

Carr Run Sediment TMDL

Crawford County, Pennsylvania

Prepared by:



pennsylvania

DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Executive Summary

“Total Maximum Daily Loads” (TMDLs) for sediment were developed for the Carr Run Subwatershed (Figure 1) to address the siltation 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 was identified as the cause of these impairments. Because Pennsylvania does not have numeric water quality criteria for sediment, the loading rates from a similar unimpaired watershed were used to calculate the TMDLs.

“TMDLs” were calculated using both a long-term annual average value (TMDL_{Avg}) which would be protective under most conditions, as well as a 99th percentile daily value (TMDL_{Max}) which would be relevant to extreme flow events. Current annual average sediment loading in the Carr Run Subwatershed was estimated to be 2,382,213 pounds per year. To meet water quality objectives, annual average sediment loading should be reduced by 51% to 1,170,069 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 63% while loading from hay/pasture lands and streambanks should be reduced by 31% each.

Table 1. Summary of Annual Average TMDL (TMDL _{Avg}) Variables for the Carr Run Subwatershed						
lbs/yr:						
Pollutant	TMDL _{Avg}	MOS _{Avg}	WLA _{Avg}	LA _{Avg}	LNR _{Avg}	ALA _{Avg}
Sediment	1,170,069	117,007	11,701	1,041,361	29,789	1,011,572

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 99th percentile daily loading in the Carr Run Subwatershed was estimated to be 141,950 pounds per day. To meet water quality objectives, 99th percentile daily sediment loading should be reduced by 57% to 61,330 pounds per day. Allocation of 99th percentile daily sediment loading among the TMDL variables is summarized in Table 2.

Table 2. Summary of 99 th Percentile Daily Loading TMDL (TMDL _{Max}) Variables for the Carr Run Subwatershed						
lbs/d:						
Pollutant	TMDL _{Max}	MOS _{Max}	WLA _{Max}	LA _{Max}	LNR _{Max}	ALA _{Max}
Sediment	61,330	6,133	613	54,584	1,561	53,023

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

Introduction

Carr Run is a tributary of the Cussewago Creek, with the confluence approximately six and a half miles east of the borough of Conneautville in Crawford County. This Total Maximum Daily Load (TMDL) document has been prepared to address the siltation from agriculture impairments listed for all stream segments within the subwatershed as delineated in Figure 1, per the 2020 Final Integrated Report (see Appendix A for a description of assessment methodology). Note that the final one-mile reach of Carr Run was purposely excluded because if the entire Carr Run Subwatershed were delineated from its mouth, another large tributary system that was not impaired, Rundelltown Creek, would have been included. This would have greatly increased the size of the study watershed, making it more difficult to find an attaining reference watershed while also making the results less specific to the impaired reaches of the Carr Run Watershed. However, since this final excluded reach was fairly well buffered and accepted no major tributaries, it is hoped that it would sufficiently improve if the upstream problems were corrected.

The Carr Run Subwatershed, as delineated in Figure 1, was approximately 11 square miles and occurred entirely within Crawford County. It contained approximately 23 stream miles, all of which were designated for Warm Water Fish (WWF) and Migratory Fishes (MF) (Table 3).

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

Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life. (25 PA Code Chapter 93.6 (a))

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

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

According to an analysis of USDA's 2020 Cropland Data Layer, as reported by Cropscape, land use in the study watershed was estimated to be 49% agriculture, 47% forest/naturally vegetated lands, and 4% mixed development. Of the agricultural lands, the amount of croplands in the watershed substantially exceeded the amount of hay/pasture lands (31% versus 19% of the total land area, Appendix B, Table B1). There were no current NPDES permitted point source discharges in the watershed with significant load limits relevant to sedimentation, although there were several wastewater treatment plants serving a single-family residences (Table 4).

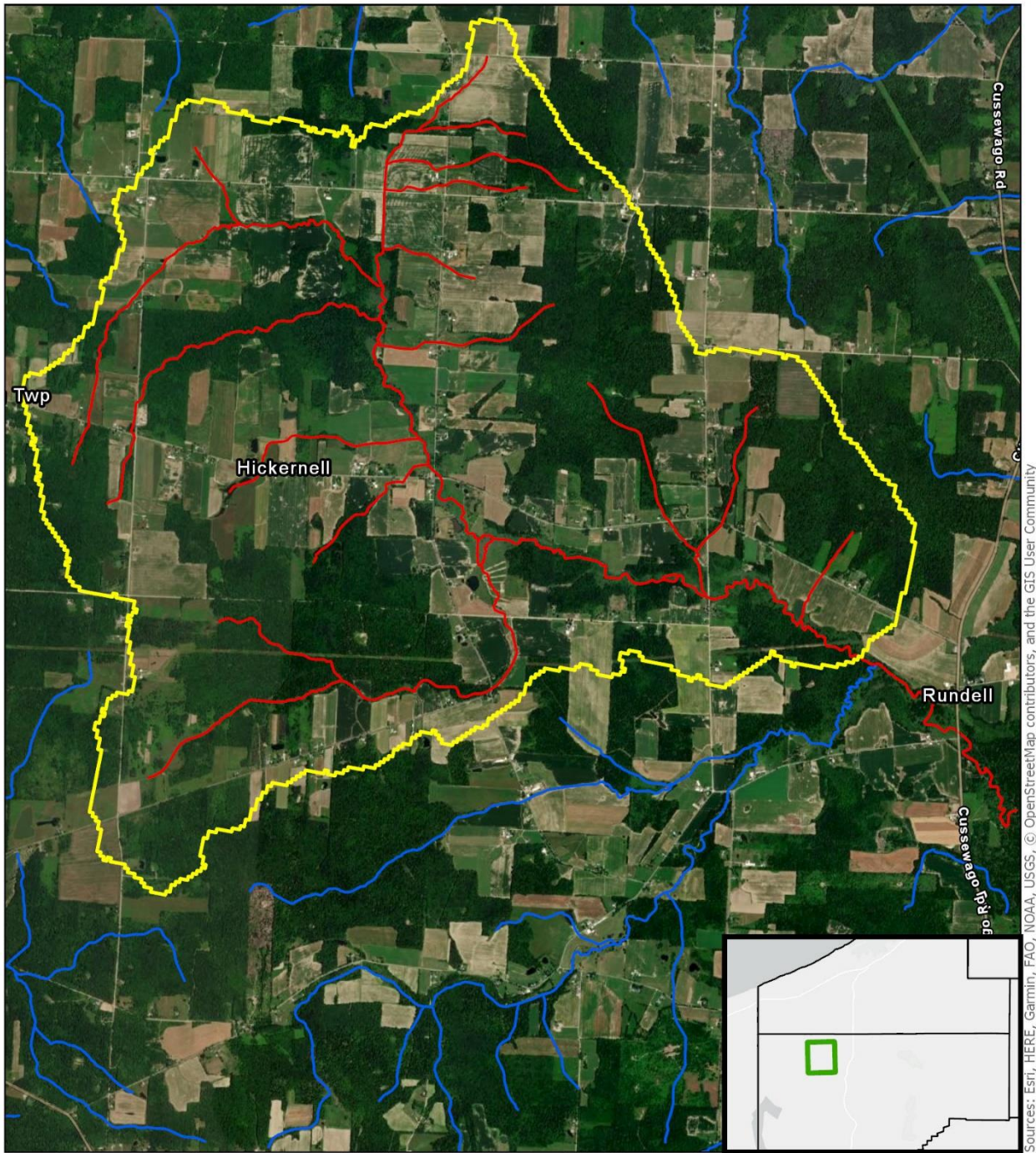
Table 3. Aquatic-Life Impaired Stream Segments in the Carr Run Subwatershed per the 2020 Final Pennsylvania Integrated Report

HUC: 05010004 – French				
Source	EPA 305(b) Cause Code	Miles	Designated Use	Use Designation
Agriculture	Siltation	23.4	WWF, MF	Aquatic Life

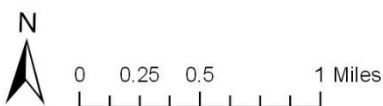
HUC= Hydrologic Unit Code; WWF=Warm Water Fish; MF= Migratory Fish

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.



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



- ▭ Carr Run Subwatershed
- Non Attaining for Aquatic Life
- Attaining for Aquatic Life

Figure 1. Carr Run Subwatershed. All stream segments within the delineated subwatershed, as well as the mainstem downstream of the subwatershed, were listed as impaired for siltation from agriculture per the 2020 Integrated Report viewer available at <https://gis.dep.pa.gov/IRViewer2020/>.

Table 4. Existing NPDES-Permitted Discharges in the Carr Run Subwatershed and their Potential Contribution to Sediment Loading.					
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
PAG048736	Brad and Robyn Fuhrer SFTF	8	0.07	NA	NA
PAG049326	Mary Ellyn & Thomas Bonanti SFTF	8	0.07	NA	NA
PAG048661	Malcolm & Susan Christhilf SFTF	8	0.07	NA	NA
PAG041017	Susan Duncan SFTF	8	0.07	NA	NA

Permits within the delineated subwatershed 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 above permits were for small flow wastewater treatment facilities serving single-family residences. Assume an average daily flow of 262.5 gpd and a daily maximum flow of 400 gpd. The average flow with an average monthly TSS concentration of 10 mg/L was used to calculate the annual average loadings. A 20 mg/L TSS concentration along with an assumed peak daily flow of 400 gpd were used to calculate the daily max loads. No eDMR data were available.

