EAST BRANCH FISHING CREEK WATERSHED ATMOSPHERIC DEPOSITION TMDL

Sullivan and Columbia Counties

Prepared for:

Pennsylvania Department of Environmental Protection

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East Branch Fishing Creek Watershed
Sullivan and Columbia Counties, Pennsylvania

INTRODUCTION

This report presents the Total Maximum Daily Loads (TMDLs) developed for impaired segments in the East Branch Fishing Creek Watershed (Attachment A). These are done to address the impairments noted on the 2002 Pennsylvania Section 303(d) list of impaired waters, required under the Clean Water Act, and covers one segment on that list and six segments on later lists/reports. East Branch Fishing Creek is listed as impaired for pH and metals. All impairments result from atmospheric deposition. The TMDL addresses the one primary metal associated with atmospheric deposition (aluminum) and pH.

Table 1. Integrated Water Quality Monitoring and Assessment Report Listed Segments

State Water Plan (SWP) Subbasin: 5C				
HUC: 02050107 – Upper Susquehanna-Lackawanna				
Watershed – East Branch Fishing Creek Watershed				
Source	**EPA 305(b) Cause Code**	**Miles**	**Designated Use**	**Use Designation**
Atmospheric Deposition*	pH	37.70	HQ-CWF, MF	Aquatic Life
Atmospheric Deposition	Metals	33.46	HQ-CWF, MF	Aquatic Life

* - Refernce Attachment H for more details

Location

The watershed is located on the U.S. Geological Survey 7.5 minute quadrangles of Elk Grove and Red Rock, Pennsylvania. The stream flows south from Pennsylvania State Game Lands No. 13 to just north of Grassmere Park, Pa., where it joins the West Branch Fishing Creek. The major tributaries to East Branch Fishing Creek include Heberly Run, Sullivan Branch, Blackberry Run, Trout Run, and Lead Run. The largest population centers in the watershed include Jamison City and Central, Pa. State Route 118 travels perpendicular through the southern portion of the watershed. Very few township and Pennsylvania State Game Lands roads provide access to East Branch Fishing Creek and its tributaries.

Hydrology, Geology, and Land Use

The headwaters of East Branch Fishing Creek begin west of Ricketts Glen State Park in Pennsylvania State Game Lands No. 13. East Branch Fishing Creek flows south to its confluence with West Branch Fishing Creek. The East Branch Fishing Creek Watershed contains approximately 19.43 square miles and 38.36 stream miles. East Branch Fishing Creek flows through the towns of Jamison City and Central, Pa.

The East Branch Fishing Creek Watershed primarily lies within the mountainous High Plateau Section of the Appalachian Plateau Province. A very small portion of the watershed south of

Jamison City lies within the Appalachian Mountain Section of the Ridge and Valley Physiographic Province. There is a vertical drop in the watershed of about 1,500 feet from its headwaters to the mouth. The average annual precipitation is 47 inches. The region is characterized by warm summers and long, cold winters. Temperatures change frequently and sometimes rapidly.

The watershed is dominated primarily by forested and developed land uses. Forested consists of 91 percent of the land use and is predominantly found throughout the East Branch Fishing Creek Watershed. Developed accounts for nearly 5 percent and is concentrated near the mouth of East Branch Fishing Creek. The remaining 4 percent consists of emergent wetlands and water.

The East Branch Fishing Creek Watershed is primarily sandstone geology, which accounts for approximately 75 percent of the area. Interbedded Sedimentary comprises the remaining 25 percent of the area. The predominant soil associations in the watershed are the Lackawanna-Arnot-Morris and Wellsboro-Oquaga-Morris. These two soils account for 100 percent of the East Branch Fishing Creek Watershed.

Segments Addressed in this TMDL

East Branch Fishing Creek is affected by pollution from atmospheric deposition. This pollution has caused low pH and high levels of metals in the watershed. There are no NPDES permits in the watershed that would require a WLA. The TMDLs will be expressed as long-term average loadings. Due to the nature and complexity of atmospheric deposition effects on the watershed, expressing the TMDL as a long-term average gives a better representation of the data used for the calculations.

Clean Water Act Requirements

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

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

- States to develop lists (Section 303(d) lists) of impaired waters for which current pollution controls are not stringent enough to meet water quality standards (the list is used to determine which streams need TMDLs);

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

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

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

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

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

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

Section 303(d) Listing Process

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

The primary method adopted by the Pennsylvania Department of Environmental Protection (PADEP) for evaluating waters changed between the publication of the 1996 and 1998 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)[1] reporting process. For this TMDL, PADEP is now used the Unassessed Waters Protocol (UWP), a modification of the USEPA Rapid Bioassessment Protocol II (RPB-II), as the primary mechanism to assess Pennsylvania's waters. The UWP provides a more consistent approach to assessing Pennsylvania's streams.

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. A biologist selects as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment can vary between sites. All the biological surveys include kick-screen sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH (Attachment C), temperature, conductivity, dissolved oxygen, and alkalinity. Benthic macroinvertebrates are identified to the family level in the field.

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

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

Basic Steps for Determining a TMDL

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

1. Collect and summarize pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculate TMDL for the waterbody using USEPA-approved methods and computer models;
3. Allocate pollutant loads to various sources;
4. Determine critical and seasonal conditions;
5. Begin public review and comment period on draft TMDL;
6. Submit final TMDL; and
7. Obtain USEPA approval of the TMDL.

This document will present the information used to develop the East Branch Fishing Creek Watershed TMDL.

METALS AND ACIDITY TMDL DETERMINATION

A two-step approach was used for the TMDL analysis of atmospheric deposition 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 are computed based on average annual flow.

The statistical analysis described below can be applied to situations where all of the pollutant loading is from nonpoint sources, as well as those where there are both point and nonpoint sources. The following defines point sources and nonpoint sources for the purposes of our evaluation. Point sources are defined as permitted discharges or a discharge that has a responsible party; nonpoint sources are any pollution sources that are not point sources. For situations where all of the impact is due to nonpoint sources, the equations shown below are applied using data for a point in the stream. The LA made at that point is for all of the watershed area that is above that point. For situations where there are point source impacts alone, or in combination with nonpoint sources, the evaluation uses the point source data and a mass balance is performed 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 dataset. Allocations were applied uniformly for the watershed area specified for each allocation point. For each source and pollutant, it was assumed that the observed data were log-normally distributed. Each pollutant source was evaluated separately using @Risk[2] 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:

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

PR = required percent reduction for the current iteration

Cc = criterion in milligrams per liter (mg/l)

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

Cd = RiskLognorm(Mean, Standard Deviation) where (1a)
Mean = average observed concentration
Standard Deviation = standard deviation of observed data

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

LTA = Mean * (1 – PR99) where (2)

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.

For pH TMDLs, acidity is compared to alkalinity. Each sample point used in the analysis of pH by this method must have measurements for total alkalinity and total acidity. Net alkalinity is

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

alkalinity minus acidity, both in units of mg/l $CaCO_3$. 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 atmospheric deposition may not be 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 comparison between observed instream conditions and conditions that are expected to restore designated uses. The endpoint is based on either the narrative or numeric criteria available in water quality standards.

Because of the nature of the pollution sources in the watershed, the TMDL's components makeup will be load allocations (LAs) that are specified above a point in the stream segment. All allocations will be specified as long-term average daily concentrations. These long-term average daily concentrations are expected to meet water quality criteria 99 percent of the time. Pa. Title 25 Chapter 96.3(c) specifies that the water quality standards must be met 99 percent of the time. Table 2 shows the water quality criteria for the selected parameters.

Table 2. Applicable Water Quality Criteria

Parameter	Criterion Value (mg/l)	Total Recoverable/Dissolved
Aluminum (Al)	0.200	Total Recoverable
pH *	6.0-9.0	N/A

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

Recognizing the issue with solubility, total aluminum is the only water quality standard established by the Commonwealth of Pennsylvania. This report will assign reductions to total aluminum for regulatory purposes. Aluminum is the metal in most cases associated with atmospheric deposition impaired stream that have listings for pH and metals. Aluminum can occur in two forms: total aluminum and dissolved aluminum. Both forms are often sampled for analysis in these streams and are usually associated with the soils in the watershed. Dissolved aluminum, in most watersheds that contain sufficient buffering, will often be stationary. However, when atmospheric deposition (low pH rainfall) is introduced, dissolved aluminum can become easier to transport in the watershed. Aluminum has an inverse correlation to low pH, generally speaking as pH decreases, aluminum levels increase. However, when pH decreases to 4.5 SU and below, there is a lack of alkalinity to precipitate aluminum and an increase of dissolved aluminum becomes more abundant. Elevated dissolved aluminum combined with low pH becomes toxic to fish and aquatic organisms (Rightnour et al, 2007).

For high quality waters, applicable water-quality criteria are determined using the unimpaired segment of the TMDL water or the 95th percentile of a reference Water Quality Network (WQN) stream. For segments on the East Branch Fishing Creek Watershed, WQN339 on Little Fishing Creek (SWP05C) is used as the reference water. Table 3 shows the criteria used in the East Branch Fishing Creek TMDL. Attachment D explains how to select a reference stream for HQ TMDL development.

Natural conditions of acidity were considered when determining the TMDL endpoints. A dissolved organic carbon study (Attachment G) in partnership with Bloomsburg University was performed to determine the influence from tannic bogs in the watershed.

Table 3. Reference Little Fishing Creek Criteria

Parameter	Criterion Value
Aluminum (Al)	0.200 mg/L
Area	18 square miles
Alkalinity	14 mg/L

TMDL Elements (WLA, LA, MOS)

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

Allocations Summary

These TMDLs will focus remediation efforts on the identified numerical reduction targets for each sampling point. The reduction schemes in Table 4 for each segment are based on the assumption that all upstream allocations are implemented and take into account all upstream reductions. Attachment E 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 long-term average 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 average flow and a conversion factor at each sample point. The allowable load is the TMDL at that 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 from nonpoint sources 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.

Table 4. East Branch Fishing Creek Watershed Summary Table

Parameter	Existing Load (lbs/day)	TMDL Allowable Load (lbs/day)	WLA (lbs/day)	LA (lbs/day)	NPS Load Reduction (lbs/day)	NPS % Reduction
EBFC12 – Sullivan Branch headwaters						
Aluminum (lbs/day)	11.77	2.35	0.00	2.35	9.42	80.0%
Acidity (lbs/day)	197.74	79.09	0.00	79.09	118.65	60.0%
EBFC11 – Sullivan Branch downstream of Ore Run						
Aluminum (lbs/day)	36.50	6.57	0.003	6.57	20.51	75.7%
Acidity (lbs/day)	624.92	181.23	0.00	181.23	325.04	64.2%
EBFC10 – Sullivan Branch downstream of Pigeon Run						
Aluminum (lbs/day)	45.94	9.19	0.00	9.19	6.82	42.5%
Acidity (lbs/day)	927.78	241.22	0.00	241.22	242.87	50.2%
EBFC9 – Sullivan Branch mouth						
Aluminum (lbs/day)	68.72	11.68	0.00	11.68	20.29	63.5%
Acidity (lbs/day)	981.26	343.44	0.00	343.44	0.00	0.0%
EBFC8 – Heberly Run headwaters						
Aluminum (lbs/day)	11.73	2.11	0.00	2.11	9.62	82.0%
Acidity (lbs/day)	212.48	101.99	0.00	0.00	110.49	52.0%
EBFC6 – Heberly Run downstream of Meeker Run						
Aluminum (lbs/day)	18.98	5.31	0.00	5.31	4.05	43.3%
Acidity (lbs/day)	309.35	309.35	0.00	309.35	0.00	0.0%
EBFC5 – Heberly Run mouth						
Aluminum (lbs/day)	29.54	12.70	0.00	12.70	3.17	20.0%
Acidity (lbs/day)	562.55	393.79	0.00	393.79	168.76	30.0%
EBFC4 – East Branch Fishing Creek downstream of Lead Run						
Aluminum (lbs/day)	316.35	9.49	0.00	9.49	232.98	96.1%
Acidity (lbs/day)	1,569.07	674.70	0.00	674.70	87.79	11.5%
EBFC3 – East Branch Fishing Creek downstream of Trout Run						
Aluminum (lbs/day)	84.12	31.13	0.00	31.13	0.00	0.0%
Acidity (lbs/day)	1,788.14	822.54	0.00	822.54	71.23	8.0%
EBFC1 – East Branch Fishing Creek mouth						
Aluminum (lbs/day)	83.40	42.53	0.00	42.53	0.00	0.0%
Acidity (lbs/day)	1,684.98	1,044.69	0.00	1,044.69	0.00	0.0%

The following (Table 4) is an example of how the allocations for a stream segment are calculated. For this example, aluminum allocations for EBFC11 of Sullivan Branch are shown. As demonstrated in the example, all upstream contributing loads are accounted for at each point. Attachment E contains the TMDLs by segment analysis for each allocation point in a detailed discussion. These analyses follow the example below. Water Quality Data used in calculations can be found in Attachment F.

