads of metals are relatively low, with magnesium being the highest and iron the lowest (Hollowell, 1999).

THE JEDDO TUNNEL SYSTEM

System Hydrology

The Jeddo Tunnel system drains mine water from the Little Black Creek, Big Black Creek, Cross Creek, and Hazleton Coal Basins (including 12.6 square miles of coal basins), and has a total drainage area of 32.24 square miles. Since the completion of the initial rock tunnels and subsequent connecting tunnels and slopes, and the loss of an effective perimeter drain system, the Jeddo Tunnel collects and discharges more than half of the precipitation received in the drainage area. Plate 3 is a plan map showing the Jeddo Tunnel drainage system and general internal flow directions. A schematic cross section of the Jeddo drainage tunnel is shown in Figure 3.

Tunnel Construction

Tunnel A was completed in July 1895, after four years of construction (Ash and others, 1950). It begins at the bottom of the Ebervale Mammoth Vein slope No. 2 at an elevation of 1,059 feet mean sea level (MSL) and discharges to the Little Nescopeck Creek at an elevation of 1,012 feet MSL. Tunnel A generally trends north to south, has dimensions of 7 by 9 feet, and is 15,292 feet long.

Tunnel B was driven during 1892 to 1895 and extends at nearly a right angle from Tunnel A, proceeding east for 9,880 feet to the Jeddo Mammoth Vein slope No. 9. At this point, the tunnel is approximately 380 feet above the lowest part of its Buck Mountain coal basin (Ash and others, 1950). Tunnel B led from Jeddo to Ebervale and drained the mines at Jeddo and the Highland collieries.

Tunnel C was extended eastward during 1924 to 1926 from Jeddo No. 4 colliery to Jeddo, a distance of 4,208 feet. Tunnel C drains the west end of Highland No. 5 mine.

Tunnel D was driven northward from Tunnel C in 1929 to the lowest point in the basin at Drifton, a distance 4,038 feet, to drain the Drifton No. 2 mine. As part of the tunnel construction agreement, the Coxe Brothers and Co. operations at both Drifton and Eckley were to be drained.

Initially, drill holes through the barrier pillar between the Highland No. 5 and the Eckley mines drained Eckley Colliery. After water that had collected in the western end of the Eckley Colliery was drained, two short tunnels (Tunnels 93 and 96, having lengths of 340 and 250 feet, respectively) were driven in rock under the barrier pillar to provide permanent drainage. Water runs from Eckley Colliery through the Highland mine workings to Tunnel C, a distance of 8,175 feet.

The final addition to the Jeddo tunnel system was Tunnel A Extension (called Tunnel X), which was completed in 1934. Tunnel X extends from the Ebervale mine to the third level of the Hazleton Shaft Colliery (of the Lehigh Valley Coal Company), at an elevation of 1,085 feet MSL. Tunnel X has dimensions of 8 by 12 feet, and a total length 9,601 feet.

Construction of the Jeddo Tunnel system started in 1891 and was finally completed in 1934. Total combined length of the tunnels is over 47,000 feet, or nearly 9 miles. The average grade in the Jeddo Tunnel system is 0.25 percent. The grade in Tunnel X at the Hazleton Shaft end is 0.30 percent, and at the Jeddo end, is 0.17 percent (Ash and others, 1950).

The Jeddo Tunnel has a capacity in excess of 150,000 gallons per minute (gpm), or 335 cubic feet per second (cfs). Prior to the Eckley and Drifton Tunnel connections, 118,000 gpm (263 cfs) was the greatest flow of the Jeddo Tunnel (Tunnels A and B) on September 30, 1924. After the Eckley and Drifton connections,

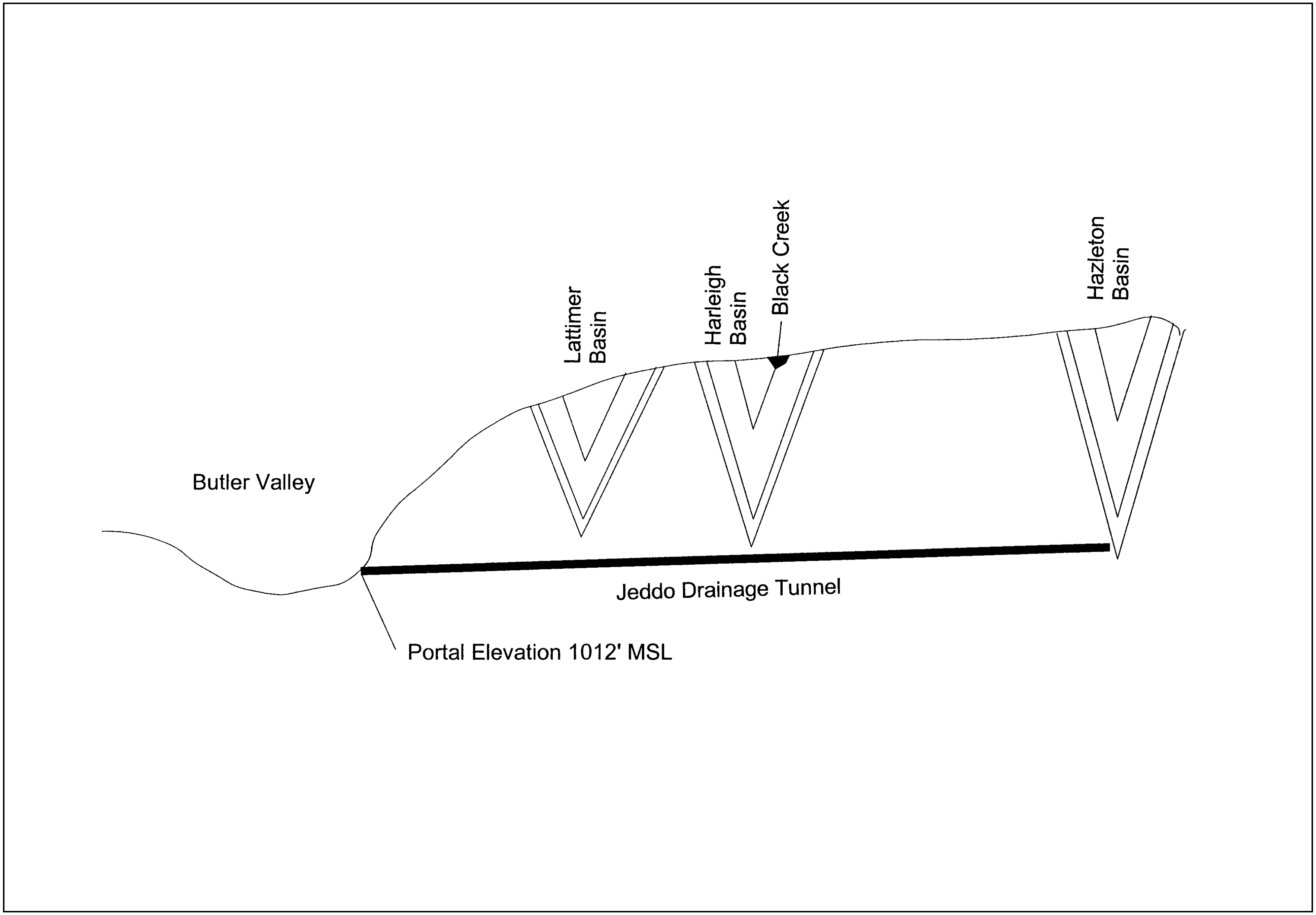

Figure 3. Schematic Cross Section of the Jeddo Tunnel *(Anonymous, circa 1960)*

but before the Hazleton shaft connection, the rate of flow through Tunnels A, B, C, and D was 138,000 gpm (308 cfs) on August 24, 1933. In 1935 and 1936, after the Hazleton Shaft connection (Tunnel X), the maximum flow the tunnel carried was 138,000 gpm (308 cfs) (Ash and others, 1950).

When Highland No. 1 and No. 2 mines were abandoned in 1936, the barrier pillar between Drifton and Highland mines was breached by drill holes. Water drains from Highland to the Drifton workings, to Tunnel D, to Tunnel C and then through Tunnel B and Tunnel A to the Little Nescopeck Creek. The Lattimer mines receive mine water from the western end of the Drifton mine, and it runs to Tunnel A.

Drainage Basin

A map was prepared showing the approximate configuration of the land ultimately draining to the Jeddo Tunnel (Plate 3). Most of the data used to prepare the map were collected during 1996 by Bloomsburg University under contract with the Conservancy. However, some adjustments were made based on field investigations by SRBC in 1997-98 and review of maps of underground mining.

The Jeddo Tunnel, and its associated tunnel complex, was constructed to dewater underground mines of four major coal basins: the Hazleton Coal Basin, the Black Creek Coal Basin, the Little Black Creek Coal Basin, and the Cross Creek Coal Basin. The tunnel drains a total of 12.6 square miles of the coal basins.

To prevent flooding during operation, water that entered the mines drained by gravity to the tunnel system or, where coal was deep mined below the elevation of the gravity drain, infiltrated water was collected in a sump and pumped up to the gravity drain. In 1965, a major drought year, it was estimated that the tunnel discharged an average 20 million gallons per day (31 cfs). On March 29, 1940, following well-above normal precipitation of 7.77 inches of rainfall for the month, a peak flow[2] of 157,000 gpm (350 cfs) was recorded (Ash and others, 1950).

Today, the deep mines are abandoned and pumping has been discontinued. Gangways, tunnels, and chambers that interconnected coal beds have collapsed in some areas. Any underground voids are filled with water to the elevation of the gravity drain (sometimes called mine pools). These flooded mine workings overflow and are collected, along with surface water that penetrates the scarred land surface and percolates into what remains of the extensive honeycomb of subsurface tunnels, into the single tunnel discharge. The abandoned mining operations have destroyed the natural surface-water and ground-water systems within the mining area. Thus, the Jeddo Tunnel discharge comes from a vast and predominantly man-made drainage system.

Nasilowski and Owens (1998) indicate that there are nine major mine pools in the Hazleton Coal Basin that contain great quantities of water and overflow to the Jeddo Tunnel. These are the West Woodside Basin, the East Woodside Basin, the Harley Colliery Pool, the Jeddo No. 7 Fishtail, the Jeddo No. 4 Slope B, the Cranberry No. 11 Plane Basin, the Hazleton Basin, the Diamond Basin, and the Stockton Basin. Some of the mine pools were contained to various levels by a system of barrier pillars that were left in place during mining to separate colliery workings and their water systems.

Analysis of existing mine maps found nearly complete mining of pillars, suggesting barrier pillar breaches were likely created by “bootleg” deep-mine operations, pillar squeeze, and/or local collapse. The basin delineation for this study assumes barrier pillars have been breached.

The basin divides developed for this study indicate the Jeddo Tunnel drains 32.24 square

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[2] During the current study, a peak flow of 195,200 gpm or 435 cfs was measured on November 9, 1996, following 3.89 inches of rain. Higher tunnel discharges (after smaller amounts of precipitation) in recent times are not surprising due to the loss of the perimeter drain system.

miles. The subbasins of Little Black Creek, Black Creek, Hazle Creek, and Cranberry Creek, delineated on Figure 4, drain areas of 4.64, 12.45, 6.62 and 8.53 square miles, respectively. Surface-water divides generally match ground-water divides. The eastern-most parts of the coal basins (Cross Creek, Big Black Creek, and Hazleton Basins) drain to the Lehigh River. The drainage divide is expressed on the surface by a broadening of the coal basins, and its location estimated from structural geology maps and field observations.

Streams in the basin have significant losses to the deep-mine complex and most water that leaves the basin flows out through the Jeddo Tunnel. However, at four locations, streams exit the Jeddo basin; these are Little Black Creek, Black Creek, Hazle Creek, and Cranberry Creek (Figure 4). The flows of Black Creek and Hazle Creek are perennial, except for an exceptionally dry season. The other streams have intermittent to ephemeral flow with sharp, multiple crest hydrography and a mobile bed, as documented by Dr. Duane Braun (Bloomsburg University, written communication, April 1997) and Witmer (1995). Current surface hydrology is represented, by subbasin, on Plates 4 through 7.

Surface Water Infiltration Into the Mines

When underground mines were operating, surface water was captured in, or diverted to, channels outside of the coal measures. Many of these channels are abandoned and no longer function as perimeter drains, as shown on the maps of current surface hydrology (Plates 4 through 7). Field reconnaissance mapped and characterized the condition of existing perimeter drains. This information is critical to the overall remediation of the Jeddo Tunnel system. The establishment, or reestablishment, of these perimeter drains will effectively reduce the infiltration of surface water into the Jeddo Tunnel system.

If surface water is not currently being channeled away from areas disturbed by mining, where does the water go? Field reconnaissance identified 22 locations where surface water enters the mines directly through sinks. These key areas are shown on Plates 4 through 7. When such an area was identified, a GPS point was taken, and an inventory of the site-specific environmental features was made.

Maps and associated descriptive information for each of these locations, including restoration options and restoration limitations, are included in Appendix B. The information includes location, GPS identification number, coal basin, hydrologic basin, 7.5-minute quadrangle, municipality, and aerial photo number. The appendix also outlines the next step to facilitate restoration for each potential remediation site.

Mine Water Levels

SRBC staff installed a float-type, water level recorder at the Hazleton shaft (Figure 5) to monitor changes in water level in the flooded mine workings in the Hazleton Coal Basin. Water level averaged about 487 feet below the land surface[3], or about 1,105 feet MSL. Ash and others (1950) reported a tunnel elevation of 1,085 feet MSL at the Hazleton Shaft—an apparent discrepancy that cannot be resolved by available data.

The range of fluctuation during the period of record was about 2.5 feet, rising to a maximum of 485.5 feet below land surface on July 1-2, 1997, and declining to a minimum of 488.1 feet below ground level on August 13, 1997. Figure 6 shows about 18 months of data collected during the study, from May 1, 1997, to October 23, 1998.

The hydrograph for the flooded mine workings shows a gradual rise and fall over the extended wet and dry periods when water levels are between 487.5 feet and 486.5 feet below ground level. This condition existed from September 1997 through October 1998 and indicates a modest seasonal response to recharge. Superimposed on this curve are small increases (on the order of 0.2 feet) that are direct responses to precipitation events. In late June and early July 1997, an abrupt rise of about 2 feet apparently is not related to precipitation. The rise may be due to a temporary, and likely local, blockage. An abrupt drop of about 0.5 feet that follows the rise

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[3] Land surface elevation was established by SRBC with an altimeter loaned by Pa. DEP-Pottsville.

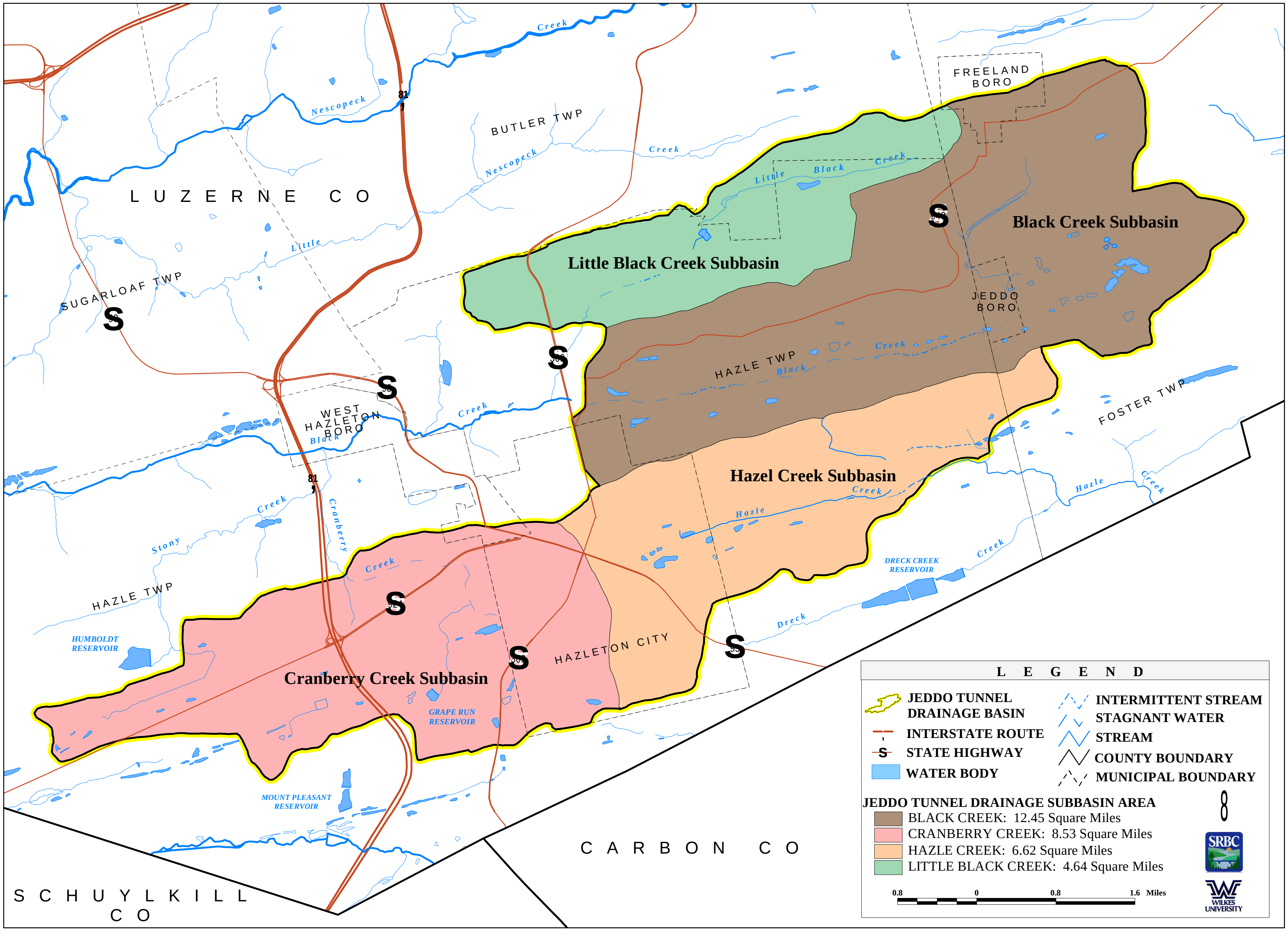

Figure 4. Little Black Creek, Black Creek, Hazle Creek, and Cranberry Creek Subbasins

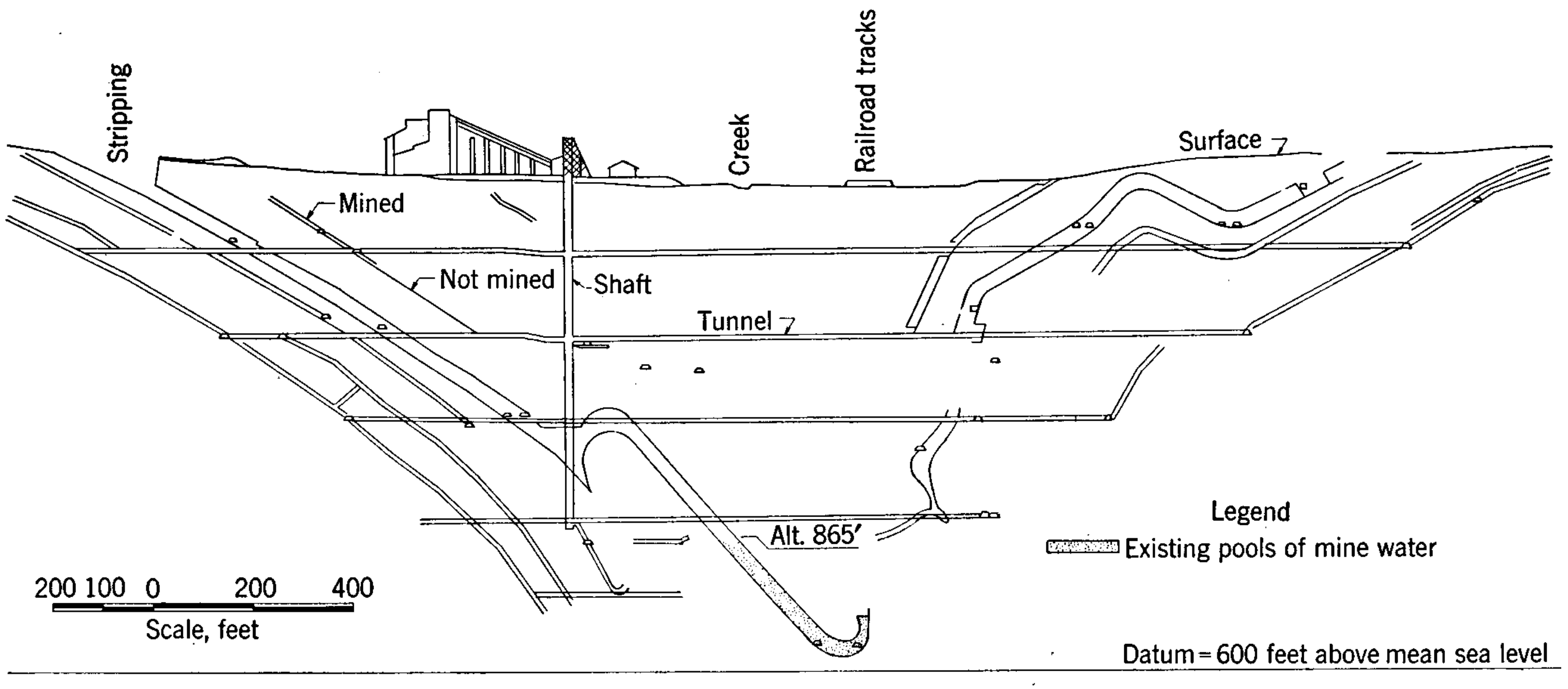

Figure 5. Cross Section of Hazleton Coal Basin Showing Hazleton Shaft *(from Ash and others, 1949)*

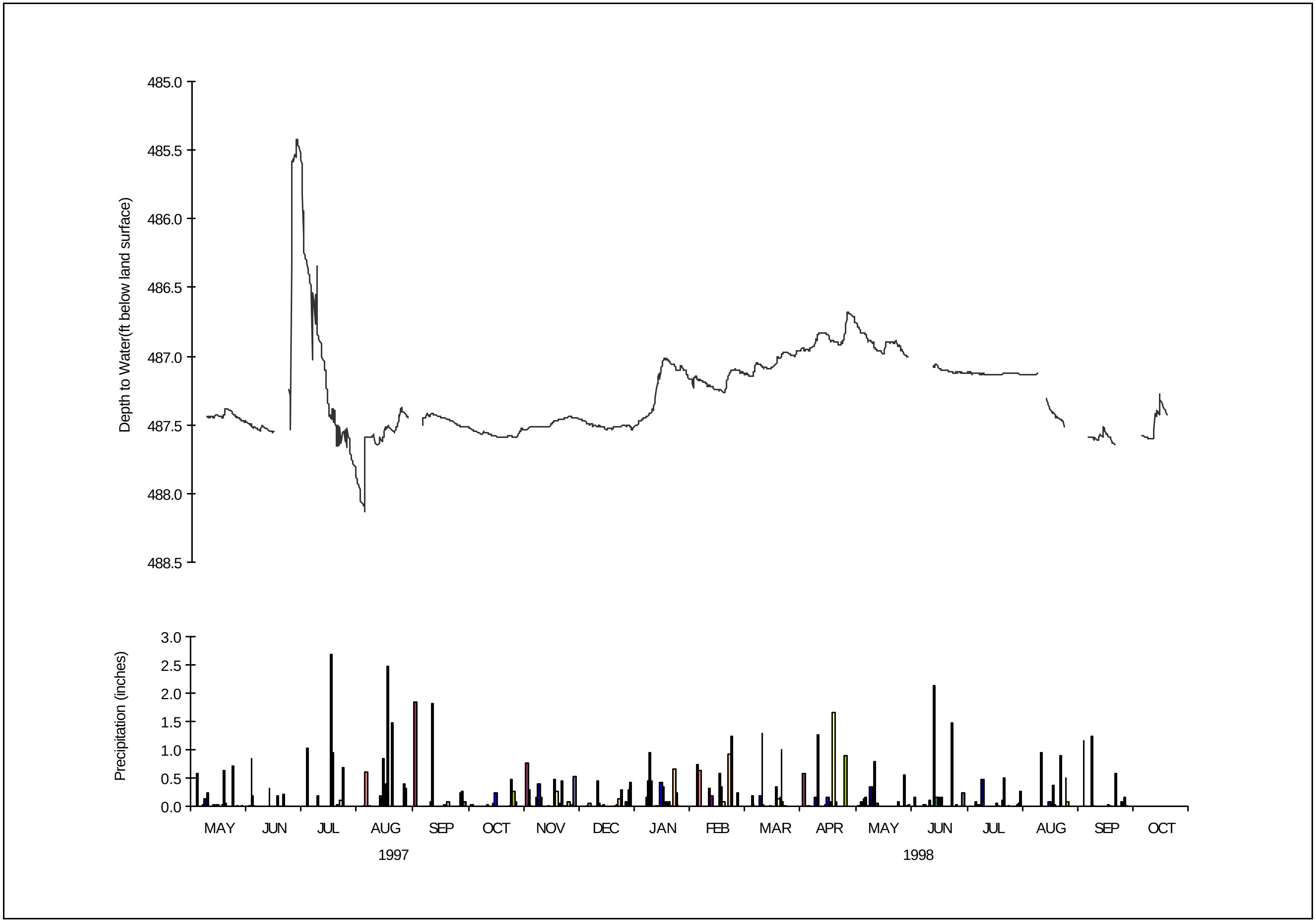

Figure 6. Flooded Mine Workings Underlying Hazleton Shaft, May 1, 1997, to October 23, 1998

would appear to be related to pumping, although none is known to exist currently in the area.

During drought conditions and minimum tunnel discharge, the water levels decline to an elevation of about 1,104.5 feet MSL. Precipitation events in summer 1998 were not sufficient to cause a water level rise. The overall record indicates that the tunnel is an efficient drain of the flooded mine workings.

Chemical Characteristics

A number of factors affect the quality of abandoned mine water discharges. The role of these factors (physical, chemical, and biological) vary with underground and surface mining conditions, spoil distribution, geology and mineralogy, and abundance of biological catalysts. These factors are discussed in detail in scientific literature on coal mine drainage (Hornberger and others, 1990; Carruccio and others, 1978).

Water chemistry—Jeddo Tunnel

The Jeddo Tunnel discharge is the major source of contamination in the Little Nescopeck Creek. Pa. DEP monitored monthly the quality of water discharged from the tunnel (Table 3 and Appendix C). The water samples were collected by volunteers from Friends of the Nescopeck, and analyzed at the Pa. DEP laboratory in Harrisburg, Pa.

The agency has concentration data for the Jeddo Tunnel outflow from April 1995 through June 1998 (Table C1). However, discharge data were available for only 1996 and 1997, so the annual loads of selected parameters were computed for those years (Ballaron, 1999) (Table 4). Loads were not calculated for 1998 because of the significant data gap (from November 24, 1997, through January 21, 1998). Loads also were computed for one sample each in 1975 and 1991.

The analyses show values typical of surface waters impacted by acid mine drainage in eastern Pennsylvania. The water discharge can be characterized as predominantly acidic, with elevated levels of dissolved metals such as iron, manganese, and aluminum. The magnesium concentration exceeds that of all other metals (Ballaron, 1999).

The pH of the discharge ranged from approximately 3.6 to 5. The average pH was approximately 4.3. Acidity levels from the Jeddo Tunnel were highest during late summer and early fall. Comparing water quality data to discharge rates has shown that, as flow rises, the pH increases, and as flow decreases, so does pH.

High concentrations of sulfide minerals and the absence of significant carbonate minerals in the bedrock result in high acidity and low alkalinity, respectively. Alkalinity (also referred to as buffering capacity) refers to the amount of carbonate present that could neutralize acidity. Acidic pollution will reduce the pH of a system with low alkalinity much more rapidly than it would a well-buffered system. In other words, the Jeddo discharge is relatively incapable of stabilizing its pH and is impacted by acidic contamination.

At pH levels this low, metals such as aluminum and lead are released in forms that are toxic to aquatic life. Mayflies and other insects are absent, and the stream is likely devoid of fish, salamanders and frogs. Furthermore, the majority of eggs lain, if any species are present to produce them, would be incapable of hatching.

The most dominant cation in solution is magnesium, having an average concentration of approximately 52 milligrams per liter (mg/l). This was closely followed by calcium, with an average concentration of approximately 35 mg/l, and to a lesser degree by sodium and potassium, with average concentrations of approximately 12 and 2.2 mg/l, respectively. The dominant anion found in solution was sulfate, which results from the oxidation of pyritic minerals. The average concentrations of sulfate and chloride were approximately 284 mg/l and 13.5 mg/l, respectively. These constituents all demonstrated an inverse relationship to flow rates, which points to a dilution and reduced exposure effect from increased discharges. Most peak concentrations of these parameters occurred between July and

Table 3. Jeddo Tunnel Water Quality, Annual Average Concentrations, 1978-98

Calender Year	Specific Conductance	pH	Alkalinity	Total Solids, as Residue	Dissolved Solids, as Residue	Suspended Solids, Nonfilterable, as Residue	Calcium	Magnesium	Sodium
	■ mhos/cm		mg/l						
1978	--	3.52	--	--	--	--	--	--	--
1979	--	3.67	--	--	--	--	--	--	--
1980	--	3.78	--	--	--	--	--	--	--
1981	--	3.66	--	--	--	--	--	--	--
1982	--	3.64	--	--	--	--	--	--	--
1983	--	3.79	--	--	--	--	--	--	--
1984	--	3.82	--	--	--	--	--	--	--
1985	--	3.78	--	--	--	--	--	--	--
1986	--	3.55	--	--	--	--	--	--	--
1987	--	3.83	--	--	--	--	--	--	--
1988	--	3.99	--	--	--	--	--	--	--
1989	--	4.06	--	--	--	--	--	--	--
1990	--	4.18	--	--	--	--	--	--	--
1995	785.71	4.16	6.33	1,074.27	854.23	221.95	37.06	50.65	9.67
1996	699.63	4.37	7.95	951.07	764.61	185.26	35.98	54.84	10.20
1997	697.14	4.39	8.25	789.37	764.10	26.76	34.39	55.44	12.21
1998	721.90	4.04	7.54	658.23	628.77	11.74	33.20	53.52	12.40

Calender Year	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity, Hot
	mg/l							
1978	--	--	410.13	5.49	--	--	--	222.75
1979	--	--	376.64	5.37	--	--	--	179.92
1980	--	--	436.33	4.21	--	--	--	136
1981	--	--	439.1	4.88	--	--	--	192.5
1982	--	--	415.73	6.06	--	--	--	151.33
1983	--	--	414.43	3.79	--	--	--	115.14
1984	--	--	414.82	3.71	--	--	--	114.67
1985		--	371.5	4.12	--	--	--	112
1986	--	--	426.27	9.56	5.42	--	17.47	114.33
1987	--	--	429.82	7.24	6.06	--	17.95	117.67
1988	--	--	411.73	8.8	6	--	15.76	107.17
1989	--	--	400.82	5.51	5.72	--	15.15	102.33
1990	--	--	359.67	17.94	4.97	--	16.15	84.83
1995	2.81	11.68	324.31	13.94	4.98	0.77	15.98	82.89
1996	2.54	12.12	286.58	12.86	4.22	0.70	13.16	73.36
1997	1.80	15.79	248.02	3.56	4.33	0.66	9.74	71.86
1998	1.59	16.18	260.39	3.05	3.87	0.59	8.61	59.82

Table 4. Annual Jeddo Tunnel Water Quality and Discharge Data *(Ballaron, 1999)*

Year	Flow	Acidity	Alkalinity	Iron	Sulfate
	cfs	lb/day			
1975	65.08	58,858.80	--	2,102.10	150,650.60
1991	24.03	16,946.00	--	362.20	77,616.00
1996	102.45	36,460.94	4,992.62	6,088.40	150,842.80
1997	55.40	19,235.47	2,720.05	882.09	69,611.85

Year	Flow	Manganese	Aluminum	Magnesium	Zinc
	cfs	lb/day			
1975	65.08	-	--	--	--
1991	24.03	1,086.60	--	--	--
1996	102.45	2,124.27	6,428.14	29,115.33	365.66
1997	55.40	1,159.96	2,606.04	15,010.41	186.41

November, the time of the year with the lowest flows.

Excessively high concentrations of dissolved metals also were identified as a characteristic of the Jeddo discharge. Iron was present in concentrations ranging from 0 to 90 mg/l, with an average of approximately 9 mg/l. For comparison, the suggested maximum contaminant level (MCL) for municipal water systems is 0.3 mg/l. Similarly, manganese exceeded the suggested MCL of 0.05 mg/l, with an average concentration of approximately 4.2 mg/l. The range for manganese was from 1.4 to 6.8 mg/l. Aluminum concentrations ranged from 2.5 mg/l to 44 mg/l, exceeding the suggested MCL of 0.05 to 0.2 mg/l. Zinc concentrations averaged 0.7 mg/l, near maximum recommended levels.

High concentrations of metals are detrimental to fish and other aquatic life, as they tend to accumulate over time in the organism's biomass. Some concentrations also may be significant enough to cause acute toxicity in various species. Raising the pH of the system would reduce metal concentrations in the aqueous form, which is the most readily available to aquatic life.

Total solids in the Jeddo Tunnel outflow range from 0 to approximately 6,800 mg/l, with an average of 900 mg/l. Suspended solids contribute an average of approximately 125 mg/l to the total solids concentration; the remainder is comprised of dissolved solids.

The average specific conductance of the Jeddo discharge is approximately 728 micromhos/cm. Specific conductance is a measure of the capacity of a water to conduct an electrical current and it varies with concentration and degree of ionization of the constituents. Specific conductance is commonly used in the field to obtain a rapid estimate of the approximate dissolved-solids content of a water.

Graphical representations of the loads measured in the study are shown on Figure 7, (Ballaron, 1999). In addition, the graphs compare parameters from two earlier samplings by the USGS in 1975 and 1991. These data are insufficient for any type of quantitative analyses; however, some qualitative observations can be made from a comparison of loads between the synoptic values and the monitored values. The 1975 and 1991 load values for sulfate and acidity are more than double the average annual values obtained since 1996. This disparity may be attributed to one or more of the following: (1) in 1991, a severe drought occurred that decreased recharge to the Jeddo Tunnel drainage system; (2) a decrease in leachable minerals available to circulating water in the Jeddo drainage system; and (3) a cessation in disposal of breaker waste water to the underground mines.

"Blackwater" events

Turbidity measurements of the Jeddo Tunnel discharge taken during the mid- to late 1990s have

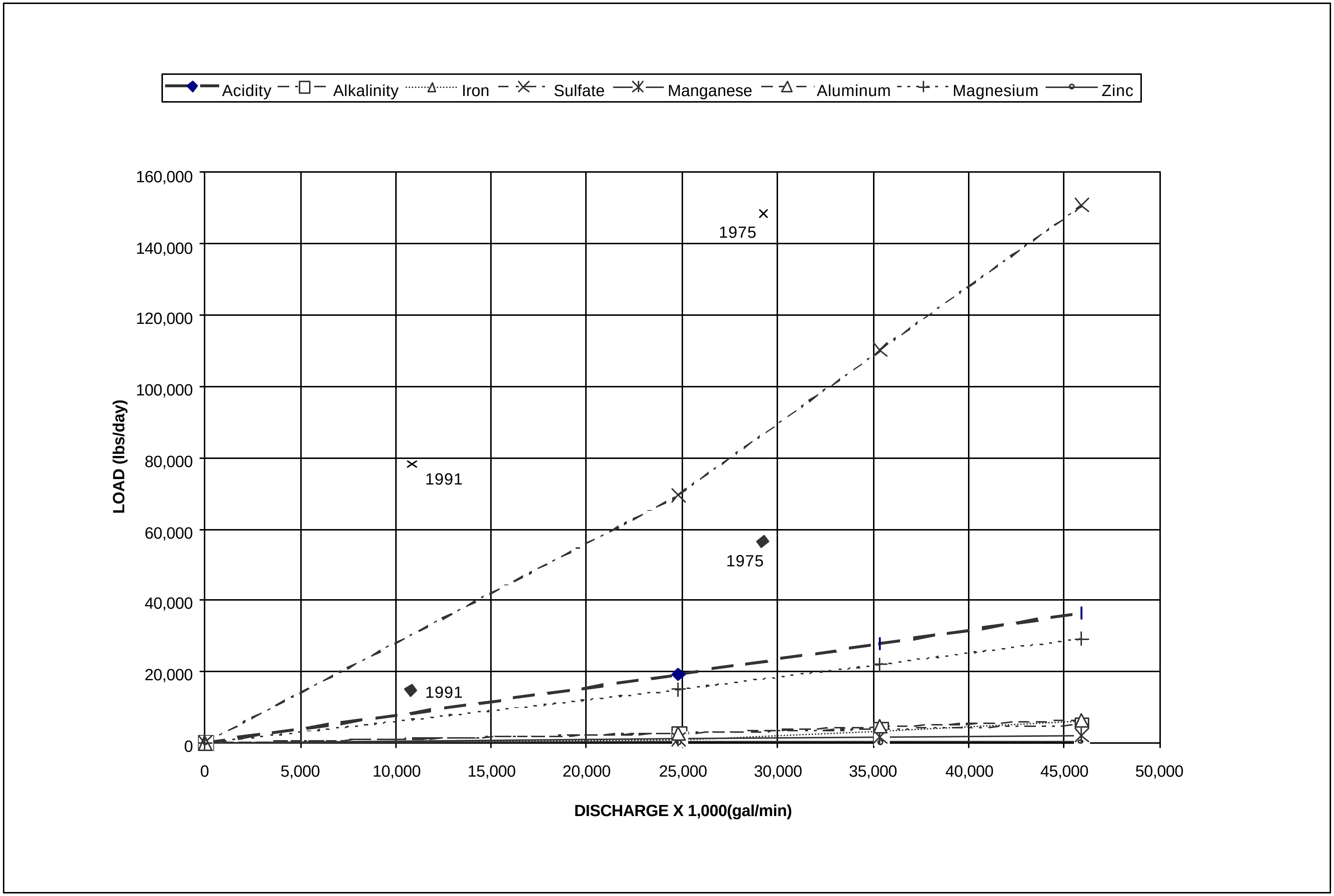

Figure 7. Jeddo Tunnel Water Quality Characteristics

Table 5. Turbidity Measurements and Water Chemistry at Jeddo Tunnel, October 22, 1997

Sample I.D. Number	Time	pH	Specific Conductance	Total Acidity H	Alkalinity	Aluminum	Total Iron
			ìmhos/cm	mg/l			
18	6:00 a.m.	4.6	638	64	10.2	9.19	8.64
19	8:00 a.m.	4.6	634	68	10.4	8.74	8.43
20	10:30 a.m.	4.6	635	68	10.6	9.17	9.66
21	11:00 a.m.	4.6	636	66	10.2	9.8	8.21
22	11:30 a.m.	4.7	638	68	11	12.6	18.2
23	12:00 p.m.	4.7	635	68	11.4	13.8	21.7
24	12:30 p.m.	4.7	636	68	11.4	14.4	23.5

Sample I.D. Number	Time	Manganese	Zinc	Residue, Total	Residue, Dissolved/105 Dissolved	Residue, Total Nonfilterable Suspended	Calcium
		mg/l					
18	6:00 a.m.	3.38	0.565	752	696	56	32.5
19	8:00 a.m.	3.42	0.569	700	666	34	32.7
20	10:30 a.m.	3.39	0.588	778	680	98	32.1
21	11:00 a.m.	3.45	0.571	810	682	138	32.7
22	11:30 a.m.	3.56	0.581	890	730	160	33.2
23	12:00 p.m.	3.64	0.585	844	558	286	33
24	12:30 p.m.	3.68	0.598	922	656	266	33.1

Sample I.D. Number	Time	Magnesium	Sulfate	Chloride	Sodium	Potassium	Turbidity
		mg/l					NTU
18	6:00 a.m.	52.9	260	12	10.8	2.23	31.9
19	8:00 a.m.	53.3	252	12	11	2.12	--
20	10:30 a.m.	52.5	258	12	10.9	2.26	109
21	11:00 a.m.	53.3	226	12	11.1	2.4	247
22	11:30 a.m.	54	271	13	11.3	3.11	394
23	12:00 p.m.	53.9	265	12	11.1	8	520
24	12:30 p.m.	53.9	208	12	11.3	7.47	1,000

shown wide fluctuations; ranging from more than 1,000 Nelson Turbidity Units (NTUs) to 10s of NTUs. An objective of this study was to identify sources and solutions for the intermittent “blackwater discharges” at the Jeddo Tunnel affecting the Little Nescopeck Creek.

Turbidity measurements were performed almost daily from November 29, 1995, to September 4, 1997. Turbidity readings ranged from 5 to just over 8,000 NTUs (Appendix E). An investigation by Pa. DEP-Pottsville personnel on October 22, 1996, confirmed this daily fluctuation. Data were collected hourly from 6:00 a.m. to 12:30 p.m. (Table 5).

The turbidity fluctuations indicate that the monitored “blackwater discharge” (in Table 5) was caused largely by the washing of coal at preparation plants in the Milnesville and Pardeesville vicinity. (At other times, blackwater discharges can be caused by the washing of abandoned refuse-filled breast openings that are broken free during significant rainfall events.) The plants began discharging about 8:45 a.m., coincident with the turbidity increase. These data were used to identify some water-handling problems at the active coal preparation sites. On October 22, 1996, Pa. DEP took compliance and enforcement actions against an active operator who was contributing to the problem. The resulting remedial water handling measures have been largely successful.

As an outgrowth of this investigation at the preparation sites, one of the operators entered into a "Reclamation in-lieu of Civil Penalty Agreement," which resulted in the abatement of one of the subsidence areas identified by this study. With the completion of the abatement project, the intensity and duration of "blackwater" episodes have been dramatically reduced, as shown by turbidity readings as low as 10 NTUs taken at the Jeddo Tunnel in early 1998 (Figure 8).

Water chemistry—Nescopeck Creek

The water quality of the Nescopeck Creek is greatly influenced by mine drainage discharging from the Jeddo Tunnel. Impacts of the Jeddo Tunnel discharge on Nescopeck Creek include a lower pH, increased acidity, elevated levels of heavy metals, and increased specific conductivity and concentrations of suspended solids.

Water samples were collected at the Pa. Route 93 bridge from November 1996 through October 1998 by Friends of the Nescopeck for analysis by the Pa. DEP laboratory in Harrisburg, Pa. (Table 6 and Appendix D). The water chemistry data were analyzed to determine their relationship to flow and other environmental factors.

The pH in the creek averages approximately 4.8, and ranged from 4.5 to 5.8 over the period of record. These values are slightly higher than the values measured at the Jeddo Tunnel discharge. These data show that the impact of the Jeddo Tunnel, with respect to pH levels, is very apparent and persistent downstream from the discharge.

The lowest pH values were recorded during the summer and fall months, and the highest values were obtained during the winter and spring. Reduced levels of acidity entering the system help prevent the pH from dropping below levels present in the outflow from the tunnel. Acidity levels dropped from an average of 74 mg/l at the tunnel to 30 mg/l in Nescopeck Creek.

Despite the drop in acidity, the creek's pH remains low, and the alkalinity has not improved significantly. The average alkalinity of the system was only raised by 2 mg/l (to 10 or 11 mg/l) from the tunnel discharge to Nescopeck Creek and is still not sufficient to stabilize pH against acidic contamination of the stream.

The distribution of dominant cations and anions in solution in Nescopeck Creek was similar to that in the Jeddo Tunnel discharge. Magnesium remains the dominant cation, although the average concentration decreased from approximately 52 to 28 mg/l. The next most abundant cation was calcium, with an average concentration of 22.15 mg/l, which was followed by sodium and potassium.

Sulfate was the dominant anion, having an average concentration of approximately 140 mg/l. This concentration has decreased significantly from the level at the tunnel outflow, and is now well below the suggested MCL for sulfate. Contrary to the other parameters, the concentration of chloride in Nescopeck Creek increased from that at the Jeddo Tunnel. Chloride concentrations ranged from 7 to 55 mg/l, with an average of 17.3 mg/l. These increases were probably due to discharge from wastewater treatment plants.

Dissolved metal concentrations remain a problem in the Nescopeck Creek downstream from its confluence with Little Nescopeck Creek. Although iron concentrations decreased significantly to an average of approximately 1.43 mg/l, the average is still well above the suggested MCL of 0.3 mg/l. Manganese values also were lower in Nescopeck Creek than at the tunnel discharge, but are in excess of the suggested MCL of 0.05 mg/l. Manganese concentrations ranged from 0.6 to 4 mg/l, with an average of 2.02 mg/l.

Aluminum concentrations also were elevated, with a range from 0.2 to 8.21 mg/l, and an average of approximately 4.23 mg/l. Zinc concentrations were below suggested limits, with an average of approximately 0.34 mg/l, which was down from an average of 0.7 mg/l in the Jeddo Tunnel discharge.

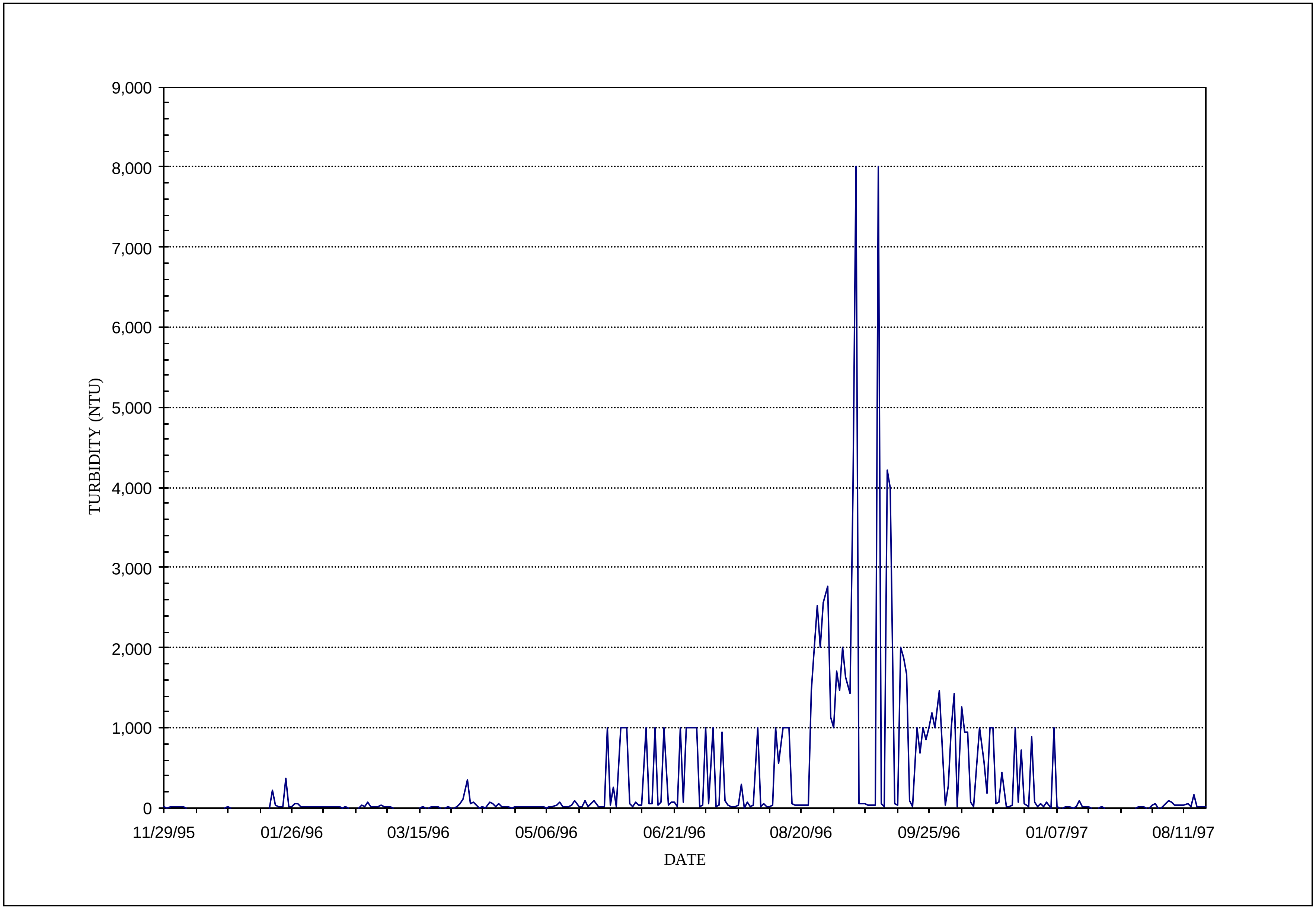

Figure 8. Jeddo Tunnel Turbidity, November 1995 to September 1997

Table 6. ***Nescopeck Creek Water Quality, Annual Average Concentrations, 1996-98*** *(samples collected by Friends of Nescopeck, analyzed by Pa. DEP)*

Sample Date	Specific Conductance	pH	Alkalinity	Residue, Total Solids	Residue, Dissolved/105 Suspended	Residue, Total Nonfilterable Dissolved	Calcium	Magnesium	Sodium
	ìmhos/cm		mg/l						
1996[1]	277.57	4.99	10.31	369.43	350.29	20.57	14.04	17.39	7.44
1997	412.77	4.77	10.20	359.43	345.67	13.56	22.76	27.75	11.53
1998	473.32	4.81	10.15	458.57	445.62	13.09	24.00	32.57	11.71

Sample Date	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity, Hot
	mg/l							
1996	1.37	10.71	80.86	3.56	1.15	0.21	2.95	17.29
1997	1.41	18.49	131.33	1.18	2.06	0.36	4.25	33.18
1998	1.52	18.05	180.43	1.30	2.27	0.35	4.88	29.43

[1] Only seven sets of data were collected in 1996.

The average concentration of total solids in the Nescopeck Creek was less than half of that from the Jeddo Tunnel. Total solids ranged from 20 to 1,200 mg/l, with an average of 388 mg/l. Contrary to analysis at the Jeddo Tunnel, suspended solids composed the majority of the total solids concentration. Suspended solids ranged in concentration from 0 to 1,190 mg/l, with an average of approximately 374 mg/l.

Dissolved solids concentrations were very low in Nescopeck Creek in comparison to the Jeddo discharge. The concentration of dissolved solids averaged approximately 17.6 mg/l. The specific conductance of the Nescopeck Creek decreased approximately 300 micromhos/cm from the level at the Jeddo Tunnel. Levels in the creek ranged from approximately 200 to 700 micromhos/cm, with an average of 417 micromhos/cm. The lower concentrations are the result of dilution due to flows in the Nescopeck Creek, as well as from the precipitation of various metals in the sediment of the stream, thus removing them from solution.

WATER BUDGET

A water budget analysis for the years 1996 to 1998 was performed as a part of this study. A water budget is a quantitative expression of the major components of the hydrologic cycle. Water that enters a drainage basin as precipitation is balanced against the water that leaves a basin as evaporation and streamflow. This balance can be expressed in a simplified equation as follows:

$$P = R_s + R_g + ET + \Delta S \qquad (1)$$

Where:

P = precipitation
R_s = direct runoff
R_g = ground-water runoff (tunnel discharge)
ET = evapotranspiration
ΔS = change in storage

Information is available on two of the items in the above equation; precipitation and runoff (streamflows and tunnel discharge). However, changes in the amount of water stored within a basin are only indirectly measured and are difficult to calculate. Normally, changes in storage are significant from season to season, but are negligible when averaged over a longer period. Therefore, the water budget equations are evaluated over a period of time in which the beginning and ending quantity of stored water is approximately equal, so the storage factor in the above equation can be ignored. In other words, recharge is assumed to equal discharge.

The time period used is the water year, which is the 12-month period from October 1 through September 30. September and October are generally the months in which the annual streamflows and ground-water levels are at their lowest values. The water year is designated by the calendar year in which it ends, and which includes 9 of the 12 months. Thus, the year ending September 30, 1998, is named the “1998 Water Year.”

Being able to ignore the changes in storage allows the evapotranspiration to be calculated as a residual, as the other two items of the equation are known. Water budgets for the Jeddo Tunnel Basin are shown in Table 7.

Table 7. Annual Water Budget for Jeddo Tunnel Basin *(based on a drainage area of 33.53 square miles)*

Water Year	Precipitation (inches)	Surface Runoff (inches)	Base Runoff—Jeddo Tunnel (inches)	Evapotranspiration (inches)
1996	54.25	4.07	36.36	13.82
1997	48.54	3.42	31.89	13.23
1998	42.71	2.88	28.28	11.55
Average	48.50	3.46	32.18	12.87

Drainage Basin

The size of the drainage basin is an important factor in calculating the water budget for a particular stream. Commonly, the area of the basin above a stream gage is used in the calculation because the surface- and ground-water divides are generally coincident. In the case of the Jeddo Tunnel, the stream gage is located about 60 feet downstream of the outlet of the tunnel and 0.3 miles upstream from the confluence with the Little Nescopeck Creek. The gage measures the discharge diverted from adjacent watersheds that include the extensively-mined Eastern Middle Anthracite Field near Hazleton.

The basin divides developed for this study indicated the Jeddo Tunnel drains approximately 32.24 square miles. For water budget calculations, an area of 1.29 square miles in the southeast that includes the Hazle Brook outfall and some land draining to Hazle Creek, near the former Ashmore Yards site, was added to the Jeddo Tunnel drainage area. This area was included because (1) information on the location of the barrier separating the mine workings that drain to the Lehigh River was not available, and (2) surface flow leaving the basin in Hazle Creek was measured downstream of the overflow.

Precipitation

Precipitation records are available for two stations in the Jeddo Tunnel Basin. The USGS precipitation gage at the Hazleton Airport has a complete, provisional data set for the period of water budget analysis (Tables 8A-8C). Precipitation in Hazleton City also was measured and recorded daily by Pa. DEP staff during the period November 28, 1995, through November 9, 1997, and at the Penn State Hazleton campus during the period November 10, 1997, through September 30, 1998. Observer data were used to supplement the airport data.

Long-term records of the National Oceanic and Atmospheric Administration station at Tamaqua, covering the period October 1931 to September 1998, were used to determine average precipitation values (Appendix F). Data from the U.S. Weather Bureau station at Freeland, covering the period January 1931 to August 1989 (Appendix F), were used to supplement the long-term records, where possible.

Precipitation varies monthly, seasonally, and annually; Tables 8A through 8C illustrates the temporal variation in Hazleton.

Precipitation averaged about 49 inches in the area (based on data from Tamaqua reservoir) for the 66-year period from 1932 to 1998. A comparison of this average with precipitation in 1996, 1997, and 1998 indicates that, in 1996, precipitation in Hazleton exceeded the average by 11 percent. Precipitation was about average in 1997. For 1998, precipitation was 13 percent below average in the Jeddo Tunnel Basin.

Runoff

Surface runoff from Black Creek, Little Black Creek, Cranberry Creek, and Hazle Creek (R_s in equation 1) was estimated from discharge data for the Jeddo Tunnel, based on measurements of flow exiting the basin. Flows were measured at the locations shown in Plate 8.

A goal of this project was to collect synchronous flow measurements of the four streams for precipitation events during several different times of the year (a summer thunderstorm event, an autumn low-intensity frontal passage, and a winter rain-snowmelt event). These data would have been useful in understanding the effect of storm intensity and season effects on the water budget. However, drought conditions during much of the study period limited opportunities for data collection.

Runoff data for Black Creek, Little Black Creek, Cranberry Creek, and Hazle Creek and total surface runoff (R_s in equation 1) are shown in Table 9. Jeddo Tunnel discharge, R_g in equation 1, also is listed for the day the flow measurements were made. As an indication of storm intensity, total precipitation from the preceding 7 days also is noted in the table.

