Acid Mine Drainage Restoration Plan for the North Branch of Bear Creek

May 24, 2004

Prepared for the

Bear Creek Watershed Association and the Butler County Conservation District

Prepared By

HedinEnvironmental

Funding for this project was provided by the Pennsylvania Department of Environmental Protection's Growing Greener Program. The opinions expressed herein are those of the authors and not necessarily those of DEP.

Executive Summary

The purpose of this project was to complete a watershed assessment and formulate a restoration plan for the North Branch of Bear Creek in Butler County, PA. Funds for this project were obtained from the Pennsylvania Department of Environmental Protection's Growing Greener Program. The assessment of the watershed was initiated using funding from the Pennsylvania Department of Environmental Protection's Technical Assistance Grant (TAG) portion of the Growing Greener Program. The Bear Creek Watershed Association (BCWA) was the project grantee and the Butler County Conservation District (BCCD) was the project sponsor responsible for administering the grant.. Hedin Environmental (HE) was the primary consultant for this project.

The North Branch of Bear Creek Watershed covers approximately 16.7 square miles of Butler County, PA. The watershed encompasses parts of Parker, Allegheny, Venango and Washington Townships. The North Branch of Bear Creek flows to Bear Creek approximately 1.3 miles upstream of where Bear Creek flows into the Allegheny River in Parker. Several seams of coal have been mined through both surface mining and deep mining activities that occurred largely before 1960. Mining activities have resulted in the pollution of the North Branch and many of its tributaries.

This project began with watershed reconnaissance, which located approximately 30 discharges. Over 50 points including these discharges and important in-stream locations were monitored monthly for one year. This data forms the basis of the Restoration Plan.

Several high-priority projects have been identified and cost estimates have been provided. These projects should be pursued immediately in order to begin the recovery of the North Branch. The projects are (in no specific order):

1. NBG25D Reclamation and Alkaline Addition ($42,000)
2. "Young Mine Complex" Phase 1 Reclamation ($48,800)
3. "Young Mine Complex" Phase 2 Reclamation ($459,100)
4. NBE28D and NBE29D Weak Alkali Liquor treatment system ($77,000)
5. NBE52D self-flushing limestone bed system ($50,000)
6. Plug NB31D and NB32D ($24,000)
7. Separate clean water from NB12D; treat NB12D and NB13D with an alkaline wetland system ($115,000)

Seven projects have been identified, but several of the projects may occur concurrently, which could result in cost savings. For instance, the first three projects listed occur adjacent to each other and could be performed concurrently under one contract to save on mapping, permitting, design, and mobilization costs. The total cost of the seven projects listed is estimated at $815,900. It should be possible to implement all of these projects within 5 to 7 years.

In addition to these projects, many other medium- and low-priority projects and recommendations are contained within this plan.

Table of Contents

I. Introduction 4
  A. Watershed Description 4
  B. Geology and Mining History 5
  C. Project Description 7
II. Problem Identification 10
  A. North Branch of Bear Creek Chemistry 10
  B. Tributary Chemistry 11
  C. Discharge Summary 12
III. Watershed Goals and Objectives 15
IV. Treatment and Mitigation Alternatives 15
  A. Mitigation Alternatives 15
  B. Active Treatment Alternatives 17
  C. Passive Treatment Alternatives 18
V. Mitigation Alternatives and Recommendations 22
  A. NBG25D Area 22
  B. "Young Mine Complex" Area 23
  C. Main Stream Banks 26
  D. Other Reclamation and Mitigation Sites 27
VI. Main Stream: Discharge-Specific Treatment Recommendations 28
  A. NB12D 28
  B. NB13D 30
  C. NB15D 32
  D. NB18D 33
  E. NB31D and NB32D 34
  F. NB36D and NB37D 36
VII. Tributary D: Discharge-Specific Treatment Recommendations 38
  A. NBD10D 38
  B. NBD40D 40
  C. NBD50D and NBD51D 41
VIII. Tributary E: Discharge-Specific Treatment Recommendations 42
  A. NBE03D 42
  B. NBE28D and NBE29D 43
  C. NBE52D 46
  D. NBE60D 48
  E. NBE62D 49
  F. NBE75D 50
  G. NBE81D 51
IX. Tributary F: Discharge-Specific Treatment Recommendations 52
  A. NBF40D 52
  B. NBF45D 53
X. Tributary G: Discharge-Specific Treatment Recommendations 54
  A. NBG10D 54
  B. NBG12D 55
  C. NBG15D 56

D. NBG25D 57
E. NBG35D 58
F. NBG45D 59
G. NBG50D 60
XI. Restoration Plan Recommendations 61
A. Priority Projects 62
B. Potential Funding Sources and Partners 62
XII. Assessing Plan Effectiveness 64

List of Tables

Table 1: Impaired Stream Segments from the 303(d) List 4
Table 2: Geologic Ages, Groups, and Formations of the North Branch Watershed 6
Table 3: Coal Seams Present in the North Branch Watershed 6
Table 4: Sampling Point Descriptions 8
Table 5: Sampling Event Dates and Precipitation Totals 10
Table 6: North Branch of Bear Creek In-Stream Chemistry 11
Table 7: Tributary Drainage Areas 12
Table 8: Average Discharge Flow, Chemistry and Loading 13
Table 9: Percent of Average Loading Contribution by Discharge 14
Table 10: “Young Mine Complex” Reclamation Phases 24
Table 11: NB12D Flow, Chemistry and Loading 28
Table 12: NB13D Flow, Chemistry and Loading 30
Table 13: NB15D Flow, Chemistry and Loading 32
Table 14: NB18D Flow, Chemistry and Loading 33
Table 15: NB31D Flow, Chemistry and Loading 34
Table 16: NB32D Flow, Chemistry and Loading 34
Table 17: NB36D Flow, Chemistry and Loading 36
Table 18: NB37D Flow, Chemistry and Loading 36
Table 19: NBD10D Flow, Chemistry and Loading 38
Table 20: NBD40D Flow, Chemistry and Loading 40
Table 21: NBD50D Flow, Chemistry and Loading 41
Table 22: NBD51D Flow, Chemistry and Loading 41
Table 23: NBE03D Flow, Chemistry and Loading 42
Table 24: NBE28D Flow, Chemistry and Loading 43
Table 25: NBE29D Flow, Chemistry and Loading 43
Table 26: NBE52D Flow, Chemistry and Loading 46
Table 27: NBE60D Chemistry 48
Table 28: NBE62D Flow, Chemistry and Loading 49
Table 29: NBE75D Flow, Chemistry and Loading 50
Table 30: NBE81D Flow, Chemistry and Loading 51
Table 31: NBF40D Flow, Chemistry and Loading 52
Table 32: NBF45D Flow, Chemistry and Loading 53
Table 33: NBG10D Flow, Chemistry and Loading 54

Table 34: NBG12D Flow, Chemistry and Loading 55
Table 35: NBG15D Flow, Chemistry and Loading 56
Table 36: NBG25D Flow, Chemistry and Loading 57
Table 37: NBG35D Flow, Chemistry and Loading 58
Table 38: NBG45D Flow, Chemistry and Loading 59
Table 39: NBG50D Flow, Chemistry and Loading 60
Table 40: Summary of Restoration Recommendations 61

List of Figures

Figure 1: North Branch of Bear Creek Watershed and Tributaries
Figure 2: Sampling Stations
Figure 3: Regional Geological Structure Lines
Figure 4: Total Monthly Actual and Mean Precipitation, Butler, PA
Figure 5: Main Stem Chemistry by Stream Mile
Figure 6: Passive Treatment Decision Flow Chart
Figure 7: Tributary G Reclamation Areas
Figure 8: NBE28D, NBE29D and Combined Acid Loading Versus Flow Rate

List of Photographs

Photo 1: BC30
Photo 2: BC40
Photo 3: NB05
Photo 4: NB12D
Photo 5: NB13D
Photo 6: NB15D
Photo 7: NB18D
Photo 8: NB32D
Photo 9: NB36D
Photo 10: NB37D
Photo 11: NBD10D
Photo 12: NBD40D
Photo 13: NBD40D Pond
Photo 14: NBE20
Photo 15: View from NBE20
Photo 16: NBE28D
Photo 17: NBE29D
Photo 18: NBE52D
Photo 19: NBE62D
Photo 20: NBE62D Ravine
Photo 21: NBE75D
Photo 22: NBE81D
Photo 23: NBG12D
Photo 24: NBG15D
Photo 25: NBG25D
Photo 26: NBG35D

Attachment 1: Complete Project Data Set

I. Introduction

The purpose of this project was to complete a watershed assessment and formulate a restoration plan for the North Branch of Bear Creek in Butler County, PA. Funds for this project were obtained from the Pennsylvania Department of Environmental Protection's Growing Greener Program. The assessment of the watershed was initiated using funding from the Pennsylvania Department of Environmental Protection's Technical Assistance Grant (TAG) Program. This project was sponsored by the Bear Creek Watershed Association (BCWA) and administered by the Butler County Conservation District (BCCD). Hedin Environmental (HE) was the primary consultant for this project.

A. Watershed Description

The North Branch of Bear Creek Watershed covers approximately 16.7 square miles of Butler County, PA. The watershed encompasses parts of Parker, Allegheny, Venango and Washington Townships. Portions of the watershed are shown on the Eau Claire, Parker, Emlenton and Hilliards USGS 7.5 minute quadrangle maps. Figure 1 shows the watershed, which is outlined and shaded. For the purposes of this report, the main tributaries of the stream were delineated and lettered A through G. Figure 2 shows the sampling stations that were monitored as part of this project.

The North Branch of Bear Creek flows into Bear Creek approximately 1.3 miles upstream of where Bear Creek flows into the Allegheny River in Parker. The North Branch watershed is roughly bounded by Route 38 in the west, by Route 58 in the north, and by SR1007 in the east. The southern boundary roughly follows the Eldorado Road from Route 38 to Eldorado and then follows SR1009.

DEP classifies Bear Creek as a part of subbasin 17C (Central Allegheny Subbasin). Bear Creek is part of the USGS HUC 05010006 (Middle Allegheny-Redbank). This subbasin includes the Allegheny River and all of its tributaries between Emlenton and Clinton.

DEP Chapter 93 classifies North Branch and its tributaries as Cold Water Fisheries (CWF), although several tributaries and most of the main stem are not meeting this usage because they are too severely polluted to support fish life. Portions of this watershed that were included on DEP's 2002 303(d) list are shown in Table 1.

Table 1: Impaired Stream Segments from the 303(d) List

DEP Segment ID	Length (miles)	Description (see Figure 1)	Impairment Reason(s)
20000627-1400-JJM	11.2	Tributaries E and G	pH, AMD
20010625-1100-JJM	3.3	Tributary D	pH, AMD
20000628-1430-JJM	7.7	North Branch main stem	pH, metals, AMD

The watershed consists mostly of forested land, with some farming and abandoned mining, particularly along streams and in the extreme headwaters. Several pipelines and numerous gas wells are located within the watershed as well. Part of State Game Lands 95 is located in the watershed near the mouth of the North Branch.

The small settlements of Six Points, Bonus and Eldorado are located within the watershed, while Annisville is located just to the southwest of the watershed boundary and Eau Claire is located just northwest of the watershed boundary.

B. Geology and Mining History

Butler County covers 794 square miles in the northern part of the Appalachian coal field. The study area is located in the northwestern segment of Pennsylvania known as the Pittsburgh Low Plateau Section of the Appalachian Physiographic Province. The North Branch of Bear Creek is located in the northeastern portion of the county and is characterized as having broad hilltops, steep sloping valley walls, and moderately dissected upland physiography.

Coal, oil, and natural gas have been extracted from within the watershed for the past 130 years. Oil and natural gas were first discovered in the 1870's with production peaking in the late 1800's. Coal mining first occurred as small drift mines, and eventually large scale deep mines were developed in the Brookville coal seam that produced into the late 1960's. Surface mining started in the 1940's and continued into the 1990's. Large amounts of coal reserves exist throughout the watershed, but most of this coal is buried deeply beneath other rocks.

The regional structure is controlled by the northeast by southwest trending Eau Claire anticline (sub-surface ridge) (See Figure 3). The anticline is situated just west of the town of Eau Claire, directing the flow of groundwater towards the southeast near the mouth of the North Branch. The dip of the geologic structure is approximately two percent to the southeast along the North Branch Bear Creek flow path. Groundwater appears to be partially directed towards the Foxburg syncline (sub-surface valley), which is located just north of the mouth of the North Branch with the synclinal axis trending in a north to south orientation.

Table 2 contains information on the geologic ages, groups, and formations present in the watershed. The groups are listed from highest (youngest) to lowest (oldest) as they appear in rock formations. Mississippian and Pennsylvanian Age bedrock is exposed in the watershed. The only exposed Mississippian age rocks in Butler County occur in the lower extent of the Bear Creek Watershed and are 150 to 200 feet in thickness. The Pennsylvanian rocks that are situated on top of the Mississippian age rocks consist of interbedded sandstone, siltstone, shale, limestone, coal, and clay. The Pennsylvanian rocks of Bear Creek are divided into the Pottsville Group and Allegheny Group. These groups of rocks cap the hilltops of the watershed and are exposed throughout.

Four main coal seams have experienced mining in the North Branch watershed; the Brookville seam, the Lower and Middle Kittanning seams, and, to a much more limited extent, the Lower Freeport coal seam. Table 3 provides more information and lists these seams as they appear in the rock structure from highest (youngest) to lowest (oldest).

Table 2: Geologic Ages, Groups, and Formations of the North Branch Watershed

Geologic Age	Group	Formations	Thickness	Coal Seams (thickness)	Notes
Pennsylvanian	Allegheny Group	Freeport	52 to 160’	Lower Freeport (13 – 42”)	On a few high knobs in headwaters area.
		Kittanning	60 to 225’	Middle and Lower (20 – 36”)	Exposed throughout watershed.
		Vanport	1 to 28’		
		Clarion	6 to 48’	Brookville (29”)	Crops at streams edge in middle reaches, above drainage in lower reaches.
	Pottsville Group	Homewood, Mercer and Connoquenessing	170’	Thin, unmined beds	Towards the mouth of the stream.
Mississippian	Burgoon Sandstone		200’	None	Exposed near mouth.

Table 3: Coal Seams Present in the North Branch Watershed

Group	Formation	Coal Seam	Seam Thickness (in)	Distance between Seams (ft)	Location
Allegheny	Freeport	Lower Freeport	Up to 42	30 to 50 below Upper	Isolated knobs in headwaters.
Allegheny	Kittanning	Middle Kittanning	Up to 28	~ 110 below Lower Freeport	Throughout watershed.
Allegheny	Kittanning	Lower Kittanning	Up to 36	~ 100 below the Middle K.	Throughout watershed
Allegheny	Clarion	Brookville	Up to 29	Up to 120 below Lower K.	Exposed in middle reaches to the mouth.

Along the North Branch, the Brookville coal seam was extensively surface mined. Abandoned surface mines along the main branch are located several hundred feet away from the stream towards the mouth of the stream, but in very close proximity to the stream in the headwaters area. Tributary streams feeding the main branch have had coal removed within a few feet of the stream with spoil spilling into the stream itself. Deep mining of the Brookville coal seam has occurred throughout the watershed. These areas were often surface mined after completion of the deep mining operations. AMD discharges originating off of the Brookville coal seam are present along the main stream and the tributaries that originate to the north and east.

Coal seams mined in the Kittanning Formation were the Lower and Middle Kittanning coal seams. These seams were surface mined at the crop edges above the Brookville coal throughout the watershed. These seams may also have experienced limited deep mining. Discharges from these seams occur on tributaries to the south of the main branch of the stream, particularly Tributaries D and E.

The Freeport Formation has experienced very little mining within the watershed. A small knob of Lower Freeport coal was extracted to the southeast of Six Points, but no other mining activity on this seam is known.

C. Project Description

The Bear Creek Watershed Association and the Butler County Conservation District initiated the assessment of the North Branch of Bear Creek in January 2002. At that time, they submitted a request for a Technical Assistance Grant (TAG) from DEP through Stream Restoration, Inc., an authorized TAG provider. BCWA/BCCD requested a rapid assessment of the mine drainage impacts to the watershed. Their request was granted and technical assistance work by SRI's contractor, Hedin Environmental, began that month.

Volunteers from BCWA and BCCD and HE personnel performed spot sampling of the watershed in January 2002. In February 2002, BCWA and BCCD applied to the Growing Greener Program for a full-scale watershed assessment based on the technical information gathered in the early TAG project.

Stream reconnaissance was performed in March and April 2002. This reconnaissance was performed in order to locate all sources of mine drainage pollution to the stream. Flow monitoring stations were installed in April.

The first complete round of stream and discharge samples was collected in May 2002. Monthly samples continued to be taken under the TAG program until August 2002, when it was announced that the Growing Greener program had funded the full-scale assessment. Sampling continued on a monthly basis under the Growing Greener project until April 2003. Additional sampling was conducted by the Knox District Mining Office (DMO) of the DEP in order to complete a Total Maximum Daily Load (TMDL) study of the North Branch.

Table 4 lists the 56 stream and discharge points that were monitored. These points are shown on Figure 2. The points are grouped according to their location in the watershed. In order to facilitate data compilation and analysis, a consistent point naming system was used. Each point was assigned 2 letters based on the stream. "BC" was used for Bear Creek points, while "NB" was used for points on the North Branch of Bear Creek. The major tributaries of the North Branch were lettered A through G (See Figure 1) and points located in the tributaries were assigned this letter in addition to "NB." Numbers were then assigned to points based on their location on the stream or tributary, starting with 01 at the mouth of each stream and proceeding upstream with higher numbers. In many cases, numbers were not assigned sequentially in order to allow more points to be added later if necessary. Finally, discharges were assigned a “D” after the number, while in-stream samples were not.

Table 4: Sampling Point Descriptions

Point ID	Description
BC30	Bear Creek at Butler County Line Downstream of North Branch of Bear Creek (Photo 1)
BC40	Bear Creek at Bruin Bridge (Upstream of North Branch Confluence) (Photo 2)
NB05	North Branch at Route 268 Bridge
NB10	North Branch at Eldorado Road
NB12D	Just east of NB13D, discharge from a ravine
NB13D	Discharge from rock face along 4-wheeler trail.
NB15D	Swamp area at toe of spoil near Eldorado Road. Many Discharge points directly to stream
NB18D	Beaver pond area fed by runoff. Take sample at the outflow of the pond.
NB20	North Branch at Stone Bridge
NB30	North Branch just downstream of NB31D and NB32D
NB31D	Gas well discharge beside North Branch.
NB32D	Similar discharge as NB31D on opposite side of stream
NB36D	Seep flowing out of old strip cut. Very near stream. Fe deposit into stream channel.
NB37D	Discharge from mine spoil just above the stream channel.
NB40	North Branch just downstream of Tributary G Mouth
NB41	North Branch just upstream of Tributary G Mouth
NBB05	Near Mouth of Tributary B at Eldorado Road
NBC01	Mouth of Tributary C
NBD10D	Pond created by spoil piles - fed by a spring. Sampled at pond outlet.
NBD40D	Large Fe contaminated flow discharging into a limestone-lined channel that by-passes a treatment pond, and flows directly to the stream.
NBD50D	Small discharge below house and barn above pond--in swamp area.
NBD51D	Larger discharge below house and barn above pond - discharge from concrete structure
NBE01	Mouth of Tributary E
NBE03D	Discharge feeding strip cut that is now occupied by beavers. Seep zone is at far end of pond. Sample for chemistry at the far end and measure the flow at the outfall structure
NBE10	Mouth of small tributary to Tributary E at Road
NBE20	Pond Outfall at mouth of tributary to Tributary E.
NBE28D	Just east of NBE29D, multiple small seep zones combine near tall grass.
NBE29D	Dean Road off 38, Large dark orange seep, multiple sources to stream. Chem at discharge, flow nearer to stream.
NBE30	Headwaters of tributary above discharges NBD28D and NBE29D.
NBE35	Small spring feeding beaver pond from south.
NBE40	Alpha Environmental Trib mouth
NBE50	Tributary E in stream above confluence with Alpha Environmental Trib
NBE52D	Spring from hill side slope.
NBE60D	Reclaimed strip mine drain. Landowner objected to sampling of any kind.

NBE62D	Orange discharge (colorless by the end of the ravine) in deep ravine originating ~ 75 yards south of stream
NBE65	Tributary mouth near site NBE75. Take sample to confirm quality--recon if necessary
NBE72	Discharge from pond on the western Alpha Environmental Trib
NBE75D	Large orange upwelling near the confluence of two tributaries. Very messy
NBE80	Downstream of NBE81D to assess chemistry change through Beaver ponds
NBE81D	Upwelling near old powerhouse (Behind autobody). Flows to Beaver ponds
NBF35	Tributary F below NBF40D and NBF45D
NBF40D	Past "Corn Field Corners" towards "Flop House", follow trail to Beaver pond outflow.
NBF41D	FLOW ONLY - Add to flow of NBF40D and assume same chemistry
NBF45D	Collection of orange seeps near NBF40D. Some flows to Beaver dam trib, some to stream.
NBF46D	FLOW ONLY - Add to flow of NBF45D and assume same chemistry
NBF47D	FLOW ONLY - Add to flow of NBF45D and assume same chemistry
NBF55	Tributary F above NBF40D and NBF45D
NBG01	Mouth of Tributary G
NBG10D	Seepage is located in stream channel along the east bank.
NBG12D	Upwelling from the spoil. Located behind house on spoil above the stream.
NBG15D	Deep mine discharge out of a pipe; behind house with equipment.
NBG20	Tributary G at road crossing
NBG25D	Part of deep mine complex above storage tank. Small seep out of diversion ditch. Flows to stream ~ 100 feet above bridge crossing stream.
NBG35D	Small opening in strip cut. Strip cut comes in off of left side of stream. Beaver dam has source of water submerged. Collect water at foot of dam for flow rates and chemistry.
NBG45D	Small Fe contaminated upwelling out from side of spoil on trib to the north of NBG35D. Flow is mostly likely result of beaver damming off strip cut adjacent to NBG45D.
NBG50D	Small Fe contaminated upwelling flowing out of the base of the highwall above NBG45D.

In the field, samples were analyzed for flow rate, pH, alkalinity, conductivity and temperature. Temperature and pH were measured using a Hanna multi-meter. Alkalinity was measured using a HACH digital titration kit. Conductivity was measured using a Hanna Instruments Model HI 8733 conductivity meter. At each location, a 500-mL raw sample and a 125-mL acidified sample were collected for laboratory analyses. The acidified sample was preserved using nitric acid. All laboratory analyses were performed by G&C Laboratories of Summerville, PA using standard and approved methods.

Flow rate was measured using a variety of methods. For small discharges (generally less than 100 gpm), pipes were installed to collect the flow. A bucket was used to collect a known amount of volume in a known time period, which was measured with a stopwatch. This is known as the "timed volume" method. For larger discharges and small streams (generally less than 400 gpm), H-flumes were temporarily installed. These flumes were equipped with dipsticks that read directly in gallons per minute. Additionally, stream flows were measured using a Swoffer Model 3000 velocity meter.

Monthly samples were taken from May 2002 until April 2003. Most discharges were sampled monthly, while a few were sampled quarterly because they were determined to have little impact on the stream based on early sampling results. Some sampling stations were not sampled in January 2003 because weather conditions made them inaccessible.

During the sampling period (May 1, 2002 through April 30, 2003), a total of 33.74 inches of precipitation (as liquid) fell in Butler, PA, which is located approximately 17 miles southwest of the watershed. This is less than the mean precipitation at this station, which is 42.8 inches with a standard deviation of 5.7 inches. Figure 4 shows the actual monthly totals of precipitation as well as the mean precipitation for each month. Four months had precipitation totals above the mean, while 8 months had precipitation totals less than the mean. Given this data, it can be concluded that the sampling period overall was drier than average. However, several sampling events occurred immediately after significant rainfall periods, effectively measuring high flow conditions.

While some sampling events were completed in one day, the majority were completed over two consecutive sampling dates. Table 5 shows the dates of each sampling event as well as precipitation totals just prior to and during each sampling event.

Table 5: Sampling Event Dates and Precipitation Totals

Sampling Event	Sampling Date(s)	4-day Total Prior Precip (in)	Total Precip During Sampling (in)
May-02	20, 21	1.19	0
June-02	18, 19	0.96	0.02
July-02	9, 10	0	0.21
August-02	7, 8	0.35	0
September-02	3, 4	0	0.22
October-02	8, 9	0.72	0
November-02	8	0.44	0
December-02	16,17	1.41	0.02
January-03	3,4	0.04	0.01
February-03	5,6	0.55	0.03
March-03	18,19	0.46	0
April-03	15	0.02	0

As shown, significant precipitation totals (over 0.5 inches) were recorded just prior to the May, June, October, and December 2002 and February 2003 sampling events. Significant rainfall amounts did not fall during any of the sampling events.

II. Problem Identification

A. North Branch of Bear Creek Chemistry

Figure 2 shows the sampling stations that were used for this project. Table 6 shows the average in-stream chemistry at each of the 6 sampling stations on the main stem of the North Branch.

Some of the data in Table 6 is presented graphically in Figure 5. As shown in the table and figure, the water quality of the stream is degraded by inputs of mine drainage from tributaries and direct discharges. However, the chemistry begins to improve downstream of station NB30 as clean water from unimpacted tributaries enters the stream.

Table 6: North Branch of Bear Creek In-Stream Chemistry

Sample Point	Stream Mile (From Mouth)	# of Samples	pH	Cond (us)	Net Acidity (mg/L as $CaCO_3$)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)
NB41	5.43	12	5.8	327	-8	3.1	1.1	0.8	130
Tributary G enters the stream									
NB40	5.34	5	5.7	261	12	4.6	1.1	1.4	98
NB37D, NB36D, NB32D, NB31D enter the stream									
NB30	4.59	5	4.6	345	37	5.9	1.6	2.3	161
Tributary F and Tributary E enter the stream									
NB20	3.49	5	4.7	329	26	2.2	2.3	2.2	154
Tributary D, NB18D, NB15D, NB13D, NB12D and Tributary C enter the stream									
NB10	1.96	12	4.4	385	26	1.4	2.5	2.2	189
Tributary B and Tributary A enter the stream									
NB05	0.55	5	5.4	313	11	1.0	1.7	1.5	141

The chemistry of the stream upstream of NB41 is of sufficient quality to sustain a biological community. Iron present in these samples is being contributed by diffuse areas of base flow. However, macroinvertebrates and some fish species are capable of surviving in this type of water. The other reaches of the main stream are net acidic and contain metal concentrations that are unlikely to allow a robust aquatic community to survive. NB05 is shown in Photo 3.

B. Tributary Chemistry

Table 7 shows the watershed area and other information on the tributaries. On Figure 1, the tributaries are shaded yellow while the headwaters and main stem drainage areas are shaded grey.

Table 7 shows that four of the major tributaries, A, B, C, and F, contribute clean water to the main branch of the stream. These tributaries drain approximately 25% of the watershed. No polluted discharges were found on Tributaries A, B, or C. Several small discharges with moderately contaminated water flow to Tributary F, but the stream is capable of assimilating this pollution by the time the water reaches the mouth of Tributary F. The headwaters area and some of the main stem area also contribute clean water, however, there are several direct discharges to the main stem of the stream.

Tributaries D, E, and G contribute polluted water to the stream. These tributaries drain approximately 43% of the watershed. Many discharges flow to each of the polluted tributaries.

Table 7: Tributary Drainage Areas

Tributary	Drainage Area (Sq. Miles)	% Area of Watershed	% of total Stream Flow Nov 2003	General Water Quality*			
				pH	Net Alk. (mg/L as CaCO3)**	Fe (mg/L)	Al (mg/L)
A	2.0	12%	15%	~ 7	20	< 0.3	< 0.5
B	1.0	6%	5%	~ 7	20	< 0.3	< 0.5
C	0.6	3%	4%	~ 7	30	< 0.3	< 0.5
D	**2.2**	**13%**	**9%**	**4 to 5**	**- 40**	**1 to 6**	**1 to 5**
E	**2.8**	**17%**	**12%**	**4.5 to 5**	**- 20 to - 40**	**0.5 to 1.5**	**1 to 4**
F	0.6	4%	3%	6 to 7	10	< 0.3	< 0.5
G	**2.1**	**13%**	**12%**	**3 to 4**	**- 20 to - 110**	**5 to 15**	**2 to 8**
Headwaters, Main Stem	5.4	32%	41%	Quality varies widely with some direct discharges to the main stem of the stream			
TOTAL	**16.7**						

**Based on results of the TMDL sampling of the watershed by Knox DMO and the watershed assessment*
***Net acidity shown as negative net alkalinity*

C. Discharge Summary

Twenty-nine discharges were identified and sampled during the course of this project. Several other discharges were identified in the field but were not sampled because they were not polluted with acidity or metals. Table 8 shows the average flow, chemistry and loading from each discharge. The number of samples taken from each discharge is also shown.