Allocations for EBFC12	
	Al (lbs/day)
Existing load at EBFC12	11.77
Allowable load at EBFC12	2.35

Allowable Load = 2.35

Load input = 24.73
(Difference between
existing loads
At EBFC12 and EBFC11)

Allocations at EBFC11	
	Al (lbs/day)
Existing load at EBFC11	36.50
Difference of measured loads between loads that enter and existing EBFC11	24.73
Percent loss due calculated at EBFC11	0.0%
Additional loads tracked from above samples	2.35
Percentage of upstream loads that reach EBFC11	100.0%
Total load tacked between EBFC12 and EBFC11	27.08
Allowable load at EBFC11	6.57
Load Reduction at EBFC11	20.51
Percent reduction required at EBFC11	75.7%

Allowable load= 6.57

The allowable aluminum load tracked from EBFC11 is 6.57 lbs/day. The existing load at EBFC12 was subtracted from the existing load at EBFC11 to show the actual measured increase of aluminum load that has entered the stream between these upstream sites and EBFC11 (24.73 lbs/day). This increased value was then added to the calculated allowable load from EBFC12 to calculate the total load that was tracked between EBFC12 and EBFC11 (allowable loads @ EBFC12 + the difference in existing load between EBFC12 and EBFC11). This total load tracked was then subtracted from the calculated allowable load at EBFC11 to determine the amount of load to be reduced at EBFC11. This total load was found to be 27.08 lbs/day; it was 20.51 lbs/day greater then the allowable load at EBFC11 (6.57 lbs/day). Therefore, a 75.7% aluminum reduction at EBFC11 is necessary.

ADDITIONAL ANALYSIS

During the water quality sampling period of the East Branch Fishing Creek TMDL, SRBC was able to collect multiple sets of data for further analysis. These processes include deploying data sondes for extended periods to collect continuous data, collecting macroinvertebrate data, and partnering with Steve Rier, Ph.D., on the collection of dissolved organic carbon (DOC). Each of these datasets is individually outlined below.

Dissolved Organic Carbon Analysis

Steve Rier, Ph.D., of Bloomsburg University collected dissolved organic carbon samples for further analysis of this watershed. The data were collected at each of the TMDL sample locations for the duration of the project. The data were collected using glass vials and filters provided by the university. For more information on these data, please refer to Attachment G: *A Preliminary Investigation Into the Natural Variability and Potential Contribution to Stream Acidity of Dissolved Organic Carbon in the East Branch Fishing Creek Watershed,* authored by Steve Rier, Ph.D.

Data Sonde Analysis

To collect additional data SRBC deployed data sondes in the East Branch Fishing Creek for the project. Two data sondes were deployed on two different occasions. Data collected included date, time, depth, pH, temperature, and specific conductance. The first data collection included one data sonde at TMDL sampling point EBFC 9 and one data sonde at TMDL sampling point EBFC 3. This data collection covered approximately 30 days (4/17/09-5/17/09) at 15 minute collection intervals. The second data collection included one data sonde at TMDL sampling point EBFC 5 and one data sonde at TMDL sampling point EBFC 3. This data collection covered approximately 30 days (8/14/09-9/13/09) at 15 minute collection intervals. Preliminary analysis showed that ph levels decreased as stream discharge levels increased during precipitation events, which supported the presence of atmospheric deposition. The data for this aspect of the project were too large to include in this document and are therefore available upon request to the Susquehanna River Basin Commission.

Macroinvertebrate Analysis

Additional data involving the collection and analysis of macroinvertebrates were used to further determine the extent on acid deposition in the watershed. This analysis included seven monitoring stations: the mouth of Quinn Run, East Branch Fishing Creek at Sullivan Falls Road, mouth of Blackberry Run, mouth of Big Run, mouth of Pigeon Run, mouth of Ore Run, north tributary to Meeker Run, west tributary to Meeker Run, and a reference site at Painter Run (located in West Branch Fishing Creek Watershed and used as a reference/control on this study). The data collection occurred from 4/27/09-4/29/09. The data collected included macroinvertebrate sampling, total phosphorus, total suspended solids, sulfate, nitrate, ammonia, dissolved aluminum, total manganese, total aluminum, total magnesium, total calcium, total iron, total potassium, total sodium, acidity, pH, specific conductance, alkalinity, and chloride. When compared to Painter Creek, results indicated that all of the remaining sites were impaired.

Meeker Run north and Meeker Run west were the two worst macroinvertebrate communities and also but differed slightly in chemical data. Meeker Run north had the lowest pH and highest aluminum of all the sites and was significantly influenced by the large tannic bog upstream whereas, Meeker Run west was mostly associated with a marsh/fen environment. Ore Run also had on of the worst macroinvertebrate communities, and seemed to suffer from episodic acid events. Summary results indicated supportive trends to the TMDL sampling. A complete report with metric results is available upon request to the Susquehanna River Basin Commission.

RECOMMENDATIONS

There are three challenges to consider when developing a strategy for implementing treatment in the East Branch Fishing Creek Watershed. These three challenges include limited access, topography, and chronic acidification. Chronic acidification characterization can be supported since presence of acidity has been documented in a wide variety of flow conditions sampled in the watershed. Sampling conditions included summer low flows to rain-induced high flow events. Two-thirds of the sampling locations recorded some level of acidity during all sampling rounds. These stream reaches require year-round treatment that addresses chemistry at all flows, not just during precipitation events.

The second challenge in developing treatment options for this watershed is dealing with the issue of access. The watershed has very limited access by vehicle since it only contains two roads: Sullivan Falls Road and an unnamed Pennsylvania Game Commission (PGC) Road. Sullivan Falls Road provides limited access to the Sullivan Branch, north to Big Run. However, Sullivan Branch still requires considerable hiking to reach the upper portion of the watershed such as Ore and Pigeon Runs. The PGC road located in Pennsylvania State Gamelands No. 13 provides limited access to the Grassy Hollow in the Heberly Run drainage. The condition of this road is poor and requires a four-wheel-drive vehicle to navigate to portions of the watershed such as Quinn Run and Meeker Run.

Another challenge in the watershed is topography. The topography includes steeply incised valleys causing difficult access to portions of the streams. The condition of the roads listed above can be directly correlated with the steep terrain. Roads that are available to address treatment are cut into the mountainside and are very narrow. However, these steeply incised valleys have also helped produce the aesthetics of this watershed. The steep terrain formed by sandstone layers has provided the watershed with numerous waterfalls reaching over twenty feet at some sites.

Given these three variables, the selection of a treatment option that is less invasive and provides a minimal footprint is important. With much of the watershed impacted by chronic acidification, projects on Heberly Run, Sullivan Branch, and Blackberry Run that continually inoculate alkaline material into the stream could be more successful and cost effective. An alkaline addition project such a lime silo doser in the headwaters of Heberly Run could restore approximately 3.6 stream miles. The current low pH of Heberly Run significantly limits fish reproduction and diversity. In addition, approximately 4.4 miles of the East Branch Fishing Creek mainstem could be improved with approximately 31 percent (516 lbs/day) reduction of acidity.

Past design efforts in the watershed include the implementation of vertical flow wetlands, high flow buffer channels, forest and road liming, instream limestone sand dosing, and diversion wells. Systems of these designs have proved to be very effective in treating episodic acidification from atmospheric deposition in many watersheds. When limited by access, topography, and chronic acidification, these systems become less chemically and cost- effective and require a larger construction footprint. The installation of lime dosing silos in the headwaters of selected tributaries could be the practice that meets all criteria listed above. However, every technique has a limitation. In the case of a lime dosing silo, yearly operational fees (i.e., alkaline material purchase) are necessary for success. Consequently, a best case scenario trust fund or a worst case scenario yearly fundraising effort must be accomplished. If this restoration option was pursued, it would be recommended that any project partners review any applicable state and federal requirements. Coordination with the Department of Conservation and Natural Resources/Pennsylvania Heritage Program should be completed to make sure the installation of this project is not harmful to endangered species.

Currently, active groups such as the Fishing Creek Watershed Association (FCWA), Columbia County Conservation District, Penn State University, and Bloomsburg University have been attempting to restore the watershed. FCWA and the Columbia County Conservation District have installed a low flow limestone diversion well that has an intake on Heberly Run and an outfall on the mainstem of East Branch Fishing Creek just upstream of Blackberry Run. In 2006, Penn State University and FCWA began forest liming in portions of Heberly Run. FCWA with Columbia County Conservation District has contracted to Water's Edge Hydrology, Inc. to develop the East Branch Fishing Creek Watershed Acid Deposition Assessment and Restoration Plan in 2007.

Future activities include FCWA and the Columbia County Conservation District applying for a PADEP renaissance watershed grant and installing limestone pods in Heberly Run Subwatershed. The pods will serve as an alkaline addition project to capture road runoff before it enters the stream.

Public Participation

A notice of availability for comments on the draft East Branch Fishing Creek Watershed TMDL was published in the Pa. Bulletin on June 5, 2010, and *Press Enterprise* newspaper on June 1, 2010, to foster public comment on the allowable loads calculated. A public meeting was held on June 24, 2010, at the Sugarloaf Township building to discuss the proposed TMDL. The public participation process (which ended on July 5, 2010) was provided for the submittal of comments. Comments and responses are summarized in Attachment I. No public comments were received for this TMDL.

Notice of final TMDL approval will be posted on the PADEP's web site.

Future TMDL Modifications

In the future, PADEP may adjust the load and/or WLAs in this TMDL to account for new information or circumstances that develop and are discovered during the implementation of the TMDL when a review of the new information or circumstances indicate that such adjustments are appropriate. Adjustment between the LA and WLA will only be made following an opportunity for public participation. A WLA adjustment will be made consistent and simultaneous with associated permit(s) revision(s)/reissuances (i.e., permits for revision/reissuance in association with a TMDL revision will be made available for public comment concurrent with the related TMDLs availability for public comment). New information generated during TMDL implementation may include, among other things, monitoring data, BMP effectiveness information, and land use information. All changes in the TMDL will be tallied and compared to the original calculations. Once the total changes exceed 1 percent of the total original TMDL allowable load, the TMDL will be revised. The adjusted TMDL, including its LAs and WLAs, will be set at a level necessary to implement the applicable water quality standards (WQS), and any adjustment increasing a WLA will be supported by reasonable assurance demonstration that LAs will be met. PADEP will notify USEPA of any adjustments to the TMDL within 30 days of its adoption and will maintain current tracking mechanisms that contain accurate loading information for TMDL waters.

Changes in TMDLs That May Require USEPA Approval

- Increase in total load capacity.
- Transfer of load between point (WLA) and nonpoint (LA) sources.
- Modification of the margin of safety (MOS).
- Change in WQS.
- Non-attainment of WQS with implementation of the TMDL.
- Allocations in trading programs.

Changes in TMDLs That May Not Require USEPA Approval

- Total loading shift less than or equal to 1 percent of the total load.
- Increase of WLA results in greater LA reductions provided reasonable assurance of implementation is demonstrated (a compliance/implementation plan and schedule).
- Changes among WLAs with no other changes; TMDL public notice concurrent with permit public notice.
- Removal of a pollutant source that will not be reallocated.
- Reallocation between LAs.
- Changes in land use.

