DRAFT

Total Maximum Daily Load for Sediment in the Indian Creek Watershed, Montgomery County, Pennsylvania

US EPA Region 3
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- Chester County Water Resources Authority
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- Green Valleys Watershed Association
- U.S. Geological Survey
- Municipalities of the Indian Creek Watershed
    - Franconia Township
    - Lower Salford Township
    - Telford Borough
    - Souderton Borough

Executive Summary

The U.S. Environmental Protection Agency, Region 3 (EPA) is establishing a Total Maximum Daily Load (TMDL) for sediment for the Indian Creek Watershed in southeastern Pennsylvania. Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Planning and Management Regulations (codified at Title 40 of the *Code of Federal Regulations* Part 130) require a TMDL to be developed for those waterbodies identified as impaired by a state where technology-based effluent limits and other pollution controls do not provide for the attainment of water quality standards (WQS). A TMDL establishes a target for the total load of a particular pollutant that a waterbody can assimilate without exceeding water quality standards and divides that load into wasteload allocations (WLA), given to point sources, load allocations (LAs), given to nonpoint sources and natural background, and a margin of safety (MOS), which takes into account any uncertainty. Mathematically, a TMDL is commonly expressed as an equation, shown below.

$$\text{TMDL} = \Sigma\, WLAs + \Sigma\, LAs + MOS$$

The Indian Creek Watershed drains approximately seven square miles in Montgomery County, PA and includes portions of four municipalities. Various degrees of residential development (low, medium and high intensity residential) are scattered throughout the watershed while the middle portion is predominantly agriculture.

The TMDL was developed to address waterbodies in the Indian Creek Watershed listed on the state's 303(d) list as not attaining aquatic life uses due to siltation (sediment). The sediment TMDL was developed to protect the applicable designated uses of the watershed using the Generalized Watershed Loading Functions (GWLF) watershed model to meet sediment loading targets established through a reference watershed analysis.

The final sediment TMDL for the Indian Creek Watershed is expressed as annual loads and maximum daily loads in **Section 6** of the report. The sediment TMDL for the Indian Creek Watershed includes an implicit MOS to account for uncertainty in the modeling process.

The final TMDL will inform future National Pollutant Discharge Elimination System (NPDES) permits (re)issued in the watershed. PADEP is authorized to administer the NPDES Program, which, among other duties, includes issuing NPDES permits to existing or futures point sources subject to the NPDES program. The effluent limitations in any new or revised NPDES permits must be consistent with "the assumptions and requirements of any available [WLA]" in an approved TMDL pursuant to 40 CFR §122.44 (d)(1)(vii)(B). While the applicable permit effluent limits need not be identical to the WLA (See **Section 6.6**), EPA anticipates that future permits will include appropriate limits and other controls on sediment discharged, including requirements for Municipal Separate Storm Sewer System (MS4) communities to develop and implement short and long-term plans to control sediment in stormwater.

Public participation for this TMDL development process is discussed in **Section 8**. EPA is offering the public an opportunity to review and comment on the TMDL.

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List of Acronyms

CFR	Code of Federal Regulations
CN	Curve Numbers
CWA	Clean Water Act
EPA	United States Environmental Protection Agency
GIS	Geographic Information Systems
GWLF	Generalized Watershed Loading Functions
HSG	Hydrologic Soil Group
ha	Hectares
KLSCP	Product of USLE Parameters
LA	Load Allocation
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristics Consortium
MS4	Municipal Separate Storm Sewer System
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
PADEP	Pennsylvania Department of Environmental Protection
t	Tonnes or Metric Ton: 1 metric ton = 1.10231 US ton = 2204.62 pounds
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UA	Urbanized Area
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
WLA	Wasteload Allocation
WQLS	Water Quality Limited Segments
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

1 Introduction

This document establishes the Total Maximum Daily Load (TMDL) for sediment for the Indian Creek Watershed as required by Section 303(d) of the Clean Water Act (CWA) and its implementing Water Quality Planning and Management Regulations (codified at Title 40 of the *Code of Federal Regulations* Part 130). Certain waters within the Indian Creek Watershed were identified by the Pennsylvania Department of Environmental Protection (PADEP) as impaired for aquatic life uses due in part to siltation in the 2004 Integrated Report. These water quality limited segments (WQLS) remain listed as impaired, and thus still require a TMDL. This TMDL replaces the sediment TMDL established by the U.S. Environmental Protection Agency, Region 3 (EPA) on June 30, 2008, which was remanded back to EPA for further action on April 3, 2014. This document sets forth EPA's documentation and rationale for the development of a sediment TMDL that meets the statutory and regulatory requirements including but not limited to:

1. TMDLs are designed to implement applicable water quality standards.
2. TMDLs include wasteload allocations and load allocations, as appropriate.
3. TMDLs consider natural background sources.
4. TMDLs consider critical conditions.
5. TMDLs consider seasonal variations.
6. TMDLs include a margin of safety.
7. TMDLs have been subject to public participation.

2 Background

The CWA sets an overarching environmental goal that all waters of the United States be "fishable" and "swimmable." More specifically it requires states to establish appropriate uses (e.g. aquatic life, primary contact recreation, etc.) for their waters and adopt water quality standards (WQS) that are protective of those uses. The CWA also requires that every two years states develop – with EPA approval – a list of waterbodies that are impaired by pollutants and do not meet WQS. For those waterbodies identified on the impaired list, states are required to establish priority rankings and develop TMDLs. TMDLs are required for those waterbodies identified as impaired by a state where technology-based effluent limits and other pollution controls do not provide for the attainment of WQS.

A TMDL is essentially a "pollution diet" that identifies the maximum amount of a pollutant the waterway can receive and still meet WQS. A mathematical definition of a TMDL is written as the sum of the individual wasteload (WLAs) for point sources, the load allocation (LAs) for nonpoint sources and natural background, and a margin of safety, and commonly expressed as an equation, shown below.

$$\text{TMDL} = \Sigma\, WLAs + \Sigma\, LAs + MOS$$

2.1 History of the Indian Creek Watershed Nutrient and Sediment TMDLs

On June 30, 2008, EPA established nutrient and sediment TMDLs for the Indian Creek Watershed in southeastern Pennsylvania (*Nutrient and Sediment TMDLs for the Indian Creek Watershed, Pennsylvania Established by the U.S. Environmental Protection Agency*).[1]

The 2008 TMDLs assigned all sources to the wasteload allocation (WLA) category. EPA assigned wasteload allocations (WLAs) to three wastewater treatment plants (WWTPs): Telford Borough Authority, Pilgrim's Pride, and Lower Salford Township Authority - Harleysville sewage treatment plant and four municipal separate storm sewer system (MS4) jurisdictions: Lower Salford, Telford, Souderton, and Franconia. Each MS4 WLA represented the sediment loading based on land-uses within their political boundaries. EPA could not identify areas within MS4 political boundaries not serviced by the MS4s; therefore, EPA was unable to separate potential nonpoint source LAs from MS4 WLAs.

The 2008 TMDLs for the Indian Creek Watershed were established by EPA at the request of PADEP, and pursuant to requirements of the Pennsylvania TMDL Consent Decree, American Littoral Society v. EPA, Civil No. 96-489 (E.D.Pa.) (J. Katz). The consent decree required EPA to establish TMDLs for WQLSs identified on Pennsylvania's 1996 CWA section 303(d) list of impaired waters if Pennsylvania did not timely establish TMDLs for those waters. Pennsylvania identified Indian Creek on its 1996 list as a WQLS impaired for aquatic life uses by dissolved solids from municipal point sources and "other" which was changed to an unknown "cause" and "source unknown" in subsequent lists. Pennsylvania's 2004 list refined this listing as impaired by

[1] *Nutrient and Sediment TMDLs for the Indian Creek Watershed, Pennsylvania Established by the U.S. Environmental Protection Agency, June 30, 2008*, (USEPA 2008) accessed at: http://www.epa.gov/tmdl/nutrient-and-sediment-tmdls-indian-creek-watershed-pennsylvania

nutrients, identified the source as municipal point sources, and added an impairment for siltation with sources from agriculture, small residential runoff and urban runoff/storm sewers. Pennsylvania's 2004 list also prioritized TMDLs to be developed in 2005. EPA established the Indian Creek TMDLs to address WQLSs listed on Pennsylvania's 303(d) list that were not meeting aquatic life uses as a result of siltation (sediment) and nutrients. Please refer to the Indian Creek Watershed TMDLs (USEPA 2008) for further details.

The Indian Creek TMDLs have been challenged in two lawsuits. Plaintiffs Lower Salford Township Authority, Lower Salford Township, Franconia Sewer Authority and Franconia Township filed a Complaint against EPA for both nutrient and sediment TMDLs on October 18, 2011, *Lower Salford Township Authority et al. v. EPA*, Civil Action No. 2:11-cv-06489-CDJ (E.D.PA). In November 20, 2012, Telford Borough Authority filed an additional challenge to the Indian Creek nutrient TMDL, *Telford Borough Authority v. EPA*, Civil No. 2:12-cv-06548-CDJ (E.D. PA) (*Telford)*.

Based on requests for reconsideration of both nutrient and sediment TMDLs by the Telford Borough Authority and Lower Salford Township et al., EPA issued a decision[2] on March 21, 2014. For the nutrient TMDL, EPA considered the additional information and comments received, reviewed the nutrient TMDL in light of that information, and determined that the nutrient TMDL remained technically sound. EPA therefore denied the requests to withdraw the nutrient TMDL. For the sediment TMDL, EPA's analysis of the Indian Creek sediment TMDL confirmed concerns that the reference watershed approach and sediment loading rates used should be revisited. Based on that analysis, EPA filed a request dated April 1, 2014 seeking a voluntary remand without vacatur of the Indian Creek sediment TMDL in the case *Lower Salford Township Authority et al. v. EPA*, Civil Action No. 2:11-cv-06489-CDJ (E.D.PA). The U.S. District Court for the Eastern District of Pennsylvania granted that request for a remand by Order dated April 3, 2014.

Following the remand of the Indian Creek sediment TMDL, EPA contracted with Michael Baker and its subcontractor MapTech to assist EPA in developing a replacement sediment TMDL for the Indian Creek Watershed. The purpose of this work was to establish a watershed-based TMDL for sediment to address the siltation impairments in the Indian Creek Watershed. EPA has worked with a stakeholder group that has provided significant input on the existing sediment loads and allocation scenarios. The stakeholder group includes representatives from municipalities and WWTPs within Franconia Township, Lower Salford Township, Souderton Borough, and Telford Borough, as well as County Conservation Districts for Chester and Montgomery Counties, Montgomery County Planning Commission, Green Valleys Watershed Association, Pennsylvania Department of Transportation (PennDOT), Pennsylvania Turnpike Commission, PADEP, and EPA.

2 *March 21, 2014 Reconsideration Decision and Rationale: Nutrient and Sediment TMDLs for the Indian Creek Watershed, Pennsylvania Established by the U.S. Environmental Protection Agency, June 30, 2008*, (USEPA 2014) accessed at: http://www.epa.gov/tmdl/nutrient-and-sediment-tmdls-indian-creek-watershed-pennsylvania

2.2 Watershed Description

Indian Creek, a third-order stream with a drainage area of approximately seven square miles, flows 6.1 miles through areas of Montgomery County, Pennsylvania (**Figure 2-1)**. Approximately 27 tributaries, some of which are intermittent, drain to Indian Creek. Indian Creek Watershed includes portions of four municipalities and has 10 National Pollutant Discharge Elimination System (NPDES) permitted discharges. Various degrees of residential development (low, medium, and high intensity residential) are scattered throughout the watershed, while the middle portion is predominantly agriculture. Developed land uses such as commercial, residential, and road comprise 53 percent of the watershed while agriculture, open areas, and forest make up the remaining 27, 13, and 7 percent, respectively. Interstate 476 bisects the Indian Creek Watershed.

The mainstem of Indian Creek flows southwesterly and discharges to the East Branch Perkiomen Creek which flows into the Perkiomen Creek which is a tributary of the Schuylkill River which discharges to the Delaware River. The nearest U.S. Geological Survey (USGS) stream gauging station (01472810) is located on East Perkiomen Creek near Schwenksville. **Figure 2-1** shows the locations of gauge stations, NPDES permittees (except PennDOT and general construction permit discharges), PADEP sampling locations, and municipal boundaries.

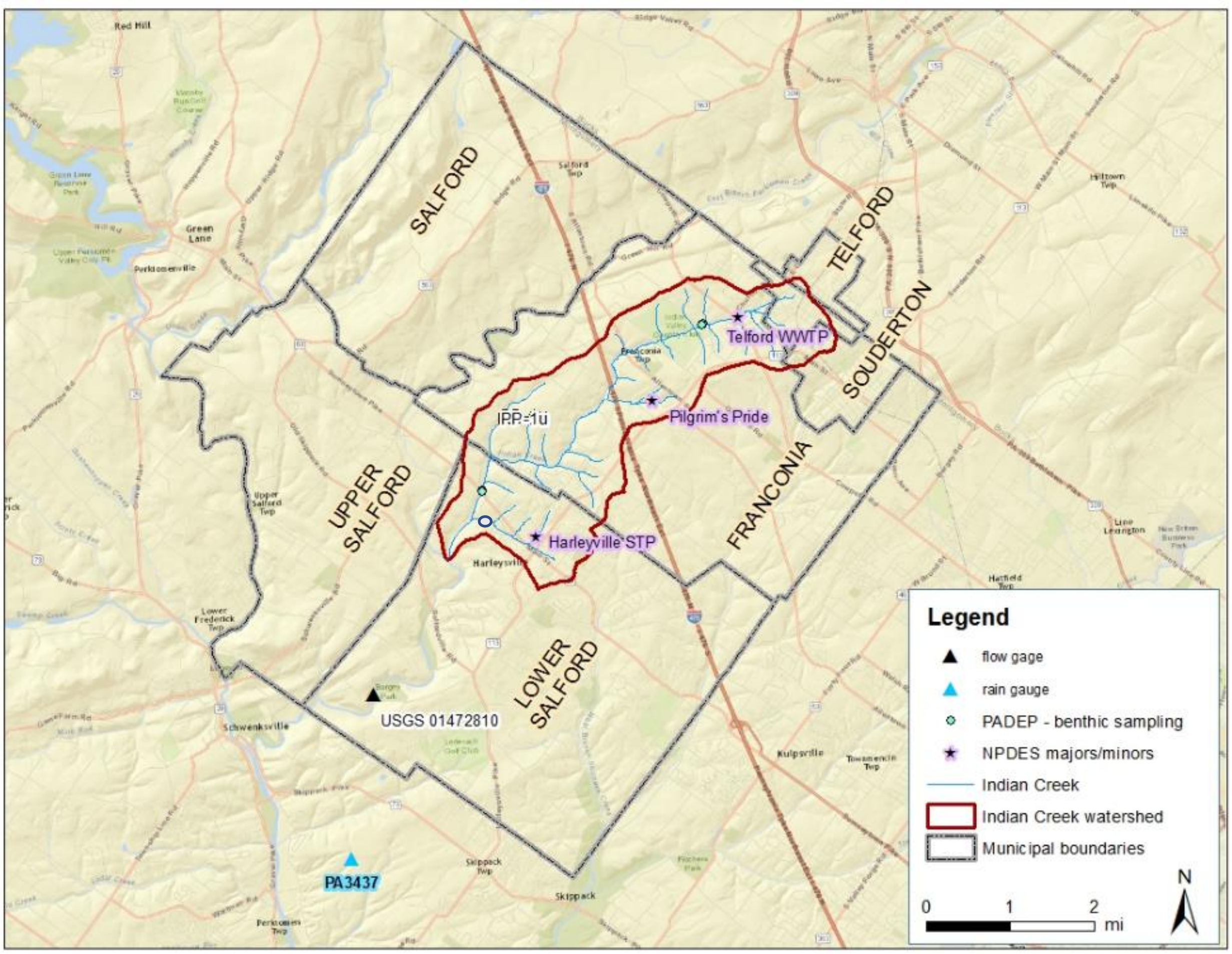

Figure 2-1. Site map of the Indian Creek Watershed.

The Indian Creek land use data provided by Franconia Township were used to generate land-use information for the entire watershed. Please refer to **Section 3.5** for more information. The resulting land use map is presented in **Figure 2-2**. Franconia Township's data layer lumped all agricultural land uses together under one title. Based on assessment of aerial photography and input from the Montgomery County Conservation District, the agricultural land use is predominantly cropland, with pasture and hay comprising less than five percent each of the total agricultural acreage.

Based on this analysis, residential is the dominant land use, comprising approximately 39.6 percent of the watershed, followed by agriculture (27.1), open areas (13.3), commercial (10.1), roads (3.0), and forest (6.9). Data provided by the Montgomery County Conservation District further segregated agricultural land into cropland (22.7), hay (2.5), and pasture (1.9).

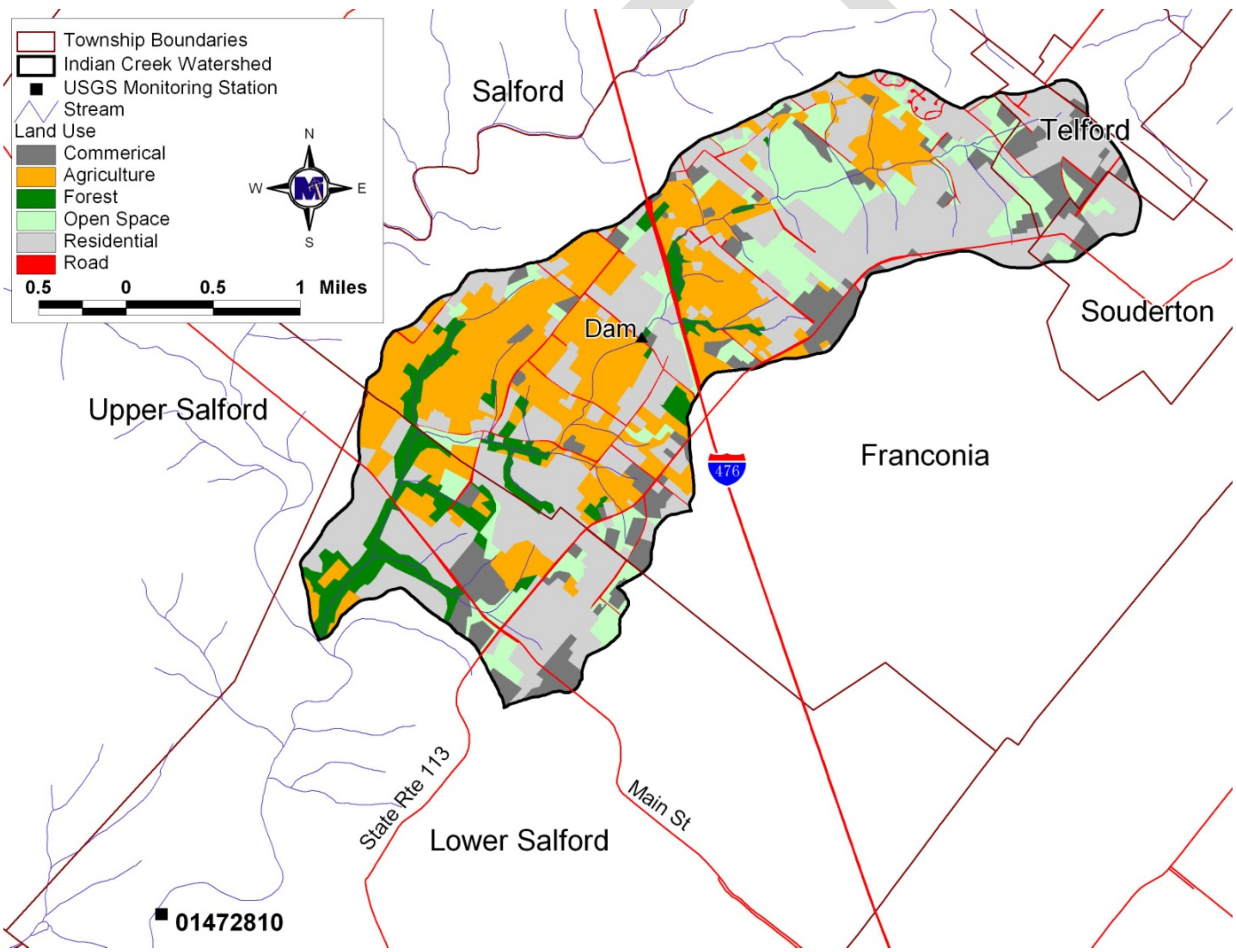

Figure 2-2. Land use distribution in the Indian Creek Watershed.

2.3 Pennsylvania's Water Quality Standards

A water quality standard (WQS) defines the water quality goals for a waterbody by designating the use or uses of the water, by setting criteria necessary to protect the uses, and by preventing or limiting degradation of water quality through antidegradation provisions. Criteria are "elements of State WQS, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use" (USEPA 1994).

Under Section 303(c) of the Clean Water Act (CWA) and its implementing regulations at 40 CFR 131, States and authorized Tribes have the primary responsibility to revise and adopt WQS. WQS are established to meet the objective set forth in Section 101(a) of the CWA which is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." CWA Section 101(a)(2) establishes a national goal in order to achieve the objective that "wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water."

Pennsylvania's WQS are set forth in Title 25, Chapter 93 of the Pennsylvania Code and implement sections 5 and 402 of the Commonwealth's Clean Streams Law and section 303 of the Federal CWA. Pennsylvania Water Quality Standards (25 PA Code Chapter 93, specifically §§§ 93.3, 93.4, and 93.9) designate water uses which shall be protected, and upon which the development of water quality criteria shall be based. Pennsylvania designates all state waters (unless specified otherwise) for aquatic life use, water supply, and recreation. **Table 2-1** shows the statewide and designated uses that apply to Indian Creek, which is a tributary to the East Branch Perkiomen Creek, pursuant to 25 PA Code § 93.4 and Chapter 93.9(f).

Table 2-1. Applicable designated uses for the Indian Creek Watershed.

Symbol	Protected Use	Description
		Aquatic Life (Statewide)
WWF	Warm Water Fishes	Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
		Aquatic Life (Designated)
MF	Migratory Fishes	Passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which move to or from flowing waters to complete their life cycle in other waters.
TSF	Trout Stocking	Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
		Water Supply (Statewide)
PWS	Potable Water Supply	Used by the public as defined by the Federal Safe Drinking Water Act, 42 U.S.C.A. § 300F, or by other water users that require a permit from the Department under the Pennsylvania Safe Drinking Water Act (35 P. S. §§ 721.1—721.18), or the act of June 24, 1939 (P. L. 842, No. 365) (32 P. S. §§ 631—641), after conventional

Symbol	Protected Use	Description
		treatment, for drinking, culinary and other domestic purposes, such as inclusion into foods, either directly or indirectly.
IWS	Industrial Water Supply	Use by industry for inclusion into nonfood products, processing and cooling.
LWS	Livestock Water Supply	Use by livestock and poultry for drinking and cleansing.
AWS	Wildlife Water Supply	Use for waterfowl habitat and for drinking and cleansing by wildlife.
IRS	Irrigation	Used to supplement precipitation for crop production, maintenance of golf courses and athletic fields and other commercial horticultural activities.
Recreation (Statewide)		
B	Boating	Use of the water for power boating, sail boating, canoeing and rowing for recreational purposes when surface water flow or impoundment conditions allow.
F	Fishing	Use of the water for the legal taking of fish. For recreation or consumption.
WC	Water Contact Sports	Use of the water for swimming and related activities.
E	Esthetics	Use of the water as an esthetic setting to recreational pursuits.

Pennsylvania does not have narrative criteria that expressly mention sediment. Instead, the General Criteria defined in Pennsylvania's WQSs (25 PA Code §93.6) provides narrative water quality criteria necessary to protect designated uses from any substances, including sediment, that may interfere with their attainment. The general water quality criteria state:

a) Water may not contain substances attributable to point or non-point 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.

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

Pennsylvania WQS regulations do not currently include numeric criteria for sediment. EPA used a reference watershed approach to develop the allowable loading rates to protect the aquatic life designated uses in Indian Creek.

2.4 Impaired Waterbodies

Excessive sediment has been identified as one of the leading causes of impairment of our nation's waters, and as contributing to the decline of populations of aquatic life in North America (USEPA, 2016). Sediment impacts aquatic life in streams and rivers through two pathways: 1) direct effects on aquatic life and 2) direct effects on physical habitat, which result in indirect effects on aquatic life (EPA, 2003).

Examples of direct effects on aquatic life include abrasion and suffocation of fish and macroinvertebrates, the clogging of filtration mechanisms thereby interfering with ingestion and respiration, and smothering and burial resulting in mortality and decreased survival in eggs and larvae. For instance, an increased supply of sediment to a streambed can cause the gravel interstices to fill in. This process can cause reduced fish and macroinvertebrate hatching due to the reduction in flow and dissolved oxygen through the streambed and also reduced larval survival because of armoring of the sediment surface, which traps the larvae.

Indirect effects on aquatic life will occur as community assemblages that rely upon aquatic habitat for reproduction, feeding, and cover are adversely affected by habitat loss or degradation. For example, indirect effects stemming from decreased light attenuation lead to changes in feeding efficiency and behavior (i.e., drift and avoidance); the sediment reduces visibility and prevents predators from finding prey. In addition, alterations of habitat stemming from changes in substrate composition affect the distribution of infaunal and epibenthic species by clogging the interstitial spaces between sand and gravel particles, increasing embeddedness, and reducing available habitat.

