

FINAL
BENS CREEK WATERSHED TMDL
Cambria County

For Acid Mine Drainage Affected Segments



Prepared by:

Pennsylvania Department of Environmental Protection

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TMDL¹
Bens Creek Watershed
Cambria County, Pennsylvania

Introduction

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

Table 1. 303(d) Sub-List								
State Water Plan (SWP) Subbasin: 18-E Stony Creek								
Year	Miles	Segment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	Source	EPA 305(b) Cause Code
1996	1	NA	46098	Bens Creek	CWF	305(b) Report	RE	Metals
1998	1.3	Part C of List	46098	Bens Creek	CWF	305(b) Report	RE	Metals
2002	0.7	New survey; new id. 20010917-1000-ALF	46908	Bens Creek	CWF	SWAP	AMD	Metals & Siltation

Resource Extraction=RE
 Cold Water Fishes = CWF
 Surface Water Assessment Program = SWAP
 Abandoned Mine Drainage = AMD

See Attachment E, *Excerpts Justifying Changes Between the 1996, 1998, and 2002 Section 303(d) Lists*.

The use designations for the stream segments in this TMDL can be found in PA Title 25 Chapter 93. For Bens Creek, upstream of the impaired segment, the use designation of the mainstem is Exceptional Value (EV).

¹ Pennsylvania's 1996 and 1998 Section 303(d) lists were approved by the Environmental Protection Agency (EPA). The 1996 Section 303(d) list provides the basis for measuring progress under the 1997 lawsuit settlement of *American Littoral Society and Public Interest Group of Pennsylvania v. EPA*.

Directions to the Bens Creek Watershed

The Bens Creek Watershed is located in southwestern Pennsylvania, occupying the central portion of Cambria County. The watershed is found on the United States Geological Survey maps covering portions of the Ebensburg, Cresson, and Blue Knob, PA 7.5 Minute Quadrangles. The area within this watershed consists of 8.0 square miles. Land uses within the watershed include, abandoned mine lands, forestland, agricultural land, reclaimed surface mines, refuse piles, and rural residential properties with small communities throughout the area.

The community of Bens Creek, formerly a coal mining town, is located approximately 2000 feet upstream of the mouth of Bens Creek and S.R. 0053. Bens Creek is the most populated community located in the watershed with rural residences scattered throughout. Approximately halfway up the watershed a public water supply reservoir is operated by the Highland Water and Sewer Authority with the remainder of the headwaters of the watershed being largely unpopulated in Portage Township, Cambria County.

The watershed area lies within the Allegheny Mountain section of the Appalachian Plateau Province, characterized by broad, open folds and gentle flanking dips. The watershed lies approximately mid-way between the Negro Mountain Anticline and the Wilmore Syncline. Elevations range from a low at the confluence of Bens Creek and Little Conemaugh River of 1730 feet above sea level to the ridges along the headwaters of Bens Creek at over 2800 feet above sea level.

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. Each segment on the Section 303(d) list will be addressed as a separate TMDL. These TMDLs will be expressed as long-term, average loadings. Due to the nature and complexity of mining effects on the watershed, expressing the TMDL as a long-term average gives a better representation of the data used for the calculations. See Attachment C for TMDL calculations.

Clean Water Act Requirements

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

Additionally, the federal Clean Water Act and the Environmental Protection Agency’s (EPA) implementing regulations (40 CFR Part 130) require:

- States to develop lists of impaired waters for which current pollution controls are not stringent enough to meet water quality standards (the list is used to determine which streams need TMDLs);
- States to establish priority rankings for waters on the lists based on severity of pollution and the designated use of the waterbody; states must also identify those waters for which TMDLs will be developed and a schedule for development;
- States to submit the list of waters to EPA every two years (April 1 of the even numbered years);
- States to develop TMDLs, specifying a pollutant budget that meets state water quality standards and allocate pollutant loads among pollution sources in a watershed, e.g., point and nonpoint sources; and
- EPA to approve or disapprove state lists and TMDLs within 30 days of final submission.

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

In the cases that have been settled to date, the consent agreements require EPA to backstop TMDL development, track TMDL development, review state monitoring programs, and fund studies on issues of concern (e.g., AMD, implementation of nonpoint source Best Management Practices (BMPs), etc.).

These TMDLs were developed in partial fulfillment of the 1997 lawsuit settlement of *American Littoral Society and Public Interest Group of Pennsylvania v. EPA*.

Section 303(d) Listing Process

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

The primary method adopted by the Pennsylvania Department of Environmental Protection (DEP) for evaluating waters changed between the publication of the 1996 and 1998 Section 303(d) lists. Prior to 1998, data used to list streams were in a variety of formats, collected under differing protocols. Information also was gathered through the Section 305(b)² reporting

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

process. DEP is now using the Statewide Surface Waters Assessment Protocol (SSWAP), a modification of the EPA's 1989 Rapid Bioassessment Protocol II (RBP-II), as the primary mechanism to assess Pennsylvania's waters. The SSWAP provides a more consistent approach to assessing Pennsylvania's streams.

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

After the survey is completed, the biologist determines the status of the stream segment. The decision is based on habitat scores and a series of narrative biological statements used to evaluate the benthic macroinvertebrate community. If the stream is determined to be impaired, the source and cause of the impairment is documented. An impaired stream must be listed on the state's Section 303(d) list with the source and cause. A TMDL must be developed for the stream segment and each pollutant. In order for the process to be more effective, adjoining stream segments with the same source and cause listing are addressed collectively, and on a watershed basis.

Basic Steps for Determining a TMDL

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

1. Collection and summarization of pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculating TMDL for the waterbody using EPA approved methods and computer models;
3. Allocating pollutant loads to various sources;
4. Determining critical and seasonal conditions;
5. Public review and comment period on draft TMDL;
6. Submittal of final TMDL; and
7. EPA approval of the TMDL.

Watershed History

Mining activities have occurred in the Bens Creek Watershed since the late 1800's by both the surface mining and deep mining processes. Deep mining on the Lower Kittanning coal seam has been watershed wide by such companies as Eastern Gas and Fuel, W. H. Piper, PA Coal and Coke Company, C.A. Hughes Coal Company, Juniata Coal Company, and Cambria Mining and Manufacturing Company as major producers. Other deep mines were also opened and operated by these same companies on the Upper Kittanning and Upper Freeport coal seams including the

Shoemaker Coal Company. Large refuse “bony” piles are located along Bens Creek at its lower reaches before flowing into the Little Conemaugh River. Unknown operators have abandoned surface mining activities on the Kittanning and Freeport coal seams. More recently in the late 60’s through the 1970’s into the early 1980’s mining was conducted largely by Ace Drilling and Cooney Brothers Coal Companies. These mining operators began strip-mining previously mined seams and reclaiming the abandoned open pits, mining unmined upper seams and daylighting portions of the seams deep mined earlier. The upper portions of the Bens Creek Watershed above the public water supply reservoir has been mainly untouched by surface mining activities but deep mining was prevalent throughout the watershed.

AMD Methodology

A two-step approach is used for the TMDL analysis of AMD impaired stream segments. The first step uses a statistical method for determining the allowable instream concentration at the point of interest necessary to meet water quality standards. This is done at each point of interest (sample point) in the watershed. The second step is a mass balance of the loads as they pass through the watershed. Loads at these points will be computed based on average annual flow.

The statistical analysis described below can be applied to situations where all of the pollutant loading is from non-point sources as well as those where there are both point and non-point sources. The following defines what are considered point sources and non-point sources for the purposes of our evaluation; point sources are defined as permitted discharges or a discharge that has a responsible party, non-point sources are then any pollution sources that are not point sources. 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 made at that point will be for all of the watershed area that is above that point. For situations where there are point-source impacts alone, or in combination with non-point sources, the evaluation will use the point-source data and perform a mass balance with the receiving water to determine the impact of the point source.

Allowable loads are determined for each point of interest using Monte Carlo simulation. Monte Carlo simulation is an analytical method meant to imitate real-life systems, especially when other analyses are too mathematically complex or too difficult to reproduce. Monte Carlo simulation calculates multiple scenarios of a model by repeatedly sampling values from the probability distribution of the uncertain variables and using those values to populate a larger data set. Allocations were applied uniformly for the watershed area specified for each allocation point. For each source and pollutant, it was assumed that the observed data were log-normally distributed. Each pollutant source was evaluated separately using @Risk³ by performing 5,000 iterations to determine the required percent reduction so that the water quality criteria, as defined in the *Pennsylvania Code. Title 25 Environmental Protection, Department of Environmental Protection, Chapter 93, Water Quality Standards*, will be met instream at least 99 percent of the time. For each iteration, the required percent reduction is:

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

$$PR = \text{maximum } \{0, (1-Cc/Cd)\} \text{ where} \quad (1)$$

PR = required percent reduction for the current iteration

Cc = criterion in mg/l

Cd = randomly generated pollutant source concentration in mg/l based on the observed data

$$Cd = \text{RiskLognorm}(\text{Mean}, \text{Standard Deviation}) \text{ where} \quad (1a)$$

Mean = average observed concentration

Standard Deviation = standard deviation of observed data

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

$$LTA = \text{Mean} * (1 - PR99) \text{ where} \quad (2)$$

LTA = allowable LTA source concentration in mg/l

Once the allowable concentration and load for each pollutant is determined, mass-balance accounting is performed starting at the top of the watershed and working down in sequence. This mass-balance or load tracking is explained below.

Load tracking through the watershed utilizes the change in measured loads from sample location to sample location, as well as the allowable load that was determined at each point using the @Risk program.

