BLACKS CREEK WATERSHED TMDL
Butler County

Prepared for:

Pennsylvania Department of Environmental Protection

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[1]TMDL
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Introduction

This report presents the Total Maximum Daily Loads (TMDLs) developed for stream segments in the Blacks Creek Watershed (Attachment A). These were done to address the impairments noted on the 1996 Pennsylvania Section 303(d) list of impaired waters, required under the Clean Water Act, and covers one segment on this list (shown in Table 1). High levels of metals caused these impairments. All impairments resulted from acid drainage from abandoned coal mines. The TMDL addresses the three primary metals associated with acid mine drainage (iron, manganese, aluminum), and pH.

Table 1. 303(d) Sub-List
State Water Plan (SWP) Subbasin: 20-C Slippery Rock Creek Watershed

Year	Miles	Segment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	Source	EPA 305(b) Cause Code
1996	4.6	4570	34731	Blacks Creek	CWF	305(b) Report	RE	Metals
1998	No additional assessment data collected for the 1998 303(d) list.			Blacks Creek	CWF			
2000	4.54	4570	34731	Blacks Creek	CWF	SWMP	AMD	Metals
1996	Not Listed on 1996 Section 303(d) List			Unt. Blacks Creek				
1998	Not Listed on 1998 Section 303(d) List			Unt. Blacks Creek				
2000	0.07	4570	34744	Unt. Blacks Creek	CWF	SWMP	AMD	Metals

Resource Extraction = RE
Cold Water Fishes=CWF
Surface Water Monitoring Program = SWMP
Abandoned Mine Drainage = AMD

[1] Pennsylvania's 1996 and 1998 Section 303(d) lists were approved by the Environmental Protection Agency (EPA). The 2000 Section 303(d) list was not required by U. S. Environmental Protection Agency. The 1996 Section 303(d) list provides the basis for measuring progress under the 1996 lawsuit settlement of *American Littoral Society and Public Interest Group of Pennsylvania v. EPA.*

See Attachment E, *Excerpts Justifying Changes Between the 1996, 1998 and Draft 2000 Section 303(d) Lists.*
The use designations for the stream segments in this TMDL can be found in PA Title 25 Chapter 93.

Directions to the Blacks Creek Watershed

Access to Blacks Creek is from Exit #29 (Barkeyville) of Interstate 80 to PA route 8 south. Take PA route 8 south 2.1 miles, turn left (east) onto County Line Road. Go 4 miles to where the road makes a 90 degree left (north) turn, BC6 is located just before the turn. Just west of BC6 is Pohlman Road, to get to BC2 and BC2B, take Pohlman Road to Porter Road, bear right onto Porter Road, go about 0.1 mile, stop just past the old farmhouse. BC2 and BC2B are below the road upstream and downstream of discharges BC19/BC19B, respectively. To get to BC1 take Porter Road about 1 mile, turn left at the intersection onto Rocky Springs Road. Go about ½ mile to a stop sign. Turn left (east) onto Creek Bottom Road, go 1 mile, turn right (south) onto VanDyke Road and park. BC1 is at the stream crossing on Creek Bottom Road. To get to BC8, take VanDyke Road to the stop sign. Turn left (east) onto State Route 58, go 0.15 mile to the bridge crossing over Blacks Creek.

Segments addressed in this TMDL

There are no active mining operations in the northern section of the watershed. There is an active limestone mine in the southern section near the mouth. All of the discharges in the watershed are from abandoned mines on the Lower and Middle Kittanning coal seams and will be treated as non-point sources. The distinction between non-point and point sources in this case is determined on the basis of whether or not there is a responsible party for the discharge. Where there is no responsible party the discharge is considered to be a non-point source. Each segment on the 303(d) list will be addressed as a separate TMDL. These TMDLs will be expressed as long-term, average loadings. Due to the nature and complexity of mining effects on the watershed, expressing the TMDL as a long-term average gives a better representation of the data used for the calculations. See Attachment E for TMDL calculations.

Clean Water Act Requirements

Section 303(d) of the 1972 Clean Water Act requires states, territories, and authorized tribes to establish water quality standards. The water quality standards identify the uses for each waterbody and the scientific criteria needed to support that use. Uses can include designations for drinking water supply, contact recreation (swimming), and aquatic life support. Minimum goals set by the Clean Water Act require that all waters be "fishable" and "swimmable."

Additionally, the federal Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) implementing regulations (40 CFR Part 130) require:

- States to develop lists of impaired waters for which current pollution controls are not stringent enough to meet water quality standards (the list is used to determine which streams need TMDLs);

- States to establish priority rankings for waters on the lists based on severity of pollution and the designated use of the waterbody; states must also identify those waters for which TMDLs will be developed and a schedule for development;

- States to submit the list of waters to USEPA every two years (April 1 of the even numbered years);

- States to develop TMDLs, specifying a pollutant budget that meets state water quality standards and allocate pollutant loads among pollution sources in a watershed, e.g., point and nonpoint sources; and

- USEPA to approve or disapprove state lists and TMDLs within 30 days of final submission.

Despite these requirements, states, territories, authorized tribes, and USEPA have not developed many TMDLs since 1972. Beginning in 1986, organizations in many states filed lawsuits against the USEPA for failing to meet the TMDL requirements contained in the federal Clean Water Act and its implementing regulations. While USEPA has entered into consent agreements with the plaintiffs in several states, many lawsuits still are pending across the country.

In the cases that have been settled to date, the consent agreements require USEPA to backstop TMDL development, track TMDL development, review state monitoring programs, and fund studies on issues of concern (e.g., AMD, implementation of nonpoint source Best Management Practices (BMPs), etc.). These TMDLs were developed in partial fulfillment of the 1996 lawsuit settlement of *American Littoral Society and Public Interest Group of Pennsylvania v. EPA*.

Section 303(d) Listing Process

Prior to developing TMDLs for specific waterbodies, there must be sufficient data available to assess which streams are impaired and should be on the Section 303(d) list. With guidance from the USEPA, the states have developed methods for assessing the waters within their respective jurisdictions.

The primary method adopted by the Pennsylvania Department of Environmental Protection (Pa. DEP) for evaluating waters changed between the publication of the 1996 and 1998 Section 303(d) lists. Prior to 1998, data used to list streams were in a variety of formats, collected under differing protocols. Information also was gathered through the Section 305(b)[2] reporting process. Pa. DEP is now using the Unassessed Waters Protocol (UWP), a modification of the USEPA Rapid Bioassessment Protocol II (RPB-II), as the primary mechanism to assess Pennsylvania’s waters. The UWP provides a more consistent approach to assessing Pennsylvania’s streams.

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[2] Section 305(b) of the Clean Water Act requires a biannual description of the water quality of the waters of the state.

The assessment method requires selecting representative stream segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist selects as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment can vary between sites. All the biological surveys included kick-screen sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Benthic macroinvertebrates are identified to the family level in the field.

After the survey is completed, the biologist determines the status of the stream segment. The decision is based on the performance of the segment using a series of biological metrics. If the stream is determined to be impaired, the source and cause of the impairment is documented. An impaired stream must be listed on the state's Section 303(d) list with the documented source and cause. A TMDL must be developed for the stream segment. A TMDL is for only one pollutant. If a stream segment is impaired by two pollutants, two TMDLs must be developed for that stream segment. In order for the process to be more effective, adjoining stream segments with the same source and cause listing are addressed collectively, and on a watershed basis.

Basic Steps for Determining a TMDL

Although all watersheds must be handled on a case-by-case basis when developing TMDLs, there are basic processes or steps that apply to all cases. They include:

1. Collection and summarization of pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculate TMDL for the waterbody using USEPA approved methods and computer models;
3. Allocate pollutant loads to various sources;
4. Determine critical and seasonal conditions;
5. Submit draft report for public review and comments; and
6. USEPA approval of the TMDL.

Watershed History

The Blacks Creek, Stream Code 34731 in Basin 20-C of the State Waterplan (Attachment B) has a drainage area of 7 sq. miles. Segment ID# 4570 is 5.5 miles in length and flows through the northwestern most area of the main bituminous coal region in Butler County PA. It enters Slippery Rock Creek one mile west of the village of Boyers. It is located on the Barkeyville 7 ½ minute series topographic maps. The impairment associated with elevated metals is the result of acid drainage from abandoned coal mines and the natural condition of ground water associated with an absence or paucity of alkaline producing material in the flow path of the water.

TMDL Endpoints

One of the major components of a TMDL is the establishment of an instream numeric endpoint, which is used to evaluate the attainment of applicable water quality. An instream numeric endpoint, therefore, represents the water quality goal that is to be achieved by implementing the load reductions specified in the TMDL. The endpoint allows for comparison between observed instream conditions and conditions that are expected to restore designated uses. The endpoint is based on either the narrative or numeric criteria available in water quality standards.

