Total Maximum Daily Load (TMDL)

Canonsburg Lake, Washington County

July 2004

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1.0 Introduction

Canonsburg Lake, also referred to as Alcoa Dam, was built in 1941 and was used by the Alcoa Company as a manufacturing water supply (Figure 1). In 1958 the lake was donated to the Pennsylvania Fish Commission who managed it as a trout-stocked lake. Its dam, which is approximately 525 feet long and 45 feet high, impounds water coming from the 46-mi^2 Little Chartiers Creek Basin (State Water Plan 20-F, Stream code 36943). Historical documents state that the resulting lake has a surface area of about 76 acres, a volume of 700 acre/feet, a mean depth of 2.8 meters, and a maximum depth of 13 meters. However, an internal study conducted in 1987 by DEP revealed that the maximum and average depths as well as the total volume have decreased considerably due to siltation, predominantly stemming from non-point sources such as agriculture. This study also determined that Canonsburg Lake was further degraded by the effects of excessive algal growth arising from excess levels of nutrients. Canonsburg Lake was subsequently listed on Pennsylvania's 1996 Section 303(d) List, and remained on all subsequent lists (ID 19861001-0000-LAK), for impairments caused by nutrients from agricultural sources.

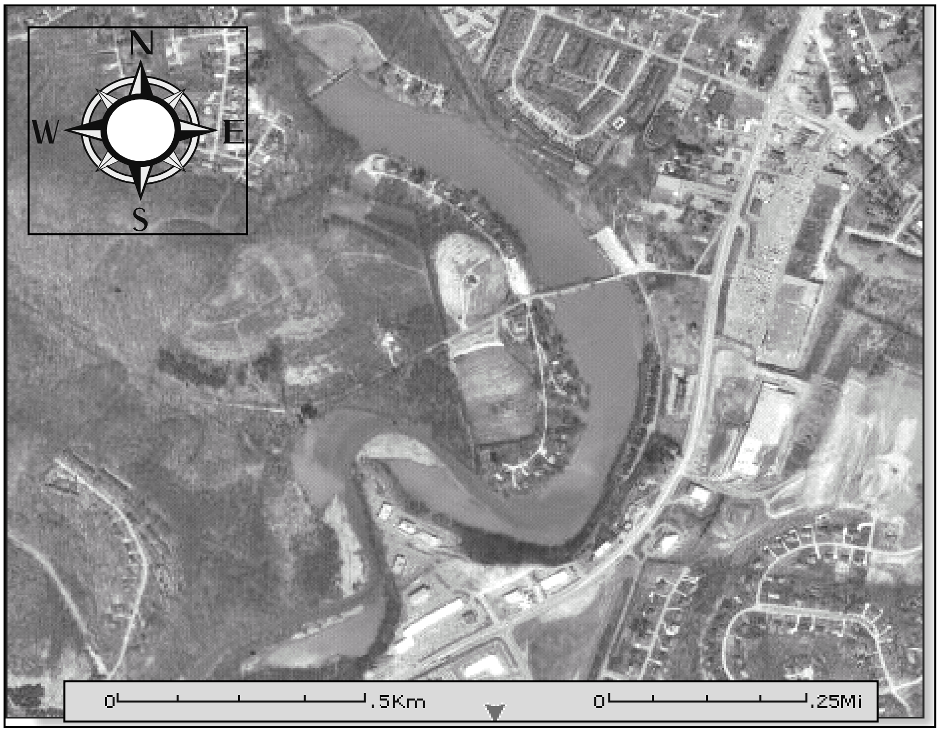
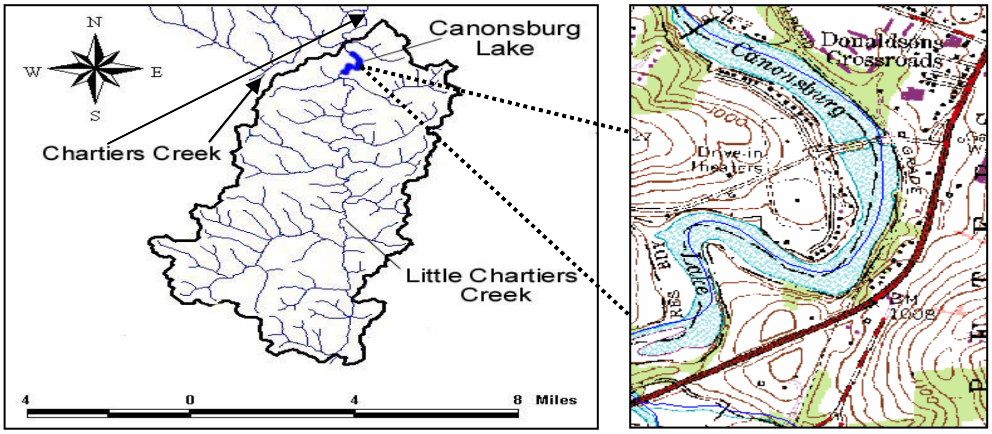


Figure 1. Aerial photograph of Canonsburg Lake, Washington County. Photo courtesy of United States Geological Survey.

1.1 Physical Setting

Canonsburg Lake is located in north-central Washington County. It lies between I79 and R19 within Peters and North Strabane Townships (Canonsburg USGS quadrangle, Figures 2 and 3). State water plan 20-F encompasses the lake. From the dam (N40º 16.403 W80º 8.253), its waters flow northward for approximately 0.37 miles before coalescing with Chartiers Creek

(36777).



Figures 2 and 3 (Left to right). Locations of Canonsburg Lake (Alcoa Dam), Chartiers Creek (only a portion is shown), and Little Chartiers Creek.

The watershed of Canonsburg Lake lies within the Pittsburgh Low Plateau Section of the Appalachian Plateau Province. This section consists of a smooth undulating upland surface cut by numerous, narrow, relatively shallow valleys. Elevation ranges from 274 to 394 m above sea level. Primary soil associations are Gilpin Dormant Culleoka (6%) and Dormont Culleoka Guernsey (94%), and the dominant hydrologic soil group is C; this soil group is characterized as having a slow infiltration rate when thoroughly wetted. The rock-type of the watershed is exclusively interbedded sedimentary.

Figure 4 illustrates the land-use for the Canonsburg Lake watershed. The watershed is dominated by forest (54%), followed by agriculture (39%), and development (7%).

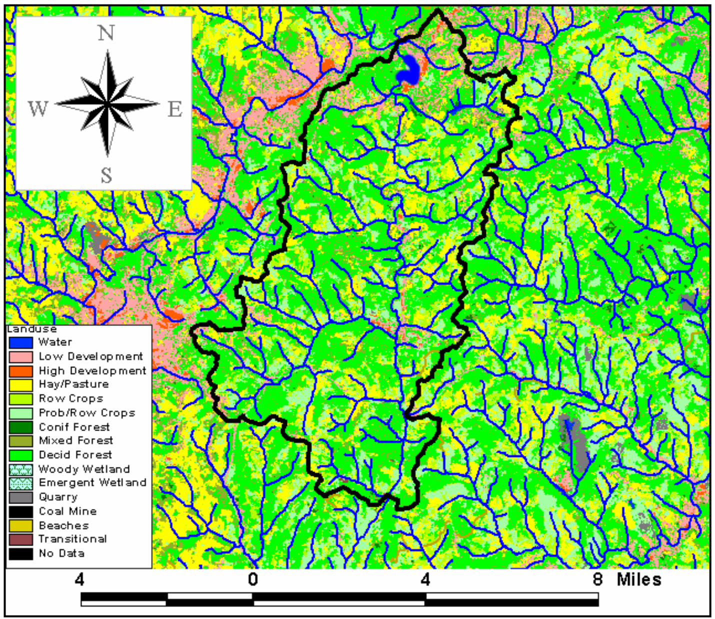


Figure 4. Landuse in Canonsburg Lake watershed.

