Sweitzers Run Sediment TMDL

Union County, Pennsylvania

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Executive Summary

"Total Maximum Daily Loads" (TMDLs) for sediment were developed for a subwatershed of Sweitzers Run (Figure 1) to address the siltation impairments noted in the 2016 Final Pennsylvania Integrated Water Quality Monitoring and Assessment Report (Integrated Report), including the Clean Water Act Section 303(d) List. Agriculture was identified as the cause of these impairments. Because Pennsylvania does not have numeric water quality criteria for sediment, the loading rates from a similar unimpaired watershed were used to calculate the TMDLs.

"TMDLs" were calculated using both a long-term annual average value ($TMDL_{Avg}$) which would be protective under most conditions, as well as a 99th percentile daily value ($TMDL_{Max}$) which would be relevant to extreme flow events. Current annual average sediment loading in the Sweitzers Run Subwatershed was estimated to be 2,107,475 pounds per year. To meet water quality objectives, annual average sediment loading should be reduced by 31% to 1,453,880 pounds per year. Allocation of annual average sediment loading among the TMDL variables is summarized in Table 1. To achieve this reduction while maintaining a 10% margin of safety and minor allowance for point sources, annual average loading from croplands should be reduced by 42% whereas loading from hay/pasture lands and streambanks should each be reduced by 25%.

Table 1. Summary of Annual Average TMDL ($TMDL_{Avg}$) Variables for the Sweitzers Run Subwatershed

lbs/yr:						
Pollutant	$TMDL_{Avg}$	MOS_{Avg}	WLA_{Avg}	LA_{Avg}	LNR_{Avg}	ALA_{Avg}
Sediment	1,453,880	145,388	14,539	1,293,953	8,390	1,285,563

TMDL=Total Maximum Daily Load; MOS = Margin of Safety; WLA=Wasteload Allocation (point sources); LA = Load Allocation (nonpoint sources). The LA is further divided into LNR = Loads Not Reduced and ALA=Adjusted Load Allocation. Subscript "Avg" indicates that these values are expressed as annual averages.

Current 99thpercentile daily loading in the Sweitzers Run Subwatershed was estimated to be 77,180 pounds per day. To meet water quality objectives, 99th percentile daily sediment loading should be reduced by 9% to 69,918 pounds per day. Allocation of 99th percentile daily sediment loading among the TMDL variables is summarized in Table 2.

Table 2. Summary of 99th Percentile Daily Loading TMDL ($TMDL_{Max}$) Variables for the Sweitzers Run Subwatershed

lbs/d:						
Pollutant	$TMDL_{Max}$	MOS_{Max}	WLA_{Max}	LA_{Max}	LNR_{Max}	ALA_{Max}
Sediment	69,918	6,992	699	62,227	404	61,824

TMDL=Total Maximum Daily Load; MOS = Margin of Safety; WLA=Wasteload Allocation (point sources); LA = Load Allocation (nonpoint sources). The LA is further divided into LNR = Loads Not Reduced and ALA=Adjusted Load Allocation. Subscript "Max" indicates that these values are expressed as 99th percentile for daily loading.

Introduction

Sweitzers Run is a tributary of Penns Creek, with the confluence approximately 1 mile southwest of the Borough of New Berlin in Union County. This Total Maximum Daily Load (TMDL) document has been prepared to address siltation from agriculture/grazing related agriculture impairments occurring upstream of the junction with the unnamed tributary that parallels Powderhouse Lane (Figure 1), per the 2016 Final Integrated Report (see Appendix A for a description of assessment methodology). The lower reaches of Sweitzers Run were not listed as impaired for aquatic life.

The resultant Sweitzers Run study subwatershed was approximately 7.7 square miles and occurred entirely within Union County. It contained approximately 16 stream miles, all of which are designated for Cold-Water Fishes (CWF) and Migratory Fishes (MF).

The removal of natural vegetation and soil disturbance associated with agriculture increases soil erosion leading to sediment deposition in streams. Excessive fine sediment deposition may destroy the coarse-substrate habitats required by many stream organisms. While Pennsylvania does not have numeric water quality criteria for sediment, it does have applicable narrative criteria:

> *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. (25 PA Code Chapter 93.6 (a)*
>
> *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, odors, turbidity or settle to form deposits. (25 PA Code, Chapter 93.6 (b))*.

While agriculture has been identified as the source of the impairments, this TMDL document is applicable to all significant sources of solids that may settle to form deposits.

According to the "Model My Watershed" application, land use in the study subwatershed was estimated to be 33% forest/naturally vegetated lands, 57% agriculture, and 8% mixed development. The agricultural lands are approximately 31% croplands and 26% hay/pasture (Appendix B, Table B1). There were no NPDES permitted point source discharges in the watershed with limits relevant to sedimentation (Table 4).

Table 3. Aquatic-Life Impaired Stream Segments in the Sweitzers Run Subwatershed per the 2016 Final Pennsylvania Integrated Report				
HUC: 02050301 – Lower Susquehanna-Penns				
Source	EPA 305(b) Cause Code	Miles	Designated Use	Use Designation
Ag. or Grazing Related Ag.	Siltation	15.9	CWF, MF	Aquatic Life
Grazing Related Ag.	Nutrients	11.7	CWF, MF	Aquatic Life

HUC= Hydrologic Unit Code; CWF=Cold Water Fishes; MF= Migratory Fishes
The use designations for the stream segments in this TMDL can be found in PA Title 25 Chapter 93.
See Appendix C for a listing of each stream segment and Appendix A for more information on the listings and listing process

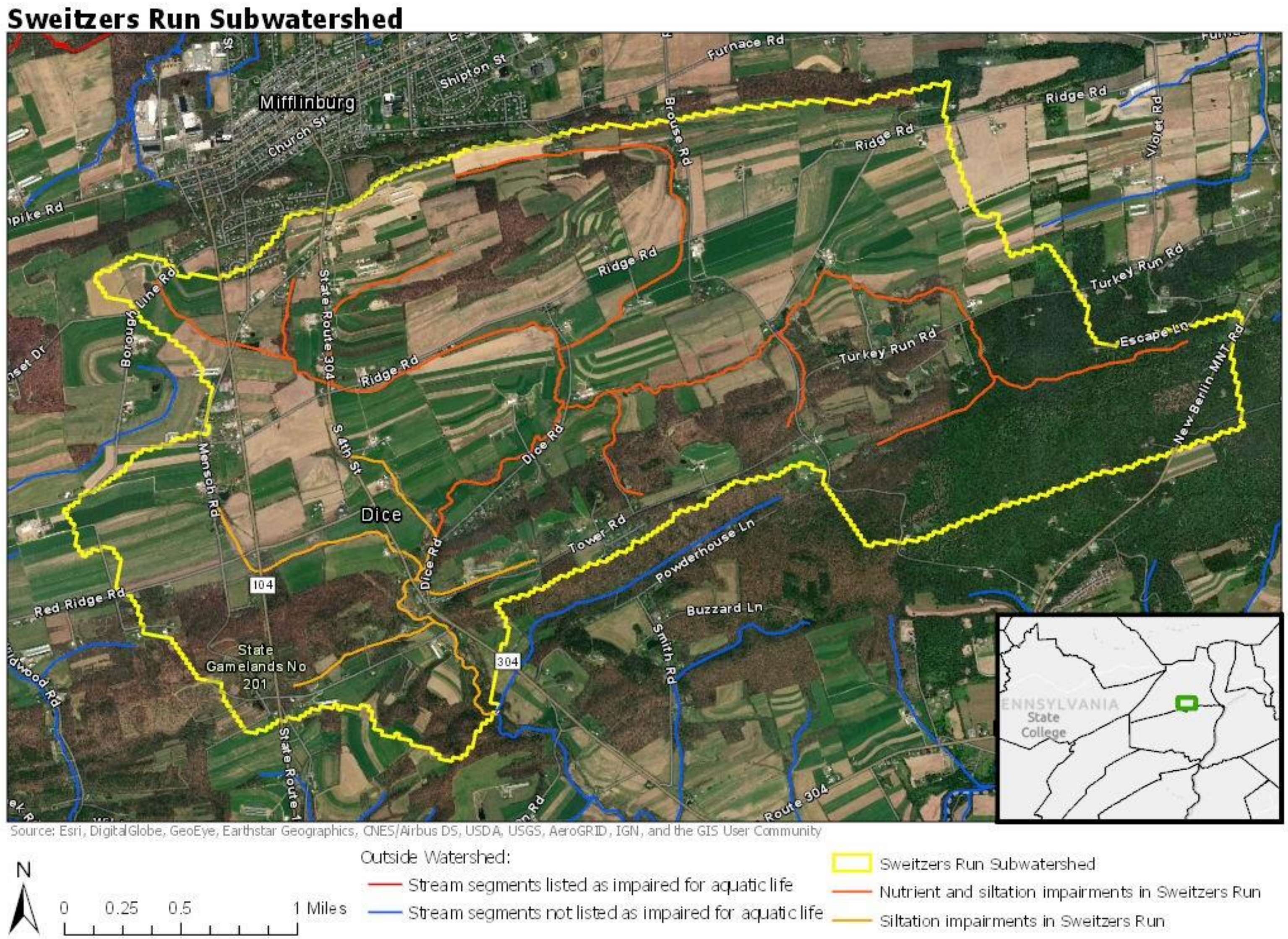

Figure 1. Sweitzers Run Subwatershed. All stream segments within the study subwatershed were listed as impaired for siltation. Some stream segments were listed as impaired for nutrients as well, and these impairments were addressed in a separate TMDL document.

