Cold Stream Watershed TMDL

For Acid Mine Drainage Affected Segments

Prepared by the Pennsylvania Department of Environmental Protection

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TMDL's
Cold Stream Watershed
Centre County, PA

Introduction

This Total Maximum Daily Load (TMDL) calculation has been prepared for the segment in the Cold Stream Watershed (Attachments A and B). It was done to address the impairments noted on the 1996 Pennsylvania 303(d) list, required under the Clean Water Act, and covers one segment on this list. Low 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: 08-D Moshannon Creek								
Year	**Miles**	**Segment ID**	**DEP Stream Code**	**Stream Name**	**Designated Use**	**Data Source**	**Source**	**EPA 305(b) Cause Code**
1996	1.0	7158	25831	Cold Stream	CWF	305(b) Report	RE	Metals
1998	1.18	7158	25831	Cold Stream	CWF	SWMP	AMD	Metals
2000	No Additional Assessment Data Collected							

RE = Resource Extraction
SWMP = Surface Water Monitoring Program
AMD = Abandoned Mine Discharge

Directions to the Cold Stream Watershed

The Cold Stream watershed is located in western Centre County Pennsylvania (Attachment A). It flows northwestward from the Sandy Ridge Trail into the Moshannon Creek, just north of Philipsburg. The stream segment addressed in this TMDL is found to intersect US Route 322, immediately east of the town of Philipsburg. It begins below the outfall of the Cold Stream Dam, and continues down to the confluence with Moshannon Creek.

Segments addressed in this TMDL

There are no active mining operations in the watershed. All of the discharges in the watershed are from abandoned mines 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. This TMDL 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.

The use designations for the stream segments in this TMDL can be found in PA Title 25 Chapter 93.

Watershed History

The Cold Stream watershed (Attachments A and B) is 21.22 square miles. It originates at the top end of Pool Hollow, and flows northwesterly for 10.4 miles to the Moshannon Creek. This watershed is classified as High Quality-Cold Water Fishery from its source to the outfall of the dam just south of the stream intersection with US Route 322. From the outfall of the dam, to the confluence with Moshannon Creek it is classified as a Cold Water Fishery. Above the dam, Cold Stream is a stocked trout fishery, and fish can be found nearly the entire length of Cold Stream, above the dam. Below the dam, the Project 70 dike flows into Cold Stream and causes red iron staining that prevents fish from inhabiting the remaining 1.18 miles of Cold Stream.

Currently the Woodduck Chapter of Trout Unlimited (TU) is working with the Department to collect water data from the pollutional sources to Cold Stream in hopes of renovating the water quality below the dam. TU has been collecting monthly samples from 20-30 different sample points within the Cold Stream watershed that are associated with the pollutional loads. The water data they have collected has been used to perform the TMDL calculations. Based on the TU's work, Bureau of Abandoned Mines and Reclamation has built passive treatment ponds in Glass City in order to reduce the acidity loadings on Cold Stream from abandoned underground mines. TU has now turned their attention further downstream to the acid mine drainage sources of pollution to the Project 70 dike. In the spring of 2000, TU was awarded a Growing Greener grant to construct passive treatment ponds on the largest source of acidity to the Project 70 dike, the "Chiller" discharges.

In Glass City, above any influences of mining, Cold Stream and its tributaries are mildly buffered streams. Cold Stream has an upstream dam (upstream of Glass City) that has been historically used as a municipal water supply reservoir. As Cold Stream flows through Glass City, it is impacted from deep mine seepage's flowing from the west. The primary sources of this pollution have had passive treatment ponds built to neutralize this source of water. As Cold Stream flows northward, it is then impacted from abandoned deep mines and surface mines that are discharging acid mine drainage along the down dip edges, and causing vegetation kill zones. The surface water from these mines is being collected by the Project 70 dike and diverted parallel to Cold Stream, and then empties into Cold Stream below the dam. Although the Project 70 dike prevents the surface flow from these mines to directly enter Cold Stream, data collected by the Woodduck Chapter of Trout Unlimited and analyzed by the Department, indicates that some impacted groundwater is reaching Cold Stream opposite the dike. The impacts include a decrease in pH and alkalinity, and an increase in acidity, metals, and sulfates.

Underground mining on the Lower Kittanning and Clarion coal seams has occurred along Cold Stream, beginning in Glass City. An increasing number of deep mines occurred as you move downstream. The last deep mine along Cold Stream was below the stream surface. Some surface mining also occurred. These surface mines occurred along the down dip portions of the coals, between the deep mines and the croplines. This mining has allowed water to freely flow from the mine sites (both surface and underground) to Cold Stream. There are some unreclaimed surface mines, with highwalls and unreclaimed pits. These unreclaimed surface mines are a continuous source of acidity as weathering processes expose toxic strata. Another surface mine was mined in the late 1970s and early 1980s has been reclaimed, but the vegetation is very sparse, thus promoting infiltration through the toxic spoil.

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 acceptable 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 a 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, most of the TMDLs' component makeup will be Load Allocations (LA) that are specified above a point in the stream segment. All allocations will be specified as long-term average concentrations. These long-term average concentrations are expected to meet water-quality criteria 99% of the time. PA Title 25 Chapter 93.5(b) specifies that a minimum 99% level of protection is required. All metals criteria evaluated in these TMDLs are specified as total recoverable. The data used for this analysis report iron as total recoverable. The following table shows the applicable water-quality criteria for the selected parameters.

Table 2. Applicable Water Quality Criteria

Parameter	Criterion value (mg/l)	Total Recoverable/ Dissolved
Aluminum*	0.1 of the 96 hour LC 50 0.75	Total recoverable
Iron	1.50 0.3	Total recoverable dissolved
Manganese	1.00	Total recoverable
PH**	6 - 9	N/A

- *- This TMDL was developed using the value of 0.75 mg/l as the in-stream criterion for aluminum. This is the EPA national acute fish and aquatic life criterion for aluminum. Pennsylvania's current aluminum criterion is 0.1 mg/l of the 96-hour LC-50 and is contained in PA Title 25 Chapter 93. The EPA national criterion was used because the Department has recommended adopting the EPA criterion and is awaiting final promulgation of it.
- ** - 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). This condition is met when the net alkalinity is maintained above zero.

Computational Methodology

A TMDL equation consists of a Wasteload Allocation (WLA), Load Allocation (LA) and a Margin of Safety (MOS). The WLA is the portion of the load assigned to Point Sources. The LA is the portion of the load assigned to Non-point Sources (NPS). The MOS is applied to account for uncertainties in the TMDL. The MOS may be expressed implicitly (documenting conservative processes in the computations) or explicitly (setting aside a portion of the allowable load).

Regressions for flow and each parameter (Table 3.) were calculated for Cold Stream. Stations 20 and 12 did not have enough paired flow/parameter data points available. There are no significant correlations between source flows and pollutant concentrations. Analyses of the data could not determine a critical flow at any sample point.

Table 3. Cold Stream Regressions

Station	Flow vs			
	Al	Fe	Mn	Acidity
3	0.062	0.067	0.181	0.288
6	0.085	0.164	0.190	0.245
10	0.455	0.479	0.426	0.430
20	NA	NA	NA	NA
12	NA	NA	NA	NA
7	0.0022	0.420	0.294	0.208
8	0.109	0.428	0.418	0.193
9	0.0001	0.231	0.234	0.0020

For purposes of this TMDL, point sources are identified as permitted discharge points and nonpoint sources are other discharges from abandoned mine lands which includes tunnel discharges, seeps (although none were specifically identified), and surface runoff. Abandoned and reclaimed mine lands are treated in the allocations as nonpoint sources because there are no NPDES permits associated with these areas. As such, the discharges associated with these lands were assigned load allocations (as opposed to wasteload allocations).

For situations where all of the impact is due to non-point sources, the equations shown below are applied using data for a point in the stream. The load allocation (LA) 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 non-point sources, the same type of evaluation is used. The point source is mass balanced with the receiving stream, and sources will be reduced as necessary to meet the water quality criteria below the discharge

TMDLs and LAs for each parameter were determined using Monte Carlo simulation. For each source and pollutant, it was assumed that the observed data are log-normally distributed. The lognormal distribution has long been assumed when dealing with environmental data.

Each pollutant source was evaluated separately using @Risk[1]. Five thousand iterations were performed to determine the required percent reduction so that water-quality criteria will be met in-stream at least 99 percent of the time. For each iteration, the required percent reduction is:

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

[1] @ Risk - Risk Analysis and Simulation Add-in for "Micorsoft Excel", Palisade Corporation, Newfield , NY, 1990-1997

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 5000 iterations, so that the allowable long-term average (LTA) concentration is:

$$LTA = Mean * (1 - PR_{99})$$ where,   (2)

LTA = allowable LTA source concentration in mg/l (the mean of five thousand iterations, from the statistics portion of the @Risk program.)

An example calculation, including detailed tabular summaries of the Monte Carlo results is presented for the Lorberry Creek TMDL in Attachment D.

Cold Stream Watershed

The Cold Stream watershed (Attachment B) has an area of 21.22 square miles, and is over 10.4 miles long. The many tributaries above Glass City are unaffected by mining. Beginning in Glass City, both the tributaries (lower sections) and Cold Stream begin to show the impacts of mining. The concentrations of metals at the upstream point are very close to EPA drinking water standards, the pH is between 6.0 and 6.5. At the furthest downstream sample point on Cold Stream, the metals concentrations are as high as 3.11 mg/L for iron, 4.57 mg/L for manganese, and 1.82 mg/L for aluminum, while the pH is between 3.8 and 6.2.

Between the Chiller discharge and the Cold Stream dam, there are many discreet seepage sources of acid mine drainage. These have been identified by TU, and are currently being sampled on a monthly basis. These untreated sources emanate either from underground or surface mines, or both. All of the surface water from these sources are currently being collected by the Project 70 dike, and conveyed overland to below the Cold Stream dam. Based on the water quality of Cold Stream immediately above the dam, and from just below the dam, there is a dramatic increase in metals. This can be seen as red staining on the stream substrate the at base of the dam, which becomes dramatically darker red where the water from the dike enters Cold Stream.