The top 9 loading contributors for each pollutant are shaded in yellow. Although the loading of NBE60D is unknown because it was not feasible to sample this station more than once due to landowner restrictions, the known chemistry and observed flow rate on that one occasion indicate that it is a major contributor of pollution to the stream.

The lowest 12 contributors in each category are shaded blue. These discharges contribute little loading of the indicated pollutant to the stream. Intermediate discharges are not shaded.

Table 9 shows the percent of the average loading contribution by each discharge. The discharges have been sorted based on the average acidity loading, with the highest contributors listed first.

The top 8 known contributors of acidity shown in Table 9 contribute an average total of 686.2 ppd of net acidity, 77.2 ppd of iron, and 61.2 ppd of aluminum. This represents 89% of the measured acidity loading, 86% of the iron loading, and 92% of the aluminum loading. Along with these top known contributors, NBE60D is assumed to be a top contributor of pollution to the stream. When this group is expanded to include the top 12 known contributors, 97% of the acidity, 95% of the iron and 98% of the aluminum loading is accounted for. Thus, these top 12 contributors plus NBE60D should be the focus of restoration efforts in the watershed.

The sampling data and a discussion of alternatives for each discharge are presented below.

Table 8: Average Discharge Flow, Chemistry and Loading

Point ID	Count	Flow (GPM)	Field pH	Cond (uS)	Net Acid (mg/L as CaCO3)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (pounds per day) Net Acid	Iron	Al
NB12D	11	80.8	4.1	448	32	2.0	0.9	2.0	237	2	15.7	0.1	0.9
NB13D	11	8.1	3.2	1,181	171	30.8	2.6	8.2	645	10	17.5	3.1	0.8
NB15D	11	7.8	3.7	676	67	8.9	1.5	3.4	318	6	4.6	0.5	0.3
NB18D	11	21.4	5.3	49	4	0.3	0.2	0.5	14	11	1.0	0.1	0.1
NB31D	12	7.3	4.5	935	124	38.1	6.4	6.2	518	5	10.3	3.3	0.5
NB32D	12	2.2	3.7	986	129	33.8	6.2	4.2	563	3	3.5	0.9	0.1
NB36D	12	22.3	3.3	1,154	230	36.2	3.6	16.4	588	4	43.8	4.2	3.6
NB37D	12	26.6	2.7	1,782	644	99.3	4.0	45.0	864	3	159.9	21.3	11.4
NBD10D	11	61.1	4.5	382	26	1.9	1.6	2.5	189	4	16.2	0.9	1.9
NBD40D	12	23.1	6.1	266	-15	13.3	2.4	0.1	57	5	-6.1	2.7	0.0
NBD50D	5	0.8	6.4	114	-24	21.0	1.0	0.1	13	8	-0.2	0.1	0.0
NBD51D	5	37.1	5.6	124	4	2.9	0.2	0.1	19	2	1.4	0.8	0.1
NBE03D	5	27.6	6.0	220	-6	2.9	1.3	0.1	84	8	-1.7	0.5	0.1
NBE28D	12	11.7	3.0	2,804	869	40.1	74.6	103.8	2,037	5	120.4	5.2	14.5
NBE29D	12	32.7	3.3	1,476	418	23.6	28.4	48.1	898	4	162.0	6.9	19.7
NBE52D	11	23.5	4.1	672	79	0.0	9.8	10.1	390	3	19.6	0.0	2.5
NBE60D	1		4.0	388	52	0.2	6.4	4.6	189	1	unknown		
NBE62D	5	20.5	6.0	348	-29	4.5	1.7	0.0	100	4	-6.6	0.9	0.0
NBE75D	10	6.9	5.4	403	17	10.9	4.4	2.0	181	6	1.4	1.0	0.2
NBE81D	12	44.7	5.5	113	3	0.1	0.1	0.1	20	3	1.4	0.0	0.1
NBF40D	8	59.4	6.1	83	-16	5.3	0.8	0.1	23	3	-4.2	1.1	0.1
NBF45D	8	9.7	6.3	154	-22	4.3	2.7	0.0	41	4	-2.6	0.5	0.0
NBG10D	12	0.9	3.0	3,945	3,068	1025.4	12.0	160.6	3,652	9	33.9	11.2	1.8
NBG12D	12	24.0	5.6	198	5	5.5	0.8	1.1	81	6	1.3	0.9	0.2
NBG15D	12	167.1	3.6	475	112	22.1	1.5	7.1	205	5	115.8	19.7	6.7
NBG25D	12	0.3	2.0	10,334	7,963	2262.4	4.4	235.2	8,839	17	30.7	8.7	0.9
NBG35D	12	21.1	4.3	420	46	5.3	2.9	3.7	210	8	6.5	0.5	0.5
NBG45D	5	1.5	6.0	461	15	16.2	4.9	0.1	175	3	0.2	0.3	0.0
NBG50D	5	9.6	6.3	329	-27	4.7	1.3	0.0	111	3	-2.9	0.5	0.0
Total Average Pollution Loading (pounds per day)*											**767.2**	**89.4**	**66.7**

** The total acidity loading was calculated by adding only the positive loading amounts*

Table 9: Percent of Average Loading Contribution by Discharge

Point ID	Loading (pounds per day) Net Acid	Iron	Al	% Contribution of Known Loading Net Acid*	Iron	Al
NBE29D	162.0	6.9	19.7	21%	8%	30%
NB37D	159.9	21.3	11.4	21%	24%	17%
NBE28D	120.4	5.2	14.5	16%	6%	22%
NBG15D	115.8	19.7	6.7	15%	22%	10%
NB36D	43.8	4.2	3.6	6%	5%	5%
NBG10D	33.9	11.2	1.8	4%	12%	3%
NBG25D	30.7	8.7	0.9	4%	10%	1%
NBE52D	19.6	0.0	2.5	3%	< 1%	4%
NBE60D	unknown**			unknown**		
NB13D	17.5	3.1	0.8	2%	3%	1%
NBD10D	16.2	0.9	1.9	2%	1%	3%
NB12D	15.7	0.1	0.9	2%	< 1%	1%
NB31D	10.3	3.3	0.5	1%	4%	< 1%
NBG35D	6.5	0.5	0.5	< 1%	< 1%	< 1%
NB15D	4.6	0.5	0.3	< 1%	< 1%	< 1%
NB32D	3.5	0.9	0.1	< 1%	1%	< 1%
NBE81D	1.4	0.0	0.1	< 1%	< 1%	< 1%
NBD51D	1.4	0.8	0.1	< 1%	< 1%	< 1%
NBE75D	1.4	1.0	0.2	< 1%	1%	< 1%
NBG12D	1.3	0.9	0.2	< 1%	1%	< 1%
NB18D	1.0	0.1	0.1	< 1%	< 1%	< 1%
NBG45D	0.2	0.3	0.0	< 1%	< 1%	< 1%
NBD50D	-0.2	0.1	0.0		< 1%	< 1%
NBE03D	-1.7	0.5	0.1		< 1%	< 1%
NBF45D	-2.6	0.5	0.0		< 1%	< 1%
NBG50D	-2.9	0.5	0.0		< 1%	< 1%
NBF40D	-4.2	1.1	0.1		1%	< 1%
NBD40D	-6.1	2.7	0.0		3%	< 1%
NBE62D	-6.6	0.9	0.0		1%	< 1%
Total*	**767.2**	**89.4**	**66.7**			

** The total acidity loading was calculated by adding only the positive loading amounts. Percentages were based on this total.*
*** Loadings for this discharge are unknown due to lack of flow rate data.*

III. Watershed Goals and Objectives

The Bear Creek Watershed Association was formed with the hope that a concerted effort by citizens can affect positive change in the watershed. The goals of the BCWA with respect to the North Branch of Bear Creek are to:

1. Treat mine drainage discharges that impair the water quality of the stream and its tributaries and restore these waters to their designated usage of "swimmable, fishable, drinkable."
2. Increase the visibility and viability of the BCWA by demonstrating early successes and gaining momentum and publicity from these early projects.
3. Become a sustainable, long-term presence in the watershed by engaging a variety of agencies, businesses, individuals and other partners in the restoration of Bear Creek.

These watershed goals will be achieved by implementing the objectives of this restoration plan, which are outlined in Section XI.

IV. Treatment and Mitigation Alternatives

There are several ways to mitigate and/or treat mine drainage that vary depending upon the origin, chemistry, and geographical surroundings of the discharge. Mitigation is also referred to as "source reduction" and indicates one-time activities that lessen the amount or severity of pollution that is produced. The purpose of this section is to describe the basic treatment and mitigation alternatives that are currently available for discharges in the study area.

A. Mitigation Alternatives

Mitigation targets the amount (flow rate) or severity (pollutant concentration) of mine drainage discharges through a one-time effort. Typical types of mitigation include surface reclamation, removal or isolation of toxic materials, revegetation, alkaline addition to the surface or subsurface, and source plugging. This section will discuss these mitigation alternatives.

When the source of contaminated mine water is a discrete point source, such as a mine opening or a well, it may be feasible to eliminate the discharge by blocking the flow path. Deep mine entries may be sealed with either wet seals that allow the discharge to flow through the seal or with dry seals that prevent discharges.

Artesian flows from abandoned oil or gas wells can be plugged with concrete. Hundreds of abandoned wells are plugged each year in Pennsylvania to prevent flows of brine water and explosive gases, and to prevent the cross-contamination of aquifers penetrated by the wells. Abandoned wells in the Bear Creek watershed and in many surrounding watersheds in Venango, Clarion and Jefferson Counties act as conduits for AMD flows. Dozens of AMD-producing wells have been plugged in Clarion County in the last two years by the USDA Natural Resource Conservation Service and other entities.

Before attempting to eliminate a point discharge, it is advisable to evaluate the hydrogeological setting and determine where the diverted water is likely to discharge. When successful, plugging can be an inexpensive alternative to treatment. It can also be a "last resort" alternative for discharges that do not allow passive treatment because of location (close to the stream or on a steep bank, for instance).

When partially successful, plugging can reduce the cost of the treatment system by reducing the flow rate. When plugging is unsuccessful, it can cause the water to emerge in an unwanted location either directly adjacent to the plugged well, from joint fractures in streams, or some distance away. Plugging deep mine entries is even more risky, as deep mine pools can represent vast quantities of water that cover large areas underground. Deep mine seals can fail dramatically, releasing large quantities of water in the plugged location or in another location that drains the same mine pool. In the adjacent Slippery Rock Creek Watershed, mines and wells were successfully sealed but AMD was not eliminated as it moved and was discharged at unsealed wells, mines, and natural springs.

If the discharge cannot be eliminated, methods to decrease the contaminant loadings should be considered. Acidity and metals loading can be decreased using several methods, including:

- Reducing contact between water and acid-producing materials by increasing runoff and eliminating impoundments;
- Isolating the materials by capping or moving them to a dry location; and
- Adding alkaline materials to neutralize acid production.

Surface reclamation is common mitigation effort that involves grading spoil piles, identifying and isolating or removing acid-producing materials, eliminating impounded water and encouraging surface runoff. Reclamation lessens contact between clean precipitation or groundwater flow and acid-producing materials. The result can be significant reductions in the quantity and/or improvements in the quality of discharges.

Reclamation, alkaline addition and revegetation are most effective for small, intermittent flows of contaminated drainage that flow directly from the surface of spoils. Reclamation is not as effective for seeps and discharges that may be influenced by groundwater flow or deep mine voids.

Reclamation usually includes revegetation and some form of alkaline addition. Establishing good cover vegetation on poor mine spoil or soil typically requires heavy additions of agricultural lime or another alkaline product. Fertilizer and mulch are also used. Vegetation prevents erosion and allows more water to run off a site rather than percolate into the spoil, where it can generate more mine drainage pollution.

Neutralization is increased through the addition of alkaline materials to the site. Limestone ($CaCO_3$) and lime ($Ca(OH)_2$ or CaO) products are widely available and are commonly used for alkaline addition. In some cases, low-grade limestone not suitable for commercial mining but suitable for alkaline addition may exist near the site. The remediation plan may include plans to mine the low-grade limestone specifically for alkaline addition. The only source of limestone near the watershed is the Vanport Limestone which can be a highly productive formation for aggregate producers. Alkaline waste products can also be used. Examples include fly ash, fluidized bed bottom ash, processed slag, bag house lime, and paper, pulp, tannery, or other industrial by-products. Locally available sources may include waste products from limestone mining and/or agricultural lime production (Boyers, Branchton) and weak alkali liquor (Parker).

Many reclamation projects are supported by state and federal reclamation programs. The Bureau of Abandoned Mine Reclamation (BAMR) is a bureau of the PA DEP that performs many such projects. The Cambria BAMR office is responsible for this watershed, as well as the Knox District Mining Office of DEP. However, the presence of marketable coal and/or coal refuse material on a site makes reclamation through coal mining activities possible. In this case, the mining company is provided with incentives to "re-mine" the coal and/or refuse and reclaim the abandoned spoils. The mining company pays the costs of the reclamation on a re-mining project. These activities can result in a reduction in the contaminant production. Government Financed Construction Contracts (GFCCs) have been used to encourage re-mining in areas where it will provide solutions to land and/or water problems. An on-site assessment by DEP has concluded that the potential for re-mining in the North Branch is limited.

While mitigation is an important component of any restoration plan, the results of mitigation are difficult or impossible to predict. Mitigation is not an option for every discharge. At some sites, reclamation and well plugging have dramatically reduced the amount of pollution to a watershed, while other efforts have had little to no effect. Often, mitigation efforts such as reclamation must be performed over wide areas to be effective and treatment may be a less expensive option. In addition, well plugging and mine sealing can have adverse consequences if the water is diverted to a less favorable location. Cost/benefit analyses that include the possible successes and failures and potential risks of treatment and mitigation should be examined in order to choose the best alternative for each specific site.

B. Active Treatment Alternatives

Active treatment involves the use of chemicals and mechanical devices to treat mine water. Active treatment methods are well-developed. Sodium-based products such as sodium hydroxide (NaOH, caustic) or sodium carbonate (Na_2CO_3, soda ash) or calcium-based products such as hydrated lime ($Ca(OH)_3$) and quick lime (CaO) are generally used. The sodium products are more soluble and are easier to use for low flows, in remote locations, and/or where a permit requires manganese removal. The calcium products are less expensive, but generally require mechanical mixing and aeration to be effective. Large flows can usually be treated more cost-effectively with lime. Regardless of the type of alkaline reagent used, chemical treatment produces metal sludge that must be periodically collected and disposed of. Disposal usually occurs in an on-site sludge disposal pond or into an underground coal mine void. The costs of sludge management are substantial, sometimes exceeding the costs of the chemicals used to treat the water.

One low-cost chemical treatment alternative that may be available to sites in the Bear Creek Watershed is weak alkali liquor (WAL), a by-product produced by Penreco in Parker, PA. The weak alkali liquor has a pH of between 9 and 12 and an alkalinity of approximately 90,000 mg/L as $CaCO_3$. In the past, this material has been granted beneficial use certification by the DEP, which indicates that it offers potential environmental benefits with few environmental risks when used correctly (General Permit WMGR080). Currently, this material is being delivered at little or no cost to several sites in the region in 4,500 gallon bulk trucks. The material can be delivered directly to ponds or to holding tanks, where it is then metered into treatment ponds. Other uses of this material, such as land application or direct pumping into deep mine pools, may also provide cost-effective solutions to land and water problems. However, as these uses have not been fully demonstrated, projects of this type would need to be performed on an experimental basis.

The long-term costs of active treatment usually make it an unattractive treatment solution. However, there are circumstances where it is the used, often with highly effective results. The quality of the East Branch of the Clarion River Reservoir is maintained through mechanical lime additions to a highly acidic stream (Swamp Creek). Major improvements in the quality of Toby Creek are largely due to installation of several active treatment systems. Active treatment is usually proposed when it is the only feasible alternative, because the chemistry of the discharge is too severe for passive treatment, because there is not enough land area to achieve treatment using passive methods, or because a suitable alkaline chemical is available at a greatly reduced price. For these reasons, chemical treatment must be considered for several of the most contaminated discharges in the North Branch.

C. Passive Treatment Alternatives

Passive treatment involves the use of natural products, natural processes, ponds, and constructed wetlands to remediate mine drainage. Limestone and microbial processes neutralize acidity. Metals are precipitated as oxides and hydroxides in sedimentation ponds and wetlands. The chemistry of the mine drainage determines what type of passive systems will be effective. The flow rate of the mine drainage determines the size of the system.

A variety of passive treatment technologies exist. In general, the more acidic the mine water the more problematic passive treatment becomes because the technology is less well developed and the O&M requirements are often greater as acidity increases. Waters with aluminum concentrations less than 20 mg/L are being effectively treated with reasonable O&M requirements. Waters with higher aluminum concentrations can be effectively treated with passive treatment, but the frequency of system renovations is likely to increase. The selection of the appropriate technology is generally dependent on the mine drainage chemistry. Figure 6 is a flow chart that can be used to select the appropriate passive treatment technology.

Ponds and Wetlands

Mine waters that are naturally net alkaline (alkalinity greater than acidity) are usually only contaminated with iron (Fe). The iron can be passively precipitated through oxidation and settling in sedimentation ponds and constructed wetlands. The systems are designed to promote aeration (sheet flow and waterfalls) and provide long retention times. Ponds are usually used to decrease iron concentrations to 10-15 mg/L, and wetlands are used to remove the residual iron.

In many cases, it is desirable to add an alkaline substrate, such as compost mixed with limestone, to the bottom of wetlands. This alkaline substrate has been shown to neutralize acidity and produce alkalinity, ensuring the success of wetland vegetation. Alkaline-amended wetlands have proven success in slightly net acidic waters where flow rates are relatively low.

Many successful pond/wetland systems have retention times of several days. Ponds and wetlands are also placed after other passive treatment system components to provide settling and polishing.

Anoxic Limestone Drains

Mine water that is net acidic (acidity greater than alkalinity), contaminated with iron, and low in dissolved oxygen, ferric iron, and aluminum concentrations can be treated with an anoxic limestone drain (ALD). An ALD is a buried bed of limestone that is designed to be completely flooded to maintain anoxic conditions throughout. Acidic mine water is directed through the bed, resulting in the generation of alkalinity (through limestone dissolution) without the precipitation of iron solids. The alkaline discharge from the anoxic limestone drain is followed by sedimentation ponds and constructed wetlands, where iron precipitates as an iron oxide solid. Properly designed and constructed anoxic limestone drain systems are among the most effective type of passive treatment and have been proven viable for treatment in the long term (over 15 years).

Vertical Flow Ponds

Mine waters that are net acidic and contain aluminum present the most challenging cases for passive treatment. The acidic waters require neutralization, but the tendency for aluminum to precipitate within alkaline substrate and decrease its permeability complicates the treatment. Many passive systems constructed to treat mine water with aluminum fail because they plug, and the acid water cannot flow through the alkaline materials. The plugging problem has been partially mitigated through the design of ponds where water flows vertically through a large bed of limestone. If iron is present in the mine water, the bed is typically covered with an organic substrate in order to remove oxygen that would otherwise cause the precipitation of iron within the limestone aggregate. These ponds have been referred to as vertical flow ponds (VFP), successive alkalinity producing systems (SAPS), and reducing and alkalinity producing systems (RAPS). While some systems may work well for several years with no maintenance, the accumulation of iron and aluminum solids eventually causes permeability problems that can result in system failure. Renovation typically requires replacement of the organic substrate and a portion of the limestone aggregate. To counter this problem, VFPs are usually constructed with solids flushing capabilities. The flushing systems operate passively and are driven by elevation differences designed into the VFPs.

The challenges presented by highly acidic mine drainage have resulted in the development of innovative technologies. There is little consensus among treatment system designers on the details of the flushing systems. A belief that increased flushing frequency results in better removal of aluminum and iron solids has resulted in the incorporation of automatic flushing devices into some passive systems. These devices cause the system to flush whenever the water reaches a predetermined level. Experimental systems that flush every 3 – 24 hours have been installed. The observation that aluminum solids tend to accumulate in the upper portion down-flow limestone beds has prompted the installation of flush systems in the top of some limestone beds. Calculations on the velocities needed to move particles suggest the need for closely spaced flush pipes with small flushing orifices. The long-term effectiveness of flushing in removing solids and extending the useful lives of passive treatment systems is not known.

Oxic Limestone Beds and Channels

Limestone is not effective for AMD treatment if it plugs or is coated with metal solids. In cases where iron and aluminum concentrations are low, additional alkalinity can be generated with flow through an open bed of limestone aggregate. Oxic limestone beds are increasingly being placed at the end of passive systems to boost pH and promote microbial manganese-removal processes.

In some cases, self-flushing units have been attached to open limestone beds in order to flush them, similar to VFPs. Experimental systems of this type have been used to treat high aluminum levels with good short-term success.

In cases where steep gradients exist between the discharge and the receiving stream, it may be feasible to partially treat the water with an open limestone channel. The velocity of water moving through the limestone carries solids out and prevents plugging. Research shows that even if the limestone in open channels is armored with iron, it is still reactive.

Sulfate-Reducing Bacteria Systems

One new type of treatment system that has recently been constructed on a pilot scale is the sulfate-reducing bacteria (SRB) system. For these systems, AMD is directed into a buried bed of organic material. The anoxic conditions that result permit sulfate-reducing bacteria to dominate the system. Their activities cause aluminum to precipitate as a dense solid and also generate alkalinity. Both iron and aluminum are removed.

A system of this kind was constructed for a discharge on Cook Run in Sproul State Forest. The system treated 1 to 3 gpm of water with 1,000 – 3,000 mg/L as $CaCO_3$ of acidity and 200 – 300 mg/L of aluminum. While the system showed some good success during its one year of operation, it also experienced some problems. In addition, it required a relatively large area to treat a relatively small flow. However, systems of this type may be the only passive method for treating extremely contaminated mine discharges. Systems of this type are expected to cost over $25,000 per gallon per minute of flow, making them viable alternatives for only small discharges. Full-scale systems of this type are planned and should be monitored for success to determine if they are successful and cost-effective.

Pyrolusite™ Beds

Manganese precipitates as an oxide under alkaline conditions in the absence of iron. The process is microbially mediated. The Pyrolusite™ process involves the inoculation of oxic limestone beds with microbes selected for manganese oxidation.

Maintenance of Passive Treatment Systems

Many design features can be incorporated into the construction of passive treatment in order to facilitate the maintenance of these systems. For instance, flow channels, berms, and pipes that discourage muskrat activities can prevent problems from developing. Designing two or more parallel cells for some treatment units, such as wetlands and vertical flow ponds, allows one cell to be taken off-line for maintenance while the rest of the system continues to operate normally. As long as maintenance is performed during low-flow conditions, this does not result in a decline in final water quality.

Despite these design improvements, some operation and maintenance activities are necessary. All systems require regular visual inspections to ensure that they are working properly and that pests or high flow events have not damaged the system. Monthly inspections are sufficient in most cases, though inspections should be performed as soon as possible after large flooding events. Other regular maintenance activities are discussed in detail below.

Wetlands usually require minimal maintenance. Most maintenance is related to the activities of pests, such as muskrats and beavers, which burrow in berms, plug outlets and destroy vegetation. Wetlands can be designed to minimize the risk of pest damage, but visual inspections are necessary. Severe pest damage can usually be controlled by trapping efforts. Wetlands have also been damaged by ATVs, which run through the wetlands and cause channels to develop.

The primary maintenance issue with settling ponds is solids removal. Ponds can also be susceptible to damage by pests. The purpose of ponds is to collect metals that form solids and accumulate. Over time, these solids build up and require removal. The solids are not hazardous and can usually be buried on site. Ponds are typically designed to operate for 15 – 25 years before being cleaned out. The required frequency of cleaning depends upon the flow rate of the discharge, the concentrations of metals, and the size of the pond. In situations where clean iron sludge is being collected, it may be possible to recover and sell the sludge, thus offsetting system maintenance costs. Research on recovering aluminum sludge is also being conducted.

When ALDs are properly constructed and designed to treat water that does not contain oxygen, aluminum or ferric iron (Fe^{3+}), they usually require no routine maintenance However, ALDs have recently been used to treat discharges that do contain low levels of oxygen, aluminum or ferric iron (Fe^{3+}). These drains are equipped with flush plumbing similar to that found in VFPs and require regular flushing. As ALDs neutralize acidity and add alkalinity, the limestone dissolves. ALDs are typically designed with enough limestone to provide full treatment for 25 years. After that period of time, more limestone must be added to the bed.

VFPs require regular flushing to avoid becoming plugged by solids. Few scientific studies have been performed to determine the best flushing frequency, which likely varies widely based on the size of the system, the design of the flush plumbing, and the chemistry of the water. Typically, the water level in the VFP is monitored and flushing is recommended when water levels rise, indicating that the VFP is beginning to plug. Alternatively, flushing can be performed on a regular basis before plugging begins. Existing systems are usually flushed once a month to once a year.

V. Mitigation Alternatives and Recommendations

Because the goal of mitigation is to alter the quantity and/or quality of the flow, mitigation efforts should typically be performed before treatment facilities are installed. Mitigation efforts may also alter the location of the discharge(s), making treatment systems constructed before these efforts obsolete.

The results of mitigation are difficult to predict. In addition, the results of mitigation efforts are often iterative, with small changes in discharge quantity/quality after each successive step. Therefore, discharges that are anticipated to be affected by mitigation efforts should be monitored after reclamation is performed to determine if additional efforts are necessary.

Tributary G should be the focus of the first reclamation efforts. Large surface and deep mines were present along both sides of Tributary G. Reclamation projects recommended for this area have the potential to impact seven discharges, including five of the top eight contributors of acidity to the entire North Branch Watershed. Two main reclamation areas are recommended; one for the NBG25D area and one for the "Young Mine Complex" on the other side of the township road. This work has been broken into several phases, which are shown on Figure #.

A. NBG25D Area

NBG25D is one of the worst mine drainage discharges in Pennsylvania. Despite the low, intermittent flow, it is still one of the top contributors of acidity and aluminum in the watershed. It is likely that the extremely high levels of contamination in this discharge are due to a small quantity of highly toxic mine refuse or other material buried on the site.

As of the writing of this report, the landowners of the NBG25D area have entered into an agreement with Amerikohl mining to allow exploration of this area. It is possible that marketable refuse will be found that will allow the area to be reclaimed during refuse removal. If this is the case, large quantities of alkaline material should be placed in the area after refuse removal is completed.

If refuse removal is not found to be viable, the recommendations for this site include:

- Construction of an up-slope diversion channel ($2,000)
- Exploratory digging to find the source of the water ($10,000)

- Removal of any refuse or other material that is causing the problem ($10,000)
- Reclamation of the site including 1,000 tons of alkaline material ($10,000)
- Removal of the NBG35D beaver dam ($2,500).

The beaver dam at NBG35D may be forcing additional water into a deep mine or through spoil or refuse to the NBG25D location. Lowering the impoundment in this area may influence NBG25D by reducing its flow rate.

As shown above, the construction work for this project is estimated at $34,500. Engineering design, permitting, and oversight are anticipated to add $9,500 to the cost of this project, for a total anticipated cost of $44,000.

After the project is conducted, former discharge locations and Tributary G immediately downstream of the former NBG25D location (station NBG20) should be monitored to determine if this effort was successful in eliminating the discharge. If the project was not successful, additional work in the area will be needed, which may include additional reclamation, chemical treatment of NBG25D, or passive treatment.

B. "Young Mine Complex" Area

A large area of unreclaimed surface and deep mine spoil is present behind the Young residence on Tributary G. This spoil has been placed immediately adjacent to the stream and in some cases is in the stream channel. Three discharges to Tributary G (NBG15D, NBG12D, NBG10D) and two discharges directly to the North Branch (NB36D, NB37D) are affected by this spoil area. These discharges include three of the top five contributors of acidity loading to the entire North Branch watershed (NB37D, NBG15D, and NB36D rank 2nd, 4th, and 5th, respectively).

Due to the uncertainty in predicating the results of reclamation and the high costs involved in fully reclaiming the site immediately, a phased approach to this area is recommended. After each phase, the discharges in the area should be monitored to assess the effectiveness of the work, and a decision about continuing with additional phases should be made. The phases are summarized in Table 10 and discussed in more detail below.

Table 10: "Young Mine Complex" Reclamation Phases

Phase	Cost Estimate	Description of Work	Potential Impacts
1	$ 48,800	Reconstruct NBG15D channel, separate clean and contaminated water, eliminate channel losses. Monitor effects .	May eliminate pollution of NBG15D; may greatly reduce flow rate of contaminated water at NBG15D; may reduce flow rate at NBG12D, NBG10D, NB36D, and/or NB37D.
2	$ 459,100	Reclaim 32 acres, add 100 tons/acre of alkaline material, establish vegetation. Monitor effects.	May further reduce or eliminate flow or contamination of NBG15D, NBG12D, NBG10D. May also affect NB36D and/or NB37D.
3	Unknown	If necessary, treat any remaining contaminated flow from NBG15D, NBG12D, and NBG10D.	Eliminating any contamination to the stream that remains after Phases 1 and 2.
4	Unknown	If necessary, provide additional reclamation around NB36D and NB37D with large alkaline additions OR treat NB36D and NB37D.	Eliminating any contamination to the stream that remains after Phases 1 and 2.

