



**BUREAU OF CLEAN WATER  
DRY RUN SEDIMENT TMDL  
NORTHUMBERLAND COUNTY  
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## **EXECUTIVE SUMMARY**

“Total Maximum Daily Loads” (TMDLs) for sediment were developed for the Dry Run watershed (Figure 1) to address the siltation impairments noted in the 2022 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 source 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<sub>Avg</sub>) which would be protective under most conditions, as well as a 99<sup>th</sup> percentile daily value (TMDL<sub>Max</sub>) which would be relevant to extreme flow events. Current annual average sediment loading in the Dry Run watershed was estimated to be 3,477,950 pounds per year. To meet water quality objectives, annual average sediment loading should be reduced by 55% to 1,554,451 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 65%, while loading from hay/pasture lands and streambanks should each be reduced by 23% each.

**Table 1.** Summary of annual average TMDL (TMDL<sub>Avg</sub>) variables for the Dry Run watershed. All values are in lbs/yr.

<b>Pollutant</b>	<b>TMDL<sub>Avg</sub></b>	<b>MOS<sub>Avg</sub></b>	<b>WLA<sub>Avg</sub></b>	<b>LA<sub>Avg</sub></b>	<b>LNR<sub>Avg</sub></b>	<b>ALA<sub>Avg</sub></b>
Sediment	1,554,451	155,445	15,545	1,383,462	9,643	1,373,818

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 99<sup>th</sup> percentile daily loading in the Dry Run watershed was estimated to be 155,847 pounds per day. To meet water quality objectives, 99<sup>th</sup> percentile daily sediment loading should be reduced by 52% to 75,157 pounds per day. Allocation of 99<sup>th</sup> percentile daily sediment loading among the TMDL variables is summarized in Table 2.

**Table 2.** Summary of 99<sup>th</sup> percentile daily loading TMDL (TMDL<sub>Max</sub>) variables for the Dry Run watershed. All values are in lbs/d.

<b>Pollutant</b>	<b>TMDL<sub>Max</sub></b>	<b>MOS<sub>Max</sub></b>	<b>WLA<sub>Max</sub></b>	<b>LA<sub>Max</sub></b>	<b>LNR<sub>Max</sub></b>	<b>ALA<sub>Max</sub></b>
Sediment	75,157	7,516	752	66,890	466	66,424

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<sup>th</sup> percentile for daily loading.

## **INTRODUCTION**

The study watershed, Dry Run, occurred in an agricultural valley area in northern Northumberland County, just north of the Borough of Watsonstown (Figure 1). This Total Maximum Daily Load (TMDL) document has been prepared to address the siltation from agriculture impairments listed for all stream segments within the watershed per the Pennsylvania Department of Environmental Protection's (DEP) 2022 Integrated Report (see Appendix A for a description of assessment methodology). The Dry Run watershed was approximately 3.8 square miles and contained approximately 6 miles of USGS high-resolution NHD flowlines, all of which were designated Warm Water Fishes, Migratory Fishes at 25 Pa. Code § 93.

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 § 93.6 (a))*

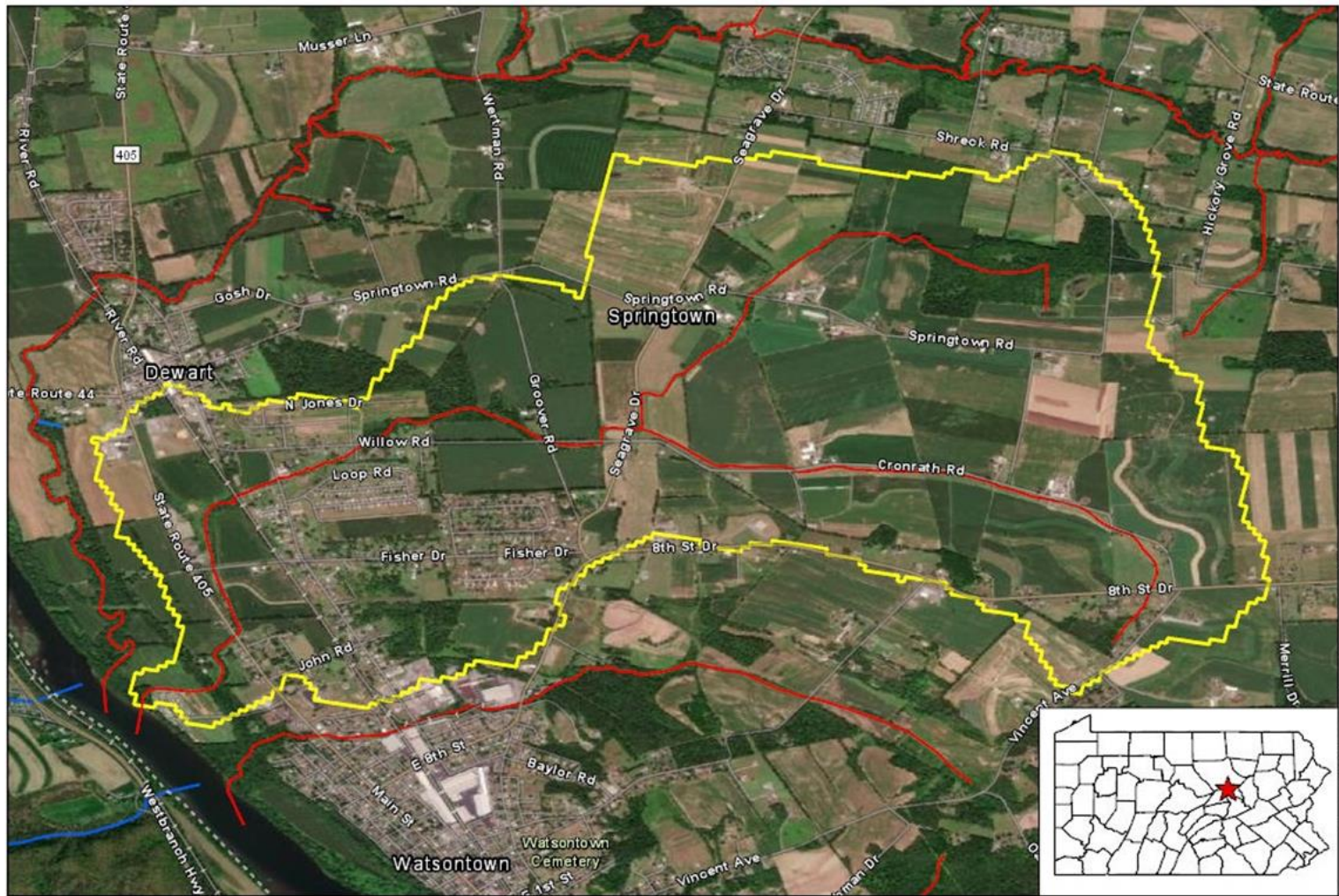
*In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances which produce color, tastes, odors, turbidity or settle to form deposits. (25 Pa. Code, § 93.6 (b)).*

While agriculture has been identified as the source of the impairments (Table 3), this TMDL document is applicable to all significant sources of solids that may settle to form deposits.