There are two basic rules that are applied in load tracking; rule one is that if the sum of the measured loads that directly affect the downstream sample point is less than the measured load at the downstream sample point it is indicative that there is an increase in load between the points being evaluated, and this amount (the difference between the sum of the upstream and downstream loads) shall be added to the allowable load(s) coming from the upstream points to give a total load that is coming into the downstream point from all sources. The second rule is that if the sum of the measured loads from the upstream points is greater than the measured load at the downstream point this is indicative that there is a loss of instream load between the evaluation points, and the ratio of the decrease shall be applied to the load that is being tracked (allowable load(s)) from the upstream point.

Tracking loads through the watershed gives the best picture of how the pollutants are affecting the watershed based on the information that is available. The analysis is done to insure that water quality standards will be met at all points in the stream. The TMDL must be designed to

meet standards at all points in the stream, and in completing the analysis, reductions that must be made to upstream points are considered to be accomplished when evaluating points that are lower in the watershed. Another key point is that the loads are being computed based on average annual flow and should not be taken out of the context for which they are intended, which is to depict how the pollutants affect the watershed and where the sources and sinks are located spatially in the watershed.

For pH TMDLs, acidity is compared to alkalinity as described in Attachment B. 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 in units of milligrams per liter (mg/l) CaCO₃. Statistical procedures are 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 streams affected by low pH from AMD may not a true reflection of acidity. This method assures that Pennsylvania’s standard for pH is met when the acid concentration reduction is met.

Information for the TMDL analysis performed using the methodology described above is contained in the “TMDLs by Segment” section of this report.

TMDL Endpoints

One of the major components of a TMDL is the establishment of an instream numeric endpoint, which is used to evaluate the attainment of applicable water quality. An instream numeric endpoint, therefore, represents the water quality goal that is to be achieved by implementing the load reductions specified in the TMDL. The endpoint allows for 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 most of the pollution sources in the watershed are nonpoint sources, the largest part of the TMDL is expressed as Load Allocations (LAs). All allocations will be specified as long-term average daily concentrations. These long-term average concentrations are expected to meet water-quality criteria 99% of the time as required in PA Title 25 Chapter 96.3(c). The following table shows the applicable water-quality criteria for the selected parameters.

Table 2. Applicable Water Quality Criteria

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

*The pH values shown will be used when applicable. In the case of freestone streams with little or no buffering capacity, the TMDL endpoint for pH will be the natural background water quality.

TMDL Elements (WLA, LA, MOS)

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

A TMDL equation consists of a waste load allocation (WLA), load allocation (LA), and a margin of safety (MOS). The waste load allocation is the portion of the load assigned to point sources. The load allocation is the portion of the load assigned to nonpoint sources. The margin of safety is applied to account for uncertainties in the computational process. The margin of safety may be expressed implicitly (documenting conservative processes in the computations) or explicitly (setting aside a portion of the allowable load). The TMDL allocations in this report are based on available data. Other allocation schemes could also meet the TMDL.

Impairment due to sedimentation

The siltation, or sedimentation, impairment noted in Bens Creek is due to runoff from large refuse piles from historic mining located along the stream in the lower reaches just before it enters the Little Conemaugh River. Bens Creek upstream of the refuse piles has been found to be attaining its uses. An existing sediment load was computed using the GWLF model. This model is being used by the Department to address sedimentation problems in other watersheds throughout the Commonwealth. The “Reference Watershed Approach” is used to determine the sediment load reduction needed for this watershed. The Reference Watershed Approach compares two watersheds, one attaining its uses and one that is impaired based on biological assessments. Both watersheds must have similar land use/cover distributions. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted in the model. The objective of the process is to reduce the loading rate of pollutants in the impaired stream segment to a level equivalent to, or slightly lower than, the loading rate in the non-impaired, reference segment. This load reduction will result in conditions favorable to the return of a healthy biological community to the impaired stream segments.

Selection of Reference Watershed

In general, three factors are considered when selecting a suitable reference watershed. The first factor is to use a watershed that the Department has assessed and determined to be attaining water quality standards. The second factor is to find a watershed that closely resembles the impaired watershed in physical properties such as land cover/land use, physiographic province, and geology. Finally, the size of the reference watershed should be within 20-30% of the impaired watershed area. The search for a reference watershed for Bens Creek that would satisfy the above characteristics was done by means of a desktop screening using several GIS coverages, including the Multi-Resolution Land Characteristics (MRLC), Landsat-derived land cover/use grid, the Pennsylvania’s 305(b) assessed streams database, and geologic rock types.

Beaverdam Run, part of the Dark Shade Creek Watershed, was selected for use as the reference watershed. The watershed is located in State Water Plan subbasin 18E and protected uses include aquatic life, water supply, and recreation. Beaverdam Run is designated as High

Quality-Cold Water Fishes (HQ-CWF) from the source to RM 1.93 and CWF from RM 1.93 to the mouth under §93.9t in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2002). Based on the Department’s 305(b) report database, Beaverdam Run is currently attaining its designated uses. The attainment of designated uses is based on sampling done by the Department in 2001, using the Unassessed Waters program protocol. A map of the Beaverdam Run Watershed is located in Attachment A.

Drainage area, location, and other physical characteristics of the Bens Creek Watershed were compared to the Beaverdam Run Watershed. An analysis of value counts for each pixel of the MRLC grid revealed that while land cover/use distributions are not an exact match, both watersheds are similar. Forestland and agriculture, including cropland and pastureland are the dominant land use categories in both watersheds. Surficial geology in the Bens Creek and Beaverdam Run Watersheds were also compared. Rock types in the Bens Creek Watershed include interbedded sedimentary (35%) and sandstone (65%). The Beaverdam Run Watershed is also comprised of interbedded sedimentary (56%) and sandstone (44%). Both watersheds are located almost entirely in the Appalachian Plateau Physiographic Province with very small areas in the Ridge and Valley Physiographic Province.

A sedimentation TMDL for the Bens Creek Watershed was developed using the ArcView Generalized Watershed Loading Function (AVGWLF) model as described in Attachment G. The AVGWLF model was used to establish existing loading conditions for the Bens Creek Watershed and the Beaverdam Run Reference Watershed. All modeling outputs have been included in Attachment I.

The sediment reduction goal for the TMDL is based on setting the watershed loading rate of the impaired Bens Creek equal to the watershed loading rate in the un-impaired Beaverdam Run. The load reduction for sediment in Bens Creek was assigned to all land uses associated with coal mining, which includes quarry areas, coalmine areas, and transition areas.

The TMDL for sediment results in a 60% reduction in loading from quarry areas, 51% reduction from coalmines, and 72% from transition areas. A more detailed explanation of sediment calculations is contained in Attachment D. The individual components of the TMDL are summarized in Table 3 and the load allocation summary is given in Table 4.

Table 3. TMDL, WLA, MOS, LA, LNR, and ALA for Bens Creek Watershed	
Component	Sediment (tons/yr.)
TMDL (Total Maximum Daily Load)	1625
WLA (Waste Load Allocation)	0
MOS (Margin of Safety)	163
LA (Load Allocation)	1462
LNR (Loads Not Reduced)	626
ALA (Adjusted Load Allocation)	836

Source	Current Loading (tons/yr.)	Allowable Loading (tons/yr.)	Percent Reduction (%)
QUARRY	1025	411	60%
COAL MINES	29	14	51%
TRANSITIONAL	1456	411	72%
NPS Loads Not Reduced	626	626	-
Total	3136	1462	53%

Allocation Summary

These TMDLs will focus remediation efforts on the identified numerical reduction targets for each watershed. The reduction schemes in Table 5 for each segment are based on the assumption that all upstream allocations are achieved and take into account all upstream reductions. Attachment C contains the TMDLs by segment analysis for each allocation point in a detailed discussion. As changes occur in the watershed, the TMDLs may be re-evaluated to reflect current conditions. An implicit MOS based on conservative assumptions in the analysis is included in the TMDL calculations.

The allowable LTA concentration in each segment is calculated using Monte Carlo Simulation as described previously. The allowable load is then determined by multiplying the allowable concentration by the flow and a conversion factor at each sample point. The allowable load is the TMDL.

Each permitted discharge in a segment is assigned a waste load allocation and the total waste load allocation (WLA) for each segment is included in this table. There are currently no permitted discharges in the watershed and therefore all WLAs are equal to zero. The difference between the TMDL and the WLA at each point is the load allocation (LA) at the point. The LA at each point includes all loads entering the segment, including those from upstream allocation points. The percent reduction is calculated to show the amount of load that needs to be reduced within a segment in order for water quality standards to be met at the point.

In some instances, instream processes, such as settling, are taking place within a stream segment. These processes are evidenced by a decrease in measured loading between consecutive sample points. It is appropriate to account for these losses when tracking upstream loading through a segment. The calculated upstream load lost within a segment is proportional to the difference in the measured loading between the sampling points.

