Cove Run Sediment and Phosphorus TMDLs

Fulton County, Pennsylvania

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pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Executive Summary

Total Maximum Daily Loads (TMDLs) for sediment and phosphorus were developed for the Cove Run Watershed (Figure 1) to address the siltation and nutrient impairments noted in the 2020 Final Pennsylvania Integrated Water Quality Monitoring and Assessment Report (Integrated Report), including the Clean Water Act Section 303(d) List. Agriculture and "grazing in riparian areas" were identified as the cause of these impairments. Because Pennsylvania does not have numeric water quality criteria for sediment or phosphorus, 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. Existing annual average sediment loading in the Cove Run Watershed was estimated to be 1,488,866 pounds per year. Phosphorus loading was estimated to be 2,180 pounds per year. To meet water quality objectives, annual average sediment loading should be reduced by 50% to 741,787 pounds per year, and phosphorus loading should be reduced by 30% to 1,516 pounds per year. Allocation among the annual average TMDL variables is summarized in Table 1. To achieve these reductions while maintaining 10% margins of safety and minor allowances for point sources, annual average sediment loading from croplands should be reduced by 62% whereas loading from and hay/pasture lands and streambanks should be reduced by 44% each. Annual average phosphorus loadings from croplands, hay/pasture lands, streambanks and farm animals should be reduced by 41% each.

Table 1. Summary of Annual Average $TMDL_{Avg}$ Variables for the Cove Run Watershed

lbs/yr:						
Pollutant	$TMDL_{Avg}$	MOS_{Avg}	WLA_{Avg}	LA_{Avg}	LNR_{Avg}	ALA_{Avg}
Sediment	741,787	74,179	7,418	660,190	6,933	653,258
Phosphorus	1,516	152	15	1,349	149	1,200

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 Cove Run Watershed was estimated to be 56,257 pounds per day of sediment and 91 pounds per day of phosphorus. To meet water quality objectives, 99th percentile daily sediment loading should be reduced by 49% to 28,564 pounds per day. 99th percentile daily phosphorus loading should be reduced by 31% to 63 pounds per day. Allocation of 99th percentile daily sediment and phosphorus loading among the TMDL variables is summarized in Table 2.

Table 2. Summary of 99th Percentile Daily Loading $TMDL_{Max}$ Variables for the Cove Run Watershed						
lbs/d:						
Pollutant	$TMDL_{Max}$	MOS_{Max}	WLA_{Max}	LA_{Max}	LNR_{Max}	ALA_{Max}
Sediment	28,564	2,856	286	25,422	267	25,155
Phosphorus	63	6	1	56	6	50

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 99^{th} percentile for daily loading.

Introduction

Cove Run is a tributary of the Little Tonoloway Creek, with the confluence less than a half mile north of the village of Warfordsburg in Fulton County. This Total Maximum Daily Loads (TMDLs) document has been prepared to address the siltation and nutrient impairments noted per the 2020 Final Integrated Report (see Appendix A for a description of assessment methodology). The watershed contained approximately 9.1 stream miles, all of which were designated for Trout Stocking (Table 3). All stream segments within the watershed were listed as impaired for siltation, whereas only the lower mainstem was listed as impaired for nutrients (Figures 1). Agriculture in general, or in some cases the more specific category of grazing in riparian areas, were listed as the causes of the impairments.

The removal of natural vegetation and disturbance of soils 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. Soil erosion, along with animal waste and fertilizer use, may lead to excessive phosphorus loading in streams and in turn eutrophication, which may lower dissolved oxygen concentrations, increase pH, change community composition, and degrade aesthetic value.

While Pennsylvania does not have numeric water quality criteria for sediment or phosphorus, 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));*
>
> *and,*
>
> *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 phosphorus that may contribute to eutrophication, as well as all significant sources of sediment and solids that may settle to form deposits, and all NPDES permitted point sources of these pollutants.

According to an analysis of NLCD 2016 landcover data, land use in this watershed is estimated to be 55% agriculture, 40% forest/naturally vegetated lands, and 5% mixed development. The majority of the agricultural lands were pasture/hay (32% or total land cover), though croplands also comprised a substantial portion (23%) of land area within the watershed as well (Appendix B, Table B1). There were no NPDES permitted point source discharges in the watershed with numeric limits relevant to sedimentation or nutrients (Table 4).

Table 3. Impaired Stream Segments in the Cove Run Watershed per the 2020 Final Pennsylvania Integrated Report

HUC 8: 02070004 – Conococheague				
Source	EPA 305(b) Cause Code	Miles	Designated Use	Use Designation
Grazing in Riparian or Shoreline Zones	Nutrients	3.1	TSF-Trout Stocking	Aquatic Life
Grazing in Riparian or Shoreline Zones	Siltation	3.1	TSF-Trout Stocking	Aquatic Life
Agriculture	Siltation	6.1	TSF-Trout Stocking	Aquatic Life

HUC= Hydrologic Unit Code; TSF=Trout Stocking; All stream segments were designated for Migratory Fish (MF) as well.
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.