Phase 1

Phase 1 of this project will focus on the NBG15D discharge. However, this phase may impact other discharges in the area.

NBG15D was sampled from the discharge end of a large culvert that was originally thought to be a deep mine opening (Photo 24). However, further reconnaissance indicated that the culvert has been placed through a large berm of mine spoil material.

This water flows from a stream channel that splits into two branches approximately 500 feet upstream of the culvert entrance. Follow-up field sampling indicated that the water entering the inlet end of the culvert is clean, with no metals, net alkalinity, and low sulfate. It is estimated that 1 – 10 gpm of extremely contaminated water, similar in quality to NBG10D and NBG25D, is entering the flow through the ruptured culvert pipe in the spoil.

Additionally, flow measurements indicated that the channel above the culvert pipe that conveys clean water is losing water, while the flow increases in the culvert pipe. The clean water being lost from the upper part of the channel may be seeping into the spoil and reemerging in the culvert pipe, or it may be traveling through the spoil and emerging at NBG10D, NBG12D, NB36D, and/or NB37D. Preventing this water from seeping out of the stream channel could significantly reduce or eliminate these discharges.

Tasks and costs involved with completing Phase 1 of this project include:

- Removal of approximately 3,000 CY of spoil to reconstruct stream channel ($9,000)
- Lining approximately 700 feet of channel with impervious liner ($5,000)
- 210 tons of limestone for channel reconstruction ($4,200)
- Location and collection of contaminated seeps ($10,000)
- Mobilization, E&S control, revegetation ($7,500)

Material removed from the stream channel as part of this work will be placed on the spoil piles surrounding the discharge, graded to a stable condition, seeded, mulched and fertilized. However, because this entire area will be targeted for reclamation in Phase 2, temporary vegetation may be used.

These tasks result in a construction and materials cost of $35,700. In addition, approximately $12,000 will be needed for site mapping, design, and permitting, which may be extensive. It is assumed that the BCCD would assist with project permitting. After the work is completed, each of the discharges that may be affected by this project and the mouth of Tributary G (station NBG01) should be sampled every two months for one year. If volunteers from BCCD/BCWA collect these samples, analyses should cost approximately $1,100. The results of this sampling effort should be compared to prior results to assess the impacts of this work. Therefore, the total project cost is estimated to be $48,800.

Phase 2

The focus of Phase 2 is on 32 acres of poorly reclaimed spoil located between the NBG15D channel (northern boundary), Tributary G (western boundary) the hill side (eastern boundary), and the North Branch (southern boundary). This area is shown shaded in blue on Figure 7.

This entire area contains surface mine spoil and a portion of this area occurs over a deep mine on the Brookville coal seam. Reclamation of this area should include the following tasks and costs:

- Earthmoving over 32 acres ($9,000 per acre or $288,000 total)
- Addition of alkaline material at 100 tons / acre ($32,000)
- Revegetation, including fertilizer, seed, lime, and mulch ($48,000)
- Mobilization, E&S control ($10,000)

Therefore, the total material and construction cost for Phase 2 is $378,000. In addition, $80,000 is estimated for site mapping, reclamation design, construction oversight, and permitting. Permitting may be problematic because spoil has been placed immediately adjacent to and in some cases directly in Tributary G in the project area and should be removed. Similarly to Phase 1, the discharges in the area that may be affected by this work should be monitored periodicially for a period of 1 year. The cost of this sampling is estimated to be $1,100. Therefore, the total cost of this phase is estimated to be $459,100.

It may be desirable to perform Phases 1 and 2 simultaneously to reduce mobilization, mapping, permitting, and monitoring costs. In addition, Phase 1 is unlikely to eliminate all of the discharges involved, making more work necessary immediately. If the two Phases are performed simultaneously, it is estimated that approximately $10,000 could be saved.

Phase 3

The focus of Phase 3 will be on treating any remaining contamination from NBG15D, NBG12D, and NBG10D. It is likely that Phases 1 and 2 will have significant impacts on the flow and/or chemistry of each of these discharges. Therefore, it is difficult to predict the type and size of treatment that will be required. It may be possible to treat the discharges passively if reclamation in Phases 1 and 2 improves the chemistry. It may not be necessary to treat the discharges at all. Therefore, the cost for Phase 3 has not been estimated. The need for this work should be evaluated based on the results of sampling after the completion of Phase 1 and Phase 2 work. At that time, a detailed plan of action and cost estimate can be developed.

Phase 4

Phase 4 will focus on NB36D and NB37D. These discharges may or may not be significantly affected by Phases 1 and 2 reclamation projects. Because the flow and/or chemistry of these discharges may be significantly altered, the nature and cost of Phase 4 is not known. The two most likely scenarios involve intensive reclamation and alkaline addition of approximately 4 acres surrounding the discharges or collection and treatment of these discharges at some downstream location. The need for this work should be evaluated based on the results of sampling after the completion of Phase 1 and Phase 2 work. At that time, a detailed plan of action and cost estimate can be developed.

C. Main Stream Banks

Many of the hill slopes along the North Branch and its tributaries are lined with mine spoil, mostly from surface mines that removed the crop coal or coal immediately behind the crop (See Figures 2 and 3). These mines generally affected the Brookville coal seam. These areas are typically less than 400 feet wide, but some stretch for several miles along the stream. They range from being located immediately adjacent to the stream, particularly in the headwaters and tributary areas, to being 500 feet away from the stream banks.

The conditions of the spoil areas vary, but all are poorly reclaimed. Vegetation consists mostly of sparse tree growth with little or no ground cover. Highwall cuts over 50 feet high and adjacent spoil piles create large impoundments in many locations. Poorly regraded spoil piles also create numerous small depressions that do not allow precipitation to run off.

In some cases, these conditions contribute to mine drainage pollution. Several discrete discharges were located and sampled (for instance, NB15D, NB18D, NBD10D, and NBG35D). However, the spoil areas likely contribute a far greater amount of pollution by contaminating the underlying aquifers, which then arrive in the streams and tributaries as base flow or diffuse seepage.

Because it is difficult if not impossible to quantify this pollution, it is difficult to prioritize these large, dispersed areas for reclamation. However, the first step on each site should be to locate impoundments and, if possible, provide free drainage. These impoundments retain water, causing clean water to become polluted through contact with spoil. In addition, they often provide an increased opportunity for water to infiltrate to the underlying aquifer or directly to the stream. Thus, eliminating these impoundments is a quick, inexpensive way to lessen water pollution from these sources.

D. Other Reclamation and Mitigation Sites

Several other small mitigation and reclamation jobs are recommended by this plan, including two well plugging projects (NB31D and NB32D) and several projects to remove spoil impoundments and beaver dams (NB15D, NB18D, NBD10D, and NBE03D). These projects are discussed in detail in following sections regarding each discharge.

VI. Main Stream: Discharge-Specific Treatment Recommendations

Several discharges enter the main stem of the North Branch. Eight discharges were located and monitored as part of this project. The following sections provide discharge-specific mitigation and/or treatment recommendations, including cost estimates. The most serious discharges in this section are NB37D and NB36D, which ranked 2nd and 5th respectively in average acidity loading in the entire North Branch watershed. The following sections discuss each of the discharges in detail. Discharges are listed beginning at the mouth of the stream and proceeding upstream.

A. NB12D

NB12D discharges from a short, steep ravine to the main North Branch stream from the northeast bank (Photo 4). Flow was measured using the timed volume method from an installed pipe. Table 11 shows the flow, chemistry and loading from the discharge.

Table 11: NB12D Flow, Chemistry and Loading

Sample Date	Flow (GPM)	Field pH	Cond (uS)	Net Acid (mg/L as CaCO3)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (pounds per day) Net Acid	Iron	Al
05/20/02	185	3.9	240	19	0.2	0.3	1.1	83	2	41.2	0.4	2.4
06/18/02	158	4.9	278	23	0.1	0.4	1.0	122	2	43.4	0.1	1.9
07/10/02	24	4.2	635	32	0.1	1.2	3.4	310	1	9.2	0.0	1.0
08/07/02	24	3.9	487	23	0.1	1.1	1.8	252	1	6.6	0.0	0.5
09/04/02	8	3.4	654	30	0.1	1.4	2.6	333	3	2.7	0.0	0.2
10/08/02	< 1	3.6	1,253	161	21.2	3.3	8.1	942	1	0.5	0.1	0.0
11/08/02	21	4.7	311	13	0.1	0.4	1.0	122	5	3.3	0.0	0.2
12/17/02	107	3.7	174	11	0.0	0.2	0.4	63	3	14.3	0.1	0.5
02/06/03	60	4.3	404	18	0.0	0.3	0.8	166	2	12.8	0.0	0.6
03/18/03	210	4.5	180	8	0.1	0.2	0.5	83	1	20.4	0.1	1.3
04/15/03	92	3.8	313	16	0.1	0.4	1.1	131	4	17.8	0.1	1.2
Average	**81**	**4.1**	**448**	**32**	**2.0**	**0.9**	**2.0**	**237**	**2**	**15.7**	**0.1**	**0.9**

NB12D was the 11th highest average contributor of acidity loading to the stream. However, on the individual sampling rounds, it ranked as high as 7th and as low as 16th.

The quality of this discharge varies widely with flow rate, with higher concentrations of acidity and aluminum occurring during low flow. This indicates that a very shallow groundwater or surface runoff source is providing dilution to the discharge during high flow events. Approximately 41 acres drain to this point, including approximately 9 acres of abandoned surface mining.

The current water quality is suitable for treatment using passive treatment, however, little room is available in the vicinity of the discharge. In addition, the large variation in the flow rate complicates passive treatment. Therefore, the primary recommendation for this discharge is to separate clean surface water and/or shallow groundwater from the contaminated flow at this site.

This will require additional reconnaissance of the ravine and field sampling of pH and conductivity to precisely locate both the clean and contaminated water sources.

Clean water can be diverted in ditches, while contaminated water should be collected in French drains or pipes and conveyed to the potential treatment location approximately 200 feet downstream. These actions would likely reduce the high flow variability of this discharge. At that time, passive treatment system sizing can take place in conjunction with NB13D treatment. If the chemistry of the discharge is similar to the average chemistry of the flow, treatment could be accomplished using an alkaline-amended wetland.

The investigation of NB12D sources and separation of clean and contaminated water is expected to cost approximately $17,000. In addition to this amount, which would cover the costs of heavy equipment, collection pipes, and revegetation of disturbed areas, approximately $8,000 will be necessary for oversight and professional services during the project, such as directing the work in the field. It is assumed that no design, mapping or permitting would be necessary. Therefore, the total cost of this investigation and collection is expected to be $25,000.

After the contaminated flow has been minimized in this manner, the remaining contaminated flow should be directed downstream of its current location, where it can be treated in conjunction with NB13D.

B. NB13D

NB13D sampled a collection of seeps that originate from a rock face that forms the northeastern bank of the North Branch (Photo 5). The seeps collect on a 4-wheeler trail and enter the stream in numerous locations. Flow was measured using the timed volume method and by directing as much flow as possible to a pipe installed at the location. Table 12 shows the flow, chemistry and loading of the discharge.

Table 12: NB13D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	11	3.1	1,197	186	31.6	2.5	7.1	507	14	23.5	4.0	0.9
06/18/02	11	4.1	1,234	240	60.3	2.7	10.5	598	7	30.3	7.6	1.3
07/10/02	10	3.4	1,370	216	44.0	3.1	10.9	613	5	25.9	5.3	1.3
08/07/02	9	3.0	1,270	214	30.0	2.8	8.3	810	5	23.1	3.2	0.9
09/04/02	9	2.2	1,302	209	36.9	3.0	10.1	571	6	22.6	4.0	1.1
10/08/02	7	3.7	1,230	201	39.5	2.8	9.6	1,028	13	16.9	3.3	0.8
11/08/02	5	3.9	1,194	165	22.9	2.6	8.1	675	20	9.9	1.4	0.5
12/17/02	18	2.2	1,010	127	16.5	2.1	6.6	519	7	27.5	3.6	1.4
02/06/03	1	3.3	1,130	165	26.1	2.3	7.1	765	18	2.0	0.3	0.1
03/18/03	4	3.2	1,005	33	18.0	2.1	5.9	563	9	1.4	0.8	0.2
04/15/03	6	2.9	1,050	127	13.6	2.3	6.0	447	3	9.1	1.0	0.4
Average	**8**	**3.2**	**1,181**	**171**	**30.8**	**2.6**	**8.2**	**645**	**10**	**17.5**	**3.1**	**0.8**

NB13D ranked as the 9th highest average contributor of acidity. On various sampling occasions, the discharge ranked from as high as the 5th highest contributor of acidity loading to as low as 19th.

The flow and chemistry of this discharge were fairly consistent, indicating that the source was a steady groundwater flow. The discharge contains moderate amounts of acidity, iron and aluminum. The chemistry of the discharge is suitable for passive treatment, however, the topography of the site will be the limiting factor. The discharge emerges from a steep rock wall immediately above the stream.

The discharge should be collected in a pipe and sent downstream approximately 300 feet, where approximately 3 acres of low, flat land exist for treatment. Collecting and piping this water will be difficult because the discharge appears close to the stream and close to the elevation of the available treatment system. Accurate mapping of the site should take place first.

Once the discharge is collected, it can be combined with the collected water from NB12D for treatment. For this design, it will be assumed that the average flow rate of NB12D will be reduced to 40 gpm and contain 5 mg/L of aluminum, no iron, and 50 mg/L of net acidity. However, these assumptions should be verified after the clean and contaminated water have been separated and water to be treated has been collected at NB12D.

If these assumptions are correct, the treatment system for NB12D and NB13D will treat an average of 48 gpm of water with 6 mg/L of aluminum and 70 mg/L of net acidity. High flow rates will likely be between 70 and 100 gpm, but once again, this should be verified after NB12D collection. This flow can be successfully treated using an alkaline amended wetland and an oxic limestone polishing bed. While other types of passive treatment would also be successful, such as a vertical flow pond or self-flushing unit, there is limited elevation difference between NB13D and the treatment location. Therefore, an alkaline wetland is recommended.

Assuming a desired retention time of 48 hours at 48 gpm and 6” of water depth, approximately 37,000 square feet of wetland should be constructed. The wetland should contain 4 inches of organic substrate that has been amended with 2 inches of limestone chips and planted with wetland vegetation. A limestone polishing bed that contains 200 tons of limestone will provide approximately 4 hours of retention at 48 gpm and will provide additional alkalinity to the system. This system is expected to discharge water with 25 – 50 mg/L of net alkalinity and less than 0.5 mg/L of aluminum.

Tasks and costs associated with this project will include:

- Discharge collection and piping ($8,000)
- 37,000 square foot wetland ($40,000 construction)
- 450 CY compost ($9,000)
- 230 CY limestone chips (310 tons) in compost ($5,000 mixed and installed)
- 230 tons for oxic limestone in polishing bed ($5,000 installed)
- Mobilization, E&S control, site access ($8,000)

Therefore, the total cost for system construction and materials is estimated to be $75,000. In addition, $20,000 is estimated for site mapping, design, permitting, and an O&M manual for the site. Site mapping to a detailed level (1’ contour intervals) will be required due to the elevation limitations. In addition, a stream encroachment permit may be necessary in order to build the system close to the stream in the only area available for treatment. Therefore, a total system cost of approximately $90,000 is anticipated.

C. NB15D

NB15D discharges from a swampy impoundment near the stream (Photo 6). The discharge is collected on an ATV trail and flows down this trail to the stream. The flow was measured using the timed volume method from a pipe installed between the impoundment and the ATV trail. Table 13 shows the flow, chemistry and loading from the discharge.

Table 13: NB15D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	20.3	3.7	416	41	0.8	0.8	2.8	151	3	10.0	0.2	0.7
06/18/02	7.5	4.5	410	49	1.6	0.8	2.0	197	5	4.4	0.1	0.2
07/10/02	2.0	3.5	971	110	19.2	2.2	3.9	403	10	2.6	0.5	0.1
08/07/02	15	3.4	830	87	17.9	1.9	2.4	428	14	15.7	3.2	0.4
09/04/02	1.1	3.1	1,178	124	26.5	3.1	5.8	590	15	1.7	0.4	0.1
10/08/02	3.0	4.4	595	28	0.1	1.4	2.3	288	1	1.0	0.0	0.1
11/08/02	0.5	4.1	1,064	123	17.0	2.6	6.7	569	6	0.7	0.1	0.0
12/17/02	7.0	3.0	451	36	2.4	0.9	2.4	217	3	3.0	0.2	0.2
02/06/03	0									0.0	0.0	0.0
03/18/03	24.0	4.0	392	34	1.4	0.9	3.1	152	1	9.8	0.4	0.9
04/15/03	5.5	3.1	454	34	2.3	1.0	2.4	188	2	2.0	0.1	0.1
Average	**7.8**	**3.7**	**676**	**67**	**8.9**	**1.5**	**3.4**	**318**	**6**	**4.6**	**0.5**	**0.3**

NB15D ranked as the 14th highest average contributor of acidity to the stream among known discharges. On one sampling occasion, it ranked as the 7th highest contributor. However, it contributed less than 1% of the average total acidity, iron and aluminum loadings to the stream.

NB15D was sampled at the discharge end of a long, narrow impoundment. This impoundment is located in spoil and is partially caused by a road along the stream. The first recommendation for this discharge is to remove the impoundment and allow the water to freely drain to the stream. The effects of this work should then be monitored and the point sources of water to the former impoundment can be identified. This work is expected to cost approximately $8,000, which will be spent on heavy equipment time to remove the impoundment. This cost does not include post-project monitoring, which is expected to cost approximately $400. This cost does not include design or permitting, which are assumed to be not required.

Based on the results of the work, treatment of the discharge or reclamation of the area should take place. Due to the uncertainties associated with the results of removing the impoundment, a cost for this work is not given. However, based on the chemistry and flow rate of the current discharge, a small alkaline wetland would provide appropriate treatment.

D. NB18D

NB18D is a discharge from a spoil impoundment (Photo 7). The discharge flows to a small drainage area that flows directly to the North Branch. This drainage is not a blue-line stream on the USGS maps and thus was not assigned a tributary letter. The flow rate was measured using a pipe installed at the outflow of the impoundment, which has been modified by beaver activity. Table 14 shows the flow, chemistry and loading from this discharge.

Table 14: NB18D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	73	5.6	45	4	0.3	0.1	0.4	18	3	3.8	0.3	0.3
06/18/02	33	6.3	58	6	0.3	0.2	0.4	15	4	2.4	0.1	0.2
07/09/02	0									0.0	0.0	0.0
08/07/02	< 1	5.7	45	6	1.0	0.2	0.5	4	31	0.0	0.0	0.0
09/04/02	0									0.0	0.0	0.0
10/08/02	0									0.0	0.0	0.0
11/08/02	0									0.0	0.0	0.0
12/16/02	41	4.2	45	5	0.1	0.1	0.3	16	9	2.5	0.1	0.1
02/05/03	5	5.0	56	5	0.2	0.2	0.9	14	21	0.3	0.0	0.1
03/19/03	43	5.2	46	2	0.2	0.1	0.6	12	5	1.1	0.1	0.3
04/15/03	40	5.3	49	2	0.1	0.1	0.2	17	4	1.0	0.1	0.1
Average	**21**	**5.3**	**49**	**4**	**0.3**	**0.2**	**0.5**	**14**	**11**	**1.0**	**0.1**	**0.1**

NB18D is not a major contributor of pollution to the stream and contributed less than 1% of the average acidity, iron, and aluminum loadings to the stream. Its rank for average acidity contribution to the stream was 20th but it ranked as high as 14th on one occasion.

The flow rate is highly variable and is based on seasonal rainfall. The discharge is marginally contaminated. The intermittent nature of the discharge suggests that it is highly dependant upon precipitation and shallow groundwater. A deep groundwater source is not present. This type of discharge usually responds well to reclamation. Due to its intermittent nature and limited pollution loading, treatment of this discharge is not recommended. The treatment system would have no impact on the water quality of the watershed when the discharge is dry.

The first recommendation for this discharge is to eliminate the impoundment. This will reveal any seepage that is feeding the impoundment and prevent impounded water from contacting spoil and possibly becoming more contaminated. This action alone may result in a remediated discharge. This project is expected to cost approximately $8,000 assuming no design, mapping, or permitting are required. An additional $400 would be required for post-project monitoring.

However, if the quality of the discharge is not affected, additional work may be necessary. This may include treatment the discharge with an alkaline wetland or self-flushing limestone bed or it may include reclamation of the surrounding area. Due to the highly variable flow rate, reclamation should be the first alternative that is considered. Treatment systems provide no treatment during times of now flow, but would be overwhelmed during flashy, high flow rates.

E. NB31D and NB32D

NB31D and NB32D (Photo 8) appear to be originating from abandoned wells on the southwest side of the stream. They each emerge less than 5 meters from the North Branch of Bear Creek and flow directly to the stream. The flow rates at these discharges were measured using the timed volume method from installed pipes. Tables 15 and 16 show the flow, chemistry and loading from these discharges.

Table 15: NB31D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	11	5.0	890	117	41.2	5.9	4.8	476	6	14.7	5.2	0.6
06/18/02	11	6.0	943	114	41.5	6.3	5.5	470	10	14.3	5.2	0.7
07/09/02	8	5.1	984	130	45.4	7.2	6.6	558	3	12.5	4.4	0.6
08/07/02	6	4.8	967	144	37.8	7.3	8.1	576	2	10.4	2.7	0.6
09/04/02	4	3.7	1,005	156	48.6	7.7	9.6	567	3	7.5	2.3	0.5
10/09/02	3	4.4	1,000	149	40.9	7.0	8.0	632	2	4.5	1.2	0.2
11/08/02	3	4.1	1,025	119	28.7	6.2	6.5	569	14	4.3	1.0	0.2
12/16/02	6	3.2	885	126	32.7	5.6	5.3	345	1	9.0	2.4	0.4
01/14/03	15	4.6	842	103	36.2	5.5	4.8	501	2	18.6	6.5	0.9
02/05/03	6	4.9	964	152	37.3	5.9	5.2	599	1	10.9	2.7	0.4
03/19/03	8	4.7	835	87	35.1	5.8	5.0	387	6	8.7	3.5	0.5
04/15/03	8	3.5	881	96	31.9	6.3	5.4	542	6	8.6	2.9	0.5
Average	**7**	**4.5**	**935**	**124**	**38.1**	**6.4**	**6.2**	**518**	**5**	**10.3**	**3.3**	**0.5**

Table 16: NB32D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	2.6	3.7	975	124	36.0	6.2	3.9	440	3	3.9	1.1	0.1
06/18/02	2.5	4.7	998	177	37.7	6.6	4.5	501	3	5.3	1.1	0.1
07/09/02	2.0	3.9	1,074	134	10.6	4.1	0.5	583	4	3.2	0.3	0.0
08/07/02	2.5	3.8	1,060	141	36.0	7.2	4.9	621	1	4.2	1.1	0.1
09/04/02	2.0	3.1	1,066	147	43.7	7.4	5.8	639	5	3.5	1.0	0.1
10/09/02	3.0	4.3	990	145	41.5	6.7	5.6	600	3	5.2	1.5	0.2
11/08/02	2.5	4.3	970	117	38.3	6.1	4.4	612	5	3.5	1.1	0.1
12/16/02	4.0	2.8	925	124	32.9	5.8	4.0	485	4	6.0	1.6	0.2
01/14/03	1.5	3.5	914	118	38.5	5.9	3.9	507	3	2.1	0.7	0.1
02/05/03	1.0	3.7	930	126	34.5	5.9	4.1	530	1	1.5	0.4	0.0
03/19/03	1.5	3.4	910	97	28.6	6.1	4.2	676	1	1.7	0.5	0.1
04/15/03	1.0	3.2	1,024	104	26.9	6.6	4.6	568	7	1.3	0.3	0.1
Average	**2.2**	**3.7**	**986**	**129**	**33.8**	**6.2**	**4.2**	**563**	**3**	**3.5**	**0.9**	**0.1**

NB31D is the 12th highest average contributor of acidity loading to the stream. On various sampling dates, the discharge ranked from the 8th to 12th highest contributor of acidity loading. It generally ranked higher during dry months, when discharges that are mainly affected by surface runoff decreased more dramatically in flow rate than this discharge. This indicates that NB31D relies upon a fairly constant groundwater source for its flow.

NB32D ranked as the 15th highest average contributor to acidity loading to the stream. However, in October 2002, the discharge ranked 9th. On two other occasions, it ranked 11th and 12th among all sampled discharges. On average, it contributed 1% or less of the total acidity, iron, and aluminum loading to the stream.

The nature of the discharges indicate that they may be abandoned wells. The location of the discharges immediately adjacent to the stream severely limits the area available for treatment. In addition, the presence of aluminum complicates any treatment that would take place. Therefore, the recommendation for these discharges is to attempt to plug the sources of the water.

Well plugging should be performed by a qualified company that has demonstrated successes in plugging this type of discharge. The project must be registered with the Oil and Gas Management Division of the Meadville DEP office. Both wells should be plugged at the same time in order to decrease mobilization costs. Access to the NB31D location should be relatively easy as an existing road that is passable by 4-wheel drive vehicles passes within 40 meters of the discharge. It will be necessary to cross the stream to access NB32D. The project should be completed in a dry time of the year to facilitate easy access to the site by the drill rig.

The overall cost of this project is estimated to be approximately $24,000, assuming that both wells are plugged at the same time. These costs include site access, well plugging registration costs, and well plugging. In addition, follow-up monitoring and inspections of the site should be performed by volunteers in order to determine the success of the plugging operation.

F. NB36D and NB37D

NB36D (Photo 9) and NB37D (Photo 10) are adjacent discharges that emerge from small ravines and flow directly to the North Branch. NB37D emerges approximately 50 meters upstream of NB36D. Flow rate was measured using the timed volume method from an installed pipe at each location. Tables 17 and 18 show the flow, chemistry and loading from these discharges.

Table 17: NB36D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	77	3.2	946	185	13.7	1.9	13.1	367	3	172.0	12.7	12.1
06/18/02	36	4.2	1,017	192	16.9	2.3	16.4	429	11	82.8	7.3	7.1
07/09/02	7	3.4	1,203	269	47.3	3.8	18.3	627	2	22.6	4.0	1.5
08/07/02	4	3.0	1,261	280	46.3	4.1	14.8	663	1	13.8	2.3	0.7
09/03/02	2	2.3	1,317	295	64.0	5.0	17.9	658	5	7.1	1.5	0.4
10/09/02	1	4.0	1,225	269	68.1	5.0	15.2	673	3	2.4	0.6	0.1
11/08/02	1	4.0	1,190	229	51.8	5.1	14.7	787	7	2.7	0.6	0.2
12/16/02	8	2.3	1,277	238	29.7	4.8	21.8	669	2	22.9	2.9	2.1
01/14/03	12	3.0	1,266	224	24.4	3.1	17.0	479	1	32.2	3.5	2.4
02/05/03	7	3.3	1,356	314	43.2	4.1	22.3	769	6	26.4	3.6	1.9
03/19/03	100	3.5	840	95	6.3	1.6	10.6	438	3	113.9	7.5	12.7
04/15/03	13	3.0	951	174	22.1	2.7	14.9	493	5	27.1	3.5	2.3
Average	**22**	**3.3**	**1,154**	**230**	**36.2**	**3.6**	**16.4**	**588**	**4**	**43.8**	**4.2**	**3.6**

Table 18: NB37D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	64	2.7	1,715	547	81	4.0	35.3	621	4	422.0	62.1	27.2
06/18/02	50	3.1	1,469	441	50	4.2	35.8	554	1	263.4	30.1	21.4
07/09/02	39	3.1	1,563	487	61	3.9	33.5	772	1	227.8	28.7	15.7
08/07/02	21	2.6	1,702	542	73	3.2	28.0	733	1	136.6	18.5	7.1
09/03/02	8	1.8	2,262	1,144	224	4.2	70.2	1,272	5	102.9	20.2	6.3
10/09/02	2	3.6	2,241	1,209	224	4.7	84.8	1,346	1	29.0	5.4	2.0
11/08/02	3	3.6	2,153	966	180	4.5	74.3	1,341	4	29.0	5.4	2.2
12/16/02	12	1.5	1,916	629	95	3.8	43.2	726	4	90.6	13.7	6.2
01/14/03	30	2.4	1,758	482	64	3.9	34.0	659	2	173.6	22.9	12.2
02/05/03	21	2.9	1,644	547	58	3.8	35.4	730	13	137.7	14.7	8.9
03/19/03	35	2.7	1,500	379	44	3.8	34.3	962	1	159.2	18.4	14.4
04/15/03	35	2.5	1,463	351	37	4.0	31.4	651	2	147.5	15.4	13.2
Average	**27**	**2.7**	**1,782**	**644**	**99**	**4.0**	**45.0**	**864**	**3**	**159.9**	**21.3**	**11.4**

NB36D is the 5^{th} highest average contributor of acidity. On various occasions, it ranked from 4^{th} to 13^{th} among all known discharges in acidity loading contribution.