Because of the nature of the pollution sources in the watershed, the TMDLs component makeup will be load allocations that are specified above a point in the stream segment. All allocations will be specified as long-term average daily concentrations. These long-term average daily concentrations are expected to meet water quality criteria 99 percent of the time. Pennsylvania Title 25 Chapter 96.3(c) specifies that the water quality standards must be met 99% of the time. The iron TMDLs are expressed at total recoverable as the iron data used for this analysis was reported as total recoverable. The following table shows the water quality criteria for the selected parameters.

Table 2. Applicable Water Quality Criteria

Parameter	***Criterion Value (mg/l)***	***Total Recoverable/Dissolved***
Aluminum (Al)	0.75	Total Recoverable
Iron (Fe)	1.50 0.3	30-day average; Total Recoverable Dissolved
Manganese (Mn)	1.00	Total Recoverable
pH *	6.0-9.0	N/A

*The pH values shown will be used when applicable. In the case of freestone streams with little or no buffering capacity, the TMDL endpoint for pH will be the natural background water quality. These values are typically as low as 5.4 (Pennsylvania Fish and Boat Commission).

TMDL Elements (WLA, LA, MOS)

A TMDL equation consists of a wasteload allocation, load allocation and a margin of safety. The wasteload allocation is the portion of the load assigned to point sources. The load allocation is the portion of the load assigned to nonpoint sources. The margin of safety is applied to account for uncertainties in the computational process. The margin of safety may be expressed implicitly (documenting conservative processes in the computations) or explicitly (setting aside a portion of the allowable load).

Allocation Summary

These TMDLs will focus remediation efforts on the identified numerical reduction targets for each watershed. As changes occur in the watershed, the TMDLs may be re-evaluated to reflect current conditions. Table 5 presents the estimated reductions identified for all points in the watershed. Attachment F gives detailed TMDLs by segment analysis for each allocation point.

Table 3. Summary Table–Blacks Creek Watershed

Station	*Parameter*	*Measured Sample Data*		*Allowable*		*Reduction Identified*
		Conc. (mg/l)	*Load (lb/day)*	*LTA Conc. (mg/l)*	*Load (lb/day)*	*Percent*
BC6						
	Al	1.45	2.4	0.12	0.2	92%
	Fe	0.16	0.3	0.16	0.3	0%
	Mn	2.11	3.5	0.44	0.7	79%
	Acidity	8.83	14.6	3.62	6.0	59%
	Alkalinity	29.20	48.3			
BC2						
	Al	0.47	1.8	0.10	0.4	NA
	Fe	15.56	60.2	0.31	1.2	NA
	Mn	6.87	26.6	0.27	1.1	NA
	Acidity	0.00	0.0	0.00	0.0	NA
	Alkalinity	97.20	376.1			
BC2B						
	Al	1.25	5.2	0.56	2.3	NA
	Fe	8.11	33.6	1.14	4.7	NA
	Mn	6.23	25.8	0.62	2.6	NA
	Acidity	0.00	0.0	0.00	0.0	NA
	Alkalinity	11.49	47.6			
BC1						
	Al	0.5	5.6	0.22	2.5	NA
	Fe	1.73	19.5	0.45	5.1	NA
	Mn	3.18	35.9	0.64	7.2	NA
	Acidity	0.00	0.0	0.00	0.0	NA
	Alkalinity	95.67	1079.2			
BC8						
	Al	0.00	0.0	0.00	0.0	NA
	Fe	0.74	10.2	0.74	10.2	NA
	Mn	1.83	25.1	0.58	8.0	NA
	Acidity	0.00	0.0	0.00	0.0	NA
	Alkalinity	77.2	1062.3			

Recommendations

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

Additional opportunities for water quality improvement are both ongoing and anticipated. Historically, a great deal of research into mine drainage has been conducted by PADEP's Bureau of Abandoned Mine Reclamation, which administers and oversees the Abandoned Mine Reclamation Program in Pennsylvania, the United States Office of Surface Mining, the National Mine Land Reclamation Center, the National Environmental Training Laboratory, and many other agencies and individuals. Funding from EPA's 319 Grant program, and Pennsylvania's Growing Greener program have been used extensively to remedy mine drainage impacts. These many activities are expected to continue and result in water quality improvement.

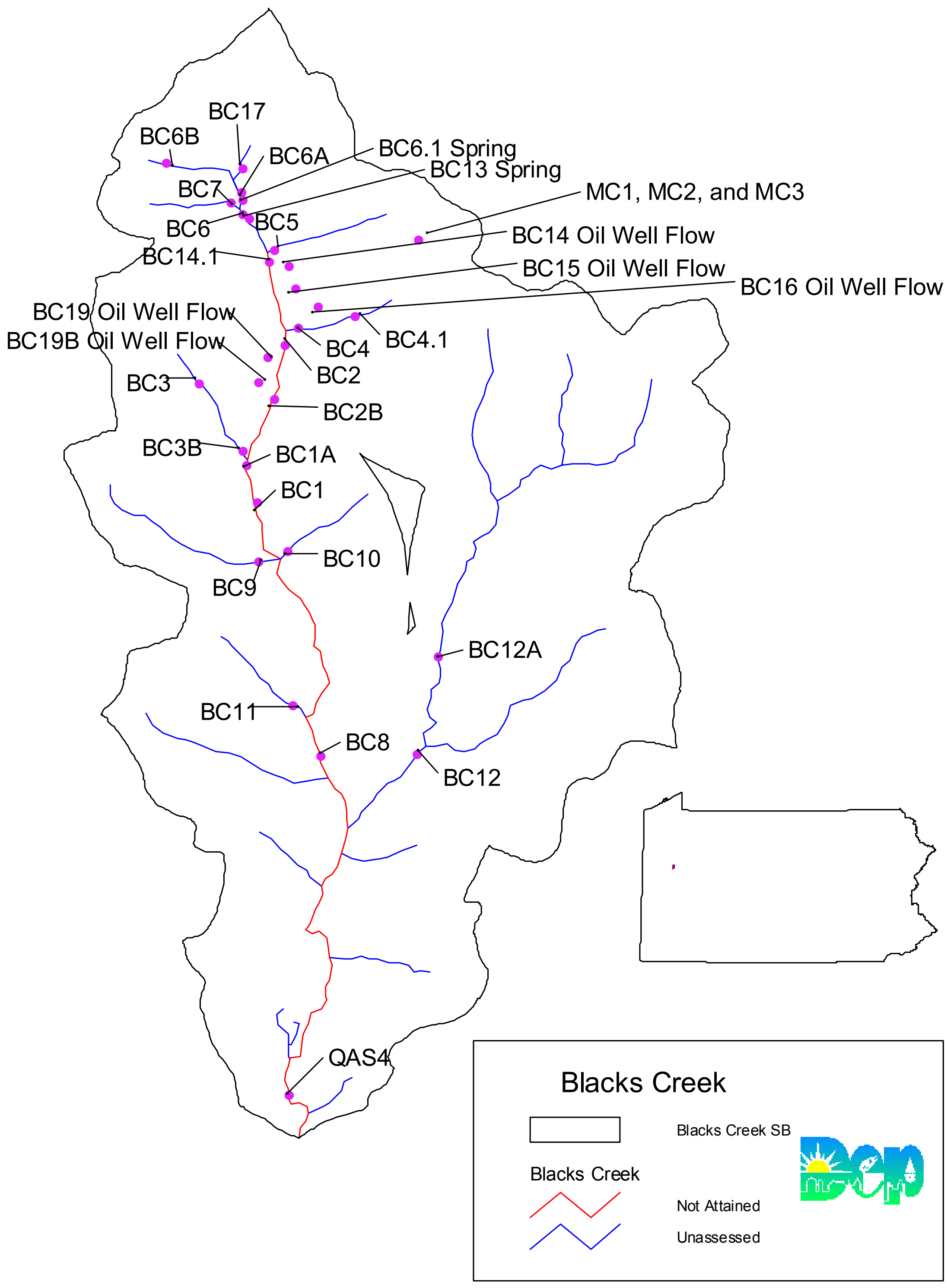
No projects have been approved in Blacks Creek, yet. Grant applications have been submitted in the past and are expected in the future. There is a proposal to do some geophysics at the McIntire site regarding discharges MC1, MC3 and possibly BC16. Bonds were forfeited at this site, so money is available. Abandoned oil well discharges are a significant source of impairment. These discharges exhibit characteristics of acid mine drainage, so there needs to be coordination between agencies regarding mine reclamation, passive treatment and well plugging.

Public Participation

Public notice of the draft TMDL was published in the *Pennsylvania Bulletin* and the on to foster public comment on the allowable loads calculated. A public meeting was held on , at , to discuss the proposed TMDL.