Immediately following rainfall events, surface runoff varies from about 5 percent of tunnel flow during drought periods to about 11 percent during

Table 8A. Precipitation Data From Hazleton, Pa., Water Year 1996 (*in inches*)

Day	October	November	December	January	February	March	April	May	June	July	August	September
1	0	0	0	0	0	0	0.35	0	0	0	0	0
2	0	0.3	0	0.4	0	0	0	0	0	0	0	0
3	0	0	0	0.4	0	0	0	0	0	0.1	0	0
4	0.68	0	0	0	0	0	0	0	0.32	0	0	0.02
5	1.41	0	0.2	0	0	0.25	0	0	0	0	0	0.05
6	0.2	0	0	0	0	0.25	0	0.18	0	0	0	0.2
7	0	0.2	0	0.55	0	0.65	0.55	0.02	0	0	0	0.86
8	0	0	0	0.18	0	0.12	0	0.07	0	0.53	0	0
9	0	0	0	0	0	0	0.12	0.1	0	0	0.07	0
10	0	0	0	0.25	0	0.11	0	0.1	1.18	0	0	0
11	0	2.32	0	0	0	0	0	1.93	0.05	0	0	0
12	0	0.37	0	0.15	0	0	0	0.03	0	0.01	0	0
13	0	0	0	0.65	0	0	0.37	0	0	2.71	0.38	0.41
14	1.85	1.8	0.25	0	0	0	0.07	0	0	0.03	0	0
15	0.05	0.42	0.13	0	0	0	0.71	0	0	0.17	0	0
16	0	0	0	0	0	0	0.87	0	0	0	0	0.18
17	0	0	0	0.38	0	0	0	0	0	0.41	0	1.32
18	0	0	0	0	0	0	0	0	0.03	0	0	0.06
19	0	0	0.75	2.56	0	1.09	0	0	0.15	0.23	0	0
20	0.6	0	0.21	0	0.55	0.21	0	0	0	0	0	0
21	3.05	0	0.1	0	0.48	0.05	0	0.1	0	0	0.22	0
22	0	0	0	0	0.1	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0.6	0	0	0	0	0
24	0	0	0	1.32	0.17	0	0	0	0.14	0	0.13	0
25	0	0	0	0	0	0.03	0	0	0	0	0	0
26	0	0	0	0.28	0	0.02	0.08	0	0	0.33	0	0
27	0.25	0	0	2.95	0	0	0	0.12	0	0	0	0
28	0.38	0	0	0.53	0.15	0.19	0	0	0	0	0	0.66
29	0.14	0.47	0	0.58	0	0.57	0.65	0	0.02	0.6	0	0.02
30	0.03	0	0	0	---	0	1.63	0	1.59	0.03	0	0
31	0.06	---	0	0	---	0	---	0	---	0	0	---
TOTAL	**8.7**	**5.88**	**1.64**	**11.18**	**1.45**	**3.54**	**6**	**2.65**	**3.48**	**5.15**	**0.8**	**3.78**
MAX	**3.05**	**2.32**	**0.75**	**2.95**	**0.55**	**1.09**	**1.63**	**1.93**	**1.59**	**2.71**	**0.38**	**1.32**

Table 8B. Precipitation Data From Hazleton, Pa., Water Year 1997 (in inches)

Day	October	November	December	January	February	March	April	May	June	July	August	September
1	0	0	2.76	0	0.02	0	0.17	0	0.03	0	0	1.83
2	0	0	0.34	0.07	0	0.15	0	0	0.83	1.05	0	0
3	0	0	0	0.1	0.03	0.23	0	0.6	0.2	0	0.03	0
4	0	0	0	0	0.15	0	0	0	0.02	0	0.17	0
5	0	0	0	0.1	0.35	0.2	0	0	0	0	0.61	0
6	0	0	0.73	0	0	0.1	0	0.05	0	0	0	0
7	0	0	0.1	0	0	0	0	0	0	0	0.02	0
8	0.6	3.8	0.05	0	0	0	0	0.13	0	0	0	0
9	0.01	0.09	0.07	0.12	0	0	0	0.25	0	0.2	0	0
10	0.14	0.14	0	0.06	0	0	0	0	0	0	0	0.1
11	0	0	0.46	0	0	0	0	0	0	0	0	1.81
12	0	0	0.3	0	0.02	0	0.25	0	0	0	0	0
13	0	0	1.14	0	0	0	0	0.05	0.31	0	0.2	0
14	0	0	0.47	0	0.28	0.87	0	0	0	0	0	0
15	0	0	0	0	0.05	0	0	0.05	0	0	0.86	0
16	0	0	0	0.5	0.01	0	0	0	0	0	0.15	0
17	0	0	0	0	0.02	0	0.03	0	0	2.69	0.4	0
18	0.07	0.11	0	0	0	0	0.05	0.05	0.2	0.95	2.47	0.05
19	4.75	0.07	0.27	0	0.05	0	0	0.63	0	0	0	0
20	0.07	0	0	0	0	0	0	0.07	0	0	1.48	0.1
21	0.1	0	0	0	0.05	0	0	0	0	0.05	0	0
22	0.03	0.03	0	0.11	0	0.1	0	0	0.22	0.05	0	0
23	0.28	0	0	0	0	0	0	0	0	0.11	0	0
24	0	0	0.58	0.5	0	0	0	0	0	0.7	0	0
25	0	0	0	0.15	0	0.02	0	0.73	0	0	0	0
26	0	0.75	0	0	0.07	0.78	0	0	0	0	0	0
27	0	0	0	0.09	0	0	0.05	0.03	0	0	0	0
28	0	0	0	0.19	0	0	0.25	0	0	0	0.4	0.25
29	0	0	0.35	0	---	0	0	0	0	0	0.31	0.28
30	0	0.25	0	0	---	0.11	0	0.02	0	0	0	0.08
31	0	---	0	0	---	1.31	---	0	---	0	0	---
TOTAL	**6.05**	**5.24**	**7.62**	**1.99**	**1.1**	**3.87**	**0.8**	**2.66**	**1.81**	**5.8**	**7.1**	**4.5**
MAX	**4.75**	**3.8**	**2.76**	**0.5**	**0.35**	**1.31**	**0.25**	**0.73**	**0.83**	**2.69**	**2.47**	**1.83**

Table 8C. Precipitation Data From Hazleton, Pa., Water Year 1998 (in inches)

Day	October	November	December	January	February	March	April	May	June	July	August	September
1	0.05	0.77	0	0	0	0	0.58	0.02	0.15	0	0	0
2	0	0.3	0	0	0	0	0.02	0.08	0	0	0	1.16
3	0	0.03	0	0	0	0.2	0	0.02	0	0	0	0
4	0	0	0.03	0	0.75	0.05	0.03	0.13	0	0.1	0	0
5	0	0	0.07	0	0.63	0	0	0.17	0	0.05	0	0
6	0	0	0	0.17	0	0	0	0.03	0	0	0	0
7	0	0.17	0.03	0.45	0	0	0	0.02	0.05	0	0	1.26
8	0	0.4	0	0.95	0	0.21	0.17	0.37	0	0.47	0	0.02
9	0	0.15	0	0.45	0	1.3	1.28	0.33	0	0	0	0
10	0.05	0	0.45	0	0	0.05	0.25	0.79	0.12	0	0.96	0
11	0	0	0.07	0	0.32	0	0	0.59	0.03	0	0	0
12	0	0	0.03	0.03	0.18	0	0	0.07	0.62	0	0	0
13	0	0	0	0.02	0	0	0	0	2.14	0	0	0
14	0.07	0.03	0.05	0	0.02	0.02	0.05	0	0.15	0	0	0
15	0.25	0	0	0.43	0	0	0.15	0	0.15	0	0.08	0
16	0.1	0	0	0.37	0	0	0.05	0	0.12	0.07	0	0
17	0	0	0	0	0.58	0	0.08	0	0.15	0.03	0.39	0.05
18	0	0.47	0	0.08	0.37	0.33	0	0	0	0	0.05	0.03
19	0	0.28	0	0.02	0.1	0.13	1.67	0	0	0	0	0
20	0	0	0	0.08	0	0.15	0.1	0	0	0.12	0	0
21	0	0.07	0.02	0	0	1	0	0	0	0.49	0	0
22	0	0.45	0.05	0.02	0	0.1	0	0	0	0	0.92	0.59
23	0	0	0.13	0.65	0.93	0.02	0	0	1.48	0	0	0
24	0.03	0.03	0.07	0.25	1.25	0	0	0	0	0.03	0	0
25	0.47	0	0.3	0.05	0	0	0	0.1	0	0	0.5	0.1
26	0.28	0.08	0	0	0	0	0.91	0	0.05	0	0.09	0
27	0.1	0	0.08	0	0	0	0.03	0	0	0	0	0.16
28	0	0.05	0.02	0	0.25	0	0	0	0	0	0	0.02
29	0	0.02	0.3	0	---	0	0	0.57	0.05	0.05	0	0
30	0	0.55	0.43	0	---	0	0	0.02	0.25	0.07	0	0
31	0	---	0	0	---	0	---	0.05	---	0.27	0	---
TOTAL	**1.4**	**3.85**	**2.13**	**4.02**	**5.38**	**3.56**	**5.37**	**3.36**	**5.51**	**1.75**	**2.99**	**3.39**
MAX	**0.47**	**0.77**	**0.45**	**0.95**	**1.25**	**1.3**	**1.67**	**0.79**	**2.14**	**0.49**	**0.96**	**1.26**

Table 9. Runoff Data for Streams Leaving the Jeddo Basin *(flow measurements in cubic feet per second)*

	10/30/1997	11/03/1997	01/09/1998	01/21/1998	03/27/1998	10/09/1998
Black Creek	Dry channel	Dry channel	5.89	Minimal flow	1.80	No flow
Little Black Creek	No flow	No flow	2.04	No flow	1	No flow
Cranberry Creek	Dry channel	NA	0.51	--	0.15	0.07
Hazle Creek	1.35	NA	17.36	--	9.98	0.89
Total Surface Flow (R_s)	1.35		25.79		12.93	0.96
Jeddo Tunnel (R_g)	28	33	200	90	113	--
Precipitation (inches)	0.88	1.1	2.02	0.98	1.12	--

spring 1998. The relationship between total surface runoff and tunnel discharge is plotted in Figure 9, which was used to estimate annual surface runoff for the water budget. Average annual surface runoff is estimated to be 9 cfs, equivalent to 3.46 inches spread across the drainage basin.

Of the surface flows leaving the Jeddo Basin, Hazle Creek is the largest, followed in decreasing order by Black Creek, Little Black Creek, and Cranberry Creek. Although Black Creek is usually perennial, the channel was dry or the stream had no measurable flow at the Pa. Route 940 bridge on several occasions during the study. Streamflows are not proportional to the drainage area of the subbasin due to direct and indirect losses to the mines.

Most water leaves the Jeddo basin through the Jeddo Tunnel (R_g in equation 1). Flow data from the Jeddo Tunnel (Figure 9) were obtained from records of the USGS gaging station 01538510 on a Little Nescopeck Creek tributary near Freeland (October 1995 through September 1998). The USGS also collected data at the station from December 1973 to October 1979; however, the gaging station was not active between 1979 and 1995.

There is one significant data gap in the recent record: data for the period November 24, 1997, through January 21, 1998, were lost, due to vandalism. For days with missing flow data, the tunnel discharge was estimated based on the daily value hydrograph for Wapwallopen Creek near Wapwallopen, about 10 miles north of the Jeddo discharge (John Rote, USGS, Lemoyne, Pa., written communication, February 24, 1999). Estimated flows account for general trends of recession and rise and are believed to be conservative (low).

The hydrograph shows the importance of winter-spring precipitation for recharging the ground-water and mine-water systems that sustain tunnel flow. Tunnel discharge responds to precipitation much like streamflow. The maximum discharge during the study is 482 cfs, which occurred on November 9, 1996; this also is the maximum discharge for the period of record. The minimum discharge recorded during the study is 20 cfs on October 13, 1995. This minimum also occurred on August 15 and 16, 1977. The average annual discharge from the Jeddo Tunnel is 79.4 cfs. This discharge is equivalent to 32.18 inches spread across the drainage basin.

Total runoff, which includes flow through the Jeddo Tunnel and streams exiting the basin, during the 3-year study period averages about 88 cfs, equivalent to 35.64 inches spread across the drainage basin. Precipitation for the same period averaged 48.50 inches. Total runoff (R_s + R_g in equation 1) is 74 percent of precipitation, on average.

Tunnel Discharge

The discharge from the Jeddo Tunnel is comprised of: (1) direct infiltration of precipitation through the mined land; (2) seepage from streams, especially where they cross mined land; (3) stream flow directly entering the mines through cave-ins or other sinks; (4) unchanneled overland runoff and interflow from upland areas; and (5) natural ground-water discharge from bedrock aquifers. The small spikes in the record (Figure 10), following precipitation events, indicate the significance of the “direct” runoff that

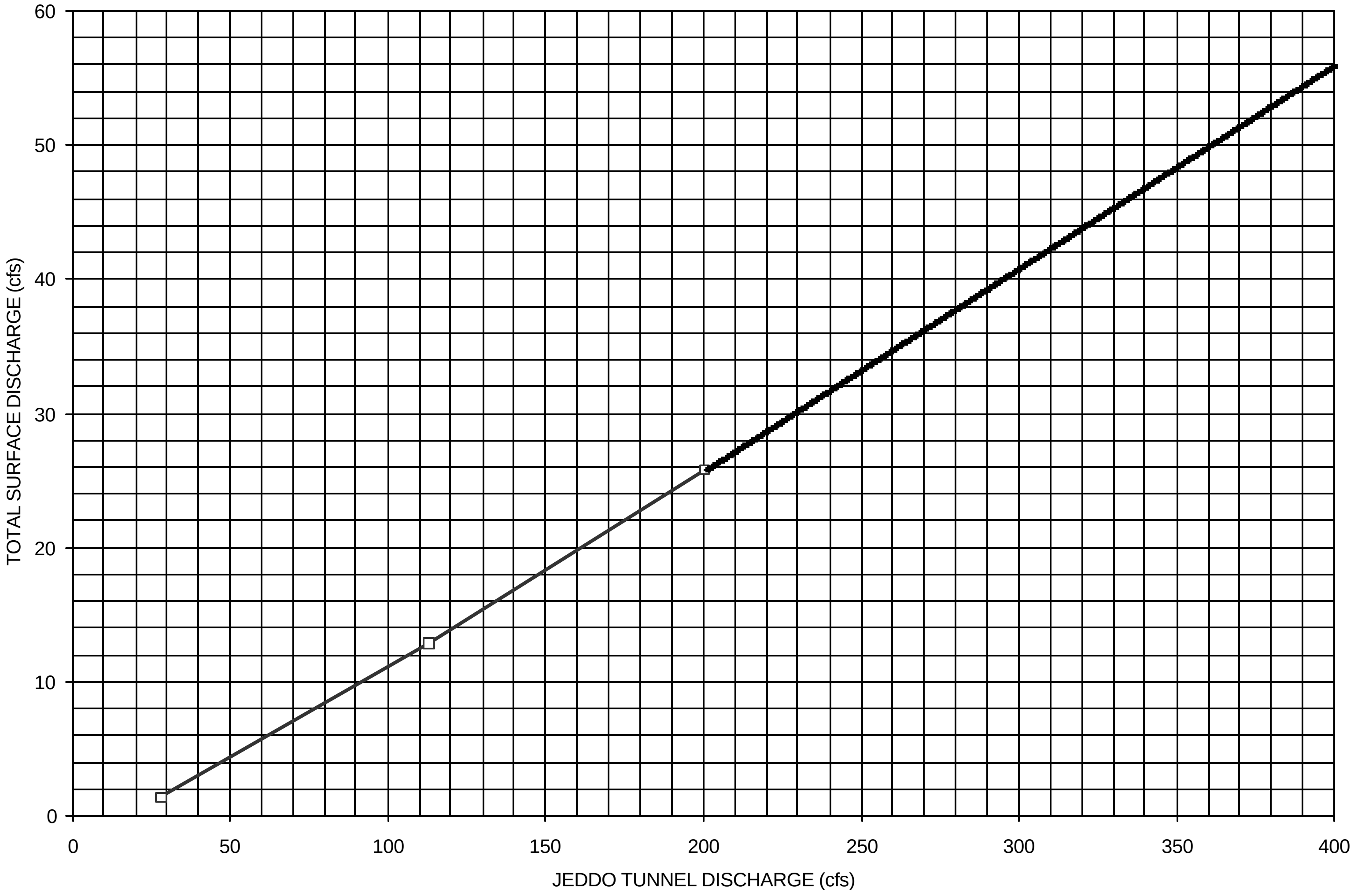

Figure 9. Relationship to Total Surface Flow Leaving the Basin and Jeddo Tunnel Discharge

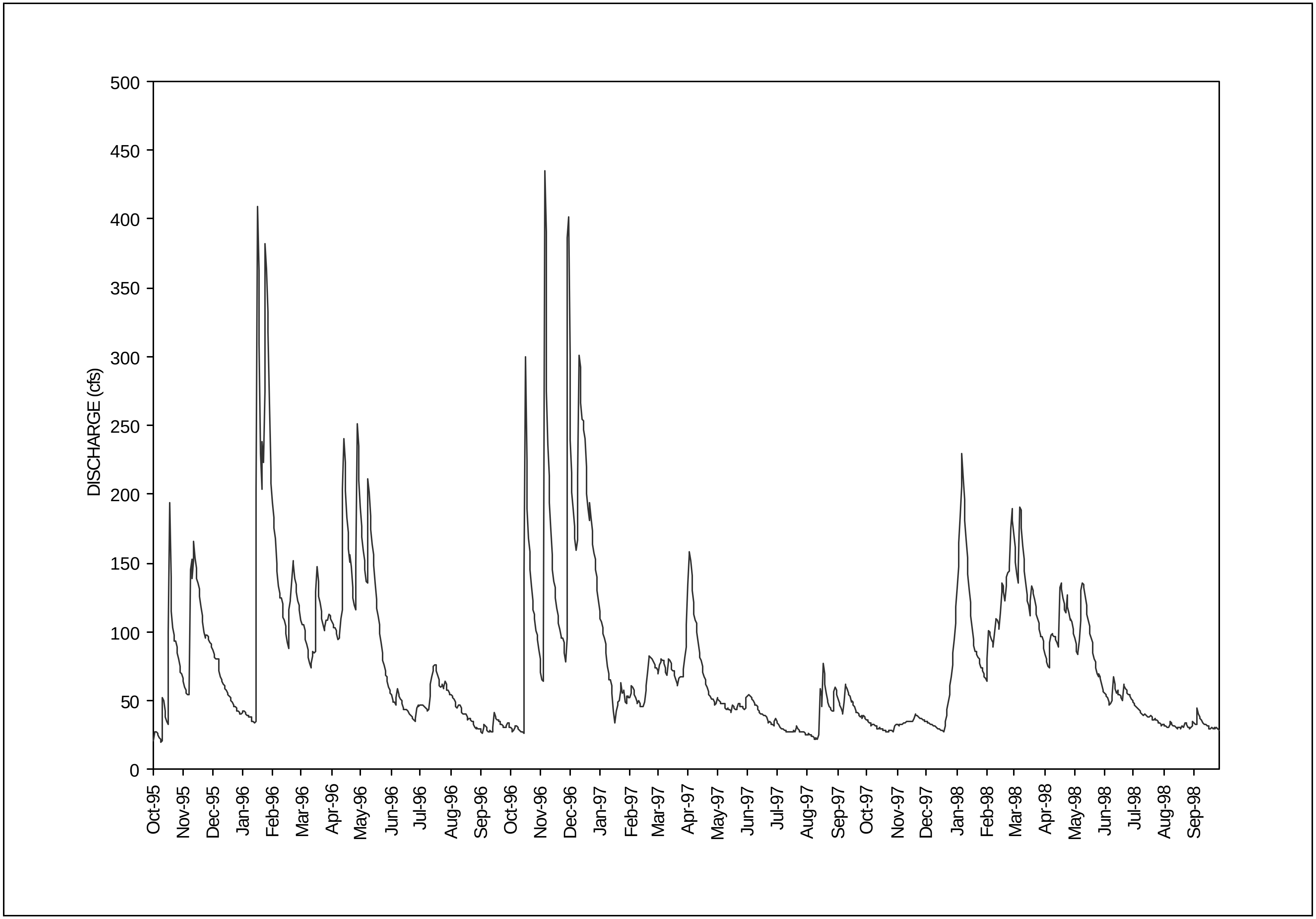

Figure 10. Discharge From Jeddo Tunnel, Water Years 1996-98

enters the mine complex. These pulses of surface water are most pronounced in the spring.

The hydrograph of tunnel discharge was analyzed with a technique commonly used for streamflow to separate ground-water discharge from total runoff. Base flow was separated from total flow using a modification (Taylor, 1997) of the local minimum technique developed by Pettyjohn and Henning (1979). The technique uses computer analysis of daily flow and allows the operator to select the time period after the peak flow, when essentially all of the flow is base flow.

Base flow averaged 72.3 cfs annually from the Jeddo Tunnel Basin (Table 10). This discharge is equivalent to about 29 inches spread over the entire basin. The direct or surface runoff component of tunnel discharge was computed as the difference between total flow and base flow. Surface runoff through the tunnel averaged 7.2 cfs, or an equivalent 3 inches spread over the basin. During 1998, a drier-than-average year, surface runoff decreased 55 percent compared to 1997, to an average discharge of 4.7 cfs.

Base flow discharged through the tunnel accounts for about 81 percent of total runoff in the basin. This percentage is high. Natural basins in the Susquehanna River Basin range from a high of 86 percent for the primarily carbonate rocks in Spring Creek Basin to between 60 and 65 percent for basins underlain by sandstone and shale of the Valley and Ridge physiographic province.

A large proportion of precipitation infiltrates to the mine workings and to the natural ground-water system through the disturbed land in mined areas (Ash and Link, 1953), reducing the amount of surface runoff and, conversely, increasing the ground-water discharge. In a mined basin above the gage on Shamokin Creek, Becher (1991) found ground water accounted for 41 percent of precipitation, or about 85 percent of total streamflow.

Currently, in the Jeddo Tunnel drainage area, there is easy ingress to precipitation through rock fissures, cave-ins, fissures in outcrops and strippings, and numerous sinks identified in Plates 4 through 7. Remedial measures can eliminate many of the direct pathways for precipitation entering the mines and channel this flow to streams outside the Jeddo basin, which should significantly reduce the direct runoff component of tunnel discharge. These measures could reduce total tunnel discharge by about 11 percent, under average conditions.

Reestablishing perimeter drains that would intercept overland runoff from adjacent ridges would likely further reduce the discharge from the Jeddo Tunnel. The unchanneled overland runoff currently flows to the mined lands and percolates through the overburden to the flooded mine workings. As such, much of the existing overland runoff may not have been accounted for in the surface runoff component of tunnel discharge.

Uplands surrounding the coal basins comprise about 55 percent of the Jeddo basin. Diverting the runoff contributed by these areas away from the mined lands could potentially reduce tunnel flow another 10 percent, providing the channels are lined to minimize any seepage to the mine-water system from reestablished streams and perimeter drains.

Even after the surface drainage network is restored, infiltration of precipitation on mined lands, the natural ground-water discharge from the bedrock aquifers, and underflow from uplands adjacent to the coal basins will continue to support tunnel flow. The significance of natural ground-water discharge is described during tunnel construction (McNair, 1951):

Table 10. Base Flow Separation of Tunnel Discharge *(flow values in cubic feet per second)*

Water Year	Total Tunnel Discharge	"Direct Runoff"	Mean Base Flow	Maximum Value (Base Flow)	Minimum Value (Base Flow)
1996	89.6	8.2	81.4	318	19
1997	78.8	8.6	70.2	253	22
1998	69.9	4.7	65.2	180	26
Average	79.4	7.2	72.3	--	--

> "The workers were troubled considerably by meeting a great many streams of underground water. These streams were of the purest spring water; on several occasions a blast would cut them in two like a hose pipe; so powerful was the force, some of them gushed two or three feet from the rock after being thus cut. As the tunnel was worked in sections having no communication with each other, except the boom-boom-boom of the dynamite blasts, it was necessary to clear out this water with pumps; 7 of these aggregating 799 HP were in constant use operated by special pump runners and attendants; 4 pumps were located in the Lattimer slope and 3 in the Ebervale-Jeddo slope."

During the moderate drought in 1998, when infiltration through the mined lands was minimal, flows declined to 30 to 33 cfs and stabilized. Flows of this magnitude also are typical during late summer and early fall in years with average levels of precipitation. This likely represents natural ground-water discharge, amounting to about 0.9 cubic feet per second per square mile (cfsm), and cannot be reduced by remedial measures.

Evapotranspiration

Water lost to the atmosphere by evaporation from surface bodies of water, wetted surfaces, moist soil, and by transpiration of plants commonly constitutes the largest component in the water budget. Evapotranspiration (ET in equation 1) losses decline rapidly in early fall as plant growth stops and temperatures decrease. Through late fall and winter, ET is negligible, but in early spring it increases rapidly and reaches a maximum in summer. Commonly, recharge to the ground-water system and streamflow are greatest when ET is least, and least when ET is greatest.

ET was calculated in the budget as the difference between precipitation and total runoff. The average annual loss to ET is about 13 inches from the basin. This loss constitutes 26 percent of average annual precipitation in the basin. The low rate of ET is probably related to the lack of vegetation in the mined areas and the character of the "soils." Soils and other overburden in the mined areas allow for rapid infiltration of precipitation. Any water that enters the soils passes quickly below the root zone.

Subbasin Contributions

Average discharge from the Jeddo Tunnel amounts to 2.463 cfsm, or 1.591 mgd/mi^2. Using drainage areas and an unitized approach, the subbasins of Black Creek, Little Black Creek, Cranberry Creek, and Hazle Creek contribute an annual average 30.66 cfs (39 percent), 11.43 cfs (14 percent), 16.31 cfs (26 percent), and 21.01 cfs (21 percent), respectively.

Flow entering the mines and that could be diverted also was measured directly at several locations. Six potential sites for flow measurements were identified (Dr. Duane Braun, Bloomsburg University, written communication, April 1997):

- Little Black Creek, in the headwaters east of Pardeesville, an example of surface flows from a near natural subbasin (the reclaimed Woodside Coal Basin);
- Black Creek headwaters, at a road culvert near Eckley, an example of a near-natural wooded area;
- Black Creek at Stockton Road, an example of the amount of surface flow coming off a section of the Pottsville conglomerate dip slope;
- Hazle Creek at Stockton Road, an example of the largest of the flows going to the mines;
- Black Creek headwaters at railroad culvert; and
- Cranberry Creek headwaters.

The last two sites listed were eliminated when field checked because of indeterminate flow direction and dry and/or discontinuous channel, respectively. Table 11 (Ballaron, 1999) shows the results, which were very limited due to the dry conditions. Additionally, Jeddo Tunnel discharge is listed for the day the flow measurements were made. As an indication of storm intensity, total precipitation from the preceding seven days also is noted in the table.

Table 11. Runoff Data for Streams That Directly Enter the Mines *(flow in cubic feet per second) (Ballaron, 1999)*

Location	Drainage Area (mi^2)	05/20/97	09/11/97	10/27/97	10/30/97
Hazle Creek at Stockton Road	4.19	--	47.81	<0.1e[1]	dry
Black Creek at Stockton Road	8.65	--	dry	<0.1e[1]	dry
Woodside Basin	1.54	3.48	--	--	1.32
Culvert near Eckley	0.10	--	--	--	0.85
Culvert under RR near Eckley	eliminated due to undetermined flow directions				
Cranberry Creek south of Pa. Route 924	eliminated due to lack of channel and water				
Jeddo Tunnel	32.64	47	49	29	28
Precipitation (inches)		0.80	1.91	0.88	0.88

Location	01/9/98	01/21/98	02/5/98	03/27/98	05/11/98	10/9/98
Hazle Creek at Stockton Road	--	ice	12.6	0.15	19.5	1.39
Black Creek at Stockton Road	--	ice	0.4e[1]	0.10	<0.30e[1]	dry
Woodside Basin	2.12	--	--	4.71	<0.30e[1]	1.25
Culvert near Eckley	0.93	--	--	1.02	--	--
Culvert under RR near Eckley	eliminated due to undetermined flow directions					
Cranberry Creek south of Pa. Route 924	eliminated due to lack of channel and water					
Jeddo Tunnel	200	90	80	113	109	--
Precipitation (inches)	2.02	0.98	1.38	1.12	2.30	--

[1] estimated

The relationship between surface runoff at each site and Jeddo Tunnel discharge is plotted in Figure 11 (Ballaron, 1999). Flows in the reestablished extension of Little Black Creek in the Woodside basin increase as tunnel discharge increases; the linear relationship is plotted in the figure. This stream is perennial and continued to flow even during the moderate drought.

Conversely, Hazle Creek data demonstrate no predictable relationship between measured surface flow and Jeddo Tunnel flow. This may be due to the intermittent flow during the study, including instances of very low flows and dry channel, and/or a failure of investigators to consistently measure peak flows, or near peak flows. Hazle Creek is the “flashiest” of the flows entering the mines, and has sharp, multicrest hydrography that made it difficult for investigators to catch the crest or crests. Measured flows of the other streams were too low and the number of measurements was insufficient to establish a relationship with the tunnel discharge data.

Using the limited data available, average annual runoff from the Woodside basin is estimated to be 2.34 cfs, or 1.51 cfsm. The Woodside basin would be expected to produce, using drainage areas and the average discharges from the Jeddo Tunnel watershed, a proportional average annual flow (total runoff) of 4.00 cfs, of which 3.79 cfs would be contributed to the tunnel discharge. Predicted flow values are substantially higher than measured values (extrapolated to an average annual flow), illustrating the benefits of the remediation. Runoff from the remediated basin is estimated at 1.51 cfsm, which is similar to that expected for a natural basin. As a general rule, natural freestone basins in the Valley and Ridge physiographic province in Pennsylvania produce flows of about 1 mgd/mi^2, or 1.547 cfsm.

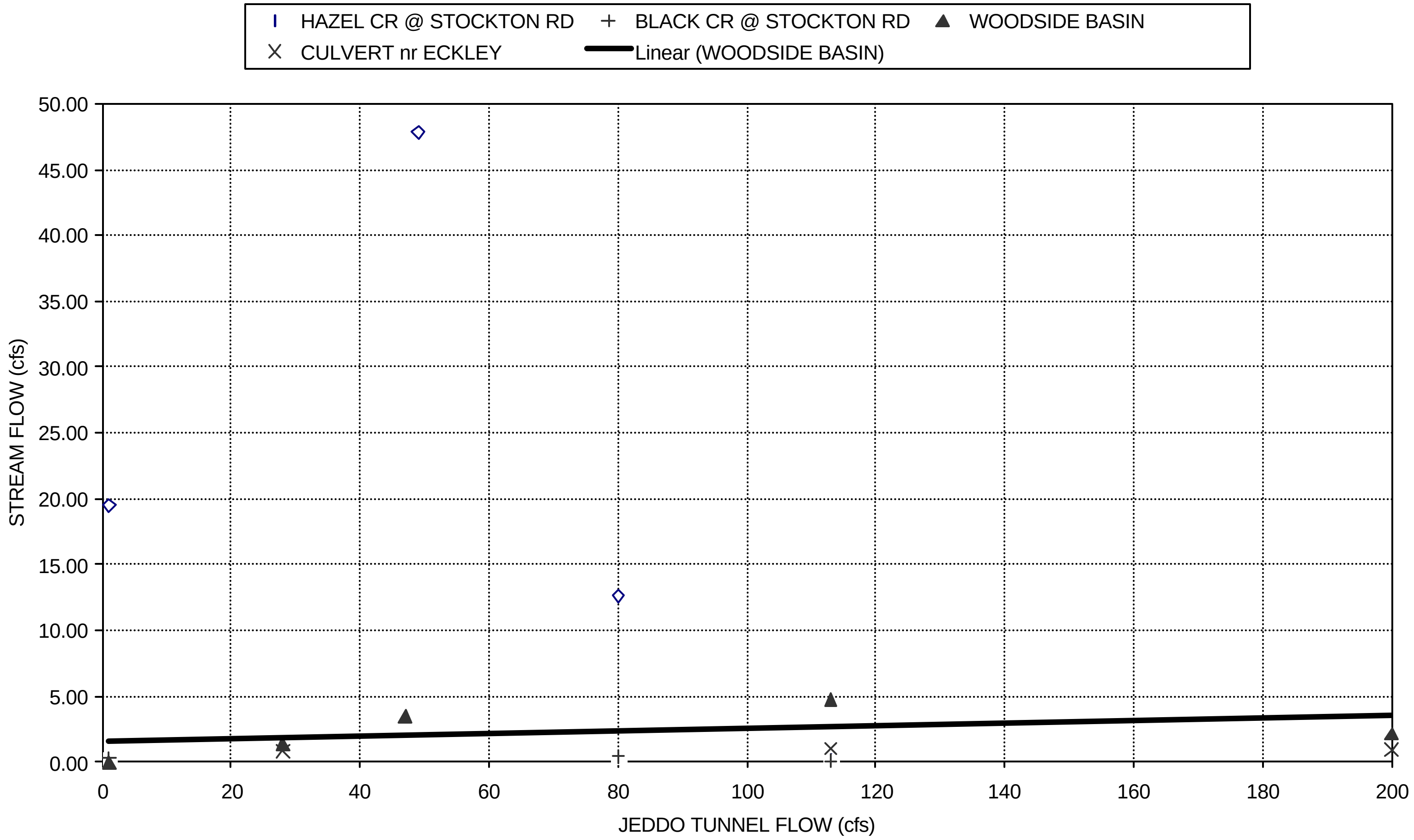

Figure 11. Relationship of Streamflow Entering the Mines and Jeddo Tunnel Discharge *(Ballaron, 1999)*

Annual runoff of 2.34 cfs is equivalent to 20.3 inches in the subbasin, or 42 percent of precipitation on the subbasin. The quantity of ground-water discharge from the Woodside basin could not be determined directly, but can be calculated as a residual, assuming an ET for the wooded basin approaches the state average of 20 inches. Ground-water discharge amounts to about 8.2 inches, or only 17 percent of average annual precipitation.

Using the Woodside basin as a surrogate for the other coal basins would predict a substantial potential reduction of infiltration, assuming similar reclamation of coal basins in each hydrologic subbasin (Ballaron, 1999). This assumes the mine areas would be completely regraded and that surface water would be directed to the reestablished surface water network and perimeter drains.

The only way to further reduce direct infiltration to the mine drainage system would be to bury a layer of low permeability material such as fly ash at a shallow depth under the regraded surface. That should reduce infiltration (and Jeddo Tunnel discharge) 10 to 25 percent (Dr. Duane Braun, Bloomsburg University, written communication, April 1997). Urbanization of the mine sites and the surrounding ridges might further reduce infiltration to the mine-water system, providing storm water is adequately controlled and the surface drainage network prevents water from entering the mines.

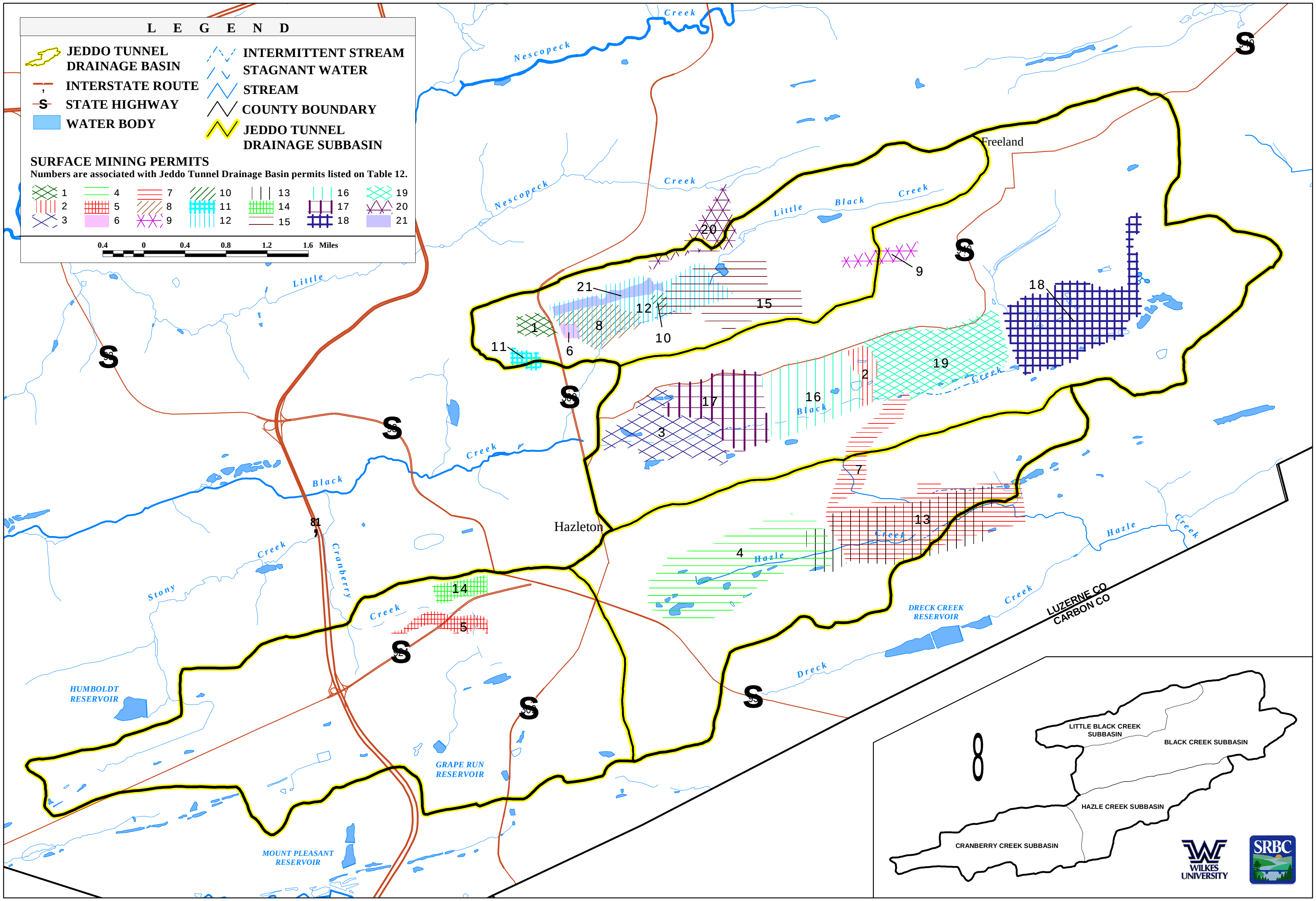

Figure 12. Approximate Areas Under Permit by Mine Operations (information provided by Pa. DEP-Pottsville)

CURRENT ENVIRONMENTAL CONDITIONS

There are 21 permitted anthracite-mining operations in the Jeddo Tunnel Watershed; 18 are active (Table 12). The areas under permit are shown on the map in Figure 12. The active operations consist of 8 surface mining (strip) operations and 10 refuse reprocessing operations.

The remaining operations are either inactive or have not yet started. There are no active underground mines in the Eastern Middle Anthracite Field. According to the 1996 Annual Production Report 52, Hazleton basin produced 166,214 tons (90.744 metric tons) of coal (Nasilowski and Owen, 1998).

All current mining operations will be reclaiming open pits in accordance with their permits. Additionally, the plans for reclamation indicate two operators also will reestablish parts of Hazle Creek, and Jeddo Highland Cranberry will reestablish flow in part of Cranberry Creek (Colleen Stutzman, Pa. DEP-Pottsville, written communication).

The tunnel system accepts surface- and ground-water drainage from Hazleton and several surrounding small mining communities. The majority of correctable flow to the tunnel system occurs through several large sinks and open shafts and breached or discontinuous perimeter drains. To effectively remediate the impacts of the Jeddo Tunnel discharge, there has to be a clear understanding of the current environmental conditions of the drainage area in which the tunnel receives its water. This was accomplished by background literature search, aerial photography, existing mapping, water quality data collection and field reconnaissance.

Table 12. List of Jeddo Basin Mining Permits *(information provided by Pa. DEP–Pottsville)*

Area Number[1]	Name of Operator	Permit Number	Company
1	JMW-Milnesville No. 7 Op.	40980104	JMW Enterprises, Inc.
2	Jeddo Highland Basin West	40663027	Jeddo Highland Coal Company
3	Jeddo Highland Jeddo H7	40663013	Jeddo Highland Coal Company
4	Hazleton Shaft West Op.	40663023	Pagnotti Enterprises, Inc.
5	Jeddo Highland Cranberry	40793211	Jeddo Highland Coal Company
6	Lattimer Refuse Bank (Diamond)	40940202	Diamond Coal Company
7	Gowen Mine Stockton Op.	40663024	Coal Contractors, Inc.
8	Lattimer Plant Op.	40830202	Rossi Excavating Company
9	Drifton West Op.	40890101	Brook Contracting Corporation
10	Lattimer Center Bank	40910201	Diamond Coal Company
11	Milnesville Mine Op.	40930201	Lonzetta Trucking Company
12	Lattimer Basin Mine	40930102	Diamond Coal Company
13	Stockton Strip Mine	40743011	Diamond Coal Company
14	Hardwood Refuse Bank	40980201	Bonner Shale Company
15	Continental Mine Oper.	40930202	Rossi Excavating Corporation
16	Jeddo C.R.D.A. No. 2	40663026	Pacton Corporation
17	Jeddo C.R.D.A. No. 1	40663025	Pacton Corporation
18	Highland S. Mine Op.	40663029	Pagnotti Enterprises, Inc.
19	Jeddo Basin East	40663028	Pagnotti Enterprises, Inc.
20	Kelly No. 1	40850103	Kelly Investors, Inc.
21	Penny's Bank	40840203	Rossi Excavating Corporation

[1] Numbers reflect the areas shown on Figure 12.

CURRENT AREAS OF REMEDIATION

The investigation of the Jeddo Tunnel system identified several areas of immediate concern. Some actions already have been taken during the study period to reduce the impact of these areas on the Jeddo Tunnel system.

1. **Blackwater discharges**—An active mine operator was identified as contributing to the "blackwater discharges" from the Jeddo Tunnel in 1996. Pa. DEP Pottsville District Mining Office investigated and took compliance and enforcement actions that resulted in remedial water handling measures. These actions have been largely successful.

   As an outgrowth of the investigation at coal preparation sites, one of the operators entered into a "Reclamation in-lieu of Civil Penalty Agreement" that resulted in the abatement of a subsidence area identified during field reconnaissance. With the abatement project completed and improved water handling procedures, the intensity and duration of "blackwater discharges" has been reduced dramatically.

2. **Perimeter drain near Humbolt—**An existing perimeter drain runs on the north side of the Western Hazleton Coal Basin. This channel is intact and transports water until it gets to P-148, the access road to the Hazleton Reservoir. No culverts had been installed under the road and the water entered sinks at P-456 and P-161.

   At this location, 30 feet of culvert was installed to channel the water under the road connecting the western and eastern segments of the perimeter drain. This project, which cost approximately $7,500, is largely successful. The perimeter drain along the northern side of the Western Hazleton Coal Basin now effectively transports water out of the Jeddo Tunnel Basin. Further work, including lining the existing channel in the area of restoration, is planned for this site.

3. **Black Creek channel from Pa. Route 940 eastward—**The existing Black Creek channel is restricted in certain locations and does not allow for positive drainage. The blockages from a 1,000-foot section of this channel were removed. This restoration project has allowed water in Black Creek to effectively exit the Jeddo basin.

PRIORITY OF REMEDIATION OPTIONS

To facilitate mining, extreme measures were taken to keep water out of the deep mines. This was accomplished by several means. Side hill ditches were constructed to catch runoff from the hillsides and direct it away from the mined areas. Log or steel flumes were constructed to carry surface water over and around the mined areas to reduce the amount of water infiltrating to the deep mines. Additionally, gravity drainage tunnels were constructed to dewater deep anthracite mine workings.

During the peak of anthracite deep mining, these devices were constructed and maintained to transport surface water out of the basin and prevent it from entering the mine workings. Since the collapse of the deep mining in the Eastern Middle field in the 1950s, many of these devices were removed or currently do not function.

Several continuous perimeter drains still exist in the Jeddo Tunnel Basin. Others are discontinuous, breached by sinks or otherwise truncated. Field reconnaissance completed for this project traced several of these channels and identified sinks where surface water directly enters the mines. To reduce the amount of water entering the mines, there is a need to reestablish perimeter drains, construct new channels outside mined lands, connect discontinuous drainageways, improve these drains by reducing the potential for infiltration, and fill and seal closed depressions in the land surface caused by internal collapse (sinks).

During the field investigation, points of interest were identified within each coal basin that could potentially reduce the infiltration to the underground workings drained by the Jeddo Tunnel. Information was collected and analyzed to determine what and where restoration options should occur.

To facilitate the restoration of the surface-water drainage system in the Jeddo Tunnel watershed, sites were grouped according to coal basin and ranked according to overall environmental benefit, once restoration is complete. The criteria were the amount of water entering the mines at the site; the size of the drainage area contributing to the site; water quality, with regard to sewage; and the amount of earth moving required for remediation. The ranking system does not consider property ownership or current mining status.

The highest priority sites in each subbasin have considerable drainage areas and are related to the highest order stream. These sites also have insignificant sewage and minimal (1,000 to 10,000 cubic yards) to moderate (10,000 to 100,000 cubic yards) earth moving requirements.

The ranking takes into account the current adverse environmental impact to the Jeddo Tunnel discharge and, consequently, the overall benefit from the proposed remediation option. During the ranking process, each subbasin was evaluated holistically, and the most effective sequence of actions is proposed. This is necessary because many of the remediation options listed depend on other sites of remediation taking place first, the goal being to establish an effective channel network for draining surface water out of the Jeddo Tunnel Watershed.

In addition to the restoration of these particular sites, the following activities should be completed:

- Remining and reclamation of abandoned mine lands causing AMD;
- Use of Title IV and other SMCRA funding to reclaim priority sites that are causing AMD;
- Use of forfeited reclamation bonds to reclaim those sites, and Reclamation In-Lieu of Penalty funding from active industry;
- Increase public awareness through local environmental organizations;
- Use of partnerships to facilitate and monitor restoration activities;
- Selection of proven and innovative technologies to reduce the pollutant loads of the Jeddo Tunnel discharge; and
- Prevention of the sewage inflow into the Jeddo drainage system.

With the completion of the above-mentioned activities, the impact of the Jeddo Tunnel discharge on its receiving stream should be reduced dramatically.

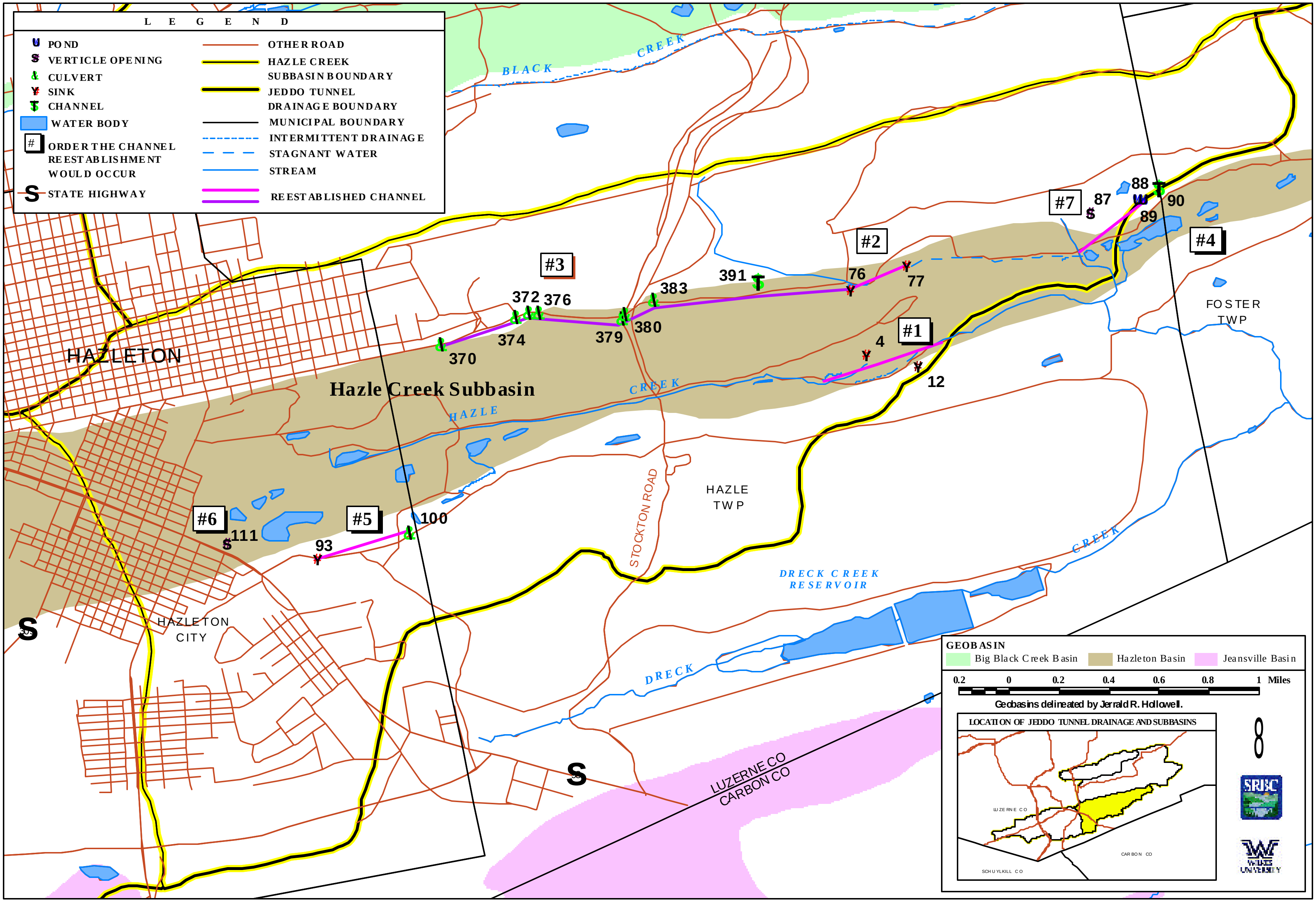

Figure 13. Future Surface Hydrology in the Hazle Creek Subbasin

Eastern Hazleton Coal Basin—Hazle Creek Drainage

Hazle Creek Subbasin covers an area of 6.62 square miles that includes the eastern part of the Hazleton Coal Basin. Approximately 32 percent of the hydrologic subbasin is underlain by coal basins and the area has been extensively mined. There are 3 mining permits within the basin. Hazle Creek, a tributary of the Lehigh River, originally drained this area.

The basin contains the main stem of Hazle Creek and several discontinuous perimeter drains. The infiltration of surface water within the Eastern Hazleton Coal Basin (Plate 6) will be effectively reduced by reestablishing the Hazle Creek channel, reconnecting the northern perimeter drain in several locations, removing sewage in the Hazle Creek channel and filling several sinks (Figure 13).

These restoration projects, when completed, will effectively reduce the quantity of surface water currently draining to the mines, which in turn will reduce the tunnel discharge and its acid load. The most significant area where surface water is entering the mine workings occurs in the Hazle Creek channel 0.6 miles east of Stockton Road.

Hazle Creek is the largest and "flashiest" stream that contributes surface water to the deep mine complex. The major limitation to restoration is the raw sewage that enters Hazle Creek from Hazleton City. This problem will need to be remediated before the channel of Hazle Creek is restored, and the water is allowed to exit the basin.

A full description of restoration options is located in Appendix B. The restoration of Hazleton basin will require work at four sites in the perimeter drain system and four sites of sinks or other features that are contributing surface water into the Jeddo drainage system. Sites shown on Figure 13 are listed in Table 13 in order of priority, based on impact to the system and on overall environmental benefit.

Table 13. Ranking of Restoration Options for the Eastern Hazleton Coal Basin—Hazle Creek Drainage

Rank	Description of Area	GPS #	Location	Type of Remediation
1	Hazle Creek Channel	4	0.6 miles east of Stockton Road	Channel restoration
2	Northern perimeter drain	76-77	Northern perimeter drain of Hazle Creek	Perimeter drain restoration
3	Perimeter drain along north side of basin	370-383, 391	North side of Hazle Creek Subbasin	Perimeter drain restoration
4	Northeast corner of basin	88-90	Northern perimeter drain of Hazle Creek	Perimeter drain restoration
5	Channel south of Hazle Creek	93, 101, 25	East of Hazleton	Fill sink, restore drain
6	Western end of Hazle Creek	111	East of Pa. Route 93	Seal opening, regrade area
7	North side of Hazle Creek Subbasin	87	0.5 miles north of Ashmore Yards	Backfill pit, regrade area
8	South of Hazle Creek channel	12	0.7 miles east of Stockton Road	Backfill pit, regrade area

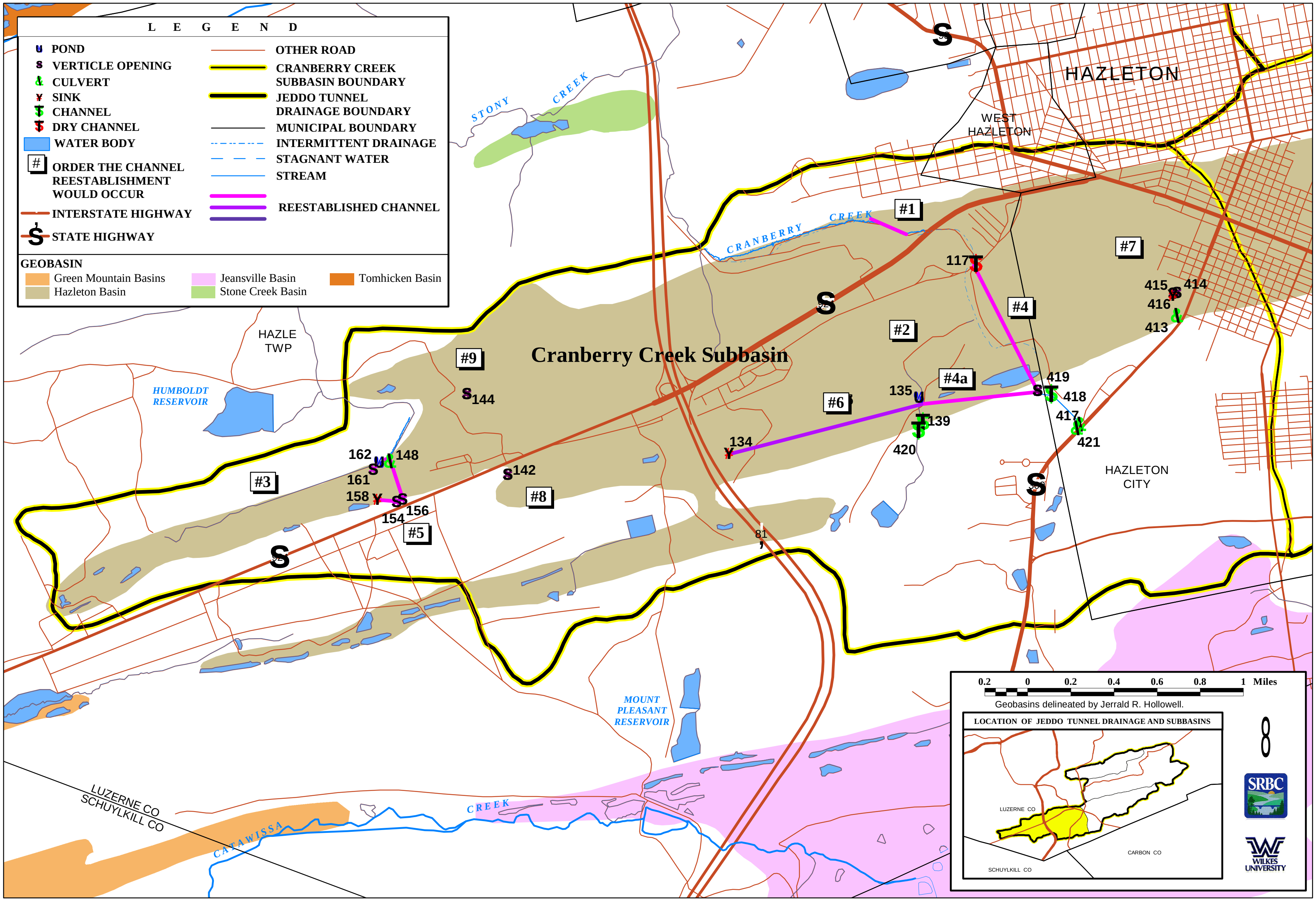

Figure 14. Future Surface Hydrology in the Cranberry Creek Subbasin

Western Hazleton Coal Basin—Cranberry Creek Drainage

The Cranberry Creek Subbasin covers an area approximately 8.53 square miles that includes the Western Hazleton Coal Basin. Approximately 49 percent of the hydrologic subbasin is underlain by coal basins and the area has been extensively mined. There are two mining permits within the basin. Cranberry Creek, a tributary of Black Creek, originally drained this area.

The basin contains the main stem of Cranberry Creek and several unattached headwater tributaries and discontinuous perimeter drains (Plate 7). The infiltration of surface water within the Western Hazleton Coal Basin will be effectively reduced by reestablishing the Cranberry Creek channel, reconnecting headwater tributaries of the creek in several locations, preventing sewage from entering the Cranberry Creek, reconnecting several perimeter drains, filling several sinks, and sealing two open shafts (Figure 14).

These restoration projects, when completed, will effectively reduce the surface area draining to the flooded mine workings, which in turn will reduce the tunnel discharge. The most significant area where restoration is required is the main stem of the Cranberry Creek channel immediately downstream of Pa. Route 924. This area needs to be restored first for the other restoration options to effectively transport water out of the Jeddo basin.

The restoration of the Western Hazleton Coal Basin will require work at six sites in the perimeter drain system and three sites of sinks or other features that are contributing surface water into the Jeddo system. Sites shown on Figure 14 are listed in Table 14 in order of priority based on impact to the system and on overall environmental benefit.

Table 14. Ranking of Restoration Options for the Western Hazleton Coal Basin—Cranberry Creek Drainage

Rank	Description of Area	GPS #	Location	Type of Remediation
1	Cranberry Creek channel	122, 123	Downstream of Pa. Route 924	Channel restoration
2	Headwaters Cranberry Creek	420, 135-139	Downstream of Grape Run Reservoir	Fill sink, restore channel
3	Perimeter drain north side of Western Hazleton Coal Basin	148, 161, 162	North of Pa. Route 924	Perimeter drain restoration
4	Headwaters Cranberry Creek	417-421	West of Pa. Pa. Route 309	Fill sink, restore channel
5	Western Hazleton Coal Basin	154, 156, 158	North of Pa. Route 924 near Humbolt	Fill sinks, construct channel
6	Western Hazleton Coal Basin	134, 135, 137	Southeast of I-81 and Pa. Route 924 interchange	Fill sinks, reestablish channel
7	Southwest part of Hazleton	413-416	North of Pa. Route 309 (Beltway Diner)	Backfill sinks, regrade area
8	Pa. Route 924	142	Near Humbolt	Seal opening, regrade area
9	Western Hazleton Coal Basin	144	North of Pa. Route 924	Seal opening, regrade area

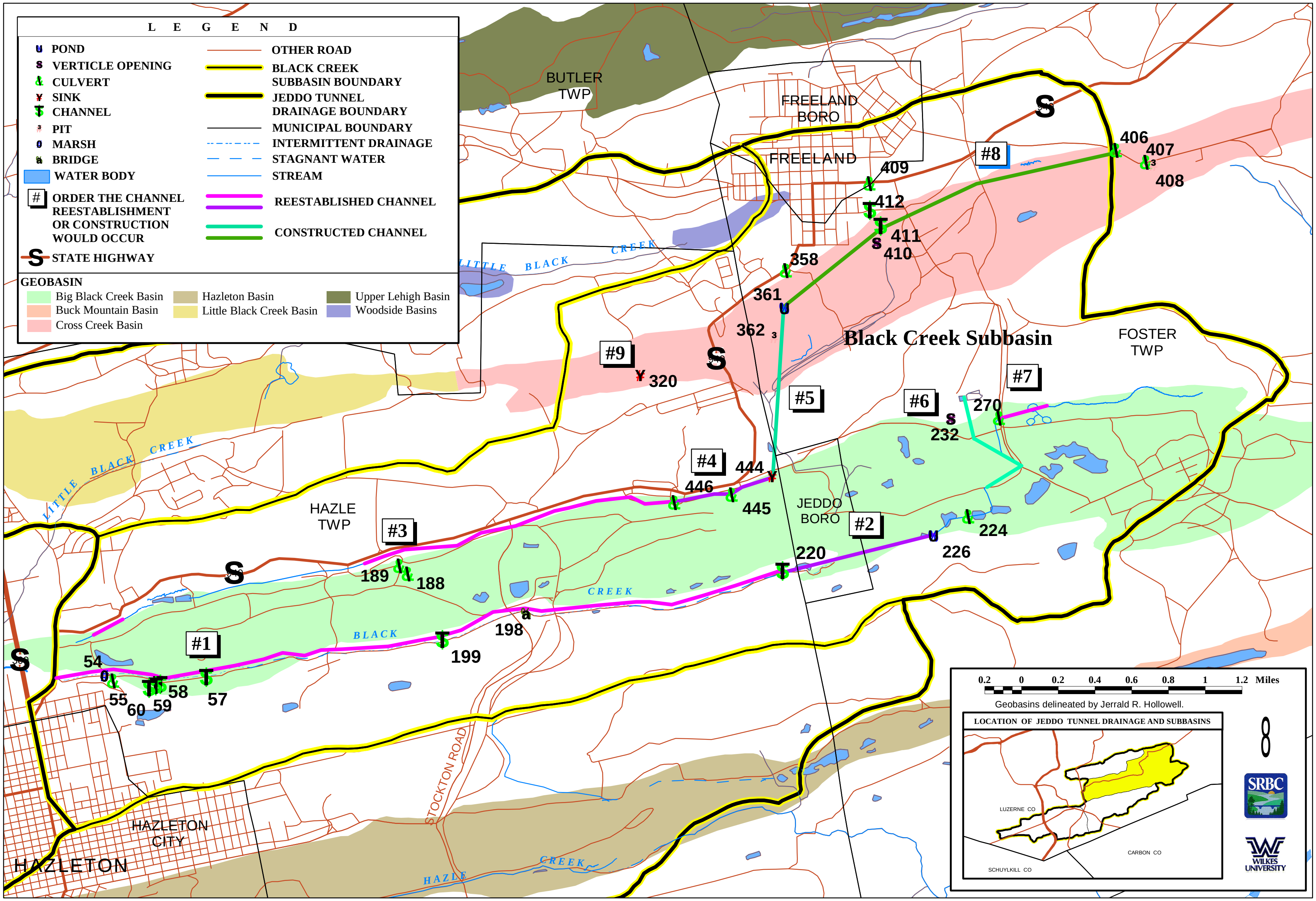

Figure 15. Future Surface Hydrology in the Black Creek Subbasin

Black Creek Coal Basin—Black Creek Drainage

The Black Creek Subbasin covers an area of 12.45 square miles that includes the Black Creek Coal Basin. Approximately 39 percent of the hydrologic subbasin is underlain by coal basins and the area has been extensively mined. There are seven mining permits within the basin. Black Creek, a tributary of Nescopeck Creek, originally drained this area.

The basin contains the main stem of Black Creek and several discontinuous headwater tributaries and a discontinuous perimeter drain on the north side of the basin. The infiltration of surface water within the Black Creek Coal Basin (Plate 5) will be effectively reduced by removing blockages associated with the Black Creek channel, reconnecting the headwater tributaries of the creek, reconnecting and constructing several perimeter drains, and the filling of several sinks (Figure 15).

The most significant area where restoration is required is the main stem of the Black Creek channel. Several blockages exist that inhibit the stream from conveying water out of the basin. This restoration option needs to be completed for many of the other projects to effectively transport water out of the basin. The main restoration limitation in this basin is the channel restriction located at the mall between Pa. Routes 309 and 940.

The restoration of the Black Creek Coal Basin will require work at seven sites in the perimeter drain system and two sites of sinks or other features that are contributing surface water into the Jeddo Tunnel system. Sites shown on Figure 15 are listed in Table 15 in order of priority, based on impact to the system and the environmental benefit.