According to an analysis of National Land Cover Database (NLCD) 2019 land cover data, as reported by Model My Watershed, the study watershed was estimated to be 75% agriculture, 6% forest/naturally vegetated lands, and 20% mixed development. Of the agricultural lands, the amount of croplands exceeded the amount of hay/pasture lands by more than three times (Appendix B, Table B1). Given the intensity of agriculture within the watershed, siltation impairments would be expected. There were no current National Pollutant Discharge Elimination System (NPDES) permitted point source discharges in the watershed with significant load limits relevant to sedimentation (Table 4).

**Table 3.** Aquatic Life Use impaired stream segments in the Dry Run watershed per the 2022 Final Pennsylvania Integrated report (DEP 2022b). See Appendix A for more information on the listing process.

<b>Source</b>	<b>USEPA 305(b) Cause Code</b>	<b>Miles</b>
Agriculture	Siltation	6.0



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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- ▭ Dry Run Watershed
- ▭ Non Attaining for Aquatic Life
- ▭ Attaining for Aquatic Life

**Figure 1.** Dry run watershed. The Aquatic Life Use impairments within the watershed were attributed to siltation from agriculture (DEP 2022b).

**Table 4.** Existing NPDES-permitted discharges in the Dry Run watershed and their potential contribution to sediment loading. Given their transient nature, stormwater construction permits were not included.

Permit No.	Facility Name	Permit Based Limits		DMR Based Loading	
		Load, mean (lbs/yr)	Load, max (lbs/d)	Load, mean (lbs/yr)	Load, max (lbs/d)
None	NA	NA	NA	NA	NA

Permits within the delineated watershed were based on eMapPA (DEP 2022a) and Watershed Resources Registry (USEPA 2022).

**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 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. United States Environmental Protection Agency (USEPA) 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 rate in the unimpaired watershed is 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 reference watershed will result in the amelioration of the siltation impairments.

**SELECTION OF THE REFERENCE WATERSHED**

In addition to anthropogenic influences, there are many other natural factors affecting sediment loading and accumulation rates in a watershed. 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 sediment reduction goals that are unattainable, or nonsensical TMDL calculations that suggest that sediment loading in the impaired watershed should be increased.

To find a reference, GIS data layers consistent with the Integrated Report were used to search for nearby watersheds that were of similar size as the Dry Run watershed, 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 watershed with regard to factors such as landscape position, topography, hydrology, soil drainage types, land covers etc. Furthermore, benthic

macroinvertebrate and physical habitat assessment scores were reviewed to confirm that a reference was acceptable. Preliminary modelling was conducted to make sure that use of a particular reference would result in a reasonable pollution reduction.

A major consideration for finding a reference for the Dry Run watershed was its very low topographic relief. In fact, the mean slope of the watershed was only 2.9%. Stream segments also tended to be fairly low gradient (Table 5). Since such characteristics have major effects on sediment loading and export, a similarly low gradient reference was sought. However, no appropriate local references were found, as similar streams in the area either also tended to be impaired or there was insufficient evidence that they were supporting their Aquatic Life Use. Thus, the search was expanded to other low relief areas of the state with high amounts of agriculture. About twenty-five potential references were closely examined for use as a reference.

The School Creek watershed in Lehigh County (Figure 2) had a fairly low average topographic relief and high amounts of agriculture, yet there was substantial evidence that it was supporting its Aquatic Life Use. Thus, it was considered 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 School Creek that was of similar size as the study watershed (Figure 2). Table 5 compares key attributes of these two watersheds. Both watersheds were within the Ridge and Valley Physiographic Province, though Dry Run was in the "Susquehanna Lowland" section whereas School Creek was in the "Great Valley" section. While both watersheds were dominated by agricultural land uses, the amount was greater in the Dry Run watershed versus the School Creek subwatershed (75 versus 59% of land area). Both watersheds had moderate amounts of developed lands (around 20%), while the amount of forested/naturally vegetated lands was greater in the School Creek subwatershed (21 versus 6%). The two watersheds had a similar distribution of soil drainage classes dominated by moderate infiltration (Group B) soils.

While both watersheds had a large amount of shale bedrock, a notable difference between the two was the presence of a significant amount of limestone in the Dry Run watershed. This was concerning in that limestone geology may lead to the formation of karst features that greatly influence watershed hydrology. However, the Dry Run watershed's limestone was of the Keyser Tonoloway formation which does not have a strong tendency to form karst features. In fact, no sinkholes or surface depressions were mapped in this area per a GIS layer provided by the Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey (PaGS). According to Model My Watershed, both watersheds were estimated to have similar surface runoff rates (Table 5).

A concerning difference between the reference and impaired watershed however was that the Dry Run watershed had both lower topographic relief as well as lower average stream channel slopes. Lower gradient stream channels may be more vulnerable to sediment deposition, as their flows may have less power to flush fine sediment from the streambed. Thus, it is possible that a tolerable sediment loading rate in the School Creek subwatershed might be problematic in the Dry Run watershed. Even so, no obviously better reference was identified after extensive searching.

**Table 5.** Comparison of the Dry Run and School Creek watersheds.

	<b>Dry Run</b>	<b>School Creek</b>
Phys. Province <sup>1</sup>	Susquehanna Lowland Section of the Ridge and Valley Physiographic Province	Great Valley Section of the Ridge and Valley Physiographic Province
Land Area <sup>2</sup> , ac	2,466	2,538
Land Cover <sup>2</sup>	75% Agriculture 6% Forest/Natural Vegetation 20% Developed	59% Agriculture 21% Forest/Natural Vegetation 20% Developed
Soil Infiltration <sup>3</sup>	4% Group A 66% Group B 1% Group B/D 15% Group C 10% Group C/D 4% Group D	13% Group A 64% Group B 7% Group B/D 9% Group C 0% Group C/D 8% Group D
Dominant Bedrock <sup>4</sup>	56% Calcareous Shale 31% Limestone 13% Shale	56% Graywacke 44% Shale
Average Precipitation <sup>5</sup> , in/yr	41.5	39.9
Average Surface Runoff <sup>5</sup> , in/yr	3.4	2.6
Average Elevation <sup>5</sup> , ft	538	697
Average Slope <sup>5</sup>	2.9%	6.9%
Average Stream Channel Slope (High Resolution NHD) <sup>5</sup>	1 <sup>st</sup> order: 0.66% 2 <sup>nd</sup> order: 0.44%	1 <sup>st</sup> order: 2.57% 2 <sup>nd</sup> order: 1.40% 3 <sup>rd</sup> order: 0.66%

<sup>1</sup>Per PA\_Physio\_Sections GIS layer provided by Pennsylvania Bureau of Topographic and Geological Survey, Dept. of Conservation and Natural Resources

<sup>2</sup>MMW output based on NLCD 2019

<sup>3</sup>As reported by Model My Watershed's analysis of USDA gSSURGO 2016. A = high infiltration soils; B=moderate infiltration soils, C= slow infiltration soils and D= very slow infiltration soils. See technical documentation for more details.