Attachment A

Blacks Creek Watershed Map


BC17
BC6B
BC6A
BC6.1 Spring
BC13 Spring
MC1, MC2, and MC3
BC7
BC6
BC5
BC14 Oil Well Flow
BC14.1
BC15 Oil Well Flow
BC16 Oil Well Flow
BC19 Oil Well Flow
BC19B Oil Well Flow
BC4
BC4.1
BC2
BC3
BC2B
BC3B
BC1A
BC1
BC10
BC9
BC12A
BC11
BC8
BC12
QAS4
Blacks Creek
Blacks Creek SB
Blacks Creek
Not Attained
Unassessed

Attachment B

AMD Methodology and The pH Method

AMD Methodology

Two approaches are used for the TMDL analysis of AMD-affected stream segments. Both of these approaches use the same statistical method for determining the instream allowable loading rate at the point of interest. The difference between the two is based on whether the pollution sources are defined as discharges that are permitted or have a responsible party, which are considered point sources. Nonpoint sources are then any pollution sources that are not point sources.

For situations where all of the impact is due to nonpoint sources, the equations shown below are applied using data for a point in the stream. The load allocation made at that point will be for all of the watershed area that is above that point. For situations where there are only point-source impacts or a combination of point and nonpoint sources, the evaluation will use the point-source data and perform a mass balance with the receiving water to determine the impact of the point source.

TMDLs and load allocations for each pollutant were determined using Monte Carlo simulation. Allocations were applied uniformly for the watershed area specified for each allocation point. For each source and pollutant, it was assumed that the observed data were log-normally distributed. Each pollutant source was evaluated separately using @Risk[3] by performing 5,000 iterations to determine any required percent reduction so that the water quality criteria will be met instream at least 99 percent of the time. For each iteration, the required percent reduction is:

PR = maximum {0, (1-Cc/Cd)} where (1)

PR = required percent reduction for the current iteration
Cc = criterion in mg/l
Cd = randomly generated pollutant source concentration in mg/l based on the observed data

Cd = RiskLognorm(Mean, Standard Deviation) where (1a)

Mean = average observed concentration
Standard Deviation = standard deviation of observed data

The overall percent reduction required is the 99th percentile value of the probability distribution generated by the 5,000 iterations, so that the allowable long-term average (LTA) concentration is:

LTA = Mean * (1 – PR99) where (2)

[3] @Risk – Risk Analysis and Simulation Add-in for Microsoft Excel, Palisade Corporation, Newfield, NY, 1990-1997.

LTA = allowable LTA source concentration in mg/l

Once the required percent reduction for each pollutant source was determined, a second series of Monte Carlo simulations were performed to determine if the cumulative loads from multiple sources allow instream water quality criteria to be met at all points at least 99 percent of the time. The second series of simulations combined the flows and loads from individual sources in a step-wise fashion, so that the level of attainment could be determined immediately downstream of each source. Where available data allowed, pollutant-source flows used were the average flows. Where data were insufficient to determine a source flow frequency distribution, the average flow derived from linear regression was used.

In general, these cumulative impact evaluations indicate that, if the percent reductions determined during the first step of the analysis are achieved, water quality criteria will be achieved at all upstream points, and no further reduction in source loadings is required.

Where a stream segment is listed on the Section 303(d) list for pH impairment, the evaluation is the same as that discussed above; the pH method is fully explained in Attachment C. An example calculation from the Swatara Creek TMDL, including detailed tabular summaries of the Monte Carlo results, is presented for the Lorberry Creek TMDL in Attachment C. Information for the TMDL analysis performed using the methodology described above is contained in the TMDLs by segment section of this report in Attachment D.

Method for Addressing Section 303(d) Listings for pH

There has been a great deal of research conducted on the relationship between alkalinity, acidity, and pH. Research published by the Pa. Department of Environmental Protection demonstrates that by plotting net alkalinity (alkalinity-acidity) vs. pH for 794 mine sample points, the resulting pH value from a sample possessing a net alkalinity of zero is approximately equal to six (Figure 1). Where net alkalinity is positive (greater than or equal to zero), the pH range is most commonly six to eight, which is within the USEPA's acceptable range of six to nine and meets Pennsylvania water quality criteria in Chapter 93.

The pH, a measurement of hydrogen ion acidity presented as a negative logarithm, is not conducive to standard statistics. Additionally, pH does not measure latent acidity. For this reason, and based on the above information, Pennsylvania is using the following approach to address the stream impairments noted on the Section 303(d) list due to pH. The concentration of acidity in a stream is at least partially chemically dependent upon metals. For this reason, it is extremely difficult to predict the exact pH values, which would result from treatment of abandoned mine drainage. Therefore, net alkalinity will be used to evaluate pH in these TMDL calculations. This methodology assures that the standard for pH will be met because net alkalinity is a measure of the reduction of acidity. When acidity in a stream is neutralized or is restored to natural levels, pH will be acceptable. Therefore, the measured instream alkalinity at the point of evaluation in the stream will serve as the goal for reducing total acidity at that point. The methodology that is applied for alkalinity (and therefore pH) is the same as that used for other parameters such as iron, aluminum, and manganese that have numeric water quality criteria.

Each sample point used in the analysis of pH by this method must have measurements for total alkalinity and total acidity. Net alkalinity is alkalinity minus acidity, both being in units of milligrams per liter (mg/l) $CaCO_3$. The same statistical procedures that have been described for use in the evaluation of the metals is applied, using the average value for total alkalinity at that point as the target to specify a reduction in the acid concentration. By maintaining a net alkaline stream, the pH value will be in the range between six and eight. This method negates the need to specifically compute the pH value, which for mine waters is not a true reflection of acidity. This method assures that Pennsylvania's standard for pH is met when the acid concentration reduction is met.

There are several documented cases of streams in Pennsylvania having a natural background pH below six. If the natural pH of a stream on the Section 303(d) list can be established from its upper unaffected regions, then the pH standard will be expanded to include this natural range. The acceptable net alkalinity of the stream after treatment/abatement in its polluted segment will be the average net alkalinity established from the stream's upper, pristine reaches added to the acidity of the polluted portion in question. Summarized, if the pH in an unaffected portion of a stream is found to be naturally occurring below six, then the average net alkalinity for that portion (added to the acidity of the polluted portion) of the stream will become the criterion for the polluted portion. This "natural net alkalinity level" will be the criterion to which a 99 percent confidence level will be applied. The pH range will be varied only for streams in which a natural unaffected net alkalinity level can be established. This can only be done for streams that have upper segments that are not impacted by mining activity. All other streams will be required to reduce the acid load so the net alkalinity is greater than zero 99% of time.

Reference: *Rose, Arthur W. and Charles A. Cravotta, III 1998. Geochemistry of Coal Mine Drainage. Chapter 1 in Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania. Pa. Dept. of Environmental Protection, Harrisburg, Pa.*