Table 15. Ranking of Restoration Options for the Black Creek Coal Basin—Black Creek Drainage

Rank	Description of Area	GPS #	Location	Type of Remediation
1	Black Creek	54-61 & 198-201	From Pa. Route 940 to 1.25 miles east of Stockton Road	Remove blockages
2	Headwaters of Black Creek	224, 226, 220	From power line eastward to the railroad	Reestablish channel
3	Perimeter drain north side of Black Creek Basin	188, 189, 213	From Ebervale west to Pa. Route 940	Reestablish perimeter drain
4	North side of Black Creek Basin	444-446, 136, 451	Near the town of Ebervale	Construct perimeter drain
5	Cross Creek Coal Basin	358, 361, 362	Headwaters of Black Creek near Freeland	Construct perimeter drain
6	North side of Black Creek Basin	232	West of Jeddo	Construct channel
7	Northeast corner, Black Creek Basin	245, 270, L97-6	West of Jeddo	Extend perimeter drain
8	Cross Creek Coal Basin	406-412	Near Freeland	Construct perimeter drain
9	Black Creek Coal Basin	320	Southwest of Freeland	Backfill sinks, regrade area

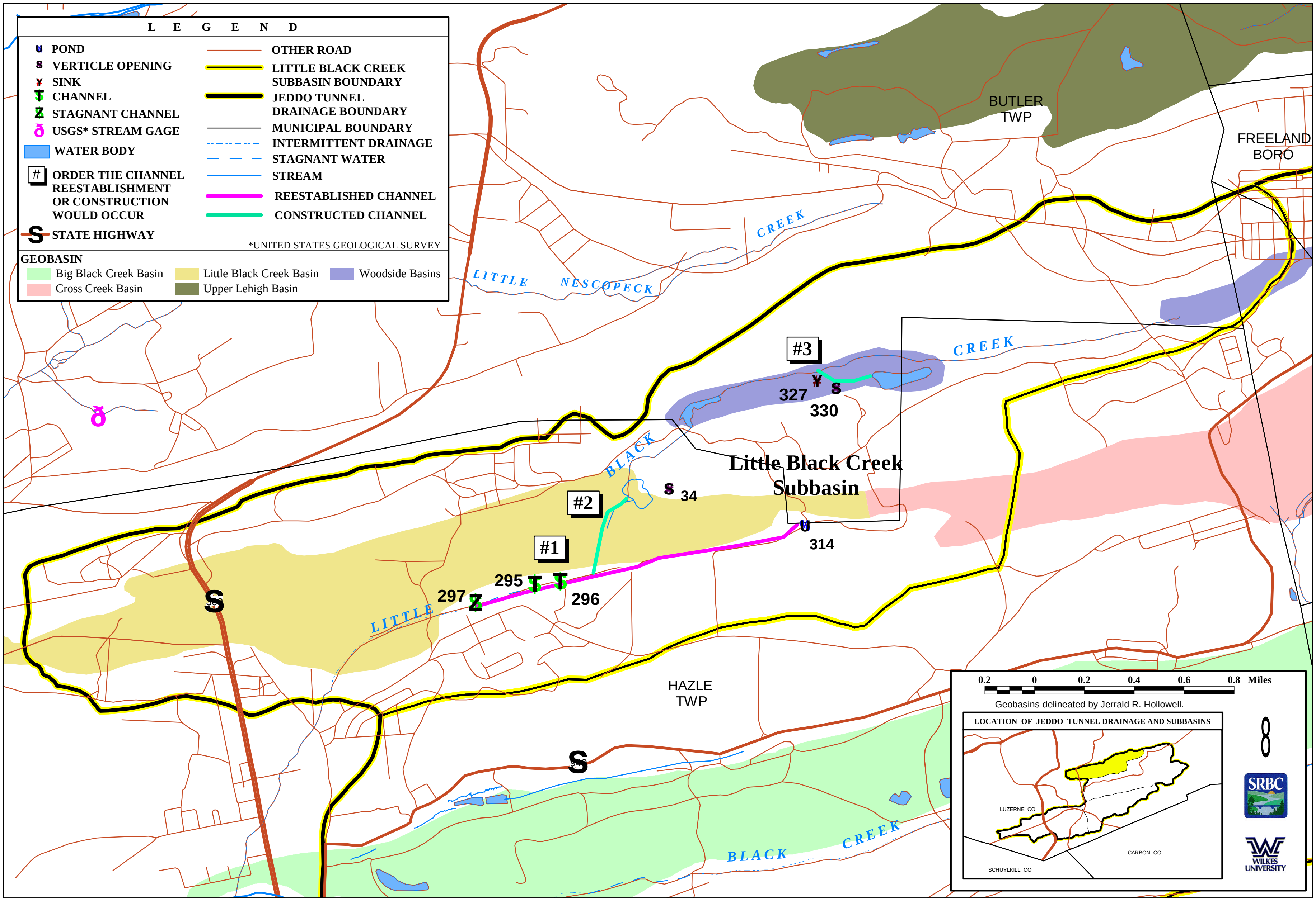

Figure 16. Future Surface Hydrology in the Little Black Creek Subbasin

Little Black Creek Coal Basin—Little Black Creek Drainage

The Little Black Creek Subbasin covers an area of 4.64 square miles that includes the Little Black Creek Coal Basin. Approximately 30 percent of the hydrologic subbasin is underlain by coal basins and the area has been extensively mined. There are 10 mining permits within the basin. Little Black Creek, a tributary of Nescopeck Creek, originally drained the area.

The restoration of the Little Black Creek Coal Basin will require work at three sites in the perimeter drain system (Figure 16). Sites shown on Figure 16 are listed in Table 16 in order of priority, based on impact to the system and on the environmental benefit.

The basin contains the main stem of Little Black Creek and several discontinuous headwater tributaries and a discontinuous perimeter drain on the north side of the basin. The infiltration of surface water within the Little Black Creek Coal Basin (Plate 4) will be effectively reduced by removing blockages associated with the Little Black Creek channel, reconnecting the headwater tributaries of the creek, and reconnecting and constructing several perimeter drains.

These restoration projects, when completed, will effectively reduce the surface area draining to the mine workings. The most significant area where restoration is required is the main stem of the Little Black Creek channel. Several blockages exist that inhibit the stream from conveying water out of the basin. This restoration needs to be completed for many of the other projects to effectively transport water out of the basin.

Table 16. Ranking of Restoration Options for the Little Black Creek Coal Basin—Little Black Creek Drainage

Rank	Description of Area	GPS Number	Location	Type of Remediation
1	Perimeter drain southern edge of basin	294-297	Near Lattimer	Remove blockages, extend drain
2	Woodside Coal Basin	34	East of Pardeesville	Channel construction
3	Woodside Coal Basin	327, 330	East of Pardeesville, Butler Twp.	Fill sinks, construct channel

SUMMARY AND CONCLUSIONS

The Little Nescopeck Creek, a tributary to the Nescopeck Creek, is severely impacted by a water-quality impaired discharge from the adjacent mined watershed. The natural watersheds were interconnected by construction of a water level drainage tunnel. This tunnel, the Jeddo, was constructed to dewater deep mined coal measures in the Eastern Middle Anthracite Field near Hazleton, Pennsylvania. The Jeddo Tunnel drainage system involves four major coal basins: Big Black Creek; Little Black Creek; Cross Creek; and Hazleton.

The Jeddo Tunnel is one of the largest mine water discharges in the anthracite region and the Little Nescopeck receives all its flow. This tunnel drains 32.24 square miles. Surface-water divides generally match ground-water divides. Most of this part of the Eastern Middle Anthracite Field drains to the Susquehanna River. The eastern-most parts of the coal basins (Cross Creek Basin, Big Black Creek Basin, and Hazleton Basin) drain to the Lehigh River. The drainage divide is expressed on the surface by a broadening of the coal basins and its location was estimated from structural geology maps and field observations.

More than a century of subsurface and surface mining activities has left a legacy of physical and chemical contamination of mine water draining the coal field through the water-level tunnel. The subsurface is a maze of collapsed gangways, tunnels, and chambers that interconnect the Buck Mountain, Gamma, Wharton, three splits of the Mammoth Vein, and numerous other beds of lesser thickness and poorer quality coal.

The surface also has been extensively disturbed by previously unregulated surface mining operations and is presently scarred with open abandoned pits, spoil piles, and refuse banks. These abandoned deep and surface mining operations have destroyed the natural surface and ground-water systems within the mining area. The open pits and fractured strata allow all surface water, not controlled at the surface, to infiltrate into the deep mine workings.

The quality of this water has been greatly affected through contact with acid-producing minerals present in the coal and associated rock exposed to infiltrating water. The water from the Jeddo Tunnel is predominantly acidic. Metal concentrations commonly exceed MCLs, and magnesium concentration exceeds that of all other metals.

The 1975 and 1991 load values for sulfate and acidity are more than double the average annual values obtained since 1996. This disparity may be attributed to one or more of the following reasons: (1) the 1991 drought; (2) a decrease in leachable minerals available to circulating water in the Jeddo Tunnel drainage system; and (3) a cessation in disposal of breaker waste water to the underground mines.

When underground mines were operating, surface water was captured in, or diverted to, channels outside the coal measures. Many of the channels are abandoned and no longer function as perimeter drains. Today, streams in the basin experience significant flow losses to the deep mine complex and most water that leaves the basin flows out through the Jeddo Tunnel. However, at four locations, streams exit the Jeddo basin; these are Black Creek, Little Black Creek, Cranberry Creek, and Hazle Creek.

The Nescopeck Creek Watershed assessment report and abatement plan focuses on factors and conditions relevant to the quality of the Jeddo Tunnel discharge to the Little Nescopeck Creek, and the potential for reducing AMD entering the Little Nescopeck Creek. The 40,000 gpm (89 cfs) average discharge from the tunnel is the only source of mine drainage nonpoint source pollution in the watershed. A reduction in AMD at the mouth of the Jeddo Tunnel will decrease the negative impact on the Nescopeck Creek, which contains a high level of biological diversity and is classified as a High Quality Cold Water Fishery (HQ-CWF) above the confluence with the Little Nescopeck Creek. This, in turn, will provide a significant benefit downstream to the Susquehanna River.

Consequently, this project focuses on the current environmental conditions in the area of the Eastern Middle Anthracite Field draining to the Jeddo Tunnel. Study activities included collecting water samples for water quality analyses, creating a hydrologic budget, identifying surface water infiltration points, and prioritizing remediation options that will improve the impact of the Jeddo Tunnel on its receiving stream.

The principal objectives of this report are to: (1) present feasible and applicable abatement measures that would eliminate or mitigate conditions and factors that contribute AMD to the Little Nescopeck Creek through the Jeddo Tunnel; and (2) prioritize remediation options based on the greatest potential environmental benefit.

Water budget analysis indicated that total runoff during the 3-year period of record is approximately 74 percent of precipitation. Tunnel discharge, on average, amounts to 66 percent of precipitation.

Base flow averaged 72.3 cfs annually from the Jeddo Tunnel Basin, and the direct or surface runoff component of tunnel discharge was computed to be 7.2 cfs (annual average). Base flow discharged through the tunnel accounts for about 81 percent of total runoff in the basin. This percentage is comparable to base flow from natural basins in the Susquehanna River Basin underlain by predominantly carbonate rocks.

The discharge from the Jeddo Tunnel is comprised of: (1) direct infiltration of precipitation through the mined land; (2) seepage from streams, especially where they cross mined land; (3) stream flow directly entering the mines through cave-ins or other sinks; (4) unchanneled overland runoff and interflow from upland areas; and (5) natural ground-water discharge from bedrock aquifers. Both underground and surface mining, with associated subsidence, create surface catchment basins, fractured rock strata, and artificial ponding that increases the amount of water discharged by the tunnel. To reduce mine water drainage from the Jeddo basin, measures will have to be taken to control water from entering at the surface.

Remedial measures can eliminate many of the direct pathways for precipitation entering the mines and channel this flow to streams outside the Jeddo basin, which should significantly reduce the direct runoff component of tunnel discharge. Water budget analyses indicate that these measures could reduce total tunnel discharge by about 11 percent, under average conditions. Reestablishing perimeter drains that would intercept overland runoff from adjacent ridges would likely further reduce the discharge from the Jeddo Tunnel, potentially another 10 percent, providing the channels are lined to minimize any seepage to the mine-water system.

During the moderate drought in 1998, when infiltration through the mined lands was minimal, flows declined to 30 to 33 cfs and stabilized. Flows of this magnitude also are typical during late summer and early fall in years with average levels of precipitation. This likely represents natural ground-water discharge, amounting to about 0.9 cubic feet per second per square mile (cfsm), and cannot be reduced by remedial measures.

Twenty-nine areas were identified where surface water is directly entering the mine drainage system. Restoration options for remediation include filling and sealing closed depressions in the land surface caused by internal collapse (sinks), sealing vertical openings, constructing or reestablishment of perimeter drains/channels, connecting discontinuous drainage-ways, lining stream channels, and removal of sewage. Recommended restoration sites are described.

These were grouped according to coal basin and ranked in order of priority, based on impact to the system and on overall environmental benefit, once restoration is complete. The ranking system takes into account the most effective sequence of restoration.

The 21 permitted anthracite-mining operations in the Jeddo Tunnel Watershed will be reclaiming open pits and completing other remediation measures in accordance with their permits. Future reclamation, assuming similar measures to those used in the Woodside basin, should reduce infiltration to the mine-water system. To further reduce direct infiltration 10 to 25 percent, a layer of low permeability material such as fly ash might be buried at a shallow depth under the regraded surface. Urbanization of the mine sites and the surrounding ridges might further reduce infiltration to the mine-water system, providing storm water is adequately controlled and the surface drainage network prevents water from entering the mines.

Even after the surface drainage network is restored and mined lands are reclaimed, infiltration of precipitation on mined lands, the natural ground-water discharge from the bedrock aquifers and underflow from uplands adjacent to the coal basins will continue to support tunnel flow.

In addition to the restoration of particular sites, the following activities should be completed:

- Remining and reclamation of abandoned mine lands causing AMD;
- Use of Title IV and other SMCRA funding to reclaim priority sites that are causing AMD;
- Use of forfeited reclamation bonds to reclaim those sites, and Reclamation In Lieu of Penalty funding from active industry;
- Increase public awareness through local environmental organizations;
- Use of partnerships to facilitate and monitor restoration activities;
- Selection of proven and innovative technologies to reduce the pollutant loads of the Jeddo Tunnel discharge; and
- Prevention of the sewage inflow into the Jeddo drainage system.

With the completion of the above-mentioned activities, the impact of the Jeddo Tunnel discharge on its receiving stream should be reduced dramatically. Monitoring of the quality and quantity of the Jeddo Tunnel discharge should be continued to document improvements.

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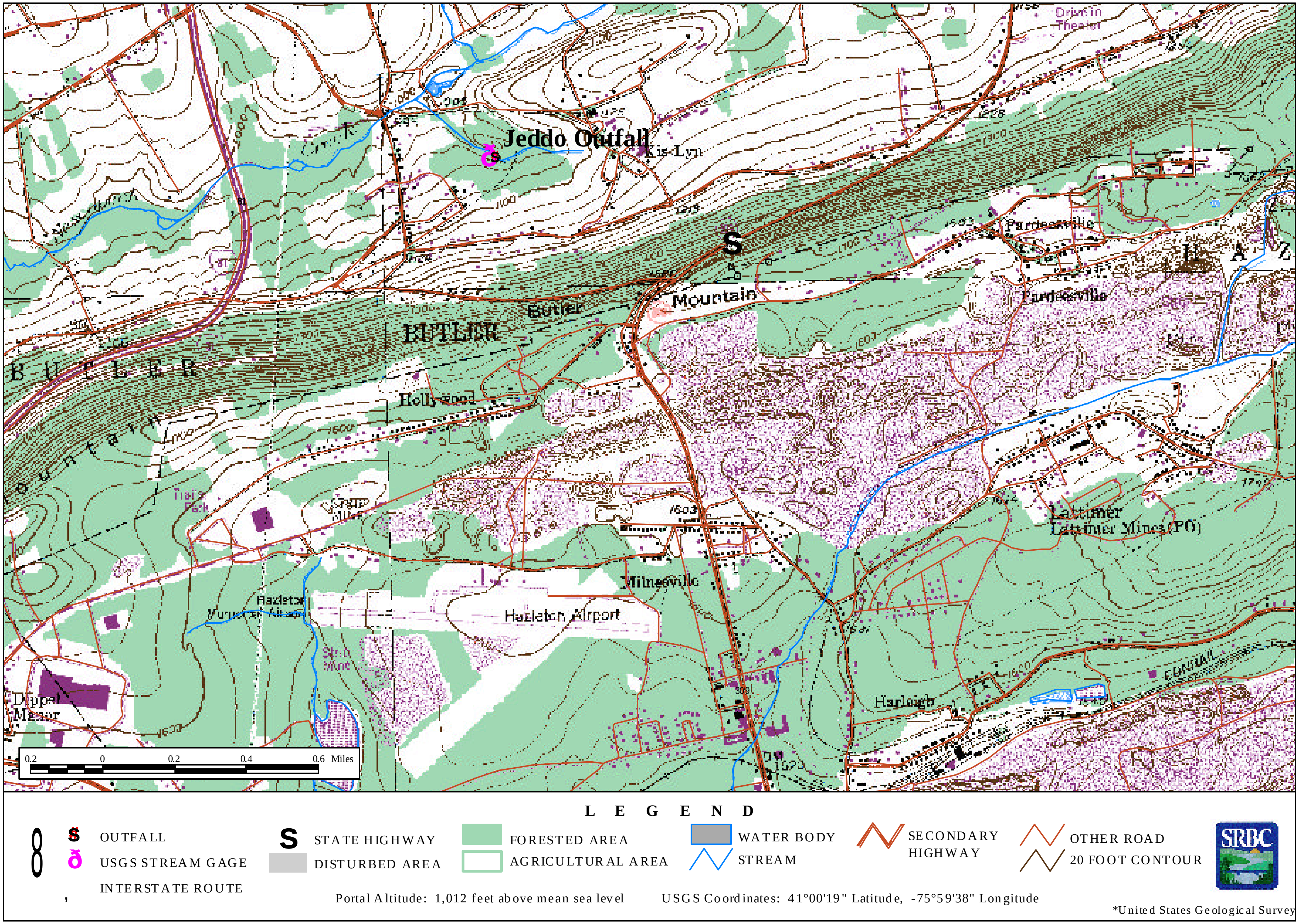
GLOSSARY OF ACRONYMS

Pa. DEP-BAMR	Pa. DEP, Bureau of Abandoned Mine Reclamation
Pa. DEP-Pottsville	Pa. Department of Environmental Protection, Pottsville District Office, District Mining Operations
SRBC	Susquehanna River Basin Commission
USGS	U.S. Geological Survey

APPENDIX A

DETAILS AND COLLIERY WATER QUALITY CHARACTERISTICS FOR SELECTED MINE DRAINAGE OUTFALLS IN THE EASTERN MIDDLE ANTRACITE FIELD

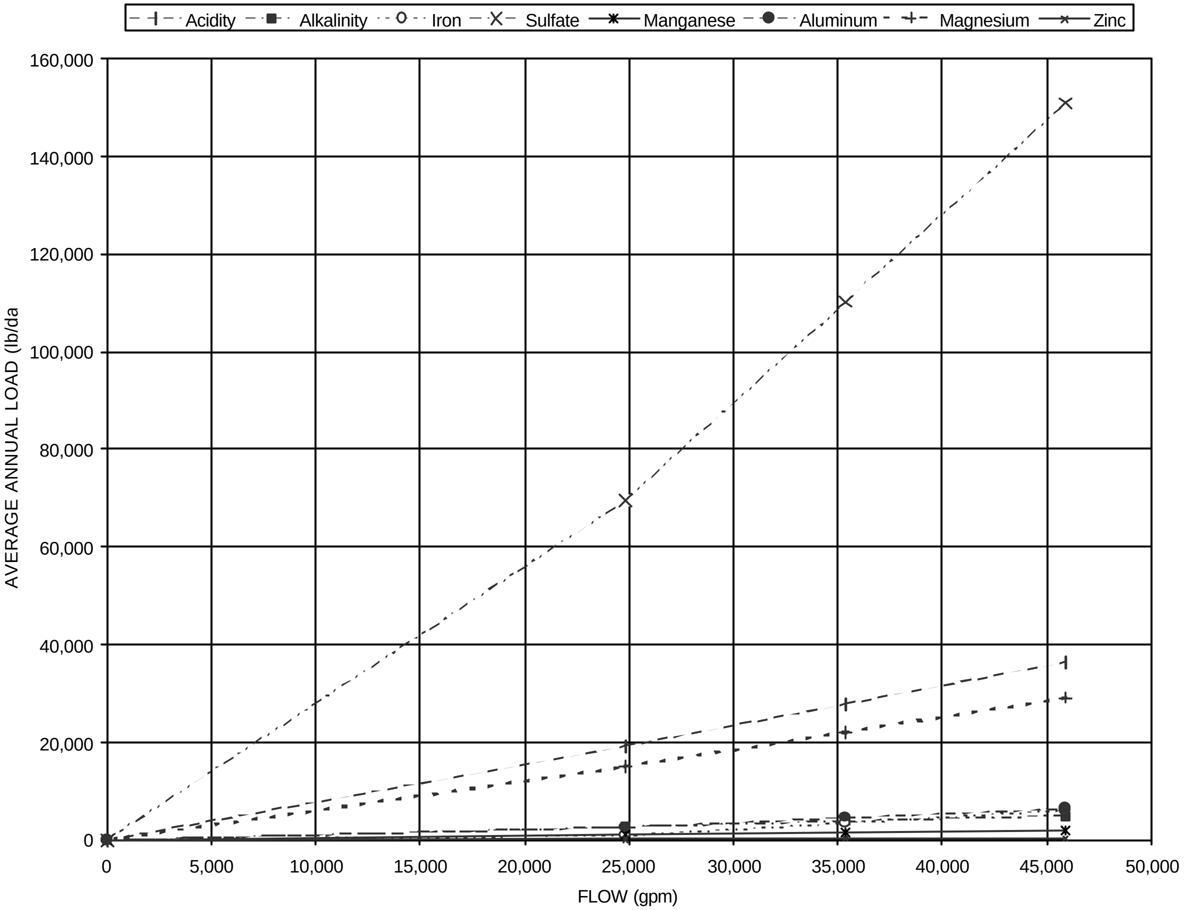
(adapted from Hollowell, 1999)



Portal Altitude: 1,012 feet above mean sea level USGS Coordinates: 41°00'19" Latitude, -75°59'38" Longitude

*United States Geological Survey

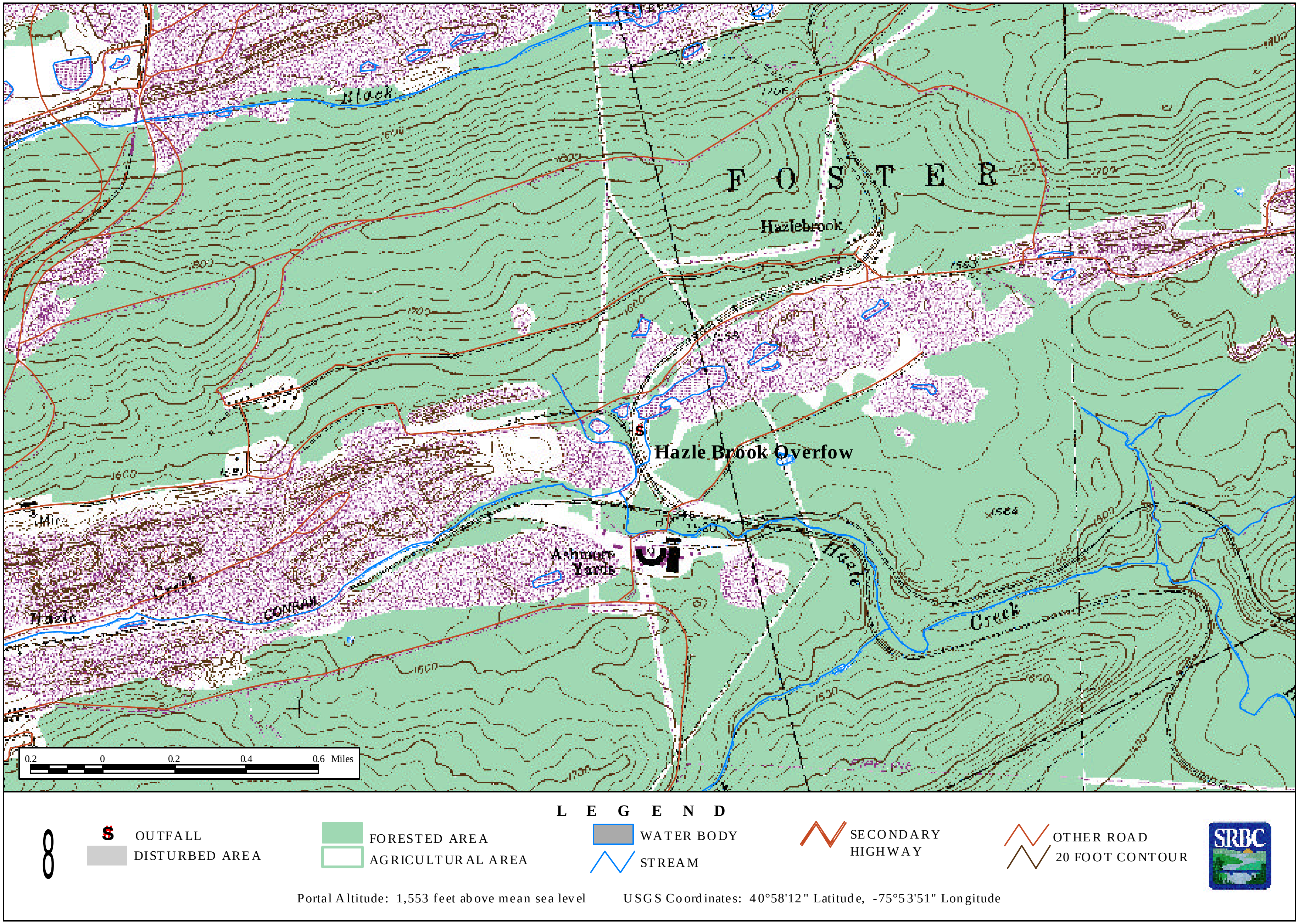
Figure A1. Jeddo Tunnel Outfall Location



AVERAGE ANNUAL CONCENTRATIONS (mg/l)

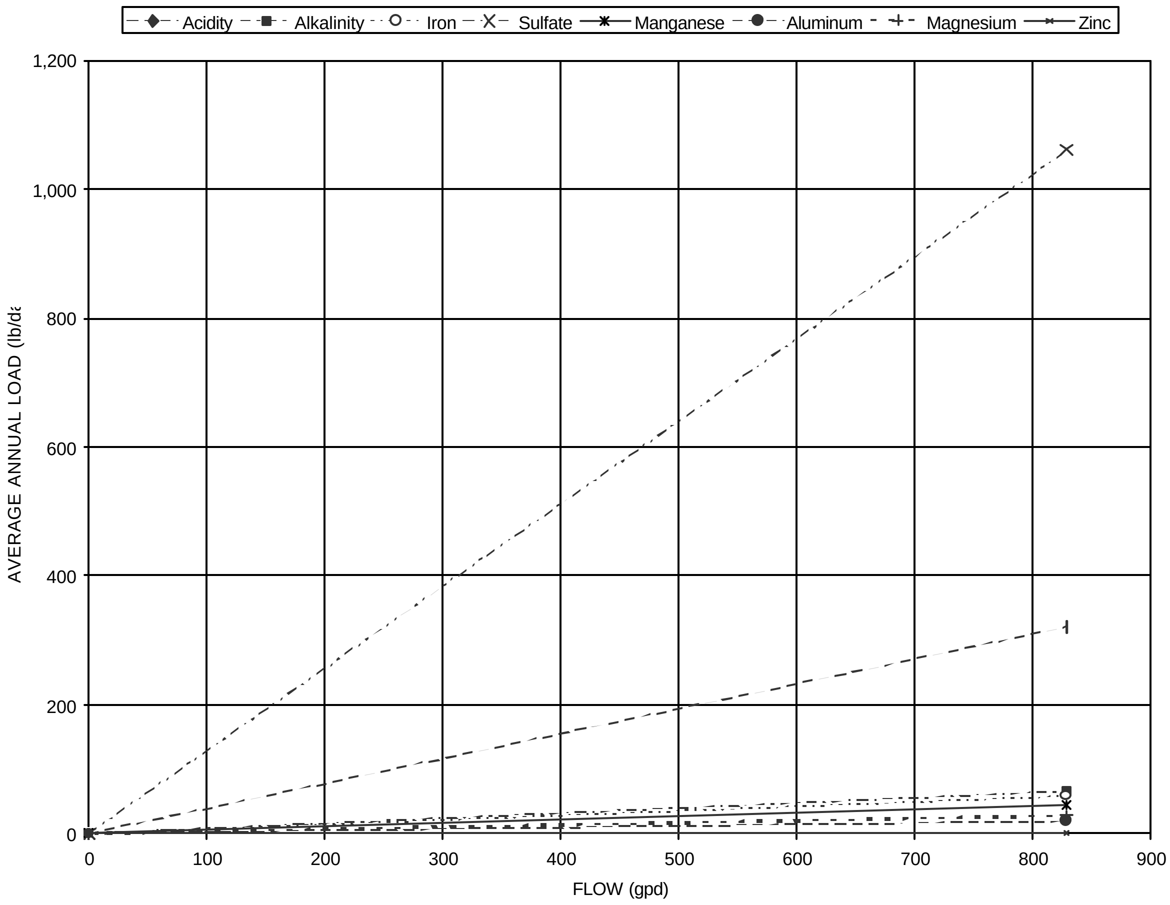
Year	Acidity	Alkalinity	Iron	Sulfate	Manganese	Aluminum	Magnesium	Zinc
1996	71.83	7.78	12.600	268.70	4.132	12.89	53.67	0.671
1997	71.86	8.25	3.560	248.00	4.333	9.74	55.44	0.663
1998	59.75	9.33	2.480	244.90	3.656	8.24	49.07	0.607

Figure A2. Jeddo Colliery Water Quality Characteristics



Portal Altitude: 1,553 feet above mean sea level USGS Coordinates: 40°58'12" Latitude, -75°53'51" Longitude

Figure A3. Hazle Brook Overflow Location



AVERAGE ANNUAL CONCENTRATIONS (mg/l)

Year	Acidity	Alkalinity	Iron	Sulfate	Manganese	Aluminum	Magnesium	Zinc
1996	NA	NA	NA	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA	NA	NA	NA
1998	29.00	6.43	5.46	88.00	0.453	1.77	2.57	0.091

Figure A4. ***Hazle Brook Colliery Water Quality Characteristics***

APPENDIX B

RESTORATION OPTIONS FOR THE REHABILITATION OF THE JEDDO MINE TUNNEL WATERSHED

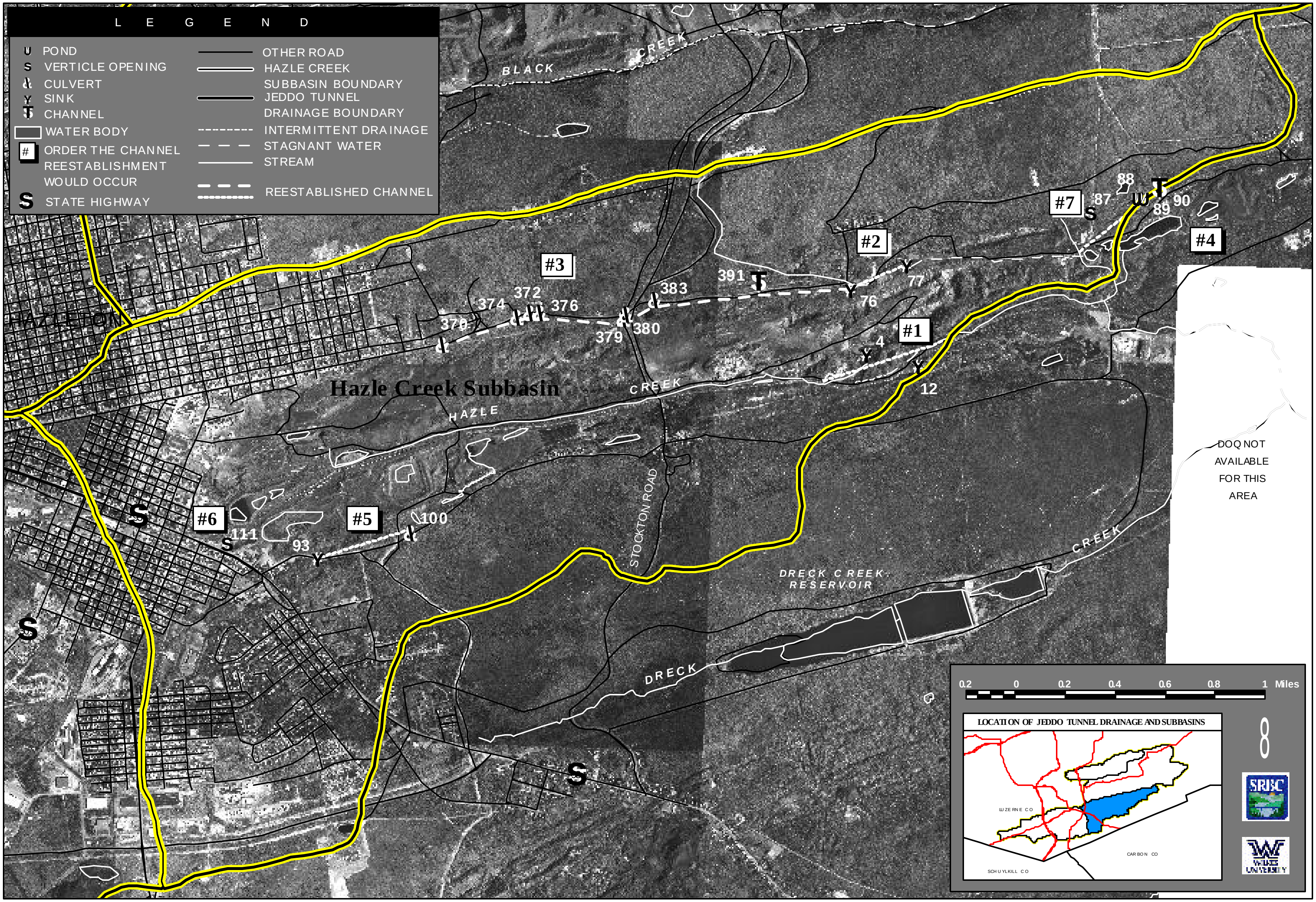


Figure B1. Digital Orthophotographs of Hazle Creek Subbasin

EASTERN HAZLETON COAL BASIN—HAZLE CREEK DRAINAGE

The eastern portion of the Hazleton Basin covers an area approximately 6.62 miles, which represents 21 percent of the current Jeddo Tunnel drainage area. This area has been extensively mined and there are several active permits within the basin. This area was originally drained by Hazle Creek, a tributary of the Lehigh River.

During the initial field investigation, several points of interest were identified within this basin that could potentially reduce the infiltration to the flooded mine workings, which is drained by the Jeddo Tunnel. This information was collected and analyzed to determine what and where restoration options should occur.

The restoration of Hazleton basin will require work at four sites in the perimeter drain system and four sites of sinks or other features that are contributing surface water into the Jeddo drainage system. Sites are listed in order of priority, based on impact to the system and on overall environmental benefit.

Location: Hazle Creek 0.6 miles east of Stockton Road
GPS ID Number: P-4
Coal Basin: Eastern Hazleton Coal Basin
Hydrologic Basin: Hazle Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 9A-5

Description of the Problem Area: The Hazle Creek channel has been interrupted by mining (see map) approximately 0.6 miles east of Stockton Road. All of the water transported by the creek is diverted into this location and enters the mine workings through the subsidence area identified in this study as GPS-4. This is most likely the largest of all problems within the drainage area of the Jeddo Tunnel. Although the drainage area of the sink is quite large, the majority of the drainage is mined, resulting in reduced stream flow to Hazle Creek. The majority of the water entering this sink is a direct result of runoff from the city of Hazleton.

Restoration Options: The reestablishment of the Hazle Creek channel would significantly reduce the inflow of water to the Jeddo Tunnel system. A new channel of approximately 2,650 feet in length would need to be constructed, and a large pit adjacent to the railroad tracks would have to be filled to effectively keep the water out of P-4. By constructing this channel with the proper lining and grade, the existing Hazle Creek channel would effectively transport water out of the Jeddo Tunnel Basin.

Restoration Limitations: This restoration option is limited primarily in the fact that Hazle Creek transports significant amounts of water impacted by a sewage overflow in the City of Hazleton. The sewage outflow (Show Map GPS #) entering into Hazle Creek, needs to be addressed before this channel can be restored and water can be put onto the surface. The cost of this restoration could be the most significant out of all of the restoration options, but the environmental gain also may be the most significant.

Next Step to Facilitate Restoration/Cost:

1. Determine the feasibility of removing the sewage impact from Hazle Creek;
2. Determine the amount of fill require to bring channel up to required grade; and
3. Determine the most effective way to line the new channel to reduce infiltration.

Location: North Perimeter Drain of Hazle Creek Basin
GPS ID Number: P-76 and P-77
Coal Basin: Eastern Hazleton Coal Basin
Hydrologic Basin: Hazle Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 9A-5

Description of the Problem Area: The perimeter drain on the north side of Hazleton basin is continuous and parallels the north side of Hazlebrook Road until the channel is taken under Hazlebrook road through a culvert. This culvert seems to be of recent construction, and the water exiting the culvert was deliberately designed to enter the sink found at point P-76. Overflow from this channel continues down L-3 Line–3 to where it enters the sink found at point P-77. The area just east of P-77 is the largest area in need of repair. It must be noted that the perimeter drain east of P-77 is not effectively draining the entirety of the area east of P-77 due to a mining pit on its northern side. A smaller secondary perimeter drain effectively takes drainage from the western side of this mining pit and flows westward into the primary perimeter drain. On the eastern side of this mining pit, a breech in the secondary perimeter drain allows the eastward flowing drainage to enter the mining pit.

Restoration Options: Construct a channel from P-76 1,318 feet to P-77. While overall topography should permit the reestablishment of a perimeter drain at this location, the area, including the sink at P-77, needs to be filled and graded. East of this location is the functioning perimeter drain. The drain is intact from this point eastward and flows into Hazle Creek at Ashmore Yards, and thus exits the Jeddo Tunnel Basin. Repairs made to the secondary perimeter drain east of P-77 would allow this perimeter drain to operate more effectively.

Restoration Limitations: The only limitation for this restoration project is the amount of material that would be needed to fill in and grade P-77.

Next Step to facilitate Restoration/Cost:

1. Determine the amount of fill require to bring P-77 up to required grade; and
2. Determine the most effective way to line the new channel to reduce infiltration.

Location:	North side of Hazle Creek Basin
GPS ID Number:	P-370 to P-383, P-391
Coal Basin:	Eastern Hazleton Coal Basin
Hydrologic Basin:	Hazle Creek
Quadrangle:	Hazleton
Municipality:	Hazle Township
Aerial Photo Number:	10A-7 & 9A-5

Description of the Problem Area: The perimeter drain that used to carry surface water to Hazle Creek needs to be reestablished. Currently, the water is just infiltrating into the mine workings.

Restoration Options: Reestablish of 3,955 feet of drainage channel from the border of Hazleton to Stockton Road. Then extend the perimeter drain east 4,928 feet (culvert under Stockton Road would be needed) along the north side of Hazle Creek Basin and connect it with the channel located at P-391, thus connecting it with the perimeter drain associated with P-76 and P-77.

Restoration Limitations: The restoration project would require significant reestablishment of perimeter drains. This project would need to be completed after the breach in the perimeter drain east of Stockton Road P-76 and P-77 was connected.

Next Step to Facilitate Restoration/Cost:

1. Determine the condition of existing perimeter drain west and east of Stockton Road; and
2. Determine the feasibility of constructing a perimeter drain along the north side of the Hazle Creek Basin.

Location: Hazle Creek north side of the Basin
GPS ID Number: P-88 to P-90
Coal Basin: Eastern Hazleton Coal Basin
Hydrologic Basin: Hazle Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 9A-5

Description of the Problem Area: The perimeter drain that used to carry surface water to Hazle Creek needs to be reestablished. Currently, the water is just infiltrating into the mine workings.

Restoration Options: Reestablish of 1,727 feet of drainage channel from the village of Hazlebrook westward along-side the railroad to the existing culvert under the railroad that connects to Hazle Creek at P-82. A culvert may be necessary to transport water across the road. Currently, the water washes out the road.

Restoration Limitations: None.

Next Step to Facilitate Restoration/Cost:

1. Determine the condition of existing perimeter drain.

Location: Channel south of the main Hazle Creek channel just East of Hazleton
GPS ID Number: P-93, P-25, P-101
Coal Basin: Eastern Hazleton Coal Basin
Hydrologic Basin: Hazle Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 10A-6

Description of the Problem Area: Surface water is entering the sink located at P-93. The hole, which is 4' X 3', allows surface water to enter into the mine workings. Overall, the contribution of this point to the Jeddo Tunnel system is quite small. The drainage area of this sink is confined to the immediate area adjacent to the strip pit. However, this is a headwaters area for Hazle Creek, so any channel reconstruction also should include this point.

Restoration Options: Fill in P-93 and reestablish 2,060 feet of channel, and connect it with an already existing channel that transports water at P-101. This channel currently transports water to the large pond located at P-25. This pond could be breached in the northeast corner and could be reconnected with the Hazle Creek channel immediately north of the pond.

Restoration Limitations: This restoration project would need to be completed after Hazle Creek channel was reestablished downstream at P-4.

Next Step to Facilitate Restoration/Cost:

1. Determine whether or not the pond could be breached, and if sufficient grade is present to bring the water into Hazle Creek.

Location: Western end of Hazle Creek Basin just east of Pa. Route 93
GPS ID Number: P-111
Coal Basin: Eastern Hazleton Coal Basin
Hydrologic Basin: Hazle Creek
Quadrangle: Hazleton
Municipality: Hazleton
Aerial Photo Number: 10A-6

Description of the Problem Area: P-111 is located in the western end of Hazle Creek Basin, just east of Pa. Route 93, behind the electrical supply building. Here a large opening exists, which is an immediate safety hazard due to its proximity to Hazleton. Drainage from the east is channeled down a cement flume and discharges into the large opening. Overall, the contribution of this point to the Jeddo Tunnel system is quite small. However, this area does constitute a safety hazard and is contributing some water to the Jeddo Mine system.

Restoration Options: Seal the opening and return the area to its original contour. Backfilling of the area will require a significant amount of material. However, this area poses a potential safety hazard, with its proximity to Hazleton.

Restoration Limitations: The only limitation for this restoration project is the amount of material that would be needed to fill in and grade P-111.

Next Step to Facilitate Restoration/Cost:

1. Determine the amount of fill required to bring P-111 up to required grade; and
2. Determine the most effective way to seal off the opening and reduce water from entering into the opening.

Location:	North side of Hazle Creek Basin 0.5 miles north of Ashmore Yards
GPS ID Number:	P-87
Coal Basin:	Eastern Hazleton Coal Basin
Hydrologic Basin:	Hazle Creek
Quadrangle:	Hazleton
Municipality:	Hazle Township
Aerial Photo Number:	9A-5

Description of the Problem Area: Surface water enters this sink, which is located on the power line just north of the perimeter drain on the north side of the Hazle Creek Basin. Overall, the contribution of this point to the Jeddo Tunnel system is quite small.

Restoration Options: Backfilling of the pit to its original contour should resolve the infiltration at this point. After the area is filled, the area should be reexamined to determine if the water is entering at any other point. The water, if possible, should be directed south along the power line approximately 1,000 feet and connected with the existing perimeter drain at P-88.

Restoration Limitations: The only limitation for this restoration project is the amount of material that would be needed to fill in and grade P-12. If restoration at this location is completed before the reestablishment of Hazle Creek, the water from this location should be directed into the existing perimeter drain east of P-4.

Next Step to Facilitate Restoration/Cost:

1. Determine the amount of fill required to bring P-87 up to required grade; and
2. Determine where the water will go after this area is filled in, and then take the appropriate steps to ensure that this water enters the perimeter drain on the north side of Hazle Creek Basin.

Location: Hazle Creek 0.7 from Stockton Road
GPS ID Number: P-12
Coal Basin: Eastern Hazleton Coal Basin
Hydrologic Basin: Hazle Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 9A-5

Description of the Problem Area: P-12 is located in the Hazleton basin, just south and east of point P-4. Surface water is entering this settling area and infiltrating into the mine workings, which is drained by the Jeddo Tunnel. Overall, the contribution of this point to the Jeddo Tunnel system is quite small. The drainage area of this sink is confined to the immediate area adjacent to the strip pit.

Restoration Options: Backfilling of the pit to its original contour should resolve the infiltration at this point. However, the water should be directed east of P-4 until the channel of Hazle Creek can be reestablished.

Restoration Limitations: The only limitation for this restoration project is the amount of material that would be needed to fill in and grade P-12. If restoration at this location is completed before the reestablishment of Hazle Creek, the water from this location should be directed into the existing perimeter drain east of P-4.

Next Step to Facilitate Restoration/Cost:

1. Determine the amount of fill required to bring P-12 up to required grade; and
2. Determine the most effective way to take runoff and direct it into the Hazle Creek channel east of P-4.

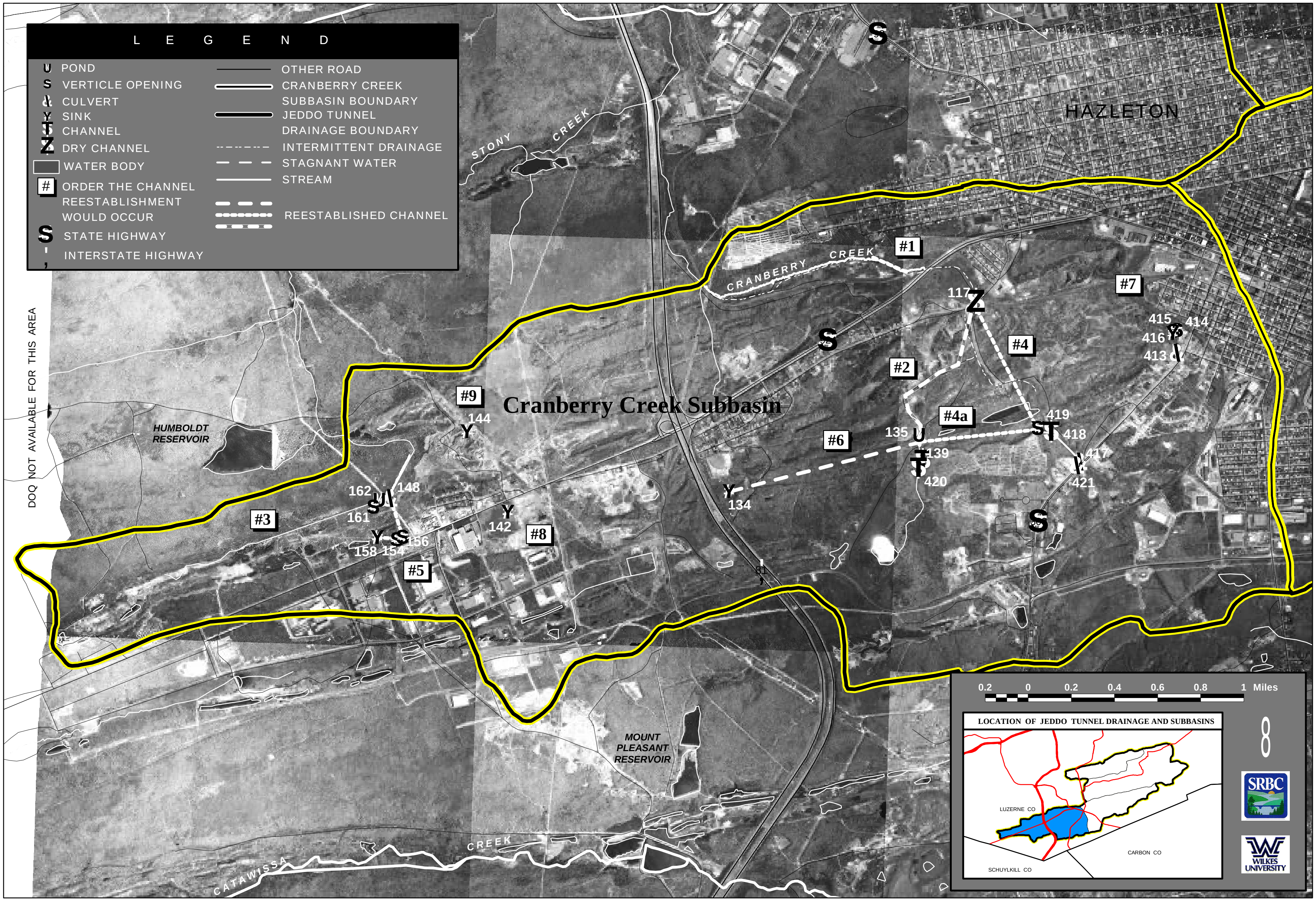


Figure B2. Digital Orthophotographs of Cranberry Creek Subbasin

WESTERN HAZLETON COAL BASIN— CRANBERRY CREEK DRAINAGE

The Western Hazleton Coal Basin covers an area approximately 8.53 square miles, which represents 26 percent of the current Jeddo Tunnel drainage area. This area has been extensively mined, and there are several active surface mining permits within the basin. This area was originally drained by Cranberry Creek, a tributary of Black Creek.

During the initial field investigation, several points of interest were identified within this basin that could potentially reduce the infiltration to the mine workings drained by the Jeddo Tunnel. This information was collected and analyzed to determine what and where restoration should occur.

The restoration of the Western Hazleton Coal Basin will require work at six sites in the perimeter drain system and three sites of sinks or other features that are contributing surface water into the Jeddo system. Sites are listed in order of priority based on impact to the system and on environmental benefit.

Location: Cranberry Creek downstream of Rte 924
GPS ID Number: P-122 and P-123
Coal Basin: Western Hazleton Coal Basin
Hydrologic Basin: Cranberry Creek
Quadrangle: Conyngham
Municipality: Hazle Township
Aerial Photo Number: 11A-6

Description of the Problem Area: The Cranberry Creek channel, immediately downstream of Pa. Route 924, is diverted into a large settling area at P-123. The drainage from Cranberry Creek is diverted into this area and ,subsequently, infiltrates to the mine workings.

Restoration Options: Reestablish channel from Pa. Route 924 to existing Cranberry Creek channel, approximately 944 feet. This would prohibit drainage from entering the sink at P-123 and allow the surface water to continue in the existing Cranberry Creek channel, and thus exit the basin. Some channel "cleaning out" may be necessary in the western portion of the channel as it approaches the railroad bridge.

Restoration Limitations: A new permit was issued for this area. We need to evaluate if this restoration project is part of the restoration goals under the new permit. Also, a restoration project proposal from Representative Todd Eachus to use the area east of Pa. Route 924, and eventually west of Pa. Route 924, needs to be evaluated and incorporated with the restoration options discussed in this report. Also, sewage from P-455 is entering Cranberry Creek channel and would need to be addressed before the surface water was allowed to enter into Cranberry Creek..

Next Step to Facilitate Restoration/Cost:

1. Determine if the new permit issued in this area will cover the restoration options identified here in this report; and
2. Make sure that the proposed development in this area contains sufficient drainage channels to carry the water into Cranberry Creek and out of the Jeddo Tunnel drainage basin.

Location: Headwaters of Cranberry Creek downstream of Grape Run Reservoir
GPS ID Number: P-420, P-135, P-136, P-138, P-139, P-137
Coal Basin: Western Hazleton Coal Basin
Hydrologic Basin: Cranberry Creek
Quadrangle: Conyngham
Municipality: Hazle Township
Aerial Photo Number: 11A-6

Description of the Problem Area: The channel from Grape Run Reservoir presently drops into a strip pit just northeast of the junkyard.

Restoration Options: Reestablish channel downstream of Grape Run Reservoir and fill in the sink at P-136, then construct a channel from P-137 to Cranberry Creek. The length of the restoration is 4,408 feet. This would prevent the water leaving Grape Run Reservoir from entering a sink at P-136 and connect this headwaters area with the rest of Cranberry Creek.

Restoration Limitations: The amount of material and construction of a channel from P-137 to P-117 will be significant. This project could only be completed after Cranberry Creek was reestablished at P-122. Also, the channel from P-117 to P-122 would need to be assessed to determine if it could handle the additional discharge. This area is between P-117 and P-122 and may be part of a restoration project proposal from Representative Todd Eachus to reclaim and use the area east of Pa. Route 924. Any work completed at this site needs to be evaluated and incorporated in with the restoration options discussed in this report.

Next Step to Facilitate Restoration/Cost:

1. Determine if the new permit issued in this area will cover the restoration options identified here in this report;
2. Make sure that the proposed development in this area will contain sufficient drainage channels to carry the water from Grape Run Reservoir to Cranberry Creek and out of the Jeddo Tunnel drainage basin; and
3. Determine the condition of the channel below this point at Grape Run Reservoir to ensure that it can handle the additional flow.

Location: Perimeter drain northwest side Western Hazleton Coal Basin near Humbolt
GPS ID Number: P-148, P-161 and P-162
Coal Basin: Western Hazleton Coal Basin
Hydrologic Basin: Cranberry Creek
Quadrangle: Conyngham
Municipality: Hazle Township
Aerial Photo Number: 13A-5

Description of the Problem Area: The existing perimeter drain runs on the north side of the Western Hazleton Coal Basin from P-148 westward approximately 5,495 feet. This channel is intact and transports water until it gets to P-162. At this point, inadequate culverts were installed, and the water entered into sinks at P-456 and P-161.

Restoration Options: Repair and extend the existing coal basin perimeter drain channel west of the village of Humbolt. This channel diverts the drainage from the western-most part of the Hazleton Coal Basin to Stony Creek, east of the Humbolt Reservoir. Construct approximately 43 feet of channel and culvert under the Humbolt Reservoir Road to carry water to the east side of the road, and allow the water to continue in the existing perimeter drain and effectively out of the Jeddo basin.

Restoration Limitations: This project was completed.

Next Step to Facilitate Restoration/Cost:

1. Determine the most effective way to line the new channel to reduce infiltration; and
2. Determine the condition of the channel below this point to determine if the channel can handle the additional flow.

Location: West of Pa. Route 309 and east of junkyard
GPS ID Number: P-419, P-418, P-421 and P-417
Coal Basin: Western Hazleton Coal Basin
Hydrologic Basin: Cranberry Creek
Quadrangle: Hazleton
Municipality: Hazleton
Aerial Photo Number: 11A-6

Description of the Problem Area: Drainage from Pa. Route 309 at P-417 flows in a channel and is directed towards a sink located at P-419 and infiltrated into the mine workings.

Restoration Options: Fill in the sink at P-419 and construct a channel from this point westward 2,856 feet to P-136, or construct a channel from P-419 3,520 feet to P-117. Either of these two restoration options would allow this water to exit the Jeddo basin. The option with the best grade or least cost should be completed.

Restoration Limitations: Either channel constructed would require considerable earthmoving. Further investigation is needed to determine which restoration option is best for this area. This project could not be completed until the other restoration projects located downstream would be completed.

Next Step to Facilitate Restoration/Cost:

1. Additional field investigation is needed to determine which of the above restoration options is feasible; and
2. The cost of the project should be considered before construction, due to the limited amount of water that would be diverted from this project.

Location: Cranberry Creek north of 924 near Humbolt
GPS ID Number: P-148, P-158, P-154, and P-156
Coal Basin: Western Hazleton Coal Basin
Hydrologic Basin: Cranberry Creek
Quadrangle: Conyngham
Municipality: Hazle Township
Aerial Photo Number: 13A-5

Description of the Problem Area: Pa. Route 924 enters three sinks at P-158, P-154, and P-156. The runoff that is directed from Pa. Route 924 is diverted to these sinks and infiltrates to the mine workings.

Restoration Options: Fill in the sinks at P-154, P-158, and P-156 and construct a drain along the north side of Pa. Route 924. Construct a new channel 1,606 feet from P-156 to P-148, and connect it with the existing perimeter drain on the north side of the basin.

Restoration Limitations: This channel would prevent flow from Pa. Route 924 from entering the sinks. However, further investigation is needed to ensure that sufficient grade is present to promote positive drainage.

Next Step to Facilitate Restoration/Cost:

1. Determine whether or not this restoration option is feasible.

Location: Cranberry Creek southeast of I-81 and Pa. Route 924 interchange
GPS ID Number: P-135, P-134 and P-137
Coal Basin: Western Hazleton Coal Basin
Hydrologic Basin: Cranberry Creek
Quadrangle: Conyngham
Municipality: Hazle Township
Aerial Photo Number: 12A-7 and 11A-6

Description of the Problem Area: Drainage from P-132 and surrounding area and ponds drains into a sink located at P-134.

Restoration Options: Fill in the sink at P-134, reestablish a drainage channel from this point eastward 4,845 feet, and connect the channel at P-137.

Restoration Limitations: This channel would flow eastward for approximately 4,845 feet. Further field investigation is needed to determine if this restoration option would adequately transport the water from P-134 to P-137

Next Step to Facilitate Restoration/Cost:

1. Determine the most effective way to line the new channel to reduce infiltration;
2. Determine the condition of the channel east of P-134 to ensure that the channel can handle the additional flow; and
3. Determine whether or not this restoration option is feasible.

Location: Southwest portion of Hazleton just off of Pa. Route 309 (Beltway Diner)
GPS ID Number: P-413, P-414, P-415 and P-416
Coal Basin: Western Hazleton Coal Basin
Hydrologic Basin: Cranberry Creek
Quadrangle: Hazleton
Municipality: Hazleton
Aerial Photo Number: 11A-6

Description of the Problem Area: Drainage from Pa. Route 309 and surrounding area is channeled into a large sink at P-414 and secondary sinks at P-415 and P-416. This water enters into the mine workings from these locations.

Restoration Options: Fill in the sinks at P-414, P-415, and P-416. After the sinks are filled, further investigation is required to determine if the water will enter at another point or if a channel can be constructed to convey the water into Cranberry Creek.

Restoration Limitations: This restoration project is limited because of the options available to construct adequate means to convey the water out of the basin. Further investigation will be required to determine the best remediation strategy for this location.

Next Step to Facilitate Restoration/Cost:

1. Determine whether or not this restoration option is feasible; and
2. Determine where the water will go after these sinks are filled in.

Location: Pa. Route 924 Near Humbolt
GPS ID Number: P-142
Coal Basin: Western Hazleton Coal Basin
Hydrologic Basin: Cranberry Creek
Quadrangle: Conyngham
Municipality: Hazle Township
Aerial Photo Number: 13A-5

Description of the Problem Area: An open mineshaft exists at P-142, just off Pa. Route 924. Overall, the contribution of this point to the Jeddo Tunnel system is quite small. However, this site does pose a safety concern.

Restoration Options: Seal the open mineshaft.

Restoration Limitations: None.

Next Step to Facilitate Restoration/Cost:

1. Determine if this project is listed in BAMR's inventory of health and safety concerns; and
2. Determine the ownership of the mineshaft.

Location:	North Pa. Route 924 near Humbolt
GPS ID Number:	P-144
Coal Basin:	Western Hazleton Coal Basin
Hydrologic Basin:	Cranberry Creek
Quadrangle:	Conyngham
Municipality:	Hazle Township
Aerial Photo Number:	13A-5

Description of the Problem Area: A vertical opening exists at P-144. Overall, the contribution of this point to the Jeddo Tunnel system is quite small. However, this site does pose a safety concern.

Restoration Options: Seal the vertical opening.

Restoration Limitations: None.