TMDL Approach

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

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

Because Pennsylvania does not have numeric water quality criteria for sediment, the "Reference Watershed Approach" was used. This method estimates pollutant loading rates in both the impaired watershed as well as a similar watershed that is not listed as impaired for the same use. Then, the loading

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 attaining watershed will result in the impaired stream segments attaining their designated uses.

Selection of the Reference Watershed

In addition to anthropogenic influences, there are many other natural factors affecting sediment loading 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, the Department’s Integrated Report GIS-based website (available at https://www.depgis.state.pa.us/integrated_report_viewer/index.html), or GIS data layers consistent with the Integrated Report, were used to search for nearby watersheds that were of similar size as the Carr Run Subwatershed, but lacked stream segments listed as impaired for sediment. Once potential references were identified, they were screened to determine which ones were most like the impaired watershed with regard to factors such as landscape position, topography, hydrology, soil drainage types, land use 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.

Considering that: it was nearby (only about twenty-five miles to the southeast), within the same physiographic province, had similar topography, soil drainage, bedrock geology, hydrologic characteristics, and there was good evidence that it was attaining its aquatic life use, a subwatershed of Mill Creek in Crawford and Venango Counties was considered for use as a reference (Figure 2 and Table 5).

	Carr Run	Mill Creek
Phys. Province ¹	Northwestern Glaciated Plateaus Section of the Appalachian Plateaus Physiographic Province	Northwestern Glaciated Plateaus Section of the Appalachian Plateaus Physiographic Province
Land Area ² , ac	6,878	6,770
Land Use ²	49% Agriculture 47% Forest/Natural Vegetation	30% Agriculture 64% Forest/Natural Vegetation

	4% Developed	5% Developed
Soil Infiltration ³	0.6% Group A 0.4% Group B 11% Group B/D 0.2% Group C 36% Group C/D 52% Group D	5% Group A 0.04% Group B 1% Group B/D 4% Group C 30% Group C/D 59% Group D
Dominant Bedrock ⁴	99.9% Sandstone 0.1% Siltstone	99% Sandstone 1% Siltstone
Average Precipitation ⁵ , in/yr	39.6	39.6
Average Surface Runoff ⁵ , in/yr	3.2	2.7
Average Elevation ⁵ (ft)	1,204	1,379
Average Slope ⁵	2.4%	5.1%
Average Stream Channel Slope ⁵	1 st order: 1.38% 2 nd order: 0.19% 3 rd order: 0.15	1 st order: 0.89% 2 nd order: 0.26%

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

²MMW output/input based on USDA's Cropland Data Layer as reported by Cropscape see <https://nassgeodata.gmu.edu/CropScape/>

³As 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.

⁴Per bedrock geology GIS layer provided by Pennsylvania Bureau of Topographic and Geological Survey, Dept. of Conservation and Natural Resources

⁵As reported by Model My Watershed

Both watersheds were within the Northwestern Glaciated Plateaus Section of the Appalachian Plateaus Physiographic Province (Table 5) and were nearly completely dominated by sandstone bedrock (Table 5). The average topographic slope in both watersheds was similar, though slightly greater in the Mill Creek Subwatershed versus the Carr Run Subwatershed (5.1% versus 2.4%, Table 5). Likewise, the stream channel slopes were comparable in both watersheds (Table 5). Both watersheds were dominated very slow infiltration (D) soils and average surface runoff rates in both watersheds were similar (3.2 versus 2.7 in/yr) (Table 5).

While there was substantial agricultural landcover in both watersheds, the amount was greater in the Carr Run Subwatershed, accounting for about half of its total landcover, versus about a third of the landcover in the Mill Creek Subwatershed (Table 5). Both watersheds had a minor amount of developed lands (4 and 5%). Thus, forest/naturally vegetated lands comprised a greater proportion of the overall land area in the Mill Creek Subwatershed (64%) versus the Carr Run Subwatershed (47%).

Whereas stream segments within the Carr Run Subwatershed were designated for Warm Water Fish (WWF), stream segments within the Mill Creek Subwatershed were designated for cold water fishes. Neither watershed had stream segments designated for special protection (high quality or exceptional value). Like the Carr Run Subwatershed, the NPDES permitted point source discharges in the Mill Creek Subwatershed (Table 6) were practically negligible as sediment source on a watershed scale. Overall, the Mill Creek Subwatershed appeared to be similar to the Carr Run Subwatershed, and thus it was accepted as a suitable reference.

Table 6. Existing NPDES-Permitted Discharges in the Mill Creek Subwatershed and their Potential Contribution to Sediment Loading.			
Permit No.	Facility Name	Load, mean lbs/yr	Load, max lbs/d
PA0100757	Country Corner RV Park	144	10.0
PAM613008	Dietrich Mine	NA	NA

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

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

Country Corner RV Park- Mean lbs/yr was based on nine years of electronic discharge monitoring report data where average monthly flows (in MGD) and total suspended solids concentrations (in mg/l) were reported. These values were used to calculate average monthly loads in lbs/d, which were then multiplied by the number of days in the month to calculate lbs for the month. All the months within a year were then summed to calculate lbs/yr. The nine years were then averaged to calculate the mean lbs/yr value reported above.

For calculating daily maximum sediment load, the design flow of 0.02 MGD per their permit along with an instantaneous maximum TSS concentration limit of 60 mg/L per their permit was used. Note that this likely overestimates their actual daily maximum.

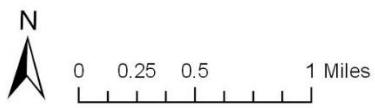
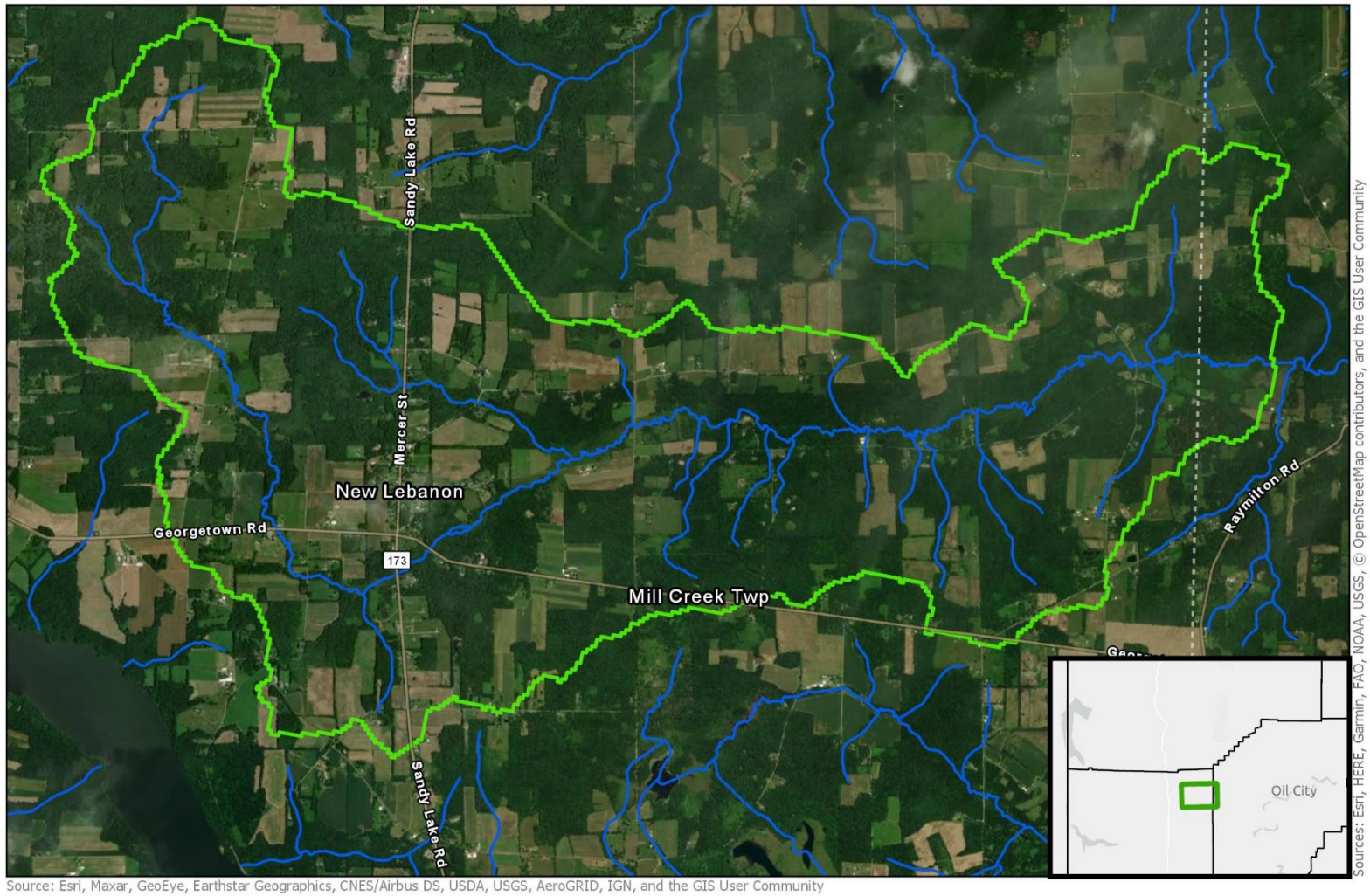
Dietrich Mine-their permit does not require flow measurement; thus, sediment loading was not directly calculated. Loading may be indirectly accounted for based on modelling of land uses in Model My Watershed.