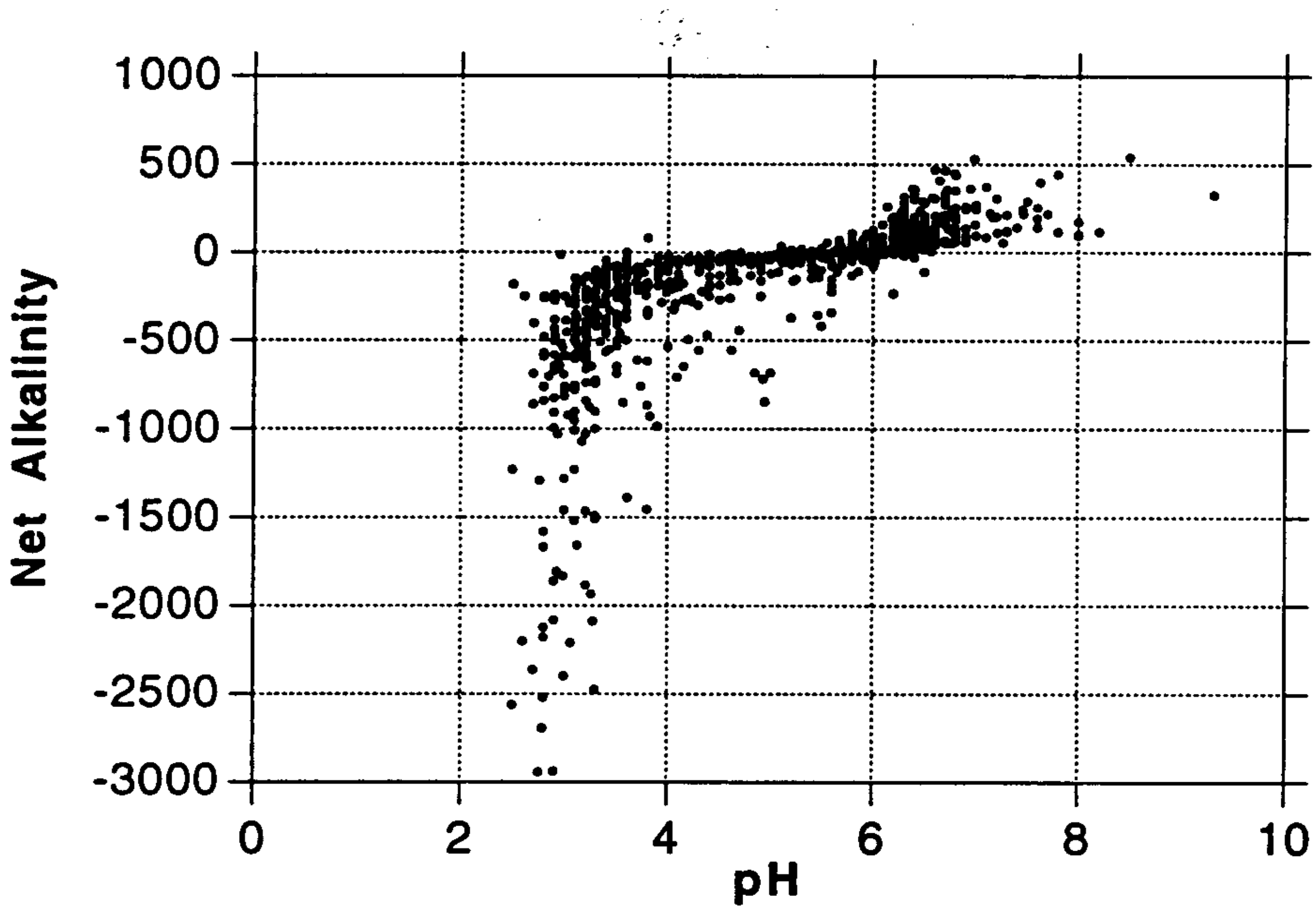


Figure 1. Net Alkalinity vs. pH. Taken from Figure 1.2 Graph C, pages 1-5, of Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania

Attachment C

Example Calculation: Lorberry Creek

Lorberry Creek was evaluated for impairment due to high metals contents in the following manner: the analysis was completed in a stepwise manner, starting at the headwaters of the stream and moving to the mouth. The Rowe Tunnel (Swat-04) was treated as the headwaters of Lorberry Creek for the purpose of this analysis.

1. A simulation of the concentration data at point Swat-04 was completed. This estimated the necessary reduction needed for each metal to meet water quality criteria 99 percent of the time as a long-term average daily concentration. Appropriate concentration reductions were made for each metal.

2. A simulation of the concentration data at point Swat-11 was completed. It was determined that no reductions in metals concentrations are needed for Stumps Run at this time. Therefore, no TMDL for metals in Stumps Run is required at this time.

3. A mass balance of loading from Swat-04 and Swat-11 was completed to determine if there was any need for additional reductions as a result of combining the loads. No additional reductions were necessary.

4. The mass balance was expanded to include the Shadle Discharge (L-1). It was estimated that best available technology (BAT) requirements for the Shadle Discharge were adequate for iron and manganese. There is no BAT requirement for aluminum. A wasteload allocation was necessary for aluminum at point L-1.

There are no other known sources below the Shadle Discharge. However, there is additional flow from overland runoff and one unnamed tributary not impacted by mining. It is reasonable to assume that the additional flow provides assimilation capacity below point L-1, and no further analysis is needed downstream.

The calculations are detailed in the following section (Tables 1-8). Table 9 shows the allocations made on Lorberry Creek.

1. A series of four equations was used to determine if a reduction was needed at point Swat-04, and, if so the magnitude of the reduction.

Table 1. Equations Used for Rowe Tunnel Analysis (SWAT 04)

	Field Description	Equation	Explanation
1	Swat-04 Initial Concentration Value (Equation 1A)	= Risklognorm (Mean, St Dev)	This simulates the existing concentration of the sampled data.
2	Swat-04 % Reduction (from the 99th percentile of percent reduction)	= (Input a percentage based on reduction target)	This is the percent reduction for the discharge.
3	Swat-04 Final Concentration Value	= Sampled Value x (1-percent reduction)	This applies the given percent reduction to the initial concentration.
4	Swat-04 Reduction Target (PR)	= Maximum (0, 1- Cd/Cc)	This computes the necessary reduction, if needed, each time a value is sampled. The final reduction target is the 99th percentile value of this computed field.

2. The reduction target (PR) was computed taking the 99th percentile value of 5,000 iterations of the equation in row four of Table 1. The targeted percent reduction is shown, in boldface type, in the following table.

Table 2. Swat-04 Estimated Target Reductions			
Name	**Swat-04 Aluminum**	**Swat-04 Iron**	**Swat-04 Manganese**
Minimum =	0	0.4836	0
Maximum =	0.8675	0.9334	0.8762
Mean =	0.2184	0.8101	0.4750
Std. Deviation =	0.2204	0.0544	0.1719
Variance =	0.0486	0.0030	0.0296
Skewness =	0.5845	-0.8768	-0.7027
Kurtosis =	2.0895	4.3513	3.1715
Errors Calculated =	0	0	0
Targeted Reduction % =	**72.2**	**90.5**	**77.0**
Target #1 (Perc%)=	99	99	99

3. This PR value was used as the percent reduction in the equation in row three of Table 1. Testing was done to see that the water quality criterion for each metal was achieved at least 99 percent of the time. This verified the estimated percent reduction necessary for each metal. Table 3 shows, in boldface type, the percent of the time criteria for each metal was achieved during 5,000 iterations of the equation in row three of Table 1.

Table 3. Swat-04 Verification of Target Reductions			
Name	**Swat-04 Aluminum**	**Swat-04 Iron**	**Swat-04 Manganese**
Minimum =	0.0444	0.2614	0.1394
Maximum =	1.5282	2.0277	1.8575
Mean =	0.2729	0.7693	0.4871
Std Deviation =	0.1358	0.2204	0.1670
Variance =	0.0185	0.0486	0.0279
Skewness =	1.6229	0.8742	1.0996
Kurtosis =	8.0010	4.3255	5.4404
Errors Calculated =	0	0	0
Target #1 (value) (WQ Criteria)=	0.75	1.5	1
Target #1 (Perc%)=	**99.15**	**99.41**	**99.02**

4. These same four equations were applied to point Swat-11. The result was that no reduction was needed for any of the metals. Tables 4 and 5 show the reduction targets computed for, and the verification of, reduction targets for Swat-11.

Table 4. Swat-11 Estimated Target Reductions			
Name	**Swat-11 Aluminum**	**Swat-11 Iron**	**Swat-11 Manganese**
Minimum =	0.0000	0.0000	0.0000
Maximum =	0.6114	0.6426	0.0000
Mean =	0.0009	0.0009	0.0000
Std Deviation =	0.0183	0.0186	0.0000
Variance =	0.0003	0.0003	0.0000
Skewness =	24.0191	23.9120	0.0000
Kurtosis =	643.4102	641.0572	0.0000
Errors Calculated =	0	0	0
Targeted Reduction % =	**0**	**0**	**0**
Target #1 (Perc%) =	99	99	99

Table 5. Swat-11 Verification of Target Reductions			
Name	**Swat-11 Aluminum**	**Swat-11 Iron**	**Swat-11 Manganese**
Minimum =	0.0013	0.0031	0.0246
Maximum =	1.9302	4.1971	0.3234
Mean =	0.0842	0.1802	0.0941
Std Deviation =	0.1104	0.2268	0.0330
Variance =	0.0122	0.0514	0.0011
Skewness =	5.0496	4.9424	1.0893
Kurtosis =	48.9148	48.8124	5.1358
Errors Calculated =	0	0	0
WQ Criteria =	**0.75**	**1.5**	**1**
% of Time Criteria Achieved =	**99.63**	**99.60**	**100**

5. Table 6 shows variables used to express mass balance computations.

Table 6. Variable Descriptions for Lorberry Creek Calculations	
Description	**Variable Shown**
Flow from Swat-04	Q_{swat04}
Swat-04 Final Concentration	C_{swat04}
Flow from Swat-11	Q_{swat11}
Swat-11 Final Concentration	C_{swat11}
Concentration below Stumps Run	C_{stumps}
Flow from L-1 (Shadle Discharge)	Q_{L1}
Final Concentration From L-1	C_{L1}
Concentration below L-1	C_{allow}

6. Swat-04 and Swat-11 were mass balanced in the following manner:

   The majority of the sampling done at point Swat-11 was done in conjunction with point Swat-04 (20 matching sampling days). This allowed for the establishment of a significant correlation between the two flows (the R-squared value was 0.85). Swat-04 was used as the base flow, and a regression analysis on point Swat-11 provided an equation for use as the flow from Swat-11.