The stream segment subject to this TMDL, the lower 1.18 miles of Cold Stream, is the most impacted, but this is due to the confluence with Project 70 dike effluent. The Project 70 dike extends 1.7 miles upstream of the confluence with Cold Stream. This dike prevents the highly acidic and high metals concentrated surface discharges of the coal mines from flowing directly into Cold Stream, further upstream of the dam.

Cold Stream TMDLs

Cold Stream Sample Point 3

The TMDL for Cold Stream Sample Point 3 consists of a load allocation to all of the area above sampling point 3 (Attachment B).

There is currently no entry for this segment on the Pa 303(d) list for impairment due to pH. Sample data at point 3 shows pH ranging between 6.0 and 6.5. This segment is net alkaline and pH will not be addressed as part of this TMDL. Upstream samples taken at sampling point 1 do not indicate mining impacts; pH at 1 ranges between 6.0 and 6.5 and the stream is also net alkaline at this point. The method and rationale for addressing pH is contained in Attachment C.

The load allocation for this stream segment was computed using water-quality sample data collected at sample point 3. The average flow, measured at sampling point 3 (44.68 MGD), is used for these computations.

An allowable long-term average in-stream concentration was determined at sample point 3 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. Table 4 shows the load allocations for this stream segment.

		Table 4. Cold Stream				
		Measured Sample Data		Allowable		Reduction Identified
Sample Point	Parameter	Conc (mg/l)	Load (lbs/day)	LTA conc (mg/l)	Load (lbs/day)	%
3						
	Al	0.32	118.1	0.13	49.6	58%
	Fe	0.37	139.5	0.16	60.0	57%
	Mn	0.12	45.4	0.12	45.4	0%
	Acidity	0.29	109.6	0.29	109.6	0%
	Alkalinity	14.92	5559.1			

The allowable loading values shown in Table 4 represent load allocations made at sample point 3.

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. 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.

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. The average of the flow measurements at sample point 3 were used to derive loading values for the TMDL.

Cold Stream Sample Point 6

The TMDL for Cold Stream Sample Point 6 consists of a load allocation to all of the area between sampling points 6 and 3 (Attachment B).

The existing and the allowable loading for sample point 6 for all parameters was determined. This was based on the sample data for this point and did not account for any load reductions already specified from upstream sources. The load reductions from sample point 3 represent the upstream load reductions. The upstream load reduction was subtracted from the existing load at sample point 6, and was compared to the allowable load at 6 for each parameter, to determine if any further reductions were needed at this point.

The existing and allowable loading values for this stream segment were computed using water-quality sample data collected at sampling point 6. The average flow, measured at sampling point 6 (51.97 MGD), is used for these computations.

This segment is not listed on the Pa 303(d) list for impairment due to pH. Sample data at point 6 shows pH ranging between 5.9 and 6.5. This segment is net alkaline and pH will not be addressed as part of this TMDL. The method and rationale for addressing pH is contained in Attachment C.

An allowable long-term average in-stream concentration was determined at sample point 6 for aluminum, iron, manganese and alkalinity. 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, five thousand 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.

		Table 5. Cold Stream			
		Measured Sample Data		Allowable	
Sample Point	Parameter	Conc (mg/l)	Load (lbs/day)	LTAConc (mg/l)	Load (lbs/day)
6					
	Al	0.20	88.5	0.20	88.5
	Fe	1.02	441.7	0.31	132.4
	Mn	0.23	100.4	0.16	70.1
	Acidity	1.00	433.4	1.00	433.4
	Alkalinity	14.69	6368.1		

The area of Cold Stream watershed upstream of sample point 6 is adversely affected by AMD and one or more allocations may be necessary at 6. In an effort to determine if there is a need for any allocations at this point the following procedure was used.

The loading reductions for sample point 3 show the total load that was removed from upstream sources. This value, for each parameter was then subtracted from the existing load at sample point 6. This value was then compared to the allowable load at sample point 6. Reductions at point 6 are necessary for any parameter that exceeded the allowable load at this point. Table 6. shows a summary of all loads that affect point 6. Table 7. illustrates the necessary reductions at point 6. The results of this analysis show that reductions for iron and manganese are necessary at this point.

Table 6. Summary of All Loads that Affect Sample Point 6				
	Al (#/day)	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
Cold Stream (Sample Point 3)				
load reduction=	68.6	79.5	0.0	0.0

Table 7. Necessary Reductions at Sample Point 6

	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at Sample Point 6	88.5	441.7	100.4	433.4
Total Load Reduction at Sample Point 3	68.6	79.5	0.0	0.0
Remaining Load (Existing Loads at 6 – TLR 3)	20.0	362.2	100.4	433.4
Allowable Loads at Sample Point 6	88.5	132.5	70.1	433.4
Percent Reduction	NA	63%	30%	0%
Additional Removal Required at 6	NA	229.7	30.2	0.0

The load allocation for this stream segment was computed using water-quality sample data collected at sample point 6 and the allowable loads from sample point 3. The average flow, measured at sample point 6, is used for these computations. The TMDL for 6 consists of load allocations for iron and manganese to all of the area between sample points 6 and 3. The Percent Reduction in Table 7, above, is calculated (refer to Table 7):

$$\left[1-\left(\frac{\text{Allowable Loads at 6}}{\text{Remaining Load (Existing Loads at 6 - TLR Sum}}\right)\right]\times 100\,\%$$

No additional loading reductions were necessary for aluminum and acidity.

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. 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.

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. The average flow, measured at sample point 6, is used for these computations.

Cold Stream Sample Point 10

The TMDL for Cold Stream Sample Point 10 consists of a load allocation to the area above sample point 10, to the head of the diversion ditch (Attachment B

This segment is not listed on the Pa 303(d) list for impairment due to pH. Sample data at point 10 shows pH ranging between 3.2 and 4.9. There are no samples upstream of sample point 10. The objective is to reduce acid loading to the stream, which will in turn raise the pH to the desired range. The alkalinity at sampling point 10 will be used in the evaluation. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see Table 2). The method and rationale for addressing pH is contained in Attachment C.

The load allocation for this stream segment was computed using water-quality sample data collected at sample point 10. The average flow, measured at sampling point 10 (3.97 MGD), is used for these computations.

An allowable long-term average in-stream concentration was determined at sample point 10 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. Table 8 shows the load allocations for this stream segment.

		Table 8. Cold Stream				
		Measured Sample Data		Allowable		Reduction Identified
Sample Point	Parameter	Conc (mg/l)	Load (lbs/day)	LTA conc (mg/l)	Load (lbs/day)	%
10						
	Al	7.34	243.0	0.22	7.3	97%
	Fe	6.98	230.9	0.28	9.3	96%
	Mn	11.62	384.5	0.23	7.7	98%
	Acidity	80.67	2669.8	0.81	26.7	99%
	Alkalinity	3.53	116.9			

The allowable loading values shown in Table 8 represent load allocations made at sample point 10.

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. 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.

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. The average of the flow measurements at sample point 3 were used to derive loading values for the TMDL.

Cold Stream Sample Point 20

The TMDL for Cold Stream Sample Point 20 consists of a load allocation to the area above sampling point 20 (Attachment B).

This segment is not listed on the Pa 303(d) list for impairment due to pH. Sample data at point 20 shows pH ranging between 2.9 and 4.7. The upstream samples at sample point 22 has pH ranging between 6.0 and 6.5. The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The alkalinity at sampling point 20 will be used in the evaluation because it is lower than at point 22. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see Table 2). The method and rationale for addressing pH is contained in Attachment C.

The load allocation for this stream segment was computed using water-quality sample data collected at sample point 20. The average flow, measured at sampling point 20 (6.9 MGD), is used for these computations.

An allowable long-term average in-stream concentration was determined at sample point 20 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. Table 9 shows the load allocations for this stream segment.

Table 9. Cold Stream

		Measured Sample Data		Allowable		Reduction Identified
Sample Point	Parameter	Conc (mg/l)	Load (lbs/day)	LTA conc (mg/l)	Load (lbs/day)	%
20						
	Al	6.56	378.6	0.13	7.6	98%
	Fe	1.50	86.5	0.15	8.7	90%
	Mn	4.75	274.0	0.14	8.2	97%
	Acidity	60.78	3505.4	1.22	70.1	98%
	Alkalinity	7.68	422.7			

The allowable loading values shown in Table 9 represent load allocations made at sample point 20.

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. 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.

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. The average of the flow measurements at sample point 20 were used to derive loading values for the TMDL.

Cold Stream Sample Point 12

The TMDL for Cold Stream Sample Point 12 consists of a load allocation to sampling point 12 (Attachment B). The existing and the allowable loading for sample point 12 for all parameters was determined

The existing and allowable loading values for this stream segment were computed using water-quality sample data collected at sampling point 12. The average flow, measured at sampling point 12 (0.55 MGD), is used for these computations.

This segment is not listed on the Pa 303(d) list for impairment due to pH and/or metals. Sample data at point 12 shows pH ranging between 2.5 and 3.4. There are no samples upstream of sample point 12. The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The alkalinity at sampling point 12 will be used in the evaluation. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see Table 2). The method and rationale for addressing pH is contained in Attachment C.

An allowable long-term average in-stream concentration was determined at sample point 12 for aluminum, iron, manganese and alkalinity. 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, five thousand 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. Table 10 shows the load allocations for this stream segment.

		Table 10. Cold Stream				
		Measured Sample Data		Allowable		Reduction Identified
Sample Point	Parameter	Conc (mg/l)	Load (lbs/day)	LTAConc (mg/l)	Load (lbs/day)	%
12						
	Al	22.24	102.1	0.22	1.0	99%
	Fe	163.65	751.7	0.33	1.5	100%
	Mn	6.76	31.0	0.37	1.7	95%
	Acidity	571.0	2622.7	0.0	0.0	100%
	Alkalinity	0.0	0.0			

The allowable loading values shown in Table 10. represent load allocations made at sample point 12.

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. 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.

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. The average flow, measured at sample point 12, is used for these computations.

Cold Stream Sample Point 7

The TMDL for Cold Stream Sample Point 7 consists of a load allocation to all of the area between sampling point 7 and 10 (Attachment B).

The existing and the allowable loading for sample point 7 for all parameters was determined. This was based on the sample data for this point and did not account for any load reductions already specified from upstream sources. The load reductions from sample points 10, 20 and 12 represent the upstream load reductions. The upstream load reduction was subtracted from the existing load at sample point 7, and was compared to the allowable load at 7 for each parameter, to determine if any further reductions were needed at this point.