Table 4. Existing NPDES-Permitted Discharges in the Sweitzers Run Subwatershed and their Potential Contribution to Sediment Loading.			
Permit No.	Facility Name	Load, mean lbs/yr	Load, max lbs/d
PAG034861	Erdley Trucking Shop[1]	NA	NA

Permits within the watershed were based on DEP's eMapPA available at http://www.depgis.state.pa.us/emappa/ and EPA's Watershed Resources Registry available at https://watershedresourcesregistry.org/map/?config=stateConfigs/pennsylvania.json

[1]Permit for industrial stormwater facilities. Note that sediment loading associated with development is accounted for in Model My Watershed.

Note that given their transient nature, any stormwater construction permits were not included above.

TMDL Approach

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

1. Collection and summarization of pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculation of a TMDL that appropriately accounts for any critical conditions and seasonal variations;
3. Allocation of pollutant loads to various sources;
4. Submission of draft reports for public review and comments; and
5. EPA approval of the TMDL.

Because Pennsylvania does not have numeric water quality criteria for sediment, the "Reference Watershed Approach" was used. This method estimates pollutant loading rates in both the impaired watershed as well as a similar watershed that is not listed as impaired for the same use. Then, the loading rates in the unimpaired watersheds are scaled to the area of the impaired watershed so that necessary load reductions may be calculated. It is assumed that reducing loading rates in the impaired watershed to the levels found in the attaining watershed will result in the impaired stream segments attaining their designated uses.

Selection of the Reference Watershed

In addition to anthropogenic influences, there are many other natural factors affecting sediment loading rates. Thus, selection of a reference watershed with similar natural characteristics to the impaired watershed is crucial. Failure to use an appropriate reference watershed could result in problems such as the setting of sediment reduction goals that are unattainable, or nonsensical TMDL calculations that suggest that sediment loading in the impaired watershed should be increased.

To determine the suitability of the reference site, the Department's Integrated Report GIS-based website (available at http://www.depgis.state.pa.us/integrated_report/index.html) was used to search for nearby watersheds that were of similar size as the Sweitzers Run Subwatershed, but lacked stream segments listed as impaired for sediment. Once potential references were identified, they were screened to determine which ones were most like the impaired subwatershed regarding factors such as landscape position, topography, bedrock geology, hydrology, soil drainage types, land use etc. Furthermore, benthic macroinvertebrate scores were reviewed to confirm that a reference was clearly attaining its aquatic life use, and preliminary modelling was conducted to make sure that use of a particular reference would result in a reasonable pollution reduction.

One difficulty in finding a reference for the Sweitzers Run Subwatershed was that other nearby watersheds with similar topographic positioning tended to have similar land uses and pollution problems. Thus, the search for a reference was extended to other parts of the state. Ultimately, a suitable reference stream was found in Lehigh County. The Trout Creek Subwatershed, as delineated per Figure 2, was confirmed to have a clearly attaining benthic macroinvertebrate community and similar characteristics to the Sweitzers Run Subwatershed (Table 5).

Table 5. Comparison of the Impaired (Sweitzers Run) and Reference (Trout Creek) Subwatersheds.

	Sweitzers Run Subwatershed	Trout Creek Subwatershed
Phys. Province[1]	100% Susquehnna Lowland Section of the Ridge and Valley Province	69% Great Valley Section of the Ridge and Valley Province 31% Blue Mountain Section of the Ridge and Valley Province
Land Area[2], ac	4,936	4,837
Land Use[2]	57% Agriculture 35% Forest/Natural Vegetation 8% Other	35% Agriculture 60% Forest/Natural Vegetation 5% Other
Soil Infiltration[3]	31% Group A 35% Group B 4% Group B/D	10% Group A 55% Group B 2% Group B/D

	4% Group C 13% Group C/D 15% Group D	10% Group C 0% Group C/D 23% Group D
Dominant Bedrock[4]	40% Shale 27% Calcareous Shale 24% Limestone 9% Quartzite	80% Shale 15% Sandstone 5% Graywacke
Average Precipitation[5], in/yr	41.5	39.9
Average Surface Runoff[5], in/yr	2.2	2.3
Average Elevation[5] (ft)	681	801
Average Slope[5]	9%	9%
Stream Channel Slope[5]	1st order: 1.3% 2nd order: 0.4%	1st order: 1.4% 2nd order: 0.7%

[1]Per PA_Physio_Sections GIS layer provided by Pennsylvania Bureau of Topographic and Geological Survey, Dept. of Conservation and Natural Resources
[2]MMW output based on NLCD 2011
[3]As reported by Model My Watershed's analysis of USDA gSSURGO 2016
[4]Per Bedrock Geology GIS layer provided by Pennsylvania Bureau of Topographic and Geological Survey, Dept. of Conservation and Natural Resources
[5]As reported by Model My Watershed

While both subwatersheds had substantial agricultural land cover, the amount was clearly greater in the Sweitzers Run Subwatershed (57%), versus the Trout Creek Subwatershed (35%), which was dominated by forest/natural vegetation (60%). In both subwatersheds agricultural lands were nearly evenly split between hay/pasture Lands and croplands. Both watersheds were dominated by shale bedrock, though Sweitzers Run had a significant amount of limestone, whereas Trout Creek did not. The two subwatersheds had nearly identical average slopes (9%) and surface runoff rates (2.2 versus 2.3 inches per year).

Like the Sweitzers Run Subwatershed, all stream segments within the Trout Creek Subwatershed were designated for cold-water fishes and there were no NPDES permitted discharge with numeric limits relevant to sediment (Table 6).

Table 6. Existing NPDES-Permitted Discharges in the Trout Creek Subwatershed and their Potential Contribution to Sediment Loading.			
Permit No.	Facility Name	Load, mean lbs/yr	Load, max lbs/d
None	None	NA	NA

Permits within the watershed were based on DEP's eMapPA available at http://www.depgis.state.pa.us/emappa/ and EPA's Watershed Resources Registry available at https://watershedresourcesregistry.org/map/?config=stateConfigs/pennsylvania.json

Note that given their transient nature, any stormwater construction permits were not included above.

After selecting the potential reference, the two watersheds were visited during the autumn of 2019 to confirm the suitability of the reference as well as to explore whether there were any obvious land use differences that may help explain why one watershed was impaired for sediment while the other was attaining.

Siltation impairments and problematic agricultural practices were obvious in many parts of the upper Sweitzers Run Subwatershed (Figures 3 and 4). Crop fields were observed near streams with minimal to no forested riparian buffers, and large numbers of cattle had direct access to the stream. There also appeared to be potential accumulations of legacy sediments, perhaps from historic mill-dams (Figure 3). It should also be noted that some protective agricultural practices were observed, including the use of riparian buffers, cover crops, grassy swales, and streambank cattle fencing (Figure 5). The most problematic areas appeared to be in the upper watershed, and based on assessment data and site visit observations, siltation pollution and aquatic community health seemed to improve in the lower watershed.

One obvious factor that may help explain why the reference subwatershed had better water quality than the Sweitzers Run subwatershed was its overall greater amount of forested landcover, which included a large forested area along Blue Mountain. While Sweitzers Run had some lesser forested tracts along Shamokin Mountain, it had nothing comparable in size. However, this factor alone does not fully explain the differences in water quality between the two subwatersheds because the southern branch of Trout Creek (see Figure 2) did not originate on a forested mountain and its catchment area was about 65% agriculture. Yet surprisingly, benthic macroinvertebrate sampling near its mouth indicated an exceptionally healthy aquatic community. Thus, it is hypothesized that the presence of expansive forested riparian buffers (see Figures 2 and 5) allowed for both high water quality and high agricultural landcover, at least for this tributary. It should be noted that the Trout Creek subwatershed did have some agricultural practices could have been improved (Figure 6), but the pollution effects in these cases must have been mostly localized. In addition to the riparian buffers, there was also a noteworthy lack of legacy sediments and far fewer livestock with stream access in the Trout Creek Subwatershed relative to the Sweitzers Run Subwatershed. It should also be noted that better streambed conditions within the Trout Creek Subwatershed may also be in part due to it having somewhat steeper stream channel slopes versus the Sweitzers Run Subwatershed (Table 5).