Sediment is composed of inorganic and organic particulate material that is transported through a stream in suspension and as bedload. Sources of sediment can be separated into two broad categories based on their origin: overland and stream channel. During wet weather events, sediment is transported overland from various land uses into streams. In addition, sediment from within the stream channel erodes into the stream when flowing water directly cuts and erodes the streambank and streambed. Although stream channel erosion is a natural process, elevated levels of erosion occur when large areas of impervious land without appropriate stormwater controls decrease infiltration and increase runoff volume and peak stormflows. This high and flashy stormflow leads to greater stream channel erosion, and therefore, more sediment within the stream. Sediment loads as a result of streambank erosion adversely affect aquatic habitat (USDI, 1998).

From both sources, sediment travels through suspension in the water column and is deposited on the streambed. Although overland sediment runoff and stream channel erosion represent two different source categories of sediment, the two forces work together to increase sediment within the stream and adversely impact aquatic life.

Reductions in sediment loads are expected to result from decreased watershed runoff and streambank erosion, which will then lead to improved benthic and fish habitat conditions. Streams have the capacity to move sediment downstream and eventually out of the watershed through natural attenuation as stormflows mobilize sediment from the streambed and transfer the sediment downstream over time. Thus, it is expected that after sediment loads are reduced (and the TMDL is met), the designated use will be restored. Specifically, sediment load reductions are expected to result in an increase in the number of benthic sensitive species present, an increase in the available and suitable habitat for a benthic community, a decrease in fine sediment, and improved stream habitat diversity, all of which will result in improved water quality.

Pennsylvania's 2015 *Assessment and Listing Methodology for Integrated Water Quality Monitoring and Assessment Reporting* documents the Commonwealth's cause definitions for water quality impairments, which are informative in interpreting Pennsylvania's narrative criteria. The cause definition for siltation (sediment) is:

> Siltation – aggradation of sediments or soils in excess of what the stream channel can transport. Results in smothering of streambed habitat for macroinvertebrates and fishes (PADEP, 2015).

Figure 2-3 shows Pennsylvania's impaired waters in the Indian Creek Watershed as presented in Pennsylvania's Final 2020 Integrated Report. Please refer to **Appendix B** for a table of the 303(d) list of siltation impaired waters in the Indian Creek watershed that are addressed by this TMDL.

In 2010, Pennsylvania identified Indian Creek on Category 4A of its Integrated Report as impaired waters with nutrient and sediment TMDLs developed in 2008. In their 2016 Integrated Report, Pennsylvania relisted Indian Creek and its tributaries on Category 5 as impaired for siltation due to the remand of the 2008 sediment TMDL. All listings on category 5 require TMDLs. This replacement Indian Creek Sediment TMDL covers all remaining siltation impairments on the 303(d) list within the Indian Creek watershed (i.e. those on Integrated Reporting Category 5).

EPA has considered the relevant and available sediment data in **Appendix C**. As stated above, all listings on category 5 of Pennsylvania's Integrated Report require a TMDL.

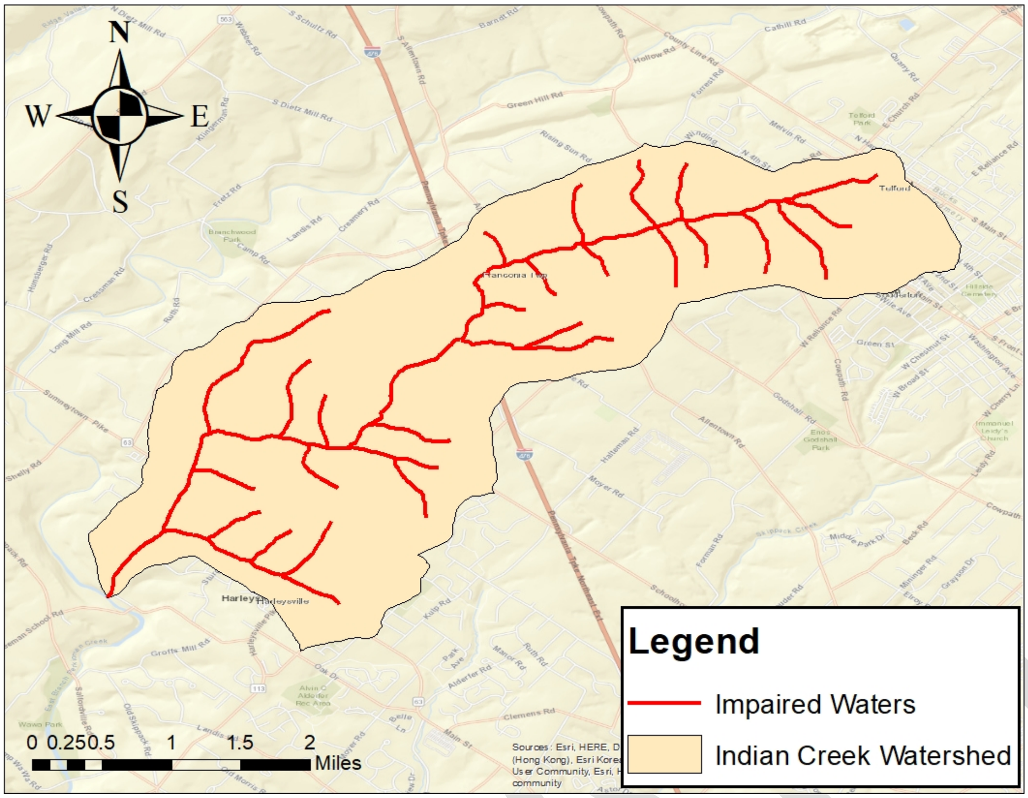

Figure 2-3. Impaired waters in the Indian Creek Watershed as presented in the 2020 Final Integrated Report.

2.5 Sediment TMDL Target

Pennsylvania WQS do not include numeric criteria for sediment. To develop an appropriate TMDL target for sediment, EPA used a reference watershed approach to estimate the total load of sediment that Indian Creek can assimilate and attain the applicable designated uses, including aquatic life. When implemented, this sediment target will ensure that excess sediment levels are not a cause of aquatic life impairment within Indian Creek.

2.5.1 Reference Watershed Approach

A reference watershed approach is used to estimate the necessary pollutant load reductions that are needed in Indian Creek to attain a healthy aquatic community and allow the streams in the watershed to achieve their designated uses. The reference watershed approach analyzes the current loading rates for the pollutants of interest from a selected unimpaired watershed that has similar physical and ecological characteristics to those of the impaired watershed. Characteristics that are considered include climate, soil properties, slope, watershed size and topography, ecoregion and stream size. Differences in land uses between the impaired and reference watersheds are displayed in **Table 2-3**. These land use differences relate to varying levels of development between the two watersheds and are typical when comparing impaired and reference watersheds. Land use differences do not impact the suitability of reference watersheds.

Birch Run represents a suitable reference watershed for the Indian Creek sediment TMDL due to similar watershed and soil characteristics and the attainment of its designated uses.

The objective of this process is to reduce the loading rate of sediment (or other pollutant) in the impaired stream segment to a level equivalent to or slightly lower than the loading rate in the unimpaired reference stream segment. Achieving the sediment loadings set forth in the TMDL will ensure that the designated aquatic life use of the impaired stream will not be degraded due to sediment.

For this sediment TMDL, the modeling process uses annual loads of sediment in the non-impaired, reference watershed as a target for load reductions in the impaired watershed. The impaired watershed is modeled to determine the current loading rates and establish reductions needed to meet the area-weighted loading rates of the unimpaired watershed.

2.5.2 Selected Reference Watershed and TMDL Target

Birch Run in Chester County, Pennsylvania was chosen as the reference watershed for the Indian Creek TMDL for sediment due to the shared watershed and soil characteristics. Birch Run is designated as an Exceptional Value stream in Pennsylvania. The Birch Run watershed and Indian Creek watershed are shown in **Figure 2-4** with watershed and soil characteristics displayed in **Table 2-2**.

On April 26, 2012, PADEP conducted benthic macroinvertebrate sampling and found that Birch Run had a maximum benthic macroinvertebrate index of biological integrity (IBI) score of 74.6 out of a possible 100. PADEP’s analysis showed that Birch Run is attaining the aquatic life use. Benthic macroinvertebrate sampling of Indian Creek by PADEP on September 6, 2013 showed a maximum IBI of 30.3 out of 100. Although several factors such as IBI score, sampling season, aquatic life designated use, and change from the baseline IBI score are used to determine if a site is impaired, an IBI score of around 50 or below will generally lead to an impairment determination. However, IBI scores above 50 can still lead to an impairment determination. Indian Creek’s IBI scores are all well below 50, thus showing that Indian Creek is not attaining the aquatic life use. Please see Chapter 2 of PADEP’s Assessment Methodology for River and Streams (2018) for more information on how impairment determinations are made.

EPA compared the Birch Run and Indian Creek watersheds and determined that they possessed similarities in watershed characteristics including size, climate, stream order, ecoregion location, slope and soil characteristics. Both the Indian Creek and Birch Run watersheds are completely within the Northern Piedmont Level III ecoregion, which is characterized by deep and well-developed soils of moderate to excellent fertility. While Indian Creek is located within the Triassic Lowland Level IV ecoregion, which is characterized by slightly less fertile soil, Birch Run is located within the Piedmont Lowlands Level IV ecoregion with very fertile soil that is intensely farmed; however, because the two watersheds share Level III ecoregions, the watersheds represent suitable matches. Both watersheds also share highly similar watershed and soil characteristics and thus represent excellent matches for sediment loading comparison. Please see **Table 2-2**. For example, watershed slope and aspect are nearly identical, which both represent factors that drive stormwater runoff, and therefore, sediment loading. In addition, the total sizes of the watersheds are similar and well within PADEP’s threshold of +/- 30 percent of watershed area, as shown in **Table 2-3**. Because the watersheds share the same stream orders and Level III ecoregions, benthic communities are expected to be comparable (EPA, 1999).

EPA, in consultation with PADEP, compared a number of other potential references watersheds and ultimately identified Birch Run as the most appropriate reference watershed for the Indian Creek Sediment TMDL. The other potential reference watersheds were not selected due to a variety of factors including the biological data to assess aquatic life being older than those in Birch Run and the watersheds differing significantly in size and other characteristics from Indian Creek.

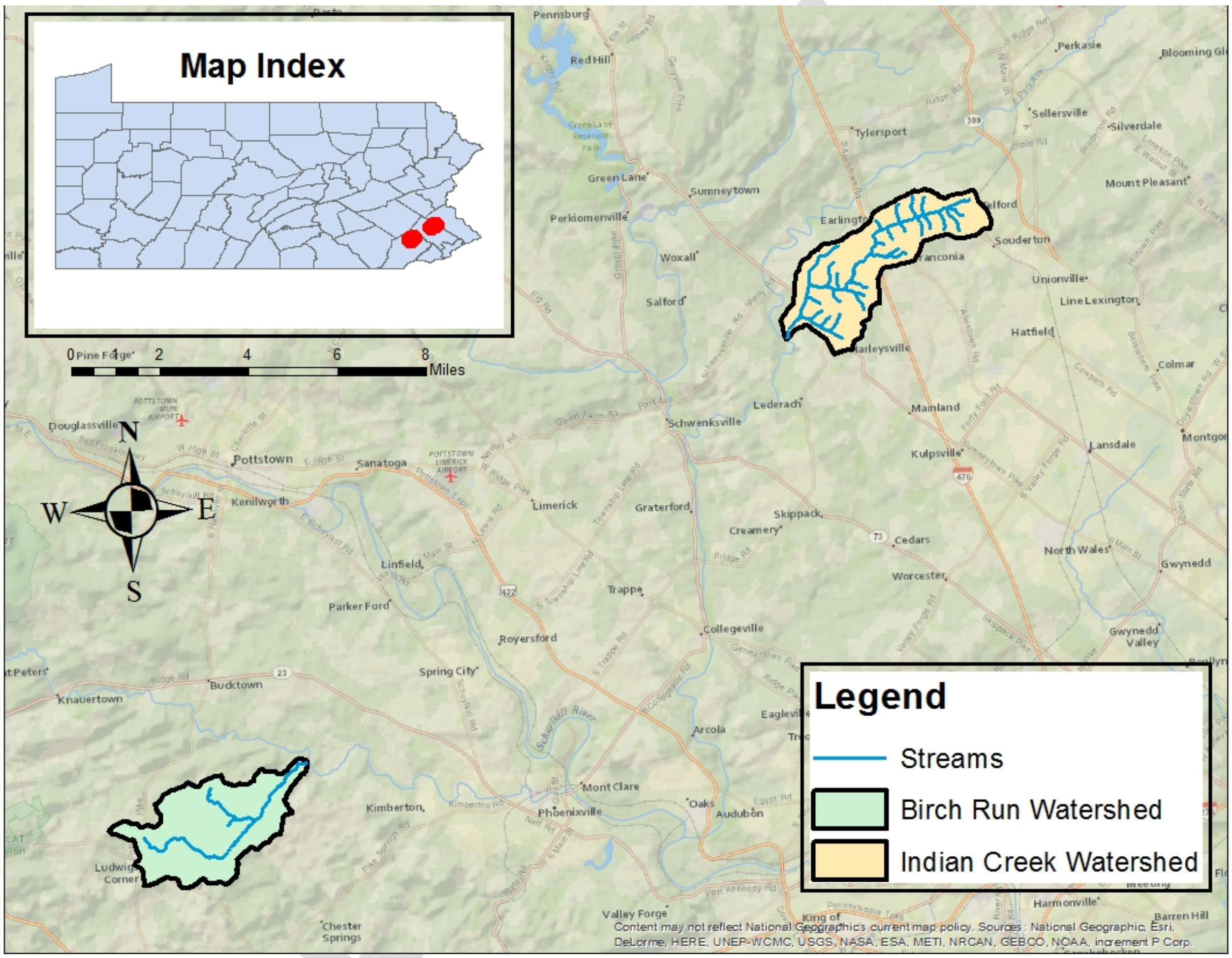

Figure 2-4. Location of Birch Run watershed in Chester County, Pennsylvania and Indian Creek Watershed in Montgomery County.

Table 2-2. Comparison of Indian Creek Watershed to Birch Run watershed.

Watershed Properties	Indian Creek	Birch Run
County	Montgomery	Chester
HUC (8-digit)	02040203	02040203
Discharges to Watershed	East Branch Perkiomen	French Creek
Square Miles	7	6.5
Benthic Macroinvertebrate IBI Score	30.3	74.6
IBI Date	9/6/2013	4/26/2012
Designated Uses	TSF, MF	EV, MF
Watershed Characteristics		
Stream Order	3	3
Slope (percent)	5.93	5.58
Aspect (degrees)	200.69	192.6
Soil Characteristics		
Hydrologic Group (avg)	2.75591	2.177083
Erodibility Kf factor	0.30033	0.426898
Available Water Capacity	0.116595	0.131346
Level 3 EcoRegion		
Northern Piedmont	100%	100%
Level 4 EcoRegion		
Triassic Lowlands	100%	1%
Piedmont Lowlands		99%

IBI: Index of Biotic Integrity; HUC: Hydrologic Unit Code
TSF: Trout Stocking Fishes; MF: Migratory Fishes; EV: Exceptional Value

Table 2-3. Land use areas in Indian Creek and Birch Run watersheds.

Sediment Source	Indian Creek (ac)	Indian Creek Percentage (%)	Birch Run (ac)	Birch Run Percentage (%)
Commercial	452	10.1	12	0.3
Crop	1,014	22.6	187	4.5
Forest	311	6.9	1,633	39.0
Hay	112	2.5	926	22.1
Open	594	13.3	179	4.3
Pasture	87	1.9	231	5.5
Residential	1,776	39.6	957	22.9
Road	134	3.0	24	0.6
Water	0	0.0	38	0.9
Watershed Total	**4,480**	**100**	**4,187**	**100**

3 Available Data

Since EPA established the 2008 sediment TMDL there has been an abundance of additional water quality and hydrology monitoring in the Indian Creek Watershed. While water quality and hydrology monitoring are ongoing even to this day, some monitoring activities are limited to a particular period of time. And while some data from these monitoring activities are readily available to EPA, other information is only available upon request. Since 2014, EPA made requests for additional information to various stakeholders in the watershed to support this TMDL development. EPA held three calls for local data including MS4 boundaries, land use/land cover, impervious surfaces, soils, topography, livestock numbers and best management practices including type, location, area treated, and efficiency. The first solicitation for data was held in December 2014 to January 2015 and requested local data for the Indian Creek Watershed. The second data call was held in February 2016 to March 2016 and requested local data for the reference watershed, Birch Run. The third data call was held in August 2017 and called for detailed MS4 sewershed boundaries. In addition, a final request for detailed MS4 sewershed boundaries was made in November 2020.

EPA received water quality and hydrology data collected by Pennsylvania Department of Environmental Protection (PADEP) and the United States Geological Survey (USGS). EPA obtained meteorological data from the National Climatic Data Center and from the North American Land Data Assimilation System. Land use data was obtained from a number of sources including: National Land Cover Data (NLCD) available through the Multi-Resolution Land Characteristics Consortium (MRLC), Franconia Township, Montgomery County Conservation District, and the Chester County Department of Computing and Information Services (DCIS). Discharge Monitoring Reports (DMRs) obtained from EPA and PADEP for certain NPDES permitted point sources were used to characterize discharges to the Indian Creek Watershed. MS4 Planning Areas were obtained by EPA from PADEP and MS4 communities. EPA also received maps, livestock numbers, permit information, photos, monitoring data, watershed plans, best management practices completed, conservation tillage data and stream channel surveys. The following is a list of the stakeholders that provided data for this study:

- Chester County Conservation District
- Chester County Department of Computing and Information Services (DCIS)
- Chester County Planning Commission
- Chester County Water Resources Authority
- Conservation Technology Information Center
- Franconia Township
- Green Valleys Watershed Association
- Lower Salford Township
- Montgomery County Conservation District
- PADEP
- Pennsylvania Department of Transportation (PennDOT)
- Pennsylvania Turnpike Commission
- Telford Borough Authority
- U.S. Geological Survey

This section provides an inventory of the data collected by EPA from various sources; and is only intended to present the breadth of the data collected to support the TMDL development. See **Section 5** for more information on the technical aspects of how the TMDL was developed.

EPA assembled the collected data into an inventory which was evaluated to determine the most suitable time period whereby the data was sufficient to give an accurate representation of the watershed (i.e., the "modeling period"). EPA selected the 1997-2004 as the modeling period due to the wealth of data available.

Although more information was available beyond the modeling period, it should not be interpreted that all inventoried data was used in the TMDL development. The modeling period of 1997-2004 is also not a limitation on what data was used, because wider ranges of information may have been necessary to support the modeling efforts, such as meteorological data after 2004. See **Section 5** for a discussion of the modeling approach and how the data was used. The inventory includes information about the source of the data, the location the data was collected, the type of data collected, and the range of dates for which the data was assembled for this effort (which may not be reflective of the actual time period for which data was collected especially in situations where data collection is ongoing). All data was reviewed for quality assurance purposes.

3.1 Hydrology

Streamflow data were not available on either the impaired stream (Indian Creek) or the reference stream (Birch Run). However, data from gauges on waterways directly downstream of the target watersheds were identified and used for calibration, which is common practice when developing a TMDL for an ungauged watershed (Yuan, 2013; Zhang and Kroll, 2007a; Cole et al. 2018). Where no gauge is available within the watershed, using a gauge outside of the watershed is appropriate so long as the gauge is representative of the target watershed in terms of regional characteristics and the estimated flows are adjusted to reflect the size of the target watershed. As such, the gauged watersheds described below were determined to be suitable surrogates for Indian Creek and Birch Run and the estimated flows were adjusted accordingly to reflect the target watersheds.

The entire watersheds draining to these monitoring locations were modeled, and these data were used to calibrate the hydrologic parameters used for modeling the impaired and reference streams. USGS station 01472810 on East Branch Perkiomen Creek near Schwenksville, PA, which is 2.5 miles downstream from the Indian Creek outlet, was used in calibrating Indian Creek, and has flow data available from 1/18/1991 to the present. USGS station 01472157 on French Creek near Phoenixville, PA, which is 1.5 miles downstream from the Birch Run outlet, was used in calibrating Birch Run, and has flow data available from 10/1/2007 to the present. Each station records and reports flow at 15-minute increments. The flow observations collected during the information gathering efforts are summarized in **Table 3-1**. Locations of the stream gauges are presented in **Figure 3-1**.

Table 3-1. Flow observations at USGS observation stations.

Station ID	Station Name	Drainage Area (mi^2)	No. of Obs.	First Date	Last Date
01472810	East Branch Perkiomen Creek, near Schwenksville, PA (for Indian Creek Watershed)	58.7	8,833	1/18/1991	3/25/2015
01472157	French Creek, near Phoenixville, PA (for Birch Run Watershed)	59.1	8,833	1/18/1991	3/35/2015

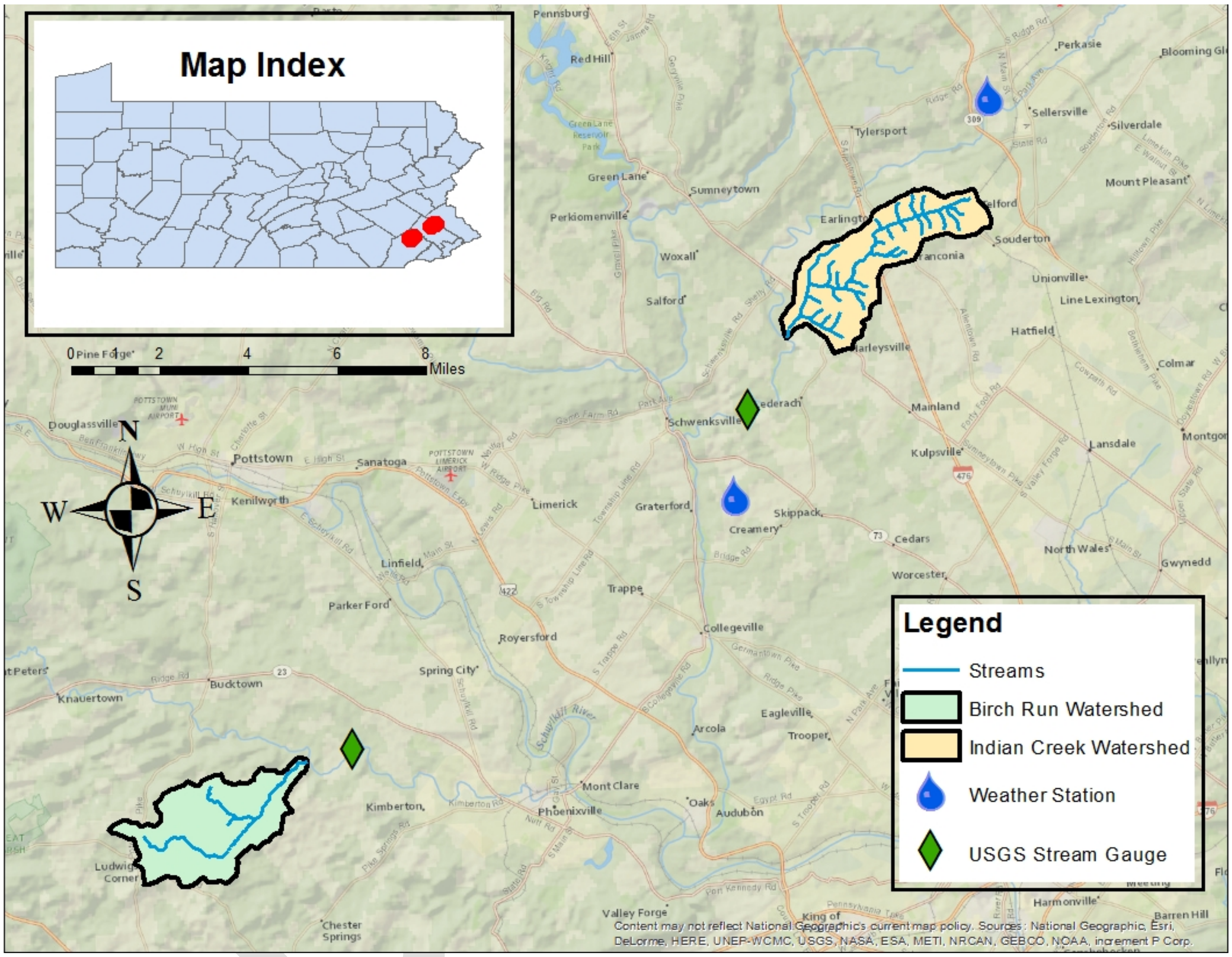

Figure 3-1. Location of USGS gauges used to collect streamflow data and weather stations used to collect precipitation data.

3.2 Meteorology

Meteorological data is a critical component of the watershed modeling effort because weather conditions drive the hydrology and associated water quality responses. Meteorological data for stations in the vicinity of the Indian Creek Watershed and Birch Run Watershed were available from the National Climatic Data Center (NCDC). The weather data include temperature, precipitation, and snow measurements, and other surface airways information (e.g., pressure and wind speed measurements). Daily precipitation data were available from the nearby Sellersville, PA (GHCND: USC00367938) and Graterford, PA (GHCND: USC00363437) weather stations as shown in **Figure 3-1**. These stations were deemed appropriate as they were the closest weather stations each within several miles of both watersheds with the required period of record and types of data needed. In addition, the stations were comparable in terms of amounts and timing of daily rainfall. The Sellersville precipitation data was used as the primary source. These data were supplemented with data from the Graterford weather station, where data were missing in the original set. Because the precipitation data provided at both stations were comparable, Graterford represents a suitable replacement. Data were available from the Sellersville station for the period of 10/2/1996 to 2/21/2015, and from the Graterford station for the period of 1/1/1994 to 9/5/2013. The NCDC weather stations used are shown in **Table 3-2**.