After selecting the potential reference, the two watersheds were visited during the spring 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 explain why one watershed was impaired for sediment while the other was attaining.

Site observations in the Carr Run Subwatershed indicated a severe fine sediment deposition problem in many areas of its mainstem and tributaries (Figure 3, 4, and 5). The streambed was often blanketed with fine sediment deposits, though some gravelly/rocky areas were observed in swifter reaches (Figure 4). While the pervasive fine sediment deposition observed in this watershed may be in part due to its susceptibility given its low gradient nature, it was clear that intensive agriculture with lack of best management practices were major factors as well (see Figures 5, 6, and 7). Indeed, at about half of the landcover in the watershed, the amount of agriculture was sufficiently high such that fine sediment deposition problems may be expected even if agricultural practices were good. However, on top of this, striking problems, including severe bank erosion (Figures 3 and 7), lack of riparian buffers, and artificial channelization were apparent (Figures 5 and 7). Another obvious source of fine sediments were the watershed's numerous dirt/gravel roads. A brief storm happened to occur during the site visit, and runoff from such a road resulted in an obvious muddy plume and high turbidity downstream (Figure 8). Because these dirt roads were made of a material that was high in fine sediments, they appeared to be more problematic than the unpaved roads made of crushed limestone or shale that are common in other parts of the state.

In contrast, streambed conditions appeared to be far better in the Mill Creek reference subwatershed. While it is true that the downstream-most reach was higher gradient and thus perhaps less vulnerable to sediment deposition, conditions tended to be far better in the lower gradient middle and upper mainstem reaches as well (Figure 10). Rather than being blanketed with fine sediment, mainstem substrate in the Mill Creek Subwatershed tended to be a more diverse mixture of gravels and cobbles with sandy fines deposits in the slackwater areas (Figure 10). The Mill Creek Subwatershed also had numerous beaver dams in some reaches, which clearly affected patterns of sediment deposition. While fine sediment deposition was observed in the ponded areas immediately above such dams, the areas below the dams tended to have a diverse mixture of substrates that included patches of coarser gravels and fines deposition in slackwater areas (Figure 11). The Mill Creek Subwatershed had numerous tributaries occurring in higher gradient forested areas that tended to be primarily rocky (Figure 12). However, as would be expected, substantial fine sediment deposition was apparent in tributaries with beaver dams and in some localized areas in close proximity to agriculture (Figure 12).

Like the Carr Run Subwatershed, there was also a large amount of agricultural landcover within the Mill Creek Subwatershed (Figure 13). However, the Mill Creek Subwatershed had substantially more forested area, especially along stream segments (Figure 14). Even so, there were areas within the Mill Creek Subwatershed where conditions clearly could have been improved. For instance, some crop fields used conventional tillage, some streams and drainageways lacked buffers, and there were areas where livestock had direct access to the stream (Figure 15). Apparently however, these deficiencies did not lead to widespread impairments.



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

Figure 2. Mill Creek Subwatershed. All stream segments were listed as attaining for aquatic life per the 2020 Integrated Report.

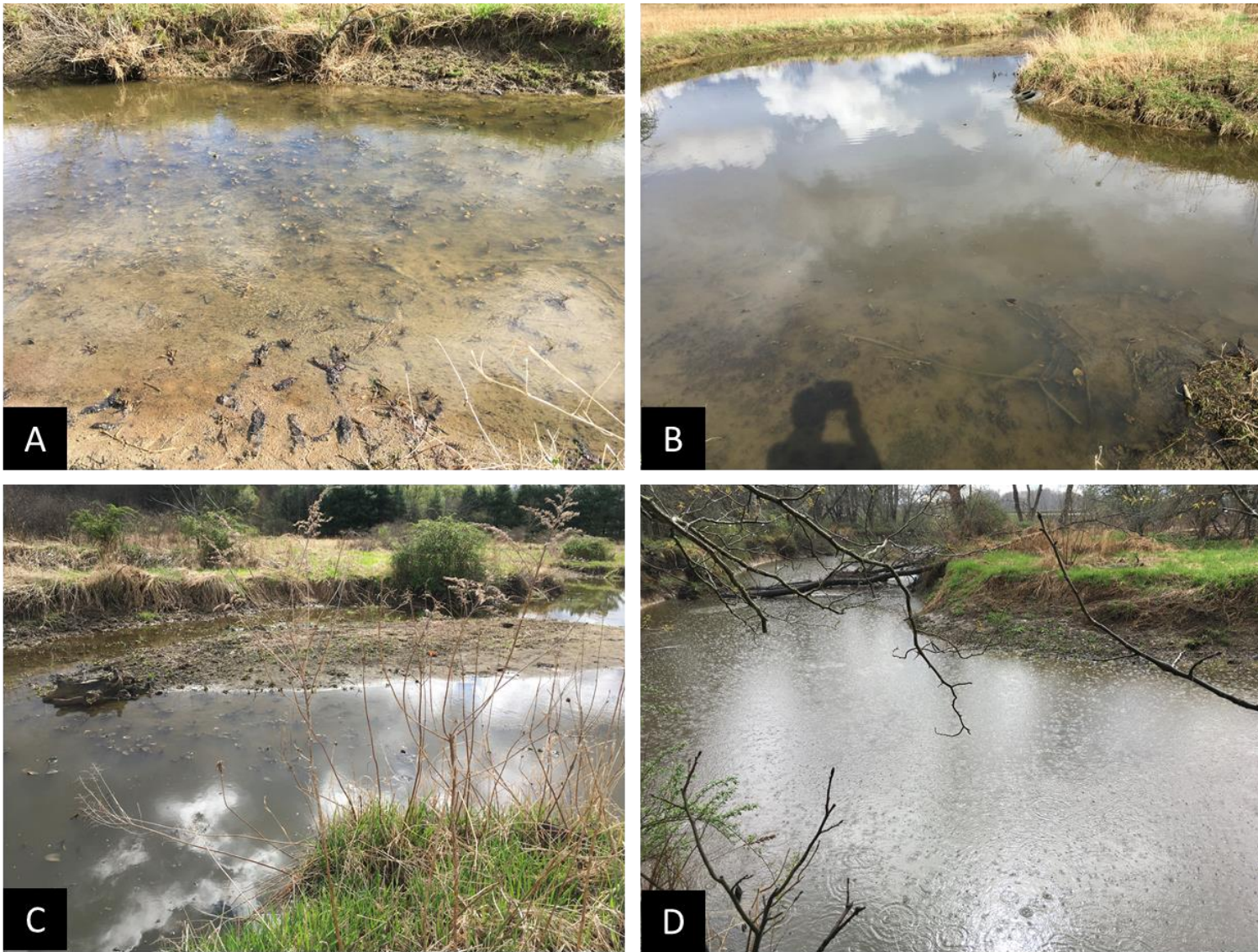


Figure 3. Sediment deposition in mainstem reaches within and just downstream of the Carr Run Subwatershed. Heavy sediment deposition was apparent in the streambed, and in some cases the fines load was large enough to form bars.



Figure 4. Examples of gravelly and rocky substrates within the Carr Run Subwatershed. In contrast to the fines observed in Figure 5, coarser substrates were observed in some swifter reaches.



Figure 5. Example substrate conditions within smaller tributary reaches of the Carr Run Subwatershed. The largely forested tributary in A had rocky substrate while fine sediment deposition was apparent in many tributaries of the agricultural area (B-D).



Figure 6. Example landscapes within the Carr Run Subwatershed. The watershed was relatively flat and had high amounts of agriculture. Forested patches, as can be observed in the distance, occurred in various areas throughout the watershed.



Figure 7. Examples of conditions that may exacerbate sediment loading in the Carr Run Subwatershed. Numerous instances were observed with severe bank erosion and where streams flowed through croplands without substantial riparian buffers. Furthermore, streams were often channelized and in some cases livestock had direct access to streams.



Figure 8. Example of high turbidity caused by an unpaved roads in the Carr Run Subwatershed. Unpaved Road substrate had a large amount of fines (A). Turbid runoff was observed along the road shoulder following a brief storm (B). This created a plume to the stream (C) and high downstream turbidity (D).



Figure 9. Examples of conditions that may be protective against sediment loading in the Carr Run Subwatershed. Some stream segments had wetland and forested buffers (A, B, and C). Note that Photograph C shows what appears to be fallow pasturelands. Photograph D shows a drainageway among croplands with herbaceous and shrub buffers.



Figure 10. Examples of substrate conditions of larger/mainstem segments within and just downstream of the Mill Creek Subwatershed. In the downstream most reaches, the stream became more constrained, higher gradient and primarily rocky. In contrast, stream segments tended to be much lower gradient in the valley areas of the middle and upper watershed. Substrate in these areas was often gravel or cobble, with some sandy fines deposition, especially in slackwater areas. Riffles typically had coarser substrate however.