The existing and allowable loading values for this stream segment were computed using water-quality sample data collected at sampling point 7. The average flow, measured at sampling point 7 (4.98 MGD), is used for these computations.

This segment is not listed on the Pa 303(d) list for impairment due to pH. Sample data at point 7 shows pH ranging between 3.1 and 4.2. There are no samples upstream of sample point 7. The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The alkalinity at sampling point 7 will be used in the evaluation. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see Table 2). The method and rationale for addressing pH is contained in Attachment C.

An allowable long-term average in-stream concentration was determined at sample point 7 for aluminum, iron, manganese and alkalinity. 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, five thousand 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

		Table 11. Cold Stream			
		Measured Sample Data		Allowable	
Sample Point	Parameter	Conc (mg/l)	Load (lbs/day)	LTAConc (mg/l)	Load (lbs/day)
7					
	Al	10.61	440.5	0.11	4.4
	Fe	28.19	1169.6	0.28	11.7
	Mn	7.72	320.3	0.23	9.6
	Acidity	140.00	5809.6	0.14	5.8
	Alkalinity	0.23	9.5		

The area of Cold Stream watershed upstream of sample point 7 is adversely affected by AMD and one or more allocations may be necessary at 7. In an effort to determine if there is a need for any allocations at this point the following procedure was used.

The loading reductions for sample points 10, 20 and 12 show the total load that was removed from upstream sources. This value, for each parameter was then subtracted from the existing load at sample point 7. This value was then compared to the allowable load at sample point 7. Reductions at point 7 are necessary for any parameter that exceeded the allowable load at this point. Table 12. shows a summary of all loads that affect point 7. Table 13. illustrates the necessary reductions at point 7. The results of this analysis show that reductions for iron are necessary at this point.

Table 12. Summary of All Loads that Affect Sample Point 7				
Cold Stream TLR (Sample Points 10, 20 & 12)	**Al (#/day)**	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
load reduction=	707.9	1049.6	671.9	8701.1

Table 13. Necessary Reductions at Sample Point 7

	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at Sample Point 7	440.5	1169.6	320.3	5809.6
Total Load Reduction Sum (10 +20+ 12)	707.9	1049.6	671.9	8701.1
Remaining Load (Existing Loads at 7 – TLR Sum)	NA	120.0	NA	NA
Allowable Loads at Sample Point 7	4.4	11.7	9.6	5.8
Percent Reduction	NA	90%	NA	NA
Additional Removal Required at 7	NA	108.3	NA	NA

The load allocation for this stream segment was computed using water-quality sample data collected at sample point 7 and the allowable loads from sample points 10, 20 and the additional removal at sample point 12. The average flow, measured at sample point 7, is used for these computations. The TMDL for 7 consists of load allocations for iron to all of the area above sample point 7. The Percent Reduction in Table 12, above, is calculated (refer to Table 12):

$$\left[1-\left(\frac{\text{Allowable Loads at 7}}{\text{Remaining Load (Existing Loads at 7 - TLR Sum}}\right)\right]\times 100\,\%$$

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

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. 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.

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. The average flow, measured at sample point 7, is used for these computations.

Cold Stream Sample Point 8

The TMDL for Cold Stream Sample Point 8 consists of a load allocation to all of the area between sampling points 8 and 7 (Attachment B).

The existing and the allowable loading for sample point 8 for all parameters was determined. This was based on the sample data for this point and did not account for any load reductions already specified from upstream sources. The load reductions from sample points 3, additional reductions at 6, 10, 20, 12 and the additional reductions at 7 represent the upstream load reductions. The upstream load reduction was subtracted from the existing load at sample point 8, and was compared to the allowable load at 8 for each parameter, to determine if any further reductions were needed at this point.

The existing and allowable loading values for this stream segment were computed using water-quality sample data collected at sampling point 8. The average flow, measured at sampling point 8 (53.25 MGD), is used for these computations.

This segment is not listed on the Pa 303(d) list for impairment due to pH. Sample data at point 8 shows pH ranging between 3.9 and 6.3. There are no samples upstream of sample point 8. The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The alkalinity at sampling point 8 will be used in the evaluation. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see Table 2). The method and rationale for addressing pH is contained in Attachment C.

An allowable long-term average in-stream concentration was determined at sample point 8 for aluminum, iron, manganese and alkalinity. 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, five thousand 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

		Table 14. Cold Stream			
		Measured Sample Data		Allowable	
Sample Point	Parameter	Conc (mg/l)	Load (lbs/day)	LTAConc (mg/l)	Load (lbs/day)
8					
	Al	1.00	444.5	0.24	106.7
	Fe	3.08	1366.0	0.46	204.9
	Mn	1.15	510.9	0.22	97.1
	Acidity	15.52	6890.4	2.02	895.4
	Alkalinity	7.44	3305.0		

The area of Cold Stream watershed upstream of sample point 8 is adversely affected by AMD and one or more allocations may be necessary at 8. In an effort to determine if there is a need for any allocations at this point the following procedure was used.

The loading reductions for sample points 3, additional removal at 6, 10, 20, 12 and the additional removal at 7 show the total load that was removed from upstream sources. This value, for each parameter was then subtracted from the existing load at sample point 8. This value was then compared to the allowable load at sample point 8. Reductions at point 8 are necessary for any parameter that exceeded the allowable load at this point. Table 15. shows a summary of all loads that affect point 12. Table 16. illustrates the necessary reductions at point 8. The results of this analysis show that no reductions for any parameters are necessary at this point.

Table 15. Summary of All Loads that Affect Sample Point 8				
Cold Stream (TLR) (Sum of 3, AR6, 10, 20, 12, & AR7)	**Al (#/day)**	**Fe (#/day)**	**Mn (#/day)**	**Acidity (#/day)**
load reduction=	776.4	1467.1	702.1	8701.1

Table 16. Necessary Reductions at Sample Point 8

	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at Sample Point 8	444.4	1366.0	510.9	6890.4
Total Load Reduction Sum (3+AR6+10+20+12+AR7)	776.4	1467.1	702.1	8701.1
Remaining Load (Existing Loads at 8 – TLR Sum)	NA	NA	NA	NA
Allowable Loads at Sample Point 8	106.7	204.9	97.1	895.4
Percent Reduction	NA	NA	NA	NA
Additional Removal Required at 8	NA	NA	NA	NA

The load allocation for this stream segment was computed using water-quality sample data collected at sample point 8 and the allowable loads from sample points 3,AR6, 10, 20, 12 and AR7. The average flow, measured at sample point 8, is used for these computations. The TMDL for 8 consists of load allocations for iron and manganese to all of the area above sample point 8. The Percent Reduction in Table 8, above, is calculated (refer to Table 16):

$$\left[1-\left(\frac{\text{Allowable Loads at 8}}{\text{Remaining Load (Existing Loads at 8 - TLR Sum}}\right)\right]\times 100\,\%$$

No additional loading reductions were necessary for any of the parameters at sample point 8.

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. 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.

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. The average flow, measured at sample point 7, is used for these computations.

Cold Stream Sample Point 9

The TMDL for Cold Stream Sample Point 3 consists of a load allocation to all of the area between sampling points 9 and 8 (Attachment B).

Allocations were calculated for the sample point down stream of 8 (9) and it too showed no additional loading reductions were necessary for any of the parameters at sample point 9. The necessary reductions at sample point 9, Table 17, are below.

Table 17. Necessary Reductions at Sample Point 9

	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at Sample Point 9	284.7	804.4	442.0	4249.0
Total Load Reduction Sum (3+AR6+10+20+12+AR7+AR8)	776.4	1467.1	702.1	8701.1
Remaining Load (Existing Loads at 9 – TLR Sum)	NA	NA	NA	NA
Allowable Loads at Sample Point 9	79.7	209.1	73.6	849.7
Percent Reduction	NA	NA	NA	NA
Additional Removal Required at 9	NA	NA	NA	NA

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. 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.

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. The average flow, measured at sample point 7, is used for these computations.

Summary of Allocations

This TMDL will focus remediation efforts on the identified numerical reduction targets for each sample point or stream segment. As changes occur in the watershed, the TMDL may be re-evaluated to reflect current conditions.

Table 18 presents the estimated reductions identified for all points in the watershed.

Table 18. Summary Table – Cold Stream Watershed

Station		Measured Sample Data		Allowable		Reduction Identified
	Parameter	Conc (mg/l)	load (lbs/day)	LTA Conc (mg/l)	load (lbs/day)	%
3	**In-Stream monitoring point located on Cold Stream**					
	Al	0.32	118.1	0.13	49.6	58%
	Fe	0.37	139.5	0.16	60.0	57%
	Mn	0.12	45.4	0.12	45.4	0%
	Acidity	0.29	109.6	0.29	109.6	0%
	Alkalinity	14.92	5559.1			
6	**In-stream monitoring point located on Cold Stream**					
	Al	0.20	88.5	NA	NA	0%
	Fe	1.02	441.7	NA	229.7	63%
	Mn	0.23	100.4	NA	30.2	30%
	Acidity	1.00	433.4	NA	0.0	0%
	Alkalinity	14.69	6368.1			
10	**In-stream sampling point located on Cold Stream**					
	Al	7.34	243.0	0.22	7.3	97%
	Fe	6.98	230.9	0.28	9.2	96%
	Mn	11.62	384.5	0.23	7.7	98%
	Acidity	80.67	2669.8	0.81	26.7	99%
	Alkalinity	3.53	116.9			

Station		Table 18. Summary Table – Cold Stream Watershed				
		Measured Sample Data		Allowable		Reduction Identified
	Parameter	Conc (mg/l)	load (lbs/day)	LTA Conc (mg/l)	load (lbs/day)	%
20	**In-stream sampling point located on Cold Stream**					
	Al	6.56	378.6	0.13	7.6	98%
	Fe	1.50	86.5	0.15	8.7	90%
	Mn	4.75	274.0	0.14	8.2	97%
	Acidity	60.78	3505.4	1.22	70.1	98%
	Alkalinity	7.68	442.7			
12	**In-stream sampling point located on Cold Stream**					
	Al	22.24	102.1	0.22	1.0	99%
	Fe	163.65	751.7	0.33	1.5	100%
	Mn	6.76	31.0	0.37	1.7	95%
	Acidity	571.0	2622.7	0.0	0.0	100%
	Alkalinity	0.0	0.0			
7	**In-stream sampling point located on Cold Stream**					
	Al	10.61	440.5	NA	NA	NA
	Fe	28.19	1169.6	NA	108.3	90%
	Mn	7.72	320.3	NA	NA	NA
	Acidity	140.0	5809.5	NA	NA	NA
	Alkalinity	0.23	9.5			
8	**In-stream sampling point located on Cold Stream**					
	Al	1.00	444.5	NA	NA	NA
	Fe	3.08	1366.0	NA	NA	NA
	Mn	1.15	510.9	NA	NA	NA
	Acidity	15.52	6890.4	NA	NA	NA
	Alkalinity	7.44	3305.0			
9	**In-stream sampling point located on Cold Stream**					
	Al	0.79	284.7	NA	NA	NA
	Fe	2.22	804.4	NA	NA	NA
	Mn	1.22	442.0	NA	NA	NA
	Acidity	11.75	4249.0	NA	NA	NA
	Alkalinity	8.97	3243.9			

All allocations are load allocations to non-point sources. The margin of safety for all points is applied implicitly through the methods used in the computations.