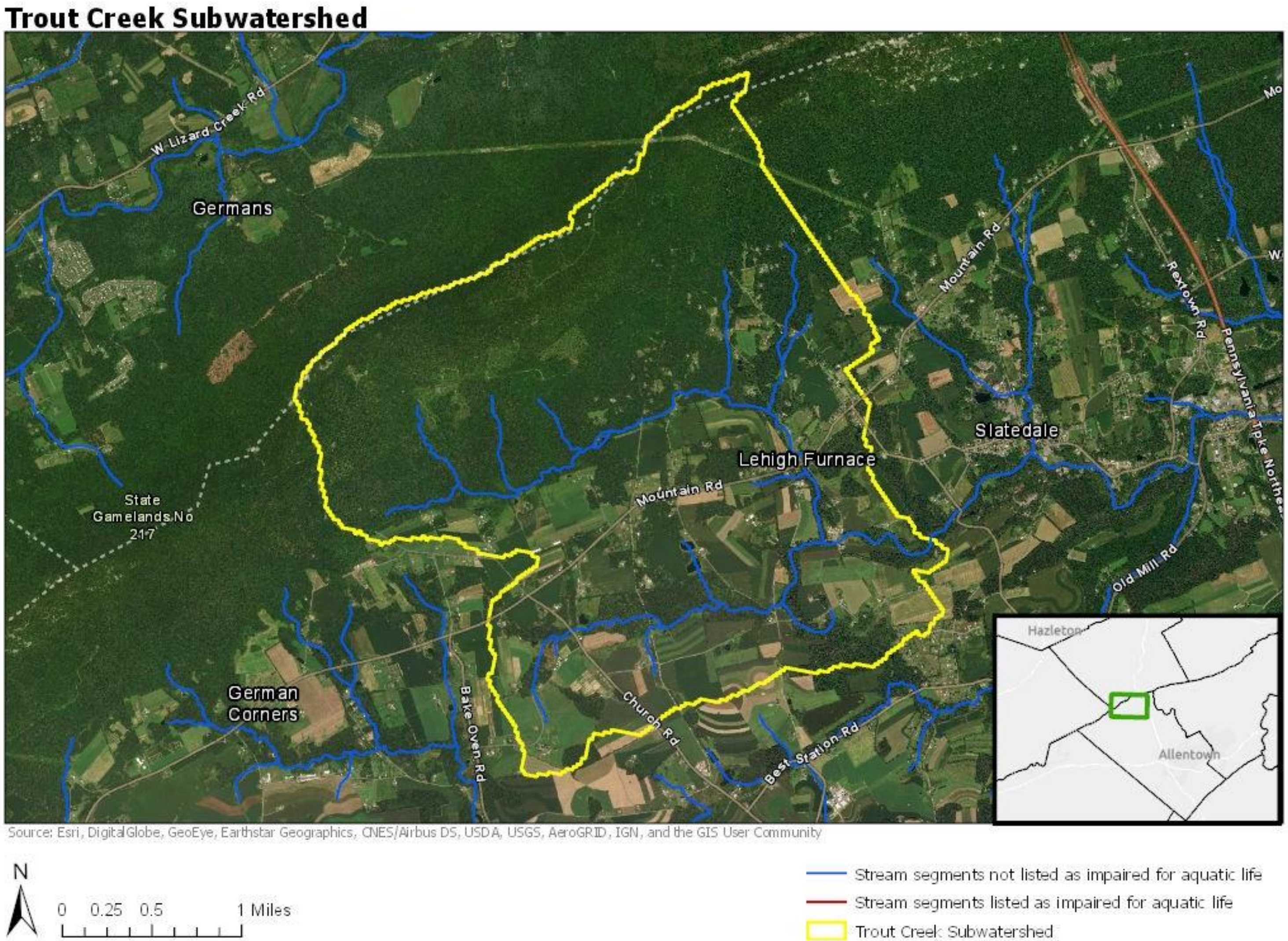

Figure 2. Trout Creek Subwatershed. All stream segments were listed as attaining per PA DEP's 2016 Integrated Report Viewer available at: http://www.depgis.state.pa.us/integrated_report/index.html.

Figure 3. Example stream segments in the Sweitzers Run Subwatershed with obvious fine sediment deposition.

Figure 4. Stream segments flowing through agricultural areas with practices that may exacerbate sediment loading in the Sweitzers Run Subwatershed. Photograph A shows a stream segment traversing cropland (soy fields) with minimal riparian buffers. Photograph B shows a plowed field on sloping topography in the foreground as well as a streamside pasture in the background. Cattle had direct access to the stream. Photograph C shows a stream segment with pasturelands on one side and a corn field on the other. Riparian buffers were minimal. Photograph D shows a large expanse of pasturelands with cattle in the stream.

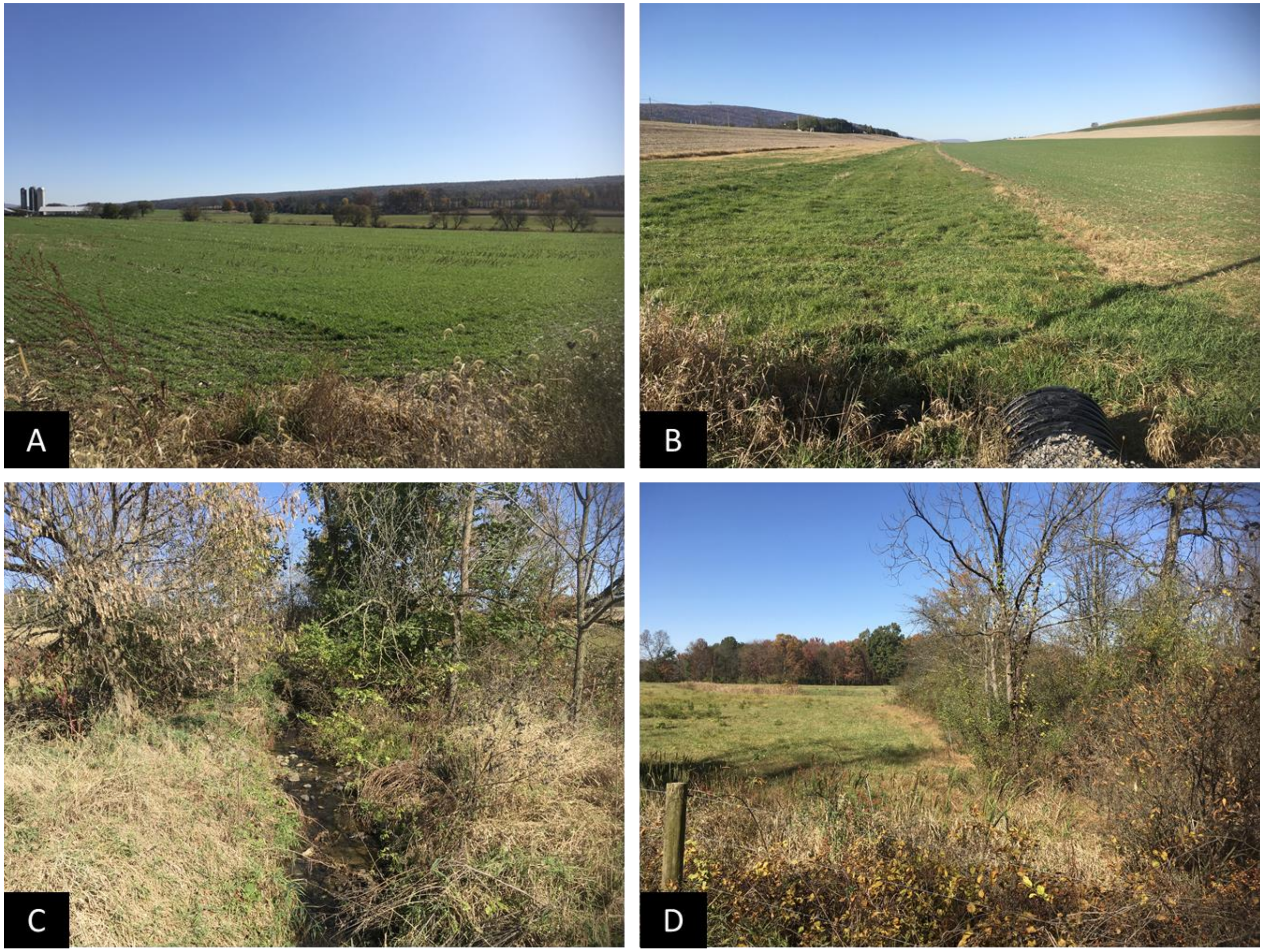

Figure 5. Example agricultural practices in the Sweitzers Run Subwatershed that may help prevent sediment loading. Photograph A shows a field with a cover crop. Photograph B shows a grassy drainageway between sloping crop fields. Cover crops and conservation tillage appear to be used. Photograph C shows a stream segment with a riparian buffer amongst agricultural lands and photograph D shows a pasture where cattle have been fenced out of the stream and the growth of a riparian buffer.

Figure 6. Riparian buffering in the Trout Creek Subwatershed. The upper photograph was taken at high point looking down into the valley. While the uplands were dominated by soy fields, forest predominated in the lowlands. The lower photograph shows an example mainchannel stream segment near the area where the upper photograph was taken.