The flow from Swat-04 (Q_{swat04}) was set into an @RISK function so it could be used to simulate loading into the stream. The cumulative probability function was used for this random flow selection. The flow at Swat-04 is as follows (Equation 1):

$$Q_{swat04} = \text{RiskCumul(min,max,bin range, cumulative percent of occurrence)} \quad (1)$$

The RiskCumul function takes four arguments: minimum value, maximum value, the bin range from the histogram, and cumulative percent of occurrence.

The flow at Swat-11 was randomized using the equation developed through the regression analysis with point Swat-04 (Equation 2).

$$Q_{swat11} = Q_{swat}04 \text{ x } 0.142 + 0.088 \quad (2)$$

The mass balance equation is as follows (Equation 3):

$$C_{stumps} = ((Q_{swat04} * C_{swat04}) + (Q_{swat11} * C_{swat11}))/(Q_{swat04}+Q_{swat11}) \quad (3)$$

This equation was simulated through 5,000 iterations, and the 99th percentile value of the data set was compared to the water quality criteria to determine if standards had been met. The results show there is no further reduction needed for any of the metals at either point. The simulation results are shown in Table 7.

Table 7. Verification of Meeting Water Quality Standards Below Stumps Run

Name	Below Stumps Run Aluminum	Below Stumps Run Iron	Below Stumps Run Manganese
Minimum =	0.0457	0.2181	0.1362
Maximum =	1.2918	1.7553	1.2751
Mean =	0.2505	0.6995	0.4404
Std Deviation =	0.1206	0.1970	0.1470
Variance =	0.0145	0.0388	0.0216
Skewness =	1.6043	0.8681	1.0371
Kurtosis =	7.7226	4.2879	4.8121
Errors Calculated =	0	0	0
WQ Criteria =	**0.75**	**1.5**	**1**
% of Time Criteria Achieved =	**99.52**	**99.80**	**99.64**

7. The mass balance was expanded to determine if any reductions would be necessary at point L-1.

The Shadle Discharge originated in 1997, and very few data are available for it. The discharge will have to be treated or eliminated. It is the current site of a USGS test remediation project. The data that were available for the discharge were collected at a point prior to a settling pond. Currently, no data for effluent from the settling pond are available.

Modeling for iron and manganese started with the BAT-required concentration value. The current effluent variability based on limited sampling was kept at its present level. There was no BAT value for aluminum, so the starting concentration for the modeling was arbitrary. The BAT values for iron and manganese are 6 mg/l and 4 mg/l, respectively. Table 8 shows the BAT-adjusted values used for point L-1.

Table 8. L-1 Adjusted BAT Concentrations

Parameter	**Measured Value**		**BAT adjusted Value**	
	Average Conc.	*Standard Deviation*	*Average Conc.*	*Standard Deviation*
Iron	538.00	19.08	6.00	0.21
Manganese	33.93	2.14	4.00	0.25

The average flow (0.048 cfs) from the discharge will be used for modeling purposes. There were not any means to establish a correlation with point Swat-04.

The same set of four equations used for point Swat-04 was used for point L-1. The equation used for evaluation of point L-1 is as follows (Equation 4):

$$C_{allow} = ((Q_{swat04}*C_{swat04})+(Q_{swat11}*C_{swat11})+(Q_{L1}*C_{L1}))/(Q_{swat04}+Q_{swat11}+Q_{L1}) \quad (4)$$

This equation was simulated through 5,000 iterations, and the 99th percentile value of the data set was compared to the water quality criteria to determine if standards had been met. It was estimated that an 81 percent reduction in aluminum concentration was needed for point L-1.

8. Table 9 shows the simulation results of the equation above.

Table 9. Verification of Meeting Water Quality Standards Below Point L-1			
Name	**Below L-1 Aluminum**	**Below L-1 Iron**	**Below L-1 Manganese**
Minimum =	0.0815	0.2711	0.1520
Maximum =	1.3189	2.2305	1.3689
Mean =	0.3369	0.7715	0.4888
Std Deviation =	0.1320	0.1978	0.1474
Variance =	0.0174	0.0391	0.0217
Skewness =	1.2259	0.8430	0.9635
Kurtosis =	5.8475	4.6019	4.7039
Errors Calculated =	0	0	0
WQ Criteria=	**0.75**	**1.5**	**1**
Percent of time achieved=	**99.02**	**99.68**	**99.48**

9. Table 10 presents the estimated reductions needed to meet water quality standards at all points in Lorberry Creek.

Table 10. Lorberry Creek Summary						
		Measured Sample Data		**Allowable**		**Reduction Identified**
Station	Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)	%
Swat 04						
	Al	1.01	21.45	0.27	5.79	73%
	Fe	8.55	181.45	0.77	16.33	91%
	Mn	2.12	44.95	0.49	10.34	77%
Swat 11						
	Al	0.08	0.24	0.08	0.24	0%
	Fe	0.18	0.51	0.18	0.51	00%
	Mn	0.09	0.27	0.09	0.27	00%
L-1						
	Al	34.90	9.03	6.63	1.71	81%
	Fe	6.00	1.55	6.00	1.55	0%
	Mn	4.00	1.03	4.00	1.03	0%

All values shown in this table are long-term average daily values

The TMDL for Lorberry Creek requires that a load allocation be made to the Rowe Tunnel Discharge (Swat-04) for the three metals listed, and that a wasteload allocation is made to the Shadle Discharge (L-1) for aluminum. There is no TMDL for metals required for Stumps Run (Swat-11) at this time.

Margin of Safety

For this study, the margin of safety is applied implicitly. The allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. Other margins of safety used for this TMDL analysis include the following:

- None of the data sets were filtered by taking out extreme measurements. Because the 99 percent level of protection is designed to protect for the extreme event, it was pertinent not to filter the data set.

- Effluent variability plays a major role in determining the average value that will meet water quality criteria over the long term. This analysis maintained that the variability at each point would remain the same. The general assumption can be made that a treated discharge would be less variable than an untreated discharge. This implicitly builds in another margin of safety.

Attachment D
TMDLs By Segment

BLACKS CREEK

The TMDL for Blacks Creek consists of load allocations to five sampling sites along the stream. Following is an explanation of the TMDL for each allocation point.

Blacks Creek is listed for high metals from AMD as being the cause of the degradation to the stream. The method and rationale for addressing pH is contained in Attachment B.

In August 1996, a water monitoring program was implemented for Blacks Creek to document the condition of the stream and the potential for remediation efforts in the watershed. There are several stream segments which exhibit water quality with metals concentrations well below the instream criteria of 1.5 mg/l for iron, 1.0 mg/l for manganese and 0.75 mg/l for aluminum. These segments are sampled at BC 3, BC5, BC9, BC10, BC11 and BC12.

There are seven documented acid mine drainage sample points contributing to the impairment of Blacks Creek. All of them enter Blacks Creek between sample point BC06 and BC2B. These discharges are associated with the abandoned mining on the Lower Kittanning coal and acid mine drainage emanating from abandoned oil wells. MC1 and MC3 are severely acidic with elevated iron, manganese and aluminum. The other discharges, BC14, BC15, BC16, BC19 and BC19B, are generally alkaline with elevated iron and manganese.

At many of the sampling locations there was not enough data to include the sites in the analysis. Sampling site QAS4 was not included in the TMDL because the concentrations of metals were small and there was sufficient reduction upstream.

<u>TMDL calculations- Above Sampling Point BC6</u>

The TMDL for sample point BC6 consists of a load allocation to all of the area above the point shown in Attachment A. The load allocation for this segment was computed using water-quality sample data collected at point BC6. The average flow, measured at the sampling point BC6 (0.20 MGD), is used for these computations.

There currently is no entry for this segment on the Pa Section 303(d) list for impairment due to pH. Sample data at point BC6 shows pH ranging between 4.7 and 6.3, ph will be addressed in this TMDL. The objective is to reduce acid loading to the stream, which will in turn raise the pH to the desired range and keep a net alkalinity above zero, 99% of the time. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see TMDL Endpoint section in the report, Table 2). The method and rationale for addressing pH is contained in Attachment B.

An allowable long-term average in-stream concentration was determined at point BC6 for aluminum, iron, manganese, and acidity. The analysis is designed to produce an average value that, when met, will be protective of the water-quality criterion for that parameter 99% of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water-quality criteria 99% of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5000 iterations of sampling were completed, and compared against the water-quality criterion for that parameter. For each sampling event a percent reduction was calculated, if necessary, to meet water-quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99% of the time. The mean value from this data set represents the long-term average concentration that needs to be met to achieve water-quality standards. The following table shows the load allocations for this stream segment.