Cove Run Watershed

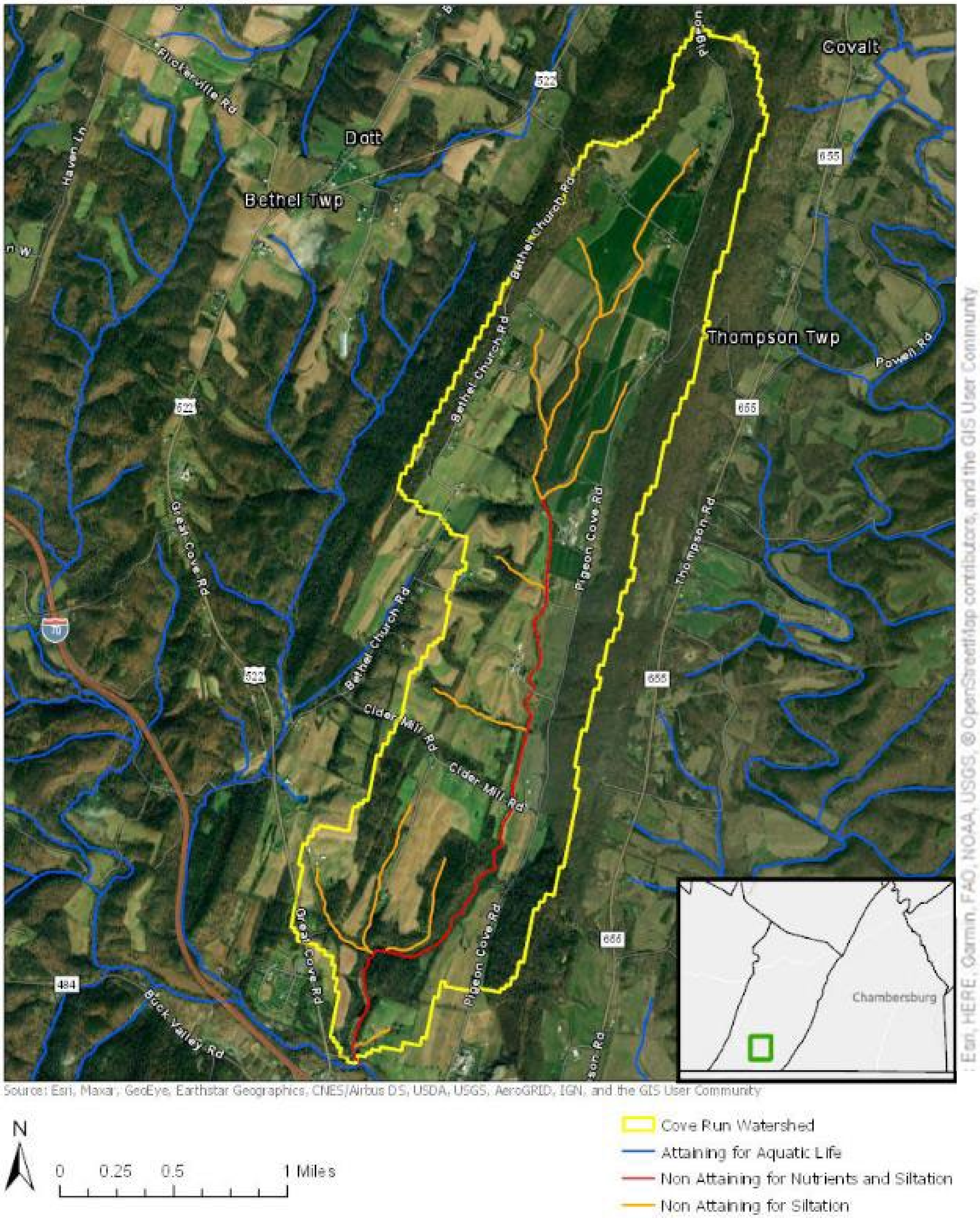

Figure 1. Cove Run Watershed, Fulton County. Stream segments are shown as either attaining or non-attaining for aquatic life use per the 2020 Final Pennsylvania Integrated Report (see PA DEP's 2020 Integrated Report Viewer available at: https://www.depgis.state.pa.us/IRViewer2020/).

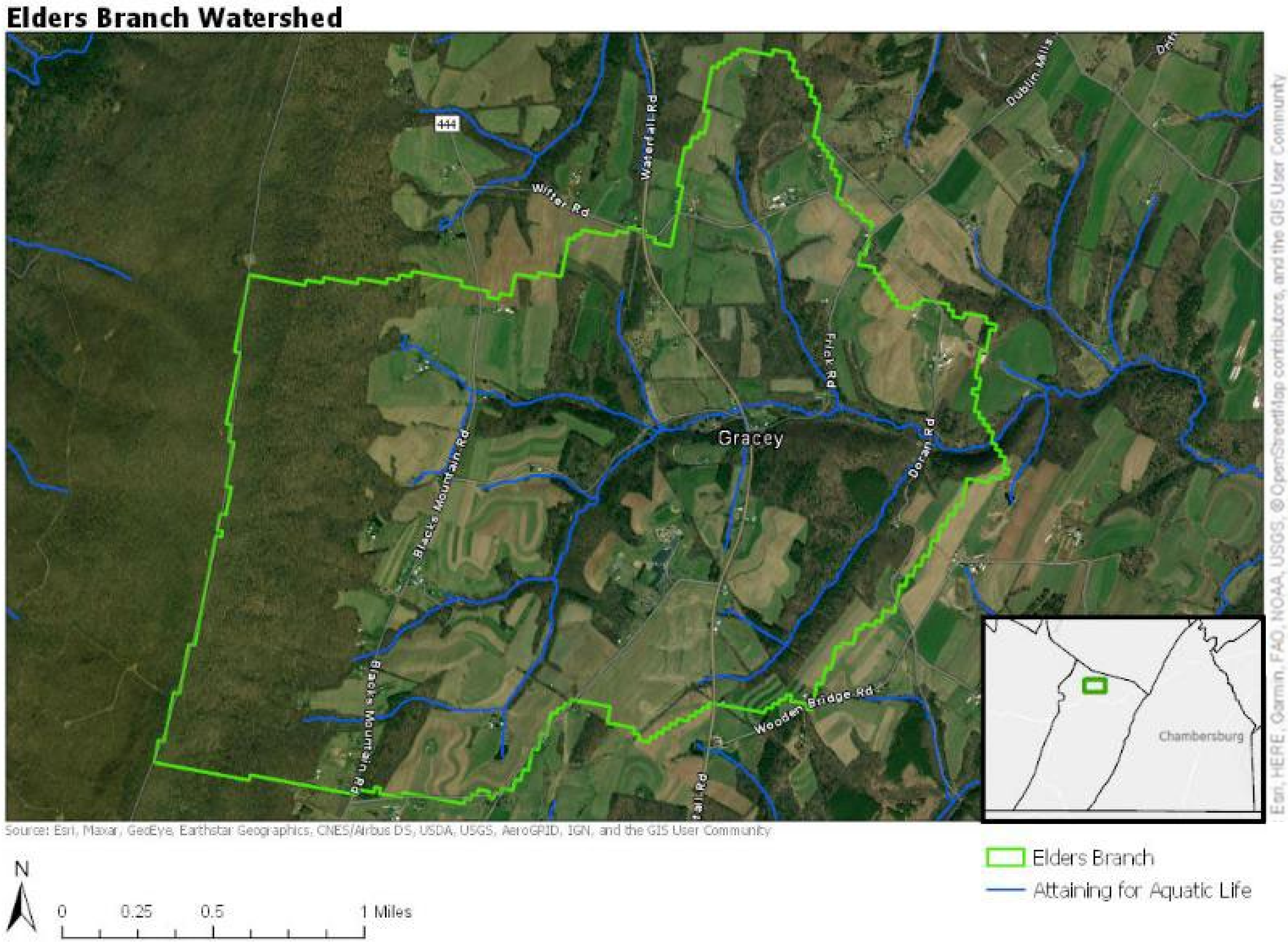

Figure 2. Elders Branch Subwatershed, Fulton County. All stream segments were listed as attaining for aquatic life use per the 2020 Final Pennsylvania Integrated Report (see PA DEP's 2020 Integrated Report Viewer available at: https://www.depgis.state.pa.us/IRViewer2020/).

Table 4. Existing NPDES Permitted Discharges in the Cove Run Watershed and their Potential Contribution to Sediment and Phosphorus Loading.					
		Sediment Load		Phosphorus Load	
Permit No.	Facility Name	mean lb/yr	max lb/d	mean lb/yr	max lb/d
None	NA	NA	NA	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

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 or phosphorus, the "Reference Watershed Approach" was used. This method estimates loading rates in both the impaired watershed as well as a similar watershed that is not listed as impaired. 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 unimpaired 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 and nutrient loading rates and accumulation. Thus, selection of a reference watershed with similar natural characteristics as the impaired watershed is crucial. Failure to use an appropriate reference watershed could result in problems such as the setting of reduction goals that are unattainable, or nonsensical TMDL calculations that suggest that loadings in the impaired watershed should be increased.

To determine the suitability of the reference site, the Department's Integrated Report GIS-based website, or GIS data layers consistent the Integrated Report, was used to search for nearby watersheds that were of similar size as the Cove Run Watershed but lacked stream segments listed as impaired for sediment or nutrients.

Considering that it was nearby, only about 18 miles to the northeast, within the same section of the same physiographic province, and had similar topographic characteristics as the Cove Run Watershed, the Elders Branch Watershed, also in Fulton County was explored for use as a reference. Since it is required that the reference watershed be +/-30% of the impaired watershed's area, a delineation point was chosen upstream of the mouth to yield a subwatershed of the Elders Branch so that it was of similar size as the study watershed (Figure 2).

To confirm the suitability of the reference site, Model My Watershed, DEP's internal GIS databases, and various other GIS based applications and layers were used to compare factors such as land cover/use, geology, soil drainage and slope (Table 5). Both watersheds were visited to explore conditions, and it was ultimately concluded that the Elders Branch was a suitable reference.