1.2 Lake Eutrophication

Lake eutrophication is both a natural and culturally-based phenomenon. Natural eutrophication is a slow, largely irreversible process associated with the gradual accumulation of organic matter and sediments in lake basins. Cultural eutrophication is an often rapid, possibly reversible process of nutrient enrichment and high biomass production stimulated by cultural activities causing nutrient transport to lakes (Novotny and Olem, 1994). Lakes are considered to undergo a process of "aging" which can be characterized by the trophic status as *oligotrophic*, *mesotrophic*, or *eutrophic*. Oligotrophic lakes are normally associated with deep lakes which have relatively high levels of dissolved oxygen throughout the year, bottom sediments typically contain small amounts of organic matter, chemical water quality is good, and aquatic populations are both productive and diverse. Mesotrophic lakes are characterized by intermediate levels of biological productivity and diversity, slightly reduced dissolved oxygen levels, and generally have adequate water quality to support designated uses. However, there is a recognition that these lakes are naturally or culturally moving towards a eutrophic state. Lakes which are classified as eutrophic typically exhibit high levels of organic matter, both suspended in the water column and in the upper portions of sediments. Biological productivity is high, often indicated by seasonal algae blooms and excessive plant growth. Dissolved oxygen concentrations are low, and may reach extreme levels during critical periods. In addition, water quality is often poor resulting in violations of the designated uses. Table 1 illustrates typical water quality values associated with these trophic designations. However, as will be discussed below in the Numeric Water Quality Target section, Canonsburg Lake does not fit the traditional definition of a lake as its detention time is less than 14 days.

Table 1. Trophic Status of Lakes

Variable	**Oligotrophic**	**Mesotrophic**	**Eutrophic**
Total P (ug/l)	<10	10-20	>20
Chlorophyll-a (ug/l)	<4	4-10	>10
Secchi disc depth (m)	>4	2-4	<2
Hypolimnetic oxygen (% sat.)	>80	10-80	<10

(Source: Thomann and Mueller, 1987)

The Secchi-disk depth listed in Table 1 is an assessment of water clarity. A Secchi-disk is a circular plate divided into alternately painted black and white quarters. The disk is attached to a rope or chain and lowered into the water until it is no longer visible. Higher Secchi-disk readings mean more rope/chain was let out before the disk disappeared from sight and indicates clearer water. Lower readings indicate turbid or colored water. Clear water lets light penetrate more deeply into the lake than does murky water. A general rule of thumb is that light can penetrate to a depth of about 2-3 times the Secchi-disk depth. Although algae, soil particles, and other materials suspended in the water affect clarity, Secchi-disk depth is primarily used as an indicator of algal abundance and general lake productivity.

In order to understand the term hypolimnion used in Table 1, one must first understand the concept of thermal stratification. Thermal stratification is where mixing in a water body is incomplete, allowing two or more distinct temperature layers to develop during at least part of the year. The two distinct temperature layers found in a vertically stratified waterbody are the epilimnion (top) and a hypolimnion (bottom). Therefore, the term “hypolimnion oxygen” refers to oxygen levels in the lower portion of a thermally stratified lake.

1.3 Canonsburg Lake Water Quality

A Lake Phosphorus Study conducted by Proch in 1987 formed the basis for Canonsburg Lake appearing on Pennsylvania’s 1996 303(d) list. The study was done to assess the potential effects of imposing TP effluent limits on phosphorus dischargers in the watershed. The study determined that Canonsburg Lake, although highly eutrophic, would realize only modest improvements in water quality with effluent limits because the overwhelming majority of the phosphorus load to the lake was delivered from nonpoint sources. Therefore, the study concluded that no TP limits were required for dischargers. At the time of the study, average TP concentrations in the lake were 0.12 mg/l making it hypereutrophic. Additionally, the Lake Phosphorus Study states that the entire Little Chartiers Creek watershed was designated as a High Quality Warm Water Fishery for the sole purpose of protecting the lake.

Observed dissolved oxygen levels in the hypolimnion of Canonsburg Lake were below the current criteria found in Pennsylvania Code, Title 25, Chapter 93, Water Quality Standards, Section 93.7 for a High Quality Warm Water Fishery (HQ WWF). The current standard requires a minimum D.O. to be met at all points in a lake, pond or impoundment. However, the HQ WWF dissolved oxygen criterion is in the process of being changed to apply only to the epilimnion. This change in Pennsylvania’s water quality standards is supported by U.S. EPA and is expected to be finalized by Fall 2004. Therefore, this TMDL will not address dissolved oxygen in Canonsburg Lake.

1.4 Water Quality Standards

Water quality standards are typically developed to control quantities of various pollutants that may enter water bodies in order to maintain healthy conditions and usually consist of three inter-related components: 1) designated and existing uses, 2) narrative and/or numerical water quality criteria necessary to support those uses, and 3) an anti-degradation statement. Furthermore, water quality standards serve the dual purposes of establishing the water quality goals for a specific waterbody and serve as the regulatory basis for the establishment of water quality-based treatment controls and strategies beyond the technology-based levels of treatment required by section 301(b) and 306 of the Act (USEPA, 1991).

According to Pennsylvania Code, Title 25, Chapter 93, Water Quality Standards, Section 93.4, all surface waters in the state shall be protected for the following uses: warm water fishes, potable water supply, industrial water supply, livestock water supply, wildlife water supply, irrigation, boating, fishing, water contact sports, and aesthetics.

Pennsylvania does not currently have specific numeric water quality criteria for suspended solids or nutrients to support these uses. However, Pennsylvania does have general water quality criteria that state in Section 93.6 that: *a) Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life; and b) In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances which produce color, tastes, orders, turbidity or settle to form deposits.* These general water quality criteria may be interpreted to identify an acceptable water quality endpoint.

1.5 Numeric Water Quality Target

In order to develop a given TMDL, a water quality indicator and numeric water quality target must be specified. As mentioned, Pennsylvania does not currently have numeric water quality standards for nutrients. Therefore, the overall goal of this TMDL will be to improve the trophic status of Canonsburg Lake. As described above, the current hyper-eutrophic conditions are due to excessive nutrient input to the lake (particularly phosphorus, since this is the limiting nutrient in this case). In this watershed, most of the phosphorus originates from nonpoint source runoff in both dissolved and particulate (i.e., sediment-attached) forms (Proch, 1987).

According to the trophic state index values given in Table 1, there are four parameters used to relate water quality with trophic state. In this case, *chlorophyll-a* will be used as the numeric water quality target. Chlorophyll-*a* is the primary photosynthetic pigment in algae and cyanobacteria (blue-green algae) and is easy to measure. Therefore, chlorophyll-a is used as a surrogate for algal biomass, and is desirable as a water quality target because algae are either the direct (nuisance algal blooms) or indirect (low dissolved oxygen, pH, and high turbidity) cause of most problems related to excessive enrichment (US EPA, 1999(a)).

Due to Canonsburg Lake's short detention time (≈ 6 days) and decreased settling rates due to higher advective flow velocities, algae is flushed from the lake before nuisance algal growths can develop.