Recommendations

In the study area, nearly all of the discharges flowing into the Project 70 dike need to be remediated. The goal is to neutralize the acid production from the mine sites that is reaching Cold Stream, via the Project 70 dike. Some of the water that is flowing through the surface mines and underground mines is reaching Cold Stream via groundwater. The ground water component of this polluted water would be the most difficult to remediate. The surface water sources are primarily from cropline seepages and failed airshaft seals from the underground mines. There are some abandoned highwalls, and poorly vegetated surface mine sites that also need remediated.

Passive treatment of discharges that flow to the Project 70 dike should be considered. Discharge-specific assessments are recommended. These assessments will consider all technical factors in determining whether passive treatment is practical, and which type would be best suited for a specific discharge. Considerations should be given to water chemistry, topographical setting, and upfront and longterm costs, including maintenance.

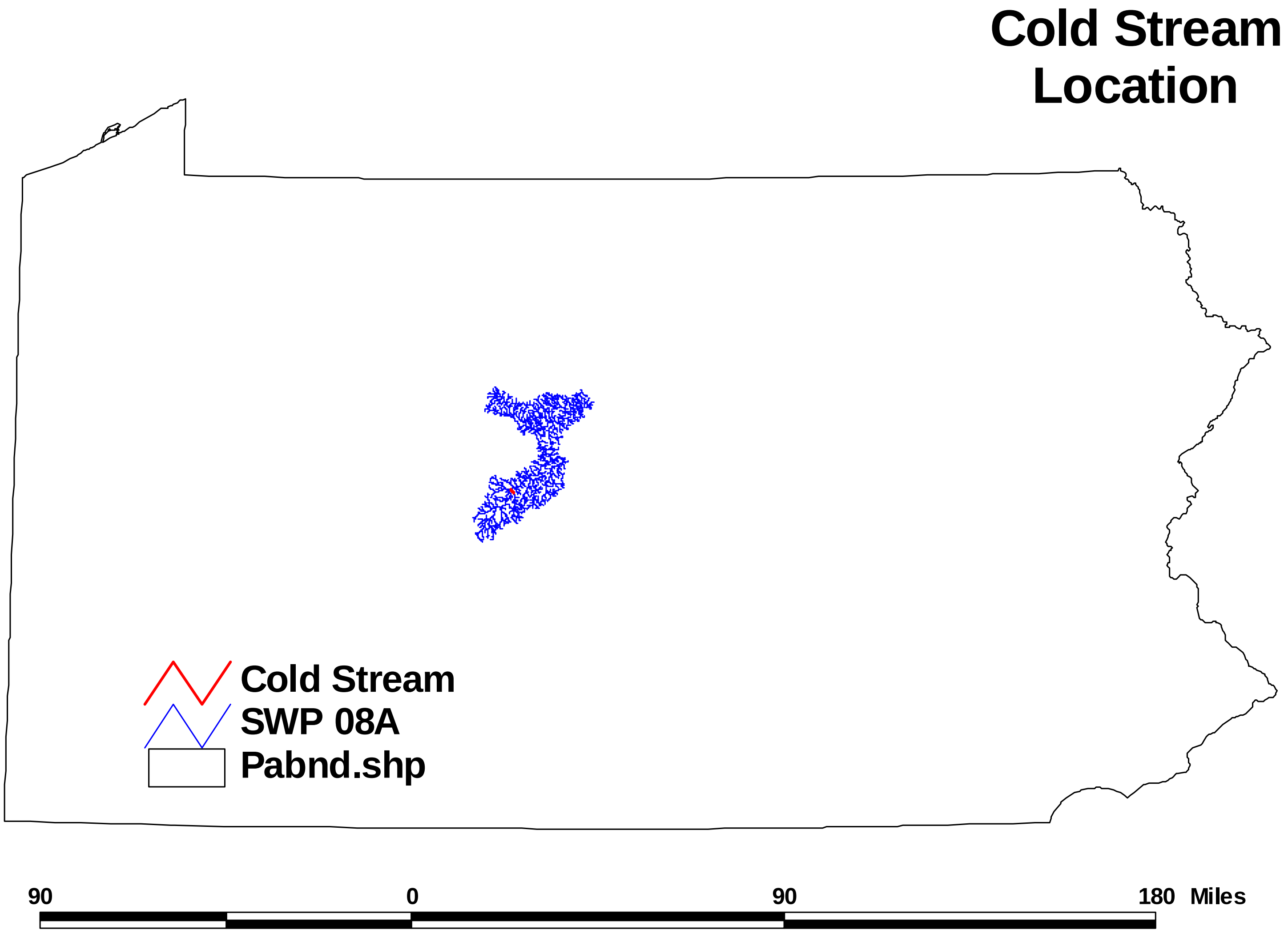
Abandoned highwall and pits need to be reclaimed to eliminate the constant weathering of fresh toxic materials. The acid and metals production from these materials is then washed downstream to the dike and Cold Stream. The unreclaimed highwalls are also a safety hazard. Once the highwalls and pits are reclaimed, the sites will then need to be properly revegetated. The Hawk Run District Office has had tremendous success with the use of biosolids on sites that have little to no topsoil. The use of biosolids has a secondary benefit of increasing the pH of the water that infiltrates through the reclaimed site. This in effect would cut off the flow of acid water through toxic material, which has been shown to compound the production of acid mine drainage. This is similar to putting out a fire by removing oxygen.

Public Participation

Notice of the draft TMDLs was published in the *PA Bulletin* and The Progress, Clearfield, PA with a 60-day comment period ending February 13, 2001 provided. A public meeting with watershed residents was held on January 11, 2001 at the DEP, Hawk Run District Mining Office to discuss the TMDLs. Notice of final TMDL approval will be posted on the Department website.