Table D1. Load Allocations at Point BC6

	Measured Sample Data		Allowable		Reduction Identified
Parameter	Conc. (mg/l)	Load (lbs/day)	LTA conc. (mg/l)	Load (lbs/day)	%
Al	1.70	2.8	0.14	0.2	92%
Fe	0.36	0.6	0.16	0.6	0%
Mn	2.11	3.5	0.44	0.7	79%
Acidity	8.83	14.6	3.62	6.0	59%
Alkalinity	29.20	48.3			

TMDL Calculation –Sampling Point BC2

The TMDL for sampling point BC2 consists of a load allocation of the area between sample points BC2 and BC6. The load allocation for this segment was computed using water-quality sample data collected at point BC2. The flow of 0.46 MGD was derived at sample point BC2 using the unit area method.

There currently is no entry for this segment on the Section Pa 303(d) list for impairment due to pH. Sample data at point BC2 shows pH ranging between 6.3 and 6.8; pH will not be addressed as part of this TMDL. The method and rationale for addressing pH is contained in Attachment B.

The existing and allowable loading for point BC2 for all parameters was computed using water-quality sample data collected at the point. This was based on the sample data for the point and did not account for any load reductions already specified from upstream sources. The load reduction from point BC6 was subtracted from the existing load at point BC2 and was compared to the allowable load at BC2 for each parameter to determine if any further reductions were needed at this point.

An allowable long-term average in-stream concentration was determined at point BC2 for aluminum, iron, and manganese. The analysis is designed to produce an average value that, when met, will be protective of the water-quality criterion for that parameter 99% of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water-quality criteria 99% of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5000 iterations of sampling were completed, and compared against the water-quality criterion for that parameter. For each sampling event a percent reduction was calculated, if necessary, to meet water-quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99% of the time. The mean value from this data set represents the long-term average concentration that needs to be met to achieve water-quality standards. The following table shows the load allocations for this stream segment.

Table D4. Load Allocations at Point BC2				
	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTAConc. (mg/l)	Load (lbs/day)
Al	1.04	1.8	0.26	1.0
Fe	15.56	60.2	0.31	1.2
Mn	6.87	26.6	0.27	1.1
Acidity	0.00	0.0	0.00	0.0
Alkalinity	97.20	376.1		

The loading reductions for point BC6 shows the total load that was removed from upstream sources. This value, for each parameter, was then subtracted from the existing load at point BC2. This value was then compared to the allowable load at point BC2. Reductions at point BC2 are necessary for any parameter that exceeded the allowable load at this point. Table D5 shows a summary of all loads that affect point BC2. Table D6 illustrates the necessary reductions at point BC2. The results of this analysis show that there are no necessary reductions for acidity at this point.

Table D5. Summary of All Loads that Affect Point BC2				
	Al (#/day)	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
Sample Point BC6				
load reduction=	2.6	0.0	2.8	8.6

Table D6. Necessary Reductions at Sample Point BC2				
	Al (#/day)	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
Existing Loads at BC2	4.0	60.2	26.6	0.0
Total Load Reduction (BC6)	2.6	0.0	2.8	8.6
Remaining Load (Existing Loads at BC2-TLR Sum)	1.4	60.2	23.8	NA
Allowable Loads at BC2	1.0	1.2	1.1	0.0
Percent Reduction	29	98	96	NA
Additional Removal Required at BC2	0.4	59.0	22.8	0.0

The average flow, measured at sample point BC2, is used for these computations. The TMDL for BC2 consists of load allocations for aluminum to all of the area upstream of BC2 shown in Attachment A. The percent reduction was calculated using below equation.

$$\left[1-\left(\frac{\text{Allowable Loads at BC2}}{\text{Remaining Load (Existing Loads at BC2 - TLR Sum}}\right)\right]\times 100\,\%$$

No additional loading reductions were necessary for acidity.

<u>TMDL Calculation – Sampling Point BC2B</u>

The TMDL for sampling point BC2B on Blacks Creek consists of a load allocation of the area between the points BC2 and BC2B shown in Attachment A. The load allocation for this stream segment was computed using water-quality sample data collected at point BC2B. The average flow, measured at the sampling point BC2B (0.50 MGD), is used for these computations.

There currently is no entry for this segment on the Pa Section 303(d) list for impairment due to pH. Sample data at point BC2B shows pH ranging between 6.5 and 6.9; pH will not be addressed as part of this TMDL. The method and rationale for addressing pH is contained in Attachment B.

The existing and allowable loading for point BC2B for all parameters was computed using water-quality sample data collected at the point. This was based on the sample data for the point and did not account for any load reductions already specified from upstream sources. The load reduction from points BC6, and BC2 was summed and then subtracted from the existing load at point BC2B. This was compared to the allowable load at BC2B for each parameter to determine if any further reductions were needed at this point.

An allowable long-term average in-stream concentration was determined at point BC2B for aluminum, iron, and manganese. The analysis is designed to produce an average value that, when met, will be protective of the water-quality criterion for that parameter 99% of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water-quality criteria 99% of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5000 iterations of sampling were completed, and compared against the water-quality criterion for that parameter. For each sampling event a percent reduction was calculated, if necessary, to meet water-quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99% of the time. The mean value from this data set represents the long-term average concentration that needs to be met to achieve water-quality standards. The following table shows the load allocations for this stream segment.

Table D7. Load Allocations at Point BC2B				
	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTAConc. (mg/l)	Load (lbs/day)
Al	1.25	5.2	0.56	2.3
Fe	8.11	33.6	1.14	4.7
Mn	6.23	25.8	0.62	2.6
Acidity	0.00	0.0	0.00	0.0
Alkalinity	11.49	47.6		

The loading reductions for points BC6, and BC2 were summed to show the total load that was removed from upstream sources. This value, for each parameter, was then subtracted from the existing load at point BC2B. This value was then compared to the allowable load at point BC2B. Reductions at point BC2B are necessary for any parameter that exceeded the allowable load at this point. Table D8 shows a summary of all loads that affect point BC2B. Table D9 illustrates the necessary reductions at point BC2B. The results of this analysis show that there are no necessary reductions at this point.

Table D8. Summary of All Loads that Affect Point BC2B				
	Al (#/day)	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
Sample Point BC6				
load reduction=	2.6	0.0	2.8	8.6
Sample Point BC2				
load reduction=	0.4	59.0	22.8	0.0

Table D9. Necessary Reductions at Sample Point BC2B				
	Al (#/day)	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
Existing Loads at BC2B	5.2	33.6	25.8	0.0
Total Load Reduction (Sum of BC6, MC1, MC3, and BC2)	3.0	59.0	25.5	8.6
Remaining Load (Existing Loads at BC2B-TLR Sum)	2.2	NA	0.27	NA
Allowable Loads at BC2B	2.3	4.7	2.6	0.0
Percent Reduction	NA	NA	NA	NA
Additional Removal Required at BC2B	NA	NA	NA	NA

The average flow, measured at sample point BC2B, is used for these computations. The TMDL for BC2B consists of load allocations for aluminum to all of the area upstream of BC2B shown in Attachment A. The percent reduction was calculated using below equation.

$$\left[1-\left(\frac{\text{Allowable Loads at BC2B}}{\text{Remaining Load (Existing Loads at BC2B - TLR Sum}}\right)\right]\times 100\,\%$$

No additional loading reductions were necessary for aluminum, iron, manganese and acidity.

<u>TMDL Calculation – Sampling Point BC1</u>

The TMDL for sampling point BC1 consists of a load allocation of the area between sampling points BC2B and BC1 shown in Attachment A. The load allocation for this stream segment was computed using water-quality sample data collected at point BC1. The average flow, measured at the sampling point BC1 (1.35 MGD), is used for these computations.

There currently is no entry for this segment on the Pa Section 303(d) list for impairment due to pH. Sample data at point BC1 shows pH ranging between 6.8 and 7.4; pH will not be addressed as part of this TMDL. The method and rationale for addressing pH is contained in Attachment B.

The existing and allowable loading for point BC1 for all parameters was computed using water-quality sample data collected at the point. This was based on the sample data for the point and did not account for any load reductions already specified from upstream sources. The load reductions from points BC6, BC2, and BC2B was subtracted from the existing load at point BC1 and was compared to the allowable load for each parameter to determine if any further reductions were needed.

An allowable long-term average in-stream concentration was determined at point BC1 for aluminum, iron, manganese and acidity. The analysis is designed to produce an average value that, when met, will be protective of the water-quality criterion for that parameter 99% of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water-quality criteria 99% of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5000 iterations of sampling were completed, and compared against the water-quality criterion for that parameter. For each sampling event a percent reduction was calculated, if necessary, to meet water-quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99% of the time. The mean value from this data set represents the long-term average concentration that needs to be met to achieve water-quality standards. The following table shows the load allocations for this stream segment.