Canonsburg Lake functions somewhere between a lake and a slowly moving stream. In fact, Pennsylvania uses a 14 day detention time to distinguish between lakes and flowing waters. The selection of the 14-day hydraulic residence time is based upon a recommendation set forth in the U.S. EPA National Eutrophication Survey Working Paper 725. A 20 ug/l seasonal average chlorophyll-a target was used for the purpose of defining a total phosphorus TMDL for Canonsburg Lake. This will result in a mildly eutrophic classification for Canonsburg Lake. Given the natural progression of all lakes and the fact that Canonsburg Lake is 63 years old, Pennsylvania believes this is consistent with water quality standards for the Lake.

As described in the next section, estimates of phosphorus reductions needed to achieve the 20 ug/l chlorophyll-a goal were made via the combined use of a watershed model (AVGWLF) and a lake water quality model (BATHTUB).

2.0 TMDL ASSESSMENT METHODOLOGY

2.1 Overview

A combined watershed modeling/lake water quality modeling approach was used to conduct the TMDL assessment for Canonsburg Lake. The lake model is BATHTUB, which performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network that accounts for advective and diffusive transport, and nutrient sedimentation (Walker, 1996). BATHTUB is used to simulate the fate and transport of nutrients and water quality conditions and responses to nutrient loads into the lake. BATHTUB has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (US EPA, 1999). In order to simulate water quality conditions, BATHTUB requires input information on various lake characteristics such as length, width, mean depth, and nutrient loads from various sources in the surrounding watershed. Basic physical and hydrologic information was obtained via a combination of field work, reports, GIS data sets, and topographic maps. Information on nutrient loading to the lake from the surrounding area was derived using the AVGWLF watershed modeling application. Subsequent to setting up the two models, calibration was performed using actual lake water quality sampling data obtained as a result of prior studies conducted in Canonsburg Lake. This calibration was needed in order to accurately estimate phosphorus reductions required to achieve the chlorophyll-a target goal of 20 ug/l.

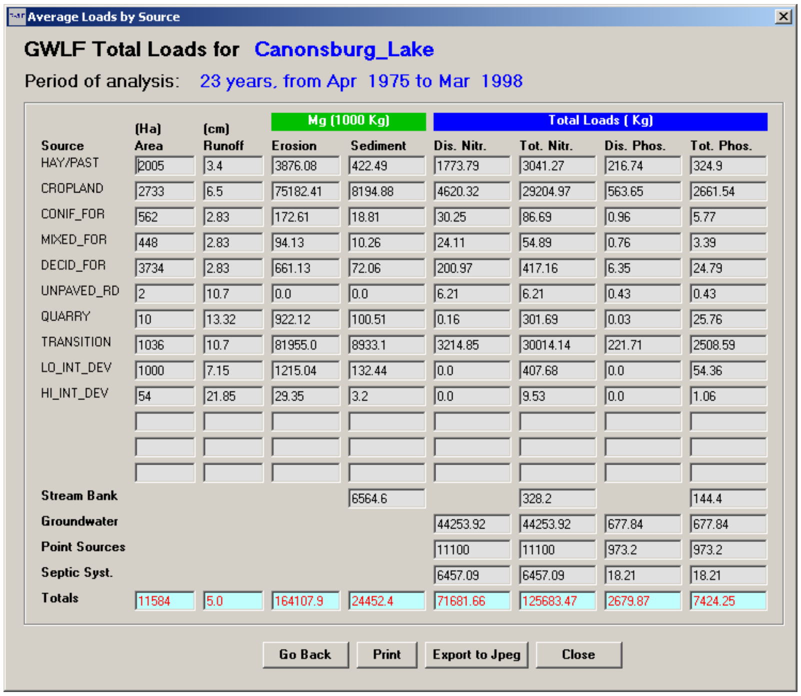
For the purposes of this TMDL assessment, mean annual nutrient loads to the lake for the period 1993-1998 were estimated. These loads were then used within BATHTUB to evaluate current water quality/trophic conditions. Once current conditions had been established and compared with existing lake water quality sampling measurements, the BATHTUB model was then used as a “diagnostic” tool in order to estimate the phosphorus load reductions required to achieve the chlorophyll-a target of 20 ug/l.

2.2 Watershed Modeling

As outlined above, AVGWLF was used to derive nutrient load information for use as input to the BATHTUB lake model. Simulations were performed for the period 1993-1998 to coincide with the time period for which existing weather and lake water sampling data were available. When using AVGWLF, the “default” GIS data sets that come with this application are typically used. This means that for most applications, the “satellite-derived”, *Pamrlc* land use/cover data set is utilized. There is only one tributary input to Canonsburg Lake, Little Chartiers Creek, so the watershed was not subdivided prior to modeling.

Screen captures of the transport- and nutrient-related input data for the AVGWLF model runs for each watershed segment are shown in Appendix A. The resulting mean annual watershed loads delivered to Canonsburg Lake are shown in Figure 5. The most important results presented in these figures are those given in the “Totals” columns. More specifically, these values were used to estimate mean annual inputs to Canonsburg Lake with respect to water flow and nutrient loads as described in the next section.

Figure 5. Mean annual load calculations by GWLF for Canonsburg Lake



GWLF Total Loads for Canonsburg_Lake

Period of analysis: 23 years, from Apr 1975 to Mar 1998

Source	(Ha) Area	(cm) Runoff	Mg (1000 Kg) Erosion	Sediment	Total Loads (Kg) Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	2005	3.4	3876.08	422.49	1773.79	3041.27	216.74	324.9
CROPLAND	2733	6.5	75182.41	8194.88	4620.32	29204.97	563.65	2661.54
CONIF_FOR	562	2.83	172.61	18.81	30.25	86.69	0.96	5.77
MIXED_FOR	448	2.83	94.13	10.26	24.11	54.89	0.76	3.39
DECID_FOR	3734	2.83	661.13	72.06	200.97	417.16	6.35	24.79
UNPAVED_RD	2	10.7	0.0	0.0	6.21	6.21	0.43	0.43
QUARRY	10	13.32	922.12	100.51	0.16	301.69	0.03	25.76
TRANSITION	1036	10.7	81955.0	8933.1	3214.85	30014.14	221.71	2508.59
LO_INT_DEV	1000	7.15	1215.04	132.44	0.0	407.68	0.0	54.36
HI_INT_DEV	54	21.85	29.35	3.2	0.0	9.53	0.0	1.06
Stream Bank				6564.6		328.2		144.4
Groundwater					44253.92	44253.92	677.84	677.84
Point Sources					11100	11100	973.2	973.2
Septic Syst.					6457.09	6457.09	18.21	18.21
Totals	11584	5.0	164107.9	24452.4	71681.66	125683.47	2679.87	7424.25

At the time of the Canonsburg Lake Phosphorus Study, there were only five permitted dischargers of phosphorus. The existing loads from those dischargers were used in the calibration of the lake model, discussed in subsequent sections, as those were the inputs that led to the measured data. The facilities and the associated loads are listed in Table 2.

Table 2. NPDES discharges in Canonsburg Lake watershed in 1987

Facility	Permit #	Flow (mgd) Design	Existing	Measured PO_4 (mg/l)	TP load (lbs)	TP load (kg)
McMillan School	PA0030651	0.008	0.004	10.20	124	56

KOA	PA6373427	0.012	0.012	10.00	365	166
Windsor	PA0024783	0.127	0.055	9.30	1,557	707
Green Cresent	PA0024775	0.009	0.009	1.35	37	17
Penn Plastics	PA6375405	0.002	0.002	10.00	61	28
		0.158	**0.082**		**2,144**	**974**

Since the 1987 study, several more discharges have been added in the watershed. While these dischargers do not have phosphorus limits in their permits, they do discharge phosphorus. Those currently discharging into waters draining to Canonsburg Lake are listed in Table 3 along with their design flows.