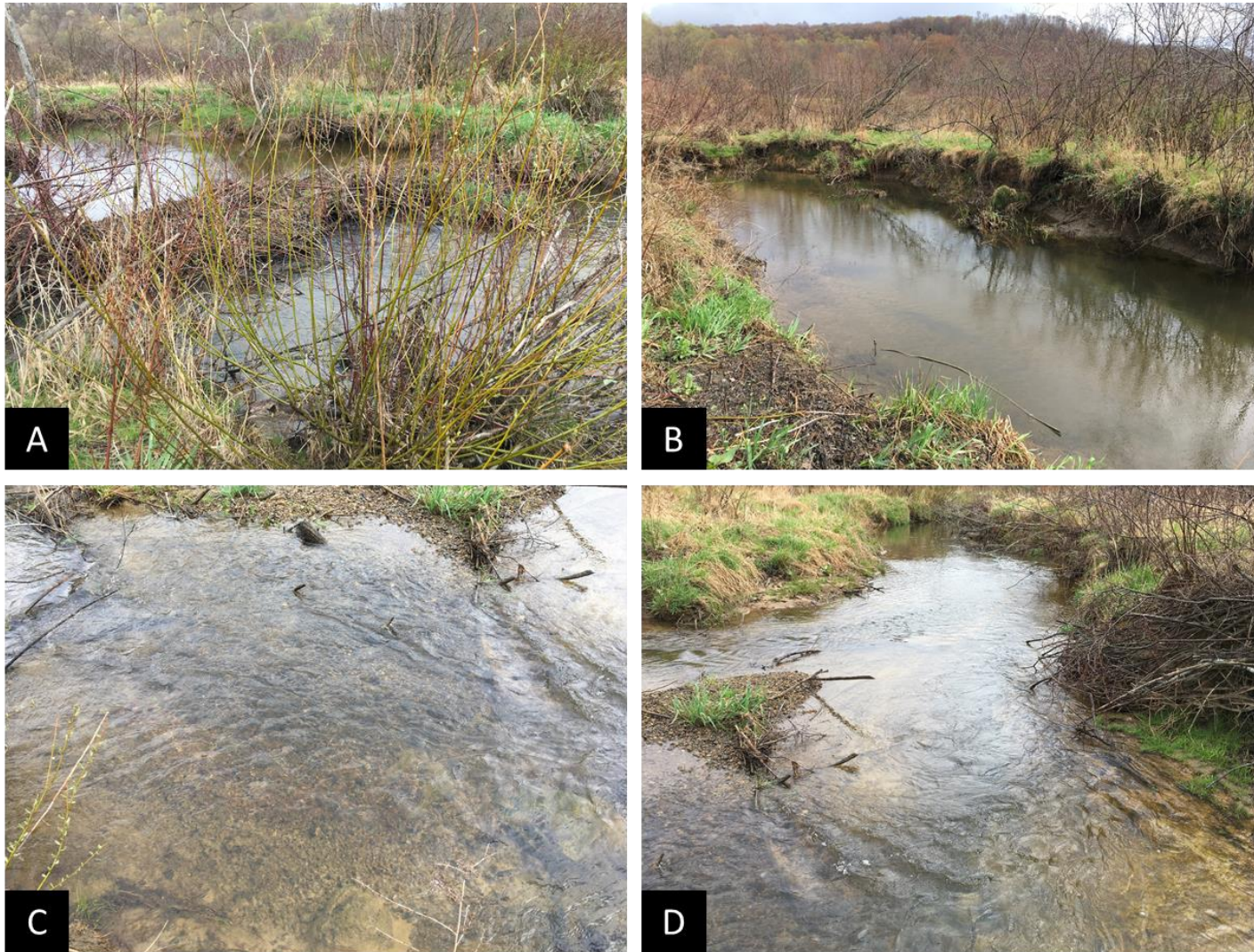


Figure 11. Examples of the effects of beaver dams in the Mill Creek Subwatershed. Fine sediments tended to accumulate in the wetland pool conditions created by such dams (B). Areas just downstream of such dams tended to have diverse substrate conditions, which included gravel substrates in many riffle areas and fine sediment deposits in slackwater areas (C and D).



Figure 12. Example tributary conditions in the Mill Creek Subwatershed. Many tributaries were fairly high gradient and rocky, as in A. Some exhibited wetland conditions as in B, or could have beaver dams as in C. However, the tributary shown in D may have exhibited localized sediment deposition due to surrounding agriculture and inadequate riparian buffers.



Figure 13. Example landscapes in the Mill Creek Subwatershed. The lower watershed (above photo) tended to have more topographic relief with agricultural fields in the uplands and forests along the stream in the valley. The upper watershed (lower photo) tended to be flatter with agricultural fields and wetland conditions along streams.

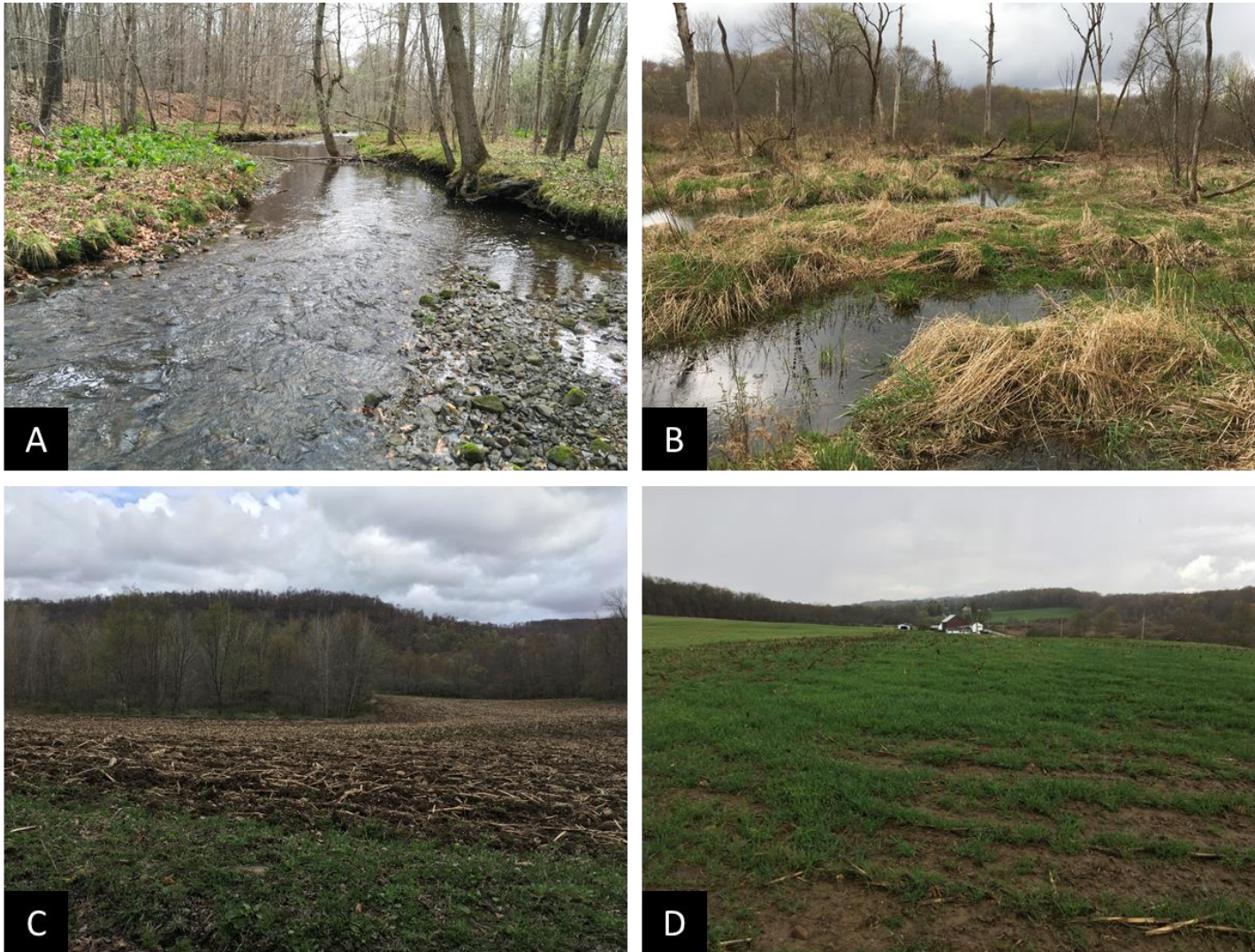


Figure 14. Example conditions that may be protective against sediment loading in the Mill Creek Subwatershed. Stream segments were often surrounded by forests (A) or wetlands (B). Photograph C shows forested buffers protecting the stream from croplands and photograph D shows the use of a cover crop.



Figure 15. Example conditions that may exacerbate sediment loading in the Mill Creek Subwatershed. Photographs A and B show extensive areas of conventional tillage. Photograph C shows a pasture with livestock access to the stream. Note the presence of bare soils and erosive streambanks. Photograph D shows an area where a stream segment/drainageway appears to have been recently excavated to improve drainage.

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), 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” (GWLFE) 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, GWLFE, was used to simulate 30-years of daily water, nitrogen, phosphorus and sediment fluxes. To provide a general understanding of how the model functions, the following excerpts are quoted from Model My Watershed’s technical documentation.

The GWLFE 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.