Attachment A

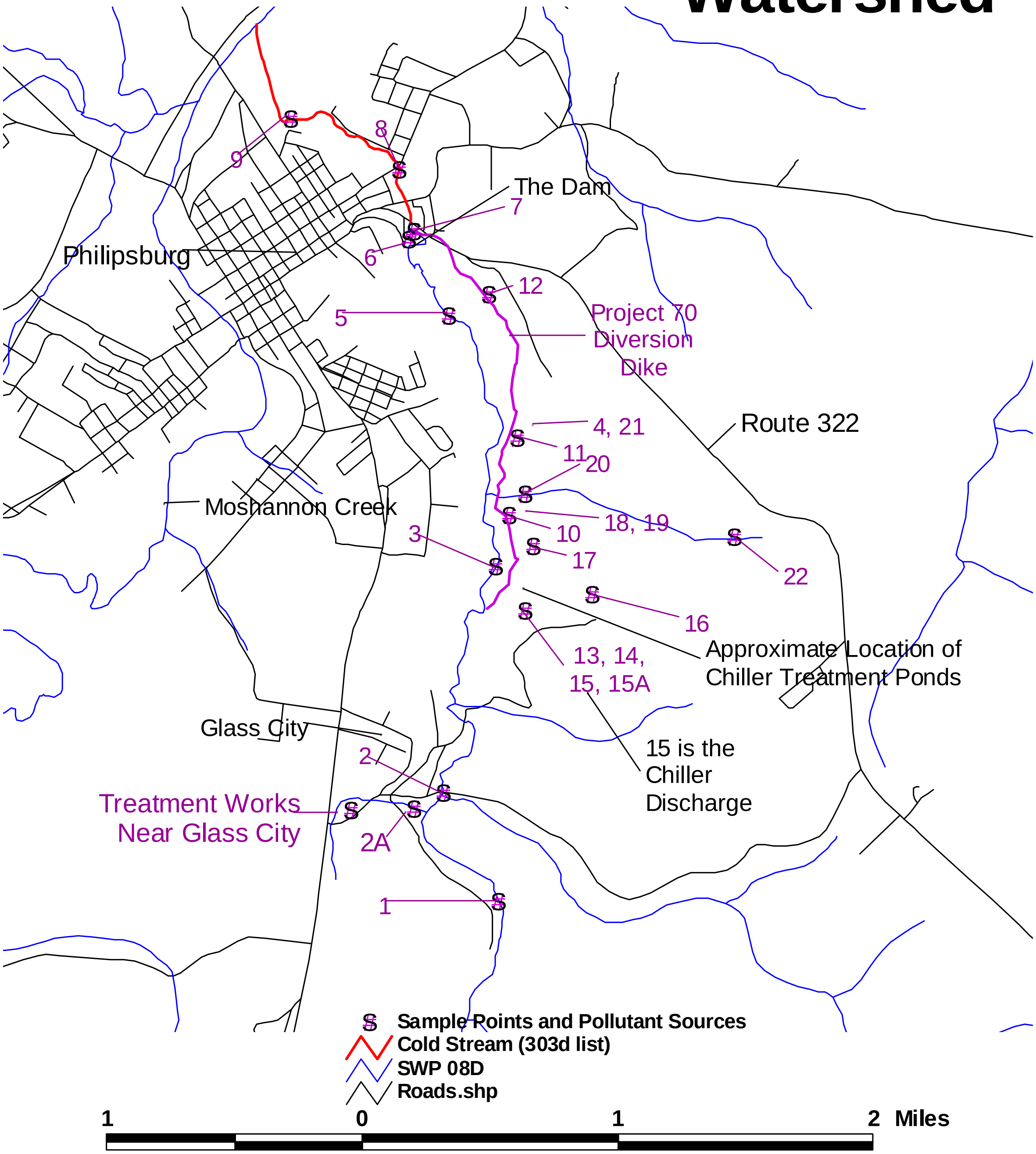
Location of Cold Stream

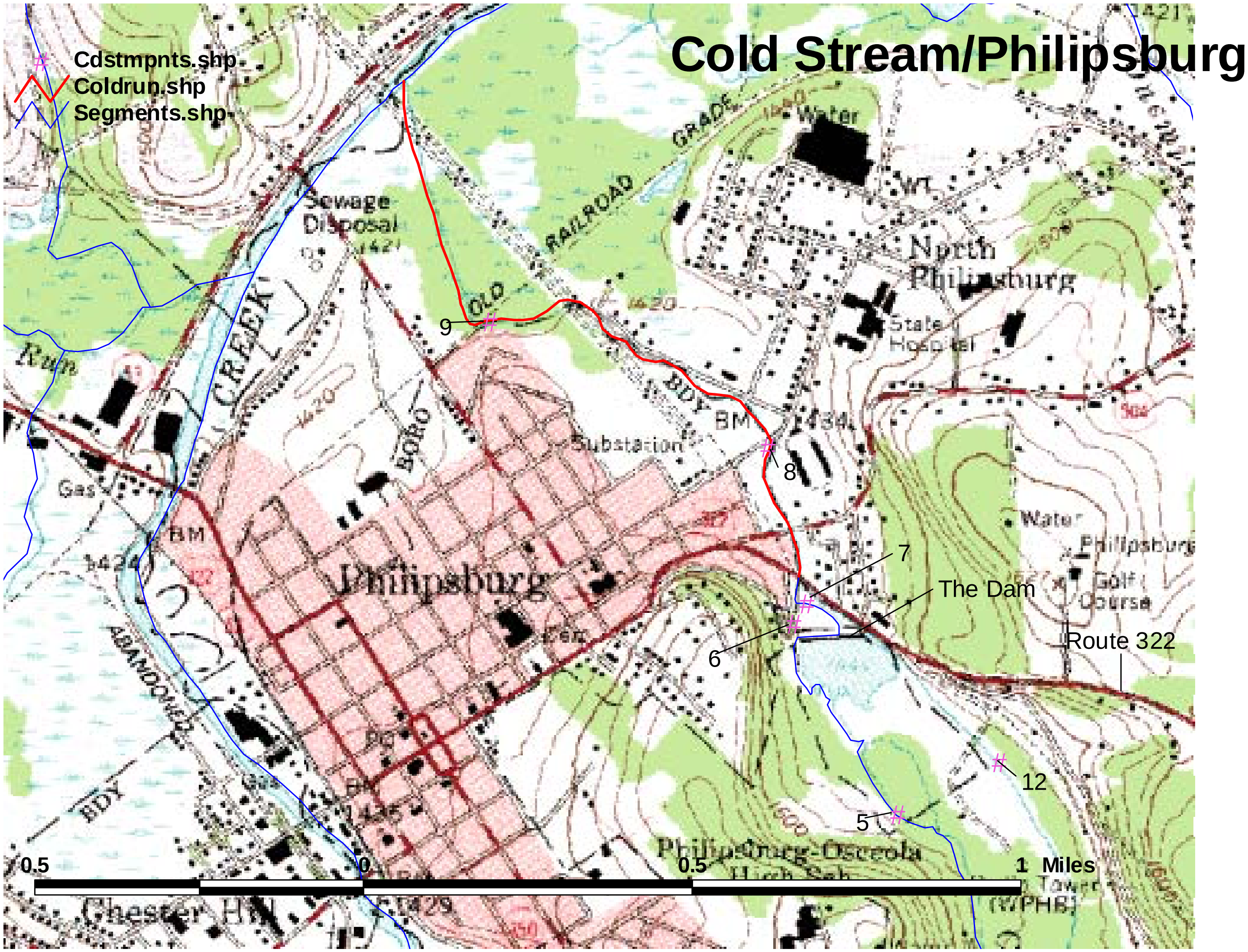

Cold Stream
Location
Cold Stream
SWP 08A
Pabnd.shp
90
0
90
180 Miles

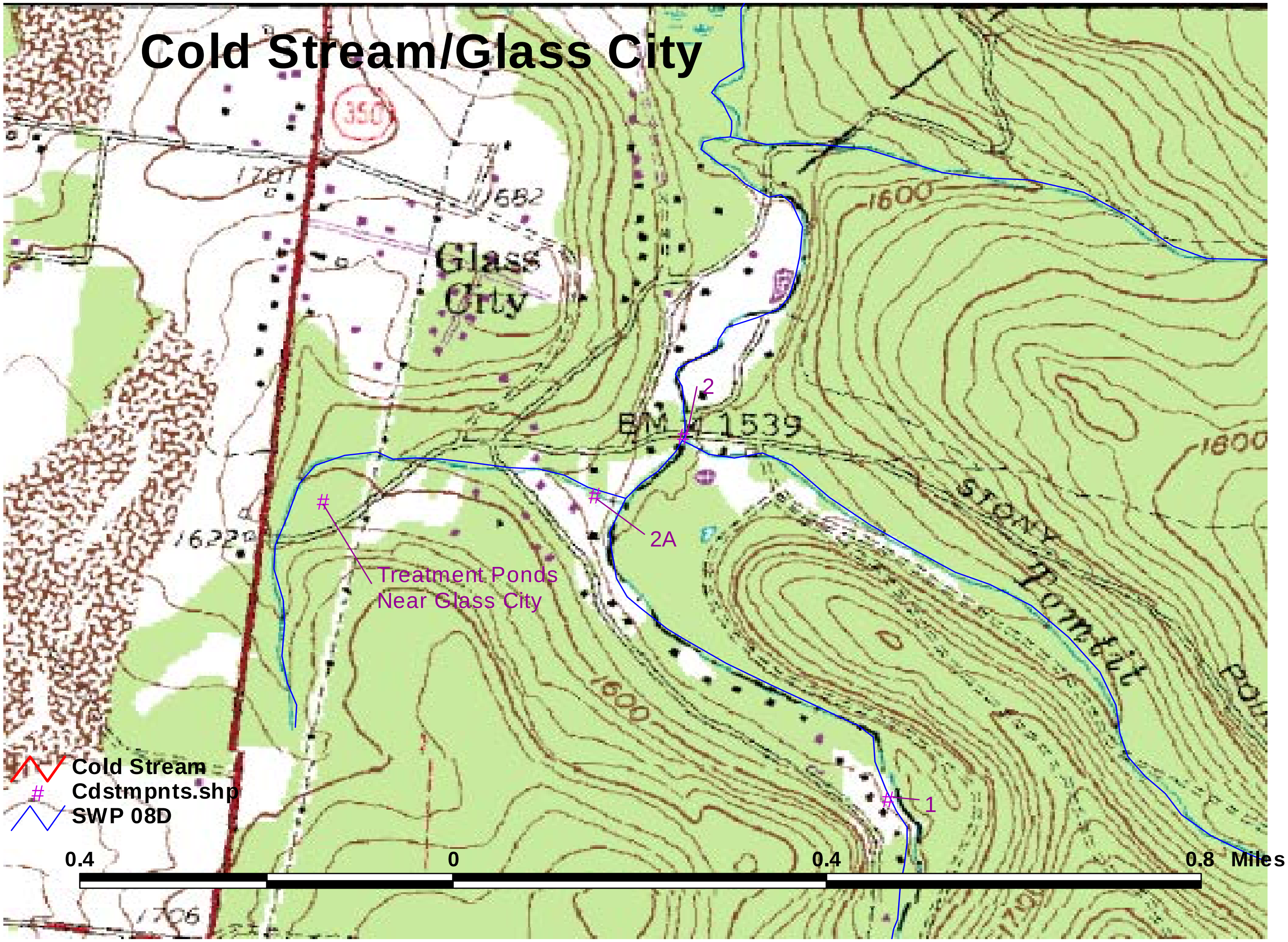
Attachment B

Cold Stream Watershed

Cold Stream Watershed




Cold Stream/Philipsburg
Cdstmpnts.shp
Coldrun.shp
Segments.shp
9
8
7
The Dam
6
Route 322
12
5
0.5
0
0.5
1 Miles


Cold Stream/Glass City
Glass City
BM 1539
2
2A
1
Treatment Ponds
Near Glass City
Stony Tomtit
Cold Stream
Cdstmpnts.shp
SWP 08D
0.4
0
0.4
0.8 Miles

Attachment C

The pH Method

Method for Addressing 303(d) listings for pH

There has been a great deal of research conducted on the relationship between alkalinity, acidity, and pH. Research published[2] by the PA Department of Environmental Protection demonstrates, that by plotting net alkalinity vs. pH for 794 mine sample points, where net alkalinity is positive (greater or equal to zero), the pH range is most commonly 6 to 8, which is within the EPA's acceptable range of 6 to 9, and meets Pennsylvania water quality criteria in Chapter 93. The included graph (page 3) presents the nonlinear relationship between net alkalinity and pH. The nonlinear positive relation between net alkalinity and pH indicates that pH generally will decline as net alkalinity declines and vice versa; however, the extent of pH change will vary depending on the buffering capacity of solution. Solutions having near-neutral pH ($6 < pH < 8$) or acidic pH ($2 < pH < 4$) tend to be buffered to remain in their respective pH ranges.[3] Relatively large additions of acid or base will be required to change their pH compared to poorly buffered solutions characterized by intermediate pH ($4 < pH < 6$) where the correlation between net alkalinity and pH is practically zero.

The parameter of pH, a measurement of hydrogen ion acidity presented as a negative logarithm of effective hydrogen ion concentration, is not conducive to standard statistics. Additionally pH does not measure latent acidity that can be produced from hydrolysis of metals. For these reasons PA is using the following approach to address the stream impairments noted on the 303(d) list due to pH. The concentration of acidity in a stream is partially dependent upon metals. For this reason, it is extremely difficult to predict the exact pH values which would result from treatment of acid 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 able to measure the reduction of acidity. When acidity in a stream is neutralized or is restored to natural levels, pH will be acceptable (>6.0). 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 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 PA’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 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. In other words, if the pH in an unaffected portion of a stream is found to be naturally occurring below 6, then the average net alkalinity for that portion of the stream will become the criterion for the polluted portion. This “natural net alkalinity level” will be the criterion to

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[2] 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.