Table D10. Load Allocation at Point BC1				
	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTAConc. (mg/l)	Load (lbs/day)
Al	0.55	6.2	0.55	6.2
Fe	1.78	20.1	0.50	5.6
Mn	3.18	35.9	0.64	7.2
Acidity	0.00	0.0	0.00	0.0
Alkalinity	95.67	1079.2		

The loading reduction for point BC6, BC2, and BC2B shows the total load that was removed from upstream sources. This value, for each parameter, was then subtracted from the existing load at point BC1. This value was then compared to the allowable load at point BC1. Reductions at point BC1 are necessary for any parameter that exceeded the allowable load at this point. Table D11 shows a summary of the load that affects point BC1. Table D12 illustrates the necessary reductions at point BC1. The results of this analysis show that there are necessary reductions for manganese at this point.

Table 11. Summary of All Loads that Affect Point BC1				
	Al (#/day)	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
Sample Point BC6, & BC2				
load reduction=	2.3	59.0	25.5	8.6
Sample Point BC2B				
load reduction=	0.0	0.0	0.0	0.0

Table D12. Necessary Reductions at Sample Point BC1				
	Al (#/day)	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
Existing Loads at BC1	6.2	20.1	35.9	0.0
Total Load Reduction (BC6, MC1, MC3, BC2, and BC2B)	3.0	59.0	25.5	8.6
Remaining Load (Existing Loads at BC1-TLR Sum)	3.2	NA	10.3	NA
Allowable Loads at BC1	6.2	5.6	7.2	0.0
Percent Reduction	NA	NA	31	NA
Additional Removal Required at BC1	NA	NA	3.2	NA

The average flow, measured at sample point BC1, is used for these computations. The TMDL for BC1 consists of load allocations for aluminum to all of the area upstream of BC1 shown in Attachment A. The percent reduction was calculated using below equation.

$$\left[1-\left(\frac{\text{Allowable Loads at BC1}}{\text{Remaining Load (Existing Loads at BC1 - TLR Sum}}\right)\right]\times 100\,\%$$

No additional loading reductions were necessary for aluminum, iron, and acidity.

TMDL Calculation – Sampling Point BC8

The TMDL for sampling point BC8 consists of a load allocation of the area between sample points BC1 and BC8. The load allocation for this stream segment was computed using water-quality sample data collected at point BC8. The flow of 1.65 MGD, derived with the unit area method, is used for these computations.

There currently is no entry for this segment on the Pa Section 303(d) list for impairment due to pH. Sample data at point BC1 shows pH ranging between 6.6 and 7.2; pH will not be addressed as part of this TMDL. The method and rationale for addressing pH is contained in Attachment B.

The existing and allowable loading for point BC8 for all parameters was computed using water-quality sample data collected at the point. This was based on the sample data for the point and did not account for any load reductions already specified from upstream sources. The load reduction from points BC6, BC2, BC2B, and BC1 were subtracted from the existing load at point BC8 and was then compared to the allowable load for each parameter to determine if any further reductions were needed at this point.

An allowable long-term average in-stream concentration was determined at point BC8 for aluminum, iron, and manganese. The analysis is designed to produce an average value that, when met, will be protective of the water-quality criterion for that parameter 99% of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water-quality criteria 99% of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5000 iterations of sampling were completed, and compared against the water-quality criterion for that parameter. For each sampling event a percent reduction was calculated, if necessary, to meet water-quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99% of the time. The mean value from this data set represents the long-term average concentration that needs to be met to achieve water-quality standards. The following table shows the load allocations for this stream segment.

Table D13. Load Allocations at Point BC8

	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTAConc. (mg/l)	Load (lbs/day)
Al	0.00	0.0	0.00	0.0
Fe	0.74	10.2	0.74	10.2
Mn	1.83	25.1	0.58	8.0
Acidity	0.00	0.0	0.00	0.0
Alkalinity	77.20	1062.3		

The loading reductions for points BC6, BC2, BC2B, and BC1 were summed to show the total load that was removed from upstream sources. This value, for each parameter, was then subtracted from the existing load at point BC8. This value was then compared to the allowable load at point BC8. Reductions at point BC8 are necessary for any parameter that exceeded the allowable load at this point. Table D14 shows a summary of all loads that affect point BC8. Table D15 illustrates the necessary reductions at point BC8. The results of this analysis show that there are no necessary reductions at this point.

Table 14. Summary of All Loads that Affect Point BC8

	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Sample Point BC6, BC2, & BC2B				
load reduction=	3.0	59.0	25.5	8.6
Sample Point BC1				
load reduction=	0.0	0.0	3.2	0.0

Table D15. Necessary Reductions at Sample Point BC8				
	Al (#/day)	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
Existing Loads at BC8	0.0	10.2	25.1	0.0
Total Load Reduction (Sum of BC6, BC2, BC2B, and BC1)	3.0	59.0	28.7	8.6
Remaining Load (Existing Loads at BC8-TLR Sum)	NA	NA	NA	NA
Allowable Loads at BC8	0.0	10.2	8.0	49.8
Percent Reduction	NA	NA	NA	NA
Additional Removal Required at BC8	NA	NA	NA	NA

The average flow, measured at sample point BC8, is used for these computations. The TMDL for BC8 consists of load allocations for aluminum to all of the area upstream of BC8 shown in Attachment A. The percent reduction was calculated using below equation.

$$\left[1-\left(\frac{\text{Allowable Loads at BC8}}{\text{Remaining Load (Existing Loads at BC8 - TLR Sum}}\right)\right]\times 100\,\%$$

No additional loading reductions were necessary for aluminum, iron, manganese and acidity.

Margin of Safety

PADEP used an implicit MOS in these TMDLs derived from the Monte Carlo statistical analysis. The Water Quality standard states that water quality criteria must be met at least 99% of the time. All of the @Risk analyses results surpass the minimum 99% level of protection. Another margin of safety used for this TMDL analysis results from:

- Effluent variability plays a major role in determining the average value that will meet water-quality criteria over the long-term. The value that provides this variability in our analysis is the standard deviation of the dataset. The simulation results are based on this variability and the existing stream conditions (an uncontrolled system). The general assumption can be made that a controlled system (one that is controlling and stabilizing the pollution load) would be less variable than an uncontrolled system. This implicitly builds in a margin of safety.
- A MOS is also the fact that the calculations were performed with a daily Iron average instead of the 30-day average.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represents all seasons.

Critical Conditions

The reductions specified in this TMDL apply at all flow conditions. A critical flow condition could not be identified from the data used for this analysis.

Attachment E

Excerpts Justifing Changes Between the 1996, 1998, and Draft 2000 Section 303(d) Lists

The following are excerpts from the Pennsylvania DEP Section 303(d) narratives that justify changes in listings between the 1996, 1998, and draft 2000 lists. The Section 303(d) listing process has undergone an evolution in Pennsylvania since the development of the 1996 list.

In the 1996 Section 303(d) list narrative, strategies were outlined for changes to the listing process. Suggestions included, but were not limited to, a migration to a Global Information System (GIS), improved monitoring and assessment, and greater public input.

The migration to a GIS was implemented prior to the development of the 1998 Section 303(d) list. As a result of additional sampling and the migration to the GIS some of the information appearing on the 1996 list differed from the 1998 list. Most common changes included:

1. mileage differences due to recalculation of segment length by the GIS;
2. slight changes in source(s)/cause(s) due to new EPA codes;
3. changes to source(s)/cause(s), and/or miles due to revised assessments;
4. corrections of misnamed streams or streams placed in inappropriate SWP subbasins; and
5. unnamed tributaries no longer identified as such and placed under the named watershed listing.

Prior to 1998, segment lengths were computed using a map wheel and calculator. The segment lengths listed on the 1998 Section 303(d) list were calculated automatically by the GIS (ArcInfo) using a constant projection and map units (meters) for each watershed. Segment lengths originally calculated by using a map wheel and those calculated by the GIS did not always match closely. This was the case even when physical identifiers (e.g., tributary confluence and road crossings) matching the original segment descriptions were used to define segments on digital quad maps. This occurred to some extent with all segments, but was most noticeable in segments with the greatest potential for human errors using a map wheel for calculating the original segment lengths (e.g., long stream segments or entire basins).

The most notable difference between the 1998 and Draft 2000 Section 303(d) lists are the listing of unnamed tributaries in 2000. In 1998, the GIS stream layer was coded to the named stream level so there was no way to identify the unnamed tributary records. As a result, the unnamed tributaries were listed as part of the first downstream named stream. The GIS stream coverage used to generate the 2000 list had the unnamed tributaries coded with the DEP's five-digit stream code. As a result, the unnamed tributary records are now split out as separate records on the 2000 Section 303(d) list. This is the reason for the change in the appearance of the list and the noticeable increase in the number of pages.