Table 3. Current NPDES discharges in Canonsburg Lake watershed

Permit #	Facility	Design Flow (mgd)
PA0030651	Canon-MacMillan School District	0.0088
PA0034818	Ametek, Inc	0.0015
PA0042579	Smith Machine STP	0.0015
PA0042587	MLM Enterprises STP	0.025
PA0091413	North Strabane Twp MSA/Eighty Four Industrial Park STP	0.035
PA0093262	Industrial Leasing Systems/BethEnergy Mines Division STP	0.002
PA0094960	William Barnes STP	0.0023
PA0097691	Lawrence and Brian Watson/Washington KOA Campgrounds STP	0.01
PA0098663	R.P. Woodhouse STP	0.009
PA0203955	84 Lumber Company STP	0.025
PA0203963	Washington Penn Plastics STP	0.0012
PA0217883	Encotech Incorporated STP	0.0003
	Total	**0.1216**

2.3 Lake Water Quality Modeling

Using descriptive information and data (Table 4) about the lake and surrounding drainage area, as well as output from AVGWLF, the BATHTUB model was set up for Canonsburg Lake to simulate current water quality and trophic conditions. For the purposes of this TMDL assessment, mean annual nutrient loadings were simulated using AVGWLF output and DEP lake sampling data for the period 2000-2001. After initial model development, the sampling data were used to “fine-tune” various input parameters and sub-model selections within BATHTUB during the calibration process. Once calibrated, as described in a later section, BATHTUB could then be used to estimate nutrient (specifically phosphorus) load reductions needed in order to achieve TMDL target loads.

In addition to the input summarized in the Tables 2 and 3, executing BATHTUB also requires that decisions be made on the use of various nutrient balance, sedimentation, and eutrophication response sub-models. Such decisions are routinely made as part of the calibration process where the primary objective is to simulate processes in a way that achieves optimal matches between values for observed lake water quality parameters and estimated values based on compiled input data. For Canonsburg Lake, optimal results were achieved using the sub-models given in Table 5.

Calibration results for Canonsburg Lake are shown in Appendix D.

Table 4. Lake and watershed data.

PARAMETER	VALUE
Lake area[1]	62 acres (0.25 km^2)
Lake length[1]	1.49 miles (2.4 km)
Lake width[1]	0.07 miles (0.11 km)
Mean depth of lake[2]	9.2 feet (2.8 m)
Atmospheric N loading to lake[3]	2700 kg/km^2
Atmospheric P loading to lake[3]	44 kg/km^2
Mean annual Total P concentration of lake[4]	120 ppb
Mean annual Chlorophyll-a concentration of lake[4]	36.3 ppb
Mean annual Secchi-disk depth of lake[4]	0.8 m
Mean annual tributary flow[5]	44.96 hm^3/yr

[1] DEP data, topographic map, GIS data
[2] DEP monitoring and report data
[3] Nizeyimana et al. (1997)
[4] DEP sample data
[5] Derived via AVGWLF-based watershed modeling

Table 5. Sub-models used within BATHTUB for Canonsburg Lake.

MODEL OPTION	SUB-MODEL USED
Phosphorus balance/sedimentation	Canfield & Bachman
Mean chlorophyll-a	P, linear
Secchi depth	Secchi vs. Chl-a and Turbidity

The matches between simulated and observed mean annual water quality conditions were considered to be acceptable (Table 6), and based on these results, it was felt that these conditions were being simulated well enough to allow estimation of phosphorus reductions needed to achieve the chlorophyll-a TMDL target. Therefore, subsequent to calibrating the lake water quality model, additional model runs were made to quantify the phosphorus reductions to the lake needed in order to achieve TMDL objectives with respect to chlorophyll-a levels. Specifically, phosphorus loads to the lake were iteratively decreased until a simulated chlorophyll-a concentration of 20.0 ug/l was reached. Upon re-running the lake model as described above, it was found that a mean annual chlorophyll-a concentration of 20 ug/l could be achieved if the annual P load was reduced to 4,316 kg/yr. If this load were reduced again by a 10% margin-of-safety factor (for a new target load of 3,884 kg/yr), a watershed-wide load reduction of 48% would be required in order to meet this target as shown in Table 7.

Table 6. Final BATHTUB simulation results for Canonsburg Lake.

VARIABLE	OBSERVED VALUE	ESTIMATED VALUE
Total P (mg/m^3)	120	128
Total N (mg/m^3)	1054	1075
Chlorophyll-a (mg/m^3)	36.3	35.8
Secchi depth (m)	0.8	0.8
Ortho-P (mg/m^3)	53.0	54.2

2.4 Load Allocation

Based on the analyses described above, the approximate mean annual load of 7,424 kg of phosphorus that enters the lake comes primarily from the sources shown in Table 7. The specific pathways by which phosphorus is transported from these sources varies considerably, and because of this, opportunities for controlling the movement and retention of this nutrient will vary considerably as well. From agricultural land, phosphorus originates principally from soil erosion and application of manure and/or fertilizers. Phosphorus is lost from wooded areas in surface water runoff in dissolved and particulate organic forms. From transitional and unpaved surfaces, it is primarily delivered via sediment during erosion events. In developed areas, phosphorus loads from the STPs is the major source.

Table 7. Load allocations needed to meet target P load

SOURCE OF P	CURRENT LOAD (kg/yr)	TMDL LOAD (kg/yr)	% Reduction
Cropland	2,662	1,156	57
Pasture	325	141	57
Groundwater	678	294	57
Streambank erosion	144	63	57
Transition	2,509	1,089	57
Point Sources	973[1]	1,008	---
Other sources	133	133	---
TOTAL	7,424	3,884	48

1 – Represents point source load at the time of data collected and used in model calibration

Table 8. WLAs for NPDES dischargers in Canonsburg Lake watershed

Permit #	Facility	Design Flow (mgd)	TMDL WLA (kg/yr)*
PA0030651	Canon-MacMillan School District	0.0088	97
PA0034818	Ametek, Inc	0.0015	17
PA0042579	Smith Machine STP	0.0015	17
PA0042587	MLM Enterprises STP	0.025	276
PA0091413	North Strabane Twp MSA/Eighty Four Industrial Park STP	0.035	387
PA0093262	Industrial Leasing Systems/BethEnergy Mines Division STP	0.002	22
PA0094960	William Barnes STP	0.0023	25
PA0097691	Lawrence and Brian Watson/Washington KOA Campgrounds STP	0.01	111
PA0098663	R.P. Woodhouse STP	0.009	100
PA0203955	84 Lumber Company STP	0.025	276
PA0203963	Washington Penn Plastics STP	0.0012	13
PA0217883	Encotech Incorporated STP	0.0003	3
TOTAL		0.1216	1,008

* Loads for dischargers assume TP concentration of 6 mg/l

The WLA has been taken as the sum of the current permitted TP loads to Canonsburg Lake for several reasons. First, nonpoint sources (even where the point source load is calculated as the total permitted load) are the dominant source of phosphorus to the lake. Further, the largest discharger in the watershed is only permitted at 0.035 mgd. Nonpoint source contributions to the lake were identified as the primary source of lake pollution in the original Lake Phosphorus Study and are still believed to be the nutrient source dictating water quality in Canonsburg Lake. Discharges greater than 0.02 mgd will be required to monitor and report TP monthly for a one year period.