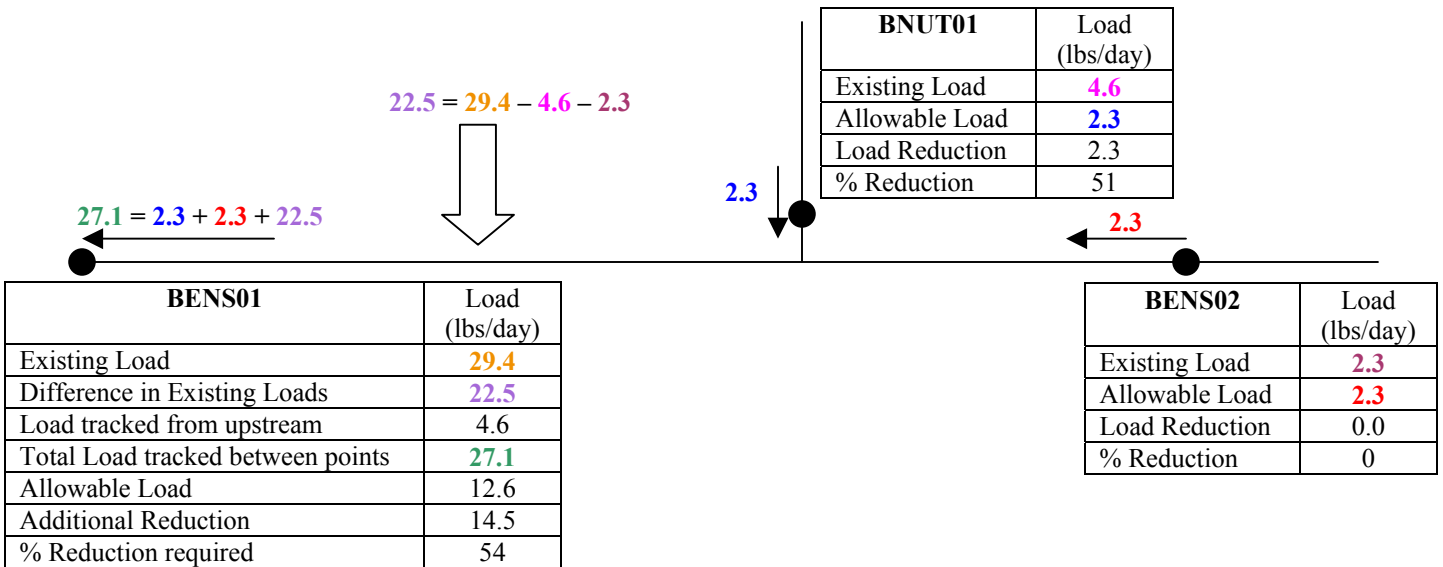
In the instance that the allowable load is equal to the existing load (e.g. aluminum point BENS02, Table 5), the simulation determined that water quality standards are being met instream 99% of the time and no TMDL is necessary for the parameter at that point. Although no TMDL is necessary, the loading at the point is considered at the next downstream point.

Table 5. TMDL Component Summary for the Bens Creek Watershed

Station	Parameter	Existing Load (lbs/day)	TMDL Allowable Load (lbs/day)	WLA (lbs/day)	LA (lbs/day)	Load Reduction (lbs/day)	Percent Reduction %
BENS02	<i>Bens Creek upstream of Unnamed Tributary 46100</i>						
	Al	2.3	2.3	NA	NA	0.0	0
	Fe	3.1	3.1	NA	NA	0.0	0
	Mn	1.1	1.1	NA	NA	0.0	0
	Acidity	120.9	60.5	0.0	60.5	60.5	50
BNUT01	<i>Mouth of Unnamed Tributary 46100</i>						
	Al	4.6	2.3	0.0	2.3	2.3	51
	Fe	0.4	0.4	NA	NA	0.0	0
	Mn	2.3	2.3	NA	NA	0.0	0
	Acidity	88.6	0.0	0.0	0.0	88.6	100
BENS01	<i>Mouth of Bens Creek</i>						
	Al	29.4	12.6	0.0	12.6	14.5	54
	Fe	5.4	5.4	NA	NA	0.0	0
	Mn	10.1	10.1	NA	NA	0.0	0
	Acidity	503.0	60.4	0.0	60.4	293.6	83

NA meets WQS. No TMDL necessary.

Following is an example of how the allocations, presented in Table 5 are calculated. For this example, aluminum allocations for Bens Creek are shown. As demonstrated in the example, all upstream contributing loads are accounted for at each point. Attachment C contains the TMDLs by segment analysis for each allocation point in a detailed discussion. These analyses follow the example. Attachment A contains a map of the sampling point locations for reference.



Recommendations

To date no projects have been initiated to clean-up any of the abandoned deep mine discharges impacting the lower portions of Bens Creek and the abandoned refuse piles lining the creek continues to cause the streams water to become acidic. Past surface mining has reclaimed the abandoned surface mine pits to remove infiltrating water through the bad pit floors and into the deep mine pools.

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

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

The DEP Bureau of Mining and Reclamation administers an environmental regulatory program for all mining activities, mine subsidence regulation, mine subsidence insurance, and coal refuse disposal; conducts a program to ensure safe underground bituminous mining and protect certain structures from subsidence; administers a mining license and permit program; administers a regulatory program for the use, storage, and handling of explosives; provides for training, examination, and certification of applicants for blaster's licenses; administers a loan program for bonding anthracite underground mines and for mine subsidence; and administers the EPA Watershed Assessment Grant Program, the Small Operator's Assistance Program (SOAP), and the Remining Operators Assistance Program (ROAP).

Mine reclamation and well plugging refers to the process of cleaning up environmental pollutants and safety hazards associated with a site and returning the land to a productive condition, similar to DEP's Brownfields program. Since the 1960s, Pennsylvania has been a national leader in establishing laws and regulations to ensure reclamation and plugging occur after active operation is completed.

Pennsylvania is striving for complete reclamation of its abandoned mines and plugging of its orphaned wells. Realizing this task is no small order, DEP has developed concepts to make abandoned mine reclamation easier. These concepts, collectively called Reclaim PA, include legislative, policy land management initiatives designed to enhance mine operator, volunteer land DEP reclamation efforts. Reclaim PA has the following four objectives.

- To encourage private and public participation in abandoned mine reclamation efforts

- To improve reclamation efficiency through better communication between reclamation partners
- To increase reclamation by reducing remaining risks
- To maximize reclamation funding by expanding existing sources and exploring new sources.

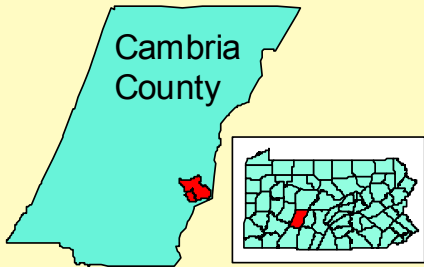
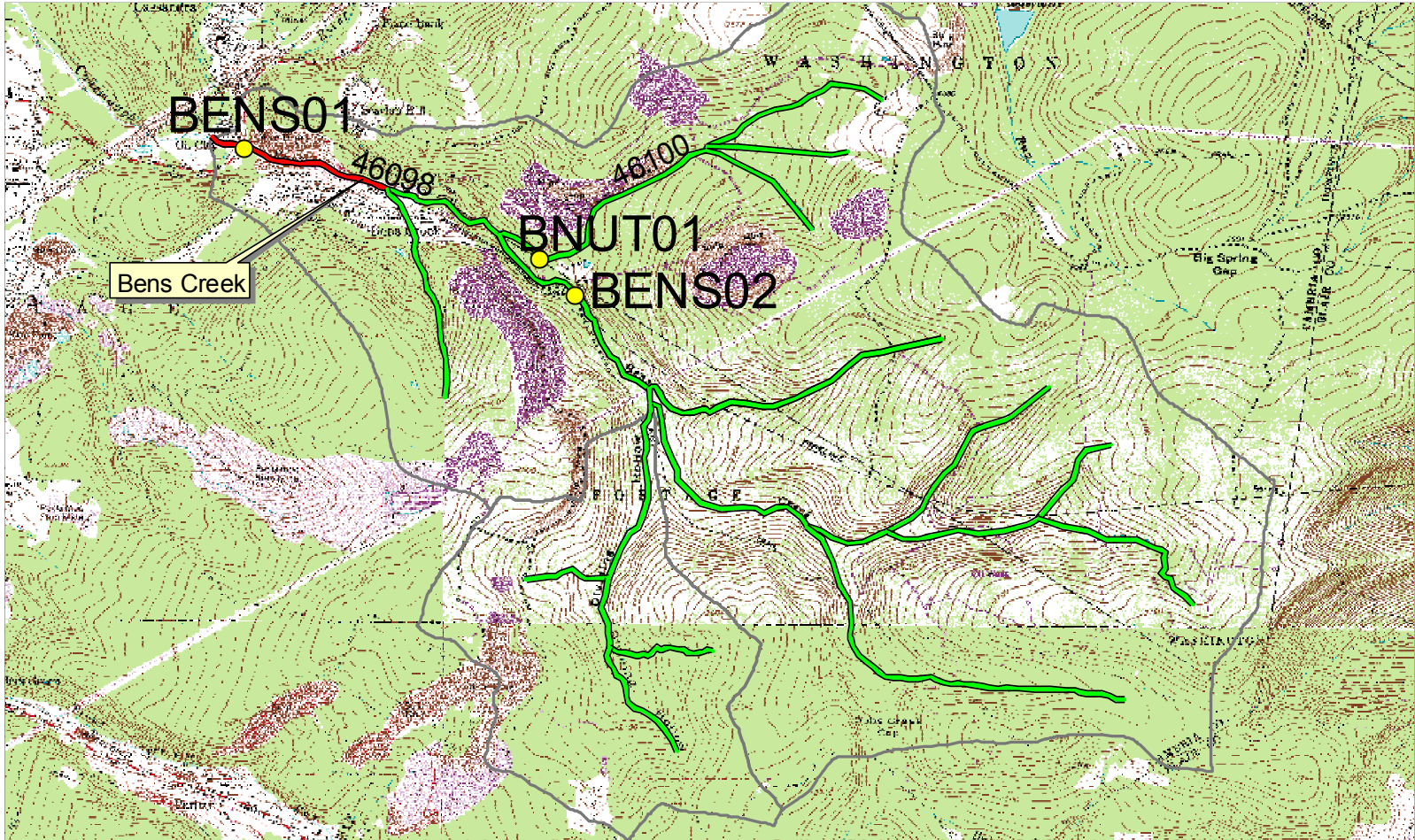
Reclaim PA is DEP's initiative designed to maximize reclamation of the state's quarter million acres of abandoned mineral extraction lands. Abandoned mineral extraction lands in Pennsylvania constituted a significant public liability – more than 250,000 acres of abandoned surface mines, 2,400 miles of streams polluted with mine drainage, over 7,000 orphaned and abandoned oil and gas wells, widespread subsidence problems, numerous hazardous mine openings, mine fires, abandoned structures and affected water supplies – representing as much as one third of the total problem nationally.