Table 5. Comparison of the Impaired (Cove Run) and Reference (Elders Branch) Subwatersheds

	Cove Run	Elders Branch
Phys. Province[1]	Appalachian Mountain Section of the Ridge and Valley Physiographic Province	Appalachian Mountain Section of the Ridge and Valley Physiographic Province
Land Area[2], ac	2,381	2,613
Land Use Distribution[2]	55% Agriculture 40% Forest/Natural Vegetation 5% Developed	45% Agriculture 50% Forest/Natural Vegetation 5% Developed
Soil Infiltration[3]	8% Group A 28% Group B 0.03% Group B/D 52% Group C 0% Group C/D 13% Group D	4% Group A 42% Group B 2% Group B/D 22% Group C 0% Group C/D 30% Group D
Bedrock type by dominant lithology[4]	58% Calcareous Shale 42% Limestone	97% Sandstone 3% Argillaceous Sandstone
Average Annual Precipitation[5], inches	40.4	40.4

Average Annual Surface Runoff[5], inches	2.6	3.0
Average Elevation[5], feet	725	1,149
Average % Slope[5]	15.1	13.7
Average Stream Channel Slope[5]	1st Order: 1.1%	1st Order: 2.1% 2nd Order: 0.9%

[1]Per PA_Physio_Sections GIS layer provided by Pennsylvania Bureau of Topographic and Geological Survey, Dept. of Conservation and Natural Resources
[2]Per NLCD 2016
[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

Based on an analysis of NLCD 2016 landcover data, land cover/use distributions in these two watersheds were similar in that approximately half of the land area in both watersheds was devoted to agriculture, though the amount of agriculture was modestly greater in the Cove Run Watershed (55% versus 45% of total land area). The discrepancy in the amount of agriculture was driven primarily by a lesser amount of croplands in the reference watershed (14% versus 23% of total landcover, Appendix B, Tables B1 and B2). The remainder of landcover in both lands was primarily forest/naturally vegetated lands, and developed lands were a minor contributor to the landcover in both watersheds (see Table 5).

One concerning difference however was that the Cove Run Watershed had large amounts of limestone bedrock whereas the Elders Branch Subwatershed did not (Table 5), as karst features may strongly influence hydrology. However, this concern was dismissed because even though limestone was present, no karst features (such as sinkholes) were mapped per a GIS layer provided by the Bureau of Topographic and Geologic Survey (PaGS), Department of Conservation and Natural Resources. Furthermore, site inspection suggested that Cove Run did not exhibit strong karst characteristics. And, as reported by Model My Watershed, soil drainage classifications and modeled hydrologic characteristics of both watersheds were similar (Table 5).

Another potentially concerning difference between the Cove Run Watershed and the Elders Branch Subwatershed was that the Elders Branch Subwatersed appears to be attaining a high-quality cold-water fishes designation whereas the Cove Run Watershed was not designated for special protection. Use of a watershed that is actually attaining a special protection status (high quality of exceptional value) as a reference for a non-special special protection watershed could cause prescribed pollution reductions to be unnecessarily stringent. However, this concern was dismissed because other non-special protection potential reference watersheds were identified that had lower estimated sediment and nutrient loading than the Elders Branch Subwatershed.

Whereas the Cove Run Watershed had no existing NPDES permitted point sources with numeric limits relevant to sediment or phosphorus, there was one such point source in the Elders Branch Subwatershed (Table 6). However, an analysis of electronic discharge monitoring report data indicated it was a relatively minor source of these pollutants.

Table 6. Existing NPDES Permitted Discharges in the Elders Branch Subwatershed and their Potential Contribution to Sediment and Phosphorus Loading.

		Sediment Load		Phosphorus Load	
Permit No.	Facility Name	mean lb/yr	max lb/d	mean lb/yr	max lb/d
PA0083020	Forbes Road High School and Elementary WWTP	63	5	22	1.4

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.

The average annual values reported above for the Forbes Road School wastewater treatment plant were based on an analysis of electronic discharge monitoring report data from one full year (2019). Monthly reported flows in MGD along with monthly reported average total suspended solids concentrations were used to calculate an average daily load for each month. This value was multiplied by the number of days in the month and then all months were summed to generate an average annual value. The average annual phosphorus load was calculated similarly, except that a single reported average annual phosphorus concentration of 2.26 mg/L was used. Reported daily maximum flows for each month from June 2018 through July 2020 along with an assumed P concentration of 8 mg/L and the instantaneous maximum total suspended solids concentration limit of 30 mg/L per their permit were used to generate the maximum daily loads. The highest of those values was reported above. Note that where there were "‹" symbols, the number value without the symbol was used.

After selecting the potential reference, the two watersheds were visited during January of 2021 to confirm the suitability of the reference as well as to explore whether there were any obvious land use differences that may help to explain why one watershed was impaired for sediment and nutrients while the other was attaining. The fine sediment impairment was obvious in the Cove Run Watershed. In the few places where stream segments readily accessible, the substrate appeared to be blanketed with fines (Figure 3). Algal blooms or other indicators of eutrophication were not apparent however, perhaps due to the winter visit. Observations of agricultural practices and land uses within the watershed were consistent with an expectation of impairment. While the margins of the watershed typically had naturally vegetated landcover, the central valley area was dominated by intensive agriculture and expansive forested riparian buffers were lacking in most cases (Figure 4). On top of this, croplands were observed on steep slopes (Figure 5) and pasture areas along streams and drainageways were sometimes so heavily used that they were bare (Figure 5). It should also be noted however that some good practices were observed as well, including: areas with forested cover, some stream segments/drainageways having forested or herbaceous buffers, and use of cover crops during the winter (Figure 6).

In contrast, stream conditions within the attaining Elders Branch reference subwatershed appeared to be far better. Stream segments were typically rocky with fairly minor fine sediment deposition. In cases were fine sediment deposition was substantial, it appeared to be relatively localized (Figure 7). Obvious symptoms of eutrophication were not observed.

Like the Cove Run Watershed, uplands within the Elders Branch Subwatershed were typically forested whereas valley areas were dominated by hilly agriculture (Figure 8). However, unlike the Cove Run Watershed, expansive forested riparian buffers were common (Figure 9). In addition, drainageway protection was observed in some (Figure 9), though not all (Figure 10) cases. While some problematic pasture lands were observed in the Elders Branch Subwatershed, the highly problematic areas appeared to be far less common and typically less severe (Figure 10). These factors, in addition to the fact that there were less overall croplands in the Elders Branch Subwatershed, may help explain why the Elders Branch was comparatively healthy relative to the Cove Run Watershed.

Figure 3. Evidence of siltation impairments in the Cove Run Watershed. High rates of fine sediment deposition were obvious in both a tributary (A) and mainstem (B-D) sites within the watershed.

Figure 4. Example landscapes within the Cove Run Watershed. The watershed existed as a narrow valley with rolling farmlands bracketed by forested uplands. Agricultural landcover was heavy in the valley area and stream segments often lacked expansive riparian buffers.