[3] Stumm, Werner, and Morgan, J.J., 1996, Aquatic Chemistry--Chemical Equilbria and Rates in Natural Waters (3rd ed.), New York, Wiley-Interscience, 1022p.

which a 99% 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 meet a minimum net alkalinity of zero.

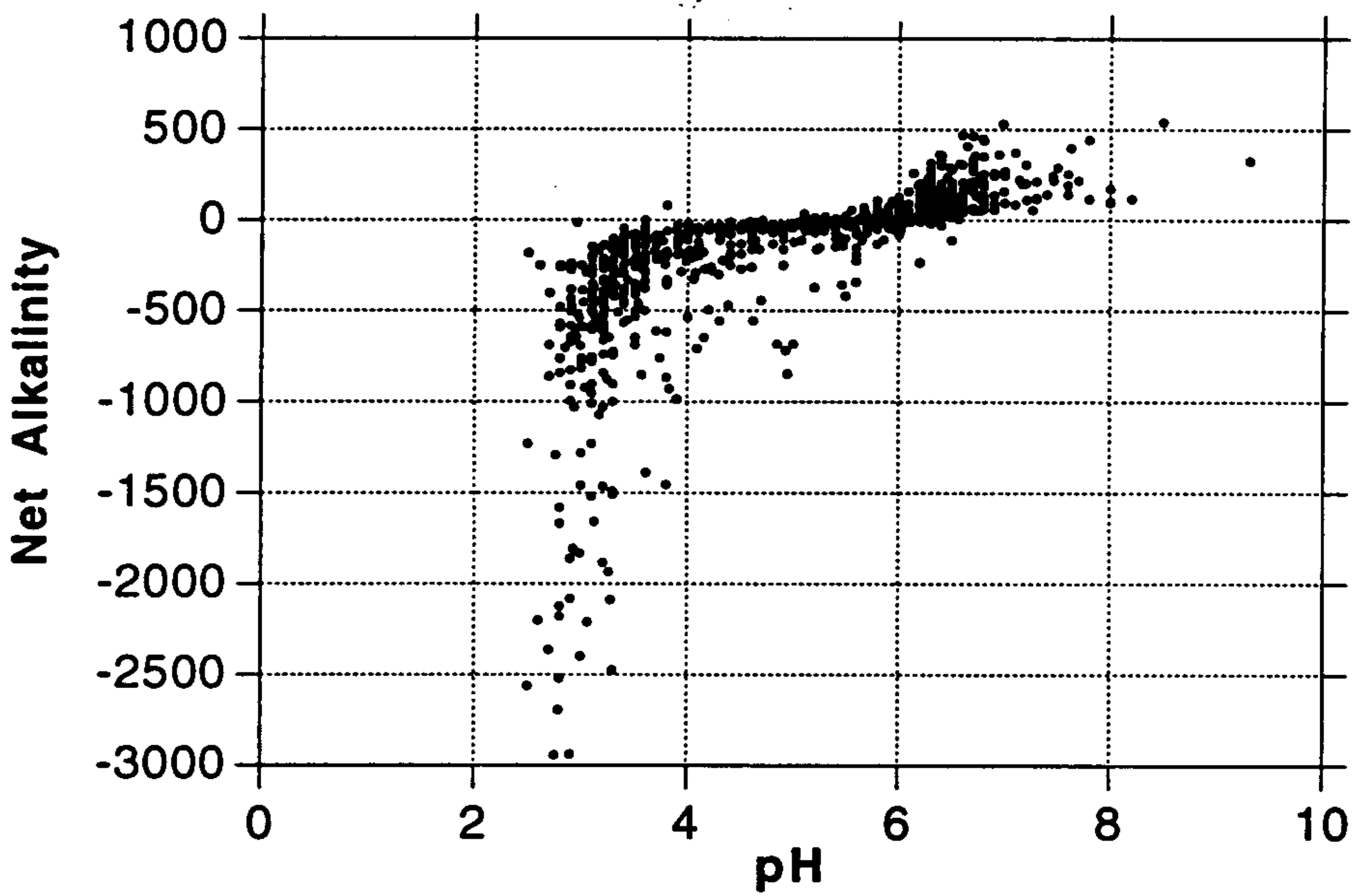

Figure 1.2, Graph C, net alkalinity vs. pH, page 1-5, of Coal Mine Drainage Prediction and Pollution Prevention in PA

Attachment D

Example Calculation: Lorberry Creek

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% 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, and 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 the 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 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 L-1 discharge. However, there is additional flow from overland runoff and one unnamed tributary not impacted by mining. We believe it is reasonable to assume the additional flow provides assimilation capacity below the L-1 discharge and no further analysis is needed downstream.

The calculations are detailed in the following section and Table 9 shows the allocations made on Lorberry Creek

1. A series of 4 equations were 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

	Field Description	Equation	Explanation
1	Swat-04 initial Concentration Value (equation 1A)	= Risklognorm(mean,StDev)	This simulates the existing concentration of the sampled data.
2	Swat-04 % Reduction (from the 99^{th} percentile of PR)	= (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 - %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 99^{th} percentile value of this computed field.

2. The reduction target (PR) was computed taking the 99th percentile value of 5000 iterations of the equation in row 4 of Table 9. 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 then used as the % reduction in the equation in row 3. It was tested by checking that the water quality criterion for each metal was achieved at least 99% of the time. This is how the estimated percent reduction necessary for each metal was verified. The following table shows, in boldface type, the percent of the time criteria for each metal was achieved during 5000 iterations of the equation in row 3 of Table 9.

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. The following two tables 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. The following table 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 Conc From L-1	C_{L1}
Concentration below L-1 discharge	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

Q_{swat04} = RiskCumul(min,max,bin range,cumulative percent of occurrence)

The RiskCumul function takes 4 arguments: minimum value, maximum value, the bin range from the histogram, cumulative percent of occurrence)

The flow at Swat-11 was randomized using the equation developed by the regression analysis with point Swat-04.

$Q_{swat11} = Q_{swat}04 \times 0.142 + 0.088$

The mass balance equation is as follows:

$$Cstumps = ((Q_{swat04} * C_{swat04}) + (Q_{swat11} * C_{swat11}))/(Q_{swat04}+Q_{swat11})$$

This equation was simulated through 5000 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 the following table.

Table 7. Verification of Meeting WQ 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%**

4. The mass balance was then expanded to determine if any reductions would be necessary at the L-1 (Shadle discharge).

   The L-1 discharge originated in 1997 and there are very little data 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. We currently do not have data for effluent from the settling pond.

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

Table 8 Shadle 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 was not any means to establish a correlation with point Swat-04.

   The same set of four equations used for point Swat-04 were set up for point L-1. The following equation was used for evaluation of point L-1.

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

This equation was simulated through 5000 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 % reduction in aluminum concentration is needed for point L-1.

The following table shows the simulation results of the equation above

Table 9. Verification of Meeting WQ 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%**

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

		Table 10. Lorberry Creek				
		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	0%
	Mn	0.09	0.27	0.09	0.27	0%
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 is made to the Rowe Tunnel abandoned discharge for the three metals listed, and that a wasteload allocation is made to the L-1 discharge for aluminum. There is no TMDL for metals required for Stumps Run 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. The 99% level of protection is designed to protect for the extreme event so we felt it 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. Our 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 E

Data Used To Calculate the TMDL

Data Table 1. Cold Stream Sample Point 3								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1/18/98	586159	6.10	11.40	2.00	20.00	0.10	0.03	0.20
2/18/98	330003	6.10	11.20	0.00	20.00	0.53	0.08	0.41
3/17/98	219350	6.10	11.60	0.00	20.00	0.24	0.13	0.20
4/15/98	244233	6.00	14.40	3.00	20.00	0.20	0.05	0.22
5/20/98	230543	6.20	13.40	0.00	20.00	0.18	0.03	0.20
6/17/98	163105	6.40	15.60	0.00	20.00	0.25	0.05	0.20
7/15/98	39145	6.40	17.60	0.00	20.00	0.05	0.05	0.20
8/19/98	20180	6.40	17.60	0.00	20.00	0.10	0.08	0.20
9/21/98	21171	6.40	17.80	0.00	20.00	3.79	0.61	1.80
10/15/98	1725	6.30	19.20	0.00	20.00	0.32	0.13	0.24
11/19/98	2061	6.40	16.40	0.00	20.00	0.08	0.21	0.20
12/18/98		6.20	14.20	0.00	20.00	0.02	0.27	0.20
1/19/99		6.10	16.00	0.00	28.00	0.25	0.33	0.27
2/17/99	186891				20.00	0.05	0.02	0.20
3/19/99	176969	6.20	13.40	0.00	20.00	0.36	0.06	0.37
4/19/99	238862	6.40	12.40	0.00	20.00	0.05	0.02	0.20
5/20/99		6.00	15.20	0.00	20.00	0.08	0.03	0.20
6/16/99	76455	6.50	16.20	0.00	20.00	0.09	0.04	0.20
7/20/99	discontinued							
Mean	169123	6.25	14.92	0.29	20.44	0.37	0.12	0.32
Std				0.85	1.88	0.86	0.15	0.37