Public Participation

Public notice of the draft TMDL was published in the *Pennsylvania Bulletin* on January 8, 2005, *The Tribune Democrat* on January 4, 2005, and the *Mainline Newspapers* on January 5, 2005 to foster public comment on the allowable loads calculated. The public comment period on this TMDL was open from January 8, 2005 to March 9, 2005. A public meeting was held on January 18, 2005 at the Portage Fire Hall in Portage, PA to discuss the proposed TMDL.

Attachment A

Bens Creek Watershed Maps







Bens Creek Watershed



Legend

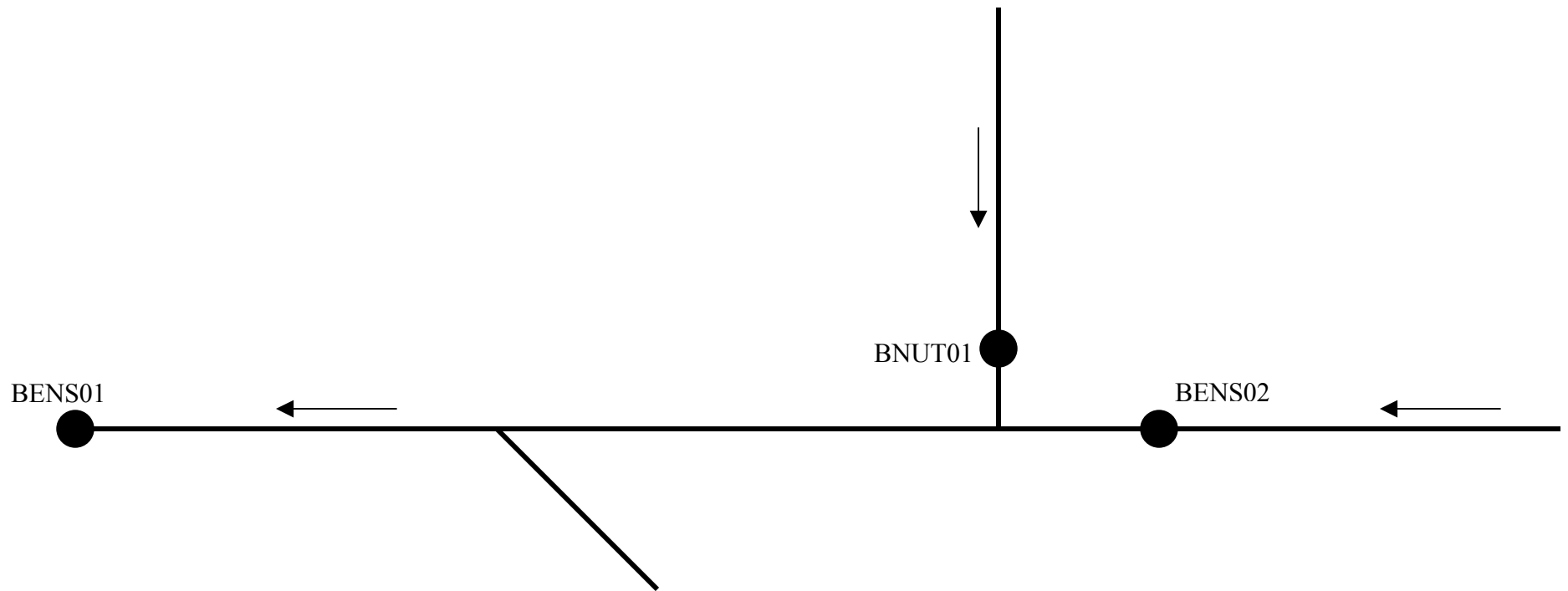


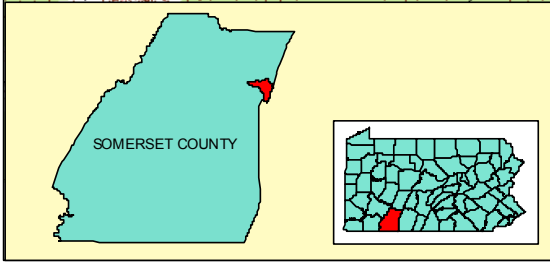
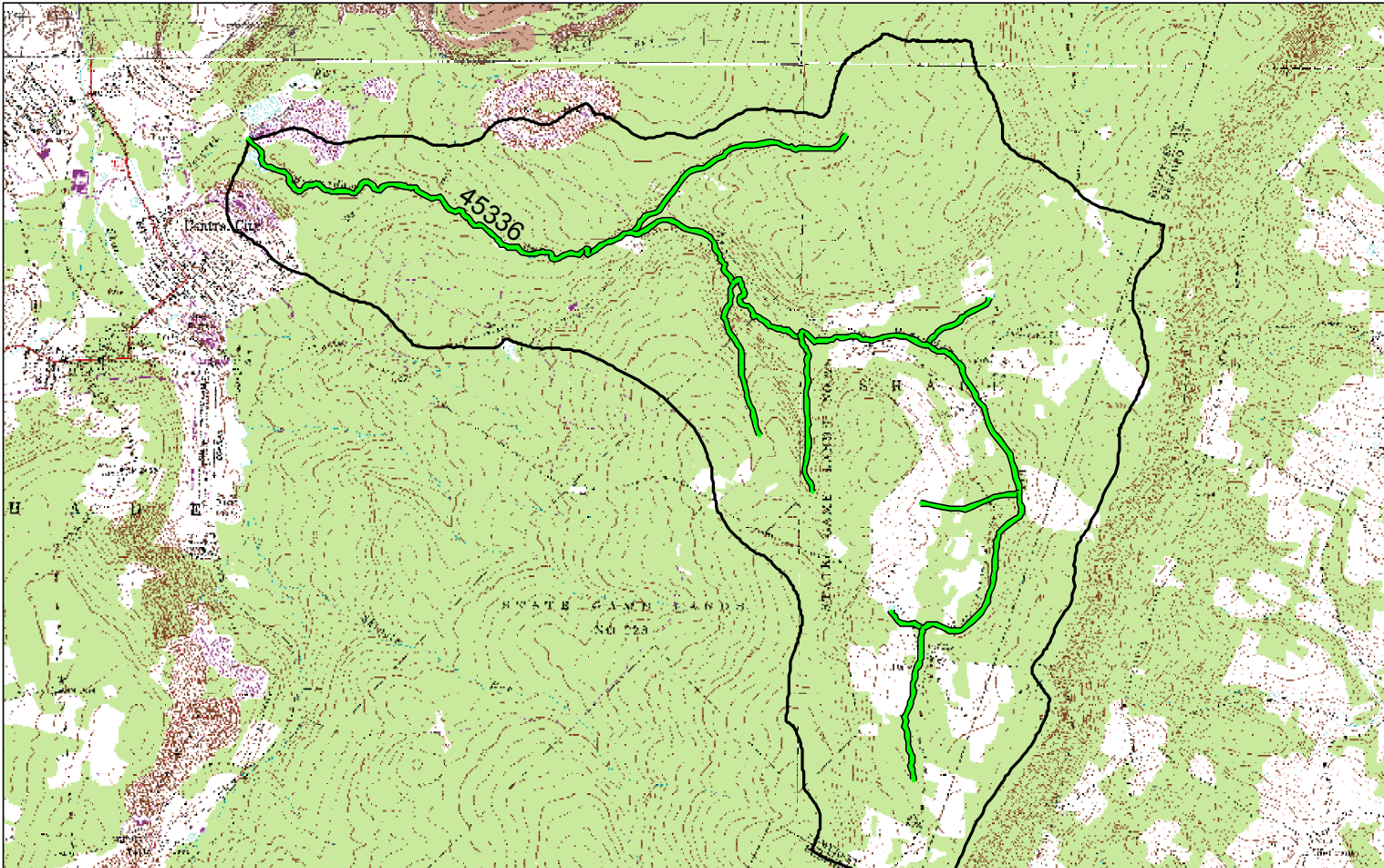
-  Sample Point
-  Watershed Boundary
- Streams**
-  Nonattaining
-  Attaining

Bens Creek Sampling Station Diagram

Arrows indicate direction of flow.

Diagram not to scale.





Beaverdam Run Reference Watershed



Legend



- Streams
 - Attaining
- Watershed Boundry

Attachment B

Method for Addressing Section 303(d) Listings for pH

Method for Addressing Section 303(d) Listings for pH

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

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

Each sample point used in the analysis of pH by this method must have measurements for total alkalinity and total acidity. Net alkalinity is alkalinity minus acidity, both being in units of milligrams per liter (mg/l) CaCO₃. The same statistical procedures that have been described for use in the evaluation of the metals is applied, using the average value for total alkalinity at that point as the target to specify a reduction in the acid concentration. By maintaining a net alkaline stream, the pH value will be in the range between six and eight. This method negates the need to specifically compute the pH value, which for mine waters is not a true reflection of acidity. This method assures that Pennsylvania's standard for pH is met when the acid concentration reduction is met.