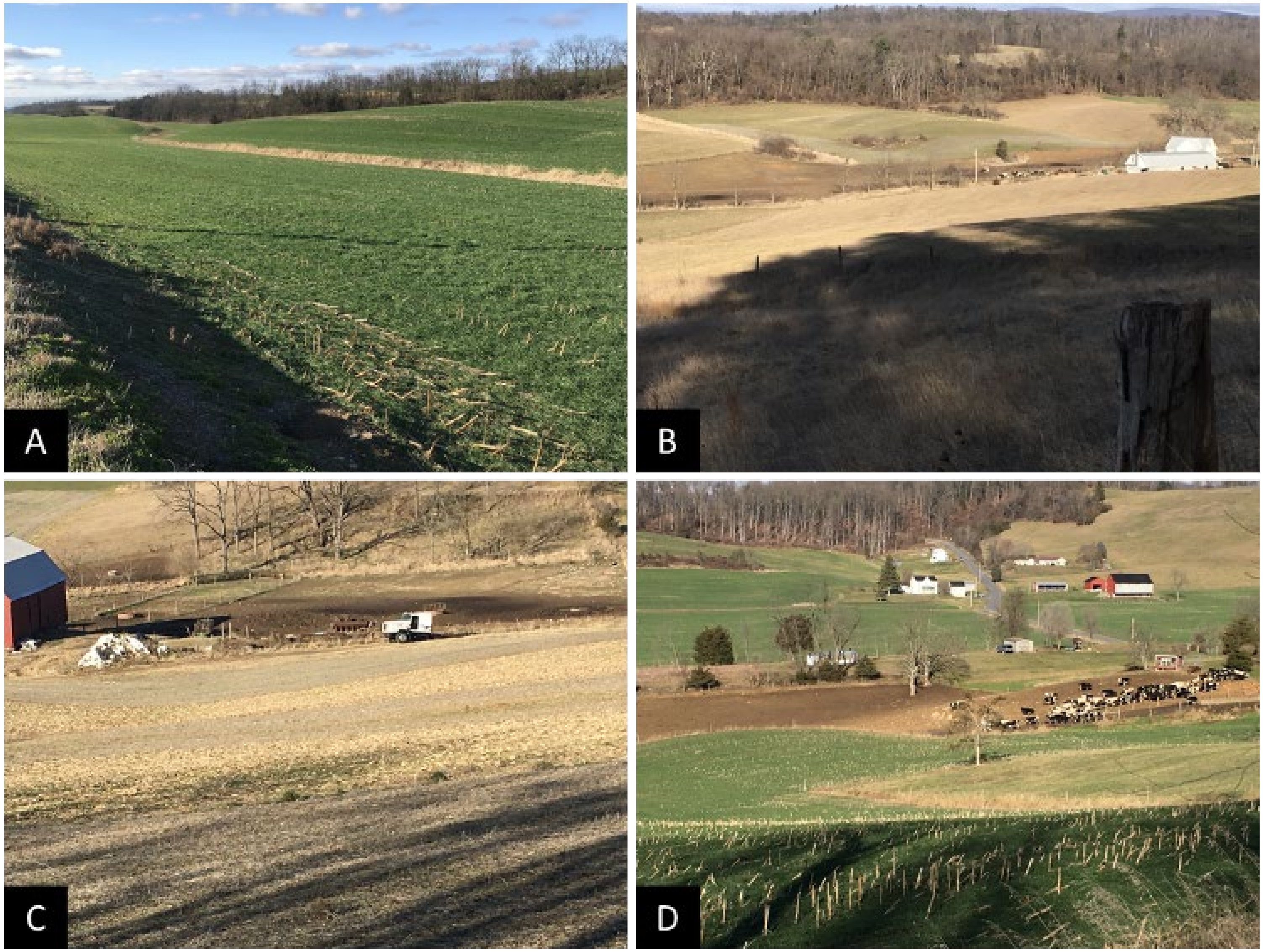

Figure 5. Agricultural practices in the Cove Run Watershed that may exacerbate sediment loading. Note the lack of expansive riparian buffers along the cropland drainageway shown in A. Figures B through D show intensive agriculture along steep slopes and bare pasture lands near stream segments or drainageways. Also note the lack of forested riparian buffers.

Figure 6. Agricultural practices in the Cove Run Watershed that may be protective against sedimentation. Photograph A shows forested area in the uplands, and forested riparian buffers were present in some cases (B). Photographs C and D show the use of cover crops and D also shows herbaceous buffers along a drainageway.

Figure 7. Substrate conditions within the Elders Branch reference subwatershed. Mainstem and tributary substrate was typically primarily rocky, as in A through C, though some apparently localized anthropogenic fines deposition could be observed as well (D).

Figure 8. Landscapes within the Elders Branch Subwatershed. Like the Cove Run Watershed, the watershed had forested uplands and a valley dominated by rolling hills with agriculture.

Figure 9. Practices within the Elders Branch Subwatershed that may be protective against sedimentation. Photographs A and B show stream segments with expansive forested buffers. Photographs C and D show areas where livestock have been fenced out of the drainageways/stream segments thus allowing for the growth of herbaceous and forested buffers.

Figure 10. Practices within the Elders Branch Subwatershed that may exacerbate pollutant loading. Sections of drainageways and low order tributaries sometimes flowed through pastures and hay lands without adequate riparian buffers. However, with an occasional exception, as in D, heavy use pastures tended to be less problematic relative to those observed in the Cove Run Watershed.

Hydrologic / Water Quality Modeling

This section deals primarily with the $TMDL_{Avg}$ calculations, 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 28-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 was 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 watershed's 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 (2021).

Model My Watershed allows the user to adjust model parameters, such as the area of land coverage types, the use of and efficiency of conservation practices, the watershed's sediment delivery ratio, etc. Default values were used for the modelling run, with the exception that landcover types were adjusted to reflect newer NLCD 2016 landcover data, and the flow associated with the wastewater treatment plant shown in Table 6 (12.05 m^3/d) were added as an input. To update land area, a raster dataset of NLCD 2016 landcover was opened in ArcGISPro and clipped to the shapefile of each subwatershed to determine the proportion of non-open water pixels accounted for by each landcover class. These proportions were then multiplied by the total area reported in Model My Watershed's landcover adjustment feature to readjust the inputs. Presumably due to rounding, the exact landcover area needed by the program for the Cove Run Watershed added up to 0.1 hectares more than the value calculated using the raster proportions. Thus, the input value for "wooded areas" was increased by a negligible 0.1 hectares to get the exact number needed by the program.

A correction for the presence of existing riparian buffers was made in 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. 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 40% in the impaired watershed versus 69% in the reference watershed (Figures 11 and 12).

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 reference watershed over the amount found in the impaired watershed, the approximate length of NHD flowlines within the reference watershed was multiplied by the difference in the proportion of buffering between 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 and phosphorus loading the spreadsheet tool assumes that loadings equivalent to loading from 2 acres of croplands are treated per acre of buffer. Thus, twice the acreage of buffer was multiplied by the sediment or phosphorus loading rate calculated for croplands and then by a reduction coefficient of 0.54 for sediment and 0.40 for phosphorus. 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.