<sup>4</sup>Per bedrock geology (V) GIS layer provided by Pennsylvania Bureau of Topographic and Geological Survey, Department of Conservation and Natural Resources

<sup>5</sup>As reported by Model My Watershed

Whereas stream segments within the Dry Run watershed were designated Warm Water Fishes, Migratory Fishes, stream segments within the School Creek subwatershed were designated Cold Water Fishes, Migratory Fishes at 25 Pa. Code § 93. Neither watershed had stream segments with

special protection designations (High Quality or Exceptional Value). As was the case for the Dry Run watershed, no NPDES-permitted point source discharges were identified within the School Creek subwatershed (Table 6).

While the School Creek subwatershed appeared to be similar to the Dry Run watershed, it is not an exact match, and this creates uncertainty in the TMDL calculations. However: 1) preliminary modelling suggests that its use will result in reasonable prescribed pollution reductions that are in accordance with the high amount of agriculture in the watershed, 2) the study will use a 10% margin of safety factor that may help ensure that the prescribed reductions are protective, and 3) these TMDLs can be updated in the future should implementation reveal that the prescribed reductions were inadequate.

**Table 6.** Existing NPDES-permitted discharges in the School Creek subwatershed and their potential contribution to sediment loading. Given their transient nature, stormwater construction permits were not included.

Permit No.	Facility Name	Permit Based Limits		DMR Based Loading	
		Load, mean (lbs/yr)	Load, max (lbs/d)	Load, mean (lbs/yr)	Load, max (lbs/d)
None	NA	NA	NA	NA	NA

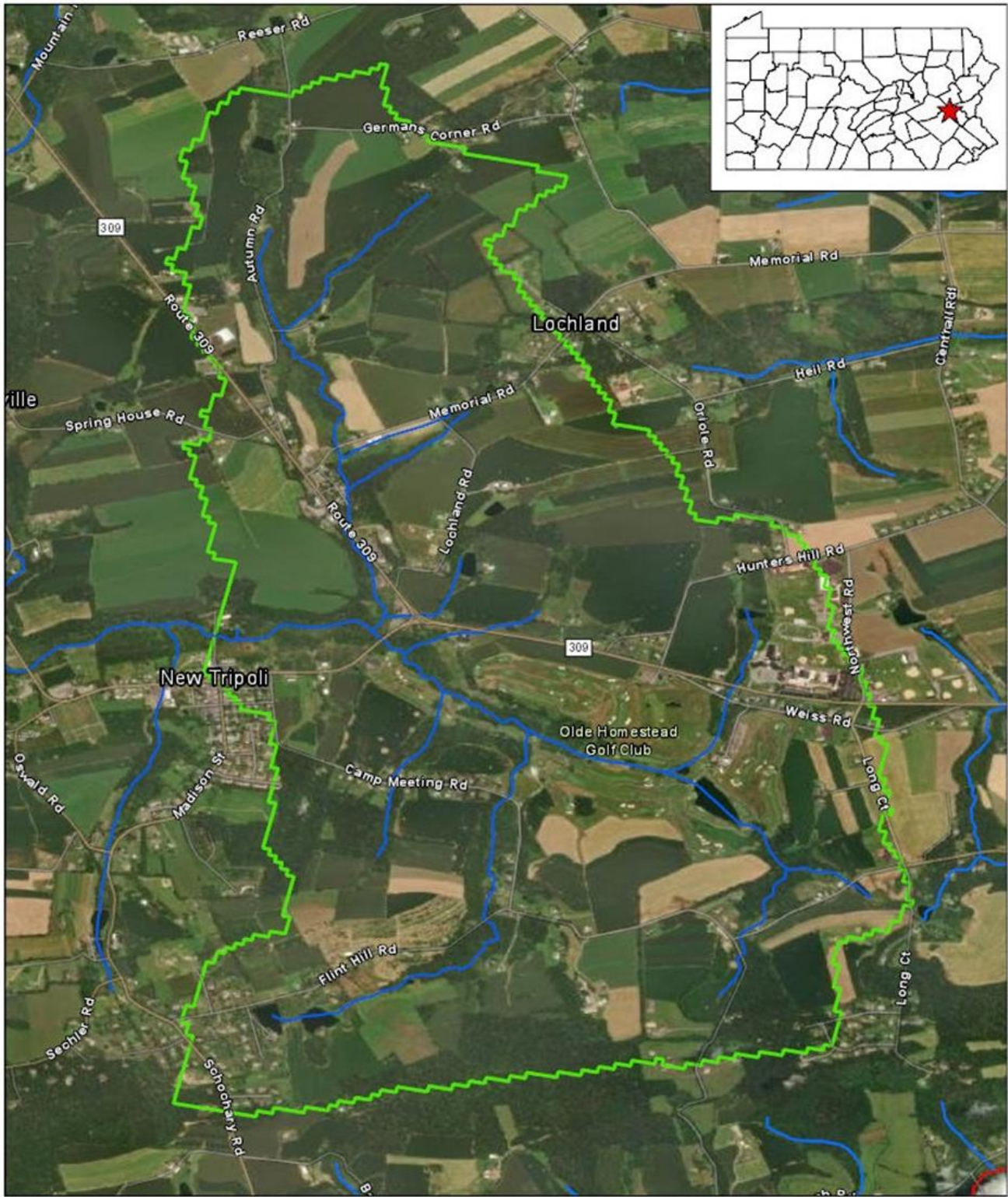
Permits within the delineated watershed were based on eMapPA (DEP 2022a) and Watershed Resources Registry (USEPA 2022).

After selecting the potential reference, the two watersheds were visited during late summer of 2021 to confirm the suitability of the reference as well as to explore whether there were any obvious land cover differences that may help explain why one watershed was impaired for sediment while the other was not.

Observations of stream conditions within the Dry Run watershed were consistent with siltation impairments. Stream segments often exhibited substantial fine sediment deposition, and in some cases, obvious turbidity (Figure 3). Figure 4 illustrates typical landscapes within the watershed. Note the dominance of low-relief agricultural fields. It was difficult to evaluate the implementation of some agricultural BMPs such as the use of conservation tillage or cover crops due to crop growth during the summer visit. However, it was obvious that stream health within the Dry Run watershed would benefit greatly from the implementation of expansive forested riparian buffers, and in some cases the fencing of livestock from stream channels/drainageways (Figure 5). While riparian buffers were observed at some sites (Figure 6), use of this practice could be greatly improved.

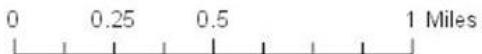
In contrast, streambed conditions appeared to be far better in the School Creek reference subwatershed (Figure 7). Rather than being blanketed with fine sediment, the lower mainstem of the School Creek subwatershed tended to be a more diverse mixture of gravels and cobbles, though with fines deposits in the slackwater areas. Smaller tributary reaches also tended to be primarily rocky, though with some apparently localized fine sediment deposition in some cases (Figure 8). However, this apparently did not result in widespread impairments.

While there was also a large amount of agricultural landcover within the School Creek subwatershed (Figure 9), it had greater forested and wetlands area, especially along stream segments (Figure 10). Still, there were areas within the School Creek subwatershed where conditions clearly could have been improved. Figure 11 shows examples of sites that may benefit from greater riparian buffering and streambank stabilization.