Table 3-2. NCDC weather stations located in the vicinity of the Indian Creek Watershed and Birch Run Watershed.

Station ID	Station Name	Elevation (m)	Percent Complete	Start Date	End Date	Temporal Scale
USC00367938	Sellersville, PA	92.0	99%	10/2/1996	2/21/2015	Daily
USC00363437	Graterford, PA	73.2	94%	1/1/1994	9/5/2013	Daily

3.3 Monitoring Data

3.3.1 Water Quality Data

During the information gathering efforts, EPA received water quality data for Indian Creek Watershed from PADEP and Franconia Township (Winter 2015). Birch Run Watershed water quality data were provided by PADEP and Green Valleys Watershed Association (Winter 2016). These data were examined and considered during TMDL development (Please see **Appendix C**).

3.3.2 Macroinvertebrate Data

In the Winters of 2015 and 2016, PADEP provided benthic macroinvertebrate and habitat data collected in Indian Creek and Birch Run (**Table 3-3**). Indian Creek showed a range of IBI scores from 17.6 – 30.3 out of 100, which indicates nonattainment of the aquatic life use. Birch Run showed a range of IBI scores from 72.3 - 74.6, which indicates that Birch Run is attaining the aquatic life use. Although several factors such as IBI score, sampling season, aquatic life designated use, and change from the baseline IBI score are used to determine if a site is impaired, an IBI score of around 50 or below will generally lead to an impairment determination. However, IBI scores above 50 can still lead to an impairment determination. Please see Chapter 2 of PADEP's Assessment Methodology for River and Streams (2018) for more information on how impairment determinations are made. In Winter 2016, Green Valleys Watershed Association also provided habitat assessment data for Birch Run collected in November 2012 to January 2013. EPA examined and considered these data; the results of which are described in **Appendix C**.

Table 3-3. Macroinvertebrate data from PADEP.

Stream	Location	Date	IBI
Indian Creek	Bergey Rd.	9/6/2013	21.4
Indian Creek	Rt. 63	9/6/2013	30.3
Indian Creek	Price Rd.	9/6/2013	28.9

Stream	Location	Date	IBI
Indian Creek	Bergey Rd.	4/15/2013	17.6
Indian Creek	Rt. 63	4/15/2013	24.2
Birch Run	Birch Run Rd.	4/26/2012	74.6
Birch Run	Buttonwood Rd.	4/26/2012	72.3

3.4 Discharge Monitoring Reports

A discharge monitoring report (DMR) is a standardized form submitted by point sources as required by their National Pollutant Discharge Elimination System (NPDES) permits, usually monthly. Not all point sources are required to submit DMRs and some may have less frequent submission of DMRs than monthly. EPA received DMR and permit information from PADEP for Lower Salford Township Authority - Harleysville sewage treatment plant, Telford Borough Authority, and Moyer & Sons Souderton Facility. DMRs show that the municipal WWTPs (listed in **Table 3-4**) contribute insignificant amounts of sediment to Indian Creek Watershed. The permitted effluent limitations for TSS were never exceeded in the monitored data. These DMRs were used to support the modeling effort. Copies of permits within the Indian Creek Watershed were also obtained from PADEP. There are no permitted facilities within the Birch Run Watershed.

Table 3-4. Summary of DMR data.

NPDES ID	Facility Name	Permit Type	Parameter	Monitoring Frequency	Obs	Average Design Flow (MGD)	Average Monitored Flow (MGD)	Average Monitored TSS (mg/L)	Date Range
PA0036978	Telford Borough Authority	Waste water	Flow, TSS	Monthly	22	1.1	0.68	4.41	1/2013 – 10/2014
Concentration Limits for TSS Average Monthly: 20 mg/L Average Weekly: 30 mg/L Instantaneous Maximum: 40 mg/L									
PA0024422	Lower Salford Township Authority, Harleysville STP	Waste water	Flow, TSS	Monthly	22	0.7	0.45	1.85	1/2013 – 10/2014
Concentration Limits for TSS Average Monthly: 30 mg/L Average Weekly: 45 mg/L Instantaneous Maximum: 60 mg/L									
PAR800012	Moyer and Sons Souderton Facility	General Stormwater	Flow, TSS	Biannual	2	NA	NA	15.2	8/2013 – 7/2014
This permit only required monitoring of TSS. The maximum monitored value was 26 mg/L.									

3.5 Land Use and Soil Geography Data

General land use and land cover data for the Indian Creek Watershed and Birch Run Watershed were initially obtained as National Land Cover Data (NLCD) available through the Multi-Resolution Land Characteristics Consortium (MRLC), a joint effort between EPA and USGS. After comparing the 2011 30-meter resolution MRLC/NLCD land use to aerial photography from similar years, it was determined that this land use dataset was not a good fit for the watersheds, as too much non-agricultural open space and residential yards were included in agricultural land uses. Instead, the land use data layers provided by local/county organizations were analyzed and determined to be a good fit, requiring few supplementary data.

EPA received GIS data for Indian Creek Watershed from Franconia Township, Lower Salford Township, Telford Borough Authority, PADEP, PennDOT, and Montgomery County Conservation District. Franconia Township also provided aerial photos. Birch Run Watershed GIS data was also received from Chester County Department of Computing and Information Services (DCIS) and PennDOT.

The Indian Creek land use data provided by Franconia Township was deemed most appropriate for this study and was extrapolated to cover areas of the watershed where the data did not extend. Using aerial photography, the methodology used to generate the Franconia Township data was analyzed. Then, by applying this methodology to the entire watershed, the land use for the remainder of the watershed was delineated based on aerial photography. This was a methodical process, through which land uses were classified based on aerial photography using the same classification scheme as was used in the original Franconia Township dataset. Land use shapefiles provided by the Chester County Department of Computing and Information Services were the basis of the Birch Run land use dataset as they were determined to be a good fit.

Additionally, supplemental data provided by the Montgomery County Conservation District further segregated agricultural land into cropland, hay, and pasture for the Indian Creek watershed while, for the Birch Run watershed, aerial photography was used to further delineate the agricultural land because the Chester County Conservation District was unable to provide that information.

Table 2-4 above summarizes the land use data for Indian Creek and Birch Run Watersheds. More detailed information regarding how land use was incorporated into the GWLF model is included in **Section 5**. Land use maps are provided in **Figure 5-2** and **Figure 5-3** for the Indian Creek and Birch Run watersheds, respectively.

3.6 Agriculture Data

3.6.1 Livestock Information

Livestock numbers for Indian Creek were provided by Montgomery County Conservation District (MCCD). Total livestock estimates included 40 sheep, 40 alpaca, veal (raised inside), 20 pheasants, 15 horses, pigs (raised inside) and 10 cattle. MCCD stated there was minimal livestock influence to waterways or streambank erosion because livestock do not have access to the streams within Indian Creek Watershed. Livestock are prevented access to streams by streambank fencing or housing of livestock underroof in barnyards or farm buildings.

Livestock numbers for Birch Run Watershed were based on a county-wide value of 0.98 animal-units/ha.

3.6.2 Conservation Tillage Data

Conservation tillage estimates for Montgomery County (Indian Creek) and Chester County (Birch Run) were provided by the Conservation Technology Information Center (CTIC, 2020). Estimates from 1998, 2000, 2002, and 2004 were very consistent (Table 2-B), so an average of these years was used. Reported percent of acreage in conservation tillage for Montgomery County and Chester County were 31.5 and 66.4 percent, respectively. Section 4.2.4 includes additional information on how conservation tillage data was incorporated into GWLF modeling.

Table 3-5. Percentage of crop area that is reported as being in conservation tillage (>30% residue).

Year	Montgomery County	Chester County
1998	27.8%	68.4%
2000	31.3%	65.5%
2002	31.3%	65.5%
2004	35.8%	66.0%

3.7 Stream Channel Survey

Since streambank erosion in the Indian Creek Watershed was anticipated to be a primary factor, EPA personnel performed a field survey to gain a better estimate of stream depth. Field surveys were conducted on December 30th, 2014 and December 21st, 2015 in the Indian Creek Watershed and the reference Birch Run Watershed, respectively. Stream bank height on both sides of the channel were surveyed at 14 and 11 locations in the Indian Creek and Birch Run watersheds, respectively. **Section 5.2.7** describes how the measured streambank heights were incorporated into the model and **Appendix A** provides further information and data regarding the stream channel surveys.

3.8 Best Management Practices

Montgomery County Conservation District identified multiple sites covered by the general permit for construction stormwater (PAG-02) within the Indian Creek Watershed, below. The PAG-02 permit details the requirements for best management practices (BMPs).

- Vistas at Highland Ridge (PAG2004603163)
- Clubview at Indian Valley (PAG2004603187R)
- Maloni Street Investors (PAG2004605211)
- Hopewell Christian Fellowship (PAG2004606205)
- Souderton Pool Complex (PAG2004610064)
- 840 Harleysville Pike (PAG2004614061)
- Telford Baseball Field

Montgomery County Conservation District also provided information on a Pennsylvania Stream Releaf project by Perkiomen Watershed Conservancy at Briarwyck Park in Lower Salford Township, which drains to a tributary of Indian Creek. This project included installation of almost two acres of native trees and shrubs to provide a riparian buffer for this stream.

In addition, Franconia Township provided information on the installation of a Rain Garden (40.313263, -75.365643) in 2014 and Riparian Buffer Plantings (40.298833, -75.379574) in 2009.

The aforementioned BMPs include but are not limited to: rain gardens, detention basins, restoration of buffers/landscapes/floodplains, soil amendments, street sweeping, rooftop disconnection, vegetated swales, pervious pavement, infiltration beds, natural area conservation, and infiltration basins. While these BMPs will reduce sediment being delivered to the stream, not enough information (e.g., land area treated and practice efficiency in removing sediment) was available to incorporate them into the model. Therefore, the estimated sediment loads presented in this TMDL do not take into account the reductions achieved through these BMPs. Consequently, these practices can and should be considered and accounted for as part of the implementation effort; whether those reductions are counted as progress towards achieving the nonpoint source load allocation or claimed by a permittee to count towards their permit requirements.

3.9 MS4 Planning Areas

Six MS4 permittees are found within the Indian Creek watershed, including four township and two transportation MS4s. To understand the area within the watershed serviced by the MS4s, and therefore regulated by PADEP under the associated permits, EPA collected maps of the MS4 Planning Areas from PADEP and the MS4 communities. MS4 Planning Areas represent the land area that drains to each MS4's sewer system to eventually be discharged into Indian Creek. It is expected that land outside of these MS4 Planning Areas drains directly to Indian Creek and is therefore considered part of the nonpoint source load allocation. Please see **Sections 4.1.2** and **6.2** for more information regarding how the estimated loads and allocations of the MS4s were calculated. Please see **Figure 4-1** for a map of the MS4 Planning Areas in the Indian Creek watershed.

4 Sediment Source Assessment

PADEP's 2020 Integrated Report identified the sources of sediment as agriculture, small residential runoff, and urban runoff/storm sewers. This section presents the information on point and nonpoint sources of sediment in the Indian Creek Watershed. Two source areas were identified as the primary contributors to sediment loading in Indian Creek and are the focus of this study – overland runoff and streambank erosion. Although the sediment-delivery process is a naturally occurring and continual process, it is accelerated in the Indian Creek watershed by human activity. Strategies to allocate sediment loadings to point and nonpoint sources, and in turn reduce sediment loadings to Indian Creek, are presented in **Section 6.2**.

4.1 Point Sources

A point source, according to 40 *Code of Federal Regulations* (CFR) 122.2, is any discernible, confined, and discrete conveyance, including any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, and vessel or other floating craft from which pollutants are or might be discharged. The NPDES program, established under CWA sections 318, 402, and 405, generally requires permits for the discharge of pollutants from point sources.

Permitted dischargers to the Indian Creek Watershed include continuous discharges from wastewater treatment plants (WWTP) with effluent discharge rates up to 1.1 million gallons per day (MGD) and stormwater discharges from MS4s and other stormwater dischargers. **Table 4-1** shows the permitted dischargers within the Indian Creek Watershed and their associated total suspended solids (TSS) limits, which require reduction of fine sediments, if applicable. Sediment loads from permitted dischargers are included in the WLA component of the TMDL, in compliance with 40 CFR§130.2(h). There are no permitted point sources in the Birch Run watershed.

Table 4-1. Permitted Sources in the Indian Creek Watershed.

Permit Number	Permit Name	Design Flow (MGD)	MS4 Planning Area (ac)	TSS Limit (mg/L)
General Stormwater Permit - Construction[1] PAG-02	General Permit for Construction Stormwater	NA	NA	NA
Individual				
PA0024422	Lower Salford Township Authority - Harleysville Sewage Treatment Plant	0.7	NA	30
PA0036978	Telford Borough Authority WWTP	1.1	NA	20
PA0054950	Pilgrim's Pride Facility (Franconia)	0.3	NA	10
MS4[1]				
PAG130147	Franconia MS4	NA	574	NA
PAG130133	Telford MS4	NA	187	NA
PAG130132	Souderton MS4	NA	108	NA
PAG130131	Lower Salford MS4	NA	701	NA
PAI-1315-00-06-0001	Pennsylvania Turnpike Commission	NA	33	NA
PAI-1315-00-05-0002	Pennsylvania Department of Transportation	NA	40	NA

1 Stormwater permits do not have TSS limits but instead require BMPs to ensure sediment limits are met.

4.1.1 Individual Wastewater Treatment Plants (WWTPs)

As shown in **Table 4-1**, there are three WWTPs within the Indian Creek Watershed. The Telford Borough Authority WWTP discharges 1.1 MGD and has a TSS limit of 20 mg/L. The Lower Salford Township Authority's Harleysville Sewage Treatment Plant discharges 0.7 MGD and has a TSS limit of 30 mg/L. The Pilgrim's Pride facility has been shut down, but the permit and associated TSS limit of 10 mg/L has been transferred to Franconia Township Authority.

4.1.2 Municipal Separate Stormwater Sewer Systems (MS4s)

MS4s are urban stormwater systems that carry stormwater through sewers to be directly deposited in streams via conveyance pipes. During dry periods, sediment from air or traffic builds up on impervious surfaces, and during precipitation events, is transported to streams by stormwater through MS4s. These stormwater discharges often contain high concentrations of pollutants. In addition, the large amount of impervious land found within MS4 communities leads to greater streambank erosion, as discussed in **Section 2.4**. Although streambank erosion is a natural process, elevated levels of erosion occur when large amounts of impervious land without appropriate stormwater controls decrease infiltration and increase stormwater runoff volume and peak stormflows. This high and flashy stormflow leads to greater streambank erosion, and therefore, more sediment within the stream. Streambank erosion represents a substantial source of sediment to Indian Creek due to the large amount of impervious cover found within (and without) of the MS4s. As a result, MS4s were assigned reductions in part based on their contributions to streambank erosion.

Additionally, management practices that allow mowing, paving, and building of material storage up to the edge of a stream cause stream bank instability. These practices prevent natural stream migration along the floodplain that allow room for flood waters to dissipate, which increases stream instability and streambank erosion.

Under the NPDES stormwater program, operators of large, medium, and regulated small MS4s must obtain authorization to discharge pollutants. The Stormwater Phase I Rule (55 Federal Register 47990, November 16, 1990) requires all operators of medium and large MS4s to obtain an NPDES permit and develop a stormwater management program. Medium and large MS4s are defined by the size of the population in the MS4 area, not including the population served by combined sewer systems. A medium MS4 has a population between 100,000 and 249,999; a large MS4 has a population of 250,000 or more. Phase II of the rule extends coverage of the NPDES Storm Water Program to certain small MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES Storm Water Program. Only a select subset of small MS4s, referred to as regulated small MS4s, require a NPDES stormwater permit. Regulated small MS4s include (1) all small MS4s in an UA as defined by the Bureau of the Census, and (2) those small MS4s outside a UA that are designated by NPDES permitting authorities.

Portions of the Indian Creek Watershed (approximately 35 percent) fall within four MS4 communities (Lower Salford, Telford, Souderton, and Franconia) and two transportation MS4s (the Pennsylvania Department of Transportation and the Pennsylvania Turnpike Commission). Another MS4 community, Upper Salford, is found in a small and insignificant portion of the watershed and is therefore excluded from WLA scenarios.

Each MS4 in Indian Creek is issued an individual NPDES permit by PADEP. Under the conditions in their permits, and in coordination with PADEP, each MS4 identified their MS4 Planning Area, which represents the land area that drains to their MS4 systems. This drainage is treated as a point source discharge and is therefore provided a WLA within this TMDL. Please see **Figure 4-1** for a map of the MS4 Planning Areas within the Indian Creek watershed**.**

EPA acknowledges that there are land areas within the political boundaries of the MS4 communities that drain directly to Indian Creek and therefore are not serviced by MS4 pipes or within their regulatory jurisdiction. EPA expects that those land areas are excluded from the MS4 Planning Areas and that the MS4 Planning Areas represent the entirety of land that drains to the MS4 systems.

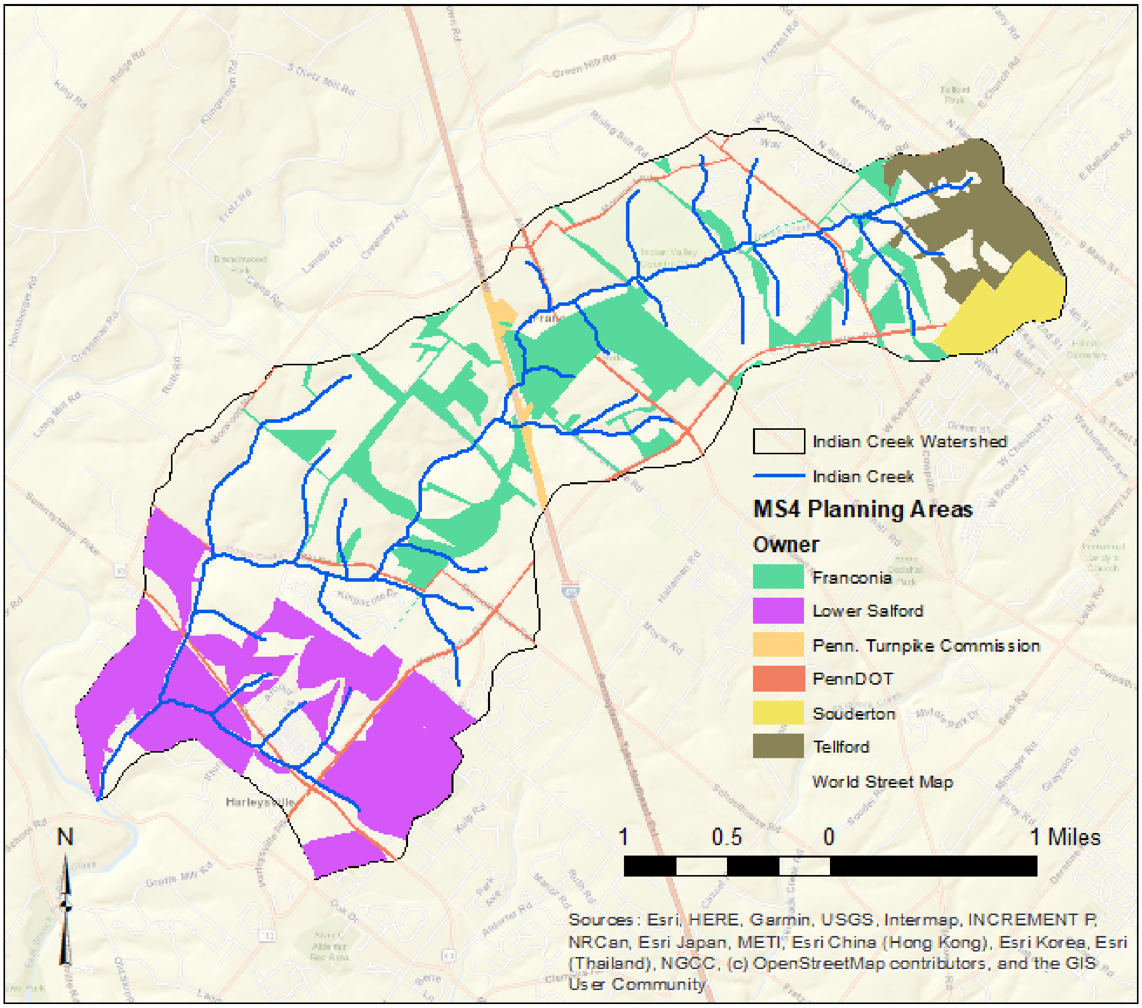

Figure 4-1. MS4 Planning Areas in the Indian Creek Watershed.

4.1.3 General Stormwater Permits - Construction

The general stormwater permit for discharges from construction sites do not have TSS limits and instead have best management practice (BMP) requirements. Permittees covered under the general stormwater permit for construction are often temporary in nature, meaning that additional permittees may be added under a general permit and current permittees may be removed over time. An aggregate reserve of the TMDL was allocated to construction stormwater discharges based on their expected loadings to the watershed at any given time, which are insignificant.

In addition to these permitted facilities within Indian Creek Watershed, stakeholders noted the Telford Baseball Field (5.6 ac) and Moyer & Son - Souderton Facility. Stormwater originating at the Telford Baseball field is discharged to the Telford MS4, and is consequently accounted for under that permit. The Moyer & Son - Souderton Facility is permitted for control of gas and oil only. Since it is not permitted for control of TSS, it is assumed that any TSS discharged is negligible and therefore not assigned a WLA.

4.1.4 Illicit Discharges

Another potential point source of sediment originates from uncontrolled discharges including illicit discharges such as straight pipes, illegal connections, etc. These illicit discharges can carry residential wastewater directly from homes to nearby waterbodies. While these are illegal, and are corrected when discovered, it is recognized that they typically continue to exist in watersheds across the country. Population, housing units, and type of sewage treatment from U.S. Census Bureau were calculated using GIS analysis. In the 1990 U.S. Census questionnaires, housing occupants were asked which type of sewage disposal existed at their location. Houses can be connected to a public sanitary sewer, a septic tank, a cesspool, or the sewage is disposed of in some other way. The Census category "Other Means" includes the houses that dispose of sewage other than by public sanitary sewer or a private septic system. The houses included in this category are assumed to be disposing of sewage via a straight pipe or other illegal connection. The TSS loading from these discharges is typically small and is not legal. This loading was accounted for in development of the existing loads for the watershed; however, no allocation was provided to illicit discharges or straight pipes since these connections are illegal and will be eliminated as detected. A TSS concentration from human waste was estimated as 320 mg/L (Lloyd, 2004) at 75 gallons of wastewater per day per person. Based on the analysis of Census data, it was estimated that there were 11 active illicit discharges used by 29 people in the Indian Creek Watershed and 4 active illicit discharges used by 13 people in the Birch Run watershed.

4.2 Nonpoint Sources

In addition to point sources, nonpoint sources contribute to water quality impairments in the Indian Creek Watershed. Nonpoint sources represent contributions from diffuse, non-permitted sources. Nonpoint sources can be precipitation driven and occur as runoff from common, widespread land uses, such as golf courses, agricultural lands, wooded areas, and other land uses. Nonpoint sources can also include runoff from more developed land uses such as commercial, road, or residential that drain directly to Indian Creek without first flowing through the MS4 sewer systems.

4.2.1 Surface Runoff

During runoff events (natural rainfall or irrigation), sediment is transported directly to streams from widespread land areas (e.g., agricultural fields, lawns, forest). Rainfall energy, soil cover, soil characteristics, topography, and land management affect the magnitude of this sediment loading. Agricultural management activities such as overgrazing (particularly on steep slopes), conventional tillage operations, livestock concentrations (e.g., along stream edge, uncontrolled access to streams), forest harvesting, and land disturbance due to mining and construction (roads, buildings, etc.) all tend to accelerate sediment loading from surface runoff at varying degrees.

Agricultural lands, forest, and open areas make up 27, 7, and 13 percent of the Indian Creek Watershed respectively and may represent non-permitted land areas (see **Table 5-1** in **Section 5.2.2**). Nonpoint sources of sediment within watersheds typically include surface runoff from these land uses; however, and as discussed in **Section 4.1.2**, a portion of these land uses may fall within the MS4 Planning Areas and are therefore provided WLAs. Alternatively, if loads from land uses typically considered developed such as commercial, residential, or road are not within the MS4 Planning Areas, these areas were determined to be nonpoint sources and prescribed load allocations.

4.2.2 Natural Background

Sources of natural background sediment loads include naturally occurring stream channel erosion and nonpoint source loadings from the different land uses that would occur under natural conditions (i.e. forest). The Birch Run reference watershed, in which there are no aquatic life use impairments, was used to account for natural background sediment loads expected in the Indian Creek Watershed as described in **Section 2.5**. Thus, by using the estimated sediment loads from Birch Run as targets for Indian Creek, natural background contributions are inherently included within the TMDL.

4.3 Other Water Quality Factors

There are other human activities that affect water quality in Indian Creek Watershed including a low-level dam.