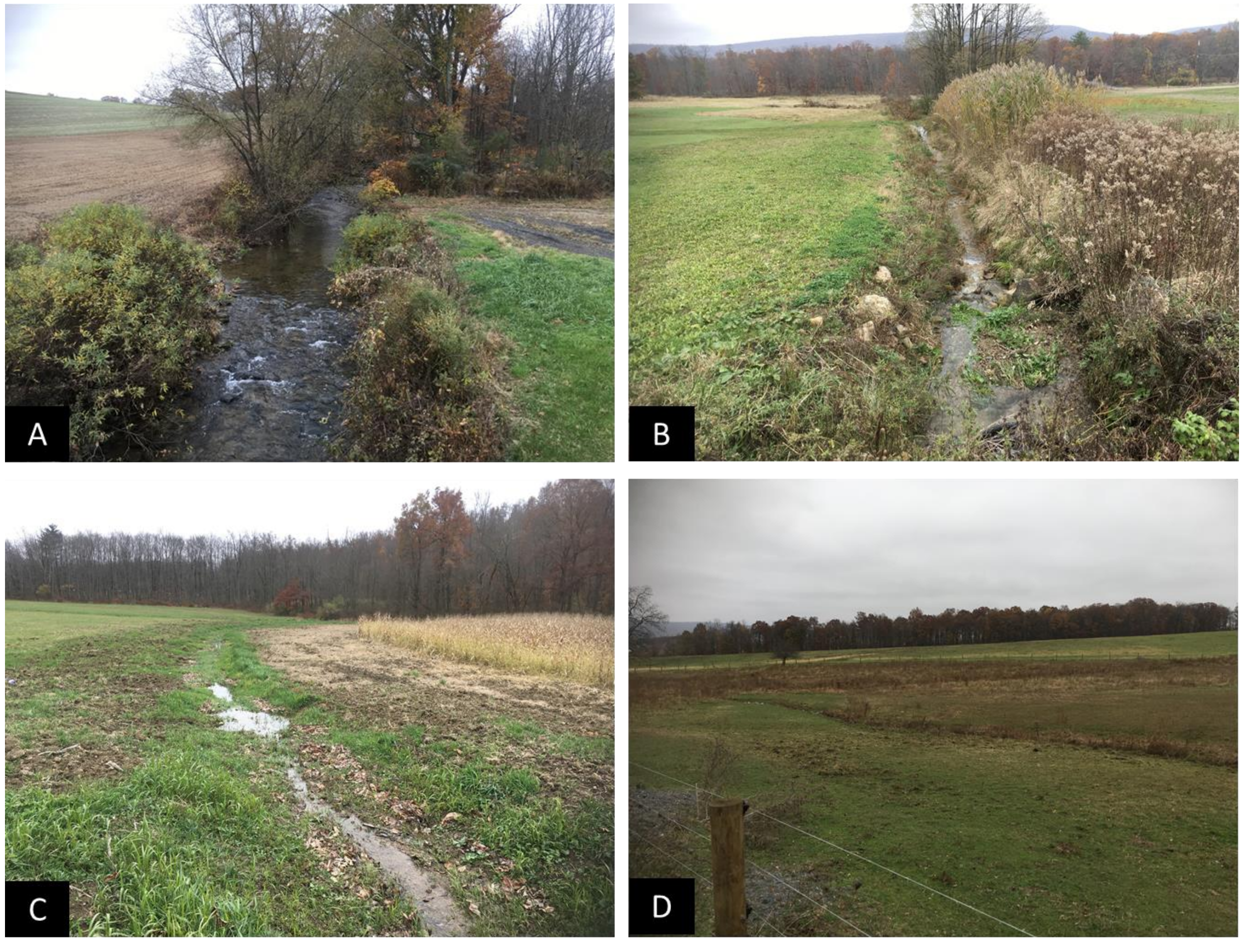

Figure 7. Example stream segments in the Trout Creek reference subwatershed with agricultural impacts. In some cases, riparian buffers were too narrow (photograph A) or virtually non-existent (photographs B, C and D). Also, streamside areas appear to have been plowed in photograph C, though this stream segment was probably dry for much of the year. Photograph D shows a pasture where horses had access to the stream. These examples largely illustrate localized impacts, as use of forested riparian buffers and overall water quality were high in this subwatershed.

Hydrologic / Water Quality Modeling

This section deals primarily with the $TMDL_{Avg}$ calculation, as use of annual average values were determined to be the most relevant way to express the "TMDL" variables. For information about modifications that were made to allow for calculation of $TMDL_{Max}$, see the later "Calculation of a Daily Maximum '$TMDL_{Max}$'" section.

Estimates of sediment loading for the impaired and reference watersheds were calculated using the "Model My Watershed" application (MMW), which is part of the WikiWatershed web toolkit developed through an initiative of the Stroud Water Research Center. MMW is a replacement for the MapShed desktop modelling application. Both programs calculate sediment and nutrient fluxes using the "Generalized Watershed Loading Function Enhanced" (GWLF-E) model. However, MapShed was built using a MapWindow GIS package that is no longer supported, whereas MMW operates with GeoTrellis, an open-source geographic data processing engine and framework. The MMW application is freely available for use at https://wikiwatershed.org/model/. In addition to the changes to the GIS framework, the MMW application continues to be updated and improved relative to its predecessor.

In the present study, watershed areas were defined using MMW's Watershed Delineation tool (see https://wikiwatershed.org/documentation/mmw-tech/#delineate-watershed). Then, the mathematical model used in MMW, GWLF-E, was used to simulate 30-years of daily water, nitrogen, phosphorus and sediment fluxes. To provide a general understanding of how the model functions, the following excerpts are quoted from Model My Watershed's technical documentation.

> The GWLF model provides the ability to simulate runoff, sediment, and nutrient (nitrogen and phosphorus) loads from a 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 that 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 considered to be a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios, but each area is assumed to be homogenous in regard to various "landscape" attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but simply aggregates the loads from each source area into a watershed total; in other words there is no spatial routing. For subsurface 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 subsurface zone, where infiltration is simply computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.
>
> With respect to major processes, GWLF simulates surface runoff using the SCS-CN approach with daily weather (temperature and precipitation) inputs from the EPA Center for Exposure

Assessment Modeling (CEAM) meteorological data distribution. Erosion and sediment yield are estimated using monthly erosion calculations based on the USLE algorithm (with monthly rainfall-runoff coefficients) and a monthly KLSCP values for each source area (i.e., land cover/soil type combination). A sediment delivery ratio based on watershed size and transport capacity, which is based on average daily runoff, is then applied to the calculated erosion to determine sediment yield for each source sector. 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.

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.

Streambank erosion is calculated as a function of factors such as the length of streams, the monthly stream flow, the percent developed land in the watershed, animal density in the watershed, the watersheds curve number and soil k factor, and mean topographic slope

For a detailed discussion of this modelling program, including a description of the data input sources, see Evans and Corradini (2016) and Stroud Research Center (2019).

Model My Watershed Version 1.25.0 allows the user to adjust model parameters, such as the area of land coverage types, the use of conservation practices and the efficiencies of those conservation practices, the watershed's sediment delivery ratio, etc. Default values were used for the modelling run, however, a correction for the presence of existing riparian buffers was made using the BMP Spreadsheet Tool provided by Model My Watershed following the model runs. The following paragraphs describe the riparian buffer correction methodology.

Riparian buffer coverage was estimated via a GIS analysis. Briefly, landcover per a high resolution landcover dataset (University of Vermont Spatial Analysis Laboratory 2016) was examined within 100 feet of NHD flowlines. To determine riparian buffering within the "agricultural area," a polygon tool was used to clip riparian areas that, based on cursory visible inspection, appeared to be in an agricultural-dominated valley or have significant, obvious agricultural land on at least one side. The selection polygons are shown in Figures 11 and 12. Then the sum of raster pixels that were classified as either "Emergent Wetlands", "Tree Canopy" or "Shrub/Scrub" was divided by the total number of non-water pixels to determine percent riparian buffer. Using this methodology, percent riparian buffer was determined to be 37% in the agricultural area of the impaired watershed versus 81% in the reference watershed.

An additional reduction credit was given to the reference watershed to account for the fact it had more riparian buffers than the impaired watershed. Applying a reduction credit solely to the reference watershed to account for its extra buffering was chosen as more appropriate than taking a reduction from both watersheds because the model has been calibrated at a number of actual sites (see https://wikiwatershed.org/help/model-help/mmw-tech/) with varying amounts of existing riparian buffers. If a reduction were taken from all sites to account for existing buffers, the datapoints would likely have a poorer fit to the calibration curve versus simply providing an additional credit to a reference site.

When accounting for the buffering of croplands using the BMP Spreadsheet Tool, the user enters the length of buffer on both sides of the stream. To estimate the extra length of buffers in the agricultural area of the reference watershed over the amount found in the impaired watershed, the length of NHD flowlines within the reference watershed was multiplied by the proportion of riparian pixels that were within the agricultural area selection polygons and then by the difference in the proportion of buffering between the agricultural area of the reference watershed versus that of the impaired watershed, and then by two since both sides of the stream are considered. The BMP spreadsheet tool then calculates sediment reduction using a similar methodology as the Chesapeake Assessment Scenario Tool (CAST). The length of riparian buffers is converted to acres, assuming that the buffers are 100 feet wide. For sediment loading the spreadsheet tool assumes that 2 acres of croplands are treated per acre of buffer. Thus, twice the acreage of buffer is multiplied by the sediment loading rate calculated for croplands and then by a reduction coefficient of 0.54. The BMP spreadsheet tool is designed to account for the area of lost cropland and gained forest when riparian buffers are created. However, this part of the reduction equation was deleted for the present study since historic rather than proposed buffers were being accounted for.