As shown in Table 17, the flow rate of NB36D varies greatly. The quality of the discharge shows some correlation to flow rate, with worse water quality at low flows, but this correlation is not a strong one. This indicates that the discharge is not receiving clean runoff directly but rather that it has a deeper groundwater source or that any runoff that is directed to this point becomes quickly contaminated before reaching the discharge.

NB37D is a highly contaminated discharge that ranked 2^{nd} in average acidity contribution of all known discharges. On 4 of the sampling events, it ranked as the highest contributor of acidity loading. On other occasions, it ranked as low as the 5^{th} highest contributor.

The quality of this discharge is significantly affected by the flow rate, with worse water quality at low flow than at high flow, indicating some dilution is occurring during high flow events. However, even at the highest flows measured, the discharge has high levels of acidity, iron and aluminum.

These discharges may be affected by Phase 1 and Phase 2 of the proposed reclamation efforts of the "Young Mine Complex." These efforts are described in detail in Section V Part B. After each phase, the effects on NB36D and NB37D should be assessed through monitoring.

If additional improvement of these discharges is necessary, alternatives may include intensive reclamation and alkaline addition on 4 acres surrounding the discharges, or collecting the discharges and piping them to a treatment location somewhere down stream. Due to the uncertain effects of Phase 1 and Phase 2, a cost for this work cannot be estimated.

VII. Tributary D: Discharge-Specific Treatment Recommendations

Four discharges were located and sampled on Tributary D. However, in-stream sampling indicates that more pollution is present at the mouth than has been accounted for by these discharges. It is likely that the majority of this additional pollution reaches the stream as contaminated base flow from unreclaimed surface mines which occur on both sides of Tributary D, particularly in the lower portion of the tributary.

However, because so few discharges were located on Tributary D, treatment of those discharges should be pursued. A limited monetary investment in this tributary should result in significant recovery of the tributary itself. Treatment of the known discharges should be followed by a re-evaluation of the tributary to determine if these efforts have successfully restored the tributary or if reclamation of the spoil areas is required.

A. NBD10D

NBD10D was sampled at the outlet of a beaver dam located between two spoil piles (Photo 11). The beaver dam appears to be abandoned. The dam impounds water against an unreclaimed surface mine highwall. Springs and seepage from the highwall fill the pit and discharge through the dam. Flow was measured using a 6” H-flume installed at the pond outlet. Table 19 shows the flow, chemistry and loading of NBD10D.

Table 19: NBD10D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02		4.8	303	24	0.4	0.9	2.9	147	1			
06/18/02	110	5.4	367	33	0.6	1.1	4.3	200	7	44.0	0.8	5.7
07/09/02	28	4.2	478	37	1.5	1.7	3.7	229	4	12.5	0.5	1.2
08/07/02	35	4.1	370	22	1.8	1.3	1.6	101	2	9.4	0.8	0.7
09/04/02	18	3.2	502	37	5.2	2.5	1.3	242	1	7.9	1.1	0.3
10/09/02	20	4.4	500	28	2.5	2.8	1.8	265	2	6.8	0.6	0.4
11/08/02	30	4.5	682	43	5.5	3.9	3.8	371	5	15.3	2.0	1.4
12/16/02	95	4.2	133	6	0.7	0.4	0.6	60	13	7.0	0.8	0.6
02/05/03	40	5.2	268	18	1.6	0.9	1.4	156	3	8.8	0.8	0.7
03/19/03	160	5.4	229	13	0.5	0.6	2.0	94	1	24.4	0.9	3.9
04/15/03	75	4.4	375	29	0.6	1.2	4.2	214	2	25.8	0.5	3.8
Average	**61**	**4.5**	**382**	**26**	**1.9**	**1.6**	**2.5**	**189**	**4**	**16.2**	**0.9**	**1.9**

NBD10D is the worst known discharge to Tributary D and ranks 10th overall in average acidity loading contribution to the stream. On various sampling events, the discharge ranked from 6th highest to 11th highest in acidity loading contribution. The other known discharges to Tributary D never ranked higher than 14th in acidity loading contribution.

The chemistry of the discharge is fairly consistent over a range of flow rates, indicating that it is not caused by shallow groundwater or runoff from rainfall events. Compared to many of the discharges in the North Branch watershed, this discharge has moderate levels of acidity and aluminum.

The first step in dealing with this discharge should be to remove the beaver dam and drain the impoundment. This will allow direct access to the discharges that are feeding the impoundment and may reduce the pollution caused by this discharge. Currently, seeps to the impoundment are retained next to the highwall and adjacent spoil, which may be adding to the pollution of the discharge. Allowing the water to freely drain may result in a less polluted discharge. The cost to remove the dam, assuming that no permits or design are required, is estimated at $5,000.

After the dam is removed, the resulting discharge should be reevaluated for flow rate and quality to assess any changes. Assuming that the flow and chemistry remain relatively constant (or if removal of the dam is not feasible), an alkaline-amended wetland and limestone polishing bed comprise the recommended treatment system.

Assuming retention of the 90th percentile flow (115 gpm) for 24 hours and a wetland depth of 6 inches, the wetland should cover approximately 1 acre. At the average flow of 61 gpm, this system will have a retention time of 45 hours. The wetland should contain 4 inches of organic substrate that has been amended with 2 inches of limestone chips and planted with wetland vegetation.

The wetland should outlet through a bed of AASHTO #1 limestone. 230 tons of limestone will retain 115 gpm for 2 hours. The average flow rate of 60 gpm will be retained for approximately 4 hours. The purpose of this limestone bed is to add additional alkalinity. This alkalinity will help to offset acidic baseflow that is entering the stream elsewhere.

Tasks and costs associated with this project will include:

- 44,300 square foot wetland ($45,000 construction)
- 550 CY compost ($11,000)
- 275 CY limestone chips (370 tons) in compost ($6,500 mixed and installed)
- 230 tons for oxic limestone in polishing bed ($5,000 installed)
- Mobilization, E&S control, site access ($8,500)

Therefore, the total cost for system construction is estimated at $81,000 including beaver dam removal. In addition, $16,000 is estimated for mapping, design, and permitting, which is expected to be minimal. Therefore, the total system cost is estimated at $97,000.

The final discharge from the system should contain 40 – 80 mg/L of net alkalinity, iron less than 1 mg/L and aluminum less than 0.5 mg/L.

B. NBD40D

NBD40D emerges near the top of a cultivated field and flows down a limestone-lined channel (Photo 12). Previously, the discharge had been routed through a small pond (Photo 13), but it is currently being diverted around the pond. Flow was measured using the timed volume method from an installed pipe. Chemistry samples were gathered at the discharge point in the channel. Table 20 shows the flow, chemistry and loading of this discharge.

Table 20: NBD40D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	60	7.0	248	-37	8.1	1.6	0.0	92	6	-26.6	5.8	0.0
06/18/02	40	7.2	269	-30	6.1	1.7	0.1	54	6	-14.4	2.9	0.0
07/09/02	11	6.4	246	-11	18.5	3.3	0.0	48	4	-1.5	2.4	0.0
08/07/02	7	6.1	267	-24	15.0	2.9	0.0	58	2	-1.9	1.2	0.0
09/04/02	5	5.7	257	-21	19.6	3.3	0.0	47	4	-1.3	1.2	0.0
10/08/02	2	5.9	260	-12	19.3	3.1	0.0	64	6	-0.3	0.5	0.0
11/08/02	5	6.0	294	-3	18.5	3.3	0.0	72	8	-0.2	1.1	0.0
12/16/02	45	5.7	272	-21	8.2	1.3	0.2	42	12	-11.5	4.4	0.1
01/13/03	12	5.6	314	-1	10.2	2.0	0.1	59	1	-0.1	1.5	0.0
02/05/03	12	5.8	293	12	13.9	2.2	0.1	64	2	1.8	2.0	0.0
03/18/03	54	6.1	202	-18	6.3	1.2	0.2	24	3	-11.5	4.1	0.1
04/15/03	24	6.2	271	-19	16.3	2.7	0.0	57	3	-5.6	4.7	0.0
Average	**23**	**6.1**	**266**	**-15**	**13.3**	**2.4**	**0.1**	**57**	**5**	**-6.1**	**2.7**	**0.0**

Because it is net alkaline with low aluminum, this discharge does not rank highly as a contributor of loading. However, at times the discharge ranks as high as 5th in iron loading (it's average rank for iron loading is 10th). It contributes, on average, 3% of the iron loading to the stream.

Because this discharge is weakly net alkaline with low metals concentrations, an alkaline-amended wetland is recommended. Additional alkalinity provided by the wetland will benefit the receiving stream by providing buffering capacity. The system should discharge water with 50 – 80 mg/L of net alkalinity (-50 – -90 mg/L net acidity) and less than 1 mg/L of iron.

Using 50 gpm as a design flow rate and a desired retention time of 24 hours, a 20,000 square foot wetland should be constructed. The wetland should be divided into two cells so that one cell can be taken off line if maintenance is needed. The wetland should contain 6 inches of water over 6 inches of alkaline-amended soil or compost as wetland substrate. The wetland should be seeded and/or planted with wetland plants. The current pond could be modified and expanded to construct this wetland. Given the relatively low iron loading of the discharge, the wetland will accumulate iron at a rate of less than 0.05 inches per year.

Assuming that a wetlands disturbance permit or stream encroachment permit are not required, this project is estimated to cost a total of approximately $40,000, with $28,000 for construction and $12,000 for mapping, design, permitting and construction oversight of the project.

C. *NBD50D and NBD51D*

NBD50D and NBD51D emerge near each other just off the road. Their flows combine before entering a large pond. The pond discharges to the headwaters of Tributary D. Because early sampling indicated that they were not major contributors of pollution to the stream, they were sampled only 5 times during the assessment. Flow at each station was measured using the timed volume method from installed pipes. Tables 21 and 22 show the flow, chemistry and loading from the discharges.

Table 21: NBD50D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	2.0	6.4	117	-22	12.0	0.9	0.0	13	9	-0.5	0.3	0.0
06/18/02	1.5	7.0	120	-30	10.6	0.9	0.0	14	9	-0.5	0.2	0.0
10/08/02	0.3	5.9	105	-21	40.3	1.2	0.1	12	7	-0.1	0.1	0.0
01/13/03	0									0.0	0.0	0.0
03/18/03	0									0.0	0.0	0.0
Average	**0.8**	**6.4**	**114**	**-24**	**21.0**	**1.0**	**0.1**	**13**	**8**	**-0.2**	**0.1**	**0.0**

Table 22: NBD51D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	56	5.6	110	4	1.5	0.1	0.2	18	5	2.7	1.0	0.2
06/18/02	47	6.2	150	-3	1.3	0.1	0.1	16	2	-1.7	0.7	0.0
10/08/02	8	5.2	113	9	8.4	0.6	0.1	37	2	0.8	0.8	0.0
01/13/03	35	5.4	128	7	1.7	0.1	0.1	14	1	3.1	0.7	0.0
03/18/03	40	5.5	120	4	1.4	0.1	0.1	12	1	2.2	0.7	0.1
Average	**37**	**5.6**	**124**	**4**	**2.9**	**0.2**	**0.1**	**19**	**2**	**1.4**	**0.8**	**0.1**

NBD50D and NBD51D are marginally polluted discharges that contribute less than 1% each of the average acidity, iron and aluminum loadings to the stream. Additionally, they flow to a large pond, where retention with uncontaminated water provides alkalinity and settling time for the low concentrations of iron in these discharges. Therefore, no action on these discharges is recommended at this time and they have been assigned a priority of "Low."

However, if treatment of these discharges is desired in the future, an alkaline-amended wetland is recommended. The size and configuration of this wetland should be similar to the one proposed to treat NBD40D.

VIII. Tributary E: Discharge-Specific Treatment Recommendations

Eight discharges were identified and sampled on Tributary E, which drains the largest area of all of the lettered tributaries (2.8 square miles). Three of the top 8 known discharges to the North Branch are located on this tributary. Treatment of these discharges is necessary in order to recover both the tributary and the North Branch.

A. NBE03D

NBE03D discharges from a beaver pond that has partially inundated a strip cut. The discharge was sampled and flow was measured at the discharge from the pond. Table 23 shows the flow, chemistry and loading from the discharge.

Table 23: NBE03D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	33	5.6	195	-7	0.3	0.2	0.1	83	1	-2.8	0.1	0.0
06/18/02	45	6.8	193	-7	2.1	1.1	0.1	78	6	-3.8	1.2	0.0
10/09/02	3	5.8	279	-8	8.2	2.0	0.0	125	2	-0.3	0.3	0.0
01/14/03	12	6.0	258	-9	2.4	1.9	0.2	80	2	-1.2	0.3	0.0
03/19/03	45	5.8	176	-1	1.5	1.5	0.3	56	30	-0.5	0.8	0.2
Average	**28**	**6.0**	**220**	**-6**	**2.9**	**1.3**	**0.1**	**84**	**8**	**-1.7**	**0.5**	**0.1**

NBE03D is net alkaline and thus does not contribute to the acidity loading of the stream. It contributes and average of less than 1% of the iron and aluminum loading to the stream. Early sampling determined that this discharge would not be a major contributor, so it was only sampled on 5 occasions.

Due to the extremely low concentration of iron in this discharge, no action is recommended at this time. If action is someday desired, the beaver dam should be removed to allow free drainage from the spoil. Retention of the discharge in a small pond or wetland should be sufficient to remove the low levels of iron that are present. Increasing the alkalinity would also aid in buffering the stream.

B. NBE28D and NBE29D

NBE28D and NBE29D are located near the end of Dean Lane off of Route 38 within 30 meters of one another. Due to their proximity and common treatment recommendation, these discharges are discussed together. NBE28D emerges at the toe of a spoil area and flows in a steep ravine to Tributary E (Photo 16). NBE29D emerges just below the toe of a road bank that leads from Dean Lane to an illegal dumping area (Photo 17). The discharge emerges as many diffuse seeps and flows to Tributary E in several locations. At each discharge, flow was measured using the timed volume method at an installed pipe. Table 24 shows the flow, chemistry and loading from NBE28D. Table 25 shows the flow, chemistry and loading from NBE29D.

Table 24: NBE28D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	22	3.0	2,817	882	27.9	77.5	102	1,706	1	232.8	7.4	26.9
06/19/02	17	4.1	2,865	987	31.9	80.8	104	1,368	4	197.7	6.4	20.9
07/10/02	8	3.3	3,165	886	37.7	90.0	113	2,029	1	85.1	3.6	10.9
08/08/02	9	3.0	3,120	963	47.5	77.8	96	2,026	4	104.0	5.1	10.4
09/04/02	8	2.1	2,981	997	56.4	83.0	112	2,299	6	89.7	5.1	10.1
10/08/02	5	3.3	2,793	866	53.6	67.8	104	2,274	5	46.8	2.9	5.6
11/08/02	7	3.9	2,502	820	58.9	60.7	92	1,986	17	66.4	4.8	7.5
12/16/02	18	2.0	2,246	635	40.4	56.2	83	1,409	6	137.2	8.7	18.0
01/14/03	15	2.8	2,818	856	44.0	76.3	118	2,023	6	154.1	7.9	21.3
02/06/03	10	3.5	2,820	987	47.2	78.0	117	2,320	6	118.5	5.7	14.1
03/18/03	16	2.9	2,590	715	16.8	67.3	104	2,491	4	137.4	3.2	20.0
04/15/03	8	2.6	2,927	829	18.6	79.8	99	2,508	4	74.6	1.7	8.9
Average	**12**	**3.0**	**2,804**	**869**	**40.1**	**74.6**	**104**	**2,037**	**5**	**120.4**	**5.2**	**14.5**

Table 25: NBE29D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	90	3.3	1,390	394	10.4	27.7	46.2	734	3	426.0	11.2	49.9
06/19/02	55	4.3	1,493	487	10.7	30.1	57.0	713	4	323.9	7.1	37.9
07/10/02	20	3.6	1,600	446	20.9	32.7	55.4	807	3	107.0	5.0	13.3
08/08/02	17	3.1	1,554	428	21.5	32.0	43.5	971	1	84.8	4.3	8.6
09/04/02	9	2.4	1,512	445	28.7	29.6	47.2	983	1	48.0	3.1	5.1
10/08/02	6	3.4	1,444	393	26.6	25.7	40.9	999	2	28.3	1.9	2.9
11/08/02	9	3.9	1,383	336	35.2	24.8	39.0	814	4	36.3	3.8	4.2
12/16/02	21	2.2	1,430	374	44.3	26.9	43.4	919	12	94.3	11.2	10.9
01/14/03	30	3.2	1,422	405	29.1	27.7	49.5	771	2	145.8	10.5	17.8
02/06/03	21	3.6	1,733	567	31.3	28.8	50.3	1,113	13	142.9	7.9	12.7
03/18/03	79	3.3	1,353	368	12.3	26.2	54.3	1,085	4	348.9	11.6	51.5
04/15/03	35	3.1	1,393	375	11.8	28.9	50.6	870	2	157.3	4.9	21.2
Average	**33**	**3.3**	**1,476**	**418**	**23.6**	**28.4**	**48.1**	**898**	**4**	**162.0**	**6.9**	**19.7**

NBE28D ranked as the 3rd average contributor of acidity loading to the watershed. On each of the sampling dates, NBE28D ranked from the highest acidity load contributor to the 4th highest contributor. NBE29D ranks as the highest average contributor of acidity loading to the stream. On the various sampling dates, NBE29D ranked from 1st to 3rd in acidity loading to the stream. Together, these discharges supplied an average of 37% of the acidity loading that was measured from all known discharges.

Neither the chemistry nor the flow rates of these discharges vary significantly, indicating that their sources are not shallow groundwater or runoff from precipitation events. Therefore, reclamation in the area surrounding the discharges is unlikely to be effective. The water quality is extremely poor, with average acidity over 800 mg/L and aluminum values over 100 mg/L for NBE28D and 400 mg/L acidity and nearly 50 mg/L aluminum for NBE29D.

Although a few experimental passive treatment systems have been installed to treat water that is nearly as polluted as these discharges, the successes of these systems have been variable and their service lives have, in some instances, been extremely short. Other experimental systems, such as self-flushing open limestone beds and sulfate reducing bacteria systems, have shown promising results at the pilot-scale level but little is known about their success in full-scale and/or long-term treatment.

Due to the unproven nature of passive treatment for this type of discharge, the recommended treatment approach is to use a chemical treatment system. Penreco alkali liquor is a cost-effective solution and can be delivered to the site for little or not cost. NBE28D and NBE29D should be combined and treated in a common treatment facility.

Considering the average combined alkalinity loading requirement of the two discharges that will result in a discharge with 100 mg/L of net alkalinity (336 pounds per day) and the average alkalinity of the alkali liquor (90,000 mg/L as CaCO3), approximately 0.3 gpm (450 gallons per day) of the liquor would be needed. However, this would vary from 0.08 gpm (116 gallons per day) to 0.7 gpm (1,050 gallons per day) depending upon the combined flow rate of the discharges.

Figure 8 shows the acidity loading versus flow rate for each discharge and for the combination of the two discharges. As shown, the loadings increase linearly with flow rate and have a good correlation. Therefore, it will be beneficial to meter the alkali liquor into the treatment system based on flow rate, with approximately 0.008 gpm of liquor for each gallon per minute of discharge flow rate. Laboratory titration tests indicate that this dosing ratio will ensure a discharge that has approximately 100 mg/L of excess alkalinity. Aluminum levels will be completely removed if proper retention time is provided.

The ideal treatment system would contain:

- a chemical holding tank (or several smaller tanks) with a total of 25,000 gallons of capacity for alkali liquor ($30,000)
- A metering device such as a water wheel that will provide the proper amount of treatment chemical even with changing flow rates ($2,000)

- 4 treatment ponds with a total capacity of 500,000 gallons ($25,000)
- A sludge disposal pond ($10,000)

An additional $10,000 is estimated for pipes, valves, and site security materials, bringing to total cost to construct the system to $77,000.

One large unknown factor for this treatment recommendation is the permitting costs. In the past, the requirements to permit such a system have varied widely. If minimal permitting is required, design, engineering, permitting and an O&M Manual for the site would cost approximately $15,000. However, these costs could rise substantially, even doubling or tripling, if more extensive permitting is required. The permitting and regulatory requirements that the DEP has for this type of system should be determined as quickly as possible.

The large sludge ponds will provide retention time for the flow rate and provide storage for 388,000 gallons of sludge per year. The ponds will need to be cleaned out on a yearly basis for an estimated cost of $7,500. This cost assumes that sludge disposal occurs near the site, possibly in one of the abandoned pits above the current discharge location.

Another yearly investment would be for site monitoring, inspections, and adjustments to the dosing system. It is assumed that volunteers will perform this work. Two or three visits to the site, lasting less than 1 hour each, may be required. The purpose of these visits will be to ensure that the dosing system is working properly and that the site is functioning as designed.

In summary, the capital costs to construct the system are estimated to be at least $92,000, and may increase substantially depending upon the requirements of the DEP and other regulatory agencies. Yearly sludge costs are estimated at $7,500, with additional costs associated with site visits and monitoring. These costs will be covered by volunteers.

By contrast, a passive treatment for this site would cost $250,000 - $400,000 to construct and would likely require significant operation, maintenance, and replacement costs in a relatively short time because of the extremely polluted nature of the discharges. The system would likely be larger than the proposed chemical system. Because of these factors, passive treatment is not recommended at this site.

C. NBE52D

NBE52D is a spring that emerges from the northern stream bank of Tributary E (Photo 18). Flow was measured using the timed volume method from an installed pipe. Table 26 shows the flow, chemistry and loading from the discharge.

Table 26: NBE52D Flow, Chemistry and Loading

Sample Date	Flow (GPM)	Field pH	Cond (uS)	Net Acid (mg/L as CaCO3)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (pounds per day) Net Acid	Iron	Al
05/21/02	60	4.3	582	66	0.0	7.4	7.7	293	2	47.2	0.0	5.6
06/19/02	35	4.4	700	89	0.1	8.8	9.9	365	6	37.5	0.0	4.2
07/10/02	10	4.3	688	81	0.0	10.5	10.4	361	1	9.8	0.0	1.2
08/08/02	15	4.0	658	83	0.0	10.0	7.5	376	1	14.9	0.0	1.4
09/04/02	4	3.5	718	90	0.1	11.4	11.6	382	1	3.8	0.0	0.5
10/08/02	5	4.2	737	98	0.0	11.4	11.7	507	1	5.3	0.0	0.6
11/08/02	6	4.6	754	89	0.0	11.4	12.8	415	6	6.4	0.0	0.9
12/16/02	26	3.2	630	68	0.0	9.5	9.0	364	9	21.4	0.0	2.8
02/06/03	15	4.2	740	95	0.0	10.9	12.4	448	1	17.1	0.0	2.2
03/18/03	53	4.2	535	47	0.1	6.9	7.8	366	3	29.9	0.0	4.9
04/15/03	30	3.9	651	63	0.0	9.6	10.0	414	4	22.8	0.0	3.6
Average	**23**	**4.1**	**672**	**79**	**0.0**	**9.8**	**10.1**	**390**	**3**	**19.6**	**0.0**	**2.5**

NBE52D ranked as the 8th highest average contributor of acidity loading to the stream. On the various sampling dates, it ranged from being the 6th highest to the 10th highest contributor of acidity loading of the known discharges.

The discharge is moderately contaminated with acidity and aluminum. The chemistry of the discharge is suitable for treatment using a variety of passive treatment systems, including an alkaline-amended wetland and limestone polishing bed, a vertical flow pond system, or a limestone bed self-flusher. The most cost-effective system is a limestone self-flushing unit followed by a settling pond and a wetland. However, design information on a vertical flow pond system is also provided as an alternative.

Approximately 200 tons of limestone is required for the self-flushing system. Tasks associated with this project should include:

- Site access ($5,000)
- Collection, transfer, and upslope diversion channels ($5,000)
- 200 tons of limestone ($3,000)
- Self-flushing device, including installation ($8,000)
- 4,000 square foot sediment pond ($5,000)
- 5,000 square foot alkaline wetland ($7,000)
- Mobilization, E&S Control ($5,000)

Therefore, the total material and construction cost for this project is estimated at $38,000. An additional $12,000 would be required for mapping, design, and an O&M manual. This cost also includes permitting, which is anticipated to be minimal. The total cost of the system is $50,000.

Water should be collected and directed to the limestone bed. Each time the bed fills, the flushing device causes all of the water in the limestone to be immediately released to the sediment pond, which is sized to hold 12 full flushes. An outflow control device will slowly release water from the retention pond, preventing large surges of water from reaching the wetland. Final polishing and some increased alkaline addition will occur in the wetland. At 50 gpm, the total system will have a retention time of 32 hours.

This system should be inspected weekly to ensure that it is working properly. No other regular O&M is anticipated. Each year, the system will consume 4 tons of the limestone in the 200-ton bed, resulting in a 2% reduction in retention time each year. Therefore, additional limestone should be added periodically. One tri-axle load of limestone (23 tons) should be placed every 5 or 6 years, with an anticipated cost of approximately $400.

If a limestone self-flusher is not desired, it would also be acceptable to construct a vertical flow pond system that would include 2 VFPs, a flush pond, and a polishing wetland. No compost would be necessary because there is no iron in this discharge. This system would contain approximately 850 tons of limestone and cost approximately $110,000 to construct based on similar systems that have recently been constructed. It would require regular inspections and flushing events to remove precipitated aluminum.

Due to cost and maintenance issues, the self-flushing system is recommended.

D. NBE60D

This discharge originates from a pipe at the base of reclaimed mine slope. This discharge was located during watershed reconnaissance and sampled at that time. However, the landowner adamantly refused to allow additional flow or chemistry sampling. Therefore, only one water quality sample exists. Table 27 shows this data.

Table 27: NBE60D Chemistry

Sample Date	Flow (GPM)	Field pH	Cond (uS)	Net Acid (mg/L as CaCO3)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)
05/21/02		4.0	388	52	0.2	6.4	4.6	189	1

On the date of sampling, a visual estimate of 150 gpm was made. If this visual estimate was accurate, the discharge would have ranked 5^{th} or 6^{th} in acidity loading on that sampling date.

Nothing else is known about the flow or chemistry variation of this discharge. More sampling of both flow and chemistry must take place before final treatment recommendations can be made.

Based upon this one chemistry sample, passive treatment is certainly an option for this discharge. An alkaline-amended wetland would be capable of treating the acidity and metals contained in this discharge, but the area required for such a system may be quite large depending upon the treatment flow rate. A vertical flow pond system could also be used but, once again, the system may be quite large depending upon flow rate.

A limestone bed containing limestone and operated by a self-flushing siphon followed by a retention pond is another viable option. The limestone in these systems generally has a low retention time, resulting in a smaller system as compared to ALDs and VFPs.

Each of these treatment recommendations will have to be reevaluated for cost and size requirements when more data is collected.

E. NBE62D

NBE62D originates in a very steep ravine that leads directly to the stream. The ravine may lead to an old mine opening. At the discharge location (Photo 19), the ravine is stained orange, but the color clears up before the water reaches the stream (Photo 20). The flow was measured using a pipe installed in the discharge. Table 28 shows the flow, chemistry and loading of the discharge.

Table 28: NBE62D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	4	6.1	356	-39	7.2	2.1	0.0	80	9	-1.9	0.3	0.0
06/19/02	30	6.2	303	-29	2.9	1.6	0.0	96	3	-10.3	1.0	0.0
10/08/02	18	6.0	345	-25	6.4	2.1	0.0	131	1	-5.5	1.4	0.0
01/14/03	25	6.0	449	-36	3.5	1.8	0.1	105	2	-10.9	1.1	0.0
03/18/03	26	5.9	286	-15	2.4	1.0	0.0	86	3	-4.5	0.7	0.0
Average	**20**	**6.0**	**348**	**-29**	**4.5**	**1.7**	**0.0**	**100**	**4**	**-6.6**	**0.9**	**0.0**

NBE62D is net alkaline and thus does not contribute acidity loading to the stream. It contributes on average less than 1% of the iron and aluminum loading to the stream. The discharge is moderately contaminated with iron, which causes the orange staining in the ravine. However, because the discharge is clear before it reaches the stream, it can be assumed that the ravine is removing all of the iron. Therefore, no additional work is necessary on this discharge at this time.

F. NBE75D

NBE75D is an artesian upwelling located between two branches of Tributary E (Photo 21). The discharge emerges less than 5 meters from the stream and has created a large iron deposit that extends into the stream. The flow was measured using the timed volume method by directing the flow to an installed pipe. Table 29 shows the flow, chemistry and loading from this discharge.