GWLFE 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, GWLFE simulates surface runoff using the SCS-CN approach with daily weather (temperature and precipitation) inputs from the EPA Center for Exposure Assessment Modeling (CEAM) meteorological data distribution. Erosion and sediment yield are

estimated using monthly erosion calculations based on the USLE algorithm (with monthly rainfall-runoff coefficients) and a monthly KLSCP values for each source area (i.e., land cover/soil type combination). A sediment delivery ratio based on watershed size and transport capacity, which is based on average daily runoff, is then applied to the calculated erosion to determine sediment yield for each source sector. Surface nutrient losses are determined by applying dissolved N and P coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area.

Evapotranspiration is determined using daily weather data and a cover factor dependent upon land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values.

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

For a detailed discussion of this modelling program, including a description of the data input sources, see Evans and Corradini (2016) and Stroud Research Center (2021).

Model My Watershed 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, except: that the flows associated with the wastewater treatment plants noted in Tables 4 and 6 were added as inputs, and landcover classes were adjusted to reflect newer (2020) USDA Cropland Data Layer values as opposed to the NLCD 2011 default values used by Model My Watershed. For the wastewater treatment plant flows, 3.975 m³/d was added for the Carr Run Subwatershed based on the assumption of 262.5 gpd per single family residential wastewater treatment plant. A flow value of 11.666 m³/d was added for the wastewater treatment plant in the Mill Creek Subwatershed based on electronic discharge monitoring report data. To adjust landcover values, watershed shapefiles were imported into Cropscape, which provided summaries of 2020 Cropland Data Layer landcover. Cropland Data Layer output classes were converted into MMW input classes as described in Table 7.

Table 7. Conversion of cropland data layer (CDL) categories into Model My Watershed (MMW) input categories.	
MMW Category	CDL Category
Hay/Pasture	Alfalfa, Other Hay/Non Alfalfa, Clover/Wildflowers, Switchgrass, Grass/Pasture
Cropland	Corn, Sorghum, Soybeans, Sunflowers, Barley, Winter Wheat, Dbl Crop WinWht/Soybeans, Rye, Oats, Speltz, Dry Beans, Potatoes, Sod/Grass Seed Peaches, Apples, Grapes, Christmas Trees, Triticale, Broccoli, Dbl Crop WinWht/Corn, Dbl Crop Triticale/Corn, Pumpkins, Blueberries, Dbl Crop WinWht/Sorghum, Dbl Crop Barley/Corn, Dbl Crop Barley/Soybeans
Wooded Areas	Deciduous Forest, Evergreen Forest, Mixed Forest, Shrubland

Wetlands	Woody Wetlands, Herbaceous Wetlands
Open Land	Fallow/Idle Cropland
Barren Areas	Barren
Low-Density Mixed	Developed/Low Intensity
Medium-Density Mixed	Developed/Medium Intensity
High-Density Mixed	Developed/High Intensity
Low-Density Open Space	Developed/Open Space

A correction for the presence of existing riparian buffers was made in the BMP Spreadsheet Tool provided by Model My Watershed following the model run. The following paragraphs describe the riparian buffer correction methodology.

Riparian buffer coverage was estimated via a GIS analysis in ArcGISPro. Briefly, NLCD 2016 landcover was examined within 100 feet of NHD flowlines. The sum of raster pixels that were classified as either forest, shrub/scrub or wetlands 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 56% in the impaired subwatershed versus 89% in the reference subwatershed.

An additional reduction credit was given to the reference subwatershed to account for the fact it had more riparian buffers than the impaired subwatershed. 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 subwatershed over the amount found in the impaired subwatershed, the approximate length of NHD flowlines within the reference subwatershed was multiplied by the difference in the proportion buffering between the reference subwatershed and the impaired subwatershed, 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 was 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.

After the modelling run, a correction was also made to account for the observed high loading associated with dirt and gravel roads. These roads typically showed up as developed open space in the 2020 Cropland Data Layer. However, the low sediment loading rate associated with this land use type seemed to conflict with the observation that these roads contained large quantities of fines that readily ran off during storm events (Figure 8). Thus it was assumed that these dirt roads loaded sediment at the same rate that was calculated for croplands. Therefore, the acreage of dirt and gravel roads in each watershed were estimated using the Penn State Center for Dirt and Gravel Road Studies GIS Mapper available at <https://gis.dirtandgravel.psu.edu/mapper/map.aspx>. Using this tool, it was estimated that there were 50,195 feet of such roads in the Carr Run Subwatershed versus 17,557 feet in the Mill Creek Subwatershed. These roads appeared to be about 20 feet wide, so it is estimated that there were approximately 23 acres of dirt and gravel roads in the Carr Run Subwatershed versus about 8 acres in the Mill Creek Subwatershed. These areas and loads were subtracted from the values reported for low intensity mixed development and they were included as a separate category that loaded at a rate equivalent to croplands.

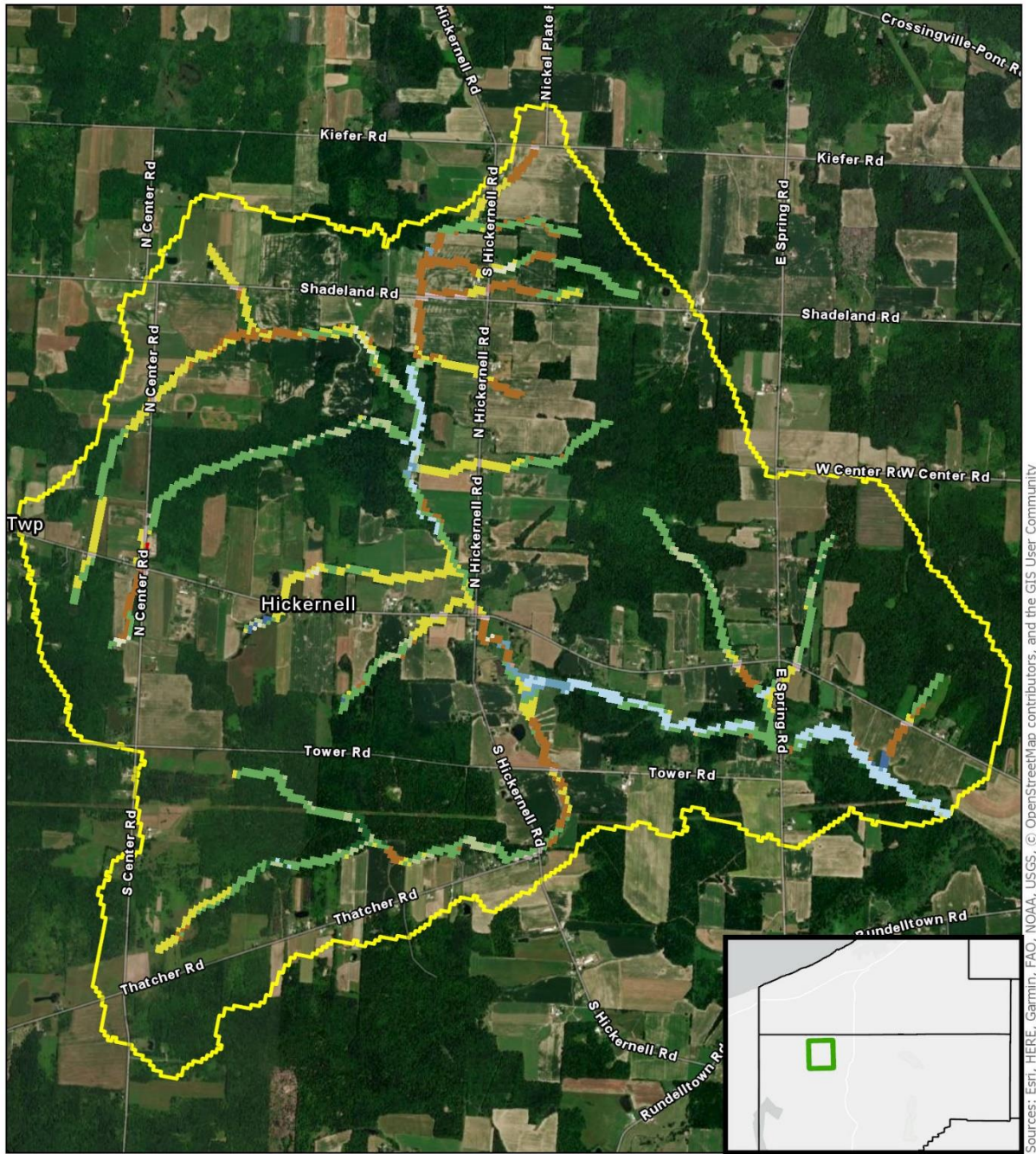


Figure 16. Riparian buffer analysis for the Carr Run Subwatershed. A raster dataset of NLCD 2016 land cover is shown within 100 feet (geodesic) of either side of NHD flowlines. It was estimated that approximately 56% of non-water pixels within 100 feet of NHD flowlines was identified as forest, shrub/scrub or woody or emergent herbaceous wetlands.