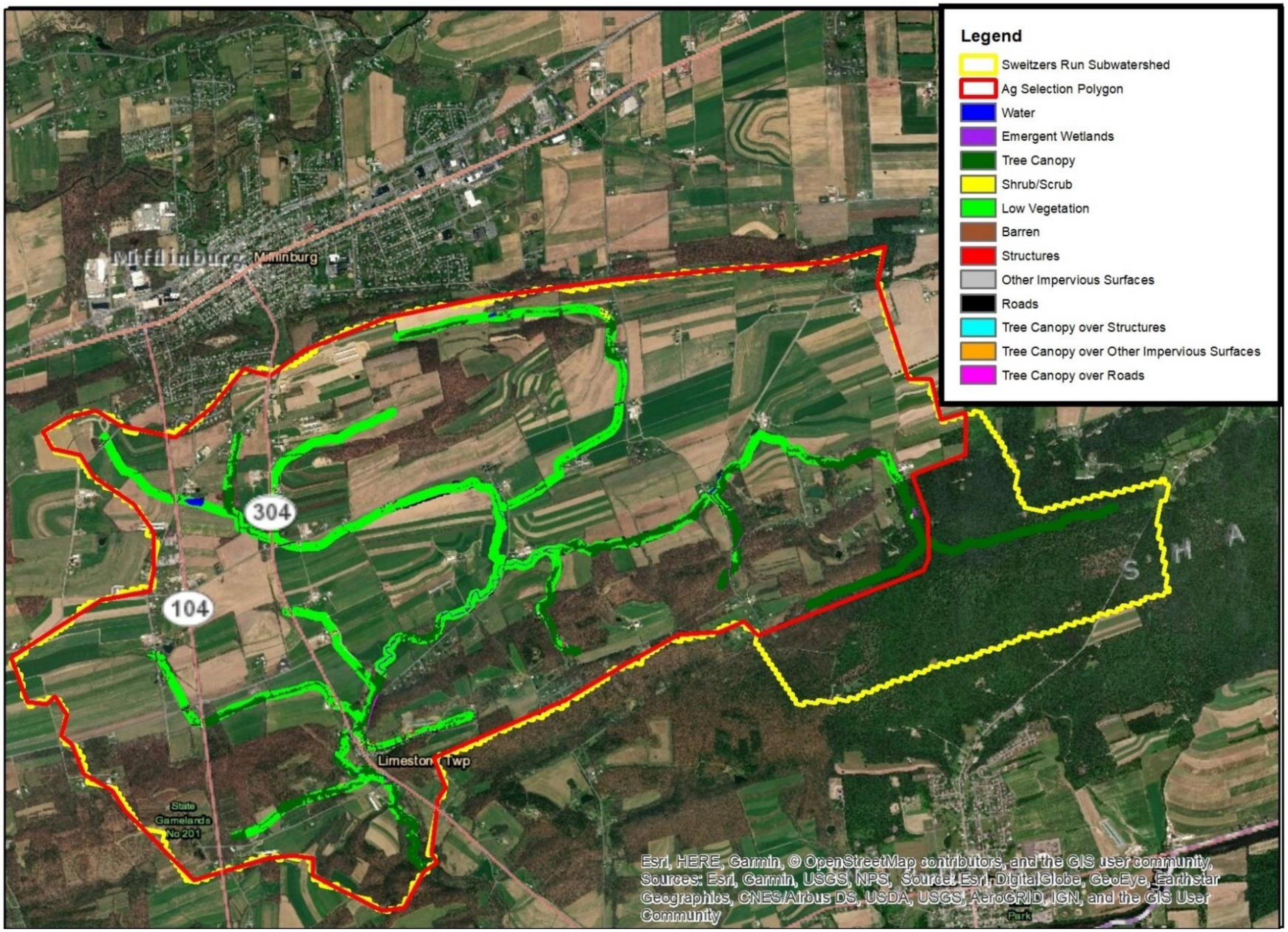

Figure 11. Riparian buffer analysis in the Sweitzers Run Subwatershed. A raster dataset of high-resolution land cover (University of Vermont Spatial Analysis Laboratory 2016) is shown within 100 feet (geodesic) of either side of NHD flowlines. The rate of riparian buffering within the agricultural selection polygon was estimated to be about 37%.

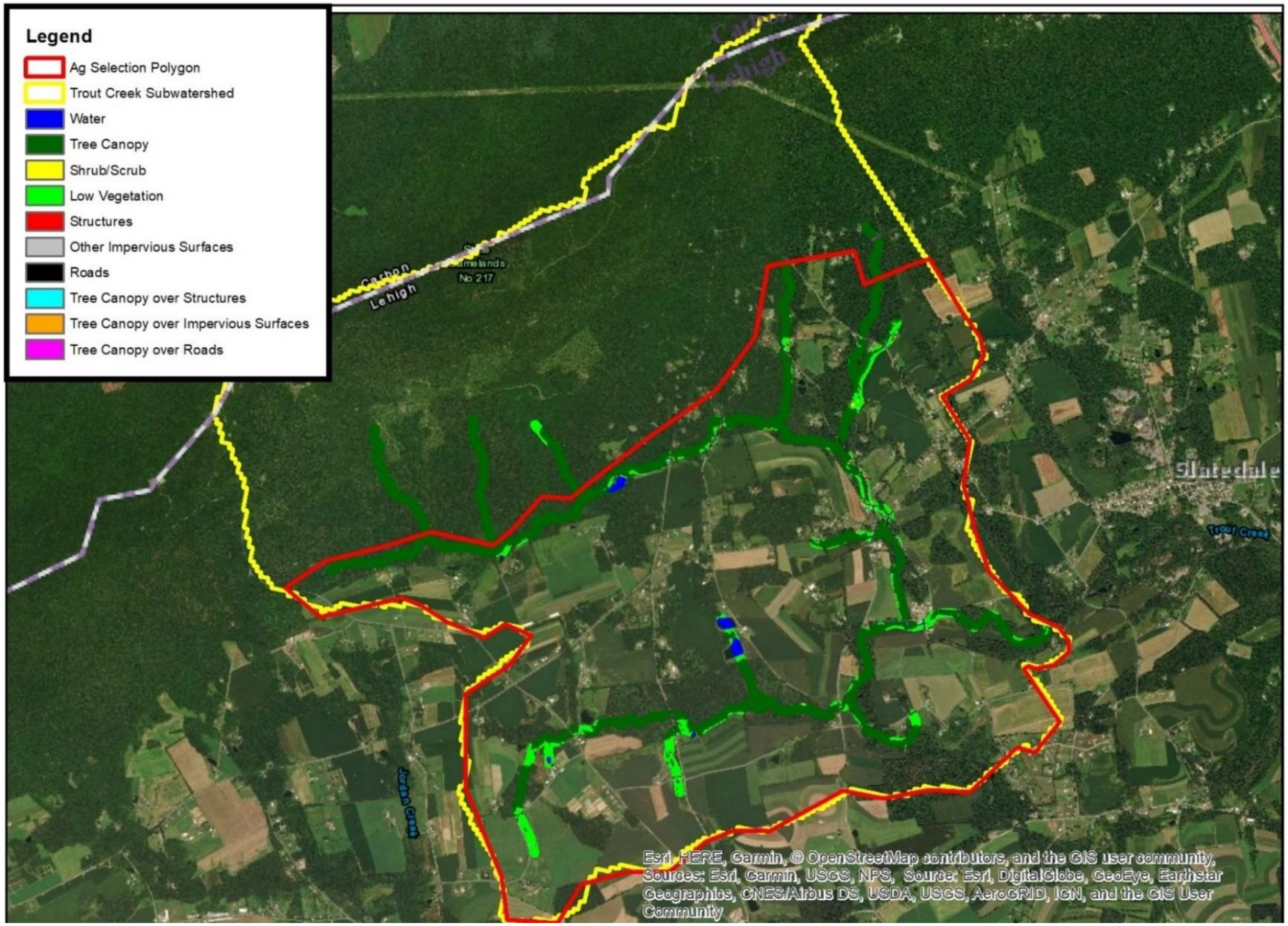

Figure 12. Riparian buffer analysis in the Trout Creek Subwatershed. A raster dataset of high-resolution land cover (University of Vermont Spatial Analysis Laboratory 2016) is shown within 100 feet (geodesic) of either side of NHD flowlines. The rate of riparian buffering within the agricultural selection polygon was estimated to be about 81%.

Calculation of the $TMDL_{Avg}$

The mean annual sediment loading rate for the unimpaired reference watershed (Trout Creek Subwatershed) was estimated to be 295 pounds per acre per year (Table 7). This was substantially lower than the estimated mean annual loading rate in the impaired Sweitzers Run Subwatershed (427 pounds per acre per year, Table 8). Thus, to achieve the loading rate of the unimpaired watershed, sediment loading in the Sweitzers Run Subwatershed should be reduced to 1,453,880 pounds per year or less (Table 9).

Table 7. Existing Annual Average Loading Values for Trout Creek Subwatershed, Reference

Source	Area ac	Sediment lbs/yr	Unit Area Load, lbs/ac/yr
Hay/Pasture	793	265,159	335
Cropland	877	1,161,685	1,325
Forest and Shrub/Scrub	2,849	4,277	2
Wetland	10	31	3
Herbaceous/Grassland	44	1,736	39
Low Intensity Mixed Development	259	2,938	11
Medium Intensity Mixed Development	2	145	59
Bare Rock	2	0	0
Streambank[1]		152,092	
Point Sources		0	
Additional Buffer Discount[2]		-163,276	
total	4,837	1,424,788	295

[1]"Streambank" sediment loads were calculated using Model My Watershed's streambank routine which uses length rather than area.

[2]Accounts for the amount of extra riparian buffering in the agricultural area of reference watershed versus the impaired watershed. For details on this calculation, see the "Hydrologic / Water Quality Modelling" section.

Table 8. Existing Annual Average Loading Values for the Sweitzers Run Subwatershed, Impaired			
Source	Area, ac	Sediment, lbs/yr	Unit Area Load, lb/ac/yr
Hay/Pasture	1,272	92,677	73
Cropland	1,553	1,679,803	1,082
Forest and Shrub/Scrub	1,709	3,485	2
Wetland	17	39	2
Low Intensity Mixed Development	375	4,104	11
Medium Intensity Mixed Development	10	731	74
High Intensity Mixed Development	0	32	
Streambank		326,605	
Point Sources		0	
total	4,936	2,107,475	427

“Streambank” sediment loads were calculated using Model My Watershed’s streambank routine which uses length rather than area.

Table 9. Calculation of an Annual Average TMDL Value for the Sweitzers Run Subwatershed			
Pollutant	Mean Loading Rate in Reference, lbs/ac/yr	Total Area in Impaired Watershed, ac	Target $TMDL_{Avg}$ Value, lbs/yr
Sediment	295	4,936	1,453,880

Calculation of Load Allocations

In the TMDL equation, the load allocation (LA) is the load derived from nonpoint sources. The LA is further divided into the adjusted loads allocation (ALA), which is comprised of the nonpoint sources causing the impairment and targeted for reduction, as well as the loads not reduced (LNR), which is comprised of the natural and anthropogenic sources that are not considered responsible for the impairment nor targeted for reduction. Thus:

LA =ALA + LNR

Considering that the total maximum daily load (TMDL) is the sum of the margin of safety (MOS), the wasteload allocation (WLA), and the load allocation (LA):

TMDL = MOS + WLA + LA,

then the load allocation is calculated as follows:

LA = TMDL - MOS - WLA

Thus, before calculating the load allocation, the margin of safety and wasteload allocation must be defined.

Margin of Safety

The margin of safety (MOS) is a portion of pollutant loading that is reserved to account for uncertainties. Reserving a portion of the load as a safety factor requires further load reductions from the ALA to achieve the TMDL. For this analysis, the MOS_{Avg} was explicitly designated as ten-percent of the $TMDL_{Avg}$ based on professional judgment. Thus:

1,453,880 lbs/yr $TMDL_{Avg}$ * 0.1 = 145,388 lbs/yr MOS_{Avg}

Wasteload Allocation

The wasteload allocation (WLA) is the pollutant loading assigned to existing permitted point sources as well as future point sources. There were no National Pollutant Discharge Elimination System (NPDES) point source discharges with numeric point source limits for sediment (Table 4). A bulk reserve was included to allow for insignificant dischargers and minor new sources.