Therefore, the TMDL for total phosphorus entering Canonsburg Lake is:

$$\text{TMDL} = \text{LA} + \text{WLA} + \text{MOS}$$
$$4{,}316 \text{ kg} = 2{,}876 \text{ kg} + 1{,}008 \text{ kg} + 432 \text{ kg}$$

3.0 CONSIDERATION OF CRITICAL CONDITIONS

The AVGWLF model used for mean annual load estimation is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is generally a significant lag time between the introduction of sediment and nutrients to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody. In this case, a 10-year simulation period reflecting actual data for the period 1993-1998 were used to account for normal year-to year fluctuations in precipitation and temperature.

4.0 CONSIDERATION OF SEASONAL VARIATIONS

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

5.0 RECOMMENDATIONS

Required reductions of phosphorus loads to Canonsburg Lake are shown in Table 7. Reductions of phosphorus from non-point sources can be attained by implementing Best Management Practices (BMPs). These land management practices are techniques that can be employed by land owners to either reduce the production of a pollutant, or prevent a pollutant from entering a water body. Each BMP is equipped to handle a unique type of pollutant; although, implementation of a single BMP can sometimes address multiple pollutants. Nevertheless, each has its own reduction efficiency, and the optimal BMP is a consideration of its efficiency as well as the feasibility of employing it. Due to the fact that most phosphorus is sediment-bound, BMPs that reduce phosphorus delivery to waterbodies will provide the added benefit of also reducing sediment eroded from the ground and delivered to downstream waters.

DEP will support local efforts to develop and implement watershed restoration plans based on the reduction goals specified in this TMDL. Interested parties should contact the appropriate Watershed Coordinator in the Department’s Southwest Regional Office (412-442-4149) for information regarding technical and financial assistance that is currently available. Individuals and/or local watershed groups interested in improving water quality in Canonsburg Lake are strongly encouraged to explore funding sources available through DEP and other state and federal agencies (e.g. Growing Greener or 319 Program).

6.0 PUBLIC PARTICIPATION

A notice of availability for comments on the draft Canonsburg Lake TMDL was published in the PA Bulletin on June 5, 2004 and on the Department’s web page shortly thereafter. In addition, a public meeting was held on June 22, 2004 at 6:30 PM at the Peters Township Municipal Building to address any outstanding concerns regarding the draft TMDLs. A 30-day period (ending on July 6, 2004) was provided for the submittal of comments. Notice of final TMDL approvals will be posted on the Department’s website.

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Appendix A

Information Sheet for Canonsburg Lake TMDLs

What is being proposed?

Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in Canonsburg Lake.

Who is proposing the plans? Why?

The Pennsylvania Department of Environmental Protection (PADEP) is proposing to submit the plans to the U.S. Environmental Protection Agency (U.S. EPA) for review and approval as required by federal regulation. In 1995, U.S. EPA was sued for not developing TMDLs when Pennsylvania failed to do so. PADEP has entered into an agreement with U.S. EPA to develop TMDLs for certain specified waters over the next several years. These TMDLs have been developed in compliance with the state/U.S. EPA agreement.

What is a TMDL?

A TMDL sets a ceiling on the pollutant loads that can enter a waterbody so that it will meet water quality standards. The Clean Water Act requires states to list all waters that do not meet their water quality standards even after pollution controls required by law are in place. For these waters, the state must calculate how much of a substance can be put in the water without violating the standard, and then distribute that quantity to all sources of the pollutant on that water body. A TMDL plan includes waste load allocations for point sources, load allocations for nonpoint sources, and a margin of safety. The Clean Water Act requires states to submit their TMDLs to U.S. EPA for approval. Also, if a state does not develop the TMDL, the Clean Water Act states that U.S. EPA must do so.

What is a water quality standard?

The Clean Water Act sets a national minimum goal that all waters are to be “fishable” and “swimmable.” To support this goal, states must adopt water quality standards. Water quality standards are state regulations that have two components. The first component is a designated use, such as “warm water fishes” or “recreation.” States must assign a use, or several uses to each of their waters. The second component relates to the instream conditions necessary to protect the designated use(s). These conditions or “criteria” are physical, chemical, or biological characteristics such as temperature and minimum levels of dissolved oxygen, and maximum concentrations of toxic pollutants. It is the combination of the “designated use” and the “criteria” to support that use that make up a water quality standard. If any criteria are being exceeded, then the use is not being meet and the water is said to be in violation of water quality standards.

What is the purpose of the plans?

Canonsburg Lake is impaired by excess nutrients. These TMDL plans include a calculation nutrient loading reductions necessary to meet water quality objectives.

Why was the Canonsburg Lake selected for TMDL development?

In 1996, Pa. DEP listed Canonsburg Lake under Section 303(d) of the federal Clean Water Act as impaired due to excess nutrient loading from agricultural activities.

What pollutants do these TMDLs address?

Based on an evaluation of the concentrations of nutrients in Canonsburg Lake, phosphorus is the cause of nutrient impairment to the stream.

Where do the pollutants come from?

The nutrient related impairments in the Canonsburg Lake come from nonpoint sources (NPS) of pollution, primarily overland runoff from agricultural land uses, development activities and stream bank erosion.

How was the TMDL developed?

There currently are no state or federal numerical water quality criteria for nutrients. Therefore, the Department utilized a chlorophyll-a endpoint to address the lake eutrophication problem. The proposed TMDL sets allowable loadings of phosphorus to the lake such that the chlorophyll-a endpoint is met in the lake. Phosphorus was chosen as the TMDL endpoint for nutrient impairments due to it being the limiting nutrient in the lake. The phosphorus loading(s) were allocated among all land use categories present in the watershed. Data used in establishing these TMDLs were generated using a watershed loading model (AVGWLF) designed by the Pennsylvania State University and a lake model (BATHTUB) developed by the United States Army Corps of Engineers.

How much pollution is too much?

The allowable amount of pollution in a water body varies depending on several conditions. TMDLs are set to meet water quality standards at the critical flow condition. For a lake, the TMDL is expressed as a yearly loading. This accounts for all flow conditions.

How will the loading limits be met?

Best Management Practices (BMPs) will be encouraged throughout the watershed to achieve the necessary load reductions.

How can I get more information on the TMDL?

The data and all supporting documentation used to develop the proposed TMDL are available from the Department. The proposed TMDL and information on the TMDL program can be viewed on the Department's web site at www.dep.state.pa.us (DEP Keyword: TMDL).

To request a copy of this TMDL, contact Joseph Boylan at Department of Environmental Protection, Water Quality Management Program, Planning Section, 400 Waterfront Drive, Pittsburgh, PA 15222.

How can I comment on the proposal?

Written comments will be accepted at the above address and must be received by close of business on July 6, 2004.

How can I comment on the proposal?

You may provide e-mail or written comments postmarked no later than July 6, 2004 to the above addresses.

Appendix B - AVGWLF Model Overview & GIS-Based Derivation of Input Data

TMDLs for the UNT 09655 to Bow Creek watershed were developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values.