4.3.1 Delp Dam at Keller Creamery Road Crossing in Franconia Township

The Delp Dam was located near Keller Creamery Road within Franconia township in the Indian Creek Watershed as shown in **Figure 2-2** and **Figure 4-2**. This dam was a low-level dam that has a small reservoir and minimal trapping capacity. During high flows, the dam did not slow the flow or delivery of sediment downstream. In June 2018 the Delp Dam was removed in a dam restoration project by American Rivers, the Pennsylvania Turnpike Commission and the Pennsylvania Fish and Boat Commission[3]. The concrete dam was removed as a compensatory mitigation for construction on the Northeast Extension of the Pennsylvania Turnpike. Dam removal could potentially have near-term and long-term impacts. Near-term impacts, due to the actual process of removing the dam, was minimized as much as possible, but it is possible that some sediment was delivered to the stream during dam removal. Long-term impacts would occur due to the absence of the reservoir behind the dam which provided some limited trapping capacity. However, since the reservoir and trapping capacity behind the dam is small, minimal long-term impacts are expected from removal of the dam. Removal of the Delp Dam was intended to provide environmental benefits to the Indian Creek watershed and opened 2,600 linear feet of Indian Creek and restored natural form and function to the stream to help support fish and wildlife habitat.

As the dam has been removed, the low-level dam at Keller Creamery Road was not specifically incorporated into the GWLF modeling. The hydrology calibration was based on a watershed without this dam.

[3] https://www.americanrivers.org/2018/08/a-story-of-woo-hoo-and-woah/

Figure 4-2. Photograph of the Delp Dam near Keller Creamery Road within Indian Creek Watershed. The Dam has since been removed.

5 TMDL Technical Approach

5.1 Sediment Modeling Framework

Computer modeling is used in this study as a tool for simulating the sediment loads to Indian Creek from various activities within the watershed. The sediment model used in this study was the *Visual Basic*^{TM} version of the Generalized Watershed Loading Functions (GWLF) model with modifications for use with ArcView (Evans et al., 2001). The GWLF model was developed at Cornell University (Haith and Shoemaker, 1987; Haith, et al., 1992) for use in ungauged watersheds. The model also included modifications made by Yagow et al., (2002) and BSE, (2003). GWLF is a widely accepted model that has been extensively used throughout the United States, and particularly in the Mid-Atlantic, for TMDL development. GWLF has been validated in a number of peer-reviewed studies, including Haith and Shoemaker (1987), Howarth et al. (1991), Swaney et al. (1996), Lee et al. (2000), and Schneiderman et al. (2002). GWLF is publicly available and the source code was developed and is available through Cornell University.

GWLF is a continuous simulation, spatially lumped model that operates on a daily time step for water balance calculations and monthly calculations for sediment and nutrients from daily water balance. The GWLF model was developed to simulate runoff, sediment, and nutrients in ungauged watersheds based on landscape conditions such as land use/land cover, topography, and soils. In essence, the model uses a form of the hydrologic units concept to estimate runoff and sediment from different pervious areas (hydrologic units) in the watershed (Li, 1975; England, 1970). In the GWLF model, the loading calculation for sediment is affected by land use activity (e.g., farming practices and development), topographic parameters, soil characteristics, soil cover conditions, stream channel conditions, livestock access, and weather. The model uses land use categories as the mechanism for defining homogeneity of source areas. A number of parameters are included in the model to index the effect of varying soil-topographic conditions by land use entities. The model considers flow input from both surface and groundwater. Land use classes are used as the basic unit for representing variable source areas. The calculation of stream-bank erosion, and the inclusion of sediment loads from point sources are also supported. As a loading function model, GWLF simulates runoff and sediment delivery using “simple, yet widely acceptable”, algorithms (EPA, 2005). These widely accepted model parameters make for reasonable estimates of sediment loading to Indian Creek. Consequently, GWLF is intended to be used without calibration.

The model uses daily precipitation records to simulate runoff based on the Natural Resources Conservation Service's Curve Number method (SCS, 1986). Erosion is calculated from a modification of the Universal Soil Loss Equation (USLE) (Schwab et al., 1981; Wischmeier and Smith, 1978). The portion of estimated erosion that reaches waterbodies is calculated based on a delivery ratio, which is calculated as a function of watershed area.

A reference watershed approach was used in this study to develop a sediment TMDL for Indian Creek. The numeric water-quality TMDL endpoint was based on the loading rate calculated for the reference watershed, Birch Run. The sediment TMDL was developed for the impaired watershed based on this endpoint and the results from load allocation scenarios.

5.1.1 GWLF Model Setup

Watershed data needed to run GWLF, and used in this study, were generated using GIS spatial coverage, local weather data, streamflow data, literature values, and other data. Subwatersheds are not required to run the GWLF model. For the sediment TMDL development, the total area for the reference watershed was equated to the area of the impaired watershed. To accomplish this, each land use category in the reference watershed was proportionately increased by a fixed ratio based on the relative size of the reference watershed to the impaired watershed as discussed in **Section 5.2.2**.

5.2 Sediment Source Representation – Input Requirements

The GWLF model was developed to simulate runoff and sediment in ungauged watersheds based on landscape conditions such as land use/land cover, topography, and soils. The following sections describe required inputs for the GWLF model.

5.2.1 Streamflow and Weather Data

The National Hydrology Dataset (NHD) was used to define stream reaches in both the impaired and reference watersheds.

Daily precipitation data were available from the nearby Sellersville, PA (GHCND: USC00367938) and Graterford, PA (GHCND: USC00363437) weather stations as shown in **Figure 5-1**. The Sellersville precipitation data was used as the primary source. These data were supplemented with data from the Graterford weather station, where data were missing in the original set. Data were available from the Sellersville station for the period of 10/2/1996 to 2/21/2015, and from the Graterford station for the period of 1/1/1994 to 9/5/2013. Please see **Section 3.2** for more information.

Streamflow data were not available on either the impaired stream (Indian Creek) or the reference stream (Birch Run). However, data from gauges on downstream waterways were identified and used for calibration. USGS station 01472810 on East Branch Perkiomen Creek, near Schwenksville, PA was used in calibrating Indian Creek, and has flow data available from 1/18/1991 to 3/25/2015. USGS station 01472157 on French Creek, near Phoenixville, PA, was used in calibrating Birch Run, and has flow data available from 1/18/1991 to 3/25/2015. Please see **Section 3.1** for more information. Locations of the stream gauges are presented in **Figure 5-1**.

The low-level dam at Keller Creamery Road was not specifically incorporated into the GWLF modeling. The hydrology calibration was based on a watershed without this dam. Therefore, the removal of this dam in 2018 did not have a direct impact on the hydrology model.

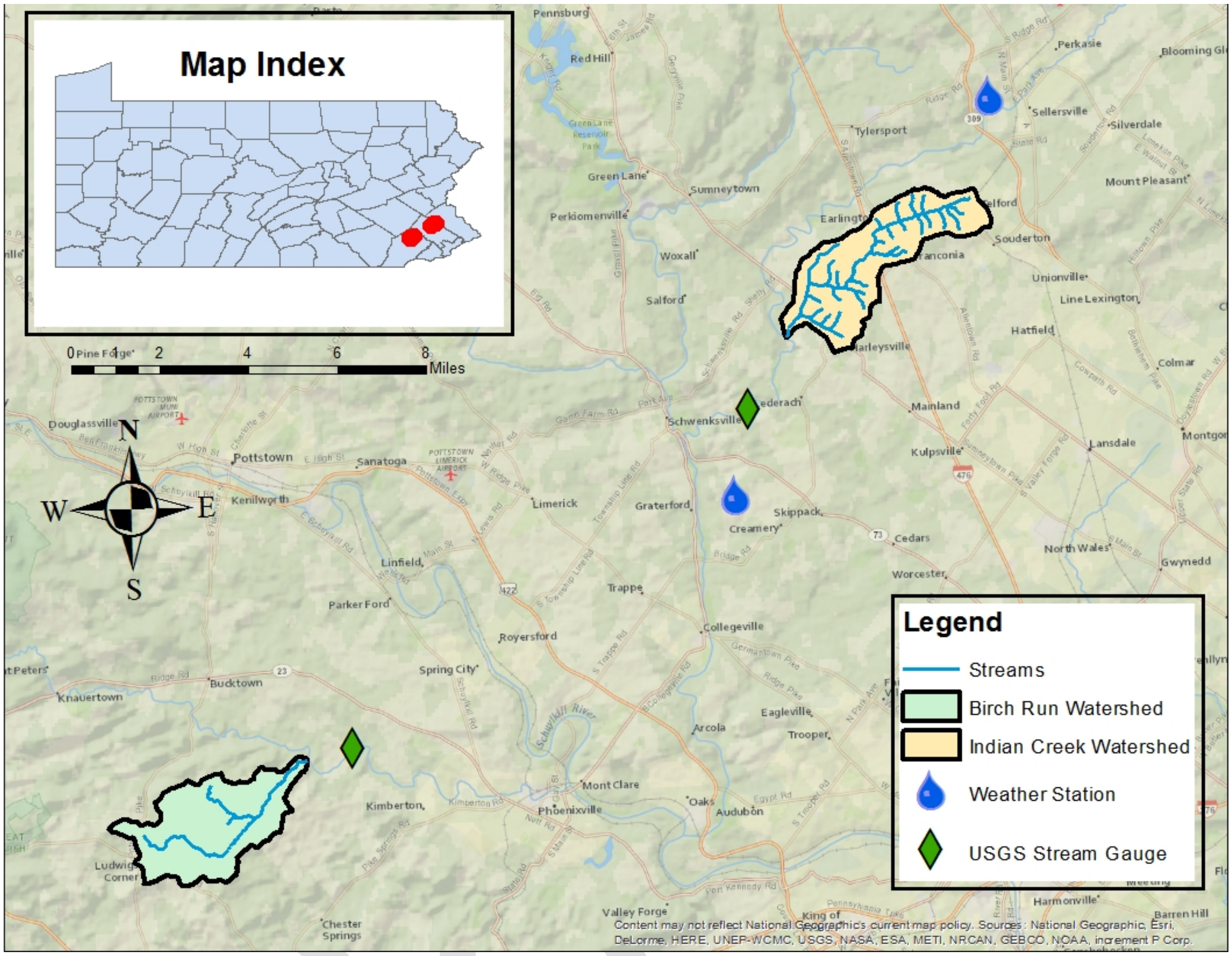

Figure 5-1. Location of weather stations used to collect precipitation data and USGS gauges used to collect streamflow data.

5.2.2 Land Use and Land Cover

Land use distributions for the Indian Creek Watershed and for the area-adjusted Birch Run watershed are given in **Table 5-1**. These areas were used for modeling sediment. Land use acreage for the reference watershed was adjusted up by the ratio of impaired watershed to reference watershed (1.07), maintaining the original land use distribution. The reference watershed was area-adjusted so that the associated modeled sediment load could be directly compared to the modeled sediment load in the Indian Creek watershed. Land use maps are provided in **Figure 5-2** and **Figure 5-3** for the Indian Creek and Birch Run watersheds, respectively. Please refer to **Section 3.5** for information regarding sources of the land-use data.

Table 5-1. Land use areas used in the GWLF model for Indian Creek and area-adjusted Birch Run watersheds.

Sediment Source	Indian Creek (ha)[1]	Area-Adjusted Birch Run (ha)[1]
Pervious Area:		
Commercial	73.2	2.6
Crop	410.3	81.1
Forest	126.0	707.2
Hay	45.3	400.8
Open	240.3	77.3
Pasture	35.2	100.2
Residential	539.1	352.3
Road	10.9	2.1
Water	0.0	16.5
Impervious Area:		
Residential	179.7	62.2
Commercial	109.9	2.6
Road	43.5	8.3
Watershed Total	**1,813**	**1,813**

[1] 1ha = 2.47 ac

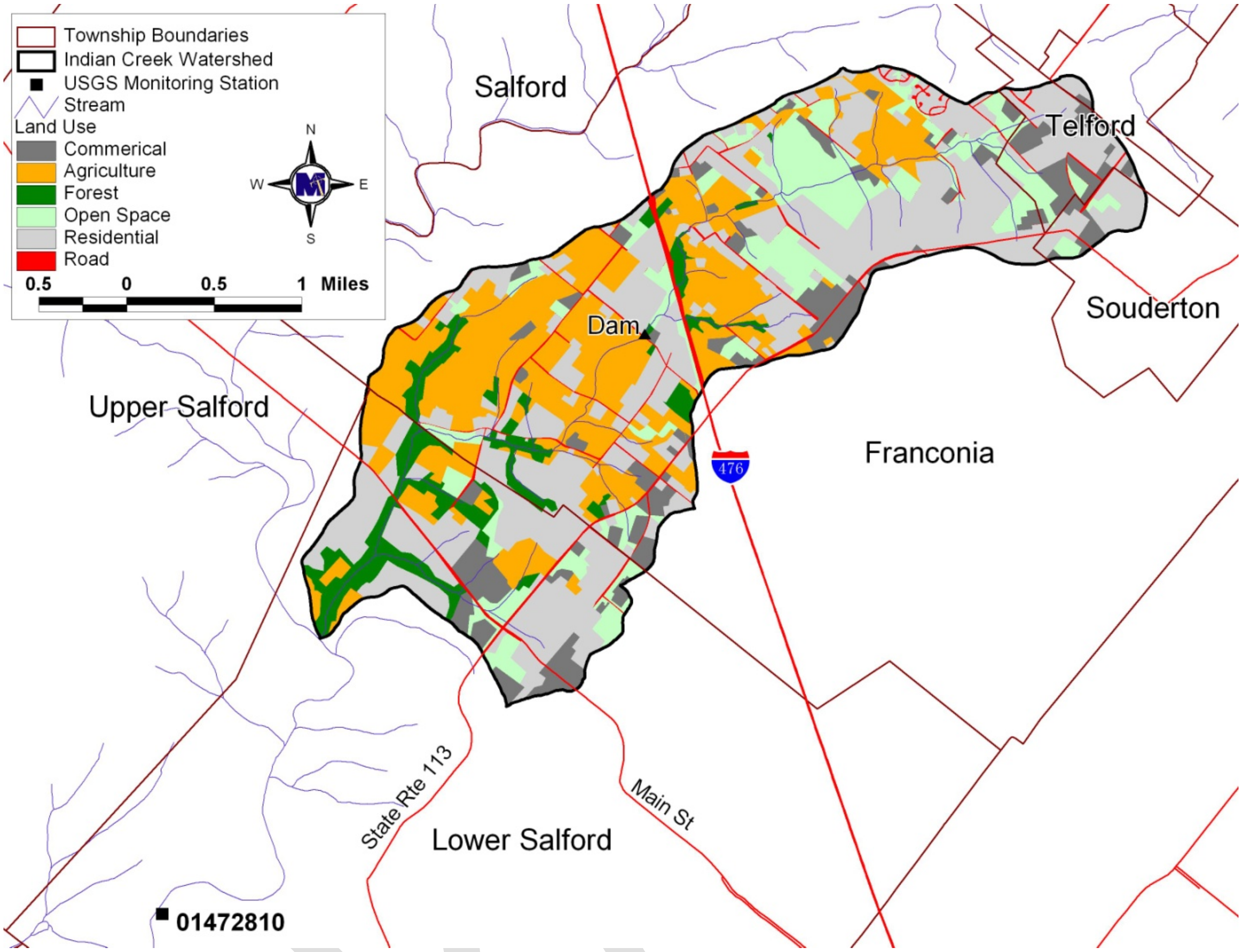

Figure 5-2. Land use distribution in the Indian Creek Watershed.

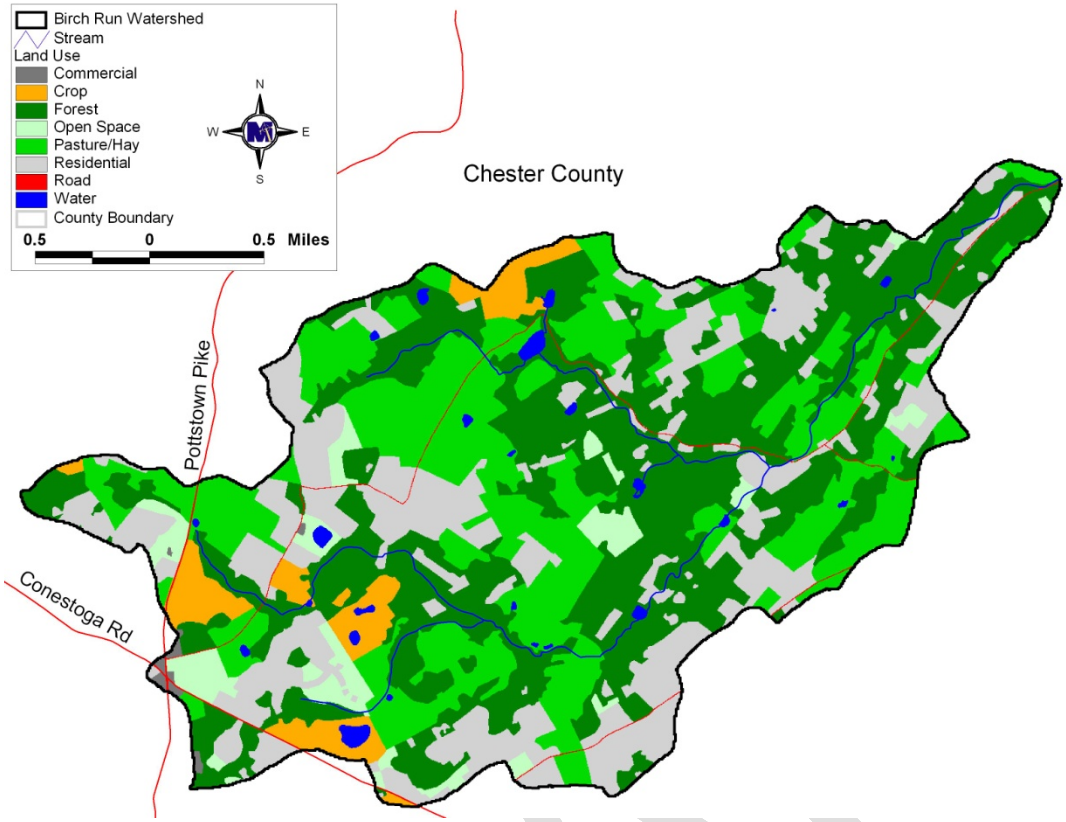

Figure 5-3. Land use distribution in the Birch Run watershed.

5.2.3. Accounting for Critical Conditions and Seasonal Variation

5.2.3.1 Selection of Representative Modeling Period

Selection of the modeling period was based on the availability of daily weather data, the need to represent variability in weather patterns over time in the watershed, and the desire to compare results from the earlier modeling effort. A long period of weather inputs was selected to represent long-term variability in the watershed. The model was run using a weather time series from October 1, 1997 to September 30, 2004, which was consistent with earlier modeling efforts. This time period was checked against more recent data to verify that it was representative of the local conditions, as shown in **Figure 5-4**.

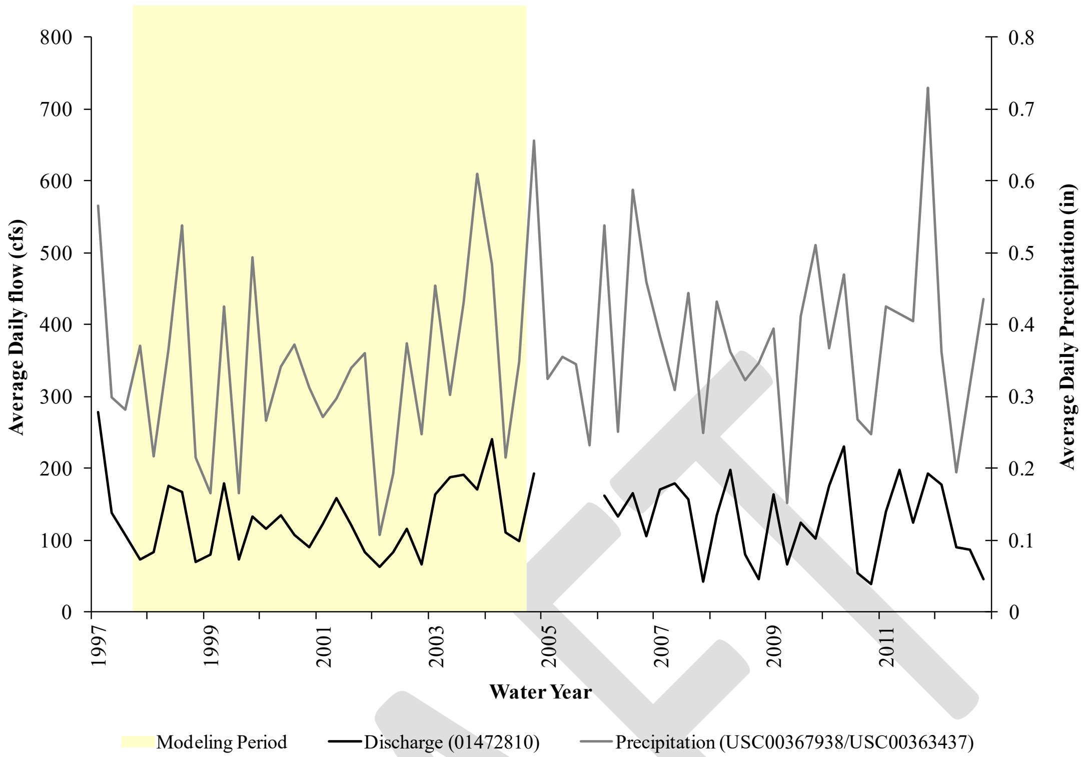

Figure 5-4. Comparison of average daily flow and precipitation between modeled period and more recent data, by quarter.

5.2.3.2 Critical Conditions

The GWLF model is a continuous simulation model that uses daily time steps for weather data and water balance calculations. The period of rainfall selected for modeling was chosen as a multi-year period that was representative of typical weather conditions for the area, and included "dry", "normal" and "wet" years. The model, therefore, incorporated the variable inputs needed to represent critical conditions during low flow – generally associated with wastewater point source loads – and critical conditions during high flow – generally associated with regulated stormwater and nonpoint source loads.

Because the impacts of sediment on aquatic life occur over time as the loading capacity of a stream becomes exceeded as a result of repeated stormflow events, the model considered critical conditions by capturing all storm events and the cumulative, long-term loading condition.

5.2.3.3 Seasonal Variability

The GWLF model used for this analysis considered seasonal variation through a number of mechanisms. Daily time steps were used for weather data and water balance calculations. The model also used monthly-variable parameter inputs for evapotranspiration cover coefficients, daylight hours/day, and rainfall erosivity coefficients for user-specified growing season months.

5.2.4 Sediment Parameters

Sediment parameters include USLE parameters erodibility factor (K), length/slope factor (LS), cover crop factor (C), and practice factor (P), sediment delivery ratio, and a buildup and loss functions for impervious surfaces. The product of the USLE parameters, KLSCP, is entered as input to GWLF. Soils data for the watersheds were obtained from the Soil Survey Geographic database. The K factor relates to a soil's inherent erodibility and affects the amount of soil erosion from a given field. The area-weighted K-factor by land use category was calculated using GIS procedures. Land slope was calculated from USGS National Elevation Dataset data using GIS techniques. The length of slope was estimated using GIS procedures developed by MapTech, Inc., which consider the path of flow in raster-based GIS. The area-weighted LS factor was calculated for each land use category using procedures recommended by Wischmeier and Smith (1978). The weighted C-factor for each land use category was estimated following guidelines given in Wischmeier and Smith, 1978, and GWLF User's Manual (Haith et al., 1992). The practice factor (P) was set at 1.0 for all, but croplands.

The cropland C-factor was adjusted using the estimates of conservation tillage from Montgomery County (Indian Creek) and Chester County (Birch Run). These estimates were provided by the Conservation Technology Information Center. Estimates from 1998, 2000, 2002, and 2004 were very consistent, so an average of these years was used.

Reported percent of acreage in conservation tillage for Montgomery County and Chester County were 31.5 and 66.4 percent, respectively. A C-factor of 0.51 and 0.20 was used to represent conventional tillage and conservation tillage, respectively. The weighted cropland C-factors are provided below:

C-factor for Indian Creek = 31.5% x 0.20 + 68.5% x 0.51 = 0.412

C-factor for Birch Run = 66.4% x 0.20 + 33.6% x 0.51 = 0.304

The P-factors used for crop land were the county average P-factors, as provided in GWLF-E software package (Evans and Corradini, 2016). The cropland P-factors are provided below:

P-factor for Indian Creek = 0.76

P-factor for Birch Run = 0.45

5.2.5 Sediment Delivery Ratio

The sediment delivery ratio specifies the percentage of eroded sediment delivered to surface water outlet and is empirically based on watershed size. The sediment delivery ratios for impaired and reference watersheds were calculated as an inverse function of watershed size (Evans et al., 2001). The value used for Indian Creek and area-adjusted Birch Run watersheds was 0.18, which indicates that approximately 18 percent of eroded soil is delivered to the outlet of the watershed.