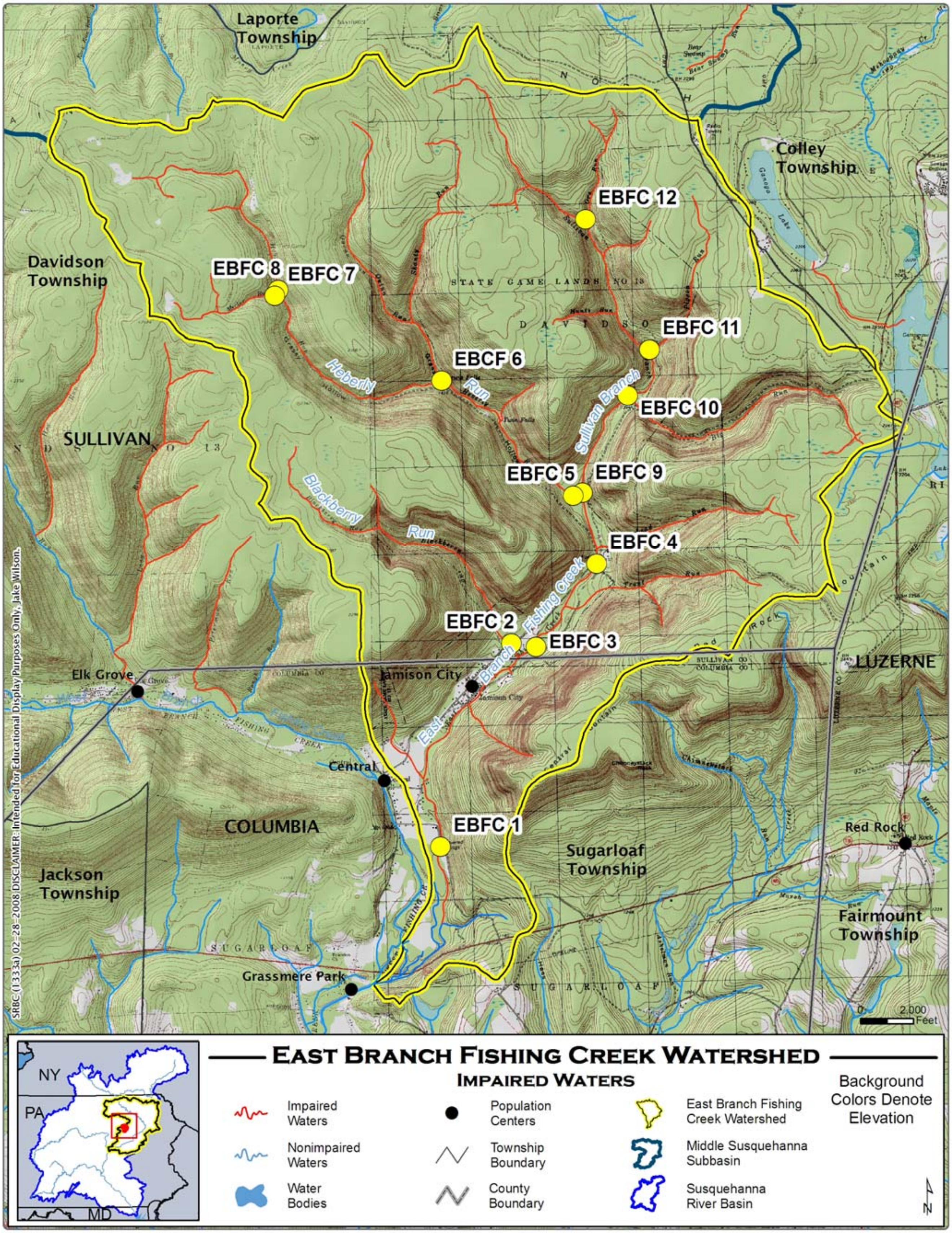
References

Commonwealth of Pennsylvania. 2005. Pennsylvania Code, Title 25. Environmental Protection, Department of Environmental Protection, Chapter 93. Water Quality Standards.

Rightnour, Hoover, and Martinchek. 2007. East Branch Fishing Creek Watershed Acid Deposition Assessment and Restoration Plan.

Attachment A

East Branch Fishing Creek Watershed Map



EAST BRANCH FISHING CREEK WATERSHED
IMPAIRED WATERS
Laporte Township
Colley Township
Davidson Township
SULLIVAN
EBFC 12
EBFC 8
EBFC 7
EBFC 11
EBCF 6
EBFC 10
EBFC 5
EBFC 9
EBFC 4
EBFC 2
EBFC 3
EBFC 1
Heberly Run
Sullivan Branch
Blackberry Run
Fishing Creek
East Branch
STATE GAME LANDS NO 13
Elk Grove
Jamison City
LUZERNE
Central
COLUMBIA
Jackson Township
Sugarloaf Township
Red Rock
Fairmount Township
Grassmere Park
0
2,000
Feet
NY
PA
MD
Impaired Waters
Nonimpaired Waters
Water Bodies
Population Centers
Township Boundary
County Boundary
East Branch Fishing Creek Watershed
Middle Susquehanna Subbasin
Susquehanna River Basin
Background Colors Denote Elevation
N
SRBC (1333a) 02-28-2008 DISCLAIMER: Intended for Educational Display Purposes Only. Jake Wilson.

Attachment B

Excerpts Justifying Changes Between the 1996, 1998, and 2002 Section 303(d) Lists and Integrated Report/List (2004, 2006)

The following are excerpts from the PADEP Section 303(d) narratives that justify changes in listings between the 1996, 1998, 2002, 2004, and 2006 303(d) Lists and Integrated Report/List (2006). 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 USEPA 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).

Migration to National Hydrography Data (NHD)

New to the 2006 report is use of the 1/24,000 National Hydrography Data (NHD) streams GIS layer. Up until 2006, PADEP relied upon its own internally developed stream layer. Subsequently, the United States Geologic Survey (USGS) developed 1/24,000 NHD streams layer for the Commonwealth based upon national geodatabase standards. In 2005, PADEP contracted with USGS to add missing streams and correct any errors in the NHD. A GIS contractor transferred the old PADEP stream assessment information to the improved NHD and the old PADEP streams layer was archived. Overall, this marked an improvement in the quality of the streams layer and made the stream assessment data compatible with national standards but it necessitated a change in the Integrated Listing format. The NHD is not attributed with the old PADEP five digit stream codes so segments can no longer be listed by stream code but rather only by stream name or a fixed combination of NHD fields known as reachcode and ComID. The NHD is aggregated by Hydrologic Unit Code (HUC) watersheds so HUCs rather than the old State Water Plan (SWP) watersheds are now used to group streams together. A more basic change was the shift in data management philosophy from one of “dynamic segmentation” to “fixed segments.” The dynamic segmentation records were proving too difficult to manage from an historical tracking perspective. The fixed segment methods will remedy that problem. The stream assessment data management has gone through many changes over the years as system requirements and software changed. It is hoped that with the shift to the NHD and Office of Information Technology’s (OIT’s) fulltime staff to manage and maintain SLIMS, the systems and formats will now remain stable over many Integrated Listing cycles.

Attachment C

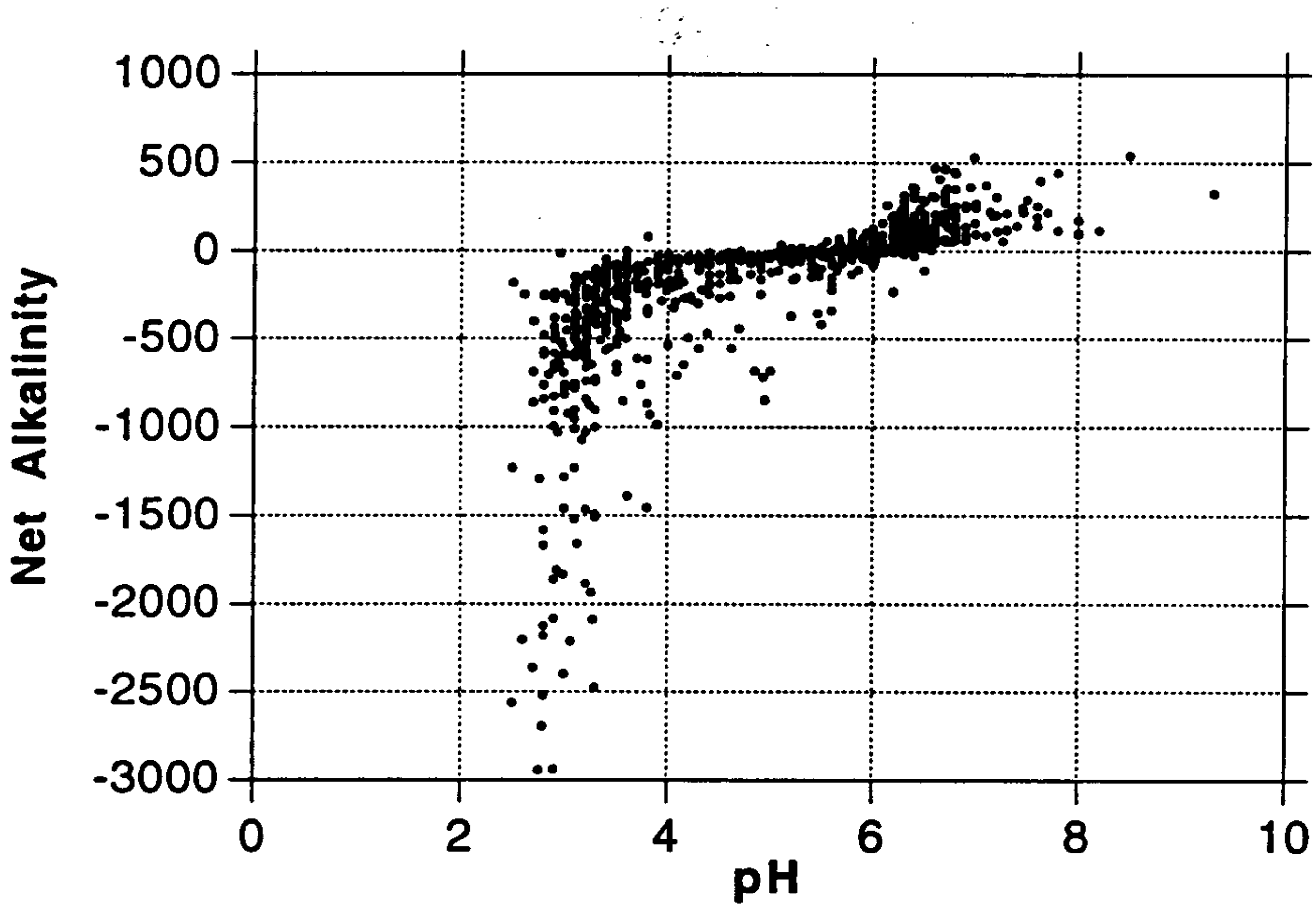
Method for Addressing 303(d) Listings for pH

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

The pH, a measurement of hydrogen ion acidity presented as a negative logarithm, is not conducive to standard statistics. Additionally, pH does not measure latent acidity. For this reason, and based on the above information, Pennsylvania is using the following approach to address the stream impairments noted on the 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 atmospheric deposition. 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 aluminum 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. 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 atmospheric deposition 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.

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.*



FigureC-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 D

Use of Reference Stream Water Quality for High Quality Waters

Streams placed on the 1996 303 (d) list with a designated use of high quality (HQ) will be subject to Pennsylvania's antidegradation policy. The antidegradation policy applies mainly to addressing new discharges to currently non-impaired special protection waters. The policy suggests protection of existing water quality for any new discharges. Due to the impairment of the designated use in the TMDL watershed, protection of existing quality is implemented through the evaluation of an applicable reference watershed as defined in Pennsylvania's *Water Quality Antidegradation Implementation Guidance.*

Therefore, DEP must establish instream goals for TMDLs that restore the waterbody to existing quality. This is accomplished by sampling an unaffected stretch of stream to use as a reference. This stretch typically is the headwaters segment of the high quality stream in question. If an unaffected stretch isn't available, a nearby-unimpaired stream will function as a surrogate reference. The reference stream data will be selected from statewide ambient Water Quality Network (WQN) stations. To determine which WQN station represents existing water quality appropriate for use in developing TMDLs for HQ waters, alkalinity and drainage area are considered.

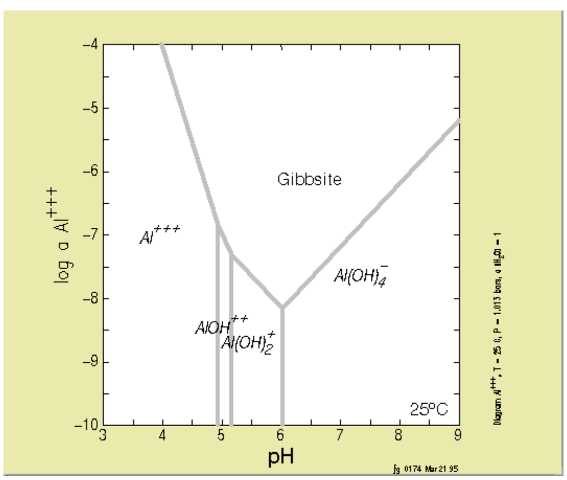
1. First step is to match alkalinities of the TMDL stream and WQN reference stream. If alkalinities for candidate stream are not available, use pH as a surrogate. As a last resort, if neither pH nor alkalinity are available, match geologies using current geological maps.

2. The second consideration is drainage area.

3. Finally, from the subset of stations with similar alkalinity and drainage area select the station nearest the TMDL stream.