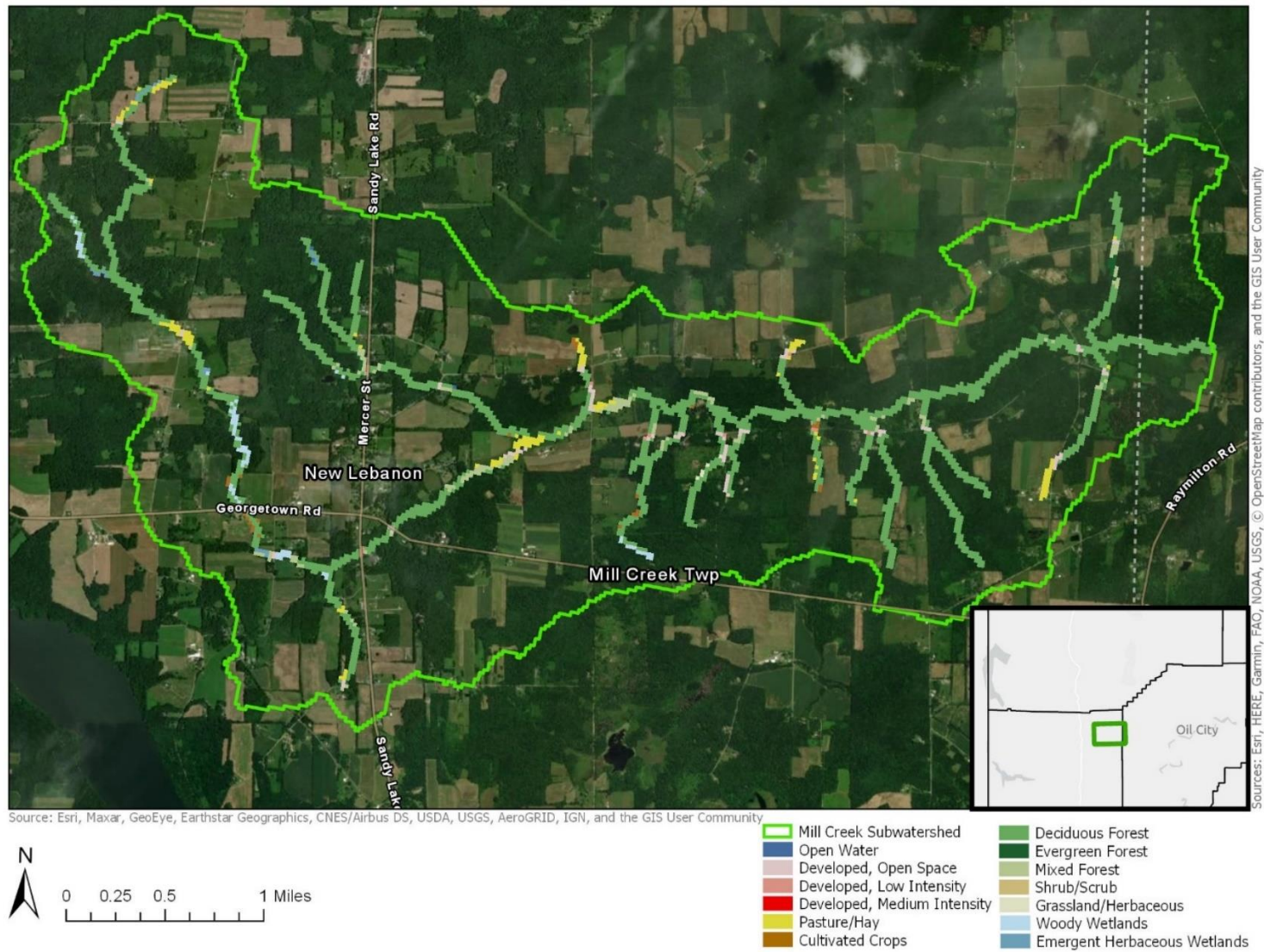


Figure 17. Riparian buffer analysis for the Mill Creek Subwatershed. A raster dataset of NLCD 2016 land cover is shown within 100 feet (geodesic) of either side of NHD flowlines. It was estimated that approximately 89% of non-water pixels within 100 feet of NHD flowlines was identified as forest, shrub/scrub or woody or emergent herbaceous wetlands.

Calculation of the TMDL_{Avg}

The mean annual sediment loading rate for the unimpaired reference subwatershed (Mill Creek) was estimated to be 170 pounds per acre per year (Table 8). This was substantially lower than the estimated mean annual loading rate in the impaired Carr Run Subwatershed (346 pounds per acre per year, Table 9). Thus, to achieve the loading rate of the unimpaired watershed, sediment loading in the Carr Run Subwatershed should be reduced to 1,170,069 pounds per year or less (Table 10).

Source	Area ac	Sediment lbs/yr	Unit Area Load, lbs/ac/yr
Hay/Pasture	1,017	68,377	67
Cropland	1,047	907,739	867
Forest and Shrub/Scrub	4,254	9,612	2
Wetland	50	108	2
Grassland/Herbaceous (Open Land)	31	2,384	76
Bare Rock	2	0	0
Low Intensity Mixed Development	358	3,597	10
Medium Intensity Mixed Development	3	298	103
High Density Mixed Development	0.2	25	125
Unpaved Roads ¹	8	6,989	867
Streambank ²		321,736	
Point Sources		144	
Riparian Buffer Discount ³		-169,256	
total	6,770	1,151,753	170

¹Unpaved roads were typically considered low intensity mixed development for Model My Watershed inputs, but based on site observations, it was assumed that they loaded sediment at a rate more comparable to croplands. Thus, after the model run, unpaved roads were subtracted from the low intensity mixed development values and added separately as the unpaved roads category, which was assumed to load at the rate of croplands.

²“Streambank” sediment loads were calculated using Model My Watershed’s streambank routine which uses length rather than area.

³Riparian buffer discount takes into account sediment reduction attributed to the extra buffering in the reference watershed.

Source	Area, ac	Sediment, lbs/yr	Unit Area Load, lb/ac/yr
Hay/Pasture	1,275	67,366	53
Cropland	2,107	1,889,952	897
Forest and Shrub/Scrub	3,099	5,956	2
Wetland	111	185	2
Grassland/Herbaceous (Open Land)	14	485	35
Bare Rock	2	0	0
Low Intensity Mixed Development	245	2,396	10
Medium Intensity Mixed Development	2	96	53
Unpaved Roads ¹	23	20,671	897
Streambank ²		395,074	
Point Sources		32	
total	6,878	2,382,213	346

¹Unpaved roads were typically considered low intensity mixed development for Model My Watershed inputs, but based on site observations, it was assumed that they loaded sediment at a rate more comparable to croplands. Thus, after the model run, unpaved roads were subtracted from the low intensity mixed development values and added separately as the unpaved roads category, which was assumed to load at the rate of croplands.

²“Streambank” sediment loads were calculated using Model My Watershed’s streambank routine which uses length rather than area.

Table 10. Calculation of an Annual Average TMDL Value for the Carr Run Subwatershed.			
Pollutant	Mean Loading Rate in Reference, lbs/ac/yr	Total Land Area in Impaired Watershed, ac	Target TMDL _{Avg} Value, lbs/yr
Sediment	170	6,878	1,170,069

Calculation of Load Allocations

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

$$LA = ALA + LNR$$

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

$$TMDL = MOS + WLA + LA,$$

then the load allocation is calculated as follows:

$$LA = TMDL - MOS - WLA$$

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

Margin of Safety

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

$$1,170,069 \text{ lbs/yr TMDL}_{Avg} * 0.1 = 117,007 \text{ lbs/yr MOS}_{Avg}$$

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 significant existing NPDES permittees with limits relevant to sediment. Thus, the wasteload allocation will consist solely of a 1% bulk reserve, which is a minor allowance for the insignificant existing dischargers, including the single-family residential wastewater treatment plants noted in Table 4 and any stormwater construction permits; as well as new sources.

Thus, the WLA was calculated as:

$$1,170,069 \text{ lbs/yr TMDL}_{\text{Avg}} * 0.01 = 11,701 \text{ lbs/yr bulk reserve}_{\text{Avg}} + 0 \text{ lb/yr permitted loads} = 11,701 \text{ lbs/yr WLA}_{\text{Avg}}$$

Since the wastewater treatment plants serving a single-family residences noted in Table 4 are estimated to only contribute a negligible 32 pounds of sediment per year, the bulk reserve will be more than sufficient to cover these facilities.

Load Allocation

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

$$1,170,069 \text{ lbs/yr TMDL}_{\text{Avg}} - (117,007 \text{ lbs/yr MOS}_{\text{Avg}} + 11,701 \text{ lbs/yr WLA}_{\text{Avg}}) = 1,041,361 \text{ lbs/yr LA}_{\text{Avg}}$$

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, non-agricultural herbaceous/grasslands bare rock, and developed lands and unpaved roads within the Carr Run Subwatershed were considered loads not reduced (LNR). LNR_{Avg} was calculated to be 29,789 lbs/yr (Table 11).

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

$$1,041,361 \text{ lbs/yr LA}_{\text{Avg}} - 29,789 \text{ lbs/yr LNR}_{\text{Avg}} = 1,011,572 \text{ lbs/yr ALA}_{\text{Avg}}$$

Table 11. Average Annual Load Allocation, Loads Not Reduced and Adjusted Load Allocation	
	Sediment, lbs/yr
Load Allocation (LA_{Avg})	1,041,361
Loads Not Reduced (LNR_{Avg}):	29,789
Forest	5,956
Wetland	185

Open Land	485
Low Intensity Mixed Development	2,396
Medium Intensity Mixed Development	96
Unpaved Roads	20,671
Adjusted Load Allocation (ALA_{Avg})	1,011,572

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

Calculation of Sediment Load Reductions

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

In this evaluation, croplands exceeded the allocable load by itself. Thus, it was given a greater reduction goal (63%) versus streambanks and hay/pasture lands (31%) (Table 12).