5.2.6 SCS Runoff Curve Number

The runoff curve number is a function of soil type, antecedent moisture conditions, and cover and management practices. The runoff potential of a specific soil type is indexed by the Hydrologic Soil Group (HSG) code. Each soil-mapping unit is assigned HSG codes that range in increasing runoff potential from A to D. The HSG code was given a numerical value of 1 to 4 to index HSG codes A to D, respectively. An area-weighted average HSG code was calculated for each land use/land cover from soil survey data using GIS techniques. Runoff curve numbers (CN) for HSG codes A to D were assigned to each land use/land cover condition for antecedent moisture condition II following GWLF guidance documents and SCS, 1986 recommended procedures. The runoff CN for each land use/land cover condition then was adjusted based on the numeric area-weighted HSG codes.

5.2.7 Parameters for Channel and Streambank Erosion

Parameters for streambank erosion include animal density, total length of natural stream channel, fraction of developed land, mean stream channel depth, average watershed curve number, average watershed erodibility, and average watershed slope. The Montgomery County Conservation District informed EPA that no animals are given stream access to Indian Creek, so animal density was determined to be zero. In Birch Run, livestock numbers were based on a county-wide value of 0.98 animal-units/ha. These estimates were confirmed by Chester County Conservation District.

The total length of the natural stream channel was estimated from USGS National Hydrography Dataset coverage using GIS techniques. The mean stream channel depth is typically estimated as a function of watershed area, using USGS regional curves. In areas where streambank erosion is a contributing, but less significant factor with regard to sediment delivery in the watershed, this is a viable option. However, because streambank erosion in the watershed was anticipated to be a primary factor, EPA personnel performed a field survey to gain a better estimate of stream depth.

EPA personnel measured the stream bank height on both sides of the channel at 14 and 11 locations in the Indian Creek and Birch Run watersheds, respectively (**Appendix A**). The measurements were averaged in each watershed. The results of both the USGS calculation and the EPA survey can be seen in **Table 5-2**. The USGS regional curves are based on properly functioning streams (*i.e.*, not exhibiting excessive streambank erosion). As expected, the actual measured stream bank heights were larger in both streams, reflecting the ongoing erosion process. Therefore, these EPA field results for stream channel depth were used instead of USGS regional values for a more accurate and site-specific estimate.

EPA's stream bank height estimates in Birch Run are above the USGS estimates suggesting that streambank erosion in Birch Run is elevated due to human activities and development. However, attaining biological assessments in Birch Run suggest that some accelerated streambank erosion can still allow for good biological conditions. This is consistent with the modeling effort and final TMDL since the TMDL allocations are based off the sediment loads from Birch Run watershed.

Table 5-2. Calculated and measured stream bank heights in Indian and Birch Run.

Average Stream Bank Height	Indian Creek (m)	Birch Run (m)
USGS Calculation	0.27	0.27
EPA Survey	1.50	0.66

5.2.8 Evapotranspiration Cover Coefficients

GWLF estimates evapotranspiration from available moisture in the unsaturated zone, potential evapotranspiration, and a cover coefficient. Potential evapotranspiration is estimated from a relationship to mean daily temperature and the number of daylight hours. Evapotranspiration cover coefficients were entered by month. Monthly evapotranspiration cover coefficients were assigned each land use/land cover condition following procedures outlined in Novotny and Chesters (1981) and GWLF guidance. Area-weighted evapotranspiration cover coefficients were then calculated for each sediment source class. These values were then adjusted during hydrology calibration. As the only calibrated parameter that has a seasonal impact, calibration of this parameter is used to improve the simulation of seasonal variations in flow volume seen in the monitored data.

5.3 GWLF Calibration

Although the GWLF model was originally developed for use in ungauged watersheds and without the need for calibration, flow calibration was performed to ensure that hydrology was being simulated accurately. This process was performed in order to minimize errors in sediment simulations due to potential gross errors in hydrology. The model's parameters were assigned based on available soils, land use, and topographic data. Parameters that were adjusted during calibration included the recession constant, the monthly evapotranspiration cover coefficients, and the seepage coefficient.

Because there is no recorded flow in the Indian Creek Watershed, a paired watershed approach was used for calibration. Observed flow from USGS station 01472810 on East Branch Perkiomen Creek, near Schwenksville, PA, was used in calibrating model hydrologic parameters for the contributing watershed, which includes Indian Creek. Adjustments made to parameters during calibration were applied to Indian Creek. The final GWLF calibration results are displayed in **Figure 5-5** through **Figure 5-7** for the calibration period, with statistics showing the accuracy of fit given in **Table 5-3**. Model calibration was considered acceptable for total runoff volume and monthly fluctuations based on visual inspection of the plotted data, a high R^2 correlation value and low total volume error. Notably, because average monthly flow values are used within GWLF to estimate streambank erosion, an overprediction or underprediction of single event flows would not impact calculations.

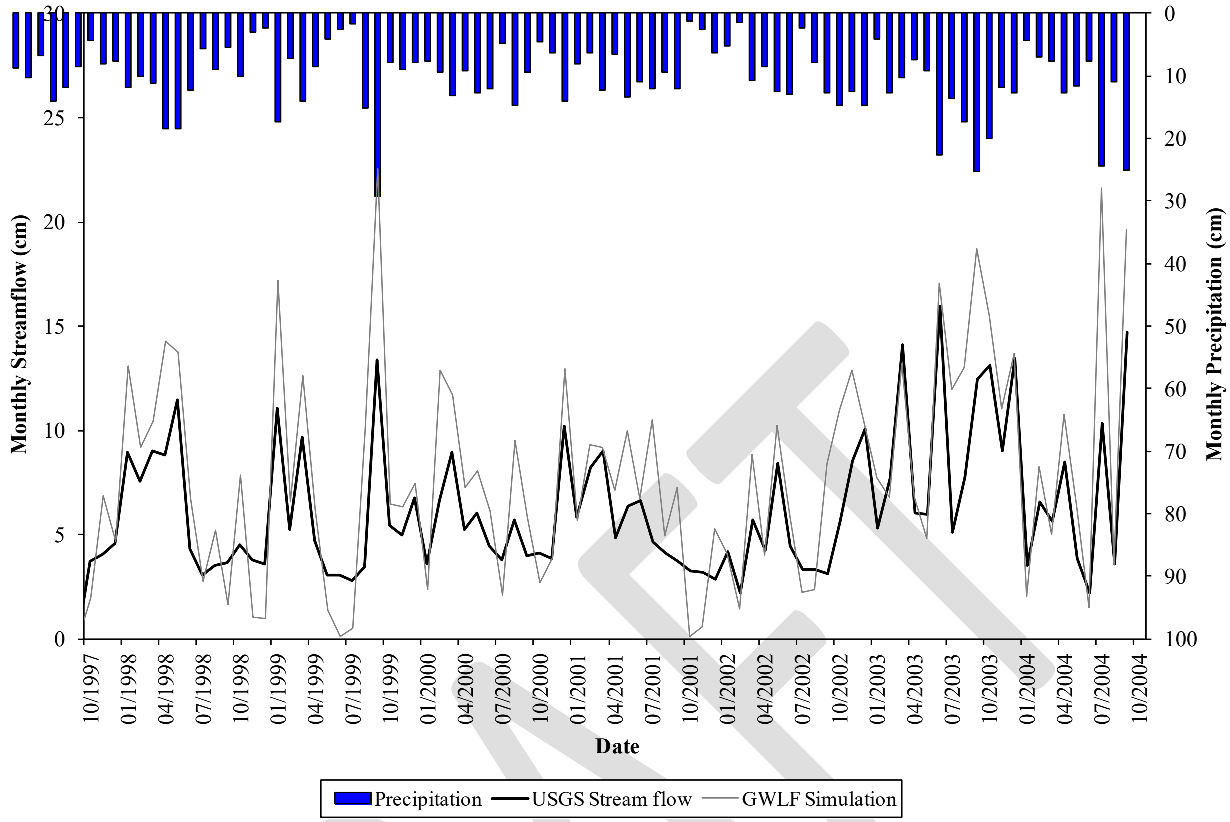

Figure 5-5. Comparison of monthly GWLF simulated (modeled) and monthly USGS (observed) stream flow in East Branch Perkiomen Creek (USGS station 01472810) for the calibration period including Indian Creek.

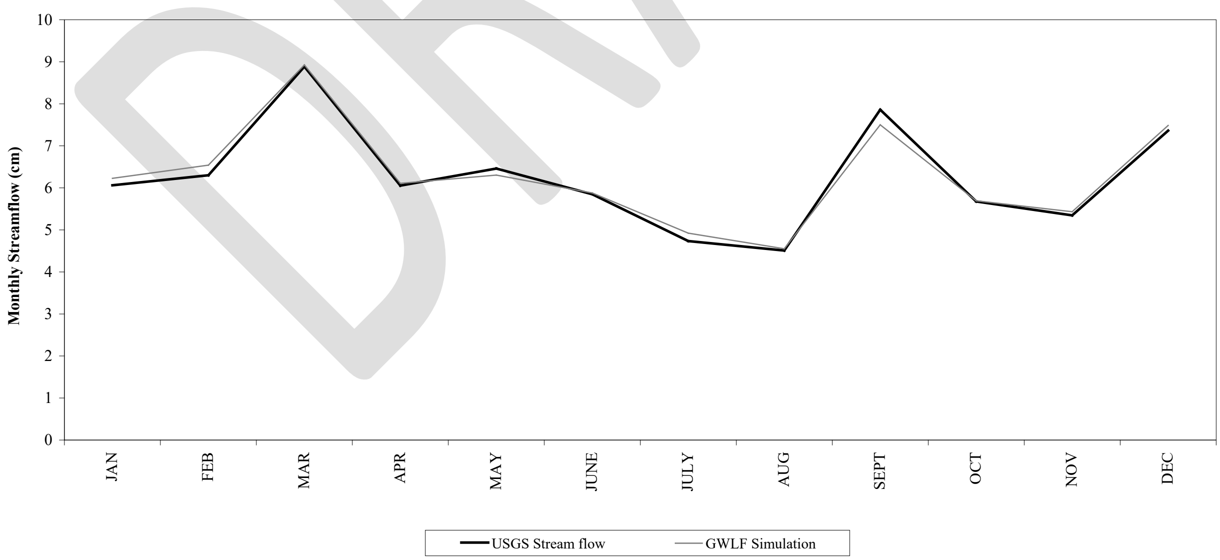

Figure 5-6. Comparison of average monthly GWLF simulated (modeled) and average monthly USGS (observed) stream flow in East Branch Perkiomen Creek (USGS station 01472810) including Indian Creek.

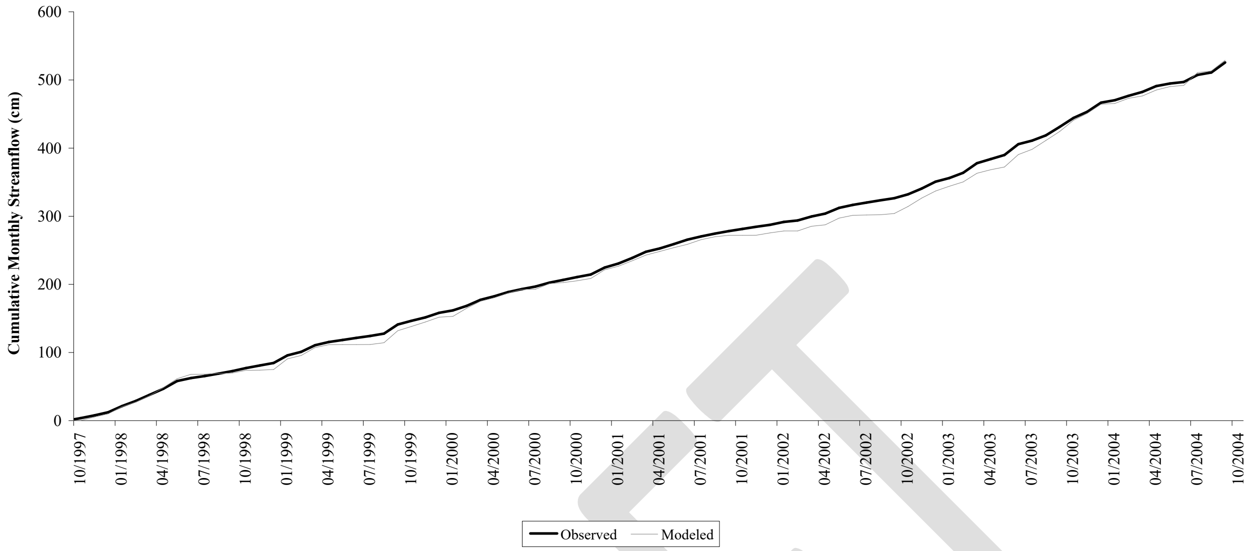

Figure 5-7. Comparison of cumulative monthly GWLF simulated (modeled) and cumulative USGS (observed) streamflow in East Branch Perkiomen Creek (USGS station 01472810) for the calibration period including Indian Creek.

Table 5-3. GWLF flow calibration statistics for East Branch Perkiomen Creek including Indian Creek.

Watershed	Simulation Period	R^2 Correlation value	Total Volume Error (Simulated-Observed)
East Branch Perkiomen Creek at USGS Station 01472810	10/1/1997 – 9/30/2004	0.914	0.63%

Similarly, there is no recorded flow in the Birch Run watershed. Consequently, a paired watershed approach was used for calibration. Observed flow from USGS station 01472157 on French Creek, near Phoenixville, PA, was used in calibrating model hydrologic parameters for the contributing watershed, which includes Birch Run. Adjustments made to parameters during calibration were applied to Birch Run. The final GWLF calibration results are displayed in **Figure 5-8** through **Figure 5-10** for the calibration period, with statistics showing the accuracy of fit given in **Table 5-4**. Model calibration was considered acceptable for total runoff volume and monthly fluctuations based on visual inspection of the plotted data, a high R^2 correlation value and low total volume error. Notably, because average monthly flow values are used within GWLF to estimate streambank erosion, an overprediction or underprediction of single event flows would not impact calculations.

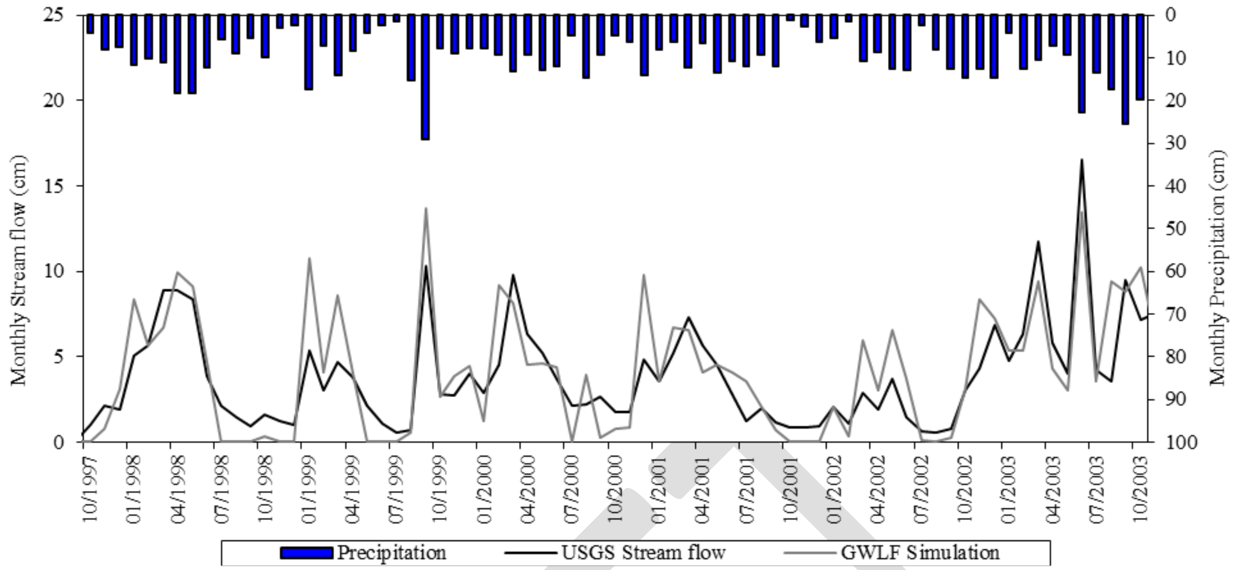

Figure 5-8. Comparison of monthly GWLF simulated (modeled) and monthly USGS (observed) stream flow in French Creek (USGS station 01472157) for the calibration period including Birch Run.

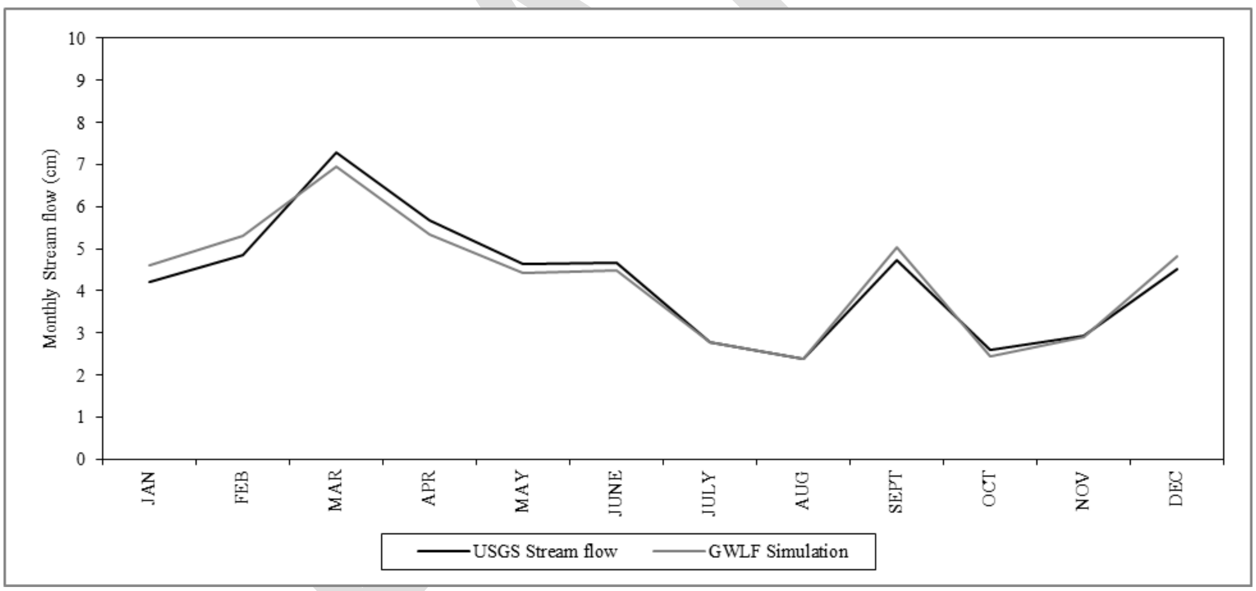

Figure 5-9. Comparison of average monthly GWLF simulated (modeled) and average monthly USGS (observed) stream flow in French Creek (USGS station 01472157) including Birch Run.

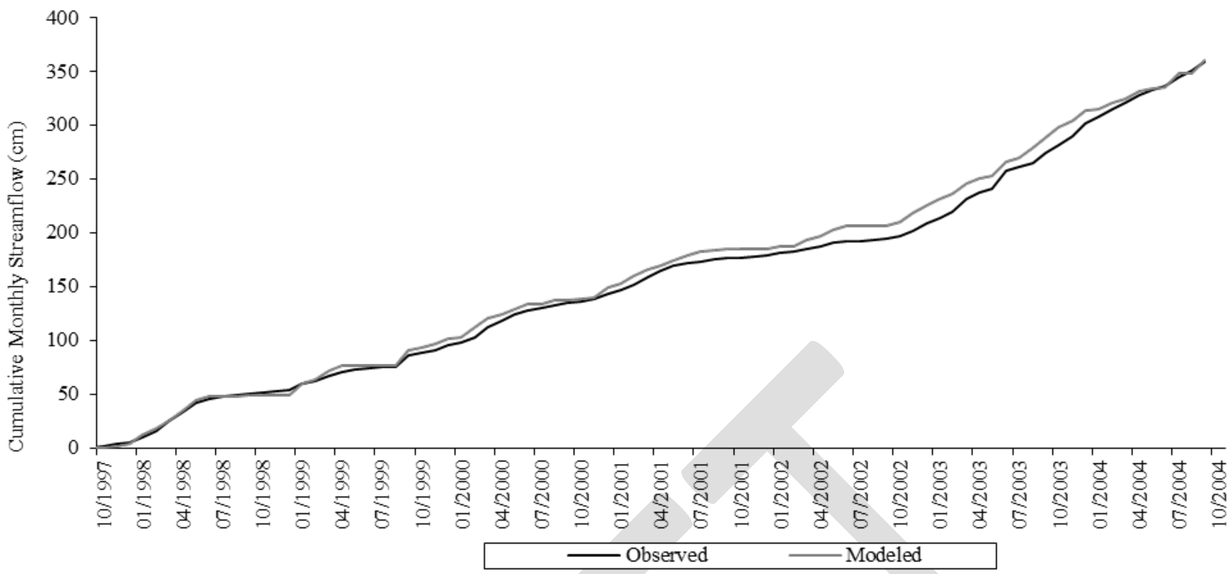

Figure 5-10. Comparison of cumulative monthly GWLF simulated (modeled) and cumulative USGS (observed) streamflow in French Creek (USGS station 01472157) for the calibration period including Birch Run.

Table 5-4. GWLF flow calibration statistics for French Creek including Birch Run.

Watershed	Simulation Period	R^2 Correlation value	Total Volume Error (Simulated-Observed)
French Creek at USGS Station 01472157	10/1/1997 – 9/30/2004	0.810	0.33%

6 Allocation Analysis and TMDLs

A TMDL is the total amount of pollutant that can be assimilated by the receiving water body while still achieving water quality standards or goals. It is composed of the sum of individual waste load allocations (WLA) for point sources and load allocations (LA) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by the following equation:

$$\text{TMDL} = \Sigma WLAs + \Sigma LAs + MOS$$

In TMDL development, allowable loadings from each pollutant source are summed to a cumulative TMDL threshold, thus providing a quantitative basis for establishing water quality-based controls. TMDLs can be expressed as a mass loading over time (e.g., grams of pollutant per day) or as a concentration or other appropriate measure in accordance with 40 CFR 130.2(i).

6.1. Sediment Existing Conditions

The approach to estimate existing sediment loadings is a land use based approach, which calculates sediment loading rates for each land use identified using local data, as discussed in **Section 2-2**. The GWLF model was parameterized to represent existing sediment conditions within the impaired and reference watersheds. A list of parameters from the GWLF transport input files that were finalized for existing conditions are given in **Table 6-1**. Monthly evapotranspiration cover coefficients are listed in **Table 6-2**, while **Table 6-3** lists the area-weighted USLE erosion parameter (KLSCP) and runoff curve number by land use for each watershed. The curve number values are area weighted by land use.

Table 6-1. GWLF watershed parameters in the calibrated impaired and reference watersheds.

GWLF Watershed Parameter	Units	Indian Creek	Birch Run
Recession Coefficient	Day^{-1}	0.5	0.5
Seepage Coefficient	Day^{-1}	0	0.23
Sediment Delivery Ratio	---	0.18	0.18
Unsaturated Water Capacity	(cm)	9.8900	11.5122
Rainfall Erosivity Coefficient (Apr-Sep)	---	0.30	0.30
Rainfall Erosivity Coefficient (Oct-Mar)	---	0.12	0.12
% Developed land	(%)	52.7	23.7
Livestock density	(AU/ac)	0	0.9824
Area-weighted soil erodibility (K)	---	0.3003	0.4269
Area-weighted Curve Number	---	78.61	63.29
Total Stream Length	(m)	31,249	15,400
Mean channel depth	(m)	1.5	0.66

Table 6-2. Calibrated GWLF monthly evapotranspiration cover coefficients.

Watershed	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Indian Creek	0.92	0.66	0.58	0.29	0.66	1.11	0.62	0.67	0.61	1.34	1.34	0.79
Birch Run	0.75	0.73	0.46	0.56	0.66	1.32	1.40	1.06	1.05	1.79	1.39	0.74

Table 6-3. The GWLF curve numbers and KLSCP values for existing conditions in the Indian Creek and Birch Run watersheds.

Sediment Source	Indian Creek		Birch Run	
	CN	KLSCP	CN	KLSCP
Pervious Area:				
Forest	64.60	0.0007	57.66	0.00228
Open	71.15	0.0109	63.30	0.02438
Residential	71.44	0.0027	63.30	0.00975
Cropland	81.40	0.068428	78.89	0.05827
Commercial	71.76	0.0036	63.30	0.00451
Road	87.98	0.0067		
Pasture	75.8	0.0164	70.77	0.04917
Hay	66.8	0.0028	60.30	0.00852
Impervious[1] Area:				
Residential	98.00	N/A	98.00	N/A
Commercial	98.00	N/A	98.00	N/A
Road	98.00	N/A	98.00	N/A

[1] Since erosion processes are not applicable to impervious surfaces, there is not an associated KLSCP value. Contributions from impervious areas are modeled as a build-up and wash-off process.

The sediment loads were modeled for existing conditions in Indian Creek and the reference watershed, Birch Run (**Table 6-4**). Please refer to **Section 5.2.3.1** for more information about the modeling period. The existing condition in Indian Creek is the combined sediment load of 4,259.50 t/yr as compared to the area-adjusted reference watershed load of 1,439.25 t/yr, which suggests a necessary reduction in total watershed sediment loadings of 66.2 percent.