	Little Fishing Creek	East Branch Fishing Creek	
Parameter	Value	Value	Units
ALUMINUM T	200		UG/L
pH	6.5	~5	pH units
ALKALINITY	11.2	~10	MG/L

As shown in the solubility diagram below, at pH 5 and higher toxic Al^{3+} is not in solution. Therefore the TMDL protects aquatic life from toxic effects of aluminum.



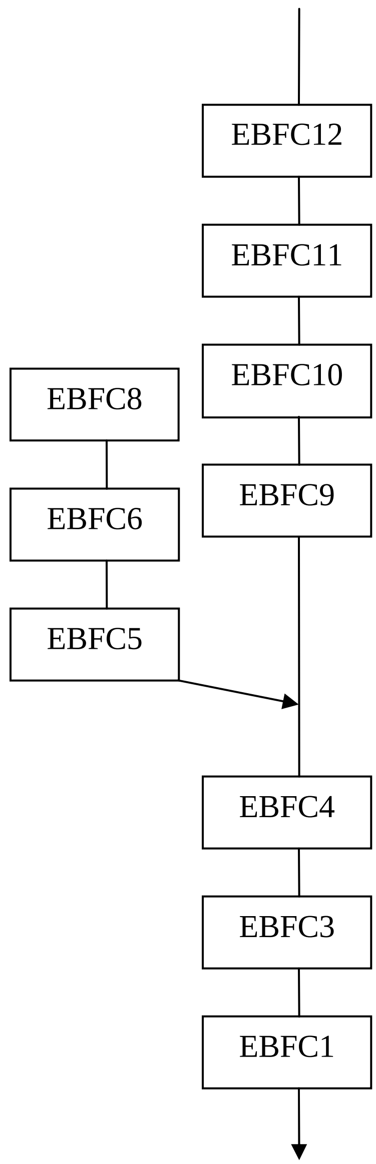
Attachment E
TMDLs By Segment

East Branch Fishing Creek

The TMDL for East Branch Fishing Creek consists of load allocations (LAs) to three sampling sites on East Branch Fishing Creek (EBFC4, EBFC3, and EBFC1), four sites on the Sullivan Branch (EBFC12, EBFC11, EBFC10, and EBFC9), and three sites on Heberly Run (EBFC8, EBFC6, and EBFC5). Sample datasets were collected in 2009. All sample points are shown on the maps in Attachment A as well as on the loading schematic presented on the following page. East Branch Fishing Creek is listed on the 2002 303(d) List for pH and metals from atmospheric deposition as the cause of the stream degradation. The method and rationale for addressing pH is contained in Attachment C.

An allowable long-term average instream concentration for aluminum and acidity is determined at each sample point. These analyses are designed to produce a long-term average value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the dataset was lognormally distributed. Using the mean and the standard deviation of the dataset, 5,000 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 percent of the time. The mean value from this dataset represents that long-term daily average concentration that needs to be met to achieve water quality standards.

East Branch Fishing Creek Sampling Diagram
Arrows represent direction of flow, and diagram is not to scale.



EBFC12: Sullivan Branch headwaters

The headwaters of Sullivan Branch begin at the south slopes of North Mountain. The point EBFC12 is located at the upstream of the confluence of Sullivan Branch and Ore Run.

The TMDL for this section of Sullivan Branch consists of a LA to the watershed area above EBFC12. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC12 (3.276 million gallons per day (MGD)). The LAs made at point EBFC12 for this stream segment are presented in Table E1.

Table E1. TMDL Calculations at Point EBFC12				
Flow = 3.276 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Al	0.43	11.77	0.09	2.35
Acidity	7.23	197.74	2.89	79.09
Alkalinity	5.03	137.60	-	-

Reductions at point EBFC12 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBFC12 are shown in Table E2.

Table E2. Calculation of Load Reduction Necessary at Point EBFC12		
	Al (lbs/day)	***Acidity (lbs/day)***
Existing load at EBFC12	11.77	197.74
Allowable load at EBFC12	2.35	79.09
Load Reduction at EBFC12	9.42	118.65
Percent reduction required at EBFC12	80.0%	60.0%

The TMDL for point EBFC12 requires a LA for total aluminum and acidity.

EBFC11: Sullivan Branch downstream of Ore Run

EBFC11 is located downstream of Ore Run in Pennsylvania State Game Lands No. 13. All measurements were recorded just upstream of the confluence of Pigeon Run and Sullivan Branch.

The TMDL for this section of Sullivan Branch consists of a LA to the watershed area between EBFC12 and EBFC11. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC11 (11.177 MGD). The LAs made at point EBFC11 for this stream segment are presented in Table E3.

Table E3. TMDL Calculations at Point EBFC11				
Flow = 11.177 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Al	0.39	36.50	0.07	6.57
Acidity	6.70	624.92	1.94	181.23
Alkalinity	5.33	497.45	-	-

The loading reduction for point EBFC12 was used to show the total load that was removed from upstream sources. For each parameter, the total load that was removed upstream was subtracted from the existing load at point EBFC11. This value was compared to the allowable load at point EBFC11. Reductions at point EBFC11 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBFC11 are shown in Table E4.

Table E4. Calculation of Load Reduction Necessary at Point EBFC11		
	Al (lbs/day)	***Acidity (lbs/day)***
Existing load at EBFC11	36.50	624.92
Difference of measured loads between loads that enter and existing EBFC11	24.73	427.18
Percent loss due calculated at EBFC11	0.0%	0.0%
Additional loads tracked from above samples	2.35	79.09
Percentage of upstream loads that reach EBFC11	100.0%	100.0%
Total load tacked between EBFC12 and EBFC11	27.08	506.27
Allowable load at EBFC11	6.57	181.23
Load Reduction at EBFC11	20.51	325.04
Percent reduction required at EBFC11	75.7%	64.2%

The TMDL for point EBFC11 requires a LA for total aluminum and acidity.

EBFC10: Sullivan Branch downstream of Pigeon Run

EBFC10 is located downstream of Pigeon Run in Pennsylvania State Game Lands No. 13. All measurements were recorded just upstream of Big Run.

The TMDL for this section of Sullivan Branch consists of a LA to the watershed area between EBFC11 and EBFC10. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC10 (14.693 MGD). The LAs made at point EBFC10 for this stream segment are presented in Table E5.

Table E5. TMDL Calculations at Point EBFC10				
Flow = 14.693 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Al	0.37	45.94	0.07	9.19
Acidity	7.57	927.78	1.97	241.22
Alkalinity	5.57	682.55	-	-

The loading reduction for point EBFC11 was used to show the total load that was removed from upstream sources. For each parameter, the total load that was removed upstream was subtracted from the existing load at point EBFC10. This value was compared to the allowable load at point EBFC10. Reductions at point EBFC10 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBFC10 are shown in Table E6.

Table E6. Calculation of Load Reduction Necessary at Point EBFC10		
	Al (lbs/day)	***Acidity (lbs/day)***
Existing load at EBFC10	45.94	927.78
Difference of measured loads between loads that enter and existing EBFC10	9.44	302.86
Percent loss due calculated at EBFC10	0.0%	0.0%
Additional loads tracked from above samples	6.57	181.23
Percentage of upstream loads that reach EBFC10	100.0%	100.0%
Total load tacked between EBFC11 and EBFC10	16.01	484.09
Allowable load at EBFC10	9.19	241.22
Load Reduction at EBFC10	6.82	242.87
Percent reduction required at EBFC10	42.5%	50.2%

The TMDL for point EBFC10 requires a LA for total aluminum and acidity.

EBFC9: Sullivan Branch mouth

EBFC9 is located downstream of Big Run in Pennsylvania State Game Lands No. 13. All measurements were recorded just upstream of the confluence of Sullivan Branch and Heberly Run.

The TMDL for this section of Sullivan Branch consists of a LA to the watershed area between EBF10 and EBFC9. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC9 (24.497 MGD). The LAs made at point EBFC9 for this stream segment are presented in Table E7.

Table E7. TMDL Calculations at Point EBFC9				
Flow = 24.497 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Al	0.34	68.72	0.06	11.68
Acidity	4.80	981.26	1.68	343.44
Alkalinity	6.57	1,342.42	-	-

The loading reduction for point EBFC10 was used to show the total load that was removed from upstream sources. For each parameter, the total load that was removed upstream was subtracted from the existing load at point EBFC9. This value was compared to the allowable load at point EBFC10. Reductions at point EBFC9 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBFC9 are shown in Table E8.

Table E8. Calculation of Load Reduction Necessary at Point EBFC9		
	Al (lbs/day)	***Acidity (lbs/day)***
Existing load at EBFC9	68.72	981.26
Difference of measured loads between loads that enter and existing EBFC(	22.78	53.48
Percent loss due calculated at EBFC9	0.0%	0.0%
Additional loads tracked from above samples	9.19	241.22
Percentage of upstream loads that reach EBFC9	100.0%	100.0%
Total load tacked between EBFC10 and EBFC9	31.97	294.70
Allowable load at EBFC9	11.68	343.44
Load Reduction at EBFC9	20.29	0.00
Percent reduction required at EBFC9	63.5%	0.0%

The TMDL for point EBFC9 requires a LA for total aluminum.

EBFC8: Heberly Run Headwaters

EBFC8 is located upstream of Meeker Run in Pennsylvania State Game Lands No. 13. All measurements were recorded just upstream of the confluence of Meeker Run and Heberly Run.

The TMDL for this section of Heberly Run consists of a LA to the watershed area upstream of EBFC8. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC8 (5.787 MGD). The LAs made at point EBFC8 for this stream segment are presented in Table E9.

Table E9. TMDL Calculations at Point EBFC8				
Flow = 5.787 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Al	0.24	11.73	0.04	2.11
Acidity	4.40	212.48	2.11	101.99
Alkalinity	5.84	282.02	-	-

Reductions at point EBFC8 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBFC8 are shown in Table E10.

Table E10. Calculation of Load Reduction Necessary at Point EBFC8		
	Al (lbs/day)	***Acidity (lbs/day)***
Existing load at EBFC8	11.73	212.48
Allowable load at EBFC8	2.11	101.99
Load Reduction at EBFC8	9.62	110.49
Percent reduction required at EBFC8	82.0%	52.0%

The TMDL for point EBFC8 requires a LA for total aluminum and acidity.

EBFC6: Heberly Run downstream of Meeker Run

EBFC6 is located downstream of Meeker Run in Pennsylvania State Game Lands No. 13. All measurements were recorded just upstream of the confluence of Quinn Run and Heberly Run.

The TMDL for this section of Heberly Run consists of a LA to the watershed area between EBFC8 and EBFC6. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC6 (12.931 MGD). The LAs made at point EBFC6 for this stream segment are presented in Table E11.

Table E11. TMDL Calculations at Point EBFC6				
Flow = 12.931 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Al	0.18	18.98	0.05	5.31
Acidity	2.87	309.35	2.87	309.35
Alkalinity	6.83	737.40	-	-

The loading reduction for point EBFC8 was used to show the total load that was removed from upstream sources. For each parameter, the total load that was removed upstream was subtracted from the existing load at point EBFC6. This value was compared to the allowable load at point EBFC6. Reductions at point EBCF6 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBFC6 are shown in Table E12.

Table E12. Calculation of Load Reduction Necessary at Point EBFC6		
	Al (lbs/day)	***Acidity (lbs/day)***
Existing load at EBFC6	18.98	309.35
Difference of measured loads between loads that enter and existing EBFC6	7.25	96.87
Percent loss due calculated at EBFC6	0.0%	0.0%
Additional loads tracked from above samples	2.11	101.99
Percentage of upstream loads that reach EBFC6	100.0%	100.0%
Total load tacked between EBFC8 and EBFC6	9.36	198.86
Allowable load at EBFC6	5.31	309.35
Load Reduction at EBFC6	4.05	0.00
Percent reduction required at EBCF6	43.3%	0.0%

The TMDL for point EBFC6 requires a LA for total aluminum.

EBFC5: Heberly Run mouth

EBFC5 is located downstream of Quinn Run in Pennsylvania State Game Lands No. 13. All measurements were recorded just upstream of the confluence of Sullivan Branch and Heberly Run.

The TMDL for this section of Heberly Run consists of a LA to the watershed area between EBFC6 and EBFC5. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC5 (24.076 MGD). The LAs made at point EBFC5 for this stream segment are presented in Table E13.

Table E13. TMDL Calculations at Point EBFC5				
Flow = 24.076 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Al	0.15	29.54	0.06	12.70
Acidity	2.80	562.55	1.96	393.79
Alkalinity	6.93	1,392.99	-	-

The loading reduction for point EBFC6 was used to show the total load that was removed from upstream sources. For each parameter, the total load that was removed upstream was subtracted from the existing load at point EBFC5. This value was compared to the allowable load at point EBFC5. Reductions at point EBFC5 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBFC5 are shown in Table E14.