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

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

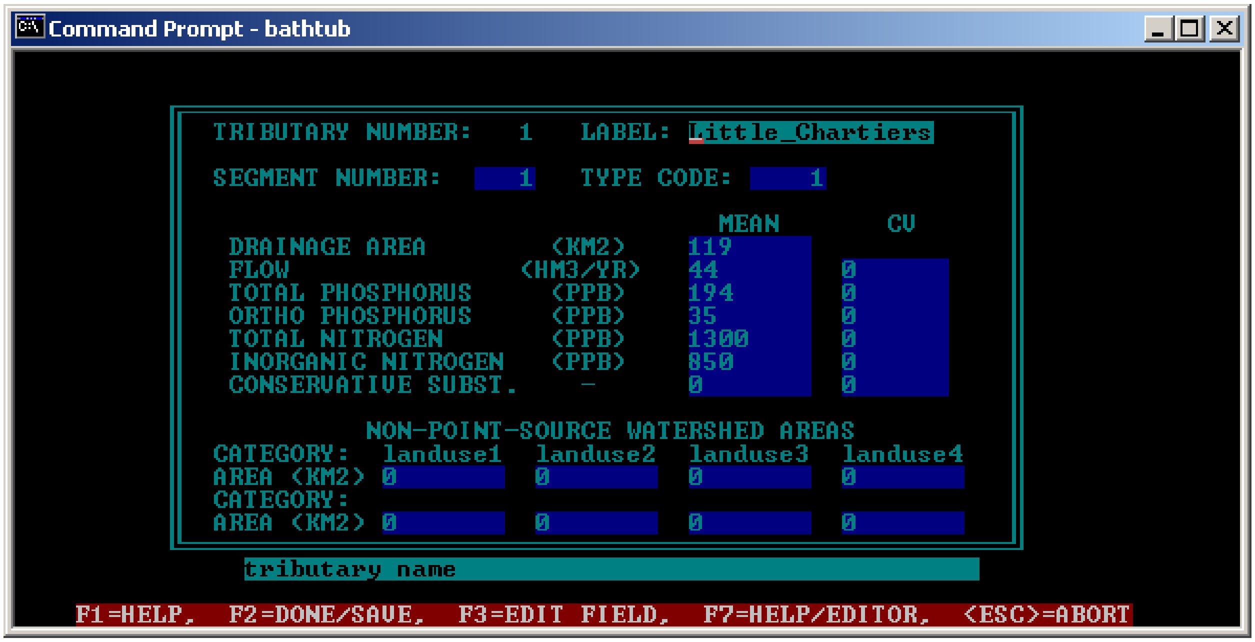
For execution, the model requires three separate input files containing transport-, nutrient-, and weather-related data. The transport (TRANSPRT.DAT) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The nutrient (NUTRIENT.DAT) file specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations, etc.). The weather (WEATHER.DAT) file contains daily average temperature and total precipitation values for each year simulated.

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

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

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

Appendix D - BATHTUB Model Output Calibration



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 SEGMENT NUMBER:      1    TYPE CODE:      1

                                    MEAN        CV
  DRAINAGE AREA          (KM2)    119
  FLOW                 (HM3/YR)   44          0
  TOTAL PHOSPHORUS       (PPB)    194         0
  ORTHO PHOSPHORUS       (PPB)    35          0
  TOTAL NITROGEN         (PPB)    1300        0
  INORGANIC NITROGEN     (PPB)    850         0
  CONSERVATIVE SUBST.      -      0           0

          NON-POINT-SOURCE WATERSHED AREAS
 CATEGORY:  landuse1  landuse2  landuse3  landuse4
 AREA (KM2) 0         0         0         0
 CATEGORY:
 AREA (KM2) 0         0         0         0

      tributary name

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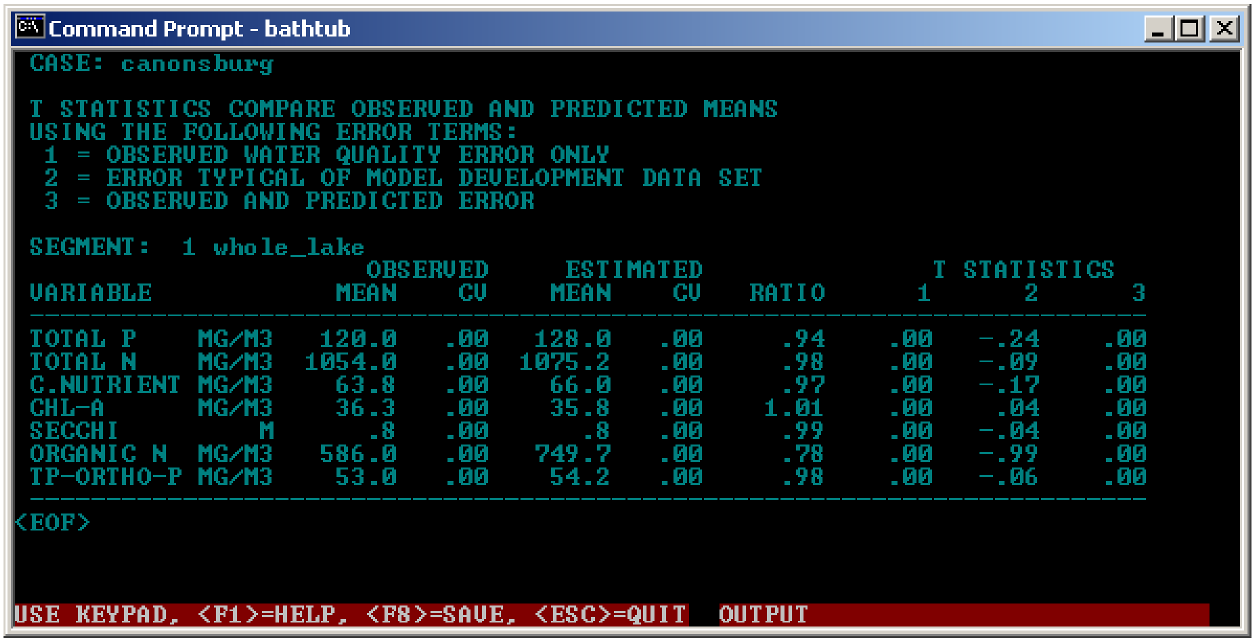

```
 CASE: canonsburg

 T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS
 USING THE FOLLOWING ERROR TERMS:
  1 = OBSERVED WATER QUALITY ERROR ONLY
  2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET
  3 = OBSERVED AND PREDICTED ERROR

 SEGMENT:  1 whole_lake
                      OBSERVED      ESTIMATED                T STATISTICS
 VARIABLE             MEAN    CV     MEAN    CV    RATIO       1      2      3
 ------------------------------------------------------------------------------
 TOTAL P    MG/M3   120.0   .00    128.0   .00     .94     .00   -.24    .00
 TOTAL N    MG/M3  1054.0   .00   1075.2   .00     .98     .00   -.09    .00
 C.NUTRIENT MG/M3    63.8   .00     66.0   .00     .97     .00   -.17    .00
 CHL-A      MG/M3    36.3   .00     35.8   .00    1.01     .00    .04    .00
 SECCHI         M      .8   .00       .8   .00     .99     .00   -.04    .00
 ORGANIC N  MG/M3   586.0   .00    749.7   .00     .78     .00   -.99    .00
 TP-ORTHO-P MG/M3    53.0   .00     54.2   .00     .98     .00   -.06    .00
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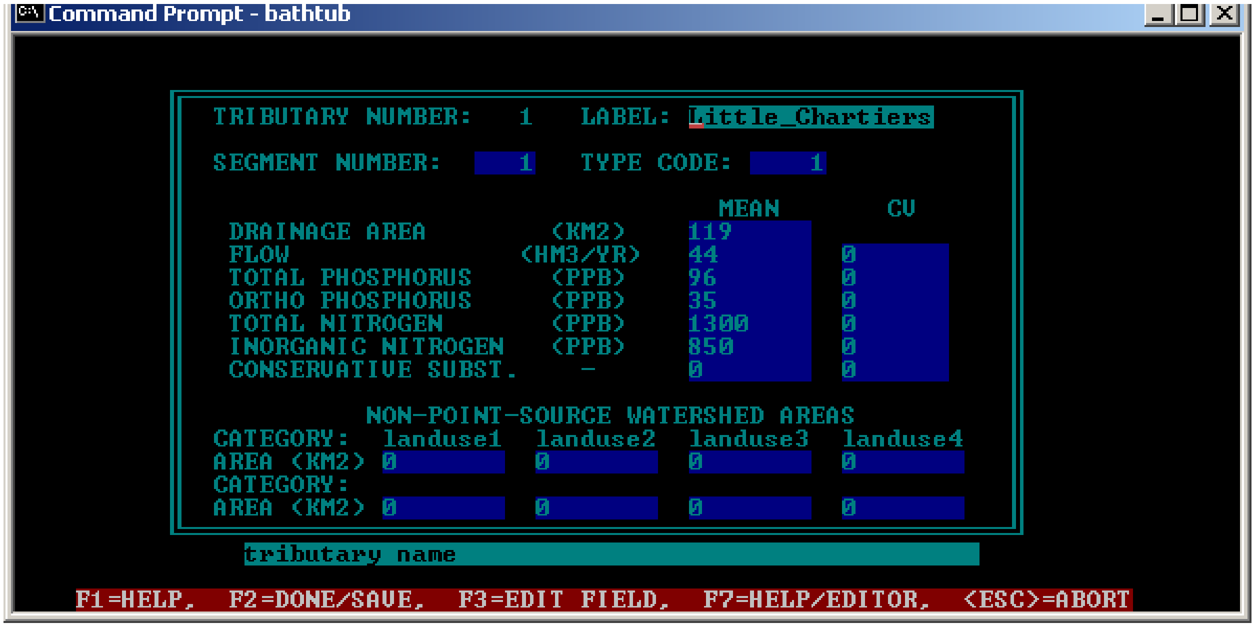
Reduction/TMDL Scenario