Next Step to Facilitate Restoration/Cost:

1. Determine if this project is listed in BAMR's inventory of health and safety concerns.

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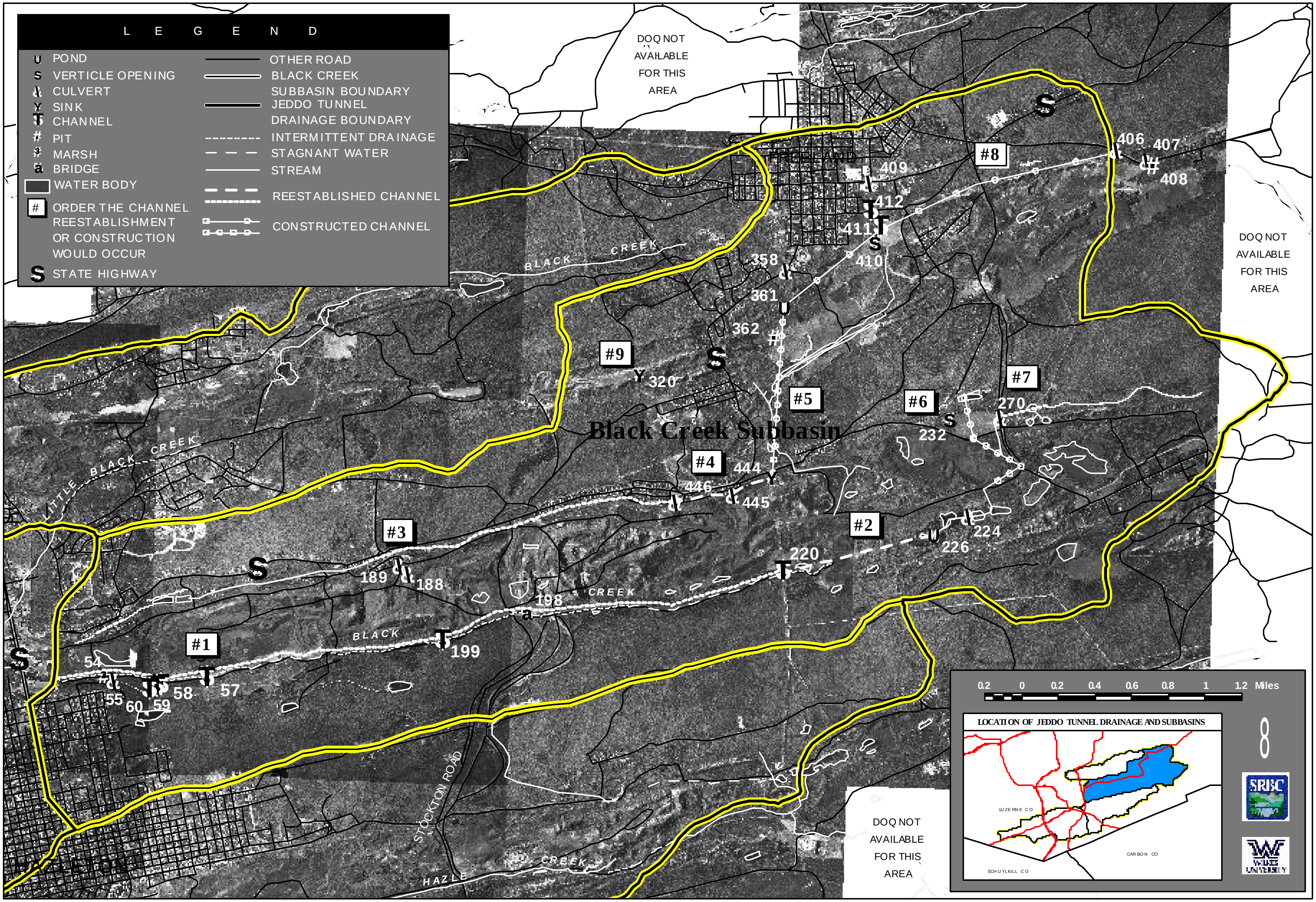

Figure B3. Digital Orthophotographs of Black Creek Subbasin

BLACK CREEK COAL BASIN—
BLACK CREEK DRAINAGE

The Black Creek Coal Basin covers an area 12.45 square miles, which represents 39 percent of the current Jeddo Tunnel drainage area.. The coal basin has been extensively mined and there are several active surface mining permits within the basin. The area was originally drained by Black Creek, a tributary of Nescopeck Creek.

During the initial field investigation, several points of interest were identified within the basin that could potentially reduce the infiltration to the mine workings drained by the Jeddo Tunnel. This information was collected and analyzed to determine what and where restoration should occur. A majority of the infiltration points in this basin are associated directly with the Black Creek channel itself.

The restoration of the Black Creek Coal Basin will require work at seven site in the perimeter drain system and two sites of sinks or other features that are contributing surface water into the Jeddo Tunnel system. Sites are listed in order of priority, based on impact to the system and on environmental benefit.

Location: Black Creek from 940 eastward to 1.25 miles east of Stockton Road
GPS ID Number: P-54, P-55, P-53, P-61, P-60, P-58, P-59, P-57, P-206, P-207, P-204, P-203, P-209, P-201, P-200, P-199, P-198
Coal Basin: Black Creek Coal Basin
Hydrologic Basin: Black Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 10A-8 & 9A-7

Description of the Problem Area: Black Creek is blocked up in certain locations, and does not allow for positive drainage. The area of concern extends from Pa. Route 940 eastward to approximately 1.25 miles east of Stockton Road.

Restoration Options: Repair and take out the existing blockages, and line the existing Black Creek stream channel to promote positive drainage out of the basin.

Restoration Limitations: Any project associated with increasing the discharge in the Black Creek channel needs to look at the impacts of the restricted channel as Black Creek flows under the mall between Pa. Routes 940 and 309.

Next Step to Facilitate Restoration/Cost:

1. Determine the most effective way to line the new channel to reduce infiltration;
2. Determine the impact of increased discharge on the channel restriction located at the mall; and
3. Determine the location and extent of each blockage in the Black Creek channel.

Location: Black Creek from power line eastward the railroad
GPS ID Number: P-224, P-226, P-220
Coal Basin: Black Creek Coal Basin
Hydrologic Basin: Black Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 8A-6

Description of the Problem Area: The Black Creek channel exists in this area, but is discontinuous. We need to reconnect the segments of Black Creek channel between several ponds that exist between the railroad tracks and the power line to the west.

Restoration Options: Reestablish the Black Creek drainage channel from the power line P-220 4,506 feet eastward to P-226, which is the outlet from the last ponds. These ponds are connected with existing channels all the way west under the railroad embankment to P-222. A settling pond will be necessary to capture the fine-grained coal waste presently being transported from upstream of the railroad embankment. Also, it is believed that water is entering the mine workings from under the railroad culvert. This culvert should be relined to ensure positive drainage.

Restoration Limitations: Any project associated with increasing the discharge in the Black Creek channel needs to look at the impacts of the restricted channel as Black Creek flows under the mall between Pa. Routes 940 309.

Next Step to Facilitate Restoration/Cost:

1. Determine the most effective way to line the new channel to reduce infiltration; and
2. Determine the impact of increased discharge on the channel restriction located at the mall.

Location: North side of Black Creek Coal Basin Ebervale to Pa. Route 940 bridge
GPS ID Number: P-188, P-189, 2P-13-outlet from ponds
Coal Basin: Black Creek Coal Basin
Hydrologic Basin: Black Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 10A-8

Description of the Problem Area: The Black Creek channel exists in this area but is discontinuous and does not transport water out of the basin.

Restoration Options: Reestablish a perimeter drain along the north side of the coal basin from the point just east of the Pa. Route 940 bridge where a channel does exist—946 feet to the existing perimeter drain.

Restoration Limitations: Any project associated with increasing the discharge in the Black Creek channel needs to look at the impacts of the restricted channel as Black Creek flows under the mall between Pa. Routes 940 and 309. An alternate option is to take the water north of the mall and run it through an existing wetlands, pipe it under the used car lot between Pa. Routes 940 309, and have it enter Black Creek below the mall, thus avoiding the restricted channel at the mall.

Next Step to Facilitate Restoration/Cost:

1. Determine the most effective way to line the new channel to reduce infiltration;
2. Determine the impact of increased discharge on the channel restriction located at the mall if the alternate option is not feasible; and
3. Determine the impact of increased discharge from the development north of Pa. Route 940 on the existing perimeter drain.

Location: North side of Black Creek Coal Basin near Ebervale
GPS ID Number: P-444, P-136, P-445, P-446, P-451
Coal Basin: Black Creek Coal Basin
Hydrologic Basin: Black Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 9A-7

Description of the Problem Area: The lack of an effectively-working perimeter drain immediately south of Ebervale has allowed surface water to enter the mine workings at several locations. The first of these is P-444 and then at multiple points extending westward along the south side of Ebervale.

Restoration Options: Establish a perimeter drain along the north side of the coal basin from P-444, near Jeddo, westward to Oakdale, a total of 17,448 feet. This perimeter drain needs to be extended westward to LP3's office and connect with the existing perimeter drain from that location westward and out of the basin.

Restoration Limitations: Any project associated with increasing the discharge in the Black Creek channel needs to look at the impacts of the restricted channel as Black Creek flows under the mall between Pa. Routes 940 and 309. This restoration option could require significant amounts of fill in order to reestablish this perimeter drain.

Next Step to Facilitate Restoration/Cost:

1. Determine the most effective way to line the new channel to reduce infiltration;
2. Determine the impact of increased discharge on the channel restriction located at the mall; and
3. Determine the scale of this project, because it may require significant amounts of fill to reestablish the perimeter drain.

Location: Cross Creek Coal Basin near Freeland
GPS ID Number: P-358 (sewage point discharge), P-361 (large sink with sewage), and P-362 (secondary sink below P-361)
Coal Basin: Black Creek Coal Basin
Hydrologic Basin: Black Creek
Quadrangle: Freeland
Municipality: Foster Township
Aerial Photo Number: 9A-7 & 9A-8

Description of the Problem Area: Surface-water runoff and sewage from the Borough of Freeland enters two sinks, P-361 and P-362, and the water infiltrates into the mine workings.

Restoration Options: Construct a perimeter channel along the north side of the Cross Creek Coal Basin from the south edge of Freeland. Fill in the sinks at P-361 and P-362 and construct a channel approximately 4,915 feet from P-362 southward along Pa. Route 940, and connect it with the perimeter drain that will need to be constructed at P-444.

Restoration Limitations: Any project associated with increasing the discharge in the Black Creek channel needs to look at the impacts of the restricted channel as Black Creek flows under the mall between Pa. Routes 940 and 309. The water entering these two sinks contains significant amounts of sewage. This issue would have to be addressed before this water was allowed to remain on the surface. The channel restoration at P-444 and the perimeter drain running westward from this point would have to be constructed first.

Next Step to Facilitate Restoration/Cost:

1. Determine if the sewage upgrades planned for this area will incorporate the problem areas identified during our initial field investigation;
2. Determine the feasibility of constructing this new channel;
3. Determine the most effective way to line the new channel to reduce infiltration; and
4. Determine the impact of increased discharge on the channel restriction located at the mall.

Location: North side of Black Creek Coal Basin West of Jeddo
GPS ID Number: P-232
Coal Basin: Black Creek Coal Basin
Hydrologic Basin: Black Creek
Quadrangle: Hazleton
Municipality: Hazle Township
Aerial Photo Number: 8A-6

Description of the Problem Area: P-232 is a sink where water is entering the mine workings. The area has a concrete foundation and is possibly an old shaft of some other structure associated with past mining activity. Water from an upstream pond and the surrounding wooded area enters this point and infiltrates to the mine workings.

Restoration Options: Construct a channel from P-232 approximately 1,232 feet to P-265, where a channel does exist. The channel runs southward along the road for a distance of 1,576 feet. A new channel then would need to be constructed from P-263 westward for approximately 1,162 feet and connect with the existing channel at P-222.

Restoration Limitations: Any project associated with increasing the discharge in the Black Creek channel needs to look at the impacts of the restricted channel as Black Creek flows under the mall between Pa. Routes 940 and 309. This project would have to be completed after the channel from P-226 to P-220 was constructed. Further investigation may be required to ensure the success of this restoration project.

Next Step to Facilitate Restoration/Cost:

1. Determine the feasibility of constructing this new channel;
2. Determine the most effective way to line the new channel to reduce infiltration;
3. Determine if the amount of water entering the point at P-232 warrants this extensive restoration project; and
4. Determine the impact of increased discharge on the channel restriction located at the mall.

Location: Northeast corner of Black Creek Coal Basin
GPS ID Number: P-245, P-270, and L97-6
Coal Basin: Black Creek Coal Basin
Hydrologic Basin: Black Creek
Quadrangle: Hazleton
Municipality: Foster Township
Aerial Photo Number: 8A-6

Description of the Problem Area: Surface water from the surrounding area and wetlands flows down the power line and enters a large sink at P-245.

Restoration Options: A perimeter drain exists directly to the east of the area, where the water is leaving the wetlands and crossing onto the power line. This existing perimeter drain could be extended westward approximately 1,439 feet to P-270. This perimeter drain would capture drainage from the wetland area and transport it to P-270, which is connected by existing channels to P-265.

Restoration Limitations: Any project associated with increasing the discharge in the Black Creek channel needs to look at the impacts of the restricted channel as Black Creek flows under the mall between Pa. Routes 940 and 309. This project would have to be completed after the channels from P-226 to P-220 and from P-265 to P-222 are constructed. This restoration option also would require the movement of a large culm pile directly west of the wetlands and in direct line of the proposed channel. Further investigation may be required to ensure the success of this restoration project.

Next Step to Facilitate Restoration/Cost:

1. Determine the feasibility of constructing this new channel;
2. Determine the most effective way to line the new channel to reduce infiltration; and
3. Determine the impact of increased discharge on the channel restriction located at the mall.

Location: Cross Creek Coal basin near Freeland
GPS ID Number: P-406 through P-412
Coal Basin: Cross Creek Coal Basin
Hydrologic Basin: Black Creek
Quadrangle: Freeland
Municipality: Foster Township
Aerial Photo Number: 8A-8 & 9A-8

Description of the Problem Area: The absence of an effectively-working perimeter drain in this area southeast of Freeland has allowed several areas where surface water is entering the mine workings to occur.

Restoration Options: Construct a perimeter channel along the north side of the Cross Creek Coal Basin from P-406 westward approximately 10,807 feet to the south edge of Freeland. This channel then could be extended westward and connect with the perimeter drain proposed from P-362. This drain also would catch drainage, which is currently entering a sink at P-410.

Restoration Limitations: Any project associated with increasing the discharge in the Black Creek channel needs to look at the impacts of the restricted channel as Black Creek flows under the mall between Pa. Routes 940 and 309. This project would have to be completed after the channel from P-362 was constructed, the channel at P-444 was restored, and the perimeter drain running westward from this point was constructed. This project will require significant amounts of fill material and channel construction. Further investigation may be required to ensure the success of this restoration project.

Next Step to Facilitate Restoration/Cost:

1. Determine the feasibility of constructing this new channel;
2. Determine the most effective way to line the new channel to reduce infiltration; and
3. Determine the impact of increased discharge on the channel restriction located at the mall.

Location: Black Creek Coal Basin southwest of Freeland
GPS ID Number: P-320
Coal Basin: Black Creek Coal Basin
Hydrologic Basin: Black Creek
Quadrangle: Hazleton/Freeland
Municipality: Hazle Township
Aerial Photo Number: 9A-8

Description of the Problem Area: Surface water is entering this sink that is located in a small mined area southwest of Freeland. Overall the contribution of this point to the Jeddo Tunnel system is quite small.

Restoration Options: Backfilling of the pit to its original contour should resolve the infiltration at this point. After the area is filled, the area should be reexamined to determine if the water is entering at any other point.

Restoration Limitations: The only limitation for this restoration project is the amount of material that would be needed to fill in and grade P-320.

Next Step to Facilitate Restoration/Cost:

1. Determine the amount of fill required to bring P-320 up to required grade;
2. Determine if the cost of the project is worth the small environmental gain expected from the project; and
3. Determine where the water will go after this area is reclaimed.

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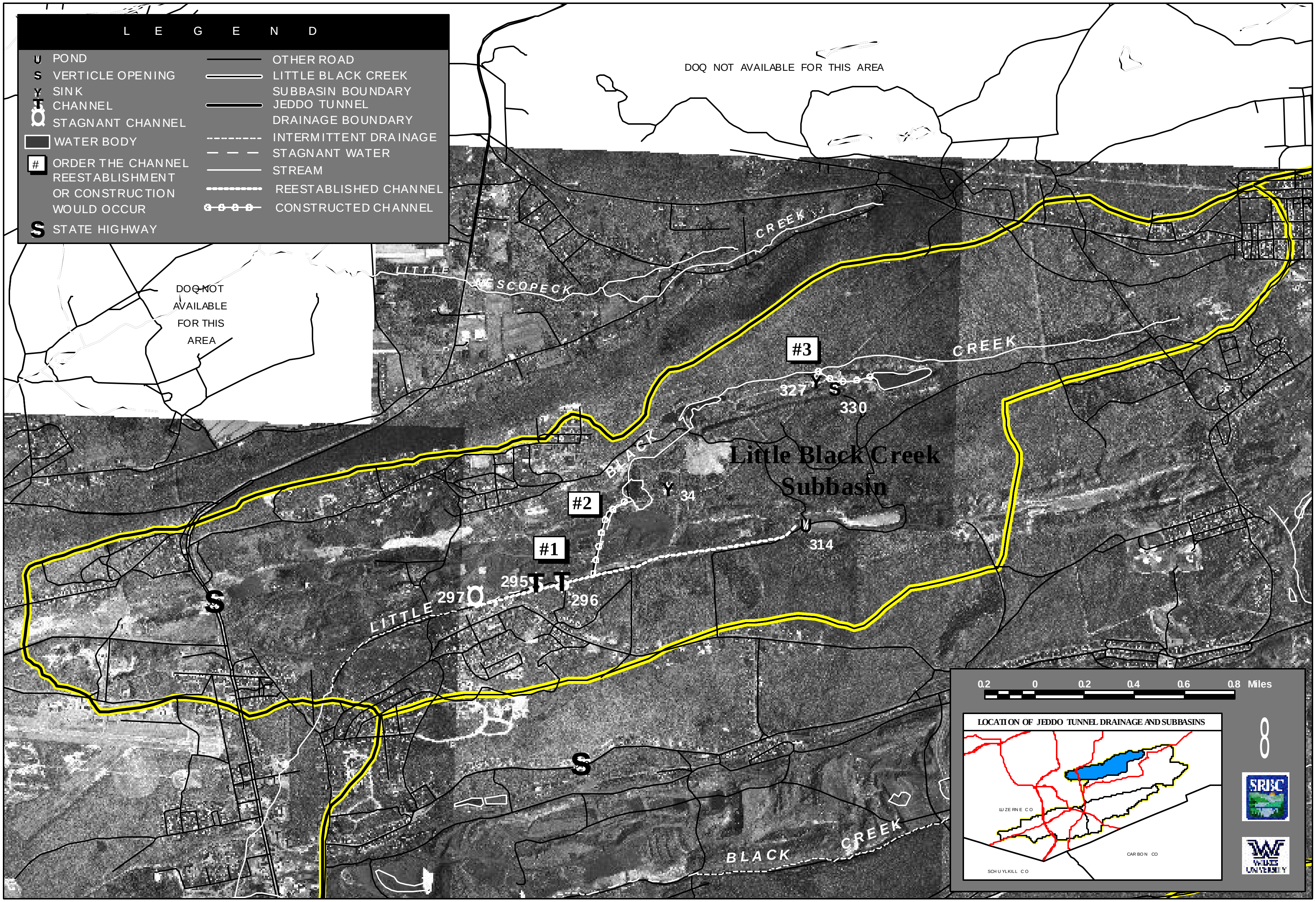

Figure B4. Digital Orthophotographs of Little Black Creek Subbasin

LITTLE BLACK CREEK COAL BASIN— LITTLE BLACK CREEK DRAINAGE

The Little Black Coal Basin covers an area of 4.64 square miles, which represents 14 percent of the current Jeddo Tunnel drainage area.. This coal basin has been extensively mined, and there are several active surface mining permits within the basin. The area was originally drained by Little Black Creek, a tributary of Nescopeck Creek.

During the initial field investigation, several points of interest were identified within this basin that could potentially reduce the infiltration to the mine workings drained by the Jeddo Tunnel. This information was collected and analyzed to determine what and where restoration options should occur. A majority of the infiltration points in this basin are associated directly with the Little Black Creek channel itself.

The restoration of the Little Black Creek Coal Basin will require work at three sites in the perimeter drain system. Sites are listed in order of priority, based on impact to the system and on environmental benefit.

Location:	Little Black Creek Coal Basin near Lattimer
GPS ID Number:	P-294, P-296, P-295, P-297
Coal Basin:	Little Black Creek Coal Basin
Hydrologic Basin:	Little Black Creek
Quadrangle:	Hazleton
Municipality:	Hazle Township
Aerial Photo Number:	10A-8

Description of the Problem Area: The perimeter drain along the southern edge of Little Black Creek Coal Basin contains several blockages and currently cannot transport water. A major channel block exists at P-297. At this point, the water would have to be piped under the existing parking lot, in order for the channel to extend to P-298, where the channel is intact and does transport water.

Restoration Options: Remove blockages from the existing perimeter drain channel on the south side of the basin in the Lattimer area. The area where the blockages occur is about 7,054 feet in length. There are roughly five or six blockages in the channel before you get to point P-297, where a major channel block exists. At this point, the water would have to be piped under the existing parking lot, in order for the channel to extend to P-298, where the channel is intact and does transport water. This channel will be extended eastward to drain the ponds at P-314 at the headwaters of Little Black Creek. Some backfilling of pits may be necessary to construct the channel from P-314 westward to the existing channel.

Restoration Limitations: Point P-297 is a potential area of concern. The existing channel has been filled, and a parking lot has been built over the existing channel. If this section on the channel cannot be restored, the water will not effectively leave the basin, and any work completed to remove the blockages upstream will not transport water out of the basin. The amount of fill material that may be necessary to connect the ponds at P-314 to the existing perimeter drain may be significant. This project can only be completed after the blockages are removed from the perimeter drain. Condition of old Little Black Creek channel from Pa. Routes 940 to 309 would have to be checked and constrictions removed.

Next Step to Facilitate Restoration/Cost:

1. Determine the most effective way to line the new channel to reduce infiltration;
2. Determine if the section of channel at P-298 can be passed before any blockages are removed;
3. Determine if the large ponds to the east of the channel can be connected once the blockages from the channel are removed; and
4. Determine the condition of old Little Black Creek channel from Pa. Route 940 to Pa. Route 309 and remove any constrictions.

Location: Woodside Coal Basin east of Pardeesville
GPS ID Number: P-34
Coal Basin: Woodside Coal Basin
Hydrologic Basin: Little Black Creek
Quadrangle: Freeland
Municipality: Hazle Township/Butler Township
Aerial Photo Number: 10A-8

Description of the Problem Area: Drainage from the Woodside Coal Basin passes through several large ponds and is diverted into a large sink located at P-34.

Restoration Options: A diversion channel would be necessary, going westward along the south edge of Pardeesville and then turning southward 1,822 feet across the Little Black Creek Coal Basin to the west end of Lattimer. At that point, a new channel would connect with the existing perimeter channel. This would require considerable backfilling of the existing pit, but there are two large waste banks on either side of the pit that could be directly pushed into the pit. (It would require a lot of material to cross Little Black Creek Coal Basin, but initial field investigation shows that enough grade would exist in the channel to create positive flow.)

Restoration limitations: This project would require considerable earthmoving to cross the existing Little Black Creek Coal Basin. This project also would be dependent on the reconnection and blockage removal of the Little Black Creek channel.

Next Step to Facilitate Restoration/Cost:

1. Determine the most effective way to line the new channel to reduce infiltration; and
2. Determine the feasibility of constructing a channel across the Little Black Creek Basin.

Location: Woodside Coal Basin east of Pardeesville
GPS ID Number: P-327, P-330
Coal Basin: Woodside Coal Basin
Hydrologic Basin: Little Black Creek
Quadrangle: Freeland
Municipality: Hazle Township/Butler Township
Aerial Photo Number: 9A-8

Description of the Problem Area: Drainage from a pond at the headwater of the Woodside Coal Basin is partially diverted into two large sinks, P-327 and P-330.

Restoration Options: Fill in the two areas of infiltration and establish a channel from this area 1,181 feet to the existing channel that transports water from the pond at P-324 to the pond at P-331.

Restoration Limitations: This project would need to be completed after the drainage from Woodside basin has been successfully transported across the Little Black Creek Coal Basin.

Next Step to Facilitate Restoration/Cost:

1. Determine the most effective way to line the new channel to reduce infiltration; and
2. Determine the feasibility of filling in and diverting the water from P-327 and P-330.

APPENDIX C

JEDDO TUNNEL OUTFALL WATER CHEMISTRY DATA

Table C1. Jeddo Tunnel Outfall Water Quality Data (Monthly, 1978-90, 1995-98)

Sample Date	pH	Sulfate	Iron, Total	Iron, Ferrous	Manganese, Total	Aluminum, Total	Acidity, Total HOT
		mg/l					
May-78	3.6	311	5.7	2.2			190
Jun-78	3.61	203	2.4	1.1			189
Jul-78	3.55	467	6.2	6			176
Aug-78	3.45	474	8.2	8			187
Sep-78	3.28	536	5.9	1.6			388
Oct-78	3.6	440	6.7	3.6			241
Nov-78	3.43	479	2.8	2.2			229
Dec-78	3.66	371	6	5.8			182
Jan-79	3.81	406	8.2	8			154
Feb-79	3.74	296	6.6	4.4			98
Mar-79	3.73	345	3.4	1.5			115
Apr-79	3.71	334	4.2	4.2			113
May-79	3.65	374	4.5	3.4			182
Jun-79	3.69	404	5.6	4.6			307
Jul-79	3.42	330	5	3.9			331
Aug-79	3.52		8.9	4.4			191
Sep-79	3.65	476	4.8	3.1			136
Oct-79	3.71	427	4.6	4.5			197
Nov-79	3.69	373	3.9	2.1			222
Dec-79	3.69	378	4.7	1.3			113
Jan-80	3.72	414	4.9	4.2			120
Feb-80	3.09	441	6	2.9			139
Mar-80	3.63	454	6.7	2.2			149
Apr-80	4.3		1.5				
May-80	3.9		2				
Jul-80	3.9		0.4				
Oct-80	3.8		8.2	5.4			
Nov-80	3.9		4	2.4			
Jan-81	3.42	615	7.2	1.9			269
Feb-81	3.72	372	5.9	3.9			122
Mar-81	3.7	401	4.9	2.4			169
Apr-81	3.65	362	6.8	1.8			150
May-81	3.77	360	4	1.1			105
Jun-81	4.2		3	2.5			142
Jul-81	3.67	484	0.6	0.4			230
Aug-81	3.64	387	7.1	2.7			273
Sep-81	3.6		4	3.2			220
Oct-81	3.4	514	9	5.5			309
Nov-81	3.49	472	5.1	5.1			182
Dec-81	3.61	424	0.9	0.5			139

Table C1. Jeddo Tunnel Outfall Water Quality Data (Monthly, 1978-90, 1995-98)—Continued

Sample Date	pH	Sulfate	Iron, Total	Iron, Ferrous	Manganese, Total	Aluminum, Total	Acidity, Total HOT
		mg/l					
Jan-82	3.52	250	0.8	0.7			261
Feb-82	3.72	400	2	0.8			159
Mar-83	3.69	331	5.4	2.6			108
Apr-82	3.69	322	4.6	2.1			103
May-82	3.67	422	6.5	1.8			219
Jun-82	3.86	409	4	1.1			103
Jul-82	3.53	466	6.5	1.2			166
Aug-82	3.59	509	10.2	1.6			137
Sep-82	3.74	508	8.1	2.6			122
Oct-82	3.48	505	8.2	3			185
Nov-82	3.53	451	7.5	2.2			135
Dec-82	3.64		8.9	3.9			118
Jan-83	3.59	366	5.9	1.4			130
Feb-83	3.65	431	4.1	0.8			124
Mar-83	3.78	350	3	1.2			92
Apr-83	3.98	290	4.4	2			81
May-83	3.68	357	2.7	0.7			103
Jun-83	3.66	607	3.7	1.5			128
Dec-83	4.16	500	2.7	2.2			148
Jan-84	3.85	466	4.2	2.1			108
Feb-84	4.12	326	2.4	1			66
Mar-84	4	323	2.5	1			79
Apr-84	4.05	321	0.3				71
May-84	3.92		4	1.2			102
Jun-84	3.87	354	3.9	1.7			101
Jul-84	3.85	398	3.5	1.1			106
Aug-84	3.82	453	3.7	1.2			114
Sep-84	3.63	391	4.2	1.2			123
Oct-84	3.41	447	6.1	1.2			218
Nov-84	3.6	762	5.3	1.5			160
Dec-84	3.69	322	4.4	2.2			128
Jan-85	3.62	396	4.3	1.4			138
Feb-85	3.83	242	4.6	1.3			96
Mar-85	3.72	339	3.6	1.2			108
Apr-85	3.61	359	3.9	1.8			109
May-85	3.75	373	3.5	1			113
Jun-85	3.89	353	2.6	1			98
Jul-85	3.66	384	4.4	1.3			122
Aug-85	3.75	376	4.8	1.7			109
Sep-85	3.93	430	6.2	3.8			145

Table C1. Jeddo Tunnel Outfall Water Quality Data (Monthly, 1978-90, 1995-98)—Continued

Sample Date	pH	Sulfate	Iron, Total	Iron, Ferrous	Manganese, Total	Aluminum, Total	Acidity, Total HOT
		mg/l					
Oct-85	3.68	472	4.2	0.7			104
Nov-85	3.93	312	3.4	1.2			94
Dec-85	3.94	422	3.9	1.3			108
Jan-86	4.07	314	3.4	1.2			93
Feb-86	3.89		1.7	1.4			136
Mar-86	3.95	406	2.6	1			113
Apr-86	4.1	282	2.35	0.86	3.64	9.9	66
May-86	4	307	5.02	1.2	4.44	12.1	80
Jun-86		457	19.51	1	6.31	20.08	106
Jul-86	3.8	600	22.89	1.86	7.12	24.01	124
Aug-86	3.8	553	13.78	2.3	0.14	21.08	148
Sep-86	3.6	592	13.2	2.7	7.85	20.82	122
Oct-86	3.7	476	18.28	2.7	7.44	22.25	140
Nov-86	3.8	402	6.94	1.8	6.4	15.47	134
Dec-86	3.9	300	5.09	2.6	5.46	11.5	110
Jan-87	3.6		2.5	0.4			160
Feb-87	3.7	415	1.75	0.44	4.85	26.48	120
Mar-87	3.9	385	3.34	1.2	5.42	12.46	104
Apr-87	4	339	7.66	0.79	4.92	15.06	88
May-87	3.7	403	6.88	1.5	5.58	15.2	102
Jun-87	3.7	485	28.6	1.5	6.91	24.79	116
Jul-87	3.8	529	5.94	1.8	7.87	17.47	128
Aug-87	3.7	441	11.61	2.9	7.17	20.04	126
Sep-87	4	465	6.32	1.7	6.17	21.65	122
Oct-87	3.8	487	4.67	1.8	7.3	17.71	124
Nov-87	4	386	4.45	0.85	5	12.75	94
Dec-87	4.1	393	3.17	0.87	5.48	13.8	128
Jan-88	3.9	427	38.2	2	5.65	23.41	104
Feb-88	4	369	3.78	1.2	5.27	12.72	88
Mar-88	3.9	375	17.05	0.11	5.29	19.4	126
Apr-88	3.9	355	13.78	1.1	5.15	17.28	110
May-88	4.21		1.4	0.7			156
Jun-88	4	424	4.26	1.2	6.34	14.78	104
Jul-88	4.3	428	4.27	1.5	4.91	11.96	82
Aug-88	4	520	4.22	1.6	7.11	15.85	114
Sep-88	4	535	4.54	2.3	7.21	16.28	110
Oct-88	3.9	484	4.92	1.7	7.13	14.77	102
Nov-88	3.9	362	4.54	3	5.1	11.42	94
Dec-88	3.9	250	4.67	1.5	6.8	15.49	96

Table C1. Jeddo Tunnel Outfall Water Quality Data (Monthly, 1978-90, 1995-98)—Continued

Sample Date	pH	Sulfate	Iron, Total	Iron, Ferrous	Manganese, Total	Aluminum, Total	Acidity, Total HOT
		mg/l					
Jan-89	4	363	6.75	2.2	5.67	14.44	104
Feb-89	4	362	4.44	1.8	5.25	12.96	94
Mar-89	4.1	286	5.94	1.4	4.19	11.75	70
Apr-89	3.77		1.7	1.4			166
May-89	4.2	364	4.26	1.7	4.83	12.9	80
Jun-89	4.4	343	3.93	2.4	4.3	10.5	78
Jul-89	4.3	380	3.13	0.72	6.36	14.5	94
Aug-89	4	572	4.38	1.4	7.32	17.3	122
Sep-89	4	510	5.56	5.5	7.21	17.7	112
Oct-89	4	436	18.1	2	6.01	22.1	116
Nov-89	3.9	354	4.35	1	5.61	15.9	96
Dec-89	4	439	3.61	0.74	6.2	16.6	96
Jan-90	4.3	271	9.66	1	3.5	10	70
Feb-90	4	359	18.3	0.77	4.53	22.9	98
Mar-90	4.2	344	35.6	0.85	4.28	16.9	70
Apr-90	4.1	378	7.71	0.67	5.26	13.7	86
May-90	4.3	369	4.93	1.3	4.96	14	82
Jun-90	4	362	4.77	0.55	5.84	16.1	78
Jul-90	4.1	445	9.34	0.65	5.35	14	100
Aug-90	4.1	421	23	2.1	4.84	18.9	100
Sep-90	4	417	79.4	2	6.95	33.5	106
Oct-90	4.3	337	4.92	1.9	4.91	11.06	70
Nov-90	4.2	314	15	1	5.49	14.4	86
Dec-90	4.5	299	2.64	1.3	3.68	8.35	72
Apr-95	4.3	293	21.2		4.86	22.7	78
May-95	4.4	344	11.4		4	14.9	76
Jun-95	4.2	287	11.7		4.44	15.7	74
Jul-95	4	303	37.6		4.58	24.7	78
Aug-95	3.9	343	68		5.09	44.4	98
Sep-95	3.9	345	4.91		5.82	12	100
Oct-95	3.8	461	9.17		6.34	15.1	104
Nov-95	4.2	354	12.7		4.9	14.4	88
Dec-95	4.4	250	4.55		4.78	11.3	78
Jan-96	4.2	365	3.53		5.1	12.2	90
Feb-96	4.6	427	2.89		3.89	10	74
Mar-96	4.4	344	2.84		3.63	9.06	72
Apr-96	4.5	286	6.36		3.62	9.23	84
May-96	4.5	284	3.65		3.57	8.59	72
Jun-96	4.3	295	9.42		4.56	13.5	82
Jul-96	4.2	307	6.16		4.58	11.3	70

Table C1. Jeddo Tunnel Outfall Water Quality Data (Monthly, 1978-90, 1995-98)—Continued

Sample Date	pH	Sulfate	Iron, Total	Iron, Ferrous	Manganese, Total	Aluminum, Total	Acidity, Total HOT
		mg/l					
Aug-96	4.3	265	7.83		4.92	10.9	92
Sep-96	4	314	25		5.11	21	104
Oct-96	4.2	360	14.4		5.25	16.9	94
Nov-96	4.5	296	29.5		4.34	22	70
Dec-96	4.6	240	6.92		2.75	8.32	50
Jan-97	4.7	251	3.84		3.83	9.46	50
Feb-97	5	95	1.13		1.33	3	38
Mar-97	4.4	213	2.98		3.71	8.77	62
Apr-97	4.5	177	2.74		3.43	7.56	58
May-97	4.5	258	2.49		4.12	8.53	76
Jun-97	4.3	251	2.72		3.69	8.04	62
Jul-97	4.3	260	5.95		5.05	12.4	76
Aug-97	4.2	178	7.3		5.3	12.2	86
Sep-97	4.7	311	3.93		4.76	11.1	66
Oct-97	4.2	239	3.09		5.05	11.3	96
Nov-97	4.3	325	4.52		4.94	10.8	80
Dec-97	4.2	227	3.49		4.06	9.02	74
Jan-98	4.2	218	3.22		3.67	8.4	72
May-98	4.7	226	2.24		2.9	6.62	48
Jun-98	4.7	308	2.340		3.890	8.79	64
Jul-98	4.5	266	2.71		4.09	8.92	70
Aug-98	4.3	269	3.16		4.5	11	68
Sep-98	4.4	344	7.8		4.34	9.32	

Data Source 05/78-12/90 provided by Pa. DEP BAMR
04/95-09/98 collected by Friends of Nescopeck, analyzed by Pa. DEP BMR

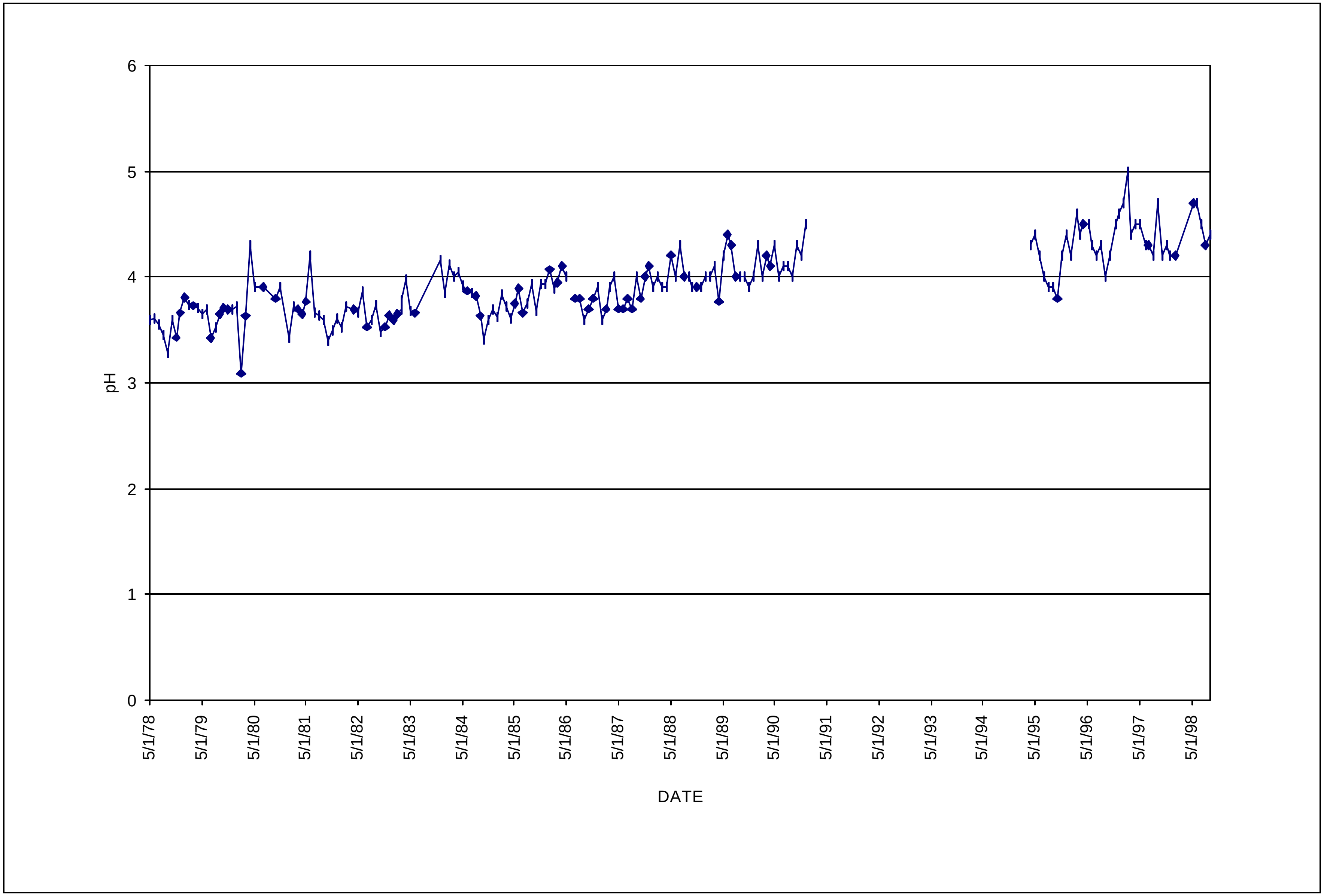

Figure C1. Jeddo Tunnel pH, 1978-98

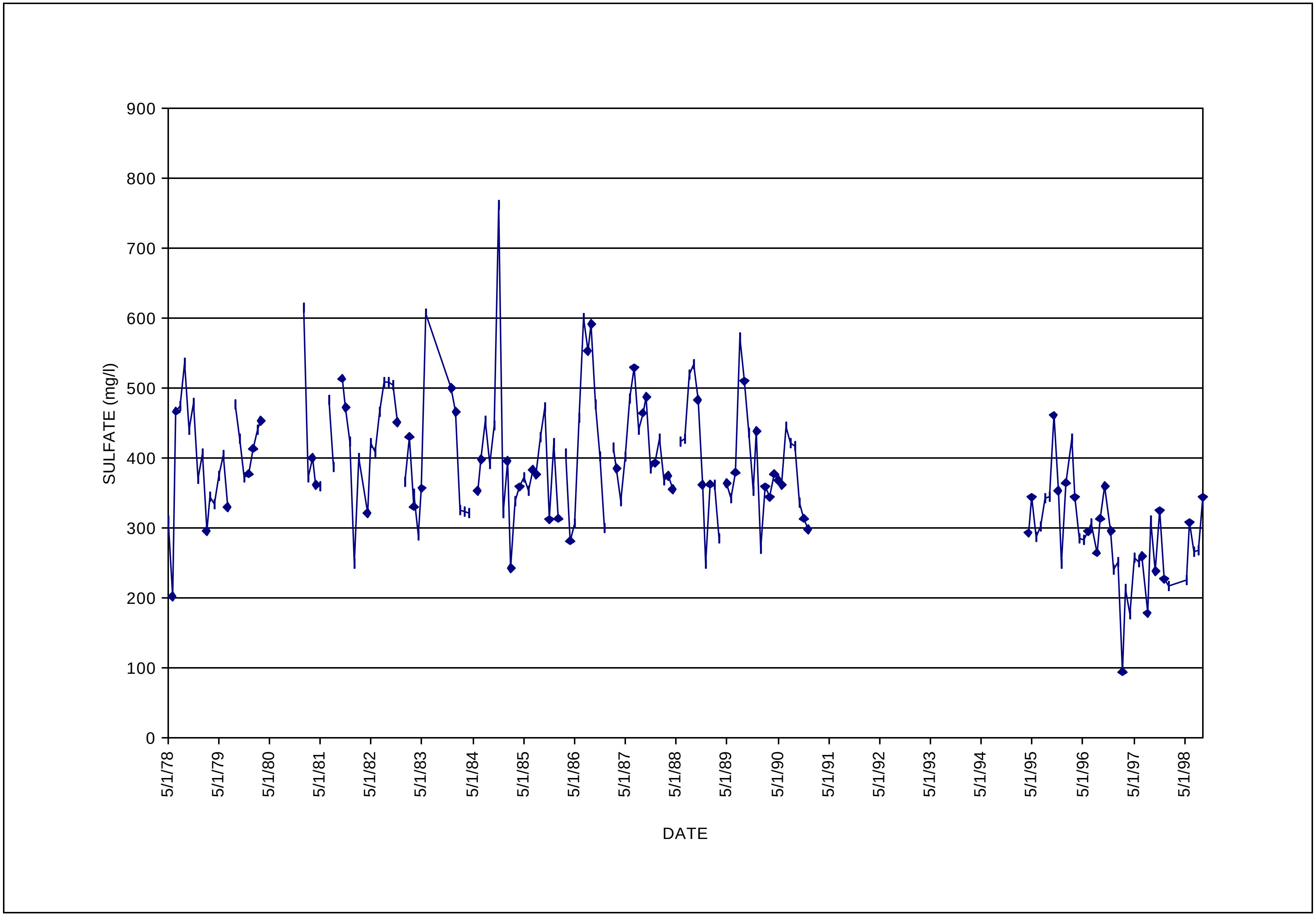

Figure C2. Jeddo Tunnel Sulfate Concentrations, 1978-98

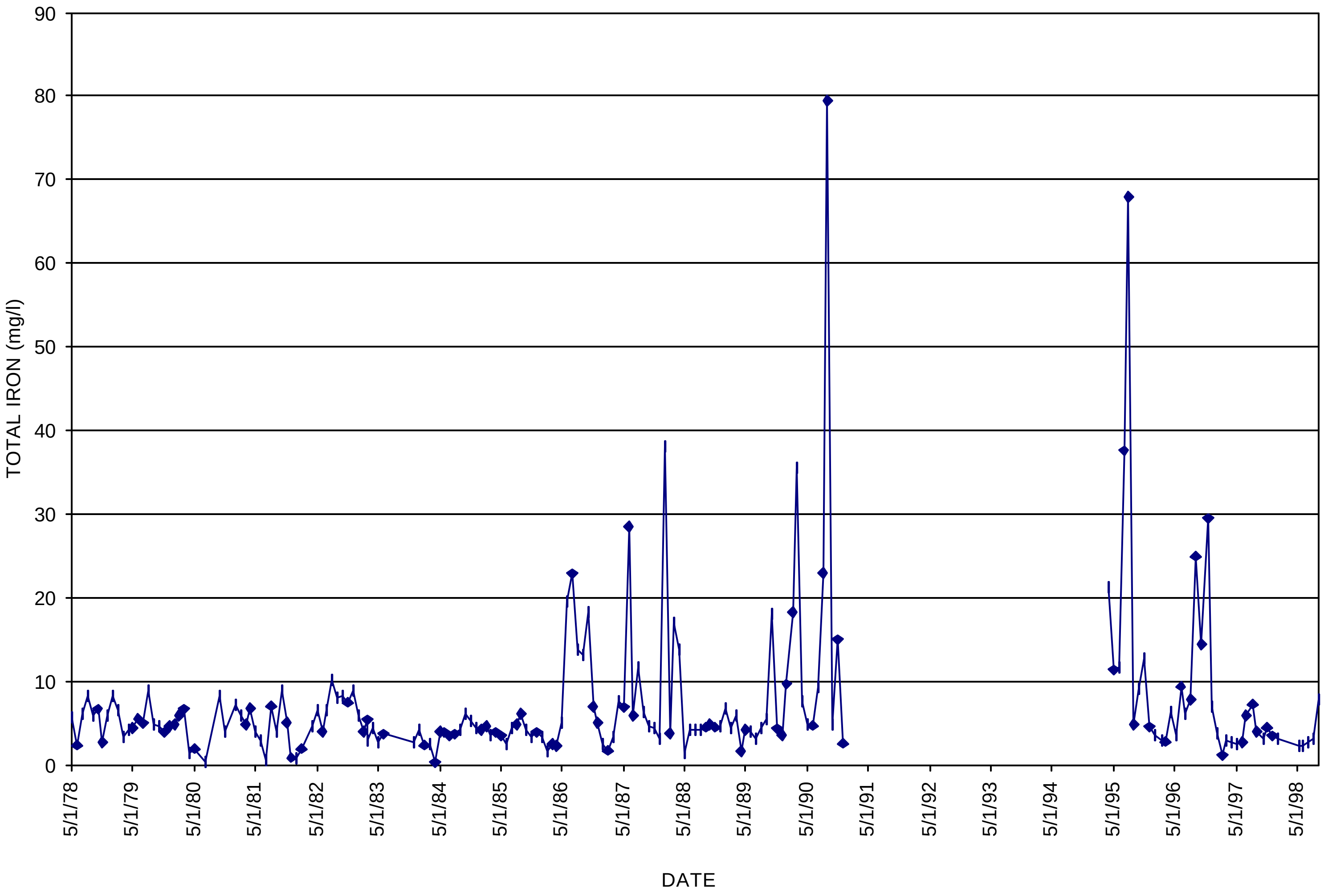

Figure C3. Jeddo Tunnel Total Iron Concentrations, 1978-98

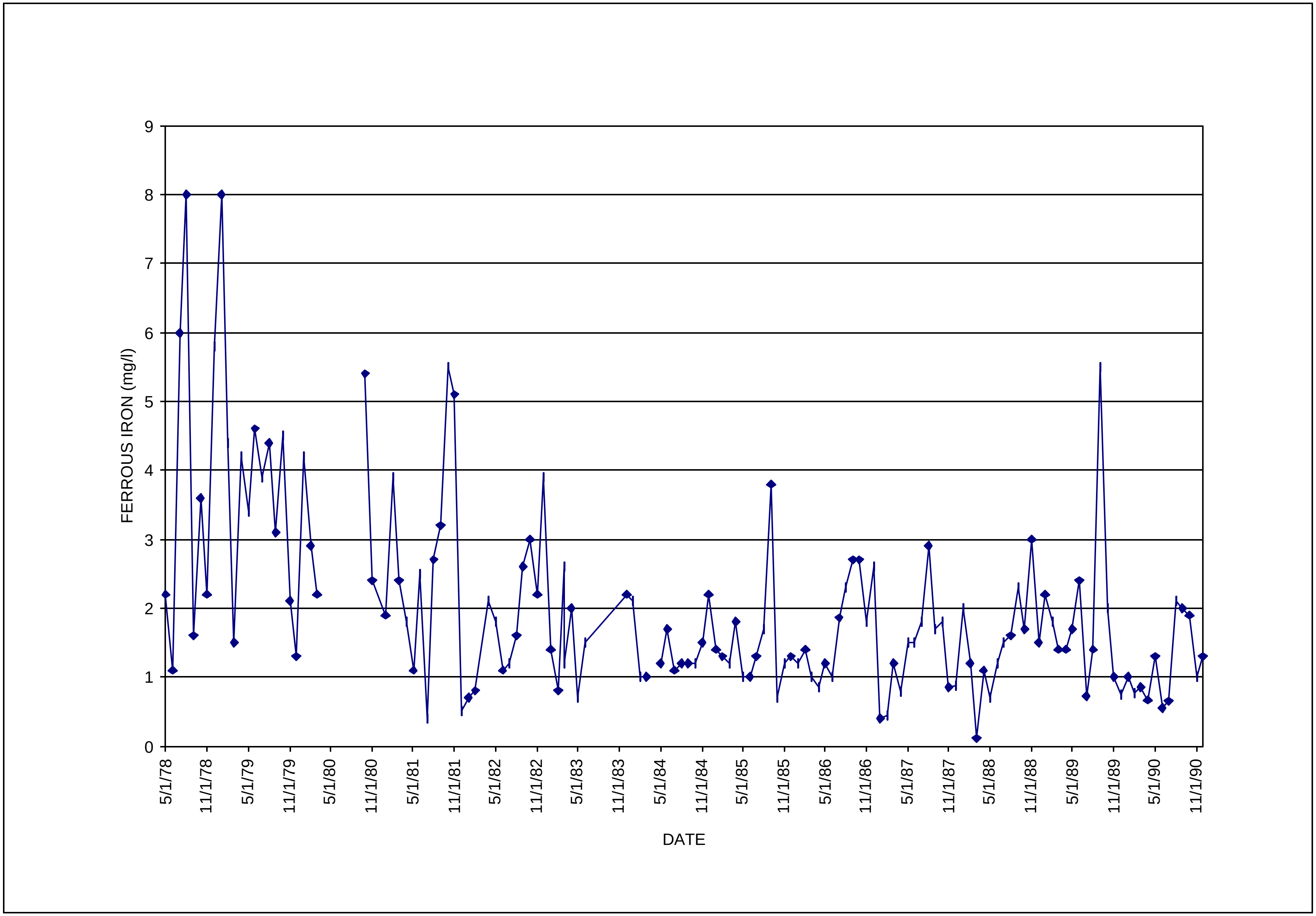

Figure C4. Jeddo Tunnel Ferrous Iron Concentrations, 1978-90

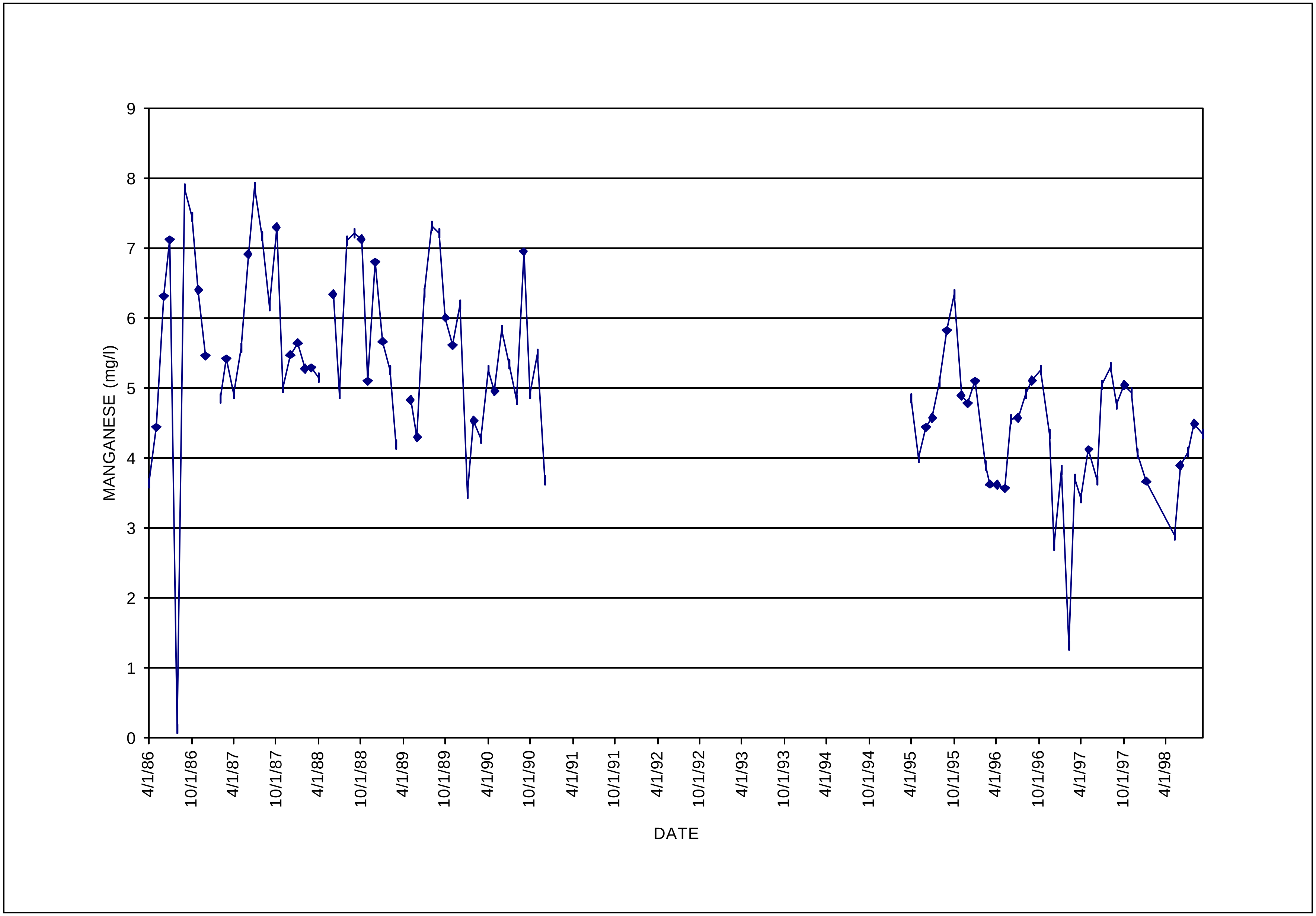

Figure C5.* *Jeddo Tunnel Manganese Concentrations, 1986-98

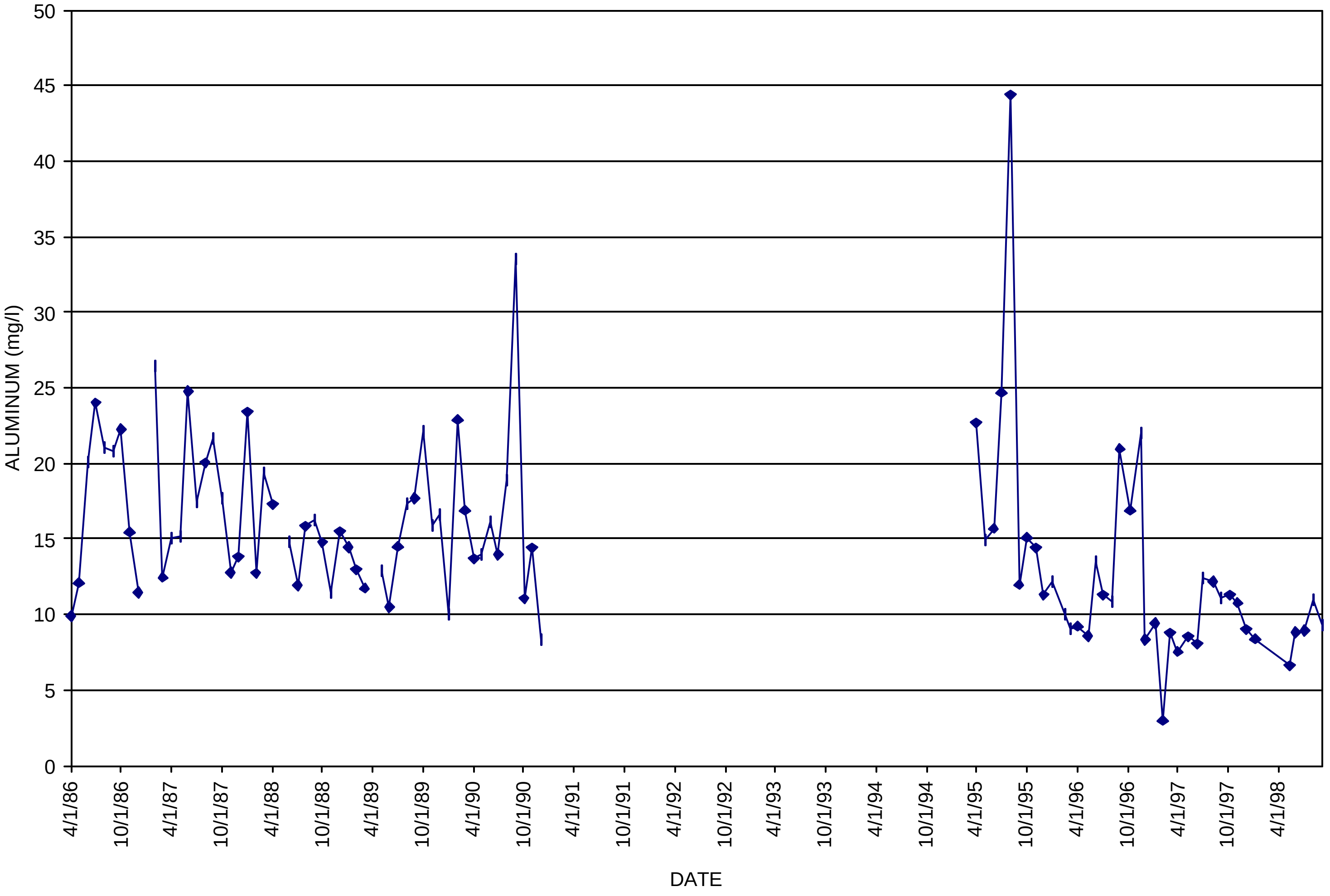

Figure C6. Jeddo Tunnel Aluminum Concentrations, 1986-98

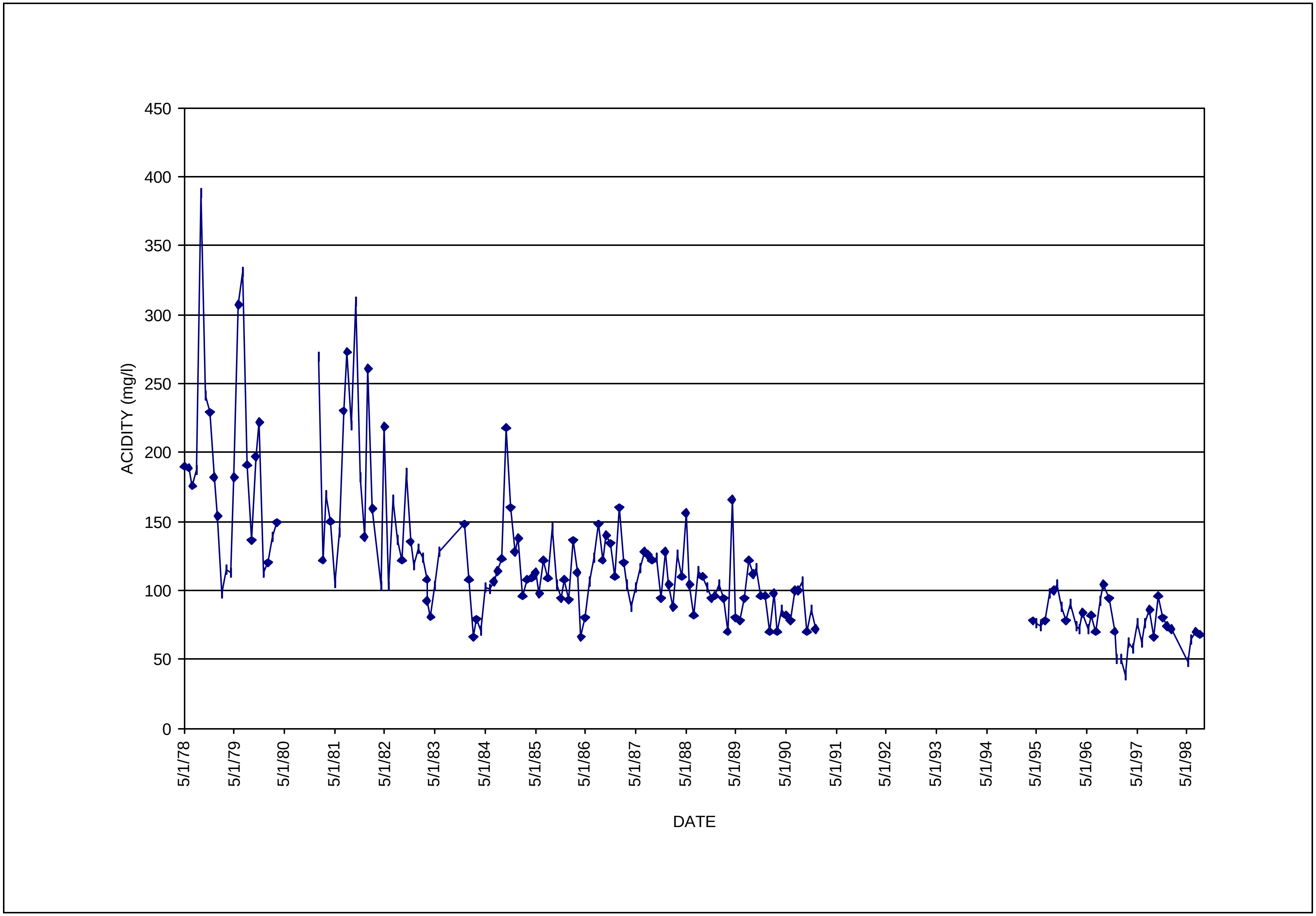

Figure C7. Jeddo Tunnel Acid Concentrations, 1978-98

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)*

Sample Date	Specific Conductance	pH	Alkalinity	Total Solids, as Residue	Dissolved Solids, As Residue	Suspended Solids, Nonfilterable, as Residue	Calcium	Magnesium
	ìmhos/cm		mg/l					
04/04/95	730	4.3	7.8	996	794	202	35	47.7
04/04/95		4.2	5.8			20		
04/11/95	747	4.3	7	882	796	86	36.2	48.1
04/18/95	699	4.4	9.6	848	604	244	28.7	40.5
04/25/95	693	4.3	6.8	952	688	264	29.1	42.3
05/02/95		4.4	8.8			8		
05/09/95		4.2	6.2			82		
05/15/95		4.2	6.4			308		
05/23/95		4.2	6.2					
05/30/95	760	4.1	4	692	620	72	34.8	42
06/06/95	729	4.2	6	1,260	876	388	36	48.9
06/13/95	724	4.2	4.8	1,038	800	238	34.6	46.1
06/20/95	673	4.2	5.8	8.32	716	116	34.6	40.9
06/28/95	711	4.1	4.4	886	766	120	34.3	43.1
07/11/95	719	4	2.8	1,610	789	812	34.6	50.9
07/18/95	742	4.4	7.8	866	826	40	39.9	59
07/25/95	813	4.1	5.4	1,708	1,202	506	37.1	49.6
08/03/95	824	3.9		1,890	1,302	588	38.2	52
08/08/95	792	4.1	4.2	1,094	918	176	35.6	47.9
08/15/95	847	4	3.4	3,212	2,796	416	35.9	47
08/22/95	859	4	2.8	1,084	1,038	46	41.3	54.2
08/29/95	875	3.9		1,732	1,120	612	42.2	54.1
09/26/95	882	3.8		2,436	1,036	1,400	41.5	52.2
09/05/95	862	3.9		256	4,282	48	39.9	53.9
09/12/95	902	3.9		1,124	1,010	114	45.5	60.8
09/19/95	874	3.8		1,566	864	592	36.9	49.4
10/03/95	901	3.8		1,188	1,086	102	42.1	63.9
10/10/95	897	4	4.6	1,089	1,034	64	40.2	56.1
10/19/95	876	4.1	4.2	1,168	700	468	47.7	65.7
10/24/95	799	4.3	6	712	690	22	38.3	53.7
10/31/95	789	4.3	7.4	950	918	32	36.8	48.2