Table E14. Calculation of Load Reduction Necessary at Point EBFC5		
	Al (lbs/day)	*Acidity (lbs/day)*
Existing load at EBFC5	29.54	562.55
Difference of measured loads between loads that enter and existing EBFC5	10.56	253.20
Percent loss due calculated at EBFC5	0.0%	0.0%
Additional loads tracked from above samples	5.31	309.35
Percentage of upstream loads that reach EBFC5	100.0%	100.0%
Total load tacked between EBFC6 and EBFC5	15.87	562.55
Allowable load at EBFC5	12.70	393.79
Load Reduction at EBFC5	3.17	168.76
Percent reduction required at EBFC5	20.0%	30.0%

The TMDL for point EBFC5 requires a LA for total aluminum and acidity.

EBFC4: East Branch Fishing Creek downstream of Lead Run

EBFC4 is located downstream of Lead Run and the confluences of Heberly Run and Sullivan Branch in Pennsylvania State Game Lands No. 13. All measurements were recorded just below a marked Pennsylvania Game Commission (PGC) road that crosses the mainstem of East Branch Fishing Creek upstream of Trout Run.

The TMDL for this section of East Branch Fishing Creek consists of a LA to the watershed area between EBFC9, EBFC5, and EBFC4. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC4 (55.301 MGD). The LAs made at point EBFC4 for this stream segment are presented in Table E15.

Table E15. TMDL Calculations at Point EBFC4				
Flow = 55.301 MGD	*Measured Sample Data*		*Allowable*	
Parameter	*Conc. (mg/l)*	*Load (lbs/day)*	*LTA Conc. (mg/l)*	*Load (lbs/day)*
Al	0.69	316.35	0.02	9.49
Acidity	3.40	1,569.07	1.46	674.70
Alkalinity	6.60	3,045.83	-	-

The loading reduction for points EBFC9 and EBFC5 was used to show the total load that was removed from upstream sources. For each parameter, the total load that was removed upstream was subtracted from the existing load at point EBFC4. This value was compared to the allowable load at point EBFC4. Reductions at point EBFC4 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBCF4 are shown in Table E16.

Table E16. Calculation of Load Reduction Necessary at Point EBFC4		
	Al (lbs/day)	***Acidity (lbs/day)***
Existing load at EBFC4	316.35	1,569.07
Difference of measured loads between loads that enter and existing EBFC4	218.09	25.26
Percent loss due calculated at EBFC4	0.0%	0.0%
Additional loads tracked from above samples	24.38	737.23
Percentage of upstream loads that reach EBFC4	100.0%	100.0%
Total load tacked between EBFC9, EBFC5 and EBFC4	242.47	762.49
Allowable load at EBFC4	9.49	674.70
Load Reduction at EBFC4	232.98	87.79
Percent reduction required at EBFC4	96.1%	11.5%

The TMDL for point EBFC4 requires a LA of total aluminum and acidity.

EBFC3: East Branch Fishing Creek downstream of Trout Run

EBFC3 is located downstream of Trout Run in Pennsylvania State Game Lands No. 13. All measurements were recorded just above the PGC boundary that crosses the mainstem of East Branch Fishing Creek upstream of Blackberry Run.

The TMDL for this section of East Branch Fishing Creek consists of a LA to the watershed area between EBFC4 and EBFC3. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC3 (63.646 MGD). The LAs made at point EBFC3 for this stream segment are presented in Table E17.

Table E17. TMDL Calculations at Point EBFC3				
Flow = 63.646 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Al	0.16	84.12	0.06	31.13
Acidity	3.37	1,788.14	1.55	822.54
Alkalinity	6.97	3,700.20	-	-

The loading reduction for point EBFC4 was used to show the total load that was removed from upstream sources. For each parameter, the total load that was removed upstream was subtracted from the existing load at point EBFC3. This value was compared to the allowable load at point EBFC3. Reductions at point EBFC3 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBFC3 are shown in Table E18.

Table E18. Calculation of Load Reduction Necessary at Point EBFC3		
	Al* *(lbs/day)	***Acidity* *(lbs/day)***
Existing load at EBFC3	84.12	1,788.14
Difference of measured loads between loads that enter and existing EBFC3	-232.23	219.07
Percent loss due calculated at EBFC3	73.4%	0.0%
Additional loads tracked from above samples	9.49	674.70
Percentage of upstream loads that reach EBFC3	26.6%	100.0%
Total load tacked between EBFC4 and EBFC3	2.52	893.77
Allowable load at EBFC3	31.13	822.54
Load Reduction at EBFC3	0.00	71.23
Percent reduction required at EBFC3	0.0%	8.0%

The TMDL for point EBFC3 requires a LA for acidity.

EBFC1: East Branch Fishing Creek mouth

EBFC1 is located downstream of Blackberry Run. All measurements were recorded just upstream of the bridge on Stevens Hill Road downstream of Central, Pa.

The TMDL for this section of East Branch Fishing Creek consists of a LA to the watershed area between EBFC3 and EBFC1. Addressing the atmospheric deposition impacts above this point addresses the impairment for the stream segment. An average instream flow measurement was available for point EBFC1 (76.677 MGD). The LAs made at point EBFC1 for this stream segment are presented in Table E19.

Table E19. TMDL Calculations at Point EBFC1				
Flow = 76.677 MGD	***Measured Sample Data***		***Allowable***	
Parameter	***Conc. (mg/l)***	***Load (lbs/day)***	***LTA Conc. (mg/l)***	***Load (lbs/day)***
Al	0.13	83.40	0.07	42.53
Acidity	2.63	1,684.98	1.63	1,044.69
Alkalinity	7.37	4,713.68	-	-

The loading reduction for point EBFC3 was used to show the total load that was removed from upstream sources. For each parameter, the total load that was removed upstream was subtracted from the existing load at point EBFC1. This value was compared to the allowable load at point EBFC1. Reductions at point EBFC1 are necessary for any parameter that exceeds the allowable load at this point. Necessary reductions at point EBFC1 are shown in Table E20.

Table E20. Calculation of Load Reduction Necessary at Point EBFC1		
	***Al* (lbs/day)**	***Acidity* (lbs/day)**
Existing load at EBFC1	83.40	1,684.98
Difference of measured loads between loads that enter and existing EBFC1	-0.72	-103.16
Percent loss due calculated at EBFC1	0.1%	5.8%
Additional loads tracked from above samples	31.13	822.54
Percentage of upstream loads that reach EBFC1	99.9%	94.2%
Total load tacked between EBFC3 and EBFC1	31.10	774.83
Allowable load at EBFC1	42.53	1,044.69
Load Reduction at EBFC1	0.00	0.00
Percent reduction required at EBFC1	0.0%	0.0%

The TMDL for point EBFC1 does not require a LA.

Margin of Safety (MOS)

An implicit MOS was used in these TMDLs derived from the Monte Carlo statistical analysis employing the @Risk software. Pa. Title 25 Chapter 96.3(c) states that water quality criteria must be met at least 99 percent of the time. All of the @Risk analyses results surpass the minimum 99 percent level of protection. Other MOS used for this TMDL analyses are:

- 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 MOS.

- An additional MOS is that the calculations were performed using a daily iron average, instead of the 30-day average.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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 F

Water Quality Data Used in TMDL Calculations

Station	Date	Time	Flow cfs	Flow gpm	Acidity mg/L	Alk mg/L	T. Al mg/L	pH (lab)	Dis. Al mg/L	DOC mg/L	D.O. mg/L	pH (field)	S.C. ms/cm3	Temp C
EBFC 1	3/12/2009	13:00:00	86.362	38759.266	1.4	8.0	0.100	6.10	na	1.705	12.19	4.55	0.023	2.4
EBFC 1	4/27/2009	17:00:00	45.047	20217.094	-1.2	8.4	0.065	6.10	0.061	1.950	6.73	5.93	0.031	18.9
EBFC 1	7/22/2009	17:00:00	4.739	2126.863	4.8	8.4	0.100	6.60	0.040	0.810	7.45	5.28	0.030	17.4
EBFC 1	9/28/2009	16:45:00	49.995	22437.756	2.6	2.6	0.143	6.30	0.141	1.560	7.79	5.78	0.032	13.5
EBFC 1	10/28/2009	14:45:00	421.110	188994.168	2.8	8.6	0.274	6.10	0.242	3.410	12.02	5.57	0.021	10.5
EBFC 1	12/15/2009	10:30:00	104.613	46950.314	5.4	8.2	0.100	6.20	0.204	0.550	8.66	6.17	0.024	5.0
Average			**118.644**	**53247.577**	**2.6**	**7.4**	**0.130**	**6.23**	**0.138**	**1.664**	**9.14**	**5.55**	**0.027**	**11.3**
Standard Dev.			**152.203**	**68308.548**	**2.4**	**2.3**	**0.075**	**0.20**	**0.088**	**1.011**	**2.38**	**0.58**	**0.005**	**6.6**
EBFC 2	3/12/2009	12:15:00	9.005	4041.444	3.4	6.6	0.438	5.00	na	2.750	12.63	3.18	0.029	1.8
EBFC 2	4/27/2009	17:13:00	5.050	2266.440	1.8	6.8	0.271	4.80	0.252	2.940	7.44	4.60	0.031	18.0
EBFC 2	7/23/2009	11:30:00	0.523	234.722	5.0	6.4	0.210	5.30	0.185	1.670	7.66	3.58	0.030	18.0
EBFC 2	9/28/2009	16:30:00	4.722	2119.234	4.2	4.5	0.730	5.20	0.610	2.480	6.25	4.89	0.027	13.6
EBFC 2	10/28/2009	12:45:00	32.081	14397.953	6.6	6.8	0.536	4.90	0.432	5.120	8.27	6.40	0.030	10.4
EBFC 2	12/15/2009	09:30:00	8.843	3968.738	9.0	6.6	0.369	5.00	0.257	1.680	8.69	5.02	0.030	4.4
Average			**10.037**	**4504.755**	**5.0**	**6.3**	**0.426**	**5.03**	**0.347**	**2.773**	**8.49**	**4.61**	**0.030**	**11.0**
Standard Dev.			**11.243**	**5046.014**	**2.5**	**0.9**	**0.189**	**0.19**	**0.173**	**1.268**	**2.19**	**1.15**	**0.001**	**6.8**
EBFC 3	3/12/2009	14:00:00	75.683	33966.530	3.6	7.8	0.100	6.10	na	1.540	12.20	4.06	0.022	2.5
EBFC 3	4/27/2009	18:00:00	30.780	13814.064	-1.2	8.2	0.082	6.00	0.076	2.020	6.48	5.64	0.028	18.8
EBFC 3	7/22/2009	16:00:00	3.330	1494.504	0.6	8.2	0.100	6.40	0.040	0.790	6.48	5.78	0.034	16.3
EBFC 3	9/28/2009	16:05:00	41.622	18679.954	6.0	1.4	0.228	5.90	0.215	2.460	6.70	5.59	0.026	13.1
EBFC 3	10/28/2009	14:00:00	356.646	160062.725	5.0	8.4	0.340	6.00	0.262	3.380	11.24	5.29	0.022	10.3
EBFC 3	12/15/2009	08:45:00	82.834	37175.899	6.2	7.8	0.100	6.10	0.161	0.710	8.99	5.91	0.027	3.8
Average			**98.483**	**44198.946**	**3.4**	**7.0**	**0.158**	**6.08**	**0.151**	**1.817**	**8.68**	**5.38**	**0.027**	**10.8**
Standard Dev.			**129.834**	**58269.323**	**3.0**	**2.7**	**0.104**	**0.17**	**0.093**	**1.025**	**2.56**	**0.68**	**0.004**	**6.6**
EBFC 4	3/12/2009	14:30:00	70.862	31802.866	2.6	8.2	2.969	6.00	na	1.690	12.75	4.11	0.022	2.9
EBFC 4	4/27/2009	17:30:00	28.058	12592.430	-0.6	7.6	0.107	5.80	0.931	2.000	6.48	5.49	0.032	18.8
EBFC 4	7/22/2009	15:00:00	3.846	1726.085	1.0	7.6	0.100	6.40	0.052	0.890	6.87	5.91	0.033	16.9
EBFC 4	9/28/2009	15:35:00	38.574	17312.011	3.6	1.4	0.276	6.10	0.255	2.790	7.20	5.58	0.026	13.0
EBFC 4	10/28/2009	13:10:00	304.504	136661.395	7.4	7.2	0.427	5.20	0.373	4.820	11.12	4.50	0.026	10.6
EBFC 4	12/15/2009	08:15:00	67.575	30327.660	6.4	7.6	0.234	5.80	0.154	1.080	8.85	3.08	0.024	4.4
Average			**85.570**	**38403.741**	**3.4**	**6.6**	**0.686**	**5.88**	**0.353**	**2.212**	**8.88**	**4.78**	**0.027**	**11.1**
Standard Dev.			**110.152**	**49436.215**	**3.1**	**2.6**	**1.125**	**0.40**	**0.344**	**1.448**	**2.55**	**1.08**	**0.004**	**6.5**
EBFC 5	3/12/2009	11:15:00	36.989	16600.663	3.6	7.8	0.100	6.10	na	1.270	12.57	4.15	0.020	1.8
EBFC 5	4/27/2009	15:00:00	14.588	6547.094	-0.8	8.0	0.060	6.00	0.049	2.010	6.64	5.76	0.028	17.9
EBFC 5	7/22/2009	13:45:00	1.215	545.292	4.2	8.0	0.100	6.20	0.034	0.680	7.09	5.69	0.035	16.0