Data Table 2. Cold Stream Sample Point 6								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1/18/98	180329	6.10	11.80	2.00	20.00	0.29	0.04	0.20
2/18/98	414036	6.20	11.60	1.20	20.00	0.57	0.12	0.24
3/17/98	317929	6.00	11.20	0.00	20.00	0.24	0.05	0.20
4/15/98	708169	6.00	14.40	0.80	20.00	0.32	0.07	0.20
5/20/98	451937	6.40	13.20	1.00	20.00	0.18	0.05	0.20
6/17/98	126899	6.40	17.40	0.00	20.00	0.59	0.13	0.20
7/15/98	19012	6.40	18.40	0.00	20.00	0.53	0.11	0.20
8/19/98	60186	6.50	22.00	0.00	20.00	0.93	0.14	0.20
9/21/98	57087	6.40	18.06	0.00	20.00	1.31	0.17	0.20
10/15/98		6.30	16.40	0.00	78.00	1.40	0.14	0.20
11/19/98	9557	6.20	15.40	0.00	42.00	1.36	0.38	0.20
12/18/98		6.10	12.40	2.80	31.00	1.44	0.65	0.20
1/19/99		5.80	11.20	7.00	61.00	3.65	1.17	0.20
2/17/99	308602	6.20	13.60	0.00	20.00	0.25	0.05	0.20
3/19/99	264318	6.00	11.20	0.00	20.00	0.32	0.08	0.20
4/19/99	15728	6.30	12.20	0.00	20.00	0.13	0.04	0.20
5/20/99	65586	6.10	15.60	0.00	20.00	0.37	0.10	0.20
6/16/99	71358	6.50	16.80	0.00	20.00	0.66	0.15	0.20
7/20/99	76455	6.40	19.40	0.00	22.00	2.42	0.16	0.20
8/18/99		5.90	11.60	5.20	76.00	3.42	0.84	0.25
Mean	196699	6.21	14.69	1.00	29.50	1.02	0.23	0.20
Std				1.93	19.17	1.04	0.30	0.01

Data Table 3. Cold Stream Sample Point 10								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1/18/98								
2/18/98								
3/17/98								
3/25/98		3.80	0.00	50.00	97.00	1.48	4.25	5.19
4/15/98	49838	4.00	4.40	44.00	73.00	1.08	3.33	3.90
5/20/98	9232	4.00	2.60	38.00	77.00	1.37	3.42	3.86
6/17/98	11026	3.90	0.00	48.00	120.00	2.55	4.92	4.17
7/15/98	2835	3.50	0.00	98.00	168.00	6.20	9.77	7.40
8/19/98	1214	3.40	0.00	138.00	268.00	7.96	16.60	11.80
9/21/98	1092	3.20	0.00	222.00	398.00	12.60	28.40	14.80
10/15/98	1402	3.30	0.00	160.00	437.00	14.00	25.30	14.30
11/19/98		3.20	0.00	188.00	512.00	21.40	28.20	15.50
12/18/98		3.30	0.00	216.00	629.30	31.20	33.70	15.90
1/19/99		3.60	0.00	86.00	186.00	6.93	17.10	9.46
2/17/99	26866	4.50	7.00	24.00	71.00	1.04	2.98	3.18
3/19/99	27184	4.40	7.00	28.00	80.00	0.88	3.10	3.26
4/19/99	19519	4.50	7.40	26.00	66.00	0.89	2.54	3.08
5/20/99		4.70	8.40	19.80	91.00	1.35	3.95	5.28
6/16/99		4.90	9.40	16.20	106.00	2.65	3.87	3.95
7/20/99		4.70	8.20	20.00	177.20	3.48	6.16	3.14
8/18/99		4.90	9.20	30.00	292.00	8.52	11.50	4.00
Mean	15021	3.99	3.53	80.67	213.80	6.98	11.62	7.34
Std				71.94	172.59	8.29	10.58	4.87

Data Table 4. Cold Stream Sample Point 20								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1/18/98								
2/18/98								
3/7/98	1672	4.70	9.20	20.00	48.00	0.11	2.08	2.74
3/17/98								
3/25/98								
4/15/98		4.70	10.40	24.00	36.00	0.11	2.15	2.76
5/20/98		4.50	7.60	34.00	23.00	0.17	3.08	4.38
6/17/98	245	4.80	8.00	10.20	61.00	0.02	1.32	0.97
7/15/98	0							
8/19/98	0							
9/21/98	0							
10/15/98	0							
11/19/98	0							
12/16/98								
1/20/99								
2/17/99	282528	4.60	8.20	20.00	91.00	0.24	2.53	3.63
3/19/99		4.90	10.60	12.00	68.00	0.10	1.52	1.88
4/19/99	3495	4.60	7.40	24.00	101.00	0.06	2.42	3.26
5/20/99		2.90	0.00	342.00	714.00	11.20	22.90	32.90
6/16/99	0							
7/20/99	0							
Mean	26176	4.46	7.67	60.77	142.75	1.50	4.75	6.56
Std				113.87	232.30	3.92	7.35	10.69

Data Table 5. Cold Stream Sample Point 12								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
3/25/98		2.60	0.00	498.00	445.00	69.60	5.73	25.70
4/15/98		2.80	0.00	368.00	409.00	51.90	4.16	18.30
5/20/98	1877	2.70	0.00	466.00	500.00	70.40	5.18	24.10
6/17/98	1877	2.80	0.00	300.00	284.00	38.30	3.91	16.30
7/15/98	331	2.50	0.00	630.00	626.00	87.10	5.14	33.60
8/19/98		2.70	0.00	588.00	675.00	152.00	7.17	20.40
9/21/98		3.20	0.00	636.00	920.00	383.00	8.90	7.64
10/15/98		3.00	0.00	486.00	585.00	163.00	7.80	16.20
11/19/98		3.30	0.00	682.00	1210.00	389.00	14.10	8.32
12/18/98		3.40	0.00	706.00	1272.20	431.00	14.30	7.52
1/19/99		3.40	0.00	74.00	95.00	6.16	2.47	5.16
2/17/99	5007	2.70	0.00	638.00	580.00	108.00	5.08	35.50
3/19/99		2.80	0.00	384.00	268.00	59.80	3.35	20.70
4/19/99	4587	2.50	0.00	802.00	675.00	157.50	5.43	35.10
5/20/99	816	2.50	0.00	776.00	691.00	147.00	5.46	35.80
6/16/99	98	2.50	0.00	960.00	932.00	177.00	6.68	52.20
7/20/99		2.60	0.00	584.00	769.60	138.00	5.49	29.60
8/18/99		3.40	0.00	700.00	986.00	317.00	11.30	8.18
Mean	2084.56	2.86	0.00	571.00	662.38	163.65	6.75	22.24
Std				206.76	316.30	129.58	3.39	12.89

Data Table 6. Cold Stream Sample Point 7								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1/18/98	19461	3.30	0.00	138.00	131.00	15.30	3.68	72.00
2/18/98	67492	3.50	0.00	80.00	110.00	8.61	3.02	4.93
3/17/98	21557	3.30	0.00	128.00	104.00	20.10	4.73	8.33
4/15/98	51754	3.50	0.00	90.00	115.00	9.87	3.27	5.28
5/20/98	18887	3.50	0.00	110.00	170.00	14.00	3.91	6.94
6/17/98	24211	3.60	0.00	86.00	122.00	18.40	4.49	4.91
7/15/98	5607	3.20	0.00	182.00	278.00	27.80	8.92	8.93
8/19/98	1502	3.20	0.00	208.00	348.00	40.30	12.70	10.20
9/21/98	2678	3.10	0.00	228.00	378.00	42.60	15.20	11.10
10/15/98	73	3.00	0.00	258.00	532.00	57.60	18.10	12.40
11/19/98	2444	3.00	0.00	276.00	476.00	61.90	18.60	12.00
12/16/98		3.10	0.00	296.00	694.00	81.30	20.80	13.30
1/19/99		3.50	0.00	112.00	197.00	25.00	8.48	6.99
2/17/99	14596	3.60	0.00	82.00	142.00	11.20	4.21	7.33
3/19/99	45605	3.50	0.00	82.00	110.00	9.23	3.64	6.56
4/19/99	25485	3.20	0.00	148.00	160.00	23.70	4.13	9.42
5/20/99	11881	3.60	0.00	62.00	175.00	15.60	4.24	3.41
6/16/99	4733	4.20	4.60	48.00	201.00	18.90	3.19	2.39
7/20/99	2192	3.60	0.00	72.00	301.20	27.40	3.76	2.21
8/18/99		3.30	0.00	114.00	359.00	34.90	5.31	3.66
Mean	18833	3.39	0.23	140.00	255.16	28.18	7.72	10.61
Std				75.52	164.60	19.73	5.93	14.82

Data Table 7. Cold Stream Sample Point 8								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1/18/98	276612	4.30	6.40	17.60	34.00	1.80	0.43	0.79
2/18/98	378366	4.50	7.40	13.60	33.00	2.13	0.72	1.28
3/17/98	372590	4.50	6.80	11.60	103.00	1.87	0.48	0.89
4/15/98	634581	4.60	9.20	15.40	24.00	1.58	0.49	0.90
5/20/98	239953	4.70	8.40	12.60	26.00	1.80	0.49	0.89
6/17/98	134562	5.80	10.60	7.80	32.00	2.10	0.57	0.61
7/15/98	34660	5.20	10.00	12.40	47.00	2.18	0.80	0.69
8/19/98	26884	5.00	9.00	11.60	53.00	3.22	1.10	0.74
9/21/98	18349	3.90	0.00	38.00	109.00	5.07	3.60	2.65
10/15/98	11809	3.90	0.00	26.00	112.00	4.44	2.41	1.59
11/19/98	16990	3.70	0.00	34.00	95.00	6.28	2.81	1.61
12/18/98		3.70	0.00	36.00	116.10	7.66	2.93	1.64
1/19/99		4.50	6.80	24.00	71.00	6.79	2.66	1.60
2/17/99	249755				20.00	1.11	0.45	0.73
3/19/99	375142	4.60	7.40	12.40	33.00	1.39	0.56	0.96
4/19/99	400349	4.20	3.80	16.60	29.00	2.73	0.55	1.22
5/20/99		5.70	10.40	4.00	20.00	2.15	0.61	0.48
6/16/99	42922	6.20	13.20	1.20	25.00	2.95	0.52	0.31
7/20/99	11213	6.10	13.40	0.00	53.70	3.12	0.64	0.26
8/18/99		6.30	18.60	0.00	21.00	1.15	0.18	0.20
Mean	201546	4.81	7.44	15.51	52.84	3.08	1.15	1.00
Std				11.53	34.76	1.94	1.06	0.60