Table 29: NBE75D Flow, Chemistry and Loading

Sample Date	Flow (GPM)	Field pH	Cond (uS)	Net Acid (mg/L as CaCO3)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (pounds per day) Net Acid	Iron	Al
07/10/02	8	5.9	417	13	43.3	7.5	5.4	157	5	1.2	4.2	0.5
08/08/02	8	5.8	420	15	9.1	4.0	0.6	182	2	1.3	0.8	0.0
09/04/02	9	5.0	414	12	9.9	4.2	0.3	185	2	1.3	1.1	0.0
10/08/02	5	5.7	400	14	7.9	4.0	0.4	154	2	0.8	0.5	0.0
11/08/02	5	5.3	397	14	5.3	3.9	1.0	187	5	0.8	0.3	0.1
12/16/02	8	4.7	385	21	7.3	4.2	2.9	188	18	2.1	0.7	0.3
01/14/03	3	5.3	492	32	6.8	4.1	2.7	220	14	1.1	0.2	0.1
02/06/03	6	5.5	382	18	8.8	4.1	2.1	199	1	1.3	0.6	0.2
03/18/03	11	5.2	360	21	5.4	4.2	2.9	145	5	2.8	0.7	0.4
04/15/03	6	5.2	366	14	5.8	4.2	2.2	190	10	1.1	0.4	0.2
Average	**7**	**5.4**	**403**	**17**	**10.9**	**4.4**	**2.0**	**181**	**6**	**1.4**	**1.0**	**0.2**

NBE75D ranked as the 18th average contributor of acidity loading to the stream. It contributed less than 1% of the average acidity, iron and aluminum loadings to the stream. Its highest rank during the sampling events was as the 14th highest contributor of acidity loading of the known discharges.

Although the chemistry of this discharge is amenable to very reliable passive treatment using an anoxic limestone drain or alkaline-amended wetland, there is no room available for treatment pond or wetlands. Additionally, the discharge does not appear to be emerging from an abandoned well, removing plugging as a potential option. Therefore, no recommendations are provided for this discharge, which has is a minor contributor of acidity and iron.

G. NBE81D

NBE81D is a discharge that forms the headwaters of one branch of Tributary E (Photo 22). The discharge emerges near an abandoned pump station but does not appear to be a result of those activities. Flow was measured using a 6" H-flume installed at the discharge. Table 30 shows the flow, chemistry and loading of the discharge.

Table 30: NBE81D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02		5.7	120	7	0.2	0.0	0.2	21	8			
06/19/02	75	6.2	113	1	0.1	0.0	0.1	21	3	1.3	0.1	0.1
07/10/02	8	5.6	85	0	0.1	0.0	0.0	16	2	0.0	0.0	0.0
08/08/02	9	5.7	103	3	0.4	0.2	0.3	20	1	0.4	0.0	0.0
09/04/02	0									0.0	0.0	0.0
10/08/02	0									0.0	0.0	0.0
11/08/02	0									0.0	0.0	0.0
12/16/02	70	4.9	96	4	0.1	0.1	0.1	21	5	3.2	0.1	0.1
01/14/03	50	5.3	121	4	0.0	0.0	0.1	18	2	2.6	0.0	0.0
02/06/03	20	6.0	178	8	0.1	0.0	0.2	29	2	1.8	0.0	0.1
03/18/03	210	5.2	87	2	0.1	0.1	0.1	16	3	6.1	0.1	0.4
04/15/03	50	5.2	115	1	0.0	0.0	0.1	22	2	0.5	0.0	0.0
Average	**45**	**5.5**	**113**	**3**	**0.1**	**0.1**	**0.1**	**20**	**3**	**1.4**	**0.0**	**0.1**

NBE81D ranked as the 16th highest average contributor of acidity loading to the stream, contributing less than 1% of the average acidity, iron and aluminum loading. The flow rate of the discharge is intermittent, with no flow measured during 3 of the sampling events. The discharge is marginally contaminated, with very low metals and net acidity values. However, because it forms the headwaters of the tributary, the entire stream would benefit if the net acidity could be removed and additional alkalinity added to the stream.

Creating an alkaline limestone pond in the abandoned beaver ponds below the discharge will provide alkalinity to the entire tributary downstream of this location. Using the average flow rate of 45 gpm and a target retention time of 10 hours, 450 tons of limestone would be required. This system would discharge water with a pH of 6 to 6.5 and 25 – 50 mg/L of net alkalinity. At higher flow rates, the alkalinity produced by this system would decrease. When no flow is emerging from the discharge, this system will not have an impact on the stream. However, because of its location at the headwaters of the tributary, this system is important to the stream. The costs involved in this system would include:

- 450 tons of limestone, installed ($9,000)
- Earthmoving ($3,500)
- Site access ($2,500)

The total construction cost is expected to be approximately $15,000. An additional $2,000 would be required for minimal design and permitting efforts for a total project cost of $17,000.

IX. Tributary F: Discharge-Specific Treatment Recommendations

Although two discharges were located on Tributary F, sampling indicates that the mouth of this tributary has good water quality. The tributary is capable of assimilating the pollution from the discharges.

A. NBF40D

NBF40D emerges near the spillway from an active beaver pond. The water discharging from the pond, which has submerged a highwall pit, is uncontaminated. It was not possible to collect all of the seepage at one point so two flow rate readings were taken, one at NBF40D and one at NBF41D, and the flow rates were combined to represent the discharge. Flow rates were measured using the timed volume method. The chemistry samples were taken at the discharge points and were similar for the two locations. Table 31 shows the flow and chemistry from the discharge.

Table 31: NBF40D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	180	6.4	56	-7	1.0	0.2	0.1	15	4	-15.1	2.2	0.2
06/18/02	65	6.8	57	-7	0.5	0.1	0.0	24	5	-5.5	0.4	0.0
07/09/02	12	6.2	105	-21	8.0	1.5	0.0	27	3	-3.0	1.2	0.0
08/07/02	11	6.2	103	-14	8.2	1.4	0.0	27	2	-1.8	1.0	0.0
09/04/02	6	5.6	108	-66	11.3	1.3	0.0	25	3	-4.8	0.8	0.0
10/08/02	8	5.5	109	-16	10.2	1.3	0.1	31	4	-1.6	1.0	0.0
01/13/03	36	6.0	66	1	1.9	0.2	0.1	16	2	0.3	0.8	0.0
03/19/03	158	6.0	63	-1	0.8	0.1	0.1	15	1	-1.9	1.6	0.2
Average	**59**	**6.1**	**83**	**-16**	**5.3**	**0.8**	**0.1**	**23**	**3**	**-4.2**	**1.1**	**0.1**

NBF40D is net alkaline and thus does not contribute acidity loading to the stream. It contributes on average less than 1% of the iron and aluminum loading to the stream.

Little or no area is available for treatment. No action is recommended for this discharge because it contributes very little contamination to Tributary F, which has good water quality at the mouth.

B. NBF45D

NBF45D is a collection of seeps that emerge between a beaver pond and Tributary F and flow to Tributary F in many locations. It was not possible to collect all of the seepage at one point so several pipes were installed to collect all of the seepage and the flow rates were combined (NBF45D, NBF46D and NBF47D represented these pipes). Flow rates were measured using the timed volume method. Table 32 shows the flow and chemistry from the discharge.

Table 32: NBF45D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/20/02	13	6.3	136	-12	2.5	1.6	0.0	37	3	-1.8	0.4	0.0
06/18/02	7	6.9	160	-18	3.6	2.1	0.0	59	7	-1.5	0.3	0.0
07/09/02	24	6.4	168	-28	3.8	3.0	0.0	57	4	-8.1	1.1	0.0
08/07/02	7	6.3	174	-28	5.8	3.5	0.0	47	3	-2.4	0.5	0.0
09/04/02	7	5.8	171	-39	7.0	4.2	0.0	50	2	-3.2	0.6	0.0
10/08/02	5	6.2	173	-24	7.9	4.3	0.0	15	4	-1.5	0.5	0.0
01/13/03	8	6.2	125	-7	2.2	1.7	0.0	29	2	-0.7	0.2	0.0
03/19/03	7	6.4	127	-17	1.3	0.9	0.0	33	3	-1.4	0.1	0.0
Average	**10**	**6.3**	**154**	**-22**	**4.3**	**2.7**	**0.0**	**41**	**4**	**-2.6**	**0.5**	**0.0**

NBF45D is net alkaline and thus does not contribute acidity loading to the stream. It contributes on average less than 1% of the iron and aluminum loading to the stream.

Little or no area is available for treatment. No action is recommended for this discharge because it contributes very little contamination to Tributary F, which has good water quality at the mouth.

X. Tributary G: Discharge-Specific Treatment Recommendations

Seven discharges were located and sampled on Tributary G, including three of the top 8 contributors of acidity to the entire watershed. A large deep and surface mine complex covers almost all of the area surrounding Tributary G, with mine spoil located in the stream in some locations.

A. NBG10D

NBG10D is a small discharge that emerges from the stream bank of Tributary G. This discharge has caused the accumulation of metals solids around the discharge point. The flow rate was measured using the timed volume method from a pipe installed at the discharge. Table 33 shows the flow, chemistry and loading from the discharge.

Table 33: NBG10D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02		2.7	5,037	4,223	1,642	15.7	210	4,084	9			
06/19/02	1.5	3.7	4,935	3,927	1,386	13.1	229	3,198	11	70.7	24.9	4.1
07/09/02	1.0	3.1	4,447	3,871	1,079	13.9	211	3,262	11	46.5	13.0	2.5
08/07/02	1.0	2.9	3,510	2,424	780	10.9	108	3,984	4	29.1	9.4	1.3
09/03/02	0.8	2.1	2,271	1,407	424	9.7	76	1,359	18	12.7	3.8	0.7
10/09/02	0.5	3.8	1,976	1,058	327	7.6	57	2,169	2	6.3	2.0	0.3
11/08/02	0.3	3.8	3,620	2,654	895	10.5	125	2,860	15	8.0	2.7	0.4
12/16/02	1.0	2.2	3,694	2,695	952	10.9	133	3,153	12	32.3	11.4	1.6
01/14/03	0.8	2.6	4,705	3,854	1,233	14.4	201	4,395	7	34.7	11.1	1.8
02/05/03	1.0	3.1	4,200	3,233	1,087	12.1	170	4,136	12	38.8	13.0	2.0
03/19/03	1.1	2.8	4,544	3,605	1,216	12.5	209	6,276	4	47.6	16.0	2.8
04/15/03	1.0	2.7	4,400	3,863	1,284	12.6	200	4,949	8	46.4	15.4	2.4
Average	**0.9**	**3.0**	**3,945**	**3,068**	**1,025**	**12.0**	**161**	**3,652**	**9**	**33.9**	**11.2**	**1.8**

Despite the low flow of this discharge, it ranks as the 6th highest average contributor of acidity loading to the North Branch. On each sampling date, NBG10D was between the 5th and 8th highest contributor of acidity loading of all the sampled discharges.

This discharge will likely be affected by Phase 1 and Phase 2 reclamation of this area. The combined cost for these phases is $507,100. These reclamation projects are described in detail in Section V Part B. Phase 3 of the work in the area will involve treating any remaining discharge from NBG15D, NBG12D, and NBG10D. It is hoped that these discharges can be treated in a common treatment system. Due to the uncertain effects of Phases 1 and 2, prices are not estimated for Phase 3.

B. NBG12D

NBG12D is a highly variable flow of water that emerges directly from unreclaimed spoil (Photo 23). The discharge flows down the spoil and directly to Tributary G. The flow rate was measured using the timed volume method from a pipe installed at the discharge. Table 34 shows the flow, chemistry and loading from the discharge.

Table 34: NBG12D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	75	5.4	131	7	3.0	0.4	0.9	47	5	6.3	2.7	0.8
06/19/02	30	6.6	132	-7	3.7	0.5	0.4	46	12	-2.5	1.3	0.1
07/09/02	3	6.0	220	-29	5.8	1.6	0.8	74	10	-1.0	0.2	0.0
08/07/02	0									0.0	0.0	0.0
09/04/02	0									0.0	0.0	0.0
10/09/02	0									0.0	0.0	0.0
11/08/02	0									0.0	0.0	0.0
12/16/02	30	4.2	215	13	4.2	0.6	1.3	101	6	4.8	1.5	0.5
01/14/03	15	5.7	229	16	6.7	0.9	0.9	84	3	2.8	1.2	0.2
02/05/03	4	5.6	408	39	15.9	1.8	3.4	202	2	1.9	0.8	0.2
03/19/03	93	5.5	111	3	1.8	0.2	0.5	32	2	3.2	2.0	0.5
04/15/03	38	5.7	141	0	2.9	0.4	0.3	61	5	-0.1	1.3	0.2
Average	**24**	**5.6**	**198**	**5**	**5.5**	**0.8**	**1.1**	**81**	**6**	**1.3**	**0.9**	**0.2**

NBG12D contributed less than 1% of the average acidity, iron, and aluminum loading to the stream. It ranked 19th in average acidity contribution, although on one sampling occasion it ranked 11th.

This discharge varies widely in both flow rate and quality. On some occasions, the discharge was net alkaline, while on others it was net acidic. Flow varied from a maximum of 93 gpm to zero flow, which occurred on four occasions.

This discharge will likely be affected by Phase 1 and Phase 2 reclamation of this area. The combined cost for these phases is $507,100. These reclamation projects are described in detail in Section V Part B. Phase 3 of the work in the area will involve treating any remaining discharge from NBG15D, NBG12D, and NBG10D. It is hoped that these discharges can be treated in a common treatment system. Due to the uncertain effects of Phases 1 and 2, prices are not estimated for Phase 3.

C. NBG15D

NBG15D was sampled from the discharge end of a large culvert that was originally thought to be a deep mine opening (Photo 24). However, further reconnaissance indicated that the culvert has been placed through a large berm of mime spoil material. The flow rate was measured using an H-flume that was temporarily installed at discharge end of the culvert the site. Table 35 shows the flow, chemistry and loading from this discharge.

Table 35: NBG15D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02		3.9	232	34	7.6	0.5	3.1	80	3			
06/19/02	275	4.7	312	66	13.8	0.8	4.1	117	5	217.5	45.4	13.6
07/09/02	40	3.5	917	259	63.8	3.6	18.1	400	5	124.5	30.6	8.7
08/07/02	30	3.2	780	216	47.8	3.2	10.8	275	1	77.7	17.2	3.9
09/04/02	22	2.3	777	185	45.0	3.0	12.3	343	6	48.9	11.9	3.2
10/09/02	8	3.9	647	181	26.0	2.3	12.8	494	1	17.3	2.5	1.2
11/08/02	18	4.0	646	146	24.1	2.1	10.4	299	7	31.5	5.2	2.2
12/16/02	430	3.5	195	14	2.1	0.2	1.1	48	12	72.9	10.8	5.7
01/14/03	165	3.5	307	51	6.4	0.3	3.4	85	2	101.8	12.8	6.7
02/05/03	250	4.3	286	49	6.3	0.4	2.0	100	4	147.6	19.0	5.9
03/19/03	450	3.3	234	51	6.3	0.3	2.5	82	2	272.7	33.9	13.3
04/15/03	150	3.5	366	89	15.5	0.8	5.0	136	7	161.1	28.0	8.9
Average	**167**	**3.6**	**475**	**112**	**22.1**	**1.5**	**7.1**	**205**	**5**	**115.8**	**19.7**	**6.7**

Overall, this discharge was the 4th highest contributor of acidity loading to the stream. On two sampling occasions (February and April 2003), the discharge was the top acidity contributor.

The quality of this discharge varies substantially with flow rate, with worse water quality occurring during low flow conditions. This water quality is diluted during high flows by clean water from the tributary that enters the upstream side of the culvert in an unpolluted condition.

This discharge is the primary focus of Phase 1 reclamation of this area. The anticipated cost for reconstructing the NBG15D channel is $48,800. Additional reclamation that may affect this discharge is anticipated to cost $459,100. These reclamation projects are described in detail in Section V Part B.

Phase 3 of the work in the area will involve treating any remaining discharge from NBG15D, NBG12D, and NBG10D. It is hoped that these discharges can be treated in a common treatment system. Due to the uncertain effects of Phases 1 and 2, prices are not estimated for Phase 3.

D. NBG25D

NBG25D is an intermittent flow that originates in an area where both deep mining and reported refuse disposal took place. The discharge collects in a washed-out gully in the partially reclaimed refuse area (Photo 25). Flow was measured using the timed volume method from a pipe installed in the gully. Table 36 shows the flow, chemistry and loading of the discharge.

Table 36: NBG25D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	0.75	1.6	12,940	10,506	3,071	6.1	283	9,473	16	94.6	27.6	2.5
06/19/02	0.75	2.9	10,380	7,565	2,070	4.1	234	6,340	16	68.1	18.6	2.1
07/09/02	0									0.0	0.0	0.0
08/07/02	0									0.0	0.0	0.0
09/04/02	0									0.0	0.0	0.0
10/09/02	0									0.0	0.0	0.0
11/08/02	0.40	2.8	16,850	14,542	4,116	6.9	405	17,586	32	69.8	19.8	1.9
12/16/02	1.12	1.1	7,600	4,883	1,375	3.5	154	4,810	13	65.6	18.5	2.1
01/13/03	0.50	1.8	6,268	3,976	1,021	2.8	117	4,245	6	23.9	6.1	0.7
02/05/03	0.25	2.0	9,860	8,537	2,391	3.9	258	11,273	24	25.6	7.2	0.8
03/19/03	0.31	2.0	8,440	5,732	1,792	3.7	195	8,146	14	21.3	6.7	0.7
04/15/03	0									0.0	0.0	0.0
Average	**0.34**	**2.0**	**10,334**	**7,963**	**2,262**	**4.4**	**235**	**8,839**	**17**	**30.7**	**8.7**	**0.9**

Despite having no flow (and this no loading contribution) on 5 of the 12 sampling dates, NBG25D still ranked as the 7th highest average contributor of acidity loading to the stream. However, when only the days when flow was available are considered, the average acidity loading from NBG25D is 52.7 pounds per day, ranking it an average of 6th highest on those days. On each individual sampling event, the discharge ranked from the highest contributor of acidity loading to as low as 9th on days when it was flowing.

NBG25D is among the most contaminated mine discharges sampled in Pennsylvania. The intermittent nature of the discharge suggests that it is fed by runoff from precipitation events or a very shallow groundwater flow. Therefore, the primary recommendation for this discharge is surface reclamation that includes the addition of alkaline material to the area.

The detailed reclamation plan is presented in Section V Part A. The total cost of the project, which includes removing the NBG35D impoundment, is $44,000. However, the site is currently under investigation as a source of marketable refuse. If the area is mined for refuse, much of the cost of reclaiming the site should be covered by the miner.

E. NBG35D

NBG35D is a discharge from a beaver dam that has blocked a narrow gap in the spoil piles. Photo 26 shows the impoundment. The beaver dam has caused water to back up between the exposed highwall and the mine spoil, creating a large pool. The origin of the seepage is not visible due to this pool. The flow was measured using the timed volume method from an installed pipe. Table 37 shows the flow, chemistry and loading from this discharge.

Table 37: NBG35D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	95	4.2	225	29	1.4	1.3	1.9	106	5	33.3	1.6	2.2
06/19/02	15	5.0	392	53	3.9	2.0	2.9	206	10	9.7	0.7	0.5
07/09/02	6	4.5	540	51	5.2	3.2	4.2	245	5	3.7	0.4	0.3
08/07/02	2	4.8	463	50	11.9	2.8	3.3	252	4	1.3	0.3	0.1
09/04/02	1	3.4	595	70	6.7	5.5	7.5	327	3	0.8	0.1	0.1
10/08/02	1	5.8	637	69	12.0	5.6	6.0	417	35	1.0	0.2	0.1
11/08/02	6	4.0	645	71	13.3	4.9	5.7	295	9	5.1	1.0	0.4
12/16/02	6	3.2	340	31	3.7	2.4	2.6	155	6	2.2	0.3	0.2
01/13/03	12	3.6	306	50	0.9	1.2	1.9	132	3	7.2	0.1	0.3
02/05/03	4	4.0	368	40	3.2	2.8	3.1	182	1	1.9	0.2	0.2
03/19/03	96	4.8	96	7	0.5	0.6	0.6	33	6	7.7	0.6	0.7
04/15/03	9	4.0	431	36	1.4	3.0	4.8	176	4	3.8	0.2	0.5
Average	**21**	**4.3**	**420**	**46**	**5.3**	**2.9**	**3.7**	**210**	**8**	**6.5**	**0.5**	**0.5**

NBG35D is the 13th highest average contributor of acidity loading among the known discharges. On average, it contributed less than 1% of the acidity, iron and aluminum loadings to the stream. On the various sampling dates, it ranked as high as 8th and as low as 18th. The discharge is moderately contaminated with acidity, iron, and aluminum.

The first recommendation for this discharge is to remove the beaver dam that is causing water to back up between the highwall and the spoil. In addition to affecting NBG35D, this may also impact NBG25D. The water that is feeding this discharge is likely seepage from the highwall or shallow groundwater that may be less contaminated when it originally enters the pool. However, as the water is retained and contacts the highwall and the spoil, it is likely becoming more contaminated. Releasing this water to create a free-flowing discharge may significantly improve the quality. This will also allow the source(s) of the water to be seen.

This project should be performed in conjunction with the NBG25D reclamation, which is detailed in Section V Part A. The expected cost of the beaver dam removal ($2,500) is included in the total $44,000 for that project.

F. NBG45D

NBG45D discharges from spoil to a small ravine that leads to Tributary G. The flow may be the result of an adjacent beaver dam, which may be leaking through the spoil to form the discharge. Flow was measured using the timed volume methods from an installed pipe. Table 38 shows the flow and chemistry of the discharge.

Table 38: NBG45D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	3.0	5.6	442	12	14.9	4.9	0.1	157	2	0.4	0.5	0.0
06/19/02	1.5	6.6	432	7	14.9	4.5	0.0	215	3	0.1	0.3	0.0
10/09/02	0									0.0	0.0	0.0
01/13/03	0.8	6.0	470	25	16.2	4.9	0.0	132	1	0.2	0.1	0.0
03/18/03	2.0	5.8	500	16	18.9	5.5	0.1	198	7	0.4	0.5	0.0
Average	**1.5**	**6.0**	**461**	**15**	**16.2**	**4.9**	**0.1**	**175**	**3**	**0.2**	**0.3**	**0.0**

Because the discharge was determined to be of minor significance to the watershed, it was only sampled 5 times. It contributed less than 1% of the average acidity, iron and aluminum loading to the stream.

Because of the minimal impact of this discharge, no action is recommended at this time. If this discharges is targeted in the future, general reclamation activities in the area surrounding the discharge should remediate the problem.

G. NBG50D

NBG50D is a small upwelling near the base of an abandoned highwall. Flow was measured using the timed volume method from an installed pipe. Table 39 shows the flow, chemistry and loading from the discharge.

Table 39: NBG50D Flow, Chemistry and Loading

										Loading (pounds per day)		
Sample Date	**Flow (GPM)**	**Field pH**	**Cond (uS)**	**Net Acid (mg/L as CaCO3)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO4 (mg/L)**	**TSS (mg/L)**	**Net Acid**	**Iron**	**Al**
05/21/02	22	6.2	365	-24	3.8	1.5	0.0	127	3	-6.4	1.0	0.0
06/19/02	10	6.7	350	-20	4.7	1.5	0.0	158	3	-2.4	0.6	0.0
10/09/02	0									0.0	0.0	0.0
01/13/03	6	6.3	289	-34	7.2	1.5	0.1	74	3	-2.5	0.5	0.0
03/18/03	10	6.0	311	-29	2.9	0.7	0.0	87	1	-3.5	0.3	0.0
Average	**10**	**6.3**	**329**	**-27**	**4.7**	**1.3**	**0.0**	**111**	**3**	**-2.9**	**0.5**	**0.0**

Because the discharge was determined to be of minor significance to the watershed, it was only sampled 5 times. NBG50D is net alkaline, and thus did not contribute acidity loading to the stream. The discharge is marginally contaminated with iron but contributes less than 1% of the average iron and aluminum loadings to the stream. Due to the extremely small loading contribution from the discharge, no action is recommended at this time.

Because of the minimal impact of this discharge, no action is recommended at this time.

XI. Restoration Plan Recommendations

Table 40 summarizes the recommendations and cost estimates discussed in detail in the previous sections. Each discharge has been assigned a priority of High, Medium or Low based on the findings of this assessment and the watershed goals established by the Bear Creek Watershed Association.

Table 40: Summary of Restoration Recommendations

Point ID	Priority	Recommendation Actions	Initial Cost (X $1,000)*	Net Acid	Iron	Al
NB12D	High	Separate clean from contaminated water, pipe to NB13D treatment location.	$ 25	15.7	0.1	0.9
NB13D	High	Collect and treat with NB12D in an alkaline wetland	$ 90	17.5	3.1	0.8
NB15D	Low	Remove impoundment; monitor effects.	$ 7.4	4.6	0.5	0.3
NB18D	Low	Remove impoundment; monitor effects.	$ 8.4	1.0	0.1	0.1
NB31D	High	Plug	$ 12	10.3	3.3	0.5
NB32D	High	Plug	$ 12	3.5	0.9	0.1
NB36D	High	Monitor effects of Phase 1 and Phase 2 Young Mine Complex reclamation; additional reclamation or treatment if necessary.	-	43.8	4.2	3.6
NB37D				159.9	21.3	11.4
NBD10D	Medium	Remove impoundment; construct passive wetland system	$ 97	16.2	0.9	1.9
NBD40D	Medium	Construct passive wetland system	$ 36	-6.1	2.7	0.0
NBD50D	Low	No action; discharges are not impacting stream	-	-0.2	0.1	0.0
NBD51D				1.4	0.8	0.1
NBE03D	Low	No action	-	-1.7	0.5	0.1
NBE28D	High	Construct system to allow for treatment using Penreco weak alkali liquor	$ 90	120.4	5.2	14.5
NBE29D				162.0	6.9	19.7
NBE52D	High	Limestone self-flusher, pond wetland system	$ 50	19.6	0.0	2.5
NBE60D	High	Gain permission to sample	-	unknown		
NBE62D	Low	No action; discharge is not impacting stream	-	-6.6	0.9	0.0
NBE75D	Low			1.4	1.0	0.2
NBE81D	Medium	Oxic limestone pond	$ 17	1.4	0.0	0.1
NBF40D	Low	No action	-	-4.2	1.1	0.1
NBF45D	Low	No action	-	-2.6	0.5	0.0
NBG10D	High	Phase 1 and Phase 2 of the Yong Mine Complex Reclamation (channel reconstruction and 32 acres of reclamation); monitor results.	$ 507.9	33.9	11.2	1.8
NBG12D				1.3	0.9	0.2
NBG15D				115.8	19.7	6.7
NBG25D	High	Removal acid materials, reclaim with heavy alkaline addition; monitor effects.	$ 42	30.7	8.7	0.9
NBG35D	Medium	Remove impoundment (in conjunction with NBG25D reclamation); monitor effects.	$ 2.5	6.5	0.5	0.5
NBG45D	Low	No action	-	0.2	0.3	0.0
NBG50D	Low	No action	-	-2.9	0.5	0.0

**Does not include costs covered by private project partners such as Penreco or ongoing maintenance costs.*

A. Priority Projects

Several high-priority projects have been identified and cost estimates have been provided. These projects should be pursued immediately in order to begin the recovery of the North Branch. The projects are:

1. NBG25D Reclamation and Alkaline Addition ($42,000)
2. "Young Mine Complex" Phase 1 ($48,800)
3. "Young Mine Complex" Phase 2 ($459,100)
4. NBE28D and NBE29D Penreco treatment system ($77,000)
5. NBE52D self-flusher ($50,000)
6. Plug NB31D and NB32D ($24,000)
7. NB12D separation of clean water followed by treatment with NB13D ($115,000)

Seven projects have been identified, but several of the projects may occur concurrently, which could result in cost savings. For instance, the first three projects listed occur adjacent to each other and could be performed concurrently under one contract to save on mapping, permitting, design, and mobilization costs. The total cost of the seven projects listed is estimated at $815,900. It should be possible to implement all of these projects within 5 to 7 years.

In addition to these "on the ground" projects, efforts should be made to obtain permission to sample NBE60D. The landowner on this project, Mr. Kelly Armstrong, did not allow sampling during this watershed assessment. Efforts to obtain landowner permissions should continue. Until sufficient quality and flow rate information is obtained, it will not be possible to recommend a treatment system for this discharge.

It is likely that these seven projects will not be sufficient to completely restore the watershed. After each project is completed, post-project monitoring should take place to assess the effectiveness of the project and determine the need for additional treatment or reclamation efforts. Monitoring should be performed at both the discharge locations and in-stream locations downstream of implemented projects. The results of the monitoring and an examination of past and current data will allow recommendations for additional work at these discharges and work at the other discharges in the watershed.

In addition, specific funding sources may be interested in funding projects that have not been listed in this section. For instance, groups interested in waterfowl may be interested in assisting with constructed wetlands or a particular landowner may be interested in contributor towards a project on their property. In this case, these projects should be pursued as desired by the BCWA.

B. Potential Funding Sources and Partners

Numerous state and federal agencies have money available to support watershed restoration activities. Some of the most common sources of funding are discussed below, however, other sources such as private foundations also exist. Each funding source has its own application procedure, funding limitation, matching funds requirements, and administrative techniques.