```
TRIBUTARY NUMBER:    1    LABEL: Little_Chartiers

SEGMENT NUMBER:         1    TYPE CODE:       1

                                     MEAN         CV
 DRAINAGE AREA          (KM2)      119
 FLOW                 (HM3/YR)     44           0
 TOTAL PHOSPHORUS       (PPB)      96           0
 ORTHO PHOSPHORUS       (PPB)      35           0
 TOTAL NITROGEN         (PPB)      1300         0
 INORGANIC NITROGEN     (PPB)      850          0
 CONSERVATIVE SUBST.      -        0            0

          NON-POINT-SOURCE WATERSHED AREAS
CATEGORY:  landuse1  landuse2  landuse3  landuse4
AREA (KM2) 0         0         0         0
CATEGORY:
AREA (KM2) 0         0         0         0

      tributary name

F1=HELP, F2=DONE/SAVE, F3=EDIT FIELD, F7=HELP/EDITOR, <ESC>=ABORT
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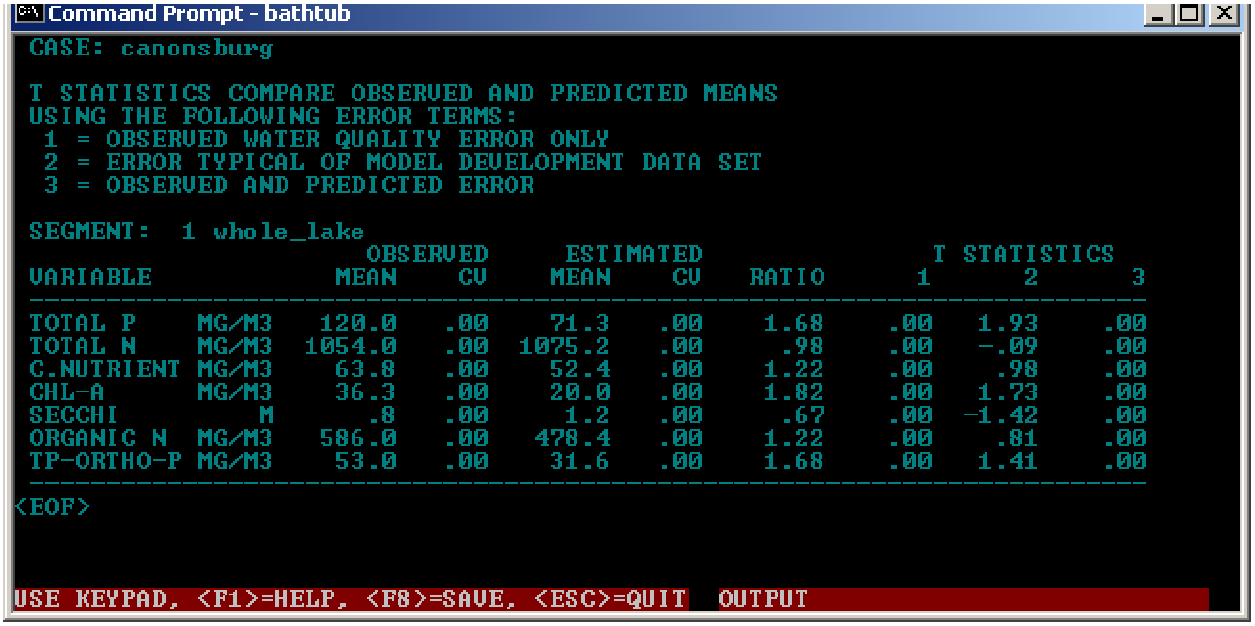

```
 CASE: canonsburg

 T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS
 USING THE FOLLOWING ERROR TERMS:
  1 = OBSERVED WATER QUALITY ERROR ONLY
  2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET
  3 = OBSERVED AND PREDICTED ERROR

 SEGMENT:  1 whole_lake
                       OBSERVED      ESTIMATED              T STATISTICS
 VARIABLE              MEAN    CV    MEAN    CV    RATIO      1      2      3
 ------------------------------------------------------------------------------
 TOTAL P    MG/M3     120.0   .00    71.3   .00    1.68     .00   1.93    .00
 TOTAL N    MG/M3    1054.0   .00  1075.2   .00     .98     .00   -.09    .00
 C.NUTRIENT MG/M3      63.8   .00    52.4   .00    1.22     .00    .98    .00
 CHL-A      MG/M3      36.3   .00    20.0   .00    1.82     .00   1.73    .00
 SECCHI         M        .8   .00     1.2   .00     .67     .00  -1.42    .00
 ORGANIC N  MG/M3     586.0   .00   478.4   .00    1.22     .00    .81    .00
 TP-ORTHO-P MG/M3      53.0   .00    31.6   .00    1.68     .00   1.41    .00
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Appendix E - Equal Marginal Percent Reduction Method

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

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

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

Step 3: Actual EMPR Process:

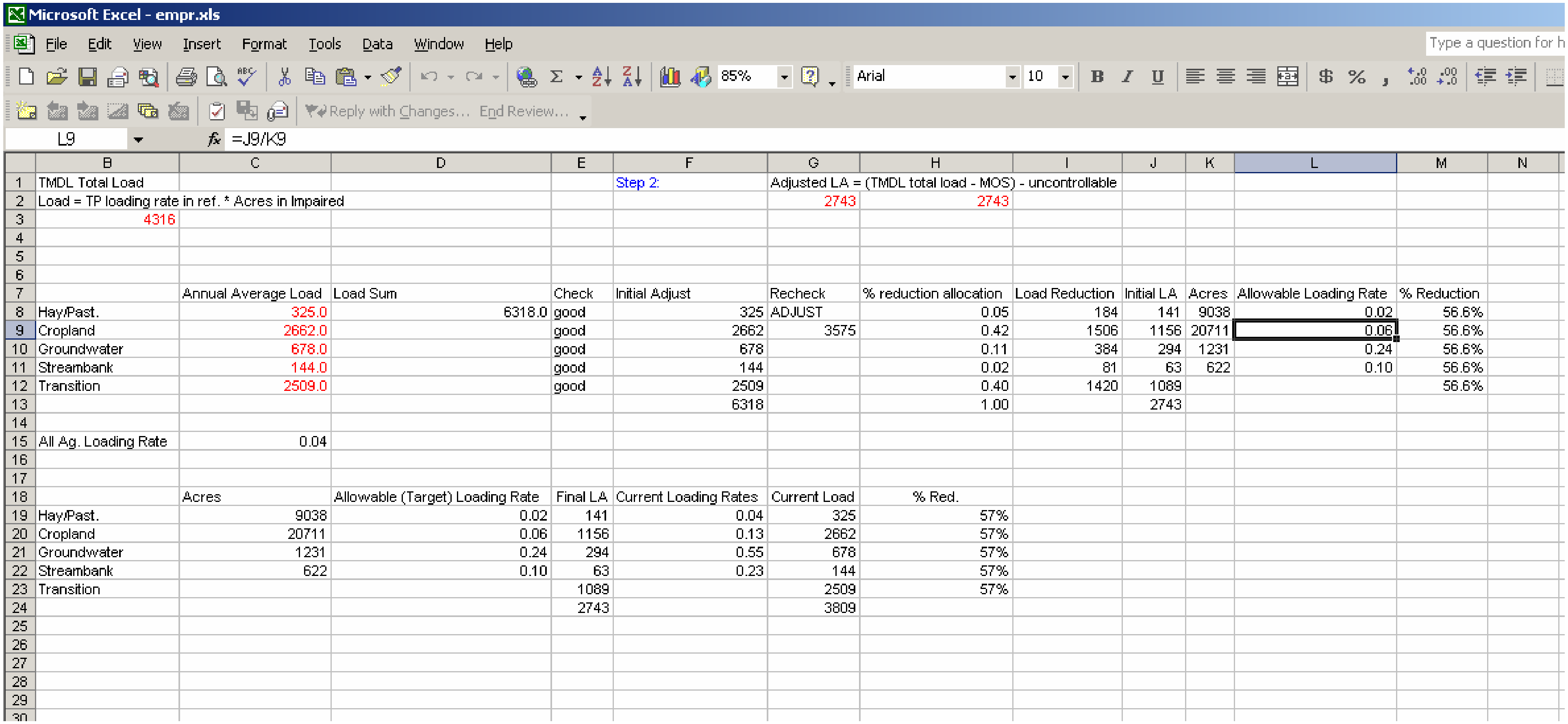
a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving waterbody. If the contributor exceeds the ALA, that contributor would be reduced to the ALA. If a contributor is less than the ALA, it is set at the existing load. This is the baseline portion of EMPR.

b. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the ALA. If the ALA is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed.

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

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

Appendix F: Equal Marginal Percent Reduction Calculation



L9 =J9/K9

	B	C	D	E	F	G	H	I	J	K	L	M	N
1	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable							
2	Load = TP loading rate in ref. * Acres in Impaired					2743	2743						
3	4316												
4													
5													
6													
7		Annual Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction	
8	Hay/Past.	325.0	6318.0	good	325	ADJUST	0.05	184	141	9038	0.02	56.6%	
9	Cropland	2662.0		good	2662	3575	0.42	1506	1156	20711	0.06	56.6%	
10	Groundwater	678.0		good	678		0.11	384	294	1231	0.24	56.6%	
11	Streambank	144.0		good	144		0.02	81	63	622	0.10	56.6%	
12	Transition	2509.0		good	2509		0.40	1420	1089			56.6%	
13					6318		1.00		2743				
14													
15	All Ag. Loading Rate	0.04											
16													
17													
18		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.						
19	Hay/Past.	9038	0.02	141	0.04	325	57%						
20	Cropland	20711	0.06	1156	0.13	2662	57%						
21	Groundwater	1231	0.24	294	0.55	678	57%						
22	Streambank	622	0.10	63	0.23	144	57%						
23	Transition			1089		2509	57%						