Station	Date	Time	Flow cfs	Flow gpm	Acidity mg/L	Alk mg/L	T. Al mg/L	pH (lab)	Dis. Al mg/L	DOC mg/L	D.O. mg/L	pH (field)	S.C. ms/cm3	Temp C
EBFC 5	9/28/2009	17:05:00	10.213	4583.594	2.6	2.0	0.264	6.40	0.237	1.760	6.35	5.49	0.023	13.0
EBFC 5	10/28/2009	13:40:00	139.809	62746.279	2.6	7.8	0.258	6.00	0.239	2.180	8.98	6.40	0.021	10.1
EBFC 5	12/15/2009	07:45:00	20.705	9292.404	4.6	8.0	0.100	6.30	0.124	0.290	11.48	6.10	0.025	3.9
Average			**37.253**	**16719.221**	**2.8**	**6.9**	**0.147**	**6.17**	**0.137**	**1.365**	**8.85**	**5.60**	**0.025**	**10.5**
Standard Dev.			**51.643**	**23177.590**	**1.9**	**2.4**	**0.090**	**0.16**	**0.099**	**0.758**	**2.65**	**0.78**	**0.006**	**6.5**
EBFC 6	3/12/2009	10:00:00	28.160	12638.208	3.8	7.4	0.100	6.00	na	1.550	12.70	3.99	0.020	1.7
EBFC 6	4/27/2009	20:00:00	6.134	2752.939	1.4	7.6	0.076	5.80	0.081	1.990	8.70	5.31	0.023	13.7
EBFC 6	7/23/2009	10:00:00	0.876	393.149	2.4	9.6	0.100	6.30	0.042	0.710	6.87	4.40	0.027	14.7
EBFC 6	9/28/2009	15:00:00	6.448	2893.862	3.2	1.2	0.423	6.30	0.490	1.930	8.27	5.87	0.022	11.7
EBFC 6	10/28/2009	11:50:00	62.436	28021.277	2.8	7.6	0.256	5.90	0.218	2.300	9.07	6.36	0.021	9.7
EBFC 6	12/14/2009	11:50:00	16.001	7181.249	3.6	7.6	0.100	6.10	0.197	2.770	9.32	3.88	0.020	4.0
Average			**20.009**	**8980.114**	**2.9**	**6.8**	**0.176**	**6.07**	**0.206**	**1.875**	**9.16**	**4.97**	**0.022**	**9.3**
Standard Dev.			**22.913**	**10283.381**	**0.9**	**2.9**	**0.138**	**0.21**	**0.176**	**0.702**	**1.94**	**1.03**	**0.003**	**5.3**
EBFC 7	4/27/2009	18:00:00	2.094	939.787	4.6	5.2	0.296	4.40	0.263	4.540	8.00	4.14	0.035	13.1
EBFC 7	7/23/2009	9:00:00	0.018	8.078	8.0	5.2	0.309	4.50	0.309	4.030	7.11	3.69	0.029	14.3
EBFC 7	9/28/2009	13:30:00	1.010	453.288	18.8	0.0	0.997	4.40	0.848	7.560	8.85	4.23	0.070	13.0
EBFC 7	10/28/2009	10:15:00	10.014	4494.283	12.0	5.8	0.427	4.60	0.393	5.620	8.83	6.20	0.033	9.5
EBFC 7	12/14/2009	10:15:00	1.861	835.217	14.0	5.0	0.357	4.50	0.304	3.400	8.15	3.65	0.031	2.4
Average			**2.999**	**1346.131**	**11.5**	**4.2**	**0.477**	**4.48**	**0.423**	**5.030**	**8.19**	**4.38**	**0.040**	**10.5**
Standard Dev.			**4.005**	**1797.538**	**5.5**	**2.4**	**0.295**	**0.08**	**0.242**	**1.631**	**0.72**	**1.05**	**0.017**	**4.8**
EBFC 8	4/27/2009	19:00:00	3.976	1784.429	1.6	7.2	0.102	5.40	0.112	2.000	8.22	4.97	0.022	13.4
EBFC 8	7/23/2009	08:20:00	0.558	250.430	2.6	7.2	0.100	6.20	0.081	0.890	7.73	4.88	0.022	13.5
EBFC 8	9/28/2009	14:00:00	2.401	1077.569	7.2	0.6	0.612	5.70	0.603	3.170	9.14	4.94	0.027	11.9
EBFC 8	10/28/2009	10:50:00	32.203	14452.706	5.0	7.4	0.301	5.60	0.273	2.400	8.77	6.30	0.021	9.5
EBFC 8	12/14/2009	10:45:00	5.633	2528.090	5.6	6.8	0.100	5.80	0.144	1.020	9.61	3.48	0.019	3.8
Average			**8.954**	**4018.645**	**4.4**	**5.8**	**0.243**	**5.74**	**0.243**	**1.896**	**8.69**	**4.91**	**0.022**	**10.4**
Standard Dev.			**13.132**	**5893.481**	**2.3**	**2.9**	**0.224**	**0.30**	**0.214**	**0.958**	**0.74**	**1.00**	**0.003**	**4.0**
EBFC 9	3/12/2009	15:30:00	29.530	13253.064	2.8	7.4	0.312	5.40	na	2.560	11.97	3.90	0.025	2.4
EBFC 9	4/27/2009	14:30:00	11.174	5014.891	1.6	7.8	0.171	5.60	0.165	2.970	6.61	5.38	0.035	19.9
EBFC 9	7/22/2009	13:30:00	1.317	591.070	0.8	8.0	0.100	6.40	0.085	1.300	7.01	5.87	0.048	16.8
EBFC 9	9/28/2009	17:00:00	17.555	7878.684	7.4	1.0	0.696	6.00	0.692	3.770	6.59	5.64	0.027	13.3
EBFC 9	10/28/2009	13:50:00	144.209	64720.999	10.4	7.6	0.466	5.40	0.424	5.685	8.93	6.20	0.026	10.1
EBFC 9	12/015/09	07:15:00	23.647	10612.774	5.8	7.6	0.272	5.70	0.251	2.190	8.75	4.89	0.026	4.5
Average			**37.905**	**17011.914**	**4.8**	**6.6**	**0.336**	**5.75**	**0.323**	**3.079**	**8.31**	**5.31**	**0.031**	**11.2**
Standard Dev.			**52.993**	**23783.285**	**3.7**	**2.7**	**0.216**	**0.39**	**0.241**	**1.517**	**2.07**	**0.82**	**0.009**	**6.9**

Station	Date	Time	Flow cfs	Flow gpm	Acidity mg/L	Alk mg/L	T. Al mg/L	pH (lab)	Dis. Al mg/L	DOC mg/L	D.O. mg/L	pH (field)	S.C. ms/cm3	Temp C
EBFC 10	3/12/2009	18:15:00	16.594	7447.387	4.2	6.8	0.379	5.00	na	2.740	12.53	4.15	0.026	1.5
EBFC 10	4/27/2009	13:00:00	7.299	3275.791	4.6	6.8	0.253	4.80	0.214	3.370	8.21	4.57	0.029	13.8
EBFC 10	7/22/2009	12:10:00	0.610	273.768	4.6	6.6	0.100	5.40	0.182	1.700	6.98	4.61	0.030	15.1
EBFC 10	9/28/2009	14:35:00	9.111	4089.017	14.2	0.0	0.624	5.00	0.559	3.840	9.15	4.25	0.028	12.6
EBFC 10	10/28/2009	12:30:00	85.638	38434.334	9.0	6.6	0.501	4.80	0.373	5.500	12.02	4.30	0.029	10.2
EBFC 10	12/14/2009	15:45:00	17.159	7700.959	8.8	6.6	0.391	5.00	0.352	1.990	11.65	3.24	0.026	3.3
Average			**22.735**	**10203.543**	**7.6**	**5.6**	**0.375**	**5.00**	**0.336**	**3.190**	**10.09**	**4.19**	**0.028**	**9.4**
Standard Dev.			**31.429**	**14105.449**	**3.9**	**2.7**	**0.184**	**0.22**	**0.150**	**1.390**	**2.29**	**0.50**	**0.002**	**5.7**
EBFC 11	3/12/2009	17:45:00	12.862	5772.466	5.0	6.6	0.369	4.80	na	2.590	12.45	4.03	0.028	1.8
EBFC 11	4/27/2009	12:00:00	5.597	2511.934	5.4	6.2	0.282	4.70	0.259	3.390	8.16	4.43	0.030	13.2
EBFC 11	7/22/2009	11:00:00	0.690	309.672	1.4	6.8	0.100	5.40	0.170	1.970	7.21	4.77	0.027	14.6
EBFC 11	9/28/2009	14:00:00	5.619	2521.807	8.8	0.0	0.682	4.60	0.629	4.440	9.18	3.61	0.031	12.6
EBFC 11	10/28/2009	11:30:00	64.170	28799.496	9.2	6.2	0.499	4.60	0.419	4.890	11.02	4.18	0.030	10.1
EBFC 11	12/14/2009	15:00:00	14.829	6655.255	10.4	6.2	0.416	4.80	0.381	2.110	11.18	3.62	0.028	3.7
Average			**17.295**	**7761.772**	**6.7**	**5.3**	**0.391**	**4.82**	**0.372**	**3.232**	**9.87**	**4.11**	**0.029**	**9.3**
Standard Dev.			**23.545**	**10567.113**	**3.4**	**2.6**	**0.197**	**0.30**	**0.175**	**1.224**	**2.01**	**0.46**	**0.002**	**5.3**
EBFC 12	3/12/2009	16:45:00	7.653	3434.666	5.6	6.6	0.411	4.70	na	2.800	12.18	3.93	0.029	2.0
EBFC 12	4/27/2009	11:00:00	1.902	853.618	4.8	5.8	0.298	4.60	0.268	3.450	9.29	4.30	0.028	11.6
EBFC 12	7/22/2009	09:45:00	0.160	71.808	8.0	5.6	0.256	4.70	0.242	2.180	7.85	4.32	0.027	14.8
EBFC 12	9/28/2009	13:10:00	2.242	1006.210	6.8	0.0	0.536	4.60	0.513	2.490	8.87	4.08	0.027	12.4
EBFC 12	10/28/2009	10:30:00	14.176	6362.189	9.0	6.2	0.717	4.60	0.424	5.200	11.40	4.24	0.028	10.3
EBFC 12	12/14/2009	14:00:00	4.280	1920.864	9.2	6.0	0.366	4.70	0.337	3.810	12.80	3.05	0.025	3.2
Average			**5.069**	**2274.892**	**7.2**	**5.0**	**0.431**	**4.65**	**0.357**	**3.322**	**10.40**	**3.99**	**0.027**	**9.1**
Standard Dev.			**5.145**	**2309.093**	**1.8**	**2.5**	**0.171**	**0.05**	**0.112**	**1.100**	**2.00**	**0.48**	**0.001**	**5.2**

Attachment G

A Preliminary Investigation into the Natural Variability and Potential Contribution to Stream Acidity of Dissolved Organic Carbon in the East Branch Fishing Creek Watershed

By

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Introduction

Dissolved organic carbon (DOC) is a designation used to describe the broad range of organic compounds that can pass through a 0.45 µm pore size filter. Collectively DOC can make up the largest pool of organic carbon in running waters (Fisher and Likens 1973) and is the primary contributor to bacterial metabolism, which can ultimately help fuel productivity at higher trophic levels, such as macroinvertebrates and fish (e.g., Rier and Stevenson 2002, Findlay 2010, Tank et al. 2010). These compounds include everything from simple carbohydrates, that are very easy for microorganisms to utilize, to very large, complex polyphenolic compounds, originating from the breakdown of lignin, that are relatively recalcitrant to microbial degradation (Allan and Castillo 2007).