Thus, the WLA was comprised solely of the bulk reserve, which we defined as one percent of the targeted TMDL. Therefore:

1,453,880 lbs/yr $TMDL_{Avg}$ * 0.01 = 14,539 lbs/yr bulk $reserve_{Avg}$ + 0 lb/yr permitted loads = 14,539 lbs/yr WLA_{Avg}

Load Allocation

Now that the margin of safety and wasteload allocation have been defined, the load allocation (LA) is calculated as:

1,453,880 lbs/yr $TMDL_{Avg}$ – (145,388 lbs/yr MOS_{Avg} + 14,539 lbs/yr WLA_{Avg}) = 1,293,953 lbs/yr LA_{Avg}

Loads Not Reduced and Adjusted Load Allocation

Since the impairments addressed by this TMDL are for sedimentation due to agriculture, sediment contributions from forests, wetlands, non-agricultural herbaceous/grasslands and developed lands within the Sweitzers Run Subwatershed were considered loads not reduced (LNR). LNR_{Avg} was calculated to be 8,390 lbs/yr (Table 10).

The LNR is subtracted from the LA to determine the ALA:

1,293,953 lbs/yr LA_{Avg} – 8,390 lbs/yr LNR_{Avg} = 1,285,563 lbs/yr ALA_{Avg}

Table 10. Average Annual Load Allocation, Loads Not Reduced and Adjusted Load Allocation

	Sediment, lbs/yr
Load Allocation (LA_{Avg})	**1,293,953**
Loads Not Reduced (LNR_{Avg}):	**8,390**
Forest	3,485
Wetlands	39
Low Intensity Mixed Development	4,104
Medium Intensity Mixed Development	731
High Density Mixed Development	32

Adjusted Load Allocation (ALA_{Avg})	1,285,563

Note, the ALA is comprised of the anthropogenic sediment sources targeted for reduction: croplands, hay/pasturelands and streambanks (assuming an elevated erosion rate). The LNR is comprised of both natural and anthropogenic sediment sources. While anthropogenic, developed lands were considered a negligible sediment source in this watershed and thus not targeted for reduction. Forests and wetlands were considered natural sediment sources.

Calculation of Sediment Load Reductions

To calculate load reductions by source, the ALA was further analyzed using the Equal Marginal Percent Reduction (EMPR) allocation method described in Appendix D. Although this Sweitzers Run TMDL was developed to address impairments caused by agricultural activities, streambanks were also significant contributors to the sediment load in the watershed, and streambank erosion rates are influenced by agricultural activities. Thus, streambanks were included in the ALA and targeted for reduction.

In this evaluation, croplands exceeded the allocable load by itself. Thus, croplands received a greater percent annual average reduction (42%) than hay/pasture lands and streambanks (25% each) (Table 11).

Table 11. Average Annual Sediment Load Allocations for Source Sectors in the Sweitzers Run Subwatershed

		Allowable Loading	Load Allocation	Current Loading	Current Load	Reduction Goal
Land Use	Acres	lbs/ac/yr	lbs/yr	lbs/ac/yr	lbs/yr	
CROPLAND	1,553	624	969,398	1,082	1,679,803	42%
HAY/PASTURE	1,272	55	69,884	73	92,677	25%
STREAMBANK			246,281		326,605	25%
AGGREGATE		ALA	1,285,563		2,099,085	39%

Calculation of a Daily Maximum “$TMDL_{Max}$” Value

When choosing the best timescale for expressing pollutant loading limits for siltation, two major factors must be considered:

1) Sediment loading is driven by storm events, and loads vary greatly even under natural conditions.
2) Siltation pollution typically harms aquatic communities through habitat degradation as a result of chronically excessive loading.

Considering then that siltation pollution has more to do with chronic degradation rather than acutely toxic loads/concentrations, pollution reduction goals based on average annual conditions are much more relevant than daily maximum values. Nevertheless, a true “Total Maximum Daily Load” ($TMDL_{Max}$) is also calculated in the following.

Model My Watershed currently does not report daily loading rates, but its predecessor program, “MapShed” does. Thus, for the calculation of a $TMDL_{Max}$ value, modelling was initially conducted in Model My Watershed, and the “Export GMS” feature was used to provide an input data file that was run in MapShed. The daily output was opened in Microsoft Excel (Version 1902), and current maximum daily loads were calculated as the 99th percentiles (using the percentile.exc function) of estimated daily sediment loads in both the Sweitzers Run and Trout Creek reference subwatersheds. The first year of data was excluded to account for the time it takes for the model calculations to become reliable. The 99th percentile was chosen because 1) sediment loading increases with the size of storm events, so, as long as there could be an even larger flood, a true upper limit to sediment loading cannot be defined and 2) 99% of the time attainment of water quality criteria is prescribed for other types of pollutants per PA regulations (see PA Code Title 25, Chapter 96, Section 96.3(e)).

As with the average loading values reported previously (see the Hydrologic / Water Quality Modelling section), a correction was made for the additional amount of existing riparian buffers in the reference watershed versus the impaired watershed. This was calculated simply by reducing the 99th percentile loading rate for the reference watershed by the same reduction percentage that was calculated previously for the average loading rate.

Then, similarly to the $TMDL_{Avg}$ value reported in Table 9, $TMDL_{Max}$ was calculated as the 99th percentile daily load of the reference watershed, divided by the acres of the reference watershed, and then multiplied by the acres of the impaired watershed. Thus, the $TMDL_{Max}$ loading rate was calculated as 69,918 pounds per day (Table 12), which would be a 9% reduction from Sweitzers Run’s current 99th percentile daily loading rate of 77,181 pounds per day.

Table 12. Calculation of $TMDL_{Max}$ for the Sweitzers Subwatershed

Pollutant	99th Percentile Loading Rate in Reference, lbs/ac/d	Total Land Area in Impaired Watershed, ac	Target $TMDL_{Max}$ Value, lbs/d
Sediment	14.2	4,936	69,918

Also, in accordance with the previous “Calculation of Load Allocations” section, the WLA_{Max} would consist solely of a bulk reserve defined as 1% of the $TMDL_{Max}$ and the MOS_{Max} would be 10% of the $TMDL_{Max}$. The LA_{Max} would then be calculated as the amount remaining after subtracting the WLA_{Max} and the MOS_{Max} from the $TMDL_{Max}$. See Table 13 for a summary of these $TMDL_{Max}$ variables.

Table 13. 99th Percentile of Daily Loading TMDL ($TMDL_{Max}$) Variables for the Sweitzers Run Subwatershed

lbs/d:

Pollutant	$TMDL_{Max}$	MOS_{Max}	WLA_{Max}	LA_{Max}
Sediment	69,918	6,992	699	62,227

Mapshed however did not break down daily loads by land use type. Thus, the daily maximum load allocation variables were calculated assuming the same distribution as occurred for the annual average load allocation variables. For instance, if the streambanks allocation was 19% of LA_{Avg} it was assumed that it was also 19% of LA_{Max}. While the distribution of sources likely changes with varying flow levels, this might be an acceptable assumption considering that the largest flow events may control the bulk of annual sediment loading (see Sloto et al. 2012). See Table 14 for a summary of these LA_{Max} variables.

Table 14. Allocation of the 99th Percentile Daily Load Allocation (LA_{Max}) for the Sweitzers Run Subwatershed

	Annual Average (lbs/yr)	Proportion of Load Allocation	Max Daily (lbs/d)
Load Allocation	1,293,953		62,227
Loads Not Reduced	8,390	0.006	404
Adjusted Loads Allocation	1,285,563	0.99	61,824
Croplands	969,398	0.75	46,619
Hay/Pasturelands	69,884	0.05	3,361
Streambanks	246,281	0.19	11,844

Because Mapshed did not break down daily loadings by land use types, the load allocations for $TMDL_{Max}$ were calculated by assuming the same distribution as occurred for the LA_{Avg} variables. For instance, if the streambanks allocation was 19% of LA_{Avg} it was assumed that it was also 19% of LA_{Max}.

Because sediment loading varies so greatly with discharge, the $TMDL_{Max}$ value would probably only be relevant on a handful of days each year with the highest flow conditions. And, while these times are especially important to overall annual sediment loading (see-Sloto and Olson 2011, Sloto et al. 2012), it is cautioned that reliance solely on a $TMDL_{Max}$ value may not be protective for the Sweitzers Run Subwatershed because chronic excessive sediment inputs occurring at lower discharge levels may be ignored. Take for instance an extreme scenario where the $TMDL_{Max}$ was met every day but never exceeded. In this case, the annual sediment loading in the Sweitzers Run Subwatershed would skyrocket to 25,520,117 lbs/yr, which is more than twelve-times the current annual average. The $TMDL_{Avg}$ value on the other hand is sensitive to typical conditions, extreme events, and long-term effects, and thus is the most relevant of the two TMDL targets for achieving restoration in the Sweitzers Run Subwatershed. Therefore, while adherence with the loading requirements of this TMDL include meeting both the $TMDL_{Avg}$ and the $TMDL_{Max}$, BMP implementation would ultimately be deemed adequate if the prescribed annual average reductions were satisfied.