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

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

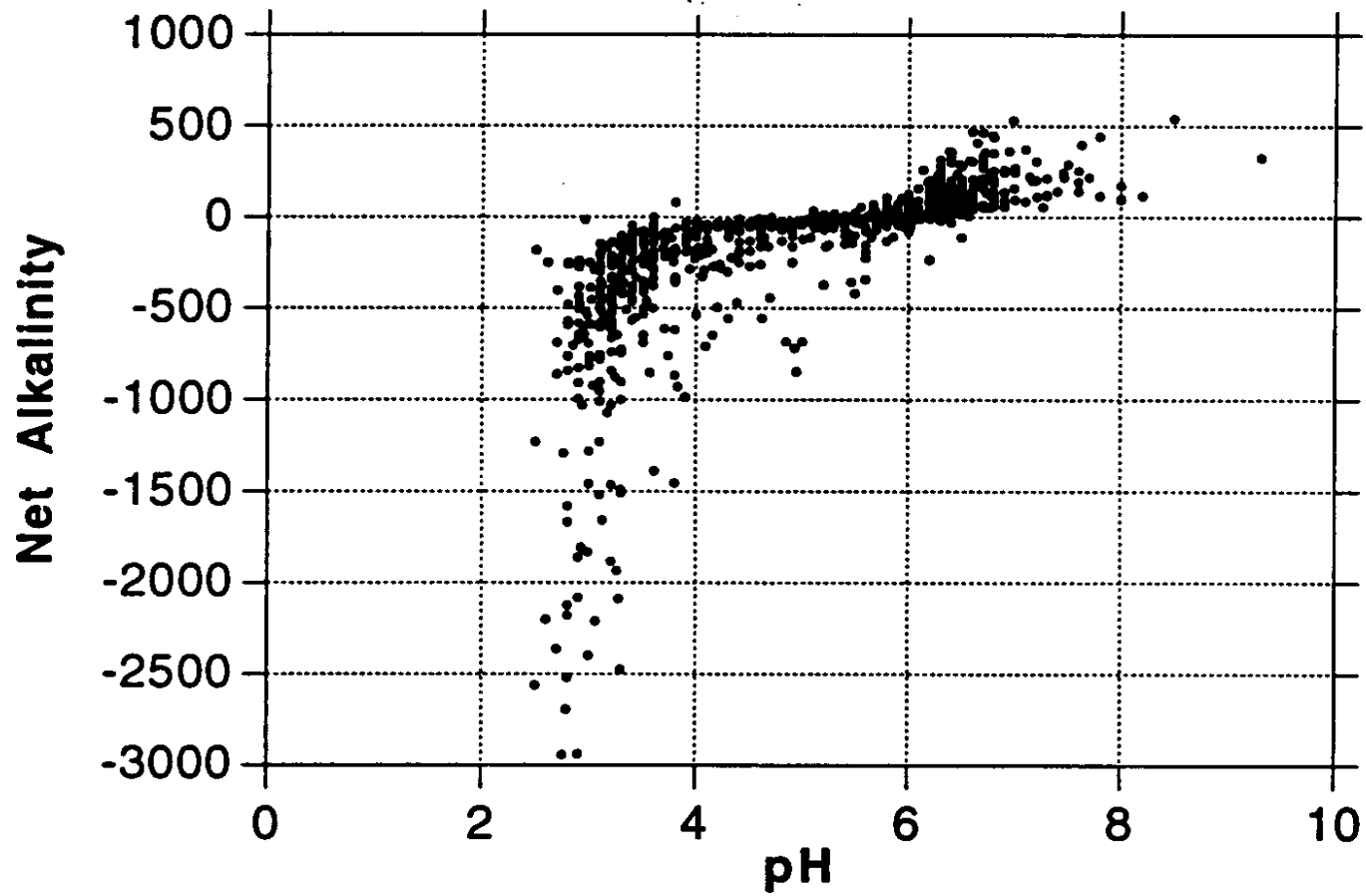


Figure 1. Net Alkalinity vs. pH. Taken from Figure 1.2 Graph C, pages 1-5, of Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania

Attachment C

TMDLs By Segment

Bens Creek

The TMDL for Bens Creek consists of load allocations of one tributary and two sampling sites along the mainstem. There are no waste load allocations in the watershed because there are no active NPDES mining permits in the watershed.

Bens Creek is listed as impaired on the PA Section 303(d) list by high metals AMD as being the cause of the degradation to the stream. Although pH is not listed as a cause of impairment, Bens Creek is impaired for pH from AMD. For pH, the objective is to reduce acid loading to the stream that will in turn raise the pH to the acceptable range. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see TMDL Endpoint section in the report, Table 2). The method and rationale for addressing pH is contained in Attachment B.

TMDLs are not necessary at any point for iron and manganese because water quality analysis shows that water quality standards are being met 99% of the time for both parameters.

An allowable long-term average in-stream concentration was determined at each sample point 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.

TMDL Calculations - Sample Point BENS02, mainstem at water supply dam, downstream of spillway

The TMDL for Bens Creek consists of a load allocation to all of the area above sampling point BENS02 (Attachment A). The load allocation for this stream segment was computed using water-quality sample data collected at point BENS02. The average flow, measured at the sampling point BENS02 (4.45 MGD), is used for these computations.

There is currently no entry for this segment on the PA Section 303(d) list. Sample data at point BENS02 shows pH ranging between 5.72 and 6.67; pH will be addressed as part of this TMDL because of the mining impacts.

Water quality analysis determined that the existing and allowable metals loads are equal. Because WQS are met, TMDLs for metals are not necessary. Although metals TMDLs are not necessary, the existing loading is considered at the next downstream point.

Table C1. TMDL Calculations at Point BENS02				
Flow = 4.45 MGD	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)
Al	0.06	2.3	0.06	2.3
Fe	0.08	3.1	0.08	3.1
Mn	0.03	1.1	0.03	1.1
Acidity	3.25	120.9	1.63	60.5
Alkalinity	6.60	245.0		

Table C2. Calculation of Load Reduction Necessary at Point BENS02				
	Al (lbs/day)	Fe (lbs/day)	Mn (lbs/day)	Acidity (lbs/day)
Existing Load	2.3	3.1	1.1	120.9
Allowable Load	2.3	3.1	1.1	60.5
Load Reduction	0.0	0.0	0.0	60.5
% Reduction Segment	0	0	0	50

TMDL Calculations - Sampling Point BNUT01, Unnamed Tributary 46100

The TMDL for sampling point BNUT01 consists of a load allocation to all of the area above the sampling point shown in Attachment A. The load allocation for this tributary was computed using water-quality sample data collected at point BNUT01. The average flow, measured at the sampling point BNUT01 (0.49 MGD), is used for these computations.

There is currently no entry for this segment on the Section PA 303(d) list. Sample data at point BNUT01 shows pH ranging between 4.30 and 4.42 and aluminum values exceeding criterion. Aluminum and pH will be addressed as part of this TMDL because of the mining impacts.

Water quality analysis determined that the iron and manganese existing loads are equal to the allowable loads. Because WQS are met, TMDLs for iron and manganese are not necessary. Although TMDLs are not necessary for iron and manganese, the loads are considered at the next downstream point, BENS01.

Table C3. TMDL Calculations at Point BNUT01				
Flow = 0.49 MGD	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)
Al	1.13	4.6	0.56	2.3
Fe	0.10	0.4	0.10	0.4
Mn	0.55	2.3	0.55	2.3
Acidity	21.65	88.6	0.00	0.0
Alkalinity	0.00	0.0		

Table C4. Calculation of Load Reduction Necessary at Point BNUT01				
	Al (lbs/day)	Fe (lbs/day)	Mn (lbs/day)	Acidity (lbs/day)
Existing Load	4.64	0.4	2.3	88.6
Allowable Load	2.27	0.4	2.3	0.0
Load Reduction	2.37	0.0	0.0	88.6
% Reduction Segment	51	0	0	100

TMDL Calculations - Sampling Point BENS01, mouth of Bens Creek

The TMDL for sampling point BENS01 consists of a load allocation of the area between sample points BENS01, BENS02, and BNUT01. The load allocation for this stream segment was computed using water-quality sample data collected at point BENS01. The average flow, measured at the sampling point BENS01 (5.70 MGD), is used for these computations.

This segment was listed on the 1996 and 1998 PA Section 303(d) lists for metals impairments. A reassessment in 2001 added siltation as a cause of impairment on the PA 2002 Section 303(d) list. There is currently no entry for this segment on the PA 1996 Section 303(d) list for impairment due to pH. Sample data at point BENS01 shows pH ranging between 4.83 and 6.39; pH will be addressed as part of this TMDL because of the mining impacts.

Water quality analysis determined that the existing iron and manganese loads are equal to the allowable loads. Because WQS are met, TMDLs for iron and manganese are not necessary.

Table C5. TMDL Calculations at Point BENS01				
Flow = 5.70 MGD	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)
Al	0.62	29.4	0.27	12.6
Fe	0.11	5.4	0.11	5.4
Mn	0.21	10.1	0.21	10.1
Acidity	10.58	503.0	1.27	60.4
Alkalinity	3.39	161.2		

The calculated load reductions for all the loads that enter point BENS01 must be accounted for in the calculated reductions at the sample point shown in Table C6. A comparison of measured loads between points BENS01, BENS02 and BNUT01 shows that there is an increase in loading for all parameters. The total segment load is the sum of the upstream-allocated loads plus the additional load entering the segment.