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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- ▭ School Creek Subwatershed
- Non Attaining for Aquatic Life
- Attaining for Aquatic Life

**Figure 2.** School Creek subwatershed. All stream segments within the delineated subwatershed were listed as supporting their Aquatic Life Use per the 2022 Integrated Report (DEP 2022b).



**Figure 3.** Substrate and turbidity conditions within stream segments of the Dry Run watershed. Note the substantial fine sediment deposition observed at these sites and obvious turbidity in A. Also note the prolific macrophyte growth in B. While the stream segment in photograph D was primarily rocky, there appeared to be a thin layer of siltation.



**Figure 4.** Landscapes within the Dry Run watershed. Note the low relief topography and high agricultural landcover.



**Figure 5.** Conditions that may promote fine sediment pollution in the Dry Run watershed. In addition to the very high amount of total agriculture, water quality could be improved via practices such as the allowance for expansive forested riparian buffers (A-D) and the fencing of livestock out of streams/drainageways (D).



**Figure 6.** Conditions that may be protective of water quality in the Dry Run watershed. In some cases, forested, wetland, or herbaceous buffers were observed to be in use.



**Figure 7.** Stream substrate and turbidity conditions within the lower School Creek subwatershed. In many cases the water was clear and stream segments were primarily rocky, though some significant fines deposition was apparent in some areas (see D).



**Figure 8.** Stream substrate and turbidity conditions within the smaller segments of the School Creek subwatershed. Such stream segments were often primarily rocky, though some substantial deposition was observed in some cases (for instance, B and D).



**Figure 9.** Typical landscapes within the School Creek subwatershed. Uplands were often dominated by agriculture while streamside areas often had expansive forested buffers.



**Figure 10.** Conditions that may be protective of water quality in the School Creek subwatershed. Stream segments tended to be exceptionally well buffered in this watershed.



**Figure 11.** Factors that may promote siltation pollution within the School Creek subwatershed. In addition to the overall high amount of agriculture (A), there were areas where buffering could be improved, such as in B and C. Photograph D shows an area of substantial bank erosion.

## **HYDROLOGIC / WATER QUALITY MODELING**

This section deals primarily with the  $TMDL_{Avg}$  calculation, as use of annual average values was determined to be the most relevant way to express the “TMDL” variables. For information about the  $TMDL_{Max}$  calculations, 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-Version 1.34.1, though watershed delineations were made with a prior version), which is part of the WikiWatershed web toolkit developed through an initiative of the Stroud Water Research Center (Stroud Water Research Center 2023). 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 (<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 MMW’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 landuse/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 landuse/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.*

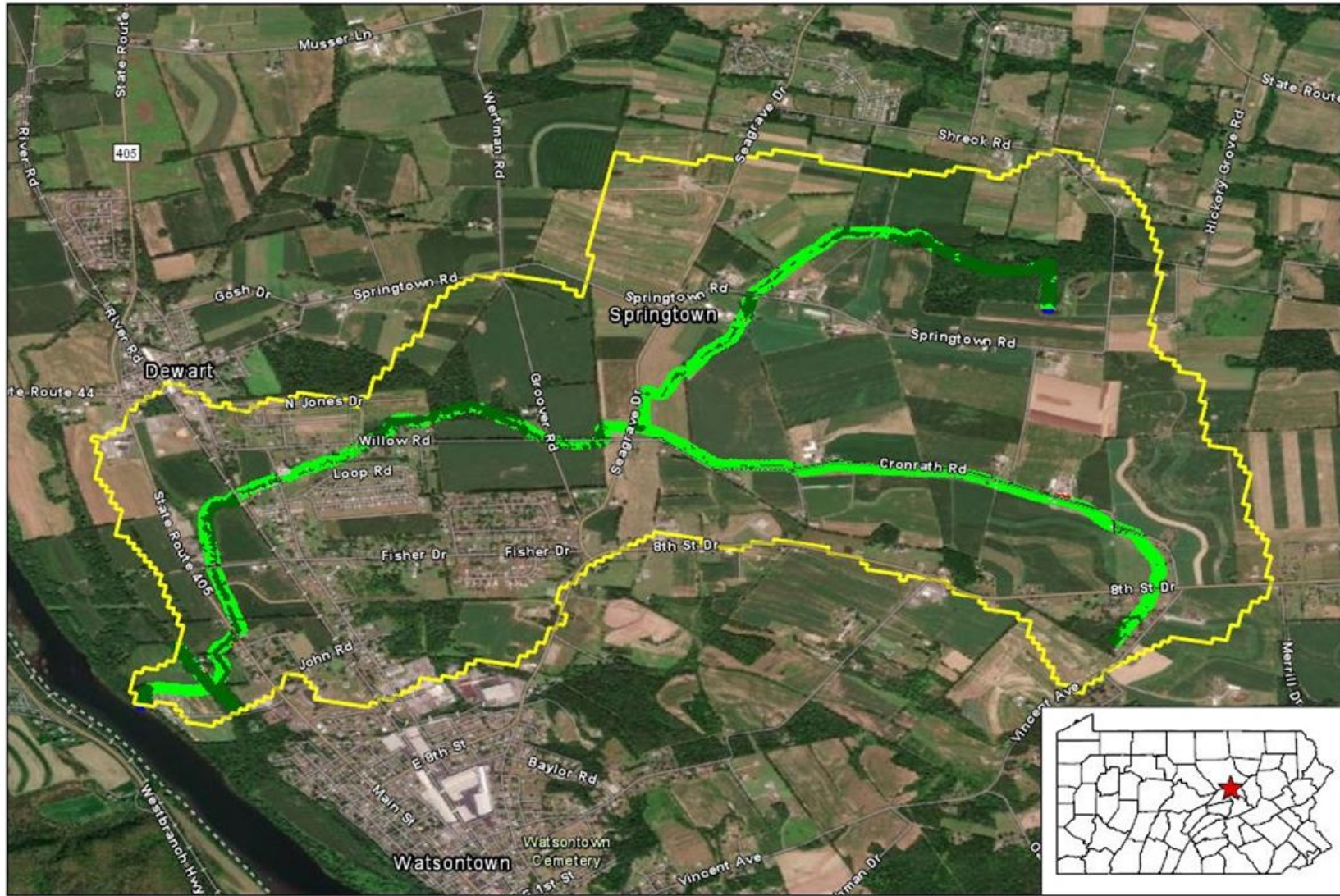
Streambank erosion is calculated as a function of factors such as the length of streams, the monthly stream flow, the percent developed land in the watershed, animal density in the watershed, the watersheds curve number and soil k factor, and mean topographic slope. For a detailed discussion of this modelling program, including a description of the data input sources, see Evans and Corradini (2016) and Stroud Research Center (2023).

MMW 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. Following the model run, a correction for the presence of existing riparian buffers was made in a BMP Spreadsheet Tool (Evans et al. 2020) that had been provided by MMW. The following paragraphs describe the riparian buffer correction method.