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Specific Conductance	pH	Alkalinity	Total Solids, as Residue	Dissolved Solids, as Residue	Suspended Solids, Nonfilterable, as Residue	Calcium	Magnesium
	ìmhos/cm		mg/l					
11/07/95	800	4.2	7.8	888	798	90	39.4	60.8
11/14/95	705	4.5	9.2	576	564	12	32.2	42.4
11/21/95	737	4.5	7.6	626	606	20	32.6	45.4
11/28/95	770	4.3	7.4	688	642	46	37.9	57.1
12/05/95	721	4.4	9	642	600	42	36.6	49.9
12/12/95	735	4.3	7.2	646	634	12	32.4	52
12/19/95	747	4.2	5.4	608	594	16	34.9	50.1
12/26/95	780	4.4	10.6	604	606	10	37	46.3
01/02/96	776	4.2	7.6	610	610	2	39.8	54.2
01/17/96	786	4.1	3.4	806	806	2	37.7	50.5
01/23/96	792	4.5	9	938	686	252	37.5	52.7
02/13/96	780	4.6	10.4	702	702	2	39.1	74.8
02/20/96	761	4.4	9	718	550	6	40.8	55
02/27/96	642	4.4	7.6	536	536	8	34.7	51.8
03/05/96	660	4.4	7.4	578	578	2	34.5	49.3
03/12/96	685	4.4	6.6	620	608	12	36	53
03/26/96		3.6						
04/03/96	626	4.5	9.6	550	548	2	34.9	50.6
04/09/96	646	4.5	8	538	524	14	34	51.1
04/16/96	578	4.4	7.6	500	492	8	29.2	42.2
04/23/96	640	4.6	10.4	568	20	48	29.9	41
04/30/96	660	4.6	9.8	682	682	2	35.7	53.6
05/08/96	616	4.5	8.6	668	626	42	31.2	47.9
05/14/96	593	4.6	9.4	730	8	722	29.9	46
05/21/96	650	4.6	10	640	762	62	28.6	39.8
06/04/96	737	4.3	8	1,470	1,140	330	36.7	54.4
06/11/96	734	4.2	4.6	792	680	112	38.7	58.4
06/18/96	737	4.4	8.6	1,076	948	128	41.7	66.5
06/25/96	649	4.2	5.2	1,034	936	98	41.5	60.3
07/02/96	706	4.2	6.4	727	742	110	38.4	55.6
07/09/96	744	4.4	7.4	880	766	114	41.8	62.5

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Specific Conductance	pH	Alkalinity	Total Solids, as Residue	Dissolved Solids, as Residue	Suspended Solids, Nonfilterable, as Residue	Calcium	Magnesium
	ìmhos/cm		mg/l					
07/16/96	678	4.4	7.8	834	750	84	32	52.1
07/23/96	700	4.3	6.6	516	468	48	34.6	45.7
07/30/96	700	4.3	7.6	844	774	70	37	51.1
08/06/96	733	4.3	6.2	914	842	72	34	50.7
08/13/96	706	4.1	4	1,242	786	456	33.8	50.5
08/20/96	759	4.2	5.6	1,034	882	152	33.9	48.9
08/27/96	756	4.1	5.6	936	844	92	42.2	68.8
09/03/96	765	4	3.2	1,202	1,010	192	43.5	69.1
09/10/96	800	4	4	1,200	818	382	39.5	62.3
09/17/96	740	4	3.4	1,030	700	330	37.6	56.8
09/24/96	765	4.2	6.8	4,352	2,982	1,370	41.1	60.5
10/08/96	828	4.2	6.2	982	776	206	41	65
10/29/96	723	4.4	8.8	800	562	238	39.7	66.4
10/22/96	713	4.6	9.8	960	752	208	32	51.1
10/15/96	820	4.2	6.4	1,652	1,646	406	42.5	61.9
11/19/96	696	4.5	9.8	1,180	514	566	33.7	52.1
11/12/96	663	4.7	10.2	556	510	26	30.2	50.1
11/05/96	727	4.3	7	3,404	2,508	896	34.4	58.4
11/26/96	678	4.8	14.8	1050	622	428	33.7	55.2
12/04/96	570	4.6	9.8	556	490	66	30.8	49.3
12/11/96	650	4.7	11.8	604	580	24	32.5	55.4
12/17/96	586	4.7	11	600	490	110	33.3	53.4
12/24/96	615	4.6	12.8	464	464	<2	34.3	57.4
12/31/96	614	4.7	11.8	474	452	22	35.5	59.3
01/07/97	633	4.7	11	622	542	80	37.4	62.7
01/14/97	676	4.6	11.6	520	520	<2	32	52.7
01/22/97	700	4.6	12.2	540	526	14	30.8	50.4
01/28/97	700	4.6	12.4	532	524	8	35.9	57.9
02/06/97	334	5	12.8	264	160	104	15.7	18
02/11/97	702	4.6	10.8	554	530	24	34.7	56.3
02/18/97	696	4.5	10.6	700	678	22	35.3	53.6

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Specific Conductance	pH	Alkalinity	Total Solids, as Residue	Dissolved Solids, as Residue	Suspended Solids, Nonfilterable, as Residue	Calcium	Magnesium
	ìmhos/cm		mg/l					
02/25/97	636	4.3	7.2	6,812	6,770	42	26.5	38.7
03/04/97	620	4.4	9.2	440	412	28	33.9	47.1
03/11/97	597	4.4	7.6			82	30	43.4
03/18/97	601	4.5	10.4	436	432	4	28.5	41.5
03/25/97	621	4.4	7.8	506	498	8	23.1	38
04/01/97	589	4.5	9	474	474	<2	33.8	52
04/08/97	563	4.5	8.2	448	442	6	27.4	44.2
04/15/97	624	4.6	11.2	528	522	6	30.6	47.3
04/29/97	668	4.6	10.6	712	712	2	37.4	63.3
05/06/97	675	4.5	11	566	564	2	34.3	52.2
06/10/97	633	4.3	6.4	614	602	12	29.6	45.8
06/17/97	671	4.3	6.4	646	610	36	35.1	54.3
06/24/97	673	4.3	5.8	740	740	2	35	53.9
07/01/97	708	4.3	7	608	564	44	36.1	57.1
07/07/97	706	4.2	4.4	780	780	2	33.1	51.2
07/15/97	722	4.3	6.8	838	760	78	39.6	60.7
07/22/97	721	4.3	6.6	854	840	14	38	60.2
07/29/97	722	4.2	5.8	810	764	46	35.7	55.8
08/05/97	758	4.2	5.8	882	804	78	37.7	65.3
08/12/97	775	4.2	5.2	856	774	82	43.8	70.5
08/19/97	750	4.4	8.4	264	244	20	41	68.1
09/02/97	780	4.7	11.8	900	872	28	40.2	74.8
09/09/97	802	4.5	8.8	942	932	10	36.6	63.6
09/16/97	755	4.4	7.8	804	796	8	33.7	58.5
09/23/97	756	4.4	8.2	754	726	28	41	69.4
09/30/97	760	4.4	10	682	644	38	40.6	63.1
10/07/97	802	4.2	5.8	786	782	4	43	63
10/14/97	805	4.2	5.4	756	748	8	39.3	74.6
10/21/97	814	4.2	6.2	482	456	26	38.2	61.7
10/28/97	820	4.2	5.8	800	790	10	37.3	74.8

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Specific Conductance	pH	Alkalinity	Total Solids, as Residue	Dissolved Solids, as Residue	Suspended Solids, Nonfilterable, as Residue	Calcium	Magnesium
	ìmhos/cm		mg/l					
11/04/97	799	4.3	7.8	682	674	8	38.5	63.2
11/18/97	756	4.4	10.4	650	558	92	31.5	47.2
12/02/97	703	4.2	6	660	652	8	35.4	58.8
12/09/97	703	4.1	4.4	602	570	32	29	48.4
12/16/97	724	4.2	6.6	360	360	<2	34.1	54.1
12/30/97	698	4.1	5.6	604	590	14	29.1	45.2
01/06/98	694	4.2	6.2	670	262	8	27.8	40.5
05/12/98	567	4.7	10.6	504	484	20	26.3	40.9
05/19/98		4.5	8.6			10		
05/26/98	644	4.6	10	566	564	2	31.1	50.8
06/02/98	660	4.7	11.8	572	562	10	33.80	53.10
06/09/98	695	4.6	11.4	496	488	8	34	54.1
06/16/98	675	4.5	8.8	764	748	16	34.3	53.8
06/23/98	723	4.6	9.6	796	772	24	33.6	53.5
06/30/98	729	4.5	9.4	580	562	18	30.9	49.9
07/06/98	745	4.5	10	842	832	10	36.5	55.4
07/14/98	747	4.5	8.4	796	784	12	34.4	53.5
07/21/98	781	4.4	7.6	734	730	4	33.5	61
07/28/98	786	4.2	6.4	826	818	8	41.3	71.2
08/04/98	810	4.3	6.8	735	731	4	44.2	67
08/11/98	800	4.4	8	800	794	6	37.1	58.8
08/18/98	807	4.3	7.8	894	850	44	39.7	64.5
08/24/98	820	4.3	7	934	926	8	39.4	56.1
09/09/98	827	4.3	8	950	938	12	43.8	61.1
09/08/98	798	4.4	7.4	340	340	2	42.1	79.3
09/15/98	815	4.3	7	834	826	8	37.2	73
09/22/98	844	4.4	7.4	764	728	36	39.9	66.1
09/29/98	853	4.3	7	656	656	10	43.3	66.9

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Sodium	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity, Hot
	mg/l								
04/04/95	9.87	3.62	11	293	21.2	4.86	0.75	22.7	4
04/04/95	10			324	15.5	4.67		18.2	78
04/11/95	10	2.94	11	271	11	4.72	0.744	14.6	74
04/18/95	8.48	3.19	28	474	15.3	3.64	0.614	15.3	64
04/25/95	8.68	3.99	11	276	15.1	4.06	0.666	17.2	86
05/02/95	9.39			344	11.4	4		14.9	76
05/09/95	9.39			323	4.94	4.56		10.5	66
05/15/95				283					78
05/23/95	9.56				9.13	5.26		13.1	96
05/30/95	10.5	1.87	11	285	4.42	4.79	0.731	9.72	84
06/06/95	9.68	3.5	9	287	11.7	4.44	0.698	15.7	74
06/13/95	13.2	2.65	12	288	14.6	4.4	0.646	14.5	60
06/20/95	8.98	2.22	10	282	5.98	4.08	0.6	10.3	86
06/28/95	12.9	2.19	14	230	5.98	4.24	0.678	11.1	70
07/11/95	9.88	3.32	9	303	37.6	4.58	0.77	24.7	78
07/18/95	10.8	1.85	10	362	4.43	5.24	0.772	12.2	72
07/25/95	10	3.17	11	389	32.6	4.83	0.809	26.7	86
08/03/95	8.94	7.37	11	343	68	5.09	0.775	44.4	98
08/08/95	8.61	2.54	11	317	9.51	4.72	0.705	13.8	8.6
08/15/95	8.18	6.91	11	319	39.6	4.59	0.81	31.5	126
08/22/95	9.04	2.03	11	368	4.88	5.84	0.843	11.7	86
08/29/95	9.54	2.44	12	512	34.9	6.28	0.814	25.7	102
09/26/95	10.5	6.33	13	373	46	6.22	0.858	30.4	128
09/05/95	9.39	1.69	12	345	4.91	5.82	0.663	12	100
09/12/95	11.9	2.18	13	360	10.5	6.75	0.9604	16.7	98
09/19/95	9.67	3.47	16	345	12.6	5.63	0.742	16.5	114
10/03/95	10.3	1.97	11	461	9.17	6.34	0.802	15.1	104
10/10/95	10.3	2.55	11	381	5.89	5.93	0.819	13.2	100
10/19/95	11.2	3.83	12	372	11.4	6.74	0.997	13.5	104
10/24/95	9.09	2.18	9	346	7.23	4.49	0.772	11.1	106
10/31/95	8.26	1.77	9	391	4.12	5.14	0.783	12.22	88
110/7/95	7.98	2.61	11	354	12.7	4.9	0.829	14.4	88
11/14/95	8.93	1.05	12	283	5.06	3.91	0.679	9.24	66

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Sodium	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity, Hot
	mg/l								
11/21/95	8.26	1.34	13	298	4.02	3.92	0.655	9.05	76
11/28/95	8.64	1.8	10	299	3.84	5.14	0.905	12	94
12/05/95	8.67	1.96	10	250	4.55	4.78	0.844	11.3	78
12/12/95	9.34	1.71	10	290	3.48	4.76	0.819	10.9	72
12/19/95	9.87	1.53	11	307	3.21	4.97	0.799	10.9	80
12/26/95	9.36	1.78	11	320	3.14	4.83	0.777	10.1	84
01/02/96	9.15	1.61	11	365	3.53	5.1	0.797	12.2	90
01/17/96	10.9	1.59	13	313	4.2	5.49	0.821	11.6	88
01/23/96	12.6	2.72	16	297	49.7	4.8	0.746	18.6	68
02/13/96	9.02	1.83	11	427	2.89	3.89	0.842	10	74
02/20/96	8.16	1.76	11	303	2.43	3.58	0.776	8.57	70
02/27/96	12.2	1.9	14	317	3.61	3.72	0.74	9.45	62
03/05/96	9.21	1.8	11	344	2.84	3.63	0.685	9.06	72
03/12/96	11.1	1.71	13	293	3.3	4.91	0.075	10.3	84
03/26/96				90	3.6	4.39		3.64	54
04/03/96	10.5	1.71	16	286	6.36	3.62	0.662	9.23	84
04/09/96	12	1.53	14	281	3.1	3.94	0.709	9.32	60
04/16/96	15.1	2.05	15.4	226	8.68	3.18	0.583	10.2	48
04/23/96	7.57	1.71	12	282	3.75	3.47	0.587	8.01	58
04/30/96	11.6	1.75	14	269.3	4.31	4.03	0.715	9.53	54
05/08/96	10.2	1.64	12	284	3.65	3.57	0.664	8.59	72
05/14/96	10	1.73	10	51	2.63	3.37	0.603	8.01	60
05/21/96	8.69	2.88	12	277	7.27	3.54	0.64	10.9	68
06/04/96	10.1	3.75	12	295	9.42	4.56	0.844	13.5	82
06/11/96	12.5	2.15	15	311	6.7	4.69	0.752	13.6	22
06/18/96	10.7	2.02	13	316	6.38	4.36	0.736	11.6	66
06/25/96	11.2	2.21	13		8.48	4.89	0.755	13.3	88
07/02/96	17.6	2.42	12	307	6.16	4.58	0.727	11.3	70
07/09/96	11.4	2.37	12	306	7.46	5	0.79	12.8	70
07/16/96	11.4	2.23	12	293	6.81	4.23	0.761	11.7	70
07/23/96	8.65		11		4.56	4.04	0.752	10.3	80
07/30/96	9.15	1.89	13	279	3.63	3.63	0.65	9.45	78
08/06/96	11.1	2.19	12	265	7.83	4.92	0.806	10.9	92

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Sodium	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity, Hot
	mg/l								
08/13/96	8.81	3.44	13	277	19.4	4.93	0.804	14.4	92
08/20/96	8.9	2.53	13	337	7.96	4.3	0.693	11.3	92
08/27/96	11.6	2.21	12	336	7.19	5.5	0.842	14.5	86
09/03/96	10.1	3.26	13	314	25	5.11	0.747	21	104
09/10/96	11.4	3.05	13	299	20.8	5.47	0.833	18.7	100
09/17/96	7.26	3.47	12	344	19.6	4.35	0.6889	15.7	90
09/24/96	10.5	5.9	13	355	90.5	4.64	0.809	37.4	100
10/08/96	11	2.73	13	360	14.4	5.25	0.773	16.9	94
10/29/96	9.11	2.95	10	345	15.1	4.34	0.746	23	76
10/22/96	8.25	2.9	11	327	16.8	3.61	0.578	14.8	72
10/15/96	11.6	3.96	13	375	48.2	5.5	0.819	30	94
11/19/96	8.94	4.36	9	296	29.5	4.34	0.778	22	70
11/12/96	6.66	1.9	10	253	4.01	2.95	0.498	6.7	50
11/05/96	8.25	6.07	10	154	50.8	4.21		25	90
11/26/96	9.5	3.72	15	305	28.2	4.14	0.662	18.1	70
12/04/96	7.39	2.02	8	240	6.92	2.75	0.555	8.32	50
12/11/96	8.56	1.63	9	211	2.88	3.7	0.652	8.42	58
12/17/96	9.83	2.3	12	202	8.3	2.96	0.534	10.5	48
12/24/96	9.85	2.26	9	240	2.54	3.53	0.643	7.84	64
12/31/96	9.69	2.43	9	249	2.93	3.62	0.654	8.32	64
01/07/97	9.82	2.82	11	251	3.84	3.83	0.715	9.46	50
01/14/97	8.95	2.03	10	311	2.36	3.96	0.74	9.54	66
01/22/97	7.92	1.67	11	315	2.83	4.21	0.761	9.21	72
01/28/97	13.2	1.91	19	263	3.12	4.31	0.722	9.3	76
02/06/97	10.5	1.31	21	95	1.13	1.33	0.21	3	38
02/11/97	15.7	1.59	20	249	2.61	3.95	0.654	8.71	66
02/18/97	8.58	1.94	17	256	3.01	4.14	0.685	8.14	70
02/25/97	12.4	2.15	18	210	2.5	3.33	0.573	7.87	58
03/04/97	12.1	1.53	16	213	2.98	3.71	0.652	8.77	62
03/11/97	14.7	1.44	17	227	2.83	3.84	0.667	9.21	64
03/18/97	14.4	1.7	19	213	2.65	3.63	0.633	8.42	62
03/25/97	11.2	1.55	16	245	2.32	3.64	0.626	7.98	68
04/01/97	13.1	1.39	17	177	2.74	3.43	0.602	7.56	58

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Sodium	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity, Hot
	mg/l								
04/08/97	15.4	1.61	18	138	2.3	3.15	0.529	7.13	52
04/15/97	13.6	1.61	17	205	2.4	3.77	0.626	8.32	54
04/29/97	13.3	1.73	16	258	2.44	3.88	0.653	8.32	60
05/06/97	15.3	1.64	18	258	2.49	4.12	0.593	8.53	76
06/10/97	11.4	1.57	14	251	2.72	3.69	0.576	8.04	62
06/17/97	13.5	1.81	16	232	4.18	4.15	0.644	9.73	74
06/24/97	15.4	1.76	15	277	2.8	4.35	0.656	9.33	70
07/01/97	11.1	1.93	15	260	5.95	5.05	0.721	12.4	76
07/07/97	12.2	1.75	15	84	2.9	4.65	0.678	9.77	64
07/15/97	13.2	2.14	15	265	5.54	5.08	0.709	13	78
07/22/97	11.2	2.49	15	329	6.05	4.87	0.689	10.7	74
07/29/97	11.9	1.94	16	284	4.6	4.52	0.707	10.4	72
08/05/97	12.4	2.26	17	178	7.3	5.3	0.723	12.2	86
08/12/97	14.1	2.35	15	335	8.44	5.64	0.808	14.1	86
08/19/97	12.3	1.92	15	297	6.54	4.7	0.74	10.7	90
09/02/97	11.1	1.95	12	311	3.93	4.76	0.79	11.1	66
09/09/97	10.1	1.89	13	161	2.67	4.53	0.741	10.5	82
09/16/97	10.4	1.27	13	145	3	4.07	0.651	8.99	82
09/23/97	11.4	2.02	13	282	3.26	4.96	0.824	11.5	82
09/30/97	11.8	1.69	14	256	2.85	4.73	0.789	11	80
10/07/97	11	1.45	15	239	3.09	5.05	0.718	11.3	96
10/14/97	11.8	1.71	16	311	3.72	5.51	0.796	11.6	86
10/21/97	12.3	1.68	16	320	3.94	5.51	<.01	11.6	92
10/28/97	13.1	1.67	18	287	4.17	5.68	0.774	11.3	104
11/04/97	13.4	1.81	17	325	4.52	4.94	0.686	10.8	80
11/18/97	11.9	1.77	17	394	3.19	4.15	0.638	9.04	76
12/02/97	12.4	1.92	16	227	3.49	4.06	0.614	9.02	74
12/09/97	11.2	1.63	16	256	3.36	4.39	0.735	9.54	72
12/16/97	13.2	1.61	15	267	3.27	4.57	0.691	9.87	70
12/30/97	12.2	1.91	19	192	3.78	4.99	0.728	11.6	66
01/06/98	13.9	1.84	22	218	3.22	3.67	0.558	8.4	72
05/12/98	12.8	1.5	17	226	2.24	2.9	0.521	6.62	48
05/19/98	12			199	2.48	3.36		7.74	52

Table C2. Jeddo Tunnel Outfall Water Quality Data, 1995-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Sodium	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity,Hot
	mg/l								
05/26/98	10.2	1.65	15	310	2.09	3.6	0.609	8.02	56
06/02/98	13.60	1.57	16.0	308	2.340	3.890	0.665	8.79	64
06/09/98	14.2	1.77	16	249	2.46	3.97	0.675	8.79	60
06/16/98	14.9	1.77	18	220	2.3	3.88	0.643	8.72	56
06/23/98	13.3	1.7	18	239	2.52	4	0.626	8.86	68
06/30/98	14.1	1.72	18	298	2.56	3.87	0.616	8.79	66
07/06/98	13.2	1.71	17	266	2.71	4.09	0.636	8.92	70
07/14/98	12.2	1.69	16	235	2.68	3.93	0.617	8.73	66
07/21/98	12.1	1.7	17	289	4.86	4.73	0.703	10.2	74
07/28/98	13.1	1.75	17	293	2.9	4.56	0.678	10	70
08/04/98	12.8	1.79	17	269	3.16	4.5	0.665	11	68
08/11/98	14.3	1.73	20	345	4.15	4.48	0.63	9.8	72
08/18/98	13.9	1.37	19	280	3.35	4.5	0.65	9.92	72
08/24/98	14.7	2.03	18	308	4.39	5.06	0.72	11.1	72
09/09/98	14.5	1.93	18	352	3.87	4.8	0.799	10.9	64
09/08/98	15.5	1.84	20	344	7.8	4.34	0.595	9.32	
09/15/98	13	1.66	17	369	3.21	4.45	0.64	10	62
09/22/98	14.1	1.9	17	305	3.46	5.04	0.66	10.2	74
09/29/98	16.5	1.93	19	375	3.73	5.34	0.746	11.9	74