Cove Run Watershed

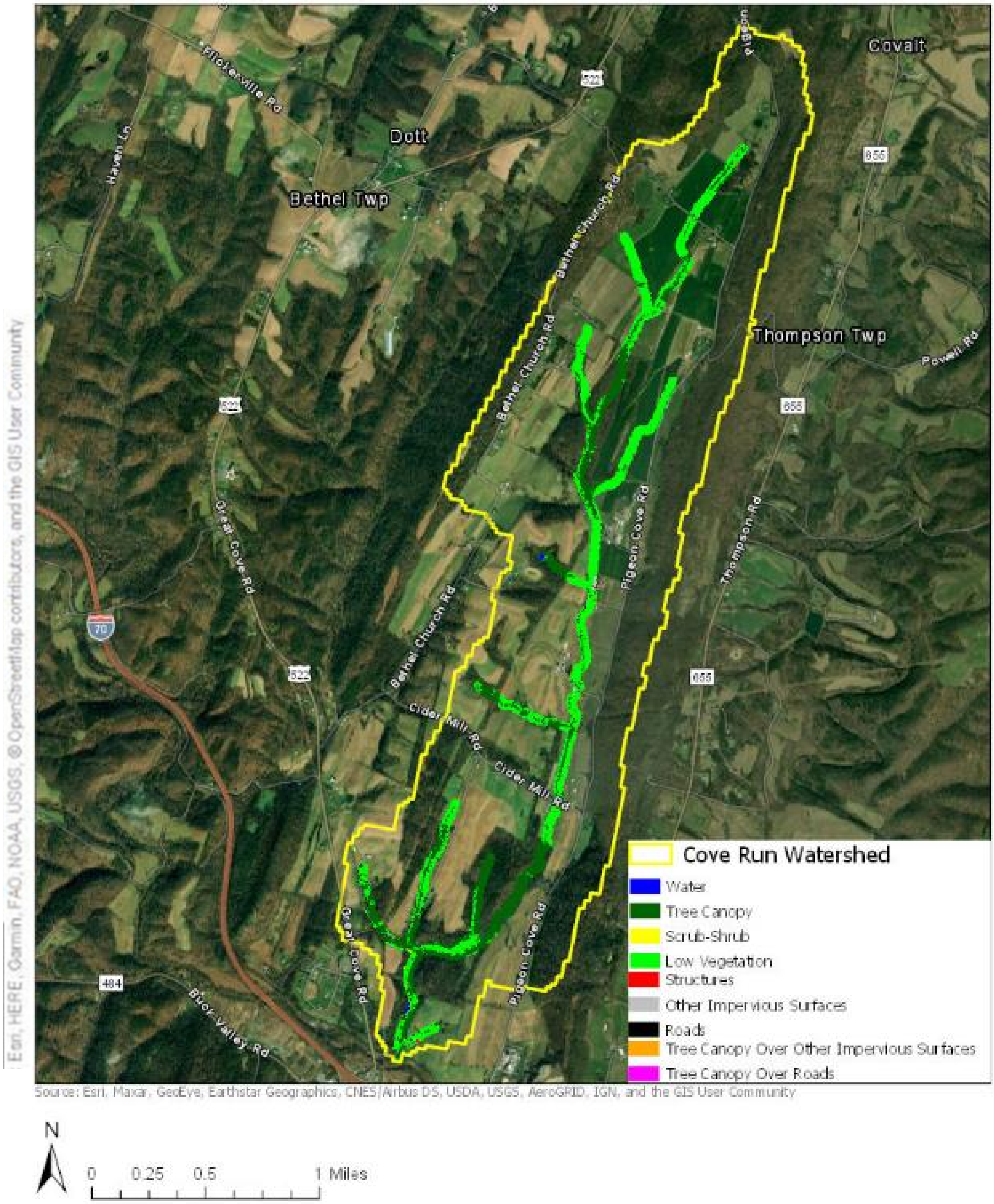

Figure 11. Riparian areas in the Cove Run Watershed**.** A raster dataset of high-resolution land cover (University of Vermont Spatial Analysis Lab 2016) is shown within 100 feet (geodesic) of either side of NHD flowlines. The rate of riparian buffering was estimated to be about 40%.

Elders Branch Subwatershed

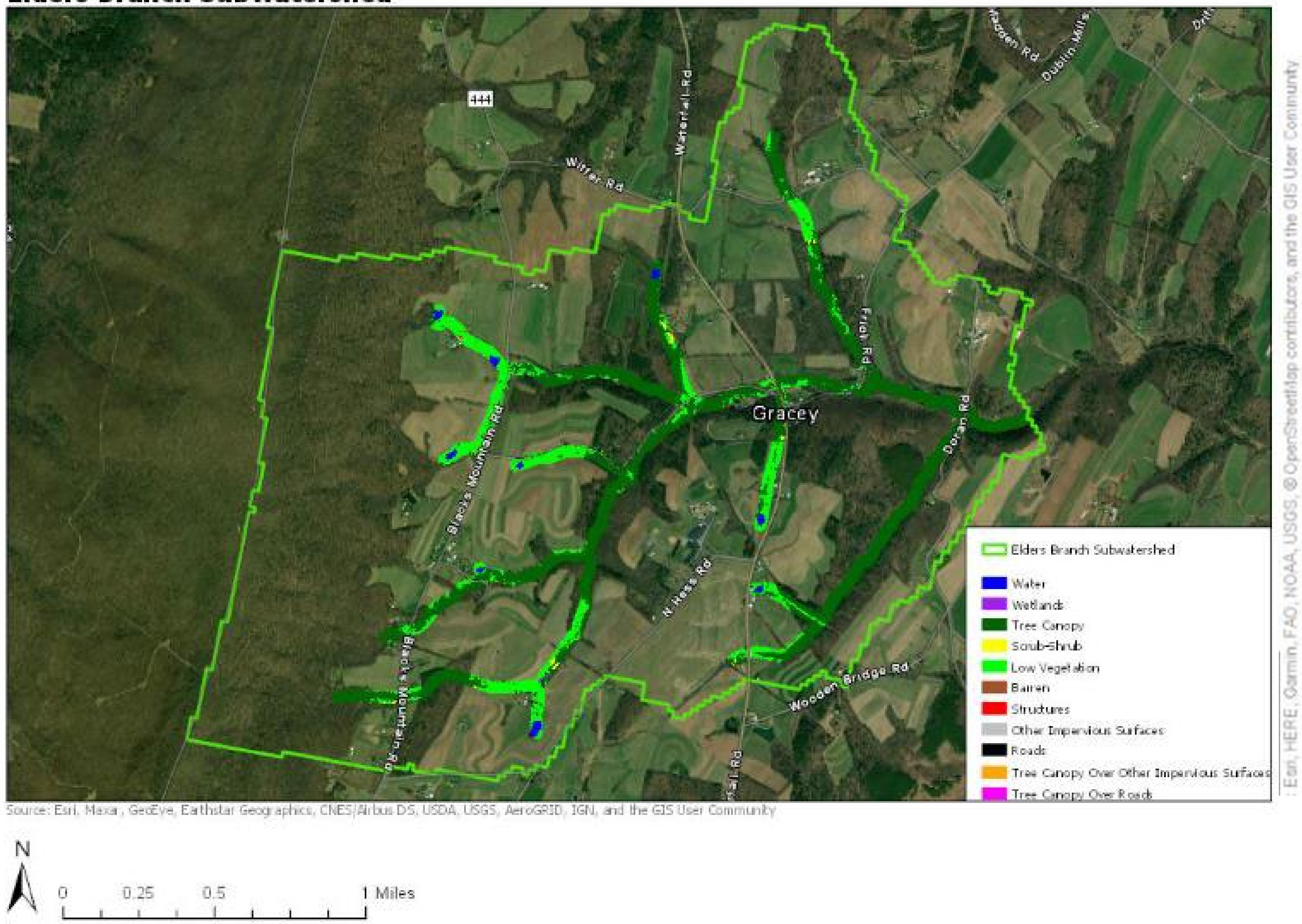

Figure 12. Riparian areas within the Elders Branch Subwatershed. A raster dataset of high-resolution land cover (University of Vermont Spatial Analysis Lab 2016) is shown within 100 feet (geodesic) of either side of NHD flowlines. The rate of riparian buffering was estimated to be approximately 69%.

Calculation of the TMDL

The mean annual loading rates for the unimpaired reference subwatershed (Elders Branch) were estimated to be 311 pounds per acre per year of sediment and 0.64 pounds per acre per year of phosphorus (Table 7). These were substantially lower than the estimated mean annual loading rates in the impaired Cove Run Watershed (625 pounds per acre per year of sediment and 0.92 pounds per acre per year of phosphorus, Table 8). To achieve the loading rates of the unimpaired watershed, loadings in the Cove Run Watershed should be reduced to 741,787 pounds per year of sediment and 1,516 pounds per year of phosphorus, or less (Table 9).