Riparian buffer coverage was estimated via a GIS analysis in ArcGIS Pro (Figures 14 and 15). Briefly, landcover per a high resolution landcover dataset (University of Vermont Spatial Analysis Laboratory 2016) was examined within 100 feet of USGS High-Resolution 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 37% in the impaired watershed versus 67% in the reference watershed (Figures 12 and 13).

An additional reduction credit was given to the reference watershed to account for its greater riparian buffering versus 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 (<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 (Version 2020-01-09, Evans et al. 2020) that was provided by a prior version of MMW, 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 USGS high-resolution NHD flowlines within the reference watershed was multiplied 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.

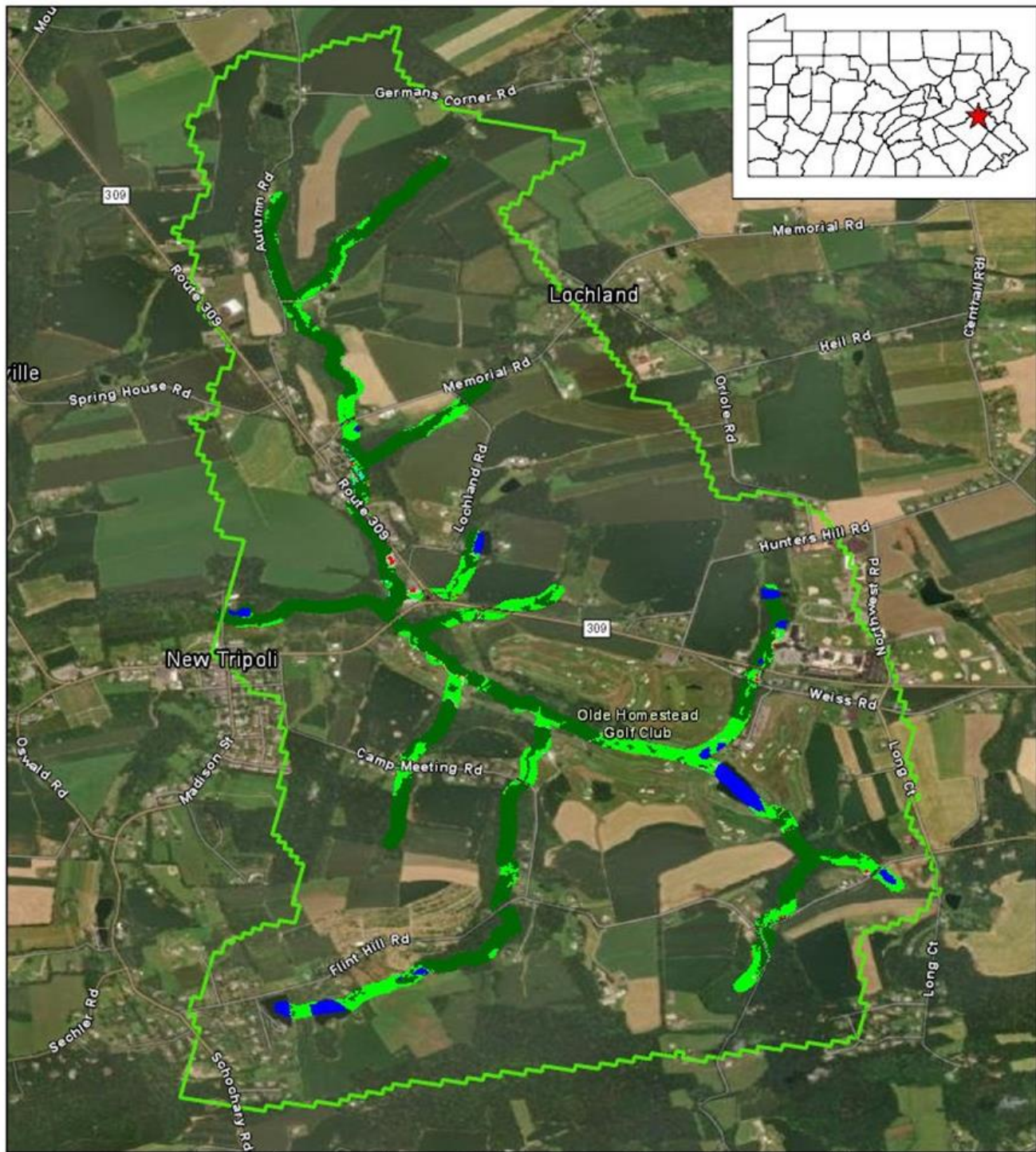


Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

**Figure 12.** Riparian buffer analysis for the Dry Run watershed. 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 (comprised of tree canopy) was estimated to be about 37%.



Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



**Figure 13.** Riparian buffer analysis for the School 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 (comprised of tree canopy) was estimated to be about 67%.

## **CALCULATION OF THE TMDL<sub>AVG</sub>**

The mean annual sediment loading rate for the unimpaired reference subwatershed (School Creek) was estimated to be 631 pounds per acre per year (Table 7). This was substantially lower than the estimated mean annual loading rate in the impaired Dry Run watershed (1,411 pounds per acre per year, Table 8). Thus, to achieve the loading rate of the unimpaired watershed, sediment loading in the Dry Run watershed should be reduced to 1,554,451 pounds per year or less (Table 9).

**Table 7.** Existing annual average loading values for the School Creek subwatershed, reference.

<b>Source</b>	<b>Area ac</b>	<b>Sediment (lbs/yr)</b>	<b>Unit Area Load (lbs/ac*yr)</b>
Hay/Pasture	319	112,586	353
Cropland	1,188	1,353,017	1,139
Forest and Shrub/Scrub	519	843	2
Wetland	5	14	3
Bare Rock	0	1	
Low Density Mixed Development	437	5,266	12
Medium Density Mixed Development	44	2,922	66
High Density Mixed Development	15	957	65
Streambank <sup>1</sup>		196,252	
Point Sources		0	
Riparian Buffer Discount <sup>2</sup>		-78,467	
total	2,526	1,593,390	631

<sup>1</sup>“Streambank” sediment loads were calculated using Model My Watershed’s streambank routine which uses length rather than area.

<sup>2</sup>Riparian buffer discount takes into account sediment reduction attributed to the extra buffering in the reference watershed.

**Table 8.** Existing annual average loading values for the Dry Run watershed, impaired.

<b>Source</b>	<b>Area ac</b>	<b>Sediment lbs/yr</b>	<b>Unit Area Load, lb/(ac*yr)</b>
Hay/Pasture	212	280,254	1,320
Cropland	1,627	3,052,451	1,876
Forest and Shrub/Scrub	114	257	2
Wetland	20	47	2
Grassland/Herbaceous	2	38	15
Bare Rock	0	1	

Low Intensity Mixed Development	425	5,085	12
Medium Intensity Mixed Development	52	3,399	66
High Intensity Mixed Development	12	817	66
Streambank <sup>1</sup>		135,601	
Point Sources		0	
total	2,464	3,477,950	1,411

**Table 9.** Calculation of an annual average TMDL value for the Dry Run watershed.

<b>Pollutant</b>	<b>Reference Mean Loading Rate</b> lbs/(ac*yr)	<b>Impaired Watershed Area</b> ac	<b>Target TMDL<sub>Avg</sub></b> lbs/yr
Sediment	631	2,464	1,554,451

### **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 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 LA is calculated as follows:

$$LA = TMDL - MOS - WLA$$

Thus, before calculating the LA, the MOS and WLA must be defined.