Table C6. Calculation of Load Reduction Necessary at Point BENS01				
	Al (lbs/day)	Fe (lbs/day)	Mn (lbs/day)	Acidity (lbs/day)
Existing Load	29.4	5.4	10.1	503.0
Difference in Existing Loads	22.5	1.9	6.7	293.5
Load tracked from upstream	4.6	3.5	3.4	60.5
Total Load tracked between points	27.1	5.4	10.1	354.0
Allowable Load at BENS01	12.6	5.4	10.1	60.4
Additional Reduction at BENS01	14.5	0.0	0.0	293.6
% Reduction required at BENS01	54	0	0	83

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is implicit because 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:

- 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.
- An additional MOS is provided because the calculations were done with a daily Fe average instead of the 30-day average

Seasonal Variation

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

Critical Conditions

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

Attachment D

Bens Creek Sediment Computations

Bens Creek Sediment TMDL Calculation

The AVGWLF model produced information on watershed size, land use, and sediment loading, (Tables D1 and D2). The sediment loads represent an annual average over the 17 years simulated by the model (1975 to 1992). This information was then used to calculate existing unit area loading rates for the Bens Creek and Beaverdam Run Watersheds.

Table D1. Existing Sediment Loads for the Bens Creek Watershed			
Pollutant Source	Area (ac.)	Mean Annual Loading (tons/yr.)	Unit Area Loading (tons/ac./yr.)
HAY/PAST	106.3	41.7	0.39
CROPLAND	96.4	364.0	3.78
CONIF_FOR	2.5	0.0	0.00
MIXED_FOR	32.1	0.7	0.02
DECID_FOR	4564	65.1	0.01
UNPAVED_RD	2.5	16.0	6.40
QUARRY	89	1025.1	11.52
COAL_MINES	7.4	29.2	3.95
TRANSITION	121.1	1456.0	12.02
LO_INT_DEV	56.8	3.6	0.06
Stream Bank	-	134.5	-
Groundwater	-	-	-
Point Source	-	-	-
Septic Systems	-	-	-
Total	5078	3135.9	0.62

Table D2. Existing Sediment Loads for the Beaverdam Run Watershed			
Pollutant Source	Area (ac.)	Mean Annual Loading (tons/yr.)	Unit Area Loading (tons/ac./yr.)
HAY/PAST	234.7	32.3	0.14
CROPLAND	323.7	414.8	1.28
CONIF_FOR	22.2	0.1	0.00
MIXED_FOR	14.8	0.1	0.01
DECID_FOR	3815.3	28.4	0.01
UNPAVED_RD	2.5	0.0	0.00
QUARRY	131	197.9	1.51
TRANSITION	163.1	784.8	4.81
LO_INT_DEV	2.5	0.0	0.00
Stream Bank	-	60.1	-
Groundwater	-	-	-
Point Source	-	-	-
Septic Systems	-	-	-
Total	4710	1518.5	0.32

The TMDL target sediment load for Bens Creek is the product of the unit area sediment loading rate in the reference watershed (Beaverdam Run) and the total area of the impaired watershed (Bens Creek). These numbers and the resulting TMDL target load are shown in Table D3.

Table D3. TMDL Total Load Computation			
Pollutant	Unit Area Loading Rate in Beaverdam Run (tons/acre/yr.)	Total Watershed Area in Bens Creek (acres)	TMDL Total Load (tons/yr.)
Sediment	0.32	5078	1625

Targeted TMDL values were then used as the basis for load allocations and reductions in the Bens Creek Watershed, using the following two equations:

1. $TMDL = WLA + LA + MOS$
2. $LA = ALA - LNR$

where:

TMDL = Total Maximum Daily Load
WLA = Waste Load Allocation (point sources)
LA = Load Allocation (nonpoint sources)
ALA = Adjusted Load Allocation
LNR = Loads not Reduced

Waste Load Allocation

The waste load allocation (WLA) portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. Reviewing the Department's permitting files identified no point sources of sediment in the Bens Creek Watershed; therefore WLAs were set at zero.

Margin of Safety

The margin of safety (MOS) is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. For this analysis, the MOS is explicit. Ten percent of the targeted TMDL for sediment was reserved as the MOS. Using 10% of the TMDL load is based on professional judgment and will provide an additional level of protection to the designated uses of Bens Creek. The MOS for the sediment TMDL was set at 163 tons/yr.

$$MOS = 0.1 * 1625 \text{ tons/yr (TMDL)} = 163 \text{ tons/yr}$$

Load Allocation

The load allocation (LA) is that portion of the TMDL that is assigned to nonpoint sources. Since there are no point sources present in the Bens Creek Watershed, the load allocation for sediment was computed by subtracting the MOS value from the targeted TMDL value.

$$\text{LA (Sediment)} = 1625 \text{ tons/yr (TMDL)} - 163 \text{ tons/yr (MOS)} = 1462 \text{ tons/yr}$$

Adjusted Load Allocation

The adjusted load allocation (ALA) is the actual portion of the LA distributed among those nonpoint sources receiving reductions. It is computed by subtracting those non-point source loads that are not being considered for reductions (loads not reduced or LNR) from the LA. Since the Bens Creek Watershed TMDLs were developed to address impairments resulting from mining activities, only mining related sources were considered for reductions. Reductions were applied to COAL_MINES, QUARRY, and TRANSITION sources for sediment. Those land uses/sources for which existing loads were not reduced (CONIF_FOR, MIXED_FOR, DECID_FOR, HAY/PAST, CROPLAND, LO_INT_DEV, HI_INT_DEV, Stream Bank, Groundwater, and Septic Systems) were carried through at their existing loading values, Table D4. The ALA for sediment is 837 tons/yr.

Table D4. Load Allocations, Loads Not Reduced, and Adjusted Load Allocations for Bens Creek TMDL	
	Sediment (tons/yr.)
Load Allocation	1462
Loads Not Reduced	625
CONIF FOR	0.0
MIXED FOR	0.7
DECID FOR	65.1
HAY/PAST	41.7
CROPLAND	364.0
LO INT DEV	3.6
UNPAVED RD	16.0
Stream Bank	134.5
Groundwater	-
Septic Systems	-
Adjusted Load Allocation	837

TMDL

The sediment TMDL established for the Bens Creek Watershed consists of a Load Allocation (LA) and a Margin of Safety (MOS). The individual components of the TMDL are summarized in Table D5.

Table D5. TMDL, WLA, MOS, LA, LNR, and ALA for Bens Creek Watershed	
Component	Sediment (tons/yr.)
TMDL (Total Maximum Daily Load)	1625
WLA (Waste Load Allocation)	0
MOS (Margin of Safety)	163
LA (Load Allocation)	1462
LNR (Loads Not Reduced)	625
ALA (Adjusted Load Allocation)	837

Calculation of Sediment Load Reductions

Adjusted load allocations established in the previous section represents the sediment load that is available for allocation between contributing sources in the Bens Creek Watershed. Data needed for load reduction analyses, including land use distribution, were obtained by GIS analysis. The Equal Marginal Percent Reduction (EMPR) allocation method (Attachment H) was used to distribute the ALA between the appropriate contributing land uses.

Table D6 contains the results of the EMPR for sediment for the appropriate contributing land uses in the Bens Creek Watershed. The load allocation for each land use is shown, along with the percent reduction of current loads necessary to reach the targeted LA.

Table D6. Sediment Load Allocations & Reductions for the Bens Creek Watershed						
Pollutant Source	Acres	Unit Area Loading Rate (tons/ac./yr.)		Pollutant Loading (tons/yr.)		Percent Reduction
		Current	Allowable	Current	Allowable	
QUARRY	89	11.52	4.62	1025	411	60%
COAL MINES	7	3.95	1.94	29	14	51%
TRANSITION	121	12.02	3.40	1456	411	72%
Total				2510	837	67%

Consideration of Critical Conditions

The AVGWLF model is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment loads based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken

into account for loading calculations. Because there is generally a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

Consideration of Seasonal Variations

The continuous simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The model also considers the months of the year when manure is applied to the land. The combination of these actions by the model accounts for seasonal variability.

Attachment E

Excerpts Justifying Changes Between the 1996, 1998, and 2002 Section 303(d) Lists

The following are excerpts from the Pennsylvania DEP Section 303(d) narratives that justify changes in listings between the 1996, 1998, and 2002 list. The Section 303(d) listing process has undergone an evolution in Pennsylvania since the development of the 1996 list.

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

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

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

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

Attachment F

Water Quality Data Used In TMDL Calculations

Site	Date	Flow (gpm)	pH	Acidity (mg/L)	Alk (mg/L)	Al (mg/L)	Fe (mg/L)	Mn (mg/L)
BENS01 Latitude: N40°40.194' Longitude: W78°64.054'	2/16/2002	4864	4.83	15.5	1.0	1.00	0.10	0.29
	4/12/2002	4195	5.57	10.3	1.8	0.83	0.10	0.24
	5/10/2002	7547	5.20	12.7	1.7	0.77	0.11	0.24
	6/17/2002	6039	5.48	13.7	2.5	0.66	0.13	0.22
	7/25/2002	715	5.35	11.3	5.5	0.27	0.14	0.14
	10/4/2002	382	6.39	0.1	7.8	0.18	0.10	0.14
	Average	3957.00000	5.47000	10.58415	3.39270	0.61902	0.11393	0.21246
	St Dev	2877.26627	0.52027	5.44414	2.68532	0.32614	0.01702	0.06140