Consideration of Critical Conditions and Seasonal Variations

"Model My Watershed" uses a continuous simulation model with daily time steps for weather data and water balance (precipitation, stream flow, surface runoff, subsurface flow, and evapotranspiration) calculations. The source of the weather data (precipitation and temperature) was a dataset compiled by USEPA ranging from 1961-1990 (Stroud Water Research Center 2019). The evapotranspiration calculations also take into account the length of the growing season and changing day length. Monthly calculations are made for sediment loads, based on daily water balance accumulated in monthly values. Therefore, variable flow conditions and seasonal changes are inherently accounted for in the loading calculations. Furthermore, this document calculates both annual average and 99th percentile daily TMDL values. See the discussion of the relevance of these values in the previous section. Seeking to attain both of these values will be protective under both long-term average and extreme flow event conditions.

Recommendations

This document proposes a 31% reduction in annual average sediment loading for the Sweitzers Run Subwatershed. To achieve this goal while maintaining a margin of safety and minor allowance for point sources, annual average sediment loading from croplands should be reduced by 42% while loading from hay/pasture lands and streambanks should be reduced by 25% each. In addition, 99th percentile daily sediment loading should be reduced by 9%. Reductions in stream sediment loading due to agricultural activities can be made through the implementation of required Erosion and Sediment Control Plans (Pennsylvania Clean Streams Law, Title 25 Environmental Protection, Chapter 102.4, see also Appendix E) and through the use of BMPs such as conservation tillage, cover crops, vegetated filter strips, rotational grazing, livestock exclusion fencing, riparian buffers, etc. Based on site observations, it appeared that there was a particular need for grazing land management, streambank fencing, streambank stabilization, and forested riparian buffer BMPs in the Sweitzers Run Subwatershed.

Use of forested riparian buffers is widely recognized as one of the best ways to promote stream health. Riparian buffers protect streams from sedimentation and nutrient impairments by filtering these pollutants from runoff and floodwaters and by protecting streambanks from erosion. However, riparian buffers are also beneficial for many other reasons beyond just protecting from sedimentation and nutrients. For instance, riparian buffers may: filter out other pollutants such as pesticides; provide habitat and nutrition for aquatic, semi-aquatic and terrestrial organisms; and moderate stream temperature. Thus, use of forested riparian buffers should be encouraged wherever possible.

Development of a more detailed watershed implementation plan is recommended. Further ground truthing should be performed to assess both the extent of existing BMPs and to determine the most cost effective and environmentally protective combination of BMPs required for meeting the prescribed sediment reductions. Key personnel from the regional DEP office, the County Conservation District, Susquehanna River Basin Commission (SRBC) and other state and local agencies and/or watershed groups should be involved in developing a restoration strategy. There are a number of possible funding sources for agricultural BMPs and stream restoration projects, including: The Federal Nonpoint Source

Management Program (§ 319 of the Clean Water Act), PA DEP's Growing Greener Grant Program, United States Department of Agriculture's Natural Resource Conservation Service funding, and National Fish and Wildlife Foundation Grants.

Public Participation

Public notice of a draft of this TMDL was published in the Pennsylvania Bulletin on February 15, 2020 to foster public comment. A 30-day period was provided for the submittal of comments. No public comments were received.

Citations

Note: maps for this document were made with either:
ArcMap version 10.4.1 by Esri.
ArcGIS Pro 2.2.0 by Esri.

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Appendix A: Background on Stream Assessment Methodology

Integrated Water Quality Monitoring and Assessment Report, List 5, 303(d), Listing Process

Assessment Methods:

Prior to developing TMDLs for specific waterbodies, there must be sufficient data available to assess which streams are impaired and should be listed in the Integrated Water Quality Monitoring and Assessment Report. Prior to 2004 the impaired waters were found on the 303(d) List; from 2004 to present, the 303(d) List was incorporated into the Integrated Water Quality Monitoring and Assessment Report and found on List 5. Table A1. summarizes the changes to listing documents and assessment methods over time.

With guidance from EPA, the states have developed methods for assessing the waters within their respective jurisdictions. From 1996-2006, the primary method adopted by the Pennsylvania Department of Environmental Protection for evaluating waters found on the 303(d) lists (1998-2002) or in the Integrated Water Quality Monitoring and Assessment Report (2004-2006) was the Statewide Surface Waters Assessment Protocol (SSWAP). SSWAP was a modification of the EPA Rapid Bioassessment Protocol II (RPB-II) and provided a more consistent approach to assessing Pennsylvania's streams.

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

The listings found in the Integrated Water Quality Monitoring and Assessment Reports from 2008 to present were derived based on the Instream Comprehensive Evaluation protocol (ICE). Like the superseded SSWAP protocol, the ICE protocol called for selecting representative segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist was to select as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment could vary between sites. The biological surveys were to include D-frame kicknet sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Collected samples were returned to the laboratory where the samples were subsampled for a target benthic macroinvertebrate sample of 200 ± 20% (N = 160-240). The benthic macroinvertebrates in this subsample were typically identified to the generic level. The ICE protocol is a modification of the EPA

Rapid Bioassessment Protocol III (RPB-III) and provides a more rigorous and consistent approach to assessing Pennsylvania's streams than the SSWAP.

After these surveys (SSWAP, 1998-2006 lists or ICE, 2008-present lists) are completed, the biologist are to determine the status of the stream segment. Decisions are to be based on the performance of the segment using a series of biological metrics. If the stream segment is classified as impaired, it was to be listed on the state's 303(d) List, or presently, the Integrated Water Quality Monitoring and Assessment Report with the source and cause documented.

Once a stream segment is listed as impaired, a TMDL typically must be developed for it. A TMDL addresses only one pollutant. If a stream segment is impaired by multiple pollutants, each pollutant receives a separate and specific TMDL within that stream segment. Adjoining stream segments with the same source and cause listings are addressed collectively on a watershed basis.

Table A1. Impairment Documentation and Assessment Chronology

Listing Date:	Listing Document:	Assessment Method:
1998	303(d) List	SSWAP
2002	303(d) List	SSWAP
2004	Integrated List	SSWAP
2006	Integrated List	SSWAP
2008-Present	Integrated List	ICE

Integrated List= Integrated Water Quality Monitoring and Assessment Report
SSWAP= Statewide Surface Waters Assessment Protocol
ICE= Instream Comprehensive Evaluation Protocol

Justification of Mapping Changes to 303(d) Lists 1998 to Present

The following are excerpts from the Pennsylvania DEP Section 303(d) narratives that justify changes in listings between the 1996-2002 303(d) Lists and the 2004 to present Integrated Water Quality Monitoring and Assessment Reports. 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. Because of additional sampling and the migration to the GIS, some of the information appearing on the 1996 list differed from the 1998 list. Most common changes included:

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

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

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 the Department 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, DEP contracted with USGS to add missing streams and correct any errors in the NHD. A GIS contractor transferred the old DEP stream assessment information to the improved NHD and the old DEP 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 DEP 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 OIT's (Office of Information Technology) fulltime staff to manage and maintain SLIMS the systems and formats will now remain stable over many Integrated Listing cycles.

Appendix B: Model My Watershed Generated Data Tables

Type	NLCD Code	Area (km²)	Coverage (%)
Open Water	11	0.03	0.1
Perennial Ice/Snow	12	0	0
Developed, Open Space	21	1.17	5.8
Developed, Low Intensity	22	0.35	1.7
Developed, Medium Intensity	23	0.04	0.2
Developed, High Intensity	24	0	0
Barren Land (Rock/Sand/Clay)	31	0	0
Deciduous Forest	41	6.02	30.1
Evergreen Forest	42	0.41	2.1
Mixed Forest	43	0.43	2.2
Shrub/Scrub	52	0.06	0.3
Grassland/Herbaceous	71	0	0
Pasture/Hay	81	5.15	25.7
Cultivated Crops	82	6.29	31.4
Woody Wetlands	90	0.02	0.1
Emergent Herbaceous Wetlands	95	0.05	0.2

Table B1. "Model My Watershed" Land Cover Outputs for the Sweitzers Run Subwatershed

Type	NLCD Code	Area (km²)	Coverage (%)
Open Water	11	0.06	0.3
Perennial Ice/Snow	12	0	0
Developed, Open Space	21	0.91	4.6
Developed, Low Intensity	22	0.14	0.7
Developed, Medium Intensity	23	0.01	0
Developed, High Intensity	24	0	0
Barren Land (Rock/Sand/Clay)	31	0.01	0
Deciduous Forest	41	11.28	57.5
Evergreen Forest	42	0.12	0.6
Mixed Forest	43	0.11	0.6
Shrub/Scrub	52	0.03	0.1
Grassland/Herbaceous	71	0.18	0.9
Pasture/Hay	81	3.21	16.3
Cultivated Crops	82	3.55	18.1
Woody Wetlands	90	0.04	0.2
Emergent Herbaceous Wetlands	95	0	0

Table B2. "Model My Watershed" Land Cover Outputs for the Trout Creek reference Subwatershed

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	5.61	0.77	4.84	0	0.31	7.15
Feb	6.35	0.96	5.38	0	0.49	7.31
Mar	7.38	0.45	6.93	0	1.75	8.36
Apr	6.23	0.12	6.11	0	4.51	8.41
May	4.28	0.1	4.18	0	8.83	10.51
Jun	3.35	0.85	2.5	0	12.32	10.58
Jul	1.25	0.15	1.11	0	11.79	9.86
Aug	0.41	0.1	0.31	0	9.32	8.64
Sep	0.83	0.7	0.12	0	5.94	9.04
Oct	1.12	0.51	0.6	0	3.6	8.06
Nov	2.14	0.35	1.79	0	1.72	9.38
Dec	4.92	0.55	4.37	0	0.68	8.11
Total	43.87	5.61	38.24	0	61.26	105.41

Table B3. “Model My Watershed” Hydrology Outputs for the Sweitzers Run Subwatershed.