Model results suggest that sediment delivery to Indian Creek through overland runoff and streambank erosion is an ongoing physical process that occurs regularly throughout the year under a variety of storm scenarios, including large and small storms. The ability of Indian Creek to assimilate sediment becomes exceeded over time as the stream's capacity to move sediment downstream becomes overwhelmed due to repeated sediment loading events. Consequently, it is the long-term cumulative load of sediment that must be addressed by the TMDL to protect the aquatic life designated use. Because sediment loads from numerous individual storm events comprise the long-term cumulative load, and GWLF captures the cumulative estimated sediment loads from all storm events, an annual load was deemed valuable for this TMDL, in addition to the maximum daily load presented.

Sediment loading rates were determined for (1) permitted sources: including individual wastewater and stormwater permits and general stormwater permits, (2) direct sources: including streambank erosion and straight pipes, and (3) impervious and pervious land uses: including commercial, residential, road, agriculture, forest, and open areas. Sediment loadings associated with land uses from both pervious and impervious areas represent the majority of loadings in both Indian Creek (68 percent) and Birch Run (88 percent). Outside of these loads, another significant sediment contributor is streambank erosion, which, in excess, can be attributed to large areas of impervious surfaces that, during storm events, create streamflow that over time erodes the streambank. In this table, the MS4 and nonpoint source loads are not directly expressed.

In both the impaired and reference watershed, agricultural land uses (crop, pasture, and hay) account for majority of the sediment loading: 57 percent in Indian Creek and 61 percent in Birch Run. Sediment loadings washing off from developed land uses from either pervious or impervious surfaces account for 7 percent of the total watershed loading in Indian Creek and 15 percent in Birch Run. A greater prevalence of streambank erosion is demonstrated in Indian Creek with those sediment loadings accounting for 30 percent of total watershed loading as compared to 12 percent in Birch Run. As stated previously, accelerated streambank erosion can be attributed to impervious surfaces within the watershed, and particularly, within the MS4s.

Table 6-4. Existing sediment loads for Indian Creek and area-adjusted Birch Run watersheds.

Sediment Source	Indian Creek			Reference Watershed Area-Adjusted Birch Run		
	t/yr	Percent (%) of Total Load	t/ha/yr	t/yr	Percent (%) of Total Load	t/ha/yr
Pervious Area:						
Forest	5.43	0.13	0.04	71.33	4.96	0.1
Open	175.86	4.13	0.73	100.87	7.01	1.3
Residential	105.2	2.47	0.21	183.73	12.77	0.52
Crop	2,394.16	56.21	5.84	380.04	26.41	4.69
Commercial	18.51	0.43	0.26	0.63	0.04	0.24
Road	6.65	0.16	0.61	4.17	0.29	0
Pasture	44.8	1.05	1.27	324.74	22.56	3.24
Hay	8.05	0.19	0.18	167.28	11.62	0.42
Impervious Area:						
Residential	81.49	1.91	0.45	28.2	1.96	0.45
Commercial	49.82	1.17	0.45	1.17	0.08	0.45
Road	19.72	0.46	0.45	3.78	0.26	0.45
Direct Sources:						
Streambank Erosion	1,283.25	30.13		172.89	12.01	
Straight Pipes	0.95	0.02		0.42	0.03	
Permitted Sources:						
Individual Permits	63.59	1.49		0	0	

Sediment Source	Indian Creek			Reference Watershed Area-Adjusted Birch Run		
	t/yr	Percent (%) of Total Load	t/ha/yr	t/yr	Percent (%) of Total Load	t/ha/yr
General Stormwater Permits - Construction	2.02	0.05		0	0	
Watershed Total	**4,259.50**	**100**	**2.35**	**1,439.25**	**100**	**0.79**

t: tonnes or metric ton; ha: hectare; yr: year
1 metric ton = 1.10231 US ton = 2204.62 pounds

Table 6-5 and **Figure 6-1** show the existing sediment loads by jurisdiction for the Franconia, Lower Salford, Souderton, Telford, PennDOT, and Pennsylvania Turnpike Commission MS4s as well as the non-MS4 nonpoint source area, which is located throughout the watershed in areas not covered by the MS4 Planning Areas. The existing loads for the township and transportation MS4s include the sediment loads generated from within their MS4 Planning Areas. Streambank erosion and agricultural sediment sources are the primary sources of existing sediment loads overall in the Indian Creek Watershed. The predominant source of sediment in the non-MS4, nonpoint source area is agricultural, while the predominant source in the MS4 area is streambank erosion, due to large amounts of impervious cover. Lesser sources of sediment within the Indian Creek Watershed include open space, residential, commercial, and road land uses.

Table 6-5. Existing sediment loads (metric tonnes/yr) by jurisdiction and source for the Indian Creek Watershed.

Jurisdiction	Franconia	Lower Salford	Souderton	Telford	PennDOT	PTC	Non-MS4 (Nonpoint Source)
Forest (t/yr)	0.23	1.63	0.00	0.00	0.01	0.03	3.54
Open Space (t/yr)	25.30	15.10	4.63	6.04	0.08	1.21	123.50
Residential (t/yr)	27.65	43.33	7.36	11.54	0.54	0.16	96.11
Agricultural (t/yr)	320.53	171.94	0.00	0.00	9.58	18.50	1926.46
Commercial (t/yr)	3.06	8.03	3.04	7.33	0.71	0.01	46.15
Road (t/yr)	6.67	1.38	0.30	1.71	4.89	3.08	8.33
Streambank Erosion (t/yr)	164.48	220.88	48.12	98.61	36.79	19.85	694.52
Total (t/yr)	547.92	462.29	63.45	125.23	52.60	42.84	2898.61

t: tonnes or metric ton; yr: year
1 metric ton = 1.10231 US ton = 2204.62 pounds

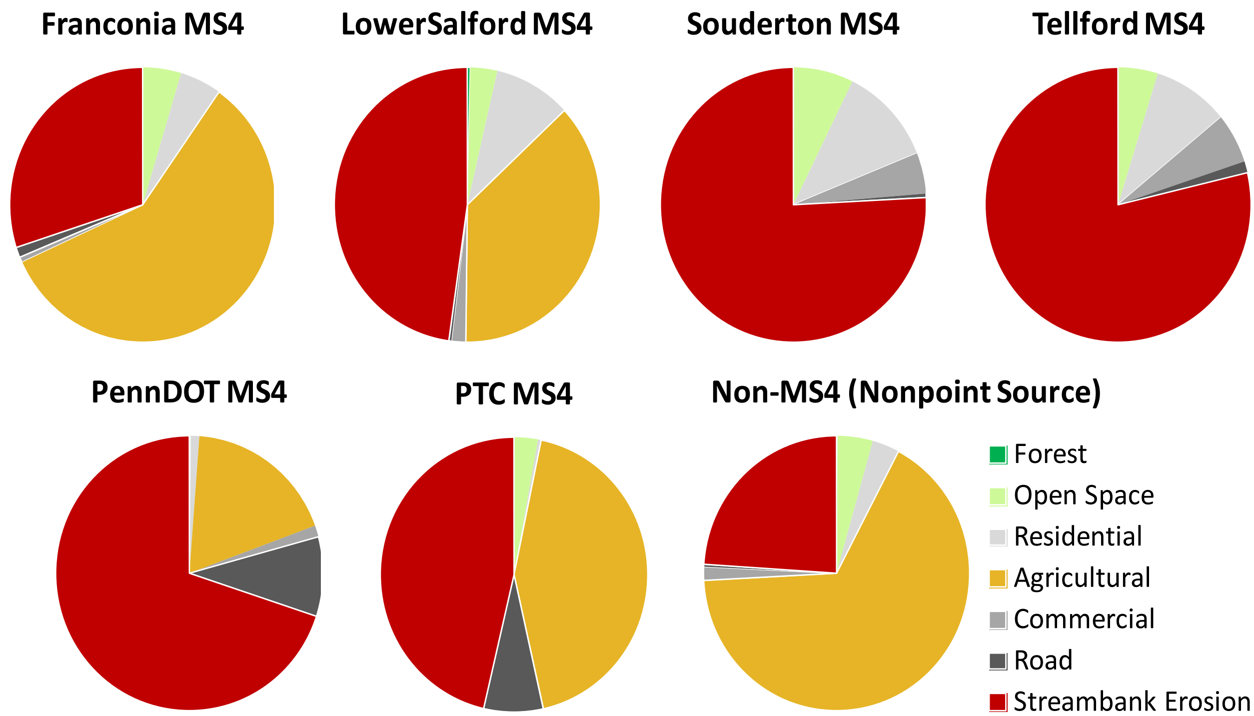

Figure 6-1. Existing load distribution by land use for each MS4 township and the non-MS4 nonpoint source area.

6.2. Allocation Strategy

The objective of the TMDL is to establish sediment loads necessary to attain and maintain applicable WQS. This is achieved by reducing the sediment loadings in Indian Creek to the existing conditions in the reference watershed, Birch Run. EPA developed individual wasteload allocations (WLAs) for the WWTPs, the four municipal MS4s, and two transportation MS4s and an aggregate WLA for stormwater discharges from construction sites, and load allocations (LAs) for nonpoint sources of sediment. Permittees with insignificant discharges or technology-based limits will continue to discharge at their current limits (see **Table 4-1**). Additionally, no allocation was provided to illicit discharges or straight pipes, as these are illegal and will be eliminated as detected.

6.2.1. Allocation Process

At a stakeholder webinar on March 22, 2018, EPA proposed two allocation strategies to address sediment reductions within the Indian Creek Watershed: 1) focused reductions on agricultural lands and streambank erosion, which are the most significant sediment sources responsible for 57 and 30 percent of the sediment load, respectively; and 2) an equal percent reduction across all anthropogenic land-based sources. Stakeholders preferred the first allocation strategy so the TMDL allocation process focused reductions on the most significant sediment sources of agriculture and streambank erosion. **Table 6-6** shows an example of the two allocation strategies presented to stakeholders.

Table 6-6. Example allocation strategies: 1) focused reductions on agriculture and streambank erosion sediment sources; and 2) equal percent reduction across all land uses.

Jurisdiction	Allocation Strategy 1 Reductions (% or t/yr)	Allocation Strategy 2 Reductions (% or t/yr)
Franconia MS4	67% or 368.14	68% or 370.36
Lower Salford MS4	65% or 299.62	67% or 311.50
Souderton MS4	58% or 37.05	68% or 42.91
Telford MS4	61% or 75.93	68% or 84.68
PennDOT MS4	68% or 35.55	68% or 35.56
PTC MS4	68% or 29.22	68% or 28.95
Non-MS4 (Nonpoint Source)	69% or 1986.16	68% or 1957.70

t: tonnes or metric ton; yr: year
1 metric ton = 1.10231 US ton = 2204.62 pounds

A portion of the reduction required from streambank erosion is attributed to the MS4s as the impervious cover present within MS4 Planning Areas is partly responsible for the high flow volumes that cut and erode the streambanks. In addition, reductions called for from streambank erosion are also attributed to the nonpoint source area. **Table 6-5**, above, shows the existing sediment loads from streambank erosion attributable to each MS4 and the nonpoint source area. Additionally, although majority of the reduction required from agriculture is attributed to the nonpoint source area, reductions from agricultural loads originating within MS4s were also called for because agriculture represents a source of sediment from within several of the MS4 Planning Areas.

6.2.2. Load Allocations (LAs)

The loads attributed to portions of the watershed, shown in **Figure 4-1**, found outside of MS4 Planning Areas were assigned load allocations and reductions were called for from the significant sediment sources of agriculture and streambank erosion.

6.2.3. Wasteload Allocations (WLAs)

Federal regulations (40 CFR 130.2(h)) require TMDLs to include waste load allocations (WLAs) for existing or future point sources of the targeted pollutant. There are three types of WLAs included in the Indian Creek Watershed TMDL: individual WWTPs, individual MS4s, and an aggregate for stormwater discharges from construction sites. No allocation is provided to illicit discharges or straight pipes, as these are illegal and will be eliminated as detected. The components of the WLA are summarized below.

WLA: Individual WWTPs

EPA assigned TMDL WLAs to each of the three WWTPs in the watershed, Telford Borough Authority, Lower Salford Township Authority - Harleysville sewage treatment plant, and Pilgrim's Pride Facility (Franconia Township). All of these permittees are already required to meet technology-based effluent limitations, as described in their permits, and represent insignificant sources of sediment in the watershed. Therefore, the WLAs for these WWTPs permits were based upon current permit limits (see **Table 4-1**).

WLA: MS4 Municipalities

EPA's stormwater permitting regulations require certain municipalities to obtain permit coverage for all stormwater discharges from urban MS4s. A November 12, 2010, EPA Memorandum (http://water.epa.gov/polwaste/npdes/stormwater/upload/sw_tmdlwla_comments.pdf) clarified existing regulatory requirements for MS4s connected with TMDLs. The key points are the following:

- NPDES-regulated MS4 discharges must be included in the WLA of the TMDL and may not be addressed by the LA component of the TMDL.
- The stormwater allotment can be a gross allotment and does not need to be apportioned to specific outfalls.
- Industrial stormwater permits need to reflect technology-based and water quality-based requirements.

In accordance with this memorandum, MS4s were treated as point sources for the TMDL and NPDES permitting purposes, and the sediment loading generated within the MS4 Planning Area of an MS4 area was assigned a WLA. Stormwater sediment loads in the MS4 regulated area are covered under the Phase II NPDES Stormwater Program. EPA's stormwater permitting regulations require public entities to obtain NPDES permit coverage for stormwater discharges from MS4s in specified urbanized areas.

MS4s within the Indian Creek Watershed include the four municipal MS4 communities (Lower Salford, Telford, Souderton, and Franconia) and two transportation MS4s (Pennsylvania Department of Transportation and the Pennsylvania Turnpike Commission). The MS4s require significant reductions in sediment loading as their MS4 Planning Areas cover much of the watershed. Sediment loads that travel directly to streams via surface runoff are excluded from MS4 WLAs as they are outside of the MS4 Planning Areas and included in the nonpoint source LA, while sediment loads that travel through the MS4 conveyance are represented by the MS4 Planning Areas and are allocated to the MS4s.

As described in **Section 3.9**, EPA requested from stakeholders detailed sewershed delineation maps to identify MS4 serviced vs. non-serviced areas, which were used to separate nonpoint source LAs from MS4 WLAs. EPA received MS4 Planning Areas that were deemed acceptable by PADEP for use within this TMDL from all MS4s aside from Souderton. Consequently, all acres within the political boundaries of Souderton in the Indian Creek Watershed were assumed to drain to the MS4 system and were therefore assigned a WLA. See **Table 6-7** for the distribution of land-use within each of the six MS4s and the nonpoint source area.

Table 6-7. Land use distribution within jurisdictions, in the Indian Creek Watershed.

	Forest	Open Space	Residential	Agricultural	Commercial	Road
Jurisdiction	**ac**	**ac**	**ac**	**ac**	**ac**	**ac**
Franconia MS4	13	85	263	159	20	34
Lower Salford MS4	93	51	412	85	53	7
Souderton MS4	0	16	70	0	20	2
Telford MS4	0	20	110	0	48	9
PennDOT MS4	0	0	5	5	5	25
PTC MS4	2	4	2	9	0	16
Non-MS4 (Nonpoint Source)	203	417	914	955	306	42

[1] These land uses can include both pervious and impervious cover. See **table 5-1** for more information.

Assigning WLAs to each of the MS4 areas based on the estimated sediment loading from their associated MS4 Planning Areas represents the most accurate allocation strategy and the strategy preferred by PADEP. Including sediment loads from all land uses within the MS4 Planning Area as well as streambank erosion allows MS4s to use a variety of best management practices (BMPs) to achieve their WLA. For instance, agricultural BMPs are often more cost effective than urban stormwater BMPs and represent an opportunity for MS4s to partner with agricultural interests from within their MS4 Planning Areas to achieve sediment reductions in a cost-effective manner. **Table 6-5** above provides the existing sediment load by source for each MS4 jurisdiction as well as the nonpoint source area so as to inform the jurisdictions, other watershed planners, and permitting bodies on potential effective BMP sectors. In the future, MS4 allocations could be refined to separate LAs from WLAs (or vice versa) if MS4 Planning Areas are revised and approved by PADEP. Until such time, this sediment TMDL should be used as a resource during Pollution Reduction Plan development to help inform BMPs to achieve the sediment TMDL allocations.

WLA: Construction Stormwater

The current general stormwater permit for discharges from construction sites do not have TSS limits and instead have BMP requirements. Permittees covered under the general stormwater permit for construction sites are often temporary in nature. An analysis was done to estimate the sediment loadings coming from these permitted acreages, represented as barren land. Results suggested that these discharges comprise less than one percent of the TMDL and represent insignificant sources of sediment in the watershed. The aggregate WLA assigned to the discharges from construction sites is one percent of the TMDL (see **Table 4-1**). It is expected that existing permit limits and requirements will achieve this WLA.

6.3. Margin of Safety (MOS)

The margin of safety (MOS) is the portion of the TMDL equation that accounts for any lack of knowledge concerning the relationship between LAs and WLAs and water quality [CWA 303(d)(1)(c) and 40 CFR 130.7(c)(1)]. For example, knowledge may be incomplete regarding the exact nature and magnitude of pollutant loads from various sources and the specific impacts of those pollutants on the chemical and biological quality of complex, natural waterbodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of environmental protection. On the basis of EPA guidance, the MOS can be achieved through two approaches (USEPA 1999): (1) implicitly incorporate the MOS by using conservative model assumptions to develop allocations; or (2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. **Table 6-8** describes different approaches that can be taken under the explicit and implicit MOS options.

Table 6-8. Different approaches available under the explicit and implicit MOS types

Type of MOS	Available approaches
Explicit	• Set numeric targets at more conservative levels than analytical results indicate. • Add a safety factor to pollutant loading estimates. • Do not allocate a portion of available loading capacity; reserve for MOS.
Implicit	• Use conservative assumptions in derivation of numeric targets. • Use conservative assumptions when developing numeric model applications. • Use conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

Source: USEPA 1999

This TMDL employs an implicit MOS due to conservative assumptions in the modeling process. The reference watershed, Birch Run, is considered an environmentally conservative choice due to its relatively high IBI scores and similar watershed characteristics shared with the Indian Creek watershed. In 2012, biological monitoring was conducted in Birch Run and IBI scores ranging from 72.3 to 74.6 were documented. Although several factors such as IBI score, sampling season, aquatic life designated use, and change from the baseline IBI score are used to determine if a site is impaired, an IBI score of around 50 or below will generally lead to an impairment determination. Birch Run's IBI scores in the low 70s demonstrated a healthy biological community. Because watershed and soil characteristics, such as watershed slope, are extremely similar (see **Table 2-2)** between the impaired and reference watersheds, EPA expects a lower degree of uncertainty in sediment loading comparisons (EPA, 1999). Therefore, setting a TMDL target based on estimated loads from a reference watershed with IBI scores above the impairment threshold represents an appropriate implicit margin of safety.

In addition, for baseline load and TMDL allocation calculations, it was assumed that the three wastewater point sources were discharging continuously at their design flow maximum concentration, which is not the case as determined by associated discharge monitoring reports. This provides an additional implicit MOS because the WTTPs typically discharge less than the prescribed WLA. Please refer to **Sections 3.4 and 4.1** for more information.

The use of an implicit MOS is based on previous experience for TMDL development using reference watersheds and best professional judgment.

6.4. Critical Conditions and Seasonal Variations

Federal regulations (40 CFR 130.7(c)(1)) require TMDLs to consider critical conditions for streamflow, loading, and water quality parameters. Critical conditions are the set of environmental conditions, which, if met, will ensure attainment of objectives for all other conditions. This is typically the period in which the impaired water body exhibits the most vulnerability. EPA selected the critical condition to be all flow conditions throughout the year. Nonpoint source and regulated stormwater loadings are typically precipitation-driven; thus, in-stream impacts can occur during wet weather in which storm events cause surface runoff to carry pollutants to water bodies. Under low-flow conditions, non-precipitation-driven wastewater point sources dominate sediment loading with their more constant flow and pollutant loading. Because the impacts of sediment on aquatic life occur over time as the loading capacity of a stream becomes exceeded as a result of repeated stormflow events, the model considered critical conditions by capturing all storm events and the cumulative, long-term loading condition. As described in **Section 5.2.3**, the TMDL accounts for critical conditions and seasonal variation.

The TMDL was developed using continuous simulation (modeling over a period of several years that captured precipitation extremes), which inherently considers critical conditions, seasonal hydrologic, and source loading variability. The GWLF model is a continuous simulation model that uses daily time steps for weather data and water balance calculations. The period of rainfall selected for modeling was October 1, 1997 to September 30, 2004 and was chosen as a multi-year period that was representative of typical weather conditions for the area, and included “dry”, “normal” and “wet” years. Additionally, this time period was compared with more recent weather data to verify that it was representative of current local conditions. The model, therefore, incorporated the variable inputs needed to represent critical conditions during low flow and high flow events.

The TMDL considers seasonal variation through a number of mechanisms. Seasonal variation is captured in the time variable GWLF simulation, which represents seasonal precipitation on a year-to-year basis as well as daily time steps used for weather data and water balance calculations. In addition, the model used monthly-variable parameter inputs for evapotranspiration cover coefficients, daylight hours/day, and rainfall erosivity coefficients for user-specified growing season months.

Furthermore, the biological monitoring data used to determine the reference watershed reflect the impacts of stressors (i.e., sediment impacts to stream biota) over the course of time and therefore capture all high and low flow events and seasonal variation. Since the TMDL endpoint is based on the loads from a reference watershed with good biological conditions, by the nature of the biological data described above, it must inherently include the critical conditions of the reference watershed. Therefore, since the TMDL reduces the watershed sediment load to a level compatible with that of the reference watershed, critical conditions and seasonal variation are inherently addressed.

6.5. TMDLs

The annual sediment TMDL for the Indian Creek Watershed are presented in **Table 6-9**.

Table 6-9. Annual sediment TMDL loads for the Indian Creek Watershed.

Source Group	Allocation Type	Source	Existing Sediment Load (t/yr)	Allocated Sediment Load (t/yr)	Sediment Load to be Reduced (t/yr)	Percent Reduction
Point Sources: WWTP	WLA	Lower Salford Township Authority - Harleysville STP (PA0024422)	29.03	29.03	0.00	0%
	WLA	Telford Borough STP (PA0036978)	30.41	30.41	0.00	0%
	WLA	Pilgrims Pride (PA0054950)	4.15	4.15	0.00	0%
Point Sources: MS4	WLA	Franconia MS4	547.92	179.78	368.14	67%
	WLA	Lower Salford MS4	462.29	162.67	299.62	65%
	WLA	Souderton MS4	63.45	26.40	37.05	58%
	WLA	Telford MS4	125.23	49.30	75.93	61%
	WLA	PennDOT MS4	52.60	17.05	35.55	68%
	WLA	PTC MS4	42.84	13.62	29.22	68%
Point Source: Construction Stormwater	WLA	Aggregate Load (1% of TMDL)	14.39	14.39	0.00	0%
Nonpoint Source	LA	Non-MS4 Nonpoint Source	2898.61	912.45	1,986.16	69%
	MOS	Implicit MOS	N/A	N/A	N/A	N/A
Total Point Sources: WWTP			63.59	63.59	0.00	0%
Total Point Sources: MS4			1,294.33	448.82	845.51	65%
Total Point Sources: Construction Stormwater			14.39	14.39	0.00	0%
Total Nonpoint Sources			2,898.61	912.45	1,986.16	69%
Total			4,270.92	1,439.25	2,831.67	66%

t: tonnes or metric ton; yr: year
1 metric ton = 1.10231 US ton = 2204.62 pounds

The maximum daily loads are presented in **Table 6-10**. The GWLF program only outputs monthly sediment load totals calculated from daily water balance calculations. To obtain daily sediment loads, additional computations were performed on the GWLF monthly outputs, which are described below. Since sediment loads are a function of both direct watershed runoff and streambank erosion (two distinctly different processes), these two processes were analyzed separately.

- For sediment yields from direct watershed runoff, total monthly sediment yields were divided into daily loads, using daily erosion from each land use, as a weighting factor. The resulting daily loads were then summed, by month, and compared to modeled monthly sediment yields to verify that the two values were similar.

- For sediment yields from streambank erosion, a daily streambank erosivity coefficient was calculated and used as a weighting factor to divide the monthly values. In the current version, a monthly erosivity coefficient is calculated based on the average monthly flow rate and used to estimate monthly streambank erosion. Since daily stream flow volumes are available, it was possible to compute this coefficient on a daily basis and use these values to compute daily sediment yields. As with the daily sediment yields from direct watershed runoff, the resulting daily loads from streambank erosion were summed, by month, and compared to modeled monthly sediment yields to verify that the two values were similar.

- For non-stormwater point sources (i.e. wastewater discharges), daily sediment loads were calculated by multiplying their daily maximum design capacity and associated permit TSS limit.

Daily existing loads across all sources were summed for daily watershed existing loads. Daily watershed allocated loads were then calculated by reducing the existing watershed loads according to the allocation strategy (i.e. 66 percent). The daily TMDL was then calculated as the 99th percentile of this data set. The daily WLAs for the non-stormwater point sources (wastewater dischargers) were calculated by multiplying their daily maximum design capacity and associated permit TSS limit. The regulated stormwater WLAs and nonpoint source LA were then apportioned out based on their proportion of the Annual TMDL. The results are provided in the table below.

Table 6-10. Maximum daily sediment TMDL loads for the Indian Creek Watershed.