Site	Date	Flow (gpm)	pH	Acidity (mg/L)	Alk (mg/L)	Al (mg/L)	Fe (mg/L)	Mn (mg/L)
BNUT01 Latitude: N40°39.554' Longitude: W78°61.704'	2/16/2002	343	4.38	21.1	0	1.29	0.08	0.56
	4/12/2002	280	4.42	20.1	0	1.20	0.07	0.55
	5/10/2002	860	4.30	20.5	0	1.10	0.12	0.55
	6/17/2002	561	4.35	24.9	0	0.94	0.13	0.55
	7/25/2002	0	NA	NA	NA	NA	NA	NA
	10/4/2002	0	NA	NA	NA	NA	NA	NA
	Average	340.66667	4.36250	21.64615	0.00000	1.13371	0.09982	0.55289
	St Dev	332.880559	0.05058	2.23313	0.00000	0.15168	0.02961	0.00578

Site	Date	Flow (gpm)	pH	Acidity (mg/L)	Alk (mg/L)	Al (mg/L)	Fe (mg/L)	Mn (mg/L)
BENS02 Latitude: N40°39.381' Longitude: W78°61.475'	2/16/2002	4298	6.23	3.5	3.1	0.05	0.03	0.05
	4/12/2002	2815	6.59	2.2	4.4	0.05	0.03	0.00
	5/10/2002	5770	5.99	5.5	3.8	0.10	0.04	0.03
	6/17/2002	4495	5.80	7.0	5.1	0.10	0.12	0.02
	7/25/2002	963	5.72	1.3	9.7	0.02	0.13	0.04
	10/4/2002	219	6.67	0.0	13.4	0.05	0.15	0.04
	Average	3093.33333	6.16667	3.25455	6.59565	0.06180	0.08339	0.02966
	St Dev	2166.01096	0.40043	2.62876	4.08696	0.03183	0.05568	0.01745

Attachment G

AVGWLF Model Overview & GIS-Based Derivation of Input Data

TMDLs for the Bens Creek watershed were developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values.

GWLF is a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogenous in regard to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For sub-surface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated sub-surface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss erosion (K), the length slope factor (LS) the vegetation cover factor (C) and conservation practices factor (P). A sediment delivery ratio based on watershed size and transport capacities based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Surface nutrient losses are determined by applying dissolved N and P coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges can also contribute to dissolved losses to the stream and are specified in terms of kilograms per month. Manured areas, as well as septic systems, can also be considered. Urban nutrient inputs are all assumed to be solid-phase, and the model uses an exponential accumulation and washoff function for these loadings. Sub-surface losses are calculated using dissolved N and P coefficients for shallow groundwater contributions to stream nutrient loads, and the sub-surface sub-model only considers a single, lumped-parameter contributing area. Evapotranspiration is determined using daily weather data and a cover factor dependent upon land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values. All of the equations used by the model can be viewed in GWLF Users Manual, available from the Department's Bureau of Water Supply and Wastewater Management, Division of Water Quality Assessment and Standards.

For execution, the model requires three separate input files containing transport-, nutrient-, and weather-related data. The transport (TRANSPRT.DAT) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global

parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The nutrient (NUTRIENT.DAT) file specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations, etc.). The weather (WEATHER.DAT) file contains daily average temperature and total precipitation values for each year simulated.

The primary sources of data for this analysis were geographic information system (GIS) formatted databases. A specially designed interface was prepared by the Environmental Resources Research Institute of the Pennsylvania State University in ArcView (GIS software) to generate the data needed to run the GWLF model, which was developed by Cornell University. The new version of this model has been named AVGWLF (ArcView Version of the Generalized Watershed Loading Function)

In using this interface, the user is prompted to identify required GIS files and to provide other information related to “non-spatial” model parameters (e.g., beginning and end of the growing season, the months during which manure is spread on agricultural land and the names of nearby weather stations). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the TRANSPRT.DAT, NUTRIENT.DAT and WEATHER.DAT input files needed to execute the GWLF model. For use in Pennsylvania, AVGWLF has been linked with statewide GIS data layers such as land use/cover, soils, topography, and physiography; and includes location-specific default information such as background N and P concentrations and cropping practices. Complete GWLF-formatted weather files are also included for eighty weather stations around the state. The following table lists the statewide GIS data sets and provides an explanation of how they were used for development of the input files for the GWLF model.

GIS Data Sets	
DATASET	DESCRIPTION
Censustr	Coverage of Census data including information on individual homes septic systems. The attribute <i>usew_sept</i> includes data on conventional systems, and <i>sew_other</i> provides data on short-circuiting and other systems.
County	The County boundaries coverage lists data on conservation practices, which provides C and P values in the Universal Soil Loss Equation (USLE).
Gwnback	A grid of background concentrations of N in groundwater derived from water well sampling.
Landuse5	Grid of the MRLC that has been reclassified into five categories. This is used primarily as a background.
Majored	Coverage of major roads. Used for reconnaissance of a watershed.
MCD	Minor civil divisions (boroughs, townships and cities).
Npdespts	A coverage of permitted point discharges. Provides background information and cross check for the point source coverage.
Padem	100-meter digital elevation model. This used to calculate landslope and slope length.
Palumrlc	A satellite image derived land cover grid that is classified into 15 different landcover categories. This dataset provides landcover loading rate for the different categories in the model.
Pasingle	The 1:24,000 scale single line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments.
Physprov	A shapefile of physiographic provinces. Attributes <i>rain_cool</i> and <i>rain_warm</i> are used to set recession coefficient
Pointsrc	Major point source discharges with permitted N and P loads.
Refwater	Shapefile of reference watersheds for which nutrient and sediment loads have been calculated.
Soilphos	A grid of soil phosphorous loads, which has been generated from soil sample data. Used to help set phosphorus and sediment values.
Smallsheds	A coverage of watersheds derived at 1:24,000 scale. This coverage is used with the stream network to delineate the desired level watershed.
Statsgo	A shapefile of generalized soil boundaries. The attribute <i>mu_k</i> sets the k factor in the USLE. The attribute <i>mu_awc</i> is the unsaturated available capacity., and the <i>muhsg_dom</i> is used with landuse cover to derive curve numbers.
Strm305	A coverage of stream water quality as reported in the Pennsylvania's 305(b) report. Current status of assessed streams.
Surfgeol	A shapefile of the surface geology used to compare watersheds of similar qualities.
T9sheds	Data derived from a DEP study conducted at PSU with N and P loads.
Zipcode	A coverage of animal densities. Attribute <i>aeu_acre</i> helps estimate N & P concentrations in runoff in agricultural lands and over manured areas.
Weather Files	Historical weather files for stations around Pennsylvania to simulate flow.

Attachment H

Equal Marginal Percent Reduction Method

The Equal Marginal Percent Reduction (EMPR) allocation method was used to distribute Adjusted Load Allocations (ALAs) between the appropriate contributing nonpoint sources. The load allocation and EMPR procedures were performed using a MS Excel spreadsheet. The 5 major steps identified in the spreadsheet are summarized below:

Step 1: Calculation of the TMDL based on impaired watershed size and unit area loading rate of reference watershed.

Step 2: Calculation of Adjusted Load Allocation based on TMDL, Margin of Safety, and existing loads not reduced.

Step 3: Actual EMPR Process:

- a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving waterbody. If the contributor exceeds the ALA, that contributor would be reduced to the ALA. If a contributor is less than the ALA, it is set at the existing load. This is the baseline portion of EMPR.
- b. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the ALA. If the ALA is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed.

Step 4: Calculation of total loading rate of all sources receiving reductions.

Step 5: Summary of existing loads, final load allocations, and % reduction for each pollutant source.

Microsoft Excel - benscreek_loadallocations.xls

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B1 =

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	SEDIMENT												
2	Step 1:	TMDL Total Load		Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable								
3		Load = Sediment loading rate in ref. * Acres in Impaired			837	837							
4		1625.0					MOS =	162.5					
5							LA =	1462.5					
6							LNR =	625.6					
7													
8	Step 3:							% reduction				Allowable	
9			Annual Average Load	Load Sum	Check	Initial Adjust	Recheck	allocation	Load Reduction	Initial LA	Acres	Loading Rate	% Reduction
10		Quarry	1025	2510	bad	837	ADJUST	0.49	426	411	89	4.62	59.9%
11		Coal Mine	29		good	29	866	0.02	15	14	7.4	1.94	50.9%
12		Transitional	1456		bad	837		0.49	426	411	121.1	3.40	71.7%
13													
14		Total				1703.2		1		837			
15													
16													
17													
18	Step 4:	All mining loading rate:	3.85										
19													
20	Step 5:			Allowable (Target)		Current							
21			Acres	Loading Rate	Final LA	Loading Rates	Current Load	% Red.					
22		Quarry	89	4.62	411	11.52	1025	60%					
23		Coal Mine	7	1.94	14	3.95	29	51%					
24		Transitional	121	3.40	411	12.02	1456	72%					
25								-					
26			218					67%					
27													
28													
29													
30													
31													
32													

Ready

Attachment I

AVGWLF OUTPUT

BENS CREEK OUTPUT

Edit Transport File
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Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	43	75	0.28418	4.80758	0.03	0.52
CROPLAND	39	82	0.27846	3.90221	0.42	0.45
CONIF_FOR	1	73	0.37	0.32747	0.002	0.45
MIXED_FOR	13	73	0.26615	4.34586	0.002	0.52
DECID_FOR	1847	73	0.22384	3.33375	0.002	0.52
UNPAVED_RD	1	87	0.22969	1.9162	0.8	1
QUARRY	36	89	0.28222	3.46904	0.8	0.8
COAL_MINES	3	87	0.34	0.98475	0.8	0.8

Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	23	83	0.34260	0.62293	0.08	0.2

Month	Ket	Day Hrs	Season	Eros Coef
APR	0.0762	13	0	0.260
MAY	0.5973	14	1	0.260
JUN	0.8995	15	1	0.260
JUL	1.0748	15	1	0.260
AUG	1.1765	14	1	0.260
SEP	1.2354	12	1	0.080
OCT	0.7496	11	0	0.080
NOV	0.4678	10	0	0.080
DEC	0.3044	9	0	0.080
JAN	0.0661	9	0	0.080
FEB	0.0714	10	0	0.080
MAR	0.0745	12	0	0.080