24				2743		3809							
25													
26													
27													
28													
29													

Appendix G: Comment and Response Document

Comment: Please include a statement or table with 303(d) listing information (i.e., impairment source and cause, listing date, subsequent lake identification numbers beyond 1996 stream code).

Response: Text has been added to the document. Please see Section 1.0 on page 1.

Comment: Is there available DO data? What are the DO conditions in the lake? Is there any DO impairment resulting from the excessive nutrient levels in the lake, or is this prevented by the lake's short retention time?

Response: Text has been added to the document. Please see Section 1.3 on page 4.

Comment: Since some of the phosphorus coming from nonpoint sources is in particulate form, it may be worth mentioning (in the future recommendations section) that BMPs suggested for addressing the nutrients from nonpoint sources may also address sediment and these other forms of phosphorus (particulates and sediment-bound).

Response: Text has been added to the document. Please see Section 5.0 on page 12.

Comment: What is the basis for assuming a TP concentration of 8 mg/L for all STPs in the watershed? It is possible that some discharges can, and are, achieving much lower concentrations and will now be allowed to increase their TP concentrations to 8 mg/L. Please include a justification for the assumed TP concentrations.

Response: The document now assumes an effluent TP concentration of 6 mg/l and assigns a WLA of 1,008 lbs TP/yr. A monitor and report requirement for dischargers over 0.02 mgd is also required by the TMDL. In the event that the WLA is exceeded, steps will be taken through permitting to meet the TMDL requirement.

Comment: Despite nonpoint sources being such a significant source of nutrients in the watershed, point sources should not be discounted so easily. Allocations should not be based on whether phosphorus removal will necessitate costly upgrades, or the cost-effectiveness of getting the same reductions from nonpoint sources. This language on page 12 should be taken out, and the allocation scheme needs to be reconsidered. The total WLA is more than half of the total LA, yet no reductions are assigned to point sources and 60% reductions occur with nonpoint sources. Perhaps having point sources reduced to at least 2 mg/L (based on Pennsylvania permitting guidance) is a possible reallocation scenario.

Response: A monitor and report requirement for dischargers over 0.02 mgd is required by the TMDL. In the event that the WLA is exceeded, steps will be taken through permitting to meet the TMDL requirement.

Comment: Table 3 - It is unclear whether these additional discharges are permitted for phosphorus. If they are, please include their existing permit limits and existing flow, similar to what is contained in Table 2. It is also unclear if all permittees listed in both Tables 2 and 3 are currently discharging to the watershed. All permittees currently discharging into the watershed for the parameters of interest must have a WLA.

Response: Currently, there are no TP effluent limits for permittees in the watershed. The dischargers listed in Table 2 are those that were discharging when the Proch study was conducted in 1987, while Table 3 includes all current dischargers. Therefore, if a permittee in Table 2 is not in Table 3, then they are no longer in existence. Conversely, if a discharger appears on Table 3 but not on Table 2, then they are one of the “new” dischargers referred to in the document. Therefore, the requirement set forth by U.S. EPA that all permittees currently discharging into the watershed have a WLA is met (see Table 8).

List of Commentators

US Environmental Protection Agency, Region 3
PA/DE/WV Branch (3WP11)
Office of Watersheds