Source Group	Allocation Type	Source	Existing Sediment Load (t/day)	Allocated Sediment Load (t/day)
Point Sources: WWTP	WLA	Lower Salford Township Authority - Harleysville STP (PA0024422)	0.08	0.08
	WLA	Telford Borough STP (PA0036978)	0.08	0.08
	WLA	Pilgrims Pride (PA0054950)	0.01	0.01
Point Sources: MS4	WLA	Franconia MS4	24.27	8.40
	WLA	Lower Salford MS4	20.48	7.60
	WLA	Souderton MS4	2.81	1.23
	WLA	Telford MS4	5.55	2.30
	WLA	PennDOT MS4	2.33	0.80
	WLA	PTC MS4	1.90	0.64
Point Source: Construction Stormwater	WLA	Aggregate Load (1% of TMDL)	0.64	0.64
Nonpoint Source	LA	Non-MS4 Nonpoint Source	127.61	41.81
	MOS	Implicit MOS	N/A	N/A
Total Point Sources: WWTP			0.17	0.17
Total Point Sources: MS4			57.34	20.97
Total Point Sources: Construction Stormwater			0.64	0.64

Source Group	Allocation Type	Source	Existing Sediment Load (t/day)	Allocated Sediment Load (t/day)
Total Nonpoint Sources			127.61	41.81
Total			185.76	63.59

t: tonnes or metric ton
1 metric ton = 1.10231 US ton = 2204.62 pounds

6.6. Future TMDL Modifications and Growth

EPA has established the Indian Creek sediment TMDL, including its component WLAs, LAs, and MOS, based on the applicable water quality standard (WQS) and the totality of the information available concerning water quality and hydrology, and present and anticipated pollutant sources and loadings. EPA recognizes, however, that neither the world at large, nor the watershed, is static. In a dynamic environment, change is inevitable.

It is possible to accommodate some of those changes in the existing TMDL without the need to revise it in whole, or in part. For example, EPA's permitting regulations at 122.44(d)(1)(vii)(B) require that permit water quality based effluent limitations be "consistent with the assumptions and requirements of any available wasteload allocation for the discharge" in the TMDL. As the EPA Environmental Appeals Board has recognized, "WLAs are not permit limits per se; rather they still require translation into permit limits." *In re City of Moscow*, NPDES Appeal No. 00-10 (July 27, 2001). In providing such translation, the Environmental Appeals Board said that "[w]hile the governing regulations require consistency, they do not require that the permit limitations that will finally be adopted in a final NPDES permit be identical to any of the WLAs that may be provided in a TMDL." Id. Accordingly, depending on the facts of a situation, Pennsylvania may write a permit limit that is consistent with (but not identical to) a given WLA without revising that WLA (either increasing or decreasing a specific WLA), provided the permit limit is consistent with the operative *assumptions* (e.g., about the applicable WQS, the sum of the delivered point source loads) that informed the decision to establish that particular WLA.

There might, however, be circumstances with the degree to which a permit limit might deviate from a WLA in the TMDL such that one or more WLAs and LAs in the TMDL would need to be revised. In such cases, it might be appropriate for EPA to revise the TMDL (or portions of it). EPA would consider a request made by the public or PADEP to revise the TMDL. Alternatively, PADEP could propose to revise a portion(s) of the TMDL (including specific WLAs and LAs) and submit those revisions to EPA for approval. A proposed WLA can be made available for public comment concurrent with the associated permits revision/reissuance public notice. If EPA approved any such revisions, those revisions would replace their respective parts in the EPA-established TMDL. In approving any such revisions or in making its own revisions, EPA would ensure that the revisions themselves met all the statutory and regulatory requirements for TMDL approval and did not result in any component of the original TMDL not meeting applicable WQS.

Strategies to account for future growth include offsetting new or increased loadings through additional reductions in sediment loadings elsewhere in the watershed in an amount necessary to implement the TMDL and applicable WQS in the Indian Creek Watershed. PADEP does not expect increased sediment loadings as a result of future development because most of the remaining undeveloped area of the watershed is agricultural. Future development would likely lead to the conversion of agricultural land to developed land-uses such as residential, commercial, or roads. Because sediment loads from agricultural land-uses are generally greater than sediment loads from developed lands in compliance with permitted post-construction stormwater management requirements, it is expected that overall watershed sediment load would decrease as a result of further development. However, these newly converted areas would need to manage and treat their associated post-construction stormwater to that of the applicable load allocation or wasteload allocation assigned to the associated land-use prior to conversion unless more stringent requirements are required.

If an offset strategy is utilized by jurisdictions to account for future growth in the Indian Creek Watershed, the offsets are to be in addition to reductions already needed to meet the allocations in the TMDL. For nonpoint sources, this assumption and expectation is based on the fact that in order to ensure WQS are met, any new or increased nonpoint source loadings not accounted for in the TMDL LA will be offset by appropriate reductions from other sources. For permitted point sources, the assumption and expectation is based on the statutory and regulatory requirements that effluent limits for any such discharger be derived from and comply with all applicable WQS and be consistent with the assumptions and requirements of any available WLAs [CWA sections 301(b)(1)(C), 303(d); 40 CFR 122.44(d)(1)(vii)(A) & (B)].

7 Reasonable Assurance for TMDL Implementation

Section 303(d) of the Clean Water Act (CWA) requires that a TMDL be "established at a level necessary to implement the applicable water quality standard". According to 40 C.F.R. §130.2(i), "[i]f best management practices or other nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent." Providing reasonable assurance that nonpoint source control measures will achieve expected load reductions increases the probability that the pollution reduction levels specified in the TMDL will be achieved and, therefore, applicable WQS will be attained.

EPA expects the state to manage the load reductions through its NPDES permitting program and other regulatory and non-regulatory programs to address both the load reductions from point and nonpoint sources, as discussed below. The Indian Creek Watershed sediment TMDL does not direct or require implementation of any specific set of actions or selection of controls. The TMDL also does not specify the rate at which implementation must occur. Therefore, EPA recommends that key personnel from the regional DEP office, the County Conservation District, and other state and local agencies and/or watershed groups be involved in implementing this TMDL.

For point sources, such as MS4s, WWTPs, and stormwater discharges from construction sites, it is expected that the TMDL will be implemented through the NPDES program. PADEP is authorized to administer the NPDES Program, which, among other duties, includes issuing NPDES permits to existing or futures point sources subject to the NPDES program. The issuance of NPDES permits provides the reasonable assurance that the WLAs assigned to point sources in the Indian Creek Watershed TMDL will be achieved. This is because 40 CFR 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with "the assumptions and requirements of any available wasteload allocation" in an EPA-approved TMDL. While the applicable permit effluent limits need not be identical to the WLA (See **Section 6.6**), EPA anticipates that future permits will include appropriate limits and other controls on sediment discharged. For the WWTPs and construction activities, it is expected that compliance with existing permit limits will achieve the prescribed WLAs. For example, the general stormwater permit for construction calls for projects to retrofit 20 percent of the existing impervious area to treat stormwater to the level of meadows in good condition. These retrofits will result in improvements over time that reduce the sediment loading to Indian Creek.

For the MS4s, it is expected that permits will include requirements for the communities to develop and implement short and long-term plans to control sediment in stormwater. PADEP requires MS4s to develop short-term (i.e. five year) plans to achieve 10 percent of the total reduction prescribed in addition to long-term plans to achieve the total reduction prescribed. Please refer to PADEP's TMDL Plan Instructions (2017) for more information. Implementation may occur using a variety of tools, such as compliance schedules, permit requirements, and/or monitoring towards progress. EPA is sensitive to the fact that the WLAs set forth in this TMDL may take time to achieve. It may be appropriate to set priorities in order to secure larger reductions early on, recognizing that final compliance by all permittees may take some time. EPA has authority to object to the issuance of an NPDES permit that is inconsistent with the assumptions and requirements of WLAs established for that point source. It is expected that

PADEP will require periodic monitoring of the point source(s), through the NPDES Program, in order to monitor and determine compliance with the applicable effluent limits.

For nonpoint sources, such as agriculture land and other land areas outside of MS4 Planning Areas, the implementation of pollutant reductions relies on a mix of regulatory and incentive-based programs. 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. Reductions in stream sediment and nutrient loading due to agricultural activities can be made through the implementation of required Erosion and Sediment Control and Nutrient Management Plans and through the use of BMPs such as conservation tillage, cover crops, vegetated filter strips, rotational grazing, livestock exclusion fencing, riparian buffers, legacy sediment removal, etc.

In addition, Pennsylvania has a number of funding programs in place to ensure that the LAs assigned to nonpoint sources in the Indian Creek Watershed TMDL can be achieved. Some of the potential sources of funding for LA implementation activities such as agricultural BMPs and stream restoration projects are 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, National Fish and Wildlife Foundation Grants, Pennsylvania's State Revolving Loan Program (also available for permitted activities), and landowner contributions. These incentive-based programs allow for implementation of a wide array of BMPS, such as forested riparian buffers, which are widely recognized as one of the best ways to promote stream health. Riparian buffers protect streams from sedimentation and nutrient impairments by filtering these pollutants from runoff and floodwaters and by protecting streambanks from erosion. However, riparian buffers are also beneficial for many other reasons beyond just protecting from sedimentation and nutrients. For instance, riparian buffers may: filter out other pollutants such as pesticides; provide habitat and nutrition for aquatic, semi-aquatic and terrestrial organisms; and moderate stream temperature.

Finally, the goal of the TMDL is to restore the watershed so that all applicable designated uses are attained, and for this TMDL in particular, the aquatic life use. Because IBIs represent one sampling point in time, continued monitoring and adaptive management are encouraged so as to assess the effectiveness of pollutant reduction strategies on aquatic life.

8 Public Participation

Consistent with EPA's belief there should be full and meaningful public participation in the TMDL development process, the Indian Creek Sediment TMDL has undergone an extensive public participation process in an effort to address stakeholders' concern and achieve effective sediment loading reductions in the Indian Creek watershed. This section describes past and anticipated public participation opportunities for this TMDL.

To date, EPA has held four stakeholder meetings regarding this TMDL to inform stakeholders about ongoing progress and to solicit data and feedback. On December 4, 2014 and February 11, 2016, informational stakeholder webinars were held during the pre-TMDL development phase to inform stakeholders of ongoing progress and to solicit relevant data and information. Approximately 30 stakeholders from 20 organizations attended each webinar. Please refer to **Section 3** for a description of the relevant and available data received. All information received was considered during the development of the TMDL. On August 3, 2017, EPA held an in-person stakeholder meeting in PADEP's northeast regional office to discuss the existing sediment loads in Indian Creek Watershed and introduce possible allocation strategies. Approximately 30 stakeholders from 15 organizations attended the meeting. In addition, an existing loads report was shared with stakeholders, and their comments were accepted until August 30, 2017. EPA received five sets of written comments and considered them during the development of the final TMDL report. On March 22, 2018, EPA held an additional stakeholder webinar to discuss the sediment allocation scenarios. Two sets of stakeholder comments were received on the proposed allocation scenarios. All comments on the draft existing loads report and the proposed allocation scenarios were considered during the development of the final TMDL.

EPA appreciates and considered all of the data and information provided by stakeholders throughout the TMDL development process. EPA is providing an additional public comment period of 45-days to allow time for stakeholder review and feedback on this TMDL. In addition, a virtual public meeting will be held to discuss the draft TMDL with stakeholders. After the TMDL is established, EPA will provide written responses to comments received during the 45-day public comment period,

This section of the document will be updated prior to finalization to reflect the public participation during the public comment period.

PUBLIC NOTICE

EPA Proposes Sediment TMDL for the Indian Creek Watershed
Notice of Availability, Solicitation of Public Comment

The U.S. Environmental Protection Agency, Region III (EPA) plans to establish a Total Maximum Daily Load (TMDL) for sediment in the Indian Creek Watershed. The TMDL will establish a cap on sediment loadings necessary to address the degraded aquatic life in Indian Creek caused by excessive sediment from regulated stormwater runoff, agricultural runoff, wastewater treatments plants, and other sources. The Indian Creek drains approximately 7 square miles in Montgomery County in Pennsylvania and discharges to the East Branch Perkiomen Creek. Municipalities impacted by this action include Lower Salford, Telford, Souderton and Franconia.

The draft TMDL will be available for public comment for 45 days from May 10, 2021 to June 24, 2021. EPA welcomes input from the public and interested parties regarding the proposed TMDL. A draft of the *TMDL for Sediment in the Indian Creek Watershed, Montgomery County, Pennsylvania* is available on EPA's website at https://www.epa.gov/tmdl/revised-sediment-tmdl-indian-creek-watershed-montgomery-county-pennsylvania. Please direct questions to Ms. Jillian Adair at (215) 814-5713 or adair.jillian@epa.gov. Written comments will be accepted through June 24, 2021. All written comments should be sent to Ms. Jillian Adair via electronic mail, or alternatively, mail (contact information below). Please reference "Indian Creek Sediment TMDL" on all submitted comments.

Ms. Jillian Adair
Adair.jillian@epa.gov
US EPA Region III, 3WD42
1650 Arch Street
Philadelphia, PA 19103

To assist the public in their understanding of the draft TMDL and provide an overview of the TMDL process, EPA invites the public to attend a virtual public meeting on June 8, 2021 at 1:00 p.m. Please use the weblink above for information on how to attend the meeting.

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Appendix A: Parameters for Channel and Streambank Erosion

GWLF simulates surface runoff and streambank erosion. Parameters for streambank erosion include animal density, total length of natural stream channel, fraction of developed land, mean stream depth, average watershed curve number, average watershed erodibility, and average watershed slope. Streambank sediment load is a function of lateral erosion rates, stream length, soil bulk density and mean channel or stream depth. The channel or stream depth is the difference between the thalweg and the top of the stream bank as shown in Figure A.

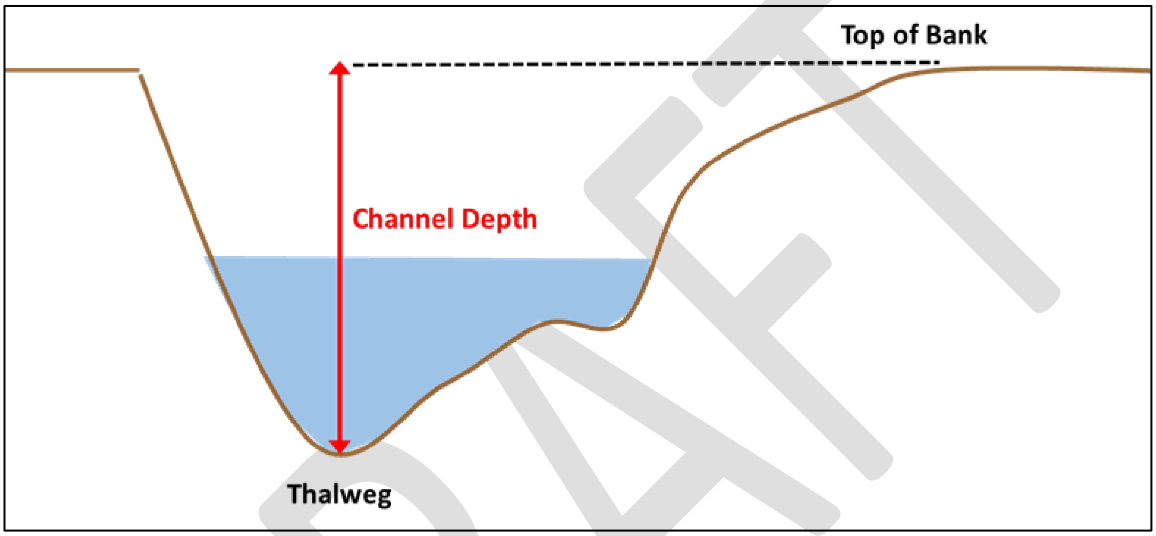


Figure A: Stream cross-section schematic showing the thalweg, top of bank and channel depth.

The mean stream depth is typically estimated as a function of watershed area, using USGS regional curves. **Figure B** shows regional curves that represents the relationship between bankfull cross-sectional mean stream depth and drainage area in non-urban Piedmont Physiographic Province, PA and MD (Cinotto, 2003). In areas where streambank erosion is a contributing, but less significant factor with regard to sediment delivery in the watershed, this is a viable option.

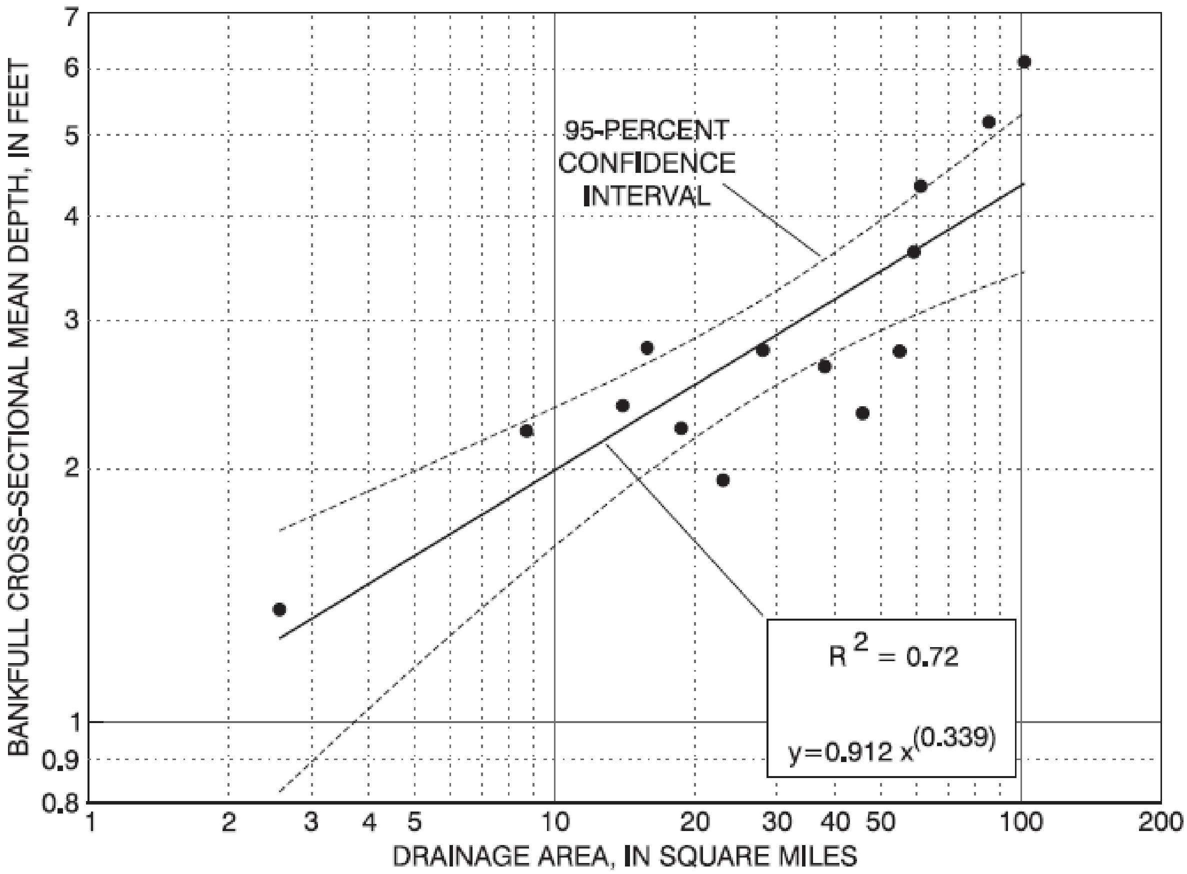


Figure B: Regional curves based on physiographic region, represents relationship between Bankfull cross-sectional mean stream depth and drainage area in non-urban Piedmont Physiographic Province, PA and MD (Cinotto, 2003).

However, because streambank erosion in the watershed was anticipated to be a primary factor, EPA personnel performed a field survey to gain a better estimate of stream depth. Field surveys were conducted on December 30th, 2014 and December 21st, 2015 in the Indian Creek and Birch Run watersheds, respectively. **Figure C** shows the 16 site locations on the mainstem and unknown tributaries of Indian Creek. **Figure D** shows the 11 site locations on the mainstem and unnamed tributaries of Birch Run.

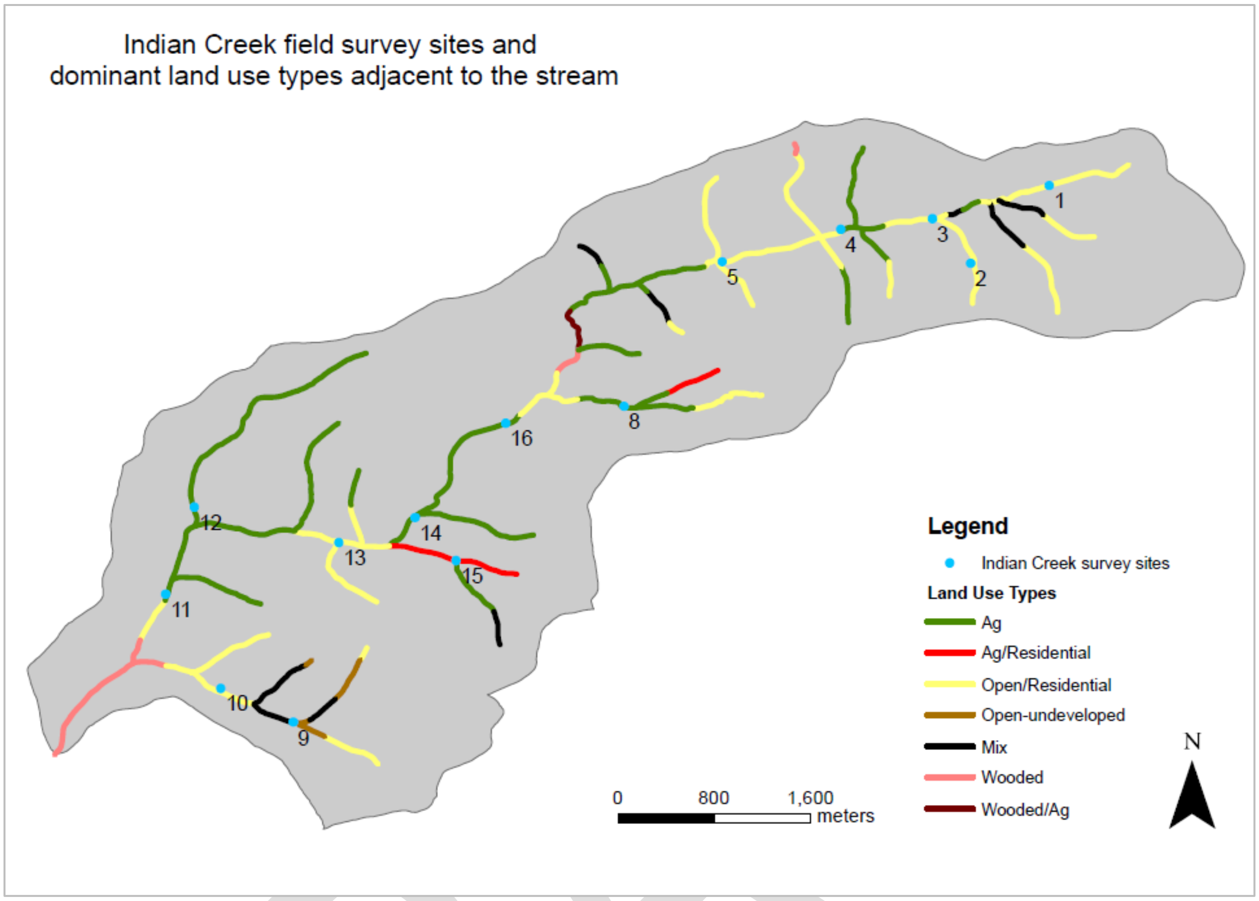
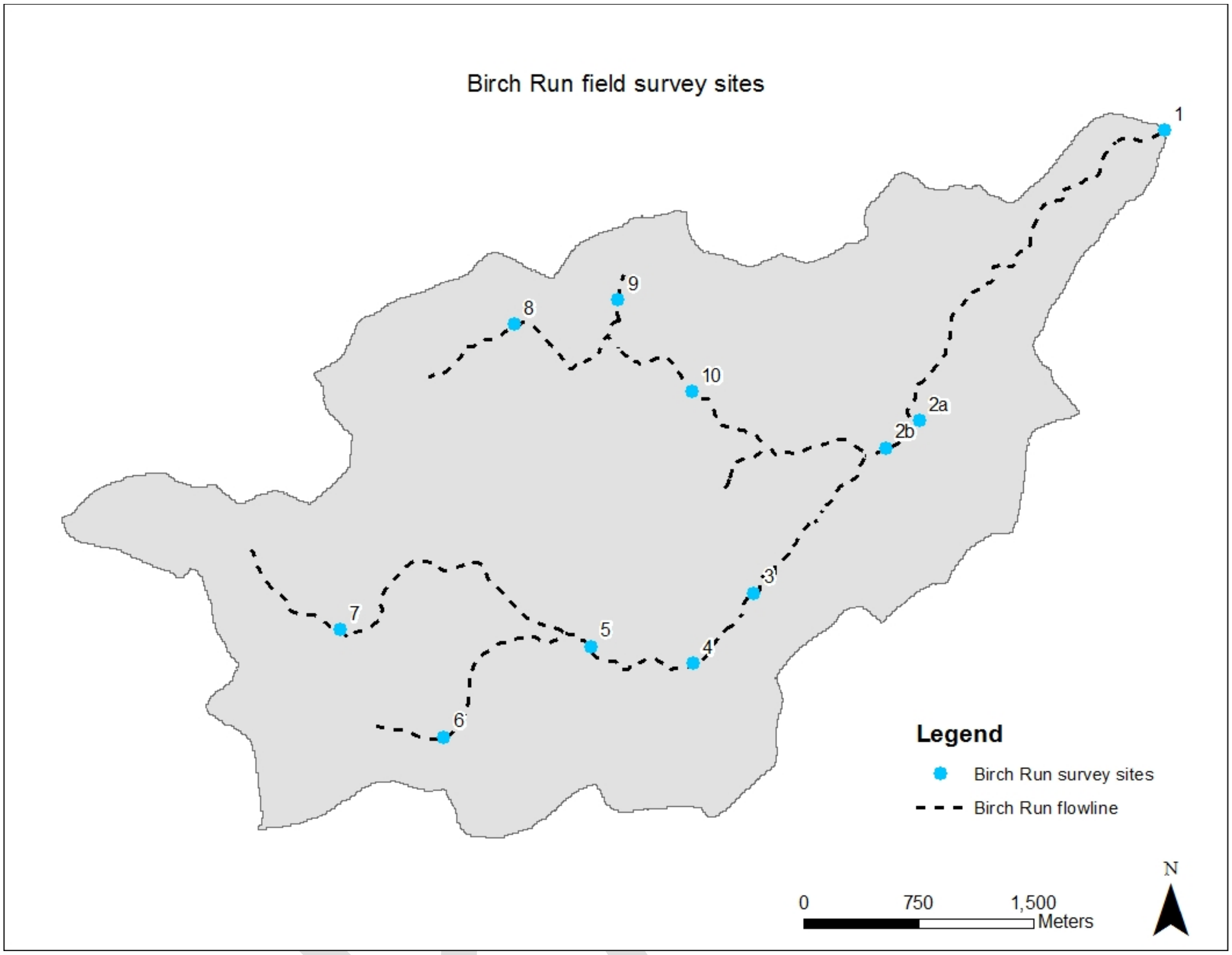


Figure C: Map of the Indian Creek field survey sites and the dominant land use types adjacent to the stream.