Antecedent Moisture Condition

Day -1	Day -2	Day -3	Day -4	Day -5
<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

Init Unsat Stor (cm)	<input type="text" value="10"/>	Initial Snow (cm)	<input type="text" value="0"/>
Init Sat Stor (cm)	<input type="text" value="0"/>	Sed Delivery Ratio	<input type="text" value="0.171"/>
Recess Coef (l/day)	<input type="text" value="0.10024"/>	Sediment A Factor	<input type="text" value="6.747E-05"/>
Seepage Coef (l/day)	<input type="text" value="0"/>	Unsat Avail Wat (cm)	<input type="text" value="15.4116"/>

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- clipthemes
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GWLF Transport Summary for benscreek

Period of analysis: 17 years, from Apr 1975 to Mar 1992

Units in Inches					
Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	3.83	0.13	3.77	0.24	4.01
MAY	4.75	1.75	3.24	0.08	3.33
JUN	4.24	3.68	1.86	0.06	1.92
JUL	4.72	5.23	0.68	0.19	0.86
AUG	3.62	4.56	0.18	0.05	0.23
SEP	4.03	2.66	0.19	0.08	0.27
OCT	3.71	1.03	1.12	0.22	1.34
NOV	3.52	0.33	1.57	0.17	1.73
DEC	3.21	0.07	2.39	0.19	2.58
JAN	3.06	0.01	1.77	0.25	2.02
FEB	2.65	0.02	2.40	0.55	2.95
MAR	4.03	0.06	3.78	0.59	4.37
Total	45.38	19.53	22.93	2.68	25.61

GWLF Nutrient Summary for benscreek

Period of analysis: 17 years, from Apr 1975 to Mar 1992

Month	Tons		Nutrient Loads (Pounds)			
	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos
APR	1965.57	44.63	2033.59	2303.41	68.01	96.99
MAY	3271.91	63.76	1675.76	2060.08	56.60	97.50
JUN	2879.18	37.41	977.91	1203.72	34.28	58.41
JUL	4046.80	278.71	452.84	2126.05	21.62	197.56
AUG	2345.43	38.18	133.74	363.16	7.00	31.19
SEP	791.20	46.47	159.44	438.50	8.28	37.66
OCT	696.36	370.68	685.85	2910.65	26.74	260.58
NOV	528.27	132.64	885.95	1682.73	32.22	116.19
DEC	279.35	173.13	1305.71	2345.93	48.38	158.08
JAN	63.77	391.15	1023.91	3372.00	40.48	287.43
FEB	159.08	625.04	1498.64	5250.22	62.37	456.73
MAR	525.35	799.63	2231.56	7031.24	79.53	584.12
Total	17552.27	3001.44	13064.90	31087.69	485.51	2362.43

GWLF Total Loads for benscreek

Period of analysis: 17 years, from Apr 1975 to Mar 1992

Source	(Acres)	(in)	[Tons]		Total Loads (Pounds)			
	Area	Runoff	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	106.3	2.75	243.57	41.65	176.98	426.88	19.17	45.41
CROPLAND	96.4	5.04	2128.64	364.00	293.92	2477.91	31.96	261.27
CONIF_FOR	2.5	2.31	0.03	0.00	0.25	0.28	0.01	0.01
MIXED_FOR	32.1	2.31	4.16	0.71	3.20	7.46	0.10	0.55
DECID_FOR	4564.0	2.31	380.96	65.14	454.55	845.41	14.35	55.39
UNPAVED_RD	2.5	7.93	93.58	16.00	12.88	108.89	0.89	10.97
QUARRY	89.0	9.62	5994.89	1025.13	2.33	6153.08	0.37	646.20
COAL_MINES	7.4	7.93	170.85	29.21	0.16	175.45	0.03	18.43
TRANSITION	121.1	7.93	8514.73	1456.02	631.05	9367.17	43.52	960.81
LO_INT_DEV	56.8	5.51	20.87	3.57	0.00	0.72	0.00	0.10
Stream Bank				134.53		13.45		5.92
Groundwater					8971.26	8971.26	350.70	350.70
Point Sources					0.00	0.00	0.00	0.00
Septic Syst.					2518.31	2518.31	24.42	24.42
Totals	5078.0	2.70	17552.3	3135.9	13064.90	31066.28	485.51	2380.19

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Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	95	75	0.20736	3.10852	0.03	0.45
CROPLAND	131	82	0.20786	2.06605	0.42	0.45
CONIF_FOR	9	73	0.19111	2.12569	0.002	0.52
MIXED_FOR	6	73	0.205	1.25051	0.002	0.45
DECID_FOR	1544	73	0.19075	2.7485	0.002	0.45
UNPAVED_RD	1	87	0.19291	0	0.8	1
QUARRY	53	89	0.18	0.83092	0.8	0.8
TRANSITION	66	87	0.20348	2.34041	0.8	0.8

Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	1	83	0.18	0.32747	0.08	0.2

Month	Ket	Day Hrs	Season	Eros Coef
APR	0.1205	13	0	0.263
MAY	0.6116	14	1	0.263
JUN	0.8965	15	1	0.263
JUL	1.0617	15	1	0.263
AUG	1.1575	14	1	0.263
SEP	1.2131	12	1	0.083
OCT	0.7558	11	0	0.083
NOV	0.4906	10	0	0.083
DEC	0.3368	9	0	0.083
JAN	0.1044	9	0	0.083
FEB	0.1128	10	0	0.083
MAR	0.1176	12	0	0.083

Antecedent Moisture Condition

Day -1	Day -2	Day -3	Day -4	Day -5
0	0	0	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.173
Recess Coef (l/day)	0.10015	Sediment A Factor	5.006E-05
Seepage Coef (l/day)	0	Unsat Avail Wat (cm)	11.5851

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- clipthemes
- Output

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GWLF Transport Summary for benscreekrw

Period of analysis: 17 years, from Apr 1975 to Mar 1992

Units in Inches					
Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	3.11	0.21	3.20	0.13	3.33
MAY	4.18	1.88	2.62	0.03	2.65
JUN	4.14	3.84	1.42	0.08	1.49
JUL	4.73	5.21	0.64	0.24	0.88
AUG	4.04	4.35	0.28	0.13	0.41
SEP	3.59	2.61	0.15	0.05	0.20
OCT	3.20	1.05	0.82	0.16	0.98
NOV	3.43	0.37	1.42	0.16	1.58
DEC	3.12	0.09	2.28	0.27	2.56
JAN	3.06	0.01	1.73	0.23	1.96
FEB	2.91	0.03	2.59	0.65	3.24
MAR	3.80	0.10	3.62	0.54	4.17
Total	43.31	19.74	20.76	2.67	23.43

GWLF Nutrient Summary for benscreekrw

Period of analysis: 17 years, from Apr 1975 to Mar 1992

Month	Tons		Nutrient Loads (Pounds)			
	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
APR	776.84	15.73	1399.95	1495.17	57.34	66.98
MAY	1294.40	1.99	1075.13	1087.74	44.19	45.65
JUN	1329.25	22.21	636.21	769.97	29.83	43.14
JUL	2088.82	159.25	458.48	1414.30	31.96	126.07
AUG	1466.55	71.25	245.68	673.38	13.44	55.57
SEP	349.69	11.15	116.49	183.47	6.56	13.18
OCT	315.58	67.70	489.25	895.76	23.52	63.58
NOV	298.99	114.39	726.08	1412.81	32.53	100.19
DEC	136.46	156.70	1147.88	2088.71	60.86	153.60
JAN	33.60	148.15	892.20	1781.68	48.65	136.31
FEB	120.87	354.49	1542.94	3670.54	94.81	304.26
MAR	219.84	335.52	1938.13	3952.13	86.70	285.05
Total	8430.87	1458.54	10668.41	19425.66	530.39	1393.57

GWLF Total Loads for **benscreekrw**

Period of analysis: 17 years, from Apr 1975 to Mar 1992

Source	(Acres)	(in)	[Tons]		Total Loads (Pounds)			
	Area	Runoff	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	234.7	2.53	186.44	32.25	355.08	548.61	40.46	59.49
CROPLAND	323.7	4.59	2397.95	414.84	891.32	3380.38	100.72	345.48
CONIF_FOR	22.2	2.12	0.86	0.15	2.03	2.92	0.06	0.15
MIXED_FOR	14.8	2.12	0.31	0.05	1.36	1.68	0.04	0.07
DECID_FOR	3815.3	2.12	164.30	28.42	348.91	519.46	11.02	27.79
UNPAVED_RD	2.5	7.14	0.00	0.00	11.59	11.59	0.80	0.80
QUARRY	131.0	8.62	1144.13	197.94	3.07	1190.68	0.49	117.27
TRANSITION	163.1	7.14	4536.67	784.84	765.11	5474.17	52.77	515.82
LO_INT_DEV	2.5	5.00	0.21	0.04	0.00	0.00	0.00	0.00
Stream Bank				60.09		6.01		2.64
Groundwater					7532.62	7532.62	314.64	314.64
Point Sources					0.00	0.00	0.00	0.00
Septic Syst.					757.32	757.32	9.39	9.39
Totals	4709.8	2.70	8430.9	1518.6	10668.41	19425.44	530.39	1393.55

Attachment J

Comment and Response

A 60-day public comment period was open on the Bens Creek Draft TMDL from January 8, 2005 until March 9, 2005. During this time no comments were received.