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	4.9	0.86	4.04	0	0.28	6.69
Feb	5.67	1.13	4.54	0	0.41	6.47
Mar	6.41	0.48	5.92	0	1.58	7.4
Apr	6.17	0.46	5.72	0	3.41	8.25
May	4.95	0.2	4.75	0	7.51	9.96
Jun	3.52	0.31	3.2	0	11.13	9.81
Jul	1.95	0.28	1.68	0	11.78	10.08
Aug	0.97	0.21	0.76	0	9.7	9.66
Sep	1.03	0.54	0.48	0	6.04	9.19
Oct	1.13	0.27	0.85	0	3.46	7.27
Nov	2.4	0.45	1.94	0	1.61	8.82
Dec	4.32	0.62	3.7	0	0.59	7.62
Total	43.42	5.81	37.58	0	57.5	101.22

Table B4. “Model My Watershed” Hydrology Outputs for the Trout Creek reference subwatershed

Sources	Sediment (kg)
Hay/Pasture	42,030.40
Cropland	761,815.60
Wooded Areas	1,580.40
Wetlands	17.8
Open Land	0
Barren Areas	0
Low-Density Mixed	426
Medium-Density Mixed	331.3
High-Density Mixed	14.7
Low-Density Open Space	1,435.00
Farm Animals	0
Stream Bank Erosion	148,120.00
Subsurface Flow	0
Point Sources	0
Septic Systems	0

Table B5. Model My Watershed outputs for sediment in the Sweitzers Run Subwatershed.

Sources	Sediment (kg)
Hay/Pasture	120,253.40
Cropland	526,841.10
Wooded Areas	1,939.80
Wetlands	14.1
Open Land	787.5
Barren Areas	0.2
Low-Density Mixed	180.6
Medium-Density Mixed	65.8
High-Density Mixed	0
Low-Density Open Space	1,151.80
Farm Animals	0
Stream Bank Erosion	68,976.00
Subsurface Flow	0
Point Sources	0
Septic Systems	0

Table B6. Model My Watershed outputs for Sediment in the Trout Creek reference subwatershed.

Appendix C: Stream Segments in the Sweitzers Run Subwatershed with Siltation Impairments for Aquatic Life Use

Stream Name:	Status:	Impairment Source:	Impairment Cause:	COMID:	Length (mi):
Sweitzers Run Unnamed To (ID:54961469)	Impaired	Grazing Related Agric	Siltation	54961273	1.11908952
Turkey Run	Impaired	Grazing Related Agric	Siltation	54961371	0.01429154
Turkey Run	Impaired	Grazing Related Agric	Siltation	54961379	1.39311421
Turkey Run	Impaired	Grazing Related Agric	Siltation	54961391	0.89166766
Sweitzers Run Unnamed To (ID:54961469)	Impaired	Grazing Related Agric	Siltation	54961469	0.99730076
Turkey Run	Impaired	Grazing Related Agric	Siltation	54961511	0.85252128
Turkey Run Unnamed To (ID:54961517)	Impaired	Grazing Related Agric	Siltation	54961517	0.48591227
Turkey Run Unnamed To (ID:54961519)	Impaired	Grazing Related Agric	Siltation	54961519	0.59589497
Sweitzers Run	Impaired	Grazing Related Agric	Siltation	54961561	0.30509326
Sweitzers Run	Impaired	Grazing Related Agric	Siltation	54961563	0.07891414
Turkey Run	Impaired	Grazing Related Agric	Siltation	54961565	0.23425694
Sweitzers Run	Impaired	Grazing Related Agric	Siltation	54961567	0.4809413
Sweitzers Run Unnamed To (ID:54961569)	Impaired	Grazing Related Agric	Siltation	54961569	0.35790981
Sweitzers Run	Impaired	Grazing Related Agric	Siltation	54961571	0.13918715
Sweitzers Run Unnamed To (ID:54961603)	Impaired	Grazing Related Agric	Siltation	54961603	0.89228903
Sweitzers Run	Impaired	Grazing Related Agric	Siltation	54961605	0.24419888
Sweitzers Run	Impaired	Grazing Related Agric	Siltation	54961609	1.1128758
Turkey Run Unnamed To (ID:54961687)	Impaired	Grazing Related Agric	Siltation	54961687	0.57414698
Sweitzers Run	Impaired	Grazing Related Agric	Siltation	54961843	0.97679551
Sweitzers Run Unnamed To (ID:54961845)	Impaired	Agriculture	Siltation	54961845	0.56979738
Sweitzers Run	Impaired	Agriculture	Siltation	54961925	0.16466337
Sweitzers Run	Impaired	Agriculture	Siltation	54961939	0.0453601
Sweitzers Run Unnamed To (ID:54961963)	Impaired	Agriculture	Siltation	54961963	0.55799133
Sweitzers Run Unnamed To (ID:54961975)	Impaired	Agriculture	Siltation	54961975	1.18806172
Sweitzers Run	Impaired	Agriculture	Siltation	54962003	0.35915255
Sweitzers Run	Impaired	Agriculture	Siltation	54962223	0.60024457
Sweitzers Run Unnamed To (ID:54962239)	Impaired	Agriculture	Siltation	54962239	0.67170226

Appendix D: Equal Marginal Percent Reduction Method

Equal Marginal Percent Reduction (EMPR) (An Allocation Strategy)

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

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

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

Step 3: Actual EMPR Process:

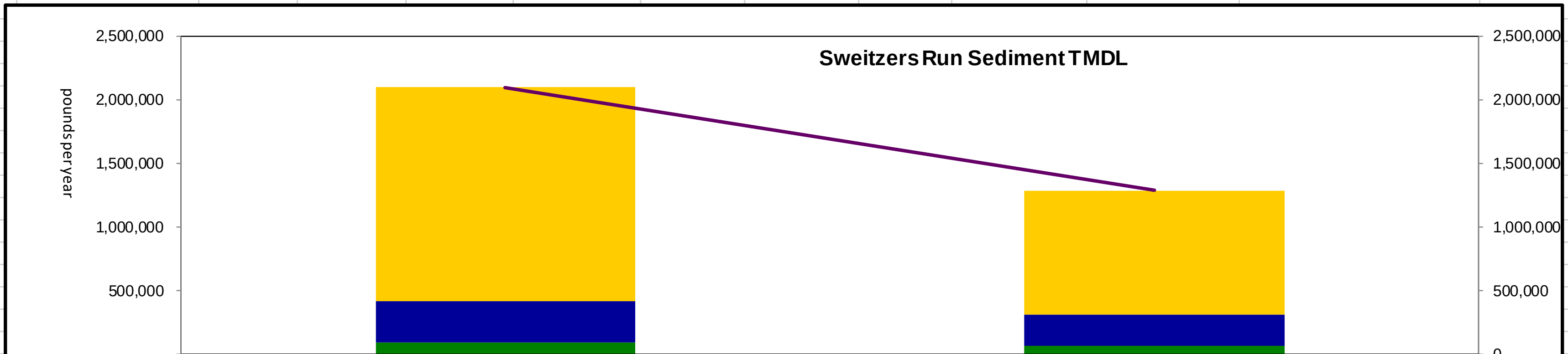
a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving waterbody. If the contributor exceeds the ALA, that contributor would 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 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 percent reduction for each pollutant source

	TMDL				2	ALA = TMDL total load - (MOS + WLA + loads not reduced)						
	TMDL = Sediment loading rate in ref. * Impaired Acres					1285562.9	1285562.9					
	1453880.2											
3		Annual Avg. Load	Load Sum	Check	Initial Adjust	Recheck Adjust	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction
	CROPLAND	1679803.4	2099085.0	bad	1285562.9		0.8	316165.4	969397.5	1553.1	624.2	42.29%
	HAY/PASTURE	92677.0		good	92677.0	419281.6	0.1	22792.6	69884.5	1271.6	55.0	24.6%
	STREAMBANK	326604.6		good	326604.6		0.2	80323.6	246281.0			24.6%
					1704844.6		1.0		1285562.9			
4	All Ag. Loading Rate	367.93										
	Land Use	Acres	Allowable loading rate	Final LA	Current Loading Rate	Current Load	**Reduction Goal**			CURRENT LOAD	FINAL LOAD ALLOCATION	
5	CROPLAND	1,553	624	969,398	1,082	1,679,803	**42.29%**		HAY/PASTURE	92,677	69,884	
	HAY/PASTURE	1,272	55	69,884	73	92,677	**25%**		STREAMBANK	326,605	246,281	
	STREAMBANK			246,281		326,605	**25%**		CROPLAND	1,679,803	969,398	
	AGGREGATE		ALA	1,285,563		2,099,085	**39%**		AGGREGATE	2,099,085	1,285,563	



	CURRENT LOAD	FINAL LOAD ALLOCATION
CROPLAND	**1,679,803**	**969,398**
STREAMBANK	**326,605**	**246,281**
HAY/PASTURE	**92,677**	**69,884**
AGGREGATE	**2,099,085**	**1,285,563**

Table D1. Equal Marginal Percent Reduction calculations for the Sweitzers Run Subwatershed

Appendix E: Legal Basis for the TMDL and Water Quality Regulations for Agricultural Operations

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 United States Environmental Protection Agency's (EPA) implementing regulations (40 CFR 130) require:

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

Pennsylvania Clean Streams Law Requirements, Agricultural Operations

Pennsylvania farms are required by law to operate within regulatory compliance by implementing the applicable requirements outlined in the Pennsylvania Clean Streams Law, Title 25 Environmental Protection, Part I Department of Environmental Protection, Subpart C Protection of Natural Resources, Article II Water Resources, Chapters: § 91.36 Pollution control and prevention at agricultural operations, § 92a.29 CAFO and § 102.4 Erosion and sediment control requirements. Water quality regulations can be found at following website: http://www.pacode.com/secure/data/025/025toc.html

Agricultural regulations are designed to reduce the amount of sediment and nutrients reaching the streams and ground water in a watershed.

Appendix F: Comment and Response

No public comments were received.