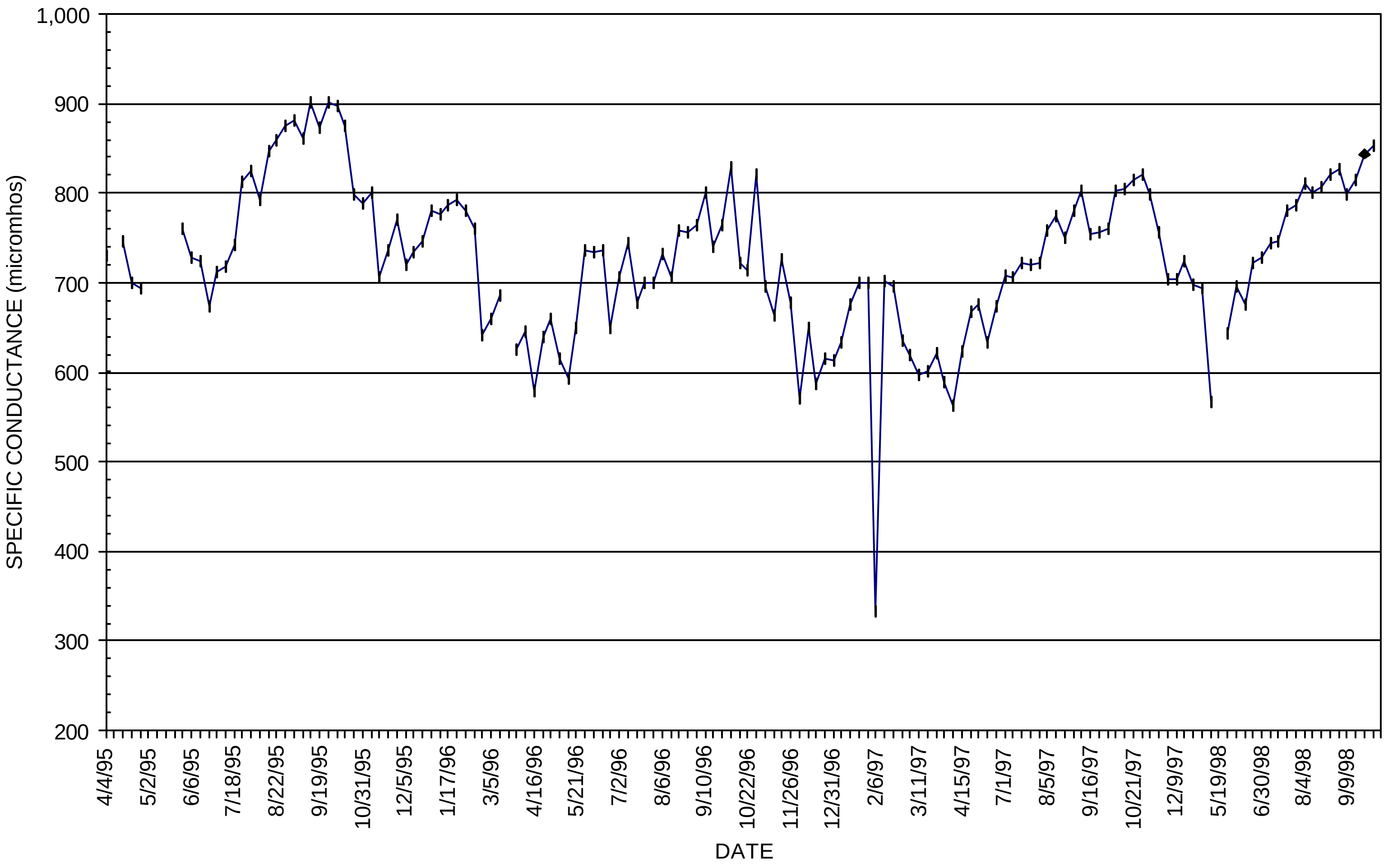

Figure C8. Jeddo Tunnel Specific Conductance, 1995-98

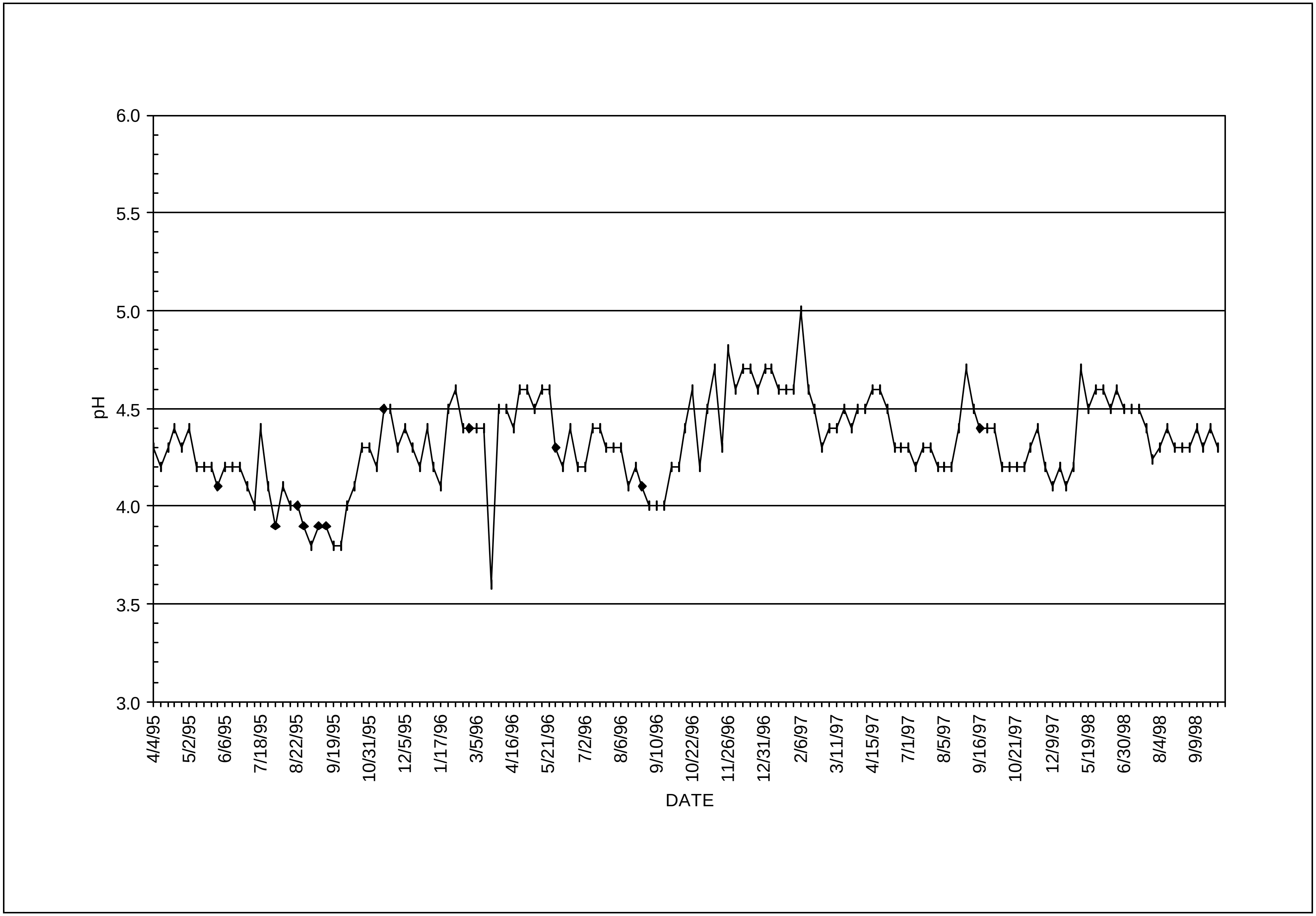

Figure C9. Jeddo Tunnel pH, 1995-98

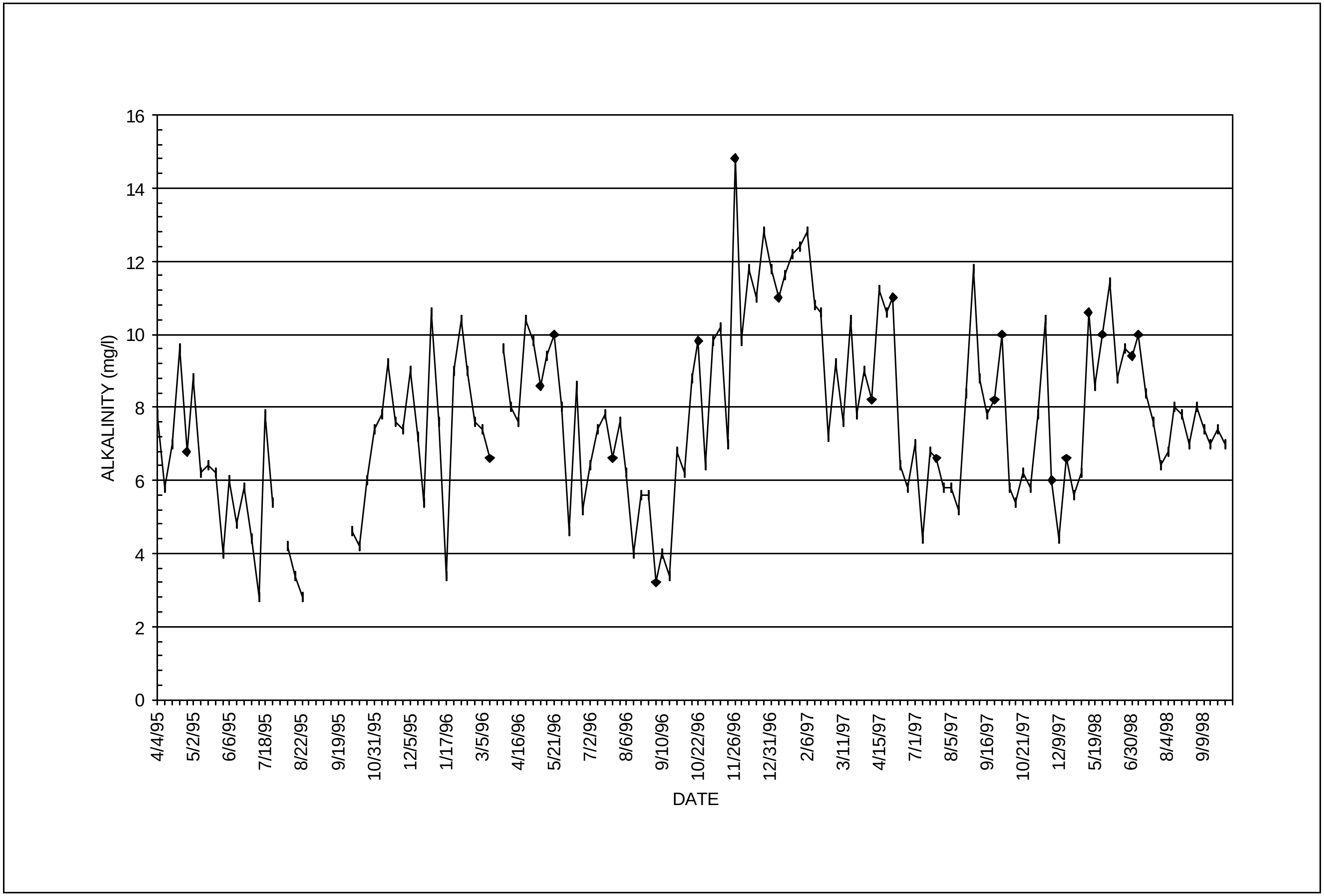

Figure C10. Jeddo Tunnel Alkaline Concentrations, 1995-98

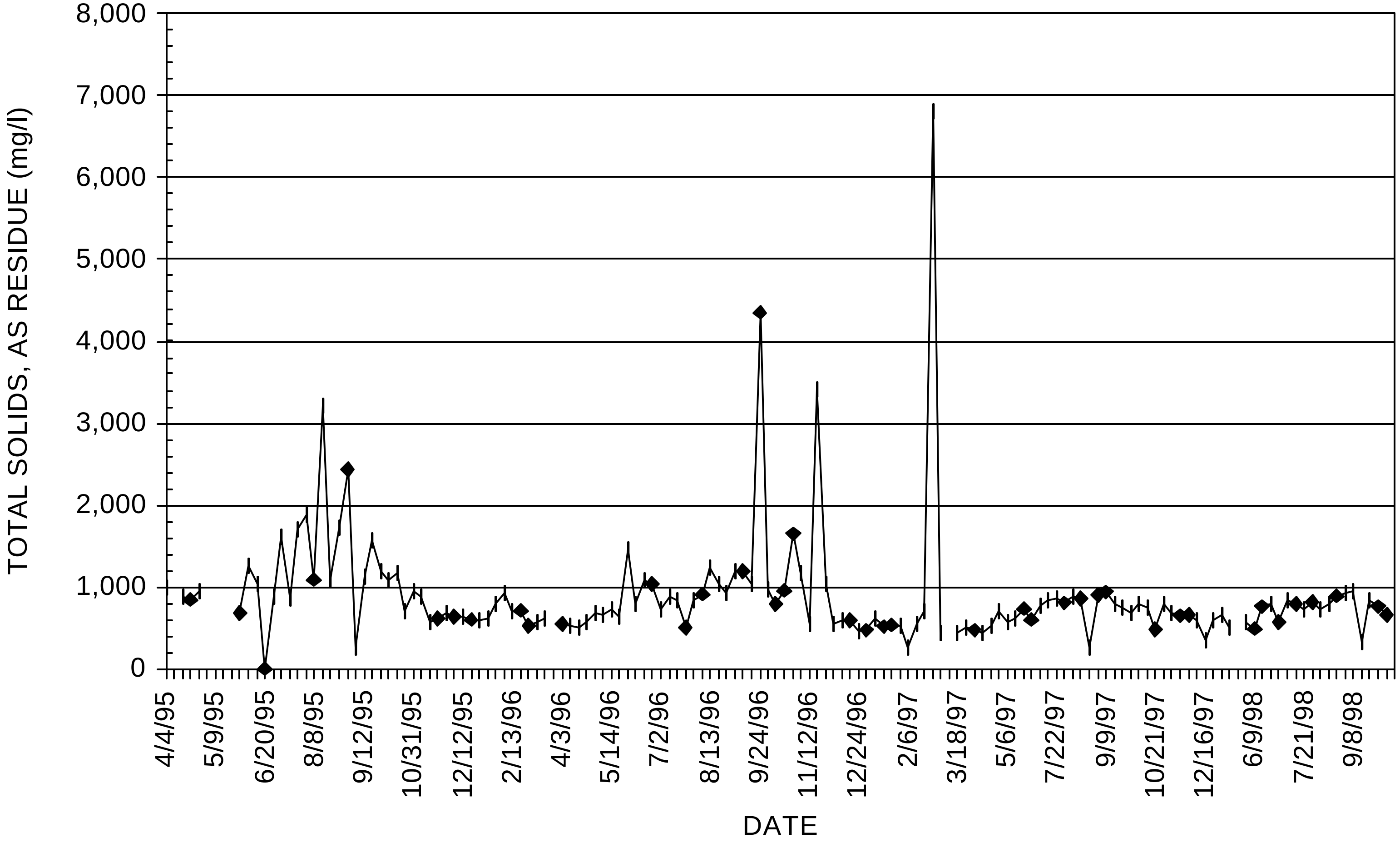

Figure C11. Jeddo Tunnel Total Solids, as Residue, 1995-98

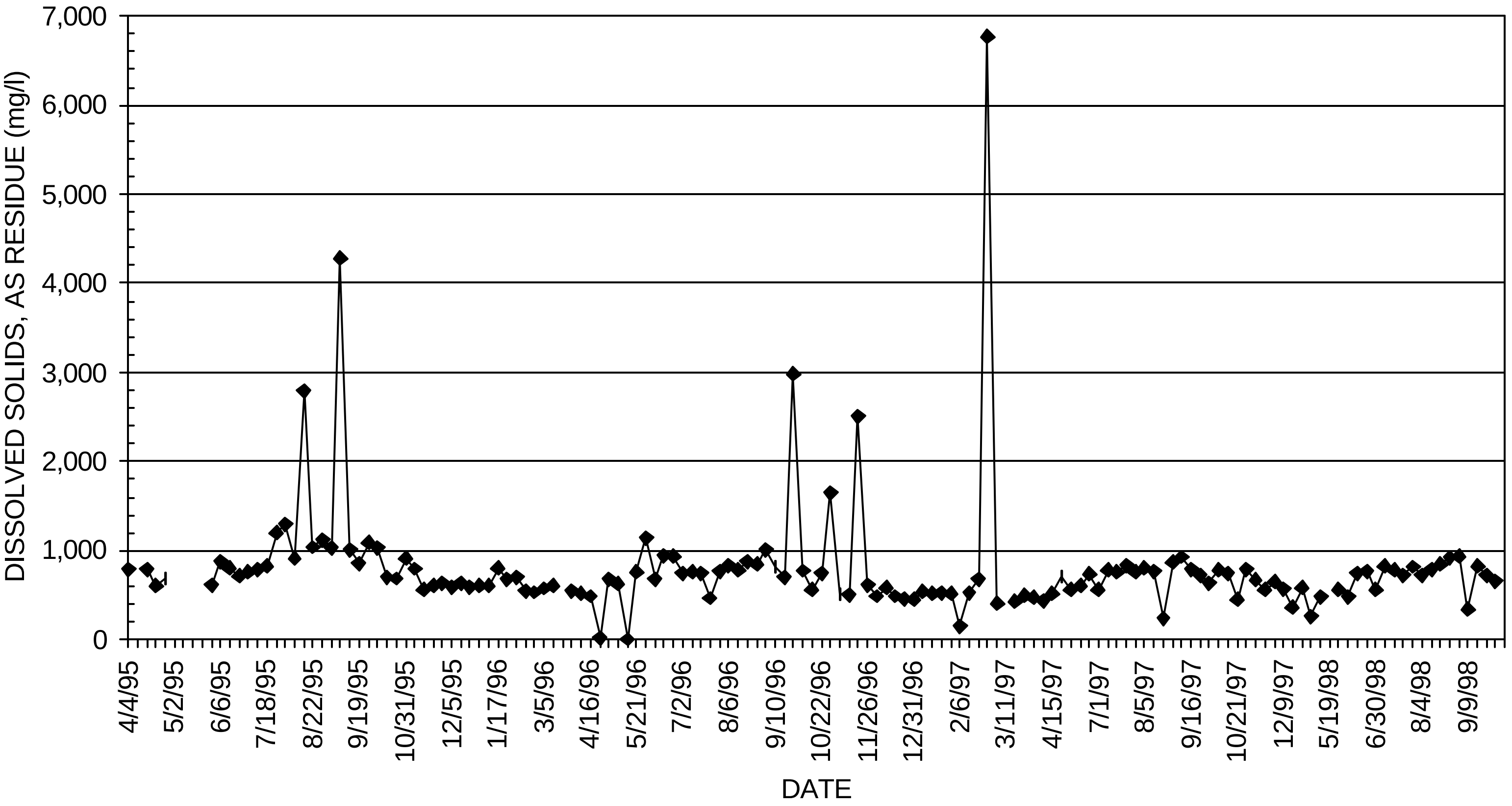

Figure C12. ***Jeddo Tunnel Dissolved Solids, as Residue, 1995-98***

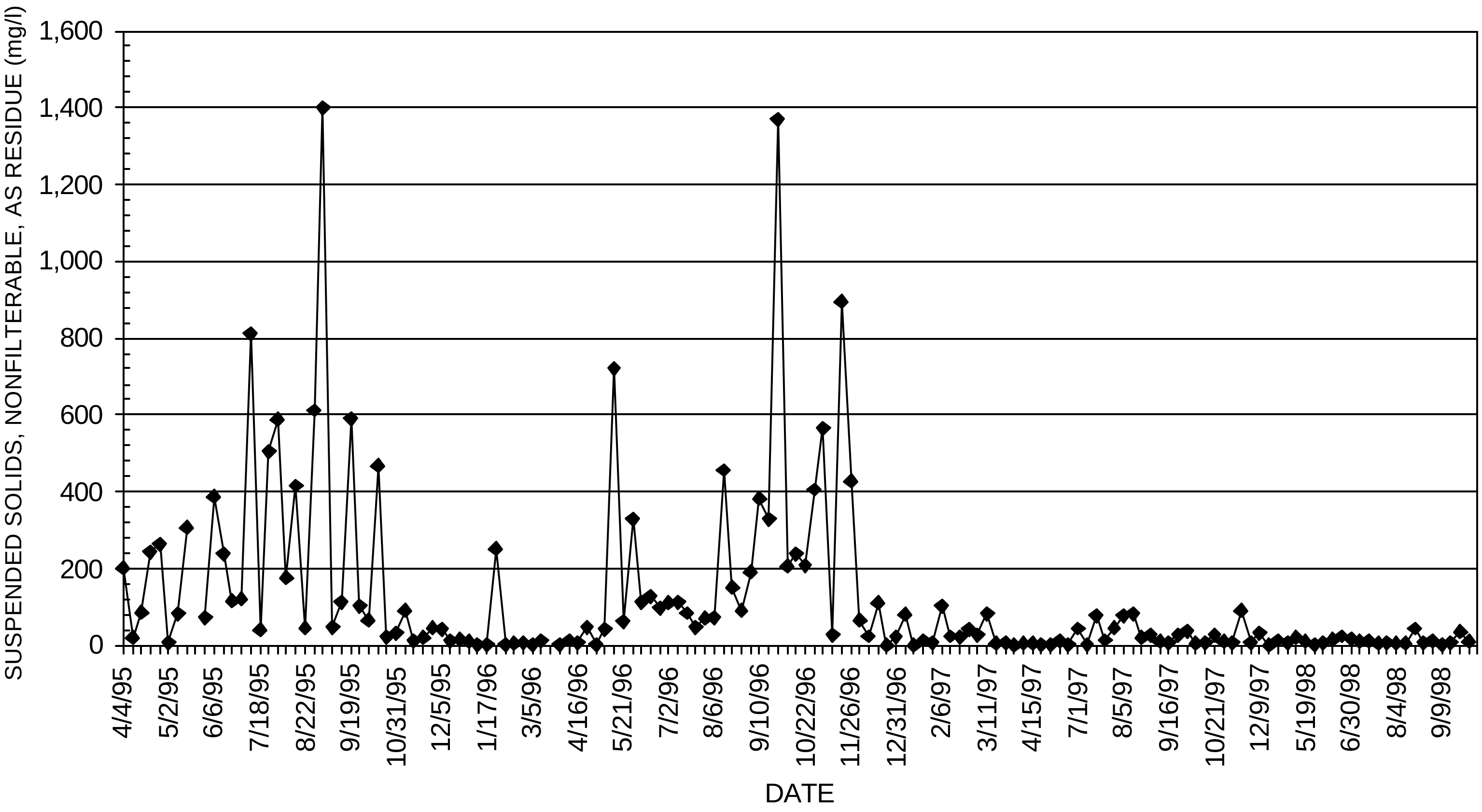

Figure C13.   Jeddo Tunnel Suspended Solids, Nonfilterable, as Residue, 1995-98

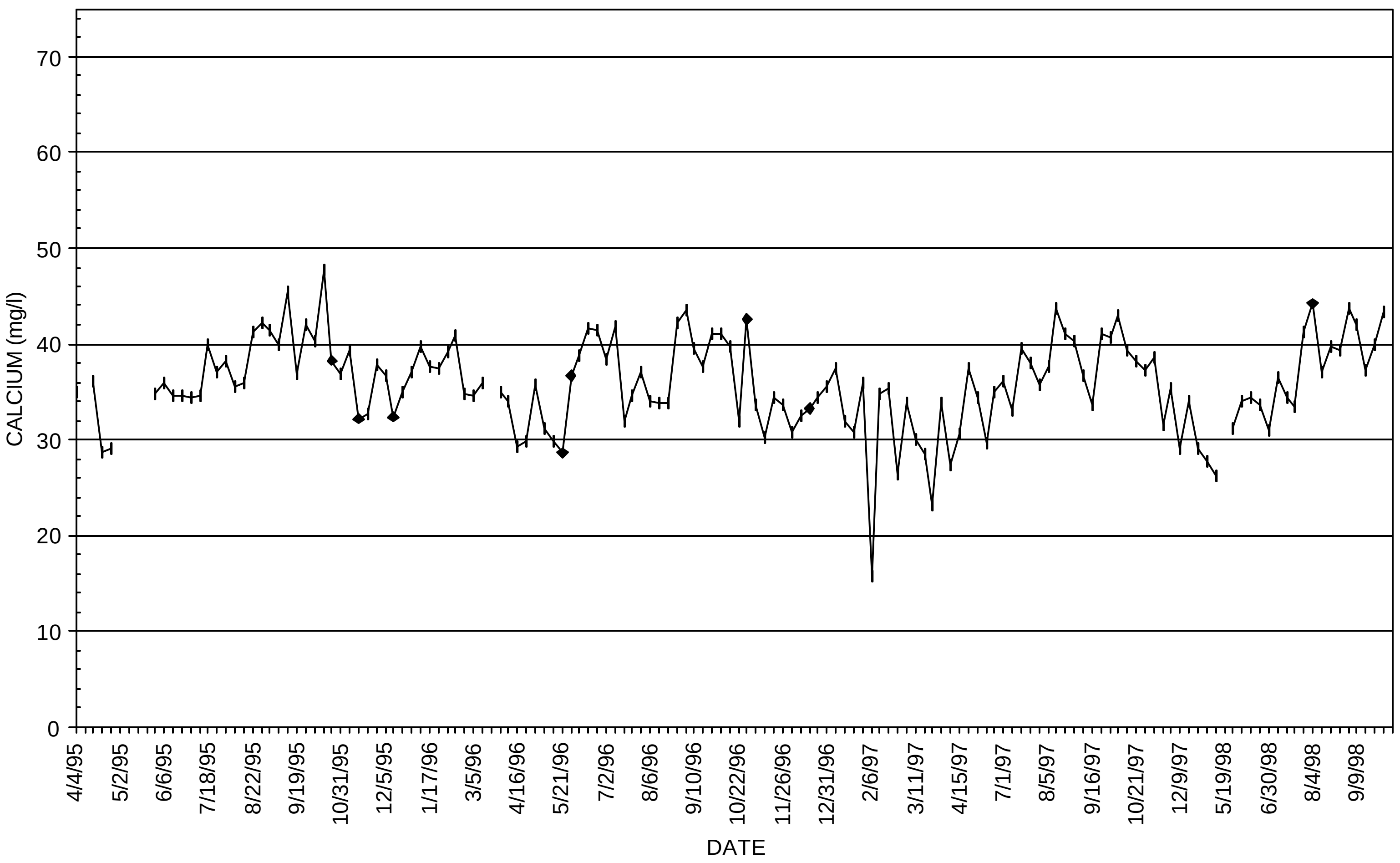

Figure C14.   Jeddo Tunnel Calcium Concentrations, 1995-98

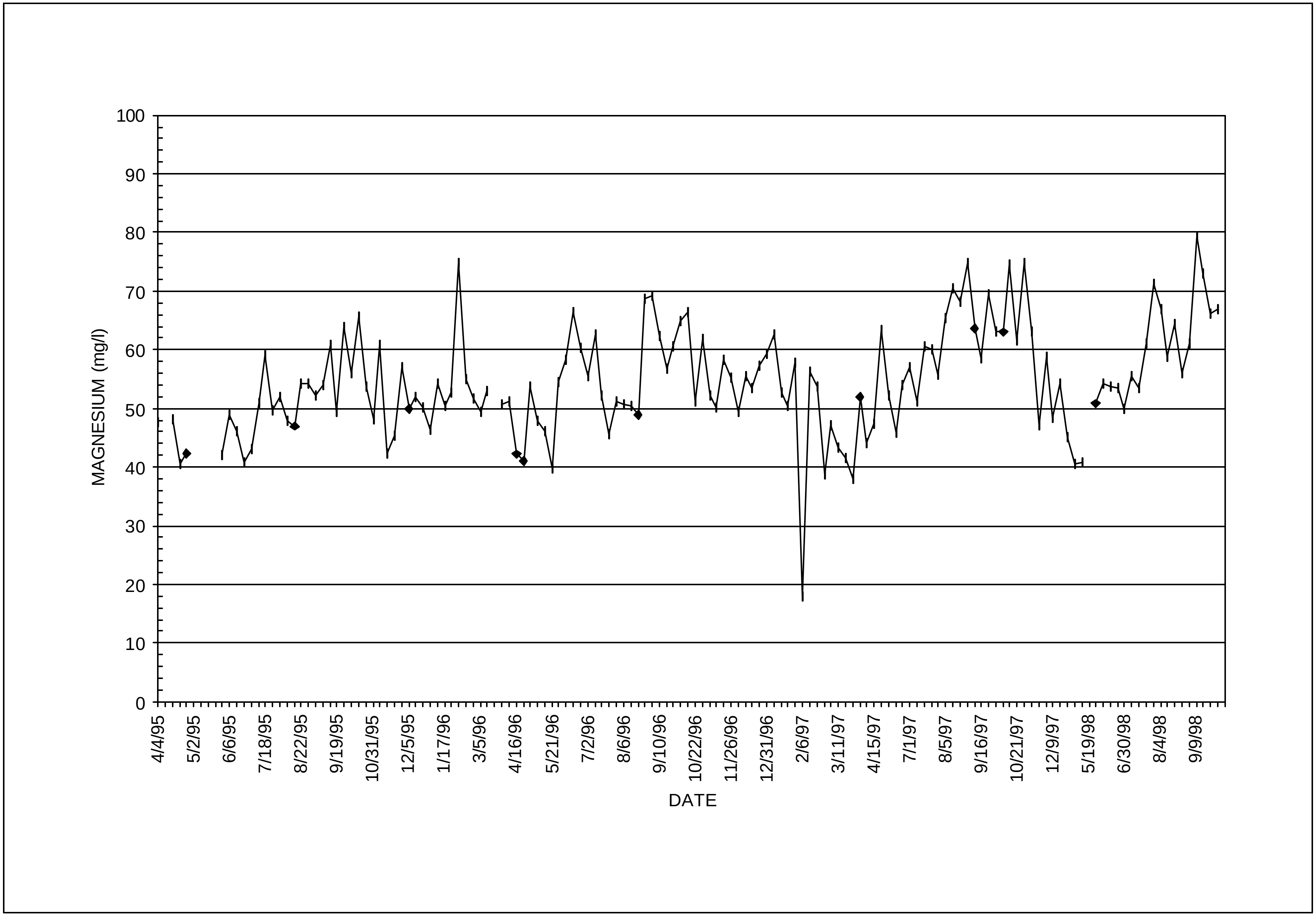

Figure C15. ***Jeddo Tunnel Magnesium Concentrations, 1995-98***

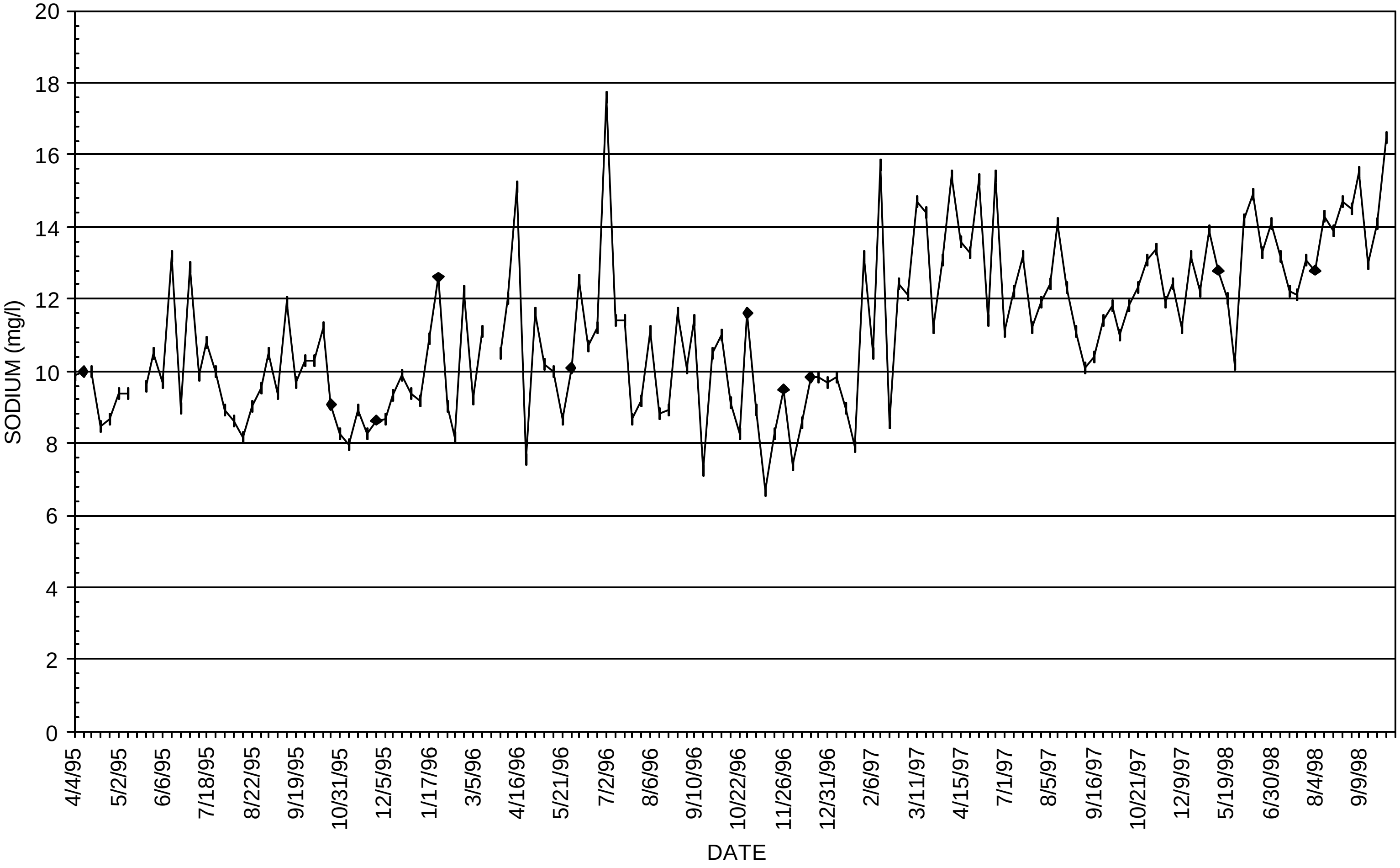

Figure C16. *Jeddo Tunnel Sodium Concentrations, 1995-98*

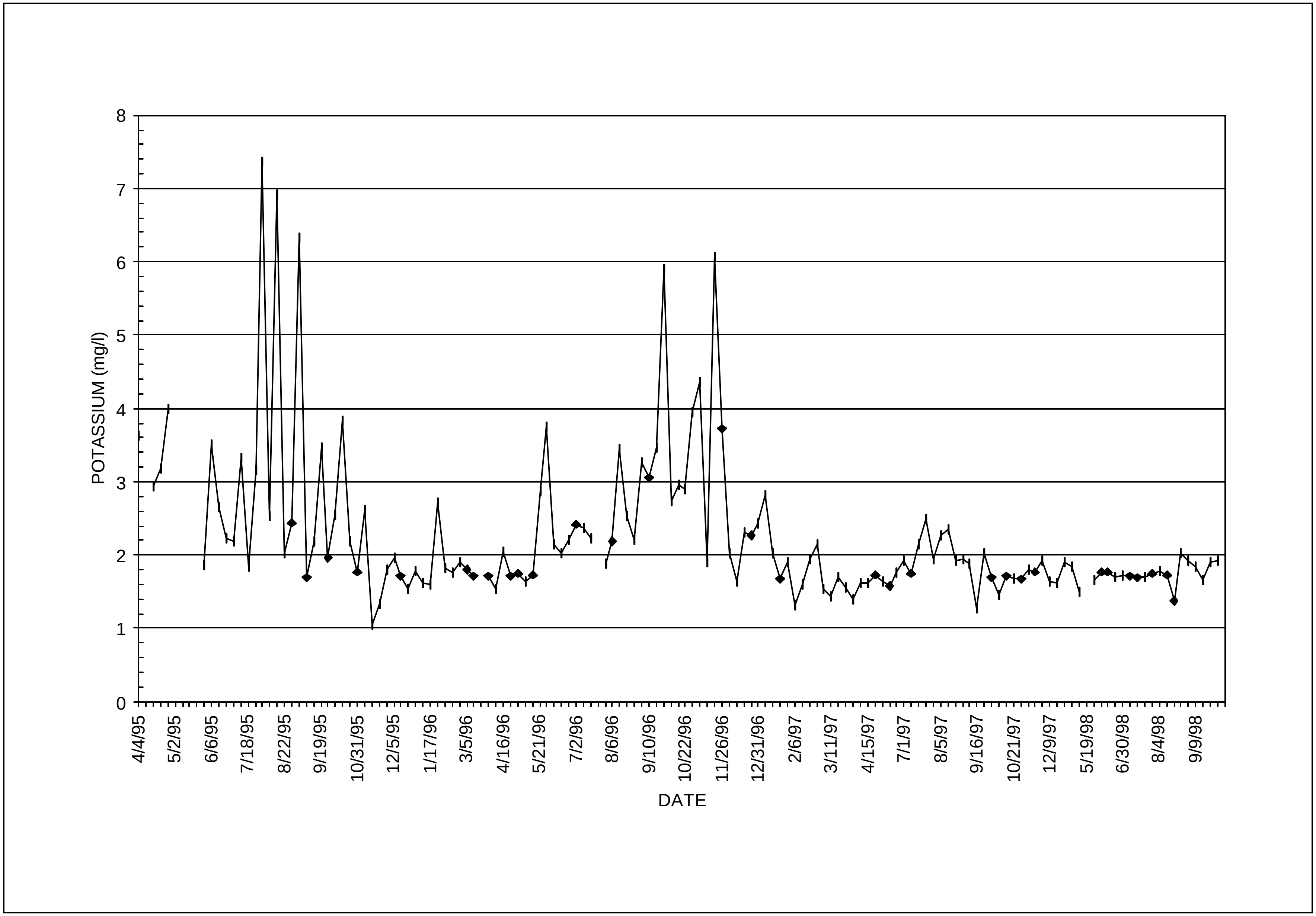

Figure C17. Jeddo Tunnel Potassium Concentrations, 1995-98

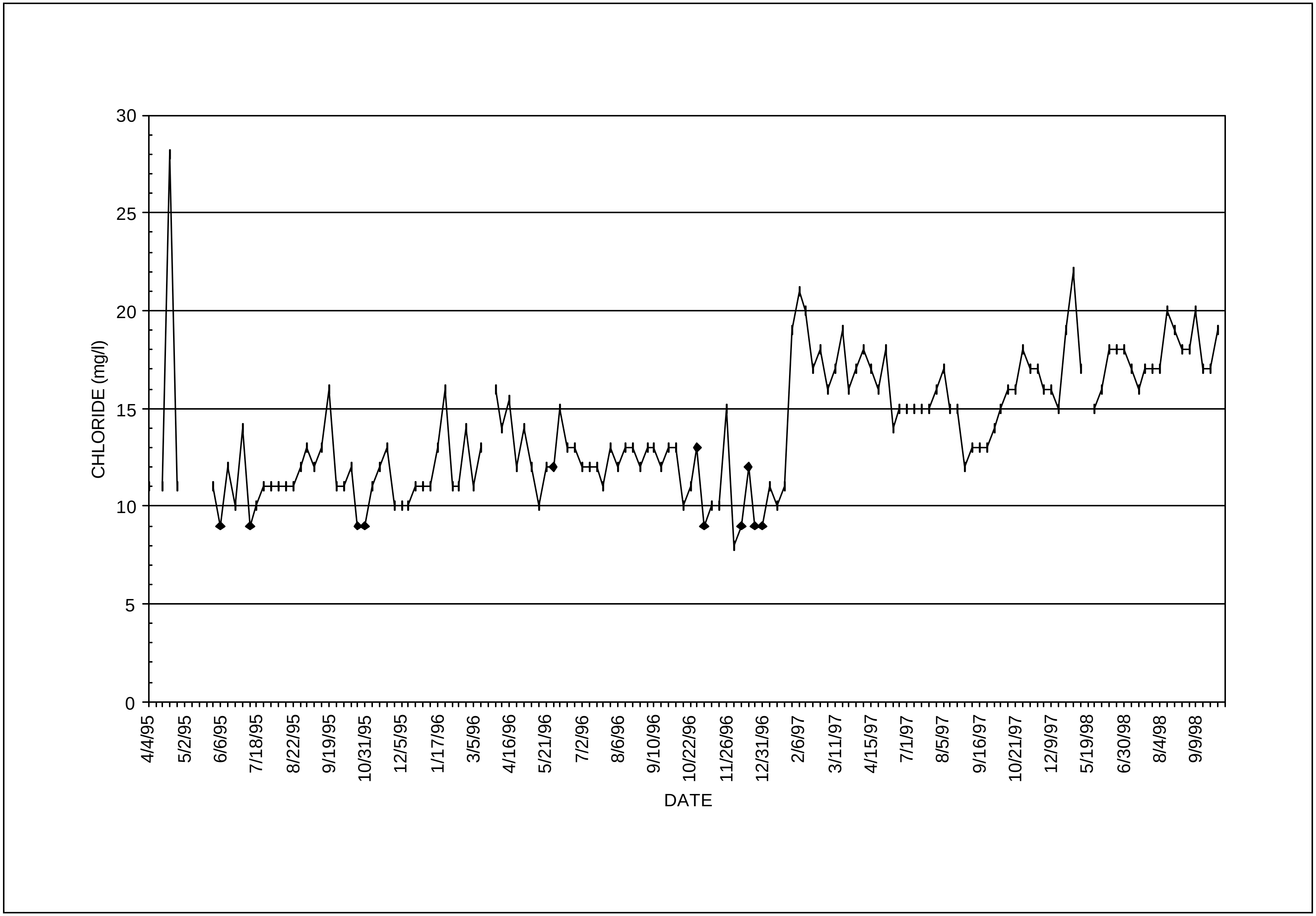

Figure C18. Jeddo Tunnel Chloride Concentrations, 1995-98

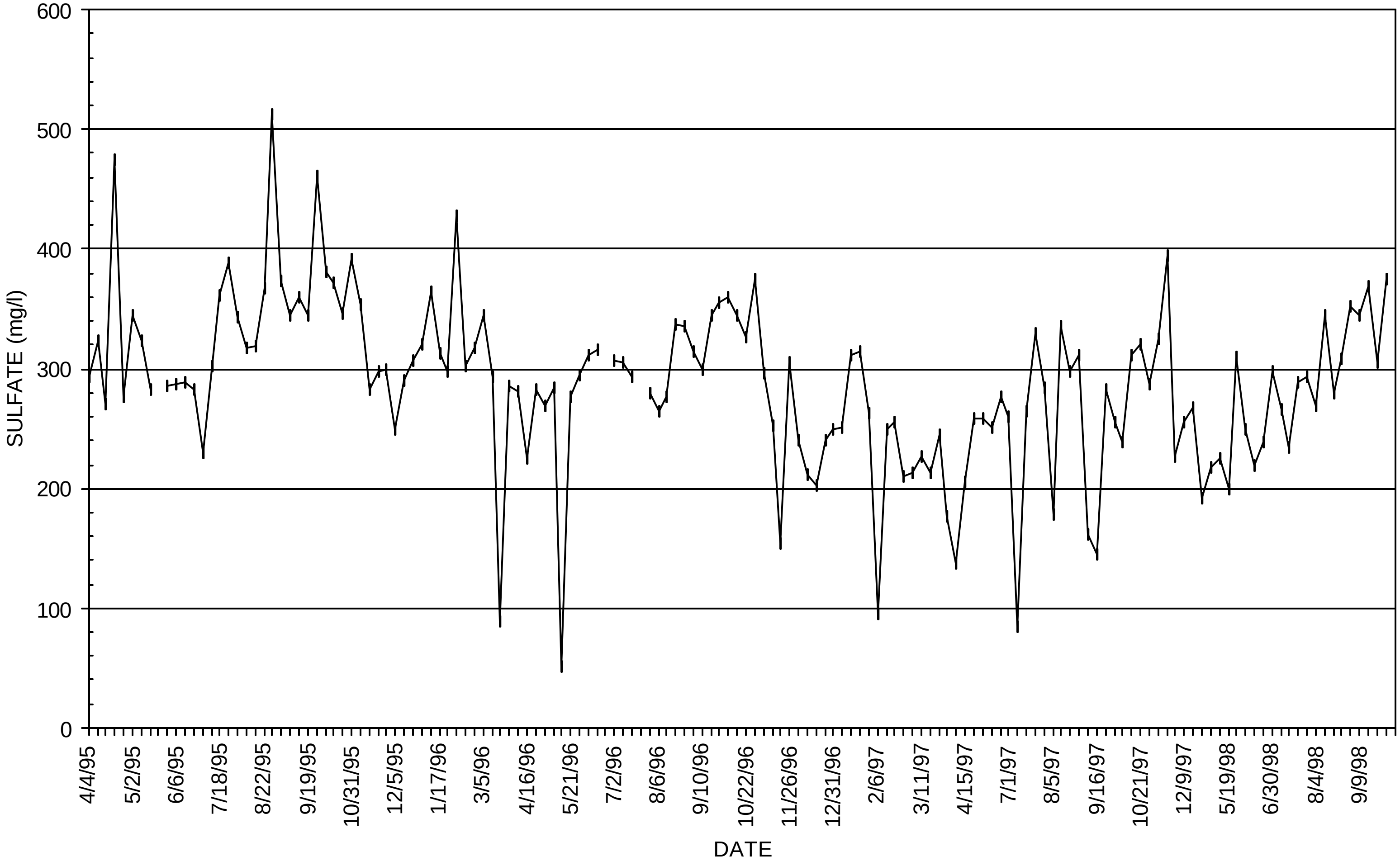

Figure C19. *Jeddo Tunnel Sulfate Concentrations, 1995-98*

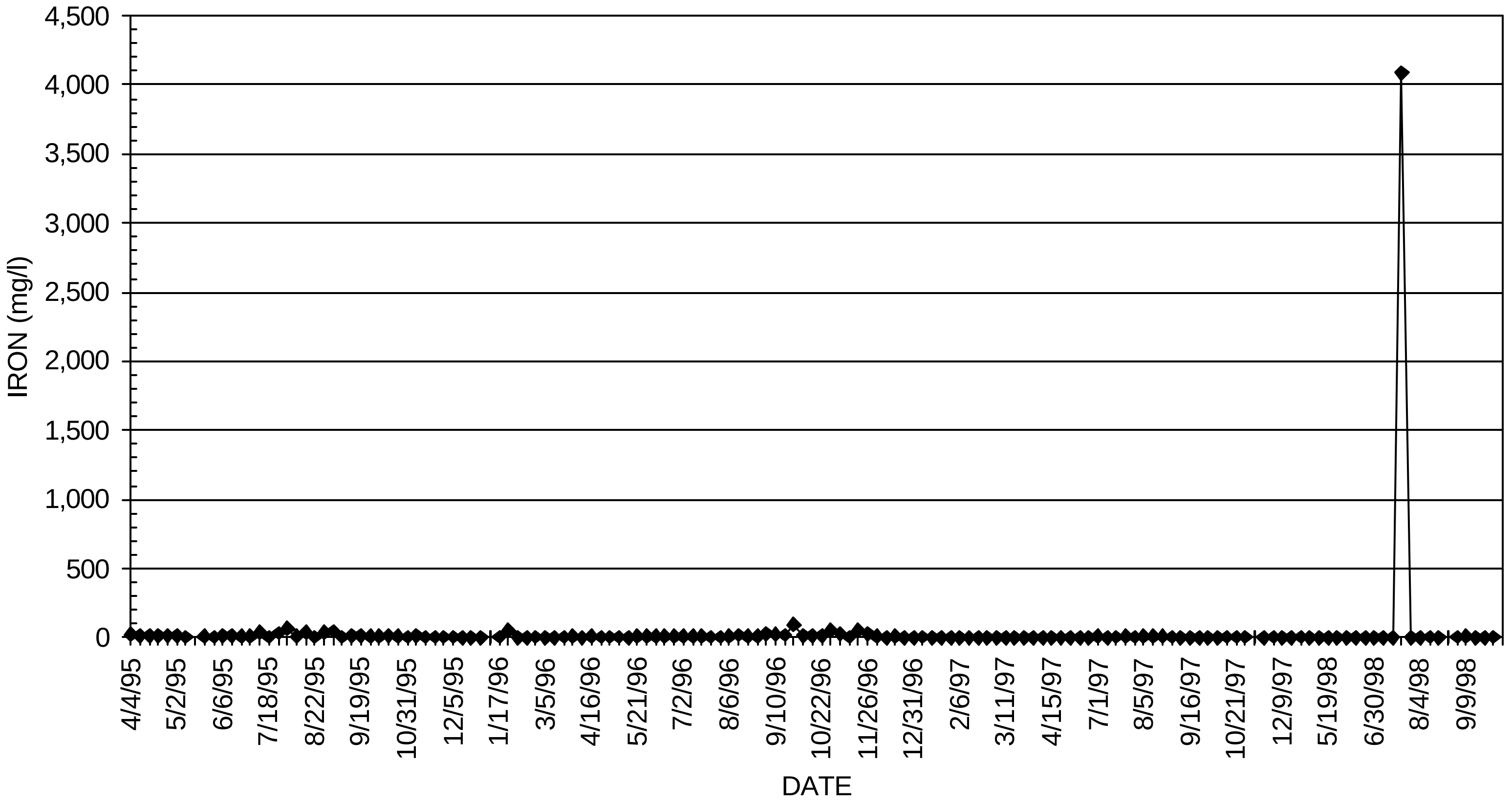

Figure C20. ***Jeddo Tunnel Iron Concentrations, 1995-98***

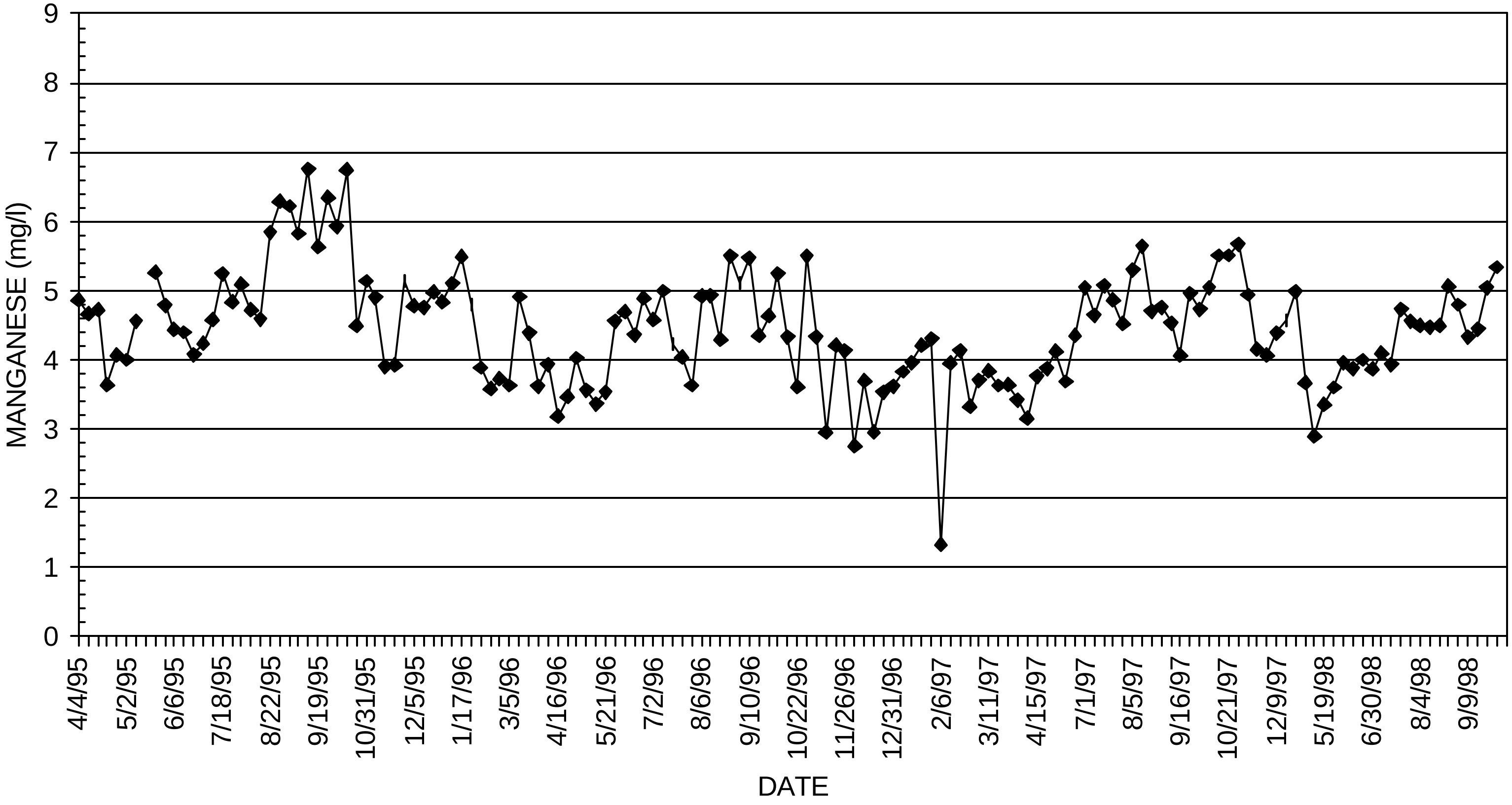

Figure C21. Jeddo Tunnel Manganese Concentrations, 1995-98

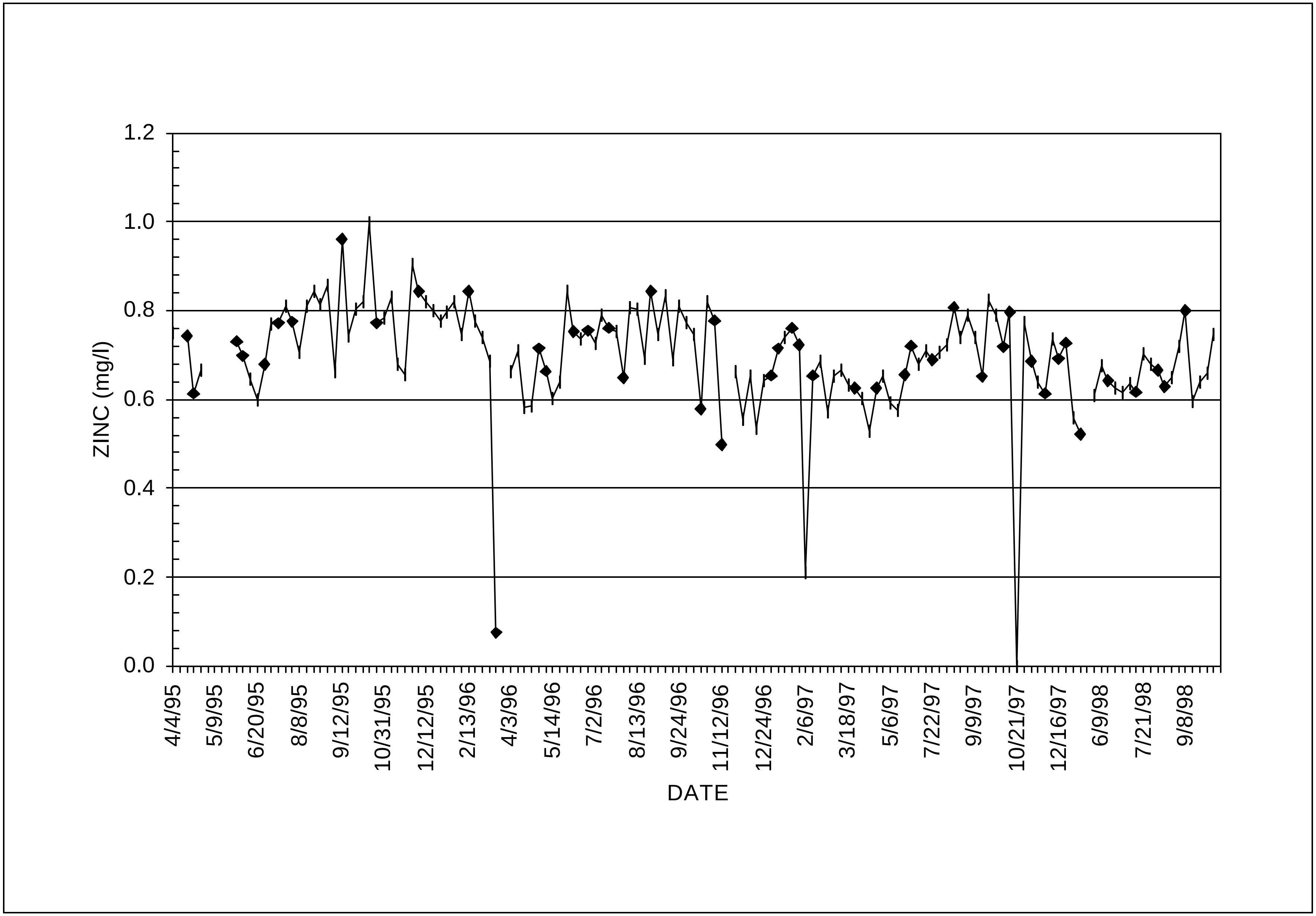

Figure C22. Jeddo Tunnel Zinc Concentrations, 1995-98

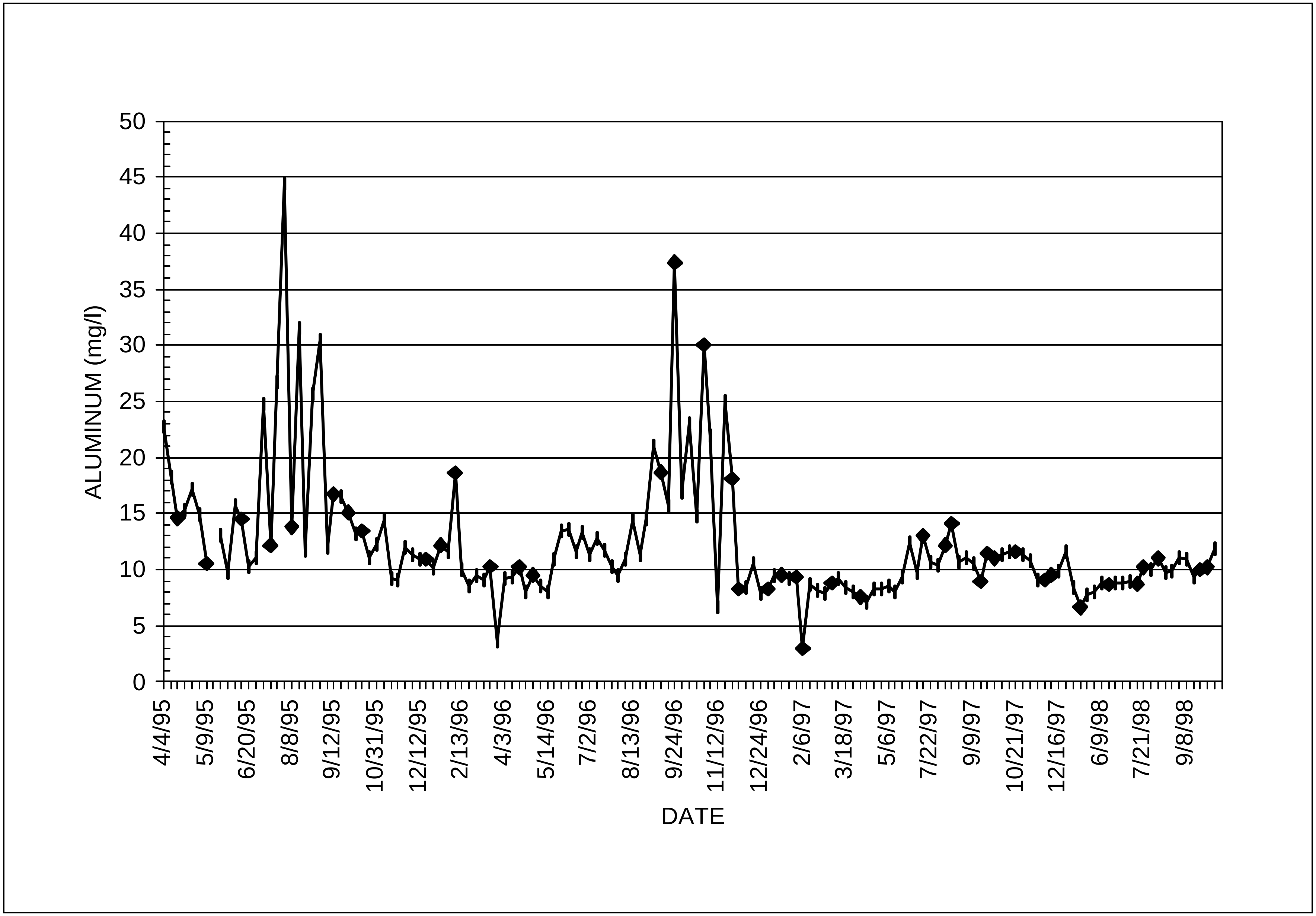

Figure C23. Jeddo Tunnel Aluminum Concentrations, 1995-98

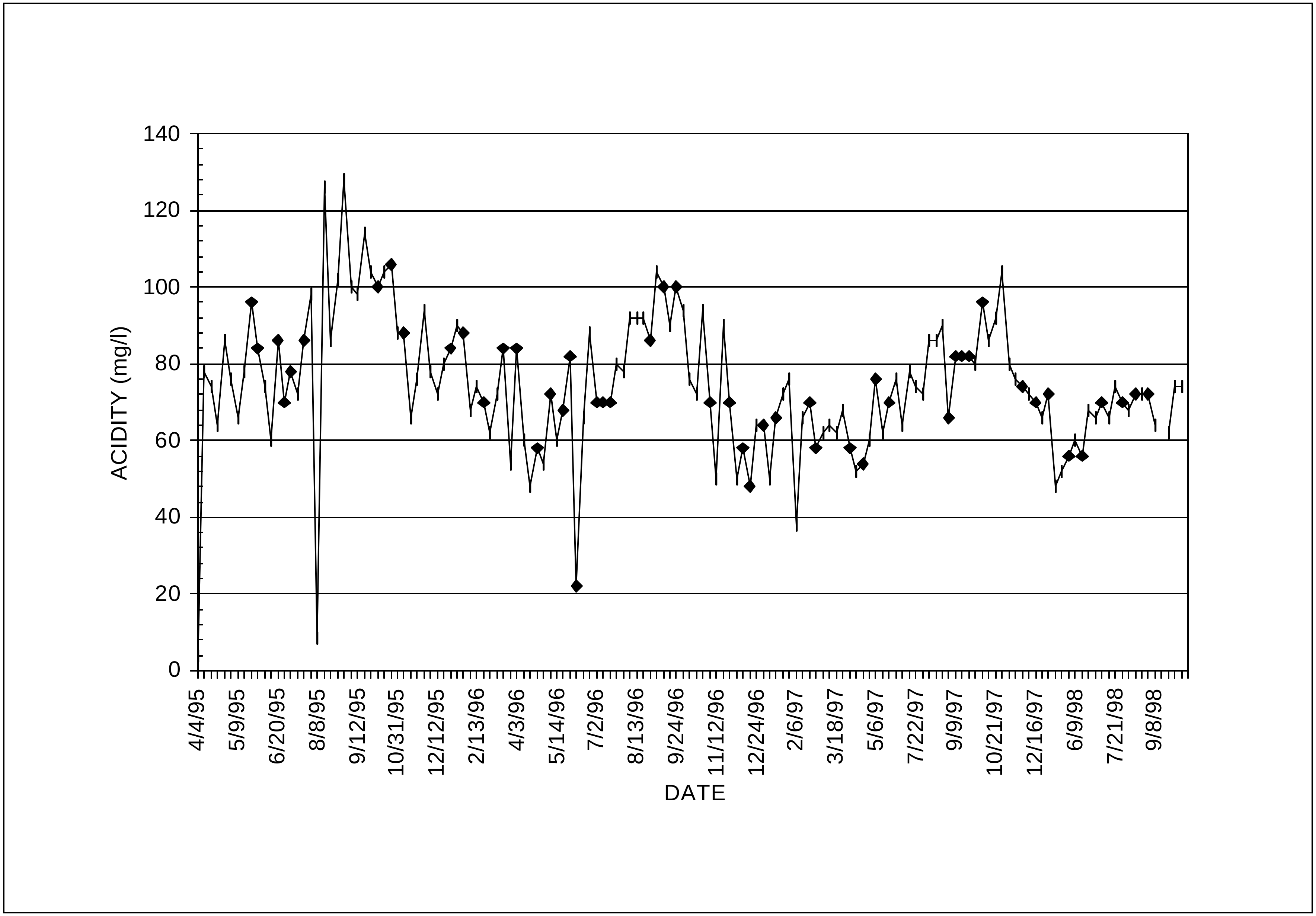

Figure C24. ***Jeddo Tunnel Acid Concentrations, 1995-98***

APPENDIX D

NESCOPECK CREEK WATER CHEMISTRY DATA

Table D1. Nescopeck Creek Water Quality, 1996-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)*

Sample Date	Specific Conductance.	pH	Alkalinity	Total Solids, as Residue	Dissolved Solids, as Residue	Suspended Solids, Nonfilterable, as Residue	Calcium	Magnesium
	ìmhos/cm		mg/l					
11/05/96	408	4.6	8.2	508	422	86	18.70	27.70
11/12/96	250	5	8.8	174	162	12	11.20	13.80
11/19/96	338	4.8	8.8	1,208	1,182	26	15.90	21.30
11/26/96	304	5.2	12.8	312	260	52	14.70	16.40
12/10/96	290	5	11	290	274	16	14.70	19.50
12/03/96	194	5	8.6	202	162	40	9.61	10.20
12/17/96	233	5.1	9.8	184	184	<2	11.20	12.40
12/24/96	302	4.9	10	194	194	<2	16.30	21.40
12/31/96	282	4.9	11.2	196	196	10	15.90	20.50
01/07/97	330	4.8	10	306	280	25	18.60	24.10
01/14/97	379	4.8	11	66	66	<2	18.10	26.30
01/21/97	375	4.9	11.8	250	240	10	17.10	22.30
01/28/97	369	5.2	12.4	262	218	44	15.60	14.50
02/04/97	696	4.6	11.2	568	560	8	32.00	50.00
02/11/97	341	4.9	11.2	216	184	32	17.10	22.20
02/18/97	360	4.9	11.8	214	200	14	18.10	22.80
02/25/97	274	4.6	8.6	228	198	30	11.80	13.20
03/04/97	297	4.8	9	152	152	<2	13.80	16.80
03/11/97	260	4.9	9.6	36,704	36,704	<2	12.70	13.20
03/18/97	283	4.9	11.2	194	194	<2	14.20	15.00
03/25/97	312	4.7	9	12	2	10	17.20	19.20
04/08/97	266	4.8	8.6	172	170	2	12.00	14.60
04/01/97	252	5.1	9.4	186	174	12	13.40	10.50
04/15/97	324	4.8	10.8	220	218	2	18.30	20.50
04/29/97	327	4.9	10.8	314	314	2	17.00	21.60
05/06/97	321	4.9	12.2	234	232	2	16.70	21.10
06/10/97	364	4.7	9	340	328	12	17.60	22.60
06/17/97	417	4.7	8.8	368	358	10	23.40	29.90
06/24/97	439	4.7	8.6	460	460	2	24.10	31.10
07/01/97	486	4.7	10.2	388	384	4	24.30	35.90
07/08/97	501	4.6	7.6	540	526	14	23.70	32.10

Table D1. Nescopeck Creek Water Quality, 1996-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Specific Conductance.	pH	Alkalinity	Total Solids, as Residue	Dissolved Solids, as Residue	Suspended Solids Nonfilterable, as Residue	Calcium	Magnesium
	ìmhos/cm		mg/l					
07/15/97	489	4.7	10	500	484	16	27.50	37.10
07/22/97	528	4.6	9.4	564	548	16	29.30	40.10
07/29/97	529	4.6	8.6	550	540	10	27.40	37.00
08/05/97	552	4.7	10.2	608	598	10	24.00	31.70
08/12/97	602	4.6	9.4	624	616	8	32.90	44.90
08/19/97	330	4.8	9.6	356	332	24	20.20	23.30
08/26/97	515	4.7	9.4	544	512	32	27.90	39.70
09/02/97	377	4.9	10.8	380	352	28	20.80	27.90
09/09/97	570	4.6	9.2	640	628	14	27.30	41.10
09/16/97	446	4.7	9.2	460	444	16	25.10	32.00
09/23/97	534	4.7	11	538	510	28	29.00	40.20
09/30/97	484	4.6	7.8	368	320	48	28.00	37.70
10/07/97	569	4.7	10	622	612	10	31.70	42.80
10/14/97	575	4.7	9.8	482	466	16	28.70	43.10
10/21/97	564	4.7	10.6	436	426	10	25.90	36.30
10/28/97	436	4.8	10.6	414	400	14	20.70	28.80
11/04/97	400	4.8	11.4	274	264	10	21.00	29.10
11/18/97	417	4.9	14	310	310	<2	18.60	21.50
12/02/97	267	4.9	10.2	298	288	10	14.70	15.30
12/09/97	339	4.8	9.4	252	220	32	92.50	39.30
12/16/97	369	4.8	14.2	266	260	6	18.90	22.00
12/30/97	301	4.8	9.8	288	288	<2	13.20	12.80
01/06/98	249	5.1	10.4	230	204	26	11.40	9.19
05/12/98	193	5.8	10.4	182	152	30	9.86	8.51
05/19/98		4.7	8			14		
05/26/98	397	4.7	9.6	336	336	<2	19.30	28.40
06/02/98	400	4.9	11.4	348	328	20	20.00	25.90
06/09/98	458	4.8	11	790	790	<2	23.10	30.90
06/16/98	256	5	9	218	194	24	13.70	15.00
06/23/98	361	4.9	9.8	382	368	14	17.20	23.50
06/30/98	412	4.8	10.2	314	308	6	18.10	23.50

Table D1. Nescopeck Creek Water Quality, 1996-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Specific Conductance.	pH	Alkalinity	Total as Residue	Dissolved Solids, as Residue	Suspended Solids, Nonfilterable, as Residue	Calcium	Magnesium
	ìmhos/cm		mg/l					
07/06/98	470	4.8	11.4	512	500	12	23.6	30.3
07/14/98	498	4.7	9.8	480	454	26	24.7	29.1
07/21/98	471	4.7	10.4	430	422	8	21.1	30.6
07/28/98	558	4.6	9.6	540	522	18	29.2	44.5
08/04/98	594	4.6	9	532	526	6	32.3	41.9
08/11/98	458	4.9	10.8	373	369	4	23	29.8
08/18/98	544	4.8	10.8	511	511	2	28.7	38.2
08/24/98	588	4.6	10.4				30.6	42.4
09/01/98	608	4.7	11	666	648	18	33.3	50
09/08/98	429	4.8	9.4	454	424	30	24.3	31
09/15/98	591	4.6	9.2	668	660	8	27.5	41.8
09/22/98	604	4.7	9.8	496	484	12	30.1	44.1
09/29/98	614	4.7	10.2	596	596	<2	33.1	44.8
10/06/98	597	4.5	10	570	554	16	30.5	41.5
10/13/98	454	4.7	10	378	360	18	22.3	30
10/27/98	561	4.7	10.4	424	412	12	28	40

Table D1. Nescopeck Creek Water Quality, 1996-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Sodium	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity, Hot
	mg/								
11/05/96	6.30	1.93	6.3	154	33.800	1.930	0.314	5.08	34.00
11/12/96	4.86	1.20	9.0	38	2.000	0.867	0.147	2.37	12.80
11/19/96	7.10	1.29	9.0	114	15.500	1.610	0.282	3.82	18.60
11/26/96	7.76	1.62	12.0	122	2.460	1.260	0.177	3.65	15.40
12/10/96	8.29	1.21	12.0	90	1.180	1.160	0.206	2.78	15.60
12/03/96	5.06	0.96	7.0	62	1.770	0.679	0.183	2.10	10.20
12/17/96	7.23	1.06	12.0	32	0.954	0.779	0.141	1.75	11.20
12/24/96	8.88	1.56	12.0	92	1.070	1.320	0.246	2.98	28.00
12/31/96	7.75	1.91	11.0	54	1.960	1.240	0.224	3.56	22.00
01/07/97	8.23	1.55	13.0	89	2.350	1.570	0.287	4.25	140.00
01/14/97	7.79	1.31	12.0	154	1.040	1.810	0.330	3.32	34.00
01/21/97	7.44	1.15	13.0	139	0.995	1.830	0.324	3.44	28.00
01/28/97	32.60	2.02	55.0	61	2.450	1.070	0.181	3.09	17.40
02/04/97	11.90	2.01	17.0	255	3.620	3.840	0.606	8.21	90.00
02/11/97	11.60	1.09	18.0	131	0.898	1.450	0.236	3.13	22.00
02/18/97	7.02	1.16	20.0	71	0.933	1.450	0.242	2.77	24.00
02/25/97	8.61	1.14	15.0	70	0.804	1.070	0.185	2.45	19.80
03/04/97	13.20	0.94	20.0	200	0.907	1.200	0.211	2.78	18.80
03/11/97	12.30	1.00	18.0	72	0.783	1.050	0.185	2.50	18.40
03/18/97	12.40	1.10	20.0	78	0.860	1.190	0.206	2.80	52.00
03/25/97	10.10	1.25	17.0	95	0.815	1.390	0.239	3.01	24.00
04/08/97	10.70	1.23	18.0	50	0.811	0.938	0.171	2.22	13.40
04/01/97	19.10	1.12	33.0	41	0.745	0.661	0.120	1.52	6.80
04/15/97	10.40	1.19	17.0	74	0.853	1.410	0.244	3.11	15.60
04/29/97	9.74	1.20	16.0	93	0.821	1.360	0.226	2.78	17.40
05/06/97	9.82	0.99	16.0	94	0.815	1.390	0.200	2.96	19.40
06/10/97	9.83	1.12	14.0	121	0.929	1.730	0.258	3.73	20.00
06/17/97	10.10	1.02	16.0	119	1.420	2.120	0.327	4.70	36.00
06/24/97	14.50	1.36	16.0	160	1.230	2.450	0.366	5.15	34.00
07/01/97	10.70	1.28	15.0	178	1.160	3.050	0.428	6.15	38.00
07/08/97	11.00	1.57	16.0	177	1.350	2.680	0.383	5.47	7.60

Table D1. Nescopeck Creek Water Quality, 1996-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Sodium	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity, Hot
	mg/l								
07/15/97	12.30	1.60	15.0	161	1.110	2.840	0.419	5.72	38.00
07/22/97	12.00	2.30	18.0	201	1.230	3.210	0.455	6.50	46.00
07/29/97	11.50	1.60	18.0	176	1.310	3.090	0.445	6.50	42.00
08/05/97	10.10	1.67	19.0	189	1.300	2.790	0.390	5.78	46.00
08/12/97	13.90	1.82	18.0	232	1.100	3.990	0.547	7.97	54.00
08/19/97	10.90	1.49	15.0	103	2.290	1.550	0.236	3.39	26.00
08/26/97	11.10	1.59	18.0	150	1.770	2.530	0.396	5.53	34.00
09/02/97	10.80	1.45	15.0	123	1.520	1.710	0.274	3.97	18.20
09/09/97	10.20	1.27	17.0	58	1.260	2.800	0.427	5.97	46.00
09/16/97	9.77	0.85	15.0	147	1.410	1.990	0.309	4.53	32.00
09/23/97	11.60	1.93	17.0	237	2.090	3.080	0.479	6.83	42.00
09/30/97	11.40	1.36	17.0	134	1.170	2.680	0.408	5.82	38.00
10/07/97	10.60	1.51	17.0	223	1.150	3.150	0.445	6.78	50.00
10/14/97	11.20	1.69	18.0	201	0.558	3.510	0.500	0.70	44.00
10/21/97	10.60	1.55	18.0	196	0.904	3.470	2.430	6.78	48.00
10/28/97	10.30	1.42	18.0	126	0.646	2.440	0.337	5.11	34.00
11/04/97	10.70	1.51	17.0	137	0.710	1.980	0.272	4.17	26.00
11/18/97	12.00	1.50	22.0	112	0.938	1.770	0.256	3.74	28.00
12/02/97	9.36	1.22	17.0	92	0.729	0.933	0.144	2.12	15.40
12/09/97	10.30	1.09	16.0	87	0.781	1.620	0.310	3.40	24.00
12/16/97	12.60	1.19	21.0	104	0.913	1.720	0.260	3.67	22.00
12/30/97	13.70	2.36	30.0	55	0.811	1.300	0.188	2.90	12.40
01/06/98	13.10	1.06	27.0	50	1.080	0.730	0.110	1.74	8.60
05/12/98	10.00	0.95	15.0	36	0.901	0.607	0.108	1.57	6.20
05/19/98	10.10			583	0.916	1.470		3.36	20.00
05/26/98	10.20	1.23	16.0	185	0.856	1.850	0.312	4.03	26.00
06/02/98	10.70	1.37	16.0	146	0.871	1.890	0.321	4.08	26.00
06/09/98	12.90	1.38	18.0	147	1.170	2.230	0.359	4.67	30.00
06/16/98	9.87	1.11	14.0	82	0.728	1.050	0.169	2.28	16.00
06/23/98	8.89	1.29	15.0	104	0.995	1.500	0.234	3.32	24.00
06/30/98	10.50	1.47	16.0	152	1.310	1.820	0.287	4.17	28.00

Table D1. Nescopeck Creek Water Quality, 1996-98 *(sample collected by Friends of Nescopeck, analyzed by Pa. DEP)—Continued*

Sample Date	Sodium	Potassium	Chloride	Sulfate	Iron	Manganese	Zinc	Aluminum	Total Acidity, Hot
	mg/l								
07/06/98	11.5	1.45	17	172	1.14	2.25	0.348	4.76	28
07/14/98	11.1	1.56	17	143	1.15	2.26	0.357	4.53	34
07/21/98	10.6	1.44	17	168	1.09	2.39	0.35	4.8	32
07/28/98	11.4	1.52	18	227	1.28	2.87	0.422	6.05	36
08/04/98	11.6	1.46	18	205	1.15	2.82	0.411	6.18	38
08/11/98	13.5	2.01	23	154	1.09	2.12	0.289	4.19	24
08/18/98	12.4	1.07	19	177	0.902	2.7	0.389	5.85	38
08/24/98	13.2	2.21	20	146	1.34	3.3	0.455	7.17	40
09/01/98	13.1	1.78	19	254	1.45	3.16	0.477	6.54	32
09/08/98	12.9	2.38	20	59	3.92	1.96	0.282	5.44	20
09/15/98	11.7	1.51	18	242	1.53	2.7	0.403	5.63	30
09/22/98	12.8	1.89	18	199	1.44	3.07	0.419	5.86	36
09/29/98	13.7	1.78	20	211	1.15	3.46	0.478	7.21	40
10/06/98	12.8	1.6	19	253	1.09	2.88	0.434	6.02	36
10/13/98	10.6	1.34	16	148	1.36	2.18	0.35	4.59	28
10/27/98	11.4	1.54	15	171	1.15	2.73	0.426	0.2	34