The **Pennsylvania DEP Growing Greener Program** provides funds to projects dealing with all aspects of watershed restoration, including mine drainage pollution. The program has funded numerous programs since its inception in 1999, including the project to fund this assessment and restoration plan. Applications for the Growing Greener Program are accepted each year, generally in the late winter. Grants do not require matching funds or services, though they are desirable. There is no funding limit and grants can last two or three years.

The **DEP Technical Assistance Grant (TAG) Program** is a special section of the Growing Greener Program. Several non-profit groups are authorized TAG providers and can assist watershed groups with small-scale projects that do not include construction. Technical assistance from this program was used to initiate the watershed assessment of the North Branch. For more information on both of these programs, visit the DEP website at http://www.dep.state.pa.us/growgreen/defaultdep.htm

The **Office of Surface Mining (OSM) Appalachian Clean Streams Initiative** also provides grants to fund projects that address abandoned mine problems, specifically mine drainage treatment systems. They can provide up to $150,000 for projects that involve construction. Matching funds or in-kind services are required, but there is no set amount of matching that is required. For more information on this program, visit http://www.osmre.gov/acsihome.htm.

The **U.S. E.P.A. 319(h) Nonpoint Source Management Grant Program** is administered by the DEP and provides funds to projects for all nonpoint sources of pollution, including mine drainage. These grants are awarded through the Growing Greener application process, so no new paperwork is required. The E.P.A. also periodically offers other grants which may pertain to mine drainage restoration.

The DEP's **Bureau of Abandoned Mine Reclamation (BAMR)** specializes in land reclamation projects and can provide mapping and design services or funding for these projects. Projects are chosen through an on-site visit process with BAMR personnel. More information is available at http://www.dep.state.pa.us/dep/deputate/minres/bamr/bamr.htm.

The **U.S. Army Corps of Engineers** has recently embarked upon several ecosystem restoration projects involving mine drainage pollution. Through their process, they provide a restoration plan document that outlines all the projects necessary to restore a watershed to its designated uses. If the watershed group accepts this document, the Corps will then provide up to $5 million dollars to complete the projects. However, the watershed group is required to provide matching funds that total at least 35% of the total project amount. This matching money can be any non-federal matching funds, such as Growing Greener funds.

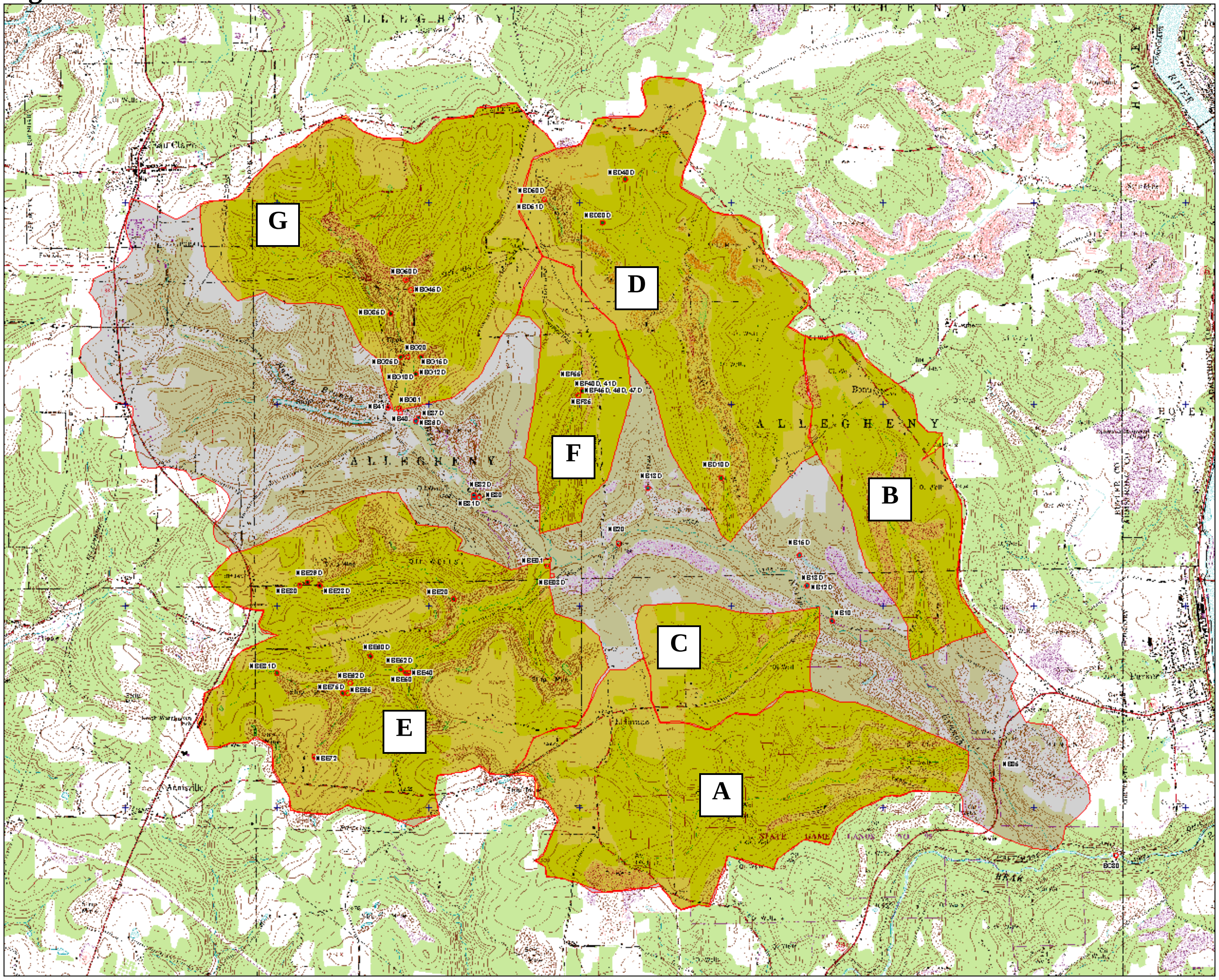
In addition to these potential funding sources, valuable partnerships can be formed with private businesses, individuals, private foundations, and others. Potential project partners include anyone who can provide funding, materials, or in-kind services such as system inspections, water sample collection, equipment use, or other matching.

There are several potential project partners located in close proximity to the North Branch watershed that may be able to provide alkaline materials at little or no cost. Penreco in Parker, PA, has expressed an interest in providing weak alkali liquor to projects in the watershed. This material could be obtained at no cost to the watershed group. In addition, several limestone producers in the area have large stockpiles of waste lime, bag-house lime, and other limestone products that are not commercially valuable.

XII. Assessing Plan Effectiveness

The effectiveness of each individual restoration project and the restoration plan as a whole can easily be evaluated by monitoring the water quality parameters at in-stream locations that were sampled as part of this project or as part of the DEP's TMDL study of the watershed. Quarterly sampling for a period of one year should be performed in order to assess the new conditions of the stream after major projects are completed. The in-stream station just upstream and just downstream of the project should be monitored, as well as other stations if desired. This data can then be directly compared to the data contained in this report in order to assess water quality improvements.

Figure 1: North Branch of Bear Creek Watershed and Tributaries



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS   1000 ft Scale: 1 : 46,875 Detail: 13-0 Datum: WGS84

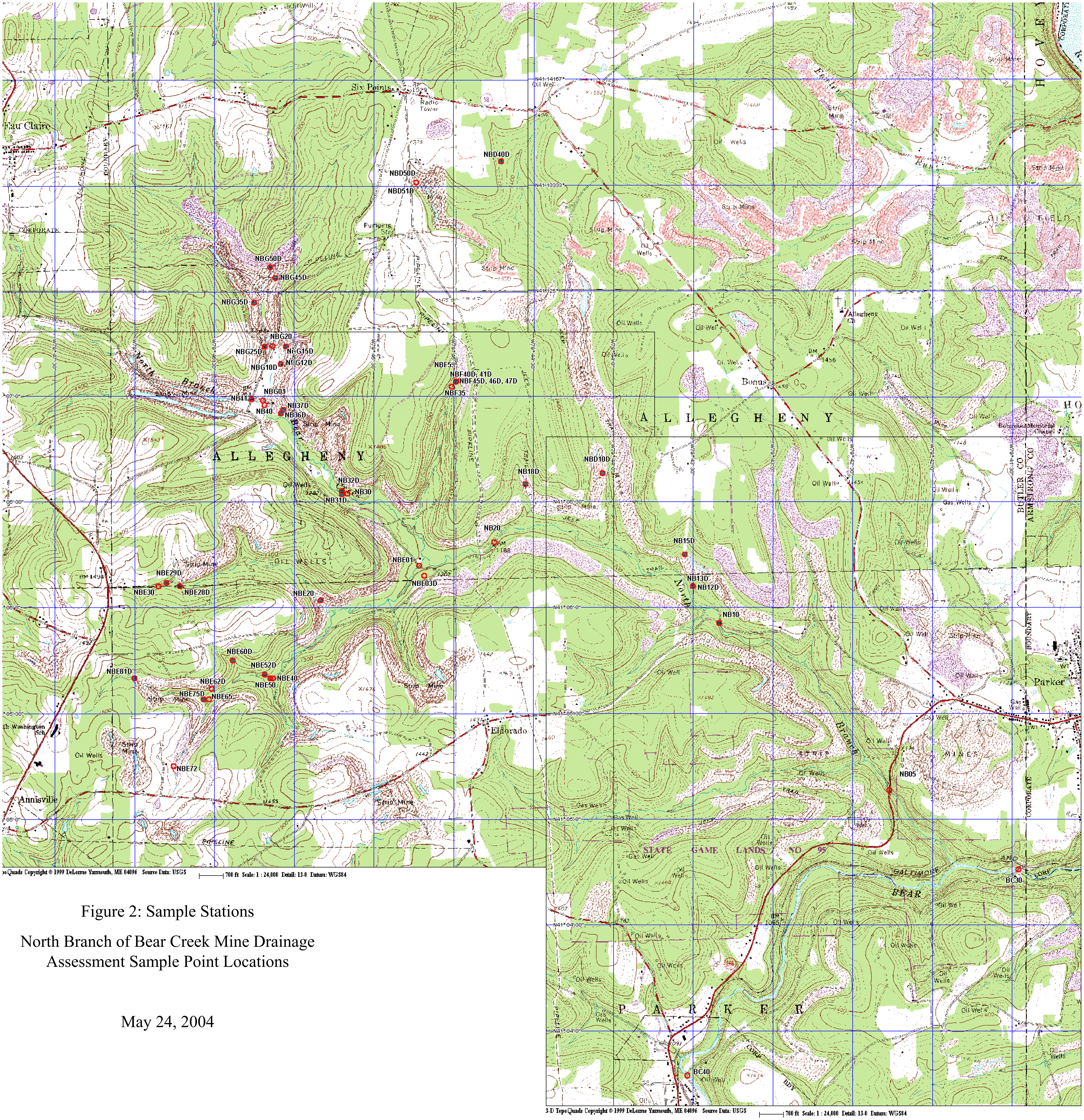


Figure 2: Sample Stations

North Branch of Bear Creek Mine Drainage
Assessment Sample Point Locations

May 24, 2004

Figure 3: Regional Geologic Structure Lines. Structural elevations are on a 20' contour interval and adapted from "Coal Resources of Butler Count, Pa   Part 1. Coal Crop Lines, Mined-Out Areas, and Structure Contours". The arrow indicates direction of general groundwater flow.

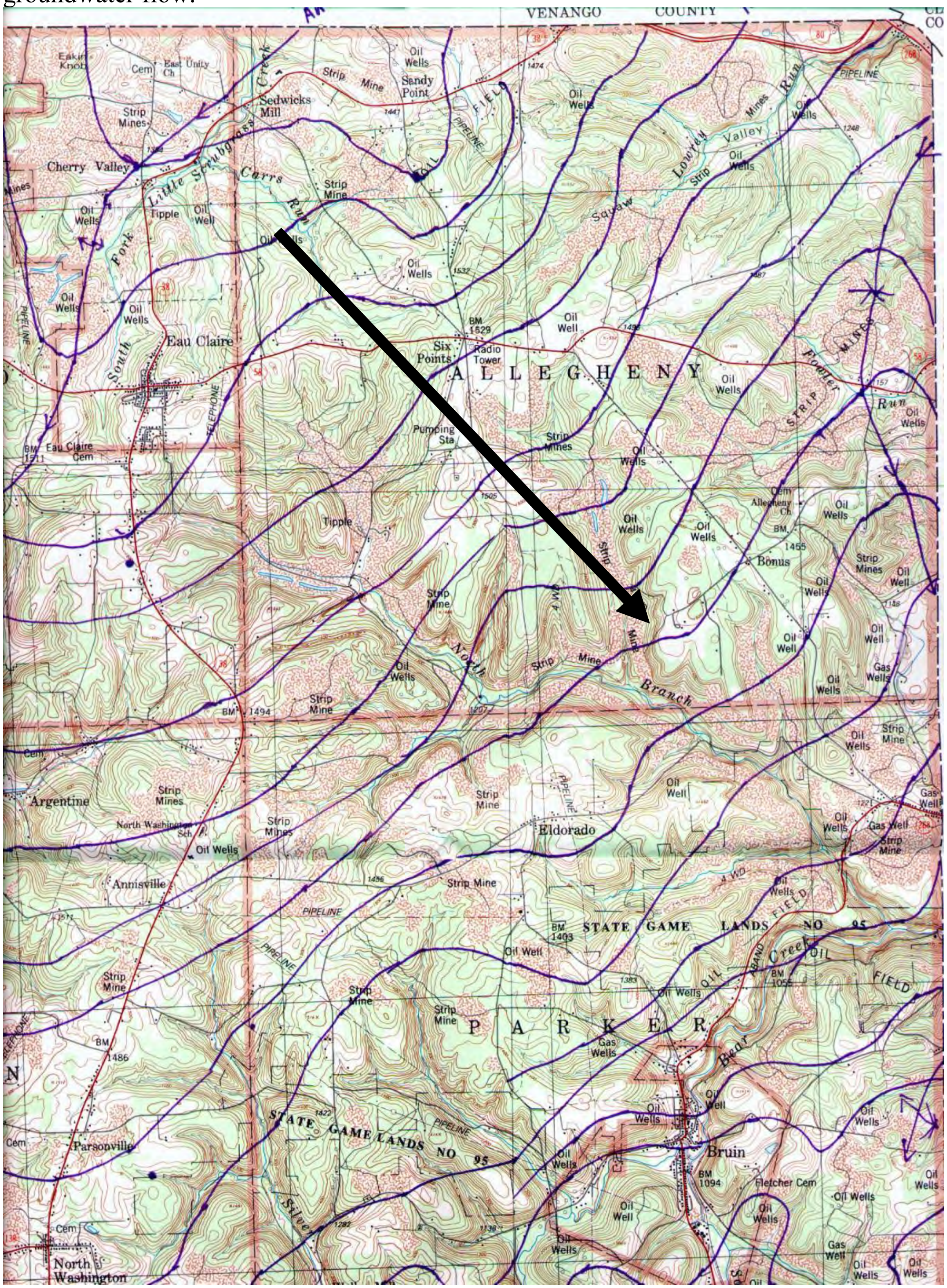


Figure 4: Total Monthly Actual and Mean Precipitation, Butler, PA

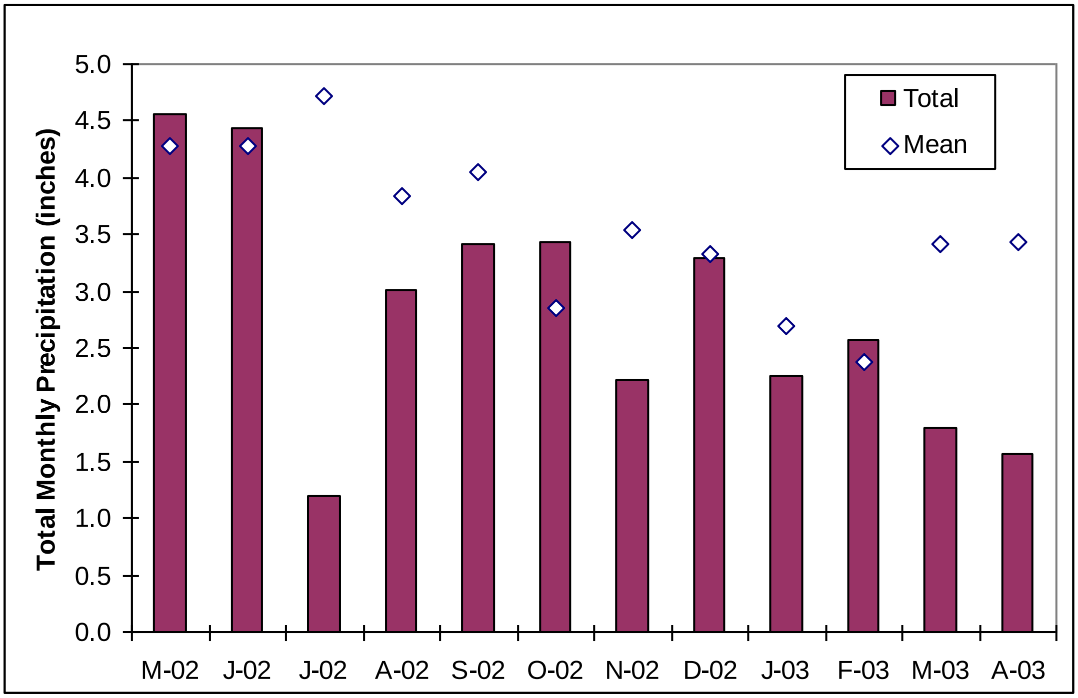


Figure 5: Main Stem Chemistry by Stream Mile

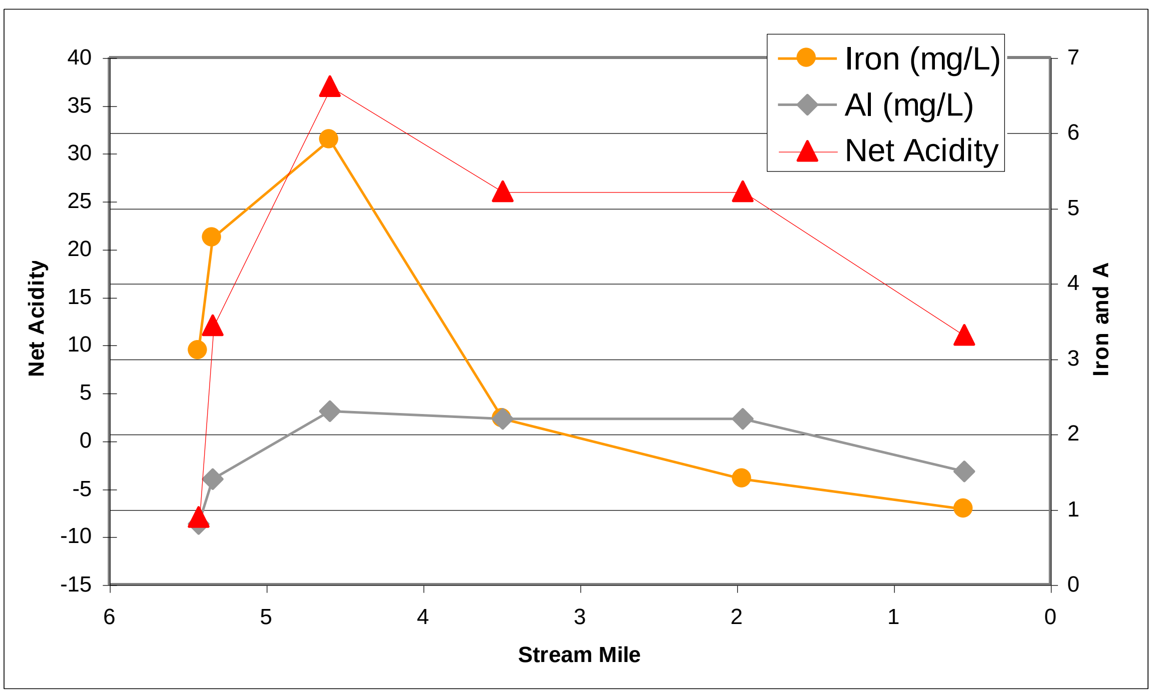


Figure 6: Passive Treatment Decision Flow Chart

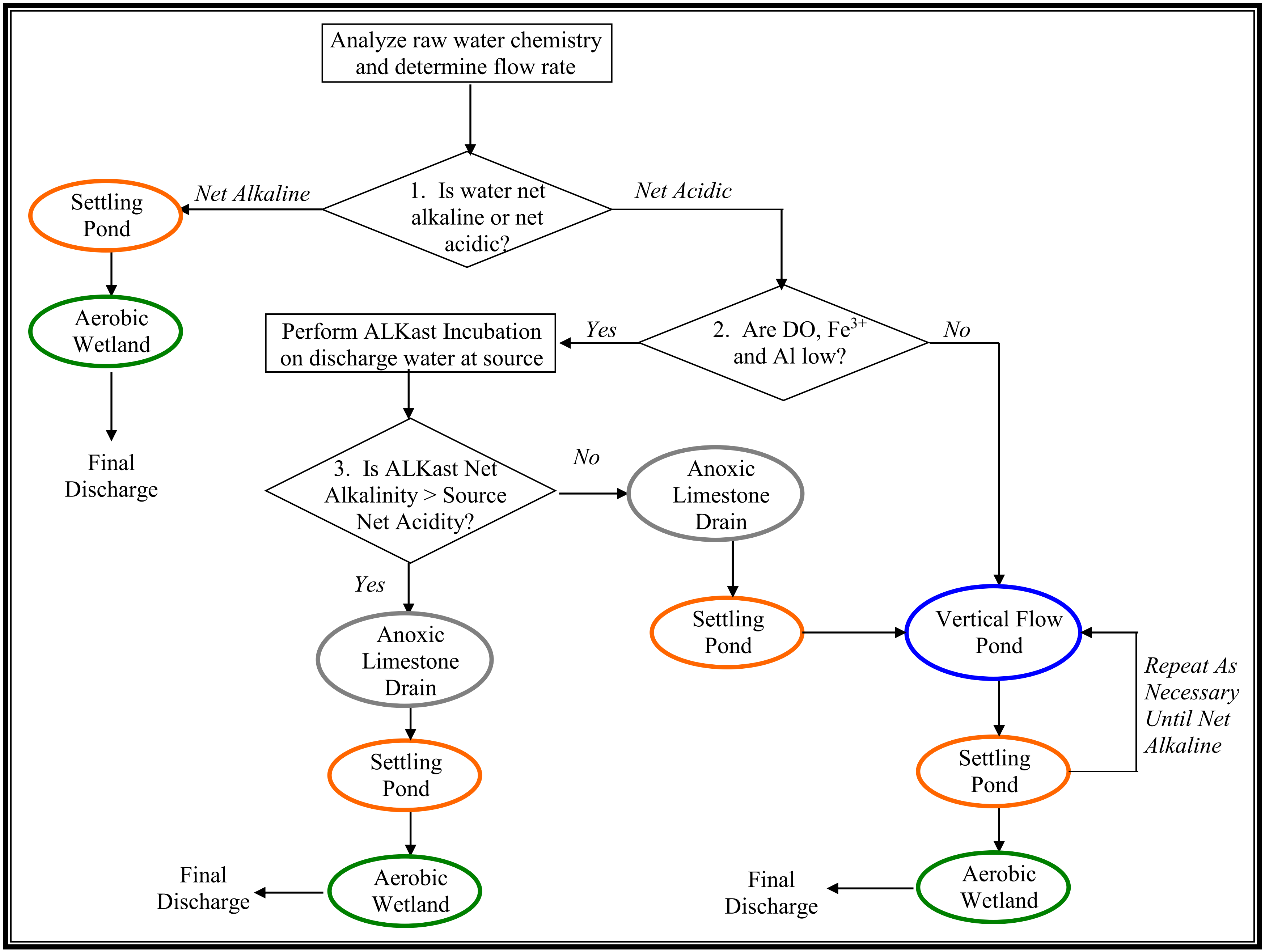


Figure 7: Tributary G Reclamation Areas

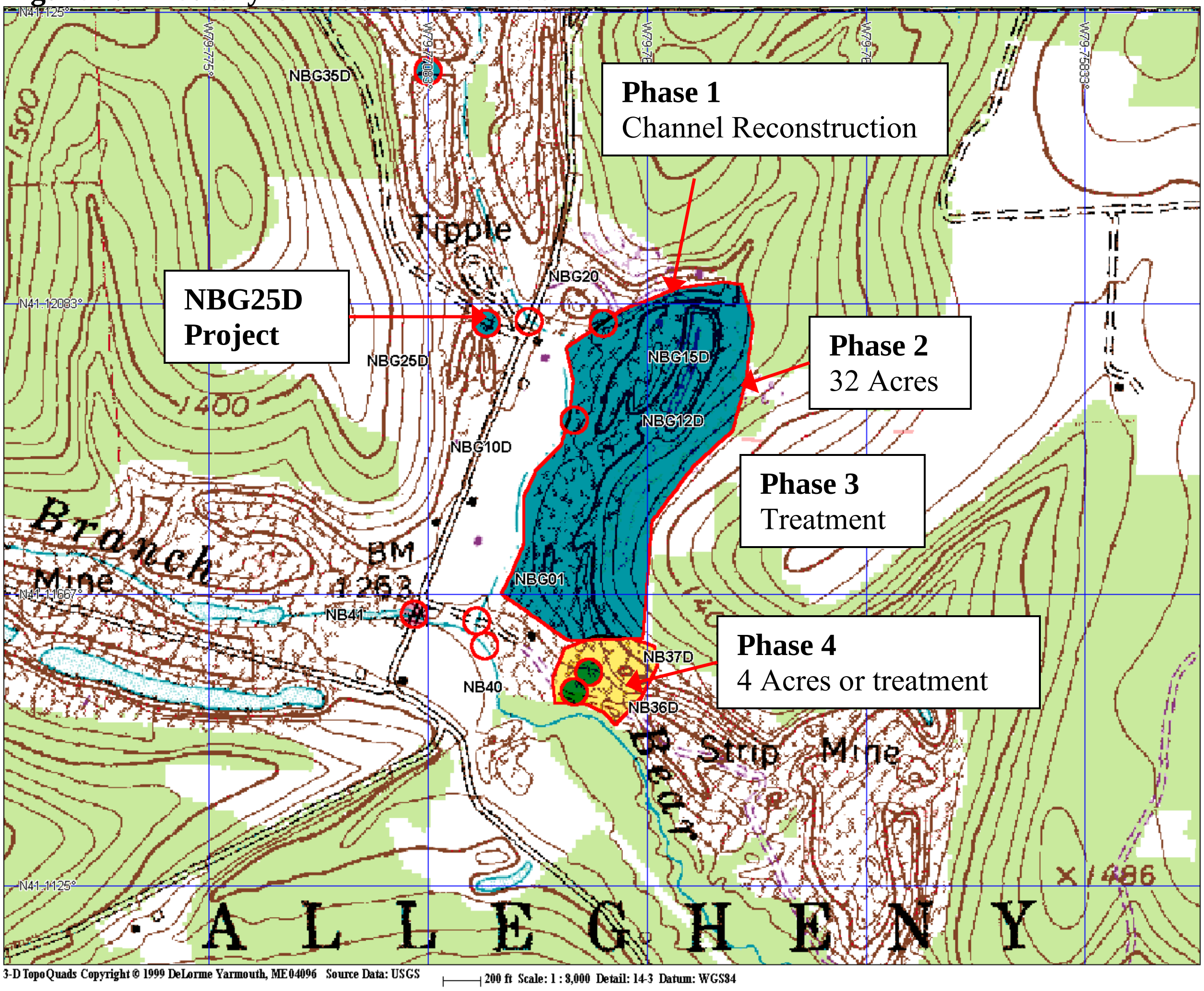
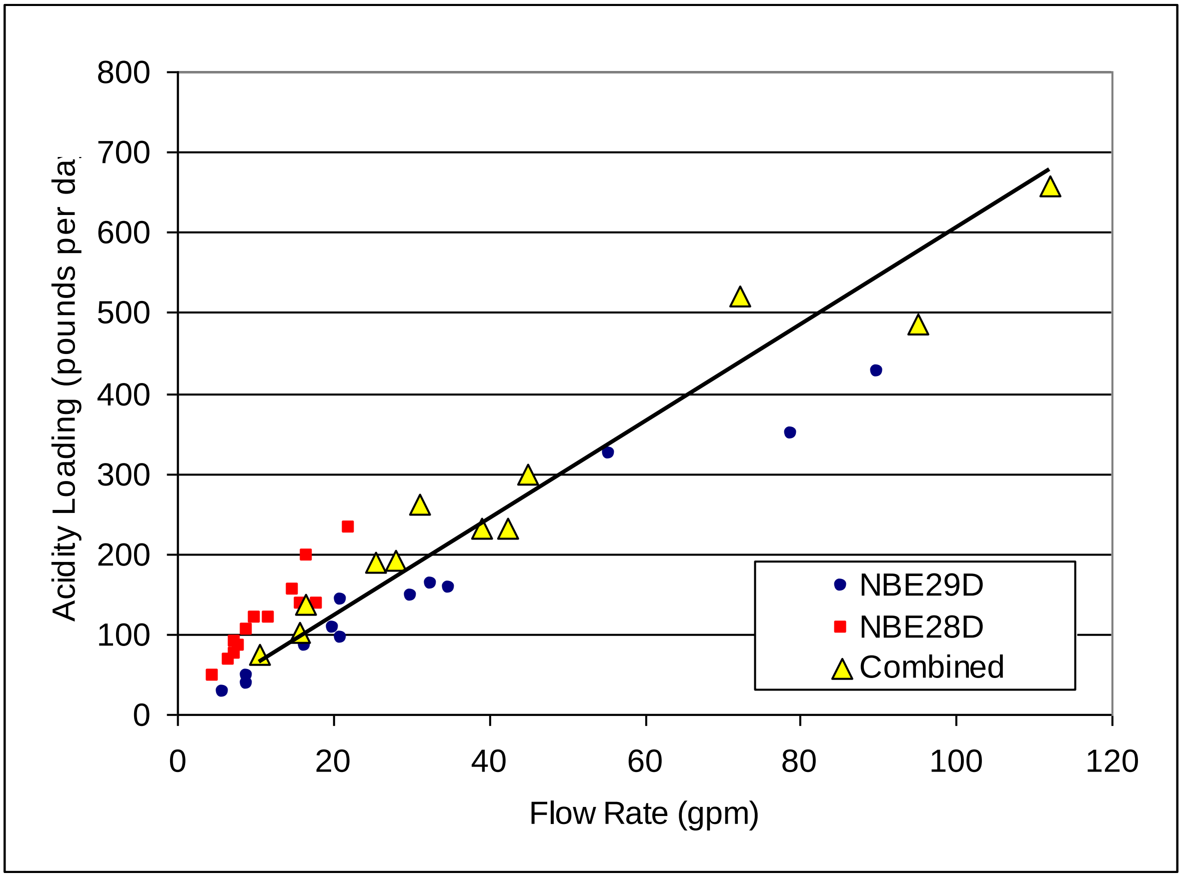