Table 7. Existing Annual Average Loading Values for the Elders Branch Subwatershed, Reference

Source	Area, ac	Sediment, lbs/yr	Sediment, lb/ac/yr	P lbs/yr	P lbs/ac/yr
Hay/Pasture	791	355,368	449	501	0.63
Cropland	376	474,823	1,264	573	1.53
Forest and Shrub/Scrub	1,296	9,960	8	17	0.013
Herbaceous/Grassland	8	0	0	0	0
Low Intensity Mixed Development	140	1,584	11	4	0.03
Medium Intensity Mixed Development	2	62	40	0	0
Streambank[1]		59,151		13	
Farm Animals				445	
Groundwater				166	
Point Sources		63		22	
Extra Buffer Discount[2]		-87,243		-78	
total	2,613	813,774	311	1,663	0.64

[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 Cove Run Watershed, Impaired

Source	Area, ac	Sediment, lbs/yr	Sediment, lb/ac/yr	P lbs/yr	P lbs/ac/yr
Hay/Pasture	762	453,508	595	564	0.74

Cropland	550	970,917	1,765	1,051	1.91
Forest and Shrub/Scrub	953	5,754	6	8	0.009
Low Intensity Mixed Development	116	1,178	10	3	0.025
Streambank[1]		57,509		13	
Farm Animals				403	
Groundwater				138	
Point Sources		0		0.0	
total	2,381	1,488,866	625	2,180	0.92

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

Table 9. Calculation of Annual Average TMDL Values for the Cove Run Watershed.

Pollutant	Mean Loading Rate in Reference, lbs/ac/yr	Total Land Area in Impaired Watershed, ac	Target $TMDL_{Avg}$ Value, lbs/yr
Sediment	311	2,381	741,787
Phosphorus	0.636	2,381	1,516

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 allocations, the margins of safety and wasteload allocations 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} for each TMDL was explicitly designated as ten-percent of the $TMDL_{Avg}$ based on professional judgment. Thus:

Sediment: 741,787 lbs/yr $TMDL_{Avg}$ * 0.1 = 74,179 lbs/yr MOS_{Avg}

Phosphorus: 1,516 lbs/yr $TMDL_{Avg}$ * 0.1= 152 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 in the impaired subwatershed with numeric limits for sediment or phosphorus (Table 4).

Thus the wasteload allocations consisted solely of a 1% bulk reserve, which was a minor allowance for insignificant dischargers and future point sources.

Therefore:

Sediment: 741,787 lbs/yr TMDL * 0.01 = 7,418 lbs/yr bulk reserve + 0 lbs/yr permitted loads = 7,418 lbs/yr WLA

Phosphorus: 1,516 lbs/yr TMDL*0.01 = 15 lbs/yr bulk reserve + 0 lbs/yr permitted loads = 15 lbs/yr WLA

Load Allocation

Now that the margins of safety and wasteload allocations have been defined, the load allocations (LA) are calculated as:

Sediment: 741,787 lbs/yr $TMDL_{Avg}$ – (74,179 lbs/yr MOS_{Avg} + 7,418 lbs/yr WLA_{Avg}) = 660,190 lbs/yr LA_{Avg}

Phosphorus: 1,516 lbs/yr $TMDL_{Avg}$ – (152 lbs/yr MOS_{Avg} + 15 lbs/yr WLA_{Avg}) = 1,349 lbs/yr LA_{Avg}

Loads Not Reduced and Adjusted Load Allocation

Since the impairments addressed by this TMDL were due to agriculture, sediment and phosphorus contributions from forests, developed lands and groundwater (for phosphorus) within the Cove Run Watershed were considered loads not reduced (LNR). LNR_{Avg} were calculated to be 6,933 lbs/yr for sediment and 149 lbs/yr for phosphorus (Table 10).

The LNRs were subtracted from the LAs to determine the ALAs:

Sediment: 660,190 lbs/yr LA_{Avg} – 6,933 lbs/yr LNR_{Avg} = 653,258 lbs/yr ALA_{Avg}

Phosphorus: 1,349 lbs/yr LA_{Avg} – 149 lbs/yr LNR_{Avg} = 1,200 lbs/yr ALA_{Avg}

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

	Sediment lbs/yr	Phosphorus lbs/yr
Load Allocation (LA_{Avg})	**660,190**	**1,349**
Loads Not Reduced (LNR_{Avg}):	**6,933**	**149**
Forest	5,754	8
Low Intensity Mixed Development	1,178	3
Groundwater		138
Adjusted Load Allocation (ALA_{Avg})	**653,258**	**1,200**

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

Calculation of Load Reductions

To calculate load reductions by source, the ALAs were further analyzed using the Equal Marginal Percent Reduction (EMPR) allocation method described in Appendix D. Although the Cove Run Watershed TMDLs were developed to address impairments caused by agricultural activities, streambanks were also significant contributors to the sediment and phosphorus loadings 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 analysis, croplands received a reduction goal of 62% whereas hay/pasture lands and streambanks received sediment reductions goals of 44% (Table 11). For phosphorus, croplands, hay/pasture lands, streambanks and farm animals each received reductions of 41% (Table 12).

Table 11. Annual Average Sediment Load Allocations for Source Sectors in the Cove Run Watershed				
		Load Allocation	Current Load	Reduction Goal
Land Use	Acres	lbs/yr	lbs/yr	
CROPLAND	550	366,533	970,917	62%
HAY/PASTURE	762	254,457	453,508	44%
STREAMBANK		32,267	57,509	44%
AGGREGATE		653,258	1,481,934	56%

Table 12. Annual Average Phosphorus Load Allocations for Source Sectors in the Elders Branch Subwatershed				
		Load Allocation	Current Load	Reduction Goal
Land Use	Acres	lbs/yr	lbs/yr	
CROPLAND	376	621	1,051	41%
HAY/PASTURE	791	333	564	41%
STREAMBANK		8	13	41%
FARM ANIMALS		238	403	41%
AGGREGATE		1,200	2,031	41%

Calculation of Daily Maximum “$TMDL_{Max}$” Values

When choosing the best timescale for expressing pollutant loading limits for siltation and phosphorus, several factors must be considered:

1) Sediment and nonpoint-source phosphorus 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.
3) Nonpoint-source phosphorus pollution typically harms aquatic communities through eutrophication degradation as a result of chronically excessive loading.

Considering then that siltation and nonpoint-source phosphorus 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, truer “Total Maximum Daily Loads” ($TMDL_{Max}$) are 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 $TMDL_{Max}$ values, modelling was initially conducted in Model My Watershed, and the "Export GMS" feature was used to provide input data files that were run in MapShed. The daily output was opened in Microsoft Excel (Version 2002), and current maximum daily loads were calculated as the 99th percentiles (using the percentile.exc function) of estimated daily sediment and phosphorus loads in both the Cove Run (impaired) and Elders Branch (reference) watersheds. The first years of data were excluded to account for the time it takes for the model calculations to become reliable. 99th percentiles were chosen because 1) sediment and phosphorus loading increases with the size of storm events, so, as long as there could be an even larger flood, true upper limits to 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 rates for land area + streambanks for the reference watershed by the same reduction percentages calculated for the average loading rates. After correcting for buffers, relevant point source loads from Tables 4 and 6 were added in.

Then, similarly to the $TMDL_{Avg}$ values reported in Table 9, $TMDL_{Max}$ values were calculated as the 99th percentile daily loads of the reference watershed, divided by the acres of the reference watershed, and then multiplied by the acres of the impaired watershed. The $TMDL_{Max}$ loading rate for sediment was calculated as 28,564 pounds per day (Table 13), which would be a 49% reduction from the Cove Run Watershed's current 99th percentile daily loading rate of 56,257 pounds per day. For phosphorus, the $TMDL_{Max}$ loading rate was calculated as 63 pounds per day (Table 13), which would be a 31% reduction from Cove Run Watershed's current 99th percentile daily loading rate of 91 pounds per day.