		Load Allocation	Current Load	Reduction Goal
Land Use	Acres	lbs/yr	lbs/yr	
CROPLAND	2,107	694,213	1,889,952	63%
HAY/PASTURE	1,275	46,231	67,366	31%
STREAMBANK		271,128	395,074	31%
AGGREGATE		1,011,572	2,352,392	57%

Note that consideration was given to the inclusion of the unpaved roads in the ALA. However, relative to agricultural lands and streambanks, they were estimated to be a substantially smaller sediment source, even with the assumption that they loaded at the rate of croplands. This is not meant to discourage the correction of problems associated with unpaved roads, especially considering the observation of their effect on high turbidity in one area (Figure 8). Furthermore, it should be noted that the model does not account for the spatial patterns of unpaved roads and the fact that they may be designed to drain

towards streams. Therefore, the present analysis might underestimate the effects of unpaved roads on water quality.

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

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

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

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

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

After calculating the 99th percentile load for the watershed, this value was increased slightly in each watershed to account for the assumption that dirt and gravel roads loaded at the rate of croplands, as described previously. This was accomplished by multiplying the 99th percentile loads by the same proportional increase as occurred under average daily conditions. Also, as with the average loading values reported previously (see the Hydrologic / Water Quality Modelling section), a correction was made for the additional amount of existing riparian buffers in the reference watershed versus the impaired watershed. This was calculated simply by reducing the 99th percentile loading rate for the reference watershed by the same reduction proportion calculated previously for the average loading rate. After making these corrections, the estimated daily maximum loading from the point sources shown in Tables 4 and 6 were added to the total load for each watershed.

Then, similarly to the TMDL_{Avg} value reported in Table 10, TMDL_{Max} was calculated as the 99th percentile daily load of the reference watershed divided by the acres of the reference watershed and then multiplied by the acres of the impaired watershed. Thus, the TMDL_{Max} loading rate was calculated as

61,330 pounds per day (Table 13), which would be an 57% reduction from the Carr Run Subwatershed’s current 99th percentile daily loading rate of 141,950 pounds per day.

Pollutant	99 th Percentile Loading Rate in Reference, lbs/ac/d	Total Land Area in Impaired Watershed, ac	Target TMDL _{Max} Value, lbs/d
Sediment	8.9	6,878	61,330

Also, in accordance with the previous “Calculation of Load Allocations” section, the WLA_{Max} would consist solely of a bulk reserve defined as 1% of the TMDL_{Max}.

The MOS_{Max} was defined as 10% of the TMDL_{Max}. The LA_{Max} was then calculated as the amount remaining after subtracting the WLA_{Max} and the MOS_{Max} from the TMDL_{Max}. See Table 14 for a summary of these TMDL_{Max} variables.

lbs/d:				
Pollutant	TMDL _{Max}	MOS _{Max}	WLA _{Max}	LA _{Max}
Sediment	61,330	6,133	613	54,584

Mapshed 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 26% of LA_{Avg} it was assumed that it was also 26% of LA_{Max}. While the distribution of sources likely changes with varying flow levels, this might be an acceptable assumption considering that the largest flow events may control the bulk of annual sediment loading (see Sloto et al. 2012). See Table 15 for a summary of the LA_{Max} variables.

	Annual Average (lbs/yr)	Proportion of Load Allocation	Max Daily (lbs/d)
Load Allocation	1,041,361		54,584
Loads Not Reduced	29,789	0.03	1,561

Adjusted Loads Allocation	1,011,572	0.97	53,023
Croplands	694,213	0.67	36,388
Hay/Pasturelands	46,231	0.04	2,423
Streambanks	271,128	0.26	14,211

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 26% of LA_{Avg} it was assumed that it was also 26% of LA_{Max}.

Because sediment loading varies so greatly with discharge, the TMDL_{Max} value would probably only be relevant on a handful of days each year with the highest flow conditions. And, while these times are especially important to overall annual sediment loading (see-Sloto and Olson 2011, Sloto et al. 2012), it is cautioned that reliance solely on a TMDL_{Max} value may not be protective of the Carr Run Subwatershed because chronic excessive sediment inputs occurring at lower discharge levels may be ignored. Take for instance an extreme scenario where the TMDL_{Max} was met every day but never exceeded. In this case, the annual sediment loading in the Carr Run Subwatershed would skyrocket to 22,385,545 lbs/yr, which is more than nine 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 Carr Run Subwatershed. Therefore, 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 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 99th percentile daily TMDL values. See the discussion of the relevance of these values in the previous section. Seeking to attain both of these values will be protective under both long-term average and extreme flow event conditions.

Recommendations

This document proposes a 51% reduction in annual average sediment loading for the Carr Run Subwatershed. To achieve this goal while maintaining a margin of safety and minor allowance for point sources, annual average sediment loading should be reduced by 63% from croplands and 31% each from hay/pasture lands and streambanks. The 99th percentile daily sediment loading should be reduced by 57%. 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.

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 12th, 2021 issue of the Pennsylvania Bulletin to foster public comment. A 30-day period was provided for the submittal of comments. No public comments were received.

Citations

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Evans, B.M. and K.J. Corradini. 2016. Mapshed Version 1.5 Users Guide. Penn State Institutes of Energy and the Environment. The Pennsylvania State University. University Park, PA 16802

Mapshed Version 1.5.1. Penn State Institutes of Energy and the Environment. The Pennsylvania State University. University Park, PA 16802

Multi-Resolution Land Characteristics Consortium. National Land Cover Database (NLCD 2016 and 2011). See <https://www.mrlc.gov/data>

Sloto, R. A. and L.E. Olson. 2011. Estimated Suspended -Sediment Loads and Yields in the French and Brandywine Creek Basins, Chester County, Pennsylvania, Water Years 2008-09. USGS Scientific Investigations Report 2011-5109. Available at <https://pubs.usgs.gov/sir/2011/5109/support/sir2011-5109.pdf>

Sloto, R.A., A.C. Gellis, and D.G. Galeone. 2012 Total Nitrogen and Suspended-Sediment Loads and Identification of Suspended-Sediment Sources in the Laurel Hill Creek Watershed, Somerset County, Pennsylvania, Water Years 2010-11. USGS Scientific Investigations Report 2012-5250. Available at <https://pubs.usgs.gov/sir/2012/5250/support/sir2012-5250.pdf>

Stroud Water Research Center (2021). Model My Watershed [Software]. Available from <https://wikiwatershed.org/> Technical Documentation available at: <https://wikiwatershed.org/documentation/mmw-tech/>

USDA National Agricultural Statistics Service Cropland Data Layer. (2020). Published crop-specific data layer [Online]. Available at <https://nassgeodata.gmu.edu/CropScape/> accessed (2021). USDA-NASS, Washington, DC

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

The listings found in the Integrated Water Quality Monitoring and Assessment Reports from 2008 to present were derived based on the Instream Comprehensive Evaluation protocol (ICE). Like the superseded SSWAP protocol, the ICE protocol called for selecting representative segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist was to select as many sites as necessary to establish an accurate

assessment for a stream segment; the length of the stream segment could vary between sites. The biological surveys were to include D-frame kicknet sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Collected samples were returned to the laboratory where the samples were 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 EPA Rapid Bioassessment Protocol III (RPB-III) and provides a more rigorous and consistent approach to assessing Pennsylvania's streams than the SSWAP.

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

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

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

Integrated List= Integrated Water Quality Monitoring and Assessment Report

SSWAP= Statewide Surface Waters Assessment Protocol

ICE= Instream Comprehensive Evaluation Protocol

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

The following are excerpts from the Pennsylvania DEP Section 303(d) narratives that justify changes in listings between the 1996-2002 303(d) Lists and the 2004 to present Integrated Water Quality

Monitoring and Assessment Reports. The Section 303(d) listing process has undergone an evolution in Pennsylvania since the development of the 1996 list.

In the 1996 Section 303(d) narrative, strategies were outlined for changes to the listing process. Suggestions included, but were not limited to, a migration to a Global Information System (GIS), improved monitoring and assessment, and greater public input.

The migration to a GIS was implemented prior to the development of the 1998 Section 303(d) list. Because of additional sampling and the migration to the GIS, some of the information appearing on the 1996 list differed from the 1998 list. Most common changes included:

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

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

Migration to National Hydrography Data (NHD)

New to the 2006 report is use of the 1/24,000 National Hydrography Data (NHD) streams GIS layer. Up until 2006 the Department relied upon its own internally developed stream layer. Subsequently, the United States Geologic Survey (USGS) developed 1/24,000 NHD streams layer for the Commonwealth based upon national geodatabase standards. In 2005, DEP contracted with USGS to add missing streams and correct any errors in the NHD. A GIS contractor transferred the old DEP stream assessment information to the improved NHD and the old DEP streams layer was archived. Overall, this marked an improvement in the quality of the streams layer and made the stream assessment data compatible with

national standards but it necessitated a change in the Integrated Listing format. The NHD is not attributed with the old DEP five-digit stream codes so segments can no longer be listed by stream code but rather only by stream name or a fixed combination of NHD fields known as reachcode and ComID. The NHD is aggregated by Hydrologic Unit Code (HUC) watersheds so HUCs rather than the old State Water Plan (SWP) watersheds are now used to group streams together. A more basic change was the shift in data management philosophy from one of “dynamic segmentation” to “fixed segments”. The dynamic segmentation records were proving too difficult to manage from an historical tracking perspective. The fixed segment methods will remedy that problem. The stream assessment data management has gone through many changes over the years as system requirements and software changed. It is hoped that with the shift to the NHD and OIT’s (Office of Information Technology) fulltime staff to manage and maintain SLIMS the systems and formats will now remain stable over many Integrated Listing cycles.