### **Margin of Safety**

The 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<sub>Avg</sub> was explicitly designated as ten-percent of the TMDL<sub>Avg</sub> based on professional judgment. Thus:

$$1,554,451 \text{ lbs/yr TMDL}_{Avg} * 0.1 = 155,445 \text{ lbs/yr MOS}_{Avg}$$

## Wasteload Allocation

There were no existing NPDES permittees in the watershed in need of individual WLA (Table 4). Thus, the WLA will consist solely of a bulk reserve, which is a minor allowance for: existing dischargers not assigned individual WLAs as well as minor increases from point sources as a result of future growth of existing or new sources. The bulk reserve was assigned a value of 1% of the TMDL load.

Thus, the total WLA was calculated as:

$$1,554,451 \text{ lbs/yr TMDL}_{\text{Avg}} * 0.01 = 15,545 \text{ lbs/yr bulk reserve}_{\text{Avg}} + 0 \text{ lb/yr permitted loads} = 15,545 \text{ lbs/yr WLA}_{\text{Avg}}$$

## Load Allocation

Now that the MOS and WLA have been defined, the LA is calculated as:

$$1,554,451 \text{ lbs/yr TMDL}_{\text{Avg}} - (155,445 \text{ lbs/yr MOS}_{\text{Avg}} + 15,545 \text{ lbs/yr WLA}_{\text{Avg}}) = 1,383,462 \text{ lbs/yr LA}_{\text{Avg}}$$

## Loads Not Reduced and Adjusted Load Allocation

Since the impairments addressed by this TMDL were for sedimentation due to agriculture, sediment contributions from forests, wetlands, open (grass/herbaceous) lands, bare rock and developed lands within the Dry Run watershed were considered loads not reduced (LNR). LNR<sub>Avg</sub> was calculated to be 9,643 lbs/yr (Table 10).

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

$$1,383,462 \text{ lbs/yr LA}_{\text{Avg}} - 9,643 \text{ lbs/yr LNR}_{\text{Avg}} = 1,373,818 \text{ lbs/yr ALA}_{\text{Avg}}$$

**Table 10.** Average annual load allocation, loads not reduced and adjusted load allocation

	<b>Sediment, lbs/yr</b>
<b>Load Allocation (LA<sub>Avg</sub>)</b>	<b>1,383,462</b>
<b>Loads Not Reduced (LNR<sub>Avg</sub>):</b>	9,643
Forest	257
Wetland	47
Open Land	38
Bare Rock	1
Low Intensity Mixed Development	5,085
Medium Intensity Mixed Development	3,399
High Intensity Mixed Development	817
<b>Adjusted Load Allocation (ALA<sub>Avg</sub>)</b>	<b>1,373,818</b>

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

wetlands, and open lands were considered natural sediment sources. Bare rock may or may not be a natural sediment source, but either way its sediment contributions were estimated to be negligible.

## **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 Dry Run sediment 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, it was given a greater reduction goal (65%) versus streambanks and hay/pasture lands (23%) (Table 11).

**Table 11.** Average annual sediment load allocations for source sectors in the Dry Run watershed.

<b>Source Sector</b>	<b>Acres</b>	<b>Load Allocation lbs/yr</b>	<b>Current Load lbs/yr</b>	<b>Reduction Goal</b>
CROPLAND	1,627	1,054,593	3,052,451	65%
HAY/PASTURE	212	215,133	280,254	23%
STREAMBANK		104,092	135,601	23%
AGGREGATE		1,373,818	3,468,306	60%

## **CALCULATION OF A DAILY MAXIMUM “TMDL<sub>MAX</sub>” 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 truer “Total Maximum Daily Load” (TMDL<sub>Max</sub>) is also calculated in the following.

MMW currently does not report daily loading rates, but its predecessor program, “MapShed” does. Note, that the original versions of the modelling program reported loads as monthly, yearly, or mean annual, and the ability to report daily output was added in 2013. Rather than reconstruct the modelling routines, it was decided to back-calculate these values using monthly loads and daily hydrology results. For sediment, monthly upland loads were reallocated to days proportionally based

on the amount of monthly runoff that each day accounted for. Streambanks were handled similarly, except that stream flow rather than runoff was used. In cases where point sources are considered by the model, the monthly loads are simply divided by the number of days in the month. Additional methods relevant to nutrient loading were also developed, but they are beyond the context of the present study. (Dr. Barry Evans, MMW Developer, personal communication).

Thus, for the calculation of a TMDL<sub>Max</sub> value, modelling was initially conducted in MMW as described above, and the “Export GMS” feature was used to provide an input data file that was run in the Generalized Watershed Loading Functions-Enhanced Version 1.51 Model Simulation application provided with MapShed. The daily output was opened in Microsoft Excel, and current “maximum” daily loads were calculated as the 99<sup>th</sup> percentiles (using the percentile.exc function) of estimated daily sediment loads in both the Dry Run (impaired) and School Creek (reference) watersheds. The first year of data was excluded to account for the time it takes for the model calculations to become reliable. The 99<sup>th</sup> 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 achievement of water quality criteria is prescribed for other types of pollutants at 25 Pa. Code § 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 99<sup>th</sup> percentile loading rate for the reference subwatershed by the same reduction proportion calculated previously for the average loading rate. After this, any relevant daily maximum point source loads, based eDMR data if available, were added to the watershed totals (note that this was unnecessary in the present study, see Tables 4 and 6).

Then, similarly to the TMDL<sub>Avg</sub> value reported in Table 9, TMDL<sub>Max</sub> was calculated as the 99<sup>th</sup> percentile daily load of the reference subwatershed divided by the acres of the reference subwatershed and then multiplied by the acres of the impaired watershed. Thus, the TMDL<sub>Max</sub> loading rate was calculated as 75,157 pounds per day (Table 12), which would be a 52% reduction from the Dry Run watershed’s current 99<sup>th</sup> percentile daily loading rate of 155,847 pounds per day.

**Table 12.** Calculation of TMDL<sub>Max</sub> for the Dry Run watershed.

<b>Pollutant</b>	<b>Reference 99<sup>th</sup> Percentile Loading Rate</b> lbs/(ac*d)	<b>Impaired Watershed Total Land Area</b> ac	<b>Target TMDL<sub>Max</sub></b> lbs/d
Sediment	30.5	2,464	75,157

Also, in accordance with the previous “Calculation of Load Allocations” section, the WLA<sub>Max</sub> will consist solely of a bulk reserve, which was defined as 1% of the TMDL<sub>Max</sub>. The MOS<sub>Max</sub> was defined as 10% of the TMDL<sub>Max</sub>. The LA<sub>Max</sub> was then calculated as the amount remaining after subtracting the WLA<sub>Max</sub> and the MOS<sub>Max</sub> from the TMDL<sub>Max</sub>. See Table 13 for a summary of these TMDL<sub>Max</sub> variables.