Figure 8: NBE28D, NBE29D and Combined Acid Loading Versus Flow Rate



Bear Creek Assessment - Final Data Set

BC30

Bear Creek at Butler County Line Downstream of North Branch of Bear Creek

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		6.8	233	-10	0.6	0.4	0.5	63	10			
6/19/2002		6.5	318	-18	0.6	0.6	0.6	114	8			
10/8/2002		6.3	690	-41	0.2	1.4	0.6	179	2			
1/13/2003		7.0	400	-11	0.9	0.8	0.5	111	4			
3/18/2003		7.0	203	-4	0.6	0.4	1.0	53	4			
Average		**6.7**	**369**	**-17**	**0.6**	**0.7**	**0.7**	**104**	**6**			

BC40

Bear Creek at Bruin Bridge (Upstream of North Branch Confluence)

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		6.8	236	-26	0.4	0.2	0.2	56	3			
6/19/2002		6.9	327	-39	0.5	0.1	0.0	100	6			
10/8/2002		6.5	870	-68	0.8	0.1	0.1	144	2			
1/13/2003		6.2	424	-23	0.6	0.3	0.2	82	2			
3/18/2003		6.9	207	-11	0.5	0.2	0.3	47	4			
Average		**6.7**	**413**	**-33**	**0.6**	**0.2**	**0.2**	**86**	**3**			

NB05

North Branch at Route 268 Bridge

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		5.1	224	11	1.1	1.0	1.5	103	3			
6/19/2002	13350	5.3	296	11	0.9	1.5	1.7	142	7	1749.4	149.0	267.5
10/8/2002		4.9	539	17	0.2	3.7	1.9	252	1			
1/13/2003		5.8	321	12	1.9	1.5	1.7	146	5			
3/18/2003		6.0	185	6	0.9	0.8	0.9	63	2			
Average	**13350**	**5.4**	**313**	**11**	**1.0**	**1.7**	**1.5**	**141**	**4**	**1749.4**	**149.0**	**267.5**

NB10

North Branch at Eldorado Road

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		4.7	248	16	1.5	1.2	1.8	105	1			
6/18/2002		5.5	276	23	1.4	1.8	2.1	140	2			
7/10/2002		4.0	526	39	0.8	4.1	3.6	229	1			
8/7/2002		3.8	491	37	0.6	3.6	2.4	250	1			
9/4/2002		3.1	626	42	0.7	4.5	2.8	305	3			
10/8/2002		4.2	550	34	1.0	4.3	2.3	291	1			
11/8/2002		4.8	430	22	0.9	2.9	1.8	209	5			
12/16/2002		4.4	236	15	1.2	1.1	1.0	105	9			
1/13/2003		4.4	401	33	3.0	2.0	2.6	259	2			
2/6/2003		5.0	321	22	2.6	1.9	1.8	153	1			
3/18/2003		5.3	190	11	1.1	1.0	1.2	64	4			
4/15/2003		4.3	321	19	1.7	2.2	2.5	161	5			
Average		**4.4**	**385**	**26**	**1.4**	**2.5**	**2.2**	**189**	**3**			

NB12D

Just east of NB13D, discharge from a ravine

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	185	3.9	240	19	0.2	0.3	1.1	83	2	41.2	0.4	2.4
6/18/2002	158	4.9	278	23	0.1	0.4	1.0	122	2	43.4	0.1	1.9
7/10/2002	24	4.2	635	32	0.1	1.2	3.4	310	1	9.2	0.0	1.0
8/7/2002	24	3.9	487	23	0.1	1.1	1.8	252	1	6.6	0.0	0.5
9/4/2002	8	3.4	654	30	0.1	1.4	2.6	333	3	2.7	0.0	0.2
10/8/2002	0	3.6	1253	161	21.2	3.3	8.1	942	1	0.5	0.1	0.0
11/8/2002	21	4.7	311	13	0.1	0.4	1.0	122	5	3.3	0.0	0.2
12/17/2002	107	3.7	174	11	0.0	0.2	0.4	63	3	14.3	0.1	0.5
2/6/2003	60	4.3	404	18	0.0	0.3	0.8	166	2	12.8	0.0	0.6
3/18/2003	210	4.5	180	8	0.1	0.2	0.5	83	1	20.4	0.1	1.3
4/15/2003	92	3.8	313	16	0.1	0.4	1.1	131	4	17.8	0.1	1.2
Average	**81**	**4.1**	**448**	**32**	**2.0**	**0.9**	**2.0**	**237**	**2**	**15.7**	**0.1**	**0.9**

NB13D Discharge from rock face along 4-wheeler trail.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	11	3.1	1197	186	31.6	2.5	7.1	507	14	23.5	4.0	0.9
6/18/2002	11	4.1	1234	240	60.3	2.7	10.5	598	7	30.3	7.6	1.3
7/10/2002	10	3.4	1370	216	44.0	3.1	10.9	613	5	25.9	5.3	1.3
8/7/2002	9	3.0	1270	214	30.0	2.8	8.3	810	5	23.1	3.2	0.9
9/4/2002	9	2.2	1302	209	36.9	3.0	10.1	571	6	22.6	4.0	1.1
10/8/2002	7	3.7	1230	201	39.5	2.8	9.6	1028	13	16.9	3.3	0.8
11/8/2002	5	3.9	1194	165	22.9	2.6	8.1	675	20	9.9	1.4	0.5
12/17/2002	18	2.2	1010	127	16.5	2.1	6.6	519	7	27.5	3.6	1.4
2/6/2003	1	3.3	1130	165	26.1	2.3	7.1	765	18	2.0	0.3	0.1
3/18/2003	4	3.2	1005	33	18.0	2.1	5.9	563	9	1.4	0.8	0.2
4/15/2003	6	2.9	1050	127	13.6	2.3	6.0	447	3	9.1	1.0	0.4
Average	**8**	**3.2**	**1181**	**171**	**30.8**	**2.6**	**8.2**	**645**	**10**	**17.5**	**3.1**	**0.8**

NB15D Swamp area at toe of spoil near El Dorado Road. Many Discharge points directly to stream

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	20	3.7	416	41	0.8	0.8	2.8	151	3	10.0	0.2	0.7
6/18/2002	8	4.5	410	49	1.6	0.8	2.0	197	5	4.4	0.1	0.2
7/10/2002	2	3.5	971	110	19.2	2.2	3.9	403	10	2.6	0.5	0.1
8/7/2002	15	3.4	830	87	17.9	1.9	2.4	428	14	15.7	3.2	0.4
9/4/2002	1	3.1	1178	124	26.5	3.1	5.8	590	15	1.7	0.4	0.1
10/8/2002	3	4.4	595	28	0.1	1.4	2.3	288	1	1.0	0.0	0.1
11/8/2002	1	4.1	1064	123	17.0	2.6	6.7	569	6	0.7	0.1	0.0
12/17/2002	7	3.0	451	36	2.4	0.9	2.4	217	3	3.0	0.2	0.2
2/6/2003	0									0.0	0.0	0.0
3/18/2003	24	4.0	392	34	1.4	0.9	3.1	152	1	9.8	0.4	0.9
4/15/2003	5	3.1	454	34	2.3	1.0	2.4	188	2	2.0	0.1	0.1
Average	**8**	**3.7**	**676**	**67**	**8.9**	**1.5**	**3.4**	**318**	**6**	**4.6**	**0.5**	**0.3**

NB18D Beaver pond area fed by runoff. Take sample at the outflow of the pond.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	73	5.6	45	4	0.3	0.1	0.4	18	3	3.8	0.3	0.3
6/18/2002	33	6.3	58	6	0.3	0.2	0.4	15	4	2.4	0.1	0.2
7/9/2002	0									0.0	0.0	0.0
8/7/2002	0	5.7	45	6	1.0	0.2	0.5	4	31	0.0	0.0	0.0
9/4/2002	0									0.0	0.0	0.0
10/8/2002	0									0.0	0.0	0.0
11/8/2002	0									0.0	0.0	0.0
12/16/2002	41	4.2	45	5	0.1	0.1	0.3	16	9	2.5	0.1	0.1
2/5/2003	5	5.0	56	5	0.2	0.2	0.9	14	21	0.3	0.0	0.1
3/19/2003	43	5.2	46	2	0.2	0.1	0.6	12	5	1.1	0.1	0.3
4/15/2003	40	5.3	49	2	0.1	0.1	0.2	17	4	1.0	0.1	0.1
Average	**21**	**5.3**	**49**	**4**	**0.3**	**0.2**	**0.5**	**14**	**11**	**1.0**	**0.1**	**0.1**

NB20 North Branch at Stone Bridge

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		4.6	236	22	2.0	1.3	2.1	106	3			
6/18/2002	9766	5.3	294	25	1.7	2.0	2.3	140	6	2945.0	200.4	270.7
10/9/2002		4.4	531	31	1.3	4.3	2.1	235	1			
1/14/2003		4.5	371	36	4.5	2.5	2.9	179	2			
3/19/2003		4.9	214	14	1.4	1.3	1.7	111	1			
Average	**9766**	**4.7**	**329**	**26**	**2.2**	**2.3**	**2.2**	**154**	**3**	**2945.0**	**200.4**	**270.7**

NB30 North Branch just downstream of NB31D and NB32D

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		4.6	237	33	4.6	0.8	2.2	103	3			
6/18/2002	4283	5.4	259	27	4.8	1.1	2.0	112	6	1376.4	245.2	100.7
10/9/2002		4.2	671	63	8.4	3.7	3.1	359	1			
1/14/2003		4.1	365	43	8.8	1.7	3.0	166	1			
3/19/2003	8332	4.8	192	18	3.2	0.7	1.4	62	4	1777.7	315.9	143.0
Average	**6308**	**4.6**	**345**	**37**	**5.9**	**1.6**	**2.3**	**161**	**3**	**1577.1**	**280.6**	**121.9**

NB31D Gas well discharge beside North Branch.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	11	5.0	890	117	41.2	5.9	4.8	476	6	14.7	5.2	0.6
6/18/2002	11	6.0	943	114	41.5	6.3	5.5	470	10	14.3	5.2	0.7
7/9/2002	8	5.1	984	130	45.4	7.2	6.6	558	3	12.5	4.4	0.6
8/7/2002	6	4.8	967	144	37.8	7.3	8.1	576	2	10.4	2.7	0.6
9/4/2002	4	3.7	1005	156	48.6	7.7	9.6	567	3	7.5	2.3	0.5
10/9/2002	3	4.4	1000	149	40.9	7.0	8.0	632	2	4.5	1.2	0.2
11/8/2002	3	4.1	1025	119	28.7	6.2	6.5	569	14	4.3	1.0	0.2
12/16/2002	6	3.2	885	126	32.7	5.6	5.3	345	1	9.0	2.4	0.4
1/14/2003	15	4.6	842	103	36.2	5.5	4.8	501	2	18.6	6.5	0.9
2/5/2003	6	4.9	964	152	37.3	5.9	5.2	599	1	10.9	2.7	0.4
3/19/2003	8	4.7	835	87	35.1	5.8	5.0	387	6	8.7	3.5	0.5
4/15/2003	8	3.5	881	96	31.9	6.3	5.4	542	6	8.6	2.9	0.5
Average	**7**	**4.5**	**935**	**124**	**38.1**	**6.4**	**6.2**	**518**	**5**	**10.3**	**3.3**	**0.5**

NB32D Similar discharge as NB31D on opposite side of stream

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	3	3.7	975	124	36.0	6.2	3.9	440	3	3.9	1.1	0.1
6/18/2002	3	4.7	998	177	37.7	6.6	4.5	501	3	5.3	1.1	0.1
7/9/2002	2	3.9	1074	134	10.6	4.1	0.5	583	4	3.2	0.3	0.0
8/7/2002	3	3.8	1060	141	36.0	7.2	4.9	621	1	4.2	1.1	0.1
9/4/2002	2	3.1	1066	147	43.7	7.4	5.8	639	5	3.5	1.0	0.1
10/9/2002	3	4.3	990	145	41.5	6.7	5.6	600	3	5.2	1.5	0.2
11/8/2002	3	4.3	970	117	38.3	6.1	4.4	612	5	3.5	1.1	0.1
12/16/2002	4	2.8	925	124	32.9	5.8	4.0	485	4	6.0	1.6	0.2
1/14/2003	2	3.5	914	118	38.5	5.9	3.9	507	3	2.1	0.7	0.1
2/5/2003	1	3.7	930	126	34.5	5.9	4.1	530	1	1.5	0.4	0.0
3/19/2003	2	3.4	910	97	28.6	6.1	4.2	676	1	1.7	0.5	0.1
4/15/2003	1	3.2	1024	104	26.9	6.6	4.6	568	7	1.3	0.3	0.1
Average	**2**	**3.7**	**986**	**129**	**33.8**	**6.2**	**4.2**	**563**	**3**	**3.5**	**0.9**	**0.1**

NB36D Seep flowing out of old strip cut. Very near stream. Fe deposit into stream channel.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	77	3.2	946	185	13.7	1.9	13.1	367	3	172.0	12.7	12.1
6/18/2002	36	4.2	1017	192	16.9	2.3	16.4	429	11	82.8	7.3	7.1
7/9/2002	7	3.4	1203	269	47.3	3.8	18.3	627	2	22.6	4.0	1.5
8/7/2002	4	3.0	1261	280	46.3	4.1	14.8	663	1	13.8	2.3	0.7
9/3/2002	2	2.3	1317	295	64.0	5.0	17.9	658	5	7.1	1.5	0.4
10/9/2002	1	4.0	1225	269	68.1	5.0	15.2	673	3	2.4	0.6	0.1
11/8/2002	1	4.0	1190	229	51.8	5.1	14.7	787	7	2.7	0.6	0.2
12/16/2002	8	2.3	1277	238	29.7	4.8	21.8	669	2	22.9	2.9	2.1
1/14/2003	12	3.0	1266	224	24.4	3.1	17.0	479	1	32.2	3.5	2.4
2/5/2003	7	3.3	1356	314	43.2	4.1	22.3	769	6	26.4	3.6	1.9
3/19/2003	100	3.5	840	95	6.3	1.6	10.6	438	3	113.9	7.5	12.7
4/15/2003	13	3.0	951	174	22.1	2.7	14.9	493	5	27.1	3.5	2.3
Average	**22**	**3.3**	**1154**	**230**	**36.2**	**3.6**	**16.4**	**588**	**4**	**43.8**	**4.2**	**3.6**

NB37D Discharge from mine spoil just above the stream channel.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	64	2.7	1715	547	80.5	4.0	35.3	621	4	422.0	62.1	27.2
6/18/2002	50	3.1	1469	441	50.4	4.2	35.8	554	1	263.4	30.1	21.4
7/9/2002	39	3.1	1563	487	61.4	3.9	33.5	772	1	227.8	28.7	15.7
8/7/2002	21	2.6	1702	542	73.3	3.2	28.0	733	1	136.6	18.5	7.1
9/3/2002	8	1.8	2262	1144	224.3	4.2	70.2	1272	5	102.9	20.2	6.3
10/9/2002	2	3.6	2241	1209	223.7	4.7	84.8	1346	1	29.0	5.4	2.0
11/8/2002	3	3.6	2153	966	179.9	4.5	74.3	1341	4	29.0	5.4	2.2
12/16/2002	12	1.5	1916	629	95.4	3.8	43.2	726	4	90.6	13.7	6.2
1/14/2003	30	2.4	1758	482	63.7	3.9	34.0	659	2	173.6	22.9	12.2
2/5/2003	21	2.9	1644	547	58.3	3.8	35.4	730	13	137.7	14.7	8.9
3/19/2003	35	2.7	1500	379	43.8	3.8	34.3	962	1	159.2	18.4	14.4
4/15/2003	35	2.5	1463	351	36.7	4.0	31.4	651	2	147.5	15.4	13.2
Average	**27**	**2.7**	**1782**	**644**	**99.3**	**4.0**	**45.0**	**864**	**3**	**159.9**	**21.3**	**11.4**

NB40 North Branch just downstream of Tributary G Mouth

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		5.4	166	16	3.2	0.5	1.2	69	5			
6/18/2002	3109	6.4	200	10	4.0	0.7	1.2	72	5	384.3	150.7	45.5
10/9/2002		5.8	501	2	5.1	2.3	1.8	194	4			
1/14/2003		5.2	282	27	7.6	1.1	1.9	105	4			
3/19/2003		5.4	156	11	3.0	0.5	1.0	50	1			
Average	**3109**	**5.7**	**261**	**13**	**4.6**	**1.0**	**1.4**	**98**	**4**	**384.3**	**150.7**	**45.5**

NB41 North Branch just upstream of Tributary G Mouth

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		6.1	164	-8	0.9	0.3	0.5	21	6			
6/19/2002	986	6.8	219	-9	1.5	0.5	0.4	82	6	-106.4	17.5	4.4
7/9/2002		6.0	458	-9	3.5	1.9	1.3	202	4			
8/7/2002		5.9	475	-5	4.0	2.0	1.2	287	3			
9/3/2002		5.3	509	2	4.5	2.5	1.7	262	5			
10/9/2002		5.2	547	49	13.8	3.0	2.1	300	3			
11/8/2002		5.7	323	-7	3.1	0.9	0.4	95	9			
12/16/2002		5.4	206	-1	0.6	0.2	0.3	45	9			
1/14/2003		6.0	355	-13	1.6	0.5	0.5	78	3			
2/5/2003		5.9	301	-5	1.1	0.4	0.3	60	2			
3/19/2003		5.8	128	0	0.5	0.2	0.4	30	7			
4/15/2003		5.7	233	-87	2.1	0.6	0.8	95	4			
Average	**986**	**5.8**	**327**	**-8**	**3.1**	**1.1**	**0.8**	**130**	**5**	**-106.4**	**17.5**	**4.4**

NBB05 Near Mouth of Tributary B at Eldorado Road

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		6.9	246	-8	0.2	0.2	0.2	80	2			
Average		**6.9**	**246**	**-8**	**0.2**	**0.2**	**0.2**	**80**	**2**			

NBC01 Mouth of Tributary C

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		6.3	91	-11	0.2	0.0	0.1	17	4			
Average		**6.3**	**91**	**-11**	**0.2**	**0.0**	**0.1**	**17**	**4**			

NBD10D Pond created by spoil piles - fed by a spring. Sampled at pond outlet.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		4.8	303	24	0.4	0.9	2.9	147	1			
6/18/2002	110	5.4	367	33	0.6	1.1	4.3	200	7	44.0	0.8	5.7
7/9/2002	28	4.2	478	37	1.5	1.7	3.7	229	4	12.5	0.5	1.2
8/7/2002	35	4.1	370	22	1.8	1.3	1.6	101	2	9.4	0.8	0.7
9/4/2002	18	3.2	502	37	5.2	2.5	1.3	242	1	7.9	1.1	0.3
10/9/2002	20	4.4	500	28	2.5	2.8	1.8	265	2	6.8	0.6	0.4
11/8/2002	30	4.5	682	43	5.5	3.9	3.8	371	5	15.3	2.0	1.4
12/16/2002	95	4.2	133	6	0.7	0.4	0.6	60	13	7.0	0.8	0.6
2/5/2003	40	5.2	268	18	1.6	0.9	1.4	156	3	8.8	0.8	0.7
3/19/2003	160	5.4	229	13	0.5	0.6	2.0	94	1	24.4	0.9	3.9
4/15/2003	75	4.4	375	29	0.6	1.2	4.2	214	2	25.8	0.5	3.8
Average	**61**	**4.5**	**382**	**26**	**1.9**	**1.6**	**2.5**	**189**	**4**	**16.2**	**0.9**	**1.9**

NBD40D Large Fe contaminated flow discharging into a limestone lined channel that by-passes a treatment pond, and flows directly the stream. Sample at discharge and take flow at woodline.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	60	7.0	248	-37	8.1	1.6	0.0	92	6	-26.6	5.8	0.0
6/18/2002	40	7.2	269	-30	6.1	1.7	0.1	54	6	-14.4	2.9	0.0
7/9/2002	11	6.4	246	-11	18.5	3.3	0.0	48	4	-1.5	2.4	0.0
8/7/2002	7	6.1	267	-24	15.0	2.9	0.0	58	2	-1.9	1.2	0.0
9/4/2002	5	5.7	257	-21	19.6	3.3	0.0	47	4	-1.3	1.2	0.0
10/8/2002	2	5.9	260	-12	19.3	3.1	0.0	64	6	-0.3	0.5	0.0
11/8/2002	5	6.0	294	-3	18.5	3.3	0.0	72	8	-0.2	1.1	0.0
12/16/2002	45	5.7	272	-21	8.2	1.3	0.2	42	12	-11.5	4.4	0.1
1/13/2003	12	5.6	314	-1	10.2	2.0	0.1	59	1	-0.1	1.5	0.0
2/5/2003	12	5.8	293	12	13.9	2.2	0.1	64	2	1.8	2.0	0.0
3/18/2003	54	6.1	202	-18	6.3	1.2	0.2	24	3	-11.5	4.1	0.1
4/15/2003	24	6.2	271	-19	16.3	2.7	0.0	57	3	-5.6	4.7	0.0
Average	**23**	**6.1**	**266**	**-15**	**13.3**	**2.4**	**0.1**	**57**	**5**	**-6.1**	**2.7**	**0.0**

NBD50D Small discharge below house and barn above pond--in swamp area.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	2	6.4	117	-22	12.0	0.9	0.0	13	9	-0.5	0.3	0.0
6/18/2002	2	7.0	120	-30	10.6	0.9	0.0	14	9	-0.5	0.2	0.0
10/8/2002	0	5.9	105	-21	40.3	1.2	0.1	12	7	-0.1	0.1	0.0
1/13/2003	0									0.0	0.0	0.0
3/18/2003	0									0.0	0.0	0.0
Average	**1**	**6.4**	**114**	**-24**	**21.0**	**1.0**	**0.1**	**13**	**8**	**-0.2**	**0.1**	**0.0**

NBD51D

Larger discharge below house and barn above pond - discharge from concrete structure

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	56	5.6	110	4	1.5	0.1	0.2	18	5	2.7	1.0	0.2
6/18/2002	47	6.2	150	-3	1.3	0.1	0.1	16	2	-1.7	0.7	0.0
10/8/2002	8	5.2	113	9	8.4	0.6	0.1	37	2	0.8	0.8	0.0
1/13/2003	35	5.4	128	7	1.7	0.1	0.1	14	1	3.1	0.7	0.0
3/18/2003	40	5.5	120	4	1.4	0.1	0.1	12	1	2.2	0.7	0.1
Average	**37**	**5.6**	**124**	**4**	**2.9**	**0.2**	**0.1**	**19**	**2**	**1.4**	**0.8**	**0.1**

NBE01

Mouth of Tributary E

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		4.4	313	28	0.5	2.7	2.8	145	4			
6/18/2002	2705	5.1	396	46	0.6	4.2	3.8	197	6	1504.5	20.4	122.7
10/9/2002		4.9	463	25	1.5	5.6	1.6	213	5			
1/14/2003		4.3	411	31	0.5	3.6	3.5	201	1			
3/19/2003		5.0	270	19	0.5	2.3	2.5	149	2			
Average	**2705**	**4.7**	**371**	**30**	**0.7**	**3.7**	**2.8**	**181**	**4**	**1504.5**	**20.4**	**122.7**

NBE03D

Discharge feeding strip cut that is now occupied by beavers. Seep zone is at far end of pond.Sample for chemistry at the far end and measure the flow at the outfall structure

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	33	5.6	195	-7	0.3	0.2	0.1	83	1	-2.8	0.1	0.0
6/18/2002	45	6.8	193	-7	2.1	1.1	0.1	78	6	-3.8	1.2	0.0
10/9/2002	3	5.8	279	-8	8.2	2.0	0.0	125	2	-0.3	0.3	0.0
1/14/2003	12	6.0	258	-9	2.4	1.9	0.2	80	2	-1.2	0.3	0.0
3/19/2003	45	5.8	176	-1	1.5	1.5	0.3	56	30	-0.5	0.8	0.2
Average	**28**	**6.0**	**220**	**-6**	**2.9**	**1.3**	**0.1**	**84**	**8**	**-1.7**	**0.5**	**0.1**

NBE10 Mouth of small tributary to Tributary E at Road

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		6.2	203	-3	0.2	0.2	0.2	75	1			
10/9/2002		6.1	250	6	0.0	0.1	0.0	114	1			
Average		**6.1**	**227**	**2**	**0.1**	**0.1**	**0.1**	**94**	**1**			

NBE20 Pond Outfall at mouth of tributary to Tributary E.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		3.8	541	87	1.1	7.4	8.7	231	2			
6/19/2002		3.9	771	171	1.9	11.9	14.5	353	1			
7/10/2002		3.7	957	145	3.1	17.7	15.6	486	1			
8/8/2002		3.3	974	151	3.3	14.7	12.0	444	1			
9/4/2002		2.6	1136	182	3.5	22.0	15.9	619	1			
10/8/2002		3.7	1062	166	3.4	20.3	13.7	762	1			
11/8/2002		4.3	903	107	2.7	15.9	12.2	558	6			
12/16/2002		3.0	488	53	1.3	6.6	6.4	235	7			
2/6/2003		3.8	676	100	2.0	10.5	11.0	389	3			
3/18/2003		4.0	334	36	0.8	4.0	5.1	187	3			
4/15/2003		3.8	604	80	1.1	9.8	9.9	347	2			
Average		**3.6**	**768**	**116**	**2.2**	**12.8**	**11.4**	**419**	**3**			

NBE28D Just east of NBE29D, multiple small seep zones combine near tall grass.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	22	3.0	2817	882	27.9	77.5	101.7	1706	1	232.8	7.4	26.9
6/19/2002	17	4.1	2865	987	31.9	80.8	104.2	1368	4	197.7	6.4	20.9
7/10/2002	8	3.3	3165	886	37.7	90.0	113.2	2029	1	85.1	3.6	10.9
8/8/2002	9	3.0	3120	963	47.5	77.8	96.0	2026	4	104.0	5.1	10.4
9/4/2002	8	2.1	2981	997	56.4	83.0	112.5	2299	6	89.7	5.1	10.1
10/8/2002	5	3.3	2793	866	53.6	67.8	103.7	2274	5	46.8	2.9	5.6
11/8/2002	7	3.9	2502	820	58.9	60.7	92.5	1986	17	66.4	4.8	7.5
12/16/2002	18	2.0	2246	635	40.4	56.2	83.2	1409	6	137.2	8.7	18.0
1/14/2003	15	2.8	2818	856	44.0	76.3	118.1	2023	6	154.1	7.9	21.3
2/6/2003	10	3.5	2820	987	47.2	78.0	117.4	2320	6	118.5	5.7	14.1
3/18/2003	16	2.9	2590	715	16.8	67.3	103.9	2491	4	137.4	3.2	20.0
4/15/2003	8	2.6	2927	829	18.6	79.8	99.4	2508	4	74.6	1.7	8.9
Average	**12**	**3.0**	**2804**	**869**	**40.1**	**74.6**	**103.8**	**2037**	**5**	**120.4**	**5.2**	**14.5**