DOC can originate from numerous natural sources such as from in-stream algal photosynthesis (e.g., Kaplan and Bott 1989) or from the leaching of leaves that fall into the stream during autumn leaf drop (Tank et al. 2010). However, the most substantial natural inputs of DOC typically originate from outside the stream channel. Surface water and ground water entering the stream from the surrounding catchment often comes in contact with soil organic matter where it has accumulates dissolved organic compounds from the decomposition of terrestrial plants. This phenomenon is most common during storm events and in steep terrain where water running off the land follows relatively shallow flow paths and remains in contact with soil layers that are rich in organic matter (David et al. 1992, Kullberg et al. 1993). Similarly, water that comes in contact with wetland sediments (especially peat) can also accumulate significant quantities of dissolved organic compounds (e.g., Buffman et al. 2007). Generally, catchments that are dominated by peat-producing wetlands, such as those found in regions of extensive boreal forests, have streams with high concentrations of DOC. Often the DOC originating from these sources is rich in humic substances that impart a tea-stained color to the water.

Terrestrial- or wetland-derived DOC often contains organic acids which can drive streams toward a natural acidic state. Natural acidification can often occur episodically such as during the high discharges associated with storm events and spring snow melt (Wellington and Driscoll 2004) and can be difficult to distinguish from anthropogenic sources such as mineral acids originating from atmospheric deposition (Buffam et al. 2007). For example, the acidity in the streams of northern Sweden has been shown to be driven primarily by organic acids as opposed to anthropogenically-derived mineral sources such as sulfate (e.g., Laudon et al. 1999). This realization occurred following years of costly efforts to mitigate all low pH streams regardless of the source of acidity (Kullberg et al 1993). It is also possible for both anthropogenic and natural organic acids to contribute to acidity in stream water. Wellington and Driscoll (2004), working in a New Hampshire stream, demonstrated that mineral acidity originating from atmospheric deposition was the primary source of acidity during spring snowmelt, while organic acids contribute a majority of the acidity during summer episodic events. In contrast, Passy (2006) found that acidity in a chronically acidified Adirondack stream was driven by atmospheric sulfate deposition during snowmelt and rain events and organic acids during base flow.

Acidification from atmospheric deposition has been of major concern for the tributaries and main stem of the East Branch of Fishing Creek located in northern Columbia County and Southern Sullivan County in North Central Pennsylvania. However, many of the tributaries draining this catchment drain extensive peat lands that are situated on the top of the Allegany Plateau. These wetlands likely contribute substantial quantities of DOC to these streams. It is possible that organic acids may contribute to the well documented acidity issues in this watershed. The purpose of this study was to couple a DOC sampling regime to a monitoring effort that was being carried out by the Susquehanna River Basin Commission in order to establish a total maximum daily load (TMDL) for anthropogenic acidity in the East Branch Fishing Creek watershed. The objective of the DOC sampling regime was to document natural variability in stream DOC concentrations throughout the catchment and to preliminarily investigate whether or not there was evidence that organic acids associated with DOC were contributing to the acidity being observed in the tributaries and main stem of this watershed.

Methods

Samples for DOC were collected at the same time and place as other samples for the TMDL study. Stream water was filtered (GF/f) in the field into 40 mL precombusted borosilicate glass vials, stored on ice, and transported to a laboratory refrigerator within 12 hours. Field blanks and duplicate samples were prepared on each sample date to insure quality control. All samples and blanks were acidified within 24 hours in order to reduce the pH to less than 2. The acidified samples were purged with nitrogen gas for 10 minutes immediately prior to DOC determination. DOC was determined using high temperature catalytic combustion (Shimadzu TOC 500, APHA 1998). Samples collected during the final two sample periods (10/28/2009 and 12/14/2009) were also analyzed for UV-absorbing organic constituents (APHA 1998) by reading the absorbance of each sample at 254 nm using a Thermo Scientific Spectronic GENESYS 2 UV/vis spectrophotometer and a 5 cm path length quartz cell. This method was used as an indicator of the relative contribution of humic substances in the DOC pool.

Results and Discussion

DOC concentrations ranged from 0.3 to 7.6 mg/l for all stream samples collected during the TMDL study. However, a single sample collected on 28 April 2009 at the outlet of a wetland located near the headwaters of Meeker Run (above station 7) had a DOC of 15.0 mg/l. DOC concentrations commonly tracked discharge in the stream sites included in the TMDL study. In general, higher DOC concentrations were observed at higher flows (Fig. 1). Field crews also observed a tea-stained color in the water at many sites during high flow. However, there were possibly other contributing factors at several stream sites (e.g., sites 6, 7, and 8). These discrepancies might indicate the flushing of organic carbon pools during extended precipitation events and hysteresis effects (Kullberg et al. 1993). A strong relationship ($p<0.001$, $r^2=0.96$, ordinary least squares regression) between DOC concentrations and absorbance at 254 nm during the final two sample dates (Fig. 2) suggests that the DOC pool in these streams is primarily composed of humic substances, which are formed during the decomposition of terrestrial or wetland plant material.

There was a strong negative relationship between DOC and pH and a strong positive relationship between DOC and acidity when all observations collected in this study were included in a single analysis (Fig. 3). Almost half the variability in pH could be explained by DOC, while approximately 40% of the variability in acidity could be explained by DOC. These statistically significant relationships ($p<0.001$, ordinary least squares regression) strongly suggest that organic acids contribute to acidity in these streams. Unfortunately, the scope of this survey did not include the collection of all data necessary for definitively calculating the contribution of organic acids to acidity in these streams. Such an analysis would require the concurrent collection of Ca^{+}, Mg^{2+}, Na^{+}, K^{+}, NH_4^{+}, SO_4^{2-}, Cl^{-}, F^{-}, and NO_3^{-} (Wellington and Driscoll 2004) in addition to the parameters collected in the current study. It is also possible that the relationships observed were, at least to some degree, the result of covariation between stream DOC concentrations and other factors associated with susceptibility to acid deposition. For example, streams that originate in wetlands and consequently have high concentrations of DOC might for other reasons be more susceptible to atmospheric acid deposition than streams not originating in wetlands.

Although it is impossible to definitively ascertain the contribution of organic acids to acidity in the East Branch Fishing Creek watershed given the current dataset, it is clear that humic substances potentially influence the biogeochemistry of these streams. Although these substances can produce natural acidification in streams, this source of acidity usually does cause substantial impairment to the structure and function of stream ecosystems (e.g., Petrin et al. 2008). Naturally acidic streams have been present over evolutionary time scales allowing organisms to adapt to potentially physiologically challenging conditions associated with high acidity. Humic substances also ameliorate the metal toxicity often associated with acidic waters. This occurs through complexation reactions, which make metals such as aluminum these less biologically active (Kullberg et al. 1993). For example, Petrin et al. (2008) found using meta-analysis that the loss of macroinvertebrate species richness is much greater across an anthropogenic acidification gradient than a natural acidification gradient.

High DOC concentrations might also be an indicator of recovery from past atmospheric deposition. Streams throughout the northern hemisphere have had increasing DOC concentrations over the past two decades (e.g., Freeman et al. 2001). Decreased atmospheric sulfate deposition is one explanation for this increase (Monteith et al. 2007, Hruska et al. 2009). Sulfate deposition can affect soil organic matter solubility through decreased pH and/or increased ionic strength (Monteith et al. 2007, Hruska et al. 2009). Therefore, decreases in sulfate deposition might result in more soil organic matter going into solution, thus increasing DOC concentrations in surface waters. Furthermore, organic acids associated with DOC might partially buffer increases in pH associated with decreased atmospheric sulfate deposition (Monteith et al. 2007)

This preliminary study constitutes only a first look at the dynamics of DOC and the potential contribution of organic acids to stream acidity in the East Brach Fishing Creek watershed. A more thorough chemical analysis that encompasses the full range of seasonal and hydraulic variability is needed before we can obtain a more definitive understanding of these dynamics. Furthermore, future chemical analyses need to be coupled to studies that simultaneously examine the effects organic versus mineral acidity on community structure (algae, macroinvertebrates, and fish) and ecosystem function (carbon and nutrient dynamics) in this watershed.

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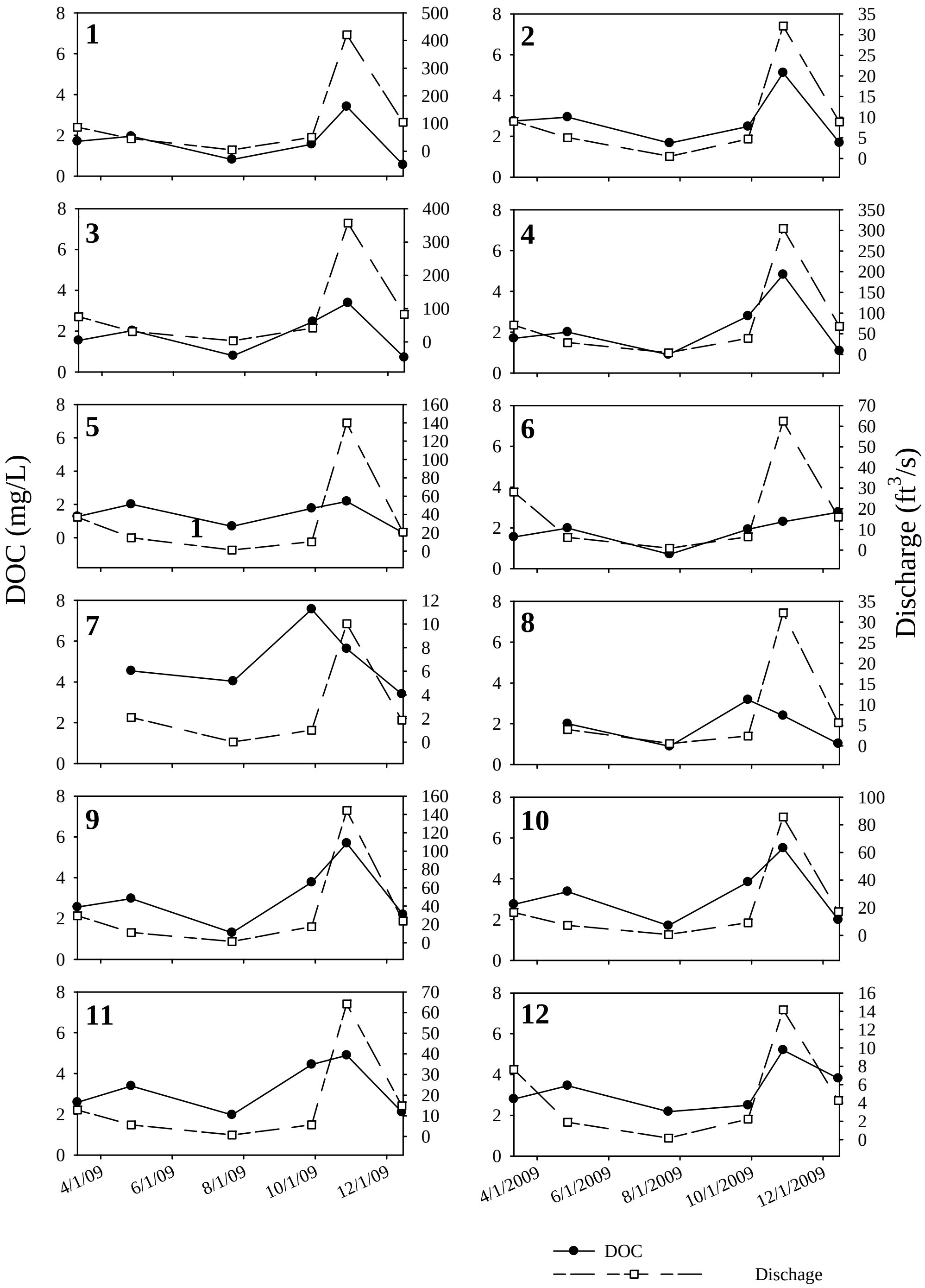

Fig. 1. Dissolved organic carbon (DOC) concentrations (left y axis) and discharge (right y axis, note differences in scale) at each sampling site (panels 1-12) included in the total maximum daily load study of the East Branch Fishing Creek watershed.