FigureD: Map of the Birch Run field survey sites.

Accessibility and predominant land use adjacent to stream was taken into account when selecting sampling locations. This ensured representative sampling within the Indian Creek Watershed. Site accessibility was limited along Birch Run; however, multiple land use categories were still represented. The Protocol for Collecting Eroding Streambank and Channel Attributes (2014) describes the site selection and data collection process for in situ measurements and observations of streambank and channel attributes. The following attributes were collected at each site: channel depth, channel length, streambank condition, and Geographic Positioning System location. Additional site information such as land use type, riparian vegetation, and flow condition were noted. The site locations and corresponding stream depth measurements for each watershed are shown in **Tables I and II**.

Table I: Channel depth measurements for the Indian Creek Watershed field survey on December 30th, 2014.

Watershed/Stream	Site	GPS Latitude	GPS Longitude	Channel Depth (m)	Channel Length (m)
Indian Creek/mainstem	1	40.32412	-75.33742	1.6	250
Indian Creek/UNT	2	40.3183	-75.34331	0.6	100
Indian Creek/mainstem	3	40.32166	-75.34617	1.7	100
Indian Creek/mainstem	4	40.32087	-75.35303	1.8	100
Indian Creek/mainstem	5	40.31843	-75.36188	2.2	150
Indian Creek/UNT	6	-	-	Dry Channel	-
Indian Creek/UNT	7	-	-	Dry Channel	-
Indian Creek/UNT	8	40.30763	-75.36923	1.7	100
Indian Creek/UNT	9	40.284	-75.394	1.2	250
Indian Creek/UNT	10	40.28653	-75.3994	0.9	200
Indian Creek/mainstem	11-RL	40.29358	-75.40354	3.0	200
Indian Creek/mainstem	11-RR	40.29358	-75.40354	0.9	200
Indian Creek/UNT	12	40.30009	-75.40138	0.7	> 250
Indian Creek/mainstem	13	40.29745	-75.39058	1.7	500
Indian Creek/mainstem	14	40.2993	-75.38489	1.4	200
Indian Creek/UNT	15	40.2961	-75.38181	0.9	200
Indian Creek/mainstem	16-RL	40.30637	-75.3781	2.8	300
Indian Creek/mainstem	16-RR	40.30637	-75.3781	1.6	300

Note: RL – river left RR – river right UNT – unnamed tributary GPS: Geographic Positioning System

Table II: Channel depth measurements for the Birch Run watershed field survey on December 21st, 2015.

Watershed/Stream	Site	GPS Latitude	GPS Longitude	Average Channel Depth (m)	Channel Length (m)
Birch Run/mainstem	1	40.1477	-75.6209	0.85	300
Birch Run/mainstem	2a	40.1311	-75.6404	0.95	200
Birch Run/mainstem	2b	40.1296	-75.6432	1.05	200
Birch Run/mainstem	3	40.1214	-75.6537	0.25	200
Birch Run/mainstem	4	40.1174	-75.6585	0.85	200
Birch Run/mainstem	5	40.1186	-75.6663	0.6	300
Birch Run/UNT	6	40.1136	-75.6778	0.6	100
Birch Run/mainstem	7	40.1201	-75.6855	0.55	400
Birch Run/UNT	8	40.1377	-75.6713	0.55	200
Birch Run/UNT	9	40.1389	-75.6632	0.45	200
Birch Run/UNT	10	40.1334	-75.6578	0.55	100

Note: RL – river left RR – river right UNT – unnamed tributary GPS: Geographic Positioning System

Photographs were taken to document the site location and streambank condition (i.e. observable erosion). **Figures E – G** show stream depth measurements taken at several sites in Indian Creek while **Figures H – J** show sites along Birch Run. The average results of both the USGS calculation, and the EPA survey can be seen in Table III (duplicated in **Table 4-2** of the TMDL report). The USGS regional curves are based on properly functioning streams (*i.e.*, not exhibiting excessive streambank erosion). As expected, the actual measured stream depths were larger, reflecting the ongoing erosion process in both streams.

Table III: Calculated and measured stream bank heights in Indian Creek and Birch Run.

Average Stream Bank Height	Indian Creek (m)	Birch Run (m)
USGS Calculation	0.27	0.27
EPA Survey	1.50	0.66

Figure E: Site 3, observable erosion on the left bank of the Indian Creek mainstem.

Figure F: Site 14, stream depth measurement taken on the left bank of the Indian Creek mainstem.

Figure G: Site 16, stream depth measurement taken on the left bank of the Indian Creek mainstem.

Figure H: Site 7, stream depth measurement taken on the left and right bank of the Birch Run mainstem. This picture shows the predominant wooded land use.

Figure I: Site 3, stream depth measurement taken on the left and right bank of Birch Run. This picture shows the predominant wooded land use along with residential.

Figure J: Site 4, stream depth measurement taken on the left and right bank of Birch Run. This picture shows residential and open land uses present within the watershed.

Appendix B: PADEP's 303(d) List of Siltation Impaired Waters in the Indian Creek Watershed

This TMDL addresses all siltation impairments within the Indian Creek watershed, listed below.

Assessment Unit ID	Assessment Unit Name	Water Size	Water Size Units	Pollutant	Integrated Reporting Category	Cycle First Listed
PA-SCR-25986884	Indian Creek-25986884	0.466	Miles	SILTATION	5	2004
PA-SCR-25986896	Indian Creek-25986896	0.3014	Miles	SILTATION	5	2004
PA-SCR-25986916	Indian Creek-25986916	0.2057	Miles	SILTATION	5	2004
PA-SCR-25986918	Indian Creek-25986918	0.1118	Miles	SILTATION	5	2004
PA-SCR-25986922	Indian Creek-25986922	0.0988	Miles	SILTATION	5	2004
PA-SCR-25986932	Indian Creek-25986932	0.4089	Miles	SILTATION	5	2004
PA-SCR-25986934	Indian Creek-25986934	0.7245	Miles	SILTATION	5	2004
PA-SCR-25986950	Indian Creek-25986950	0.0715	Miles	SILTATION	5	2004
PA-SCR-25987244	Indian Creek-25987244	0.1162	Miles	SILTATION	5	2004
PA-SCR-25987246	Indian Creek-25987246	0.0398	Miles	SILTATION	5	2004
PA-SCR-25987424	Indian Creek-25987424	0.2274	Miles	SILTATION	5	2004
PA-SCR-25987426	Indian Creek-25987426	0.2125	Miles	SILTATION	5	2004
PA-SCR-25987428	Indian Creek-25987428	0.1485	Miles	SILTATION	5	2004
PA-SCR-25987758	Indian Creek-25987758	0.0224	Miles	SILTATION	5	2004
PA-SCR-25987762	Indian Creek-25987762	0.0857	Miles	SILTATION	5	2004
PA-SCR-25999084	Indian Creek-25999084	0.1218	Miles	SILTATION	5	2004
PA-SCR-25999086	Indian Creek-25999086	0.1982	Miles	SILTATION	5	2004
PA-SCR-25999088	Indian Creek-25999088	0.064	Miles	SILTATION	5	2004
PA-SCR-25999090	Indian Creek-25999090	0.0081	Miles	SILTATION	5	2004
PA-SCR-25999094	Indian Creek-25999094	0.2162	Miles	SILTATION	5	2004
PA-SCR-25999098	Indian Creek-25999098	0.0913	Miles	SILTATION	5	2004
PA-SCR-25999100	Indian Creek-25999100	0.1485	Miles	SILTATION	5	2004
PA-SCR-25999122	Indian Creek-25999122	0.0472	Miles	SILTATION	5	2004

Assessment Unit ID	Assessment Unit Name	Water Size	Water Size Units	Pollutant	Integrated Reporting Category	Cycle First Listed
PA-SCR-25999426	Indian Creek-25999426	0.2796	Miles	SILTATION	5	2004
PA-SCR-25999520	Indian Creek-25999520	0.4461	Miles	SILTATION	5	2004
PA-SCR-25999524	Indian Creek-25999524	0.0503	Miles	SILTATION	5	2004
PA-SCR-25999526	Indian Creek-25999526	0.32	Miles	SILTATION	5	2004
PA-SCR-25999814	Indian Creek-25999814	0.0547	Miles	SILTATION	5	2004
PA-SCR-25999818	Indian Creek-25999818	0.1299	Miles	SILTATION	5	2004
PA-SCR-25999820	Indian Creek-25999820	0.082	Miles	SILTATION	5	2004
PA-SCR-25999828	Indian Creek-25999828	0.0814	Miles	SILTATION	5	2004
PA-SCR-25986868	Unnamed Tributary to Indian Creek-25986868	0.3877	Miles	SILTATION	5	2004
PA-SCR-25986872	Unnamed Tributary to Indian Creek-25986872	0.0336	Miles	SILTATION	5	2004
PA-SCR-25986874	Unnamed Tributary to Indian Creek-25986874	0.2044	Miles	SILTATION	5	2004
PA-SCR-25986878	Unnamed Tributary to Indian Creek-25986878	0.3299	Miles	SILTATION	5	2004
PA-SCR-25986882	Unnamed Tributary to Indian Creek-25986882	0.1653	Miles	SILTATION	5	2004
PA-SCR-25986892	Unnamed Tributary to Indian Creek-25986892	0.3859	Miles	SILTATION	5	2004
PA-SCR-25986902	Unnamed Tributary to Indian Creek-25986902	0.2535	Miles	SILTATION	5	2004
PA-SCR-25986904	Unnamed Tributary to Indian Creek-25986904	0.2778	Miles	SILTATION	5	2004
PA-SCR-25986920	Unnamed Tributary to Indian Creek-25986920	0.4026	Miles	SILTATION	5	2004
PA-SCR-25986926	Unnamed Tributary to Indian Creek-25986926	0.4896	Miles	SILTATION	5	2004
PA-SCR-25986930	Unnamed Tributary to Indian Creek-25986930	0.6251	Miles	SILTATION	5	2004
PA-SCR-25986954	Unnamed Tributary to Indian Creek-25986954	0.1727	Miles	SILTATION	5	2004
PA-SCR-25987060	Unnamed Tributary to Indian Creek-25987060	1.0613	Miles	SILTATION	5	2004
PA-SCR-25987062	Unnamed Tributary to Indian Creek-25987062	0.4082	Miles	SILTATION	5	2004

Assessment Unit ID	Assessment Unit Name	Water Size	Water Size Units	Pollutant	Integrated Reporting Category	Cycle First Listed
PA-SCR-25987064	Unnamed Tributary to Indian Creek-25987064	0.4872	Miles	SILTATION	5	2004
PA-SCR-25987252	Unnamed Tributary to Indian Creek-25987252	0.3523	Miles	SILTATION	5	2004
PA-SCR-25987254	Unnamed Tributary to Indian Creek-25987254	0.3772	Miles	SILTATION	5	2004
PA-SCR-25987756	Unnamed Tributary to Indian Creek-25987756	0.0292	Miles	SILTATION	5	2004
PA-SCR-25987764	Unnamed Tributary to Indian Creek-25987764	0.0671	Miles	SILTATION	5	2004
PA-SCR-25987766	Unnamed Tributary to Indian Creek-25987766	0.0186	Miles	SILTATION	5	2004
PA-SCR-25999064	Unnamed Tributary to Indian Creek-25999064	0.3759	Miles	SILTATION	5	2004
PA-SCR-25999066	Unnamed Tributary to Indian Creek-25999066	0.54	Miles	SILTATION	5	2004
PA-SCR-25999068	Unnamed Tributary to Indian Creek-25999068	0.2523	Miles	SILTATION	5	2004
PA-SCR-25999070	Unnamed Tributary to Indian Creek-25999070	0.3169	Miles	SILTATION	5	2004
PA-SCR-25999072	Unnamed Tributary to Indian Creek-25999072	0.4679	Miles	SILTATION	5	2004
PA-SCR-25999074	Unnamed Tributary to Indian Creek-25999074	0.6555	Miles	SILTATION	5	2004
PA-SCR-25999076	Unnamed Tributary to Indian Creek-25999076	0.2889	Miles	SILTATION	5	2004
PA-SCR-25999078	Unnamed Tributary to Indian Creek-25999078	0.4965	Miles	SILTATION	5	2004
PA-SCR-25999080	Unnamed Tributary to Indian Creek-25999080	0.3865	Miles	SILTATION	5	2004
PA-SCR-25999082	Unnamed Tributary to Indian Creek-25999082	0.2778	Miles	SILTATION	5	2004
PA-SCR-25999092	Unnamed Tributary to Indian Creek-25999092	0.4499	Miles	SILTATION	5	2004
PA-SCR-25999102	Unnamed Tributary to Indian Creek-25999102	0.133	Miles	SILTATION	5	2004
PA-SCR-25999132	Unnamed Tributary to Indian Creek-25999132	0.133	Miles	SILTATION	5	2004
PA-SCR-25999424	Unnamed Tributary to Indian Creek-25999424	0.3766	Miles	SILTATION	5	2004

Assessment Unit ID	Assessment Unit Name	Water Size	Water Size Units	Pollutant	Integrated Reporting Category	Cycle First Listed
PA-SCR-25999518	Unnamed Tributary to Indian Creek-25999518	0.2069	Miles	SILTATION	5	2004
PA-SCR-25999528	Unnamed Tributary to Indian Creek-25999528	0.43	Miles	SILTATION	5	2004
PA-SCR-25999812	Unnamed Tributary to Indian Creek-25999812	0.0317	Miles	SILTATION	5	2004
PA-SCR-25999816	Unnamed Tributary to Indian Creek-25999816	0.0435	Miles	SILTATION	5	2004

Appendix C: Sediment Data Assessment

As explained in **Section 2.4,** excess sediment has been identified as one of the leading causes of impairment of our nation's waters, contributing to the decline of populations of aquatic life nationwide. **Figure A** illustrates many of the sediment related processes that can impact aquatic life. For example, excessive deposited and bedded sediment can alter benthic habitat quality and availability, thus shifting fish and macroinvertebrate communities (Kaller and Hartman, 2004). While changes in land use impact overland sediment transport to streams, storm events in heavily impervious areas cause high and flashy stream flow resulting in stream bank erosion and increased sediment delivery to streams.

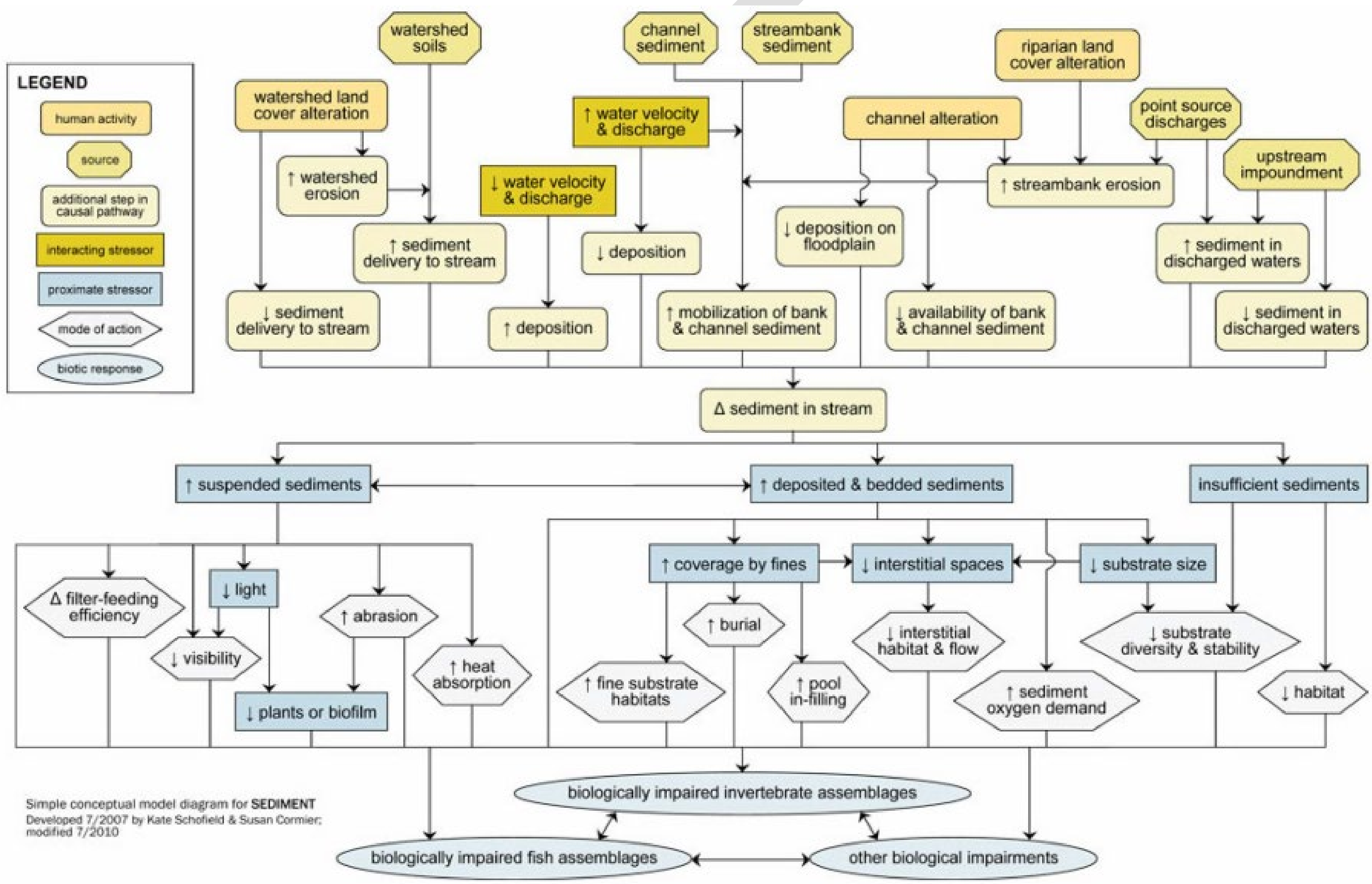


Figure A Conceptual Model of the Causal Relationship between Sediment and Responses in Streams (Cormier, 2007)

Because Pennsylvania does not have a numeric criterion for sediment, PADEP interprets its narrative criteria to assess if sediment is the cause of impaired aquatic life. Elements of the narrative criteria that are relevant to excess sediment include "…substances in amounts to be harmful to aquatic life use" and "substances which produce… turbidity or settle to form deposits.".

As a result of stakeholder concern, EPA assessed the readily available habitat data in Indian Creek to confirm the sediment impairment that was previously identified by PADEP in their

303(d) integrated report. The considerations presented below in the evaluation of habitat data collected by PADEP function as lines of evidence that PADEP typically uses to assess the narrative criteria and to make siltation impairment determinations. Pennsylvania's Methodology for Habitat assessment has been modified from EPA's Rapid Bioassessment Protocol and is used to assess the physical characteristics of a stream. Please refer to Chapter 4 of PADEP's Assessment Methodology for Rivers and Streams (2018) for more information. EPA looked at data collected by PADEP at each sample site, compared the results as described below, and summarized the sample site data for the watershed.

In addition, EPA examined data and information presented in Appendix A collected during EPA's field survey to further illustrate the sediment impairment within Indian Creek. Furthermore, EPA considered information gained through analyses of land-use and land management data from within Indian Creek to further support the sediment impairment determination.

Evaluation of Habitat Data collected by PADEP
The habitat assessment is used to evaluate potential impacts of existing physical stream conditions on aquatic life. The habitat assessment process involves rating twelve parameters as excellent, good, fair, or poor, by assigning a numeric value (ranging from 0-20), based on the criteria included in the Habitat Assessment Field Data Sheets (PADEP, 2013). Three metrics in the habitat assessment are related to impacts from excess sediment: embeddedness, sediment deposition, and conditions of the bank. These metrics are critical because they evaluate the instream habitat components that have direct and indirect effects on benthic macroinvertebrate and fish communities. Embeddedness estimates the percent (vertical depth) of the substrate interstitial spaces filled with fine sediments. Sediment deposition estimates the extent of sediment effects in the formation of islands, point bars, and pool deposition. Condition of the bank evaluates the extent of bank failure or signs of erosion. Scores in the "suboptimal" (11-15), "marginal" (6-10), or "poor" (0-5) categories for these parameters are of concern due to their ability to influence instream benthic macroinvertebrate, fish, and periphyton habitat. Total habitat scores of all 12 metrics in the "optimal" category range from 240-192; "suboptimal" 180-132, "marginal" 120-72, and "poor" is 60 or less. The decision gaps between these categories are left to the discretion of the field investigator.

EPA used the sediment relevant habitat metrics as lines of evidence regarding the sediment impairment in Indian Creek. Scores in the "poor", "marginal", and "suboptimal" range were considered evidence for sediment impairment. PADEP sampled three locations on September 6, 2013 and two locations on April 15, 2014. PADEP uses the following scoring categories for individual metrics: the "optimal" category ranges from 16-20, "suboptimal" from 11- 15, "marginal" from 6-10, and "poor" from 0-5. Habitat scores and metrics related to sediment impacts are presented in Table A. Values highlighted in yellow represent "suboptimal" scores, whereas red values represent "marginal" scores. All habitat metrics related to sediment are in either the "marginal" or "suboptimal" category with 10 in "marginal" and five in "suboptimal".

Table A: Indian Creek Sediment-Related Habitat Assessment Results ("marginal" results in red; "suboptimal" results in yellow)

Location	Date	Embeddedness	Sediment Deposition	Condition of Banks
Bergey Rd.	9/6/2013	9	7	11
Rt. 63	9/6/2013	9	12	10
Price Rd.	9/6/2013	6	6	6
Bergey Rd.	4/15/2013	11	10	14
Rt. 63	4/15/2013	7	8	9

Consideration of Field Data Collected by EPA
In addition to the habitat assessment performed above, EPA examined field data and information collected as part of the effort to calculate a watershed-specific stream bank height for the Indian Creek watershed. Average stream bank height for Indian Creek as calculated by EPA measured 1.50 meters, as compared to the USGS regional estimate for properly functioning streams of 0.27 meters. This difference in stream bank heights highlights the ongoing erosion process and resulting sediment issues present within Indian Creek. In addition to stream bank height measurements, Figures E through G provide telling visuals of the ongoing streambank erosion and sediment impairment.

Sediment Impairment Summary
The habitat scores for the sediment related metrics in Indian Creek range from "marginal" to "suboptimal" for all PADEP samples, confirming that aquatic life is impaired by excess sediment. In addition, the data collected by EPA highlights the ongoing streambank erosion and resultant excessive sediment delivery occuring within Indian Creek.

After examining the above in-stream data collected within Indian Creek, EPA considered the cumulative information it gained through the TMDL analysis, including land-use information, from within the Indian Creek watershed. As EPA's Causal Analysis/Diagnosis Decision Information System outlines, among other factors, evidence of eroding and collapsing streambanks, presence of impervious surfaces within the watershed, embedded in-stream substrate, degraded aquatic life scores, slow-moving water, deposits of sediment, and incised stream channels are all factors that lead to the identification of sediment as a candidate cause of impairment. These factors are well documented in the Indian Creek watershed. Consequently, EPA is confident that the above habitat assessment, in addition to PADEP's previous habitat assessments, appropriately identified sediment as a cause of impairment within the Indian Creek watershed.