Attachment F

Water Quality Data Used In TMDL Calculations

BC6

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
8/23/1996		6.2	20	0	0.639	2.8	<.5	164.3
3/30/2000	100	4.7	9	40	<.3	3.14	4.23	146.3
4/25/2000	334	5	10.2	13	<.3	2.31	3.64	158.6
6/28/2000		6.3	24	0	0.338	2.21	0.847	132.5
9/28/2001	60	6.8	64	0	<.3	1.21	<.5	187
11/7/2001	57	6.9	48	0	<.3	0.977	<.5	172
Avg=	137.75		29.20	8.83	0.49	2.11	2.91	
Stdev=			22.11	16.13	0.21	0.86	1.81	

BC2

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
8/23/1996		6.8	86	0	4	2.94	<.5	229.7
11/7/1996		6.4	80	0	9.25	6.52	0.996	189
3/11/1997		6.7	70	0	5.46	4.09	1.83	211
3/30/2000		6.3	182	0	49	15	<.5	841.6
6/28/2000		6.4	68	0	10.1	5.82	1.39	280.6
	322.20							
avg=			97.20	0.00	15.56	6.87	1.41	
stdev=				0.00	18.86	4.76	0.42	

BC2B

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
3/30/2000		6.6	74	0	7.67	4.56	1.11	295.6
6/28/2000		6.5	74	0	9.48	6.07	1.29	314.6
9/28/2001	157	6.7	98	0	7.35	6.71	1.13	>300.
11/7/2001	157	6.9	78	0	7.95	7.58	1.46	393.6
avg=	157		81	0	8.11	6.23	1.25	
stdev=	0		11.49	0	0.94	1.27	0.16	
UAF=	344.89							

BC1

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
8/23/1996		7	88	0	0.811	4.07	<.5	219.7
3/30/2000		6.8	92	0	2.8	3.05	0.562	263.8
4/25/2000	1625	7.4	102	0	2.41	2.29	0.644	310
4/19/2001		7.2	78	0	2.67	2.7	0.591	234.7
5/8/2001	915	7.3	108	0	1.69	3.8	<.5	306
9/28/2001	278	7.1	106	0	<.3	3.17	<.5	>300.
avg=	939.33		95.67	0	2.08	3.18	0.59	
stdev=			11.69	0	0.83	0.67	0.04	

BC8

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
8/23/1996		6.9	74	0	0.525	1.78	<.5	160.3
3/30/2000		6.7	76	0	0.743	1.79	<.5	215.4
4/25/2000		7.2	82	0	0.629	1.42	<.5	215.4
6/28/2000		6.6	60	0	1.01	2.57	<.5	191.9
9/28/2001	553	7	94	0	0.782	1.57	<.5	232
UAF=	1145.811							
avg=			77.20		0.74	1.83		
stdev=					0.18	0.44		

BC1A

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
3/30/2000		6.9	94	0	3.65	3.12	0.906	278.4

BC3

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
8/23/1996		6.8	198	0	0.35	0.108	<.5	221.2

BC3B

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
3/30/2000		7.9	216	0	<.3	<.05	<.5	302.3

BC4

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
8/23/1996		5.9	42	48	30	19.5	2.61	620.2
11/7/1996		3.4	0	154	3.57	22.2	9.6	403
6/28/2000	130	6.1	72	32	31.5	19.4	6.07	652.4

BC4.1

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
6/28/2000	120	3.3	0	162	7.52	20.9	12.4	467.8

BC5

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
8/23/1996		7.6	298	0	<.3	0.168	<.5	430
8/28/1996		6.2	34	0.8	0.775	0.468	0.524	223
3/30/2000	15	6.4	46	0	<.3	0.137	<.5	234.8

MC1

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
4/19/2001	20	3.8	0	1042	300	83.6	61.7	2951.9
5/8/2001	15	3.9	0	998	300	87.9	67	1688.9
9/28/2001	2	4.5	16.4	1057.2	3.19	77.3	20.6	300
11/7/2001	0.75	4.5	13.6	1190.4	300	89.4	22.5	2092.8
Avg=	9.44		7.50	1071.90	225.79	84.55	42.95	
Stdev=				82.89	148.41	5.42	24.82	

MC3

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
5/8/2001	15	3.8	0	1550	495	102	68.9	2283.3
9/28/2001	85	4.5	18.4	1066	300	83.3	22.4	300
11/7/2001	10	4.5	14.6	1183.8	300	88.2	22.2	2239.4
Avg=	36.67		11.00	1266.60	365.00	91.17	37.83	
Stdev=				252.40	112.58	9.69	26.90	

BC6.1

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
3/30/2000	5	6.8	116	0	0.311	0.186	<.5	471.1

BC6A

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
3/30/2000	100	4.5	7.8	50	<.3	3.29	4.63	134.9

BC7

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
8/23/1996		6.6	48	0	0.502	0.061	<.5	26.1
3/30/2000	25	6.7	78	0	<.3	0.247	<.5	177.8

BC9

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
8/23/1996		6.9	86	0	<.3	0.639	<.5	155.5

BC10

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
8/23/1996		6.5	34	0	0.38	0.147	<.5	72.1

BC11

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
8/23/1996		7.3	126	0	<.3	0.062	<.5	155.8

BC12

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
8/23/1996		6.9	62	0	0.328	0.159	<.5	151.7

BC12A

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- ------	--------	--------	--------	--------
9/28/2001	90	7.3	96	0	<.3	<.05	<.5	<182.

BC13

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
3/30/2000	30	7.6	314	0	<.3	0.066	<.5	547.9

BC14

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
8/28/1996	20	6.2	56	78	0.985	42.4	<.135	614
11/7/1996	35	6.3	46	30	0.397	21.1	<.135	285
3/11/1997		6.3	156	62	67	28.4	0.17	529
3/30/2000	10	6.1	42	0	<.3	1.85	<.5	414.8
6/28/2000	20	6.3	70	0	1.92	8.57	<.5	487.9
avg=	21.25		74.00	34.00	17.58	20.46		
stdev=				35.52	32.96	16.07		

BC14.1

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
3/11/1997		6.9	68	0	0.21	1.45	1.74	179
3/30/2000		6.7	70	0	<.3	1.54	1.57	211.3

BC15

Date	Final	pH	ALK	ACID	FE	MN	AL	SO4
Collected	Flow	pH units	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
8/28/1996	100	6.3	116	12.4	40.6	12.6	<.135	527
11/7/1996	100	6.3	134	3.8	38.4	9.31	<.135	265
3/11/1997		6.4	134	16	40.7	15.2	0.399	397
3/30/2000	80	6.3	118	0	32.8	9.26	<.5	401.2
6/28/2000	60	6.4	114	0	29.9	8.76	<.5	370.8
avg=	85.00		123.20	6.44	36.48	11.03		
stdev=				7.36	4.88	2.79		

BC16

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
8/28/1996	175	6.3	190	96	73.9	26	<.135	754
11/7/1996	100	6.3	228	16	62.2	18.6	<.135	388
3/11/1997		6.4	228	32	44.7	19.3	0.218	488
3/30/2000	60	6.5	66	0	6.8	4.24	1.19	391
6/28/2000	91	6.3	238	0	55.1	17.1	<.5	687.7
4/19/2001	106	6.4	206	0	59.1	18.6	<.5	536
5/8/2001	90	6.2	174	0	65.7	20.4	<.2	867
9/28/2001	8	6.3	156	101	71.7	21.3	<.5	>300.
11/7/2001	3	6.3	128	74.4	61	15.1	0.578	736.3
avg=	79.12		179.33	35.49	55.58	17.85		
stdev=				43.15	20.25	5.93		

BC19

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
1/28/1997	30	6.7	168	0	14.5	7.1	<.135	425
3/11/1997		6.6	190	0	25.7	7.33	0.158	364
3/30/2000	40	6.4	170	0	26.2	6.88	<.5	659.4
6/28/2000		6.4	198	0	27	7.59	<.5	467.2
9/28/2001	30	6.5	256	0	25.4	7.57	<.5	>300.
11/7/2001	20	6.5	230	0	28.8	8.47	<.5	659.8
avg=	30.0		202.0	0	24.60	7.49		
stdev=	8.16			0	5.09	0.55		

BC19B

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- --------	--------	--------	--------	--------
3/30/2000	20	6.5	248	0	26.2	7.78	<.5	544.9
6/28/2000	24	6.4	280	0	30.7	9.34	<.5	573.7
avg=	22		264.0	0	28.45	8.56		
stdev=	2.83			0	3.18	1.10		

QAS4

Date Collected	Final Flow	pH pH units	ALK MG/L	ACID MG/L	FE MG/L	MN MG/L	AL MG/L	SO4 MG/L
----------	-------	--------	-------	- ------	-- --------	--------	--------	--------
11/3/2000	>500	7.6	88	0	1.03	0.75	0.12	181
1/17/2001		7.34	70	0	0.32	0.56	0.12	161
4/3/2001		7.55	67	0	0.32	0.8	0.07	165
7/11/2001		7.44	90	0	0.33	0.53	0.04	219
avg=		7.48	78.75	0	0.5	0.66	0.09	181.5
stdev=		0.12	11.93	0	0.35	0.14	0.04	26.45

Attachment G
Comment and Response