Data Table 8. Cold Stream Sample Point 9								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1/18/98	180834	4.40	7.00	13.40	34.00	1.65	0.40	0.73
2/18/98	341383	4.80	8.00	19.60	22.00	1.65	0.57	0.96
3/17/98	214967	4.50	6.60	12.80		3.05	0.57	1.17
4/15/98	284584	4.80	10.60	13.40	24.00	1.15	0.43	0.75
5/20/98	232425	4.80	9.00	9.60	20.00	1.41	0.43	0.78
6/17/98	114437	5.80	10.20	6.80	35.00	1.98	0.57	0.52
7/15/98	12061	5.70	11.00	7.80	33.00	1.56	0.82	0.21
8/19/98	15291	6.00	13.40	5.80	46.00	3.11	1.18	0.20
9/21/98		6.00	14.40	2.60	60.00	2.78	4.57	0.20
10/15/98	5663	4.50	7.40	18.40	114.00	2.35	2.32	1.51
11/19/98	9744	3.80	0	30	102	2.52	2.76	1.65
12/18/98		3.80	0.00	32.00	120.10	3.82	2.85	1.62
1/19/99		4.80	8.60	18.00	76.00	5.63	3.04	1.82
2/17/99	121574				20.00	1.18	0.48	0.79
3/19/99	733973	4.80	8.40	12.80	32.00	1.24	0.50	0.84
4/19/99	135921	4.40	5.40	13.60	27.00	2.06	0.42	0.96
5/20/99		5.80	10.60	4.80	34.00	2.01	0.60	0.44
6/16/99	43940	6.20	13.00	1.80	30.00	2.33	0.51	0.20
7/20/99	15485	6.20	13.20	0.00	42.30	1.74	0.61	0.20
8/18/99		6.10	13.60	0.00	75.00	1.26	0.82	0.20
Mean	164152	5.12	8.97	11.75	49.81	2.22	1.22	0.79
Std				9.09	32.26	1.08	1.20	0.54

Data Table 9. Cold Stream Sample Point 1								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1/18/98	102705	6.10	11.80	0.00	20.00	0.02	0.01	0.20
2/18/98	132523	6.20	12.40	0.00	20.00	0.07	0.03	0.20
3/17/98	143411	6.10	12.00	0.00	20.00	0.22	0.01	0.20
4/15/98	249376	6.10	15.20	5.20	20.00	0.11	0.03	0.20
5/20/98	140377	6.20	13.80	0.00	24.00	0.06	0.01	0.20
6/17/98	14885	6.30	14.60	0.00	20.00	0.26	0.01	0.20
7/15/98	13398	6.50	18.60	0.00	20.00	0.09	0.01	0.20
8/19/98	9258	6.40	19.20	0.00	20.00	0.17	0.02	0.20
9/21/98	5123	6.40	22.00	0.00	20.00	0.04	0.01	0.20
10/15/98	12206	6.40	22.00	0.00	20.00	0.14	0.01	0.20
11/19/98		6.40	22.00	0.00	20.00	0.06	0.01	0.20
12/18/98		6.40	19.60	0.00	20.00	0.07	0.02	0.20
1/19/99		6.20	16.40	0.00	20.00	0.04	0.03	0.20
2/17/99	106373				20.00	0.02	0.01	0.20
3/19/99	179718	6.00	12.40	0.00	20.00	0.05	0.04	0.20
4/19/99	131783	6.40	11.60	0.00	20.00	0.02	0.01	0.20
5/20/99	21605	6.10	15.20	0.00	20.00	0.20	0.03	0.20
6/16/99	27129	6.50	17.60	0.00	20.00	0.10	0.01	0.20
7/20/99	discontinued							
Mean	85991	6.28	16.26	0.31	20.22	0.10	0.02	0.20
Std				1.26	0.94	0.07	0.01	0.00

Data Table 10. Cold Stream Sample Point 22								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	SO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
1/18/98								
2/18/98								
3/7/98								
3/17/98								
3/25/98		6.10	16.00	0.00	65.00	0.32	0.06	**0.20**
4/15/98		6.00	22.00	0.00	**20.00**	0.06	0.09	**0.20**
5/20/98		6.30	36.00	0.00	87.00	0.08	0.01	0.22
6/17/98		6.40	48.00	0.00	**20.00**	0.06	0.24	**0.20**
7/15/98	0							
8/19/98		6.30	40.00	0.00	**20.00**	**0.02**	0.17	**0.20**
9/21/98		6.50	52.00	0.00	52.00	**0.02**	0.18	**0.20**
10/15/98		6.30	34.00	0.00	**20.00**	**0.02**	0.20	**0.20**
11/19/98		6.50	42.00	0.00	51.00	0.03	0.18	**0.20**
12/16/98								
1/20/99								
2/17/99		6.10	24.00	0.00	**20.00**	**0.02**	0.11	**0.20**
3/19/99		6.30	16.20	0.00	24.00	0.04	0.07	**0.20**
3/22/99		6.20	18.00	0.00	26.00	0.03	0.05	**0.20**
4/19/99		6.30	24.00	0.00	**20.00**	0.07	0.06	**0.20**
5/19/99								
6/16/99		6.10	26.00	0.00	**20.00**	**0.02**	0.15	**0.20**
7/20/99		6.30	32.00	0.00	20.00	**0.02**	0.14	**0.20**
8/18/99		6.20	36.00	0.00	26.00	0.03	0.16	**0.20**
Mean	0.00	6.26	31.08	0.00	32.73	0.06	0.12	0.20
Std				0.00	20.97	0.08	0.07	0.00

Data Table 11. Cold Stream Sample Point 2A								
Date	Q (m^3/day)	Lab pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	Acidity (mg/L as $CaCO_3$)	So4 (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
9/21/98		6.50	42.00	0.00	600.00	7.09	0.64	0.35
10/15/98		6.50	44.00	0.00	33.00	6.69	0.51	0.23
11/19/98		6.40	36.00	0.00	36.00	9.38	0.56	0.52
12/18/98		6.40	32.00	0.00	**20.00**	33.40	0.62	3.35
1/19/99		6.20	22.00	0.00	43.00	2.05	0.59	0.26
2/17/99		6.80	96.00	0.00	302.00	2.81	0.54	0.44
3/19/99		6.70	52.00	0.00	209.00	1.07	0.34	0.26
4/19/99		6.60	50.00	0.00	193.00	1.37	0.42	1.09
5/20/99		6.50	82.00	0.00	**20.00**	5.33	0.73	0.31
6/16/99		6.60	44.00	0.00	58.00	9.49	1.04	0.97
7/20/99		6.60	48.00	0.00	74.40	9.96	1.09	1.60
8/18/99		6.40	40.00	0.00	62.00	3.05	0.90	0.71
avg=			49.00	0.00	137.53	7.64	0.66	0.84

Attachment F

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

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

In the 1996 303(d) 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 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,
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 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 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 DEP’s five-digit stream code. As a result, the unnamed tributary records are now split out as separate records on the 2000 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 G

Comment and Response

Comments for Cold Stream Watershed, Centre County, PA

Comment:

1. The average flow values given in the discussion of Cold Stream Point 20 and 8 don't agree with the average values listed in the Data Tables in Attachment E. Examination of both the average flows and flows by date indicate considerable losses both along the diversion dike and between points 8 and 9. Identify known or suspected reasons for this, *e.g.,* losses to underground mines, seepage losses through the dike, etc.

Response:

The flows in question have been corrected. Sample point 8 is just upstream, and at the southeast edge of the "Penelec No.4 Deep Mine and an expansive wetland; while sample point 9 is underlain by this deep mine, and on the edge of the wetland. The difference is probably a combination of loss to the wetland and the deep mine. A second map, Cold Stream/Philipsburg, is included and is zoomed in on this area.

Comment:

2. The aluminum and manganese data is identified as [Al^{3+}] and [Mn^{2+}] and calculations were performed with these values. It is unclear whether this notation indicates the ionic species or dissolved fraction. The water quality criteria for aluminum and manganese is based on the total recoverable values. The total iron notation is $[Fe]_{total}$ which is unambiguous. Please provide the analytical method used and explain the notation.

Response:

The Al and Mn column headings were mislabeled at the District Mining Office. The Al and Mn data are total recoverable.

Comment:

3. Identify the location and completion date of the constructed treatment ponds and any effluent data associated with them. A portion of any developed TMDL needs to be allocated to them, or, based on the wording in the TMDL report, the required percent reduction would also apply to the ponds' effluent. Also identify the location of the "Chiller" discharges and proposed location of the treatment ponds.

Response:

The location of the treatment ponds near Glass City are noted on two maps in Attachment B. Sample point 2A has been included in Attachment E. The location of the "Chiller" discharges and the location of the treatment ponds have been added to two maps in Attachment B.

Comment:

4. Consistent with previous TMDL reports, include a final summary table that lists the allowable loads. Identify the listed segment which apparently includes points 8 and 9 but which may or may not include points 6 and 7. Provide a unique identification for segment for which a TMDL has been developed.

Response:

A summary table has been added. The listed segment is shown on the first two maps in Attachment B as a red line as opposed to a blue line for the other streams shown.

Comment:

5. Points 3 and 6 do not appear to meet section 303(d) listing criteria but point 5 does with 4 out of 18 samples greater than 1.5 mg/l of total iron. Identify whether or not point 5 lies within the reservoir.

Response:

As shown on the second map in Attachment B sample point t is downstream or north of the dam.

Comment:

6. Include on Attachment B pertinent labels that correspond with key locations described in the "Watershed History". This will make it possible to understand the "Watershed History" section. Moshannon Creek, US Route 322, the dam, Glass City, treatment ponds, and even pollutant sources since they are known, need to be indicated.

Response:

The requested additions have been added the original map in AttachmentB. In addition two new maps have been added to attachment B, both are on quads, and the show greater detail to the area downstream of the dam around Philipsburg and the second new map shows greater detail around the Glass City area.

In addition, the following changes should be considered:

Comment:

7. Load allocations are described as applicable to areas above sample points 3, 10, and 20 with no indication of the upstream limit. However, point 10 should only include those areas up slope of the diversion dike.

Response:

The applicable area descriptors have been added to the report.

Comment:

8. Not all of the arithmetic results shown in the tables appears correct. For example, the Fe load reduction in Table 12 should be 1080.0 instead of 1049.6 when using the loads shown in previous tables for points 10, 20, and 12. Occasionally, errors shown in a table are not carried forward, for example, the error in Table 14 for the existing acidity load is not carried forward to Table 16. It would be helpful to verify that all numbers are correct.

Response:

All tables checked in the body of the report and in Attachment E have been checked.