Table 13. Calculation of $TMDL_{Max}$ Values for the Cove Run Watershed

Pollutant	99th Percentile Loading Rate in Reference, lbs/ac/d	Total Land Area in Impaired Watershed, ac	Target $TMDL_{Max}$ Value, lbs/d
Sediment	12.0	2,381	28,564
Phosphorus	0.026	2,381	63

Also, in accordance with the previous "Calculation of Load Allocations" section, the $WLAs_{Max}$ would consist of a bulk reserves defined as 1% of the $TMDLs_{Max}$. The $MOSs_{Max}$ would be 10% of the $TMDLs_{Max}$. The LAs_{Max} would then be calculated as the amount remaining after subtracting the $WLAs_{Max}$ and the $MOSs_{Max}$ from the $TMDLs_{Max}$. See Table 14 for a summary of these $TMDL_{Max}$ variables.

Table 14. 99th Percentile of Daily Loading TMDL ($TMDL_{Max}$) Variables for the Cove Run Watershed				
lbs/d:				
Pollutant	$TMDL_{Max}$	MOS_{Max}	WLA_{Max}	LA_{Max}
Sediment	28,564	2,856	286	25,422
Phosphorus	63	6	1	56

The modelling program 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 5% of LA_{Avg} it was assumed that it was also 5% 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 Tables 15 and 16 for a summary of these LA_{Max} variables.

Table 15. Allocation of the 99th Percentile Daily Sediment Load Allocation (LA_{Max}) for the Cove Run Watershed.			
	Annual Average (lbs/yr)	Proportion of Load Allocation	Max Daily (lbs/d)
Load Allocation	660,190		25,422
Loads Not Reduced	6,933	0.011	267
Adjusted Loads Allocation	653,258	0.99	25,155
Croplands	366,533	0.56	14,114
Hay/Pasturelands	254,457	0.39	9,798
Streambanks	32,267	0.05	1,243

Because the modelling program 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 5% of LA_{Avg} it was assumed that it was also 5% of LA_{Max}.

Table 16. Allocation of the 99th Percentile Daily Phosphorus Load Allocation (LA_{Max}) for the Cove Run Watershed.			
	Annual Average (lbs/yr)	Proportion of Load Allocation	Max Daily (lbs/d)
Load Allocation	1,349		56
Loads Not Reduced	149	0.11	6
Adjusted Loads Allocation	1,200	0.89	50

Croplands	621	0.46	26
Hay/Pasturelands	333	0.25	14
Streambanks	8	0.01	0
Farm Animals	238	0.18	10

Because the modelling program 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 1% of LA_{Avg} it was assumed that it was also 1% of LA_{Max}.

Because both sediment and phosphorus loading vary so greatly with discharge, the $TMDL_{Max}$ values 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 and nutrient loading (see-Sloto and Olson 2011, Sloto et al. 2012), it is cautioned that reliance solely on a $TMDL_{Max}$ values may not be protective because chronic excessive inputs occurring at lower discharge levels may be ignored. Take for instance an extreme scenario where the $TMDL_{Max}$ value for sediment was met every day but never exceeded. In this case, annual sediment loading in the Cove Run Watershed would skyrocket to 10,425,913 lbs/yr, which is approximately seven-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 Cove Run Watershed. 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

According to Model My Watershed's technical documentation (see Stroud Water Research Center 2019), Model My Watershed uses a "continuous simulation model that uses daily time steps for weather data and water balance. Monthly calculations are made for sediment and nutrient loads based on the daily water balance accumulated to monthly values." The source of the weather data (precipitation and temperature) was a dataset compiled by USEPA ranging from 1963-1990. Therefore, variable flow conditions and seasonal changes are inherently accounted for in the loading calculations. Furthermore, this document calculates both annual average and 99^{th} 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.

Summary and Recommendations

This document proposes a 50% reduction in annual average sediment loading and 30% reduction in annual average phosphorus loading for the Cove Run Subwatershed. To achieve these goals while maintaining margins of safety and minor allowances for point sources, it is proposed to reduce sediment loading from croplands by 62% and hay/pasture lands and streambanks by 44% each. Annual average phosphorus loading from croplands, hay/pasture lands, streambanks and farm animals should be reduced by 41% each. In addition, 99^{th} percentile daily sediment and phosphorus loading should be reduced by 49% and 31%, respectively.

Reductions in stream sediment and nutrient loading due to agricultural activities can be made through the implementation of required Erosion and Sediment Control and Nutrient Management Plans (Pennsylvania Clean Streams Law, Title 25 Environmental Protection, Chapter 102.4) and through the use of BMPs such as conservation tillage, cover crops, vegetated filter strips, rotational grazing, livestock exclusion fencing, riparian buffers, legacy sediment removal etc. Based on site observations, cattle exclusion fencing along stream segments and drainageways in concert with the establishment of forested riparian buffers appeared to be especially necessary in this watershed.

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 new BMPs needed to achieve the prescribed sediment and phosphorus reductions. Key personnel from the regional DEP office, the County Conservation District, 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 February 27, 2021 issue of the Pennsylvania Bulletin to foster public comment. A 30-day period was provided for the submittal of comments. No comments were received.

Citations

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Appendix A: Background on Stream Assessment Methodology

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

Note that the following contains generalizations about DEP's most commonly used aquatic life assessment methods, but doesn't seek to describe all of the current and historic variations of such methodology. For more information, see DEP's 2018 Assessment Methodology for Rivers and Stream, available at https://files.dep.state.pa.us/Water/Drinking%20Water%20and%20Facility%20Regulation/WaterQualityPortalFiles/Methodology/2015%20Methodology/Assessment_Book.pdf

Documentation of other historic methodologies are available upon request.

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 sought to select 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 then 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) were completed, the biologist determined the status of the stream segment. The decision was based on the performance of the segment using a series of biological metrics. If the stream segment was classified as impaired, it was then 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 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

NLCD Code	Description	ha	%
21	Developed, Open Space	43.6	5
22	Developed, Low Intensity	3.5	0
41	Deciduous Forest	206.4	21
42	Evergreen Forest	5.3	1
43	Mixed Forest	173.7	18
52	Shrub/Scrub	0.5	0
81	Hay/Pasture	308.6	32
82	Cultivated Crops	222.8	23
	Total	*964.50*	

Table B1. NLCD 2016 Inputs for "Model My Watershed" in the Cove Run Watershed. Open water pixels were excluded from the analysis. When entered into Model My Watershed, "wooded areas" (deciduous forest + evergreen forest + mixed forest + shrub/scrub) were increased by a negligible 0.1 ha to create the exact total needed by the program.

NLCD Code	Description	ha	%
21	Developed, Open Space	42.7	4
22	Developed, Low Intensity	14.1	1
23	Developed, Medium Intensity	0.6	0
41	Deciduous Forest	395.0	37
42	Evergreen Forest	19.1	2
43	Mixed Forest	106.4	10
52	Shrub/Scrub	4.5	0
71	Herbaceous	3.2	0
81	Hay/Pasture	320.5	30
82	Cultivated Crops	152.1	14
	Total	*1058.1*	

Table B2. NLCD 2016 Inputs for "Model My Watershed" in the Elders Branch Subwatershed. Open water pixels were excluded from the analysis.