NBE29D Dean Road off 38, Large dark orange seep, multiple sources to stream. Chem at discharge, flow nearer to stream.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	90	3.3	1390	394	10.4	27.7	46.2	734	3	426.0	11.2	49.9
6/19/2002	55	4.3	1493	487	10.7	30.1	57.0	713	4	323.9	7.1	37.9
7/10/2002	20	3.6	1600	446	20.9	32.7	55.4	807	3	107.0	5.0	13.3
8/8/2002	17	3.1	1554	428	21.5	32.0	43.5	971	1	84.8	4.3	8.6
9/4/2002	9	2.4	1512	445	28.7	29.6	47.2	983	1	48.0	3.1	5.1
10/8/2002	6	3.4	1444	393	26.6	25.7	40.9	999	2	28.3	1.9	2.9
11/8/2002	9	3.9	1383	336	35.2	24.8	39.0	814	4	36.3	3.8	4.2
12/16/2002	21	2.2	1430	374	44.3	26.9	43.4	919	12	94.3	11.2	10.9
1/14/2003	30	3.2	1422	405	29.1	27.7	49.5	771	2	145.8	10.5	17.8
2/6/2003	21	3.6	1733	567	31.3	28.8	50.3	1113	13	142.9	7.9	12.7
3/18/2003	79	3.3	1353	368	12.3	26.2	54.3	1085	4	348.9	11.6	51.5
4/15/2003	35	3.1	1393	375	11.8	28.9	50.6	870	2	157.3	4.9	21.2
Average	**33**	**3.3**	**1476**	**418**	**23.6**	**28.4**	**48.1**	**898**	**4**	**162.0**	**6.9**	**19.7**

NBE30 Headwaters of tributary above discharges NBD28D and NBE29D.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	125	5.8	174	1	0.4	0.1	0.3	32	4	1.9	0.6	0.4
6/19/2002	82	7.0	194	1	0.2	0.1	0.0	28	3	1.4	0.2	0.0
10/8/2002	0									0.0	0.0	0.0
1/14/2003	40	5.7	232	1	0.2	0.1	0.1	14	2	0.6	0.1	0.0
3/18/2003	198	5.9	131	-2	0.2	0.1	0.2	18	18	-4.3	0.4	0.5
Average	**89**	**6.1**	**183**	**1**	**0.2**	**0.1**	**0.2**	**23**	**7**	**-0.1**	**0.2**	**0.2**

NBE35 Small spring feeding beaver pond from south.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	15	6.6	120	1	0.2	0.1	0.1	39	3	0.3	0.0	0.0
Average	**15**	**6.6**	**120**	**1**	**0.2**	**0.1**	**0.1**	**39**	**3**	**0.3**	**0.0**	**0.0**

NBE40 Alpha Environmental Trib mouth

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		6.7	178	2	0.2	0.3	0.3	63	6			
6/19/2002	372	6.3	247	-7	0.3	0.2	0.1	115	2	-31.2	1.1	0.5
10/8/2002		6.1	466	2	0.0	0.2	0.1	181	2			
3/18/2003		5.9	148	3	0.4	0.4	0.3	51	7			
Average	**372**	**6.2**	**260**	**0**	**0.2**	**0.3**	**0.2**	**102**	**4**	**-31.2**	**1.1**	**0.5**

NBE50

Tributary E in stream above confluence with Alpha Environmental Trib

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		4.7	301	28	0.2	2.7	3.1	138	5			
6/19/2002	573	5.0	330	25	0.3	2.8	2.6	161	6	168.5	2.2	17.9
7/10/2002		4.9	342	17	0.2	3.5	2.0	152	1			
8/8/2002		4.9	330	16	0.3	2.9	1.5	167	2			
9/4/2002		4.2	364	19	0.3	3.4	1.5	173	8			
10/8/2002		5.5	392	17	0.3	3.7	1.7	170	2			
11/8/2002		5.2	377	13	0.2	3.4	1.9	188	3			
12/16/2002		3.6	290	14	0.1	2.3	1.6	130	8			
2/6/2003		5.1	420	25	0.4	2.7	2.5	213	3			
3/18/2003		4.7	274	18	0.5	2.3	2.4	139	1			
4/15/2003		4.5	306	19	0.3	2.6	2.6	150	4			
Average	**573**	**4.7**	**339**	**19**	**0.3**	**2.9**	**2.1**	**162**	**4**	**168.5**	**2.2**	**17.9**

NBE52D

Spring from hill side slope.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	60	4.3	582	66	0.0	7.4	7.7	293	2	47.2	0.0	5.6
6/19/2002	35	4.4	700	89	0.1	8.8	9.9	365	6	37.5	0.0	4.2
7/10/2002	10	4.3	688	81	0.0	10.5	10.4	361	1	9.8	0.0	1.2
8/8/2002	15	4.0	658	83	0.0	10.0	7.5	376	1	14.9	0.0	1.4
9/4/2002	4	3.5	718	90	0.1	11.4	11.6	382	1	3.8	0.0	0.5
10/8/2002	5	4.2	737	98	0.0	11.4	11.7	507	1	5.3	0.0	0.6
11/8/2002	6	4.6	754	89	0.0	11.4	12.8	415	6	6.4	0.0	0.9
12/16/2002	26	3.2	630	68	0.0	9.5	9.0	364	9	21.4	0.0	2.8
2/6/2003	15	4.2	740	95	0.0	10.9	12.4	448	1	17.1	0.0	2.2
3/18/2003	53	4.2	535	47	0.1	6.9	7.8	366	3	29.9	0.0	4.9
4/15/2003	30	3.9	651	63	0.0	9.6	10.0	414	4	22.8	0.0	3.6
Average	**23**	**4.1**	**672**	**79**	**0.0**	**9.8**	**10.1**	**390**	**3**	**19.6**	**0.0**	**2.5**

NBE72

Discharge from pond on the western Alpha Environmental Trib

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		5.8	260	2	0.4	0.2	0.3	116	5			
6/19/2002		5.7	265	-5	0.5	0.2	0.1	115	8			
10/8/2002		5.8	324	-1	0.6	0.1	0.1	125	6			
Average		**5.8**	**283**	**-1**	**0.5**	**0.1**	**0.2**	**118**	**6**			

NBE75D

Large orange upwelling near the confluence of two tributaries. Very messy

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
7/10/2002	8	5.9	417	13	43.3	7.5	5.4	157	5	1.2	4.2	0.5
8/8/2002	8	5.8	420	15	9.1	4.0	0.6	182	2	1.3	0.8	0.0
9/4/2002	9	5.0	414	12	9.9	4.2	0.3	185	2	1.3	1.1	0.0
10/8/2002	5	5.7	400	14	7.9	4.0	0.4	154	2	0.8	0.5	0.0
11/8/2002	5	5.3	397	14	5.3	3.9	1.0	187	5	0.8	0.3	0.1
12/16/2002	8	4.7	385	21	7.3	4.2	2.9	188	18	2.1	0.7	0.3
1/14/2003	3	5.3	492	32	6.8	4.1	2.7	220	14	1.1	0.2	0.1
2/6/2003	6	5.5	382	18	8.8	4.1	2.1	199	1	1.3	0.6	0.2
3/18/2003	11	5.2	360	21	5.4	4.2	2.9	145	5	2.8	0.7	0.4
4/15/2003	6	5.2	366	14	5.8	4.2	2.2	190	10	1.1	0.4	0.2
Average	**7**	**5.4**	**403**	**17**	**10.9**	**4.4**	**2.0**	**181**	**6**	**1.4**	**1.0**	**0.2**

NBE80

Downstream of NBE81D to assess chemistry change through Beaver ponds

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		5.9	133	3	0.4	0.1	0.2	29	2			
Average		**5.9**	**133**	**3**	**0.4**	**0.1**	**0.2**	**29**	**2**			

NBE81D Upwelling near old powerhouse (Behind autobody). Flows to Beaver ponds

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		5.7	120	7	0.2	0.0	0.2	21	8			
6/19/2002	75	6.2	113	1	0.1	0.0	0.1	21	3	1.3	0.1	0.1
7/10/2002	8	5.6	85	0	0.1	0.0	0.0	16	2	0.0	0.0	0.0
8/8/2002	9	5.7	103	3	0.4	0.2	0.3	20	1	0.4	0.0	0.0
9/4/2002	0									0.0	0.0	0.0
10/8/2002	0									0.0	0.0	0.0
11/8/2002	0									0.0	0.0	0.0
12/16/2002	70	4.9	96	4	0.1	0.1	0.1	21	5	3.2	0.1	0.1
1/14/2003	50	5.3	121	4	0.0	0.0	0.1	18	2	2.6	0.0	0.0
2/6/2003	20	6.0	178	8	0.1	0.0	0.2	29	2	1.8	0.0	0.1
3/18/2003	210	5.2	87	2	0.1	0.1	0.1	16	3	6.1	0.1	0.4
4/15/2003	50	5.2	115	1	0.0	0.0	0.1	22	2	0.5	0.0	0.0
Average	**45**	**5.5**	**113**	**3**	**0.1**	**0.1**	**0.1**	**20**	**3**	**1.4**	**0.0**	**0.1**

NBF35 Tributary F below NBF40D and NBF45D

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		6.2	91	3	3.0	0.4	0.3	13	4			
6/18/2002	399	7.3	120	-5	1.6	0.4	0.2	21	7	-23.9	7.7	0.8
10/8/2002		6.3	128	-15	1.0	0.9	0.1	39	3			
1/13/2003		6.4	122	1	2.5	0.2	0.1	12	1			
3/19/2003		6.1	100	2	2.0	0.3	0.3	21	3			
Average	**399**	**6.5**	**112**	**-3**	**2.0**	**0.4**	**0.2**	**21**	**4**	**-23.9**	**7.7**	**0.8**

NBF40D

Past "Corn Field Corners" towards "Flop House", follow 4-wheeler trail to Beaver pond outflow.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	180	6.4	56	-7	1.0	0.2	0.1	15	4	-15.1	2.2	0.2
6/18/2002	65	6.8	57	-7	0.5	0.1	0.0	24	5	-5.5	0.4	0.0
7/9/2002	12	6.2	105	-21	8.0	1.5	0.0	27	3	-3.0	1.2	0.0
8/7/2002	11	6.2	103	-14	8.2	1.4	0.0	27	2	-1.8	1.0	0.0
9/4/2002	6	5.6	108	-66	11.3	1.3	0.0	25	3	-4.8	0.8	0.0
10/8/2002	8	5.5	109	-16	10.2	1.3	0.1	31	4	-1.6	1.0	0.0
1/13/2003	36	6.0	66	1	1.9	0.2	0.1	16	2	0.3	0.8	0.0
3/19/2003	158	6.0	63	-1	0.8	0.1	0.1	15	1	-1.9	1.6	0.2
Average	**59**	**6.1**	**83**	**-16**	**5.3**	**0.8**	**0.1**	**23**	**3**	**-4.2**	**1.1**	**0.1**

NBF45D

Collection of orange seeps near NBF40D. Some flows to Beaver dam trib, some to stream.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	13	6.3	136	-12	2.5	1.6	0.0	37	3	-1.8	0.4	0.0
6/18/2002	7	6.9	160	-18	3.6	2.1	0.0	59	7	-1.5	0.3	0.0
7/9/2002	24	6.4	168	-28	3.8	3.0	0.0	57	4	-8.1	1.1	0.0
8/7/2002	7	6.3	174	-28	5.8	3.5	0.0	47	3	-2.4	0.5	0.0
9/4/2002	7	5.8	171	-39	7.0	4.2	0.0	50	2	-3.2	0.6	0.0
10/8/2002	5	6.2	173	-24	7.9	4.3	0.0	15	4	-1.5	0.5	0.0
1/13/2003	8	6.2	125	-7	2.2	1.7	0.0	29	2	-0.7	0.2	0.0
3/19/2003	7	6.4	127	-17	1.3	0.9	0.0	33	3	-1.4	0.1	0.0
Average	**10**	**6.3**	**154**	**-22**	**4.3**	**2.7**	**0.0**	**41**	**4**	**-2.6**	**0.5**	**0.0**

NBF55

Tributary F above NBF40D and NBF45D

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		6.3	122	2	0.2	0.1	0.2	9	2			
6/18/2002		7.2	142	1	0.3	0.1	0.2	17	9			
10/8/2002		6.4	86	-9	0.2	0.3	0.1	27	2			
1/13/2003		6.2	148	3	0.1	0.0	0.1	9	1			
3/19/2003		5.1	117	2	0.2	0.1	0.2	9	3			
Average		**6.2**	**123**	**0**	**0.2**	**0.1**	**0.2**	**14**	**3**			

NBF40D Past "Corn Field Corners" towards "Flop House", follow 4-wheeler trail to Beaver pond outflow.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	180	6.4	56	-7	1.0	0.2	0.1	15	4	-15.1	2.2	0.2
6/18/2002	65	6.8	57	-7	0.5	0.1	0.0	24	5	-5.5	0.4	0.0
7/9/2002	12	6.2	105	-21	8.0	1.5	0.0	27	3	-3.0	1.2	0.0
8/7/2002	11	6.2	103	-14	8.2	1.4	0.0	27	2	-1.8	1.0	0.0
9/4/2002	6	5.6	108	-66	11.3	1.3	0.0	25	3	-4.8	0.8	0.0
10/8/2002	8	5.5	109	-16	10.2	1.3	0.1	31	4	-1.6	1.0	0.0
1/13/2003	36	6.0	66	1	1.9	0.2	0.1	16	2	0.3	0.8	0.0
3/19/2003	158	6.0	63	-1	0.8	0.1	0.1	15	1	-1.9	1.6	0.2
Average	**59**	**6.1**	**83**	**-16**	**5.3**	**0.8**	**0.1**	**23**	**3**	**-4.2**	**1.1**	**0.1**

NBF45D Collection of orange seeps near NBF40D. Some flows to Beaver dam trib, some to stream.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002	13	6.3	136	-12	2.5	1.6	0.0	37	3	-1.8	0.4	0.0
6/18/2002	7	6.9	160	-18	3.6	2.1	0.0	59	7	-1.5	0.3	0.0
7/9/2002	24	6.4	168	-28	3.8	3.0	0.0	57	4	-8.1	1.1	0.0
8/7/2002	7	6.3	174	-28	5.8	3.5	0.0	47	3	-2.4	0.5	0.0
9/4/2002	7	5.8	171	-39	7.0	4.2	0.0	50	2	-3.2	0.6	0.0
10/8/2002	5	6.2	173	-24	7.9	4.3	0.0	15	4	-1.5	0.5	0.0
1/13/2003	8	6.2	125	-7	2.2	1.7	0.0	29	2	-0.7	0.2	0.0
3/19/2003	7	6.4	127	-17	1.3	0.9	0.0	33	3	-1.4	0.1	0.0
Average	**10**	**6.3**	**154**	**-22**	**4.3**	**2.7**	**0.0**	**41**	**4**	**-2.6**	**0.5**	**0.0**

NBF55 Tributary F above NBF40D and NBF45D

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/20/2002		6.3	122	2	0.2	0.1	0.2	9	2			
6/18/2002		7.2	142	1	0.3	0.1	0.2	17	9			
10/8/2002		6.4	86	-9	0.2	0.3	0.1	27	2			
1/13/2003		6.2	148	3	0.1	0.0	0.1	9	1			
3/19/2003		5.1	117	2	0.2	0.1	0.2	9	3			
Average		**6.2**	**123**	**0**	**0.2**	**0.1**	**0.2**	**14**	**3**			

NBG01 Mouth of Tributary G

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		4.4	220	38	6.9	0.8	2.8	91	4			
6/19/2002	1290	5.0	253	44	9.3	1.1	3.3	109	10	685.6	144.3	50.6
10/9/2002		4.1	643	115	11.5	3.8	7.6	485	1			
1/14/2003		4.0	538	110	15.7	1.3	5.2	256	10			
3/19/2003		4.6	170	21	5.3	0.6	1.8	54	1			
Average	**1290**	**4.4**	**365**	**66**	**9.8**	**1.5**	**4.1**	**199**	**5**	**685.6**	**144.3**	**50.6**

NBG10D Seepage is located in stream channe along the east bank.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		2.7	5037	4223	1642.0	15.7	209.9	4084	9			
6/19/2002	2	3.7	4935	3927	1385.8	13.1	229.2	3198	11	70.7	24.9	4.1
7/9/2002	1	3.1	4447	3871	1079.3	13.9	210.8	3262	11	46.5	13.0	2.5
8/7/2002	1	2.9	3510	2424	780.0	10.9	108.3	3984	4	29.1	9.4	1.3
9/3/2002	1	2.1	2271	1407	424.2	9.7	75.5	1359	18	12.7	3.8	0.7
10/9/2002	1	3.8	1976	1058	327.4	7.6	56.9	2169	2	6.3	2.0	0.3
11/8/2002	0	3.8	3620	2654	894.6	10.5	124.6	2860	15	8.0	2.7	0.4
12/16/2002	1	2.2	3694	2695	951.6	10.9	132.5	3153	12	32.3	11.4	1.6
1/14/2003	1	2.6	4705	3854	1233.0	14.4	201.2	4395	7	34.7	11.1	1.8
2/5/2003	1	3.1	4200	3233	1087.4	12.1	169.5	4136	12	38.8	13.0	2.0
3/19/2003	1	2.8	4544	3605	1215.6	12.5	208.8	6276	4	47.6	16.0	2.8
4/15/2003	1	2.7	4400	3863	1284.0	12.6	200.2	4949	8	46.4	15.4	2.4
Average	**1**	**3.0**	**3945**	**3068**	**1025.4**	**12.0**	**160.6**	**3652**	**9**	**33.9**	**11.2**	**1.8**

NBG12D

Upwelling from the spoil. Located behind house on spoil above the stream.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	75	5.4	131	7	3.0	0.4	0.9	47	5	6.3	2.7	0.8
6/19/2002	30	6.6	132	-7	3.7	0.5	0.4	46	12	-2.5	1.3	0.1
7/9/2002	3	6.0	220	-29	5.8	1.6	0.8	74	10	-1.0	0.2	0.0
8/7/2002	0									0.0	0.0	0.0
9/4/2002	0									0.0	0.0	0.0
10/9/2002	0									0.0	0.0	0.0
11/8/2002	0									0.0	0.0	0.0
12/16/2002	30	4.2	215	13	4.2	0.6	1.3	101	6	4.8	1.5	0.5
1/14/2003	15	5.7	229	16	6.7	0.9	0.9	84	3	2.8	1.2	0.2
2/5/2003	4	5.6	408	39	15.9	1.8	3.4	202	2	1.9	0.8	0.2
3/19/2003	93	5.5	111	3	1.8	0.2	0.5	32	2	3.2	2.0	0.5
4/15/2003	38	5.7	141	0	2.9	0.4	0.3	61	5	-0.1	1.3	0.2
Average	**24**	**5.6**	**198**	**5**	**5.5**	**0.8**	**1.1**	**81**	**6**	**1.3**	**0.9**	**0.2**

NBG15D

Deep mine discharge out of a pipe; behind house with equipment.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		3.9	232	34	7.6	0.5	3.1	80	3			
6/19/2002	275	4.7	312	66	13.8	0.8	4.1	117	5	217.5	45.4	13.6
7/9/2002	40	3.5	917	259	63.8	3.6	18.1	400	5	124.5	30.6	8.7
8/7/2002	30	3.2	780	216	47.8	3.2	10.8	275	1	77.7	17.2	3.9
9/4/2002	22	2.3	777	185	45.0	3.0	12.3	343	6	48.9	11.9	3.2
10/9/2002	8	3.9	647	181	26.0	2.3	12.8	494	1	17.3	2.5	1.2
11/8/2002	18	4.0	646	146	24.1	2.1	10.4	299	7	31.5	5.2	2.2
12/16/2002	430	3.5	195	14	2.1	0.2	1.1	48	12	72.9	10.8	5.7
1/14/2003	165	3.5	307	51	6.4	0.3	3.4	85	2	101.8	12.8	6.7
2/5/2003	250	4.3	286	49	6.3	0.4	2.0	100	4	147.6	19.0	5.9
3/19/2003	450	3.3	234	51	6.3	0.3	2.5	82	2	272.7	33.9	13.3
4/15/2003	150	3.5	366	89	15.5	0.8	5.0	136	7	161.1	28.0	8.9
Average	**167**	**3.6**	**475**	**112**	**22.1**	**1.5**	**7.1**	**205**	**5**	**115.8**	**19.7**	**6.7**

NBG20 Tributary G at road crossing

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002		5.0	126	11	2.7	0.5	0.8	47	4			
6/19/2002	1004	6.4	149	8	3.7	0.9	0.8	66	6	101.8	44.1	9.3
10/9/2002		5.8	231	1	3.1	2.1	0.4	107	4			
1/13/2003		5.0	193	19	3.8	0.8	0.7	67	3			
3/19/2003	3257	4.8	136	14	2.2	0.5	0.7	45	1	537.0	86.0	27.4
Average	**2131**	**5.4**	**167**	**11**	**3.1**	**0.9**	**0.7**	**67**	**4**	**319.4**	**65.0**	**18.3**

NBG25D Part of deep mine complex above storage tank. Small seep out of diversion ditch. Flows to stream ~ 100 feet above bridge crossing stream.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	1	1.6	12940	10506	3071.0	6.1	283.2	9473	16	94.6	27.6	2.5
6/19/2002	1	2.9	10380	7565	2069.8	4.1	234.5	6340	16	68.1	18.6	2.1
7/9/2002	0									0.0	0.0	0.0
8/7/2002	0									0.0	0.0	0.0
9/4/2002	0									0.0	0.0	0.0
10/9/2002	0									0.0	0.0	0.0
11/8/2002	0	2.8	16850	14542	4116.4	6.9	404.8	17586	32	69.8	19.8	1.9
12/16/2002	1	1.1	7600	4883	1374.9	3.5	154.3	4810	13	65.6	18.5	2.1
1/13/2003	1	1.8	6268	3976	1021.4	2.8	117.5	4245	6	23.9	6.1	0.7
2/5/2003	0	2.0	9860	8537	2391.0	3.9	258.0	11273	24	25.6	7.2	0.8
3/19/2003	0	2.0	8440	5732	1792.4	3.7	194.6	8146	14	21.3	6.7	0.7
4/15/2003	0									0.0	0.0	0.0
Average	**0**	**2.0**	**10334**	**7963**	**2262.4**	**4.4**	**235.2**	**8839**	**17**	**30.7**	**8.7**	**0.9**

NBG35D

Small opening in strip cut. Strip cut comes in off of left side of stream. Beaver have water dammed and source of water is submerged. Cannot determine origination of seepage. Can collect water at foot of dam for flow rates and chemistry.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	95	4.2	225	29	1.4	1.3	1.9	106	5	33.3	1.6	2.2
6/19/2002	15	5.0	392	53	3.9	2.0	2.9	206	10	9.7	0.7	0.5
7/9/2002	6	4.5	540	51	5.2	3.2	4.2	245	5	3.7	0.4	0.3
8/7/2002	2	4.8	463	50	11.9	2.8	3.3	252	4	1.3	0.3	0.1
9/4/2002	1	3.4	595	70	6.7	5.5	7.5	327	3	0.8	0.1	0.1
10/8/2002	1	5.8	637	69	12.0	5.6	6.0	417	35	1.0	0.2	0.1
11/8/2002	6	4.0	645	71	13.3	4.9	5.7	295	9	5.1	1.0	0.4
12/16/2002	6	3.2	340	31	3.7	2.4	2.6	155	6	2.2	0.3	0.2
1/13/2003	12	3.6	306	50	0.9	1.2	1.9	132	3	7.2	0.1	0.3
2/5/2003	4	4.0	368	40	3.2	2.8	3.1	182	1	1.9	0.2	0.2
3/19/2003	96	4.8	96	7	0.5	0.6	0.6	33	6	7.7	0.6	0.7
4/15/2003	9	4.0	431	36	1.4	3.0	4.8	176	4	3.8	0.2	0.5
Average	**21**	**4.3**	**420**	**46**	**5.3**	**2.9**	**3.7**	**210**	**8**	**6.5**	**0.5**	**0.5**

NBG45D

Small Fe contaminated upwelling out from side of spoil on trib to the north of NBG35D. Flow is mostly likely result of beaver damming off strip cut adjacent to NBG45D.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	3	5.6	442	12	14.9	4.9	0.1	157	2	0.4	0.5	0.0
6/19/2002	2	6.6	432	7	14.9	4.5	0.0	215	3	0.1	0.3	0.0
10/9/2002	0									0.0	0.0	0.0
1/13/2003	1	6.0	470	25	16.2	4.9	0.0	132	1	0.2	0.1	0.0
3/18/2003	2	5.8	500	16	18.9	5.5	0.1	198	7	0.4	0.5	0.0
Average	**1**	**6.0**	**461**	**15**	**16.2**	**4.9**	**0.1**	**175**	**3**	**0.2**	**0.3**	**0.0**

NBG50D Small Fe contaminated upwelling flowing out of the base of the highwall above NBG45D.

Date	Flow (GPM)	Field pH	Cond (us)	Net Acidity	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	SO4 (mg/L)	TSS (mg/L)	Loading (ppd) Net Acid	Loading (ppd) Iron	Loading (ppd) Al
5/21/2002	22	6.2	365	-24	3.8	1.5	0.0	127	3	-6.4	1.0	0.0
6/19/2002	10	6.7	350	-20	4.7	1.5	0.0	158	3	-2.4	0.6	0.0
10/9/2002	0									0.0	0.0	0.0
1/13/2003	6	6.3	289	-34	7.2	1.5	0.1	74	3	-2.5	0.5	0.0
3/18/2003	10	6.0	311	-29	2.9	0.7	0.0	87	1	-3.5	0.3	0.0
Average	**10**	**6.3**	**329**	**-27**	**4.7**	**1.3**	**0.0**	**111**	**3**	**-2.9**	**0.5**	**0.0**

Photographs

The small arrow at the beginning of each caption points towards the picture it refers to.

 Photo 1: BC30. This photograph shows Bear Creek below the confluence with the North Branch of Bear Creek.

 Photo 2: BC40. This station shows Bear Creek above the confluence with the North Branch of Bear Creek.

▯ **Photo 3**: NB05. This photograph shows the North Branch of Bear Creek near the mouth.

▯ **Photo 4**: NB12D. The flow rate of the discharge was measured from the pipe as shown.

Photo 5: NB13D. The discharge flows immediately to the stream, which is shown in the far left of the photograph.

Photo 6: NB15D. The discharge originates in the area of cattails and flows to the stream down the trail, shown at the bottom of the photograph.

 Photo 7: NB18D. The flow and chemistry from the discharge was measured at pond outlet in the lower left of the photograph

 Photo 8: NB32D. The discharge flows directly to the stream which is shown in the lower left of the photograph.

 Photo 9: NB36D. The North Branch of Bear Creek is shown at the bottom of the photograph. The discharge flows from this short ravine direction to the stream.

 Photo 10: NB37D. The discharge flows immediately to the stream, which is shown at the bottom of the photograph.

□ **Photo 11**: NBD10D. The former highwall area is shown behind the area of impounded water. The discharge was sampled at the outfall of the impoundment.

□ **Photo 12**: NBD40D. The discharge originiates in this channel.

□ **Photo 13**: NBD40D Pond. The discharge flows around this pond, which could be retrofitted for treatment of the discharge.

? **Photo 14**: NBE20. This in-stream sampling station was located at the outfall of this pond, shown in the lower right of this photograph.

? **Photo 15**: View from NBE20. Additional impoundments impede the stream flow downstream of NBE20.

□ **Photo 16**: NBE28D. Several small seeps accumulate in the ravine, which is where the discharge was sampled for flow and chemistry

□ **Photo 17**: NBE29D. The bright green growth indicates highly acidic water.

Photo 18: NBE52D. The discharge was sampled at its discharge point in a small depression above the stream.

Photo 19: NBE62D. At its discharge point, the flow is bright orange as iron precipitates.

Photo 20: NBE62D Ravine. By the time the NBE62D discharge reaches the stream, all of the iron as precipuated in the ravine.

□ **Photo 21**: NBE75D. The discharge is immediately adjacent to the stream, which is shown in the bottom of the photograph.

□ **Photo 22**: NBE81D. The discharge emerges behind this abandoned building and becomes impounded as shown.

Photo 23: NBG12D. The discharge emerges as an artesian flow from spoil.

Photo 24: NBG15D. The discharge was sampled at the flume in the lower left of the photograph. The culvert is in the background.

□ **Photo 25**: NBG25D. The discharge emerges from reclaimed mine spoil which is shown in the background. The discharge was collected and sampled in this erosion channel.

□ **Photo 26**: NBG35D Impoundment. The mine highwall is shown in the background. The discharge was sampled at the pond discharge shown in the lower right of the photograph.