**Table 13.** 99th percentile of daily loading TMDL (TMDL<sub>Max</sub>) variables for the Dry Run watershed. All values are lbs/d.

Pollutant	TMDL <sub>Max</sub>	MOS <sub>Max</sub>	WLA <sub>Max</sub>	LA <sub>Max</sub>
Sediment	75,157	7,516	752	66,890

Mapshed did not break down daily loads by land cover 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 10% of LA<sub>Avg</sub> it was assumed that it was also 10% of LA<sub>Max</sub>. 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 (Sloto et al. 2012). See Table 14 for a summary of the LA<sub>Max</sub> variables.

**Table 14.** Allocation of the 99<sup>th</sup> percentile daily load allocation (LA<sub>Max</sub>) for the Dry Run watershed.

	Annual Average (lbs/yr)	Proportion of Load Allocation <sup>1</sup>	Max Daily (lbs/d)
Load Allocation	1,383,462		66,890
Loads Not Reduced	9,643	0.007	466
Adjusted Loads Allocation	1,373,818	0.993	66,424
Croplands	1,054,593	0.76	50,989
Hay/Pasturelands	215,133	0.16	10,402
Streambanks	104,092	0.08	5,033

<sup>1</sup>Because the modelling program did not break down daily loadings by land cover types, the load allocations for TMDL<sub>Max</sub> were calculated by assuming the same distribution as occurred for the LA<sub>Avg</sub> variables. For instance, if the streambanks allocation was 8% of LA<sub>Avg</sub> it was assumed that it was also 8% of LA<sub>Max</sub>.

Because sediment loading varies so greatly with discharge, the TMDL<sub>Max</sub> 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 (Sloto and Olson 2011, Sloto et al. 2012), it is cautioned that reliance solely on a TMDL<sub>Max</sub> value may not be protective of the Dry Run watershed since chronic excessive sediment inputs occurring at lower discharge levels may be ignored. Take for instance an extreme scenario where the TMDL<sub>Max</sub> was met every day but never exceeded. In this case, the annual sediment loading in the Dry Run watershed would skyrocket to 27,432,390 lbs/yr, which is nearly eight-times the current annual average. The TMDL<sub>Avg</sub> 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 Dry Run watershed. Therefore, BMP implementation would ultimately be deemed adequate if the prescribed annual average reduction was satisfied.

**CONSIDERATION OF CRITICAL CONDITIONS AND SEASONAL VARIATIONS**

According to MMW's technical documentation (Stroud Water Research Center 2023), MMW uses 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." The source of the weather data (precipitation and temperature) was a dataset compiled by USEPA ranging from 1961-1990. Therefore, variable flow conditions and seasonal changes are inherently accounted for in the loading calculations. Furthermore, this document calculates both annual average and 99<sup>th</sup> percentile daily TMDL values. See the discussion of the relevance of these values in the previous section. Seeking to support both of these values will be protective under both long-term average and extreme flow event conditions.

## **RECOMMENDATIONS**

This document proposes a 55% reduction in annual average sediment loading for the Dry Run watershed. To achieve this goal while maintaining a margin of safety and minor allowance for point sources, annual average sediment loading should be reduced by 65% from croplands and 23% each from hay/pasture lands and streambanks. The 99<sup>th</sup> percentile daily sediment loading should be reduced by 52%. 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, livestock exclusion fencing, riparian buffers, etc.

It should be noted that there has been some recent progress in BMP implementation in the Dry Run watershed. Based on coordination with the Northumberland County Conservation District and a review of BMP data in the Practice Keeper database, it is estimated that recent BMP implementation might have already reduced sediment loading within the watershed by more than 352,000 lbs/yr. If so, this would be about 17% of the way towards the overall sediment load reduction prescribed for the watershed (Table 11). It should be cautioned however, that these reductions are based on preliminary analyses, and details about these BMPs and their crediting are not provided herein in order to protect landowner privacy. This being the case, recent BMP implementation was not credited when reporting Dry Run's current loading above (Table 8). But, such recent work could be credited if a watershed restoration plan is developed as a follow-up to this TMDL.

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. Furthermore, 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, 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 June 3, 2023 issue of the *Pennsylvania Bulletin* to foster public comment. A 30-day period is provided for the submittal of comments. Public comments and their responses will be placed in Appendix F.

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## **APPENDIX A: BACKGROUND ON STREAM ASSESSMENT METHODOLOGY**

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 *Assessment Methodology for Streams and Rivers* (Shull and Whiteash 2021).

Documentation of other historic methodologies is available upon request.

Prior to developing TMDLs for specific waterbodies, there must be sufficient data available to assess which streams are impaired and should be listed as such 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 (IR) and found on List 5. Table A1. summarizes the changes to listing documents and assessment methods over time.

With guidance from USEPA, the states have developed methods for assessing the waters within their respective jurisdictions. From 1996-2006, the primary method adopted by DEP for evaluating waters found on the 303(d) lists (1998-2002) or in the IR (2004-2006) was the Statewide Surface Waters Assessment Protocol (SSWAP). SSWAP was a modification of the USEPA 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 landuses, 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 2018 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 landuses, 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 typically to be subsampled for a target benthic macroinvertebrate sample of  $200 \pm 20\%$  ( $N = 160-240$ ). The benthic macroinvertebrates in this subsample were typically identified to the generic level. The ICE protocol is a modification of the USEPA Rapid Bioassessment Protocol III (RPB-III) and provides a more rigorous and consistent approach to assessing Pennsylvania's streams than the SSWAP. More recent listings from 2020 to present were based on updated data collection protocols and Aquatic Life Use (ALU) assessment methods that are specific to the use(s) being assessed.

After these surveys (SSWAP, 1998-2006 lists; or ICE, 2008-2018 lists; ALU 2020-present lists) are completed, biologists 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 is to be listed on the state’s 303(d) List, or presently, the IR 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 generally receives a separate and specific TMDL within that stream segment. Adjoining stream segments with the same source and cause listings may be addressed collectively on a watershed basis.

**Table A1.** Impairment Documentation and Assessment Chronology

<b>Listing Date:</b>	<b>Listing Document:</b>	<b>Assessment Method:</b>
1998	303(d) List	SSWAP
2002	303(d) List	SSWAP
2004	Integrated List	SSWAP
2006	Integrated List	SSWAP
2008-2018	Integrated List	ICE
2020-present	Integrated List	ALU

**APPENDIX B: MODEL MY WATERSHED GENERATED DATA TABLES**

**Table B1.** Model My Watershed land cover outputs for the Dry Run watershed based on NLCD 2019.

Type	NLCD Code	Area (km <sup>2</sup> )	Coverage (%)
Open Water	11	0	0
Perennial Ice/Snow	12	0	0
Developed, Open Space	21	1.02	10.21
Developed, Low Intensity	22	0.7	6.97
Developed, Medium Intensity	23	0.21	2.08
Developed, High Intensity	24	0.05	0.5
Barren Land (Rock/Sand/Clay)	31	0	0.03
Deciduous Forest	41	0.45	4.53
Evergreen Forest	42	0	0
Mixed Forest	43	0.01	0.14
Shrub/Scrub	52	0	0
Grassland/Herbaceous	71	0.01	0.05
Pasture/Hay	81	0.86	8.64
Cultivated Crops	82	6.59	66.06
Woody Wetlands	90	0.07	0.72
Emergent Herbaceous Wetlar	95	0.01	0.06
Total		9.98	100