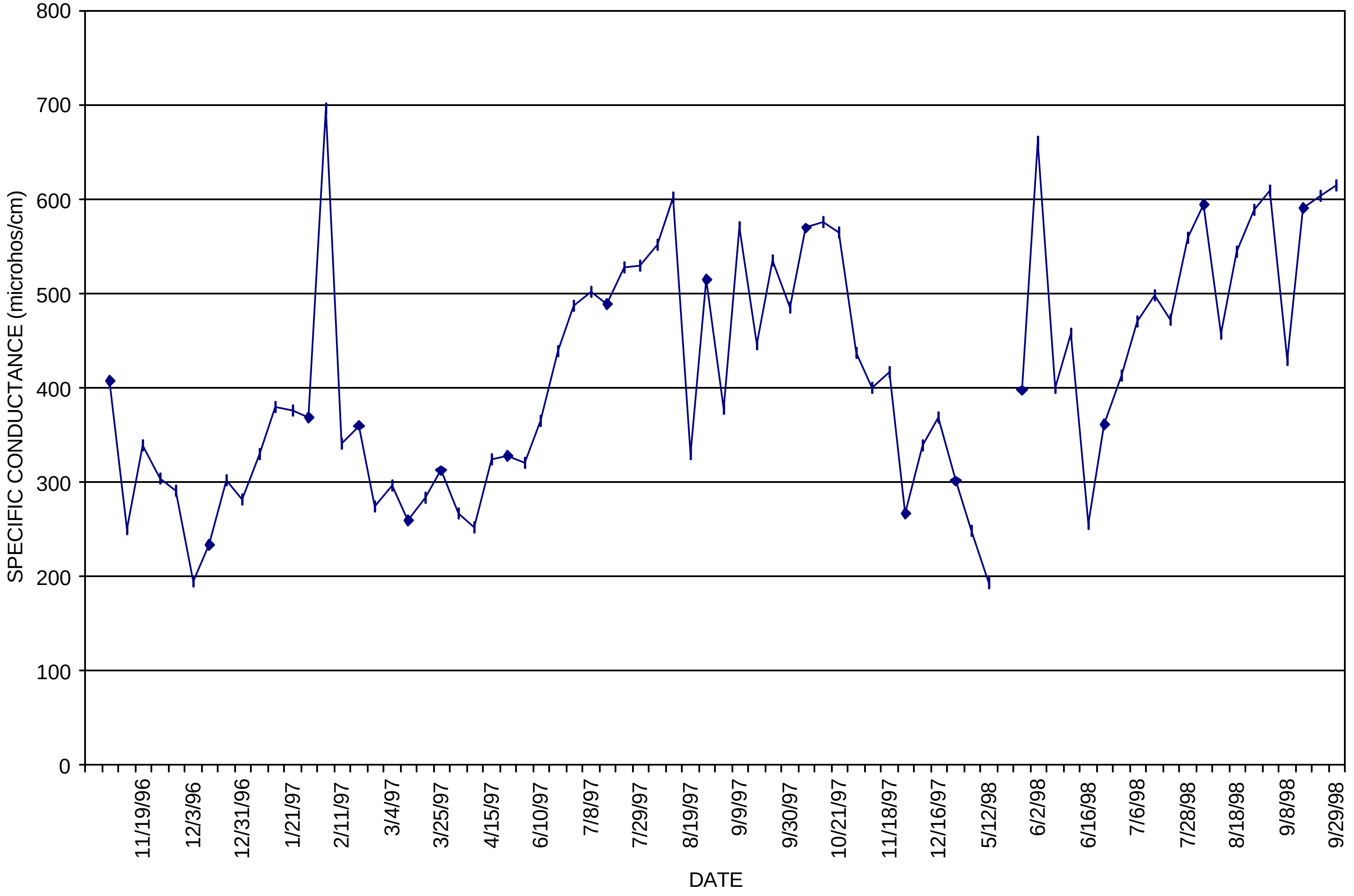

Figure D1.   Nescopeck Creek Specific Conductance, 1996-98

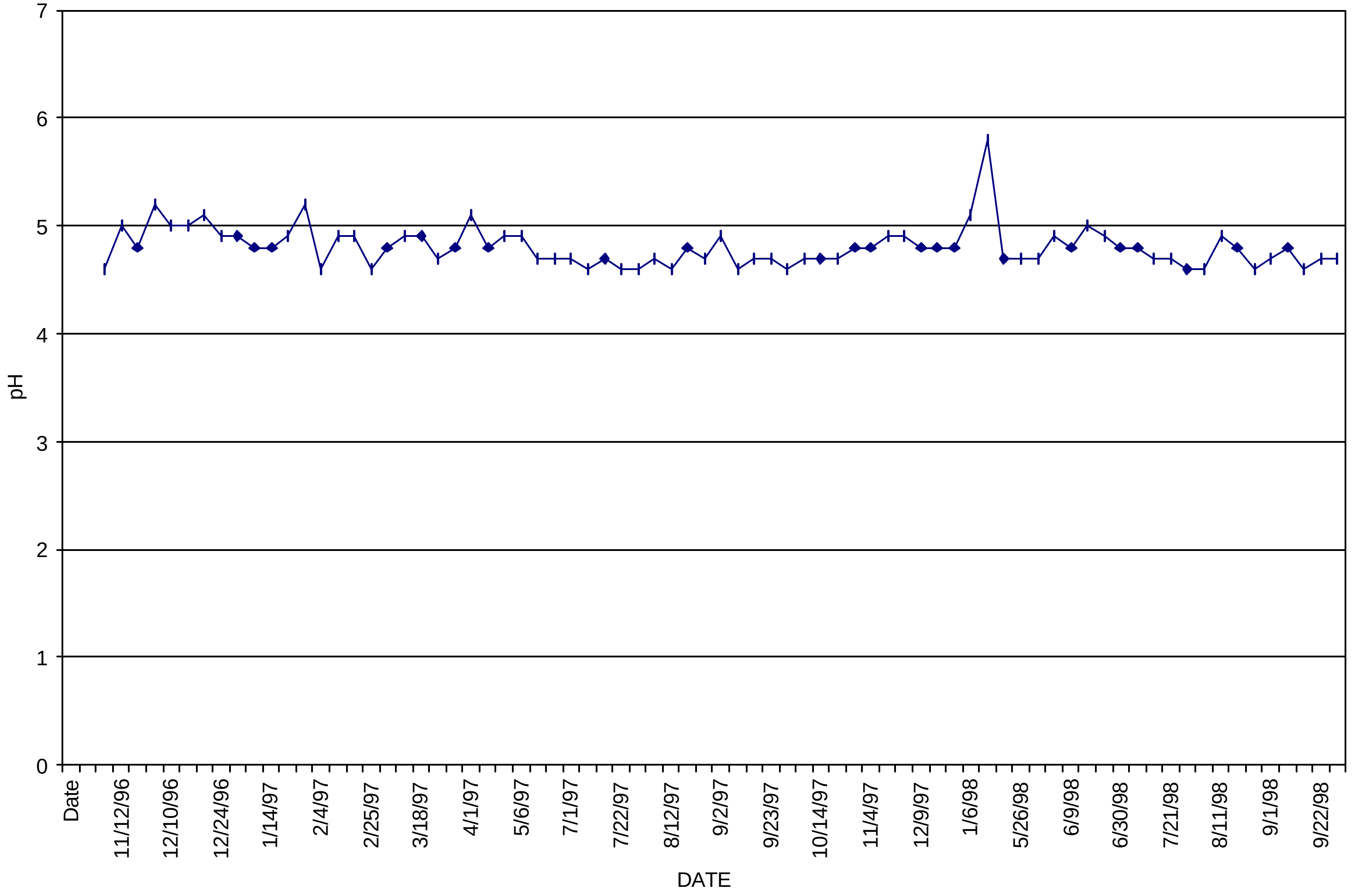

Figure D2. *Nescopeck Creek pH, 1996-98*

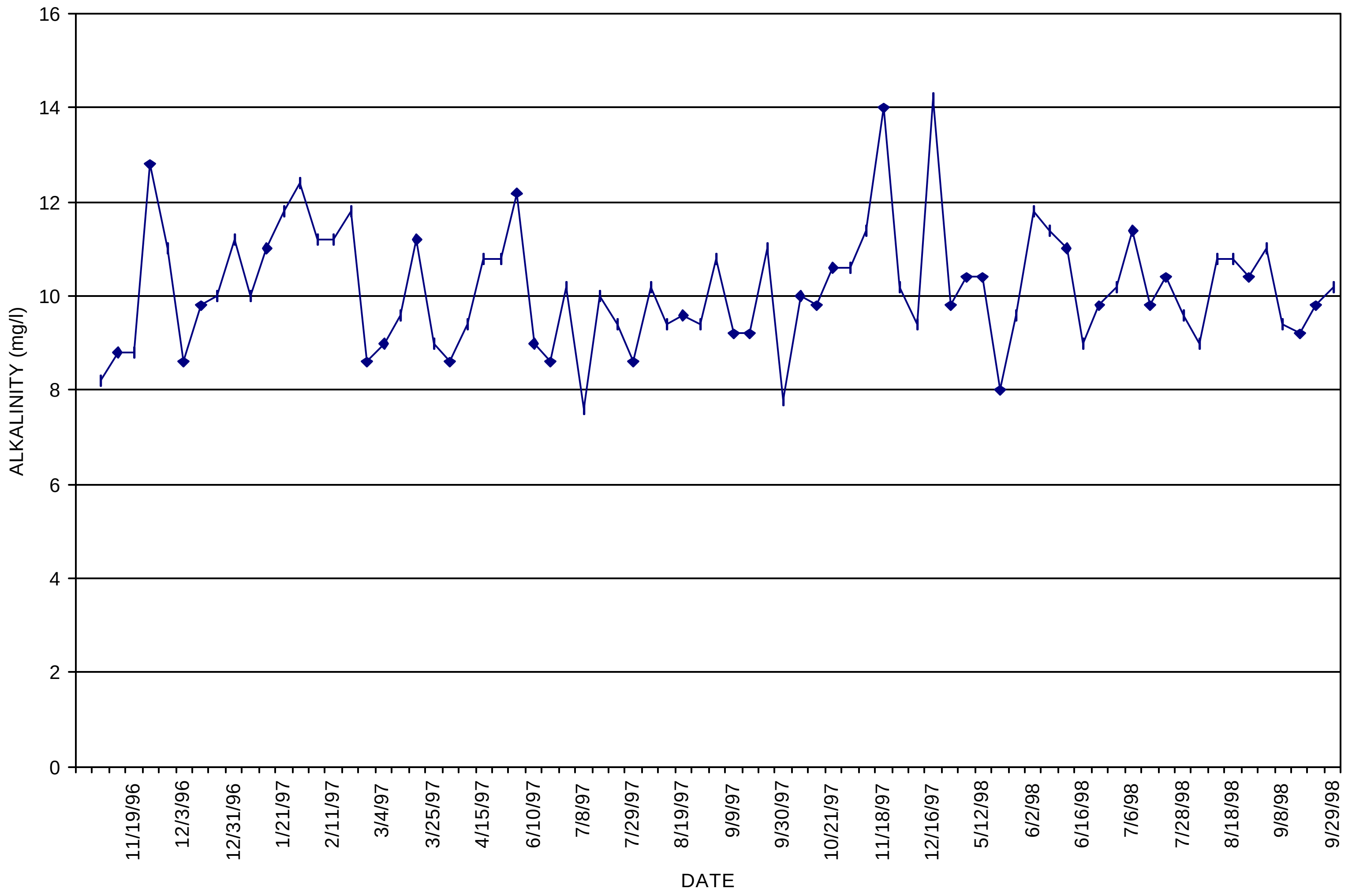

Figure D3. ***Nescopeck Creek Alkaline Concentrations, 1996-98***

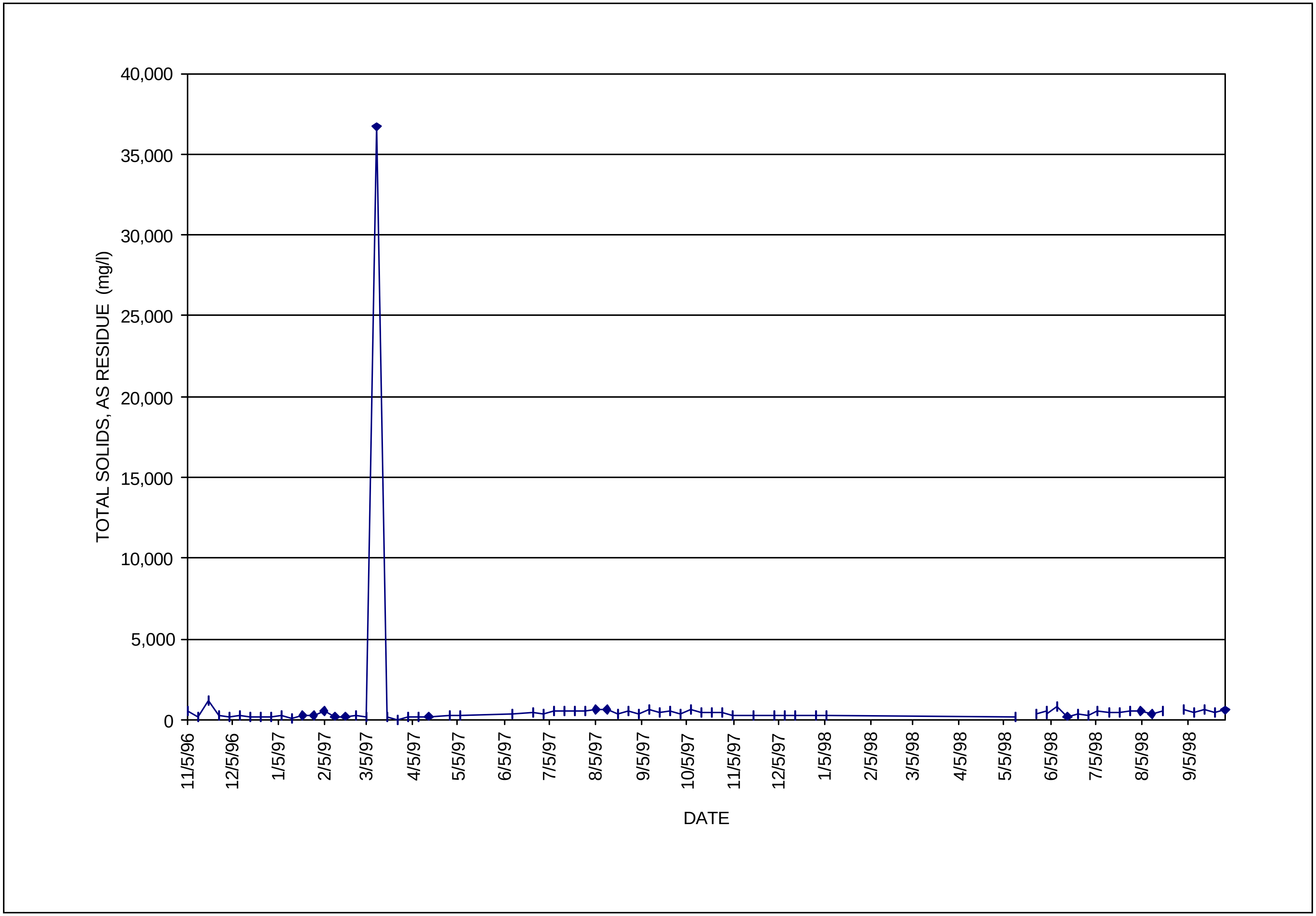

Figure D4. Nescopeck Creek Total Solids, as Residue, 1996-98

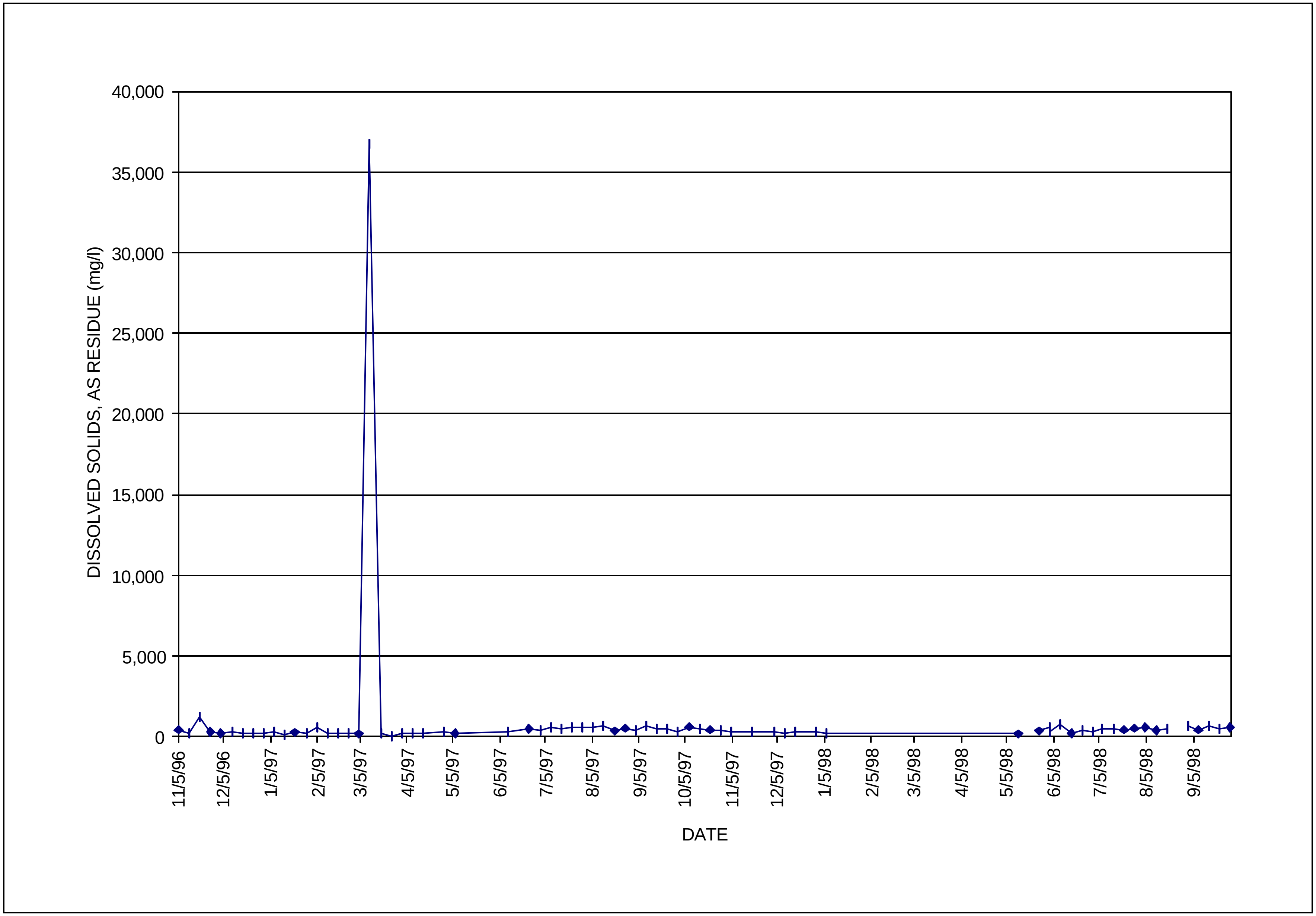

Figure D5. Nescopeck Creek Dissolved Solids, as Residue, 1996-98

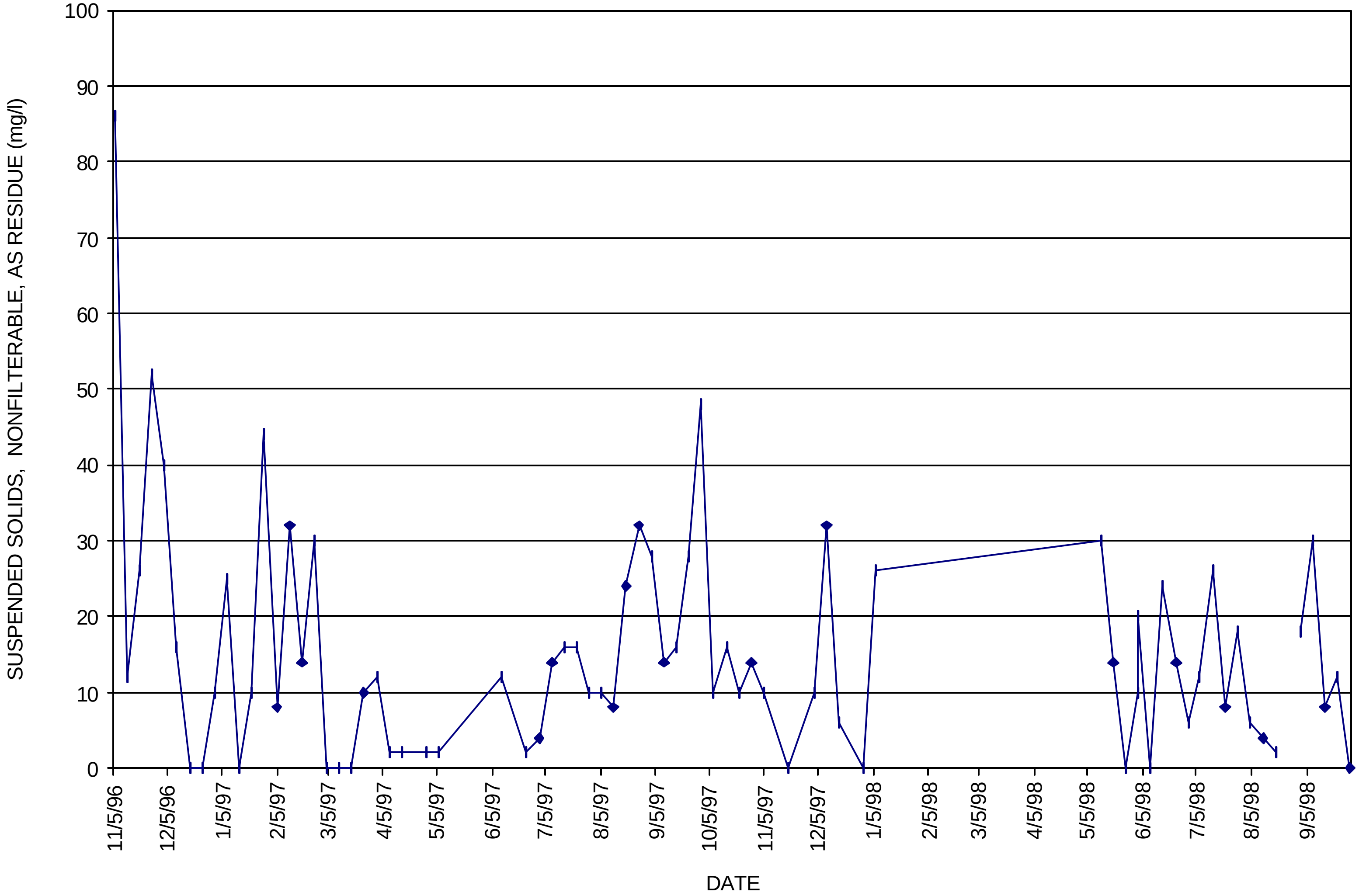

Figure D6. Nescopeck Creek Suspended Solids, Nonfilterable, as Residue, 1996-98

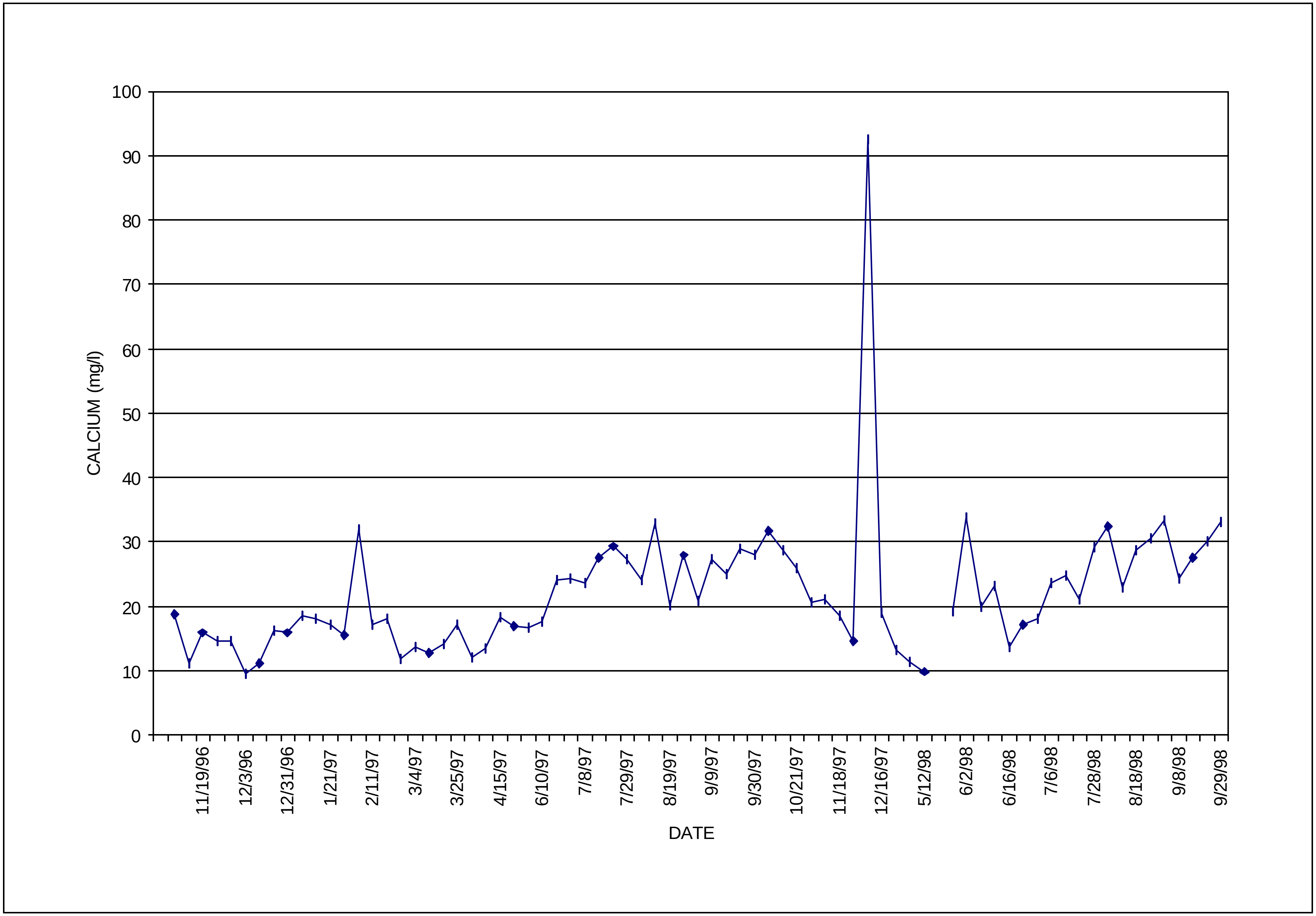

Figure D7. Nescopeck Creek Calcium Concentrations, 1996-98

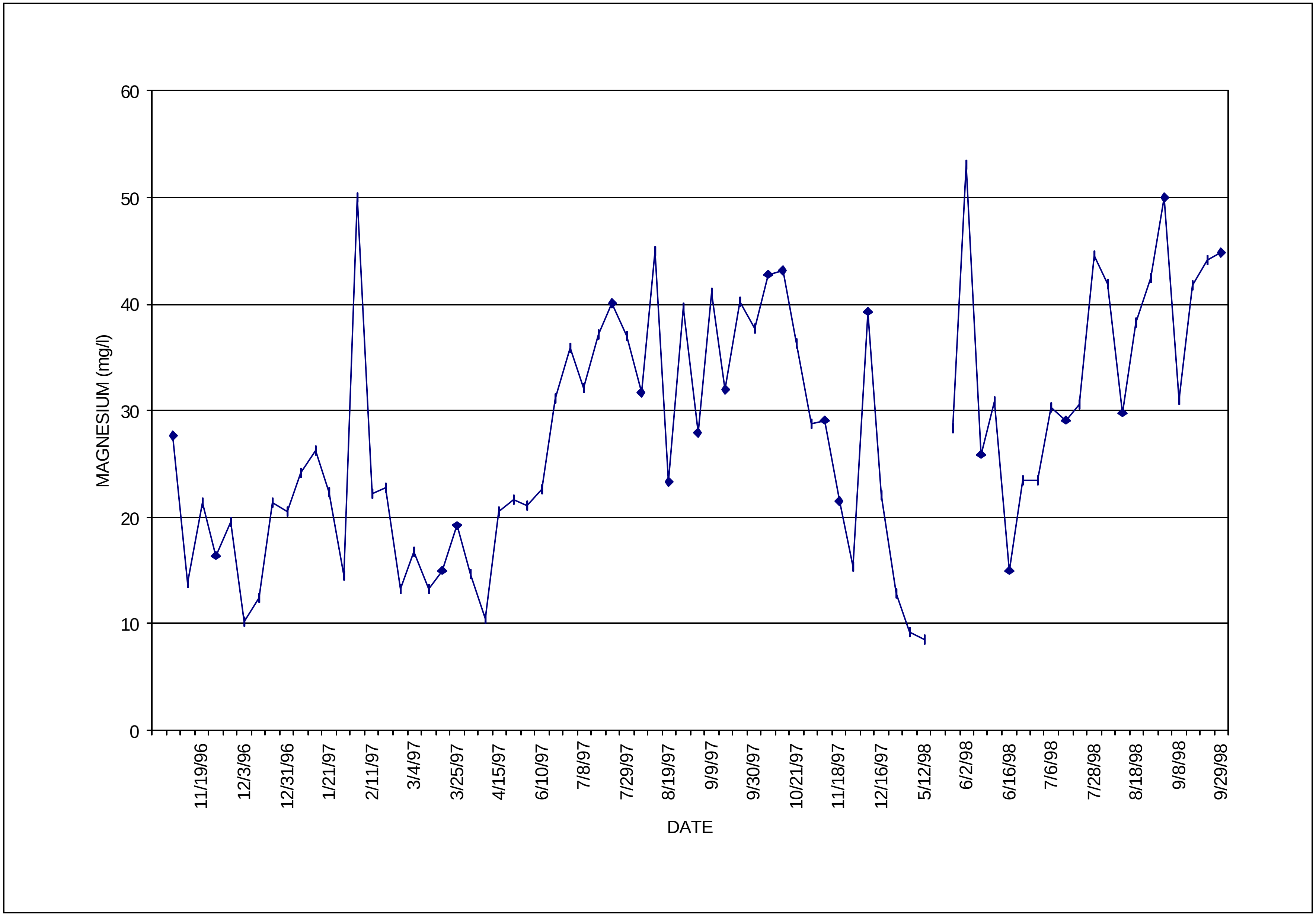

Figure D8. Nescopeck Creek Magnesium Concentrations, 1996-98

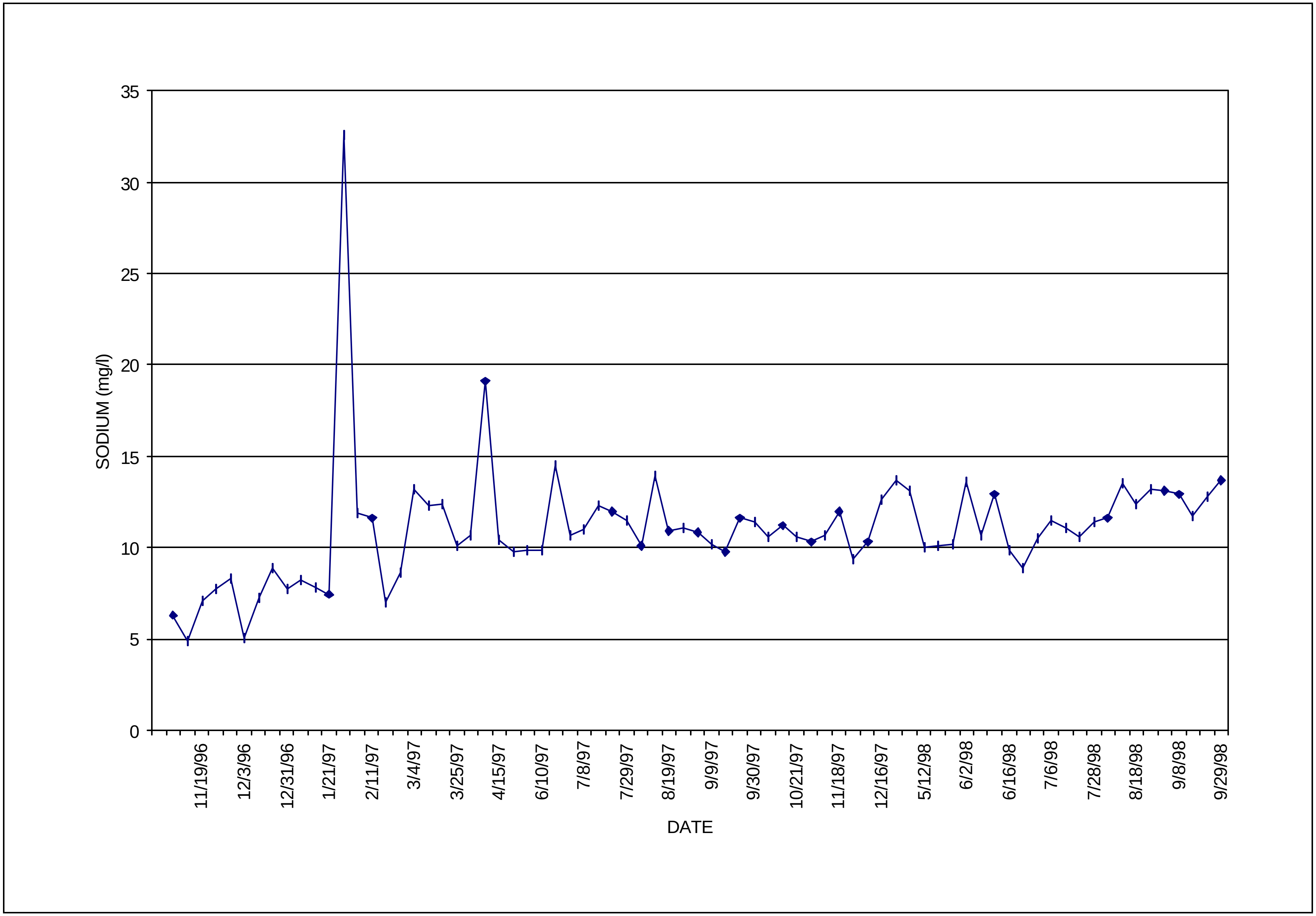

Figure D9. Nescopeck Creek Sodium Concentrations, 1996-98

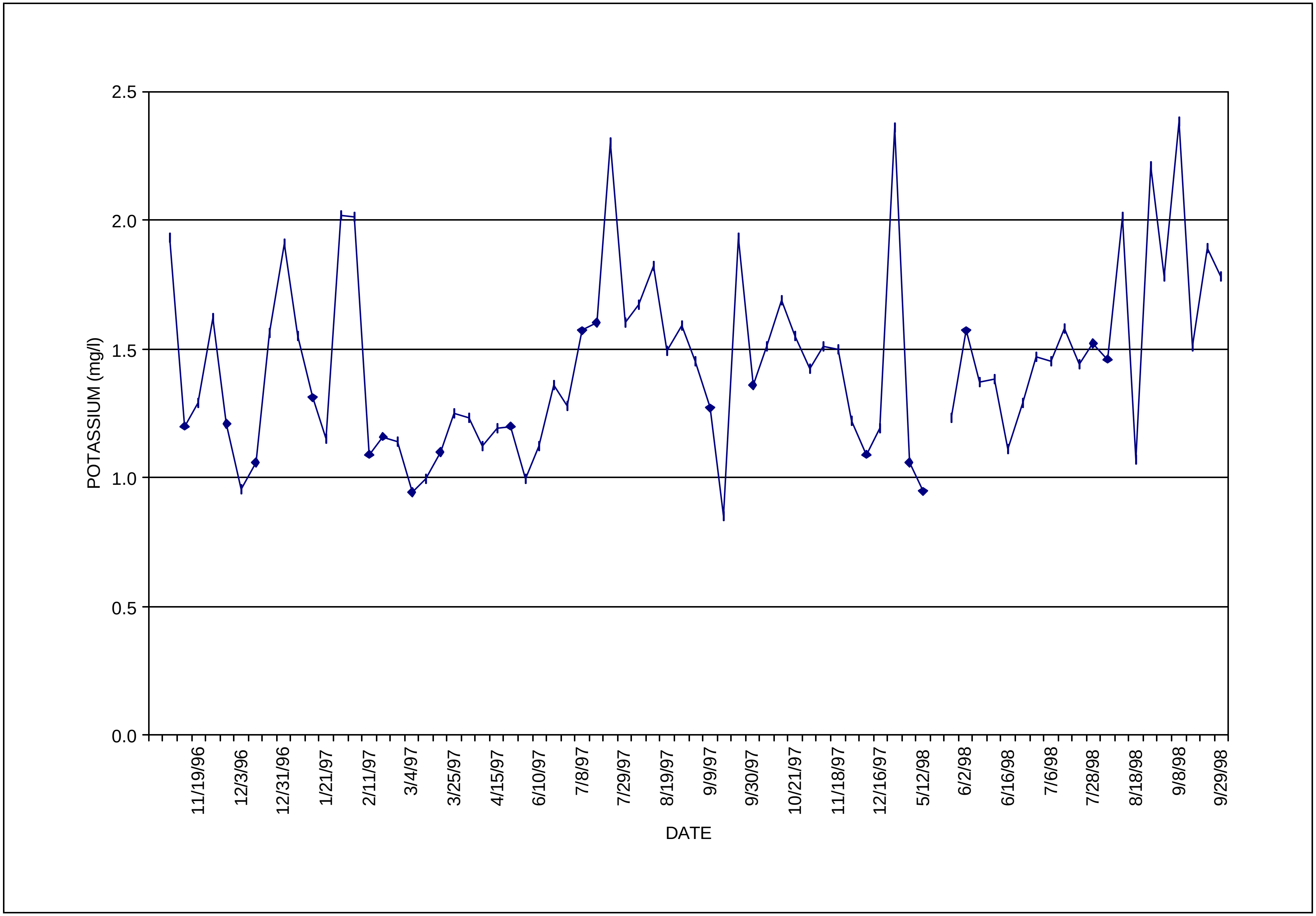

Figure D10. Nescopeck Creek Potassium Concentrations, 1996-98

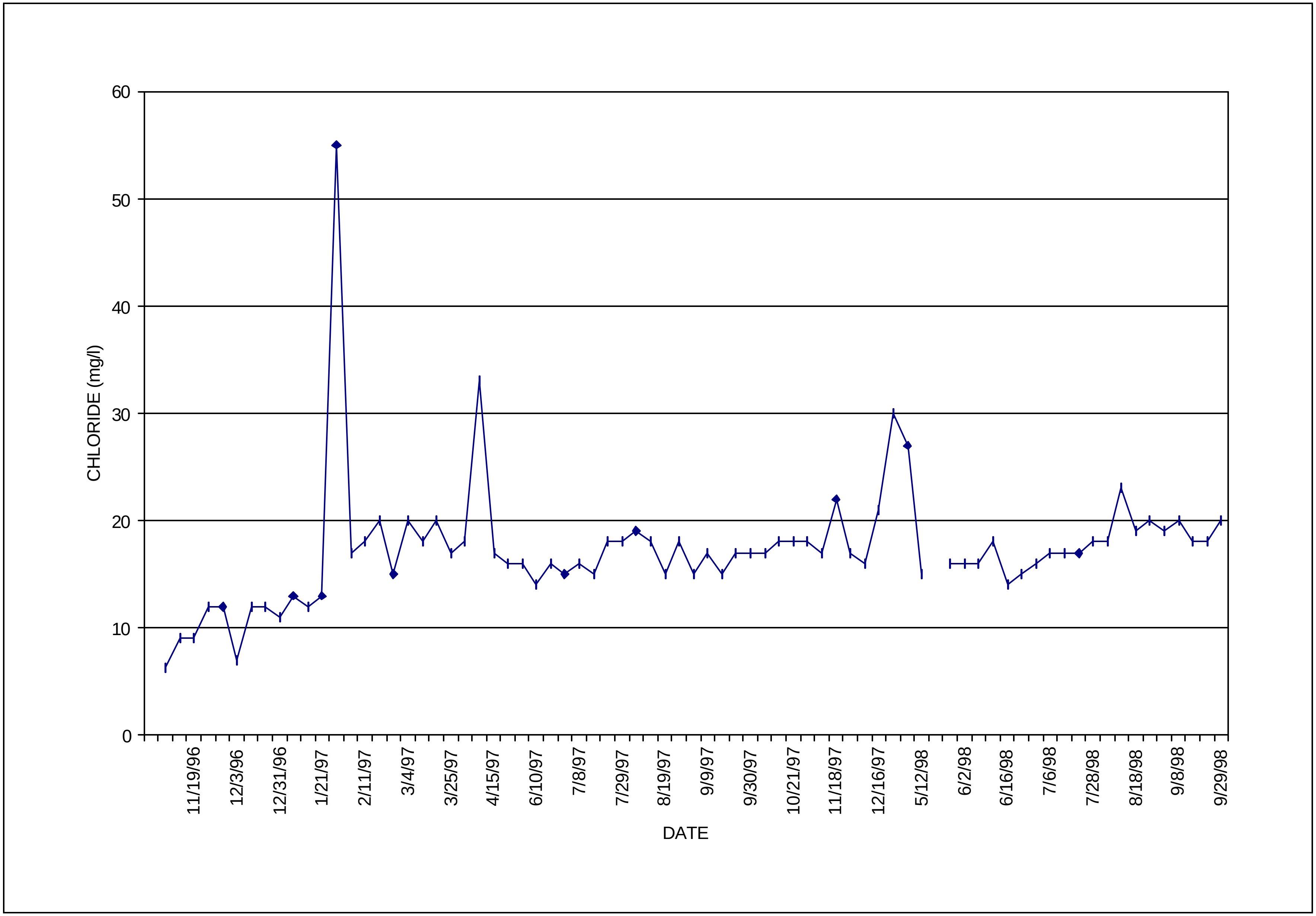

Figure D11. ***Nescopeck Creek Chloride Concentrations, 1996-98***

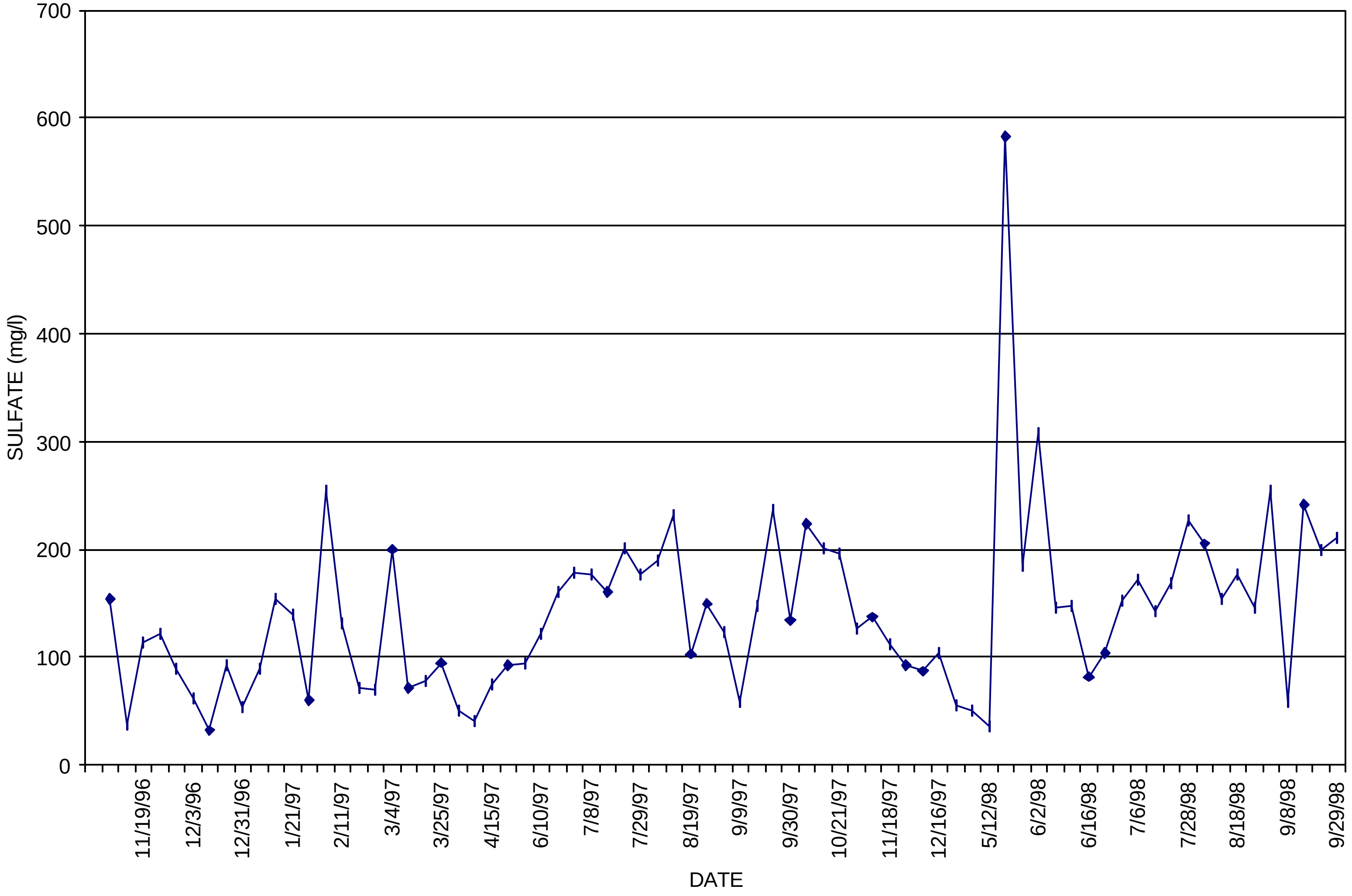

Figure D12. ***Nescopeck Creek Sulfate Concentrations, 1996-98***

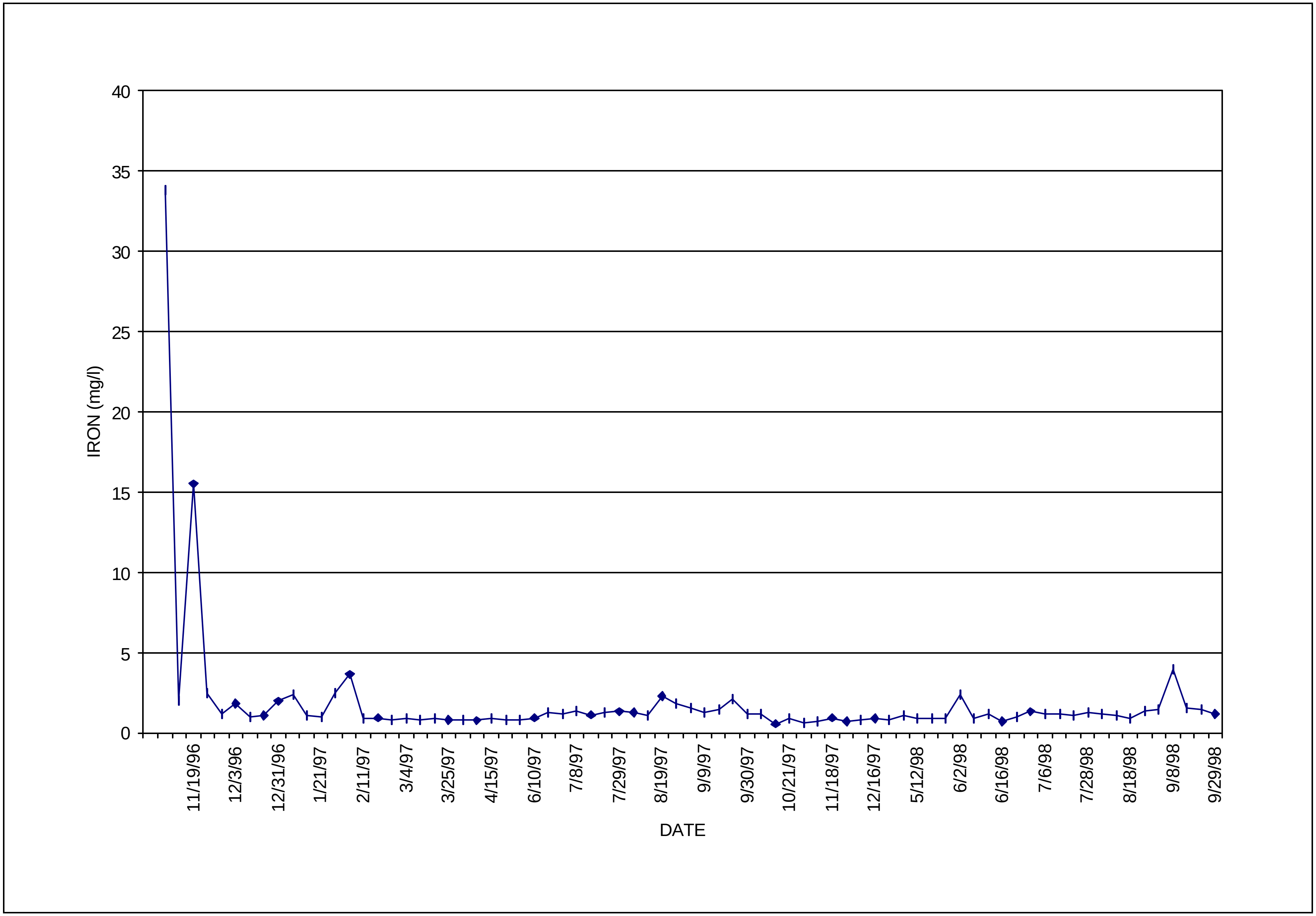

Figure D13. Nescopeck Creek Iron Concentrations, 1996-98

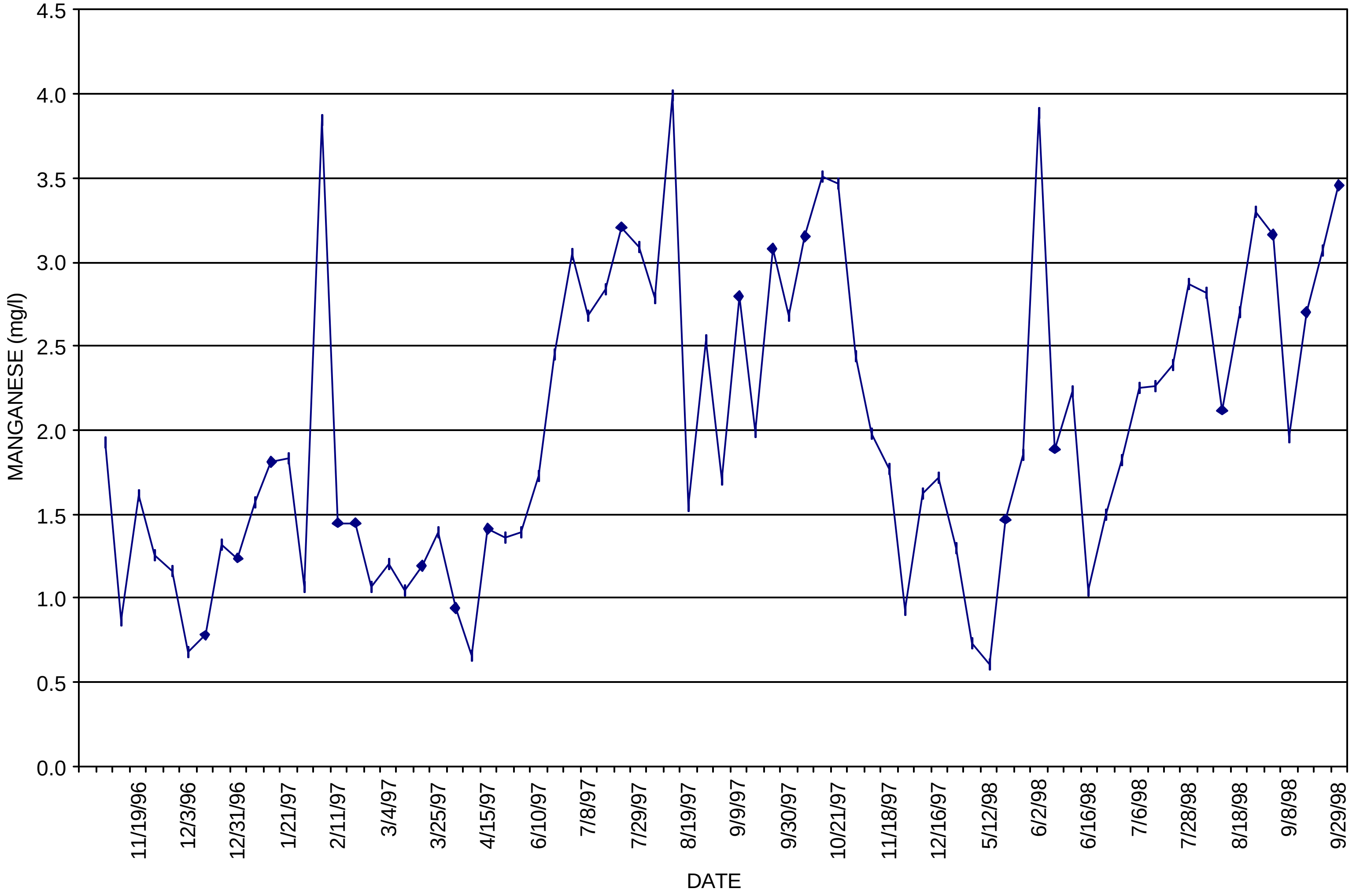

Figure D14. ***Nescopeck Creek Manganese Concentrations, 1996-98***

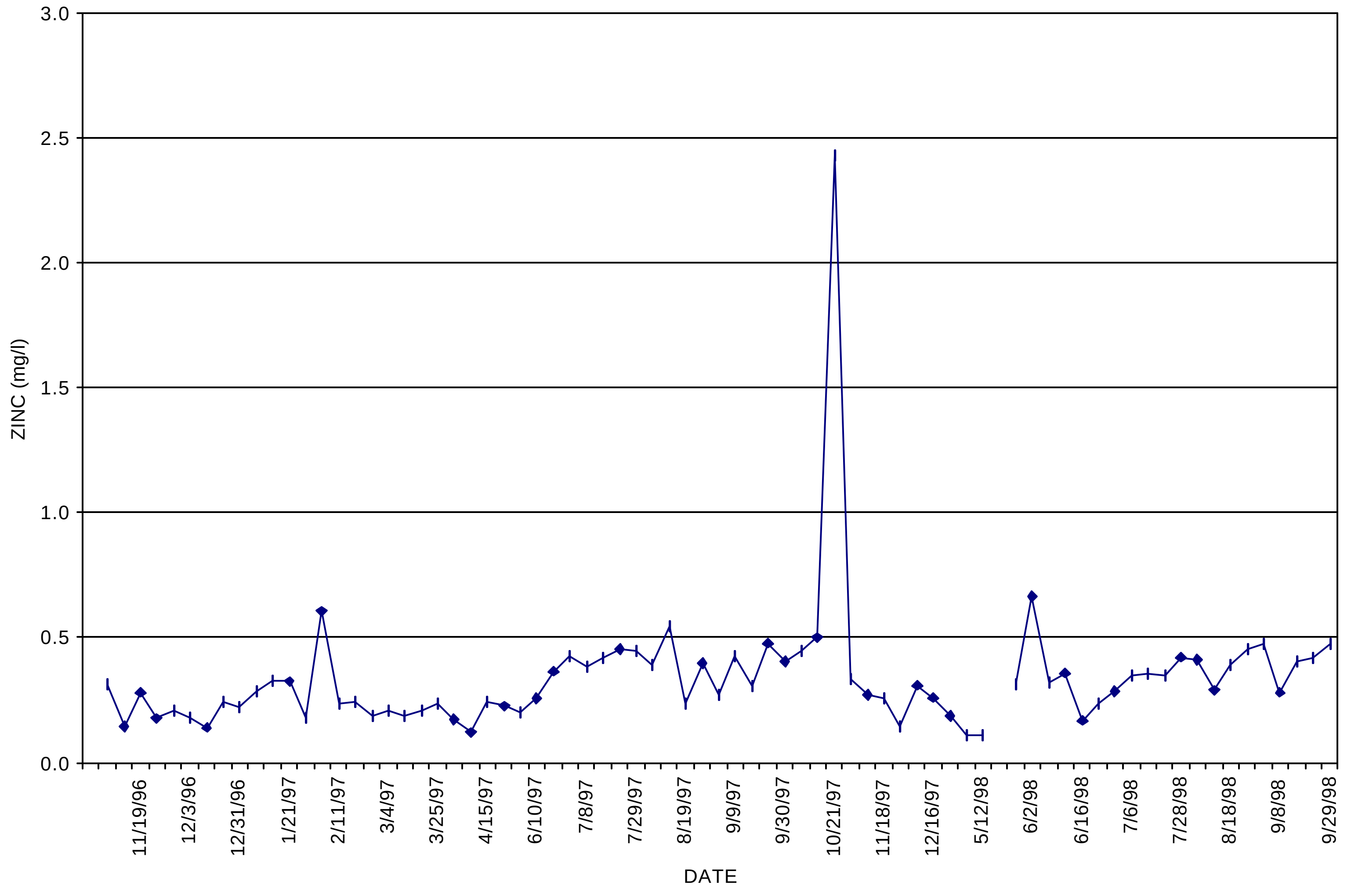

Figure D15. Nescopeck Creek Zinc Concentrations, 1996-98

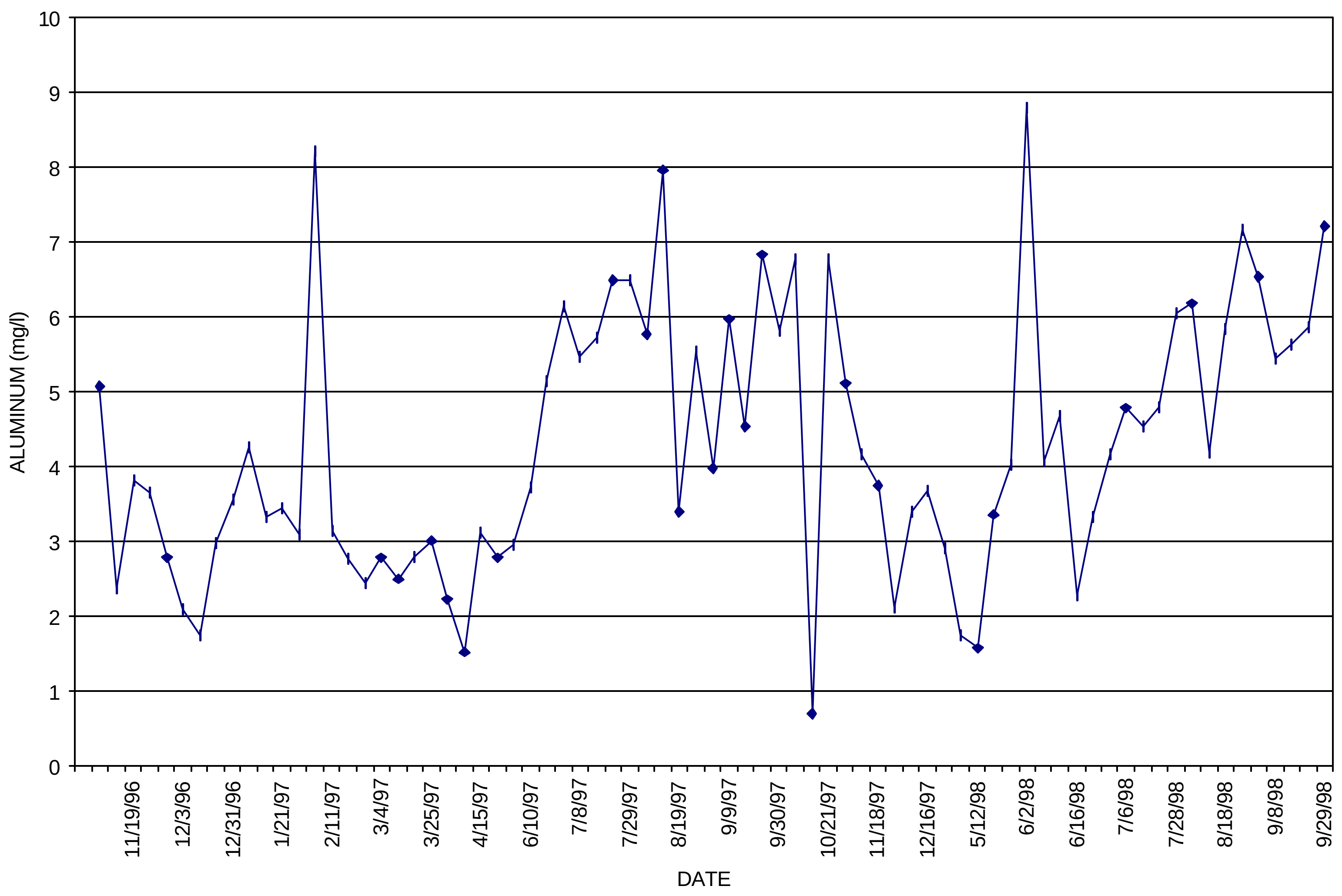

Figure D16. ***Nescopeck Creek Aluminum Concentrations, 1996-98***

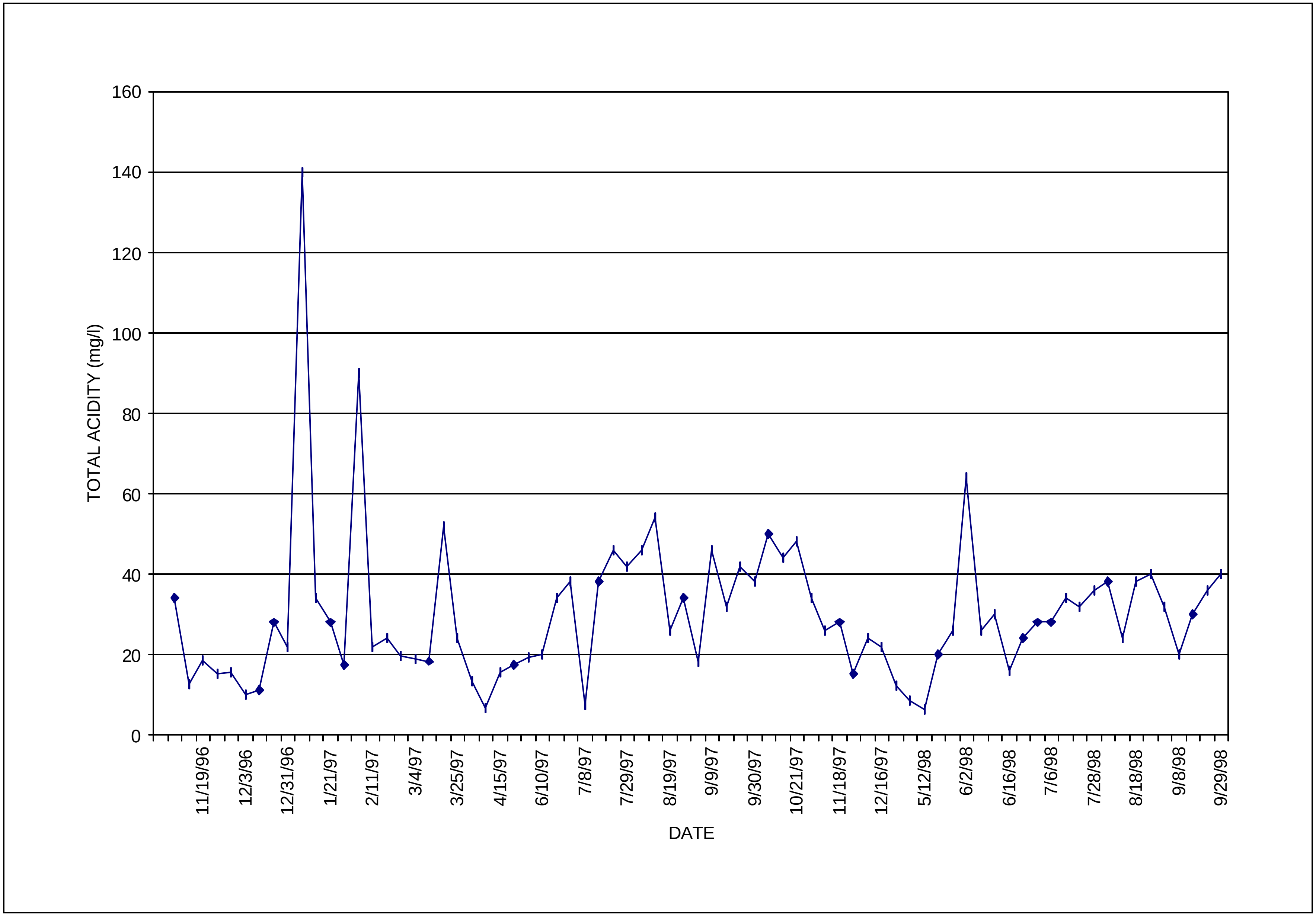

Figure D17. ***Nescopeck Creek Total Acid Concentrations, 1996-98***

APPENDIX E

TURBIDITY DATA

Table E1. Jeddo Tunnel Turbidity Readings, 1995-97

Day	Date	Time	Turbidity Reading (NTU)	Weather	Comments
Wednesday	11/29/95	10:45	11.4		
Friday	12/01/95	11:00	8.03		
Sunday	12/03/95	9:15	11.6		
Monday	12/04/95	13:30	18.1		
Tuesday	12/05/95	11:30	14.7		
Wednesday	12/06/95	10:45	13		
Friday	12/08/95	10:15	12.7		
Sunday	12/10/95	9:30	6.14		
Tuesday	12/12/95	8:30	5.76		
Wednesday	12/13/95	11:30	5.27		
Friday	12/15/95	9:00	6.36		
Saturday	12/16/95	9:30	7.51		
Sunday	12/17/95	9:30	5.55		
Tuesday	12/19/95	9:30	6.39		
Thursday	12/21/95	10:15	6.57		
Friday	12/22/95	10:00	5.09		
Saturday	12/23/95	8:30	7.38		
Sunday	12/24/95	9:00	6.36		
Tuesday	12/26/95	10:30	4.45		
Wednesday	12/27/95	10:15	7.33		
Thursday	12/28/95	10:00	8.64		
Saturday	12/30/95	12:30	6.73		
Monday	01/01/96	10:30	7.5		
Tuesday	01/02/96	10:30	5.64		
Thursday	01/04/96	10:30	6.48		
Friday	01/05/96	10:30	7.3		
Wednesday	01/10/96	16:30	5.65	snow, frozen	
Thursday	01/11/96	10:30	6.18		
Friday	01/12/96	10:30	7.32		
Saturday	01/13/96	10:00	7.58		
Sunday	01/14/96	11:00	5.63		
Tuesday	01/16/96	9:30	7.46		
Wednesday	01/17/96	9:00	5.77		
Thursday	01/18/96	8:00	7.67		
Friday	01/19/96	7:30	231		main creek 311 (thawing and flooding)
Saturday	01/20/96	8:30	32.2		brown(thawing and flooding)
Sunday	01/21/96	8:30	14		brown(thawing and flooding)
Monday	01/22/96	7:30	20.4		
Tuesday	01/23/96	8:30	368		
Thursday	01/25/96	9:30	17.8		
Friday	01/26/96	9:00	17.6		
Saturday	01/27/96	10:30	63.3		Brown Creek, Grey Tunnel (rain and flooding)
Sunday	01/28/96	10:00	52.5		
Monday	01/29/96	7:30	13.2		
Tuesday	01/30/96	10:00	13.5		
Thursday	02/01/96	17:00	20.8		
Friday	02/02/96	8:30	15.4		
Saturday	02/03/96	9:30	14.1	extreme cold	

Table E1. ***Jeddo Tunnel Turbidity Readings, 1995-97****—Continued*

Day	Date	Time	Turbidity Reading (NTU)	Weather	Comments
Sunday	02/04/96	10:00	15.5	extreme cold	
Tuesday	02/06/96	9:30	11.5	extreme cold	
Wednesday	02/07/96	10:00	10.9		
Friday	02/09/96	9:00	11.5		greenish yellow
Saturday	02/10/96	9:00	11.6		greenish yellow
Sunday	02/11/96	8:00	11.6		greenish yellow
Monday	02/12/96	8:30	9.13		greenish yellow
Tuesday	02/13/96	9:30	9.9	extreme cold	
Wednesday	02/14/96	9:00	7.66		
Thursday	02/15/96	9:30	12.9		yellow
Saturday	02/17/96	9:00	7.21		yellow
Sunday	02/18/96	9:30	6.08		low water
Monday	02/19/96	9:00	6.23		low water
Tuesday	02/20/96	9:30	7.51	rain	low water
Wednesday	02/21/96	9:00	28.2		gray foamy high water
Friday	02/23/96	8:00	12.6		gray, high water
Saturday	02/24/96	9:00	82.6		gray foamy high water
Sunday	02/25/96	9:30	10.5		gray, high water
Monday	02/26/96	9:00	10.2		gray, going down
Tuesday	02/27/96	9:30	12.6		gray, going down
Thursday	02/29/96	9:30	28.6		gray, lower
Friday	03/01/96	9:30	17.7		gray, lower
Saturday	03/02/96	9:30	19.9		gray, lower
Sunday	03/03/96	10:00	14.6		gray, lower
Tuesday	03/05/96	9:00	6.06	rain	low water
Wednesday	03/06/96	9:30	8.39		rising
Thursday	03/07/96	9:45	6.87	snow	rising
Saturday	03/09/96	9:45	6.68	cold snow	
Sunday	03/10/96	10:00	5.8	cold	
Monday	03/11/96	10:00	7.53	cold	
Tuesday	03/12/96	9:30	5.42	cold	
Thursday	03/14/96	9:30	6.92	thawing	clear
Friday	03/15/96	9:00	7.24	warm	clear
Saturday	03/15/96	10:00	20.8	warm	gray visible fines
Monday	03/18/96	9:30	7.74	warm	greenish
Tuesday	03/19/96	9:00	7.95	warm	greenish
Wednesday	03/20/96	9:00	25	rain storm	gray silt
Thursday	03/21/96	8:30	14.2	rain	high water, gray/green
Saturday	03/23/96	9:00	9.38		green
Sunday	03/24/96	9:30	7.14		greenish
Tuesday	03/26/96	9:00	6.32		
Thursday	03/28/96	9:30	8.85		gray, green
Friday	03/29/96	9:00	7.09		green
Saturday	03/30/96	9:30	5.49		green
Monday	04/01/96		10		green
Tuesday	04/02/96		48.7		black
Wednesday	04/03/96	14:30	107		black
Wednesday	04/03/96	15:15	347		very black
Thursday	04/04/96	12:30	52.1		black

Table E1. Jeddo Tunnel Turbidity Readings, 1995-97*—Continued*

Day	Date	Time	Turbidity Reading (NTU)	Weather	Comments
Friday	04/05/96	10:30	66.1	light snow	black
Saturday	04/06/96	8:00	37.5		black
Monday	04/08/96	15:15	5.66	clear	grayish
Tuesday	04/09/96	9:00	9.67	snow	grayish
Wednesday	04/10/96	9:00	4.74		greenish
Friday	04/12/96	11:30	73.3	medium water	black
Saturday	04/13/96	9:00	56.2	medium water	black
Sunday	04/14/96	10:00	8.74	light rain	greenish
Tuesday	04/16/96	9:00	45.3	heavy rain	high water, gray/black
Wednesday	04/17/96	9:30	25.4		high water, brownish gray
Thursday	04/18/96	9:00	9.14		high water, brownish gray
Saturday	04/20/96	12:30	16.9		high water, gray
Sunday	04/21/96	10:00	5.69	clear	high green
Tuesday	04/23/96	9:30	19.7		med water gray
Wednesday	04/24/96	10:00	24.7	rain night before	gray
Thursday	04/25/96	9:15	10.7		high green-gray
Friday	04/26/96	12:00	26.1		high gray
Sunday	04/28/96	10:00	9.95		med water greenish
Monday	04/30/96	9:30	11.5	heavy rain	greenish
Tuesday	04/31/96	9:00	13.8	rain	high water green/gray
Wednesday	05/01/96	10:00	22.5		very high water gray
Friday	05/03/96	10:00	26.1		high water, gray
Sunday	05/05/96	9:00	9.46		high gray
Monday	05/06/96	10:00	5.48	rain	high greenish
Tuesday	05/07/96	7:30	17.5		high water greenish
Thursday	05/09/96	10:00	18.9	rain	high greenish
Friday	05/10/96	9:00	45.1	rain	high gray/black
Saturday	05/11/96	11:00	66.4	rain	black high
Sunday	05/12/96	8:30	18.6		gray raging
Tuesday	05/14/96	9:30	11.1		high gray
Wednesday	05/15/96	8:30	17.7		high gray
Wednesday	05/15/96	20:30	44.5		Mill hill bridge
Friday	05/17/96	11:00	94.4		high water black
Saturday	05/18/96	9:00	10.6		high water gray
Monday	05/20/96	7:00	9.22		medium-high, gray-green
Tuesday	05/21/96	9:30	91.8		medium-high, black
Wednesday	05/22/96	10:00	19.6		medium-high, greenish gray
Thursday	05/23/96	8:00	47.6		Mill hill bridge
Friday	05/24/96	10:00	87.2		medium-high, black
Saturday	05/25/96	9:15	14.4		medium, greenish-gray
Monday	05/27/96	10:00	14.9		medium-low, greenish
Tuesday	05/28/96	7:00	8.82		medium, greenish
Wednesday	05/29/96	11:30	1,000		medium-low, black
Thursday	05/30/96	13:00	40.8		medium-low, gray-black
Saturday	06/01/96	11:00	252		medium-low, black
Sunday	06/02/96	10:30	15.7		low, greenish
Monday	06/03/96	14:00	1,000		low, black
Tuesday	06/04/96	10:30	1,000		low, black
Thursday	06/06/96	13:30	1,000		low, sludge