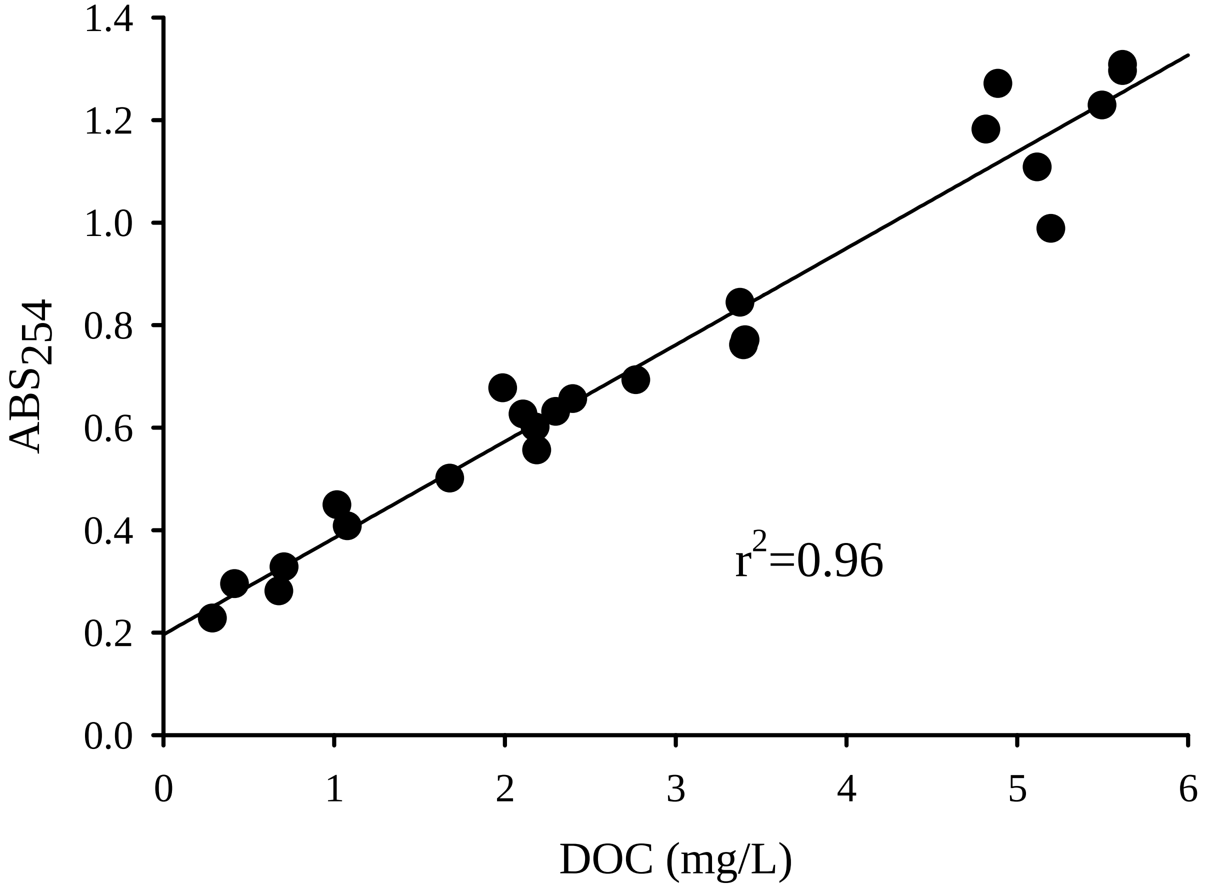

Fig. 2. Relationship between dissolved organic carbon (DOC) concentration and absorbance at 254 nm (5 cm path length quartz cell) for water samples collected on 10/28/2009 and 12/15/2009 during the total maximum daily load study of the East Branch Fishing Creek watershed.

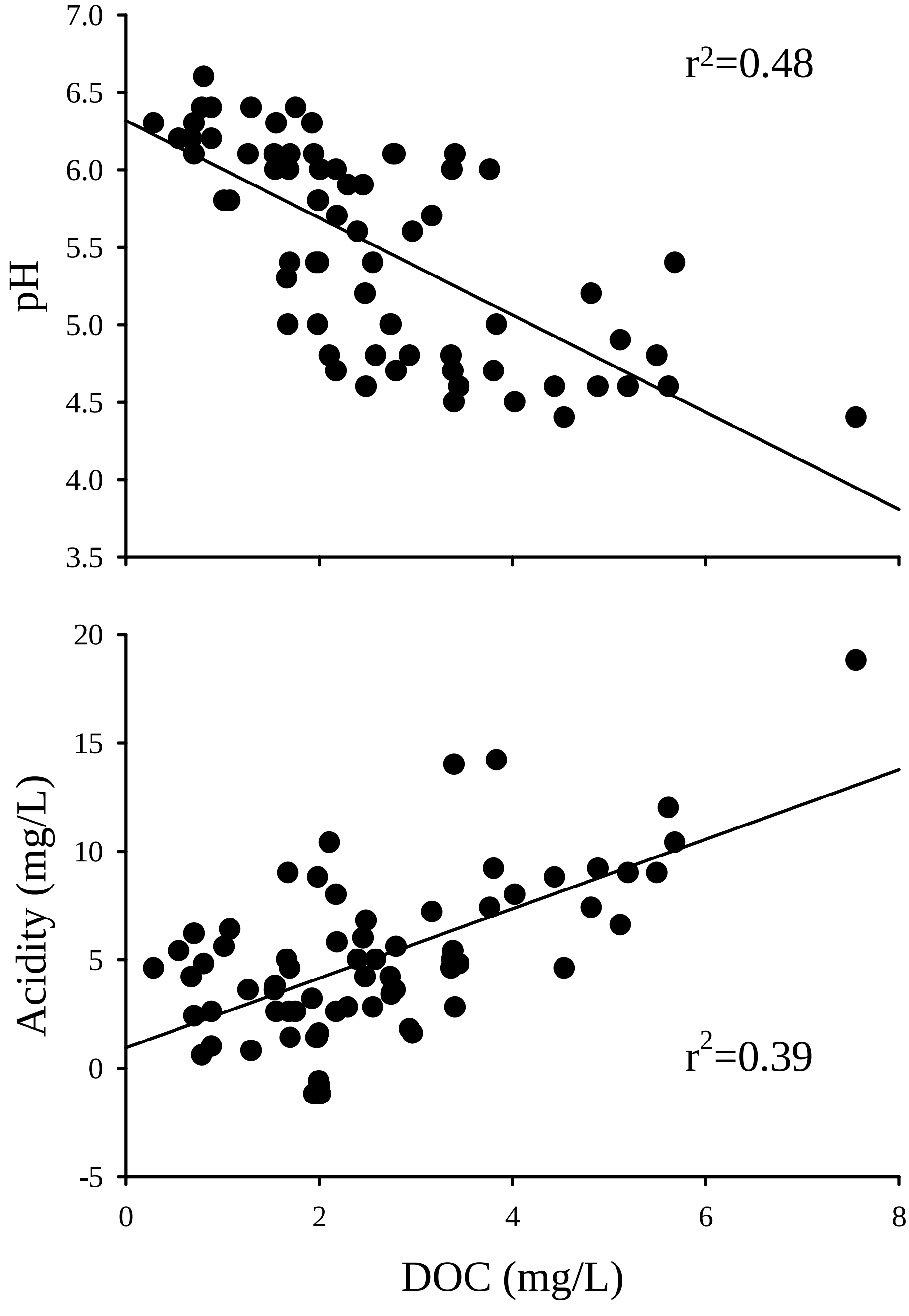

Fig. 3. Relationship between dissolved organic carbon (DOC) concentration and pH (top panel) and acidity (bottom panel) for all samples collected during the total maximum daily load study of the East Branch Fishing Creek watershed. Both relationships were statistically significant ($p<0.001$).

Attachment H

East Branch Fishing Creek Impaired Segment Listing

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date

Hydrologic Unit Code: 02050107 - Upper Susquehanna-Lackawanna

Big Run
HUC: 02050107

Aquatic Life (581) - 2.73 miles; 5 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015

Big Run (Unt 28011)
HUC: 02050107

Aquatic Life (581) - 0.15 miles; 2 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015

Big Run (Unt 28012)
HUC: 02050107

Aquatic Life (581) - 0.07 miles; 1 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015

Blackberry Run
HUC: 02050107

Aquatic Life (581) - 2.72 miles; 8 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015

Blackberry Run (Unt 27994)
HUC: 02050107

Aquatic Life (581) - 0.54 miles; 2 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015

East Branch Fishing Creek
HUC: 02050107

Aquatic Life (581) - 4.53 miles; 9 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015

East Branch Fishing Creek (Unt 27990)
HUC: 02050107

Aquatic Life (581) - 0.86 miles; 1 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015

*Segments are defined as individual COM IDs.

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date
East Branch Fishing Creek (Unt 27991) HUC: 02050107			
Aquatic Life (581) - 0.63 miles; 1 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
East Branch Fishing Creek (Unt 27992) HUC: 02050107			
Aquatic Life (581) - 0.06 miles; 2 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
East Branch Fishing Creek (Unt 64671) HUC: 02050107			
Aquatic Life (581) - 0.03 miles; 2 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Heberly Run HUC: 02050107			
Aquatic Life (581) - 5.35 miles; 10 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Heberly Run (Unt 28001) HUC: 02050107			
Aquatic Life (581) - 0.41 miles; 1 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Heberly Run (Unt 28007) HUC: 02050107			
Aquatic Life (581) - 0.57 miles; 6 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Hunts Run HUC: 02050107			
Aquatic Life (581) - 0.66 miles; 2 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Lead Run HUC: 02050107			
Aquatic Life (581) - 1.52 miles; 3 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015

*Segments are defined as individual COM IDs.

Stream Name / Use Designation (Assessment ID) / Source	Cause	Date Listed	TMDL Date
Lead Run			
HUC: 02050107			
Aquatic Life (581) - 1.52 miles; 3 Segment(s)*			
Atmospheric Deposition	pH	2002	2015
Lead Run (Unt 27998)			
HUC: 02050107			
Aquatic Life (581) - 0.12 miles; 3 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Lead Run (Unt 27999)			
HUC: 02050107			
Aquatic Life (581) - 0.22 miles; 3 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Meeker Run			
HUC: 02050107			
Aquatic Life (520) - 0.96 miles; 3 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Meeker Run (Unt 28006)			
HUC: 02050107			
Aquatic Life (520) - 0.55 miles; 2 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Ore Run			
HUC: 02050107			
Aquatic Life (581) - 0.92 miles; 5 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Ore Run (Unt 28017)			
HUC: 02050107			
Aquatic Life (581) - 0.28 miles; 2 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Pigeon Run			
HUC: 02050107			
Aquatic Life (581) - 1.40 miles; 3 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015

*Segments are defined as individual COM IDs.

Stream Name / Use Designation (Assessment ID) / Source	Cause	Date Listed	TMDL Date
Pigeon Run HUC: 02050107			
Quinn Run HUC: 02050107			
Aquatic Life (451) - 2.26 miles; 3 Segment(s)*			
Atmospheric Deposition	pH	2002	2015
Shanty Run HUC: 02050107			
Aquatic Life (451) - 1.68 miles; 9 Segment(s)*			
Atmospheric Deposition	pH	2002	2015
Shanty Run (Unt 28004) HUC: 02050107			
Aquatic Life (451) - 0.30 miles; 2 Segment(s)*			
Atmospheric Deposition	pH	2002	2015
Sullivan Branch HUC: 02050107			
Aquatic Life (581) - 3.31 miles; 9 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Sullivan Branch (Unt 28015) HUC: 02050107			
Aquatic Life (581) - 0.51 miles; 1 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Sullivan Branch (Unt 28018) HUC: 02050107			
Aquatic Life (581) - 0.29 miles; 3 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Sullivan Branch (Unt 28019) HUC: 02050107			
Aquatic Life (581) - 0.21 miles; 2 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Trout Run HUC: 02050107			
Aquatic Life (581) - 1.63 miles; 4 Segment(s)*			

*Segments are defined as individual COM IDs.

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date
Trout Run HUC: 02050107			
Aquatic Life (581) - 1.63 miles; 4 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015
Trout Run (Unt 27996) HUC: 02050107			
Aquatic Life (581) - 0.33 miles; 1 Segment(s)*			
Atmospheric Deposition	Metals	2002	2015
Atmospheric Deposition	pH	2002	2015

Report Summary

Watershed Summary

	Stream Miles	Assessment Units	Segments (COMIDs)
Watershed Characteristics	38.37	3	121

Impairment Summary

Source	Cause	Miles	Assessment Units	Segments (COMIDs)
Atmospheric Deposition	Metals	31.55	2	96
Atmospheric Deposition	pH	35.79	3	110
		35.79 **	**3** **	**110** **

**Totals reflect actual miles of impaired stream. Each stream segment may have multiple impairments (different sources or causes contributing to the impairment), so the sum of individual impairment numbers may not add up to the totals shown.

Use Designation Summary

	Miles	Assessment Units	Segments (COMIDs)
Aquatic Life	35.79	3	110

Attachment I

Comment and Response

No official comments were received for this TMDL.