**Table B2.** Model My Watershed land cover outputs for the School Creek subwatershed based on NLCD 2019.

Type	NLCD Code	Area (km <sup>2</sup> )	Coverage (%)
Open Water	11	0.05	0.48
Perennial Ice/Snow	12	0	0
Developed, Open Space	21	1.3	12.62
Developed, Low Intensity	22	0.47	4.6
Developed, Medium Intensity	23	0.18	1.72
Developed, High Intensity	24	0.06	0.56
Barren Land (Rock/Sand/Clay)	31	0	0.03
Deciduous Forest	41	1.9	18.52
Evergreen Forest	42	0.01	0.07
Mixed Forest	43	0.19	1.81
Shrub/Scrub	52	0	0
Grassland/Herbaceous	71	0	0
Pasture/Hay	81	1.29	12.53
Cultivated Crops	82	4.81	46.85
Woody Wetlands	90	0.02	0.2
Emergent Herbaceous Wetlands	95	0	0.03
Total		10.27	100

**Table B3.** Model My Watershed hydrology outputs for the Dry Run watershed.

<b>Month</b>	<b>Stream Flow (cm)</b>	<b>Surface Runoff (cm)</b>	<b>Subsurface Flow (cm)</b>	<b>Point Src Flow (cm)</b>	<b>ET (cm)</b>	<b>Precip (cm)</b>
Jan	5.42	1.2	4.22	0	0.26	7.15
Feb	6.5	1.48	5.01	0	0.41	7.31
Mar	7.5	0.8	6.71	0	1.47	8.36
Apr	6.28	0.22	6.06	0	4.1	8.41
May	4.42	0.2	4.23	0	8.29	10.51
Jun	3.47	1.01	2.46	0	12.26	10.58
Jul	1.23	0.24	0.99	0	12.81	9.86
Aug	0.42	0.18	0.24	0	9.88	8.64
Sep	0.98	0.92	0.06	0	6.45	9.04
Oct	1.07	0.75	0.32	0	3.37	8.06
Nov	1.88	0.63	1.25	0	1.54	9.38
Dec	4.58	0.89	3.69	0	0.58	8.11
Total	43.75	8.52	35.24	0	61.42	105.41

**Table B4.** Model My Watershed hydrology outputs for the School Creek subwatershed.

<b>Month</b>	<b>Stream Flow (cm)</b>	<b>Surface Runoff (cm)</b>	<b>Subsurface Flow (cm)</b>	<b>Point Src Flow (cm)</b>	<b>ET (cm)</b>	<b>Precip (cm)</b>
Jan	5.42	0.97	4.45	0	0.26	6.69
Feb	5.97	1.27	4.7	0	0.39	6.47
Mar	6.6	0.59	6.01	0	1.47	7.4
Apr	6.3	0.54	5.77	0	3.19	8.25
May	5	0.23	4.77	0	7.28	9.96
Jun	3.5	0.34	3.16	0	10.52	9.81
Jul	1.86	0.31	1.55	0	10.75	10.08
Aug	0.94	0.24	0.7	0	9.12	9.66
Sep	1.16	0.58	0.57	0	5.93	9.19
Oct	1.59	0.33	1.26	0	3.36	7.27
Nov	3.1	0.52	2.58	0	1.55	8.82
Dec	5.26	0.72	4.54	0	0.56	7.62
Total	46.7	6.64	40.06	0	54.38	101.22

**Table B5.** Model My Watershed outputs for sediment in the Dry Run watershed.

<b>Sources</b>	<b>Sediment (kg)</b>
Hay/Pasture	127,099.30
Cropland	1,384,331.70
Wooded Areas	116.4
Wetlands	21.4
Open Land	17.1
Barren Areas	0.3
Low-Density Mixed	935.9
Medium-Density Mixed	1,541.40
High-Density Mixed	370.5
Low-Density Open Space	1,370.40
Farm Animals	0
Stream Bank Erosion	61,497.00
Subsurface Flow	0
Point Sources	0
Septic Systems	0

**Table B6.** Model My Watershed outputs for sediment in the School Creek subwatershed.

<b>Sources</b>	<b>Sediment (kg)</b>
Hay/Pasture	51,059.50
Cropland	613,613.10
Wooded Areas	382.5
Wetlands	6.2
Open Land	0
Barren Areas	0.3
Low-Density Mixed	637.1
Medium-Density Mixed	1,325.00
High-Density Mixed	434.2
Low-Density Open Space	1,751.10
Farm Animals	0
Stream Bank Erosion	89,003.00
Subsurface Flow	0
Point Sources	0
Septic Systems	0

**APPENDIX C: STREAM SEGMENTS IN THE DRY RUN WATERSHED WITH AQUATIC LIFE USE  
IMPAIRMENTS**

<b>ATTAINS ID:</b>	<b>Length (miles):</b>	<b>Impairment Source:</b>	<b>Impairment Cause:</b>
PA-SCR-66918351	0.10	AGRICULTURE	SILTATION
PA-SCR-66918263	2.08	AGRICULTURE	SILTATION
PA-SCR-66918015	1.21	AGRICULTURE	SILTATION
PA-SCR-66917879	0.63	AGRICULTURE	SILTATION
PA-SCR-66918303	0.22	AGRICULTURE	SILTATION
PA-SCR-66917847	1.72	AGRICULTURE	SILTATION

## **APPENDIX D: EQUAL MARGINAL PERCENT REDUCTION METHOD**

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 landuse/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

**Table D1.** Equal marginal percent reduction calculations for the Dry Run watershed.

	<b>Current Load, lbs/yr</b>	<b>Any &gt; ALA?</b>	<b>If &gt; ALA, reduce to ALA</b>	<b>How much does sum exceed ALA?</b>	<b>Proportions of total after initial adjust</b>	<b>Assign reductions still needed per proportions after intial adjust</b>	<b>ALA: subtract reductions still needed from initial adjust</b>	<b>proportion Reduction</b>
Cropland	3,052,451	yes	1,373,818		0.77	319,225	1,054,593	0.65
Hay/Pasture	280,254	no	280,254	415,855	0.16	65,121	215,133	0.23
Streambank	135,601	no	135,601		0.08	31,509	104,092	0.23
<i>sum</i>	<b>3,468,306</b>		<b>1,789,673</b>		<b>1.00</b>	<b>415,855</b>	<b>1,373,818</b>	<b>0.60</b>

**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 USEPA’s 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 USEPA every two years (April 1 of the even numbered years);
- States to develop TMDLs, specifying a pollutant budget that meets state water quality standards and allocate pollutant loads among pollution sources in a watershed, e.g., point and nonpoint sources; and
- USEPA to approve or disapprove state lists and TMDLs within 30 days of final submission.

## **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 DEP, 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 groundwater in a watershed.

## **APPENDIX F: COMMENT AND RESPONSE**

This section is reserved for public comments.