Appendix B: Model My Watershed Data Tables

Land Use	propprtion	Area (ha)
Hay/Pasture	0.19	516.5
Cropland	0.31	853.5
Wooded Areas	0.45	1254.9
Wetlands	0.02	44.8
Open Land	0.00	5.6
Barren Areas	0.00	0.7
Low Density-Mixed Development	0.00	10.3
Medium Density Mixed Development	0.00	0.7
High Density Mixed Development	0.00	0.0
Low Density Open Space	0.04	98.2

Table B1. “Model My Watershed” Land Cover Inputs for the Carr Run Subwatershed based on the 2020 Cropland Data Layer.

Land Use	Proportion	Area (ha)
Hay/Pasture	0.15	411.8
Cropland	0.15	424.0
Wooded Areas	0.63	1722.7
Wetlands	0.01	20.1
Open Land	0.00	12.7
Barren Areas	0.00	1.0
Low Density-Mixed Development	0.01	19.9
Medium Density Mixed Development	0.00	1.2
High Density Mixed Development	0.00	0.1
Low Density Open Space	0.05	128.4

Table B2. “Model My Watershed” Land Cover Inputs for the Mill Creek Subwatershed based on the 2020 Cropland Data Layer.

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	4.39	0.92	3.46	0	0.29	5.53
Feb	5.02	1.32	3.7	0	0.39	5.47
Mar	6.5	1.04	5.45	0	1.41	7.77
Apr	6.04	0.55	5.48	0	3.48	7.99
May	3.72	0.22	3.5	0	7.99	9.1
Jun	2.11	0.33	1.78	0	12.35	10.2
Jul	0.85	0.31	0.54	0	14	9.59
Aug	0.62	0.47	0.15	0	10.63	9.36
Sep	0.71	0.58	0.14	0	6.76	10.05
Oct	0.8	0.42	0.38	0	3.69	8.09
Nov	1.59	0.63	0.96	0	1.7	9.06
Dec	4.5	1.32	3.18	0	0.6	8.31
Total	36.85	8.11	28.72	0	63.29	100.52

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

Month	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	Point Src Flow (cm)	ET (cm)	Precip (cm)
Jan	4.54	0.79	3.74	0	0.3	5.53
Feb	4.98	1.14	3.84	0	0.41	5.47
Mar	6.37	0.88	5.5	0	1.48	7.77
Apr	5.99	0.46	5.54	0	3.59	7.99
May	3.88	0.17	3.71	0	7.99	9.1
Jun	2.27	0.26	2.02	0	12.35	10.2
Jul	0.96	0.24	0.72	0	13.59	9.59
Aug	0.63	0.38	0.25	0	10.26	9.36
Sep	0.68	0.5	0.18	0	6.65	10.05
Oct	0.79	0.34	0.45	0	3.79	8.09
Nov	1.64	0.52	1.11	0	1.77	9.06
Dec	4.63	1.15	3.47	0	0.62	8.31
Total	37.36	6.83	30.53	0	62.8	100.52

Table B4. "Model My Watershed" Hydrology Outputs for the Mill Creek Subwatershed.

Sources	Sediment (kg)
Hay/Pasture	30,551.30
Cropland	857,121.20
Wooded Areas	2,701.30
Wetlands	84
Open Land	219.8
Barren Areas	0
Low-Density Mixed	112.9
Medium-Density Mixed	43.4
High-Density Mixed	0
Low-Density Open Space	1,076.00
Farm Animals	0
Stream Bank Erosion	179,172.00
Subsurface Flow	0
Point Sources	0
Septic Systems	0

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

Sources	Sediment (kg)
Hay/Pasture	31,010.10
Cropland	411,673.00
Wooded Areas	4,359.00
Wetlands	49
Open Land	1,081.30
Barren Areas	0
Low-Density Mixed	223.8
Medium-Density Mixed	135.1
High-Density Mixed	11.3
Low-Density Open Space	1,444.30
Farm Animals	0
Stream Bank Erosion	145,912.00
Subsurface Flow	0
Point Sources	0
Septic Systems	0

Table B6. Model My Watershed Outputs for Sediment in the Mill Creek Subwatershed.

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

NHD Flowline COMID:	Length (miles):	ATTAINS ID:	Impairment Source:	Impairment Cause:	Date Listed As Impaired:
127346830	1.06	PA-SCR-127346830	AGRICULTURE	SILTATION	2016
127346853	0.46	PA-SCR-127346853	AGRICULTURE	SILTATION	2016
127346845	0.96	PA-SCR-127346845	AGRICULTURE	SILTATION	2016
127346859	0.55	PA-SCR-127346859	AGRICULTURE	SILTATION	2016
127346834	0.82	PA-SCR-127346834	AGRICULTURE	SILTATION	2016
127346812	1.15	PA-SCR-127346812	AGRICULTURE	SILTATION	2016
127346819	0.78	PA-SCR-127346819	AGRICULTURE	SILTATION	2016
127346856	1.03	PA-SCR-127346856	AGRICULTURE	SILTATION	2016
127346857	0.26	PA-SCR-127346857	AGRICULTURE	SILTATION	2016
127346841	0.15	PA-SCR-127346841	AGRICULTURE	SILTATION	2016
127346837	0.56	PA-SCR-127346837	AGRICULTURE	SILTATION	2016
127346831	0.17	PA-SCR-127346831	AGRICULTURE	SILTATION	2016
127346836	0.09	PA-SCR-127346836	AGRICULTURE	SILTATION	2016
127346828	0.08	PA-SCR-127346828	AGRICULTURE	SILTATION	2016
127346826	0.26	PA-SCR-127346826	AGRICULTURE	SILTATION	2016
127346840	1.65	PA-SCR-127346840	AGRICULTURE	SILTATION	2016
127346832	0.14	PA-SCR-127346832	AGRICULTURE	SILTATION	2016
127346827	0.20	PA-SCR-127346827	AGRICULTURE	SILTATION	2016
127346825	0.79	PA-SCR-127346825	AGRICULTURE	SILTATION	2016
127346914	0.08	PA-SCR-127346914	AGRICULTURE	SILTATION	2016
127346913	0.03	PA-SCR-127346913	AGRICULTURE	SILTATION	2016
127346839	1.08	PA-SCR-127346839	AGRICULTURE	SILTATION	2016
127346849	1.00	PA-SCR-127346849	AGRICULTURE	SILTATION	2016
127346850	0.50	PA-SCR-127346850	AGRICULTURE	SILTATION	2016
127346854	0.73	PA-SCR-127346854	AGRICULTURE	SILTATION	2016
127346822	0.07	PA-SCR-127346822	AGRICULTURE	SILTATION	2016
127346833	0.74	PA-SCR-127346833	AGRICULTURE	SILTATION	2016
127346855	0.13	PA-SCR-127346855	AGRICULTURE	SILTATION	2016
127346846	0.21	PA-SCR-127346846	AGRICULTURE	SILTATION	2016
127346835	1.05	PA-SCR-127346835	AGRICULTURE	SILTATION	2016
127346829	0.10	PA-SCR-127346829	AGRICULTURE	SILTATION	2016
127346824	0.52	PA-SCR-127346824	AGRICULTURE	SILTATION	2016
127346838	2.11	PA-SCR-127346838	AGRICULTURE	SILTATION	2016
127346820	1.63	PA-SCR-127346820	AGRICULTURE	SILTATION	2016
127346843	0.62	PA-SCR-127346843	AGRICULTURE	SILTATION	2016
127346848	0.20	PA-SCR-127346848	AGRICULTURE	SILTATION	2016
127346851	0.30	PA-SCR-127346851	AGRICULTURE	SILTATION	2016
127346844	0.17	PA-SCR-127346844	AGRICULTURE	SILTATION	2016
127346860	0.52	PA-SCR-127346860	AGRICULTURE	SILTATION	2016
127346823	0.48	PA-SCR-127346823	AGRICULTURE	SILTATION	2016

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 initial adjust	ALA: subtract reductions still needed from initial adjust	proportion Reduction
Cropland	1,889,952	yes	1,011,572		0.69	317,359	694,213	0.63
Hay/Pasture	67,366	no	67,366	462,440	0.05	21,135	46,231	0.31
Streambank	395,074	no	395,074		0.27	123,946	271,128	0.31
<i>sum</i>	2,352,392		1,474,012		1.00	462,440	1,011,572	0.57

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

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

Clean Water Act Requirements

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

Additionally, the federal Clean Water Act and the United States Environmental Protection Agency’s (EPA) implementing regulations (40 CFR 130) require:

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

Pennsylvania Clean Streams Law Requirements, Agricultural Operations

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

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

Appendix F: Comment and Response

No public comments were received.