Table E1. Jeddo Tunnel Turbidity Readings, 1995-97—Continued

Day	Date	Time	Turbidity Reading (NTU)	Weather	Comments
Saturday	06/08/96	7:45	54.7	rain night before	low, gray
Sunday	06/09/96	10:15	22.7		low, greenish
Monday	06/10/96	9:00	70.9	rain	rising, gray
Tuesday	06/11/96	8:30	37.2		rising, gray
Wednesday	06/12/96	9:45	30.6		medium-low, greenish
Thursday	06/13/96	13:00	1,000		medium-low, black, diamond discharging
Friday	06/14/96	9:00	52.6		medium-low, gray, diamond not discharging
Saturday	06/15/96	9:30	56.2		medium-low, gray
Monday	06/17/96	14:30	1,000		medium-low, black, diamond coal discharging
Tuesday	06/18/96	9:15	34.1	a.m. rain	med., blackish-gray. 9:30am diamond not discharging.
Tuesday	06/18/96	10:30	83.6	a.m. rain	med., blackish-gray.10:15 a.m. diamond discharging.
Tuesday	06/18/96	11:30	1,000	a.m. rain	low, black, diamond coal discharging
Wednesday	06/19/96	8:30	38.3		medium-low, gray. 8:45 diamond coal discharging.
Thursday	06/20/96	9:30	73.8		low, gray. 9:45 AM diamond coal not discharging.
Friday	06/21/96	10:30	65.1		low, gray. 10:35 diamond coal not discharging.
Monday	06/24/96	9:30	12.6		low, greenish. 9:35 a.m. diamond coal discharging.
Monday	06/24/96	13:15	1,000		low, black. 1:10 p.m. diamond coal discharging.
Tuesday	06/25/96	9:00	70.2		low, gray. 9:15 diamond coal discharging.
Tuesday	06/25/96	13:20	1,000		black, diamond discharging
Wednesday	06/26/96	10:45	1,000		black, diamond discharging
Wednesday	06/26/96	20:00	1,000		diamond discharging
Thursday	06/27/96	12:05	1,000		low, black, diamond coal discharging
Monday	07/01/96	9:45	24.1	weekend rain	rising, greenish. 9:55 a.m. diamond coal not discharging.
Tuesday	07/02/96	9:30	39.8		medium, gray. 9:45 a.m. diamond coal discharging.
Tuesday	07/02/96	13:00	1,000		diamond discharging
Wednesday	07/03/96	8:45	52.8		diamond discharging
Friday	07/05/96	15:15	1,000		diamond discharging
Monday	07/08/96	9:00	23.2		No discharge
Tuesday	07/09/96	8:30	37.8		No discharge
Wednesday	07/10/96	14:00	951		diamond discharging
Thursday	07/11/96	9:30	98.4		diamond discharging
Sunday	07/14/96	10:00	33.5		Heavy rain, High water
Monday	07/15/96	10:45	14.2		Heavy rain, High water
Tuesday	07/16/96	8:30	26.8		diamond discharging
Thursday	07/18/96	9:15	32.9		diamond discharging
Friday	07/19/96	12:30	290		diamond discharging
Monday	07/22/96	10:30	8.31		diamond discharging
Monday	07/22/96	14:00	65		diamond discharging

Table E1. Jeddo Tunnel Turbidity Readings, 1995-97—Continued

Day	Date	Time	Turbidity Reading (NTU)	Weather	Comments
Tuesday	07/24/96	9:00	25.9		diamond discharging
Thursday	07/26/96	9:15	32.2		diamond discharging
Friday	07/28/96	11:30	1,000		diamond discharging
Tuesday	08/01/96	9:30	21.3		Discharge low
Friday	08/04/96	9:00	53.18		Working on silt pond
Monday	08/07/96	9:15	11.3		diamond discharging
Tuesday	08/08/96	9:30	16.2		diamond discharging
Thursday	08/10/96	9:00	28.1		diamond discharging
Monday	08/14/96	13:30	1,000		diamond discharging
Tuesday	08/15/96	10:00	566		diamond discharging
Thursday	08/17/96	12:00	1,000		diamond discharging
Friday	08/16/96	16:35	1,000		3152 actual reading after dilution
Monday	08/19/96	16:25	1,000		
Tuesday	08/20/96	7:30	49.9		Low water 7:45 Diamond Coal discharging starts (light)
Tuesday	08/20/96	8:00	43.2		Diamond discharging heavy 8:15 a.m.
Tuesday	08/20/96	8:30	41.6		
Tuesday	08/20/96	9:00	34.6		
Tuesday	08/20/96	9:30	43		
Tuesday	08/20/96	10:15	30.8		
Tuesday	08/20/96	10:45	1,470		
Tuesday	08/20/96	11:15	2,000		
Tuesday	08/20/96	11:45	2,520		
Tuesday	08/20/96	12:15	2,000		
Tuesday	08/20/96	12:45	2,560		
Tuesday	08/20/96	13:15	2,768		
Thursday	08/22/96	16:00	1,134		
Thursday	08/22/96	16:30	1,000		
Thursday	08/22/96	17:00	1,710		
Thursday	08/22/96	17:30	1,464		
Thursday	08/22/96	18:00	2,000		
Thursday	08/22/96	18:30	1,640		
Thursday	08/22/96	19:00	1,440		
Friday	08/23/96	0:15	4,000		
Saturday	08/24/96	0:15	8,000		
Tuesday	08/27/96	8:30	49.3		8:45 Diamond discharging (clear water)
Tuesday	08/27/96	9:00	49		
Tuesday	08/27/96	9:30	46.6		9:45 no discharge at Diamond
Tuesday	08/27/96	10:00	36.8		
Tuesday	08/27/96	10:30	29.8		
Tuesday	08/27/96	11:00	32.6		10:45 or 11:15 no discharge at Diamond
Thursday	08/29/96	12:30	8,000		
Friday	08/30/96	10:00	53		
Monday	09/02/96	9:30	16.1		
Tuesday	09/03/96	9:30	9.81		
		10:00	9.46		
		10:30	10.6		
		11:00	10		

Table E1. Jeddo Tunnel Turbidity Readings, 1995-97*—Continued*

Day	Date	Time	Turbidity Reading (NTU)	Weather	Comments
Tuesday	09/03/96	11:30	392		Diamond discharge appears clear
		12:00	2,148		
		1:00	4,000		
		1:30	3,944		
		2:00	4,216		
		8:30 p.m.	6,352		2:15 Diamond discharging black
		9:00	84.9		
Wednesday	09/04/96	9:15			
		9:30	77		Diamond discharging black
		10:00	63.8		
		10:30	903		
		11:00	3,128		
		11:30	4,000		
		12:30	5,344		
		8:30	8,000		
		9:30	53.8		
Thursday	09/05/96	10:00	47.7		9:45 a.m. Diamond not discharging
		10:30	50.3		
		11:00	43.7		10:45 No Discharge
		11:30	37.5		
		12:00	39		11:45 No Discharge
		2:05	42.7		
		4:35	41.9		2:15 No Discharge
		12:30	6,272		4:45 Diamond Coal discharging black
Friday	09/06/96	9:30	44.5		
Monday	09/08/96	10:00	45.5		9:45 Diamond Coal discharging
		10:30	47.6		
		11:00	38.2		
		11:15	127		
		11:20	1,000		
		11:25	2,000		
		11:30	2,908		
		11:45	3,604		
		12:00	4,000		
		10:15	50		
Tuesday	09/10/96	10:45	53.6		10:30 a.m. Diamond discharging
		11:00	51.4		
		11:10	314		
		11:15	874		
		11:20	1,506		
		11:25	1,878		
		11:30	1,454		
		11:45	374		very sudden drop at tunnel mouth
Friday	09/13/96	10:30	106		10:45 Diamond Coal discharging
		11:00	771		
		11:30	1,680		
		12:00	2,000		

Table E1. Jeddo Tunnel Turbidity Readings, 1995-97—*Continued*

Day	Date	Time	Turbidity Reading (NTU)	Weather	Comments
Saturday	09/14/96	10:00	99.9		10:15 Diamond not discharging
		10:30	98.4		Clear weather creek higher
		11:00	116		
		11:30	97.5		
		12:00	108		
Monday	9/16/96	12:00	20.7		12:15 Diamond discharging black
Tuesday	9/17/96	10:30	60.8		10:45 Diamond discharge black
		11:00	46.2	rain	water rising slightly very foamy
		11:30	43.1		
		12:00	38.2		
		12:30	250		
		1:00	1,000		
		1:30	1,000		
		2:00	1,664		
Thursday	09/19/96	11:00	31.1		11:10 Diamond Coal discharging
		11:30	31.8		
		12:00	36		
		12:30	31.7		
		1:00	28.7		
		1:30	696		
		2:00	1,258		
Monday	09/23/96	11:00	1,000		11:15 diamond coal discharge is black
Tuesday	09/24/96	10:15	68.2		10:30 no discharge
		10:45	859		11:00 no discharge
		11:15	2,000		11:30 no discharge
Wednesday	09/25/96	9:00	83.3		
		4:00	1,000		
Monday	09/30/96	10:25	10.5		
		10:45	15.8		
		11:00	516		
		11:15	1,194		
Tuesday	10/01/96	10:15	84.5		10:30 Diamond discharging
		10:45	1,000		
		11:00	553		battery low
		11:15	584		battery low
		11:30	1,250		
Thurday	10/03/96	10:15	56.6		
		10:45	74.2		Diamond Coal discharging
		11:15	1,476		
Friday	10/04/96	10:30	745		Diamond discharging
		4:00	648		
Sunday	10/05/96	10:30	39		no discharge
Tuesday	10/08/96	8:15	278		discharging
Wednesday	10/09/96	10:15	139		10:30 Diamond not discharging
		10:45	1,000		11:00 not discharging
		11:15	1,312		11:30 Diamond discharge black
Friday	10/11/96	10:15	43.6		10:30 Diamond discharging
		10:45	1,438		
		11:15	1,000		

Table E1. Jeddo Tunnel Turbidity Readings, 1995-97—*Continued*

Day	Date	Time	Turbidity Reading (NTU)	Weather	Comments
Monday	10/14/96	10:00	20.7		10:15 no discharge
		10:30	20.3		
		11:00	21.6		11:15 no discharge
Tuesday	10/15/96	10:15	359		10:30 Diamond discharging
		10:45	1,262		
		11:00	1,352		
Friday	10/18/96	9:45	949		10:00 Diamond discharge black
Saturday	10/19/96	9:30	957	heavy rain	raging water, large particles, black and foamy
Sunday	10/20/96	9:45	69.1	rain stopped	water raging, brown foamy level higher than Saturday
Monday	10/21/96	10:45	15.8		water greenish brown 11:00 no discharge
		11:15	16.3		
		11:45	15.1		
Tuesday	10/22/96	6:30	31.9		8:45 Diamond starts discharging
		10:45	109		
		11:15	247		
		11:45	394		
		12:15	520		
Friday	10/22/96	1:00	1,000		
Monday	10/28/96	11:30	577		
Tuesday	10/29/96	10:15	190		2.35
Thursday	10/31/96	11:30	1,000		2.25-2.3
Monday	11/04/96	2:45	1,000		
Thursday	11/07/96	11:30	54.4		2.2 - 2.5
Saturday	11/09/96	8:15	75.8		2.9-3.0
Monday	11/11/96	3:00	443		3.3+
Tuesday	11/12/96	10:00	10.6		2.9-3.0
Thursday	11/14/96	8:30	9.97		2.7-2.8
Friday	11/15/96	10:30	44.8		2.7
Tuesday	11/19/96	1:40	1,000		2.45-2.5
Friday	11/22/96	8:30	69.4		2.4
Tuesday	11/26/96	1:00	724		2.25
Tuesday	12/03/96	1:35	48.6		3.2-3.3
Tuesday	12/10/96	11:25	9.33		2.65-2.7
Wednesday	12/11/96	4:30	901		
Friday	12/13/96	19:30	76.4		
Saturday	12/14/96	9:10	16.4		3-3.2
Monday	12/16/96	19:30	48		
Tuesday	12/17/96	8:10	8.64		
Tuesday	12/17/96	12:45	79.5		2.9-3
Tuesday	12/24/96	9:00	7.97		2.7-2.8
Friday	01/03/97	5:00	1,000		
Tuesday	01/07/97	9:10	14.3		
Tuesday	01/14/97	?	7.37		2.09+
Tuesday	01/21/97	1:20	7.94		
Tuesday	01/28/97	12:45	8.8		
Tuesday	02/04/97	11:30	13.4		

Table E1. Jeddo Tunnel Turbidity Readings, 1995-97*—Continued*

Day	Date	Time	Turbidity Reading (NTU)	Weather	Comments
Tuesday	02/11/97	11:30	6.52		
Tuesday	02/18/97	12:00	15		
Tuesday	02/18/97	8:00	89.2		
Tuesday	02/25/97	10:15	12.5		
Tuesday	03/04/97	11:00	15.6		
Tuesday	03/11/97	11:00	10.8		
Tuesday	03/18/97	10:30	7.54		
Tuesday	03/25/97	11:30	5.11		no discharge
Tuesday	04/01/97	10:30	7.03		no discharge
Thursday	04/03/97	14:30	8.93		
Tuesday	04/08/97	11:15	4.41		no discharge
Tuesday	04/15/97	11:45	4.49		
Tuesday	04/22/97	10:25	5.4		
Tuesday	04/29/97	10:30	6.73		
Tuesday	05/06/97	9:30	5.15		
Tuesday	05/13/97	11:00	5.55		
Tuesday	05/20/97	10:45	6.82		
Tuesday	05/27/97	9:30	4.81		
Tuesday	06/03/97		8.42		
Tuesday	06/10/97	10:45	7.21		
Tuesday	06/17/97	9:30	6.23		
Thursday	06/19/97	9:30	21.6	rain last night	
Friday	06/20/97	10:30	9.34		
Tuesday	06/24/97	10:30	7.08		
Friday	06/27/97		5.84		water greenish gray, bottom visible yellow rocks
Tuesday	07/01/97	10:15	39.4		gray silty water
Wednesday	07/02/97	9:30	49.1	heavy rain	
Monday	07/07/97		5.1		
Tuesday	07/08/97	10:15	5.2		water greenish yellow
Tuesday	07/15/97	10:15	46.8		water black fine sediment on bottom
Friday	07/18/97	21:30	85.1	Rain storm	
Saturday	07/19/97	9:00	64.9		
Tuesday	07/22/97	11:45	33.4		gray visible sediment
Tuesday	07/29/97	11:15	32.3		gray silty
Tuesday	08/05/97	11:45	41.6		moderate rain night before
Thursday	08/07/97				
Monday	08/11/97	12:00	33		
Tuesday	08/12/97	10:30	50.9		Tunnel water silty
Thursday	08/14/97				
Sunday	08/17/97	12:30	23.3		showers previous evening
Monday	08/18/97	11:30	158		3 inches of rain previous evening
Tuesday	08/19/97	9:30	22.1		brownish gray water
Thursday	08/21/97				
Monday	08/24/97	12:40	13		
Tuesday	08/26/97	10:45	9.54		
Thursday	08/28/97				
Tuesday	09/02/97	10:00	10.3		grayish water
Thursday	09/04/97				

APPENDIX F

PRECIPITATION DATA FOR LONG-TERM STATIONS

Table F1. Tamaqua Precipitation for Period of Record, 1932-98 (in inches)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1932	1.53	0.90	2.33	4.78	2.25	6.23	0.97	3.46	5.35	1.88	3.21	1.17	34.06
1933	8.33	6.67	1.83	2.00	2.79	6.18	6.52	5.75	3.65	5.96	14.93	10.46	75.07
1934	3.58	1.07	1.89	3.18	1.04	2.79	4.96	3.54	4.90	2.46	4.02	8.21	41.64
1935	1.81	6.09	3.52	2.35	1.99	2.58	3.77	1.36	7.53	10.55	2.77	3.16	47.48
1936	2.60	5.63	1.94	4.92	2.62	8.27	3.90	1.81	5.32	1.85	6.31	1.78	46.95
1937	3.17	2.53	5.63	6.00	3.50	1.96	6.32	2.09	3.47	4.51	7.70	1.45	48.33
1938	8.77	3.26	2.07	5.08	3.51	2.48	3.30	5.86	6.61	6.15	3.02	6.75	56.86
1939	2.49	4.26	5.36	4.03	4.73	3.98	4.53	1.20	3.60	1.83	4.24	3.79	44.04
1940	5.27	0.77	3.07	1.66	2.36	7.60	4.84	3.65	3.95	2.23	7.80	3.64	46.84
1941	2.79	4.74	2.63	2.97	1.57	1.94	2.04	1.37	3.54	4.03	5.05	0.99	33.66
1942	2.53	3.27	4.35	2.94	2.75	4.19	1.41	11.73	4.70	6.66	5.05	7.79	57.37
1943	4.89	3.24	6.03	2.04	2.17	2.60	2.82	7.47	4.57	3.32	3.75	0.39	43.29
1944	9.78	5.60	0.98	2.13	1.94	4.55	3.76	2.88	5.39	1.73	1.62	6.57	46.93
1945	1.87	3.52	3.51	3.33	1.95	2.53	4.76	5.75	4.13	10.64	3.90	6.53	52.42
1946	2.76	6.72	3.47	2.05	2.66	3.95	1.00	10.96	4.22	5.66	3.44	4.88	51.77
1947	3.94	1.00	2.32	3.62	1.48	3.74	4.31	8.98	4.73	14.82	3.58	3.34	55.86
1948	3.25	6.15	1.45	2.85	2.03	3.75	6.38	7.29	3.74	4.27	2.84	0.93	44.93
1949	2.79	6.95	6.12	3.47	3.02	1.66	5.46	4.40	2.11	4.01	5.07	4.47	49.53
1950	2.21	2.09	4.06	4.13	3.98	6.37	2.38	4.06	3.06	5.20	2.79	3.48	43.81
1951	3.99	7.10	7.00	5.70	5.75	5.91	3.53	2.18	3.83	8.35	4.30	4.74	62.38
1952	4.14	7.81	7.69	3.95	2.24	5.86	10.15	7.11	1.47	9.61	6.91	5.39	72.33
1953	1.03	9.23	5.55	5.88	3.24	5.42	5.99	7.87	2.57	2.95	1.12	4.22	55.07
1954	2.95	3.04	4.79	1.67	3.36	5.28	4.39	4.22	1.46	1.53	6.38	2.97	42.04
1955	3.74	4.15	3.55	0.79	3.20	4.40	2.70	3.02	2.99	0.62	18.22		47.38
1956	4.42		6.07	3.49		2.69		4.09	3.21	7.88	3.83	5.50	41.18
1957	3.10	2.18	4.52		2.65	1.70	6.87	2.24	5.89	1.24	2.14	2.46	34.99
1958	3.56	3.25		4.05	4.16	4.04	4.79	3.72	4.47	4.09	3.38	4.19	43.70
1959	3.74	3.58	0.90	3.00				1.59	5.29	4.18	3.16	3.15	28.59
1960	6.14	5.69	4.06	3.24	5.35	4.75	3.46	7.60	5.58	7.90	4.26	8.12	66.15
1961	1.90	2.09	1.50	2.87	3.62		3.31	3.86	7.61	5.46	5.36	1.46	39.04
1962	0.85	6.10	2.41	1.27		2.24	3.60	2.31	3.39	2.59	5.00	4.30	34.06
1963	4.36	3.40	3.95	2.40	2.38	3.20	1.10	3.63	1.88	3.00	1.83	2.58	33.71
1964	0.19	5.92	2.15	6.08	2.89	3.69	5.73	1.38	4.71	2.23	1.13	3.36	39.46
1965	1.17	2.98	4.14	2.08	4.00	2.61	2.72	1.57	0.60	2.66	5.77	3.49	33.79

Table F1. Tamaqua Precipitation for Period of Record, 1932-98 (in inches)*—Continued*

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1966	4.31	2.37	1.75	3.50	3.07	2.79	3.41	2.83	1.09	2.64	2.33	4.84	34.93
1967	2.93	4.27	3.03	1.98	1.48	5.58	3.36	5.67	2.96	5.28	4.07	2.89	43.50
1968	3.34	3.78	3.98	3.02	0.29	3.15	2.63	6.56	5.38	1.51	2.25	7.65	43.54
1969	2.62	3.48	3.05	1.72	1.39	2.55	4.20	3.39	2.98	8.77	4.78	2.32	41.25
1970	2.24	5.02	4.75	0.45	3.85	3.18	4.56	3.49	3.39	8.57	2.08	2.73	44.31
1971	5.59	7.14	1.24	2.05	6.08	3.20	0.94	4.47	2.71	7.12	6.73	5.05	52.32
1972	2.69	5.65	2.69	3.14	3.45	3.94	3.35	6.83	14.15	2.19	3.78	1.29	53.15
1973	2.57	9.63	6.59	4.41	3.07	4.25	5.53	5.22	6.88	2.32	6.56	7.34	64.37
1974	4.30	2.13	8.77	4.06	2.99	5.68	3.19	4.45	4.70	4.76	5.28	6.44	56.75
1975	1.14	2.94	5.69	5.51	3.81	4.89	2.86	4.32	7.13	9.24	3.89	8.14	59.56
1976	4.88	4.60	3.31	5.91	2.96	2.67	3.27	4.59	5.81	5.48	4.55	6.74	54.77
1977	9.41		1.75	1.16	2.58	8.45	4.91	2.79	3.83	3.15	3.39	6.65	48.07
1978	6.59	6.15	6.05	9.22	1.08	5.07	2.17	8.36	4.02	2.98	5.74	2.58	60.01
1979	4.50	2.84	4.03	11.42	3.87	3.48	4.93	6.51	2.64	3.92	4.71	8.79	61.64
1980	6.29	4.90	3.25	1.54	1.22	7.07	5.99	3.48	3.16	3.27	2.11	2.08	44.36
1981	2.89	3.15	1.40	1.21	10.59	1.41	4.06	5.90	7.53	4.72	2.33	4.35	49.54
1982	4.29	2.40	3.37	4.11	3.57	3.36	5.44	4.64	8.68	3.85	6.52	3.01	53.24
1983	2.18	3.29	3.30	2.69	4.28	4.80	13.33	5.70	8.33	2.67	1.69	2.25	54.51
1984	4.47	7.57	9.04	1.87	5.03	4.48	5.76	8.58	7.04	7.20	2.40	0.82	64.26
1985	2.65	4.32	3.25	1.13	2.40	2.31	1.75	4.28	4.39	4.15	4.86	4.96	40.45
1986	2.80	6.61	2.27	4.53	3.81	3.88	4.53	2.37	4.62	4.34	3.23	3.12	46.11
1987	2.69	5.73	4.61	3.52	0.79	2.58	5.95	2.04	5.12	5.71	4.99	11.55	55.28
1988	3.25	3.95	1.79	2.43	3.85	2.98	2.90	6.96	1.73	13.32	4.25	3.58	50.99
1989	2.77	4.27	1.17	2.44	2.39	3.00	1.38	11.80	7.11	4.65	1.91	4.26	47.15
1990	5.47	5.00	1.11	5.79	3.00	2.34	3.62	9.28	2.52	3.00	8.00	4.58	53.71
1991	7.64	3.66	9.29	2.64	1.48	5.36	3.34	3.38	2.00	3.60	4.78	2.54	49.71
1992	3.22	4.14	3.45	2.42	2.56	5.30	3.66	6.70	3.66	6.58		6.08	47.77
1993	3.86	7.04	3.24		2.12	6.08	10.71	1.96	4.02	3.82	5.72	6.50	55.07
1994	3.83	6.65	5.22	6.26	2.76	5.66	5.12	4.46	8.48	4.25	7.64	4.16	64.49
1995	0.84	6.72	2.48	4.30	1.79	1.82	2.36	3.55	6.18	5.18	1.50	2.61	39.33
1996	8.76	5.54	2.62	8.56	2.86		5.96	4.88	9.48	7.63	1.84	5.14	63.27
1997	7.34	4.54	8.58	3.72	1.99	4.20	2.30	3.70	3.16	4.64	6.22	4.76	55.15
1998	2.18	3.92	3.22	4.50	5.06	4.00	5.50	4.08	5.80	2.16	3.50	3.39	47.31
LTM Average	**3.79**	**4.53**	**3.79**	**3.56**	**3.01**	**4.04**	**4.23**	**4.73**	**4.63**	**4.85**	**4.51**	**4.38**	**49.17**

Table F2. Freeland Precipitation for Period of Record, 1931-89 (in inches)

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1931	1.79	2.28	4.10	3.92	6.31	2.64	5.92	2.20	3.39	1.76	1.16	2.66	38.13
1932	4.55	2.25	4.84	2.20	3.74	5.29	2.41	2.47	1.80	8.99	6.56	1.88	46.98
1933	2.00	3.30	4.87	5.00	4.06	2.89	6.31	11.30	6.51	3.80	1.69	2.60	54.33
1934	3.41	1.80	2.96	5.38	4.38	3.73	7.24	2.96	7.43	1.69	5.25	4.34	50.57
1935	2.92	2.73	2.97	3.77	2.15	5.52	8.32	3.53	3.29	1.19	6.35	2.24	44.98
1936	4.25	2.09	7.78	2.74	3.14	3.62	2.04	3.10	1.48	3.19	3.10	4.75	41.28
1937	5.52	3.52	2.31	4.81	3.77	3.58	3.68	6.60	1.70	9.50	3.74	1.80	50.53
1938	3.68	2.40	2.58	4.76	4.78	5.91	6.28	3.29	6.79	2.93	5.62	5.49	54.51
1939	3.51	4.31	4.12	4.45	1.79	2.74	1.42	4.14	1.94	3.72	1.39	2.98	36.51
1940	1.68	3.44	8.46	5.46	3.83	4.64	3.60	3.84	5.83	2.57	4.91	2.29	50.55
1941	2.19	0.91	2.55	2.02	1.69	5.47	6.26	4.48	1.15	2.19	3.76	4.46	37.13
1942	1.59	2.60	3.06	1.69	9.44	4.68	6.53	2.61	5.58	4.49	2.86	6.43	51.56
1943	2.70	2.55	3.14	2.27	5.84	3.41	3.14	2.74	0.36	9.84	5.41	0.87	42.27
1944	1.67	1.72	4.61	4.29	3.28	8.20	1.48	3.27	4.57	2.72	2.92	3.21	41.94
1945	3.36	2.29	2.37	4.09	4.48	3.82	10.14	3.50	5.62	2.46	5.94	4.26	52.33
1946	1.71	1.73	4.91	0.88	10.19	5.71	5.27	4.18	3.59	4.12	1.11	1.98	45.38
1947	3.74	1.64	3.12	4.67	11.84	3.91	15.32	2.77	2.14	1.23	3.13	2.53	56.04
1948	3.45	1.54	3.40	5.27	6.90	3.70	7.72	2.14	0.74	3.04	7.09	5.33	50.32
1949	3.47		1.59	4.76	5.66	1.85	4.01	4.38	3.93	1.41	1.43	4.69	37.18
1950	4.26	4.08	5.97	4.49		4.04			3.76	3.23	7.10	6.29	43.22
1951	4.58	3.76	4.15	1.61	3.31	2.61		1.71	2.22		8.34	6.25	38.54
1952	3.85	2.20	4.07	9.39	6.36	3.54	12.83		5.68	1.25	7.01	6.98	63.16
1953	6.87	2.88	5.35	4.92	6.49	2.23		1.40	5.81	3.50	3.45	4.66	47.56
1954	1.40	2.85	3.11	6.09	4.88	3.20	1.81	5.93	3.84	3.53	4.71	2.45	43.80
1955	1.25	3.25	3.13	2.27	2.29	5.47	0.86						18.52
1955								17.91	3.43		3.36	0.90	25.60
1956			2.90	2.73	4.02	3.91	5.61	3.79	6.59	4.42		6.07	40.04
1957	1.98				3.32	8.17	1.17	2.48	4.64	3.05	3.35	7.90	36.06
1958			3.68	4.30	3.24	3.33		2.70		3.54			20.79
1959				4.40	2.30	3.56			3.60	7.25		4.06	25.17
1960	2.40				7.78	4.68		7.77	7.53			1.84	32.00
1961		2.09		3.31		4.91		5.36	1.03				16.70
1962	1.27					1.86	3.30	7.84	4.09	5.88	1.58	1.26	27.08
1963			2.34							0.13			2.47
1964		3.67	1.39					2.88		1.81		3.62	13.37

Table F2. *Freeland Precipitation for Period of Record, 1931-89* (in inches)—*Continued*

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1965	3.37	1.83	2.42	1.79	2.40	2.51	1.29	6.40	4.47	4.32	2.51	1.22	34.53
1966	2.94	2.66	1.58	3.17		0.52	2.02	3.48	3.91		5.39	2.79	28.46
1967	1.61				6.24	1.84	4.44	6.04	3.33	3.83		2.62	29.95
1968		0.23		2.72	5.64	4.87	1.75	2.78	6.29	1.84	4.06	3.00	33.18
1969	1.31	0.99	2.27	4.71	2.75	6.25	9.02	3.92	2.12	1.60	3.90	7.96	46.80
1970	0.40	3.30	3.46	4.77	2.81	3.82	4.87	3.69	2.71	5.72	7.62	2.48	45.65
1971	2.02	6.17	2.63	0.98	4.29	1.58	4.66	5.49	5.10	3.56	5.82	2.23	44.53
1972	2.58	4.18	3.60	3.30	7.52	9.37	2.43	2.26	1.21	3.15	9.31	4.31	53.22
1973	3.97	1.77	3.67	6.47	6.80	8.74	2.57	8.04	5.68	4.13	2.32	7.90	62.06
1974	2.73	3.04	3.89	1.89	3.02	5.98	4.77	5.29	8.19	1.18	2.59	3.80	46.37
1975	2.70	3.41	4.07	2.63	3.71	9.56	8.49	4.05	6.36	3.79	3.66	1.89	54.32
1976	4.34	2.79	3.16	2.78	4.69		5.40	5.63	5.35	9.67		2.38	46.19
1977	1.89		5.95	4.55		2.48	4.15	2.76	7.49	6.54	3.51		39.32
1978		1.33											1.33
1979							2.20	5.09	8.06	4.81	4.08		24.24
1980	0.64	1.07		4.50	3.42	3.47	2.91	2.54	1.69	2.51	3.15	0.71	26.61
1981	1.15	7.28	1.24	3.85	4.42	6.86	3.62	2.12	3.62	3.98	2.32	2.58	43.04
1982	2.40	2.66	1.19	6.78	3.12	6.08	3.50	5.12	3.01	2.46	3.27	2.36	41.95
1983	1.96	3.88	4.12	12.35	6.09	7.24	1.37	3.57	2.60	4.33	6.85	8.02	62.38
1984	1.56	4.35		6.94	8.22	5.38	5.15	3.51	0.77	2.83	3.97	2.56	45.24
1985		2.28	1.72	1.59	4.90	6.11	4.50	5.77	6.82	2.48	7.18	2.51	45.86
1986	4.38	3.62	3.57	5.12	2.95	5.85	4.35	5.66	2.63	2.74	4.79	3.67	49.33
1987	3.94	0.70	1.68	6.00	1.47	2.06	5.99	7.75	10.43	3.02	5.29	2.11	50.44
1988	2.97		2.52		6.83	1.74	13.32	3.76	3.21	3.01	4.27		41.63
1989	0.31				7.96	7.85	2.75	2.68					21.55
LTM AVERAGE	**2.74**	**2.73**	**3.46**	**4.14**	**4.81**	**4.50**	**4.86**	**4.46**	**4.17**	**3.65**	**4.34**	**3.61**	**39.91**

Blank cells are insufficient or no data.

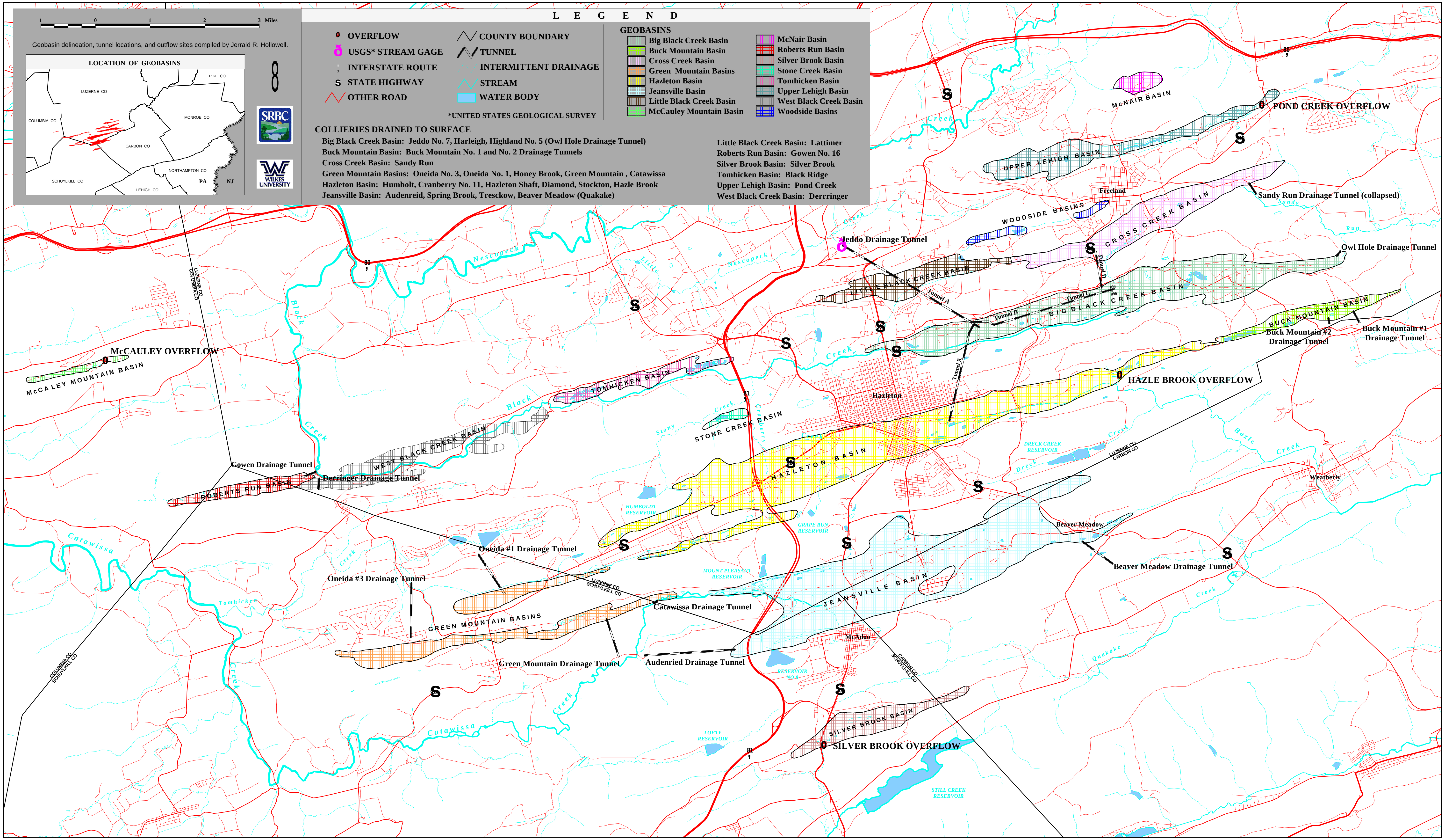

Plate 1. Location of Coal Basins and Mine Water Discharges in the Eastern Middle Anthracite Field.

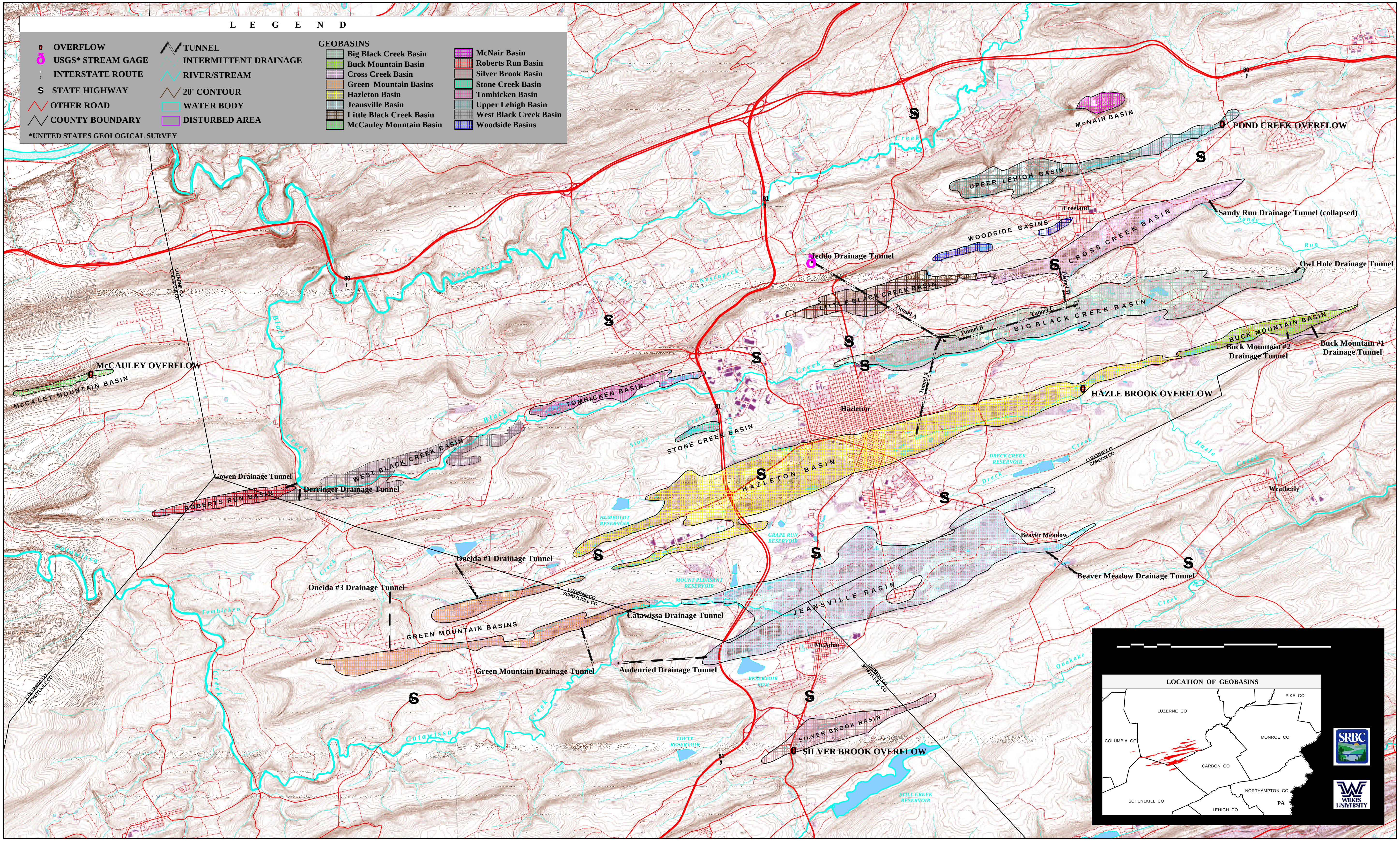

Plate 2. U.S. Geological Survey Topographic Map Showing Outfall Location

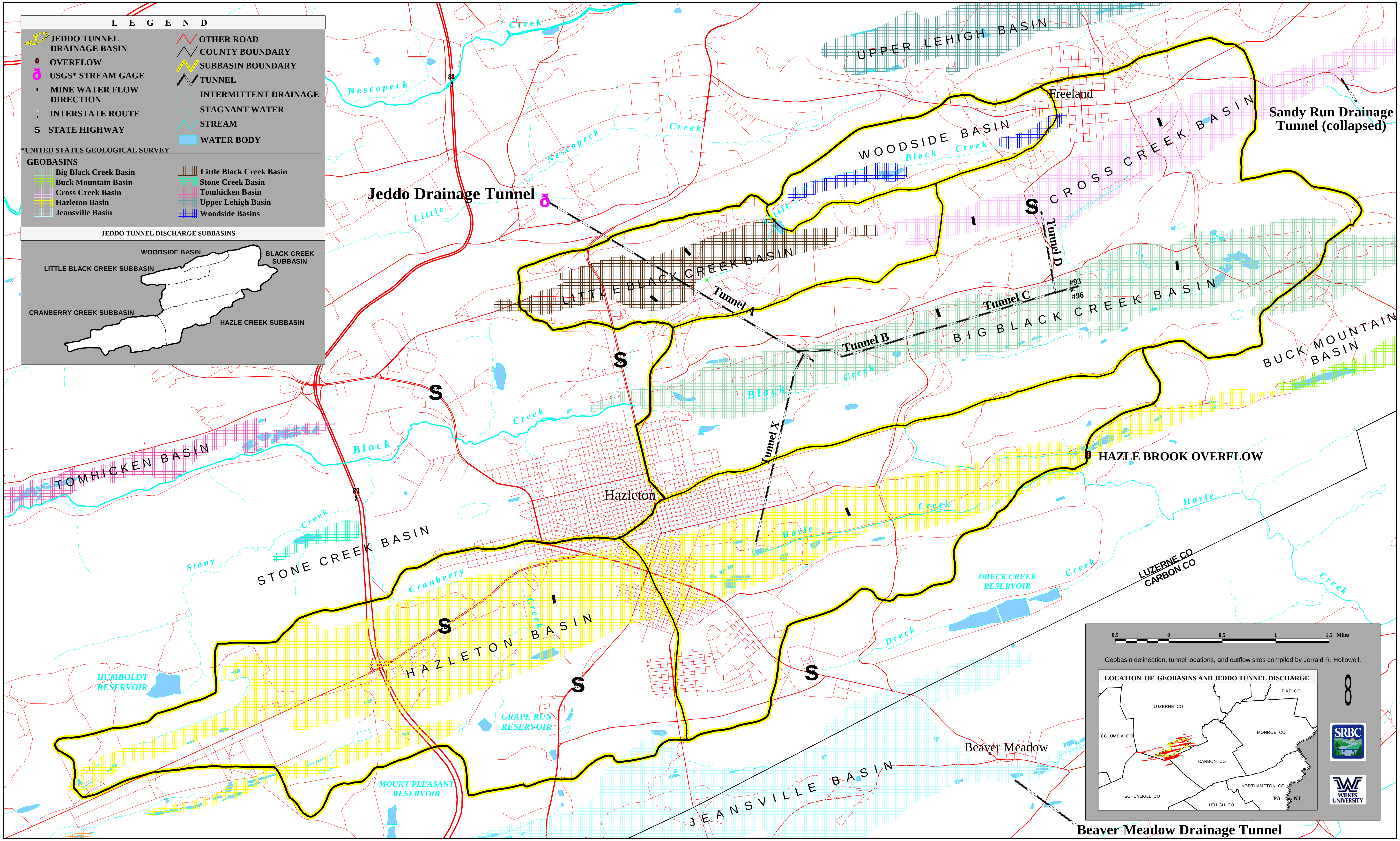

Plate 3. Jeddo Tunnel Drainage System

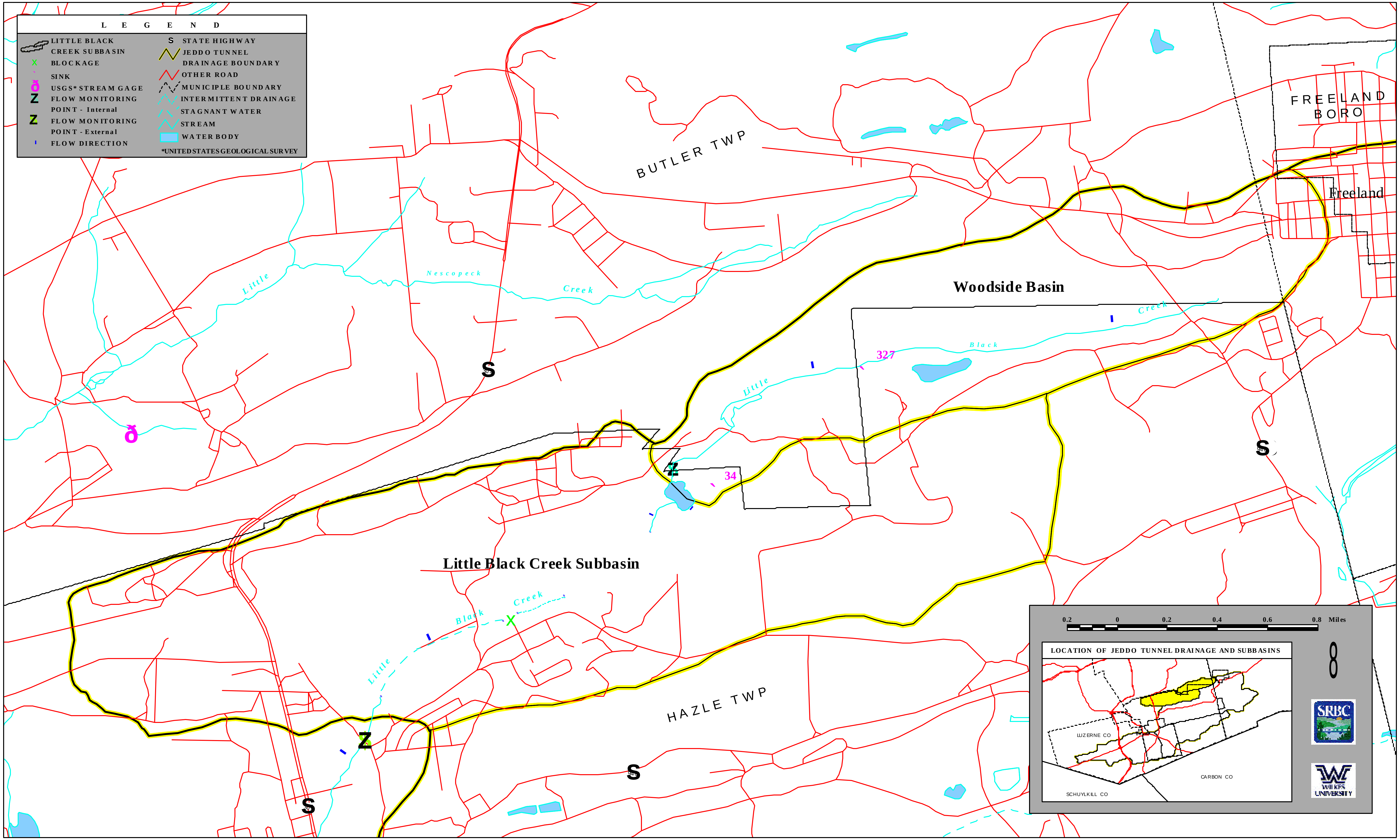

Plate 4. Current Surface Hydrology in Little Black Creek Subbasin

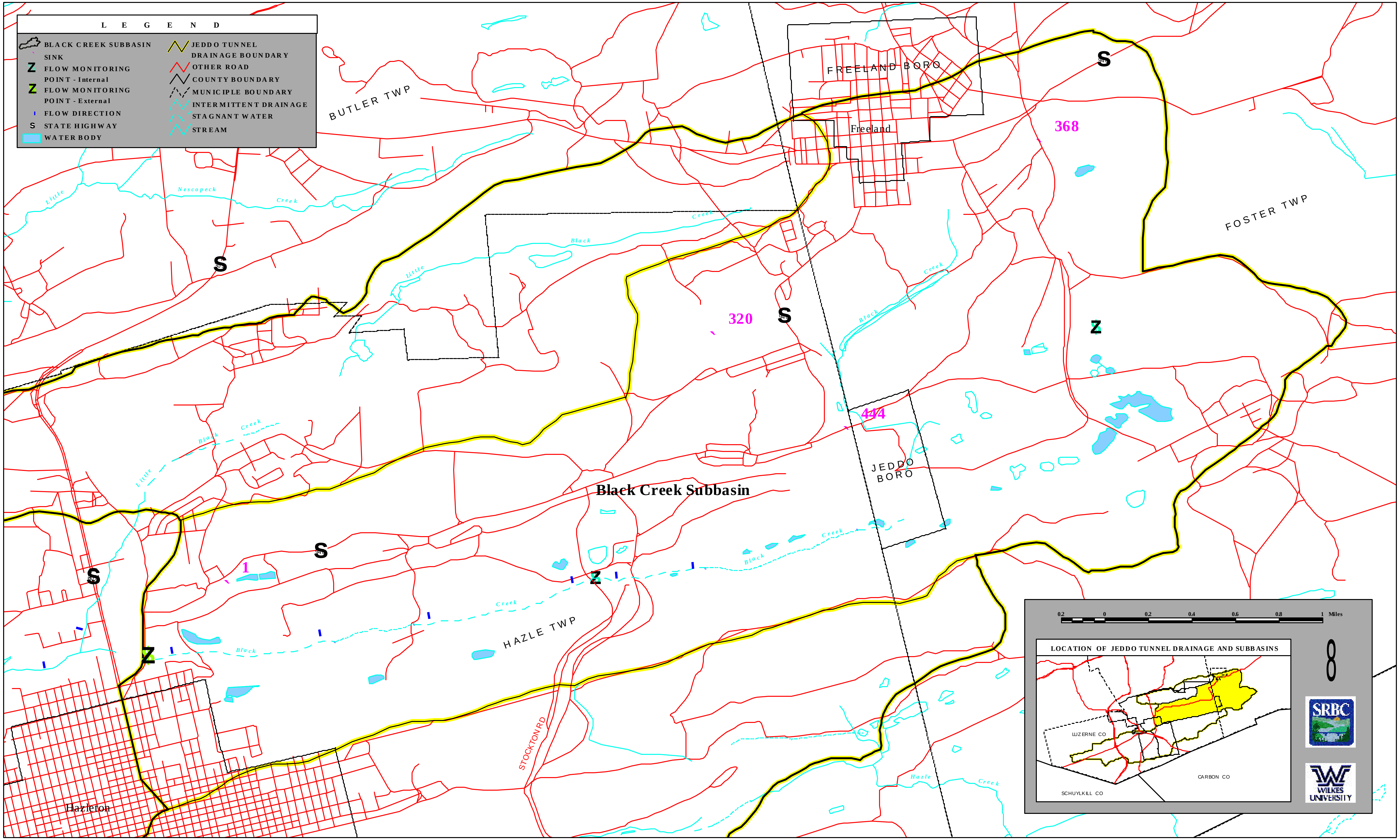

Plate 5. Current Surface Hydrology in the Black Creek Subbasin

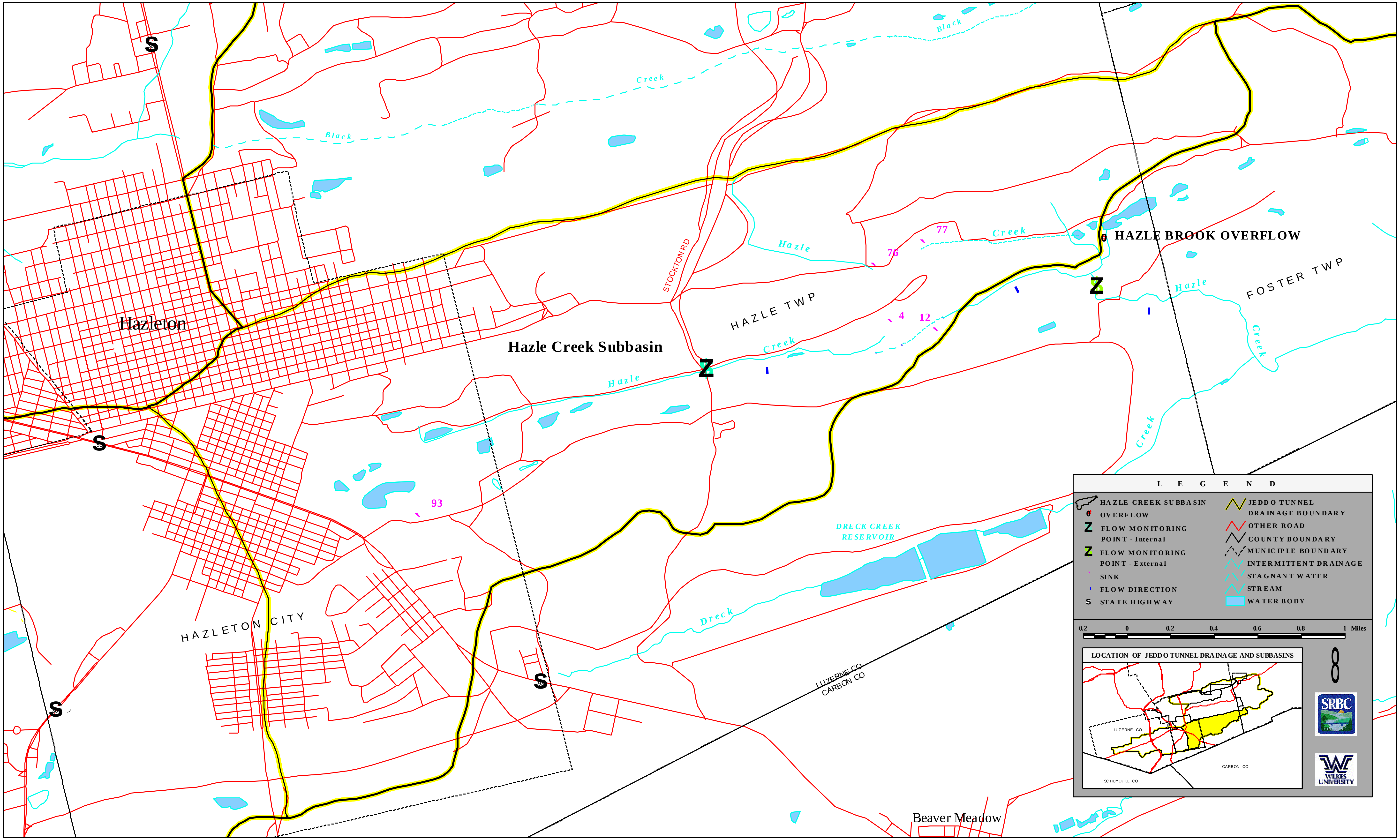

Plate 6. Current Surface Hydrology in Hazle Creek Subbasin

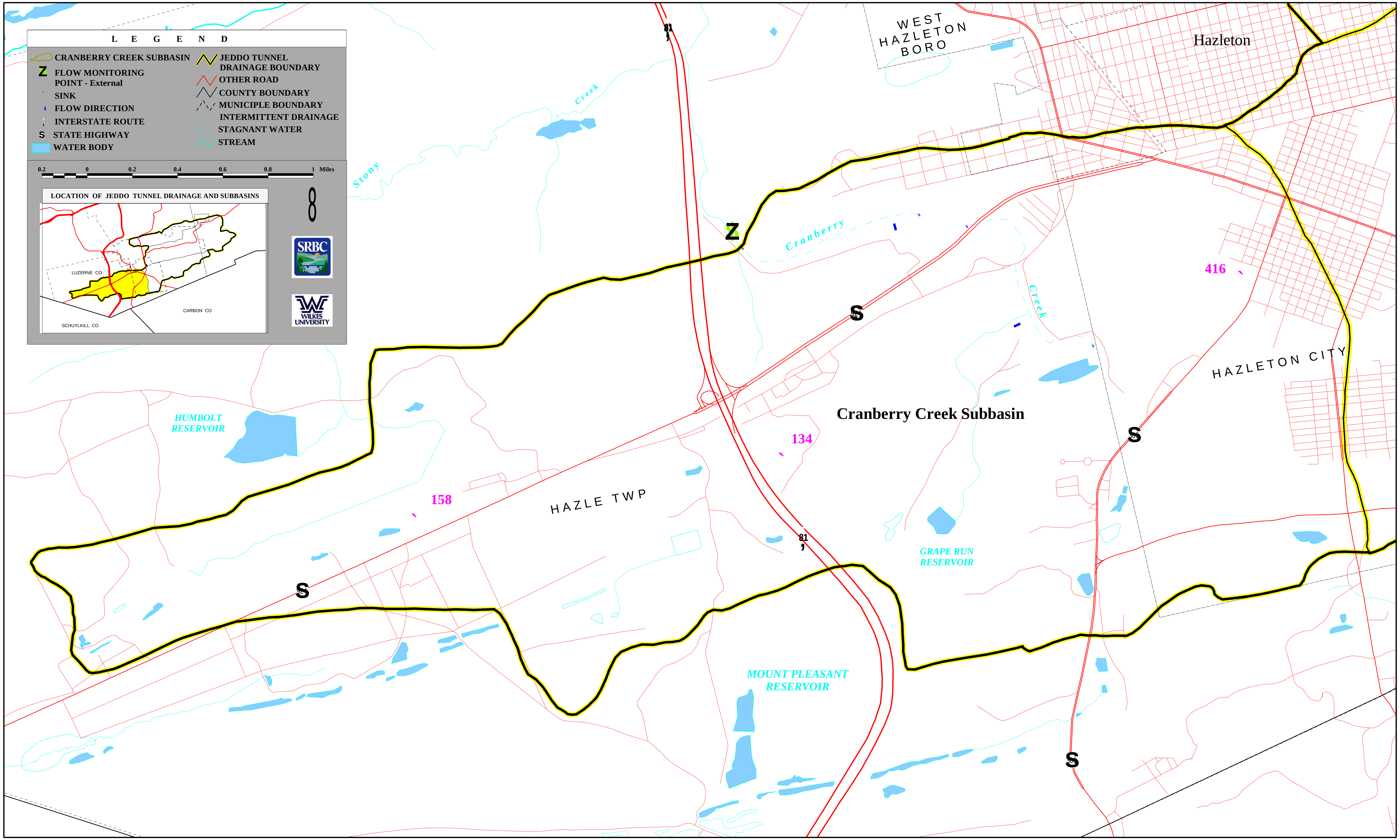

Plate 7. Current Surface Hydrology in the Cranberry Creek Subbasin

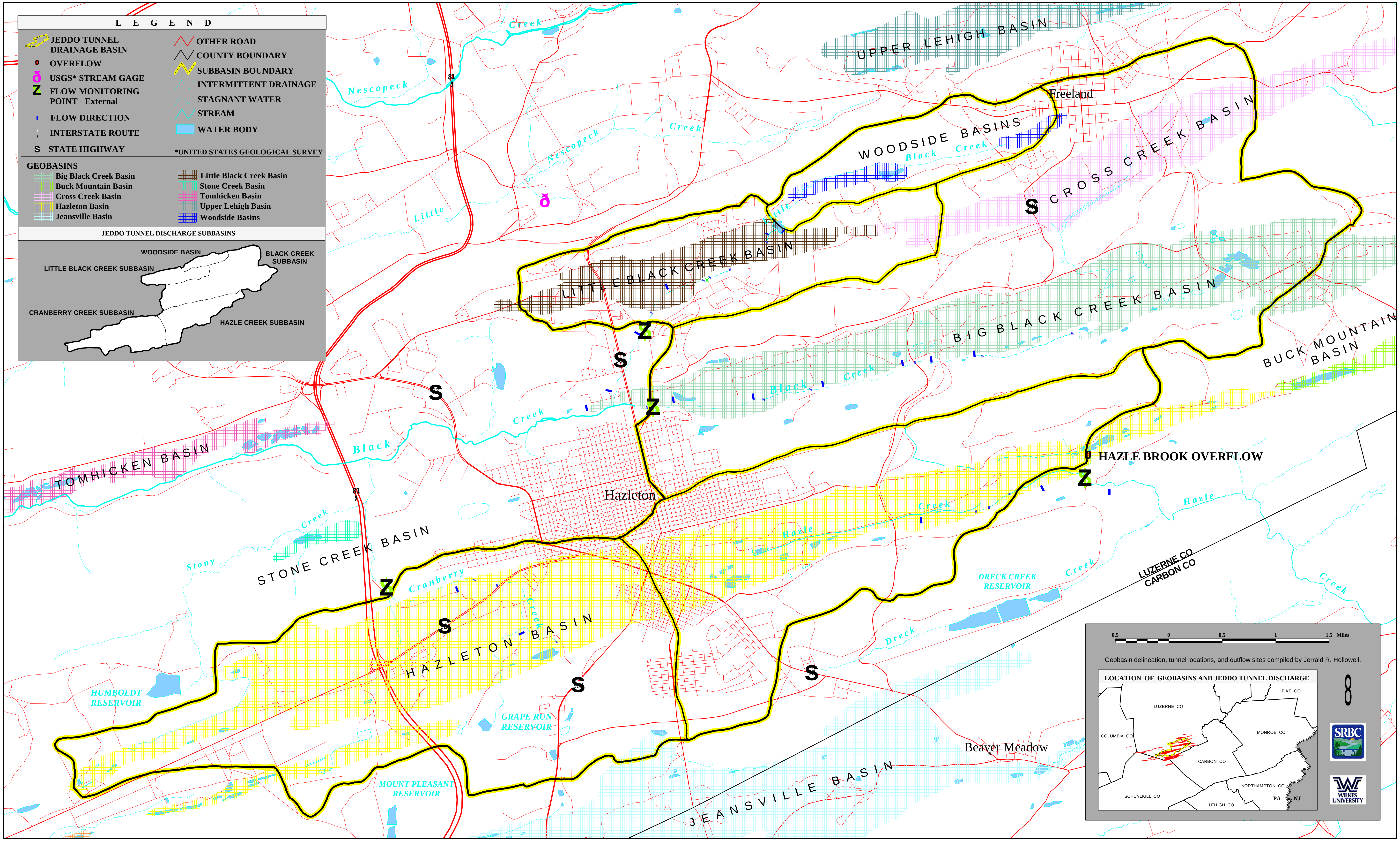

Plate 8. Locations of Flow Measurements for Streams Leaving the Jeddo Basin