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	4.79	0.91	3.88	0	0.51	6.99
Feb	5.84	0.87	4.97	0	0.77	7.05
Mar	6.27	0.42	5.85	0	2.37	8.11
Apr	5.16	0.08	5.08	0	5.49	7.97
May	3.36	0.29	3.07	0	10.26	10.69
Jun	2.49	0.99	1.5	0	13.77	9.93
Jul	0.79	0.28	0.5	0	11.71	9
Aug	0.37	0.28	0.09	0	9.02	9.19
Sep	0.88	0.84	0.04	0	5.97	8.94
Oct	1.02	0.63	0.38	0	4	7.94
Nov	1.07	0.42	0.64	0	2.15	8.57
Dec	3.21	0.7	2.51	0	1.01	8.2
Total	35.25	6.71	28.51	0	67.03	102.58

Table B3. "Model My Watershed" Hydrology Outputs for the Cove Run Watershed.

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	5.4	1.07	4.32	0	0.52	6.99
Feb	6.07	1.02	5.05	0	0.79	7.05
Mar	6.28	0.5	5.77	0	2.44	8.11
Apr	5.11	0.09	5.01	0	5.54	7.97
May	3.38	0.34	3.04	0	10.27	10.69
Jun	2.53	1.08	1.45	0	12.96	9.93
Jul	0.8	0.32	0.48	0	10.19	9
Aug	0.41	0.32	0.09	0	8.72	9.19
Sep	1.04	0.96	0.07	0	5.93	8.94
Oct	1.3	0.72	0.58	0	4.02	7.94
Nov	1.5	0.5	0.99	0	2.18	8.57
Dec	4	0.82	3.18	0	1.01	8.2
Total	37.82	7.74	30.03	0	64.57	102.58

Table B4. "Model My Watershed" Hydrology Outputs for the Elders Branch Subwatershed.

Sources	Sediment (kg)	Total P (kg)
Hay/Pasture	205,672.70	255.6
Cropland	440,325.00	476.7
Wooded Areas	2,609.70	3.7
Wetlands	0	0
Open Land	0	0
Barren Areas	0	0
Low-Density Mixed	39.7	0.1
Medium-Density Mixed	0	0
High-Density Mixed	0	0
Low-Density Open Space	494.7	1.2
Farm Animals	0	182.8
Stream Bank Erosion	26,081.00	6
Subsurface Flow	0	62.7
Point Sources	0	0
Septic Systems	0	0

Table B5. Model My Watershed outputs for sediment and phosphorus in the Cove Run Watershed.

Sources	Sediment (kg)	Total P (kg)
Hay/Pasture	161,164.80	227.3
Cropland	215,339.40	259.8
Wooded Areas	4,516.90	7.8
Wetlands	0	0
Open Land	0	0
Barren Areas	0	0
Low-Density Mixed	178.3	0.5
Medium-Density Mixed	28.2	0
High-Density Mixed	0	0
Low-Density Open Space	540	1.4
Farm Animals	0	201.6
Stream Bank Erosion	26,828.00	6
Subsurface Flow	0	75.1
Point Sources	0	0
Septic Systems	0	0

Table B6. Model My Watershed outputs for sediment and phosphorus in the Elders Branch Subwatershed.

Appendix C: Stream Segments in the Cove Run Watershed with Aquatic Life Impairments

NHD Flowline COMID:	Stream Name:	Length (miles):	Impairment Source:	Impairment Cause:
49477882	Cove Run	0.47	GRAZING IN RIPARIAN OR SHORELINE ZONES	SILTATION
49477882	Cove Run	0.47	GRAZING IN RIPARIAN OR SHORELINE ZONES	NUTRIENTS
49487748	Unnamed Tributary to Cove Run	0.46	AGRICULTURE	SILTATION
49487980	Unnamed Tributary to Cove Run	0.03	AGRICULTURE	SILTATION
49477880	Cove Run	0.05	GRAZING IN RIPARIAN OR SHORELINE ZONES	NUTRIENTS
49487606	Unnamed Tributary to Cove Run	0.02	AGRICULTURE	SILTATION
49487608	Unnamed Tributary to Cove Run	0.25	AGRICULTURE	SILTATION
49477874	Cove Run	0.41	GRAZING IN RIPARIAN OR SHORELINE ZONES	NUTRIENTS
49477884	Cove Run	0.07	GRAZING IN RIPARIAN OR SHORELINE ZONES	SILTATION
49487864	Unnamed Tributary to Cove Run	0.69	AGRICULTURE	SILTATION
49477878	Cove Run	1.36	GRAZING IN RIPARIAN OR SHORELINE ZONES	NUTRIENTS
49477876	Cove Run	0.70	GRAZING IN RIPARIAN OR SHORELINE ZONES	NUTRIENTS
49477880	Cove Run	0.05	GRAZING IN RIPARIAN OR SHORELINE ZONES	SILTATION
49488064	Unnamed Tributary to Cove Run	0.01	AGRICULTURE	SILTATION
49487900	Unnamed Tributary to Cove Run	0.57	AGRICULTURE	SILTATION
49477876	Cove Run	0.70	GRAZING IN RIPARIAN OR SHORELINE ZONES	SILTATION
49487452	Unnamed Tributary to Cove Run	0.68	AGRICULTURE	SILTATION
49487390	Unnamed Tributary to Cove Run	0.48	AGRICULTURE	SILTATION
49488066	Unnamed Tributary to Cove Run	0.18	AGRICULTURE	SILTATION
49477878	Cove Run	1.36	GRAZING IN RIPARIAN OR SHORELINE ZONES	SILTATION
49477870	Cove Run	0.58	AGRICULTURE	SILTATION
49487296	Unnamed Tributary to Cove Run	0.37	AGRICULTURE	SILTATION
49477868	Cove Run	0.92	AGRICULTURE	SILTATION
49477884	Cove Run	0.07	GRAZING IN RIPARIAN OR SHORELINE ZONES	NUTRIENTS
49487910	Unnamed Tributary to Cove Run	0.47	AGRICULTURE	SILTATION
49477872	Cove Run	0.33	AGRICULTURE	SILTATION
49477874	Cove Run	0.41	GRAZING IN RIPARIAN OR SHORELINE ZONES	SILTATION

Table C1. Stream segments with aquatic life impairments in the Cove Run Watershed.

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

	Current Load, lbs/yr	Any > ALA?	If > ALA, reduce to ALA	How much does sum exceed ALA?	Proportions of total after initial adjust	Assign reductions still needed per proportions after intial adjust	ALA: subtract reductions still needed from initial adjust	proportion Reduction
Cropland	970,917	yes	653,258		0.56	286,724	366,533	0.62
Hay/Pasture	453,508	no	453,508	511,017	0.39	199,051	254,457	0.44
Streambank	57,509	no	57,509		0.05	25,241	32,267	0.44
sum	**1,481,934**		**1,164,275**		**1.00**	**511,017**	**653,258**	**0.56**

Table D1. Sediment Equal Marginal Percent Reduction calculations for the Cove Run Watershed.

	Non-MS4 Sewershed Current Load, lbs/yr	Any > ALA?	If > ALA, reduce to ALA	How much does sum exceed ALA?	Proportions of total after initial adjust	Assign reductions still needed per proportions after intial adjust	ALA: subtract reductions still needed from initial adjust	proportion Reduction
Cropland	1,051	no	1,051		0.52	430	621	0.41
Hay/Pasture	564	no	564	831	0.28	231	333	0.41
Streambank	13	no	13		0.01	5	8	0.41
Farm Animals	403	no	403		0.20	165	238	0.41
sum	**2,031**		**2,031**		**1.00**	**831**	**1,200**	**0.41**

Table D2. Phosphorus Equal Marginal Percent Reduction calculations for the Cove Run Watershed.

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

This section is reserved for public comments and their responses. No public comments were received.